ISUZU

ISUZU COMMERCIAL TRUCK

FSR, FTR, FVR
Equipped with 6 HK1 engine

SERVICE MANUAL (1998)

BOOK 2 OF 3

CAUTION

In order to reduce the chance of personal injury and/or property damage, carefully observe the instructions that follow:

The service manuals of Isuzu Motors America Inc. are intended for use by professional, qualified technicians. Attempting repairs or service without the appropriate training, tools, and equipment could cause injury to you or others. This could also damage the vehicle, or cause the vehicle to operate improperly.

Proper vehicle service and repair are important to the safety of the service technician and to the safe, reliable operation of all motor vehicles. If you need to replace a part, use the same part number or an equivalent part. Do not use a replacement part of lesser quality.

The service procedures we recommend and describe in this service manual are effective methods of performing service and repair. Some of the procedures require the use of tools that are designed for specific purposes.

Accordingly, any person who intends to use a replacement part, a service procedure, or a tool that is not recommended by Isuzu, must first establish that there is no jeopardy to personal safety or the safe operation of the vehicle.

This manual contains various *CAUTIONS* and *NOTICES* that you must observe carefully in order to reduce the risk of personal injury during service or repair. Improper service or repair may damage the vehicle or render the vehicle unsafe. These *CAUTIONS* and *NOTICES* are not exhaustive. Isuzu can not possibly warn of all the potentially hazardous consequences of your failure to follow these instructions.

This manual covers service procedures to vehicles that are equipped with a Supplemental Inflatable Restraint (SIR). Refer to the *CAUTIONS* in Cautions and Notices and in Restraints. Refer to SIR component and wiring location views in Restraints before performing a service on or around SIR components or wiring. Failure to follow these *CAUTIONS* could cause air bag deployment, personal injury, or otherwise unneeded SIR repairs.

In order to help avoid accidental air bag deployment and personal injury, whenever you service a vehicle that requires repair of the SIR and another vehicle system, we recommend that you first repair the SIR, then go on to the other system.

BLANK

New Style Service Manual Structure

This new style service manual is constructed with the following 10 sections:

0. General Information
1. Heating, Ventilation, and Air Conditioning (HVAC)
2. Steering
3. Suspension
4. Driveline and Axle
5. Brakes
6. Engine
7. Transmission
8. Body and Accessories
9. Restraints

The following table gives the previous service manual sub-sections with the name of the new section and sub-section. Almost all of the diagnosis that was in section 8A is now located in its applicable sub-section.

Truck Service Manual Sub-Section to Section and Sub-Section Conversion Table

Old Sub-Section	Old Sub-Section	New Section	Section Name	Sub-Section Name
0A	General Information	0	General Information	General Information
0B	Maintenance and Lubrication	0	General Information	Maintenance and Lubrication
0C	Vibration Diagnosis	0	General Information	Vibration Diagnosis
1A	Heating and Ventilation	1	HVAC	Heating and Ventilation (Non A/C)
1B	Heating, Ventilation, and Air Conditioning	1	HVAC	HVAC systems with Air Conditioning
1D	A/C Compressors	1	HVAC	HVAC systems with Air Conditioning
2A	Frame and Bumpers	8	Body and Accessories	Frame and Underbody, and Bumpers
3A	Front Wheel Alignment	3	Suspension	Wheel Alignment
3B, 3B1A, 3B1B	Power Steering Gear and Pump	2	Steering	Power Steering System
3B3	Steering Linkage	2	Steering	Steering Linkage
3C	Front Suspension	3	Suspension	Front Suspension
3D	Rear Suspension	3	Suspension	Rear Suspension
3E	Tires and Wheels	3	Suspension	Tires and Wheels
3F	Steering Columns	2	Steering	Steering Wheel and Column
4A	Propeller Shaft	4	Driveline/Axle	Propeller Shaft
4B	Rear Axle and Differential	4	Driveline/Axle	Rear Drive Axle
4C	Front Drive Axles and Differential	4	Driveline/Axle	Front Wheel Drive Shafts and Front Drive Axle
5	Hydraulic Brakes	5	Brakes	Hydraulic Brakes
5A	Master Cylinder	5	Brakes	Hydraulic Brakes
5B	Front Disc Brakes	5	Brakes	Disc Brakes
5C	Drum Brakes	5	Brakes	Drum Brakes
5D	Hydraulic or Vacuum Booster	5	Brakes	Hydraulic Brakes
5E	Antilock Brakes	5	Brakes	Antilock Brakes
5F	Parking Brake	5	Brakes	Parking Brake
6, 6A	Engine Mechanical	6	Engine	Engine Mechanical
6B	Engine Cooling and Radiator	6	Engine	Engine Cooling
6C	Engine Fuel	6	Engine	Engine Controls
6D	Engine Electrical	6	Engine	Engine Electrical
—	Driveability and Emissions	6	—	Engine Controls
6F	Exhaust System	6	—	Exhaust System
6H	Vacuum Pump	6	Engine	Vacuum Pump
6J	Turbocharger	6	Engine	Turbocharger
7A	Automatic Transmission	7	Transmission/Transaxle	Automatic Transmission and Transmission/Transfer Case Unit Repair Manual

Truck Service Manual Sub-Section to Section and Sub-Section Conversion Table (cont'd)

Old Sub-Section	Old Sub-Section	New Section	Section Name	Sub-Section Name
7B	Manual Transmission	7	Transmission/Transaxle	Manual Transmission and Transmission/Transfer Case Unit Repair Manual
7C	Clutch	7	Transmission/Transaxle	Clutch
7D	Transfer Case	4	Driveline/Axle	Transfer Case and Transmission/Transfer Case Unit Repair Manual
8B	Lighting Systems	8	Body and Accessories	Lighting Systems
8C	Instrument Panel and Gages	8	Body and Accessories	Instrument Panel, Gages and Console
8D	Chassis Electrical	8	—	Refer to the Index at the end of the manual
8E	Wipers and Washers	8	Body and Accessories	Wiper/Washer Systems
9A	Audio Systems	8	Body and Accessories	Entertainment
9B	Cruise Control	8	Body and Accessories	Cruise Control
9E	Engine Coolant Heater	6	Engine	Engine Cooling
9F	Luggage Carrier	8	Body and Accessories	Roof
9J	Supplemental Inflatable Restraint	9	Restraints	Supplemental Inflatable Restraints
9K	Remote Keyless Entry	8	Body and Accessories	Keyless Entry
10A1	Doors	8	Body and Accessories	Doors
10A2	Seats	8	Body and Accessories	Seats
		9	Restraints	Seat Belts
10A3	Stationary Windows	8	Body and Accessories	Stationary Glass
10A4	Interior Trim	8	Body and Accessories	Exterior/Interior Trim
10A5	Endgate	8	Body and Accessories	Body Rear End
10B	Cab and Body Maintenance	—	—	Refer to the Index at the end of the manual

BLANK

1998 Medium Duty Truck FSR, FTR, FVR Service Manual

Volume 2

This manual provides information on the diagnosis, the service procedures, the adjustments, and the specifications for the 1998 Isuzu Medium Duty Truck.

The technicians who understand the material in this manual and in the appropriate Dealer Service Bulletins better service the vehicle owners.

When this manual refers to a brand name, a part number, or a specific tool, you may use an equivalent product in place of the recommended item. All information, illustrations and specifications in this manual are based on the latest product information available at the time of publication approval. Isuzu reserves the right to make changes at any time without notice.

Published by

ISUZU MOTORS AMERICA, INC.

©1998 ISUZU MOTORS AMERICA, INC.
The information cutoff date is 12/1/97.

ALL RIGHTS RESERVED
LITHO IN U.S.A.

No part of this manual may be reproduced, stored in any retrieval system, or transmitted in any form or by any means (including but not limited to electronic, mechanical, photocopying, and recording) without the prior written permission of Isuzu Motors America, Inc. This applies to all text, illustrations, and tables.

BLANK

Table of Contents

Volume 1

Preface 1
- Cautions and Notices 3

General Information 0-1
- General Information 0-3
- Maintenance and Lubrication 0-33
- Vibration Diagnosis and Correction 0-51

HVAC 1-1
- Heating and Ventilation (Non-A/C) 1-3
- HVAC Systems with A/C - Manual 1-57

Body and Accessories 8-1
- Lighting Systems 8-7
- Wipers/Washer Systems 8-103
- Entertainment 8-123
- Wiring Systems 8-143
- Instrument Panel, Gauges and Console 8-283
- Horns 8-351
- Exterior Trim 8-361
- Waterleaks 8-363
- Stationary Windows 8-365
- Bumpers 8-373
- Body Front End 8-377
- Doors 8-399
- Seats 8-431
- Interior Trim 8-441
- Plastic Panel Information and Repair 8-453
- Paint/Coatings 8-455
- Frame and Underbody 8-463
- Collision Repair 8-485

Restraints 9-1
- Seat Belts 9-3

Volume 2

Preface 1
- Cautions and Notices 3

Steering 2-1
- Power Steering System 2-3
- Steering Linkage (Non-Rack & Pinion) 2-53
- Steering Wheel and Column - Tilt 2-63

Suspension 3-1
- Suspension General Diagnosis 3-3
- Wheel Alignment 3-17
- Front Suspension 3-25
- Rear Suspension 3-63
- Tires and Wheels 3-87
- Air Suspension 3-107

Driveline/Axle 4-1
- Propeller Shaft 4-3
- Rear Drive Axle 4-63
- Rear Axle Controls 4-89

Brakes 5-7
- Hydraulic Brakes 5-7
- Disc Brakes 5-41
- Park Brakes 5-89
- Air Brakes 5-113
- Air Drums 5-227
- Air Compressor 5-287
- Antilock Brake System 5-303
- Air Antilock Brake System 5-399

Volume 3

Preface 1
- Cautions and Notices 3

Engine 6-1
- Engine Cooling 6-3
- Engine Electrical 6-43
- Engine Controls - 7.8L 6-111
- Engine Exhaust 6-137
- Engine, On-vehicle Service 6A6
- Engine Overhaul 6A6B
- Water Pump 6B1B
- Fuel System 6C
- Fuel Injection 6C2
- Diesel Electrical 6D6
- Emission and Electrical Diagnosis 6E
- Turbocharger 6J

Transmission/Transaxle 7-1
- Manual Transmission - Medium Duty 7-3
- Automatic Transmission - Allison 7-15
- Clutch 7-43
- Manual Transmission Overhaul 7-49

BLANK

Cautions and Notices

Cautions and Notices 3
Definition of Caution, Notice, and Important 3
ABS Handling Caution 3
Battery Disconnect Caution 3
Brake Dust Caution 3
Brake Fluid Caution 4
Clutch Dust Caution 4
Fuel and EVAP Pipe Caution 4
Fuel Gauge Leak Caution 4
Fuel Pipe Fitting Caution 4
Fuel Storage Caution 4
Gasoline/Gasoline Vapors Caution 4
Moving Parts and Hot Surfaces Caution 4
Road Test Caution 4
Safety Glasses and Compressed Air Caution 4
Safety Goggles and Fuel Caution 4
Vehicle Lifting Caution 4
Window Removal Caution 4
Work Stall Test Caution 5
Defective Scan Tool Notice 5
Fastener Notice 5
Fuel Pressure Notice 5
Handling ESD Sensitive Parts Notice 5
Ignition OFF When Disconnecting Battery Notice 5
Nylon Fuel Lines Notice 5
PCM and ESD Notice 5
Single Cylinder Flooding Notice 5

BLANK

Cautions and Notices

Definition of Caution, Notice, and Important

The diagnosis and repair procedures in the Isuzu Service Manual contain both general and specific Cautions, Notices, and Importants. Isuzu is dedicated to the presentation of service information that helps the technician to diagnose and repair the systems necessary for the proper operation of the vehicle, however, certain procedures may present a hazard to the technician if they are not followed in the recommended manner. Cautions, Notices, and Importants are elements designed to prevent these hazards, however, not all hazards can be foreseen. This information is placed at strategic locations within the service manual. This information is designed to prevent the following from occurring:

- Serious bodily injury to the technician
- Damage to the vehicle
- Unnecessary vehicle repairs
- Unnecessary component replacement
- Improper repair or replacement of vehicle components. Any caution or notice that appears in general information is referenced from the individual service categories.

CAUTION Defined

When encountering a CAUTION, you will be asked to take a necessary action or not to take a prohibited action. If a CAUTION is not heeded, the following consequences may occur:

- Serious bodily injury to the technician
- Serious bodily injury to other technicians in the workplace area
- Serious bodily injury to the driver and/or passenger(s) of the vehicle, if the vehicle has been improperly repaired

NOTICE Defined

Notices call special attention to a necessary action or to a prohibited action. If a NOTICE is not heeded, the following consequences may occur:

- Damage to the vehicle
- Unnecessary vehicle repairs
- Unnecessary component replacement
- Improper operation or performance of the system or component under repair
- Damage to any systems or components which are dependent upon the proper operation of the system or component under repair
- Improper operation or performance of any systems or components which are dependent upon the proper operation or performance of the system or component under repair
- Damage to fasteners, basic tools, or special tools
- The leakage of coolant, lubricant, or other vital fluids

IMPORTANT Defined

IMPORTANT statements emphasize a necessary characteristic of a diagnostic or repair procedure. IMPORTANT statements are designed to do the following:

- Clarify a procedure
- Present additional information for accomplishing a procedure
- Give insight into the reason or reasons for performing a procedure in the manner recommended
- Present information that will help to accomplish a procedure in a more effective manner
- Present information that gives the technician the benefit of past experience in accomplishing a procedure with greater ease

ABS Handling Caution

Caution: Certain components in the Antilock Brake System (ABS) are not intended to be serviced individually. Attempting to remove or disconnect certain system components may result in personal injury and/or improper system operation. Only those component with approved removal and installation procedures should be serviced.

Battery Disconnect Caution

Caution: Before servicing any electrical component, the ignition key must be in the OFF or LOCK position and all electrical loads must be OFF, unless instructed otherwise in these procedures. If a tool or equipment could easily come in contact with a live exposed electrical terminal, also disconnect the negative battery cable. Failure to follow these precautions may cause personal injury and/or damage to the vehicle or its components.

Brake Dust Caution

Caution: Avoid taking the following actions when you service wheel brake parts:

- ***Do not grind brake linings.***
- ***Do not sand brake linings.***
- ***Do not clean wheel brake parts with a dry brush or with compressed air.***

Some models or aftermarket brake parts may contain asbestos fibers which can become airborne in dust. Breathing dust with asbestos fibers may cause serious bodily harm. Use a water-dampened cloth in order to remove any dust on brake parts. Equipment is available commercially in order to perform this washing function. These wet methods prevent fibers from becoming airborne.

Brake Fluid Caution

Caution: Brake fluid may be irritating to the skin or eyes. In case of contact, take the following actions:

- *Eye contact—rinse eyes thoroughly with water.*
- *Skin contact—wash skin with soap and water.*

Clutch Dust Caution

Caution: When servicing clutch parts, do not create dust by grinding or sanding the clutch disc or by cleaning parts with a dry brush or with compressed air. A water-dampened cloth—NOT SOAKED—should be used. The clutch disc contains asbestos fibers which can become airborne if dust is created during servicing. Breathing dust containing asbestos fibers may cause serious bodily harm.

Fuel and EVAP Pipe Caution

Caution: In order to Reduce the Risk of Fire and Personal Injury observe the following items:

- *Replace all nylon fuel pipes that are nicked, scratched or damaged during installation, Do Not attempt to repair the sections of the nylon fuel pipes*
- *Do Not hammer directly on the fuel harness body clips when installing new fuel pipes. Damage to the nylon pipes may result in a fuel leak.*
- *Always cover nylon vapor pipes with a wet towel before using a torch near them. Also, never expose the vehicle to temperatures higher than 115°C (239°F) for more than one hour, or more than 90°C (194°F) for any extended period.*
- *Apply a few drops of clean engine oil to the male pipe ends before connecting fuel pipe fittings. This will ensure proper reconnection and prevent a possible fuel leak. (During normal operation, the O-rings located in the female connector will swell and may prevent proper reconnection if not lubricated.)*

Fuel Gauge Leak Caution

Caution: Wrap a shop towel around the fuel pressure connection in order to reduce the risk of fire and personal injury. The towel will absorb any fuel leakage that occurs during the connection of the fuel pressure gauge. Place the towel in an approved container when the connection of the fuel pressure gauge is complete.

Fuel Pipe Fitting Caution

Caution: Always apply a few drops of clean engine oil to the male pipe ends before connecting fuel pipe fittings in order to reduce the risk of fire and personal injury.

This will ensure proper reconnection and prevent a possible fuel leak.

During normal operation, the O-rings located in the female connector will swell and may prevent proper reconnection if not lubricated.

Fuel Storage Caution

Caution: Do not drain the fuel into an open container. Never store the fuel in an open container due to the possibility of a fire or an explosion.

Gasoline/Gasoline Vapors Caution

Caution: Gasoline or gasoline vapors are highly flammable. A fire could occur if an ignition source is present. Never drain or store gasoline or diesel fuel in an open container, due to the possibility of fire or explosion. Have a dry chemical (Class B) fire extinguisher nearby.

Moving Parts and Hot Surfaces Caution

Caution: While working around a running engine, avoid contact with moving parts and hot surfaces to prevent possible bodily injury.

Road Test Caution

Caution: Road test a vehicle under safe conditions and while obeying all traffic laws. Do not attempt any maneuvers that could jeopardize vehicle control. Failure to adhere to these precautions could lead to serious personal injury.

Safety Glasses and Compressed Air Caution

Caution: Wear safety glasses when using compressed air in order to prevent eye injury.

Safety Goggles and Fuel Caution

Caution: Always wear safety goggles when working with fuel in order to protect the eyes from fuel splash.

Vehicle Lifting Caution

Caution: To help avoid personal injury, when a vehicle is on a hoist, provide additional support for the vehicle at the opposite end from which you are removing components. The additional support will reduce the possibility of the vehicle falling off the hoist. When you are removing major components from the vehicle while the vehicle is on a hoist, chain the vehicle frame to the hoist pads at the same end from which you are removing the major components to prevent tip-off. If you fail to follow these precautionary measures, vehicle damage, serious personal injury, or death may result.

Window Removal Caution

Caution: When working with any type of glass, use approved safety glasses and gloves to reduce the chance of personal injury.

Work Stall Test Caution

Caution: One or more of the following guidelines may apply when performing specific required tests in the work stall:

- ***When a test requires spinning the drive wheels with the vehicle jacked up, adhere to the following precautions:***
  - ***Do not exceed 56 km/h (35 mph) when spinning one drive wheel with the other drive wheel stopped. This limit is necessary because the speedometer indicates only one-half the actual vehicle speed under these conditions. Personal injury may result from excessive wheel spinning.***
  - ***If all of the drive wheels are spinning at the same speed, do not exceed 112 km/h (70 mph). Personal injury may result from excessive wheel spinning.***
  - ***All persons should stay clear of the rotating components and the balance weight areas in order to avoid possible personal injury.***
  - ***When running an engine in the repair stall for an extended period of time, use care not to overheat the engine and the transmission.***
- ***When a test requires jacking up the vehicle and running with the wheels and brake rotors removed, adhere to the following precautions:***
  - ***Do not apply the brake with the brake rotors removed.***
  - ***Do not place the transmission in PARK with the drive wheels still spinning.***
  - ***Turn Off the ignition in order to stop the powertrain components from spinning.***

Defective Scan Tool Notice

Notice: Do not use a scan tool that displays faulty data. Report the scan tool problem to the manufacturer. Use of a faulty scan tool can result in misdiagnosis and unnecessary parts replacement.

Fastener Notice

Notice: Use the correct fastener in the correct location. Replacement fasteners must be the correct part number for that application. Fasteners requiring replacement or fasteners requiring the use of thread locking compound or sealant are identified in the service procedure. Do not use paints, lubricants, or corrosion inhibitors on fasteners or fastener joint surfaces unless specified. These coatings affect fastener torque and joint clamping force and may damage the fastener. Use the correct tightening sequence and specifications when installing fasteners in order to avoid damage to parts and systems.

Fuel Pressure Notice

Notice: Do not allow the fuel pressure to exceed the specified value because damage to the fuel pressure regulator or the fuel pressure gauge may result.

Handling ESD Sensitive Parts Notice

Notice: Electrostatic discharge (ESD) can damage many solid-state electrical components. ESD susceptible components may or may not be labeled with the ESD symbol. Handle all electrical components carefully. Use the following precautions in order to avoid ESD damage:

Touch a metal ground point in order to remove your body's static charge before servicing any electronic component; especially after sliding across the vehicle seat.

Do not touch exposed terminals. Terminals may connect to circuits susceptible the ESD damage.

Do not allow tools to contact exposed terminals when servicing connectors.

Do not remove components from their protective packaging until required to do so.

Avoid the following actions unless required by the diagnostic procedure:

Jumpering or grounding of the components or connectors.

Connecting test equipment probes to components or connectors. Connect the ground lead first when using test probes.

Ground the protective packaging of any component before opening. Do not rest solid-state components on metal workbenches, or on top of TVs, radios, or other electrical devices.

Ignition OFF When Disconnecting Battery Notice

Notice: Always turn the ignition OFF when connecting or disconnecting battery cables, battery chargers, or jumper cables. Failing to do so may damage the Powertrain Control Module (PCM) or other electronic components.

Nylon Fuel Lines Notice

Notice: Do not attempt to straighten the kinked nylon fuel lines. Replace any kinked nylon fuel feed or return pipes in order to prevent damage to the vehicle.

PCM and ESD Notice

Notice: Do not touch the connector pins or soldered components on the circuit board in order to prevent possible electrostatic discharge (ESD) damage to the PCM.

Single Cylinder Flooding Notice

Notice: In order to prevent flooding of a single cylinder and possible engine damage, relieve the fuel pressure before performing the fuel injector coil test procedure.

BLANK

Section 2
Steering

Power Steering System 2-3
Specifications 2-3
Fastener Tightening Specifications 2-3
Diagnostic Information and Procedures 2-3
Power Steering System Test Procedure 2-3
Objectionable Hiss 2-5
Rattle or Chuckle Noise in Steering Gear 2-5
Excessive Wheel Kickback or Loose Steering 2-5
Increase in Effort While Turning Steering Wheel 2-6
Poor Return of Steering Wheel 2-6
Steering Wheel Surges/Jerks While Turning 2-6
Steering Effort Hard in Both Directions 2-6
Vehicle Leads to One Side or the Other 2-7
Foaming, Milky-Appearing PS Fluid, Low in Level 2-7
Low Oil Pressure Due to Restriction in the Hose 2-7
Low Oil Pressure Due to Steering Gear 2-7
Low Oil Pressure Due to Steering Pump 2-8
Groan Noise in Steering Pump 2-8
Growl Noise in Steering Pump 2-8
Rattle or Knock Noise in Steering Pump 2-9
Swish Noise in Steering Pump 2-9
Whine Noise in Steering Pump 2-9
Repair Instructions 2-10
Power Steering Pump Replacement 2-10
Power Steering Pump Assemble (P/S Pump Repair W/ Air Brakes) 2-12
Power Steering Pump Assemble (P/S Pump Repair W/ Hyd Brakes) 2-18
Bleeding Power Steering System 2-27
Flushing the Power Steering System 2-28
Power Steering Hose Flushing 2-29
Power Steering Hoses Replacement 2-31
Power Steering Gear Replacement 2-34
Sector Shaft Dust Cap Replacement 2-36
Input Shaft Dust Cap Replacement 2-37
Input Shaft Bearing Protector Cap Replacement 2-40
End Limiters Replacement 2-42
Pressure Relief Valve Replacement 2-44
Resuction Valve Replacement 2-46
Power Steering Reservoir Replacement 2-47
Description and Operation 2-51
Power Steering System Description 2-51
Special Tools and Equipment 2-51
Special Tools 2-51
Steering Linkage (Non-Rack & Pinion) 2-53
Specifications 2-53
Fastener Tightening Specifications 2-53
Repair Instructions 2-53
Steering Linkage Inspection 2-53
Tie Rod Replacement 2-54
Steering Arm Replacement 2-56
Tie Rod Arm Replacement 2-57
Relay Rod Replacement 2-58
Pitman Arm Replacement 2-59
Description and Operation 2-62
Steering Linkage Description 2-62
Special Tools and Equipment 2-62
Special Tools 2-62
Steering Wheel and Column - Tilt 2-63
Specifications 2-63
Fastener Tightening Specifications 2-63
Diagnostic Information and Procedures 2-63
Lock System Sticks in Start 2-63
Key Cannot Be Removed in the Off Lock Position 2-63
Noise in Steering Column 2-63
High Steering Shaft Effort 2-63
Loose Steering Wheel (Every Other Tilt Position) 2-64
Steering Wheel Does Not Lock in Any Tilt Position 2-64
Steering Wheel Not Returning to Top Tilt Position 2-64
Noise When Tilting Steering Column 2-64
Turn Signal Does Not Cancel 2-64
Repair Instructions 2-65
Ignition Switch Replacement 2-65
Multifunction Turn Signal Lever Replacement 2-66
Tilt Lever Replacement 2-67
Steering Wheel Replacement 2-68
Upper Steering Shaft Assembly Replacement 2-71
Lower Steering Shaft Assembly Replacement 2-74
Description and Operation 2-77
Steering Wheel and Column Description 2-77
Special Tools and Equipment 2-78
Special Tools 2-78

BLANK

Power Steering System

Specifications

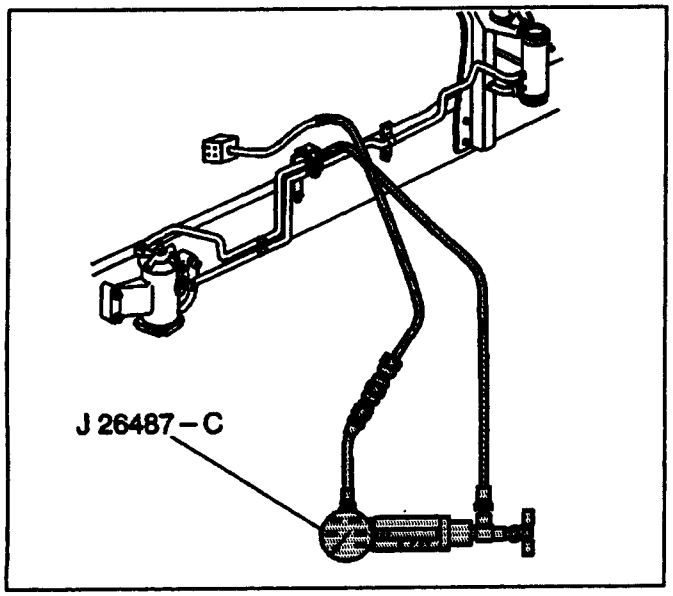
Fastener Tightening Specifications

Application	Specification	
	Metric	English
Cardan Nut	55 N.m	41 lb ft
Power Steering Gear Mounting Nut	450 N.m	330 lb ft
Power Steering Pipe Adapter Nut at Bulk Head	52 N.m	38 lb ft
Power Steering Pipe Mounting Nut	22 N.m	16 lb ft
Reservoir Mounting Bolt	40 N.m	30 lb ft
Power Steering Pump Hose Adapter Mounting Bolt	52 N.m	38 lb ft
Pressure Plate Screw	8 N.m	71 lb in
Pump Body Bolt	54 N.m	40 lb ft
Valve Plug	54 N.m	40 lb ft

Diagnostic Information and Procedures

Power Steering System Test Procedure

Tools Required
J 26487-C Power Steering Analyzer



227945

The *J 26487-C* tool set includes the following components:

- The 0–3000 psi pressure gage
- The 0–10 gpm (gallons per minute) flow meter
- The Gate Valve
- Hoses
- Hose Adapters

Important: The steering gear has end limiter valves (end limiters) which provide an increase in steering effort at a point within 1/3 turn of the axle stop contact. This is normal operation.

1. Place a container under the power steering hoses at the power steering hose bulk head in order to catch the fluid when disconnecting or connecting the hoses.

   Clean the surface of the hoses before disconnecting the hoses.
2. Use the J-42971 (Hydraulic Line Seperator) to disconnect the pressure hose snap-to-connect fittings at the power steering hose bulk head.

Important: Lubricate the tool end in power steering fluid to ensure smooth engagement with the quik disconnectors.

3. Connect the analyzer hoses to the adapters.
4. Bleed the power steering system if the analyzer has never been used. Refer to *Bleeding Power Steering System.*

   Ensure that the analyzer gate valve remains open during the bleeding procedure.

   Important: Throughout the following testing procedure, the letters in parentheses indicate specific pressures and flows.

   Document the values of the pressures and the flows. Use the letters in parentheses as references for comparing the values.
5. Run the engine at idle speed with the gate valve open. Record the flow (A) and the pressure (B).
   5.1. If the flow is below 2 gpm, then the pump may need repair. Continue the test.
   5.2. If the pressure is above 200 psi, inspect the hoses for restrictions.

6. Partially close the gate valve in order to build up to 700 psi. Record the flow (C).
7. Compare the values of flow (A) and flow (C).

   If flow (C) drops more than 1 gpm under flow (A) then:
8. Replace or rebuild the pump.
9. Refer to the appropriate procedure:
   - *Power Steering Pump Assemble (P/S Pump Repair W/ Air Brakes)* or
   - *Power Steering Pump Assemble (P/S Pump Repair W/ Hyd Brakes).*
10. Replace the following components:
    - The ring
    - The rotor
    - The vanes
    - The O-ring seals
11. Complete the following steps in order to obtain the pressure value (D):
    11.1. Close the gate valve for not more than five seconds. partially open the gate valve.
    11.2. Close and partially open the valve two more times. Observe and record the pressure (D) each time that the gate is closed.
12. Compare the pressures (D) to the specified pressures.
    - If the recorded pressures are 100 psi lower than specifications, than replace the pump flow control valve.
    - If the pressures (D) are greater than the low specifications and vary from each other by more than 100 psi (1,450 BAR) than remove and clean the pump flow control valve.
    - Inspect the pump flow control valve bore for dirt or foreign materials. clean the pump flow control valve bore.
    - Inspect the system fluid for contamination. If the fluid is contaminated, dissemble and clean the steering gear and the pump before assembly.
13. Increase the engine speed from idle to approximately 1500 RPM. Record the flow (E).
14. Compare the values of flow (A) and flow (E). Complete the folowing steps if flow (E) varies by more than 1 gpm from flow (A).
    14.1. Remove and clean the pump flow control valve.
    14.2. Inspect the pump flow control valve bore for dirt or foreign materials. Clean the pump flow control bore.
    14.3. Inspect the fluid for contamination. If the fluid is contaminated, dissemble and clean the steering gear and the pump before assembly.
15. Have an assistant lightly turn the steering wheel into the left steering stop and then the right steering stop.

    Caution: This test can be dangerous if not performed correctly. Keep your fingers clear of steering stops and spacer block during this test. Make sure that the spacer block contacts the steering stop squarely. Contact that is not square could break the steering stop or dangerously throw or eject the spacer block.

    Notice: Do not hold the steering wheel in the full turn position longer than five seconds. To do so may damage the power steering pump.

    Important: Use a non-hardened 1.3 cm (0.5 in) steel spacer on the steering gear.
16. Use a long handle to hold the spacer in place in front of the steering stops. this action will prevent pressure relief poppets from tripping.
17. Record the pressure and the flow (F).

    Verify that the following conditions exist:
    - The pressures measured at the steering stops are close in value to the maximum pump output (D).
    - The flow drops below 1 gpm.

    If the above conditions do not exist, the steering gear is leaking internally. Repair the steering gear.
18. Perform the following actions simultaneously.
    - Have an assistant turn the steering wheel slightly in both directions and then quickly release the wheel.
    - Observe the pressure gage.

    Under normal conditions, the needle will move from the normal back pressure reading and snap back when the wheel is released. A slow or sticking needle indicates a sticking rotary valve in the steering gear.
19. Complete the following steps if the pressure gage needle moves slowly or sticks:
    19.1. Remove the rotary valve.
    19.2. Disassemble and clean the rotary valve
20. If contamination exists in the system oil, dissemble and clean or replace the pump.
21. Refer to the appropriate procedure:
    21.1. *Power Steering Pump Assemble (P/S Pump Repair W/ Air Brakes)* or
    21.2. *Power Steering Pump Assemble (P/S Pump Repair W/ Hyd Brakes).*

Objectionable Hiss

Problem	Action
There is a noisy relief valve in the hydraulic pump.	• Noise is evident in all power steering systems. • Hissing is a common noise. The hissing noise is most evident at standstill parking. A hiss is a high frequency noise. • The noise is present in every valve and results from a high velocity fluid passing over the valve orifice edges. • There is not a relationship between the hissing noise and the performance of the steering. A hiss may be expected when the steering wheel is at the end of travel or when it is slowly turning at a standstill. • Do not replace the valve unless the hiss is extremely objectionable. A replacement valve will also exhibit some slight noise and is not always a cure for the objection.

Rattle or Chuckle Noise in Steering Gear

Problem	Action
The steering gear mounting is loose.	1. Inspect the mounting hardware on the steering gear. 2. Torque the hardware to specifications.
The steering linkage is loose.	1. Inspect the linkage pivot points for wear. 2. Replace any worn component.
The pressure hose is touching other parts of the vehicle.	Adjust the hose position. Do not bend the tubing by hand.
The Pitman arm is loose.	Torque the pitman arm nut.
The over-center adjustment is improper. A slight rattle may occur on turns because of an increased clearance off the High Point. This is a normal condition. Do not reduce the clearance below the specified limit in an attempt to eliminate this slight rattle.	Adjust to specifications.

Excessive Wheel Kickback or Loose Steering

Problem	Action
Air is present in the system.	1. Add power steering fluid to the power steering reservoir. 2. Bleed the system. 3. Inspect the hose connectors for proper torque and leakage.
The steering gear mounting is loose.	Tighten the attaching bolts to the specified torque. Refer to *Fastener Tightening Specifications.*
The steering linkage joints are worn.	Replace any loose parts.
The steering gear mounting is improper.	Tighten the steering gear mounting bolt nuts to specifications. Refer to *Fastener Tightening Specifications.*
Worn or maladjusted front wheel bearings	Adjust or replace the bearings
Worn or damaged steering gear	Replace the steering gear.

Increase in Effort While Turning Steering Wheel

Problem	Action
The power steering fluid is low.	Add an adequate amount of power steering fluid.
There is a high degree of internal leakage (power steering pump or power steering gear).	Refer to *Power Steering System Test Procedure.*

Poor Return of Steering Wheel

Problem	Action
Under-inflated tires	Inflate the tires to the specified pressure.
The steering wheel is rubbing against the steering column cover.	Adjust the steering column cover.
The steering shaft bearings are tight or frozen.	Replace the bearings.
There is a binding in the steering linkage.	Replace any of the affected parts.
Misalignment of the steering gear to the column.	Align the steering column.
The suspension joints and the steering linkage are not adequately lubricated.	Lubricate the suspension joints and the steering linkage. Refer to *Fluid and Lubricant Recommendations* in Maintenance and Lubrication.
Sticking or plugging in the steering gear valve spool.	Replace the steering gear. Refer to *Power Steering Gear Replacement.*
Improper front wheel alignment.	1. Inspect the front wheel alignment. 2. Adjust the front wheel alignment to specifications.
A kink in the supply hose.	Replace the hose.

Steering Wheel Surges/Jerks While Turning

Problem	Action
The power steering fluid is low.	Add an adequate amount of power steering fluid.
The pump pressure is insufficient.	Refer to *Power Steering System Test Procedure.*
The gear pressure relief valve is faulty.	Replace the faulty gear pressure relief valve.
The steering linkage is binding.	1. Inspect the steering linkage for any worn components. 2. Replace the worn components.

Steering Effort Hard in Both Directions

Problem	Action
The tire pressure is low.	Inflate the tires to the specified pressure. Refer to *Tire Inflation Description* in Tires and Wheels.
A lack of lubrication in the suspension or ball joint (worn/contaminated joints).	Lubricate and relubricate at the proper intervals or replace the joints. Refer to *Fluid and Lubricant Recommendations* in Maintenance and Lubrication.
There is a binding in the steering linkage.	Replace any affected parts.
There is a misalignment of the steering gear to the column.	Align the steering column.
The power steering fluid is low.	1. Add an adequate amount of power steering fluid. 2. nspect the lines and the joints for any external leakage.

Steering Effort Hard in Both Directions (cont'd)

Problem	Action
High internal leakage exists in the steering gear or in the pump.	Refer to *Power Steering System Test Procedure.*
Misalignment of the front wheels.	Check and adjust the front wheel alignment to specifications.

Vehicle Leads to One Side or the Other

Problem	Action
The road or wind conditions are poor.	1. Test drive the vehicle on a flat road. 2. Turn the vehicle in both directions.
The front wheels are misaligned.	Adjust the front wheels to specifications.
An unbalanced steering gear valve. If the steering gear valve is unbalanced, the steering effort will be very light in the direction of the lead and heavy in the opposite direction.	Replace the steering gear. Refer to *Power Steering Gear Replacement.*
The steering shaft is rubbing the I.D. of the shaft tube.	Align or replace the steering column.

Foaming, Milky-Appearing PS Fluid, Low in Level

Problem	Action
Air in the fluid and a loss of fluid due to internal pump leakage causing overflow.	1. Locate and repair the leak. 2. Bleed the power steering system. Refer to *Bleeding Power Steering System.* Extremely cold temperatures will cause system aeration if the power steering fluid is low.
Hose or air leakage in the reservoir line.	1. Locate and repair the leak 2. Bleed the power steering system. Refer to *Bleeding Power Steering System.* Extremely cold temperatures will cause system aeration if the power steering fluid is low.

Low Oil Pressure Due to Restriction in the Hose

Problem	Action
The hoses are kinked.	1. Remove the kinks. 2. Replace the hoses as necessary.
A foreign object is stuck in the hoses.	1. Remove the foreign object. 2. Replace the hoses as necessary.

Low Oil Pressure Due to Steering Gear

Problem	Action
There is a loss of pressure due to a worn piston ring or a scored housing bore.	Replace the steering gear. Refer to *Power Steering Gear Replacement.*
There is leakage in the steering gear.	Replace the steering gear. Refer to *Power Steering Gear Replacement.*
A damaged end limiter	Replace the end limiters. Refer to *End Limiters Replacement.*

Low Oil Pressure Due to Steering Pump

Problem	Action
The flow control valve is stuck or inoperative.	1. Replace or clean the vanes. 2. Refer to the appropriate procedure: • *Power Steering Pump Assemble (P/S Pump Repair W/ Air Brakes)* • *Power Steering Pump Assemble (P/S Pump Repair W/ Hyd Brakes)*
The pressure plate is not flat against the cam ring.	1. Replace the pressure plate. 2. Refer to the appropriate procedure: • *Power Steering Pump Assemble (P/S Pump Repair W/ Air Brakes)* • *Power Steering Pump Assemble (P/S Pump Repair W/ Hyd Brakes)*
An excessively worn cam ring.	1. Replace the cam ring. 2. Refer to the appropriate procedure: • *Power Steering Pump Assemble (P/S Pump Repair W/ Air Brakes)* • *Power Steering Pump Assemble (P/S Pump Repair W/ Hyd Brakes)*
A scored pressure plate, thrust plate, or rotor.	1. Replace the components. 2. Refer to the appropriate procedure: • *Power Steering Pump Assemble (P/S Pump Repair W/ Air Brakes)* • *Power Steering Pump Assemble (P/S Pump Repair W/ Hyd Brakes)*
The vanes are sticking in the rotor slots.	1. Clean the vanes. 2. Refer to the appropriate procedure: • *Power Steering Pump Assemble (P/S Pump Repair W/ Air Brakes)* • *Power Steering Pump Assemble (P/S Pump Repair W/ Hyd Brakes)*
Improperly installed vanes	1. Inspect the pump for internal damage. 2. Refer to the appropriate procedure: • *Power Steering Pump Assemble (P/S Pump Repair W/ Air Brakes)* • *Power Steering Pump Assemble (P/S Pump Repair W/ Hyd Brakes)*
There is air in the fluid.	Locate and repair the leak.
There is damage on the hoses or the steering gear.	Replace any damaged components.
The power steering fluid is low.	Add an adequate amount of power steering fluid.

Groan Noise in Steering Pump

Problem	Action
The power steering fluid is low.	Add an adequate amount of power steering fluid.
Air is present in the power steering system.	Locate and repair the leak.

Growl Noise in Steering Pump

Problem	Action
Excessive back pressure in the hoses or the steering gear caused by restriction	Locate and repair the restriction.

Growl Noise in Steering Pump

Problem	Action
Scoring on the pressure plates, thrust plates, or rotor	1. Replace the components. 2. Refer to the appropriate procedure: • *Power Steering Pump Assemble (P/S Pump Repair W/ Air Brakes)* • *Power Steering Pump Assemble (P/S Pump Repair W/ Hyd Brakes)*
An excessively worn cam ring	1. Replace the components. 2. Refer to the appropriate procedure: • *Power Steering Pump Assemble (P/S Pump Repair W/ Air Brakes)* • *Power Steering Pump Assemble (P/S Pump Repair W/ Hyd Brakes)*

Rattle or Knock Noise in Steering Pump

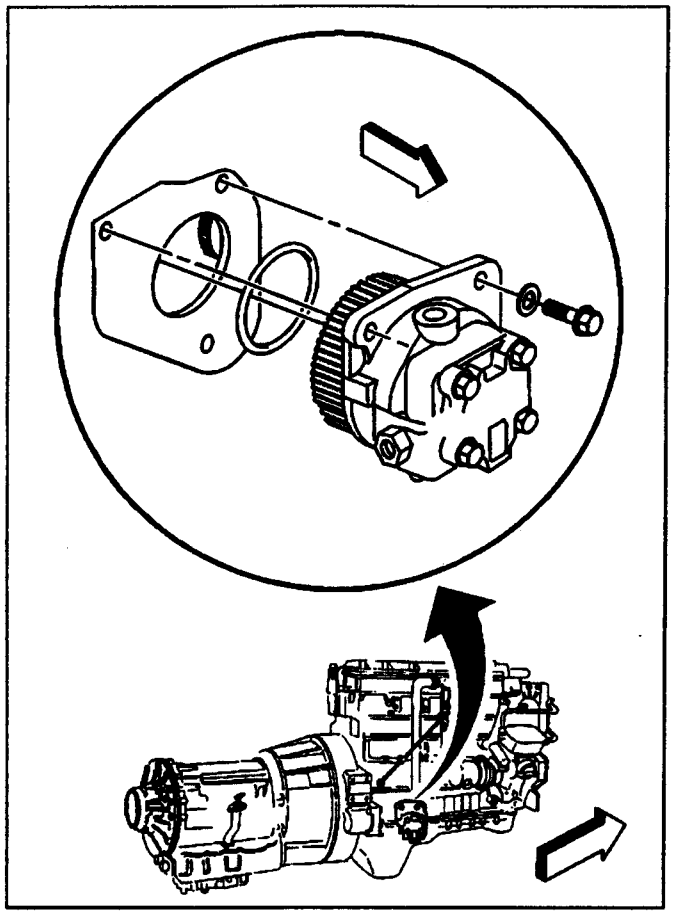
Problem	Action
Loose power steering pump gear nut	Tighten the gear nut to specifications.
The pump vanes are sticking in the rotor slots.	1. Free the pump vanes by removing any burrs, varnish, or dirt. 2. Refer to the appropriate procedure: • *Power Steering Pump Assemble (P/S Pump Repair W/ Air Brakes)* • *Power Steering Pump Assemble (P/S Pump Repair W/ Hyd Brakes)*
The pressure hose is touching other parts of the vehicle.	Adjust the hose position.

Swish Noise in Steering Pump

Problem	Action
A faulty control valve	1. Replace the components. 2. Refer to the appropriate procedure: • *Power Steering Pump Assemble (P/S Pump Repair W/ Air Brakes)* • *Power Steering Pump Assemble (P/S Pump Repair W/ Hyd Brakes)*

Whine Noise in Steering Pump

Problem	Action
A scored pump shaft bearing	1. Replace the components. 2. Refer to the appropriate procedure: • *Power Steering Pump Assemble (P/S Pump Repair W/ Air Brakes)* • *Power Steering Pump Assemble (P/S Pump Repair W/ Hyd Brakes)*



344760

Repair Instructions

Power Steering Pump Replacement

Removal Procedure

1. Tilt the cab. Refer to *Cab Tilting* in General Information.

   Notice: Avoid contaminating the power steering system. Cap open hoses and ports to prevent dirt and debris from entering system. Contaminated power steering fluid and dirt can cause early parts failure.

2. Place a container under the power steering hoses at the power steering pump in order to catch the fluid when disconnecting or connecting the hoses.

   Clean the hose surfaces before disconnecting the hoses.

3. Remove the power steering hoses at the power steering pump.
4. Cap the hoses to prevent any dirt from entering the system.
5. Tag the hose locations.
6. Remove the power steering pump mounting bolts and the washers.

   Notice: Do not Hammer the pump off the engine. Damage to the pump housing may result.

7. Gently pry the power steering pump and the O-ring from the engine.
8. Remove the power steering pump hose adapters mounting bolts and the power steering pump hose adapter, if necessary.

Installation Procedure

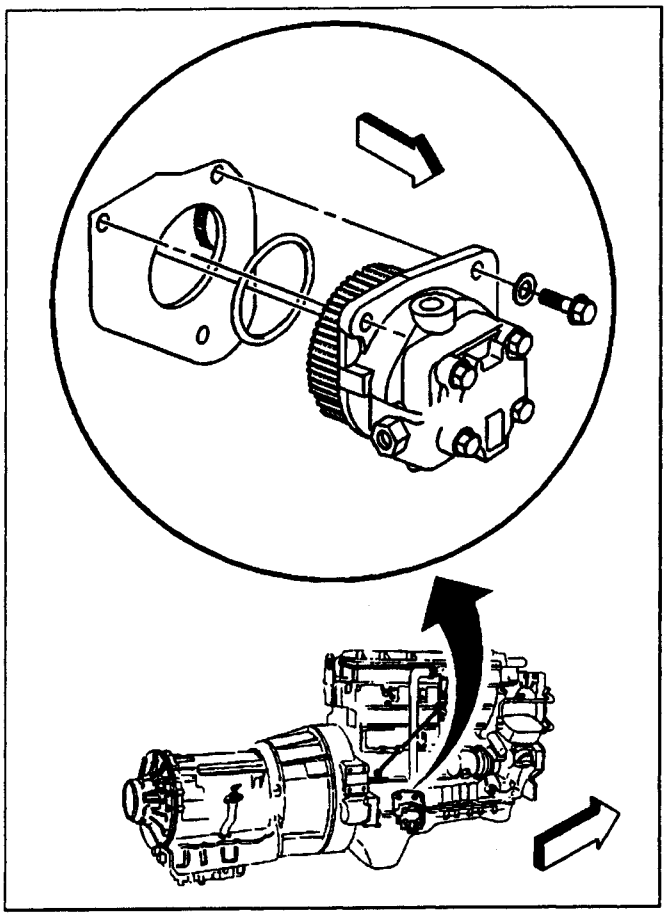
Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the power steering pump hose adapter to the power steering pump hose, if necessary.

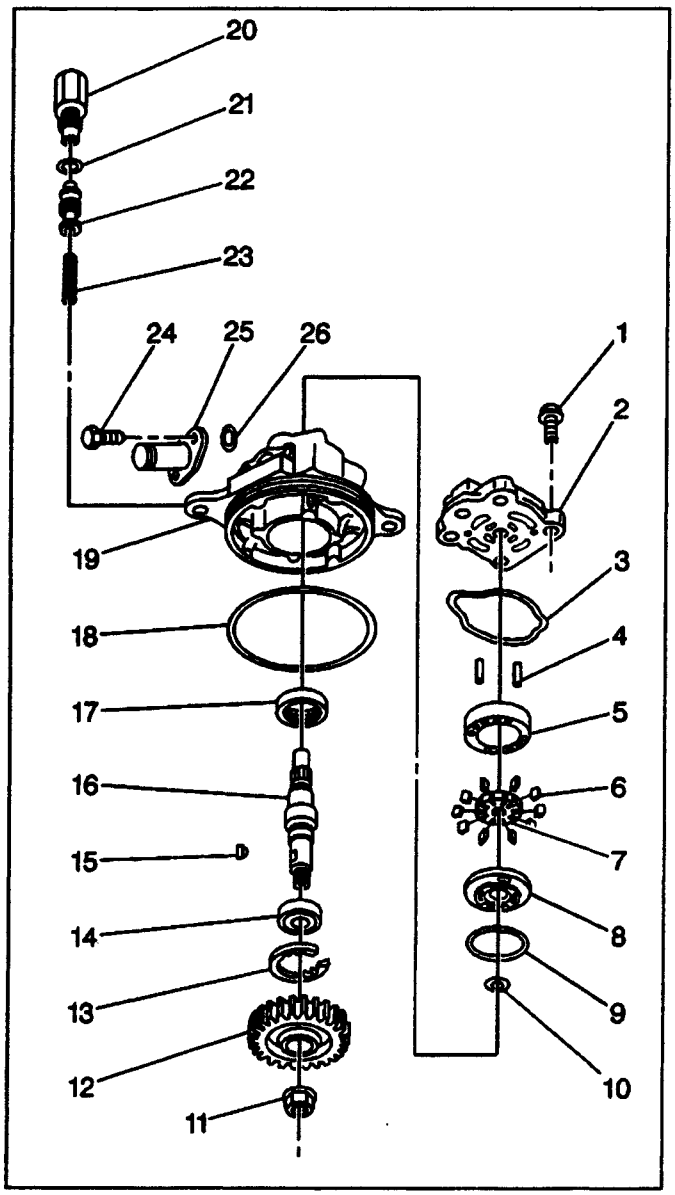
   Secure the adapter with the adapter mounting bolts.

   Tighten

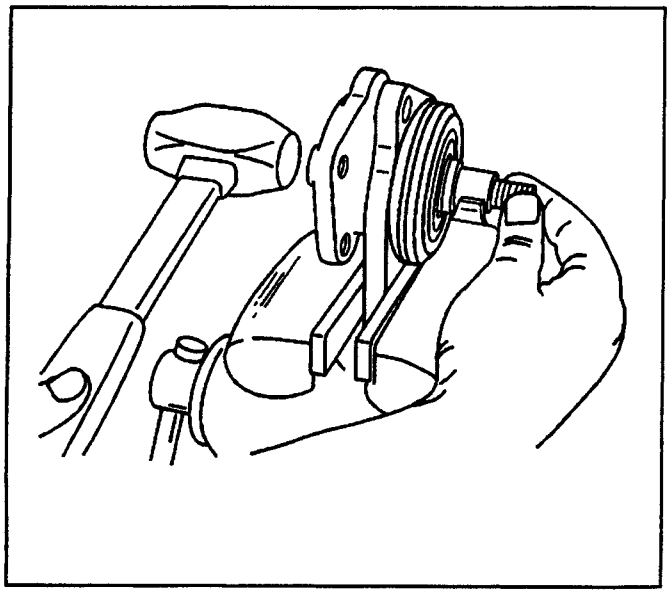
   Tighten the power steering pump hose adapter mounting bolts to 52 N·m (38 lb ft).
2. Position the O-ring and the power steering pump to the engine.
3. Install the power steering pump mounting washers and bolt.
4. Install the power steering pump hoses to the power steering pump.
5. Fill and bleed the power steering system. Refer to *Bleeding Power Steering System.*
6. Lower the cab.



344760



361660



228874

Power Steering Pump Assemble (P/S Pump Repair W/ Air Brakes)

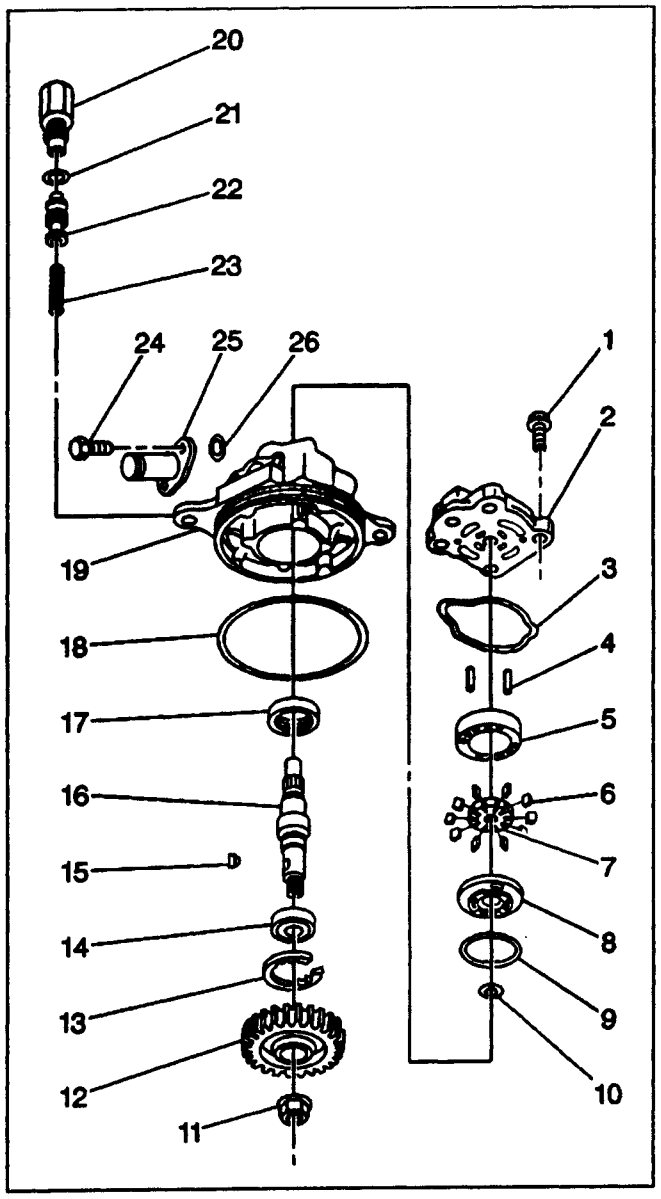
Disassemble Procedure

1. Clean the exterior of the power steering pump with a suitable cleaning solvent that will not damage the rubber components.
2. Remove the following components from the shaft:
   - The nut (11).
   - The gear (2). (the gear is a slip fit)
   - The key (5).
3. Remove the pump body bolts (1).
4. Remove the rear cover (2) and gasket (3) from the pump body (19).
5. Remove the side plate(12) and ring (5) assembly.
6. Dissemble the following components:
   - The side plate (8)
   - The pins (4)
   - The rotor (7)
   - The vanes (6)
7. Remove the snap ring (13) from the pump body.

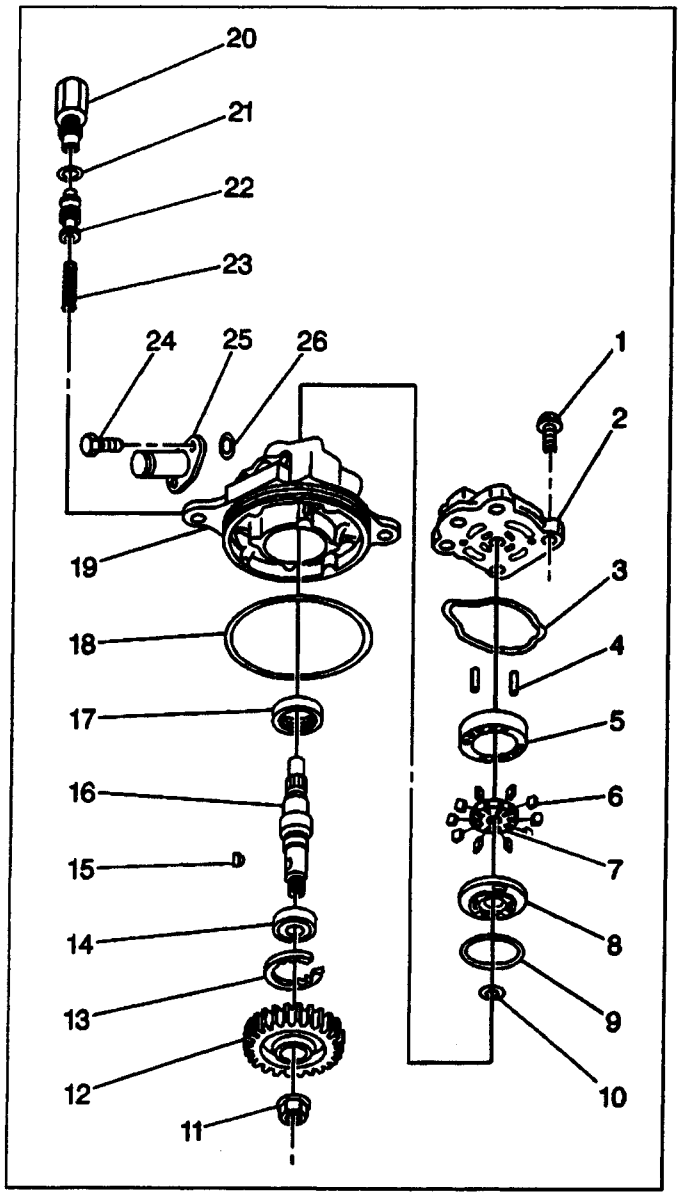
Important: Gently tap with a plastic mallet on the end opposite the drive end to remove the shaft from the pump body.

8. Remove the shaft from the pump body.

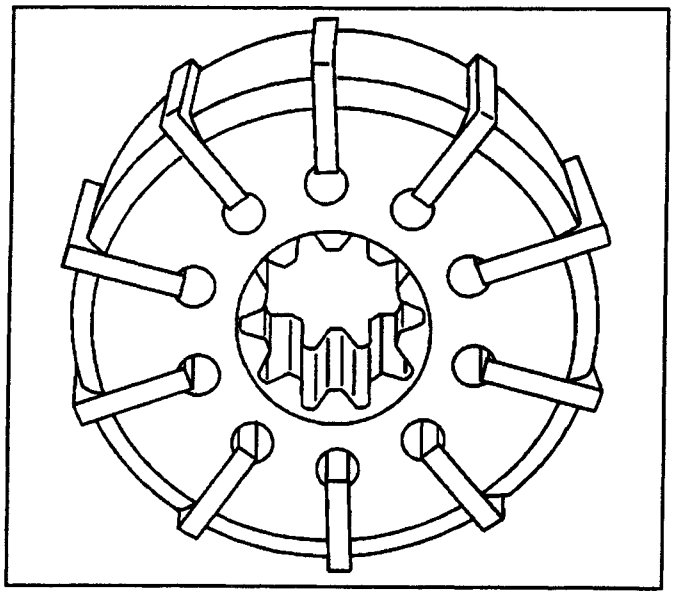
9. Remove the shaft seal from the pump body.
10. Remove the O-ring from the pump body.



361660



361660



228886

Inspection Procedure

1. Inspect the bushing for the following conditions:
   - Scores
   - Wear

   Important: The bushing is not serviced.

   If the bushing shows abnormal conditions, the rear cover must be replaced (2).
2. Use a suitable solvent in order to clean all of the parts.

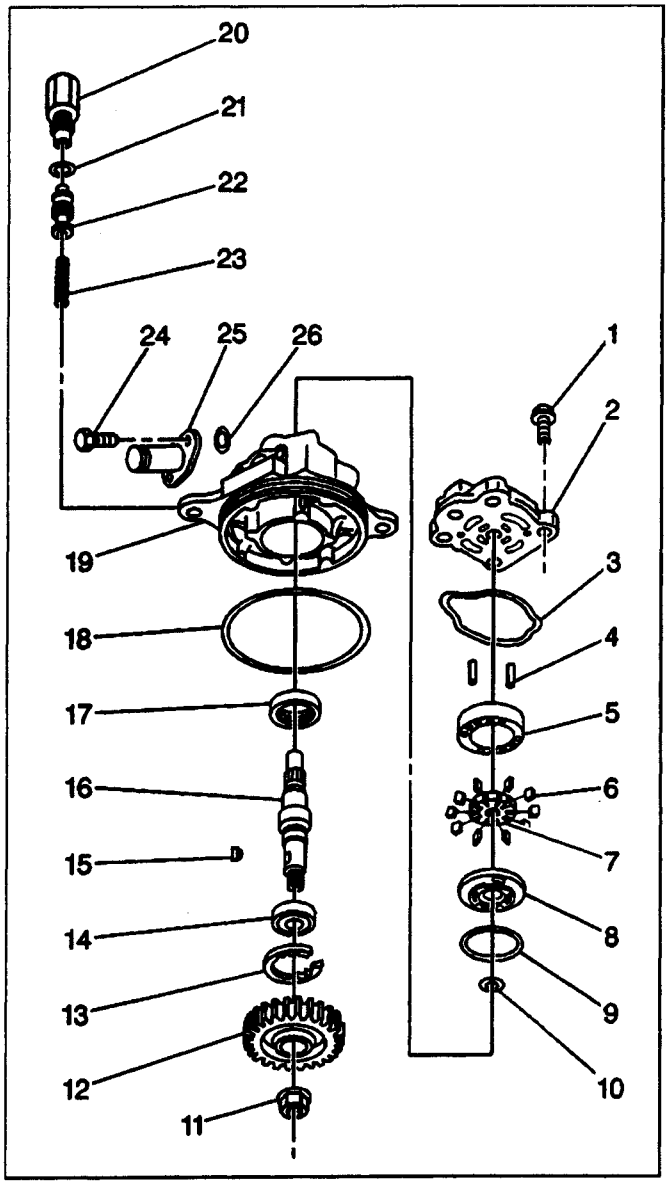
   Dry all of the parts.
3. Inspect the vane tips (6) for the following conditions:
   - Wear
   - Damage
4. Inspect the inner surface of the ring (5) for the following conditions:
   - Scoring
   - Wear
   - Damage

Important: The vanes must fit properly in the rotor slots, without sticking or excessive play.

5. Inspect the fit of the vanes in the rotor
6. Inspect for the following conditions:
   - Burrs in the rotor slots
   - Excessive wear at the thrust faces
7. Replace the rotor, the ring, and all the vanes if any of the following conditions are present:
   - Heavy wear
   - Damage

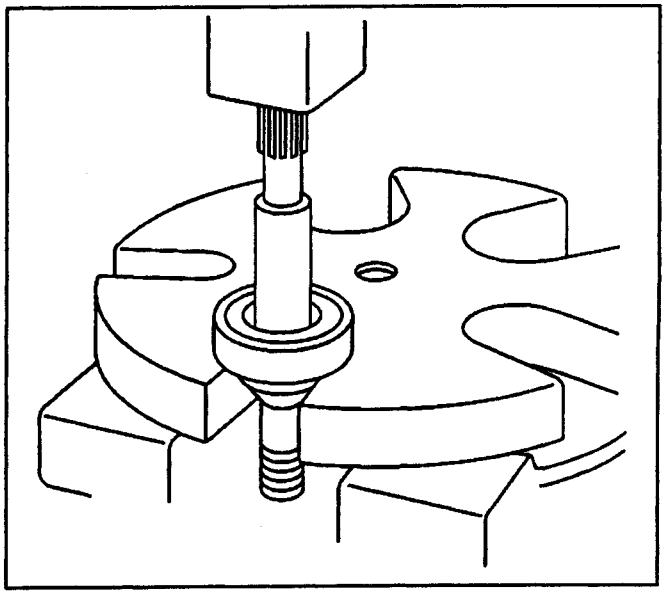
8. Inspect the side plate (8) and rear cover for wear at the thrust faces.
9. Replace the side plate (8) and the rear cover (2) if wear is excessive.
10. Inspect the shaft (16) for the following conditions:
    - Scoring
    - Damage

    Important: Replace the rear cover (2) whenever a shaft replacement is necessary.
11. Secure the pump body (19).
12. Remove the connector (20) and the O-ring (21).
13. Remove the valve body (22) and spring (23).

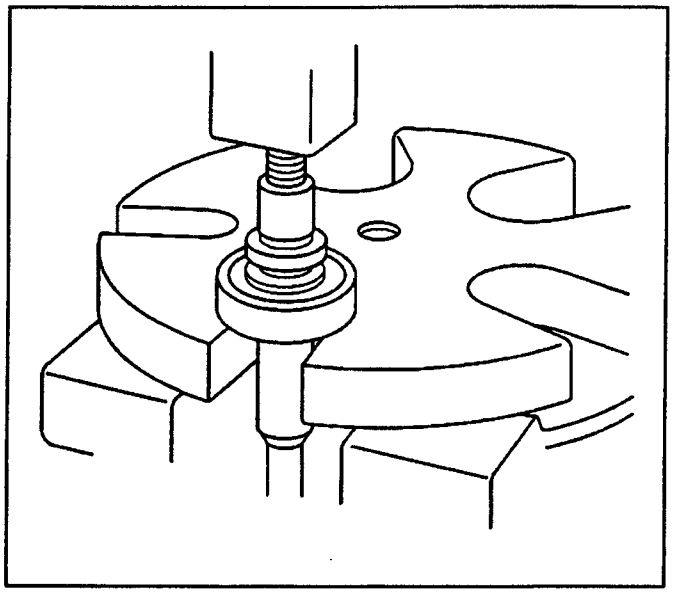


361660

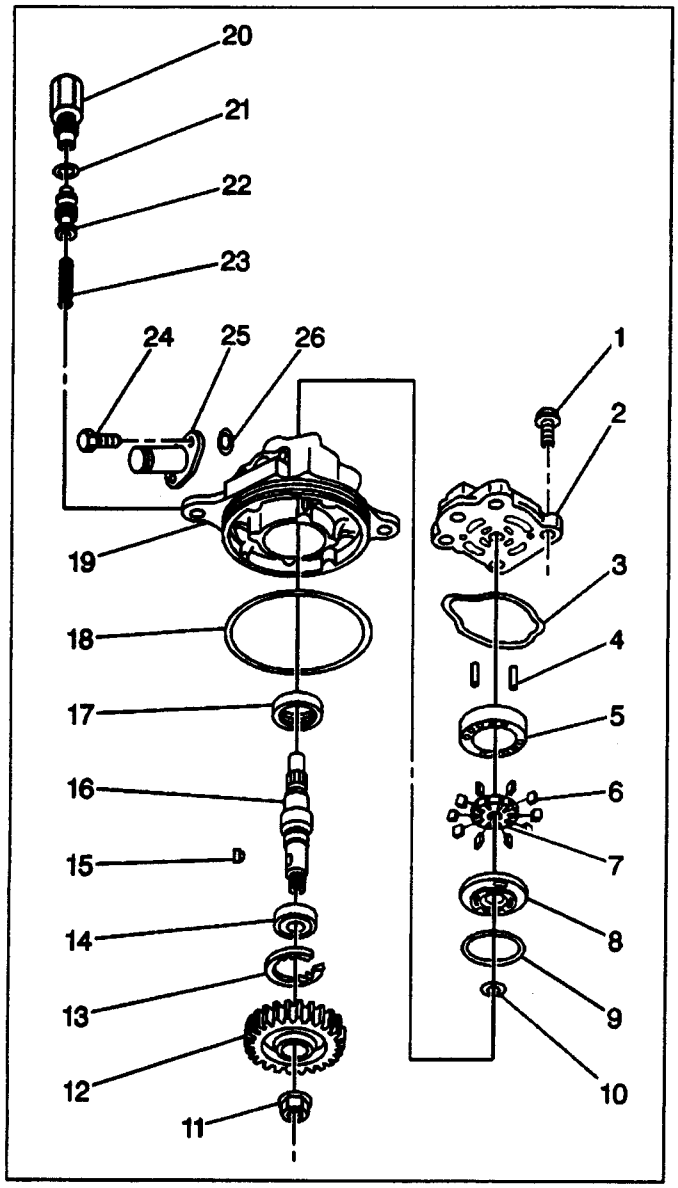
14. Inspect the shaft bearing. Refer to *Wheel Bearings Diagnosis*
15. If the shaft or bearing needs to be replaced, perform the following steps:
    - Press the shaft bearing off of the shaft using an arbor press.
    - Discard the shaft bearing.



228883



228885



361660

Assembly procedure

1. Press the new bearing on to the shaft using an arbor press.

   Important: Lubricate the new bearing with power steering fluid prior to pressing.

2. Install the O-ring (18) into the pump body (19).

   Important: Lubricate the lips of the new seal (17) with petroleum jelly.

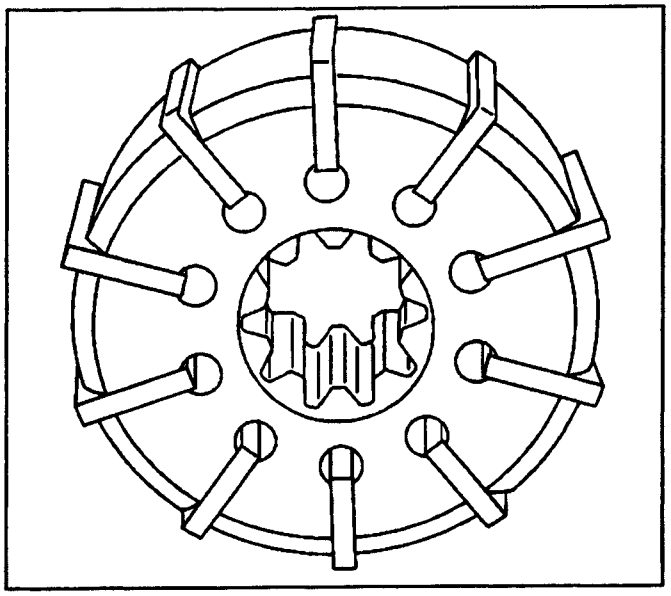
3. Install a new shaft seal (17) into the pump housing (19) using an arbor press and a suitable spacer.
4. Install the shaft bearing assembly (14, 16) into the pump housing (19).
5. Install the retainer ring (13) into the pump housing (19).

   Important: Lubricate the rotor (7), ring (5) and the vanes (6) with power steering fluid prior to assembly.

6. Install the rotor (7) into the ring (5).

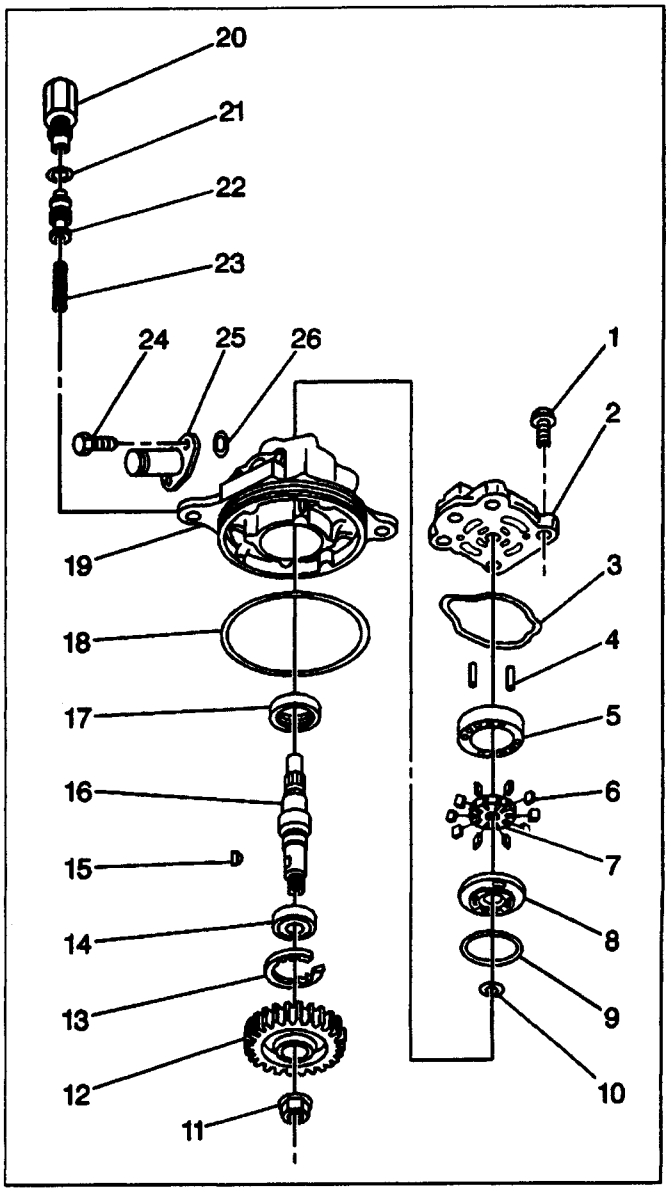
Important: Ensure that the rounded edges of the vanes contact the rotor.

7. Install the vanes into the rotor.

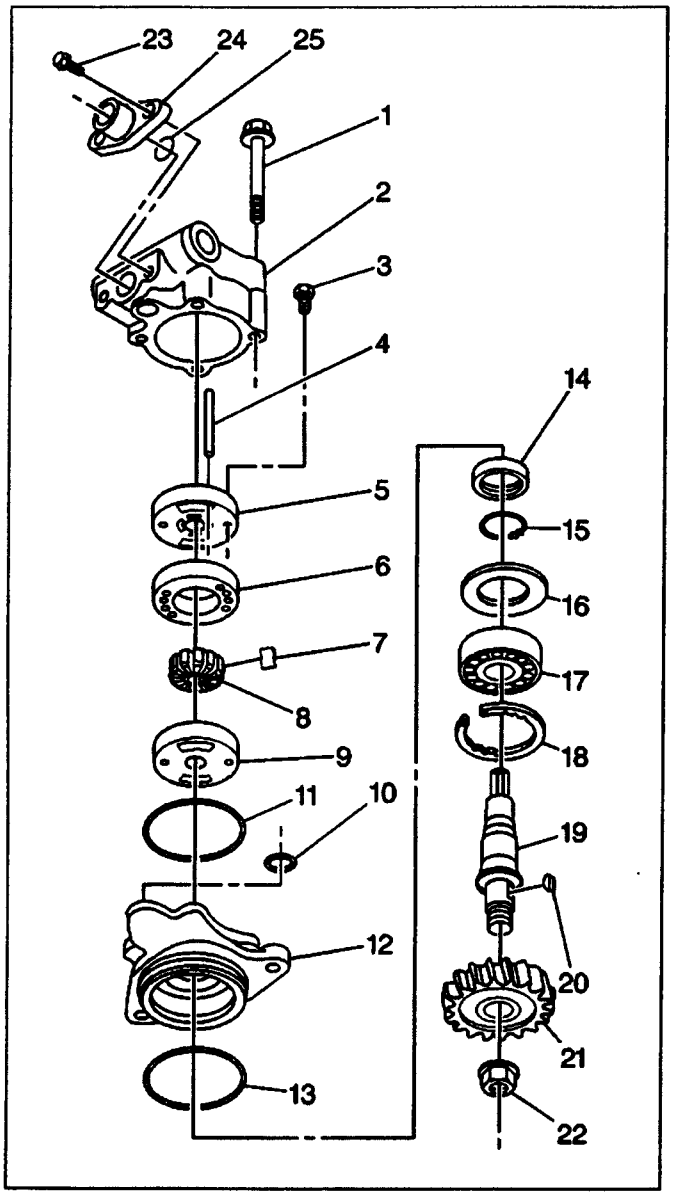


228886

8. Install the O-rings into the pump body.
9. Install the following components into the pump housing (19):
   9.1. The side plate (8)
   9.2. The rotor (7)
   9.3. The pins (4)
10. Install the rear cover (2) and gasket (3) to the pump housing (19) with the rear cover bolts (1).
    Tighten
    Tighten the rear cover bolts to 21 N.m (15 lb ft).
11. Install the valve spring (23) and valve body (22) into the pump housing (19).
12. Install the O-ring (21) and connector (20) into the pump housing (19).
    Tighten
    Tighten the connector to 49 N.m (36 lb ft).
13. Install the following components:
    13.1. The key (15)
    13.2. The gear (12)
    13.3. The washered nut (11)



361660

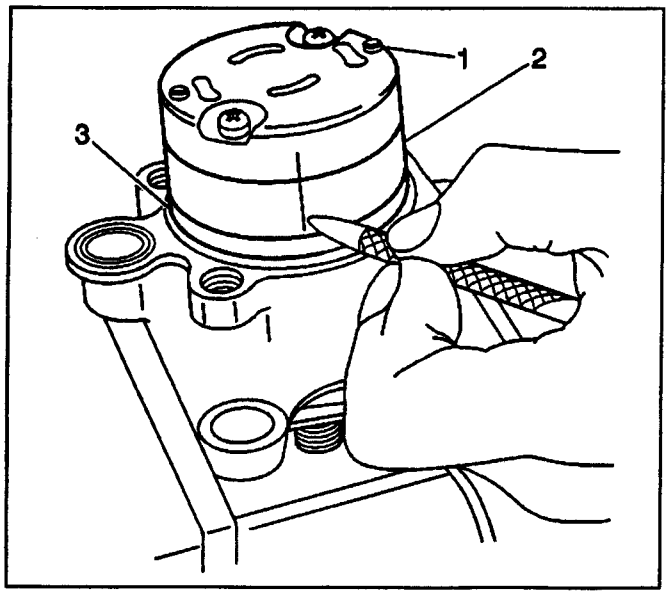


361652

Power Steering Pump Assemble (P/S Pump Repair W/ Hyd Brakes)

Disassemble Procedure

1. Clean the exterior of the power steering pump with a suitable cleaning solvent that will not damage the rubber components.
2. Remove the following components from the shaft (18):
   - The nut (22).
   - The gear (21) (the gear is a slip fit)
   - The key (19)
3. Remove the pump body bolts (1).
4. Remove the following components from the front cover (12):
   - The pump body (2)
   - The O-rings (10, 11)

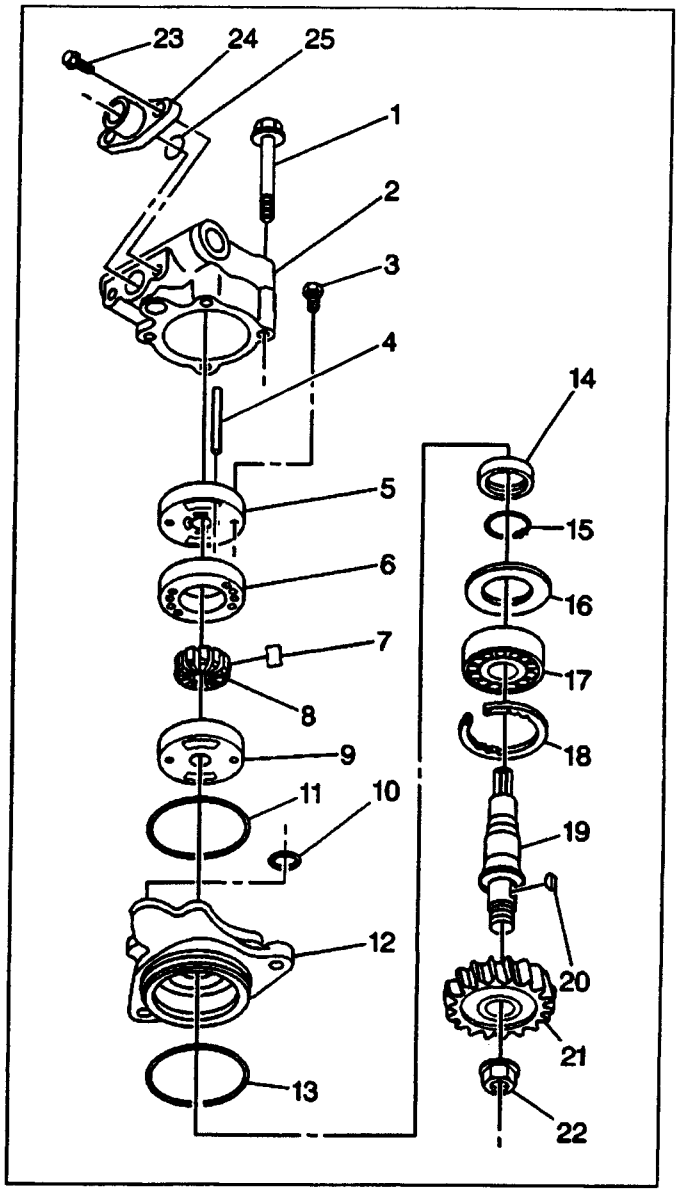


228844

Important: The side plate, the ring, and the pressure plate must be assembled in the exact position that they were removed.

5. Mark the following components:
   - The side plate (3)
   - The ring (2)
   - The pressure plate (1)

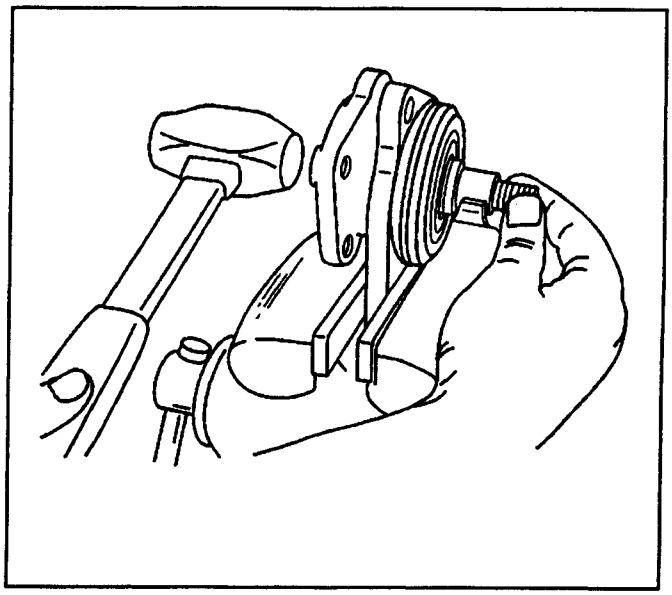
6. Remove the following components from the ring (6):
   - The pressure plate screws (3)
   - The pressure plate (5)
7. Remove the following components from the ring (6)
   - The side plate (9)
   - The pin (4)
   - The rotor (8)
   - The vanes (7)
8. Remove the snap ring (20) from the front cover (12)



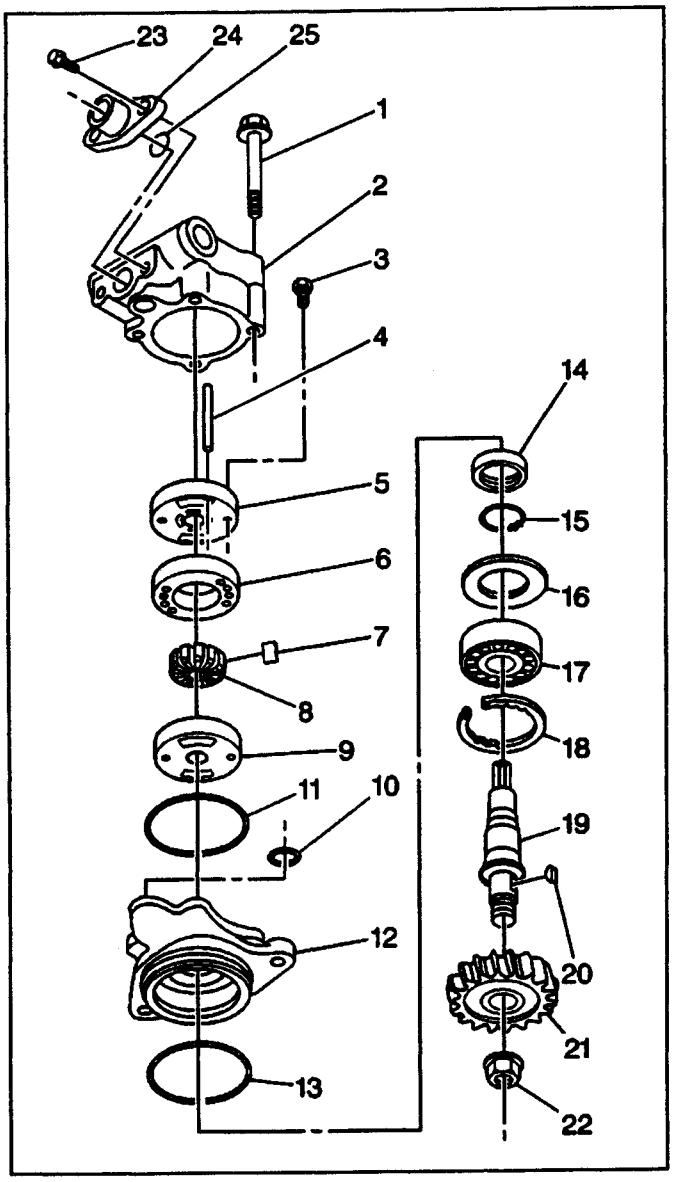
361652

Important: Gently tap with a plastic mallet on the end opposite the drive end in order to remove the shaft from the front cover.

9. Remove the shaft from the front cover.

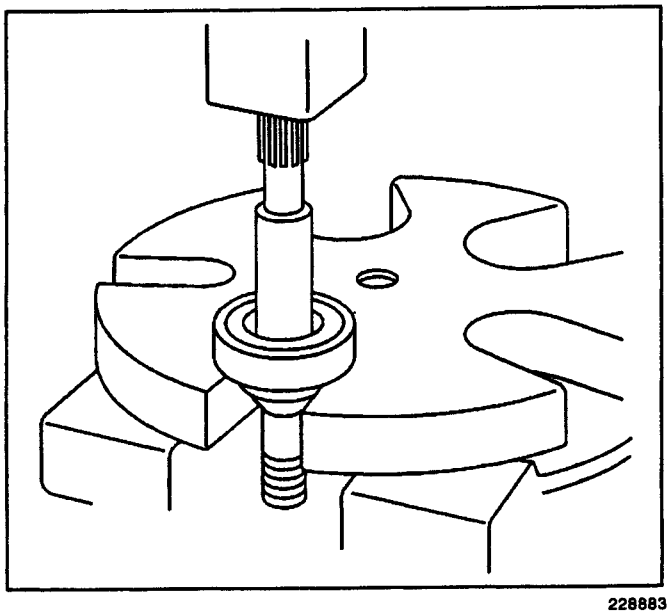


228874



361652

10. Remove the retainer ring (16) from the shaft (18)
11. Remove the shaft seal (14) from the front cover (12)
12. Remove the O-ring (13) from the front cover (12)



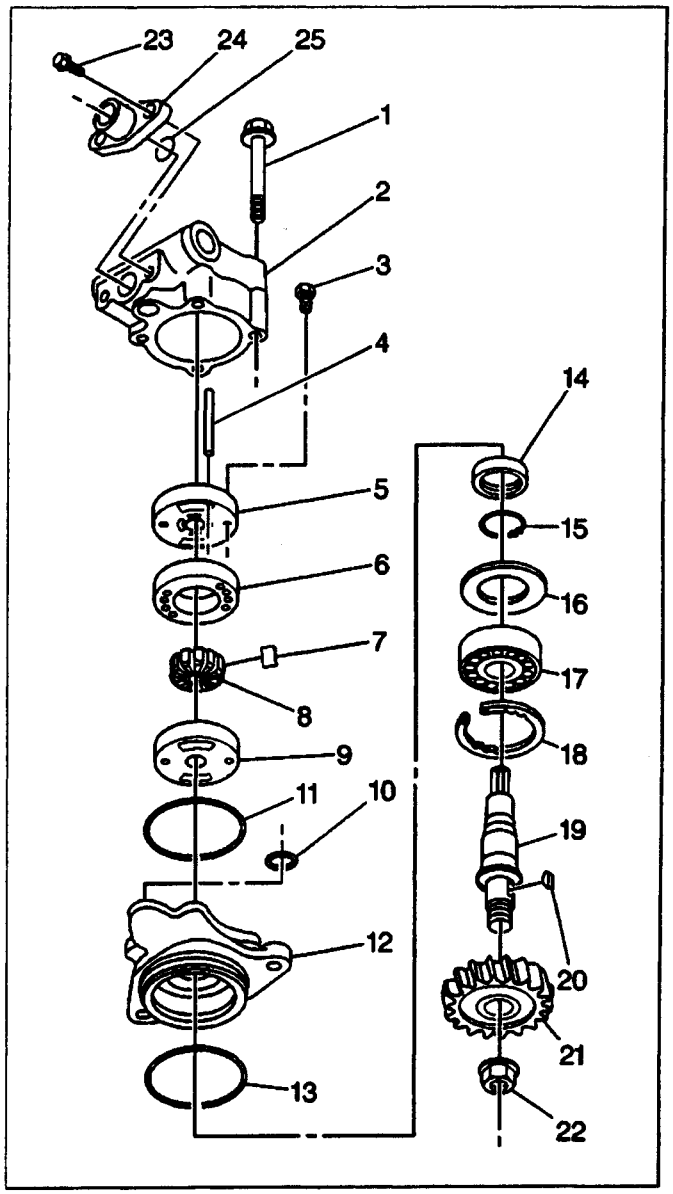
228883

13. Inspect the shaft bearing Refer to *Wheel Bearings Diagnosis* in Suspension General Diagnosis.
14. If the shaft bearing needs to be replaced, perform the following steps:
    - Remove the snap ring from the shaft
    - Press the shaft bearing off of the shaft
    - Discard the shaft bearing

Inspection Procedure

1. Inspect the bushing for the following conditions:
   - Scores
   - Wear
2. If the bushing shows any of these conditions, the pump body (2) must be replaced.
3. Use a suitable solvent in order to clean all of the parts.

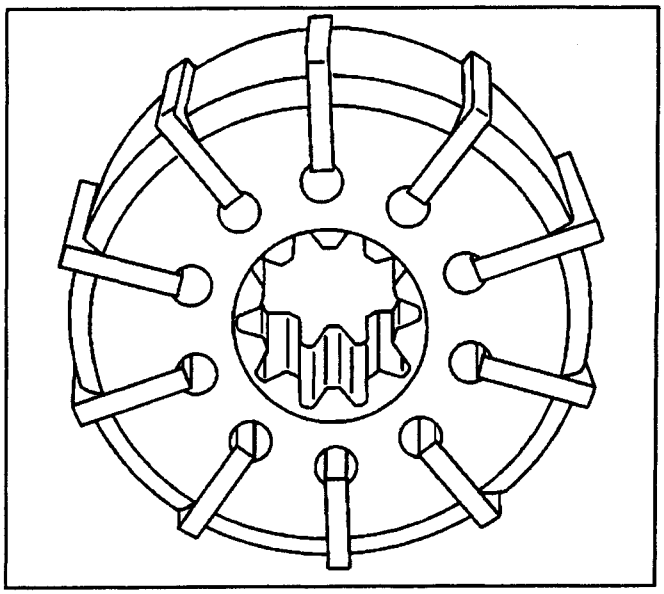
   Dry all of the parts.
4. Inspect the vane tips (7) for the following conditions:
   - Wear
   - Damage
5. Inspect the inner surface of the ring (6) for the following conditions:
   - Scoring
   - Wear
   - Damage



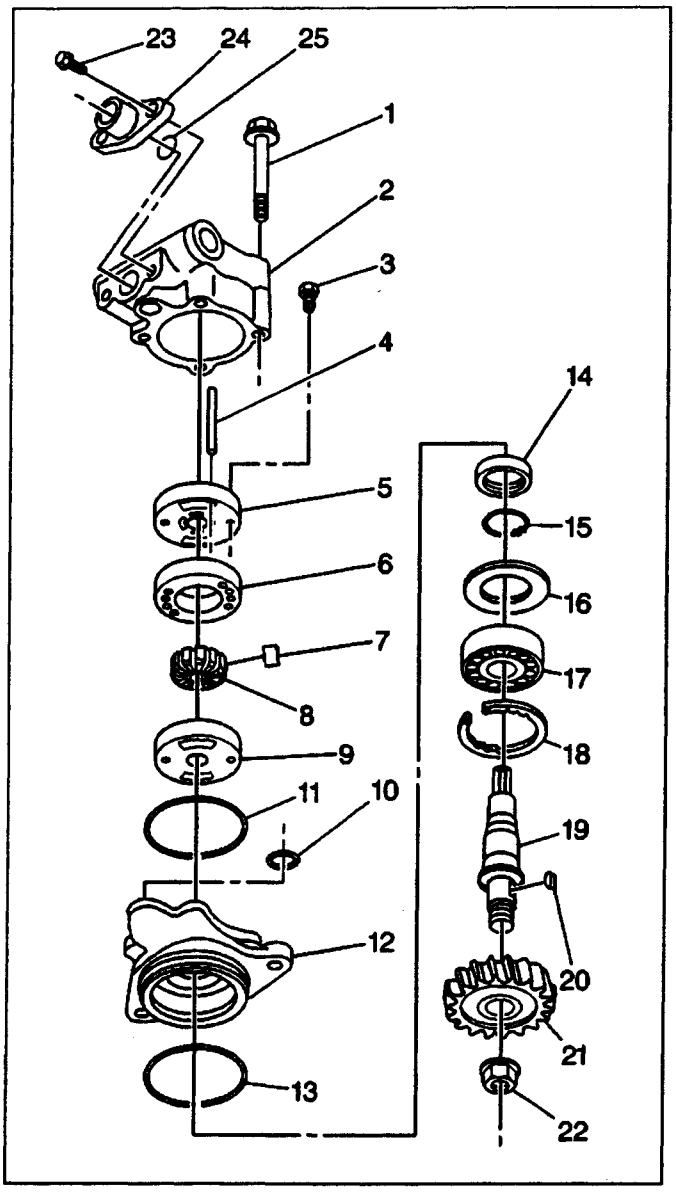
361652

Important: The vanes must fit properly in the rotor slots, without sticking or excessive play.

6. Inspect the fit of the vanes in the rotor.
7. Inspect for the following conditions:
   - Burrs in the rotor slots
   - Excessive wear at the thrust faces
8. Replace the rotor, the ring, and all the vanes if any of the following conditions are present:
   - Heavy wear
   - Damage



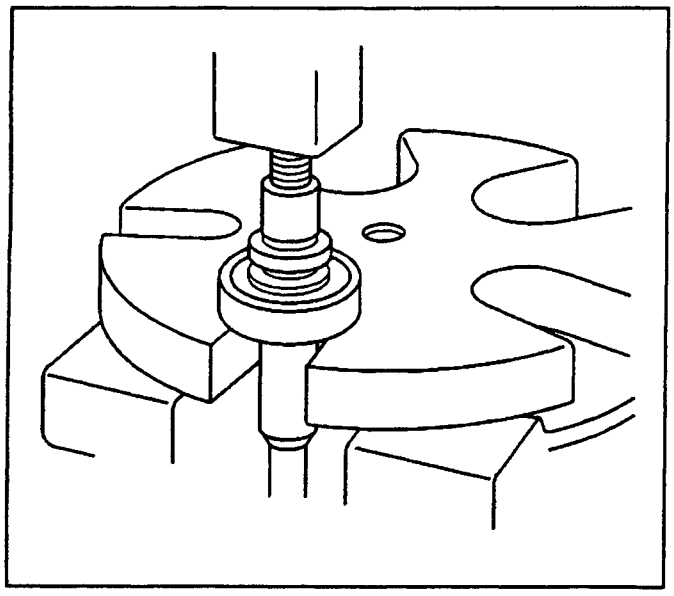
228886



361652

9. Inspect the side plate (9) for wear at the thrust faces.
10. Replace the side plate (9) if wear is excessive.
11. Inspect the pressure plate (5) for wear at the thrust faces.
12. Replace the pressure plate (5) if wear is excessive.
13. Inspect the shaft bearing (17). Refer to *Wheel Bearings Diagnosis* in Suspension General Diagnosis.
14. Inspect the shaft (18) for the following conditions:
    - Scoring
    - Damage

    Important: Replace the pump body (2) whenever a shaft replacement or bushing replacement is necessary.
15. Replace the shaft (18) if it is necessary.



228885

Assemble Procedure

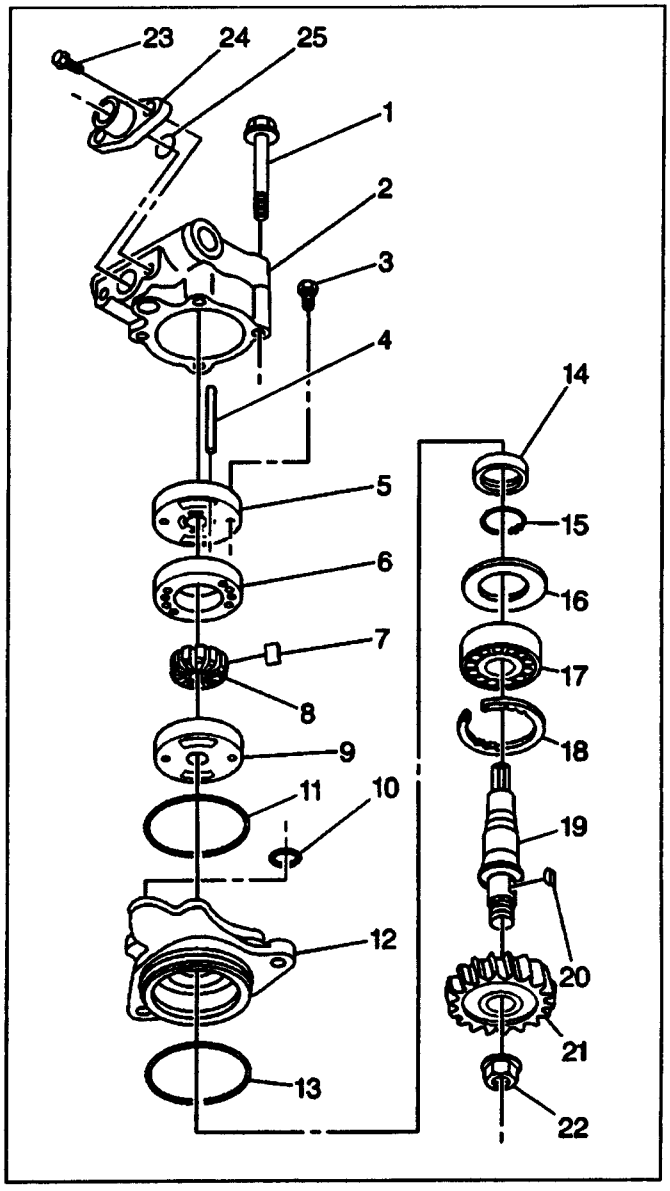
Important: Lubricate the new shaft bearing with power steering fluid prior to pressing the new shaft bearing onto the shaft.

1. Use an arbor press and a suitable spacer in order to press the new shaft bearing onto the shaft.

2. If the shaft bearing (17) was removed, install the snap ring (15) on the shaft (18).
3. Install the O-ring (13) into the front cover (12).

   Important: Lubricate the lips of the new seal (14) with petroleium jelly.
4. Install a new shaft seal (14) into the pump housing (2) using an arbor press and a suitable spacer.
5. Install the retainer ring (16) on the shaft (18)
6. Install the following components into the front cover (12):
   - A new O-ring (13)
   - The bearing shaft assembly
7. Install the snap ring (20) into the front cover (12)

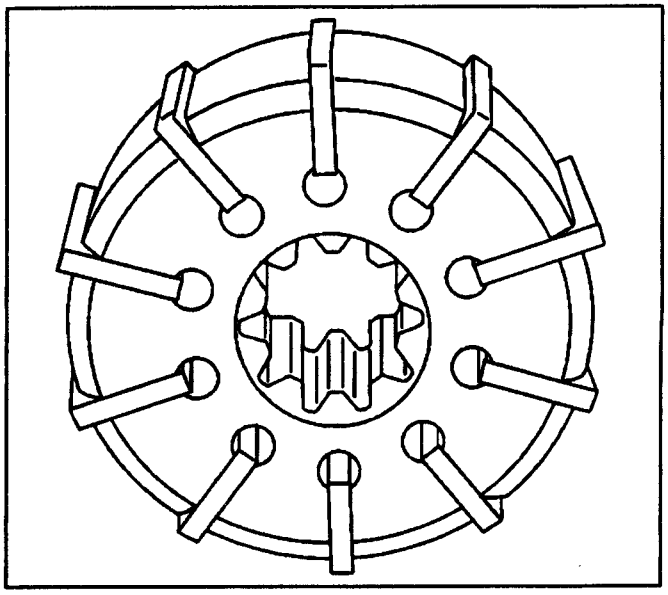
   Important: Lubricate the rotor (8), ring (6), and the vanes (7) with power steering fluid prior to assembly.
8. Install the rotor (8) into the ring (6).



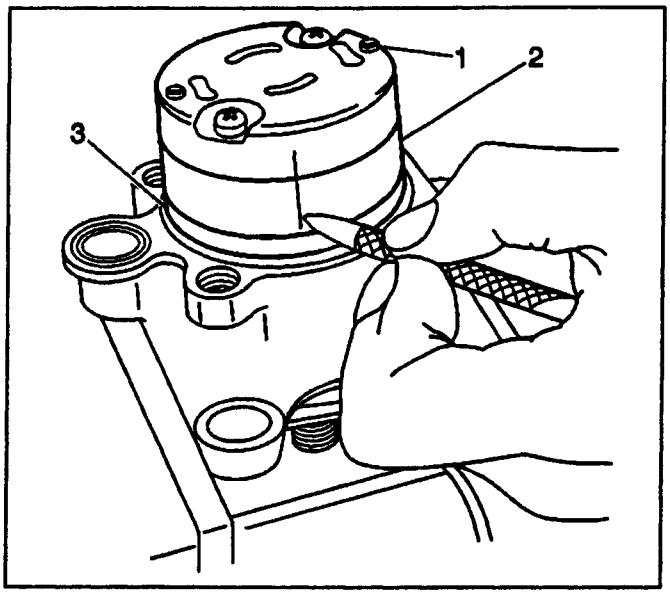
361652

Important: Ensure that the rounded edges of the vanes contact the rotor.

9. Install the vanes into the rotor.



228886



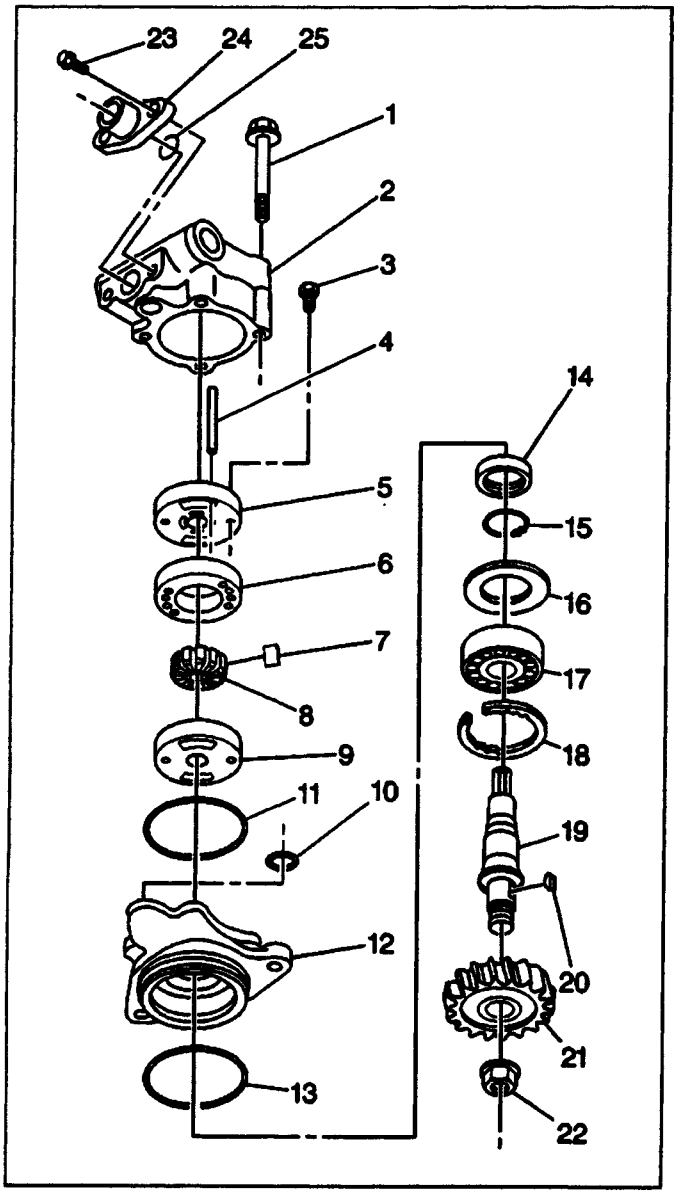
228844

10. Align the marks on the following components:
    - The side plate (3)
    - The pins
    - The ring (2)
11. Install the following components on the ring (2):
    - The side plate (3)
    - The pins

    Notice: Refer to *Fastener Notice* in Cautions and Notices.
12. Install the pressure plate (1) on the ring (2) with screws.

    Tighten

    Tighten the pressure plate screws to 8 N.m (71 lb in).



361652

13. Install the following components into the pump housing (2):
    - The pressure plate (5)
    - The ring (6)
    - The rotor assembly (7, 8)
14. Install both O-rings (10, 11) into the front cover (12)
15. Install the front cover (12) on the pump housing (2)

    Secure the front cover with the pump body bolts (1)

    Tighten

    Tighten the pump body bolts to 54 N.m (40 lb ft).
16. Install the gear (21) on the shaft (18) using the washer nut (22).

Disassemble Procedure (Pressure Relief Valve)

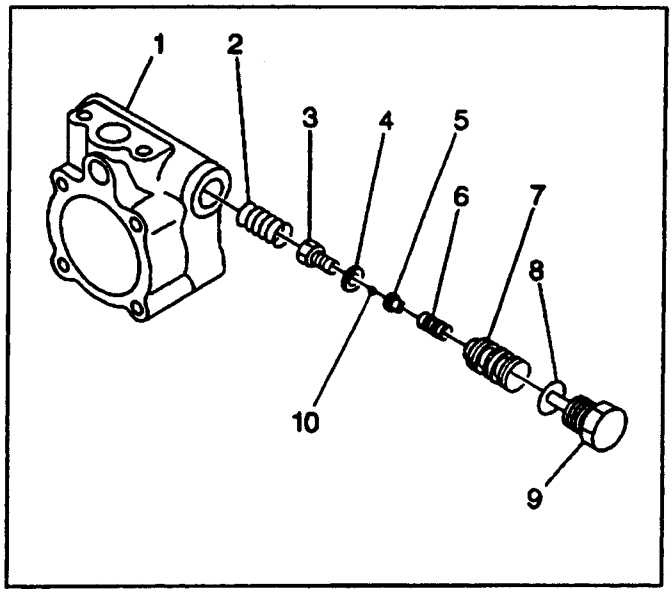
Important: Do not disassemble the pressure relief valve unless the system pressure is incorrect. Refer to *Power Steering System Test Procedure.*

Important: Do not disassemble the pressure relief valve unless it is absolutely necessary. It is difficult to hold the valve body while removing the valve plug. This increases the possibility of damaging the valve body.

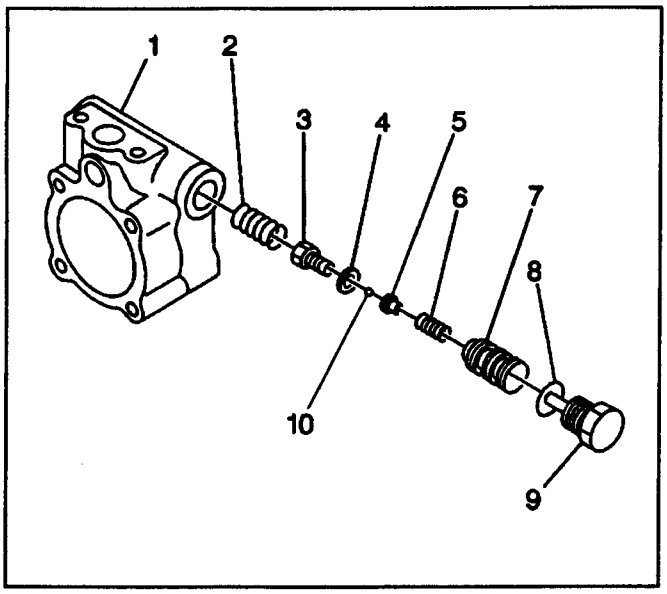
1. Secure the pump.
2. Remove the following components from the pump:
   - The plug (9)
   - The O-ring (8)

   Notice: Always protect the pressure relief valve body when securing the valve body. Following this instruction can help you avoid damage to the valve body.
3. Remove the following components from the pump housing (1):
   - The valve body (7)
   - The valve spring (2)
4. Secure the valve body (7).

   Important: Note the number of shims (4) that are removed from the pressure relief valve.
5. Remove the following components from the valve body (7):
   - The valve retainer (3)
   - The shim(s) (4)
6. Remove the ball (10) from the valve body (7).
7. Remove the following components from the valve body (7):
   - The retainer (5)
   - The spring (6)



361648



361648

Assemble Procedure

1. Install the following components into the valve body (7):
   1.1. The retainer spring (6)
   1.2. The retainer (5)

   Important: Be certain to install all of the shims which were removed.
2. Install the shims (4) into the valve body (7).

   Notice: Always protect the pressure relief valve body when securing the valve body. Following this instruction can help you avoid damage to the valve body.
3. Secure the valve body (7).

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
4. Install the valve plug (3)

   Tighten

   Tighten the valve body plug to 54 N·m (40 lb ft).
5. Install the following components into the pump housing (1):
   5.1. The valve spring (2)
   5.2. The valve body (7)
   5.3. The O-ring (8)
   5.4. The plug (9)

Bleeding Power Steering System

Bleed the air from the system before operating the vehicle whenever the following components are installed:

- The power steering pump
- The power steering hose

Air in the power steering fluid system may cause the following conditions:

- Noise
- Unsatisfactory operation

Use only the specified power steering fluid whenever fluid is added to the power steering system. Do not use automatic transmission fluid or any other unapproved fluids. Refer to *Fluid and Lubricant Recommendations* in Maintenance and Lubrication.

Before bleeding the system, ensure that the following components are closed tightly enough to prevent air or fluid leaks:

- The hose clamps
- The hose connectors
- The fittings

Have enough power steering fluid to maintain the fluid in the reservoir at all times during the bleeding procedure. Refer to *Fluid and Lubricant Recommendations* in Maintenance and Lubrication.

This procedure is designed to minimize the chance of fluid aeration or overflow during the bleeding process.

Important: Do not install the reservoir cap during the bleeding procedure. Air may be trapped in the system. When the engine stops, power steering fluid will be forced out through the breather hole in the cap.

1. Raise the front end of the vehicle until the wheels can turn freely. Support the vehicle with suitable safety stands. Refer to *Lifting and Jacking the Vehicle* in General Information.

   Important: Removing the drag link at the pitman arm and turning the steering wheel stop to stop may cause the following conditions:
   - Increased steering gear travel
   - End limiter valve misadjustment
   - End limiter valve damage

2. Replace the end limiters if any of the above conditions exist. Refer to *End Limiters Replacement.*

   Notice: When adding fluid to the reservoir, do not overfill. The fluid expands when hot and overfilling could result in the spillage of fluid from the reservoir.

3. Fill the reservoir.

   Ensure that the following conditions are met:
   - The glass sight is covered.
   - The fluid level is within 50 mm (2 in) of the top of the reservoir.

4. Leave the cap off.

   Important: Do not turn the steering wheel before completing operationals steps thru 10.

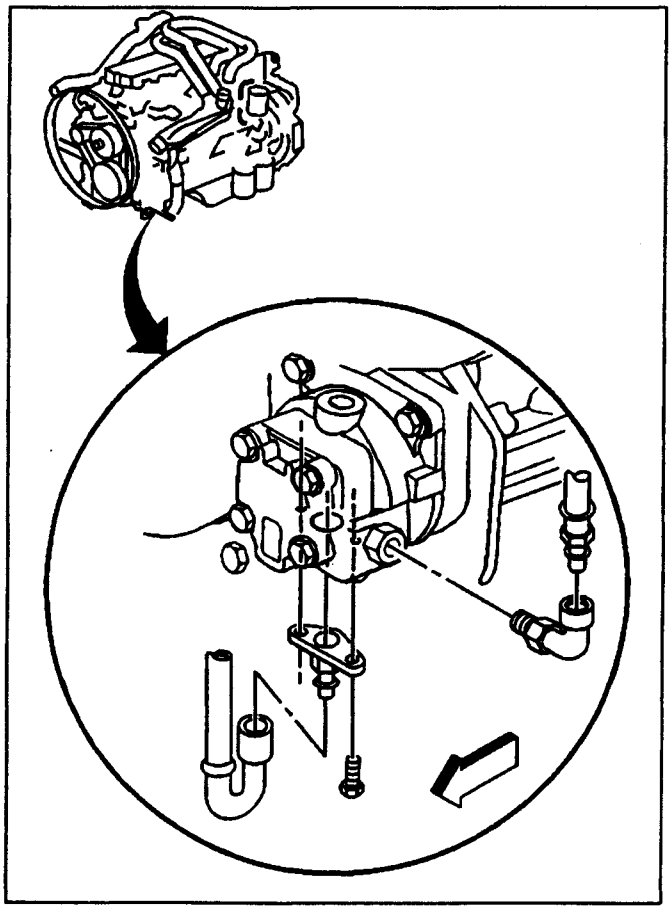
5. Start the engine.
6. Operate the vehicle for 10 seconds.
7. Turn the ignition switch to the OFF position.
8. Continuously fill the reservoir.

   Ensure that the following conditions are met at all times:
   - The glass sight is covered.
   - The fluid level is within 50 mm (2 in) of the top of the reservoir.

9. Repeat the procedure until no more bubbles appear in the reservoir.
10. Fill the reservoir in order to cover slight glass within 50 mm (2 in) of the top of the reservoir.
11. Start the engine.
12. Operate the vehicle for 10 seconds while turning the steering wheel completely to the right and to the left.
13. Turn the ignition switch to the OFF position.
14. Continuously fill the reservoir.

    Ensure that the following conditions are met at all times:
    - The glass sight is covered.
    - The fluid level is within 50 mm (2 in) of the top of the reservoir.

15. Repeat the procedure until no more bubbles appear in the reservoir.



228859

Flushing the Power Steering System

1. Raise the front of the vehicle until the wheels can turn freely. Support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.

   Notice: Avoid contaminating the power steering system. Cap open hoses and ports to prevent dirt and debris from entering system. Contaminated power steering fluid and dirt can cause early parts failure.

   Important: Plug the connector port on the pump in order to prevent dirt from entering the system.
2. Remove the fluid return hose at the pump inlet connector.
3. Position the hose towards a large container to catch the draining fluid.
4. Start the engine
5. Run the engine at idle.

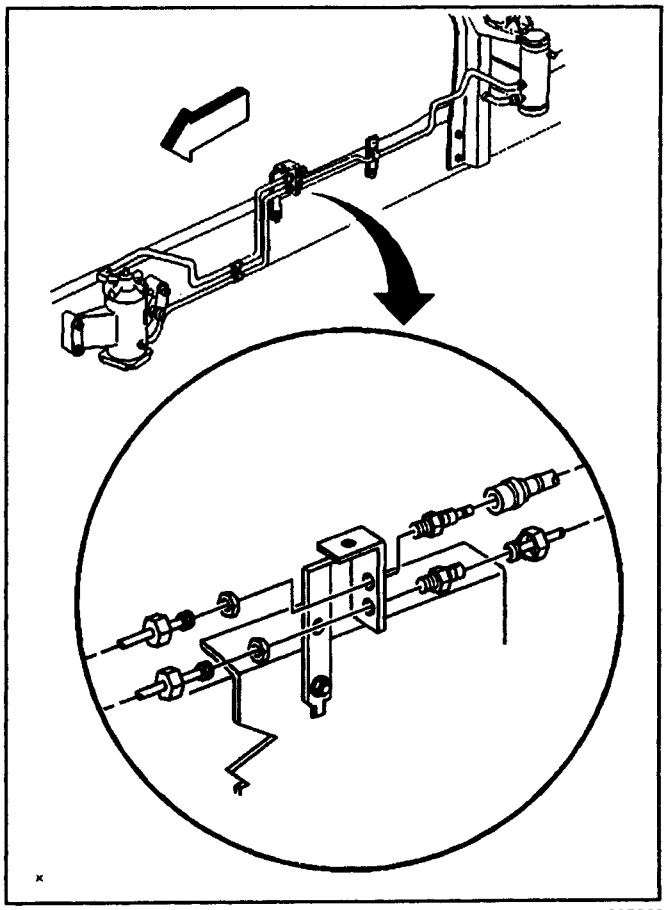
   Notice: Do not contact wheel stops or hold wheel in a corner. Fluid flow will stop and pump will be in relief pressure mode. A sudden overflow from the reservoir may also develop if wheel is held at a corner.
6. While an assistant is filling the reservoir with new power steering fluid, turn the steering wheel from right to left.

   Repeat this step until all of the foreign material is cleared from the draining fluid.
7. Flush the individual components if foreign material is still evident. Refer to *Power Steering Hose Flushing.*
8. Install the fluid return hose at the pump inlet connector.
9. Fill the system with new power steering fluid.
10. Bleed the power steering system. Refer to *Bleeding Power Steering System.*
11. Operate the engine for approximately 15 minutes.
12. Remove the pump return hose at the pump inlet.
13. Plug the connection on the pump.
14. Inspect the draining fluid for foreign material while replenishing the fluid in the reservoir.
15. Repeat the procedure if foreign material is present in the draining fluid.

    Important: Do not reuse any drained power steering fluid.
16. Replace the hoses and repair or replace all of the power steering components if foreign material is still present. Refer to *Power Steering Hoses Replacement* and *Bleeding Power Steering System.*

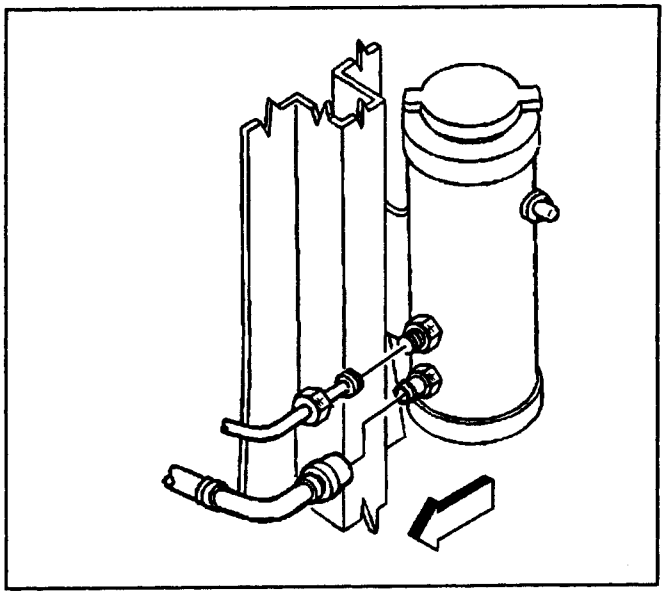
Power Steering Hose Flushing

1. Position a drainage container under the connectors at the bulkkhead bracket.
2. Disconnect the fluid hoses at the bulkhead bracket.
3. Drain the hoses into the container.

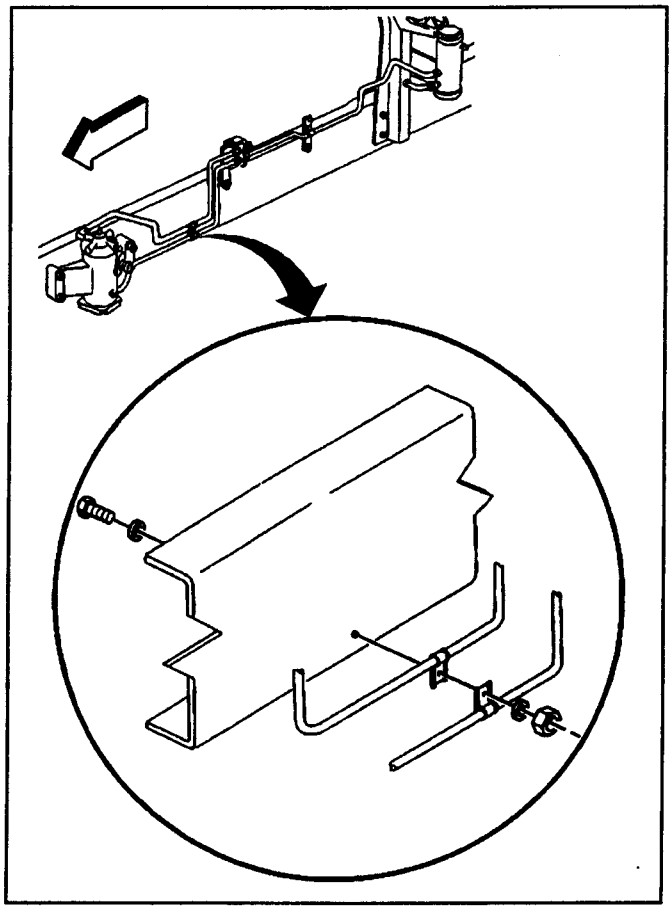


227963

4. Remove the power steering hoses at the reservoir.
5. Drain the hoses and the reservoir into the container.

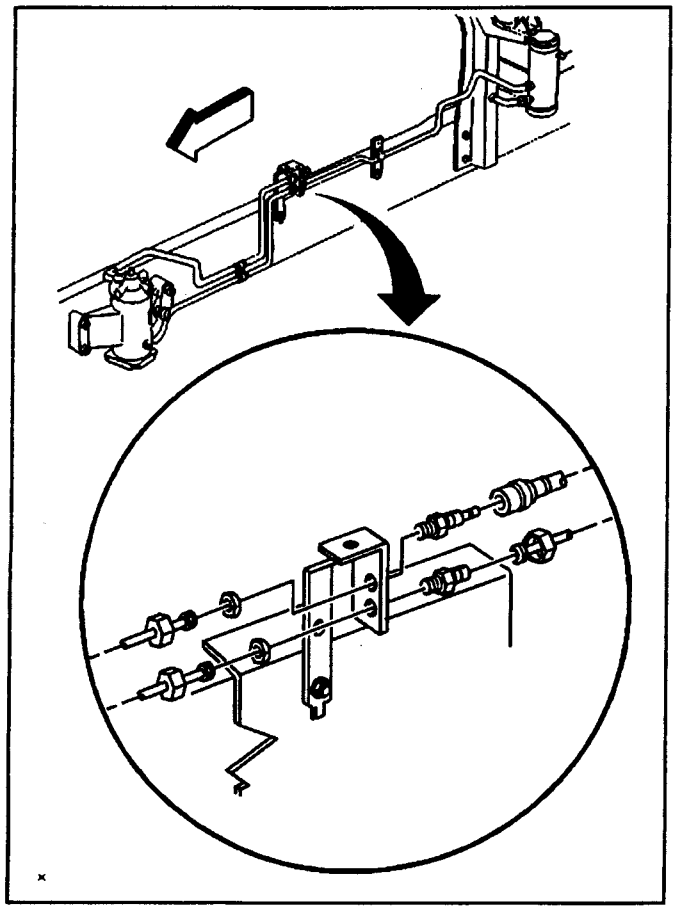


227966



227964

6. Remove the hose mounting brackets.
7. Drain the power steering system.
8. Raise the front of the vehicle until the wheels can turn freely. Support the vehicle. Refer to *Lifting and Jacking the Vehicle*
9. Ensure that the ignition switch is in the OFF position.
10. Turn the steering wheel from wheel stop to wheel stop.



227963

11. Remove all of the power steering hoses.
12. Drain all of the hoses.
13. Use compressed air in order to blow out the fluid.
14. Flush the hoses with new power steering fluid.
15. Drain and reinstall the hoses.
16. Fill the power steering system. Refer to *Bleeding Power Steering System*
17. Perform the following procedure:
    - 17.1. Set the parking brake.
    - 17.2. Place the gear selector in the N (Neutral) position.
    - 17.3. Start the engine.
    - 17.4. Operate the vehicle at idle.

    Caution: Do not touch the inner edges of the steering wheel spokes when testing. If the power steering lines have been crossed by mistake, the steering wheel may spin violently when it is turned, causing injury to the hands. In order to stop the steering wheel from spinning, turn off the engine and make the necessary corrections.
18. Turn the steering wheel.

    Be sure to make hand contact only with the outer edge of the wheel.

Power Steering Hoses Replacement

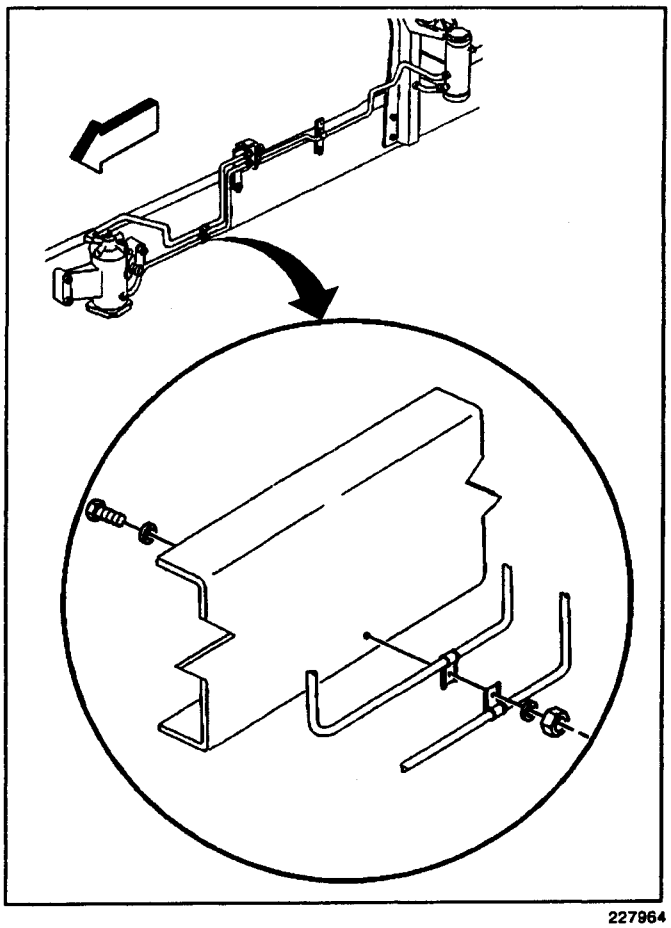
Removal Procedure

Tools required

- J 42971 Hydraulic Line seperator
- The J 42971 is used to separate quik connects on hydraulic lines.

Important: Always clean the connectors and lubricate the tool end in power steering fluid when inserting into the coupling.

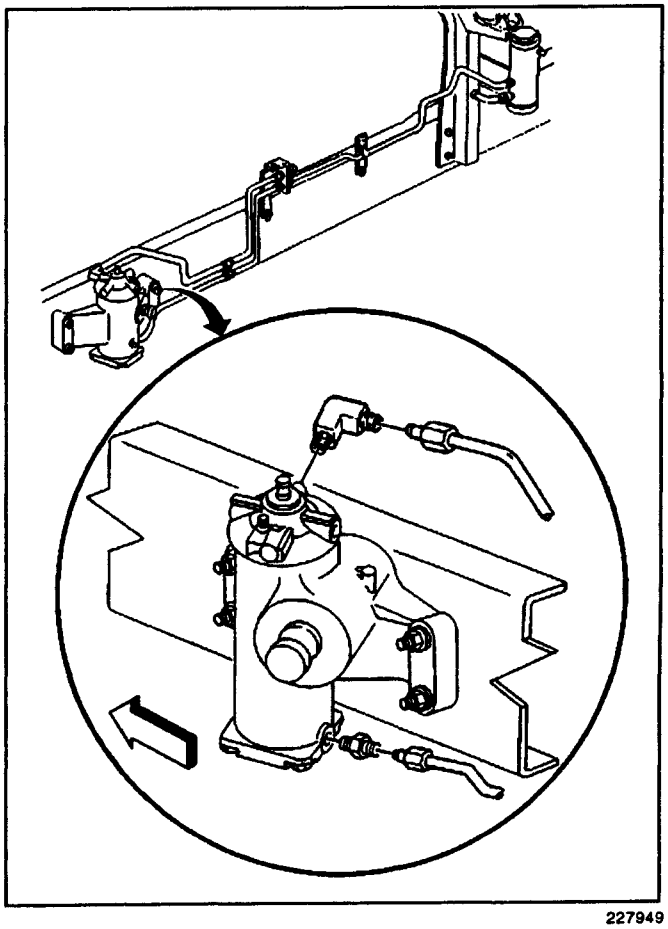
1. Tilt the cab. Refer to *Cab Tilting*
2. Remove the power steering hose clamp nuts, bolts and washers as needed.



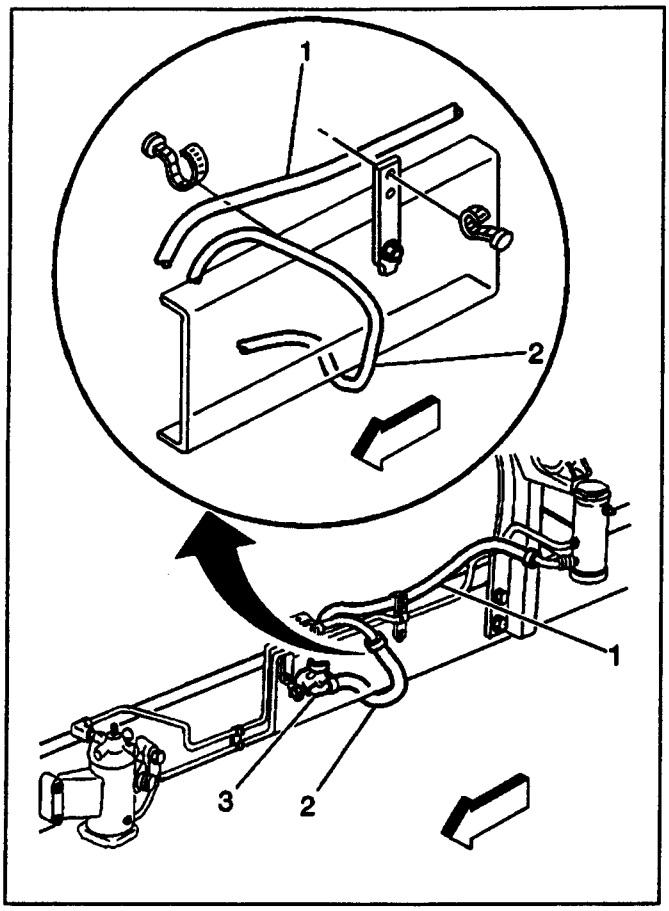
227964

Notice: Avoid contaminating the power steering system. Cap open hoses and ports to prevent dirt and debris from entering system. Contaminated power steering fluid and dirt can cause early parts failure.

3. Place a container under the power steering hose at the place of disconnection in order to catch the fluid when disconnecting or connecting hoses.
4. Clean the surface of the hoses prior to disconnection.

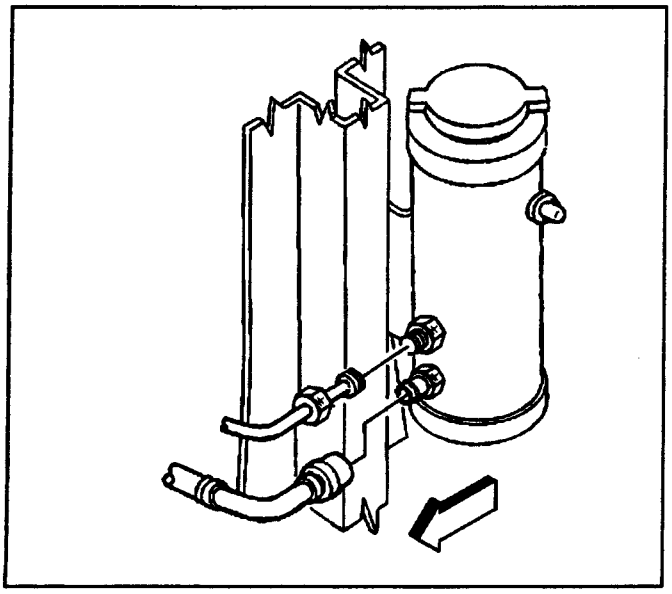


227949



227965

5. Disconnect the power steering pump hose (2) from the component (3) or the hose (1).

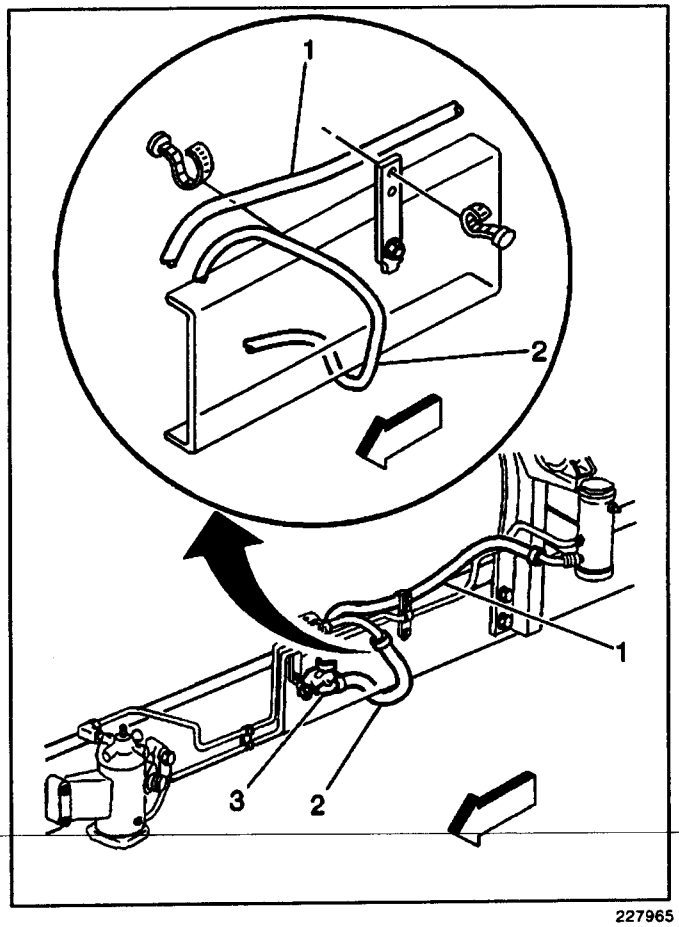


227966

6. Cap the hose and the component the at the hose was connected to in order to prevent dirt from entering the system.

Installation Procedure

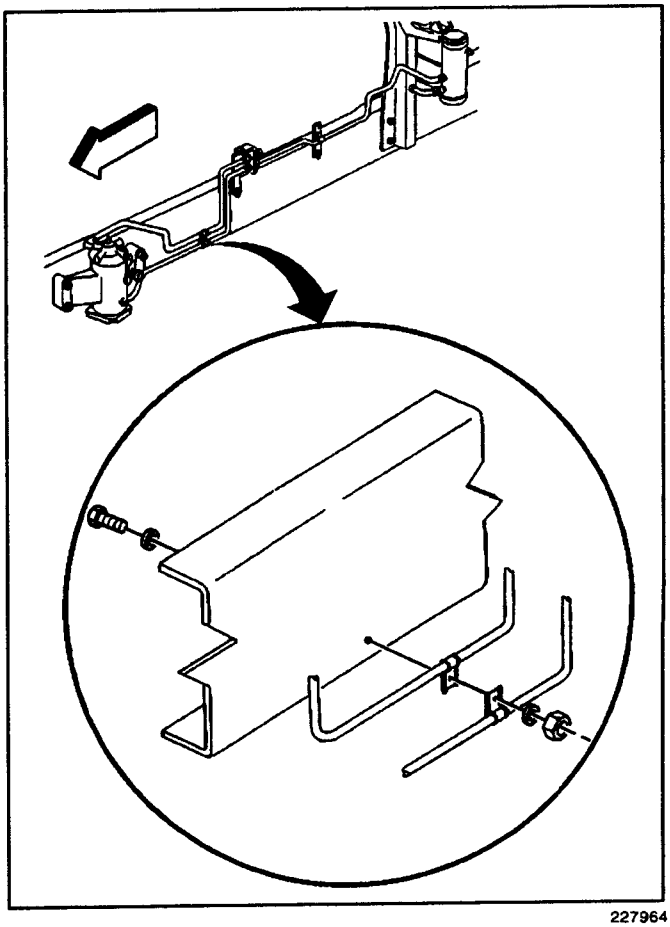
1. Connect the power steering pump hose (2) to the component (3) or the hose (1).



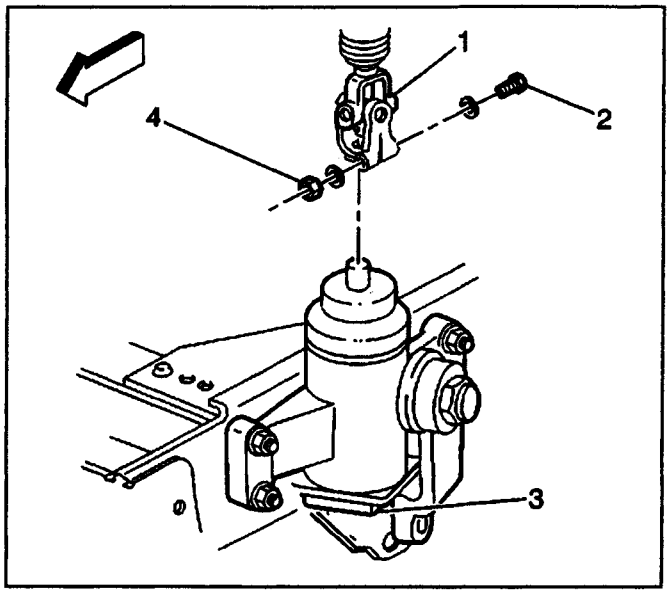
227965

Notice: Refer to *Fastener Notice*

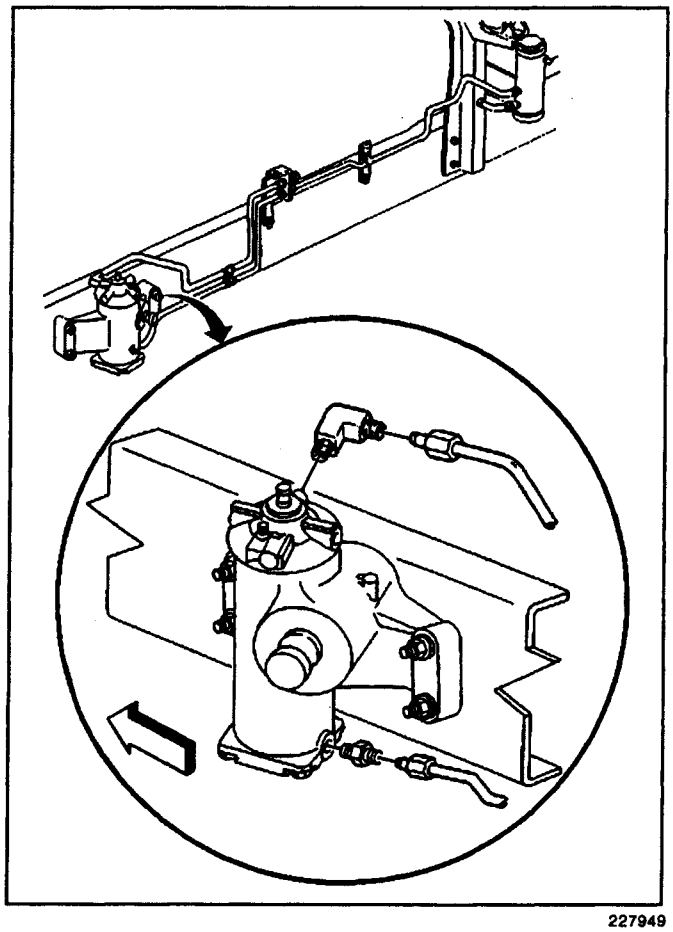
2. Install the power steering hose clamp nuts, bolts and washers as needed.
   Tighten
   - Tighten the power steering pipe mounting to 22 N.m (16 lb ft).
   - Tighten the power steering pipe adapter nuts at bulk head to 52 N.m (38 lb ft).
3. Fill and bleed the power steering system. Refer to *Bleeding Power Steering System*
4. Lower the cab.



227964



227947



227949

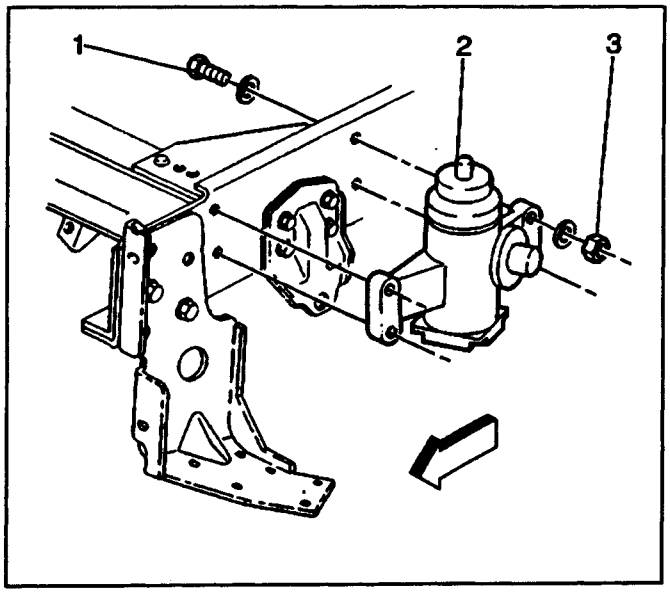
Power Steering Gear Replacement

Removal Procedure

1. Position the front wheels and the steering wheel straight ahead.
2. Tilt the cab. Refer to *Cab Tilting*
3. Mark the position of the steering gear input shaft and the cardan joint (1) of the lower steering shaft.
4. Remove the cardan joint nut (4) and the washer.
5. Remove the cardan joint bolt (2) and the washer.
6. Gently pry the cardan joint off from the steering gear input shaft.
7. Remove the Pitman Arm. Refer to *Pitman Arm Replacement*

   Notice: Avoid contaminating the power steering system. Cap open hoses and ports to prevent dirt and debris from entering system. Contaminated power steering fluid and dirt can cause early parts failure.
8. Place a container under the power steering gear in order to catch the fluid.
9. Remove the power steering hoses from the steering gear.

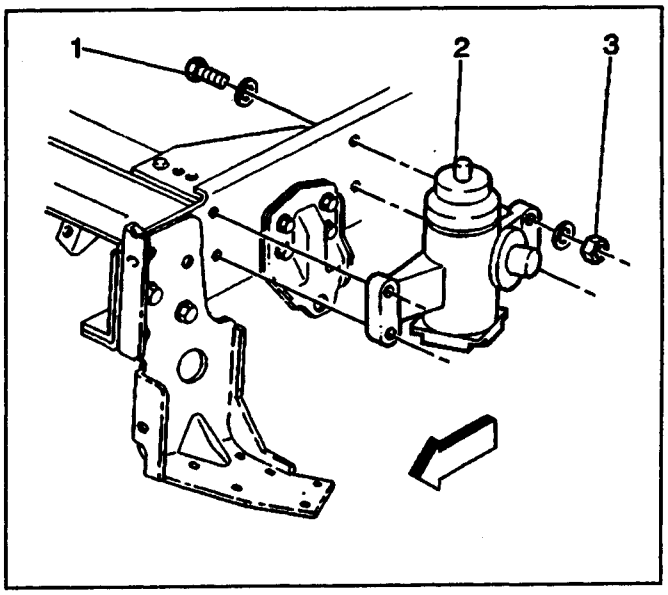
10. Remove the following components from the vehicle:
    10.1. The mounting nuts (3)
    10.2. The washers
    10.3. The mounting bolts (1)
    10.4. The steering gear (2)



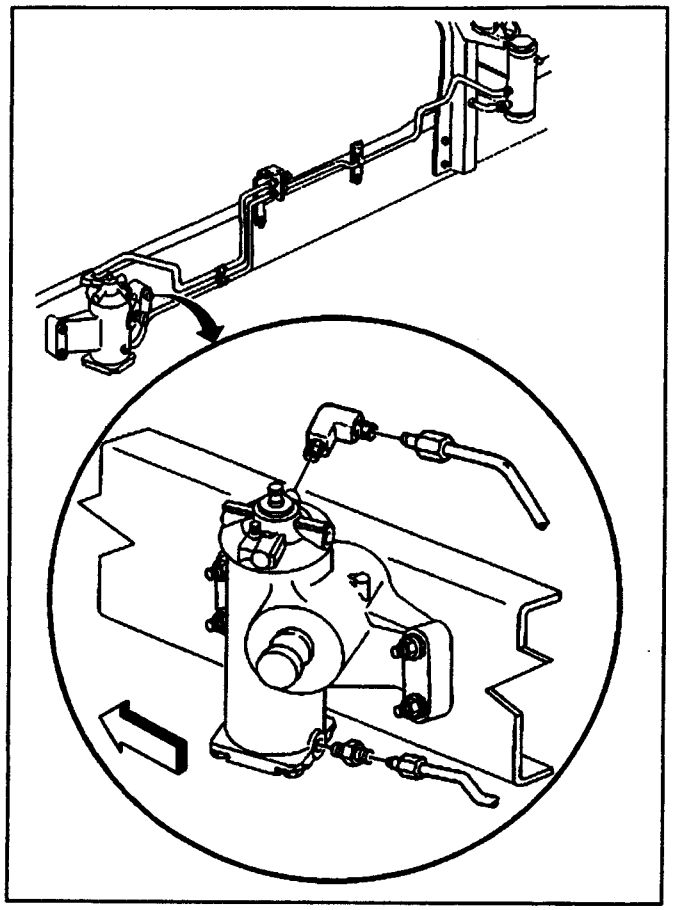
227951

Installation Procedure

1. Install the steering gear (2) onto the vehicle.
   Tighten
   Tighten the power steering gear mounting nuts to 450 N.m (330 lb ft).
   Notice: Refer to *Fastener Notice*
2. Secure the steering gear (2) with the following components:
   - The mounting nuts (3)
   - The washers
   - The mounting bolts (1)

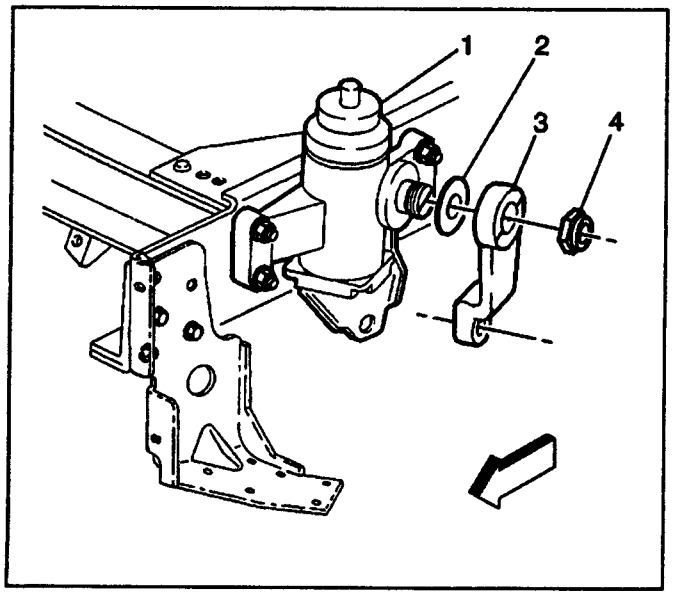


227951



227949

3. Install the power steering hoses onto the steering gear.



294139

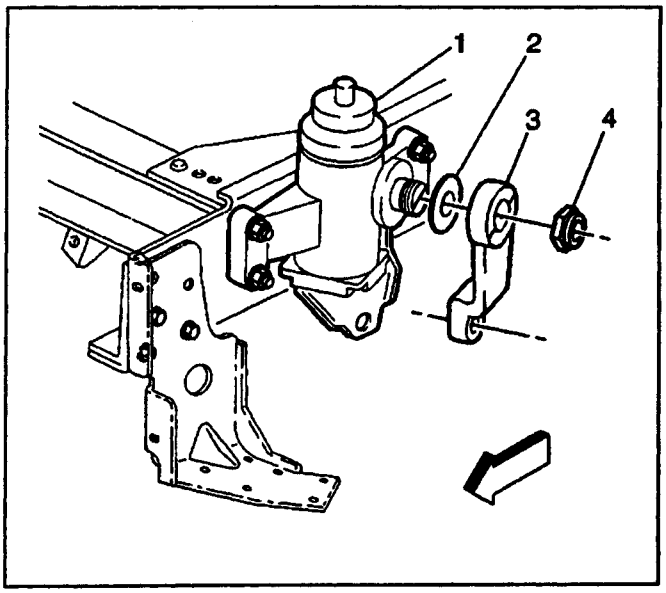
Sector Shaft Dust Cap Replacement

Removal Procedure

1. Position the front wheels and the steering wheel straight ahead.
2. Tilt the cab. Refer to *Cab Tilting* in General Information.
3. Remove the Pitman arm (3). Refer to *Pitman Arm Replacement* in Steering Linkage (Non-Rack and Pinion).
4. Gently pry the steering gear sector shaft dust cap (2) away from the sector shaft.
5. Remove the steering gear sector shaft dust cap.

Installation Procedure

1. Install the steering gear sector shaft dust cap (2) onto the sector shaft.
2. Install the Pitman arm (3). Refer to *Pitman Arm Replacement* in Steering Linkage (Non-Rack and Pinion).
3. Lower the cab.

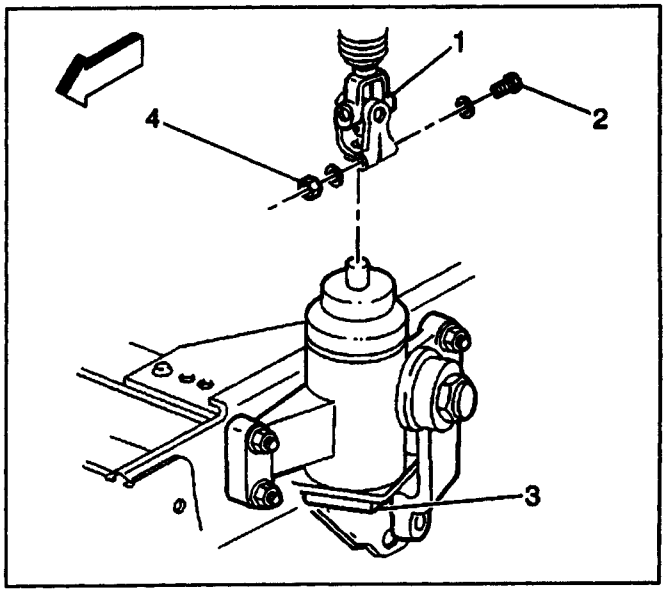


294139

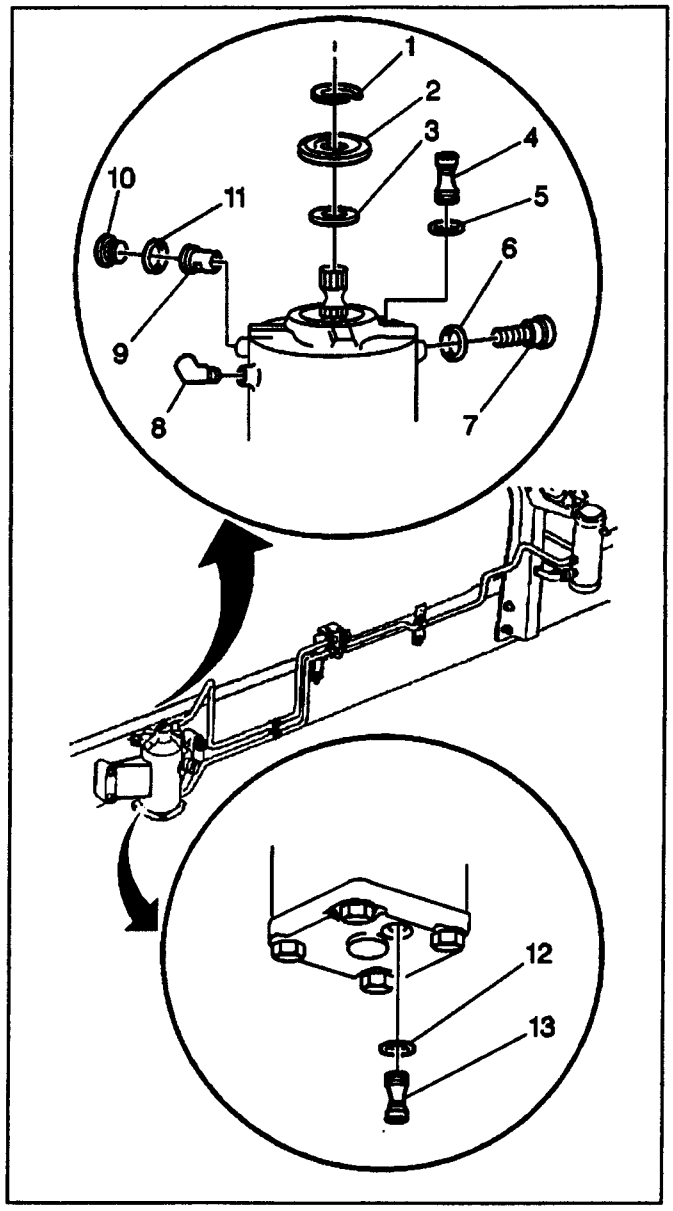
Input Shaft Dust Cap Replacement

Removal Procedure

1. Position the front wheels and the steering wheel straight ahead.
2. Tilt the cab. Refer to *Cab Tilting* in General Information.
3. Mark the position of the following components.
   - The steering gear input shaft.
   - the cardan joint of the lower steering shaft.
4. Remove the following components from the cardan joint:
   4.1. The cardan joint nut (4)
   4.2. The washer
   4.3. The cardan joint bolt (2)
5. Gently pry the cardan joint (1) off the steering gear input shaft.



227947

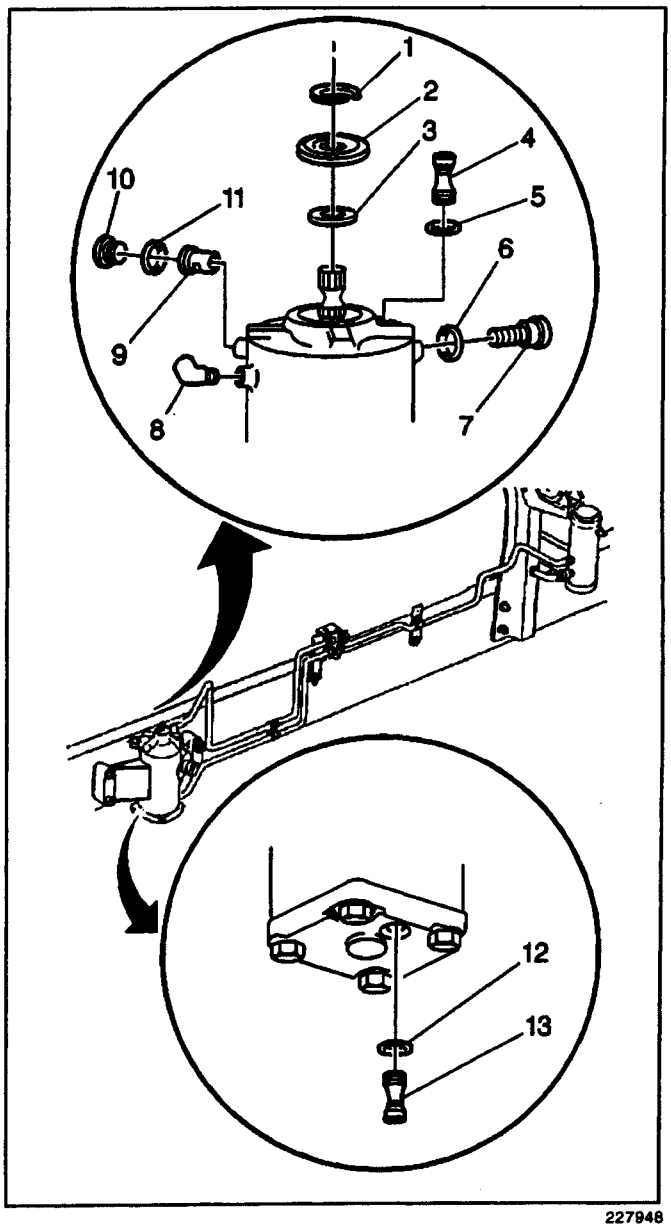


227948

6. Remove the snap ring (1) from the steering gear input shaft.
7. Remove the steering gear input shaft dust cap (2) from the steering gear input shaft.

Installation Procedure

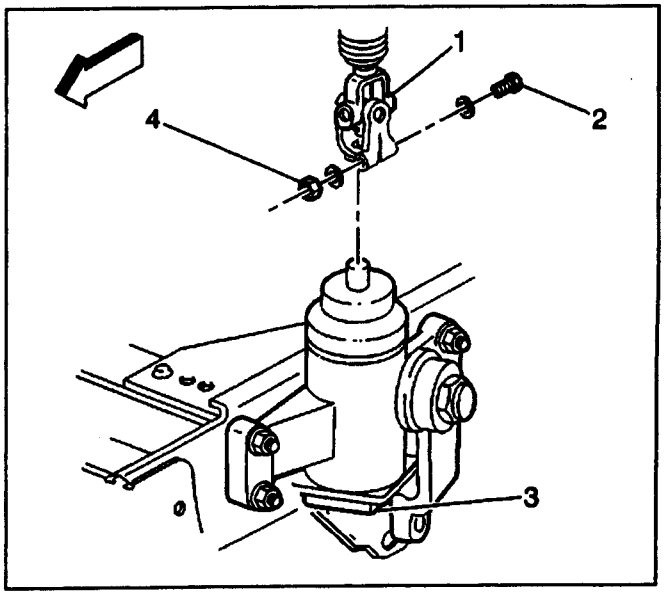
1. Install the input shaft dust cap (2).
2. Install the snap ring (1) onto the input shaft.
3. Align the marks on the cardan joint and the steering gear input shaft.
4. Position the cardan joint on the steering gear input shaft.



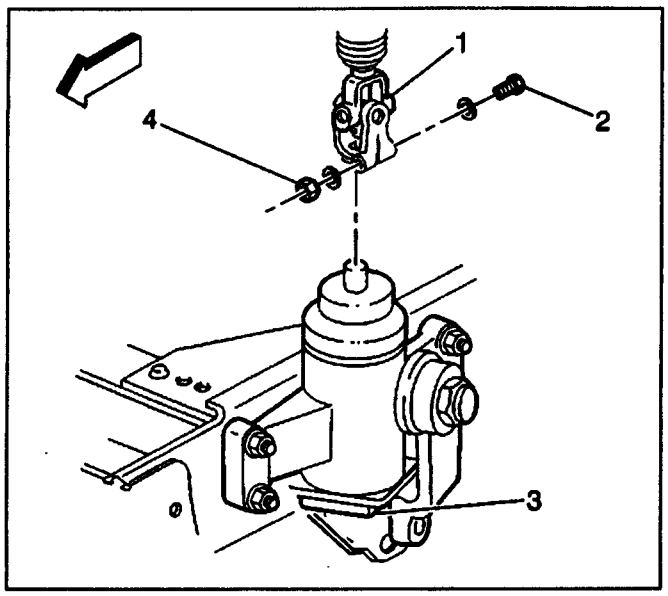
227948

5. Install the following components:
   5.1. The cardan joint washer
   5.2. The bolt (2)

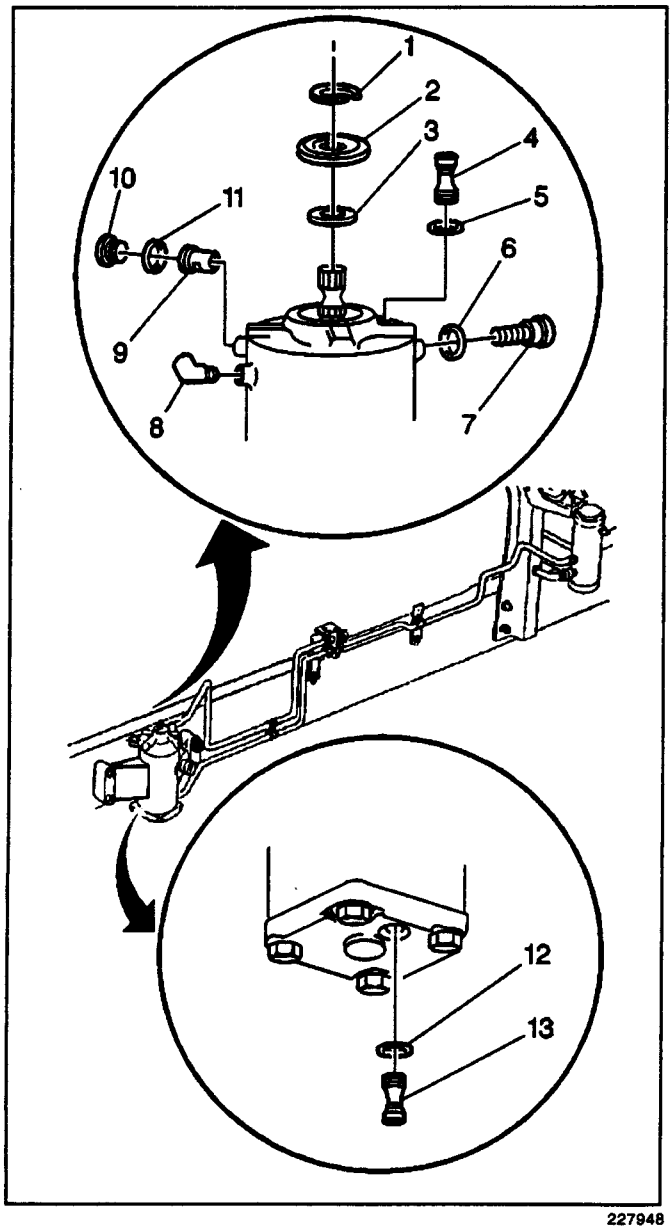
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
6. Install the cardan joint washer and the nut (4).
   Tighten
   Tighten the cardan joint nut to 55 N.m (41 lb ft).
7. Lower the cab.



227947



227947



227948

Input Shaft Bearing Protector Cap Replacement

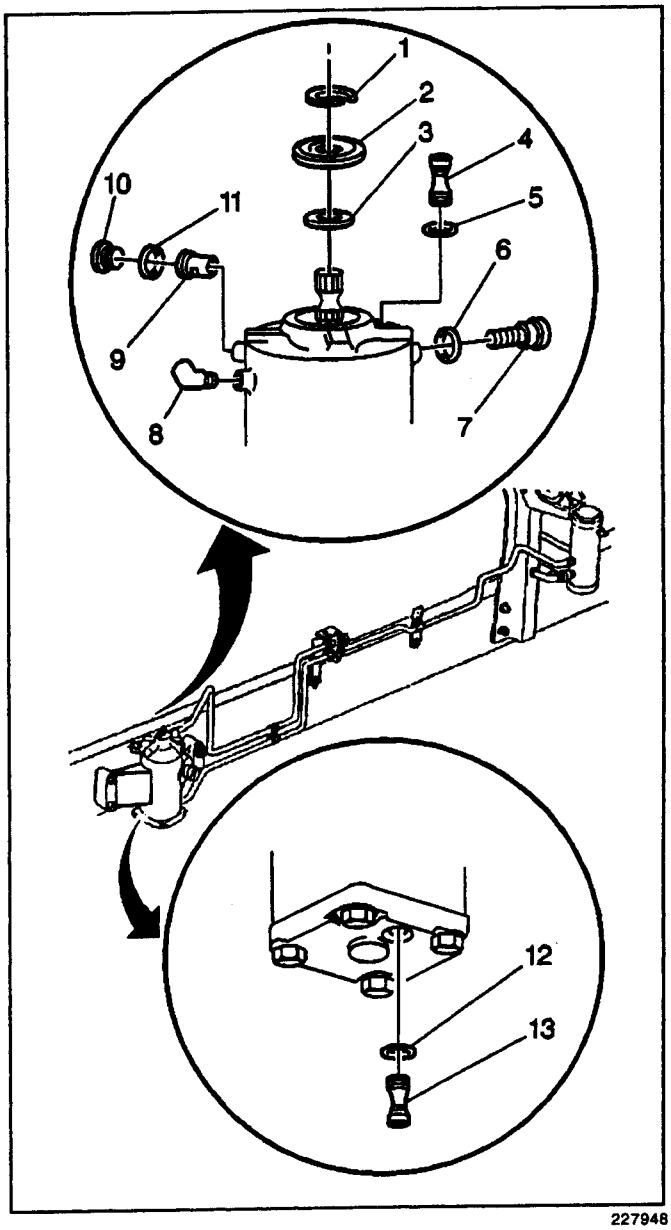
Removal Procedure

1. Position the front wheels and the steering wheel straight ahead.
2. Tilt the cab. Refer to *Cab Tilting* in General Information.
3. Mark the position of the steering gear input shaft and the cardan joint of the lower steering shaft.
4. Remove the following components:
   - 4.1. The cardan joint nut (4)
   - 4.2. The washer
   - 4.3. The cardan joint bolt (2)
5. Gently pry the cardan joint off the steering gear input shaft.
6. Remove the snap ring (1) from the steering gear input shaft.
7. Remove the steering gear input shaft dust cap (2) from the steering gear input shaft.
8. Remove the steering gear input shaft bearing protecting cap (3) from the steering gear input shaft.

Installation Procedure

Remove the following components.

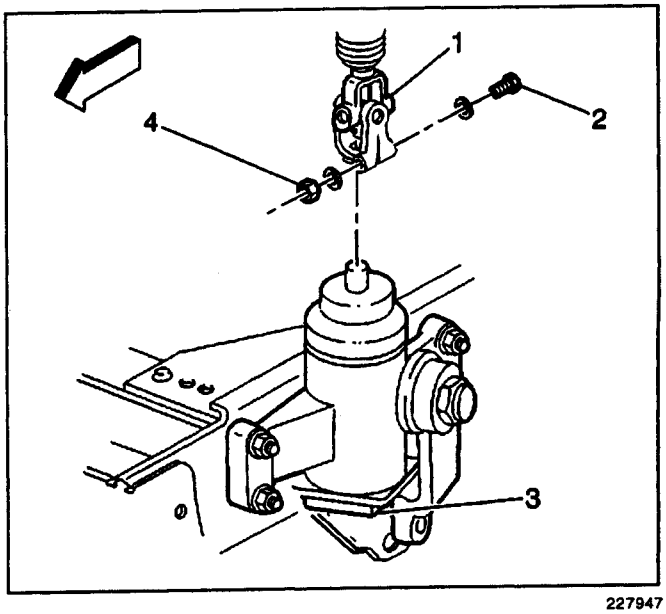
1. Install the input shaft bearing protecting cap (3).
2. Install the input shaft dust cap (2).
3. Align the marks on the cardan joint and the steering gear input shaft.
4. Position the cardan joint on the steering gear input shaft.



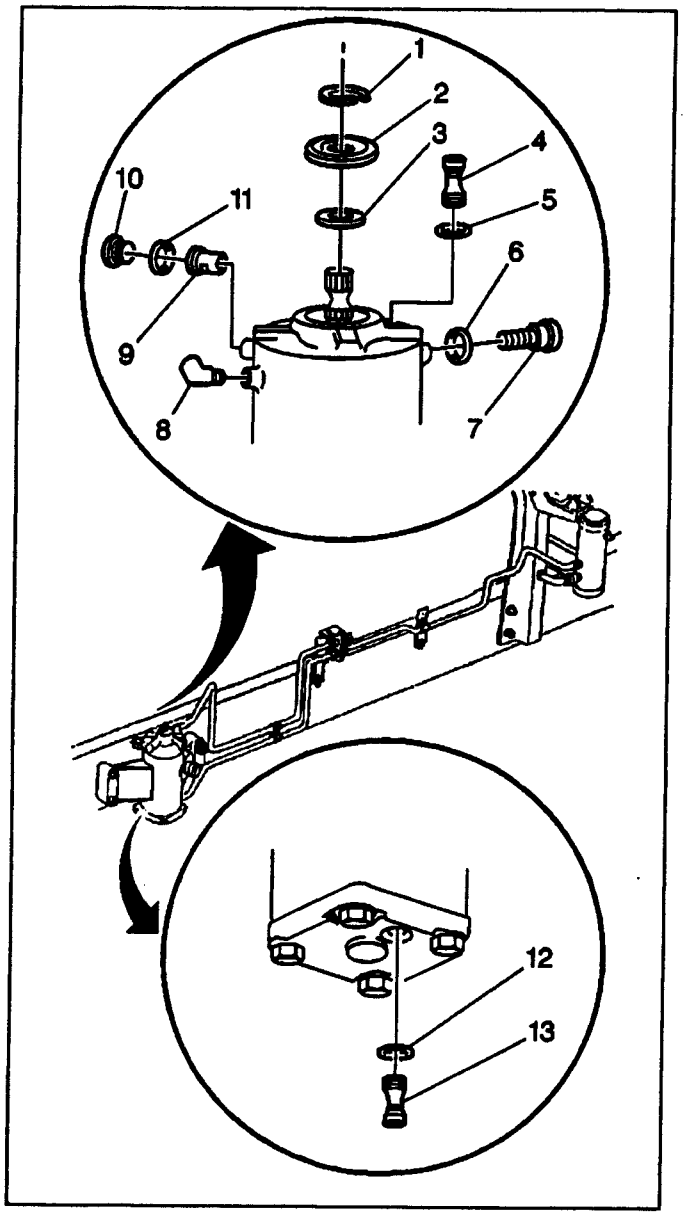
227948

5. Install the following components:
   5.1. The cardan joint washer
   5.2. The bolt (2)

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
6. Install the cardan joint washer and the nut (4).
   Tighten
   Tighten the cardan nut to 55 N.m (41 lb ft).
7. Lower the cab.



227947



227948

End Limiters Replacement

Removal Procedure

1. Position the front wheels and the steering wheel straight ahead.
2. Tilt the cab. Refer to *Cab Tilting* in General Information.

   Notice: Avoid contaminating the power steering system. Cap open hoses and ports to prevent dirt and debris from entering system. Contaminated power steering fluid and dirt can cause early parts failure.
3. Place a container under the power steering gear in order to catch the fluid.
4. Remove the following components from the steering gear:
   - 4.1. The top end limiter (4)
   - 4.2. The O-ring (5)
5. Remove the following components from the steering gear:
   - 5.1. The bottom end limiter (13)
   - 5.2. The O-ring (12)

Installation Procedure

1. Install the following components into the steering gear.
   1.1. The O-ring (12)
   1.2. The bottom end limiter (13)
2. Install the folowing components into the steering gear.
   2.1. the O-ring (5).
   2.2. the top end limiter (4)
3. Fill and bleed the power steering system. Refer to *Bleeding Power Steering System.*

Adjustment Procedure

Important: Check the end limiter valves whenever different sized tires are installed on a vehicle.

1. Ensure that the steering stop screws are properly adjusted. Refer to Wheel Alignment in Suspension.
2. Start the engine.

   Operate the vehicle at idle.

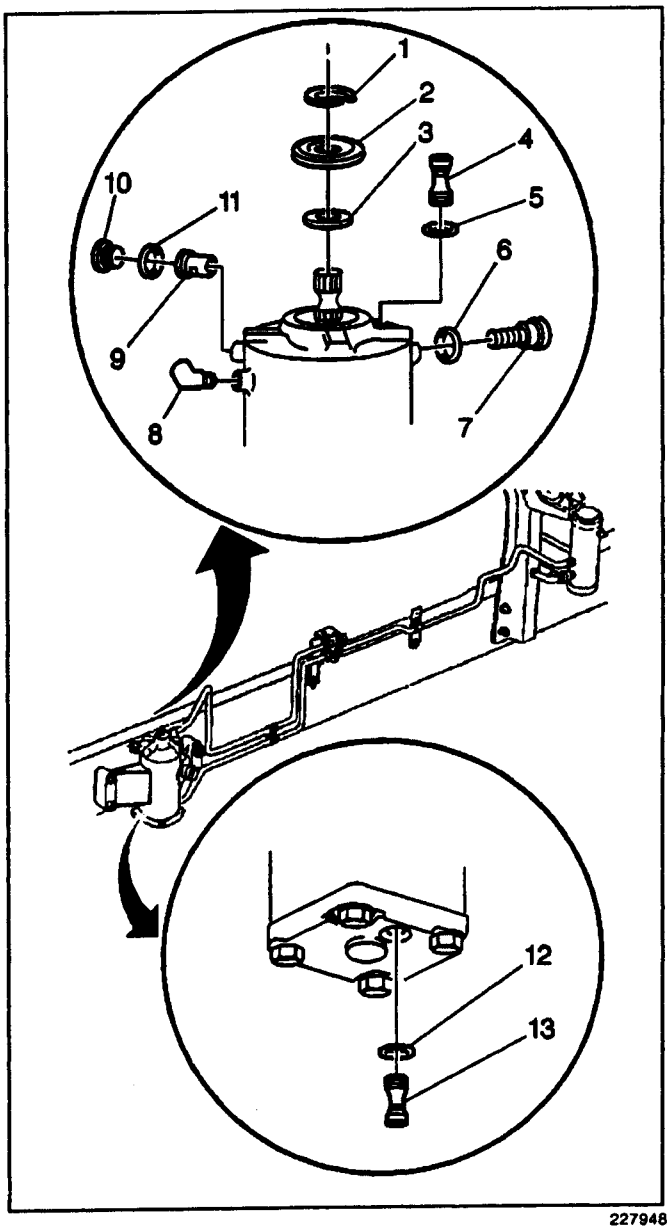
   Notice: Do not hold the steering wheel in the full turn position longer than 5 seconds, as damage to the steering pump may result.
3. Perform the following procedures:
   3.1. Turn the steering wheel counter-clockwise until the steering effort increases

   Turn the steering wheel to a full lock

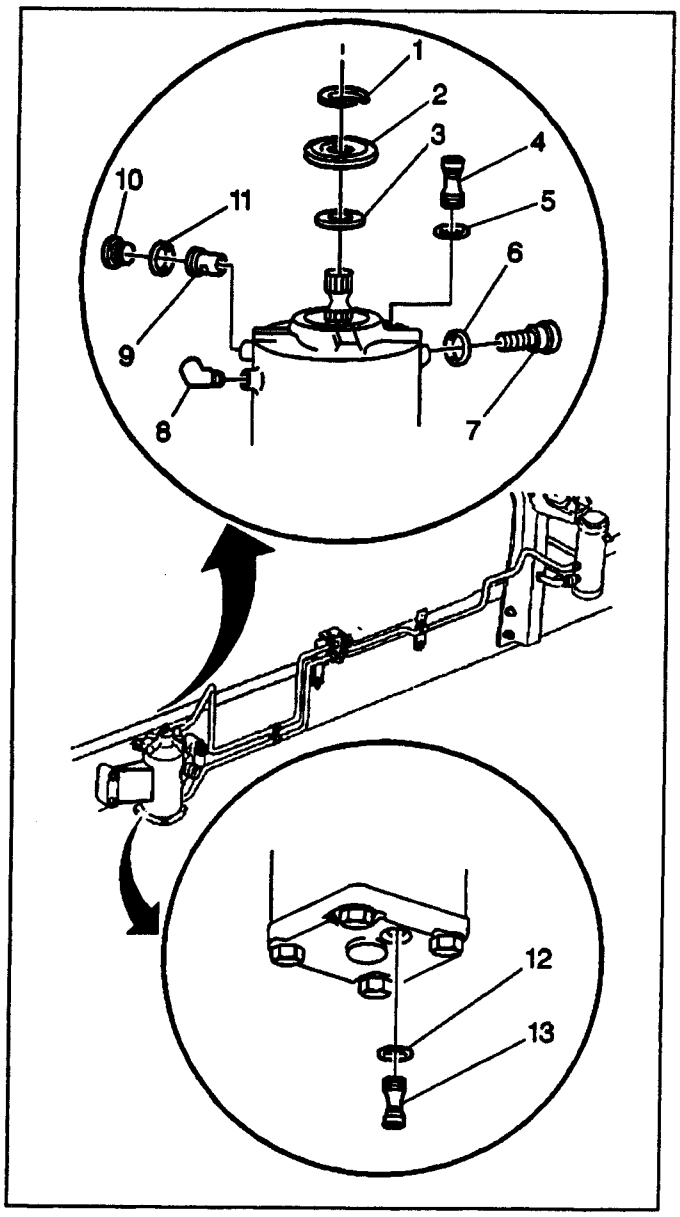
   Do not use force on the steering wheel.
   3.2. Observe the steering pump in order to determine if the steering pump goes into pressure relief. The following actions occur when the steering pump goes into pressure relief:
   - Engine loading begins
   - The chassis rises or lowers

   The movement of the chassis depends on the turn direction.
   3.3. If the steering pump goes into pressure relief, replace the end limiter valves.
   3.4. Proceed to step 4 if the power steering pump does not go into pressure relief.
4. Measure the clearance between the steering stop bolt and the axle center.

   The correct clearance value is 3–5 mm (0.1250-0.1875 in) with the steering at full lock.
5. Replace the end limiter valves if the clearance is incorrect.
6. Lower the cab.



227948



227948

Pressure Relief Valve Replacement

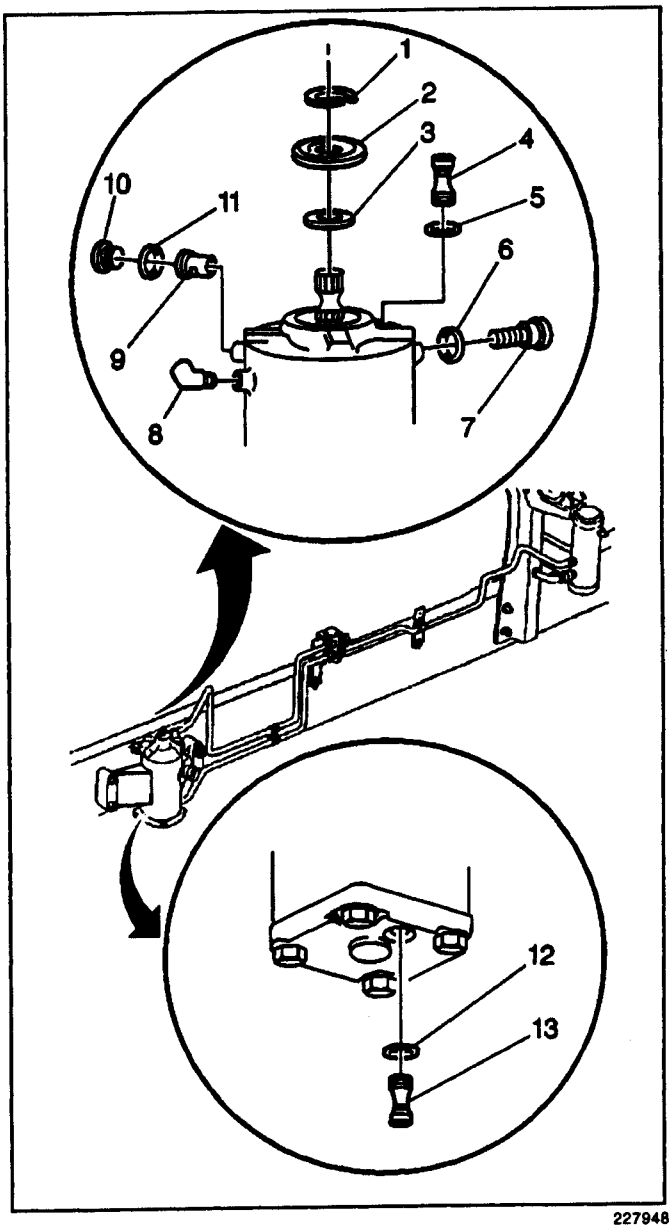
Removal Procedure

1. Position the front wheels and the steering wheel straight ahead.
2. Tilt the cab. Refer to *Cab Tilting* in General Information.

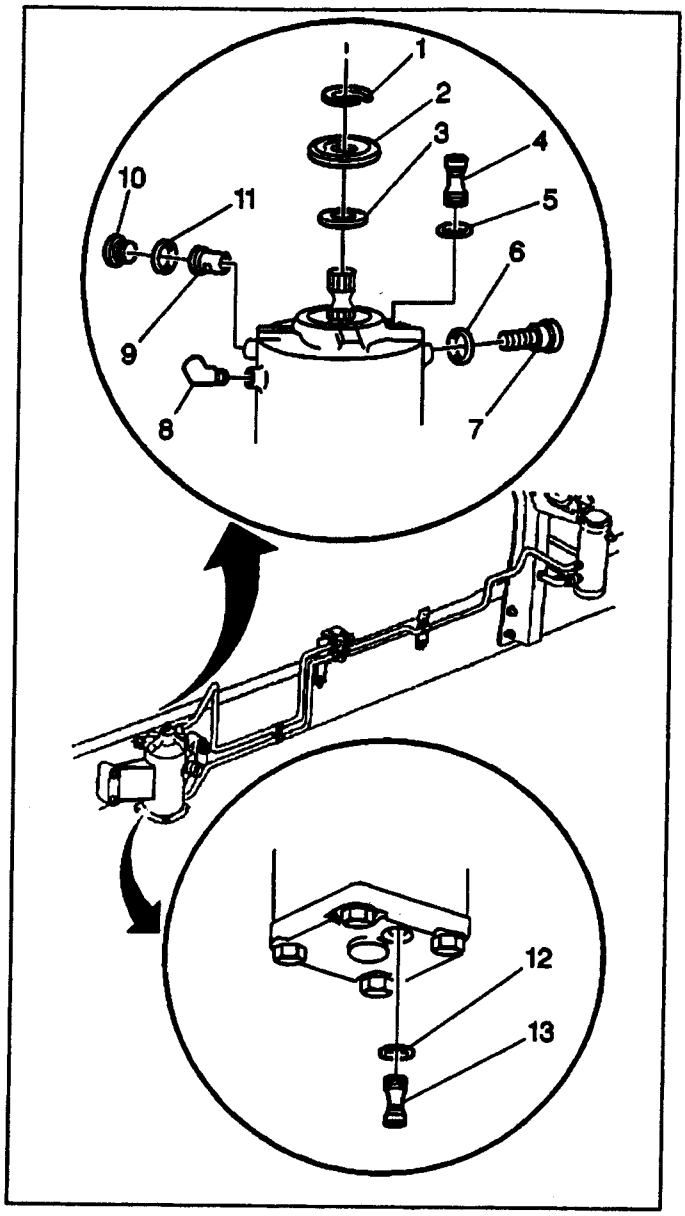
   Notice: Avoid contaminating the power steering system. Cap open hoses and ports to prevent dirt and debris from entering system. Contaminated power steering fluid and dirt can cause early parts failure.
3. Place a container under the power steering gear in order to catch the fluid.
4. Remove the following components from the steering gear:
   - 4.1. The pressure relief valve (7)
   - 4.2. The O-ring (6)

Installation Procedure

1. Install the following components into the steering gear:
   1.1. The O-ring (6)
   1.2. The pressure relief valve (7)
2. Fill and bleed the power steering system. Refer to *Bleeding Power Steering System.*
3. Lower the cab.



227948



227948

Resuction Valve Replacement

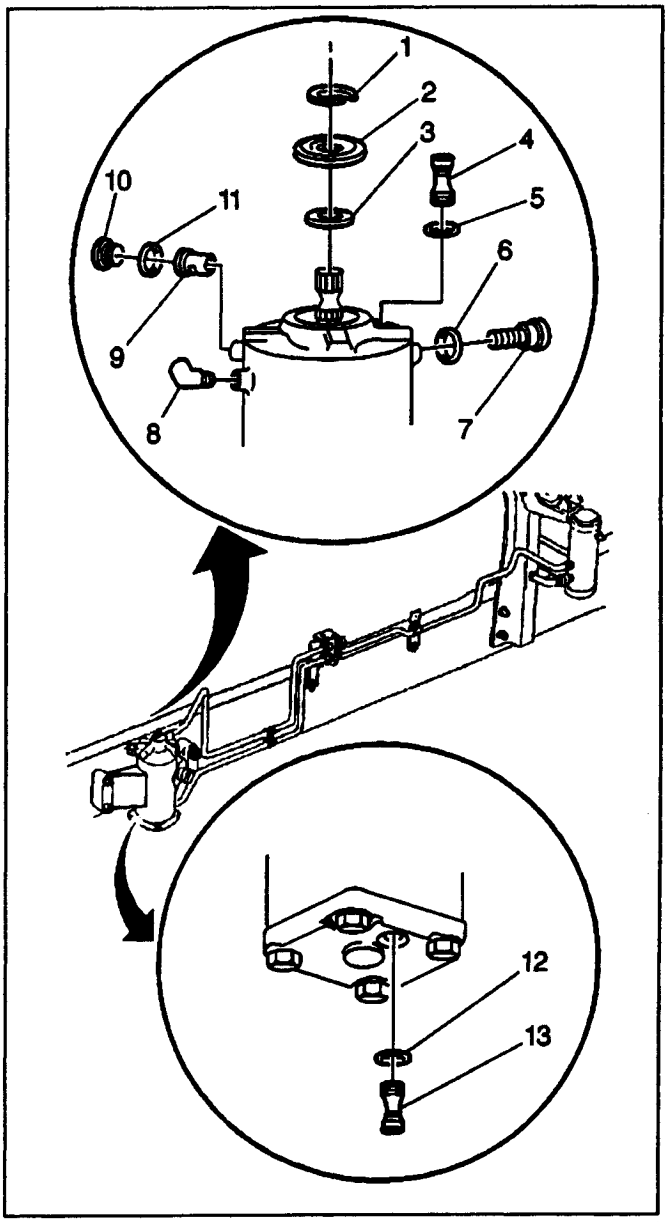
Removal Procedure

1. Position the front wheels and the steering wheel straight ahead.
2. Tilt the cab. Refer to *Cab Tilting* in General Information.

   Notice: Avoid contaminating the power steering system. Cap open hoses and ports to prevent dirt and debris from entering system. Contaminated power steering fluid and dirt can cause early parts failure.
3. Place a container under the power steering gear in order to catch the fluid.
4. Remove the following components from the steering gear:
   - 4.1. The resuction valve plug (10)
   - 4.2. The O-ring (12)
   - 4.3. The resuction valve (9)

Installation Procedure

1. Install the following components into the steering gear:
   1.1. The resuction valve (9)
   1.2. The O-ring (12),
   1.3. The resuction valve plug (10)
2. Fill and bleed the power steering system. Refer to *Bleeding Power Steering System.*
3. Lower the cab.



227948

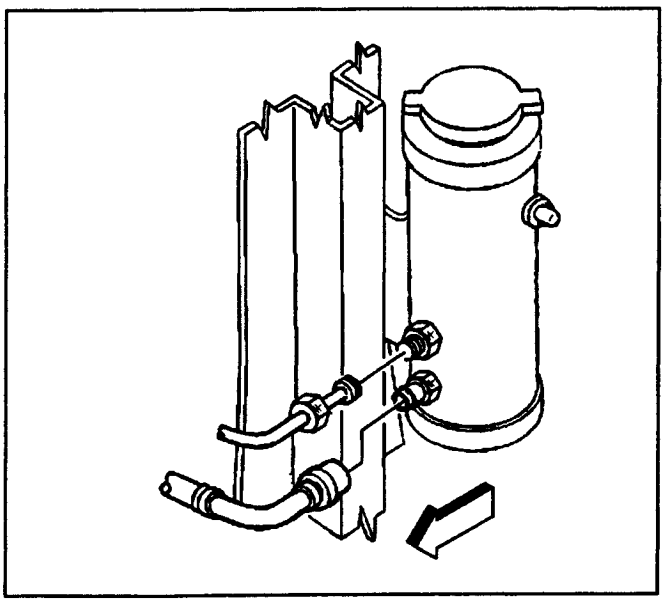
Power Steering Reservoir Replacement

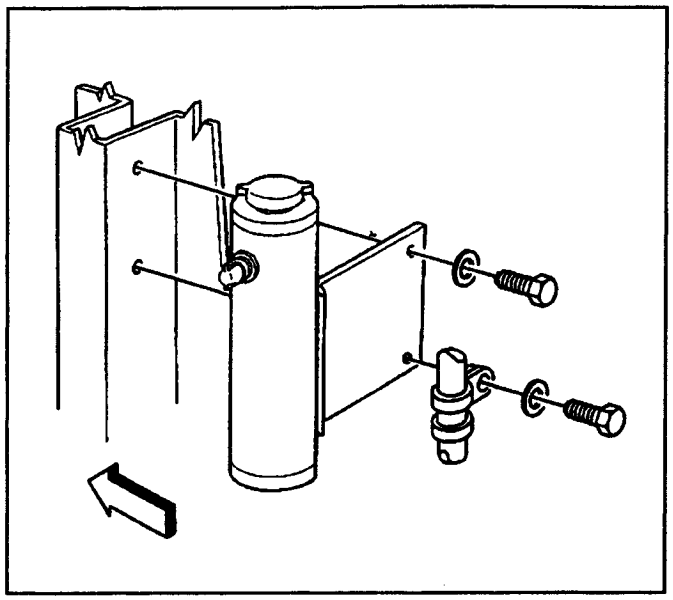
Removal Procedure

1. Tilt the cab. Refer to *Cab Tilting* in General Information.
2. Place a container under the power steering reservoir hoses.
3. Clean the surfaces of the power steering reservoir hoses.
4. Disconnect the power steering reservoir hoses.
5. Remove the hoses from the reservoir.

   Notice: Avoid contaminating the power steering system. Cap open hoses and ports to prevent dirt and debris from entering system. Contaminated power steering fluid and dirt can cause early parts failure.

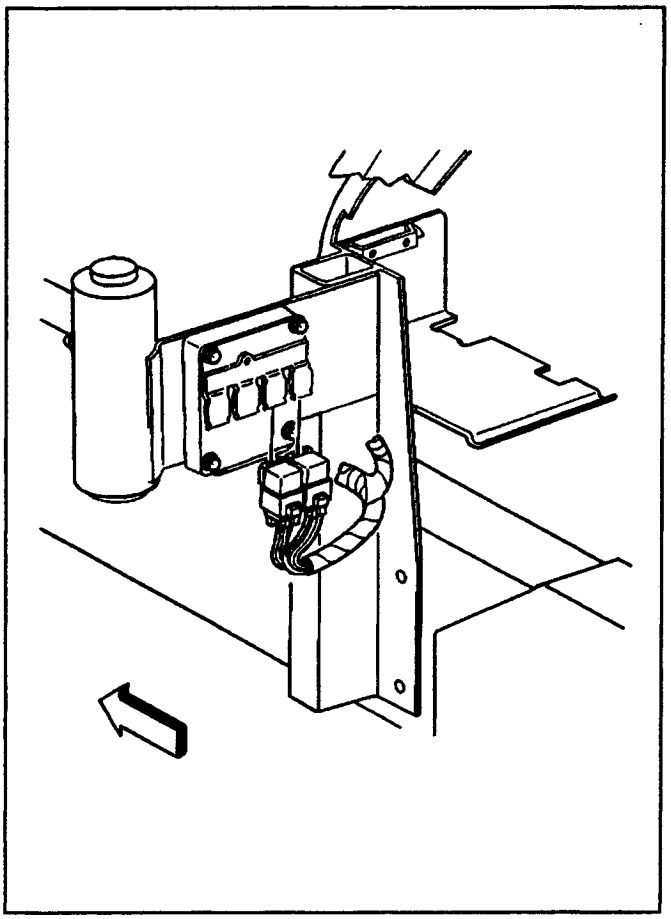
   Important: Cap the hoses to prevent dirt from entering the system.
6. Allow the reservoir to drain.


227966



227967

7. Remove the following components:
   - The bracket bolts.
   - The washers
8. Remove the following components:
   - The reservoir
   - The overflow hose clamp
   - The relay bracket



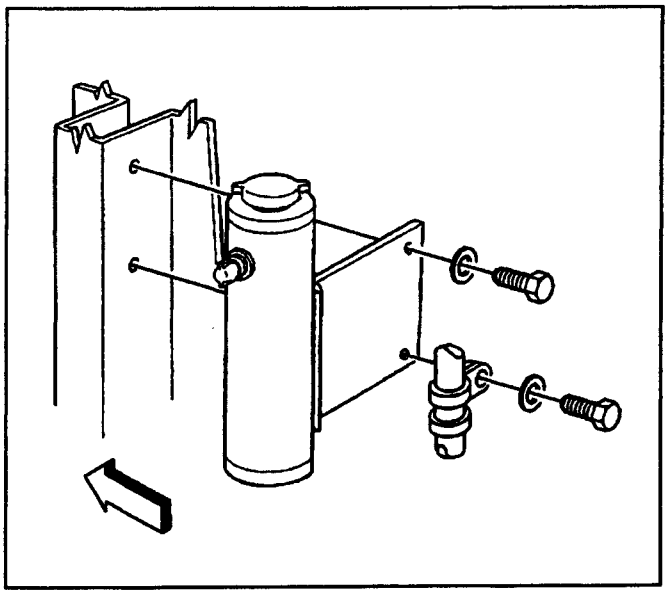
227969

Important: The ABS control module is only on the vehicles equipped with ABS.

9. Remove the ABS control module from the vehicle (if the vehicle is equipped).

Installation Procedure

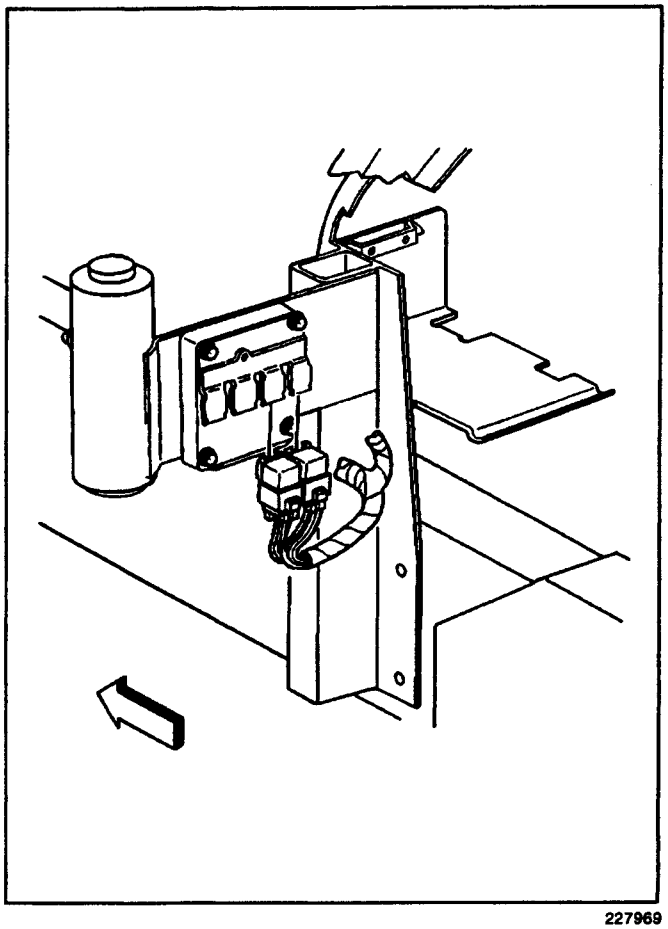
1. Position the following components on the vehicle:
   - The reservoir.
   - The overflow hose clamp.
   - The relay bracket.



227967

Important: The ABS control module is only on the vehicles equipped with ABS.

2. Position the ABS control module on the vehicle (if the vehicle is equipped).



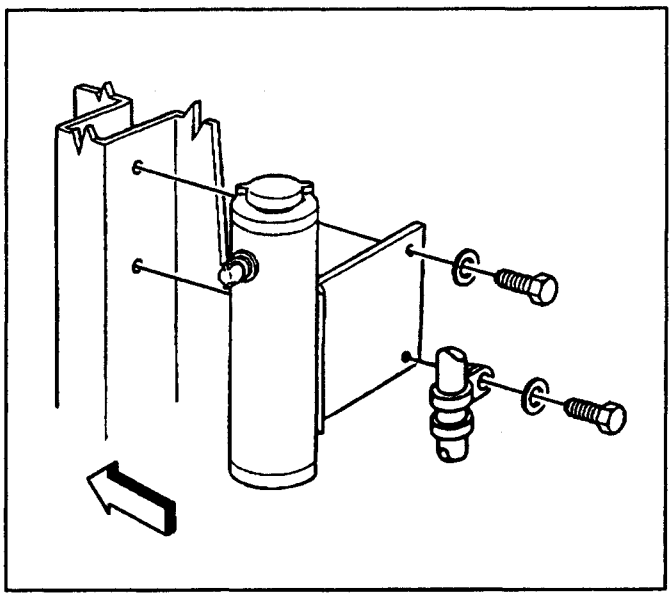
227969

Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the following components:
   - The bracket bolts.
   - The washers.

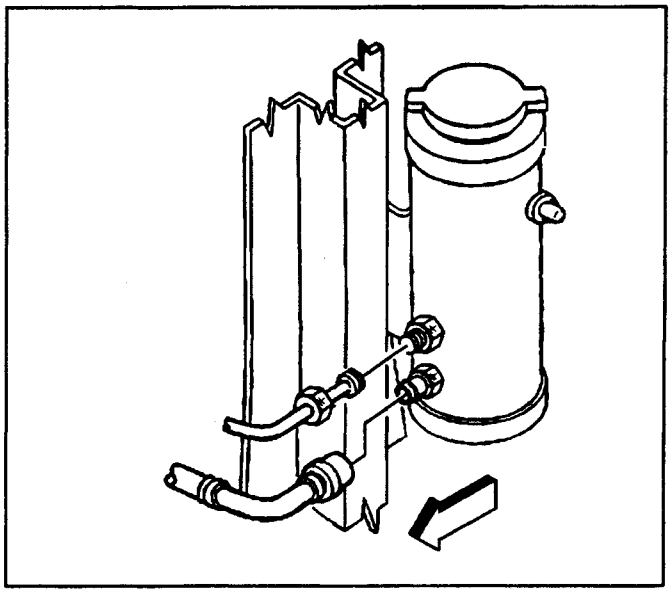
   Tighten

   Tighten the reservoir mounting bolts to 40 N.m (30 lb ft).



227967

4. Install the hoses to the reservoir.
5. Fill the system with new power steering fluid.
6. Bleed the system. Refer to *Bleeding Power Steering System.*
7. Lower the cab.



227966

Description and Operation

Power Steering System Description

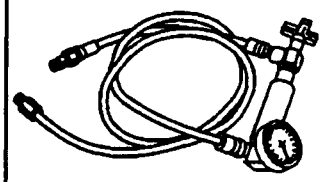
This vehicle uses an integral power steering system. The integral power steering system integrates the power steering cylinder and the control valves into the steering gear unit. The integral power steering system does not require a seperate power steering cylinder. The integral power steering system consists of the following components:

- The power steering gear
- The power steering pump
- The hydraulic reservoir

The power steering pump components are a combination of many machined and polished surfaces with very fine tolerances.

Care and cleanliness are very important when servicing the power steering pump components. The entry of even small amounts of dirt may cause an unsatisfactory repair and possible damage. Clean the power steering components in a solvent that will not damage any of the rubber parts.

Special Tools and Equipment

Illustration	Tool Number/Description
 219426	J 26487-C Power Steering Analyzer

BLANK

Steering Linkage (Non-Rack & Pinion)

Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Ball Joint Nut		
Axle Assemblies with a 3675 kg (8100 lb) Rating	130 N.m	95 lb ft
All other Axle Assemblies	160 N.m	120 lb ft
Pitman Arm Nut	370 N.m	275 lb ft
Relay Rod Nut	160 N.m	120 lb ft
Steering Arm Bolt	620–700 N.m	457–516 lb ft
Tie Rod Arm Bolt	620–700 N.m	457–516 lb ft
Tie Rod Tube Clamp Bolt Nut	75 N.m	55 lb ft

Repair Instructions

Steering Linkage Inspection

Important: Replace any parts that exhibit damage or wear. Do not attempt to repair the parts by welding.

The steering linkage rod ends are adjustable for toe adjustment and require periodic lubrication. Refer to *Fluid and Lubricant Recommendations.*

Replace the steering linkage rod ends when any of the following conditions exist:

- Excessive up-and-down motion
- Excessive end play
- Loss of motion at the ball stud

Note the following items before beginning any repairs:

- The position of the tie rod adjuster tube
- The direction from which the bolts are installed

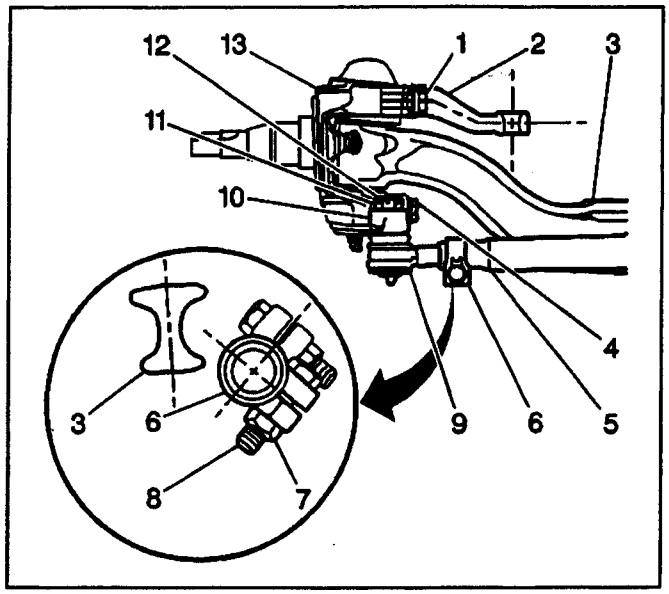
Inspect the tie rod adjuster tube components for rust. If rust is found, apply penetrating oil between the clamp and the tube. Rotate the clamps until they move freely.

Install all of the components in the proper positions. Ensure that each of the components has the correct part number.

The following conditions may cause a "shimmy":

- Suspension system defects
- Steering system defects
- Dynamic imbalance in the wheel and tire assembly
- Runout
- Force variations
- Road surface irregularities

Refer to *Tire and Wheel Vibration* in Tires and Wheels.



216055

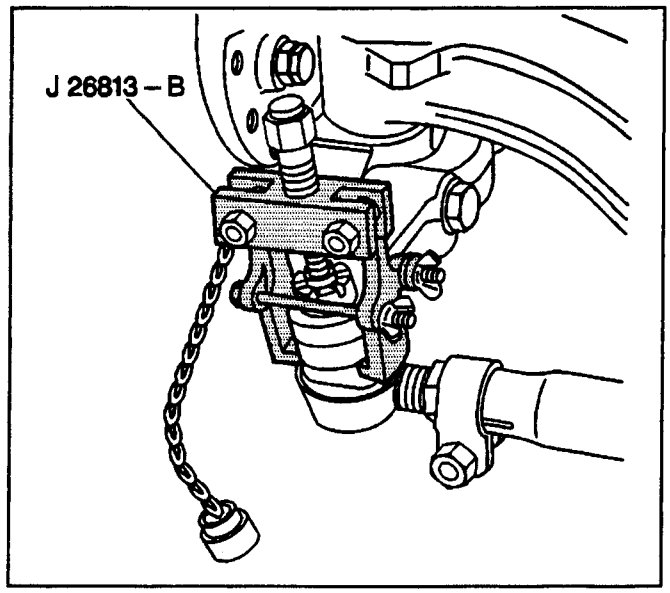
Tie Rod Replacement

Removal Procedure

Tools Required

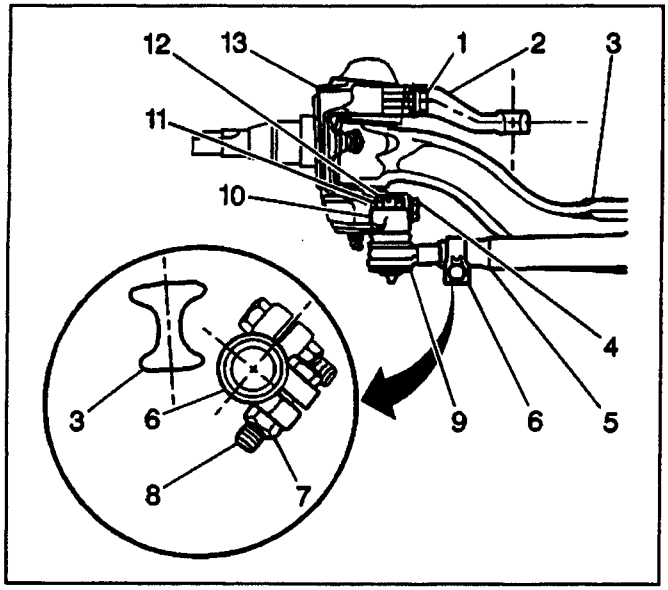
J 26813-B Steering Linkage Puller.

1. Remove the cotter pin (12) from the tie rod end ball joint (9).
2. Discard the cotter pin (12).
3. Remove the nut (11) from the tie rod ball joint (9).



216045

4. Use the *J 26813-B* to remove the relay rod from the steering arm.



216055

5. Loosen the tie rod tube clamp (6).
6. Remove the tie rod ball joint (9) from the tie rod tube (5).
7. Inspect the tie rod end threads for the following conditions:
   - Damage
   - Corrosion
8. Inspect the rod stud threads for the following conditions:
   - Damage
   - Corrosion
9. Inspect the rod stud nut threads for the following conditions:
   - Damage
   - Corrosion

10. Inspect the rod stud taper for the following conditions:
    - Nicks
    - Dirt

    Important:
    - If the tube is bent less than 5 degrees, cold straighten the tube.
    - If the tube is bent more than 5 degrees, replace the tube.
11. Inspect the tie rod tube (5) for straightness.
12. Clean any dirt or rust from all of the threads.
13. Clean any dirt or rust from the tapers.

Installation Procedure

Important: Thread in the tie rod ball joints an equal distance.

1. Install the tie rod ball joint (9) into the tie rod tube (5).
2. Install the tie rod ball joint (9) into the tie rod arm (10).

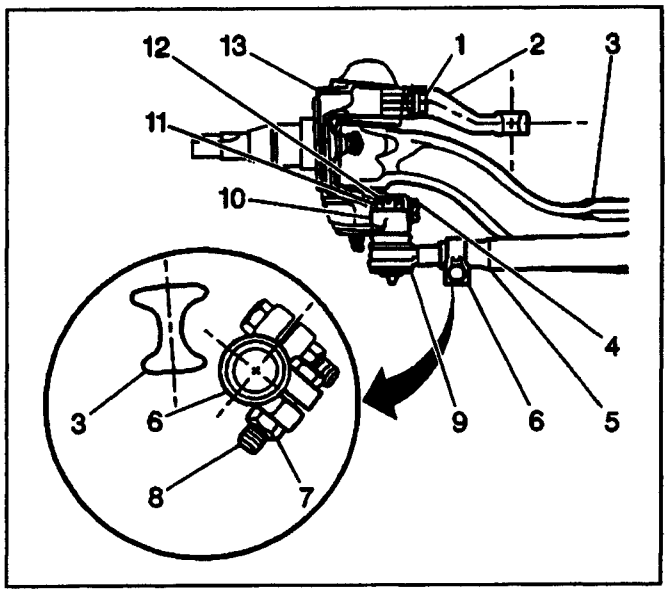
   Notice: Refer to *Fastener Notice* in Cautions and Notices.

   Important:
   - Advance the ball joint nut (11) to the nearest cotter pin slot.
   - Do not back off a ball joint nut in order to insert a cotter pin.
3. Install the ball joint nut (11).

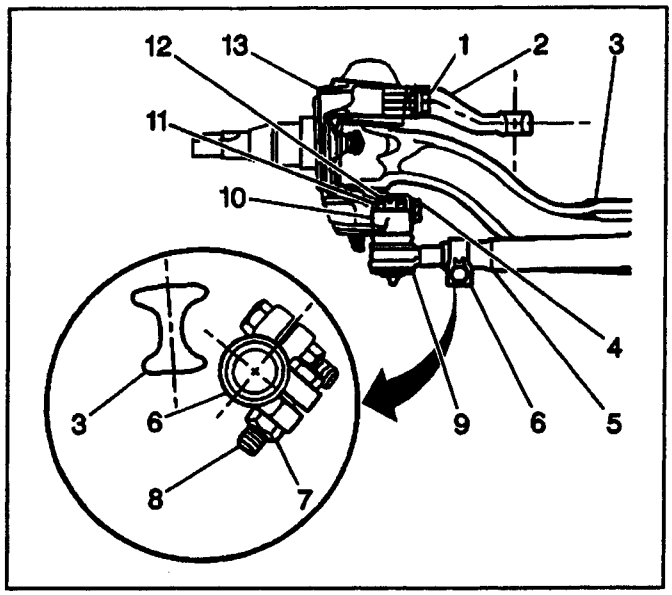
   Tighten
   - Tighten the ball joint nuts in the axle assemblies with a 3675 kg (8100 lb) rating to 130 N.m (95 lb ft).
   - Tighten the ball joint nuts in all other axle assemblies to 160 N.m (120 lb ft).
4. Install the new cotter pin (12).
5. Lubricate the tie rod ball with the chassis lubricant. Refer to *Fluid and Lubricant Recommendations.*
6. Adjust the toe-in. Refer to *Front Toe Adjustment.*
7. Install the tie rod tube clamp bolt nuts.

   Tighten

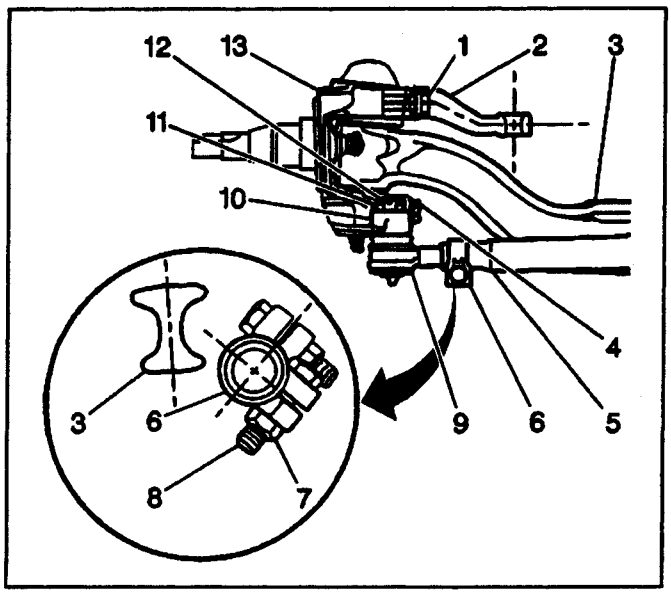
   Tighten the tie rod tube clamp bolt nuts to 75 N.m (55 lb ft).



216055



216055



216055

Steering Arm Replacement

Removal Procedure

1. Remove the relay rod. Refer to *Relay Rod Replacement.*
2. Remove the steering arm bolts (1) and the flat washers from the steering knuckle (13).
3. Remove the steering arm (2).

   Important: The steering arm is non-repairable. Replace the steering arm if it is damaged or worn.
4. Inspect the steering arm for the following conditions:
   - Damage
   - Wear

Installation Procedure

1. Install the steering arm (2) to the knuckle (13).
2. Install the flat washers.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
3. Install the steering arm bolts (1).

   Tighten

   Tighten the steering arm bolts to 620–700 N·m (457–516 lb ft).
4. Install the relay rod to the steering arm. Refer to *Relay Rod Replacement*
5. Install the relay rod nut.

   Tighten

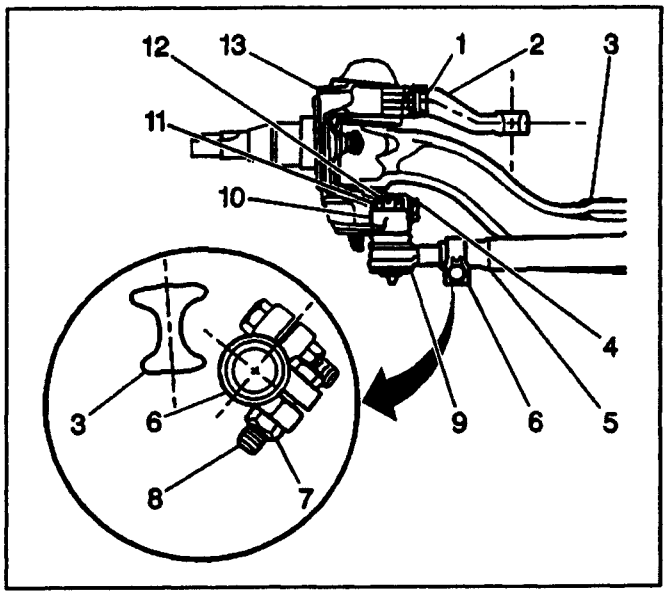
   Tighten the relay rod nut to 160 N·m (120 lb ft).
6. Advance the pins to the nearest cotter pin slot.
7. Install the new cotter pins.
8. Lower the cab.
9. Adjust the toe-in. Refer to *Front Toe Adjustment.*

Tie Rod Arm Replacement

Removal Procedure

1. Remove the tie rod ball joint from the tie rod arm. Refer to *Tie Rod Replacement.*
2. Remove the following components from the steering knuckle:
   - The tie rod arm bolts (4)
   - The flat washers
   - The tie rod arm (10).

   Important: The tie rod arm is not serviceable. Replace the rod arm if it is worn or damaged.
3. Inspect the tie rod arm for the following conditions:
   - Damage
   - Wear



216055

Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

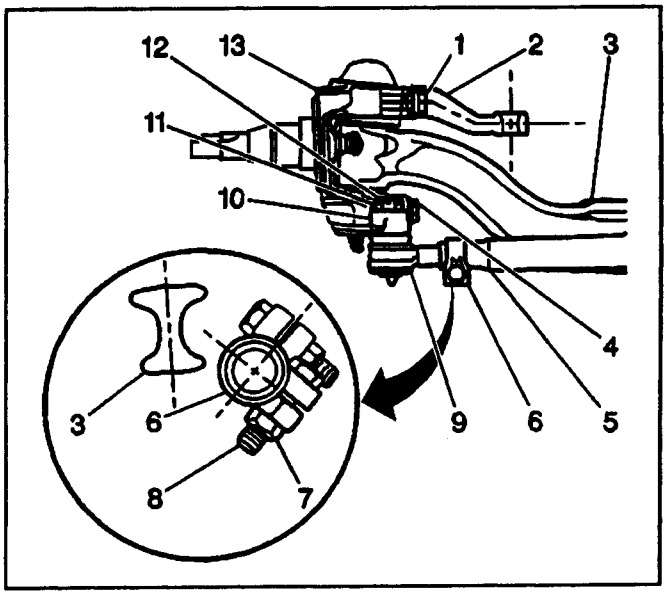
1. Install the tie rod arm to the steering knuckle.
2. Secure the tie rod arm (10) with the following components:
   - The flat washers
   - The tie rod arm bolts (4)

   Tighten

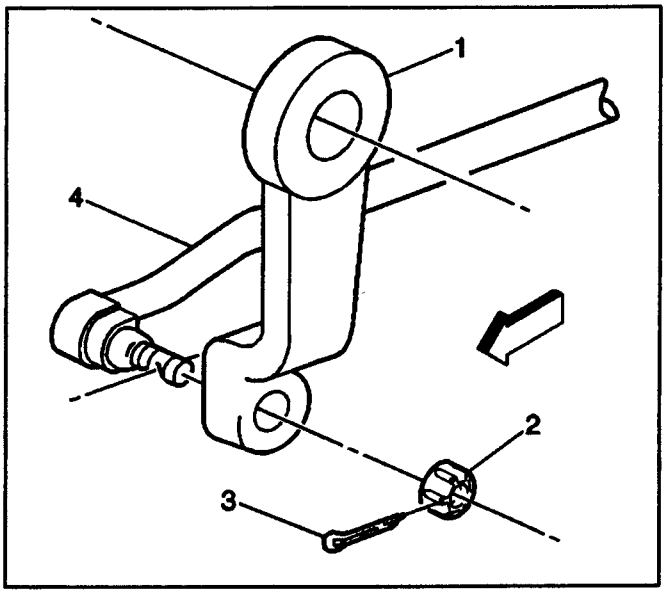
   Tighten the tie rod arm bolts to 620–700 N.m (457–516 lb ft).
3. Install the tie rod ball joint (9) to the tie rod arm (10).

   Important: Do not back off a tie rod ball joint nut in order to insert a cotter pin.
4. Install the tie rod ball joint nut (12).

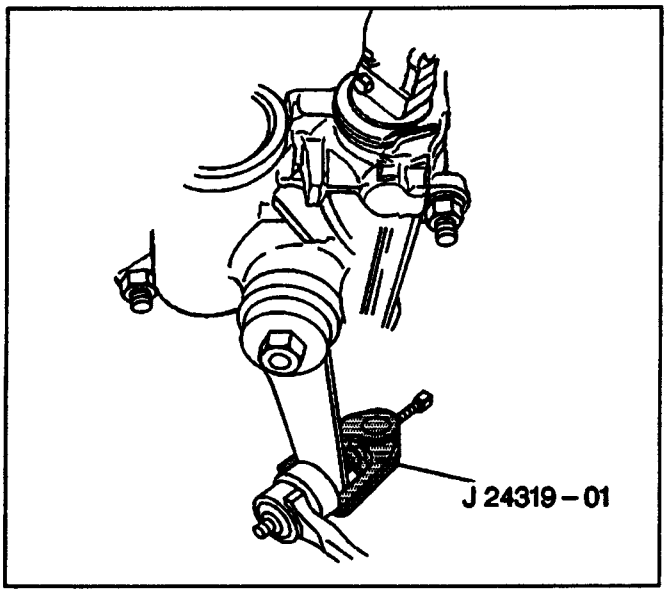
   Tighten
   - Tighten the ball joint nuts on axle (2) assemblies with a 3675 kg (8100 lb) rating to 130 N.m (95 lb ft).
   - Tighten the ball joint nuts on all other axle assemblies to 160 N.m (120 lb ft).
5. Advance the tie rod ball joint nut to the nearest cotter pin slot.
6. Install the new cotter pin (12).
7. Adjust the toe-in. Refer to *Front Toe Adjustment.*



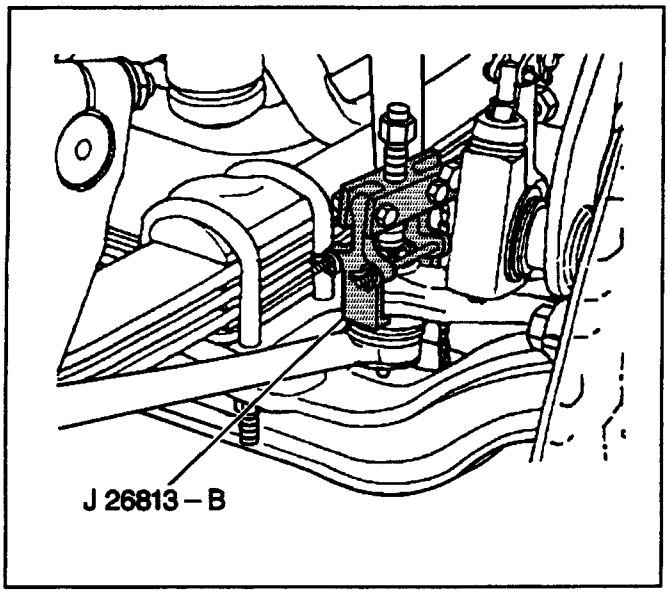
216055



228469



228476



215978

Relay Rod Replacement

Removal Procedure

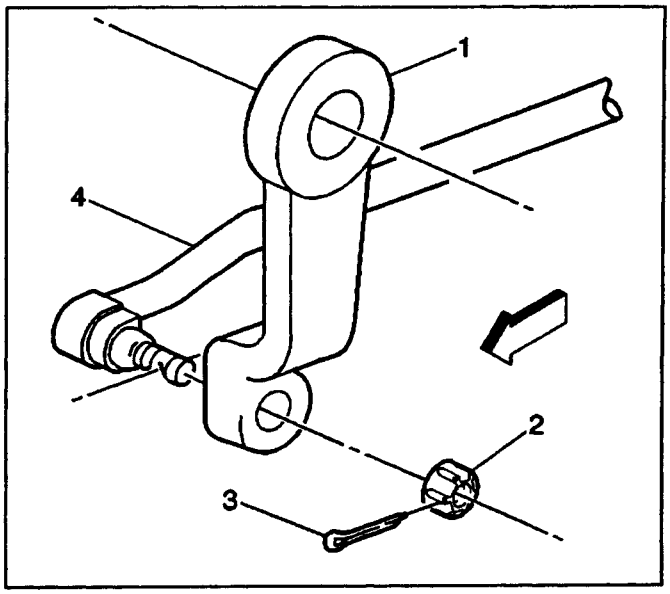
Tools Required

- *J 24319-01* Steering Linkage Puller
- *J 26813-B* Steering Linkage Puller

1. Position the front wheels and the steering wheel straight ahead.
2. Tilt the cab. Refer to *Cab Tilting* in General Information.
3. Remove the cotter pins (3) at each end of the relay rod (4).
4. Discard the cotter pins.
5. Remove the relay rod nuts (2).
6. Use the *J 24319-01* in order to remove the relay rod from the pitman arm.
7. Use the *J 26813-B* in order to remove the relay rod from the steering arm.
8. Inspect the relay rod for damage.
9. Inspect the end assembly stud threads for damage.
10. Inspect the end assembly rubber seals for the following conditions:
    - Damage
    - Deterioration
11. Install the relay rod nut (2).
12. Install the cotter pin (3).
13. Measure the torque required to turn the ball stud.
14. Replace the relay rod if the turning torque is less than 0.5 N·m (5 lb in).
15. Repeat steps 11 through 14 for the other ball stud.

Installation Procedure

1. Install the relay rod (4) assembly to the pitman arm (1).
2. Install the relay rod nut (2).



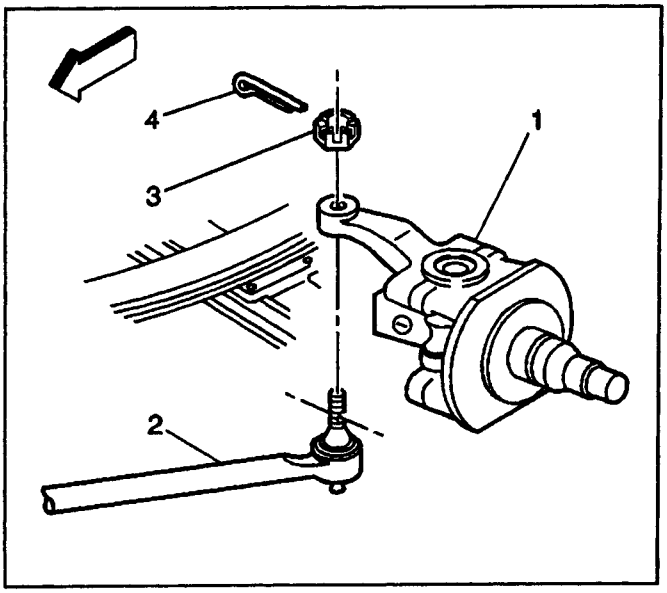
228469

3. Install the relay rod end assembly (2) to the steering arm (1).

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
4. Install the relay rod nut (3).

   Tighten

   Tighten the relay rod nut to 160 N.m (120 lb ft).
5. Advance the nuts (3) to the nearest cotter pin slot.
6. Install the new cotter pins (4)..
7. Lower the cab.
8. Lubricate the relay rod with the chassis lubricant. Refer to *Fluid and Lubricant Recommendations* in Maintenance and Lubrication.



228484

Pitman Arm Replacement

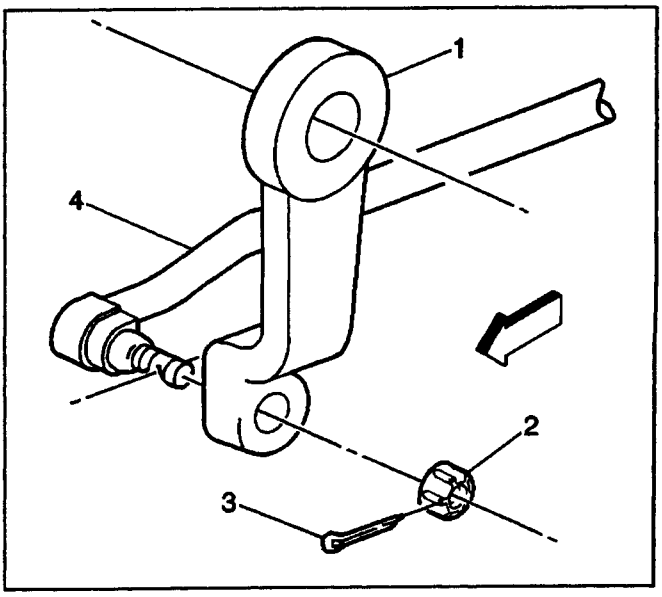
Removal Procedure

Tools Required

- *J 39256* Pitman Arm Puller
- *J 24319-01* Steering Linkage Puller

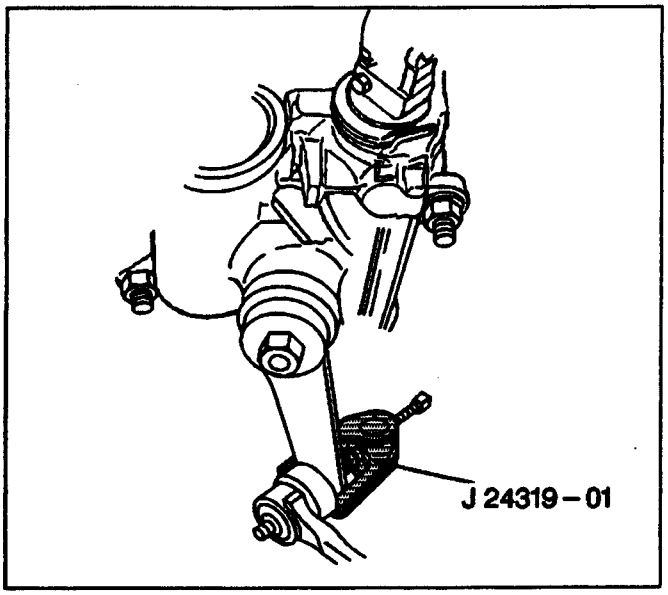
Notice: Do not hammer on the pitman arm, pitman arm shaft, or puller. Damage to the pitman or steering gear may result. Pitman arms are non-repairable and must be replaced when damaged or worn.

1. Position the front wheels and the steering wheel straight ahead.
2. Tilt the cab. Refer to *Cab Tilting* in General Information.

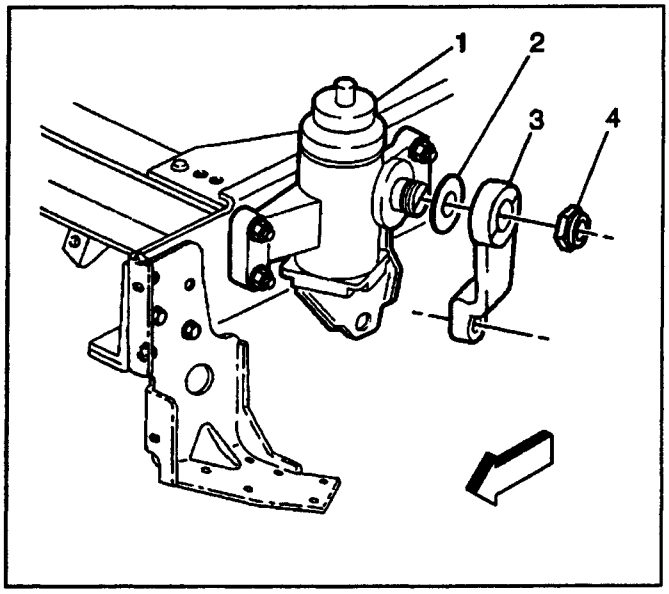


228469

3. Remove the cotter pin (3).
4. Discard the cotter pin.
5. Remove the relay rod nut (2)
6. Mark the position of the pitman arm (1) on the pitman shaft.
7. Use the *J 24319-01* in order to remove the relay rod end from the pitman arm end.



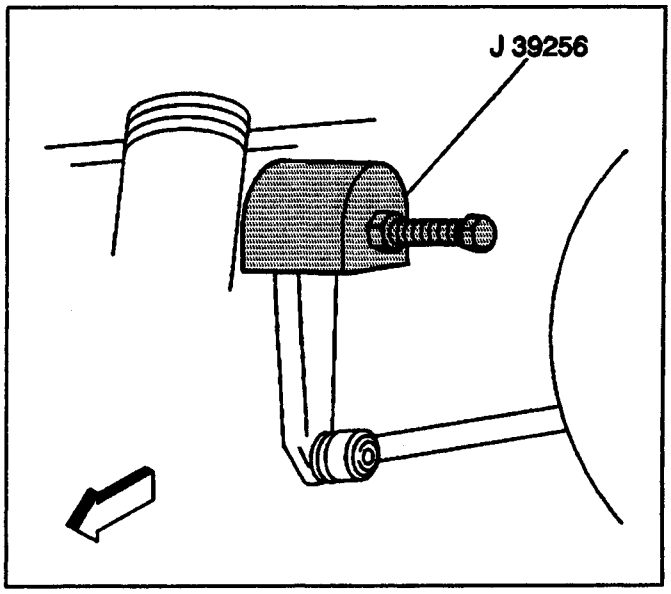
228476



294139

8. Remove the pitman arm nut (4).

9. Use the *J 39256* in order to remove the pitman arm (3) from the pitman arm shaft.



228480

Installation Procedure

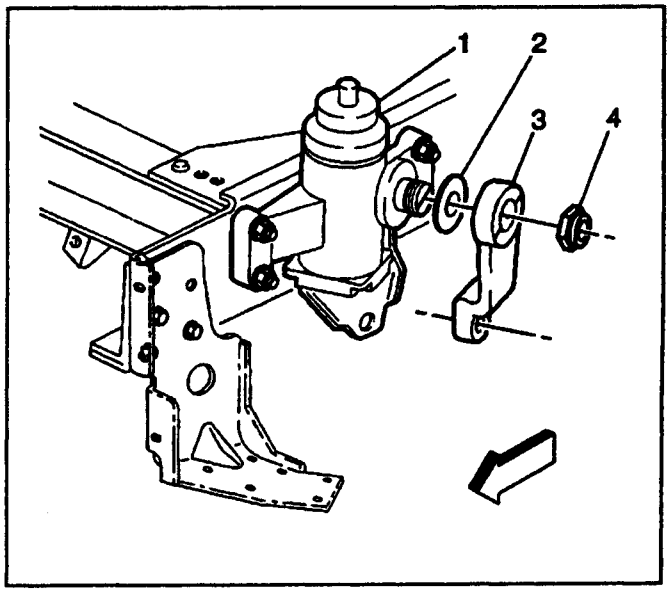
Important: Align the position marks made during removal on the pitman arm and the pitman shaft.

1. Install the pitman arm (3) on the pitman shaft.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the pitman arm nut (4).

   Tighten

   Tighten the pitman arm nut to 370 N.m (275 lb ft).



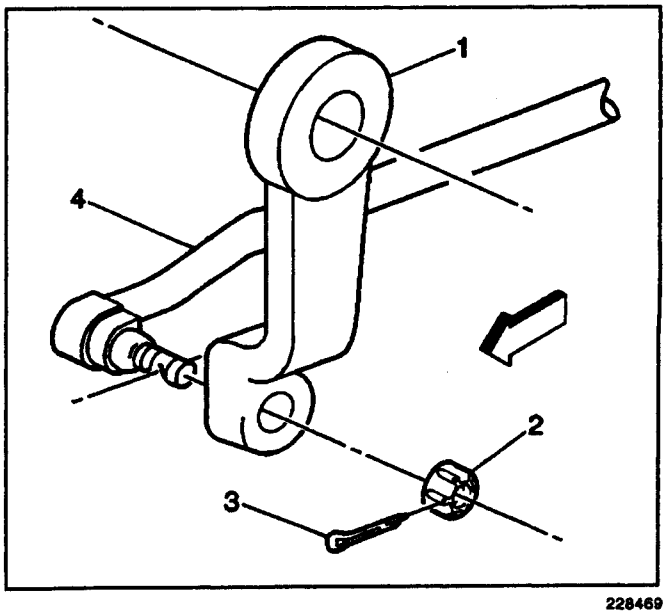
294139

3. Install the relay rod (4).

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
4. Install the relay rod nut (2).

   Tighten

   Tighten the relay rod nut to 160 N.m (120 lb ft).
5. Advance the relay rod nuts to the nearest cotter pin slot.
6. Install the new cotter pin (3).
7. Lower the cab.



228469

Description and Operation

Steering Linkage Description

The steering linkage consists of the following components:

- The pitman arm
- The relay rod
- The steering arms
- The tie rod

The turning motion of the steering wheel is transmitted through the steering gear and the pitman arm to the relay rod.

Inspect the following conditions whenever any steering linkage components are repaired or replaced:

- The steering geometry
- The front end alignment

Refer to *Front Caster Adjustment,Front Camber Adjustment* and *Front Toe Adjustment* in Wheel Alignment.

Relay Rod

The relay rod has a ball joint at each end. The relay rod connects to the forward steering arm on the left side.

The tie rod extends the length of the axle. The tie rod connects the left and the right steering arms. This arrangement provides control of the right wheel.

The overall condition of the steering linkage affects the steering performance. The following conditions may cause poor steering performance:

- Bent parts
- Damaged parts
- Worn parts
- Poorly lubricated parts

Tie Rod

The tie rod assembly consists the following components:

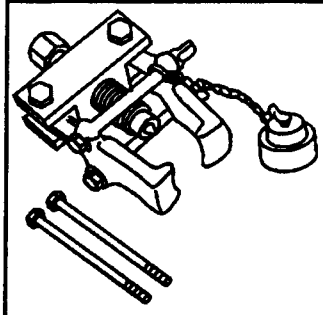
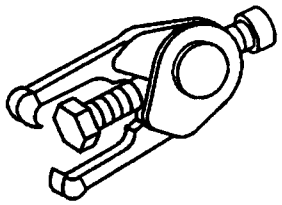
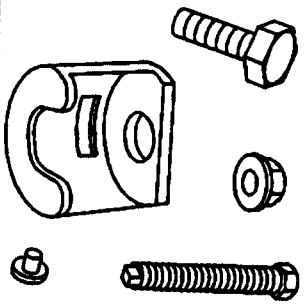
- The tie rod tube
- The two tie rod ends

The tie rod ends thread into the tube. Clamps secure the tied rod end to the tube. The right and left hand threads provide a convenient method of adjusting the toe-in. Replace the tie rod ends when an any of the following conditions are noted:

- An excessive up and down motion is present
- Excessive end play at the ball end of the stud is present
- Loss of motion at the ball end of the stud is present

Before any repair is undertaken, note the position of the tie rod end clamps and the direction from which the bolts are installed. Reinstall the parts in the proper position in order to avoid interference with the adjacent parts of the vehicle.

Special Tools and Equipment

Illustration	Tool Number Description
 216198	J 26813-B Steering Linkage Puller
 82244	J 24319-01 Steering Linkage Puller
 216175	J 39256 Pitman Arm Puller

Steering Wheel and Column - Tilt

Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Cardan Joint Nut	55 N.m	41 lb ft
Steering Wheel Nut	55 N.m	41 lb ft

Diagnostic Information and Procedures

Lock System Sticks in Start

Problem	Action
The ignition switch is worn.	Replace the ignition switch.
A high effort condition exists.	Refer to *High Steering Shaft Effort.*

Key Cannot Be Removed in the Off Lock Position

Problem	Action
The ignition switch faulty or loose.	Tighten the mounting bolts or replace the ignition switch

Noise in Steering Column

Problem	Action
The upper steering shaft bearings are worn, tight or frozen.	Replace the upper steering shaft.
The column mounting is loose.	Tighten the attaching bolts.
One click in the OFF-LOCK position is heard during movement of the steering wheel.	Seat the lock bolt normally.
The horn contact ring is not lubricated.	Lubricate as necessary.
The column is improperly mounted.	Tighten the attaching bolts.
The tilt shoe or the attaching hardware is loose.	1. Tighten the tilt shoe or the attaching hardware. 2. Replace the tilt shoe, if necessary.

High Steering Shaft Effort

Problem	Action
The upper steering shaft bearings are worn, tight or frozen.	Replace the upper steering shaft.
The lower shaft universal joints are binding.	Replace the lower steering shaft universal joints.

Loose Steering Wheel (Every Other Tilt Position)

Problem	Action
A loose fit exists between the tilt shoe and the pivot pin.	Replace the tilt shoe.

Steering Wheel Does Not Lock in Any Tilt Position

Problem	Action
The tilt shoe grooves have burrs or dirt.	Replace the tilt shoe. Clean the grooves.
The tilt spring is weak or broken.	Replace the spring.
The tilt shoe is seized on the pivot pin.	Replace the tilt shoe.

Steering Wheel Not Returning to Top Tilt Position

Problem	Action
The pivot bolts are bound.	Replace the pivot bolts.
The tilt springs are broken or missing.	Replace the tilt springs.
Column binding exists in the following components: • The ignition switch • The combination switch wiring harness	Reroute the harness.

Noise When Tilting Steering Column

Problem	Action
The tilt springs are rubbing in the housing.	1. Reposition the tilt springs. 2. Lubricate the tilt springs.
The tilt shoe grooves have burrs or dirt.	1. Replace the tilt shoe. 2. Clean the grooves.

Turn Signal Does Not Cancel

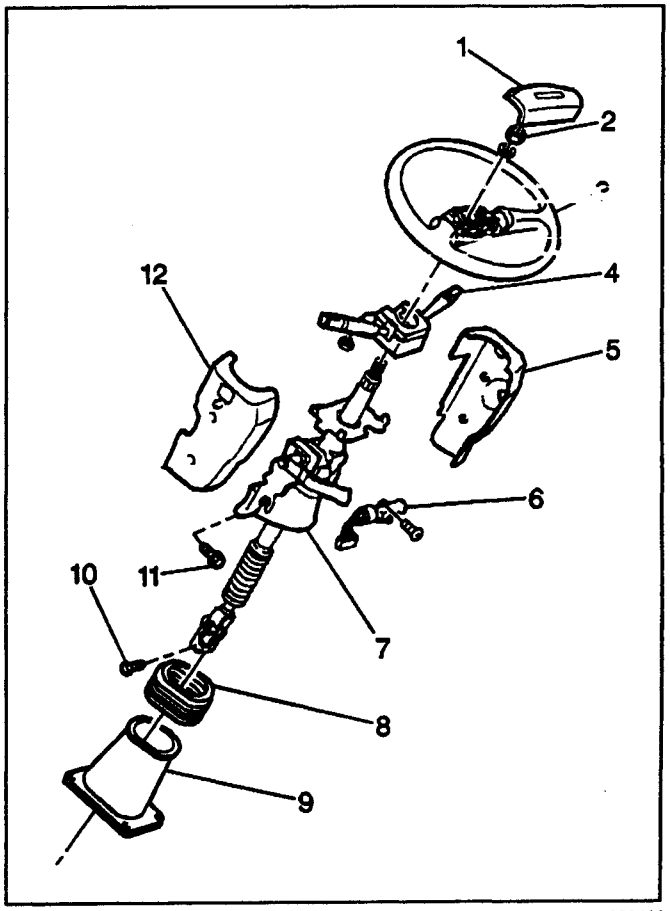
Problem	Action
The combination switch mounting is loose.	Tighten the combination switch mounting screws.
The detent is broken or missing.	Replace the combination switch.
The combination switch is faulty.	Replace the combination switch.

Repair Instructions

Ignition Switch Replacement

Removal Procedure

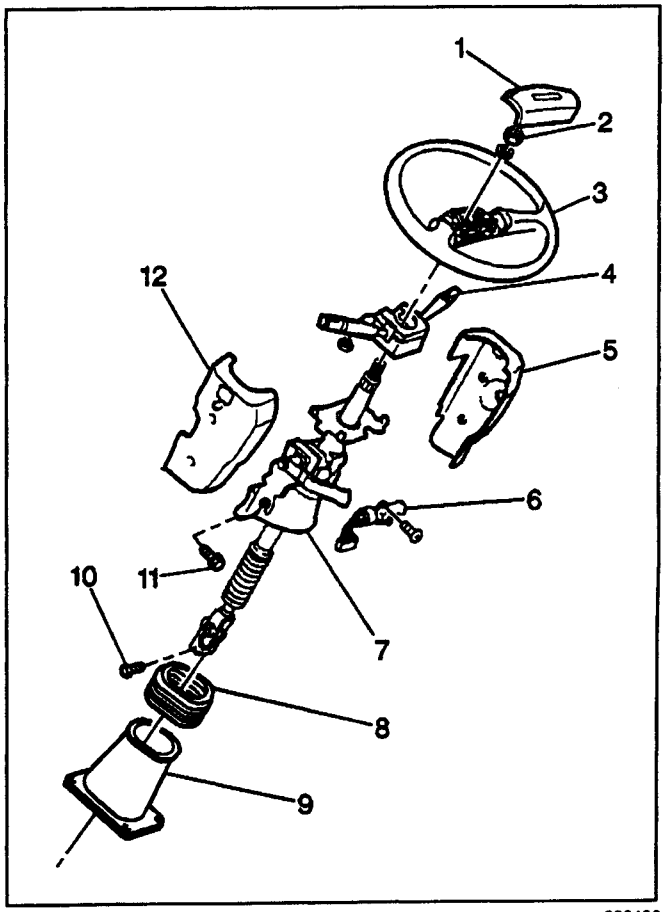
1. Remove the steering wheel (3). Refer to *Steering Wheel Replacement.*
2. Push the boot (8) off of the cowl halves (5, 12) onto the lower steering shaft cover (9).
3. Remove the left and right side cowl half screws.
4. Remove the left (12) and right (5) side cowl halves from the upper steering shaft assembly (7).
5. Disconnect the electrical connector from the ignition switch (6).
6. Remove the following components from the upper steering shaft assembly (7):
   - 6.1. The ignition switch screws
   - 6.2. The wiring harness clamp
   - 6.3. The ignition switch (6)



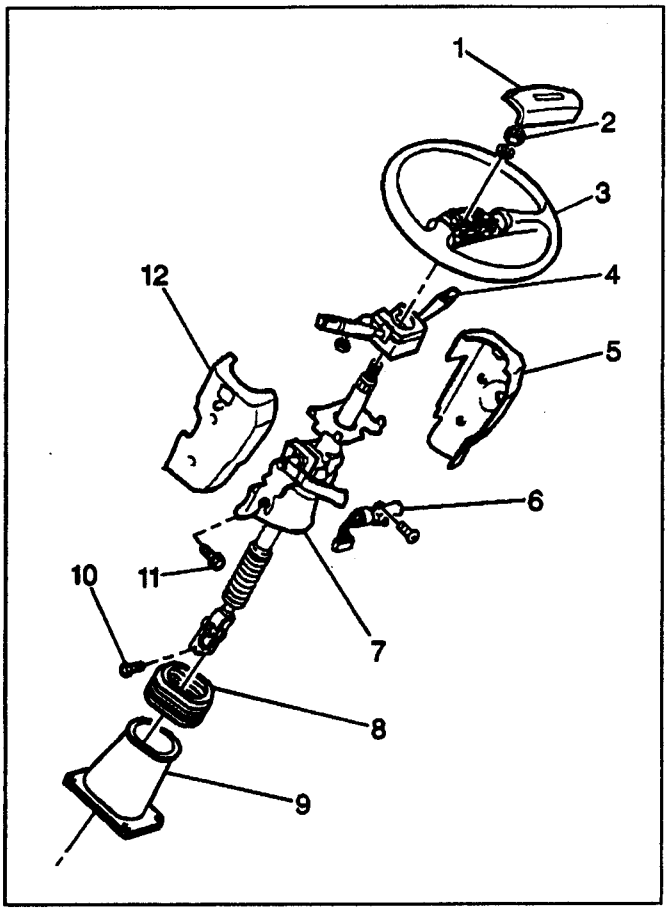
228496

Installation Procedure

1. Install the ignition switch (6) to the upper steering shaft assembly (7), with the wiring harness clamp and screws.
2. Connect the electrical connector to the ignition switch (6).
3. Install the left (12) and the right (5) side cowl halves to the upper steering shaft assembly (7) with screws.
4. Position the boot (8) over the lower steering shaft cover (9).
5. Install the steering wheel (3).



228496

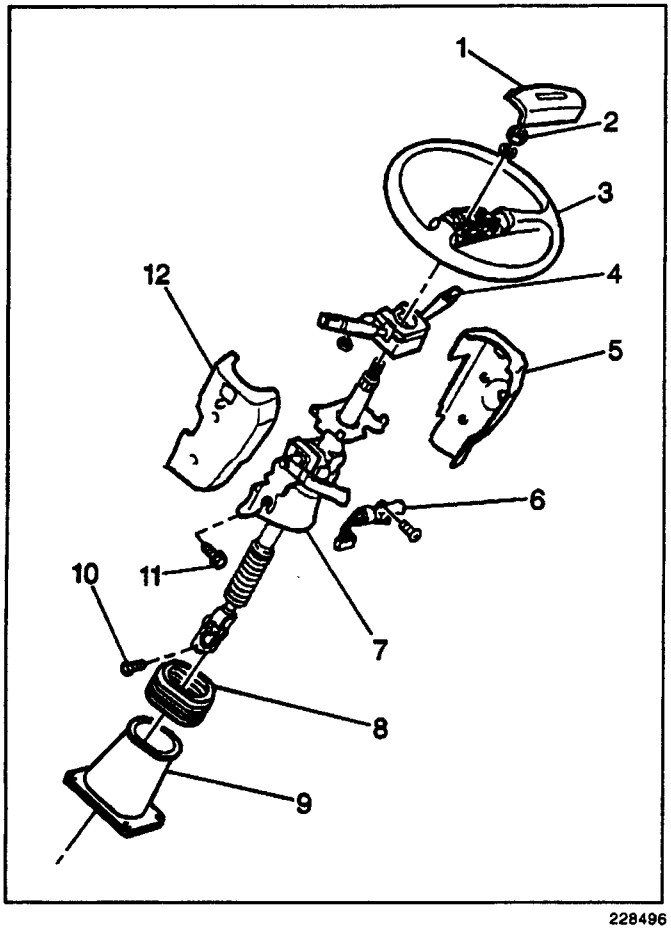


228496

Multifunction Turn Signal Lever Replacement

Removal Procedure

1. Remove the steering wheel (3). Refer to *Steering Wheel Replacement.*
2. Push the boot (8) off of the cowl halves (5, 12) onto the lower steering shaft cover (9).
3. Remove the left and right side cowl half screws.
4. Remove the left (12) and right (5) side cowl halves from the upper steering shaft assembly (7).
5. Disconnect the electrical connector from the combination switch (4).
6. Remove the combination switch screws and the combination switch (4) from the upper steering shaft assembly (7).



228496

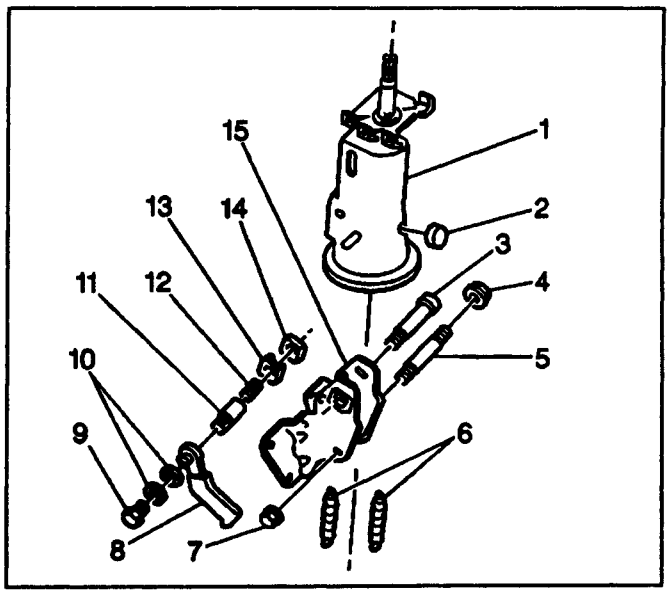
Installation Procedure

1. Install the combination switch (4) to the upper steering shaft assembly (7).
2. Connect the electrical connector to the combination switch (4).
3. Install the left (12) and the right (5) side cowl halves to the upper steering shaft assembly (7) with screws.
4. Position the boot (8) over the lower steering shaft cover (9).
5. Install the steering wheel (3).

Tilt Lever Replacement

Removal Procedure

1. Remove the upper steering shaft assembly. Refer to *Upper Steering Shaft Assembly Replacement.*
2. Remove the following components:
   2.1. The bolt (9)
   2.2. The washer (10)
   2.3. The tilt lever (8)
3. Remove the following components:
   3.1. The tilt lever bolt (3)
   3.2. The spacer (11)
   3.3. The spring (12)
   3.4. The tilt shoe holder (13)
   3.5. The tilt shoe (14)

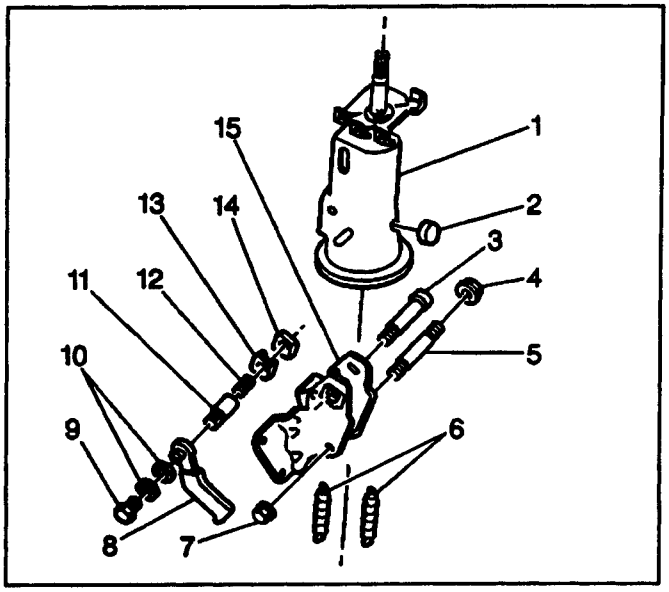


345418

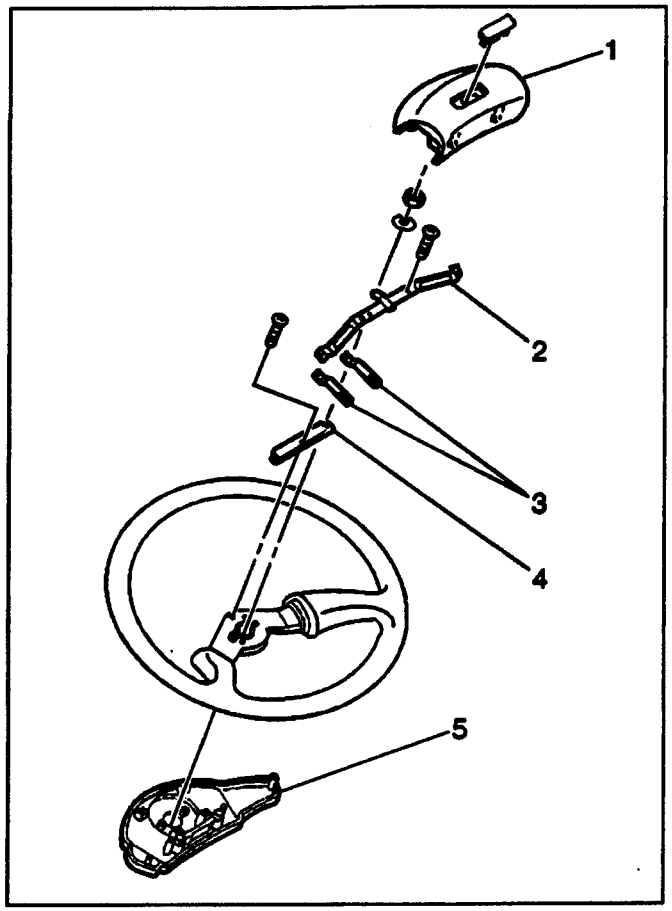
Installation Procedure

1. Position the tilt shoe in the tilt shoe holder in order for the teeth of the shoe to align with the teeth of the steering column mounting bracket.
2. Install the following components:
   2.1. The tilt lever bolt (3).
   2.2. The tilt shoe holder (13).
   2.3. The tilt shoe (14).
   2.4. The spacer (11).
   2.5. The spring (12).

   Important: To ensure that the tilt lever will be in a locked position, it may be necessary to reposition or turn the tilt lever bolt 90 degrees.
   2.6. Install the following components:
   2.7. The tilt lever (8).
   2.8. The washer (10).
   2.9. The bolt (9).
   2.10. Install the upper steering shaft assembly.



345418



228492

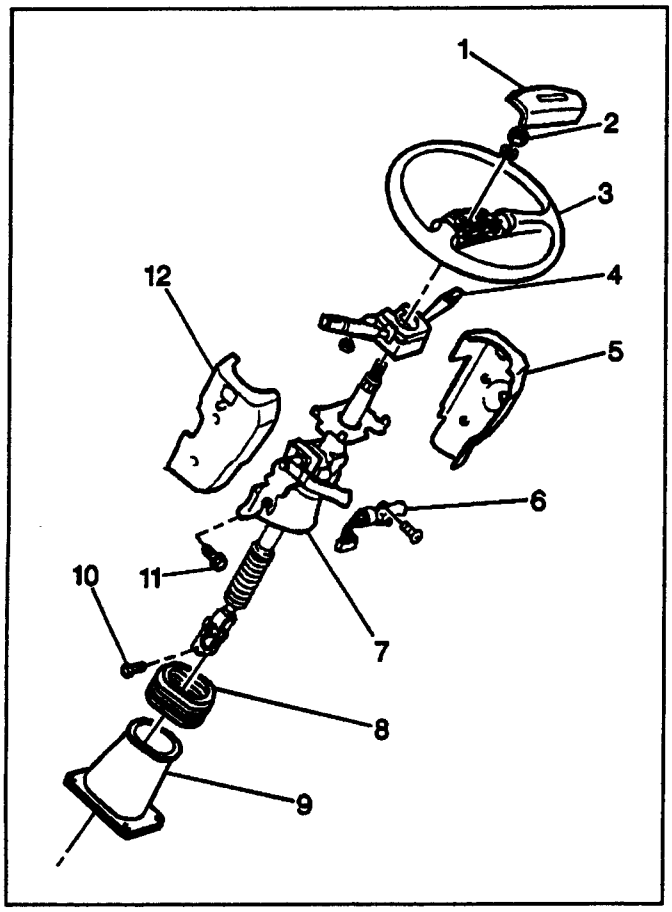
Steering Wheel Replacement

Removal Procedure

Tools Required
J 1859-A Universal Steering Wheel Puller

Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

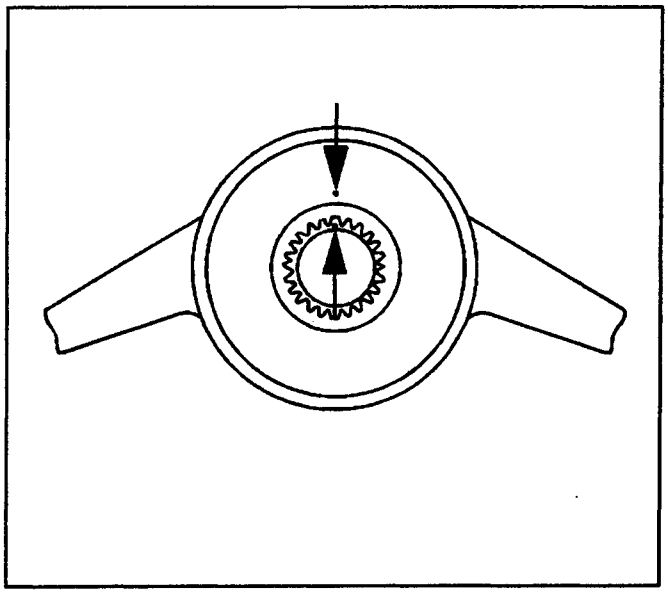
1. Disconnect the negative battery cable. Refer to *Battery Replacement* in Engine Electrical.
2. Remove the horn pad (1).



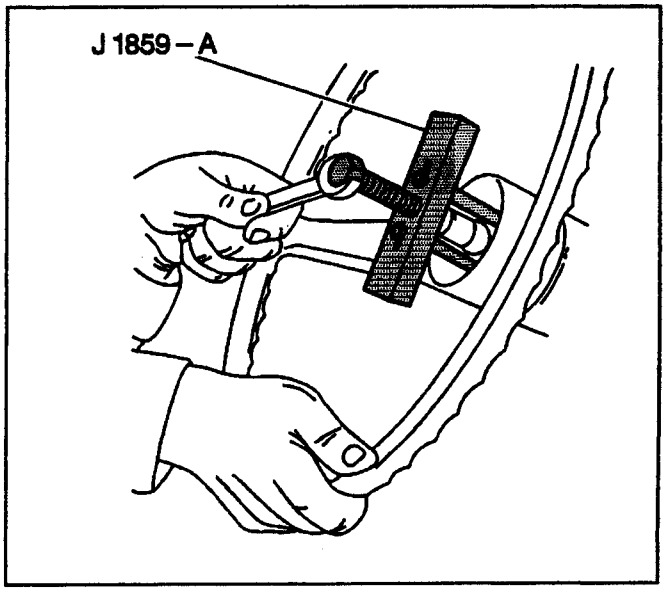
228496

3. Remove the steering wheel nut (2) and the washer.
4. Disconnect the horn electrical connector.

5. Mark the position of the steering wheel in relation to the steering column shaft for installation.


228500

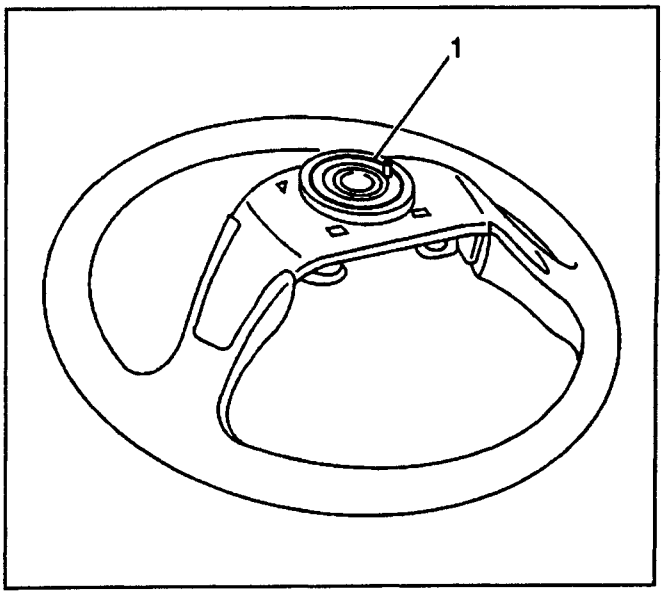
6. Use the *J 1859-A* in order to remove the steering wheel from the steering column shaft.



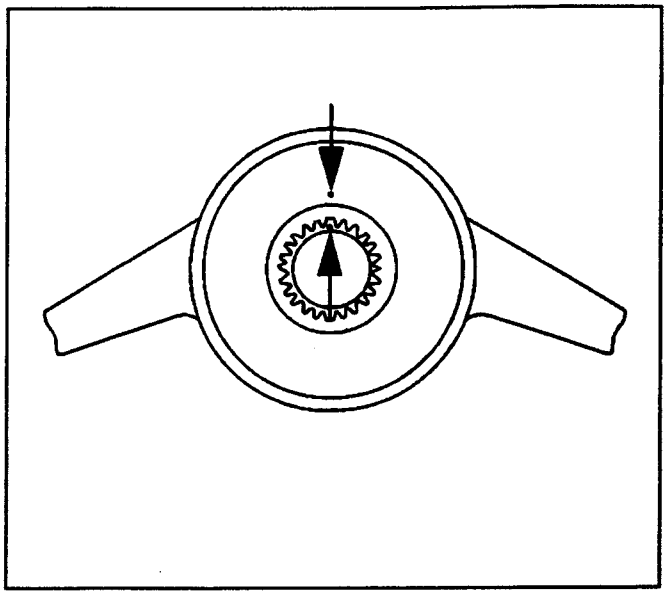
215719

Installation Procedure

1. Apply a thin coat of lithium grease to the bottom of the horn contact ring (1).

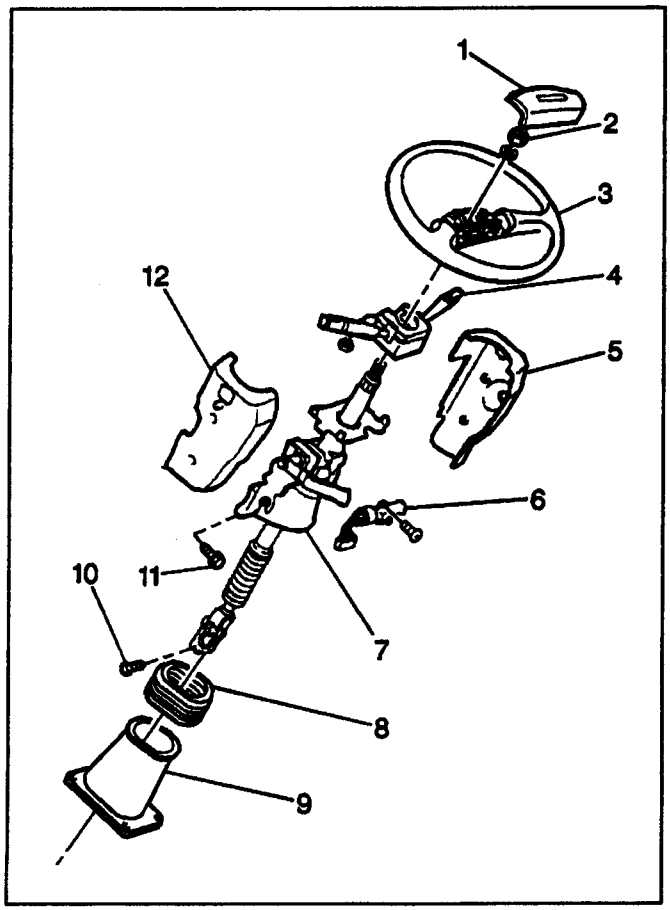


228512



228500

2. Install the steering wheel on the steering shaft. Be sure to align the marks.

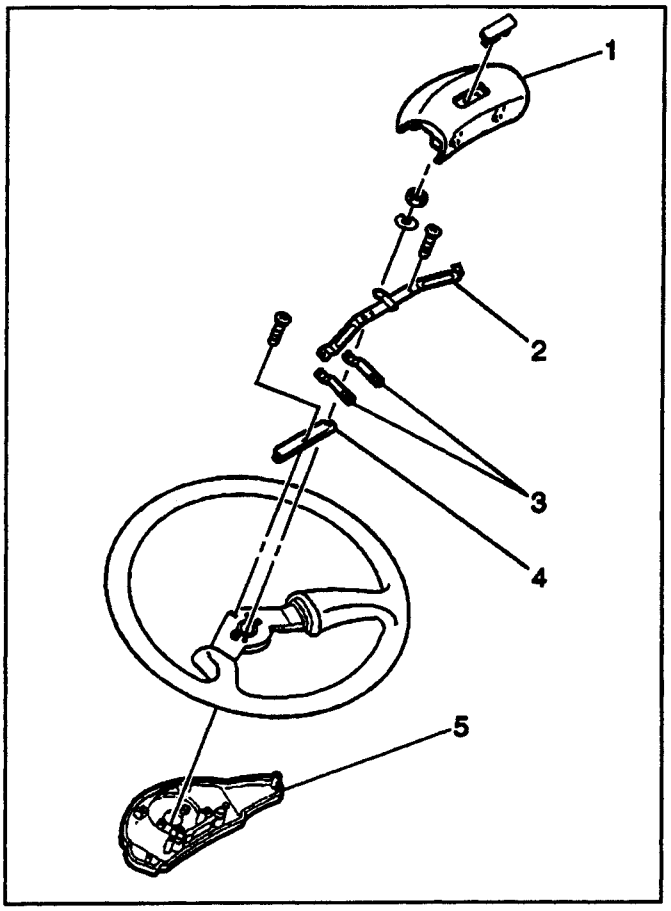


228496

Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the washer and the steering wheel nut (2).
   Tighten
   Tighten the steering wheel nut to 55 N·m (41 lb ft).
4. Connect the horn electrical connector.

5. Install the horn pad (1).
6. Connect the negative battery cable.

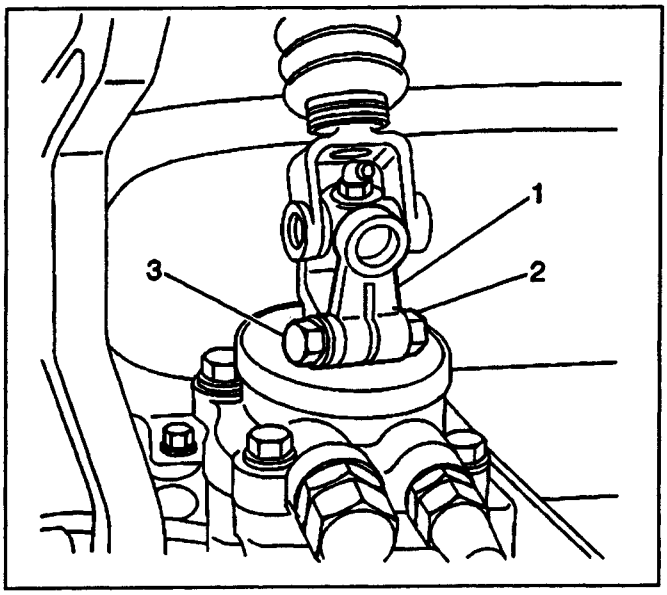


228492

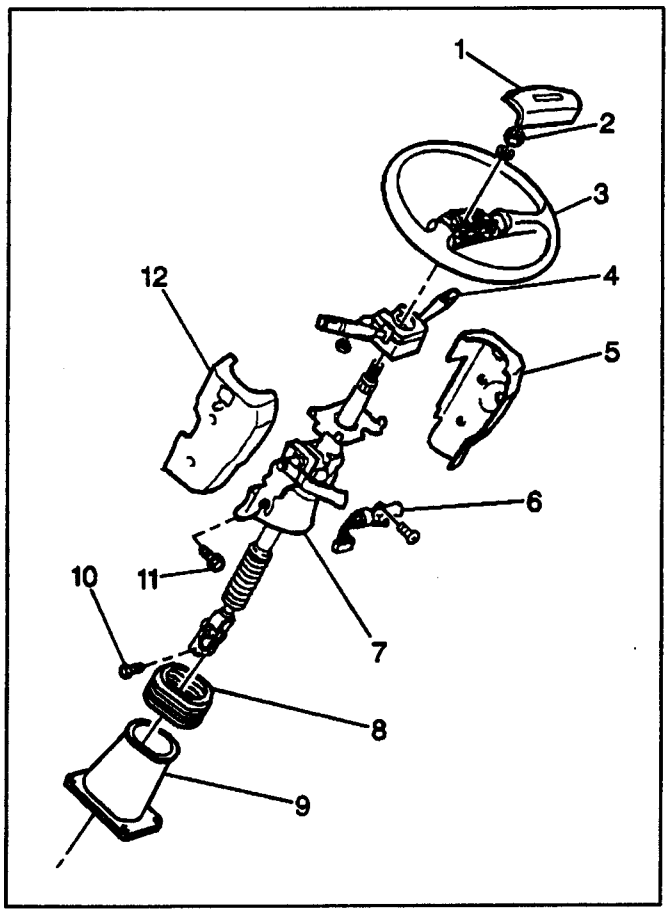
Upper Steering Shaft Assembly Replacement

Removal Procedure

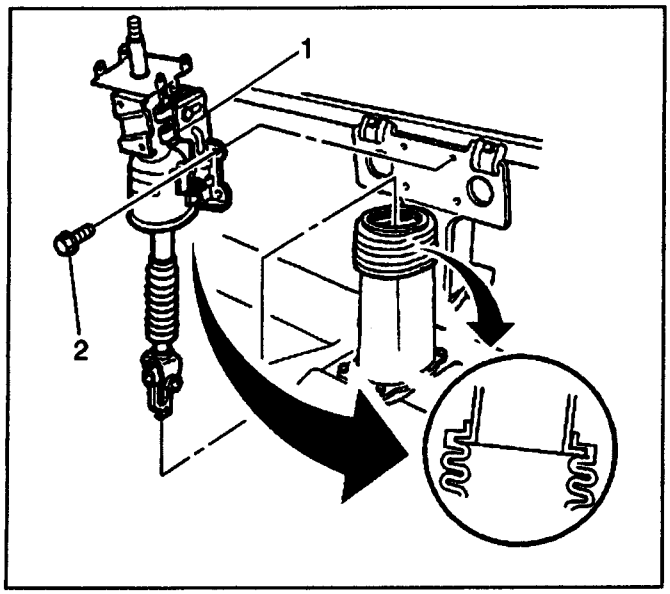
1. Position the front wheels and the steering wheel straight ahead.
2. Tilt the cab. Refer to *Cab Tilting* in General Information.
3. Mark the position of the steering gear input shaft and the lower cardan joint (1) of the lower steering shaft.
4. Remove the following components from the lower cardan joint (1):
   - The nut (2)
   - The washer
   - The cardan bolt (3)
5. Gently pry the lower cardan joint (1) off of the steering gear input shaft.
6. Retract the lower steering shaft toward the cab.
7. Close the cab slowly, in order to ensure the lower steering shaft does not come in contact with the cab.



228516



228496

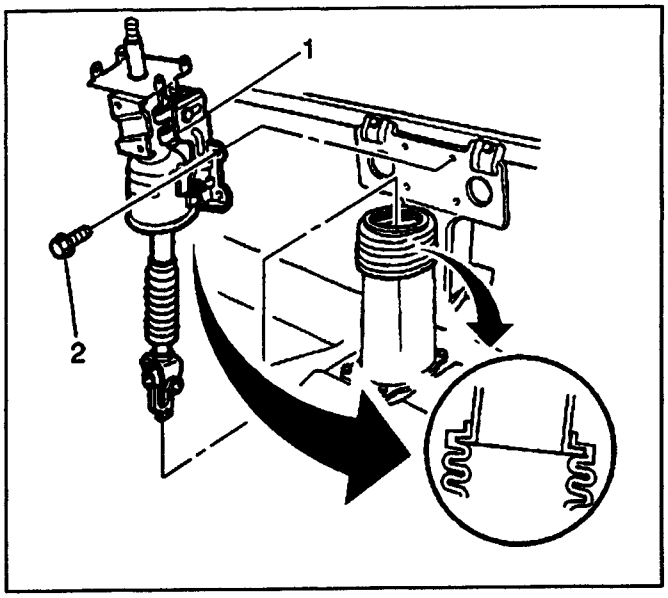


228520

8. Remove the steering wheel (3). Refer to *Steering Wheel Replacement.*
9. Push the boot (8) off of the cowl halves (5, 12) and onto the lower steering shaft cover (9).
10. Remove the following components from the upper steering shaft assembly (7):
    - The left side cowl half screws
    - The right side cowl half screws
    - The left side cowl half (12)
    - The right side cowl half (5)
11. Remove the electrical connector from the combination switch (6).
12. Remove the following components from the upper steering shaft assembly (7):
    - The combination switch screws
    - The combination switch (4)
13. Remove the electrical connector from the ignition switch (6).
14. Remove the following components from the upper steering shaft assembly (7):
    - The ignition switch screws
    - The ignition switch (6)
15. Remove the following components from the wire harness:
    - The wiring harness screw
    - The clamp
16. Remove the tie wraps from the wiring harness, as necessary.
17. Remove the following components from the vehicle:
    - The upper steering shaft assembly mounting bolt (2)
    - The upper steering shaft assembly (1)

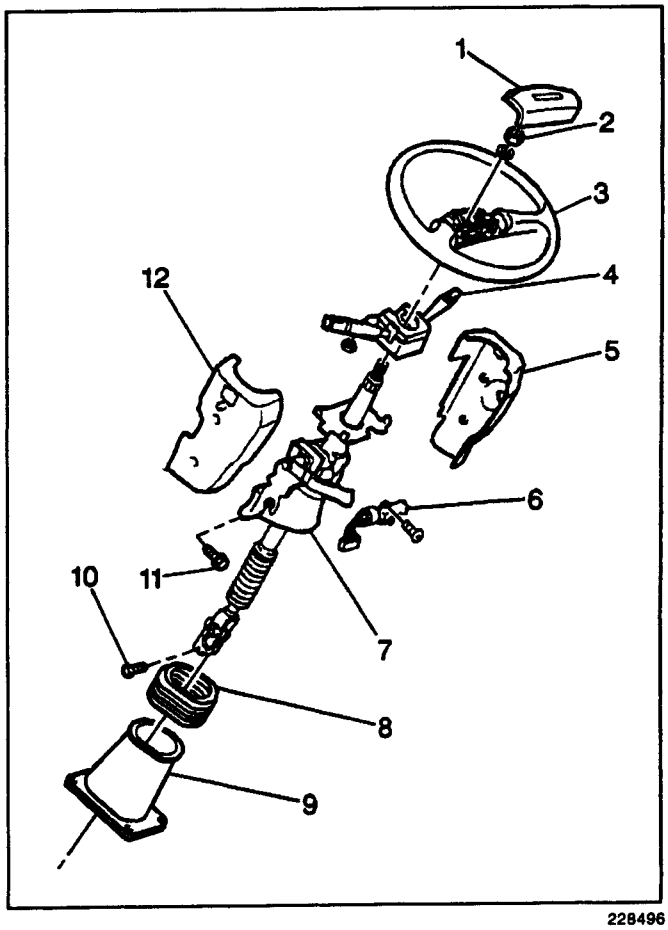
Installation Procedure

1. Install the following components to the vehicle:
   - The upper steering shaft assembly (1)
   - The upper steering shaft assembly mounting bolts (2)

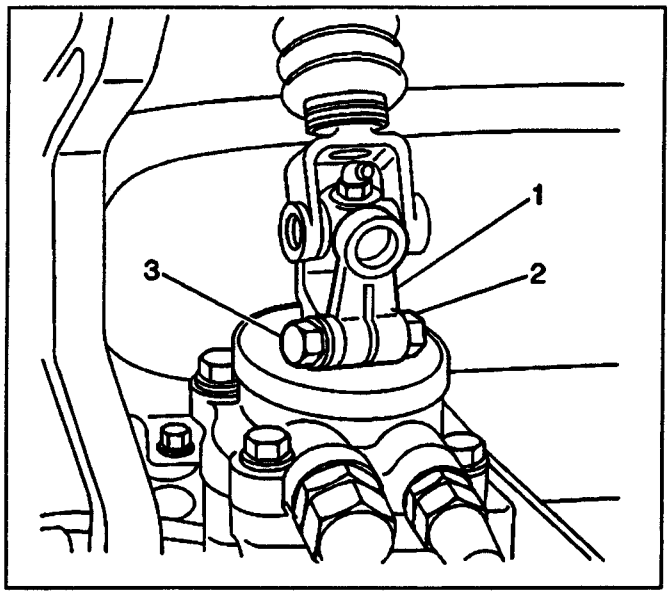


228520

2. Install the ignition switch (6) to the upper steering shaft assembly (7).
   Secure the ignition switch with the following components:
   - The wiring harness clamp
   - The screws
3. Install the electrical connector to the ignition switch (6).
4. Install the combination switch (4) to the upper steering shaft assembly (7).
   Secure the combination switch with screws.
5. Install the electrical connector to the combination switch (4).
6. Install the wiring harness clamp to the upper steering shaft assembly (7).
   Secure the wiring harness clamp with a screw.
7. Install the tie wraps to the wiring harness, as necessary.
8. Install the following components to the upper steering shaft assembly:
   - The left side cowl half (12)
   - The right side cowl half (5)
9. Secure the cowl halves with screws.
10. Position the boot (8) over the lower steering shaft cover (9).
11. Install the steering wheel (3).
12. Slowly lower the cab. Ensure that the lower steering shaft does not come in contact with the cab.
13. Align the marks on the steering gear input shaft and the lower cardan joint (1) of the lower steering shaft.
14. Position the lower steering shaft lower cardan joint (1) on the steering gear input shaft.



228496

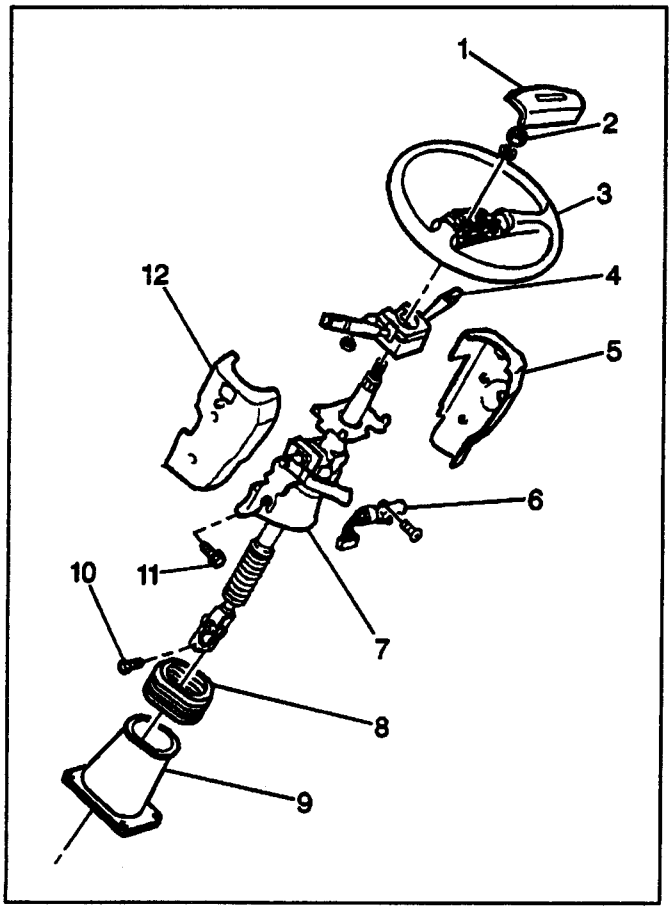


228516

15. Install the following components:
    - The lower cardan joint (1).
    - The lower cardan joint bolt (3)
    - The lower cardan joint nut (2)

    Tighten

    Tighten to 55 N.m (41 lb ft).
16. Lower the cab.



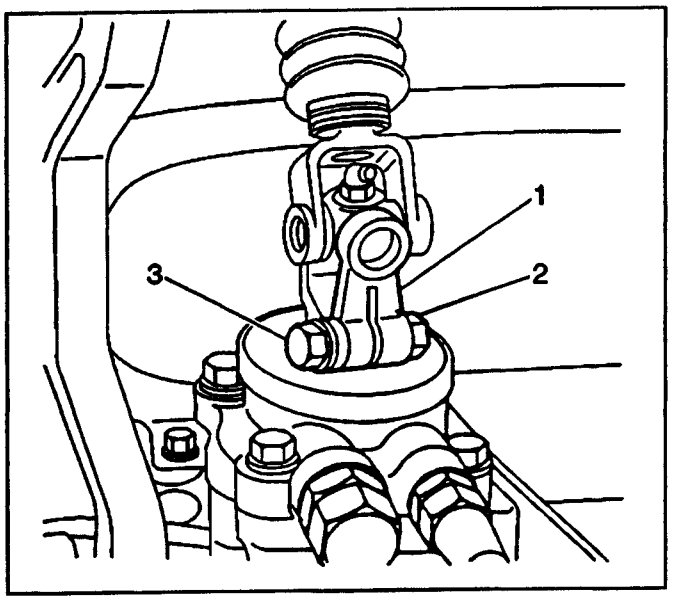
228496

Lower Steering Shaft Assembly Replacement

Removal Procedure

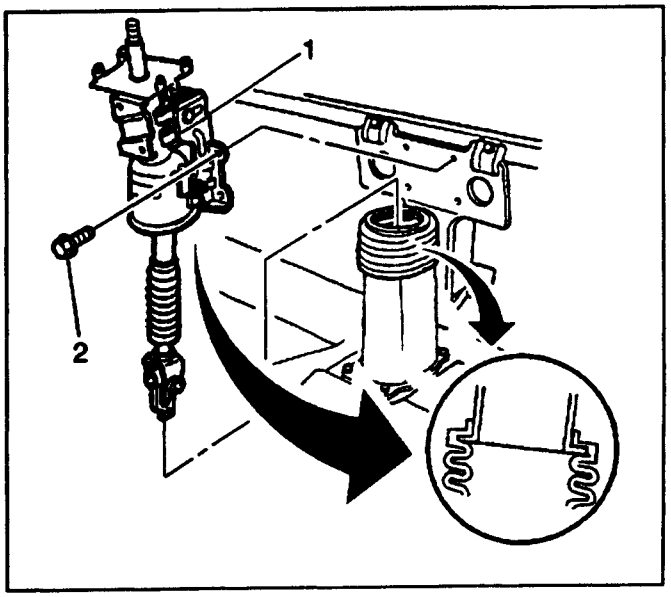
1. Remove the upper steering shaft assembly. Refer to *Upper Steering Shaft Assembly Replacement.*
2. Mark the position of the upper steering shaft (7) and the upper cardan joint of the lower steering shaft.

3. Remove the following components from the upper cardan joint:
   - The nut (2)
   - The washer
   - The cardan bolt (3)
   - The washer



228516

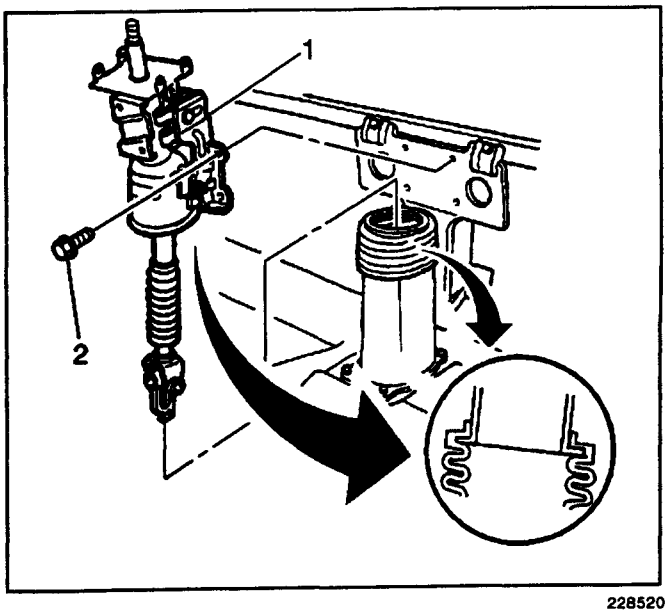
4. Gently pry the upper cardan joint off of the upper steering shaft (1).



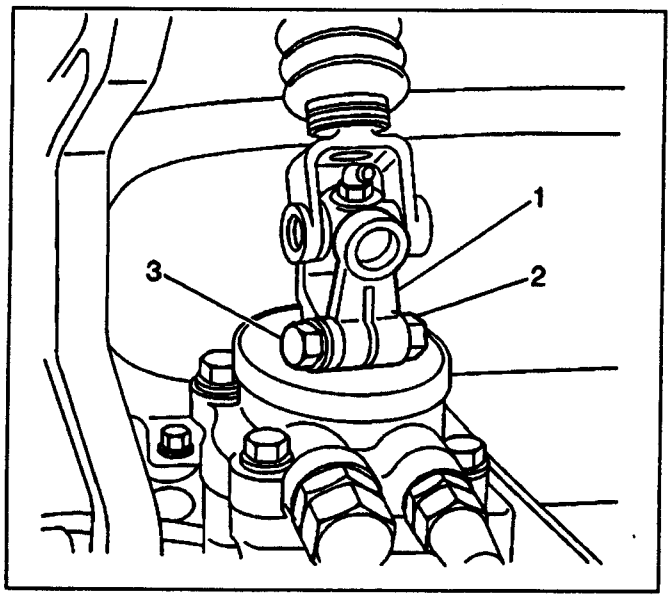
228520

Installation Procedure

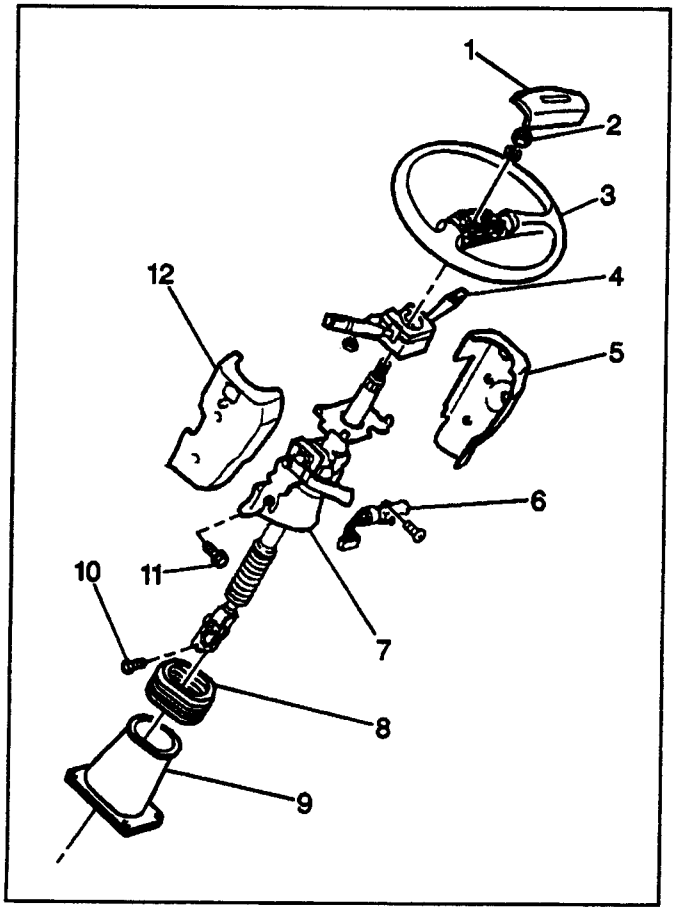
1. Align the marks on the lower steering shaft upper cardan joint and the upper steering shaft (1).
2. Position the lower steering shaft upper cardan joint on to the upper steering shaft (1).



228520



228516



228496

Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the following components:
   - The cardan joint washer
   - The bolt (3)
   - The washer
   - The nut (2)

   Tighten

   Tighten the cardan nut to 55 N.m (41 lb ft).

4. Install the upper shaft assembly (7).

Description and Operation

Steering Wheel and Column Description

The steering column is a tilt column. The left hand lock lever releases the column for tilt adjustment.

A combination switch is present on the steering column. The combination switch, on the steering column, controls the following components:

- The headlamps
- The turn signals
- The windshield washers
- The windshield wipers

The engine control switch is mounted on the column.

Sealed bearings support the upper steering shaft at both ends.

The steering column is connected to the steering gear by a slip-type shaft with cardan universal joints. Fittings for the slip-type shaft with the cardan universal joints provide lubrication.

Special Tools and Equipment

Illustration	Tool Number Description
 802	J 1859-A Steering Wheel Puller

Section 3
Suspension

Suspension General Diagnosis 3-3
Diagnostic Information and Procedures 3-3
Vehicle Leads/Pulls 3-3
Suspension Bottoms 3-3
Abnormal or Excessive Tire Wear 3-3
Wander or Poor Steering Stability 3-6
Noisy Front Suspension 3-6
Poor Directional Stability 3-7
Tire Hop or Poor Handling 3-7
Excessive Road Shock 3-7
Struts or Shock Absorbers Binding 3-8
Struts or Shock Absorbers Bench Test 3-8
Struts or Shock Absorbers On-Vehicle Testing 3-8
Spring Noise 3-8
Spring Sags or Bottoms 3-8
Spring Breakage 3-9
Front Wheel Shimmy 3-9
Hard Steering 3-9
Wheel Bearings Diagnosis 3-10
Low or Uneven Trim Height 3-14
Description and Operation 3-15
General Description 3-15
Wheel Alignment 3-17
Specifications 3-17
Wheel Alignment Specifications 3-17
Fastener Tightening Specifications 3-17
Repair Instructions 3-17
Front Caster Adjustment 3-17
Front Camber Adjustment 3-20
Front Toe Adjustment 3-21
Checking and Correcting King Pin Inclination 3-21
Stop Screw Adjustment 3-22
Description and Operation 3-23
General Description 3-23
Caster Description 3-23
Camber Description 3-23
Toe Description 3-23
Frame Misalignment Description 3-24
Steering Axis Inclination Description 3-24
Front Suspension 3-25
Specifications 3-25
Fastener Tightening Specifications 3-25
Diagnostic Information and Procedures 3-25
Wheel Bearing Test 3-25
Repair Instructions 3-26
Stabilizer Shaft Replacement 3-26
Steering Knuckle and King Pin Replacement 3-27
Spring Bumper Replacement 3-33
Leaf Springs Replacement 3-33
Wheel Hub, Bearing, and Seal Replacement (Drum Brakes) 3-36
Wheel Hub, Bearing, and Seal Replacement (Disc Brakes) 3-40
Hub Cap Replacement 3-44
Adding Lubricant to Hub Caps 3-45
Wheel Bearing Adjustment 3-45
Shock Absorber Replacement 3-47
King Pin Bushing and Bearing Cup Replacement 3-49
King Pin Upper Bearing Repack 3-52
King Pin Bearing Preload 3-57
Front Axle Replacement 3-59
Description and Operation 3-61
General Description 3-61
Special Tools and Equipment 3-62
Special Tools 3-62
Rear Suspension 3-63
Specifications 3-63
Fastener Tightening Specifications 3-63
Diagnostic Information and Procedures 3-63
Spring Maintenance 3-63
Repair Instructions 3-64
Stabilizer Shaft Replacement 3-64
Shock Absorber Replacement 3-70
Spring Bushing Replacement 3-71
Leaf Spring Replacement 3-74
Spring Leaf Replacement 3-78
Spring Hanger Replacement 3-80
Spring Bumper Replacement 3-84
Description and Operation 3-86
General Description 3-86
Special Tools and Equipment 3-86
Special Tools 3-86
Tires and Wheels 3-87
Specifications 3-87
Fastener Tightening Specifications 3-87

Diagnostic Information and Procedures 3-87
Wheel Mounting Surface Check 3-87
Hub Bolt and Nut 3-87
Rim/Hub Bolt Check 3-88
Repair Instructions 3-89
Aluminum Wheel Refinishing 3-89
Clearcoat Damage to Aluminum Wheels 3-89
Wheel Removal (Front) 3-90
Wheel Removal (Dual/Rear) 3-90
Wheel Installation (Front) 3-91
Wheel Installation (Dual/Rear) 3-92
Tire Mounting and Dismounting 3-94
Tire Rotation 3-98
Tire Matching 3-98
Tire Measuring 3-101
Valve Core and Cap Replacement 3-102
Description and Operation 3-102
Tires Description 3-102
Tire Repair Description 3-103
Tire Inflation Description 3-103
Load Range/Ply Rating Description 3-105
Vehicle Certification Label Description 3-105
Wheels Description 3-105
Air Suspension 3-107
Specifications 3-107
Fastener Tightening Specifications 3-107
Schematic and Routing Diagrams 3-107
Suspension Controls Schematic References 3-107
Suspension Controls Schematics 3-108
Component Locator 3-109
Suspension Controls Components 3-109
Suspension Controls Component Views 3-109
Suspension Controls Connector End Views 3-110
Diagnostic Information and Procedures 3-110
Rear Air Springs Do Not Deflate 3-110
Air Suspension Dump Indicator Inoperative 3-111
Repair Instructions 3-111
Suspension Alignment 3-111
Preventive Maintenance 3-112
Main Support Beam 3-113
Cross Channel Replacement 3-116
Air Spring Frame Hanger Replacement 3-117
Spring Hanger Bracket Insulator Replacement 3-119
Torque Rod Replacement 3-120
Torque Rod Bushing Replacement 3-121
Transverse Rod Replacement (with RPO-GPG) 3-122
Transverse Rod Replacement (without RPO-GPG) 3-124
Height Leveling Valve Replacement (with RPO-GPG) 3-126
Height Leveling Valve Replacement (without RPO-GPG) 3-127
Air Suspension Relief Valve Replacement 3-128
Shock Absorber Replacement 3-129
Air Spring Replacement 3-130
Description and Operation 3-132
Rear Air Suspension 3-132
Air Control System 3-132
Height Leveling Valve 3-132
Air Suspension Relief Valve 3-132
Suspension Controls Circuit Description 3-132

Suspension General Diagnosis

Diagnostic Information and Procedures

Vehicle Leads/Pulls

Condition	Correction
Camber incorrectly adjusted. Steering will pull to the side of the axle having the greatest positive camber.	Adjust the camber. Refer to *Front Camber Adjustment* in Front Wheel Alignment.
Low air pressure in the right or left tire. Steering will pull to the side having the lowest air pressure.	1. Inflate the tires to the correct pressure. 2. Inspect the tire for an air leak and repair as required.
Axle loose and shifted at the spring U-bolts.	1. Align and tighten the axle U-bolt nuts to specifications. 2. Inspect, replace damaged parts as required.
Rear axle loose at the spring. U-bolt shifted at one side causes the steering to pull.	1. Align the rear axle and replace defective components. 2. Tighten the U-bolts to specifications.

Suspension Bottoms

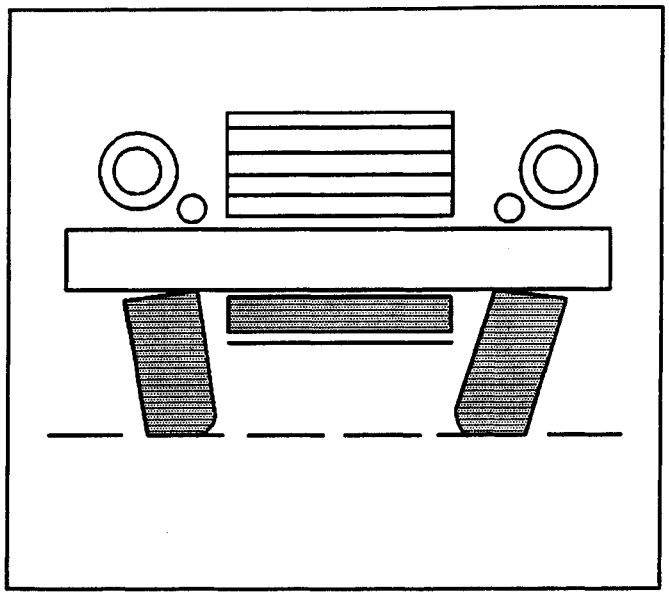
Problem	Action
The shock absorbers are inoperative.	Replace the shock absorbers.
The spring leaf is broken (Tapered Leaf).	Replace the spring assembly.
The spring leaf is broken (Multi Leaf).	Replace the leaf for the spring assembly.
Driver has severely operated or has overloaded the vehicle.	Verify the load capacity rating.

Abnormal or Excessive Tire Wear

Condition	Correction
The tire pressure is incorrect.	Properly inflate the tires to the recommended pressure. Refer to *Tire Inflation Description* in Tires and Wheels.
The tire and wheel usage is incorrect.	Install the correct tire and wheel combination. Refer to *Tire Matching* in Tires and Wheels.
The shock absorbers are defective.	Replace defective shock absorbers. Refer to *Shock Absorber Replacement* in Front Suspension.
The front end is out of alignment.	Align the front end. Refer to *Front Caster Adjustment* or *Front Camber Adjustment* or *Front Toe Adjustment* in Wheel Alignment.
The steering linkage, bushings, ball joints, and other suspension components are loose, worn, or damaged.	Inspect, repair, or replace suspension and steering components as needed.

Inspect all tires on the vehicle for signs of wear. Refer to *Wheel Alignment Specifications* in Front Wheel Alignment.

Uneven Wear



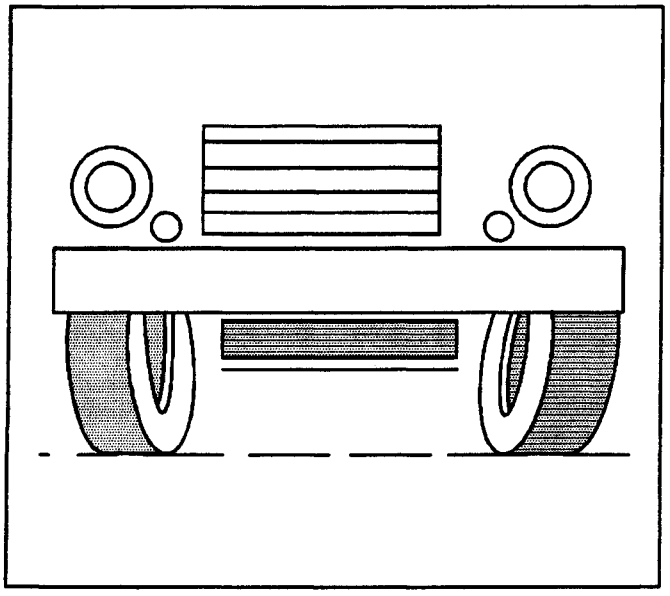
222195

The following conditions may cause spotty or uneven wear:

- Unequal caster or camber
- Bent suspension parts
- Out-of-balance wheels
- Out-of-round brake drums
- Brakes out of adjustment
- Other mechanical conditions

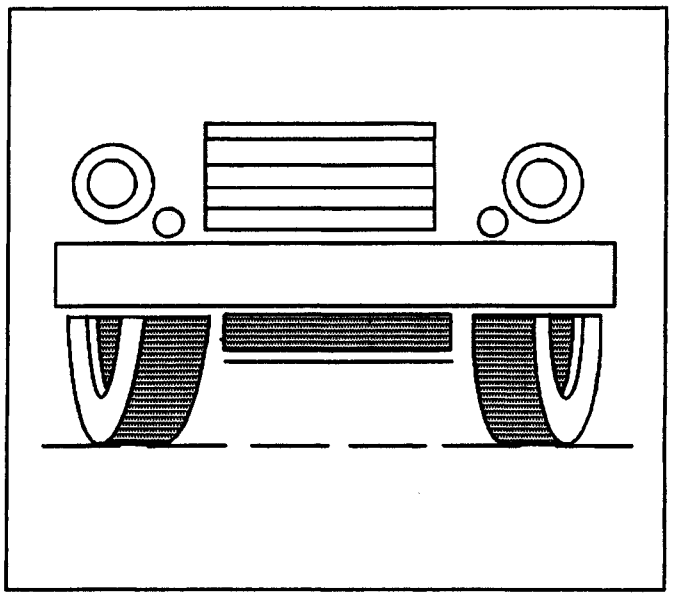
Locate the mechanical condition that causes uneven wear. Correct the condition.

Misalignment Wear



222202

Too much toe-in or toe-out on the front axle tires causes misalignment wear. The tires revolve with a side motion which scrapes off the tread rubber. The scraping action against the face of the tire causes a small feather edge of rubber to appear on one side of the tread. This feathering is an indication of misalignment.



222192

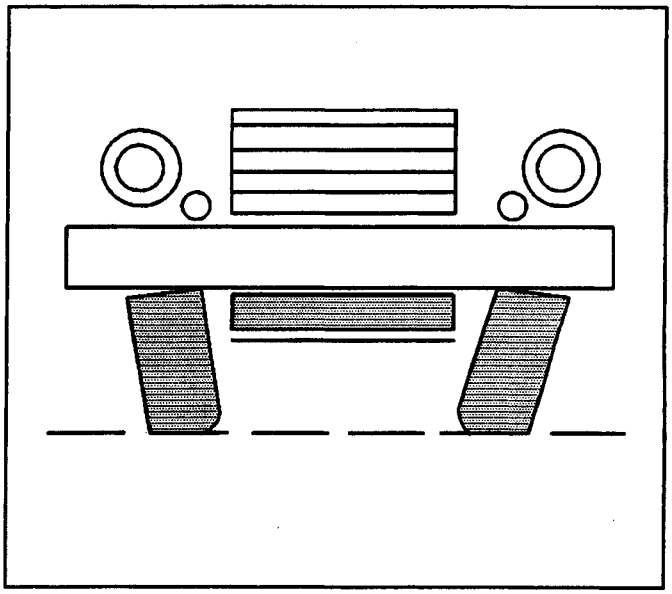
If the misalignment is severe, the rubber will be scraped off both tires. If the misalignment is slight, only one tire will be affected. In order to correct misalignment, adjust the toe-in or verify that the entire front end alignment settings are correct. Refer to *Front Toe Adjustment* in Front Wheel Alignment.

Side Wear

Side wear may be caused by the following conditions:

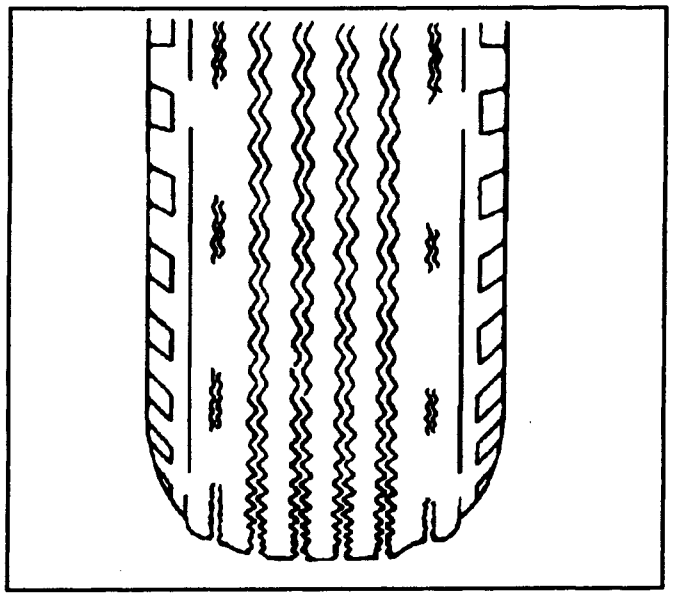
- Incorrect wheel camber
- Underinflation
- High cambered roads
- Excessive cornering speed

Incorrect wheel camber and underinflation are the most common causes of side wear.



222195

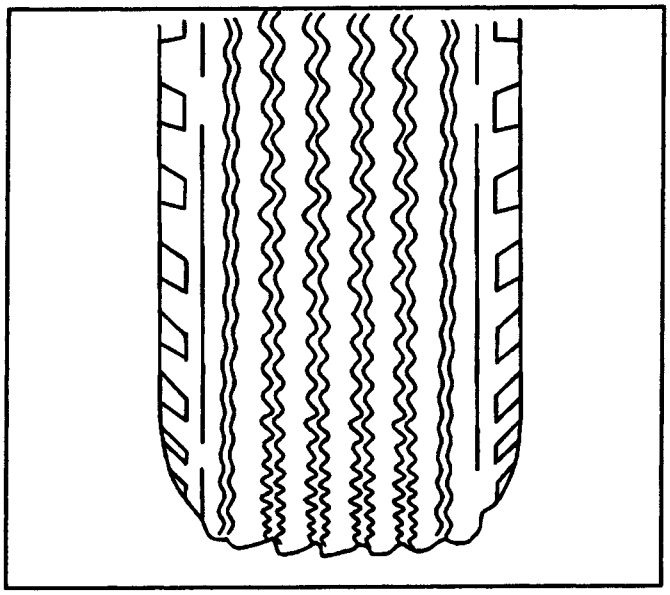
Camber wear occurs on one side of the tread.



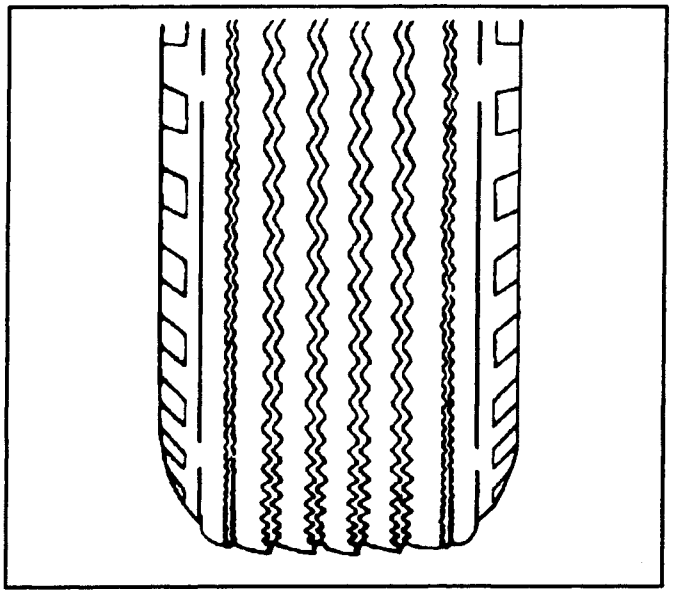
222209

Underinflation causes wear on both sides of the tread. Correct the camber first. Refer to *Front Camber Adjustment* in Front Wheel Alignment. Then rotate the tires.

Heel and Toe Wear



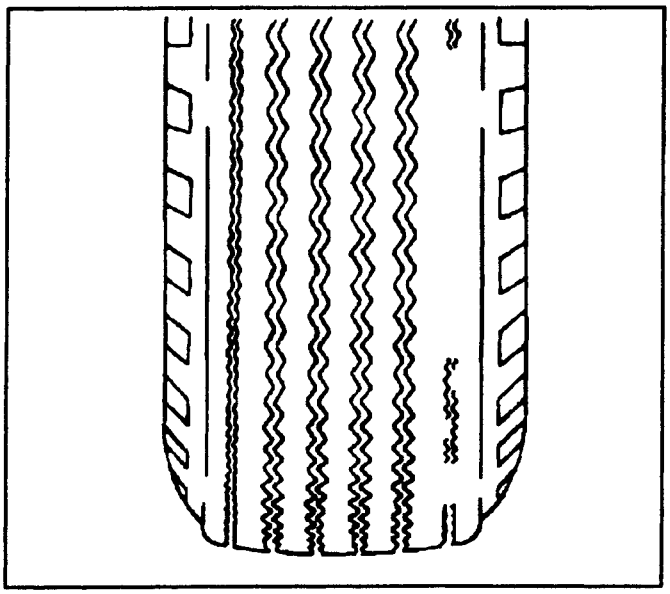
222205



222207

This saw toothed effect is caused by tire wear in the areas that first grip the road when the brakes are applied. In order to avoid this problem, rotate the tires regularly.

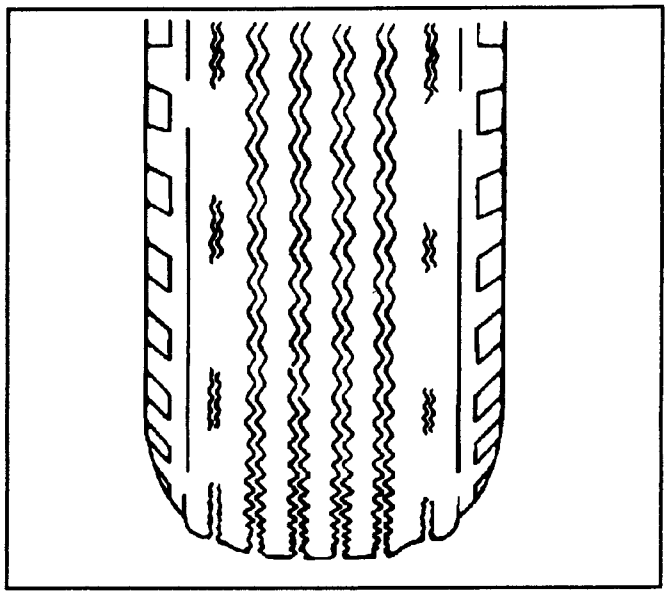
Cornering Wear



222242

During normal driving, weight is distributed evenly on all of the wheels. When a vehicle makes a fast turn, the weight is shifted to an abnormal overload on the outside tires and a very light load on the inside tires. This unequal loading may have two harmful results:

- The rear tire on the inside of the curve may be relieved of so much load that the tire is no longer geared to the road and slips. This grinds off the tread on the inside half of the tire. This type of tire wear resembles tire wear caused by negative camber.
- Weight transfer may overload the outside tires so much that these tires become laterally distorted. This excessive wear on the outside half of the tire resembles positive camber.



222209

Cornering wear differs from abnormal camber wear by the rounding off of the outside shoulder or edge of the tire, and by the roughening of the tread surface which shows abrasion. Cornering wear often produces a fin, or raised portion, along the inside edge of each row in the tread pattern.

In some cases this fin resembles a toe-in fin and in other cases the fin tapers into a row of tread blocks, giving the tire a step wear pattern. In order to offset normal cornering wear, rotate the tires on a regular basis.

Wander or Poor Steering Stability

Condition	Correction
Incorrectly adjusted front wheel bearings	Adjust the bearing or replace with new components as required. Refer to *Wheel Bearing Adjustment* in Front Suspension.
Worn coupling or steering shaft U-joints	Replace as needed.
Steering wheel loose on the shaft, a loose pitman arm, tie rods, steering arms, or steering linkage ball studs	Tighten fasteners to specifications. Refer to *Fastener Tightening Specifications* in Front Suspension.
Worn steering gear or bearings improperly adjusted	Adjust the preload.
Excessive pitman shaft to ball nut lash in the steering gear	Adjust the preload.
Toe-in being out of adjustment, worn intermediate rod or tie rod sockets	1. Replace the tie rod end if worn and adjust the Toe-in. Refer to *Front Toe Adjustment* in Wheel Alignment. 2. Inspect the steering arm and tie rod for a bent condition.
Steering system out of alignment	1. Completely align the front wheels. Refer to *Front Caster Adjustment* or *Front Camber Adjustment* or *Front Toe Adjustment* in Wheel Alignment. 2. Inspect the spring components for wear. Repair or replace as required.
Badly worn tires, edges rounded off	Adjust the front wheel alignment. Refer to *Front Caster Adjustment* or *Front Camber Adjustment* or *Front Toe Adjustment* in Wheel Alignment.
Lack of lubrication in the linkage and the king pins	1. Free up and lubricate any components that are frozen and will not take lubrication. 2. Inspect for wear and damage.

Noisy Front Suspension

Condition	Correction
The tie rod ends are worn.	Replace the tie rod ends. Refer to Tie Rod Replacement in Steering Linkage.
The suspension bolts are loose.	Refer to *Fastener Tightening Specifications* in Front Suspension.
The front suspension lacks the proper lubrication.	Refer to *Fastener Tightening Specifications* in Maintenance and Lubrication.
The shock absorbers are loose.	Tighten the bolts. Refer to *Shock Absorber Replacement* in Front Suspension.

Noisy Front Suspension (cont'd)

Condition	Correction
The shock absorber bushings are worn.	Replace the bushings.
The king pins and/or bearings are loose or worn.	Adjust and/or replace the king pin and the bearings.
The stabilizer shaft is loose.	Tighten the bolts. Refer to *Stabilizer Shaft Replacement* in Front Suspension.
The stabilizer shaft insulators are worn.	Replace the insulators.

Poor Directional Stability

Problem	Action
The steering linkage or the ball joints need lubrication.	Lubricate as needed.
The steering gear is adjusted too tightly.	Adjust the preload.
The front wheel alignment is incorrect.	Check the alignment and correct as necessary.
The steering gear to column is misaligned.	Align the column.

Tire Hop or Poor Handling

Condition	Correction
The wheel and tire out of balance	Refer to *Front Wheel Shimmy* in Suspension General Diagnosis.
A blister or bump on the tire	Replace the tire. Refer to *Tire Mounting and Dismounting* in Tires and Wheels.
Improper shock absorber action	Replace the shock absorber. Refer to *Shock Absorber Replacement* in Front Suspension.
Excessive wheel or tire runout	Refer to *Front Wheel Shimmy* in Suspension General Diagnosis.
Tire lead	Refer to *Front Wheel Shimmy* in Suspension General Diagnosis.

Excessive Road Shock

Condition	Action
The tire air pressure is too high.	Deflate the tire to the correct pressure. Refer to *Tire Inflation Description* in Tires and Wheels.
The wheel bearing are improperly adjusted.	Adjust the wheel bearings to specifications. Refer to *Wheel Bearing Adjustment* in Front Suspension.
The camber adjustment is incorrect (Negative camber contributes to road shock).	Adjust camber. Refer to *Wheel Bearing Adjustment* in Wheel Alignment.
The spring is broken or sagging.	Replace the spring. Refer to *Leaf Springs Replacement* in Front Suspension.
Inspect for defective shock absorbers.	Replace the shock absorbers. Refer to *Shock Absorber Replacement* in Front Suspension or refer to *Shock Absorber Replacement* in Rear Suspension.
The suspension components are loose.	Inspect, repair, adjust, the components as needed.Refer to *King Pin Bearing Preload* in Front Suspension.

Struts or Shock Absorbers Binding

Problem	Action
The shock has a scored rod.	Replace the shock absorber. Refer to *Shock Absorber Replacement* in Rear Suspension.
The shock has dents.	Replace the shock absorber. Refer to *Shock Absorber Replacement* in Rear Suspension.
The shock leaks at the seal cover.	Replace the shock absorber. Refer to *Shock Absorber Replacement* in Rear Suspension.

Struts or Shock Absorbers Bench Test

Notice: Do not clamp the vise jaws on the shock absorber reservoir tube or shaft. Doing so could damage component.

1. Place the shock absorber in a vertical position (top end up). Clamp the bottom mount in a vise.
2. Rotate the dust tube. Notice if any binding condition exists. Compare the action with a known good shock, if necessary. A binding condition indicates a scored rod. Replace shocks with scored pistons.
3. Fully extend the shocks and examine the shocks for leaks in the seal cover area. Shock fluid is a very thin hydraulic fluid and has a characteristic odor and dark brown tint. A slight trace of shock fluid around the seal cover area is not cause for shock replacement. The shock seal is made to permit a very slight seepage in order to lubricate the rod. Replace leaky units.
4. Inspect the shock for dents. A bent rod could cause the shock to bind.
5. Extend and compress each shock in order to determine that the shock has control (resistance) in both jounce and rebound.
6. Visually inspect the shock mounting for the following:
   - Broken mounts
   - Extreme bushing wear
   - A shifted bushing or wear
   - Deep cracks in the bushing material, shallow surface cracks are normal.

Struts or Shock Absorbers On-Vehicle Testing

1. Set the parking brake.
2. Block the front wheels.
3. Loosen the lower mounting of both shocks.
4. Raise and lower the bottom of each shock, noting the rate of jounce and rebound of the shock absorber. Shock absorbers are non-adjustable and non-repairable. Replace both shocks if you detect a definite rate differential.

Spring Noise

Condition	Correction
Loose U-bolts	Tighten to the specified torque. Refer to *Fastener Tightening Specifications* in Rear Suspension or refer to *Fastener Tightening Specifications* in Front Suspension.
Loose or worn eye bushings	Replace the eye bushings. Refer to *Spring Bushing Replacement* in Rear Suspension.
Lack of lubrication.	Lubricate as required.
Faulty shock absorber	Replace the shock absorber. Refer to *Shock Absorber Replacement* in Rear Suspension or refer to *Shock Absorber Replacement* in Front Suspension.

Spring Sags or Bottoms

Condition	Correction
The shock absorbers are inoperative.	Replace the shock absorbers. Refer to *Shock Absorber Replacement* in Rear Suspension or refer to *Shock Absorber Replacement* in Front Suspension.
The spring has a broken leaf.	Replace the leaf or spring assembly. Refer to *Spring Leaf Replacement* in Rear Suspension or refer to *Leaf Springs Replacement* in Front Suspension.
The vehicle was used under severe operation or the vehicle has been overloaded.	Check the load capacity rating. Refer to *Label - Vehicle Certification* in General Information.

Spring Breakage

Condition	Correction
The spring has loose U-bolts.	Tighten the U-bolts. Refer to *Fastener Tightening Specifications* in Rear Suspension or refer to *Fastener Tightening Specifications* in Front Suspension.
The spring shows normal fatigue.	Replace the spring. Refer to *Leaf Spring Replacement* in Rear Suspension.
The vehicle is overloaded.	Check the load capacity rating.

Front Wheel Shimmy

Condition	Correction
The seals are damaged and leaking, resulting in loss of lubricant, corrosion, and excessive wear.	Replace the damaged parts as necessary.
The tires, wheels, or brake drums are out of balance.	Balance the tires and wheels, preferably with a on-vehicle balancer. This method balances the entire wheel and drum assembly.
The wheel is bent or the tire is out of round. The wheel nuts are not tightened evenly.	Replace the wheel and remount or replace the tire.
The steering linkage components are loose.	Adjust, tighten to specifications. Repair the linkage as necessary.
The wheel is loose on the hub.	1. Inspect the wheel bolt holes for damage. Refer to *Rim/Hub Bolt Check* in Tires and Wheels. 2. Replace all of the wheel studs. 3. Replace the wheel if needed.
The king pin or king pin bearing are worn or loose.	1. Replace the worn parts as needed. 2. Adjust the king pin bearing.
The propeller shaft universal joint(s) are rough or defective. This condition may be confused with steering vibration.	Repair the propeller shaft.
The engine is missing or is in a out of balance condition. This condition may be confused with steering vibration.	1. Correct the engine miss, or repair the out of balance condition. 2. Repair the clutch, pressure plate, or harmonic balancer.
The shock absorbers are malfunctioning.	Replace the shock absorbers.
The wheel alignment is incorrect.	Align the front wheels.

Hard Steering

Condition	Correction
The front tire inflation pressure is low or uneven.	Inflate the tires to the recommended pressure.
The steering linkage, king pins, or ball joints need lubrication.	1. Lubricate, and free up the steering linkage. 2. Inspect for wear and damage.
The intermediate rod, the tie rod, or the idler socket is tight or frozen.	Lubricate or replace as necessary.
There is a misalignment of the steering gear to column.	Align the column.
The steering gear is adjusted too tightly.	Adjust the preload.

Hard Steering (cont'd)

Condition	Correction
The front wheel alignment is incorrect.	Verify the wheel alignment and correct as necessary.
A binding condition in the steering column.	1. Inspect the column mounting and the column bearings. 2. Adjust or replace as necessary.
The knuckle thrust bearings are worn.	1. Replace the bearings. 2. Inspect the axle for wear and damage.

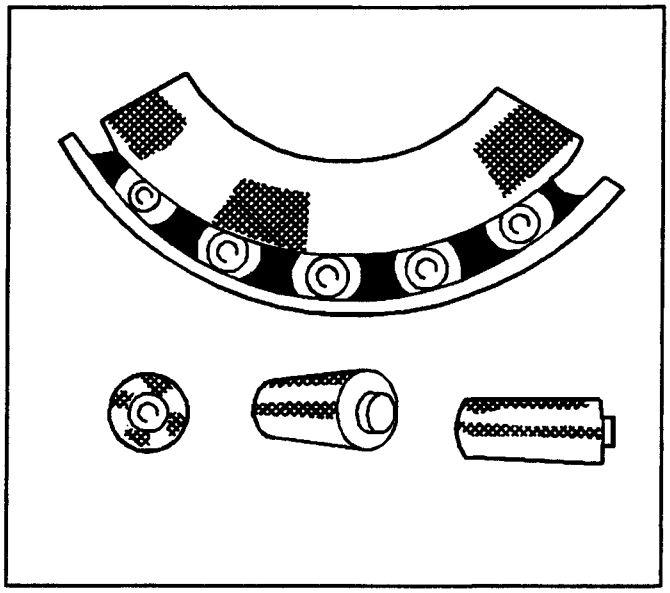
Wheel Bearings Diagnosis

Tapered Roller Bearing Diagnosis

Consider the following factors when diagnosing bearing condition:

- General condition of all parts during disassembly and inspection.
- Classify the failure with the aid of the illustrations.
- Determine the cause.
- Make all repairs following recommended procedures.

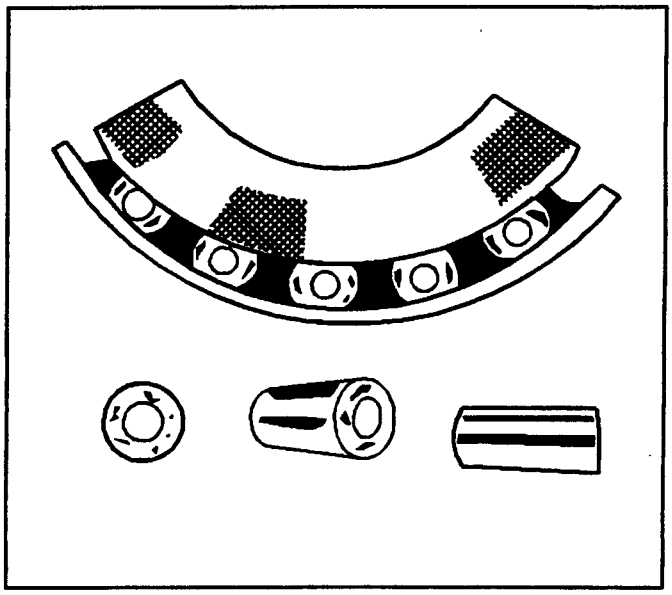
Abrasive Roller Wear



1453

A pattern on the roller ends may be caused by fine abrasives. Clean all of the parts and the housings. Check the seals and the bearings. Replace any leaky, rough, or noisy bearings.

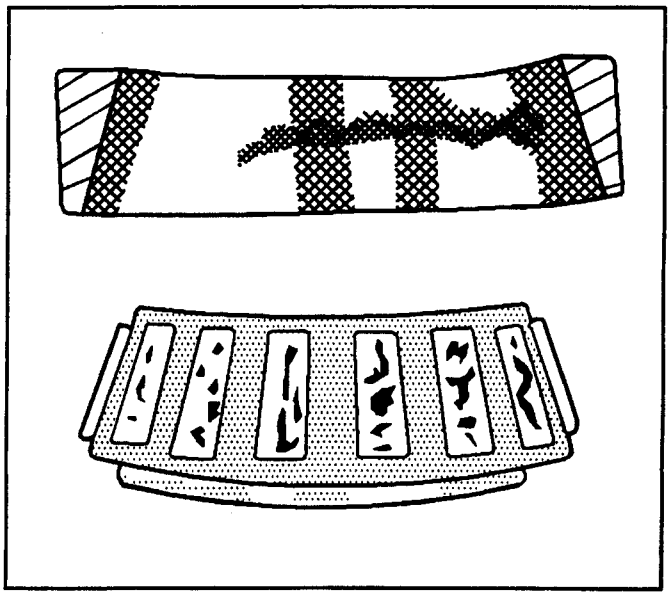
Galling



1454

Metal smears on the roller ends may be due to overheating, lubricant failure, or lubricant overload. Replace the bearing. Check the seals. Check for proper lubrication.

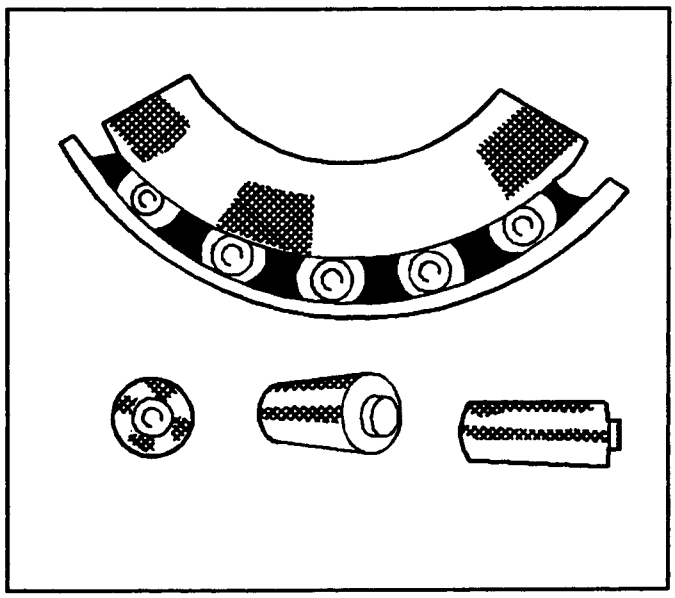
Etching



1455

Bearing surfaces may appear gray or grayish black in color; with related etching away of material, usually at the roller spacing. Replace the bearings. Check the seals. Check for proper lubrication.

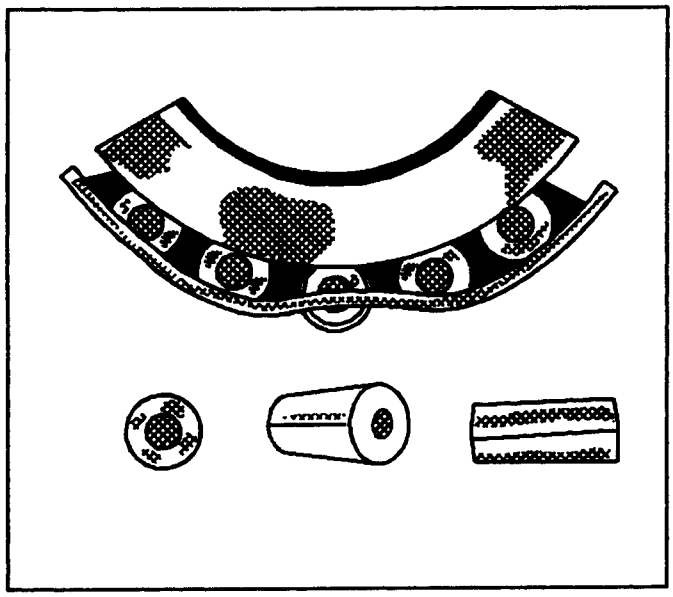
Abrasive Step Wear



1453

A pattern on the roller ends may be caused by fine abrasives. Clean all of the parts and housings. Check the seals and the bearings. Replace the bearing if the bearing is leaking, rough, or noisy.

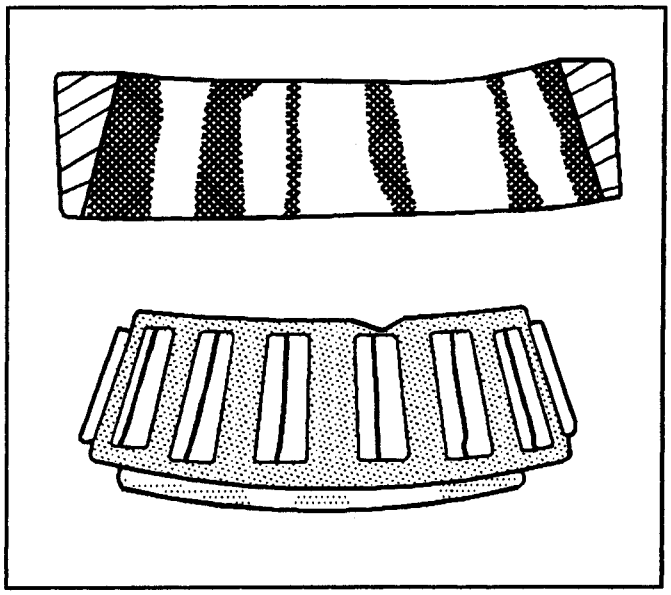
Bent Cage



1648

The cage may be damaged due to improper handling or improper tool usage. Replace the bearing.

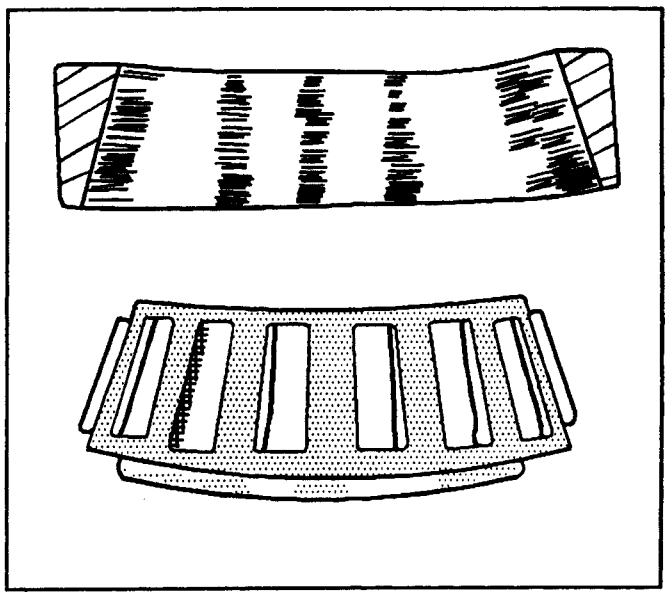
Bent Cage



1456

The cage may be damaged due to improper handling or improper tool usage. Replace the bearing.

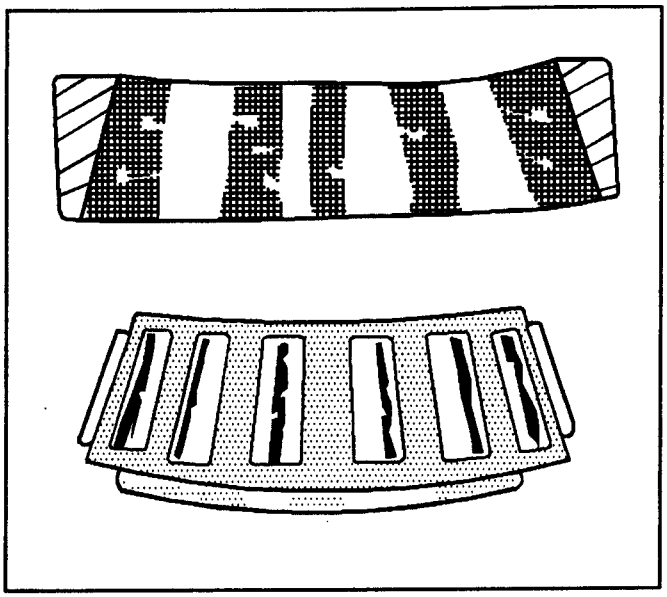
Cage Wear



1457

Wear around the outside diameter of the cage and the roller pockets may be caused by abrasive material. Wear may be caused from inefficient lubrication. Clean the related parts and the housings. Check the seals. Replace the bearings.

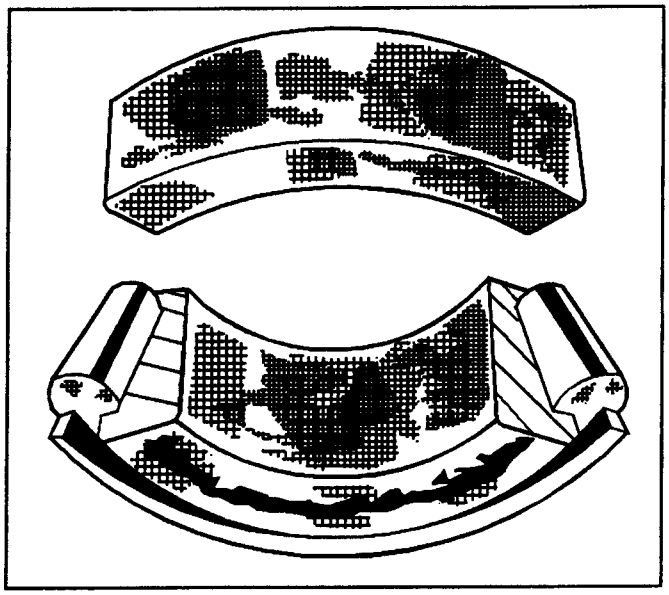
Indentations



1458

Surface depressions on the race and the rollers may be caused by hard particles of foreign matter. Clean all the parts and the housings. Check the seals. Replace rough or noisy bearings.

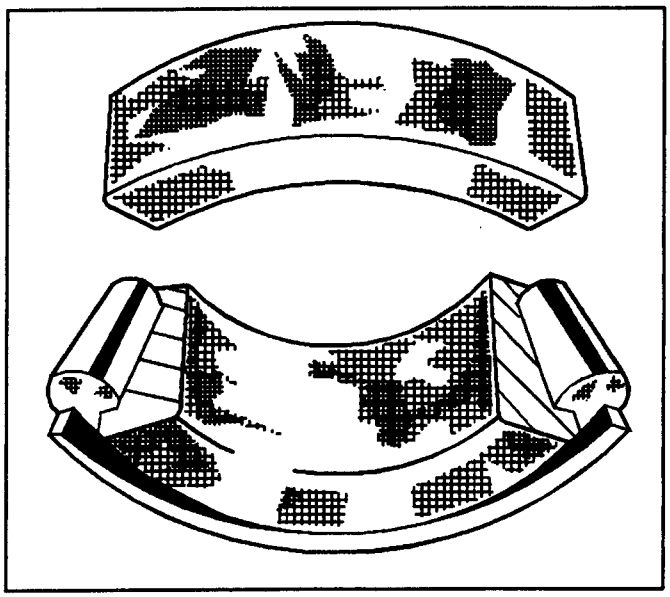
Frettage



1459

Corrosion may be caused by a small relative movement of parts with no lubrication. Replace the bearing. Clean the related parts. Check the seals. Check for proper lubrication.

Smears



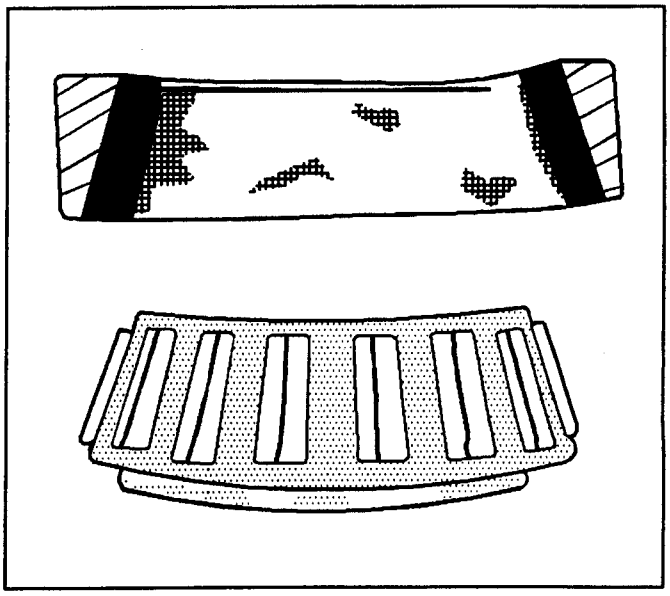
1460

Smearing of the metal may be due to slippage. Slippage can be caused by the following factors:

- Poor fits
- Inadequate lubrication
- Overheating
- Overloads
- Handling damage

Replace the bearings. Clean the related parts. Check for proper fit and lubrication.

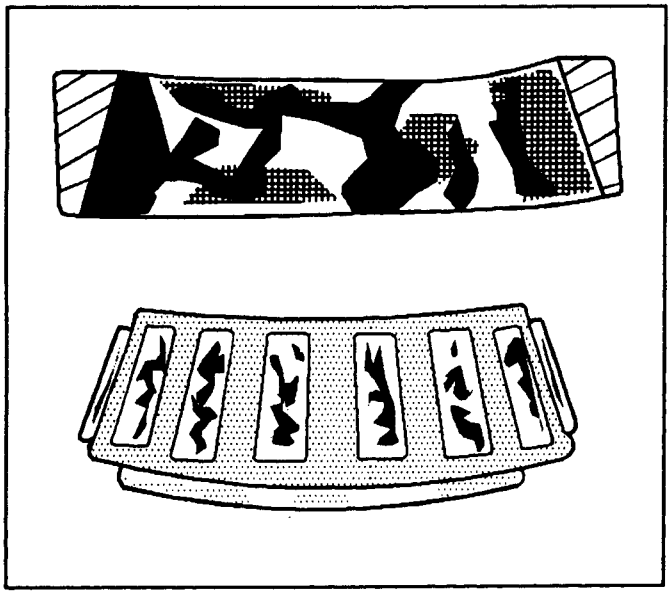
Stain Discoloration



1461

Discoloration, ranging from light brown to black, is caused by incorrect lubrication or moisture. Reuse the bearing if you can remove the stains with light polishing. Reuse the bearing if there is no evidence of overheating. Check the seals and the related parts for damage.

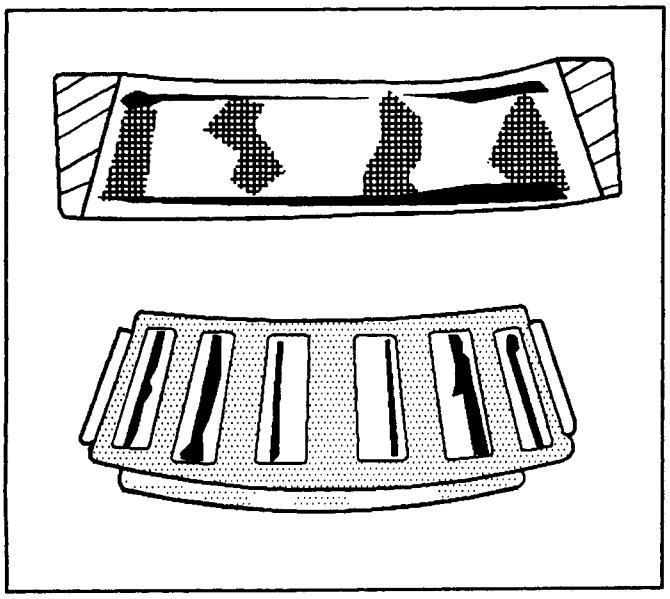
Heat Discoloration



1462

Heat discoloration ranges from faint yellow to dark blue. This discoloration results from overload or an incorrect lubricant. Excessive heat causes softening of the races or the rollers. In order to check for loss of temper on the races and the rollers, perform a file test. A file drawn over a tempered part will grab and cut the metal. A file drawn over a hard part will glide readily with no metal cutting. Replace the bearings if overheating damage is indicated. Check the seals and the other related parts.

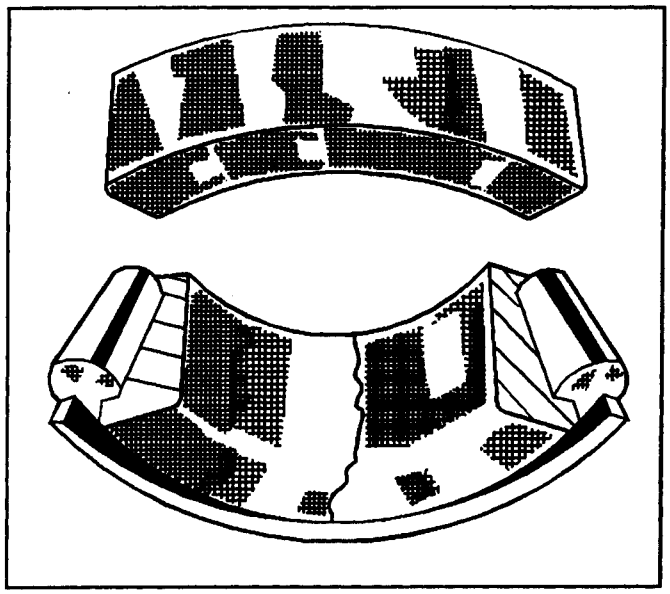
Misalignment



1463

The outer race is misaligned due to a foreign object. Clean the related parts. Replace the bearing. Ensure the races are properly sealed.

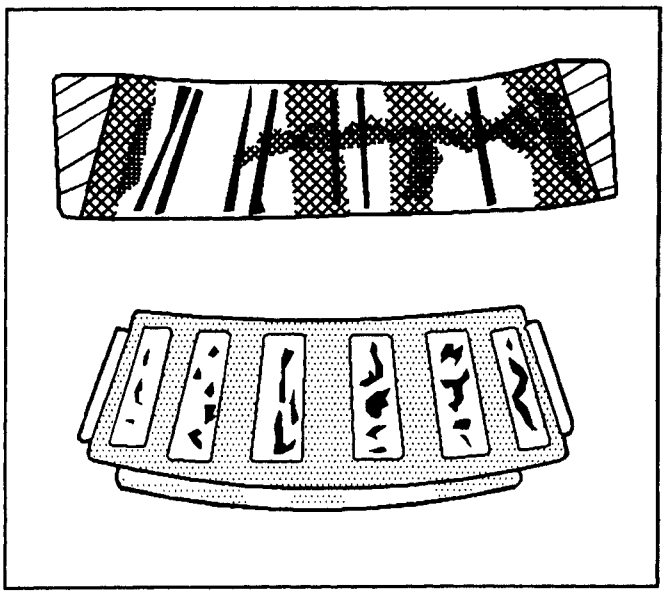
Cracked Inner Race



1464

A cracked race may be due to improper fit, cocking, or poor bearing seats. Replace the bearing. Correct the bearing seats.

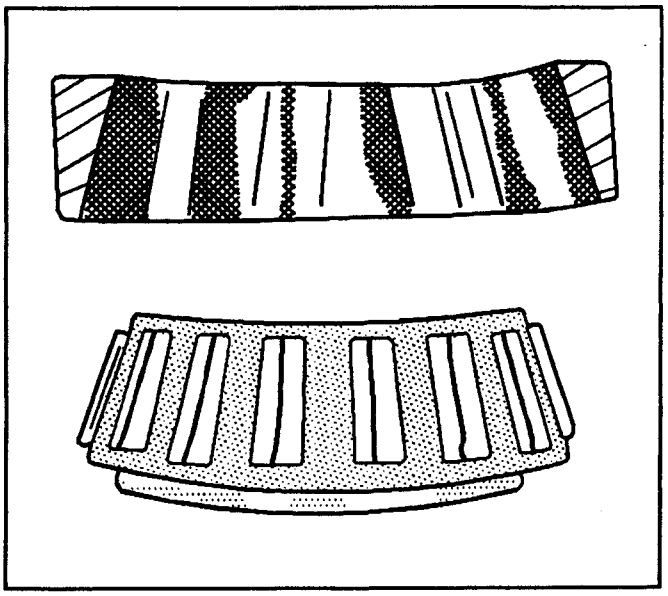
Fatigue Spalling



1465

Spalling is a flaked surface metal that results from fatigue. Replace the bearing. Clean all related parts.

Brinelling



1466

Surface indentations in the race way are caused by the rollers under impact loading or are caused from vibration while the bearing is not rotating. Replace a rough or noisy bearing.

Low or Uneven Trim Height

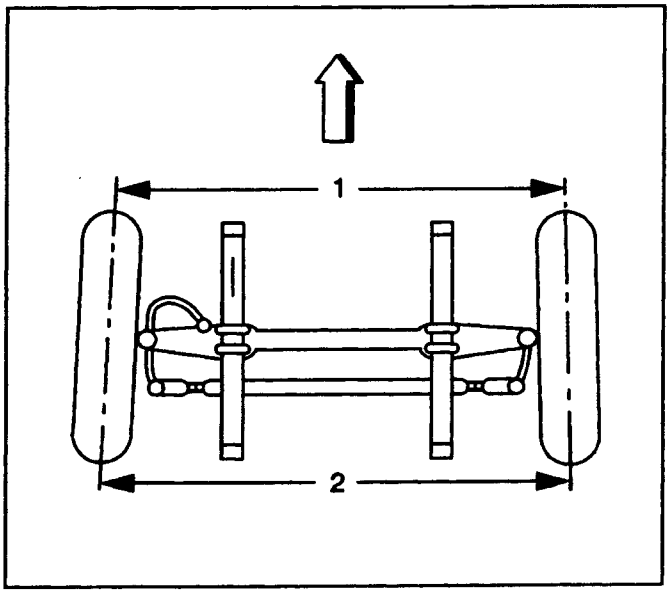
Problem	Action
The springs are broken or sagging.	Replace the springs. Refer to *Leaf Springs Replacement* in Front Suspension.
The vehicle is overloaded or improperly loaded.	Avoid overloading the vehicle. Refer to *Label - Vehicle Certification* in General Information.

Description and Operation

General Description

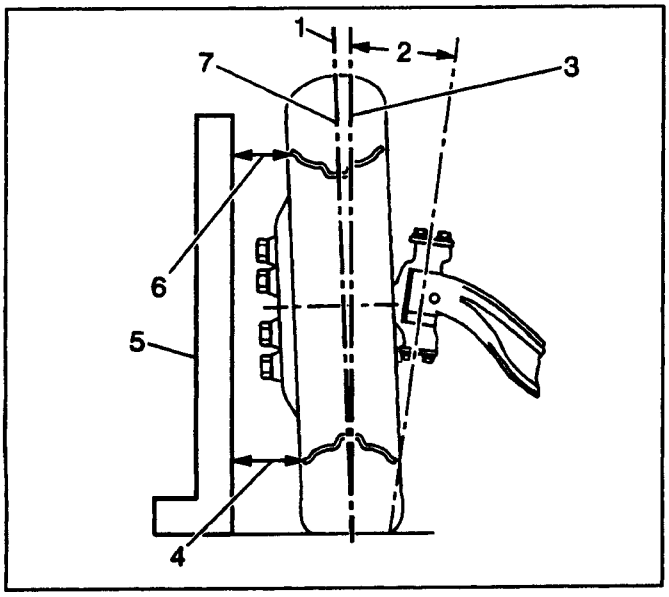
Alignment is the proper positioning or state of adjustment of parts in relation to each other. In order to ensure efficient steering and satisfactory tire life, proper alignment of the front wheels must be maintained. For details on tire wear patterns caused by alignment problems. Refer to *Wheel Alignment Specifications* in Suspension.

The most important factors of front wheel alignment are:



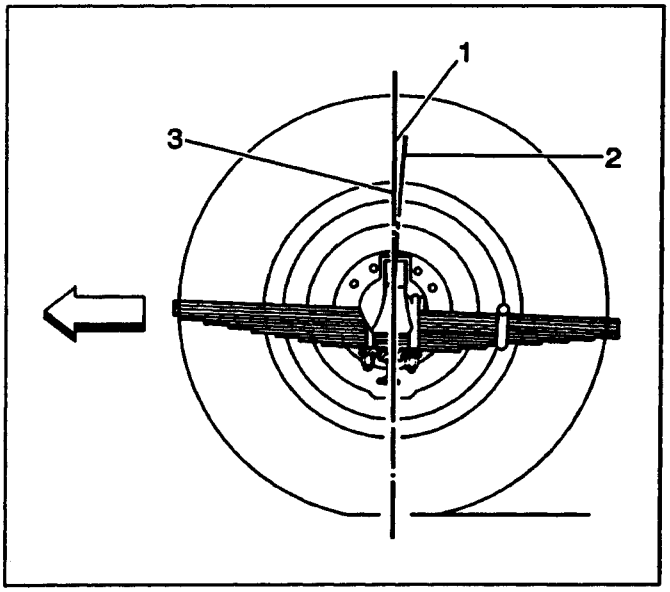
200188

- Wheel toe-in



200191

- Wheel camber



200311

- Axle caster.

  Kingpin inclination and camber are designed into the axle end. Check the front wheel alignment at regular intervals and particularly after the front axle has been subjected to heavy impacts such as a collision or a hard curb impact. The wheel bearings must be properly adjusted before checking the alignment.

  Loose wheel bearings will affect the instrument measurements when checking the wheel toe-in, wheel camber, and axle caster. When checking the alignment, follow the instructions carefully. Also follow the instructions covering each of these units:

- The brakes
- The springs
- The steering gear
- The hubs and bearings
- The tires and wheels

BLANK

Wheel Alignment

Specifications

Wheel Alignment Specifications

Application	Specification	
	Check	Set
Angular Toe-In per Wheel	0.028°–0.056°	0.028°–0.028°
Camber	0°–25°	—
Caster	Refer to *Front Caster Adjustment*	—
King Pin Inclination	6°	—
Linear Sum Toe-In	0.7940 mm–1.5875 mm (0.03125 in–0.0625 in)	0.7940 mm–0.7940 mm (0.03125 in–0.03125 in)

Fastener Tightening Specifications

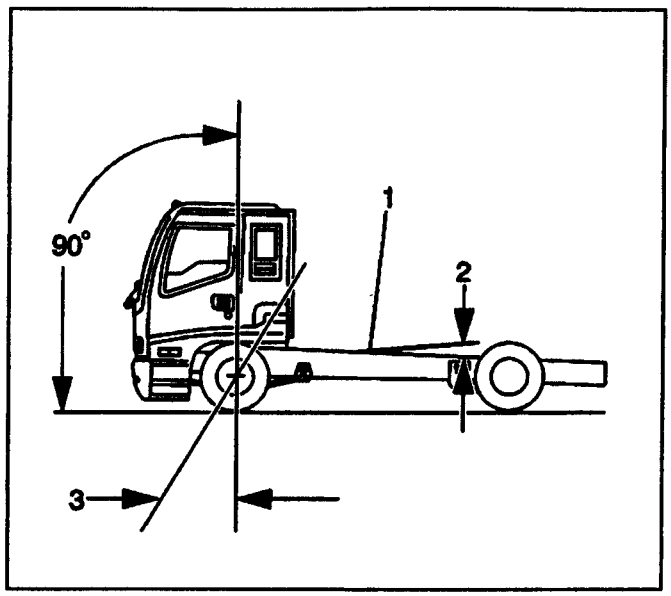
Application	Specification	
	Metric	English
Stop Screw Jam Nut	65 N·m	48 lb ft
Tie Rod End Clamp Nut	75 N·m	55 lb ft

Repair Instructions

Front Caster Adjustment

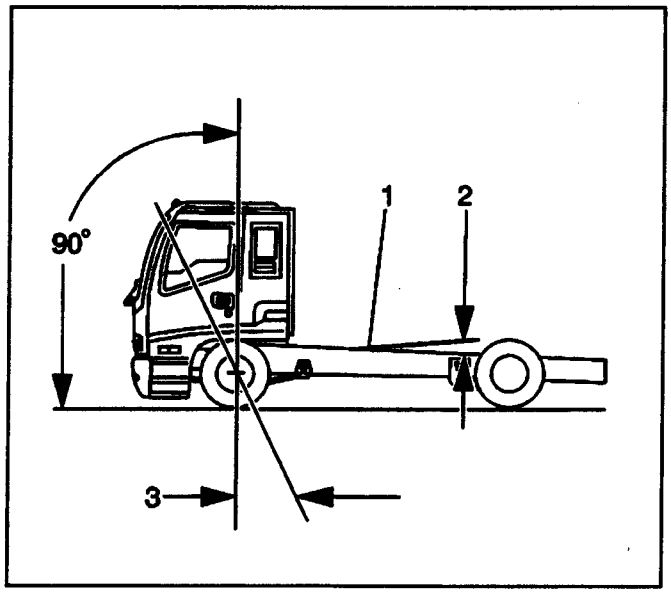
Caster dimensions are given for a vehicle carrying its design load equal to the capacity of the vehicle's suspension (GVWR). Perform alignment checks when the frame is level. If you make an alignment check when the frame is not level, determine the frame angle and add this angle to the caster angle, in order to obtain a true caster measurement. In order to determine the frame angle and the caster, complete the following steps:

1. Place the vehicle on a smooth level surface.
2. Measure the frame angle using a bubble protractor. The frame angle is the degree of tilt in the frame from the level position. Up in Rear, or negative frame angle, occurs when the frame is above level in the rear. Down in Rear, or positive frame angle, occurs when the frame is below level in the rear.
3. Determine the caster angle for the left wheel using alignment equipment.
4. Add or subtract the frame angle to or from the left wheel caster measurement in order to determine the corrected caster for the left wheel.
5. Determine the corrected caster with various frame and caster measurements according to the following rules:



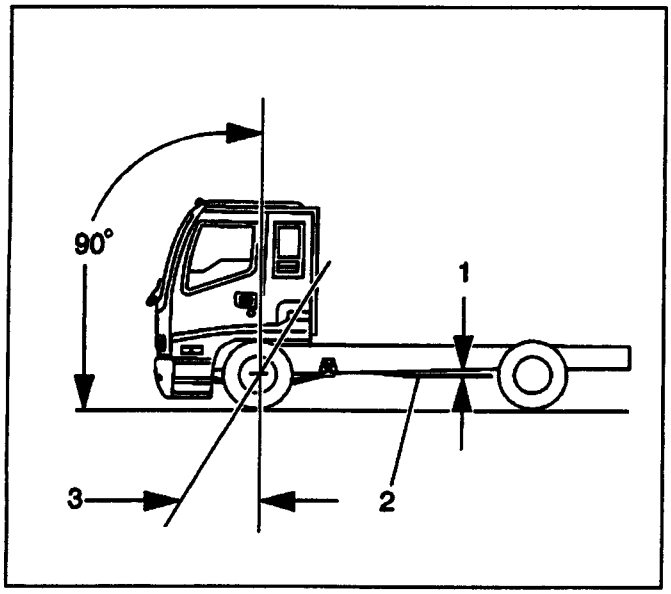
218690

6. Subtract the positive frame angle (2) from a positive caster measurement (3).



218696

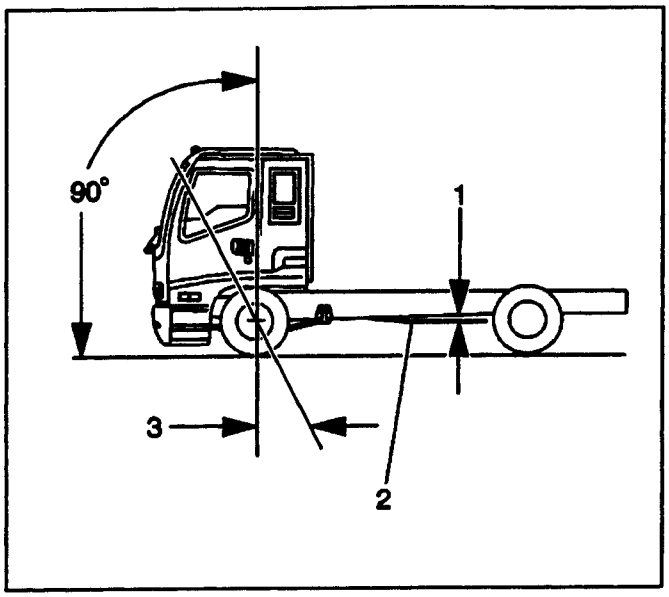
7. Add the negative frame angle (1) to a positive caster measurement (3).



218700

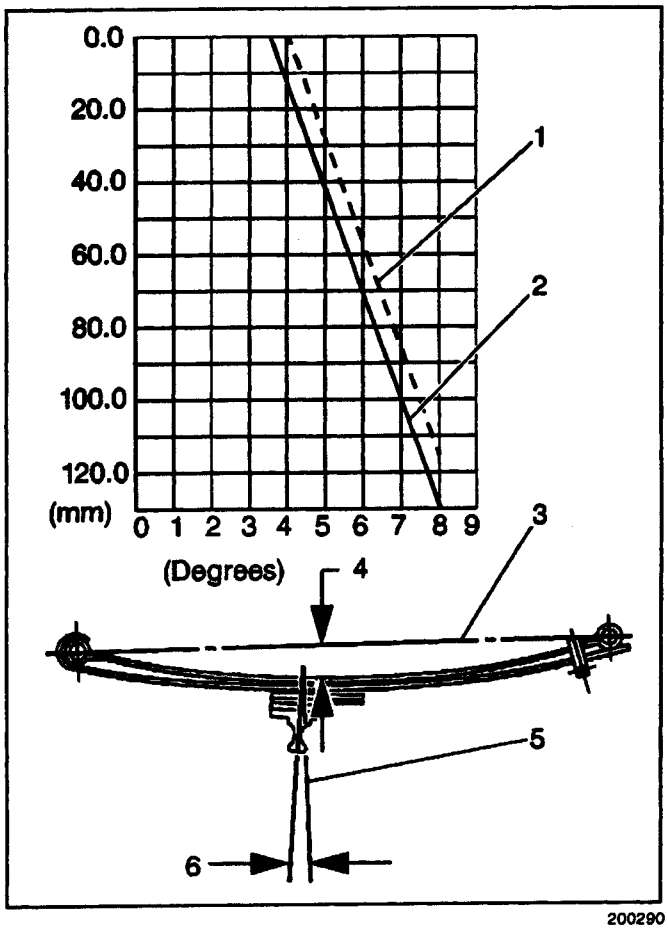
8. Add the positive frame angle (2) to a negative caster measurement (3).

9. Subtract the negative frame angle (1) from a negative caster measurement (3).
10. Repeat steps 1 through 9 for the right wheel.

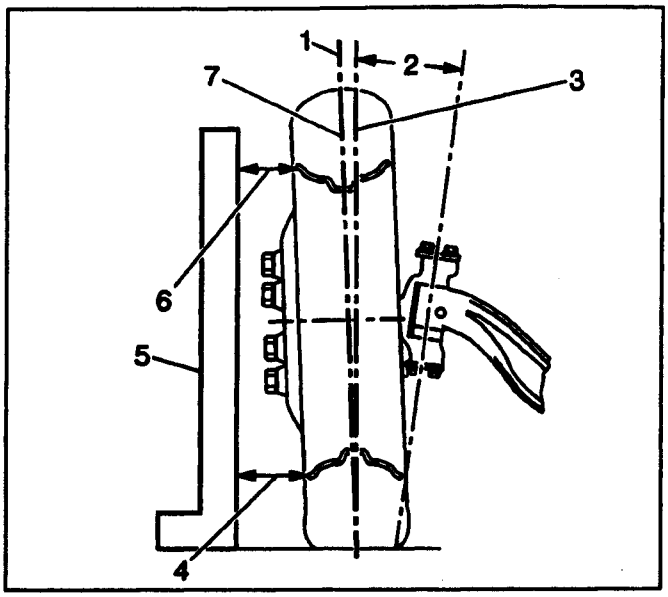


218703

11. Determine the specified caster by performing the following steps:
    - Hold a taut string (3) between the centers of the spring eyes.
    - Measure the distance from the taut string to the top surface of the upper spring leaf, on a line that is perpendicular to the bottom of the frame rail (5) and at the centerline of the spring. Note the distance in millimeters from the centerline of the spring eyes to the top of the spring at the spring centerline (4).
    - Determine the specified caster angle using the graph (as shown).
    - Compare the specified caster angle with the measured caster angle.
    - If the specified caster angle does not coincide with the measured caster angle (plus or minus one degree), determine the cause of the error and replace the faulty component.



200290



200191

Front Camber Adjustment

Camber variations may be caused by one of the following conditions:

- Wear at the wheel bearings
- Wear at the steering knuckle bushings
- Bent steering knuckle
- Bent axle center

Refer to *Wheel Alignment Specifications* for camber specifications.

Important: Before checking the camber, inspect the king pin wear. Complete the following steps:

1. Raise the front of the vehicle.
2. Pull the bottom of the wheel outward and measure the camber.
3. Pull the top of the wheel outward and take a camber measurement (use a camber gauge, if available).
4. If a camber gauge is not available, place a square (5) against the tire and take the measurements.
5. If the measurements vary by more than 15 minutes (1/4 degree), adjust the wheel bearing. Refer to *Wheel Bearing Adjustment.*
6. Take the camber measurements again. If the measurements still vary by more than 15 minutes (1/4 degree), replace the steering knuckle bearing and/or the bushings and the king pins. Refer to *Steering Knuckle and King Pin Replacement* in Front Suspension.
7. Inspect the wheel runout. Refer to *Abnormal or Excessive Tire Wear*. Replace the wheel if the wheel runout is excessive.
8. Place the vehicle on a level surface, with the normal weight of the vehicle on the wheels. Take a final camber measurement.
9. Note the dimension of the top measurement and the dimension of the bottom measurement.
10. Ensure that the dimension of the bottom measurement exceeds the dimension of the top measurement. Verify that the camber dimensions of the right wheel do not vary by more than 2.4 mm (0.0938 in) from the camber dimensions of the left wheel. If the final camber measurement is incorrect, then either the steering knuckle or the axle center is bent. In order to determine which part is bent, inspect the king pin inclination. Add the camber plus the king pin inclination dimensions. This measurement is the included angle of the steering knuckle. Replace the steering knuckle if the included angle of the steering knuckle varies from specifications by more than 30 minutes (1/2 degrees), (the knuckle is bent). Straighten the axle center if the included angle of each knuckle end is within the specifications, but the final camber is incorrect (the axle center is bent).

Front Toe Adjustment

Measure toe-in at the following locations:

- From the center of the tire treads or from the inboard side of the tires
- At the front and the rear of the axle
- At the horizontal axis of the wheel

When setting the toe-in adjustment, neutralize the front suspension. Ensure that all component parts are in the same relative position when making the adjustment as they will be when in operation. In order to neutralize the suspension, roll the vehicle 3.5–4.5 meters (12–15 ft). When the vehicle is rolled forward, all normal tolerances in the suspension and the steering linkage are in the correct operating position. Neutralize the front suspension if the vehicle has been raised.

1. Loosen the tie rod end clamps.
2. Turn the tie rod using a pipe wrench until the wheels have the proper toe-in.

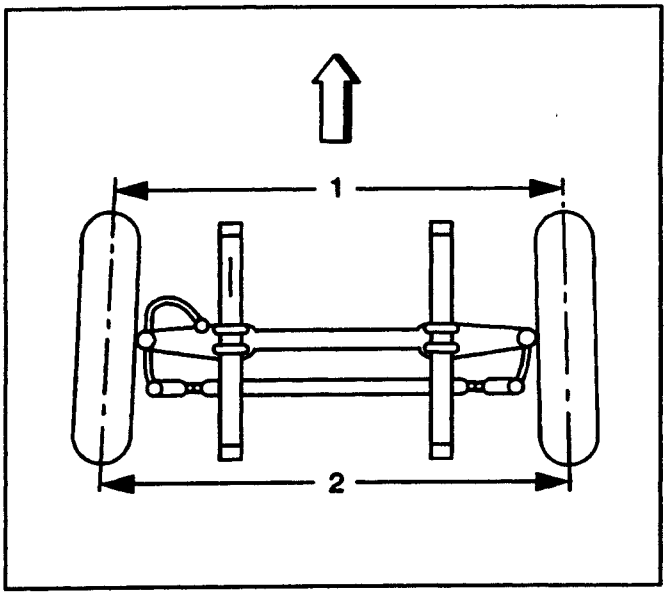
   Set

   Angular toe-in (set) should be 0.028–0.028 degrees per wheel or 7940 mm–0.7940 mm (0.03125 in–0.03125 in) linear sum toe-in.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
3. Tighten the tie rod end clamp nuts.

   Tighten

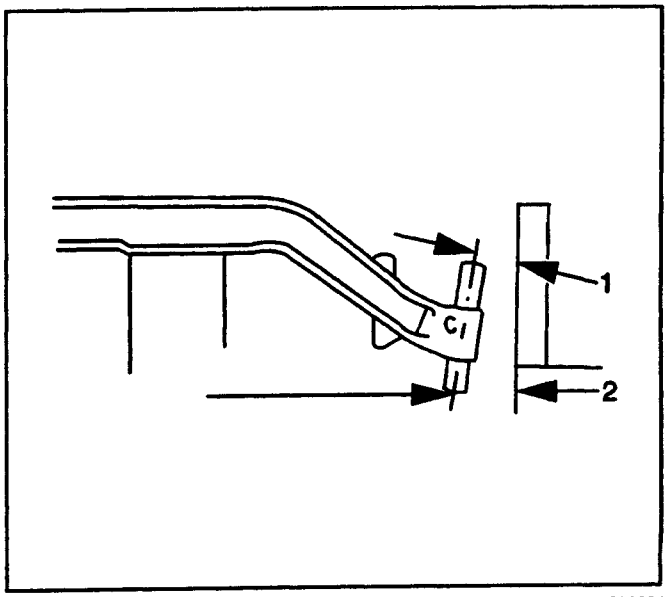
   Tighten the tie rod end clamp nuts to 75 N·m (55 lb ft).



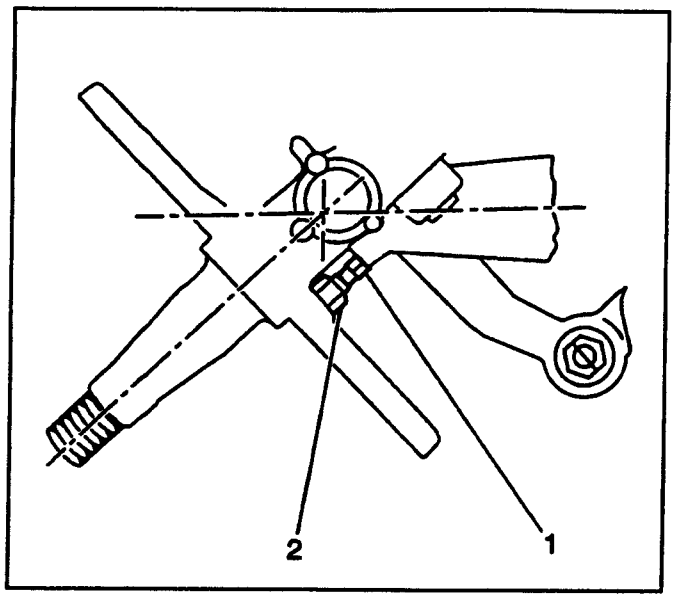
200188

Checking and Correcting King Pin Inclination

Kingpin inclination is the amount that the top of the kingpin is inclined toward the center of the vehicle. This is measured by substracting the top (1) from the bottom (2) measurements. Use precision instruments to check the king pin inclination. If the axle is bent or twisted, refer to *Front Axle Replacement* in Front Suspension. Straightening the axle center in order to correct the king pin inclination will also change the camber. Recheck the camber after correcting the king pin inclination.



200224



200195

Stop Screw Adjustment

The angle of the steering arms determines the turning angle or toe-out on turns.

Ensure that the stop screw adjustment provides 16 mm (0.6250 in) minimum clearance of the tire with all chassis components installed, regardless of the maximum turning angles. The stop screws are installed in the steering knuckles and stop against the axle center.

1. Loosen the jam nut (2) and the right stop screw (1) in order to prevent the stop screw from contacting its stop when the wheels are turned to the extreme right.
2. Hold the right wheel tightly against the right turn position, with the wheels turned to the extreme right.
3. Turn out the stop screw until the stop screw contacts firmly against the stop.
4. Turn the stop screw one more turn against the stop.
5. Verify the position of the tire. Adjust the tire as necessary in order to provide 16 mm (0.6250 in) clearance to all chassis components.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
6. Tighten the jam nut on the stop screw.

   Tighten

   Tighten the jam nut to 65 N.m (48 lb ft).
7. Repeat the previous six steps for the left side stop screw adjustment.
8. Recheck the turning clearance and the stop screw setting when installing oversize tires.
9. Verify the position of the tire. Adjust the tire as necessary in order to provide 16 mm (0.6250 in) clearance to all of the chassis components.

Description and Operation

General Description

Alignment is the proper positioning, or the state of adjustment, of parts in relation to each other. Maintain proper alignment of the front wheels in order to ensure efficient steering and satisfactory tire life. For details on tire wear patterns caused by alignment problems, refer to *Abnormal or Excessive Tire Wear* in Suspension General diagnosis. The most important factors of wheel alignment are:

- Wheel toe-in
- Wheel camber
- Axle caster

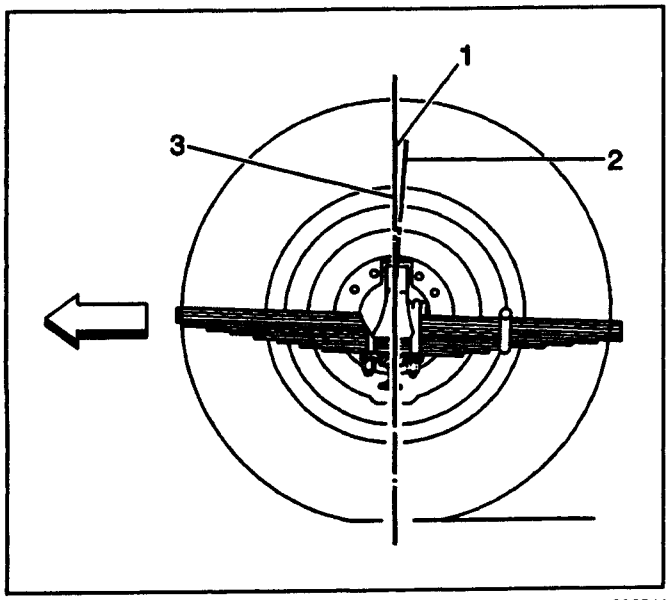
King pin inclination and camber are designed into the axle end. Inspect the front wheel alignment at regular intervals, particularly after the front axle has been subjected to heavy impacts, such as a collision or a hard curb impact. Adjust the wheel bearings before checking the alignment. Loose wheel bearings will affect the instrument measurements when checking wheel toe-in, wheel camber, and axle caster.

When inspecting the alignment, follow the instructions outlined in this section. Follow the instructions in other sections that cover any of the following units:

- The brakes
- The springs
- The steering gear
- The hubs and bearings
- The tires and wheels

Caster Description

Caster (1) is the inclination (tilt) of the king pin (2) or the steering axis either forward or backward from the vertical line (3).



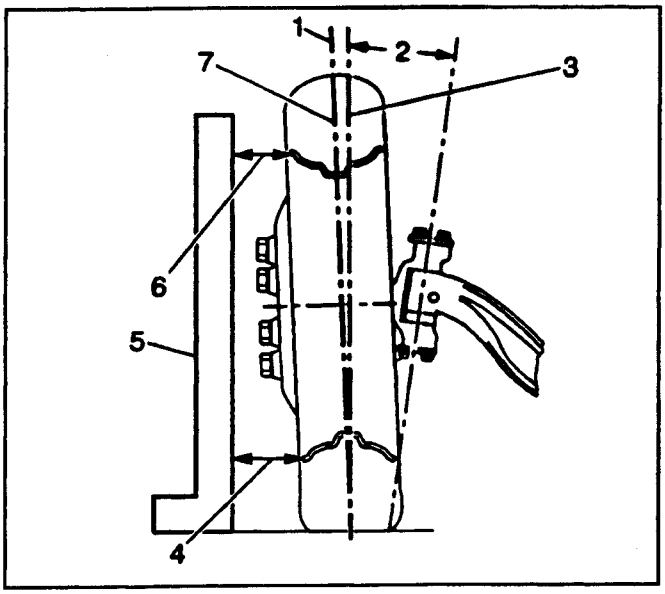
200311

Incorrect caster may result from one of the following conditions:

- Sagging springs
- A bent axle
- A twisted axle
- Uneven tightening of the spring U-bolt nuts

Tighten all of the U-bolt nuts equally. Refer to *Fastener Tightening Specifications*. The caster will be unequal for the right and left sides if the axle is twisted.

Camber Description



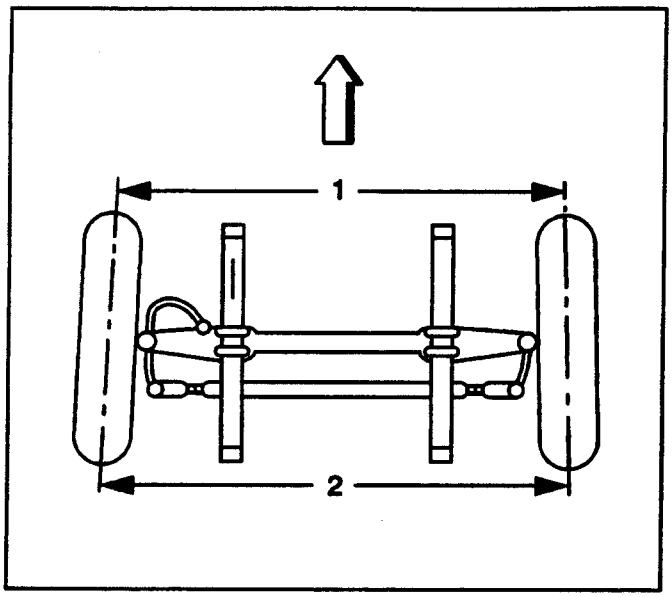
200191

Wheel camber is the measurement in degrees that the front wheels are tilted inward or outward at the top from the vertical position. Determine wheel camber by subtracting the top measurements (6) from the bottom measurements (4). Camber offsets wheel deflection caused by wear of the front axle parts, and prevents a reverse or negative camber condition. Extreme or unequal camber will cause improper steering and excessive tire wear.

Toe Description

Toe-in is the angle of the tires and wheels toward each other. The amount of toe-in is normally a fraction of a degree. Measure the toe-in from the center of the tire treads or from the inboard side of the tires. Toe-in ensures parallel rolling of the front wheels and offsets any small deflections of the wheel support system, which occur when the vehicle is rolling forward. Incorrect toe-in results in excessive tire wear and unstable steering. Set the toe-in alignment last in the front wheel alignment procedure.

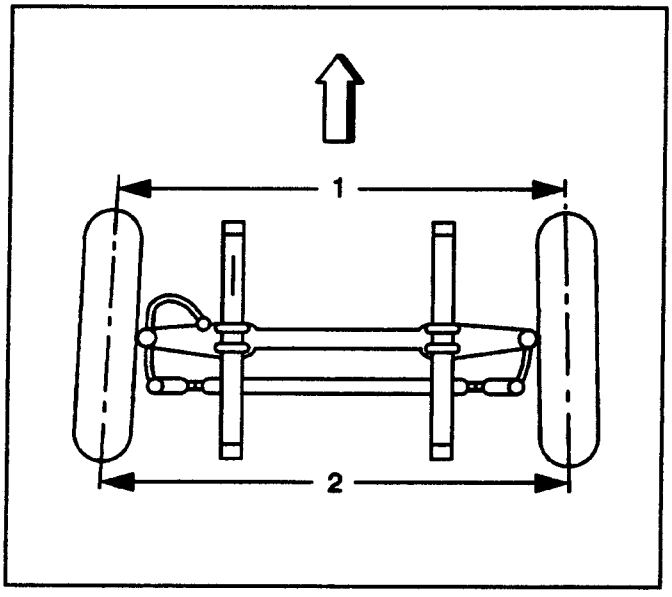
Linear Sum Toe-In



200188

Linear Sum Toe-In is the distance between the front wheels. The toe-in distance is less at the front of the axle (1) than at the rear of the axle (2).

Angular Toe-In



200188

Angular Toe-In is the angle of the front wheel centerline, relative to the intersection of the forward projected vehicle centerline.

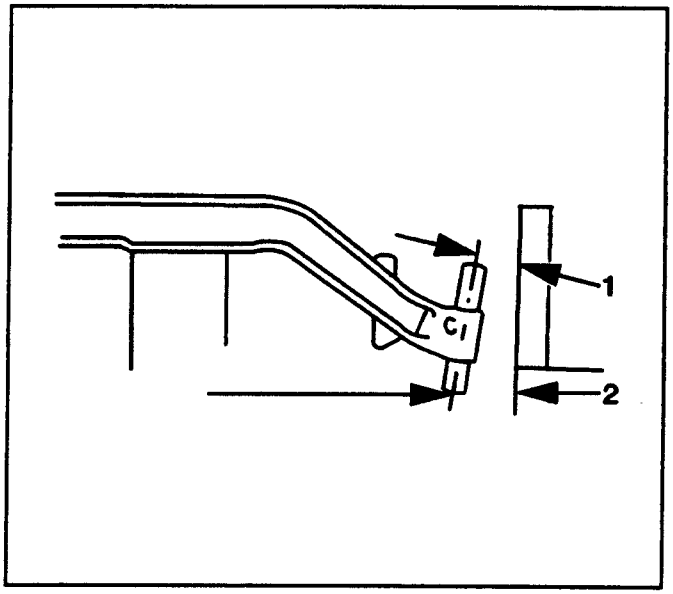
Frame Misalignment Description

Determine the following dimensions for the vehicle at the design load with the frame level:

- Caster
- Camber
- Toe-in

Consider the normal frame angle when using alignment equipment. Keep in mind the normal frame angle when checking the caster angle, in order to obtain a true setting.

Steering Axis Inclination Description



200224

King pin inclination is the amount that the top of the king pin is inclined toward the center of the vehicle. Measure king pin inclination by subtracting the top measurement (1) from the bottom measurement (2). The king pin inclination is designed into the axle end. King pins are inclined in order to assist the front wheel return to the center after a turn is made.

Front Suspension

Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Bumper Bracket Nut	68 N·m	50 lb ft
Bump Stop Nut	40 N·m	30 lb ft
Eye Bolt	330 N·m	243 lb ft
Hub Cap Bolt	13 N·m	115 lb in
King Pin Cap Bolt	24 N·m	18 lb ft
King Pin Nut	550 N·m	406 lb ft
Shock Absorber Nut	84 N·m	62 lb ft
Stabilizer Nut	170 N·m	125 lb ft
U-Bolt Nut	400 N·m	295 lb ft

Diagnostic Information and Procedures

Wheel Bearing Test

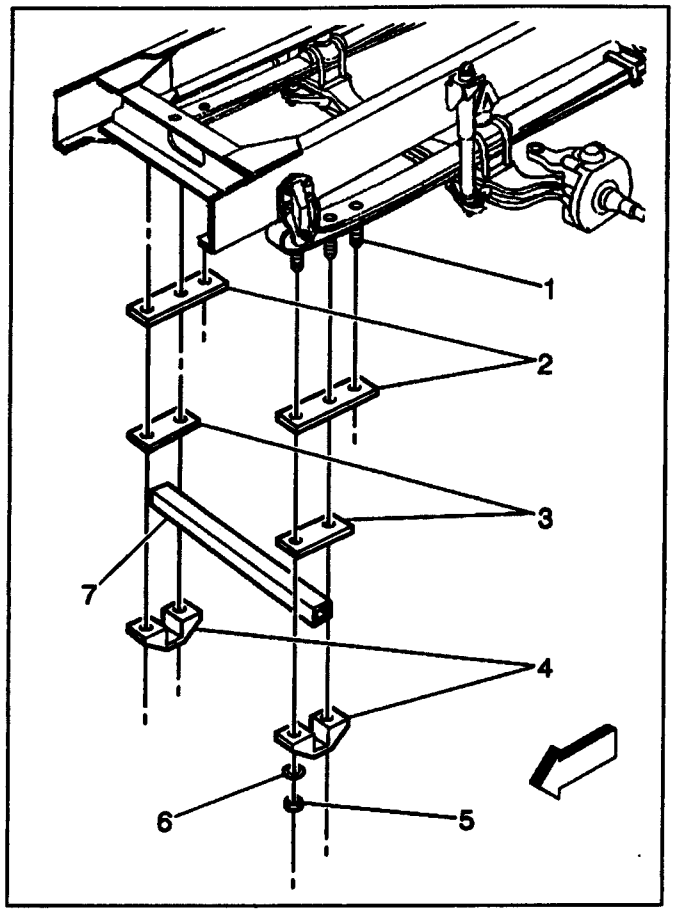
Before checking the wheel bearing adjustment, fully release the brakes. Raise the front axle until the wheels clear the floor.

Inspect the bearing play using either of the following procedures:

- Grasp the tire at the top and pull the tire back and forth.
- Use a pry bar under the tire.

If the bearings are properly adjusted, movement of the brake drum will be barely noticeable in relation to the backing plate, and the wheel will turn freely.

If movement is excessive, adjust the bearings. Refer to *Wheel Bearing Adjustment*.



214490

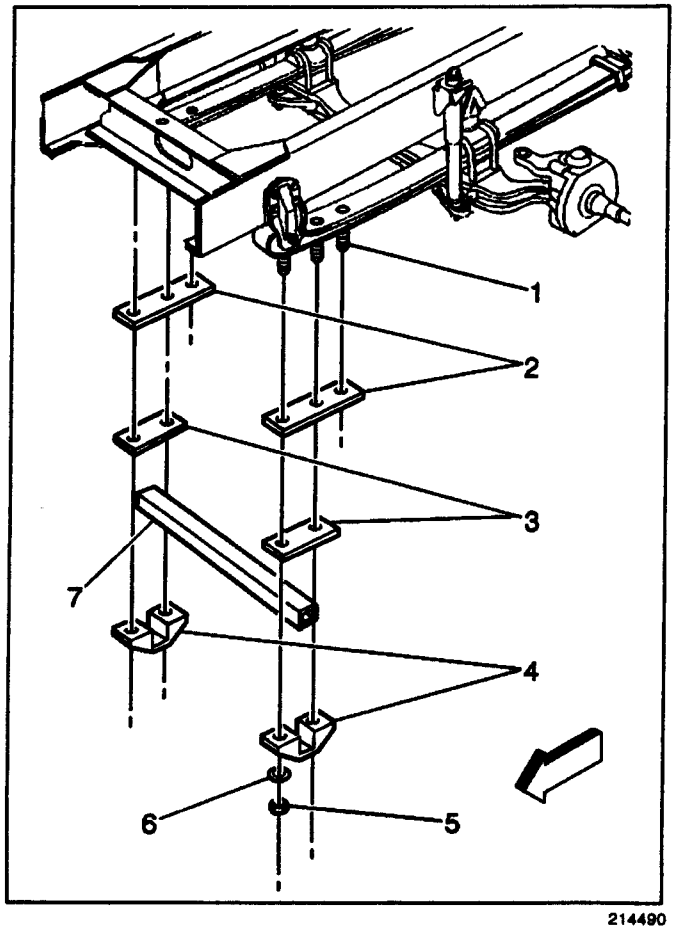
Repair Instructions

Stabilizer Shaft Replacement

Removal Procedure

Remove the following components from the springs:

1. The nuts (5)
2. The washers (6)
3. The shaft mounting brackets (4)
4. The stabilizer shaft (7)
5. The shims (2,3)



214490

Installation Procedure

1. Install the following components to the springs:
   1.1. The shims (2,3)
   1.2. The stabilizer shaft (7)
   1.3. The shaft mounting brackets (4)
   1.4. The washers (6)
   1.5. The nuts (5)

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Tighten the stabilizer nuts (5) alternately and evenly until the shaft mounting brackets (4) contact the lower shim (3).

   Tighten

   Tighten the stabilizer nuts to 170 N.m (125 lb ft).

Steering Knuckle and King Pin Replacement

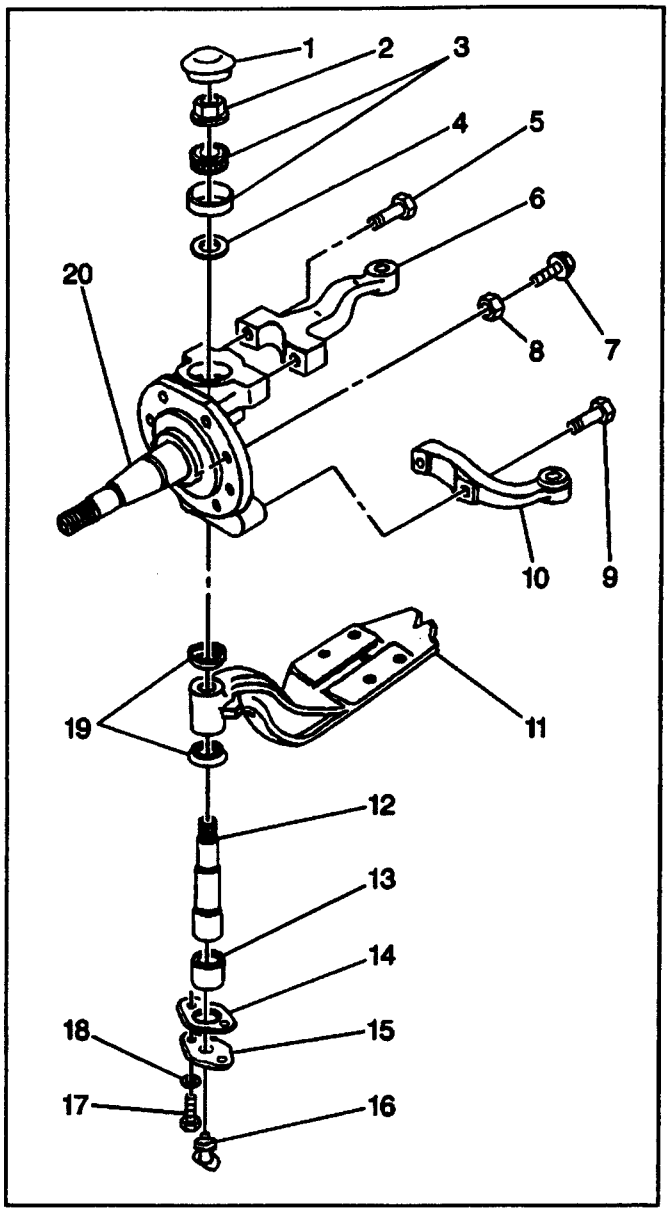
Removal Procedure

Tools Required

- *J 35999* Tension Scale
- *J 39758* King Pin Holding Tool

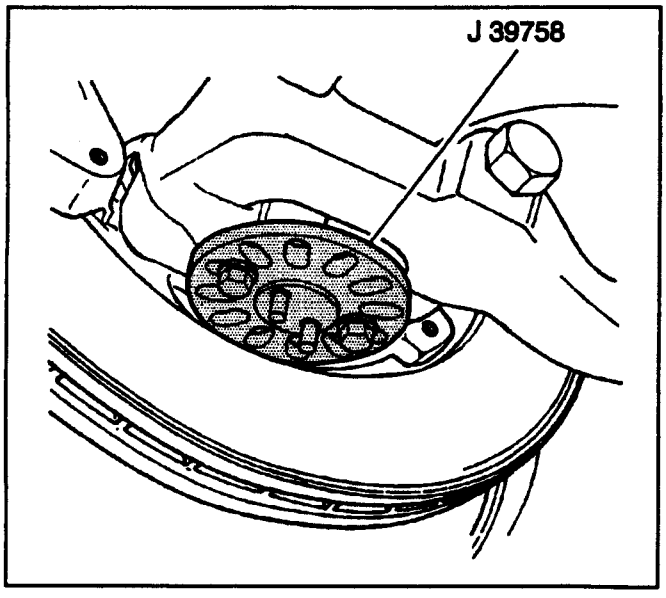
1. Set the parking brake.
2. Block the vehicle rear wheels.
3. Raise the front of the vehicle until the tires clear the floor.

   Notice: Refer to *Crossmember Support Notice* in Cautions and Notices.
4. Support the frame using suitable safety stands.
5. Remove the wheels, the hubs, and the bearings.
6. Refer to the asppropriate procedure:
   - *Wheel Hub, Bearing, and Seal Replacement (Drum Brakes)*
   - *Wheel Hub, Bearing, and Seal Replacement (Disc Brakes).*
7. Remove the brake components as needed.
8. Refer to the appropriate procedure:
   - *Brake Caliper Replacement (Front, Bendix)*
   - *Brake Caliper Replacement (Front, Dayton-Walther)*
9. Remove the brake backing plates and the dust covers.



201703

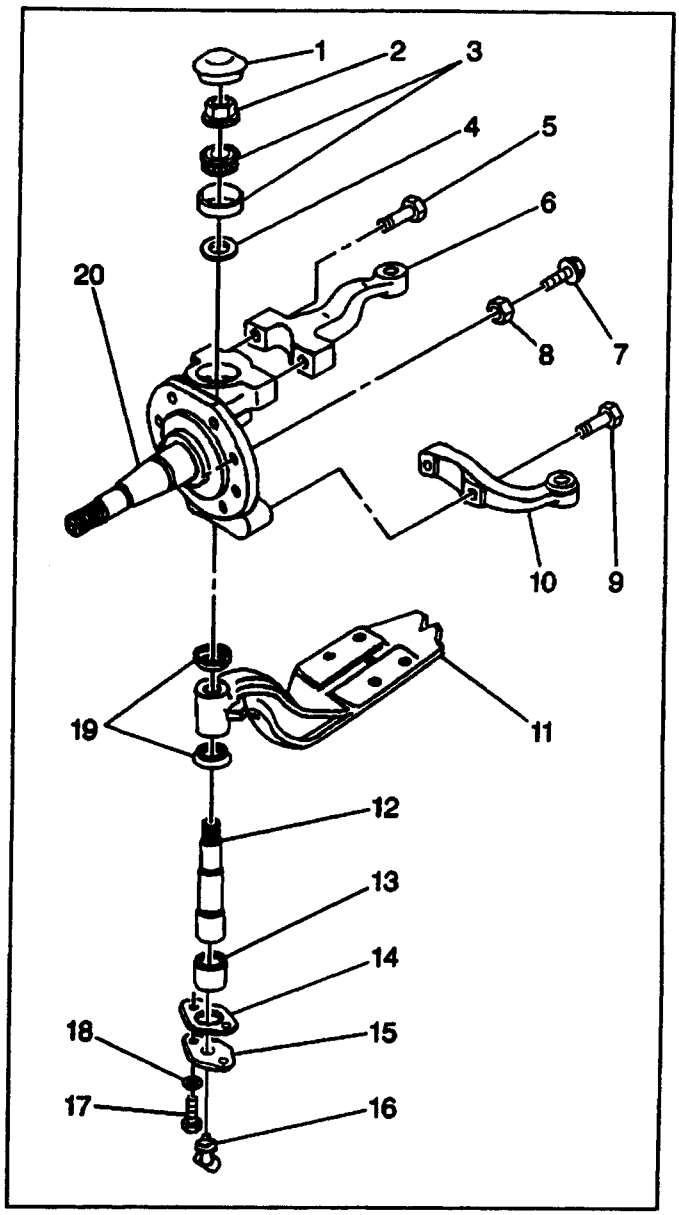
10. Remove the tie rod arm bolts (9). Lower the tie rod arm (10) and the tie rod to the floor.
11. Remove the steering arm bolts (5). Support the steering arm (6) and the steering rod out of the way.
12. Remove the king pin upper cap (1).
13. Remove the following components:
    - The bolts (17)
    - The washers (18)
    - The king pin lower cap (15)
    - The gasket (14)
14. Remove the king pin nut (2).



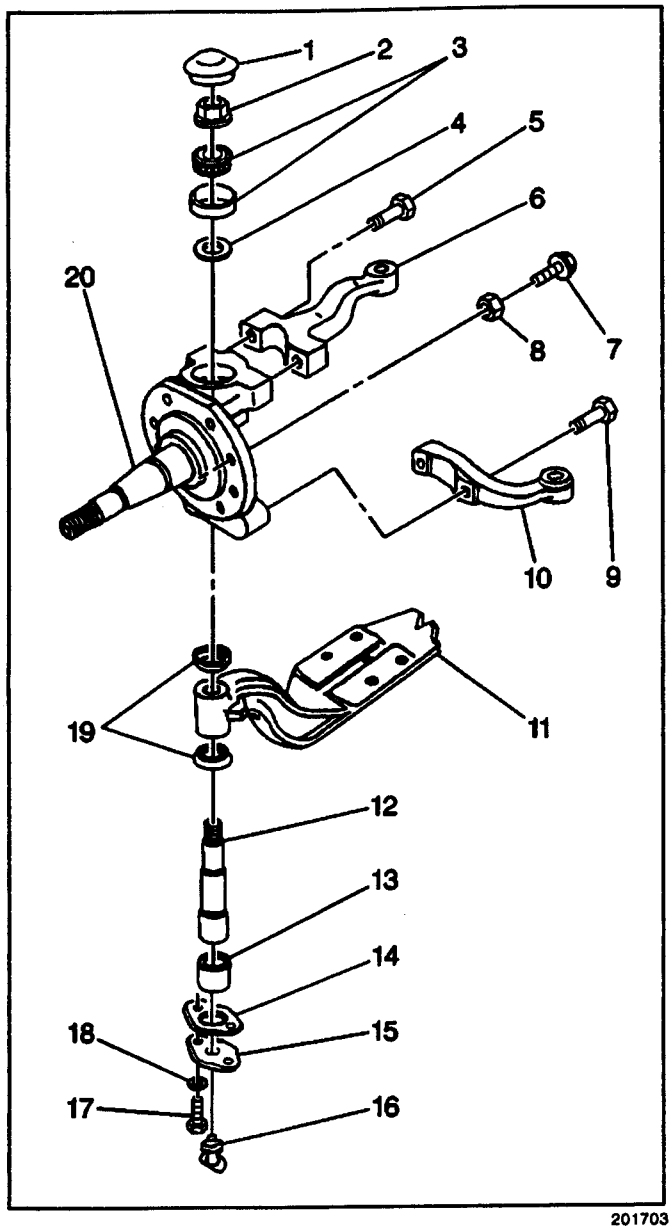
201706

15. Using the *J 39758*, insert the tool pins into the holes at the bottom of the king pin.
16. Align the tool's bolt holes.
17. Secure with two bolts into the steering knuckle in order to prevent the king pin from spinning.

18. Remove the king pin (12) by knocking out the pin with a soft-faced mallet.
19. Remove the steering knuckle (20).
20. Support the knuckle in a vise.
21. Remove the following components from the knuckle (20):
    - The seals (19)
    - The bearing (3)
    - The shim or spacer (4)
    - The bushing (13)
22. Remove the king pin bushing (13), if required. Refer to *King Pin Bushing and Bearing Cup Replacement.*



201703



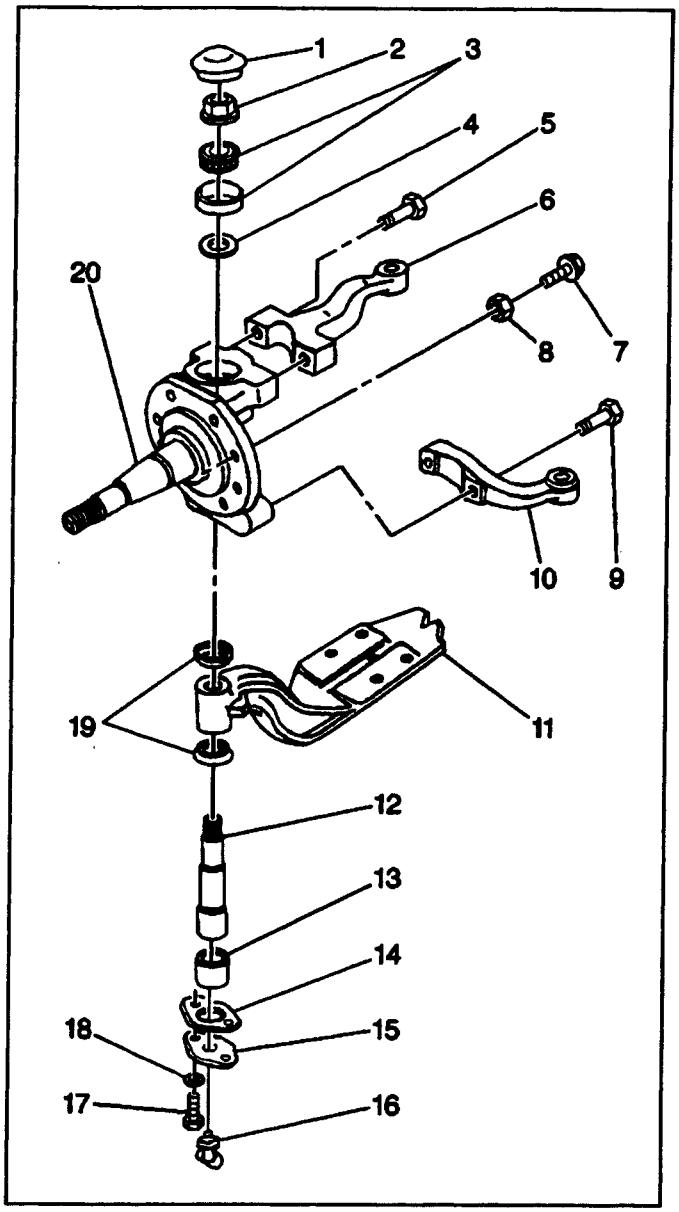
201703

Inspection Procedure

1. Clean the axle components using a cleaning solvent.
2. Soak the thrust bearing until all of the old lubricant is gone.
3. Inspect the axle components for the following conditions:
   - Wear
   - Pitting
   - Cracks
   - Damage
4. Use Magna-Flux™ inspection, if available, in order to inspect the steering knuckles (20) and the kingpins (12) for minute cracks, checks, or fractures.
5. Inspect the king pin bearings and the cups for rough rotation.
6. Inspect the bores in the axle king pin (12) for the following conditions:
   - Scratches
   - Burrs
   - Corrosion
7. Inspect the bores in the king pin bushing (13) for the following:
   - Scratches
   - Burrs
   - Corrosion
8. Smooth the bore using a crocus cloth or a fine grit sandpaper if needed. Clean the bore.

Installation Procedure

1. Install the king pin bushings (13), if removed.
2. Install the king pin bearing cup, if removed.
3. Install the steering knuckle (20).
4. Install the king pin (12) and install the dust seals (19).
5. Install a shim or spacer (4).
6. Install the king pin thrust bearing (3). Pack the bearing thoroughly with high temperature wheel bearing grease.
7. Install the king pin nut (2).



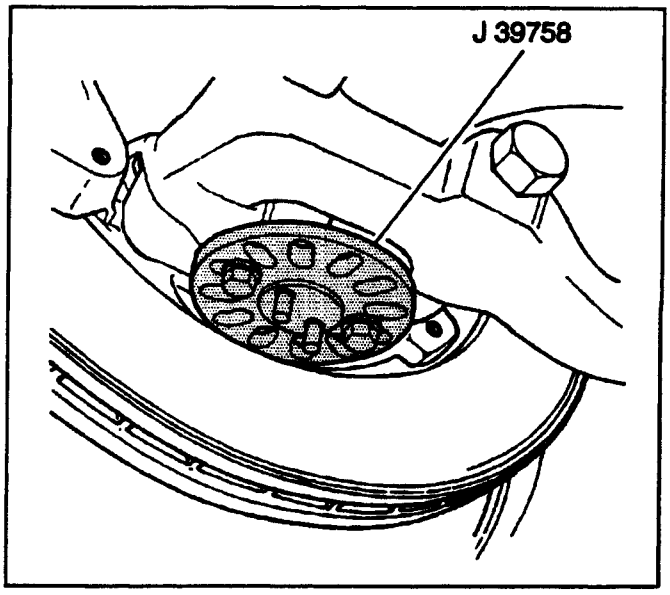
201703

8. Using the *J 39758* insert the tool pins into the holes at the bottom of the king pin.
9. Align the tool's bolt holes.

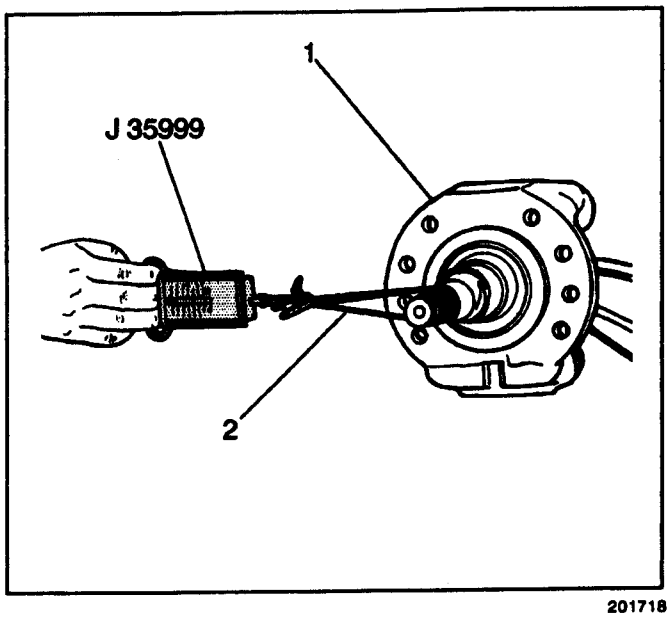
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
10. Secure the tool with two bolts into the steering knuckle in order to keep the king pin from spinning.

    Tighten

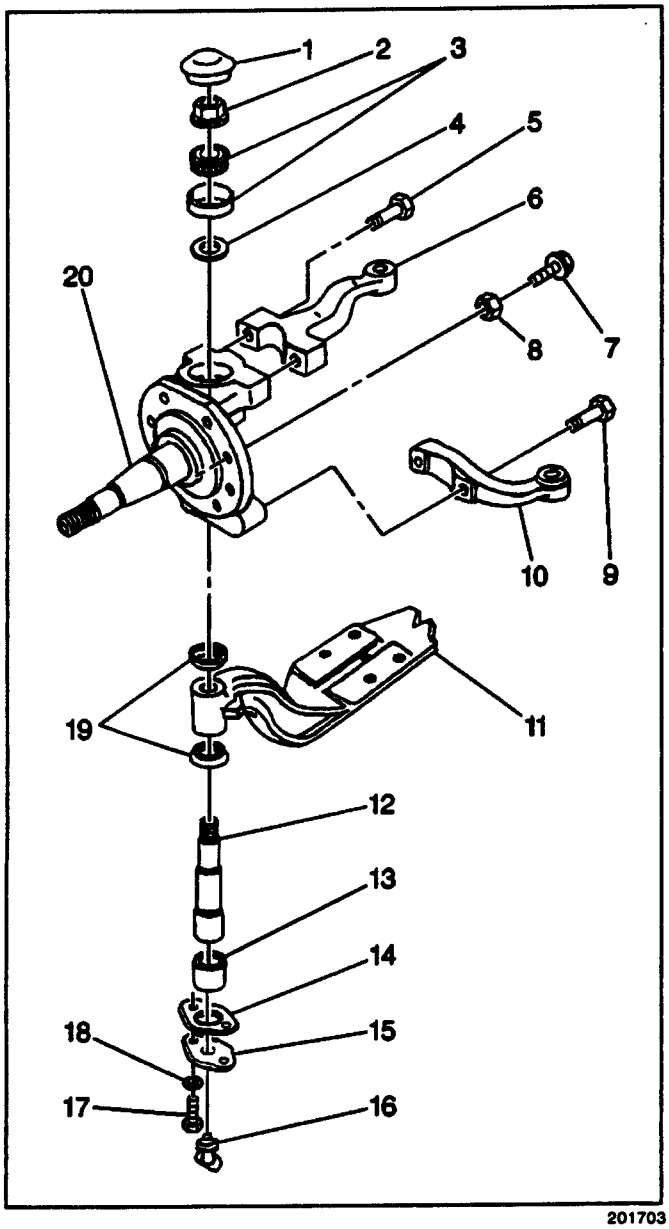
    Tighten the king pin nut (2) to 550 N·m (406 lb ft).



201706



201718



201703

11. Measure the king pin bearing preload. Refer to *King Pin Bearing Preload.*

12. Install the following components:
    - The bottom gasket (14)
    - The dust cap (15)
    - The washers (18)
    - The bolts (17)

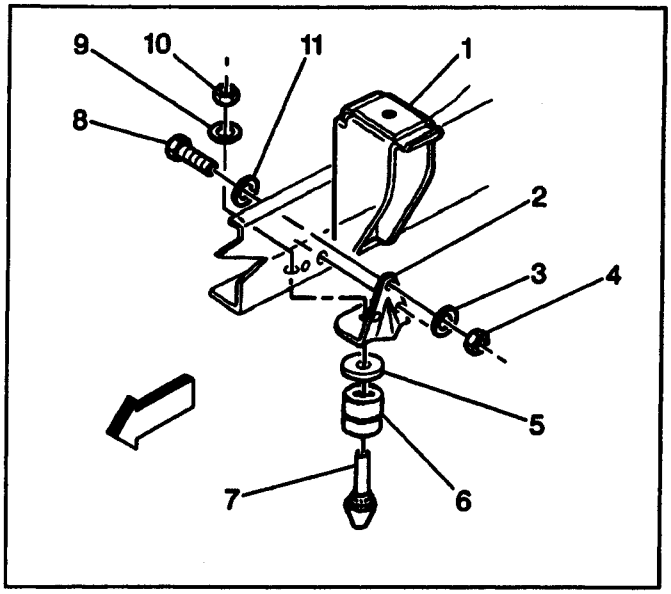
    Tighten

    Tighten the dust cap bolt to 24 N.m (18 lb ft).
13. Install the king pin upper dust cap (1). Tap the dust cap into place using a soft-faced mallet. Grease the knuckle (20) through the lubrication fitting (16) on the bottom.
14. Install the tie rod arm (10).
15. Install the steering arm (6), if removed.
16. Install the brake backing plate and the dust cover.
17. Install the brake components as needed.
18. Refer to the appropriate procedure:
    - *Brake Caliper Replacement (Front, Bendix)*
    - *Brake Caliper Replacement (Front, Dayton-Walther)*
19. Install the wheel bearings, the hubs, and the wheels.
20. Refer to the appropriate procedure:
    - *Wheel Hub, Bearing, and Seal Replacement (Drum Brakes)*
    - *Wheel Hub, Bearing, and Seal Replacement (Disc Brakes).*
21. Remove the safety stands and lower the vehicle.
22. Check the axle alignment.
23. Check the stop screw (7,8) adjustment. Adjust as needed. Refer to *Stop Screw Adjustment* in Wheel Alignment.

Spring Bumper Replacement

Removal Procedure

1. Remove the nut (10) and the washer (9).
2. Remove the bumper stop (7) and the bumper (6).
3. Remove the spacer (5), if equipped.
4. Remove the following components:
   - The nuts (4)
   - The washers (3,11)
   - The bolts (8)
5. Remove the bumper bracket (2) from the frame (1).

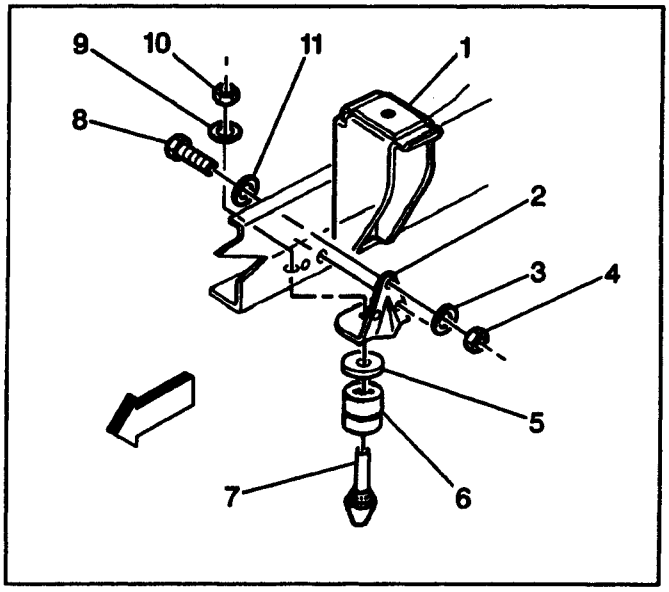


201855

Installation Procedure

1. Install the bumper bracket (2) to the frame (1).
2. Install the following components:
   - The bolts (8)
   - The washers (3,11)
   - The nuts (4)
3. Install the bumper stop (7) through the bumper (6).
4. Install a spacer (5) on the bumper.
5. Install the bumper stop through the bracket (2) and the frame (1).

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
6. Install the washer (9) and the nut (10).
   Tighten
   - Tighten the spring bumper mounting nut (4) to 68 N·m (50 lb ft).
   - Tighten the bumper stop nut (10) to 40 N·m (30 lb ft).



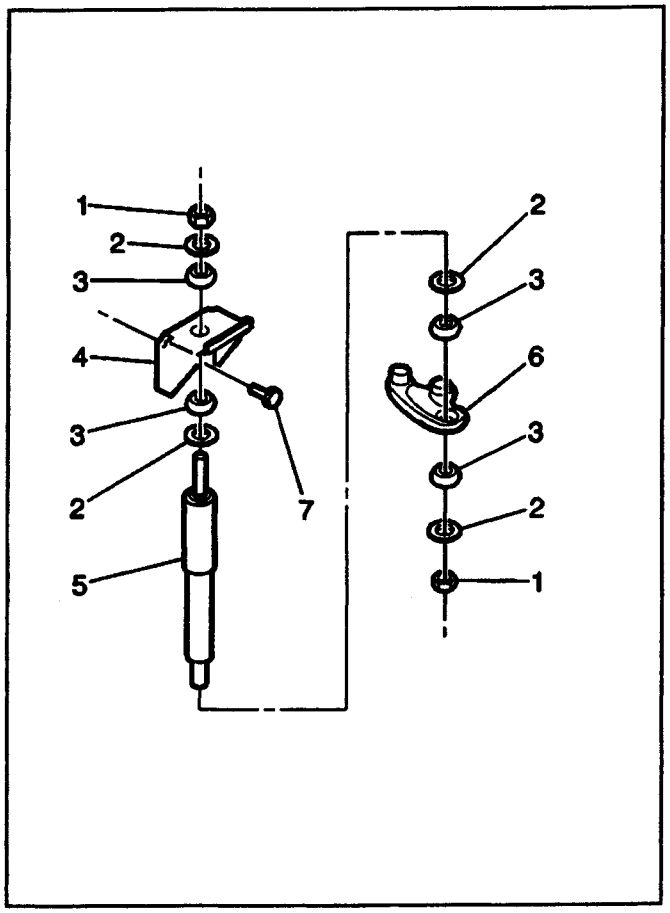
201855

Leaf Springs Replacement

Removal Procedure

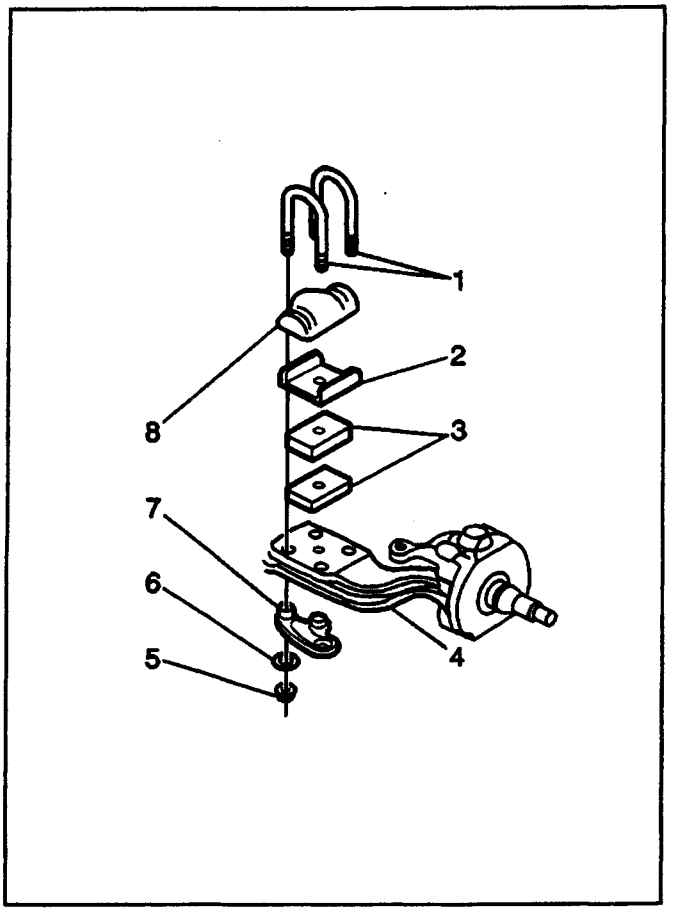
1. Set the parking brake.
2. Block the vehicle's rear wheels.
3. Raise the frame until the front tires clear the floor.
4. Support the axle using a jack. Raise the axle high enough in order to allow the spring to clear the brackets when you remove the spring.

   Notice: Do not use the front crossmember to support the vehicle or the crossmember may buckle.
5. Support the frame using suitable safety stands.



294158

6. Remove the following components from the lower mounting brackets (6). Push the shock absorbers into the fully retracted position:
   - The nuts (1)
   - The washers (2)
   - The insulators (3)
   - The shock absorbers (5)
7. Remove the insulator (3) and the washer (2) from the shock absorber lower stem.



294161

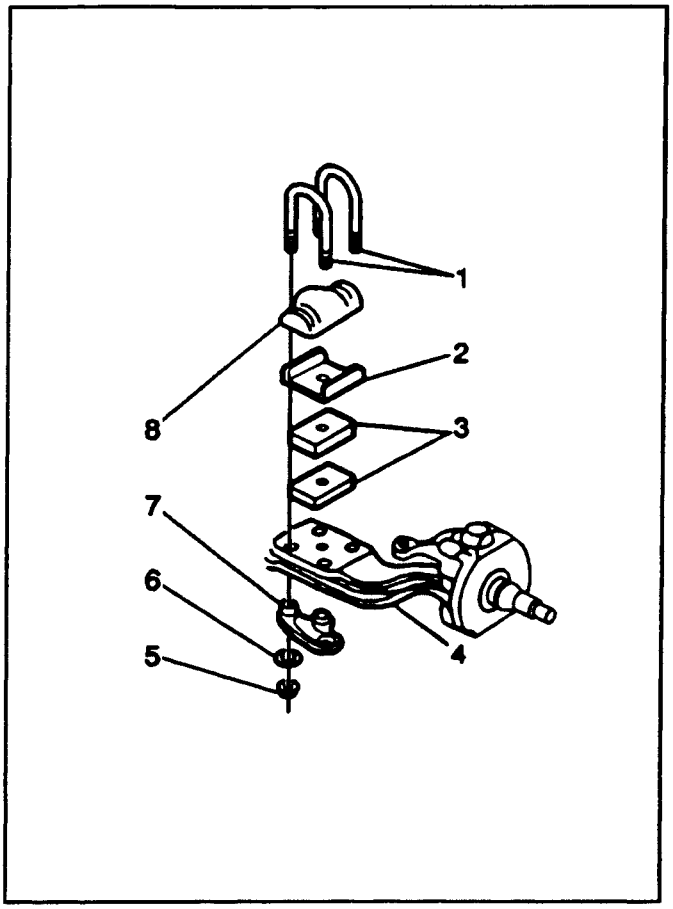
8. Remove the nuts from the front and rear eye bolts. Loosen the upper rear shackle bolt in order to allow the hanger to pivot.
9. Remove the nuts (5) the washers (6) and the U-bolts (1). Lower the axle (4) far enough in order to relieve the tension on the spring.
10. Remove the front eye bolt.
11. Remove the rear eye bolt.
12. Remove the following components from the vehicle:
    - The spring.
    - The spring spacers (2).
    - The U-bolt upper spacer (8).

Installation Procedure

Important: Assemble all of the components and remove all of the jacks and lifting devices before you tighten the suspension fasteners.

1. Install the spring (2).
2. Install the rear eye bolt and nut.
   2.1. Raise the axle in order to support the spring.
   2.2. Install the spring spacers (2) and the U-bolt spacer (8) on the spring.
   2.3. Align the spring center bolt to the axle.

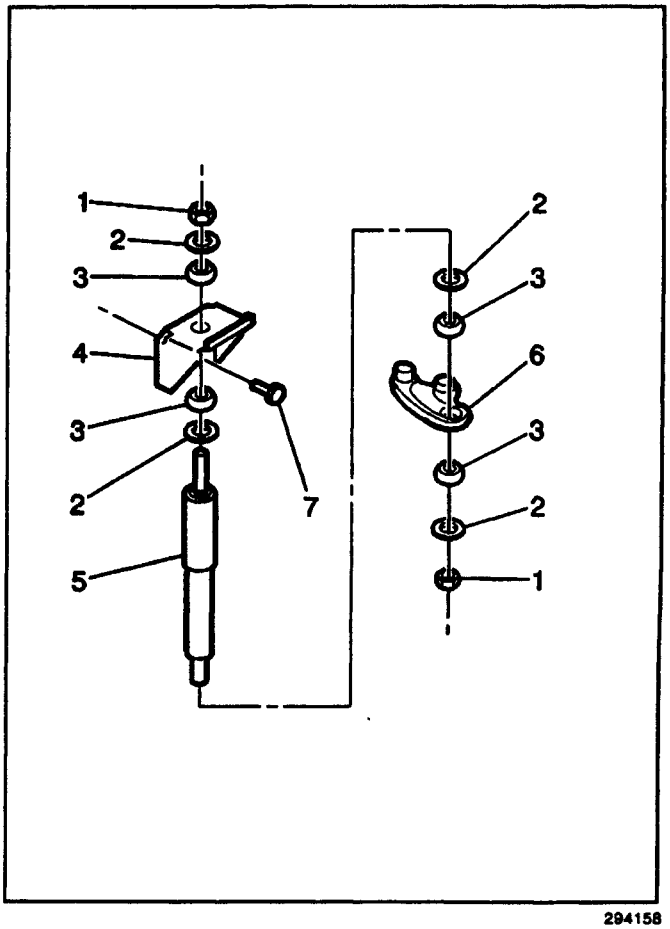
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
3. Install the front eye bolt and nut.
   Tighten
   Tighten the eye bolts to 330 N.m (243 lb ft).
4. Install the U-bolts (1), the washers (6) and the nuts (5).
   Tighten
   Tighten the U-bolt nuts to 400 N.m (295 lb ft).



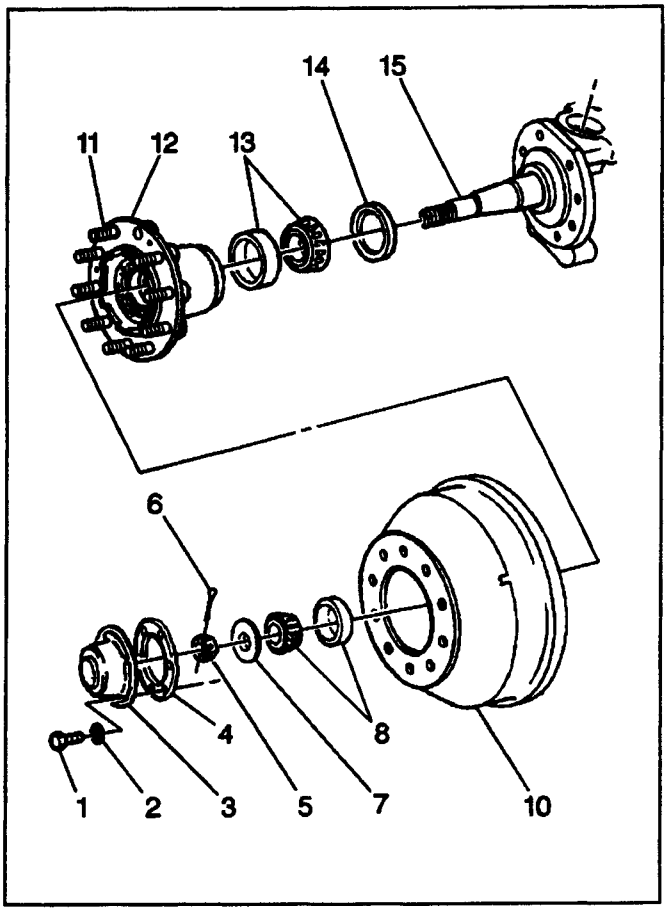
294161

5. Install the flat washer (2) and the insulator (3) onto the shock absorber lower stem.
6. Install the shock absorber (5) into the lower mounting bracket (6).
7. Install the following components:
   - The insulators (3)
   - The flat washers (2)
   - The nut (1)

   Tighten
   Tighten the lower shock absorber nut to 84 N.m (62 lb ft).
8. Remove the safety stands.
9. Lower the vehicle.



294158



201858

Wheel Hub, Bearing, and Seal Replacement (Drum Brakes)

Removal Procedure

1. Set the parking brake.
2. Block the vehicle rear wheels.
3. Lift the vehicle frame until the front tire is off the ground.

   Notice: Refer to *Crossmember Support Notice* in Cautions and Notices.
4. Support the frame using suitable safety stands.
5. Remove the front tire and wheel assembly. Refer to *Wheel Removal (Front)* in Tires and Wheels.
6. Remove the hub cap (3) and the gasket (4).
7. Remove the following components:
   - The cotter pin (6)
   - The adjusting nut (5)
   - The washer (7)

   Notice: Refer to *Do not let the bearing fall to the floor* in Cautions and Notices.
8. Pull the hub-and-drum assembly (10,11) part way off of the spindle of the steering knuckle (15). Remove the outer wheel bearing (8).

   Notice: Refer to *Spindle Damage Notice* in Cautions and Notices.
9. Remove the hub-and-drum assembly (10,11) straight off the spindle (15).
10. Remove the seal (14).
11. Remove the inner wheel bearing (13).
12. Remove the bearing cups.
    12.1. Insert a mild steel rod through the opposite end of the hub. Drive the rod against the inner edge of the cups.
    12.2. In order to avoid cocking the cups and damaging the inside of the hub, alternately drive the rod on opposite sides of the cups.
    12.3. Remove the brake drum (10) by removing the hub-to-drum bolts.
13. Refer to *Brake Drum Replacement* Replacement in Air Drum.

    Caution: If one stud is damaged, replace all the studs. A loose-running wheel may cause only one stud to break, but the other studs could have internal fatigue. Replacing only the broken stud and remounting the wheel may cause further damage and personal injury. If the stud holes in the wheels have become enlarged or distorted, replace the wheel.
14. Remove the wheel studs (11), if needed, using a press.

Inspection Procedure

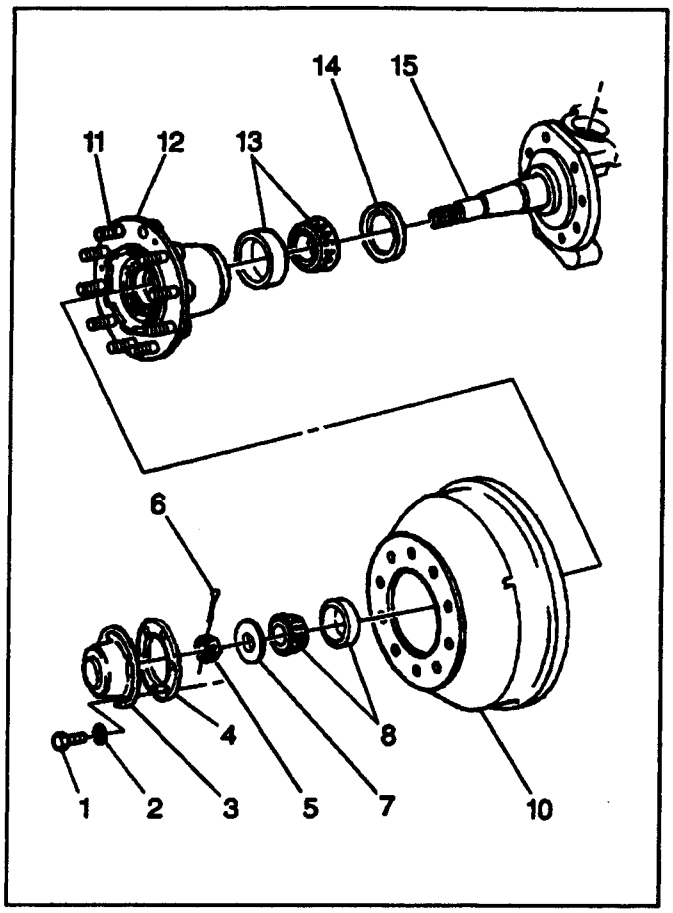
Caution: When servicing wheel brake parts, do not create dust by grinding or sanding brake linings or by cleaning wheel bearing parts with compressed air. Many wheel brake parts contain fibers that can become air borne if dust is created during servicing. Breathing dust containing fibers may cause serious bodily harm. A water dampened cloth or water based solution should be used to remove any dust on brake parts. Equipment is commercially available to perform this washing function. These wet methods will prevent fibers from becoming airborne.

Notice: Refer to *Spin the Bearings with Lubricant* in Cautions and Notices.

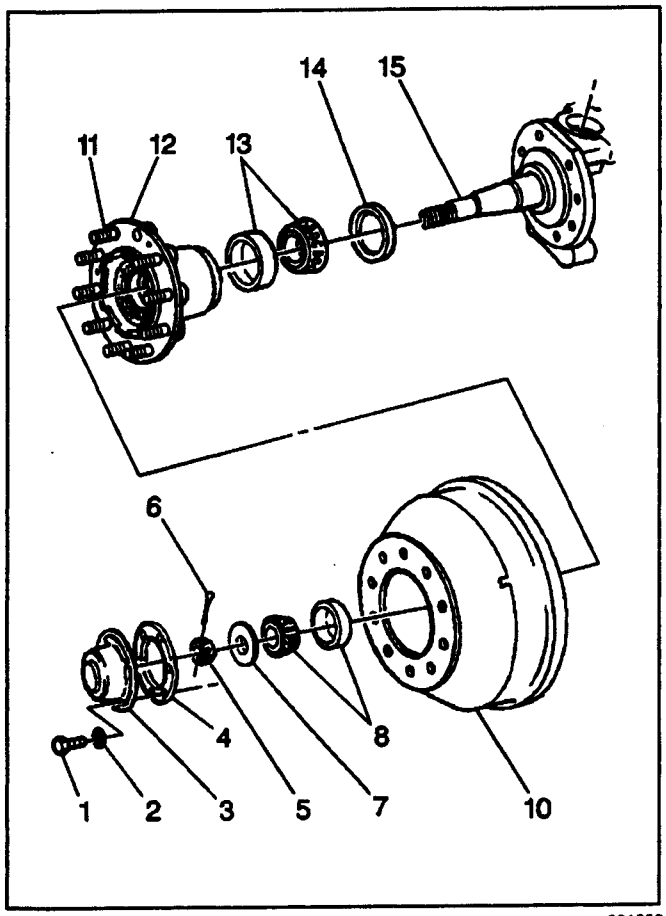
Notice: Refer to *Do Not Use Oil-Based Solvent* in Cautions and Notices.

1. Clean the bearings (8, 13) in a suitable solvent. Use a stiff brush in order to remove all of the old lubricant.
2. Clean inside the hub (12) and the drum (10) assembly. Thoroughly clean all of the lubricant out of the inside of the hub. Wipe dry.
3. Remove all of the gasket particles from the hub (3) outer end. Clean all of the sealing compound out of the oil seal bore in the hub inner end.

   Important: Keep the lubricant off of the drum (10) friction surface. Remove the lubricant with a suitable non-toxic, greaseless type of solvent. Wipe the surface clean with clean cloths.
4. Clean the steering knuckle spindle (15). Remove all lubricant with a cloth which has been soaked in solvent.
5. Clean the cap (3) in solvent. Blow dry. Remove all traces of the old gasket.
6. Clean the adjusting nut (5) and the washer (7) in solvent. Blow dry.
7. Clean the spindle shoulder and the hub bore. Remove all burrs and sharp edges with an emery cloth. Wipe clean with solvent.
8. Inspect the bearing cups for cracks and pits. Replace any cups that are cracked or pitted.
9. Inspect the cup fit in the hub. If the cups are loose or if the cups can be rotated in the bore, replace the hub.
10. Inspect the bearings (8, 13) for excessive wear, chipped edges, and other damage. Refer to *Wheel Bearings Diagnosis* in Suspension General Diagnosis.
11. Inspect the brake drum (10). Refer to *Air Drum Brake System Inspection* in Air Drum.
12. Inspect the wheel studs (11) for cracks or damaged threads.



201858

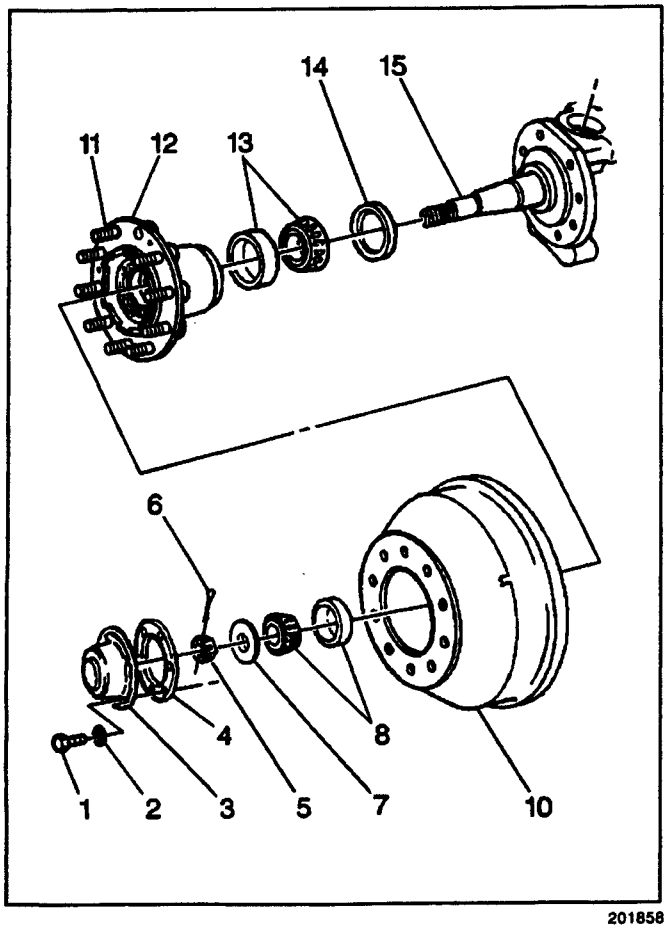


201858

Installation Procedure

Important: If all of the studs were removed, verify that the shield is in place, if used.

1. Install the wheel studs (11), if needed, using a press. Fit the studs tightly.
2. Install the brake drum (10). Refer to *Brake Drum Replacement* in Air Drum.
3. Install the bearing cups to the hub. Position each cup in the hub and drive the cup into place using a suitable driver or a brass drift against the outer edge of the cup. If you use a drift, alternately drive against the opposite side in order to drive the cup squarely. Cups must seat against the shoulder in the hub.
4. Install the wheel bearings.



201858

Oil or Grease Lubricated Wheel Bearing Installation

1. Whenever oil or grease is indicated in this procedure. Refer to *Fluid and Lubricant Recommendations* in Maintenance and Lubrication.

   Important:

   - Use a greasing machine, if available. If a greasing machine is not available, pack the bearings by hand. Thoroughly work the grease into the bearings, between the rollers, the core, and the cage.
   - Apply a thin coat of grease to the inside of the hub (12) and the spindle (15). DO NOT fill the hub with grease. A thin coat of grease 3 mm (1/8 in) thick will help to retard rusting. Allow some excess grease at the inside of the bearings and around the adjusting nut.
2. If the bearings are not oil lubricated, pack the bearings with high-temperature wheel bearing grease.
3. Install the inner bearing (13) to the hub (12).
4. Apply grease to the lips of the new seal.

5. Apply a thin layer of non-hardening sealing compound to the hub seal bore.

   Important: Face the seal lip inside the hub (12). Provide enough clearance between the seal (14) and the bearing (13) so that the bearing can rotate freely without rubbing against the seal.

6. Install the new seal (14) to the hub (12). Press the seal into the hub (12) until the seal seats against the bearing cup.
7. Install the hub (12) and the drum assembly (10) to the spindle (15). DO NOT damage the seal or the flange ring.
8. Install the outer wheel bearing (8).
9. Install the washer (7).
10. Install the adjusting nut (5).

    Important: DO NOT tighten the nut.

11. Install the front tire and wheel assembly. Refer to *Wheel Installation (Front)* in Tires and Wheels.
12. Adjust the front wheel bearings. Refer to *Wheel Bearing Adjustment.*
13. Install a new gasket (4). Install the hub cap (3).

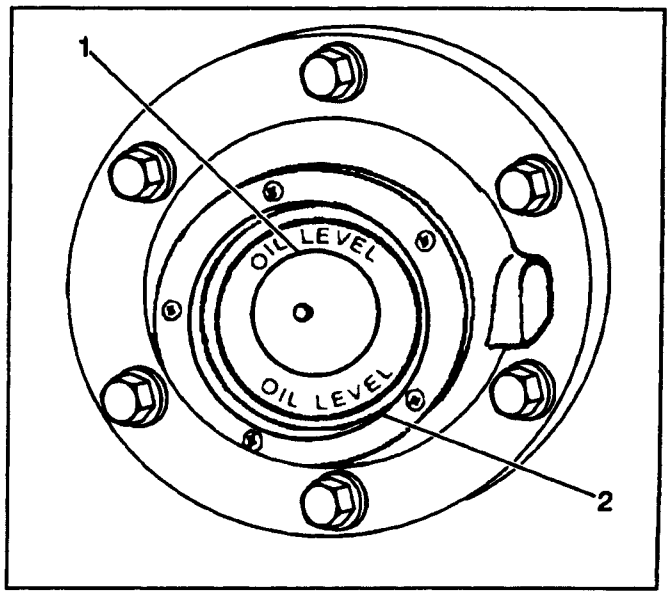
    Notice: Refer to *Fastener Notice* in Cautions and Notices.

14. Install the washers (2) and the bolts (1).

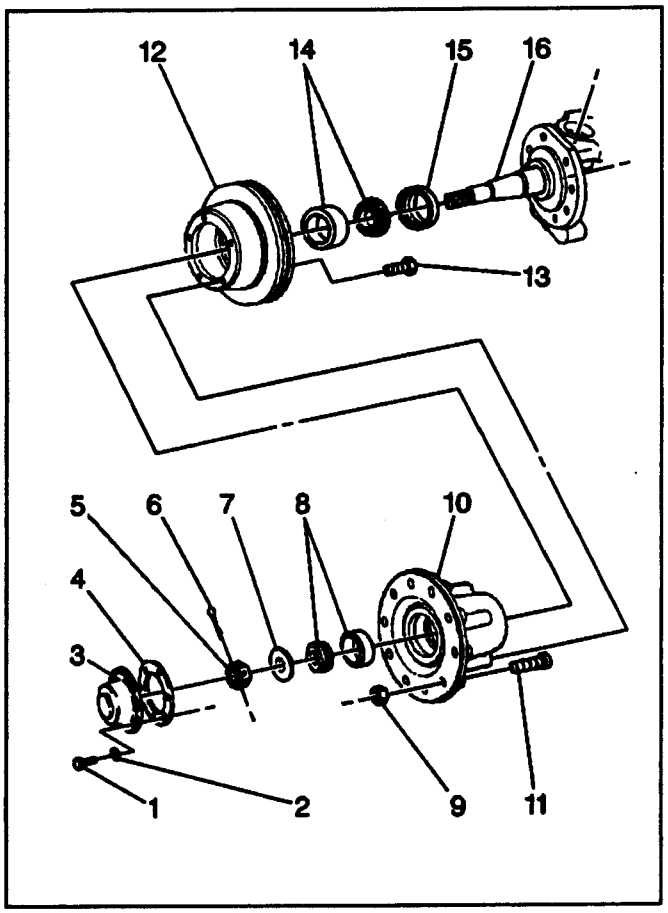
    Tighten

    Tighten the hub cap bolt (1) evenly to 13 N·m (115 lb in).

15. If oil lubrication is used, fill oil to the level on the window (2).
16. Install the window plug (1).
17. Adjust the brakes. Refer to *Brake Drum Replacement* in Air Drum.
18. Lower the vehicle.
19. Remove the blocks.



201869



201863

Wheel Hub, Bearing, and Seal Replacement (Disc Brakes)

Removal Procedure

1. Set the parking brake.
2. Block the vehicle rear wheels.
3. Lift the vehicle frame until the front tire is off the ground.

   Notice: Refer to *Crossmember Support Notice* in Cautions and Notices.
4. Support the frame using suitable safety stands.
5. Remove the front tire and wheel assembly. Refer to *Wheel Removal (Front)* in Tires and Wheels.
6. Remove the caliper assembly.
7. Refer to the appropriate procedure:
   - *Brake Caliper Replacement (Front, Bendix)*
   - *Brake Caliper Replacement (Front, Dayton-Walther)*
8. Remove the hub cap (3) and the gasket (4).
9. Remove the following components:
   - The cotter pin (6)
   - The adjusting nut (5)
   - The washer (7)

   Notice: Refer to *Do not let the bearing fall to the floor* in Cautions and Notices.
10. Pull the hub and rotor assembly (10,12) part way off of the spindle of the steering knuckle (16). Remove the outer wheel bearing (8).

    Notice: Refer to *Spindle Damage Notice* in Cautions and Notices.
11. Remove the hub and rotor assembly (10,12) straight off the spindle (16).
12. Remove the seal (15).
13. Remove the inner wheel bearing (14).
14. Remove the bearing cups.
    14.1. Insert a mild steel rod through the opposite end of the hub. Drive the rod against the inner edge of the cups.
    14.2. In order to avoid cocking the cups and damaging the inside of the hub, alternately drive the rod on opposite sides of the cups.
15. Remove the brake rotor (12) by removing the hub-to-rotor bolts (13).

    Caution: If one stud is damaged, replace all the studs. A loose-running wheel may cause only one stud to break, but the other studs could have internal fatigue. Replacing only the broken stud and remounting the wheel may cause further damage and personal injury. If the stud holes in the wheels have become enlarged or distorted, replace the wheel.
16. Remove the wheel studs (11), if needed, using a press.

Inspection Procedure

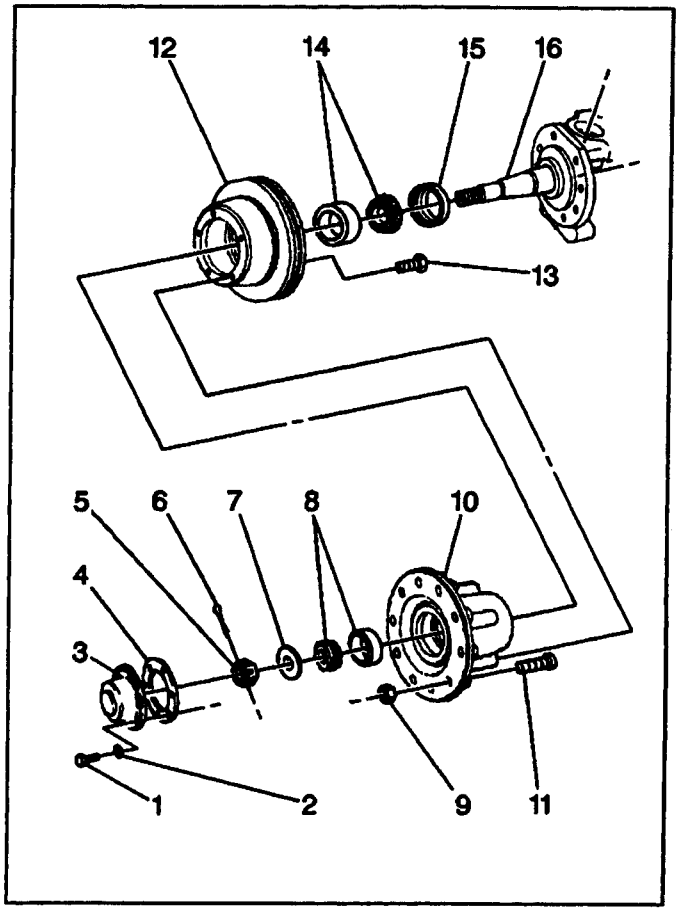
Caution: When servicing wheel brake parts, do not create dust by grinding or sanding brake linings or by cleaning wheel bearing parts with compressed air. Many wheel brake parts contain fibers that can become air borne if dust is created during servicing. Breathing dust containing fibers may cause serious bodily harm. A water dampened cloth or water based solution should be used to remove any dust on brake parts. Equipment is commercially available to perform this washing function. These wet methods will prevent fibers from becoming airborne.

Notice: Refer to *Spin the Bearings with Lubricant* in Cautions and Notices.

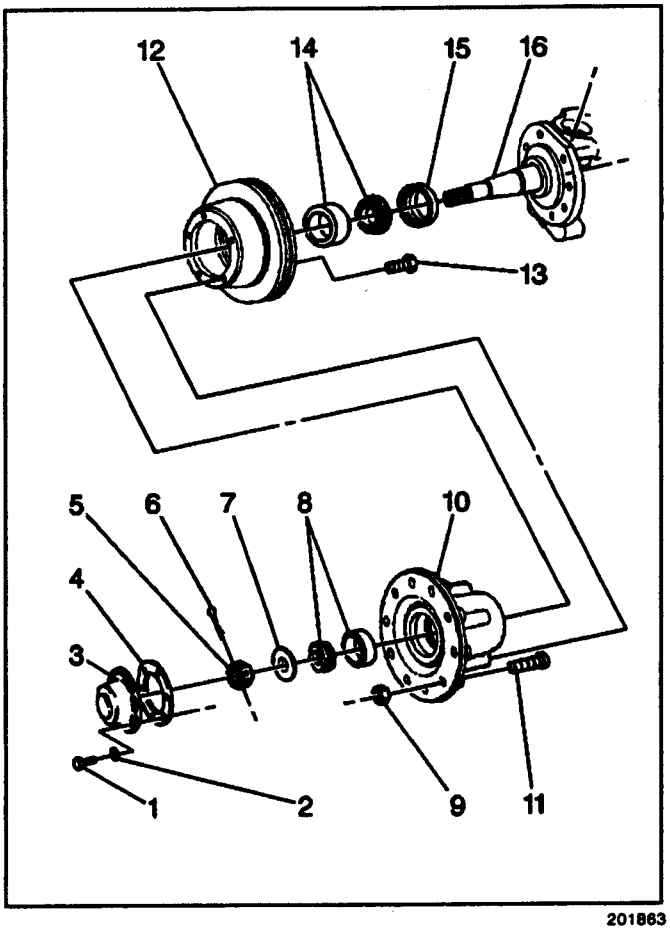
Notice: Refer to *Do Not Use Oil-Based Solvent* in Cautions and Notices.

1. Clean the bearings (8, 14) in a suitable solvent. Use a stiff brush in order to remove all of the old lubricant.
2. Clean inside the hub (10) and the disc (12) assembly. Thoroughly clean all of the lubricant out of the inside of the hub. Wipe dry.
3. Remove all of the gasket particles from the hub (10) outer end. Clean all of the sealing compound out of the oil seal bore in the hub inner end.

   Important: Keep the lubricant off of the disc (12) friction surface. Remove the lubricant with a suitable non-toxic, greaseless type of solvent. Wipe the surface clean with clean cloths.
4. Clean the steering knuckle spindle (16). Remove all lubricant with a cloth which has been soaked in solvent.
5. Clean the cap (3) in solvent. Blow dry. Remove all traces of the old gasket.
6. Clean the adjusting nut (5) and the washer (7) in solvent. Blow dry.
7. Clean the spindle shoulder (16) and the hub (10) bore. Remove all burrs and sharp edges with an emery cloth. Wipe clean with solvent.
8. Inspect the bearing cups for cracks and pits. Replace any cups that are cracked or pitted.
9. Inspect the cup fit in the hub. If the cups are loose or if the cups can be rotated in the bore, replace the hub.
10. Inspect the bearings (8, 14) for excessive wear, chipped edges, and other damage. Refer to *Wheel Bearings Diagnosis* in Suspension General Diagnosis.
11. Inspect the brake rotor (12). Refer to *Brake Rotor Thickness Variation Check* Brake Pad Inspection in Disc Brakes.
12. Inspect the wheel studs (11) for cracks or damaged threads.



201863

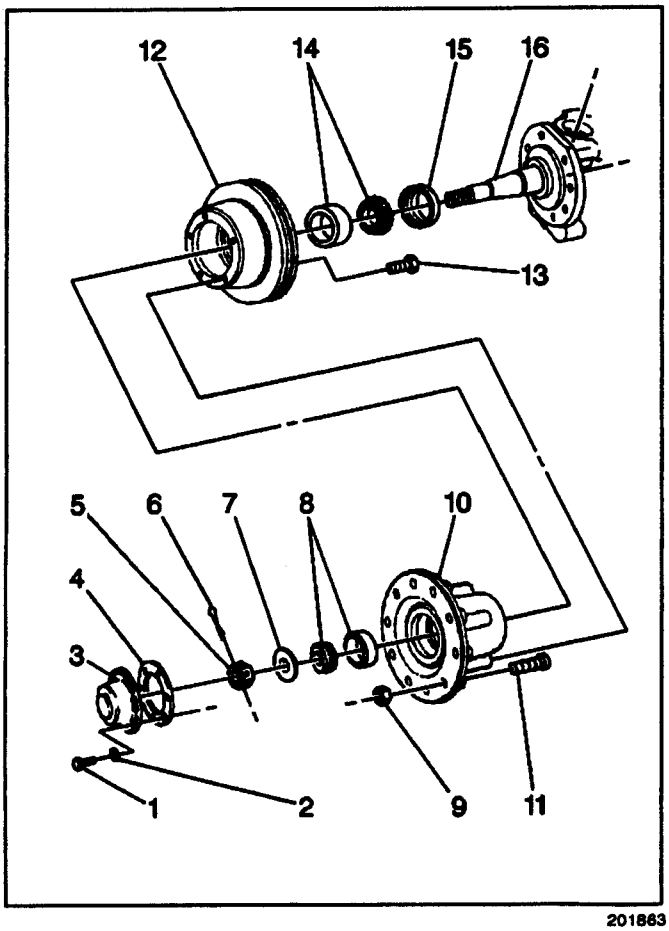


201863

Installation Procedure

Important: If all of the studs were removed, verify that the shield is in place, if used.

1. Install the wheel studs (11), if needed, using a press. Fit the studs tightly.
2. Install the brake rotor (12).
3. Install the bearing cups to the hub. Position each cup in the hub and drive the cup into place using a suitable driver or a brass drift against the outer edge of the cup. If you use a drift, alternately drive against the opposite side in order to drive the cup squarely. Cups must seat against the shoulder in the hub.
4. Install the wheel bearings.



201863

Oil or Grease Lubricated Wheel Bearing Installation

1. Whenever oil or grease is indicated in this procedure. Refer to *Fluid and Lubricant Recommendations* in Maintenance and Lubrication.

   Important:

   - Use a greasing machine, if available. If a greasing machine is not available, pack the bearings by hand. Thoroughly work the grease into the bearings, between the rollers, the core, and the cage.
   - Apply a thin coat of grease to the inside of the hub (10) and the spindle (16). DO NOT fill the hub with grease. A thin coat of grease 3 mm (1/8 in) thick will help to retard rusting. Allow some excess grease at the inside of the bearings and around the adjusting nut.
2. If the bearings are not oil lubricated, pack the bearings with high-temperature wheel bearing grease.
3. Install the inner bearing (14) to the hub (10).
4. Apply grease to the lips of the new seal.

5. Apply a thin layer of non-hardening sealing compound to the hub seal bore.

   Important: Face the seal lip inside the hub (10). Provide enough clearance between the seal (15) and the bearing (14) so that the bearing can rotate freely without rubbing against the seal.

6. Install the new seal (15) to the hub (10). Press the seal into the hub (10) until the seal seats against the bearing cup.
7. Install the hub (10) and the disc assembly (12) to the spindle (16). DO NOT damage the seal or the flange ring.
8. Install the outer wheel bearing (8).
9. Install the washer (7).
10. Install the adjusting nut (5).

    Important: DO NOT tighten the nut.

11. Install the caliper assembly.
12. Refer to the appropriate procedure:
    - *Brake Caliper Replacement (Front, Bendix)*
    - *Brake Caliper Replacement (Front, Dayton-Walther)* in Disc Brakes.
13. Install the front tire and wheel assembly. Refer to *Wheel Installation (Front)* in Tires and Wheels.
14. Adjust the front wheel bearings. Refer to *Wheel Bearing Adjustment* in this section.
15. Install a new gasket (4). Install the hub cap (3).

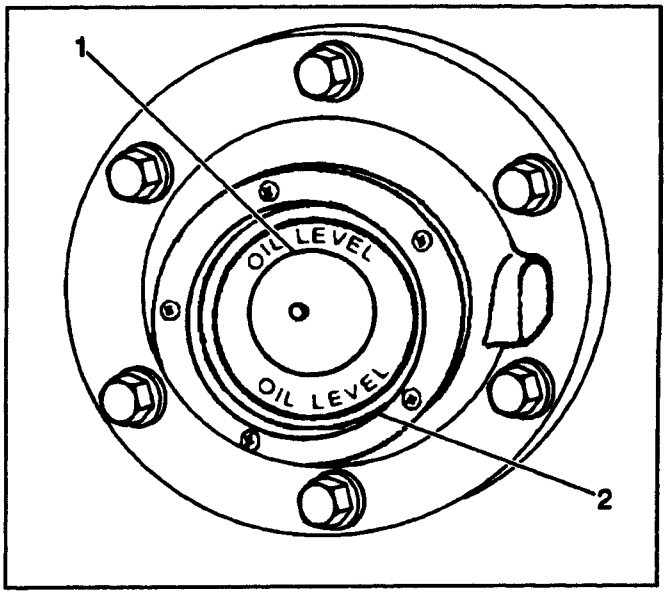
    Notice: Refer to *Fastener Notice* in Cautions and Notices.

16. Install the washers (2) and the bolts (1).

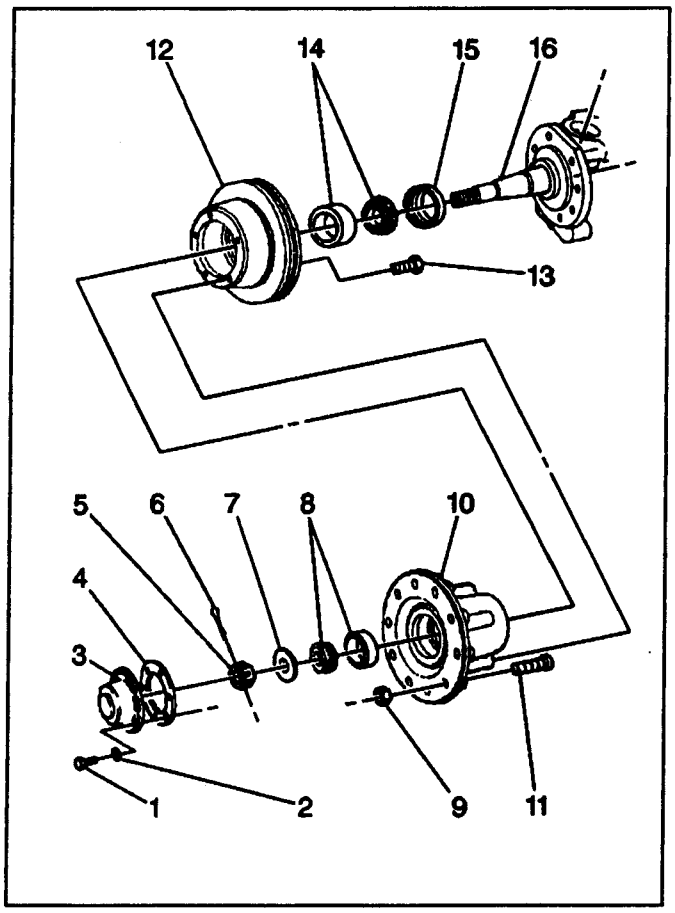
    Tighten

    Tighten the hub cap bolt (1) evenly to 13 N·m (115 lb in).

17. If oil lubrication is used, fill oil to the level on the window (2).
18. Install the window plug (1).
19. Lower the vehicle.
20. Remove the blocks.



201869

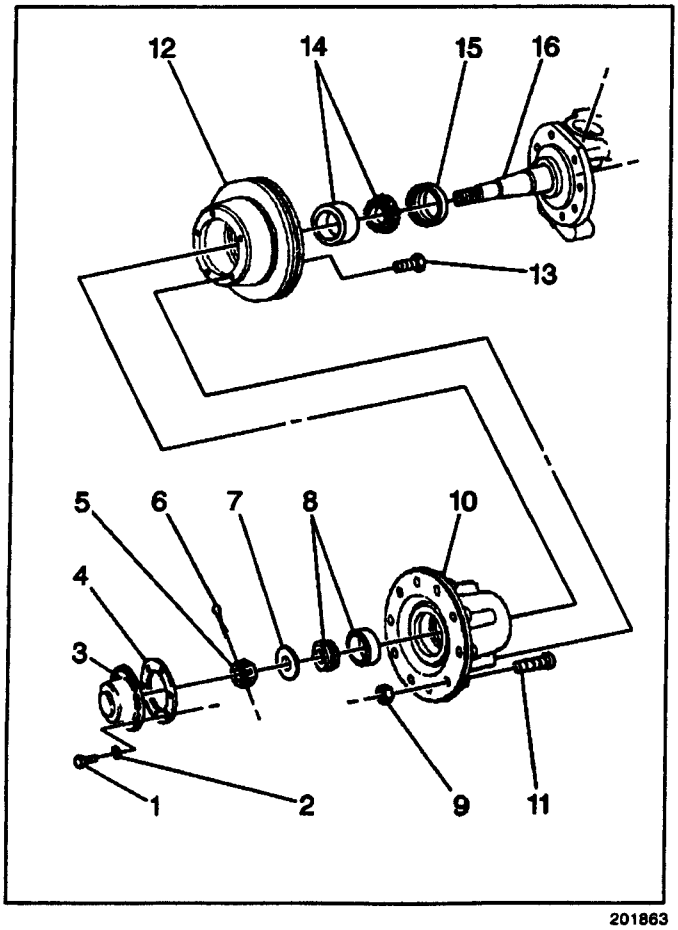


201863

Hub Cap Replacement

Removal Procedure

1. Place a suitable container under the hub cap in order to catch the oil.
2. Remove the bolts (1) and the washers (2).
3. Remove the hub cap (3) and the gasket (4). Do not allow gasket material to fall into the hub (10).



201863

Installation Procedure

1. Install a new gasket (4) and the hub cap (3) onto the hub (10). Align the gasket properly.

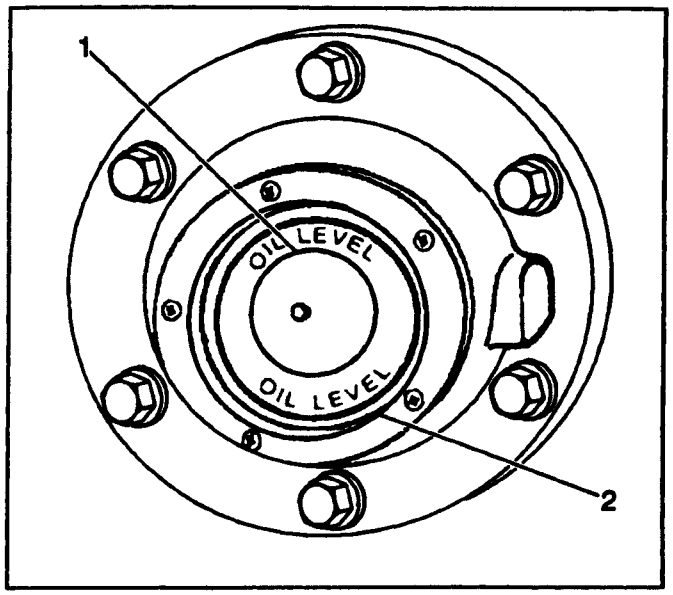
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the bolts (1) and new washers (2).

   Tighten

   Tighten bolts evenly to 13 N·m (115 lb in).
3. Install new lubricant. Refer to *Adding Lubricant to Hub Caps.*

Adding Lubricant to Hub Caps

1. With the vehicle in a level position, the oil level should be at the oil level line.
2. If oil is required, remove the rubber window plug (1).
3. Add lubricant until the fluid is level with the oil level line. Refer to *Fluid and Lubricant Recommendations* in Maintenance and Lubrication.



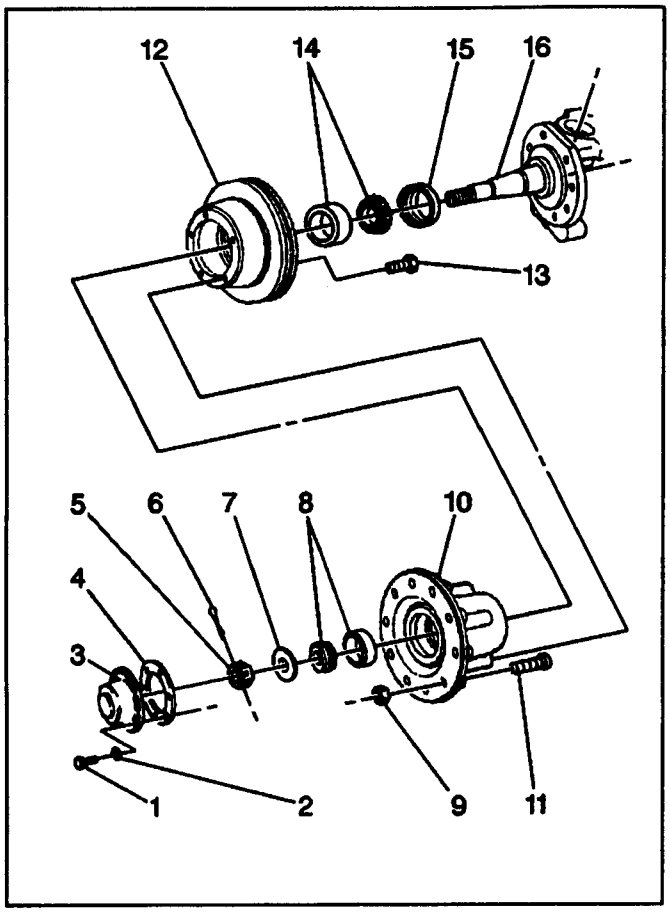
201869

Wheel Bearing Adjustment

Removal Procedure

1. Set the parking brake.
2. Block the vehicle rear wheels.
3. Lift the vehicle frame until the front tire is off the ground.

   Notice: Do not use the front crossmember to support the vehicle or the crossmember may buckle.
4. Support the frame using suitable safety stands.



201863

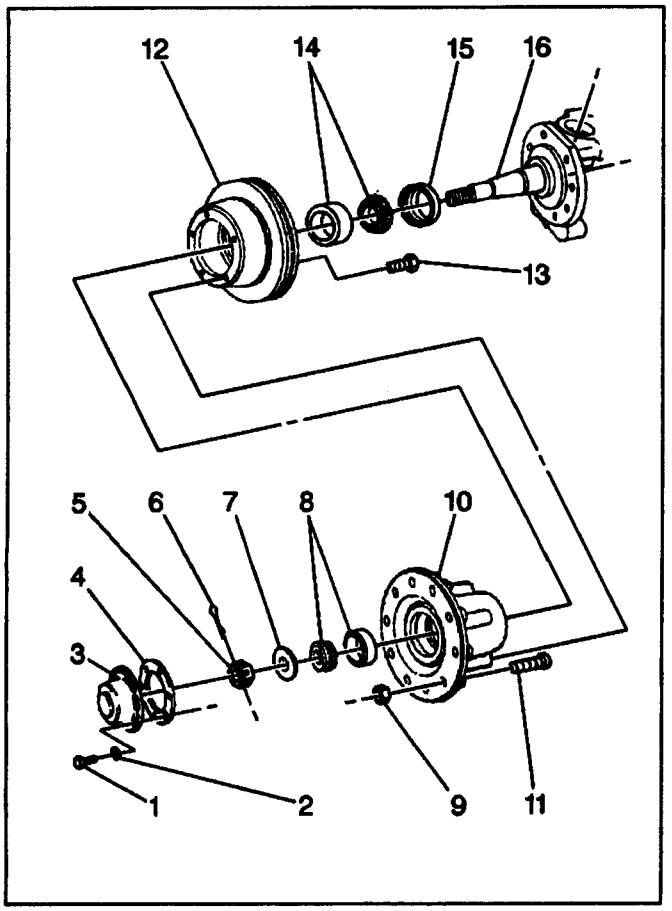
5. Remove the bolts (1) and the washers (2). (The illustration shows a wheel hub with disc brakes, but you will perform the bearing adjustment in the same manner for any kind of axle.)
6. Remove the hub cap (3) and the gasket (4). DO NOT allow the gasket material to fall into the hub, where applicable.
7. Remove the cotter pin (6).

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
8. Adjust the nut (5).

   Tighten

   Tighten the nut to 153 N·m (113 lb ft) while rotating the wheel 360 degrees in both directions. This rotation will correctly position the bearings.

   Important: Always back off the nut 1/4–1/6 turn. This adjustment should result in bearing end play of 0.025–0.200 mm (0.001–0.008 in).
9. Back off the nut 1/4–1/6 turn until the slot in the nut lines up with hole in the spindle (16) of the steering knuckle.



201863

Installation Procedure

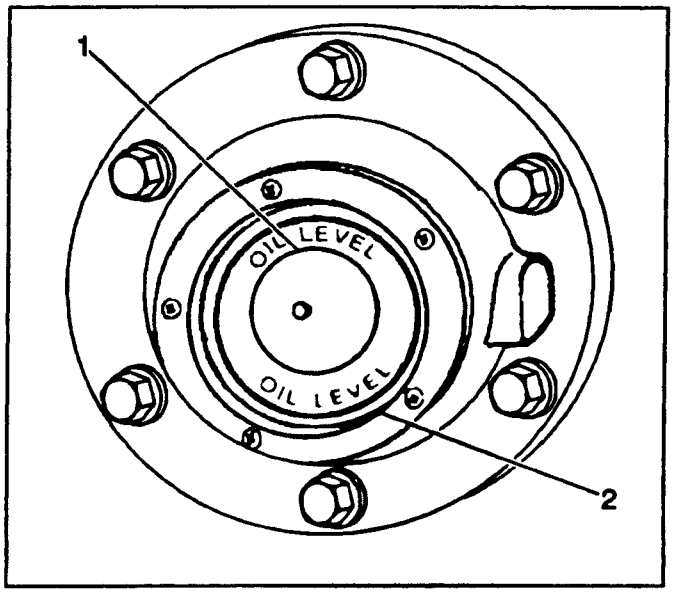
1. Install a new cotter pin (6). Bend the cotter pin for proper clearance of the rotating components.
2. Install a new gasket (4) and align the gasket properly. Attach the hub cap (3).

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
3. Install the hub cap bolts (1) with new washers (2).

   Tighten

   Tighten the hub cap bolts evenly to 13 N·m (115 lb in).

4. Add new lubricant to the oil lubricated bearings only. Refer to *Adding Lubricant to Hub Caps.*
5. Remove the safety stands.
6. Lower the vehicle.

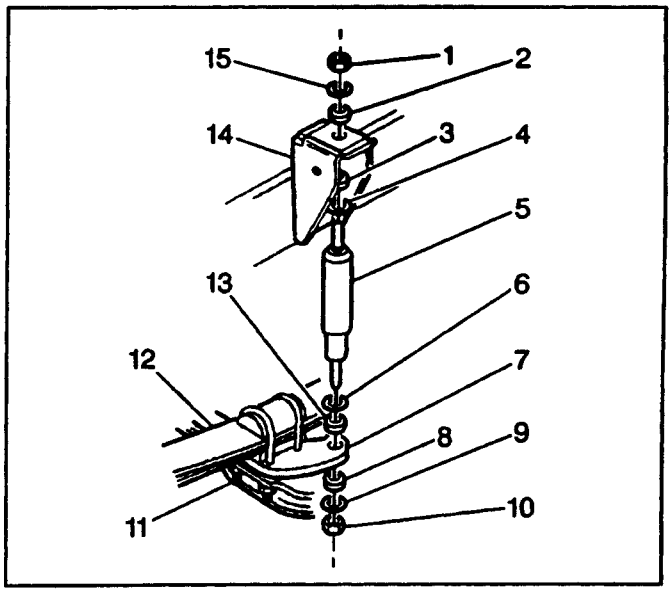


201869

Shock Absorber Replacement

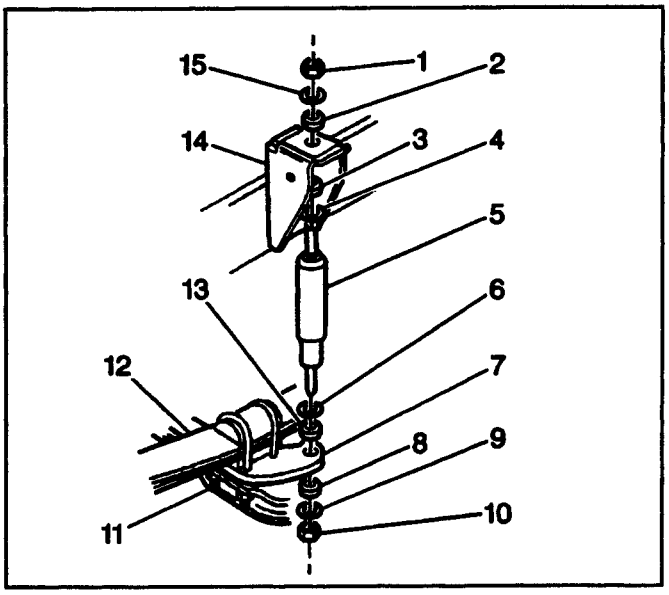
Removal Procedure

1. Set the parking brake.
2. Block the vehicle wheels.
3. Remove the following components from the shock absorber (5) at the lower bracket (7):
   - The nut (10)
   - The flat washer (9)
   - The insulator (8)
4. Remove the following components from the shock absorber at the upper bracket (14):
   - The nut (1)
   - The flat washer (15)
   - The insulator (2)
5. Remove the shock absorber (5) from the upper and the lower mounting brackets. Compress the shock absorber slightly in order to remove.
6. Remove the remaining flat washers (4,6) and the insulators (3,13).
7. Clean the shock absorber of the following conditions:
   - Dirt
   - Oil
   - Corrosion
8. Inspect the shock absorber for the following conditions:
   - Wear
   - Cracks
   - Damage
   - Signs of leaking
   - A bent damper rod
   - Worn or torn insulators



201719

9. Inspect the upper and the lower mounting brackets for the following conditions:
   - Cracks
   - Bends
   - Wear
   - Damage
10. Inspect the frame mounting hole for the following conditions:
   - Cracks
   - Wear
   - Burrs
11. Diagnose the shock absorbers.
12. Refer to the appropriate procedure:
   - *Struts or Shock Absorbers Bench Test*
   - *Struts or Shock Absorbers On-Vehicle Testing*



201719

Installation Procedure

1. Install the flat washer (6) and the insulator (13) onto the shock absorber lower stem.
2. Install the shock absorber lower stem into the lower mounting bracket (7).
3. Install the flat washer (4) and the insulator (3) onto the shock absorber upper stem.
4. Install the shock absorber upper stem into the upper mounting bracket (14).

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
5. Install the following components onto the shock absorber lower stem:
   - The insulator (8)
   - The flat washer (9)
   - The nut (10)

   Tighten

   Tighten the lower shock absorber nuts (10) to 84 N.m (62 lb ft).
6. Install the following components onto the shock absorber upper stem:
   - The insulator (2)
   - The flat washer (15)
   - The nut (1)

   Tighten

   Tighten the upper shock absorber nuts (1) to 84 N.m (62 lb ft).
7. Lower the vehicle.
8. Remove the blocks.

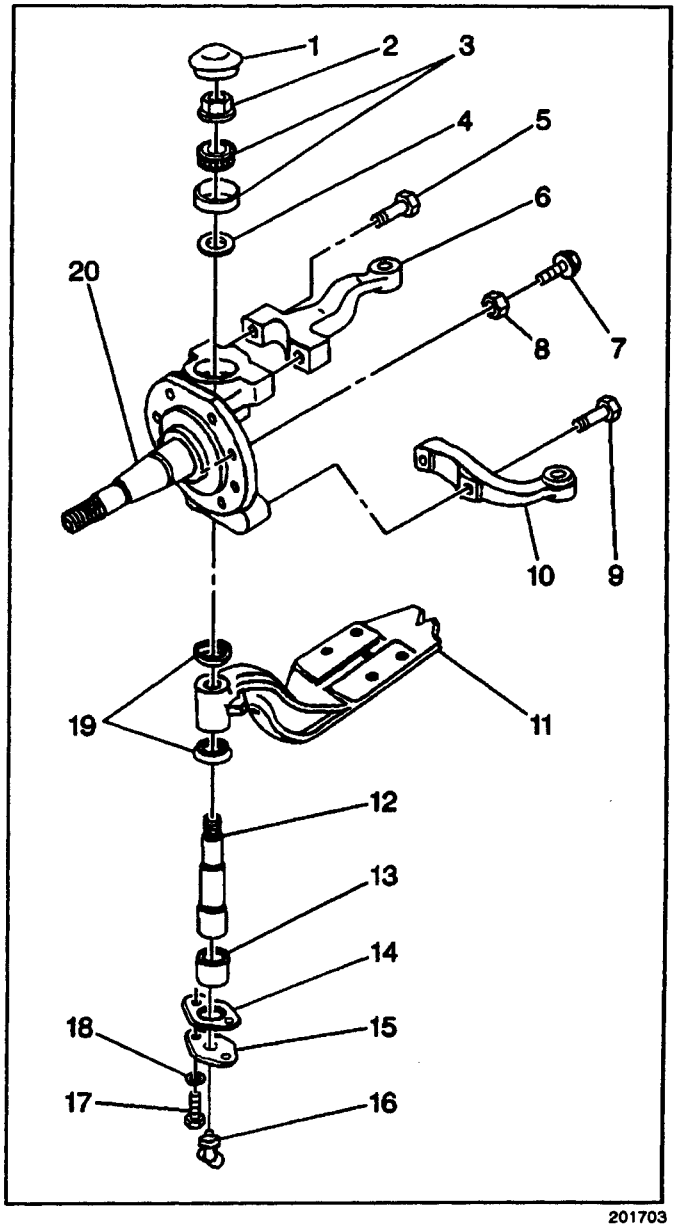
King Pin Bushing and Bearing Cup Replacement

Removal Procedure

Tools Required

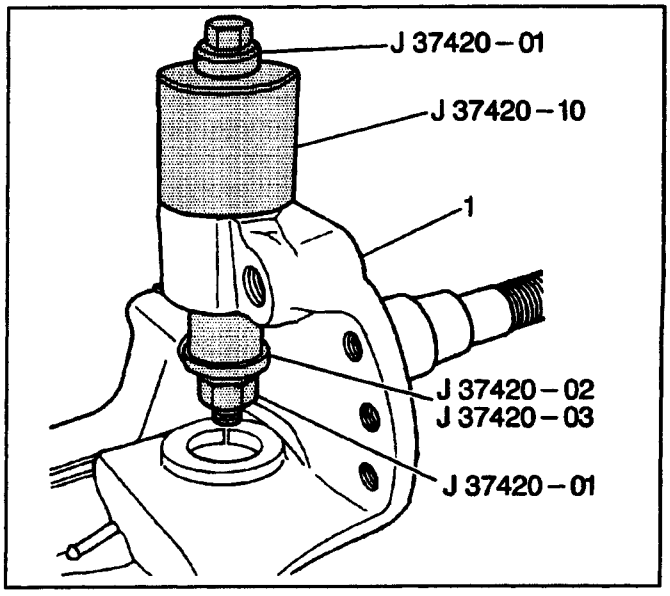
- *J 37420* Steering Knuckle Service Set
- *J 39758* King Pin Holding Tool

1. Remove the steering knuckle (20) and the king pin (12). Refer to *Steering Knuckle and King Pin Replacement*
2. Clamp the knuckle in a vise.

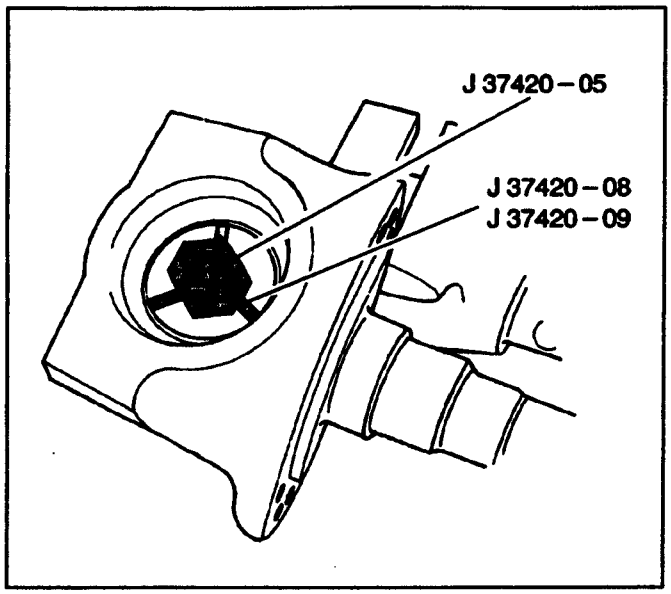


201703

3. Remove the king pin bushing from the steering knuckle (1). Use components of the *J 37420* shown in the illistration



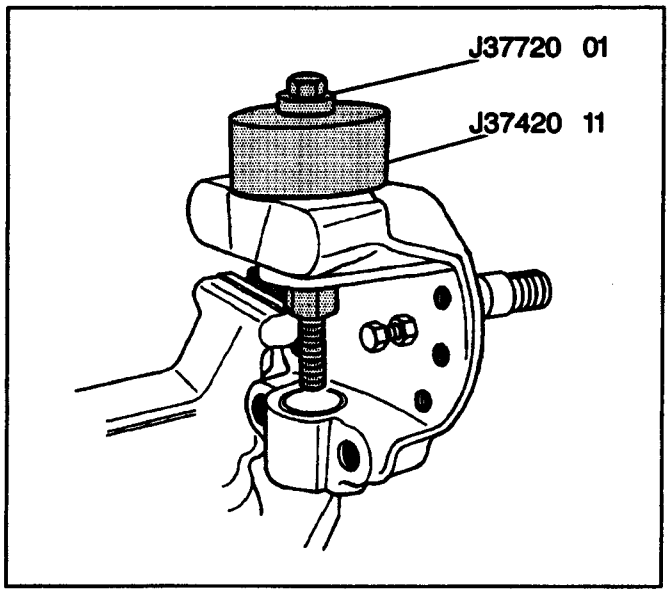
201708



201710

Notice: Refer to *Fastener Notice* in Cautions and Notices.

4. In order to remove the king pin bearing cup, assemble components of *J 37420.* First install *J 37420* -08 (or *J 37420* -09), *J 37420* -05 and *J 37420* -04 , (not shown in the illustration).
   Tighten
   Tighten the nut to 27 N.m (20 lb ft).



201712

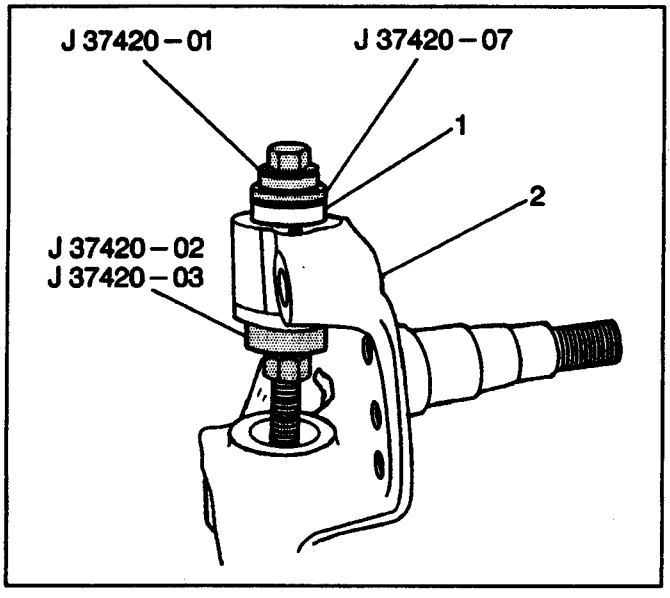
5. Remove the king pin bearing cup using the *J 37420* -11 and the *J 37420* -01 screw (you will not use the nut in this task).

Installation Procedure

Tools Required

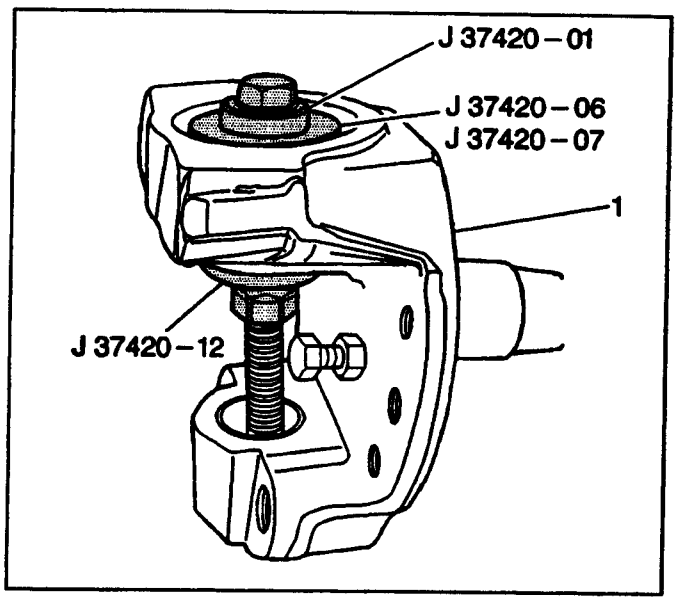
- *J 37420* Steering Knuckle Service Set
- *J 35999* Tension Scale

1. Install the king pin bushing (1) onto the steering knuckle (2). Use components of the *J 37420.*



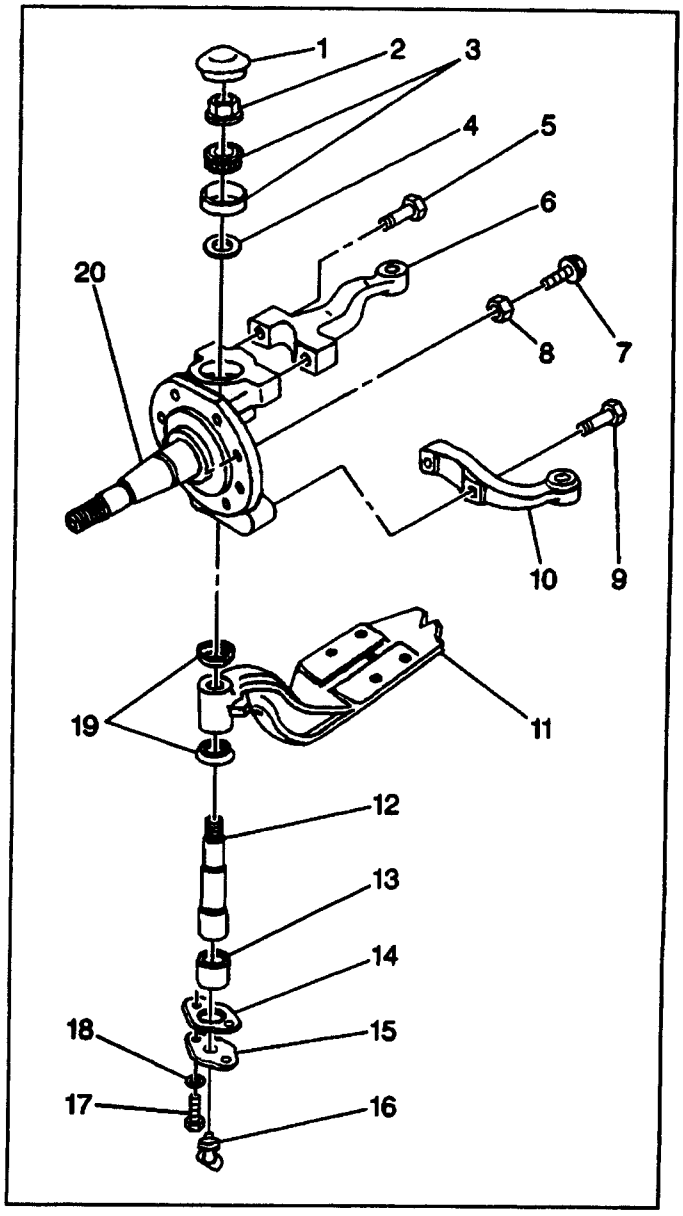
201714

2. Install the king pin bearing cup onto the steering knuckle (1). Use components of the *J 37420* as shown in the illustration.

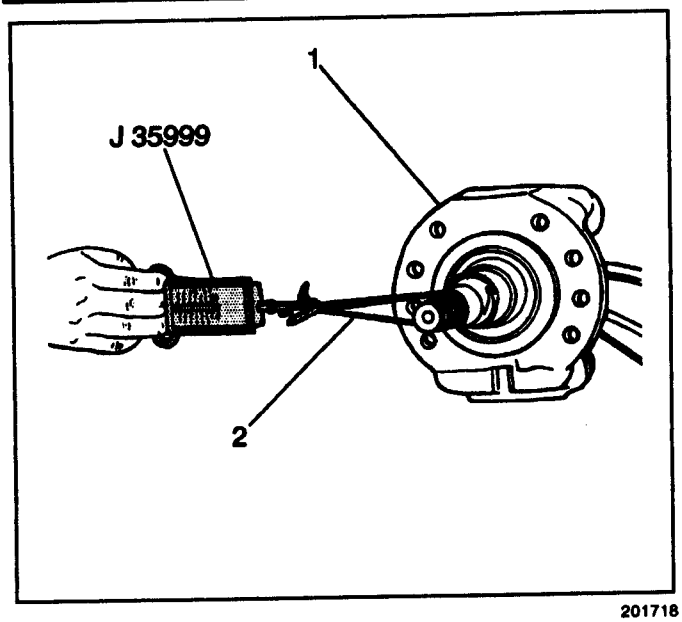


201716

3. Install the knuckle (20) and the king pin (12).



201703



201718

4. Measure the king pin bearing preload, using the *J 35999*. Refer to *King Pin Bearing Preload*

King Pin Upper Bearing Repack

Removal Procedure

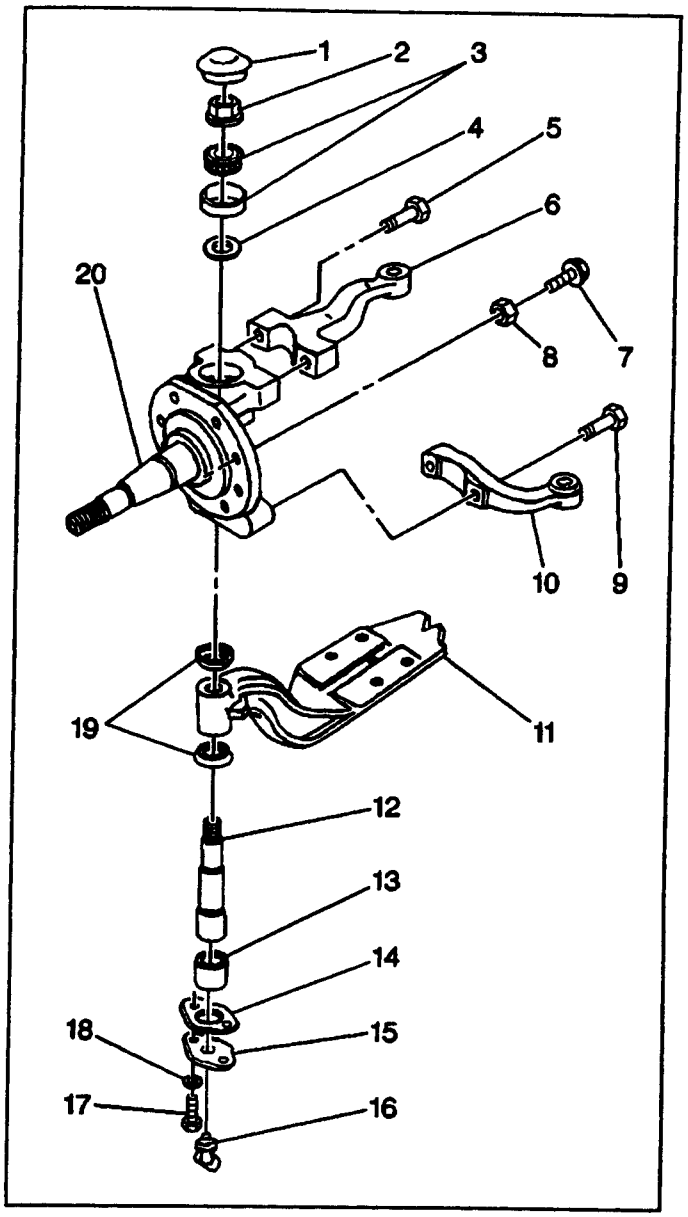
Tools Required

J 39758 King Pin Holding Tool

1. Set the parking brake.
2. Block the vehicle rear wheels.
3. Raise the vehicle frame until the front tires clear the floor.

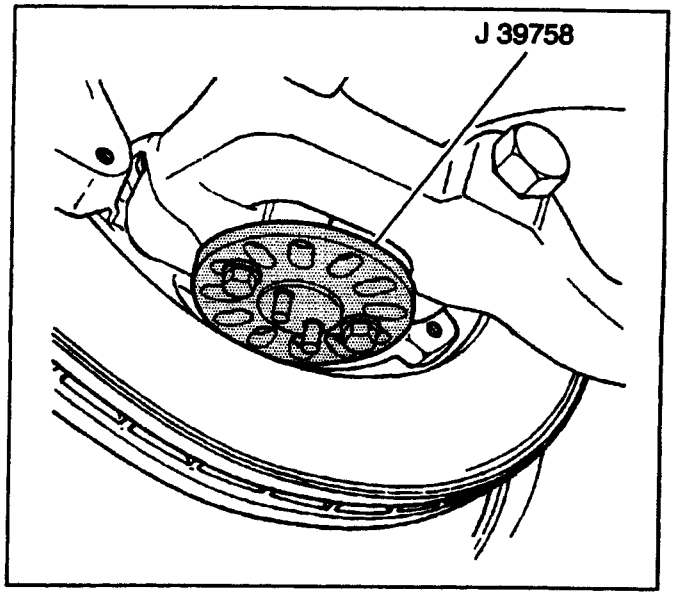
   Notice: Refer to *Crossmember Support Notice* in Cautions and Notices.
4. Support the frame using suitable safety stands.
5. Remove the wheels, the hubs, and the bearings. Refer to *Wheel Hub, Bearing, and Seal Replacement (Drum Brakes)* or *Wheel Hub, Bearing, and Seal Replacement (Disc Brakes)* in this section.
6. Remove the brake components as needed. Refer to Brake Caliper Replacement (Front, Bendix) or to Brake Caliper Replacement (Front, Dayton-Walther) in Disc Brakes.
7. Remove the brake backing plates and the dust covers.

8. Remove the upper king pin dust cap (1).

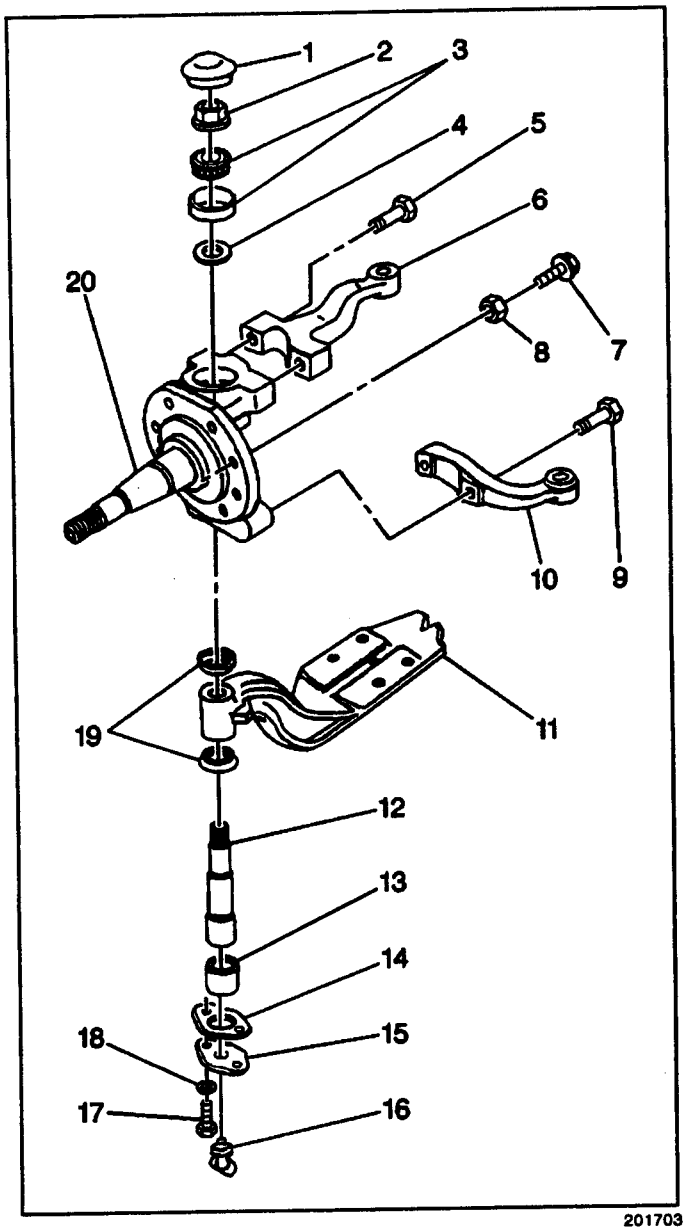


201703

9. In order to remove the king pin nut, use the *J 39758.*
10. Insert the tool pins into the holes at the bottom of the king pin.
11. Align the tool's bolt holes and secure the tool with two bolts into the steering knuckle. This will keep the king pin from spinning.



201706



201703

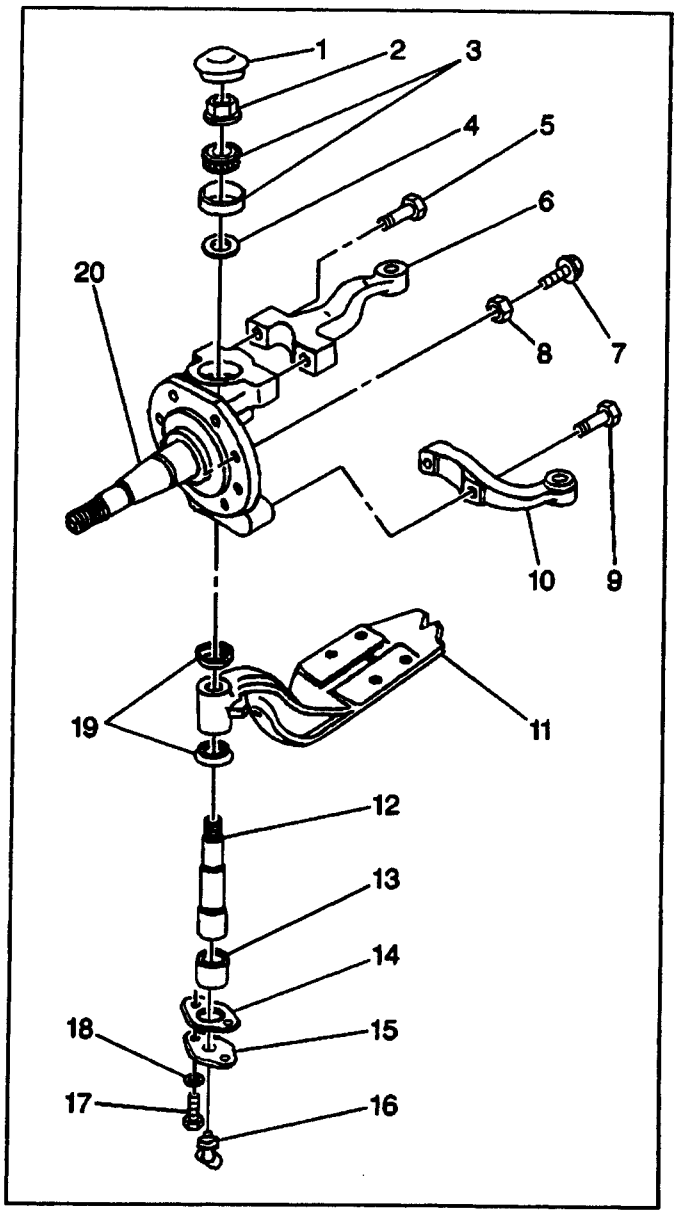
12. Remove the king pin nut (2).
13. Remove the king pin bearing-and-cup assembly (3).
14. Clean the following components using cleaning solvent:
    - The king pin nut
    - The bearing. Soak the bearing until all of the old lubricant is gone.
    - The cavity

Installation Procedure

Tools Required

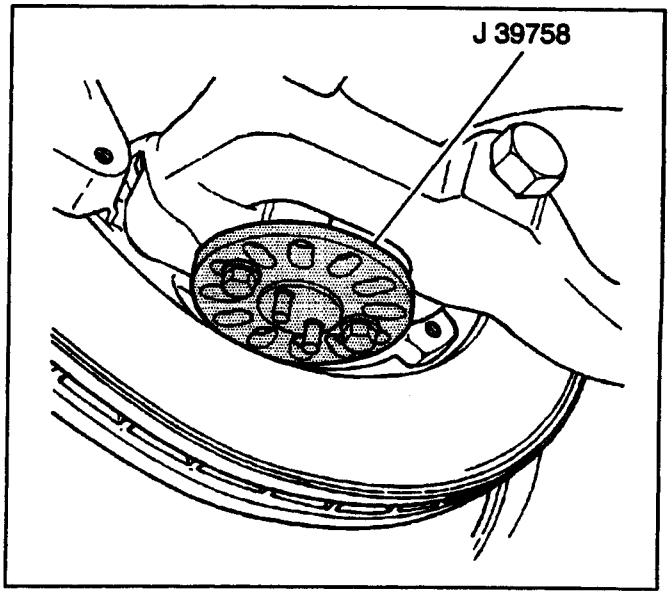
- *J 35999* Tension Scale
- *J 39758* King Pin Holding Tool

1. Pack the cavity and the king pin thrust bearing (3) using high-temperature wheel bearing grease.
2. Install the king pin bearing (3).

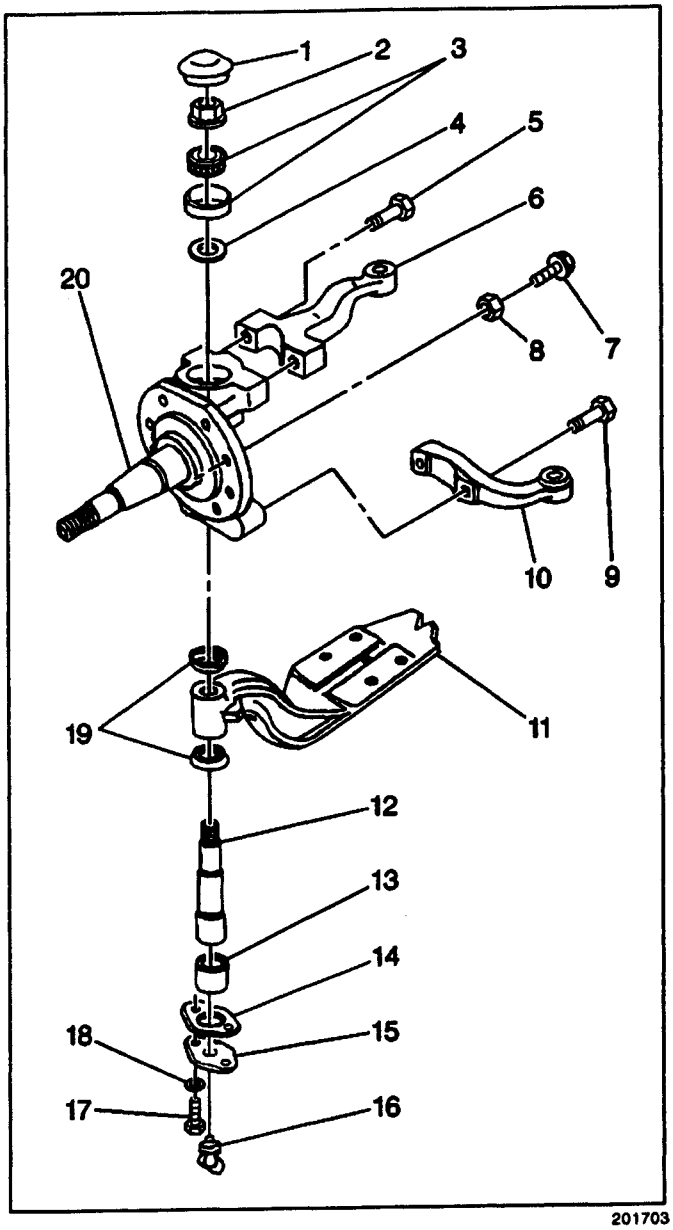


201703

3. In order to install the king pin nut, use the *J 39758*.
4. Insert the tool pins into the holes at the bottom of the king pin.
5. Align the tool's bolt holes and secure the tool with two bolts into the steering knuckle. This will keep the king pin from spinning.



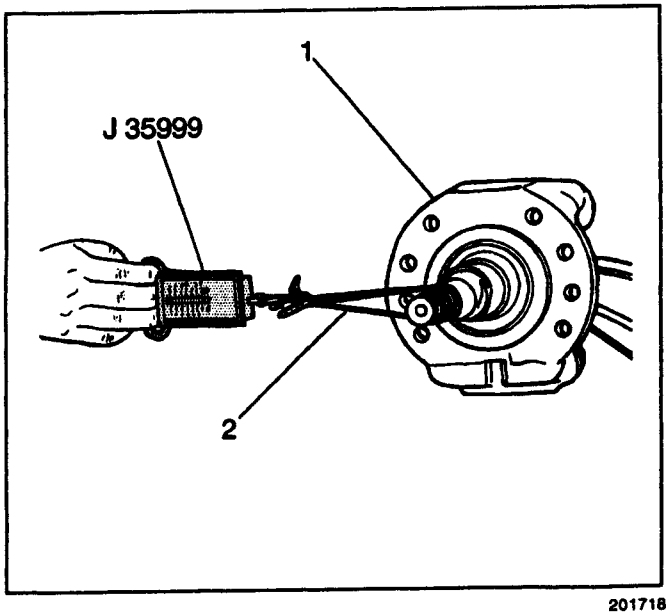
201706



201703

Notice: Refer to *Fastener Notice* in Cautions and Notices.

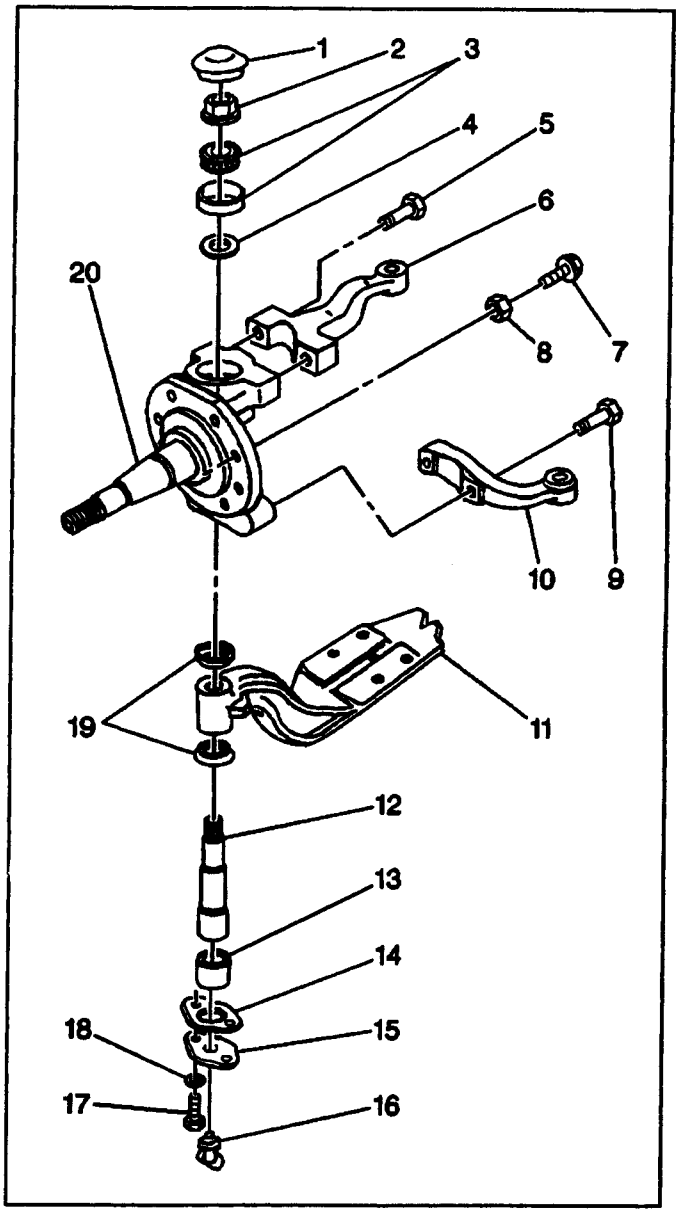
6. Install the king pin nut (2).
   Tighten
   Tighten the king pin nut to 550 N·m (406 lb ft).



201718

7. Use the *J 35999* in order to measure the king pin bearing preload. Refer to *King Pin Bearing Preload.*

8. Install the dust cap (15) and install the snap ring.
9. Install the following parts:
   - The bottom gasket
   - The cap
   - The washers and the bolts
10. Install the lower king pin cap bolt (17).
    Tighten
    Tighten the lower king pin cap bolt to 24 N·m (18 lb ft).
11. Lower the vehicle.
12. Remove the blocks.



201703

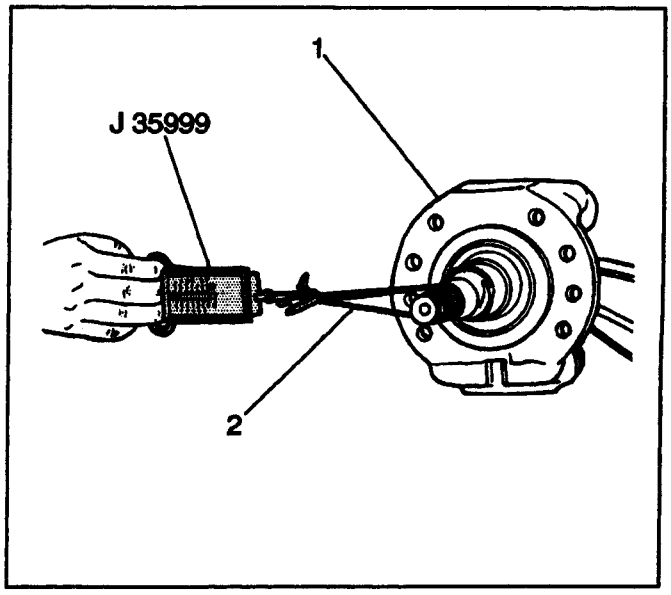
King Pin Bearing Preload

Adjustment Procedure

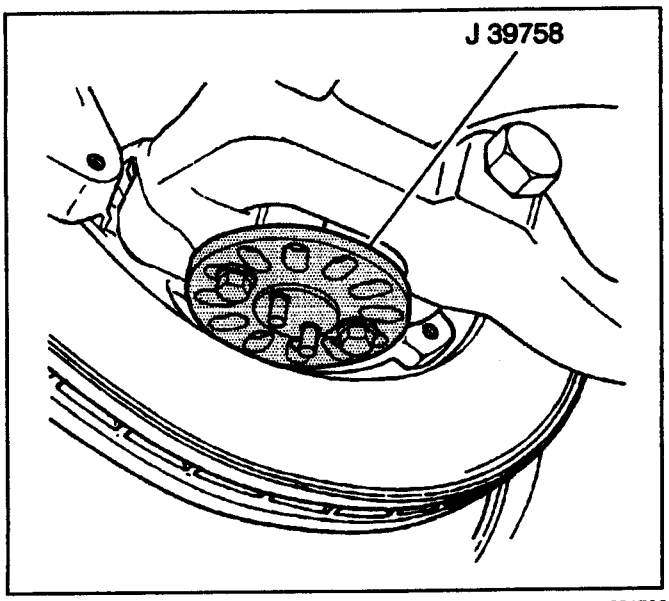
Tools Required

- *J 35999* Tension Scale
- *J 39758* King Pin Holding Tool

1. Check the king pin bearing or steering knuckle preload torque. Use the *J 35999* and a piece of string.
2. Place the string (2) on the steering knuckle (1) at the point where the threads meet the spindle.
3. Pull the knuckle from lock position to lock position. Note the scale reading, ignoring the force needed to start the rotation.
   Reading
   The correct reading on the *J 35999* should be 10–50 N·m (8–37 lb ft). If the reading is outside of these limits, change the shim thickness.

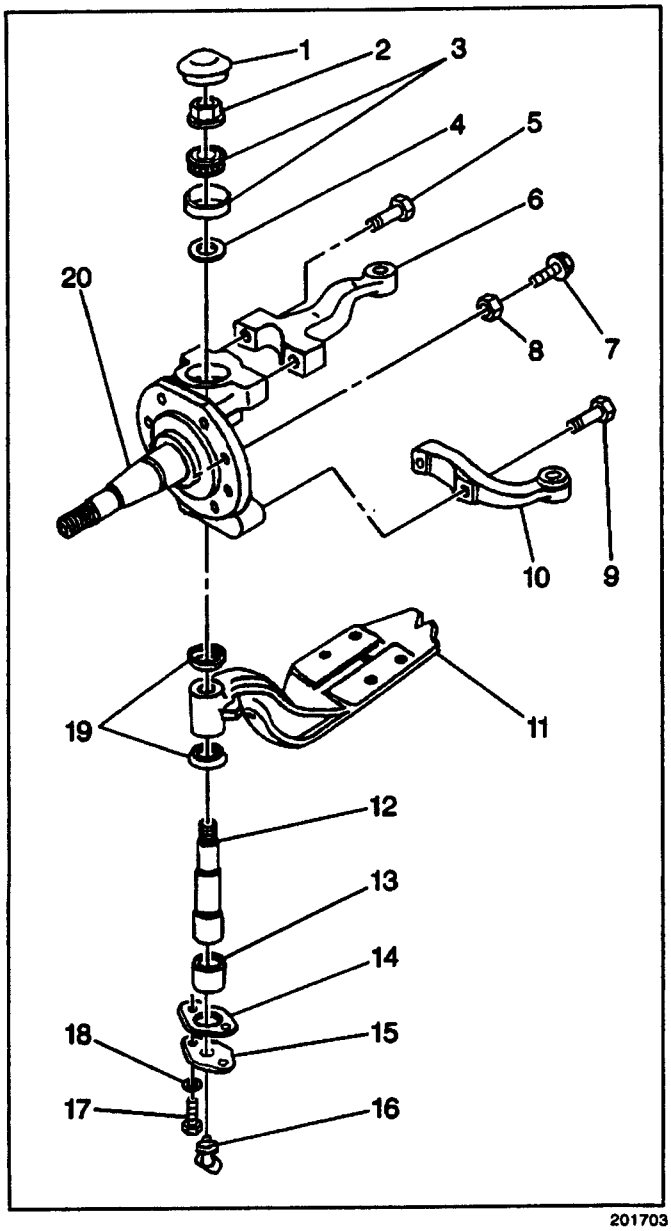


201718



201706

4. In order to change the shim, you must first remove the king pin nut. Use the *J 39758* and refer to *Steering Knuckle and King Pin Replacement.*



201703

5. Change the thickness of the shim (4).
   - In order to increase the torque, reduce the shim thickness.
   - In order to decrease the torque, increase the shim thickness.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
6. Check the king pin nut (2) for correct torque specification.

   Tighten

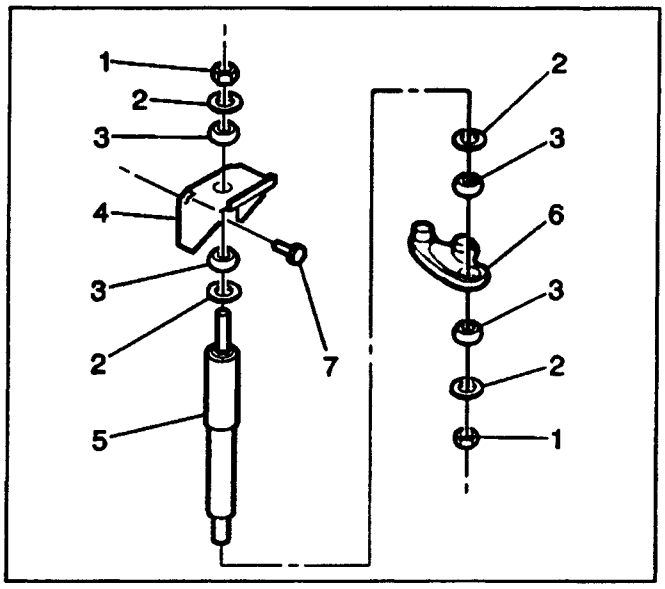
   Tighten the king pin nut (2) to 550 N·m (406 lb ft).

Front Axle Replacement

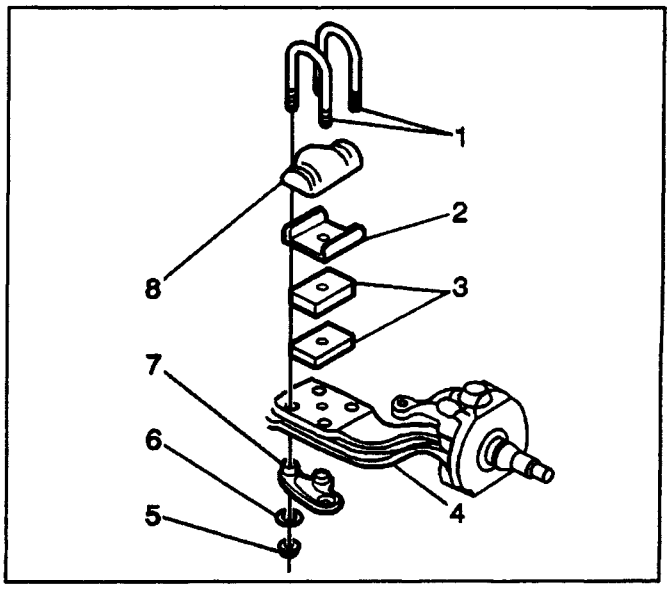
Removal Procedure

1. Set the parking brakes
2. Block the vehicle rear wheels.
3. Raise the vehicle frame until the front tires clear the floor.

   Notice: Refer to *Crossmember Support Notice* in Cautions and Notices.
4. Support the frame using suitable safety stands.
5. Remove the wheels, the hubs, and the bearings as needed
6. Refer to the appropriate procedure:
   - *Wheel Hub, Bearing, and Seal Replacement (Drum Brakes)*
   - *Wheel Hub, Bearing, and Seal Replacement (Disc Brakes)*
7. Remove the relay rod from the steering arm. Refer to *Relay Rod Replacement* in Steering Linkage.
8. Remove the tie rod arm. Refer to *Tie Rod Arm Replacement* in Steering Linkage.
9. Remove the brake lines and the hoses as needed from each front brake assembly.
10. Remove the following components from the lower brackets (6). Push the shock absorbers into the fully retracted position:
    - The nuts (1)
    - The washers (2)
    - The insulators (3)
    - The shock absorbers (5)
11. Remove the lower insulator (13) and the washers (6) from the shock absorber lower stem.
12. Remove the nuts (7), the washers (6) and the U-bolts (1).
13. Lower the axle partially and remove the U-bolt spacers.
14. Remove the following components:
    - The spring spacers (2).
    - The spacers (3).
    - The shock absorber brackets (5).
15. Remove the axle tie rod from under the vehicle.
16. Clean the axle components using a cleaning solvent.

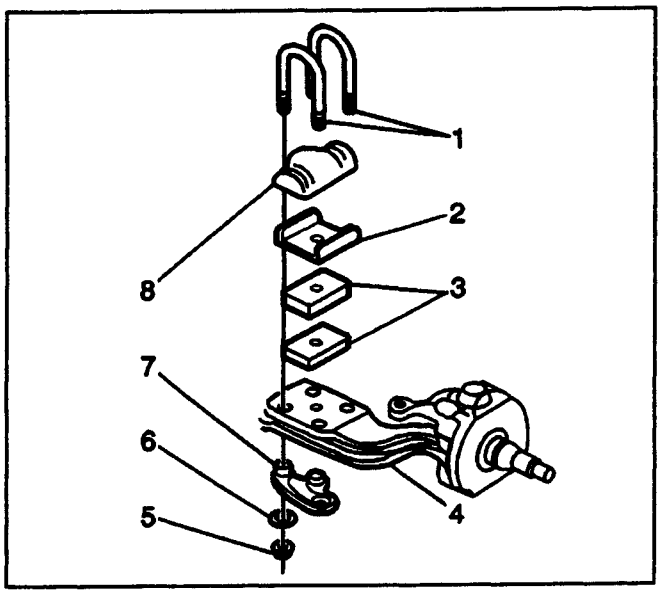


294158



294161

17. Inspect the axle for wear and damage. Use Magna-Flux™ inspection equipment if available. Inspect the axle for the following conditions:
    - Minute cracks
    - Checks
    - Fractures
18. Using alignment instruments, inspect the axle center for twist. If the axle center has been twisted or bent more than 5 degrees (13 mm or 1/2 in) from the original shape, replace the axle.
19. Inspect the axle king pin bore for the following conditions:
    - Scratches
    - Burrs
    - Corrosion
20. Smooth the bore using a crocus cloth or a fine grit sandpaper if needed. Clean the bore.



294161

Installation Procedure

1. With the vehicle on a floor jack, install the axle tie rod.
2. Raise the axle and align the spring center bolt to the axle.
3. Install the following components:
    - The spring spacers (2)
    - The spacers (3)

    Notice: Refer to *Fastener Notice* in Cautions and Notices.

    Important: Assemble all of the components and remove all of the jacks and lifting devices before you finally tighten the suspension fasteners.
4. Install the following components:
    - The U-bolts (1)
    - The U-bolt spacers.
    - The shock brackets (6).
    - The washers (6).
    - The nuts (7).

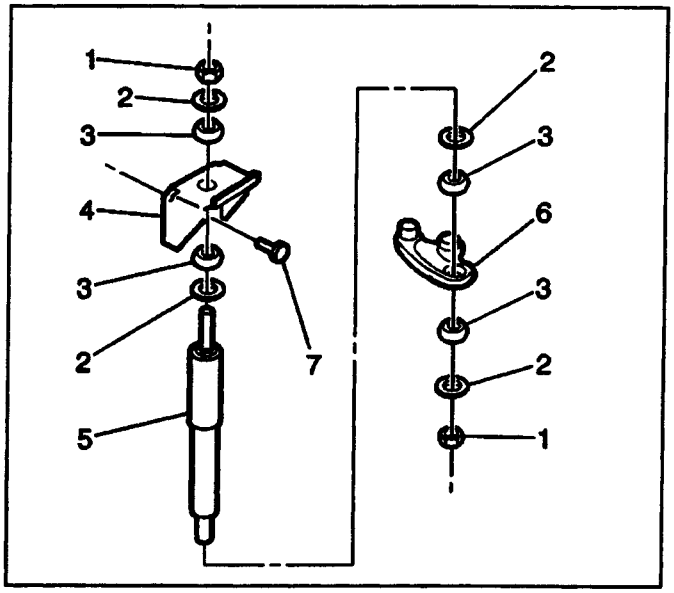
    Tighten

    Tighten the U-bolt nuts to 400 N.m (295 lb ft).

5. Install the flat washer (2) and the insulator (3) onto the shock absorber lower stem (5).
6. Install the shock absorber (5) into the lower bracket (6).
7. Install the following components:
   - The lower insulator (3)
   - The flat washer (2)
   - The nut (1)

   Tighten

   Tighten the lower shock absorber nut (10) to 84 N·m (62 lb ft)
8. Install the wheels, the hubs, and the bearings as needed.
9. Refer to the appropriate procedure:
   - *Wheel Hub, Bearing, and Seal Replacement (Drum Brakes)*
   - *Wheel Hub, Bearing, and Seal Replacement (Disc Brakes)*
10. Install the relay rod to the steering arm.
11. Install the tie rod arm and the steering arm as needed.
12. Remove the safety stands.
13. Lower the vehicle.



294158

Description and Operation

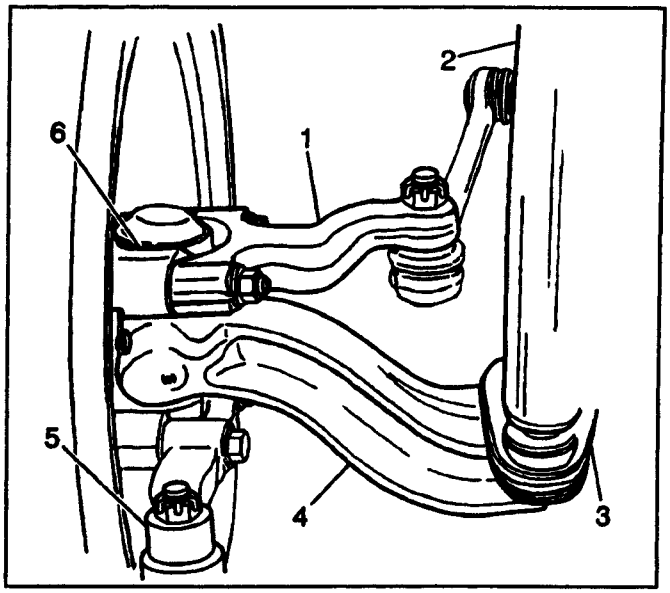
General Description

Front Axle

The front axle (4) is a one-piece, steel-forged I-beam section. The outer ends of the axle center are machined in order to accommodate the steering king pins and the knuckles (6). King pin inclination is built into the knuckle end. The front axle is available in the following four weights:

- 3 675 kg (8,100 lbs)
- 5 000 kg (11,000 lbs)
- 5 450 kg (12,000 lbs)
- 6 610 kg (14,600 lbs)

The steering arm (1) and the tie rod arms (5) attach to the knuckle (6) with bolts.



201696

The stepped king pin is located in the following locations:

- In a steel-backed bronze bushing at the lower end
- In a high-angle tapered roller bearing at the upper end

The lower bushings are greased through fittings in the lower covers; excess grease is purged through skirt-type seals. The upper bearing is packed with grease during assembly.

The upper bearing is pre-loaded against a thrust washer by placing a shim or a spacer between the inner race and the axle beam king pin boss, then by tightening the pivot pin prevailing torque locknut to a specified torque.

The upper bearing cover is press fit into the knuckle. The lower cover is a gasket and a flat plate retained with bolts.

Front Suspension

The springs are tapered leaf type with an eye-and-compression shackle. All springs and shackles are rubber bushed.

The spring assembly rests on the shock mounting bracket, and both are attached to the front axle with U-bolts. A rubber bumper is attached to the frame. This bumper hangs suspended above the spring center.

The stabilizer assembly consists of the following components:

- A shaft
- Two shaft mounting brackets
- Shims

The springs have six studs that mount the stabilizer shaft to the springs. The studs are a part of the springs.

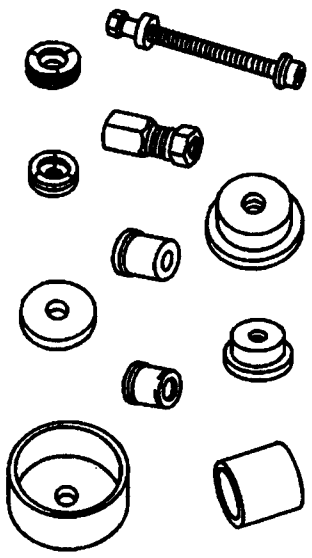
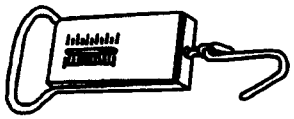
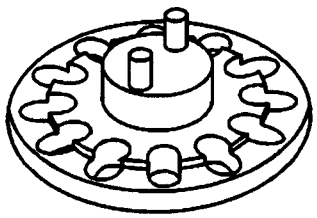
Twin-tube shock absorbers provide damping. The shock absorbers are mounted vertically behind the front axle. The top and bottom attachments are pin type with rubber insulators. The shock absorber upper mounting is a stamping that is attached to the frame. The lower attachment is a forging between the axle spring seat and the spring.

Front Hubs and Bearings

The front wheel bearings consist of two tapered roller bearings. These bearings are closed at the outer end by a cap and a gasket. The bearings are closed at the inner end by a seal. Lubricate these bearings using either grease or oil.

Brake drum and rotor mounting bolts, studs, and nuts vary in form and type, depending on the vehicle series and equipment.

Special Tools and Equipment

Illustration	Tool Number/ Description
 206815	J 37420 Steering Knuckle Service Set
 157140	J 35999 Tension Scale
 206824	J 39758 King Pin Holding Tool

Rear Suspension

Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Bumper Nut	40 N·m	30 lb ft
Rear Spring Hanger Rebound Bolt, Taperleaf Spring	415 N·m	305 lb ft
Shock Absorber (Lower) Nut	61 N·m	45 lb ft
Spring Center Bolt Nut	81 N·m	60 lb ft
Spring Eye Bolt (Front) Nut	415 N·m	305 lb ft
Spring Hanger Nut	70 N·m	52 lb ft
Stabilizer Bracket Nut	70 N·m	52 lb ft
Stabilizer Clamp Nut	220 N·m	162 lb ft
Stabilizer Link Nut	240 N·m	177 lb ft
Stabilizer Shaft Nut	240 N·m	177 lb ft
20 mm (0.787 in) U-Bolt Anchor Plate Nut Final Torque	388 N·m	287 lb ft
22 mm (0.866 in) U-Bolt Anchor Plate Nut Final Torque	437 N·m	344 lb ft

Diagnostic Information and Procedures

Spring Maintenance

Lubrication

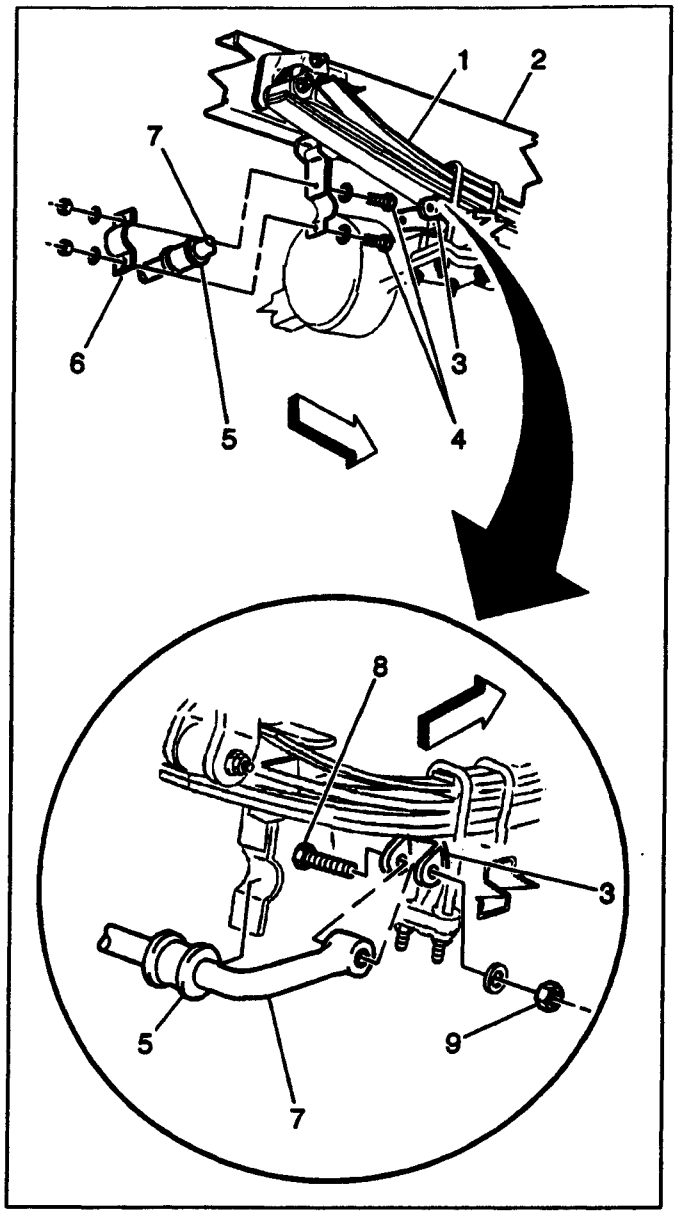
Spring leaves are lubricated at the time of manufacturing and require no further lubrication unless the spring is disassembled. Radius leaf bushings that are rubber mounted do not require lubrication.

Tightening

Keep the U-bolts tight at all times in order to hold the axle in place at the spring. If the U-bolts are not tight, the axle may shift, causing misalignment and spring leaf malfunction at the spring center bolt. Refer to Fasteners in General Information for tightening intervals.

Center Bolt

The spring center bolt holds the spring together while in shipment and during installation. The center bolt is also a locating point when assembling the spring to the axle. After assembly, the U-bolts hold the spring and the axle in alignment.



202158

Repair Instructions

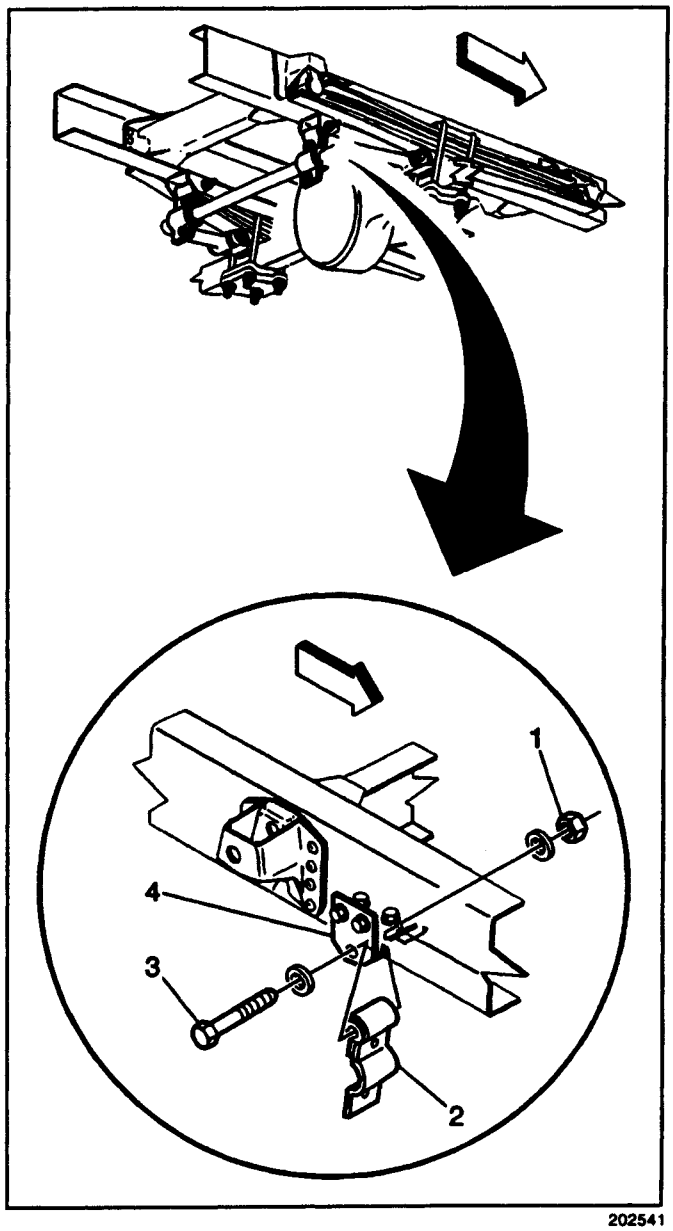
Stabilizer Shaft Replacement

Removal Procedure

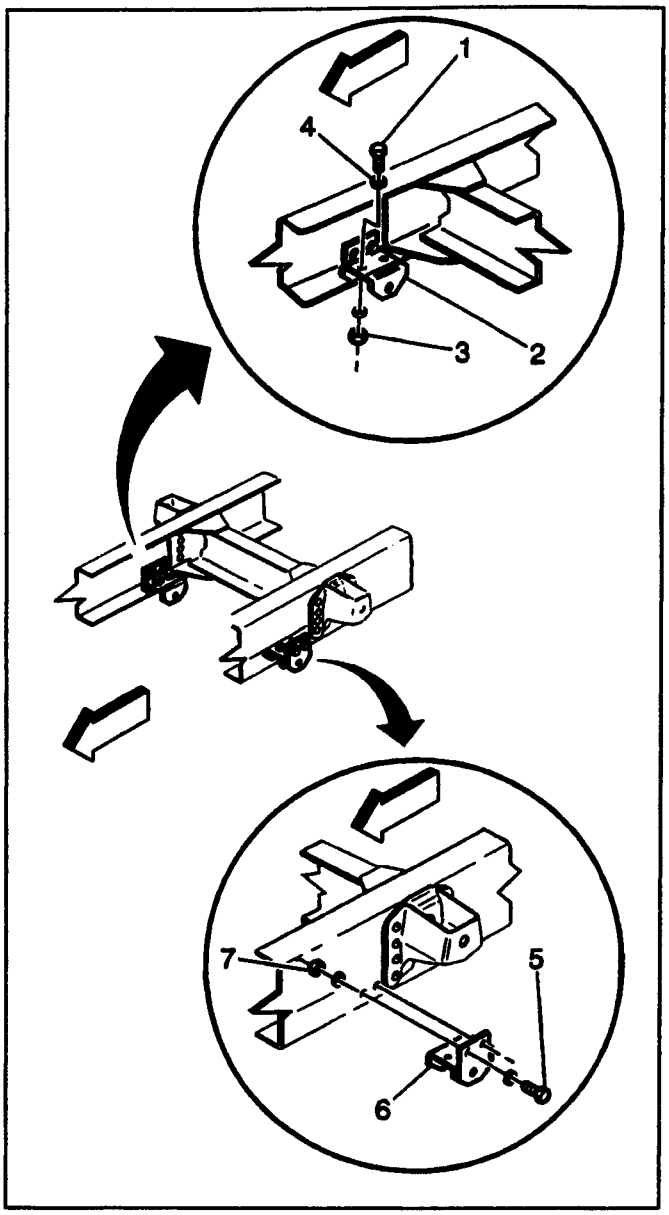
1. Set the parking brake.
2. Block the front wheels.
3. Remove the following stabilizer clamp components from the stabilizer links:
   - The bolt nuts
   - The washers
   - The bolts (4)
   - The clamps (6)
4. Remove the following stabilizer shaft (7) components from the stabilizer bracket/spring seats (3):
   - The bolt nut (9)
   - The washers
   - The bolts (8)
5. Remove the stabilizer shaft (7) from the stabilizer bracket spring/seats (3).
6. Inspect the stabilizer insulators (5) for wear and damage. Replace the stabilizer insulators if wear or damage is evident.
7. Remove the stabilizer insulator from the stabilizer shaft.

Important: If the stabilizer brackets require replacement, perform the next two steps.

8. Remove the following components from the stabilizer bracket (4) and the stabilizer link (2):
   - The stabilizer link nuts (1)
   - The washers
   - The bolts (3)



202541



202546

9. Remove the following components from the side member:
   - The stabilizer bracket nuts (3,7)
   - The washers (4)
   - The bolts (1,5)
   - The stabilizer bracket (2,6)

Installation Procedure

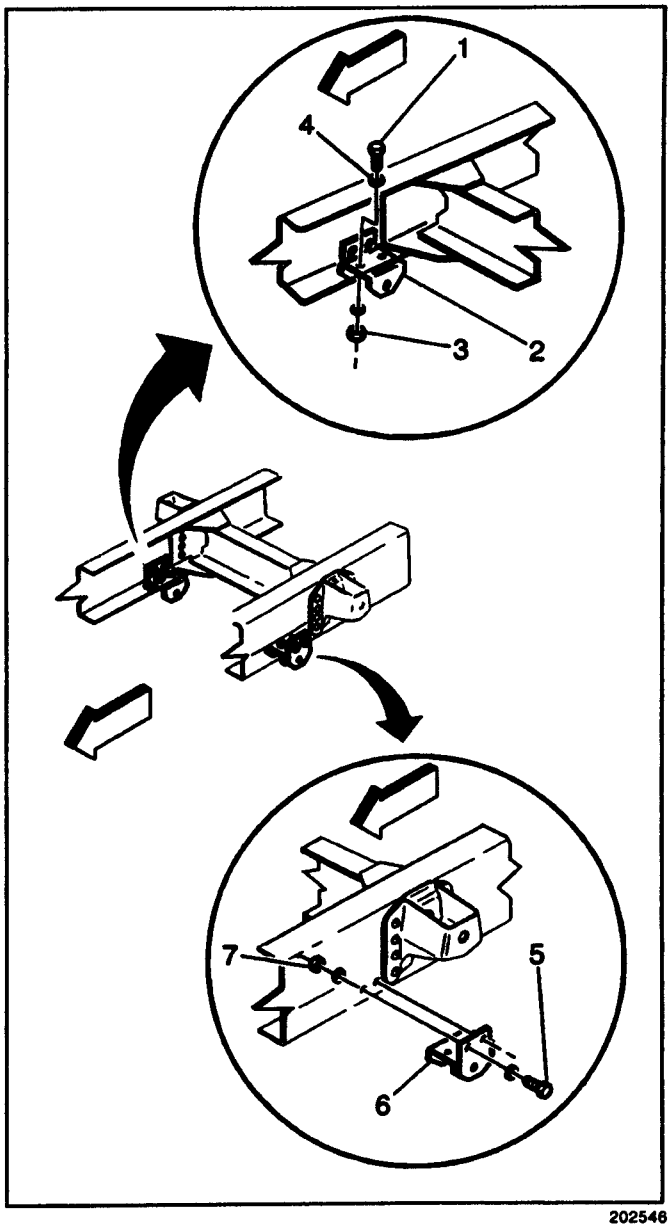
Notice: Refer to *Fastener Notice* in Cautions and Notices.

Important: If the stabilizer brackets require replacement, perform the first two steps.

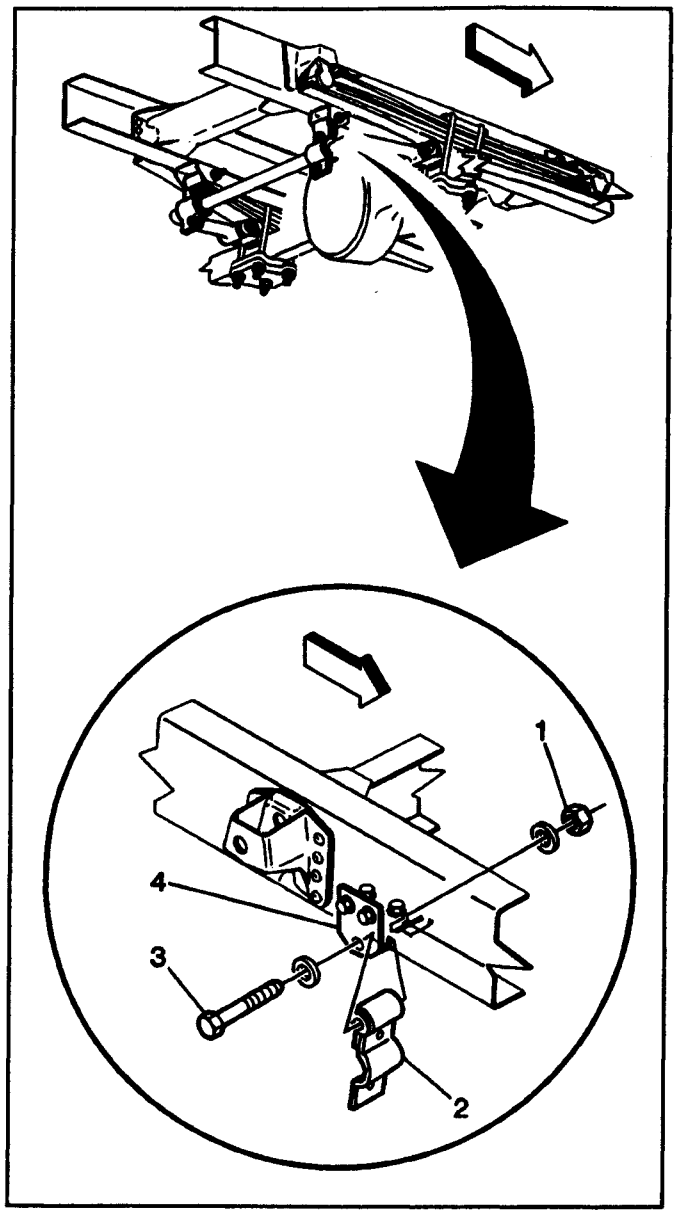
1. Install the following components to the side member:
   - The stabilizer bracket (2,6)
   - The bolts (1,5)
   - The washers (4)
   - The stabilizer bracket nuts (3,7)

   Tighten

   Tighten the stabilizer bracket nut to 70 N.m (52 lb ft).



202546



202541

2. Install the following components:
   - The stabilizer link (2) to the stabilizer bracket (4)
   - The stabilizer link bolts (3)
   - The washers
   - The nuts (1)

   Tighten

   Tighten the stabilizer link nut to 240 N·m (177 lb ft).
3. Install the stabilizer insulator on the stabilizer shaft.

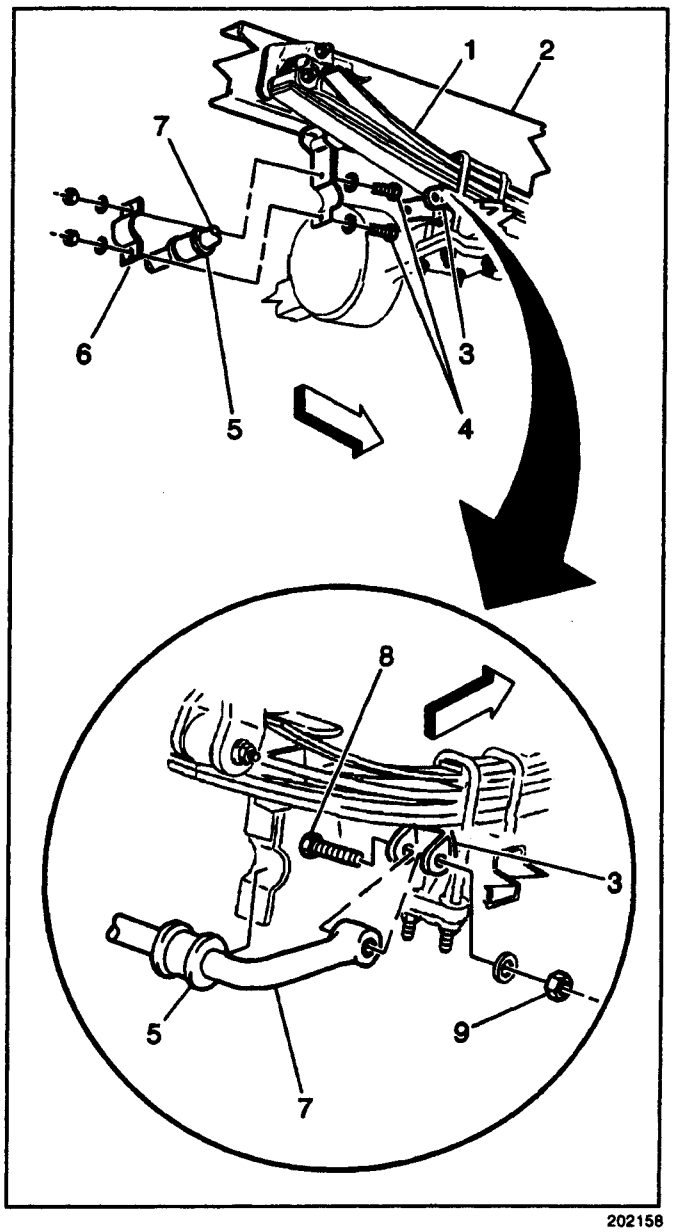
4. Install the stabilizer shaft (7) to the stabilizer bracket/spring seats (3).
5. Install the following components on the stabilizer shaft and the stabilizer bracket/spring seats:
   - The stabilizer shaft bolts (8)
   - The washers
   - The nuts (9)

   Tighten

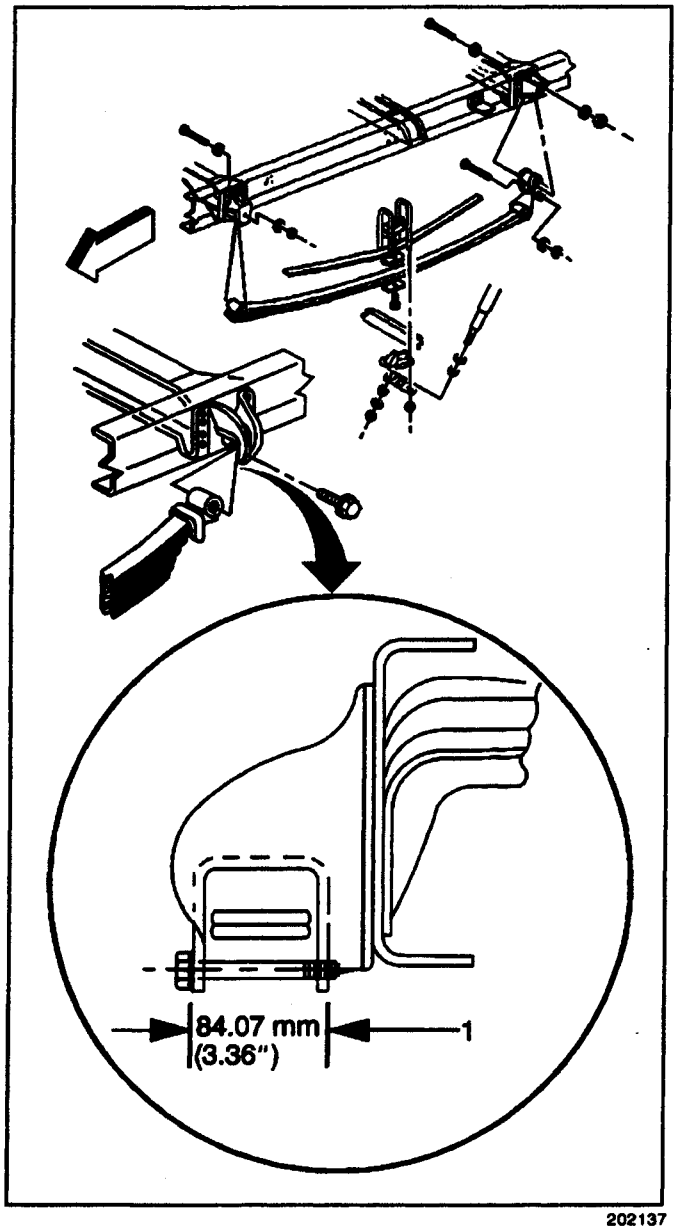
   Tighten the stabilizer shaft nut to 240 N.m (177 lb ft).
6. Install the following components on the stabilizer links:
   - The stabilizer clamps (6)
   - The bolts (4)
   - The washers
   - The nuts

   Tighten

   Tighten the stabilizer clamp nut to 220 N.m (162 lb ft).



202158



202137

Shock Absorber Replacement

Removal Procedure

Important: If a shock absorber is faulty, replace the complete unit. Refer to *Struts or Shock Absorbers Bench Test* and *Struts or Shock Absorbers On-Vehicle Testing.*

1. Set the parking brake.
2. Block the front and rear wheels.
3. Remove the upper nut and bolt.
4. Remove the shock absorber from the crossmember.
5. Remove the nut and the washer.
6. Remove the shock absorber from the lower mounting bracket.

Installation Procedure

1. Install the shock absorber to the lower mounting bracket.

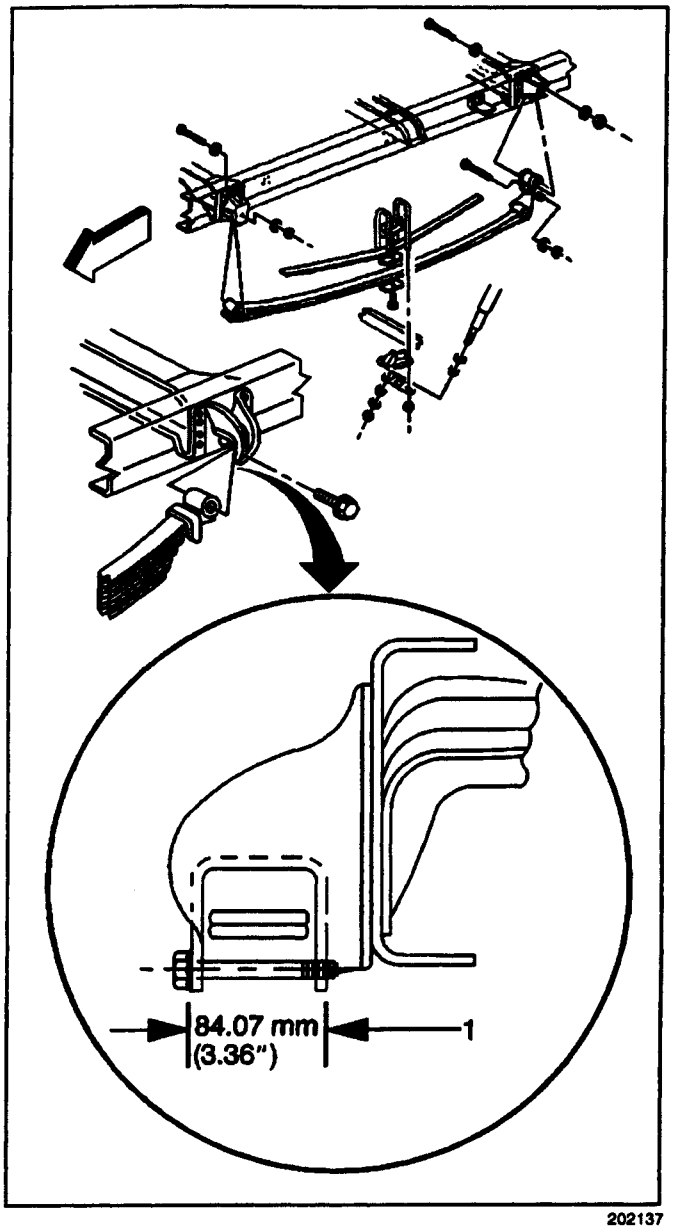
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the washer and the nut.

   Tighten

   Tighten the lower shock absorber nut to 61 N·m (45 lb ft).
3. Install the shock absorber to the crossmember.
4. Install the upper bolt and nut.

   Tighten

   Tighten the upper shock absorber nut to 160 N·m (120 lb ft).



202137

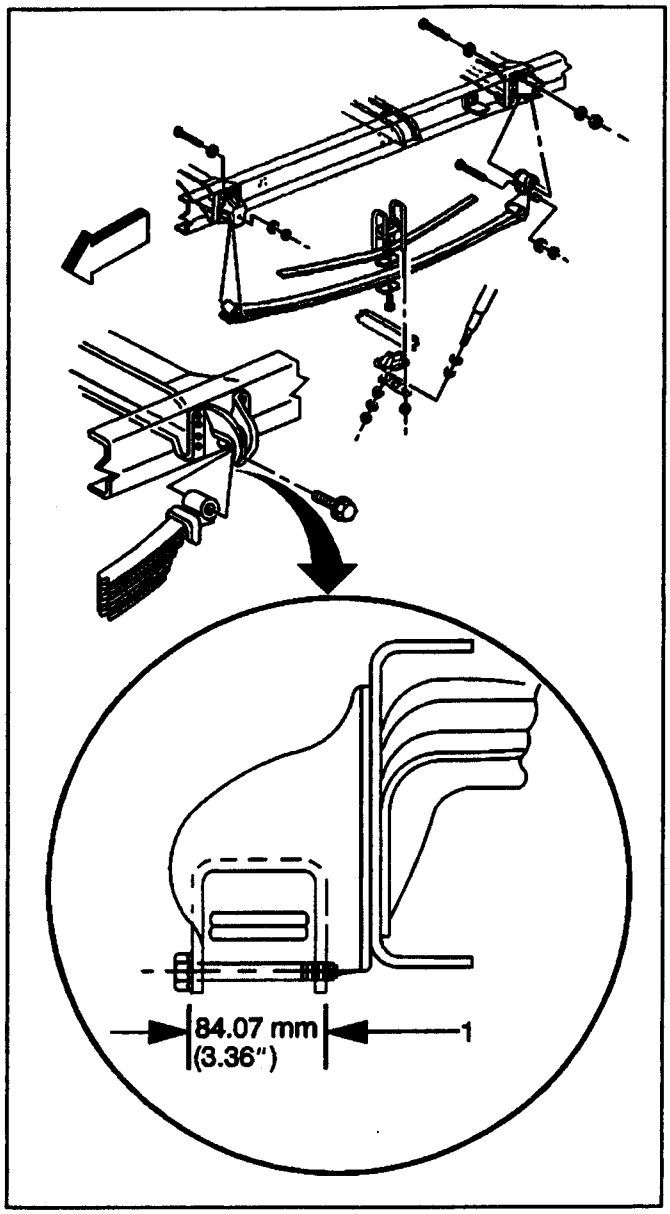
Spring Bushing Replacement

Removal Procedure

Tools Required

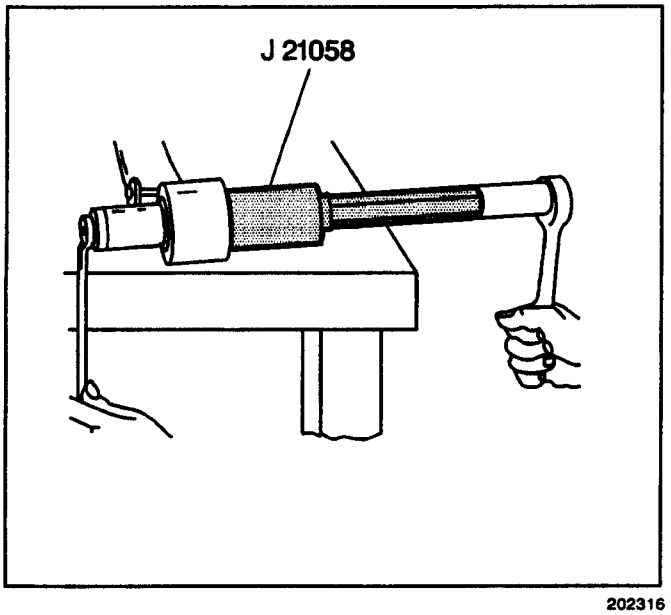
J 21058 Bushing Remover and Installer

1. Set the parking brake.
2. Block the front wheels.
3. Raise the vehicle frame using a suitable lifting device in order to remove the weight of the vehicle from the spring assembly.
4. Place jack stands under the rear axle in order to support the frame rearward of the of the rear axle.
5. Remove the rear wheel assembly, if necessary. Refer to *Wheel Removal (Front)* in Tires and Wheels.



202137

6. For taperleaf springs, remove the following components:
   - The rear spring hanger rebound nut
   - The washer
   - The bolt
7. For multileaf springs, remove the rear spring hanger bolt.
8. Remove the following components:
   - The lower shock absorber nut
   - The washer
   - The insulator
   - The shock
   - The washer (if equipped)
9. Remove the U-bolt nuts and the washers.
10. Remove the following components:
    - The U-bolt anchor plate
    - The seat
    - The shock absorber bracket (if equipped).
11. Remove the U-bolts.
12. Lower the axle slightly in order to gain access to the spring front eye bolt.
13. Remove the following components:
    - The front eye bolt nut
    - The washer
    - The eye bolt
14. Raise the frame in order to provide clearance between the spring assembly and hanger bracket.



202316

15. Remove the bushing using the *J 21058*.

Installation Procedure

Tools Required

J 21058 Bushing Remover and Installer

1. Install the eye bushing using the *J 21058*.
2. Lower the frame slightly in order to install the spring front eye bolt.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
3. Install the following components:
   - The spring front eye bolt

     Tighten

     Tighten the spring front eye bolt to 415 N·m (305 lb ft).
   - The washer
   - The nut
4. Lower the frame until the hanger touches the surface of the rear spring eye.
5. For taperleaf springs, install the following components:
   - The rear spring hanger rebound bolt
   - The washer
   - The nut

     Tighten

     Tighten the rear hanger rebound bolt to 415 N·m (305 lb ft).
6. Install the U-bolt spacer over the center bolt.
7. Install the U-bolts into the spacer grooves.
8. Install the U-bolt anchor plate and the seat.
9. Install the shock absorber bracket (if equipped).

   Important: In order to properly tighten the U-bolts, tighten the bolts in the specified sequence.
10. Install the U-bolt nuts and washers according to the next two steps.
11. For 20 mm (0.78 in) U-bolts:

    Tighten

    11.1. Tighten U-bolt nuts to 100 N·m (74 lb ft) in sequence.

    11.2. Tighten U-bolt nuts to 250 N·m (184 lb ft) in sequence.

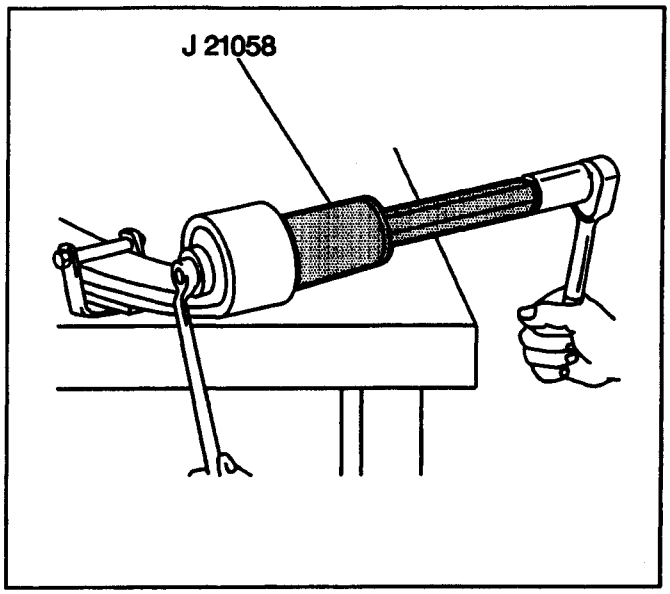
    11.3. Tighten U-bolt nuts to 375–400 N·m (276–295 lb ft) in sequence.
12. For 22 mm (0.875 in) U-bolts:

    Tighten

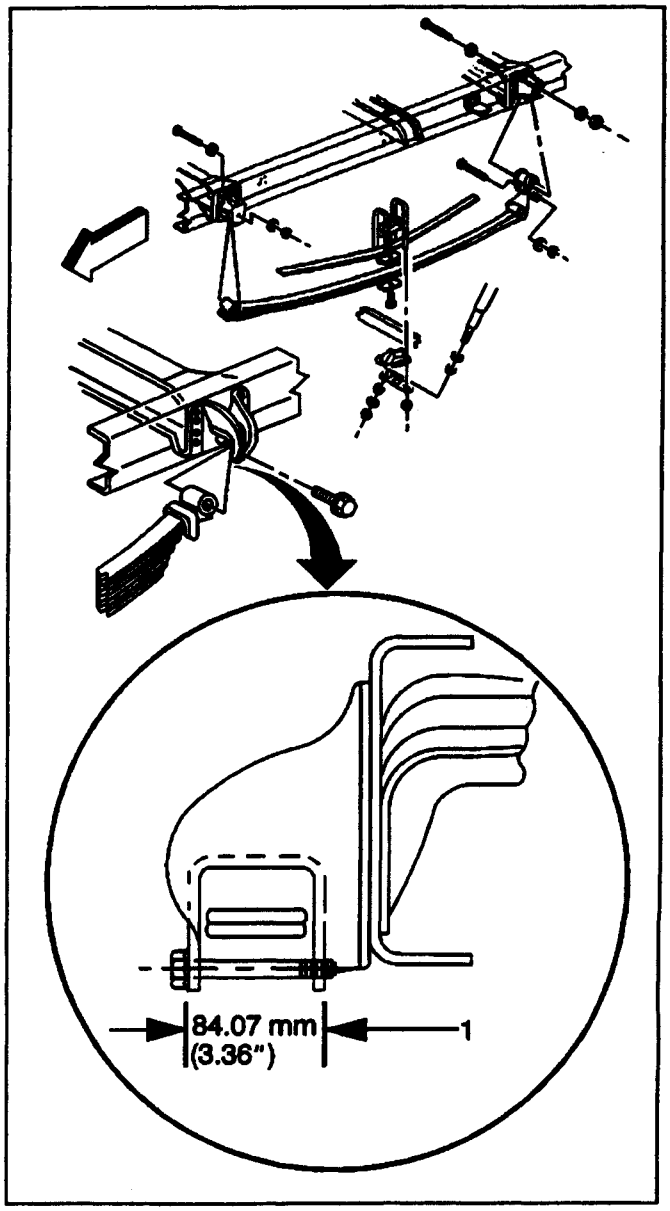
    12.1. Tighten U-bolt nuts to 150 N·m (111 lb ft) in sequence.

    12.2. Tighten U-bolt nuts to 275 N·m (203 lb ft) in sequence.

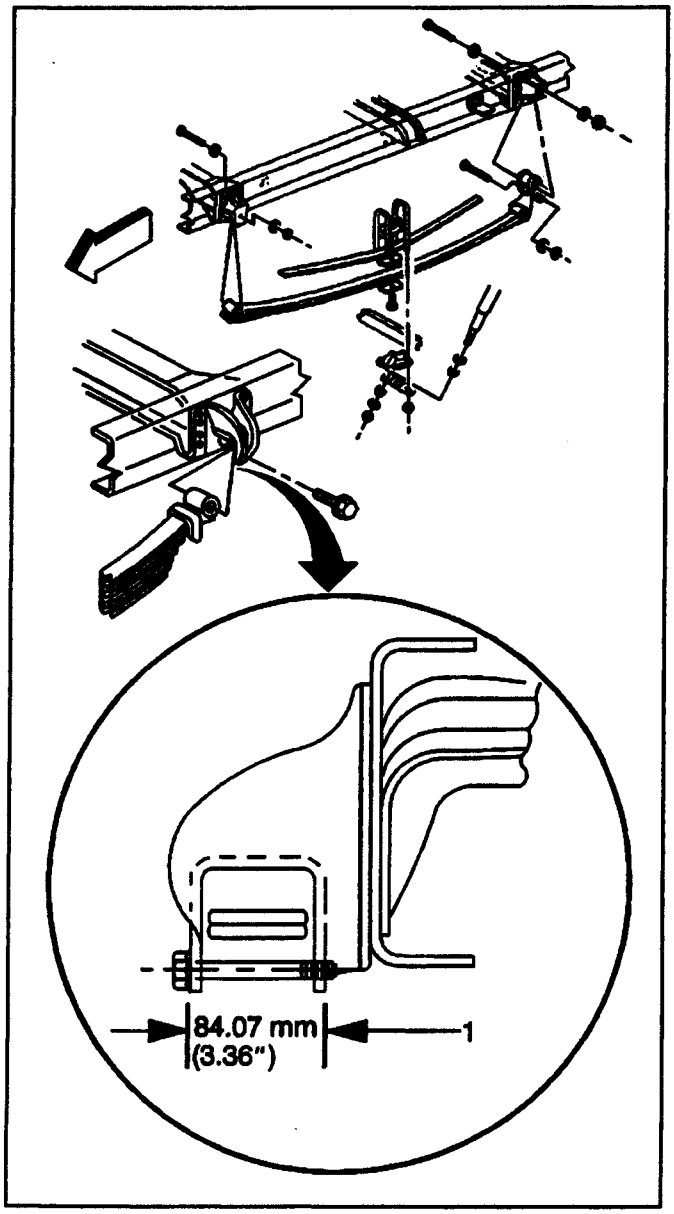
    12.3. Tighten U-bolt nuts to 425–450 N·m (313–332 lb ft) in sequence.



202322



202137



202137

13. For multileaf springs, install the rear spring hanger bolt.
    Tighten
    Tighten the rear spring hanger bolt. Ensure that a minimum of 84.07 mm (3.36 in) is between the ears of the rear spring hanger.
14. Raise the vehicle.
15. Remove the jack stands.
16. Lower the vehicle.
17. Remove the blocks from the front wheels.

Leaf Spring Replacement

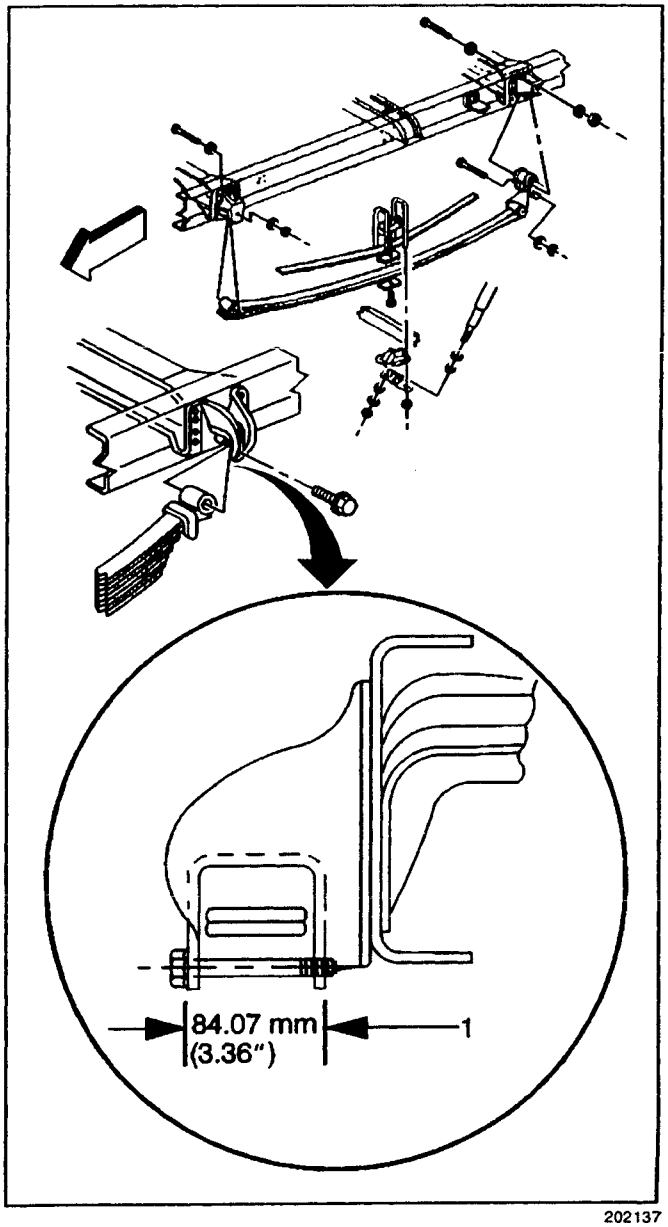
Removal Procedure

1. Set the parking brake.
2. Block the front wheels.
3. Raise and support the vehicle using a suitable lifting device in order to remove the weight from the spring assembly.
4. Place the jack stands under the rear axle in order to support the axle weight.
5. Remove the rear wheel assembly, if necessary. Refer to *Wheel Removal (Dual/Rear)* in Tires and Wheels.
6. Remove the following rear spring hanger components:
   - The rebound nut
   - The washer
   - The bolt
7. Remove the following components:
   - The shock absorber nut
   - The washer
   - The insulator
   - The shock
   - The washer (if equipped)
8. Remove the U-bolt nuts and the washers.
9. Remove the following components:
   - The U-bolt anchor plate
   - The seat
   - The shock absorber bracket (if equipped)
10. Remove the U-bolts.
11. Lower the axle slightly.
12. Remove the following components:
    - The eye bolt nut
    - The washer
    - The eye bolt

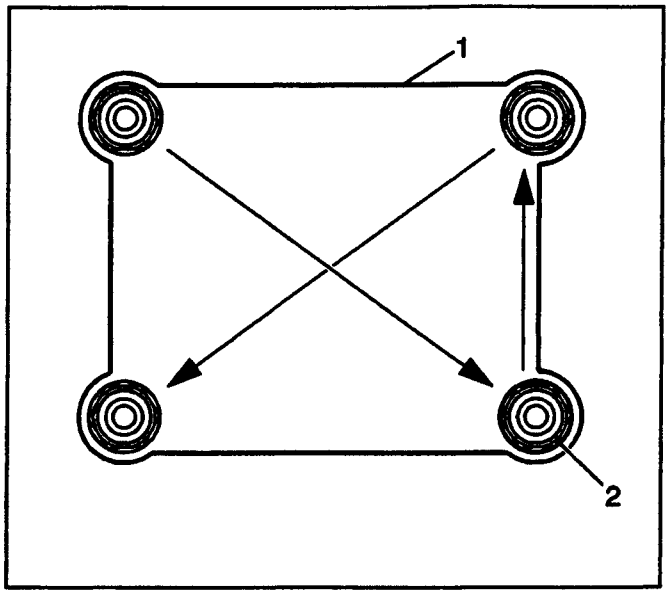
13. Raise and support the frame using a suitable lifting device in order to provide clearance between the spring assembly and the hanger bracket.
14. Remove the spring assembly using a suitable hoist.
15. Remove the following components:
    - The auxiliary spring
    - The bolt
    - The spacers
    - The U-bolt spacers (if equipped)

Installation Procedure

1. Install the following components:
    - The auxiliary spring
    - The U-bolt spacers
    - The spacers
    - The bolt (if removed)
2. Install the spring assembly onto the axle pad or the axle stabilizer/spring seat (if equipped), using a suitable hoist.
3. Install the U-bolt spacer over the center bolt.
4. Install the U-bolts into the spacer grooves.



202137



202329

5. Install the U-bolt anchor plate (1) and the seat.
6. Install the shock absorber bracket or the stabilizer shaft/spring seat, if equipped.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.

   Important: In order to properly tighten the U-bolt nuts, torque them progressively as described in the next two steps.
7. For a 20 mm (0.787 in) U-bolt, install the U-bolt nuts (2) and the washers.

   Tighten

   7.1. Tighten the U-bolt nut to 100 N.m (74 lb ft) in sequence.

   7.2. Tighten the U-bolt nut to 250 N.m (184 lb ft) in sequence.

   7.3. Tighten the U-bolt nut to 375–400 N.m (276–295 lb ft) in sequence.
8. For a 22 mm (0.866 in) U-bolt, install the U-bolt nuts (2) and the washers.

   Tighten

   8.1. Tighten the U-bolt nut to 150 N.m (111 lb ft) in sequence.

   8.2. Tighten the U-bolt nut to 275 N.m (203 lb ft) in sequence.

   8.3. Tighten the U-bolt nut to 425–450 N.m (313–332 lb ft) in sequence.

9. Install the following components:
   - The spring front eye nut
   - The washer
   - The spring front eye bolt

   Tighten

   Tighten the spring front eye bolt to 415 N·m (305 lb ft).
10. Install the following components:
   - The shock absorber washer
   - The shock
   - The insulator
   - The washer
   - The nut

   Tighten

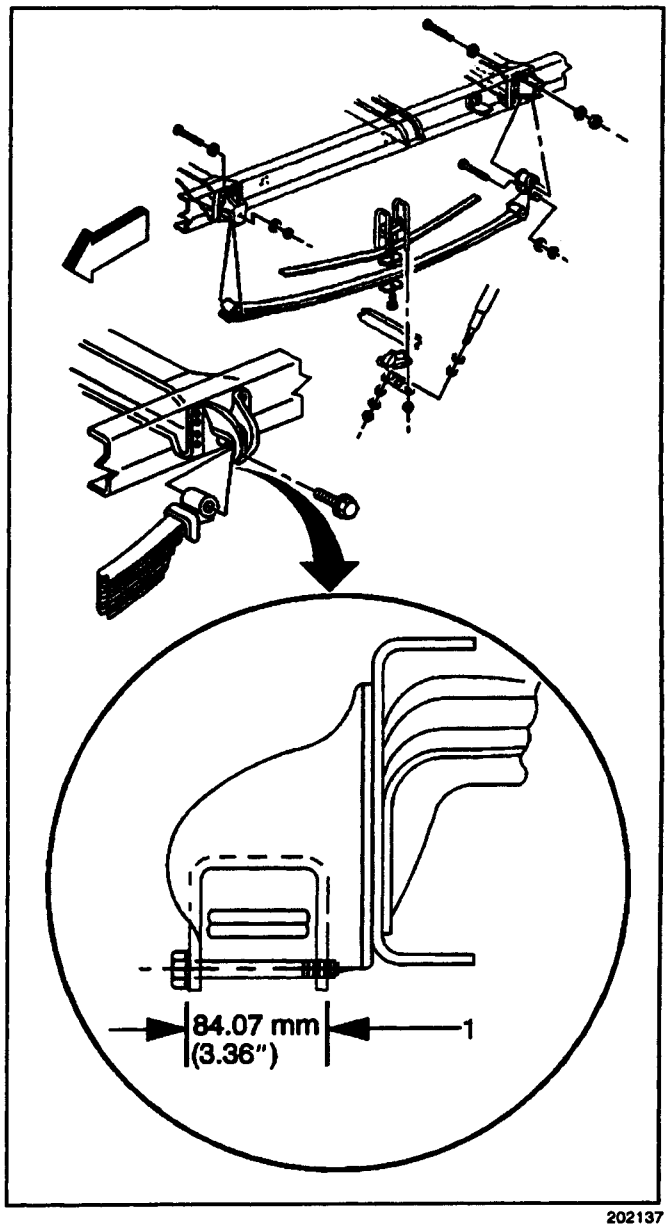
   Tighten the lower shock absorber nut to 61 N·m (45 lb ft).
11. Lower the frame until the hangers touch the surface of the spring eye.
12. For tapered leaf springs, install the following components:
   - The washer
   - The nut
   - The rear spring hanger rebound bolt

   Tighten

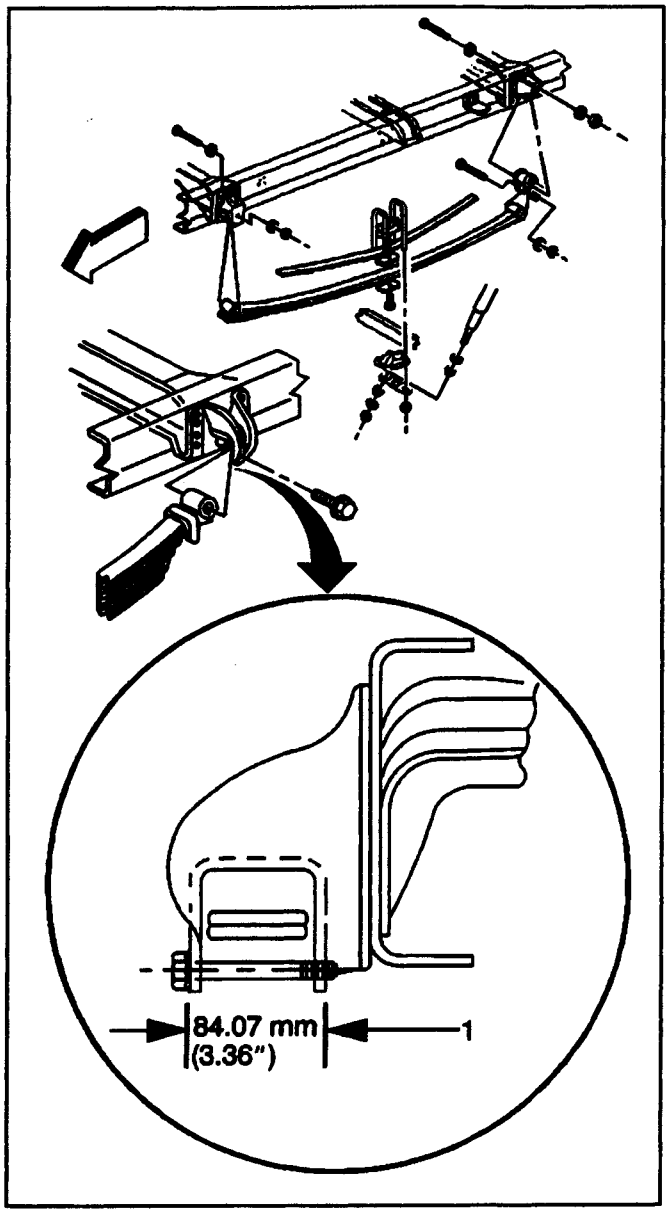
   Tighten the rear spring hanger rebound bolt to 415 N·m (305 lb ft).
13. For multileaf springs, install the rear spring hanger bolt.

   Tighten

   Tighten the rear spring hanger bolt. Ensure that a minimum of 84.07 mm (3.36 in) is between the ears of the rear spring hanger.
14. Raise the vehicle.
15. Remove the jack stands.
16. Lower the vehicle.
17. Remove the blocks from the front wheels.



202137



202137

Spring Leaf Replacement

Removal Procedure

Important: A leaf spring replacement is only possible on the multileaf spring. The leaf replacement is usually necessary on only the first or second, main leaf. If any of the secondary leaves need replacement, replace the complete spring assembly.

1. Remove the spring assembly. Refer to *Leaf Spring Replacement* in Rear Suspension.

   Notice: Do not use a machinist's scribe or a screwdriver to match/mark spring leaves. Marking the spring leaves with any sharp tool can cause metal stress and could contribute to early fatigue and malfunction.

2. Mark the spring assembly alignment on one side using a grease pencil or chalk.
3. Secure the spring assembly in a vise or an arbor press.
4. Remove the rebound clip bolts and the nuts.
5. Remove the rebound clips.

   Caution: Relieve the spring tension slowly. Spring leaves are under great pressure and could fly apart causing serious injury.

6. Remove the center bolt and the nut.

   File the peened portion of the center bolt.

7. Remove the center bolt.

   Open the vise or arbor press slowly in order to let the spring assembly expand.

8. Clean the spring leaves using a brush, if necessary.

   Do not disturb the alignment marks.

9. Inspect the spring leaves for cracks or signs of fatique. Replace only the first or second main leaf.

   Replace the entire spring assembly if additional springs are broken.

10. Inspect the rebound clips for cracks or breaks.
11. Inspect the center bolt hole for distortion or wear.

Installation Procedure

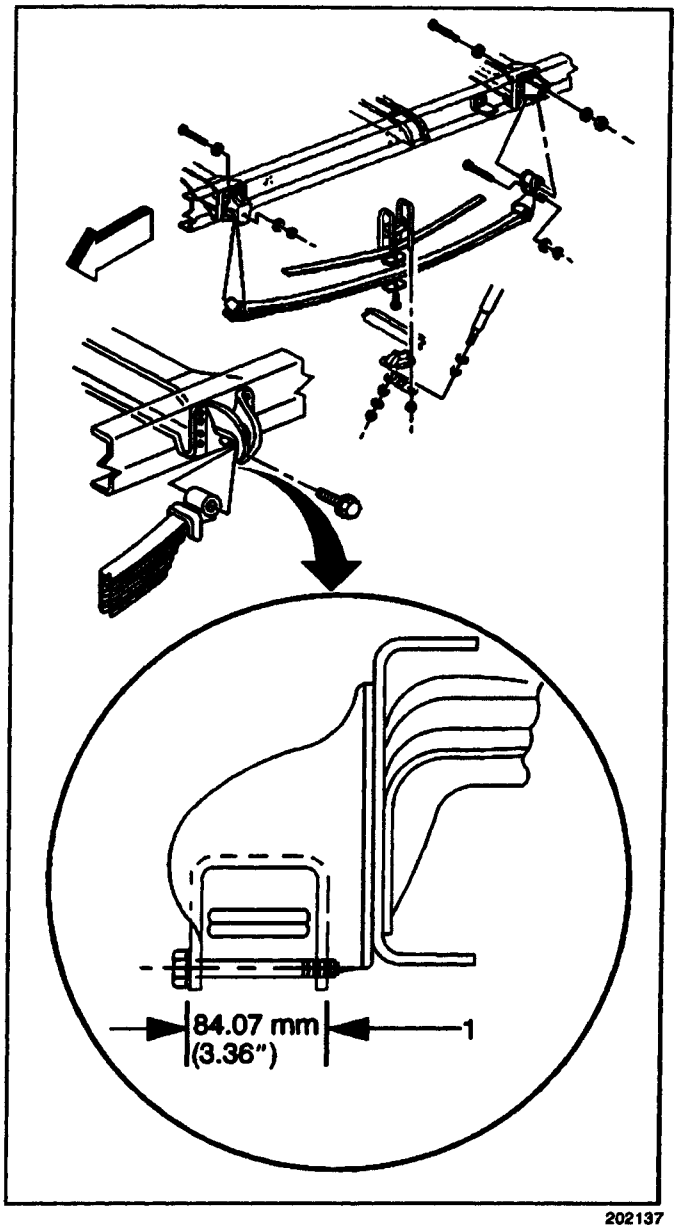
1. Install the spring.
   1.1. Apply a thin film of graphite grease to each leaf.
   1.2. Stack the leaves in the correct order.
   1.3. Align the center bolt holes in the spring leaves using a long drift.
   1.4. Align the match marks.
   1.5. Mount the assembled spring in a vise or an arbor press.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install a new center bolt and nut.
   Tighten

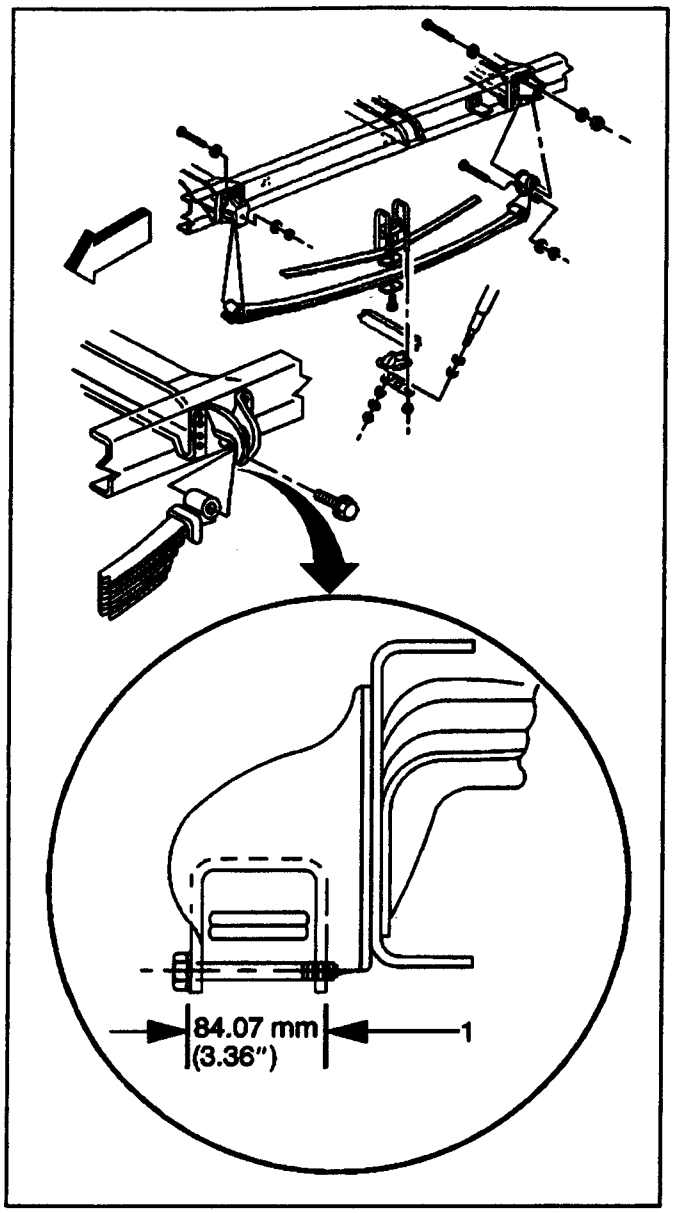
   Tighten the spring center bolt nut to 81 N.m (60 lb ft).
3. Peen the end of the center bolt.
4. Remove the spring assembly from the vise or the arbor press.

   Important: Ensure that the rebound clips are tight enough in order to hold the spring leaves in alignment, but not tight enough to restrict the free movement of the leaves.
5. Install the rebound clips using new bolts and nuts.

   Align the leaves using a soft faced hammer (if needed).
6. Peen the end of the bolts.
7. Install the spring assembly. Refer to *Leaf Spring Replacement* in Rear Suspension.



202137



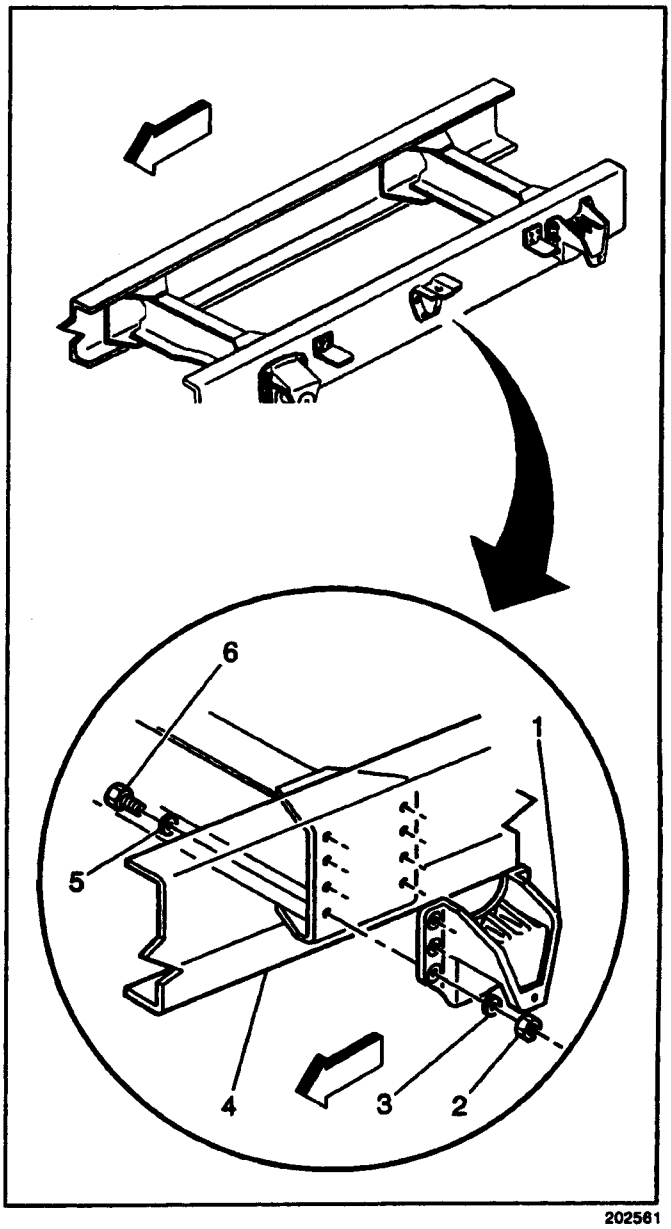
202137

Spring Hanger Replacement

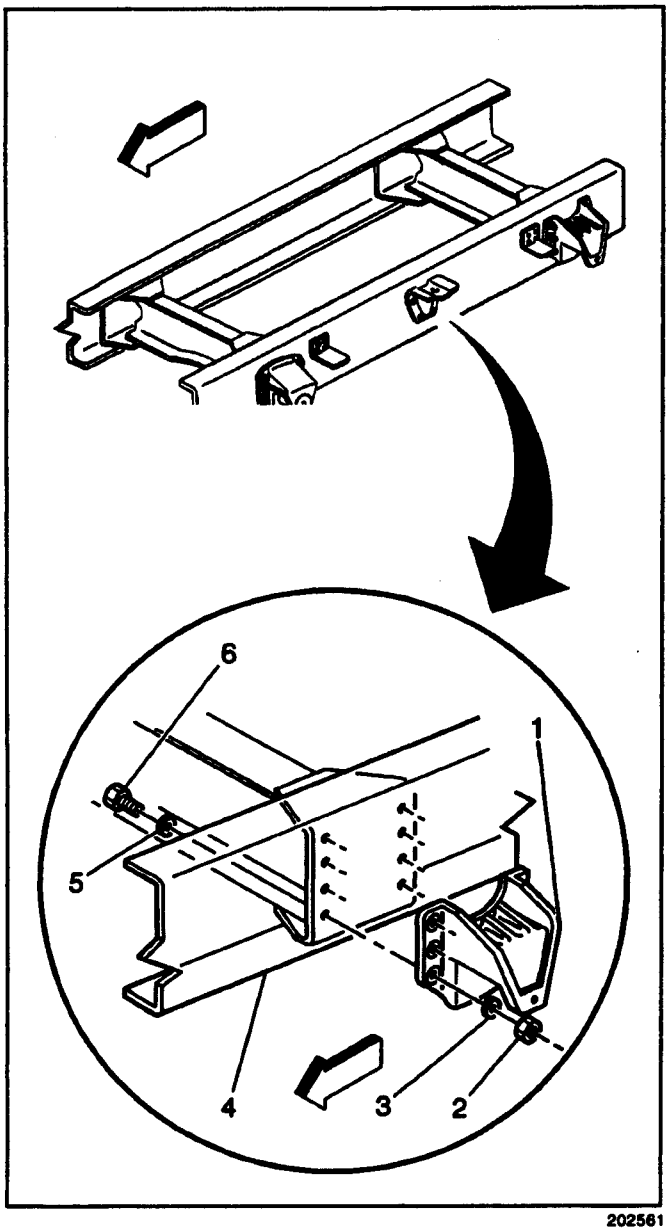
Removal Procedure

1. Set the parking brake.
2. Block the front wheels.
3. Raise the frame until the tension is released from the spring and the hanger bolt.
4. Remove the following components from the spring and the hanger:
   - The spring to hanger nut
   - The washers
   - The bolt
5. Remove the spring hanger rivets, if equipped.

6. Remove the following components from the side member (4):
   - The spring hanger nuts (2)
   - The washers (3,5)
   - The bolts (6)
   - The spring hanger (1)



202561



202561

Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the spring hanger (1) to the side member (4) using the following components:
   - The bolts (6)
   - The washers (3,5)
   - The nuts (2)

   Tighten

   Tighten the spring hanger nuts to 70 N·m (52 lb ft).
2. Raise the spring in order to align the spring eye and the spring hanger holes.

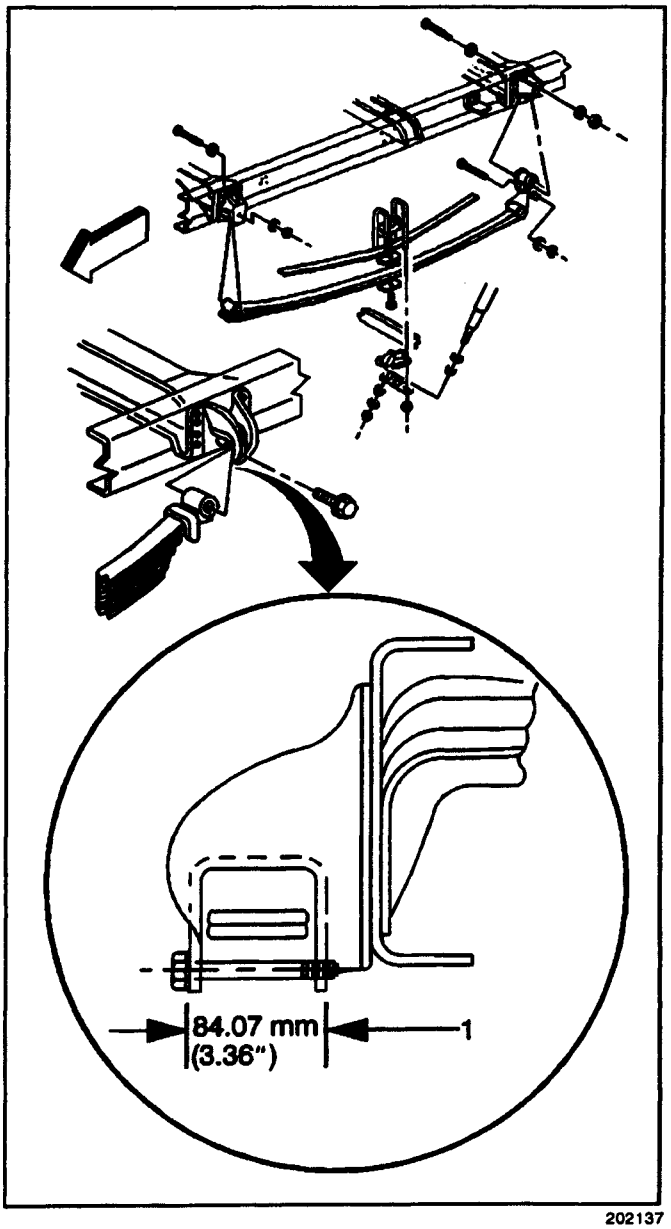
3. For tapered leaf springs, install the following rear spring hanger components:
   - The rebound bolt
   - The washer
   - The nut

   Tighten

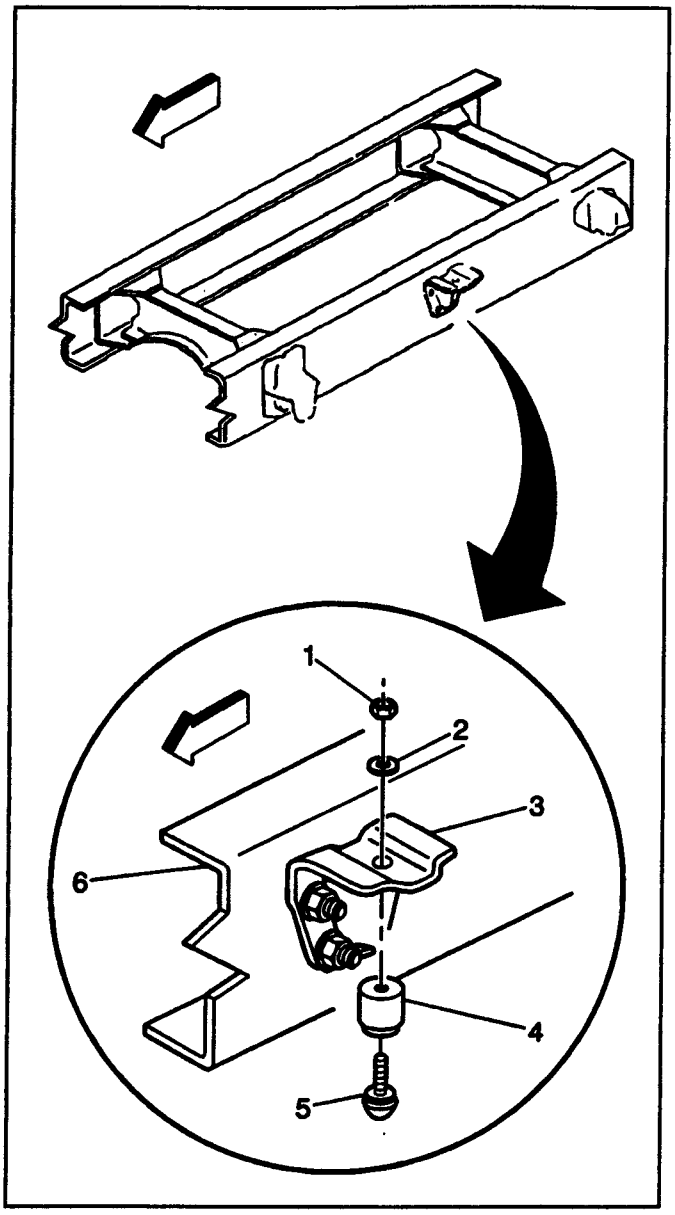
   Tighten the rear spring hanger rebound bolt to 415 N·m (305 lb ft).
4. For multileaf springs, install the rear spring hanger bolt.

   Tighten

   Tighten the rear spring hanger bolt. Ensure that a minimum of 84.07 mm (3.36 in) is between the ears of the rear spring hanger.
5. Lower the vehicle.
6. Remove the blocks from the wheels.



202137



202550

Spring Bumper Replacement

Removal Procedure

Remove the following components from the bumper bracket (3):

- The nut (1)
- The washer (2)
- The bumper bolt (5)
- The bumper (4)

Installation Procedure

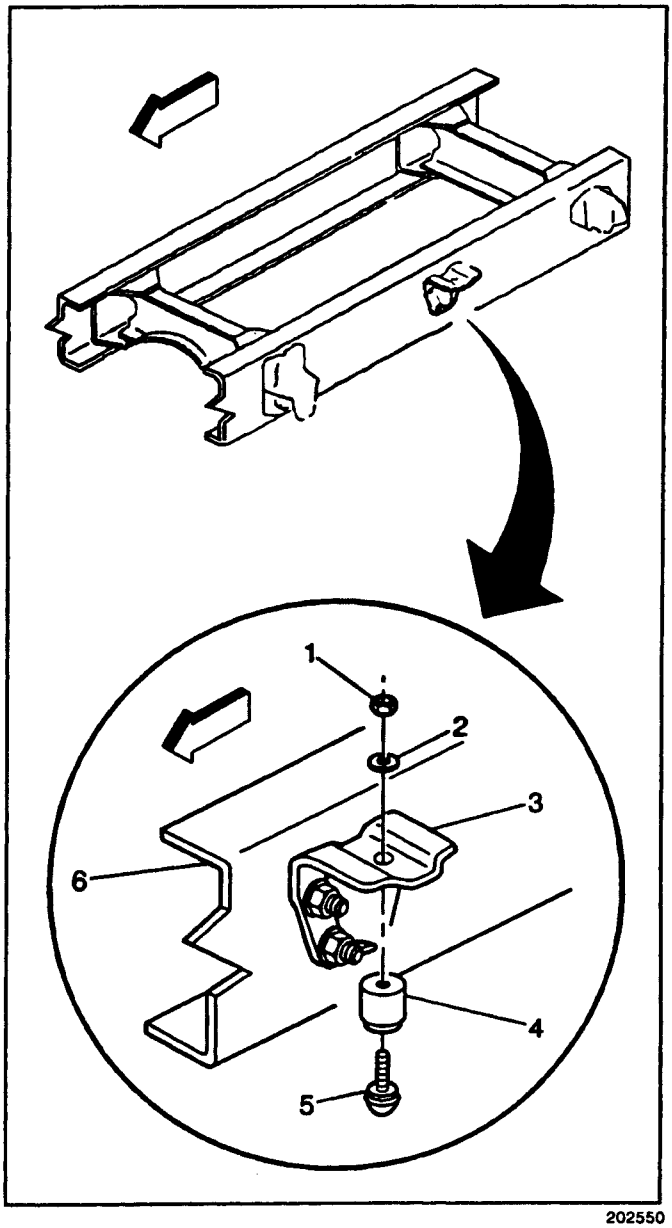
Notice: Refer to *Fastener Notice* in Cautions and Notices.

Install the following components to the bumper bracket (3):

- The bumper (4)
- The bumper bolt (5)
- The washer (2)
- The nut (1)

  Tighten

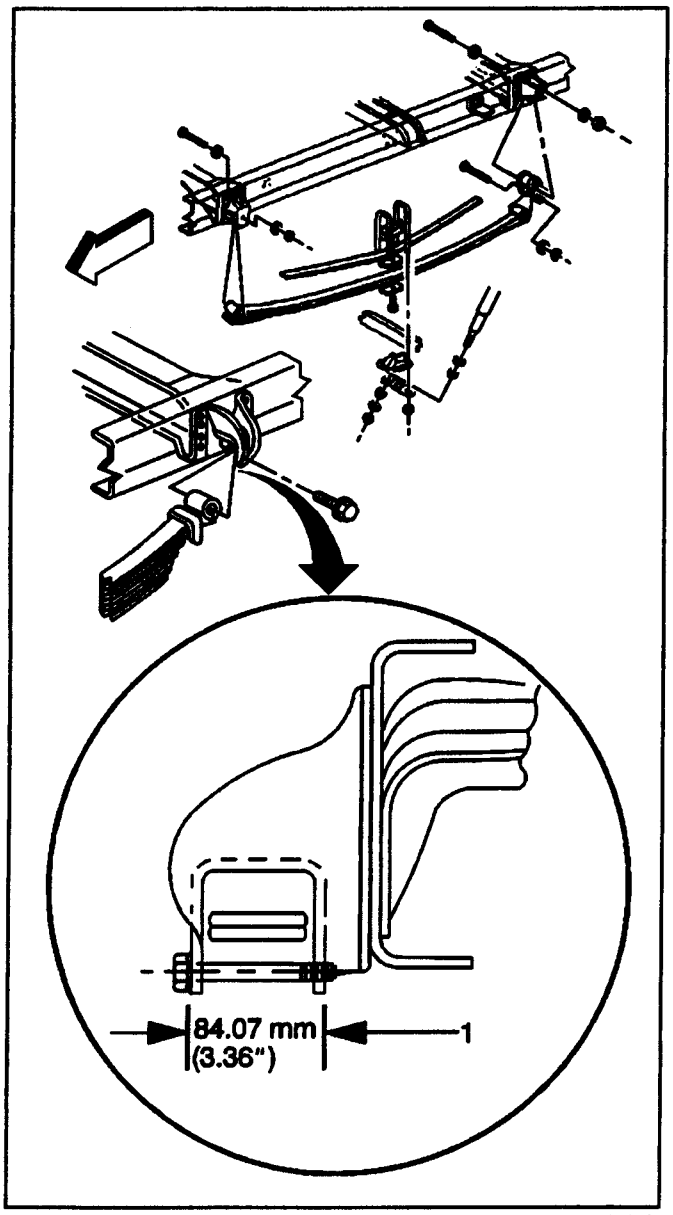
  Tighten the bumper nut to 40 N.m (30 lb ft).



202550

Description and Operation

General Description



202137

Tapered leaf springs have three leaves of parabolic taper form. Tapered leaf springs use a front eye and rear compression shackle.

Multileaf springs use a front eye and rear slider. All springs are a two stage-design. All spring and shackle eyes are rubber bushed and non-lubricated.

Spring eyes are fully reamed in order to accept the rubber bushings. The auxiliary spring is a single leaf parabolic taper form and the frame brackets are shaped cams to produce a variable rate.

A polyurethane spring aid and rubber bump stop are attached to the frame. The spring aid and the rubber bump stop hang suspended above the spring center.

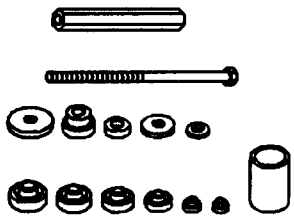
Dampening is provided by twin-tube shock absorbers mounted vertically behind the axle. Top and bottom attachments are pin type with rubber insulators. The upper end is attached to a frame crossmember while the lower end is attached to a bracket that mounts below the axle housing.

Shocks are required with the tapered leaf springs and optional with the multileaf springs.

The stabilizer shaft assembly consists of the following components:

- A shaft attached to the frame by two links
- The shaft ends attached to the axle by castings mounted between the spring assembly and the axle housing

Special Tools and Equipment

Illustration	Tool Number/ Description
 3287	J 21058 Bushing Remover and Installer Set

Tires and Wheels

Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
8-Hole Wheel Nut Final Torque	520–580 N·m	383–427 lb ft
10-Hole Wheel Nut Final Torque	610–678 N·m	450–500 lb ft
Valve Stem Nut	6 N·m	53 lb in

Diagnostic Information and Procedures

Wheel Mounting Surface Check

1. Clean grease and road dirt from the wheel.
2. Clean the rubber from the bead seat using a wire brush or steel wool.

   Notice: Do not heat wheels in an attempt to soften them for straightening or repair damage from striking curbs, etc. Do not weld wheels. The alloy used in these wheels is heat-treated and uncontrolled heating from welding affects the properties of the material.
3. Inspect the gutter areas for bulges. Remove any bulges that you find.

   Bulges will cause the following conditions:
   - Uneven seating of the side ring
   - Uneven seating of the lock ring
   - Chipping of the gutter
4. Inspect the mounting area for bulges. Smooth any bulges that you find.
5. Inspect the fixed flange area for nicks and gouges that may cause rim fracture.

Wheel Mounting Surface Check

Problem	Possible Cause	Correction
Tire Slippage on Rim	Improper storage or operating conditions	Correct as required.
	Poor maintenance	Follow the proper maintenance procedures.
	Rust, corrosion or faulty bead seating	Correct as required.
	Loss of pressure	Follow the proper maintenance procedures.
Tire Mounting Difficulties	Mismatched tire and rim size	Correct as required
	Over inflation of the tires	Follow the proper maintenance procedures.
	Corrosion and dirt	Correct as required.

Hub Bolt and Nut

Problem	Possible Cause	Correction
Broken Wheel Studs	Loose wheel nuts	Replace the studs and follow the recommended torque procedure.
	Overloading	Replace the stud.
Stripped Threads	Excessive clamp load	Replace the studs and follow the recommended torque procedure.
Rusted Streaks from Stud Holes	Loose wheel nuts	Inspect the complete assembly. Replace the studs and follow the recommended torque procedure.
Damaged Wheel Nuts	Loose wheel assembly	Replace the wheel nuts and follow the recommended torque procedure.
Frozen Wheel Nuts	Corrosion or galling	Replace the wheel nuts. Replace the wheel studs.

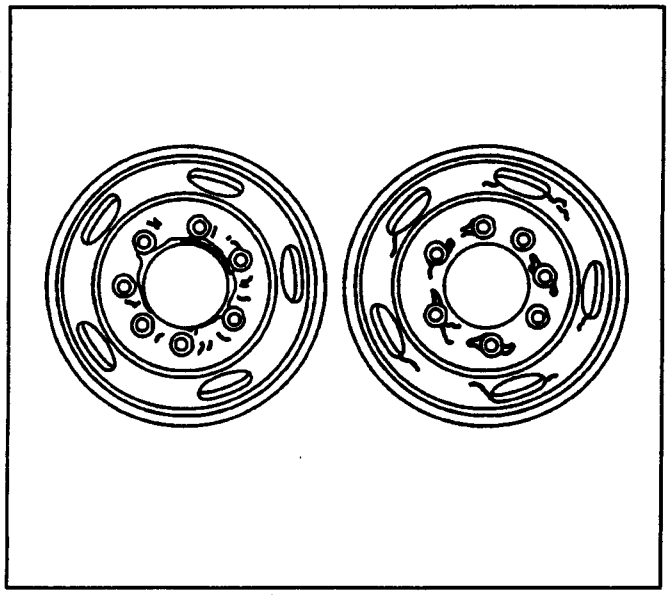
Hub Bolt and Nut

Problem	Possible Cause	Correction
Cracked or Broken Wheel Discs, Cracks Developed in the Wheel Disc around Hand Holes, Rims, or Studs	Metal fatigue resulting from overheating	Replace the wheel. Inspect the position of the wheel on the vehicle for proper working load specifications.
Damaged Stud Holes, Stud Holes become Worn, Elongated or Deformed, Metal Builds Up around Stud Hole Edges, Cracks Develop from Stud Hole to Stud Hole	Loose wheel mounting	Replace the wheel and perform the following inspections: • Inspect the installation for correct wheel studs and wheel nuts. • Replace cracked or broken wheel studs. • Replace a hub with worn, damaged or cracked wheel pilot pads. • Clean the mounting surfaces and retorque the wheel nuts periodically. • Rust streaks fanning out from the stud holes indicate that the wheel nuts are loose or were loose.

Rim/Hub Bolt Check

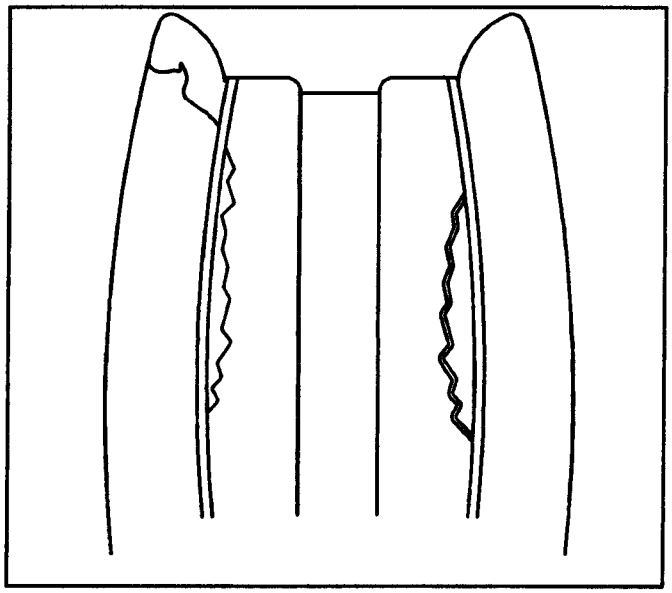
Inspect the wheel for worn wheel stud holes. Worn stud holes may appear as a shiny worn surface on the wheel face. If the stud holes are oval and if metal is built up around the holes, replace the wheels.

Inspect the wheel for cracks radiating from the hand, the stud, the bolt, or the center holes. Cracks are a result of overloading. Replace damaged wheels and inspect the wheel studs. The hub assembly may have a worn mounting face. Inspect the wheel ball seats for wear. Replace all damaged parts.



203149

Inspect the wheel for damaged or cracked rims.



203162

Carefully inspect the rims before mounting the tires. Replace all cracked rims. Cracked rims are dangerous to use.

Inspect for damaged bead seats. Excessive corrosion and improper bead seating can cause erosion and chipping of the bead seats.

Wheel Stud Check Procedure

Caution: If one stud is damaged, replace all the studs. A loose-running wheel may cause only one stud to break, but the other studs could have internal fatigue. Replacing only the broken stud and remounting the wheel may cause further damage and personal injury. If the stud holes in the wheels have become enlarged or distorted, replace the wheel.

Notice: Excessive mounting torque can cause stripped or broken studs, out of round rims, or cracks in the stud hole area.

Stripped threads on the studs may be caused by the following conditions:

- Over-torquing the wheel nuts
- Stud damage which occurred during wheel installation

Replace any studs which show damaged threads.

Broken studs may be caused by the following conditions:

- Operating with loose wheel nuts
- Over-torqued wheel nuts
- Improperly seated wheels

Wheel Nut Check Procedure

Notice: Excessive mounting torque can cause stripped or broken studs, out of round rims, or cracks in the stud hole area.

A loose mounting condition can cause damaged wheel nuts. Replace all damaged wheel nuts and wheel studs.

Repair Instructions

Aluminum Wheel Refinishing

Aluminum resists corrosion. Therefore aluminum wheels do not need painting for most operating conditions. Wash the aluminum wheels when you wash the vehicle. Do NOT use highly alkaline cleaning agents.

Certain environments created by some operations may lead to aluminum wheel corrosion. Some of these operations include the following conditions:

- Livestock hauling
- Snow removal using salt or chloride compounds
- Using highly alkaline cleaning agents

If these operating conditions exist, clean the wheels often with a stream of high-pressure water and mild detergent. Whenever you remove the tires, thoroughly clean the wheels.

Various protective coatings give good results. When using a protective coating, refer to the following suggested procedures:

1. Use a general purpose pad (such as 3M Scotch-Brite® No. 7447), or use a buffing wheel and a medium abrasive rubbing compound (such as 3M No. 05979 Clean-N-Glaze™). Aggressively rub the machined surfaces in order to remove some of the corrosion and to restore most of the luster.
2. Wipe the surface with aluminum cleaner-polish (such as Mag Wheel Cleaner Polish™ Stock No. PGC) in order to obtain maximum luster.
3. Clean the wheel with silicone remover (such as 3M No. 08984 General Purpose Adhesive Cleaner and Wax Remover™, or Prep-Sol®). Wash the wheel with clean water and dry with compressed air.
4. Wipe the wheel again with aluminum cleaner-polish. Apply a metal preparation (such as C.I.L. Metal Prep. No. 33 for aluminum) following manufacturer's instructions.
5. Apply a zinc chromate primer in four light applications, rotating the wheel 90 degrees between applications.
6. Spray the wheel with two light coats of wheel protectant (such as Coricone 1700 Clear Metal Protectant™ Stock Code DDC).

Clearcoat Damage to Aluminum Wheels

Aluminum resists corrosion. Therefore aluminum wheels do not need painting for most operating conditions. Wash the aluminum wheels when you wash the vehicle. Do NOT use highly alkaline cleaning agents.

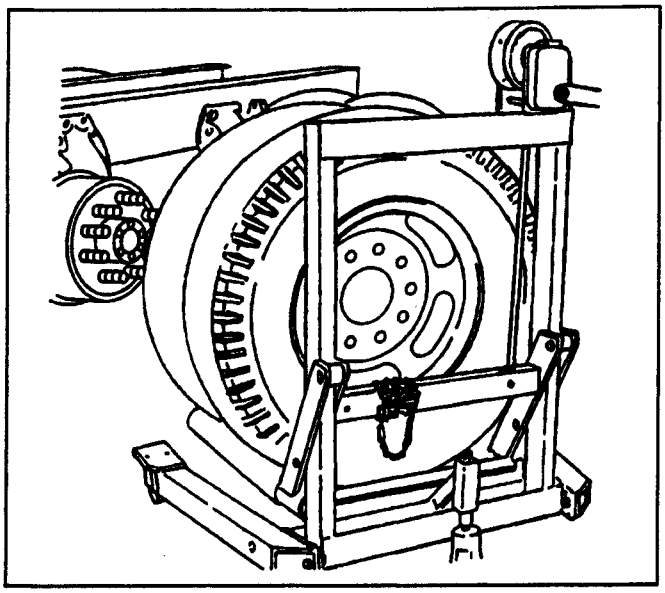
Certain environments created by some operations may lead to aluminum wheel corrosion. Some of these operations include the following conditions:

- Livestock hauling
- Snow removal using salt or chloride compounds
- Using highly alkaline cleaning agents

If these operating conditions exist, clean the wheels often with a stream of high-pressure water and mild detergent. Whenever you remove the tires, thoroughly clean the wheels.

Various protective coatings give good results. When using a protective coating, refer to the following suggested procedures:

1. Use a general purpose pad (such as 3M Scotch-Brite® No. 7447), or use a buffing wheel and a medium abrasive rubbing compound (such as 3M No. 05979 Clean-N-Glaze™). Aggressively rub the machined surfaces in order to remove some of the corrosion and to restore most of the luster.
2. Wipe the surface with aluminum cleaner-polish (such as Mag Wheel Cleaner Polish™ Stock No. PGC) in order to obtain maximum luster.
3. Clean the wheel with silicone remover (such as 3M No. 08984 General Purpose Adhesive Cleaner and Wax Remover™, or Prep-Sol®). Wash the wheel with clean water and dry with compressed air.
4. Wipe the wheel again with aluminum cleaner-polish. Apply a metal preparation (such as C.I.L. Metal Prep. No. 33 for aluminum) following manufacturer's instructions.
5. Apply a zinc chromate primer in four light applications, rotating the wheel 90 degrees between applications.
6. Spray the wheel with two light coats of wheel protectant (such as Coricone 1700 Clear Metal Protectant™ Stock Code DDC).



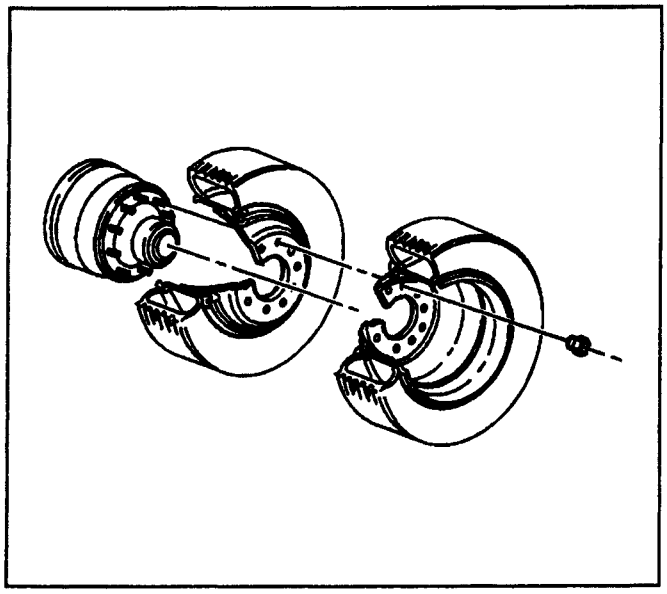
203150

Wheel Removal (Front)

Caution: To avoid eye injury, use approved safety lenses, goggles, or face shield to prevent eye injury when deflating tires.

Important: When removing and demounting any tire and wheel assembly, deflate the tire by removing the valve core. Perform this procedure before removing the tire assembly from the vehicle.

1. Raise the vehicle until the tire clears the floor. Support the vehicle. Refer to *Notice* in General Information.
2. Remove the wheel nuts.
3. Remove the wheel from the hub.



290802

Wheel Removal (Dual/Rear)

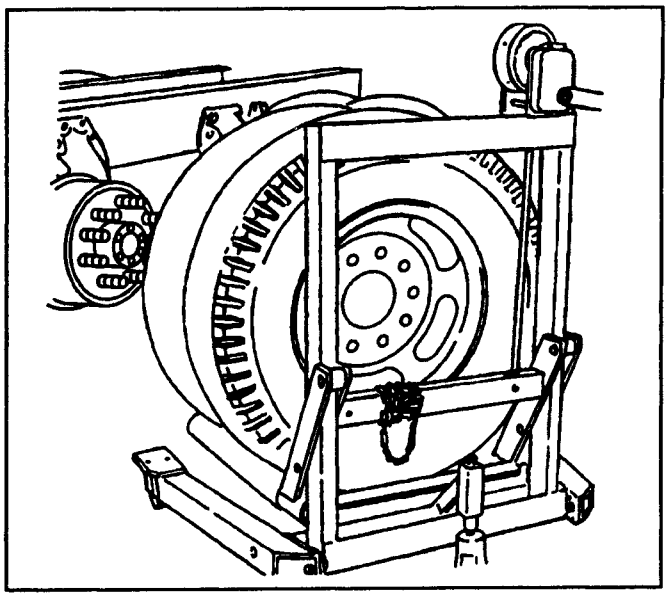
Caution: To avoid eye injury, use approved safety lenses, goggles, or face shield to prevent eye injury when deflating tires.

Notice: Wheel hub flanges, wheel studs, and stud nuts should be free of rust, lubricants, dirt, and finish color paint on all contact surfaces to ensure proper torque retention.

Important: When removing and demounting any tire and wheel assembly, deflate the tire by removing the valve core. Perform this procedure before removing the tire assembly from the vehicle.

1. Break the wheel nuts loose.
2. Raise the vehicle until the tire clears the floor. Support the vehicle. Refer to *Notice* in General Information.
3. Remove the wheel nuts.
4. Remove the wheel from the hub. Refer to Wheels Description.
5. If applicable, remove the stud nuts from the inner wheel.

6. If applicable, remove the inner wheel from the hub.



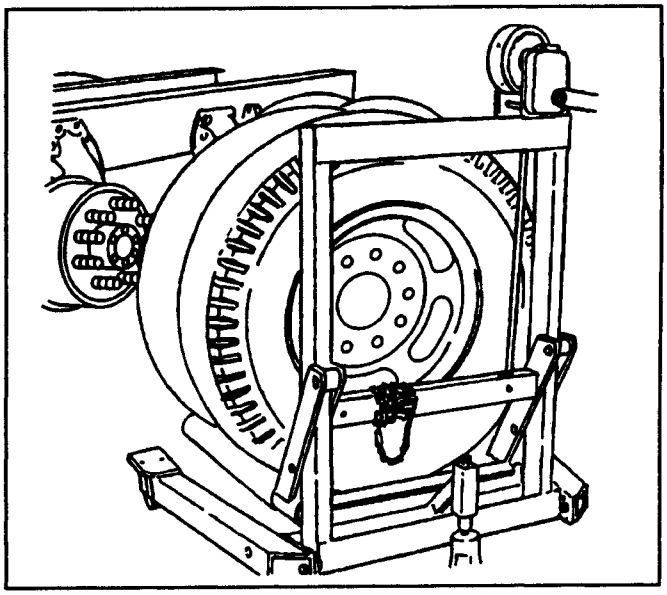
203150

Wheel Installation (Front)

Installation Procedure

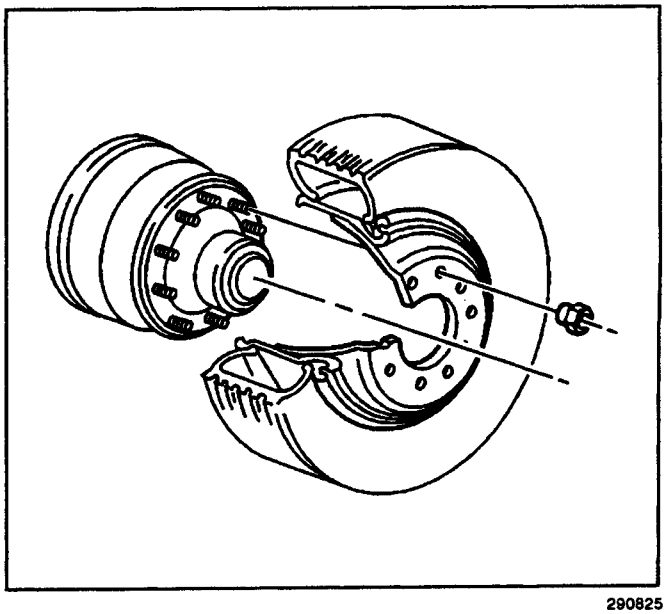
Notice: Wheel hub flanges, wheel studs, and stud nuts should be free of rust, lubricants, dirt, and finish color paint on all contact surfaces to ensure proper torque retention.

1. Apply a thin coat of grease to the hub pads in order to prevent corrosion.
2. Turn the hub in order to position the hub pad at a 12 o'clock position.

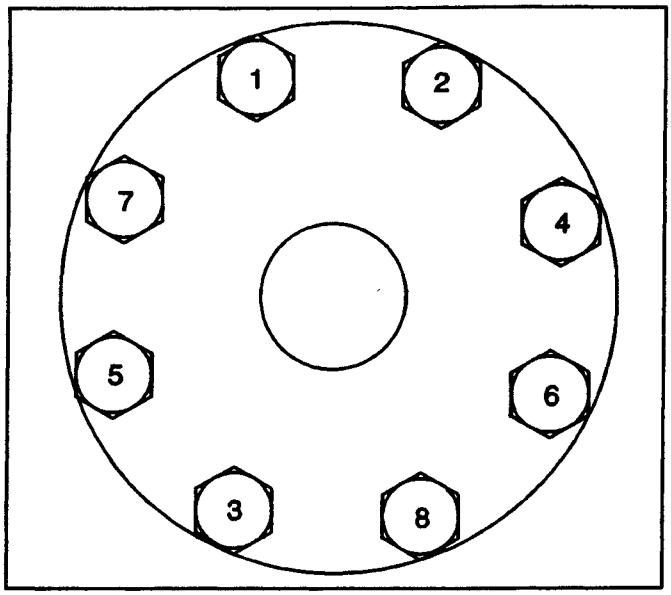


203150

3. Install the wheel on the hub.



290825

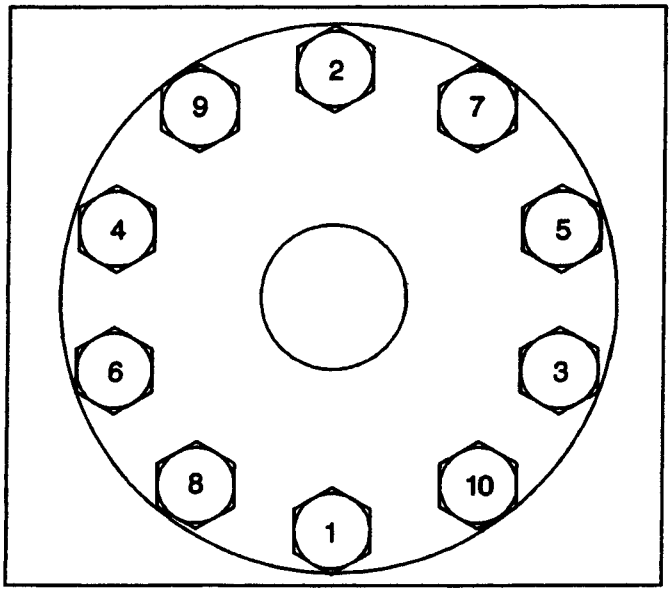


203172

Notice: Refer to *Fastener Notice* in Cautions and Notices.

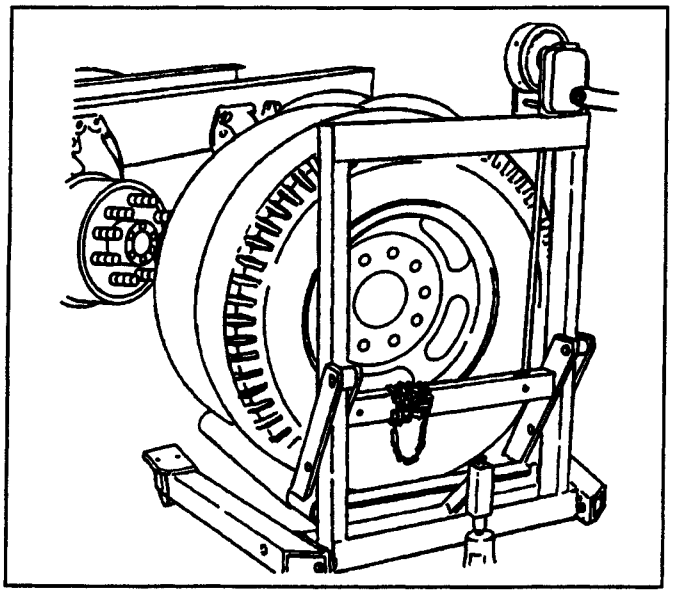
Important: Tighten the wheel nuts progressively using the first specification; then retighten the nuts using the second specification.

4. For 8-hole wheels, install the wheel nuts.
   Tighten
   - Tighten the wheel nuts to 100 N·m (74 lb ft) in the sequence shown.
   - Tighten the wheel nuts to 520–580 N·m (383–427 lb ft) in the sequence shown.



203173

5. For 10-hole wheels, install the wheel nuts.
   Tighten
   - Tighten the wheel nuts to 225 N·m (166 lb ft) in the sequence shown.
   - Tighten the wheel nuts to 610–678 N·m (450–500 lb ft) in the sequence shown.



203150

Wheel Installation (Dual/Rear)

Installation Procedure

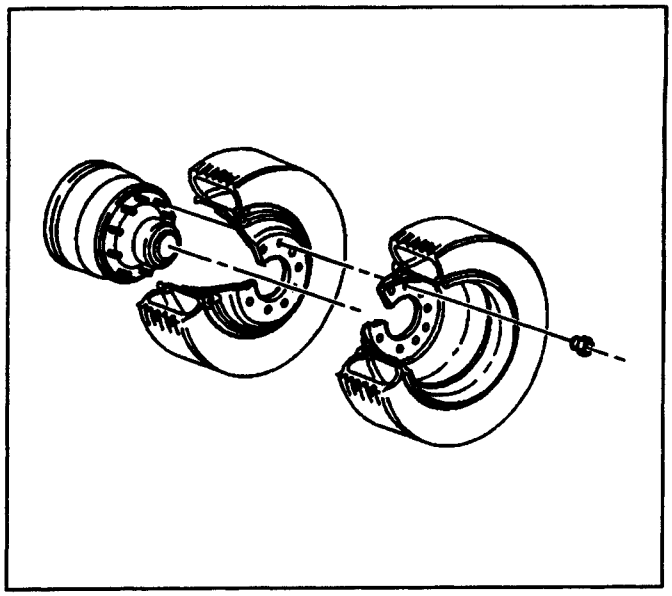
Notice: Wheel hub flanges, wheel studs, and stud nuts should be free of rust, lubricants, dirt, and finish color paint on all contact surfaces to ensure proper torque retention.

1. Apply a thin coat of grease to the hub pads in order to prevent corrosion.
2. Turn the hub in order to position the hub pad at a 12 o'clock position.

3. Install the wheel on the hub.

   Important: Perform steps 4 and 5 for dual wheel applications only. For single wheel applications, proceed to step 6.

4. Install the inner wheel on the hub.
5. Install the outer wheel on the hub with the valve stems of both wheels positioned as close to 180 degrees as possible.

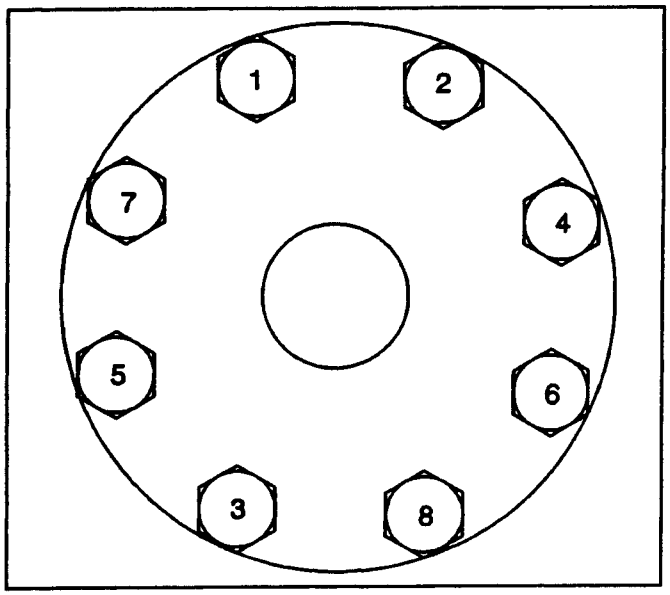


290802

Notice: Refer to *Fastener Notice* in Cautions and Notices.

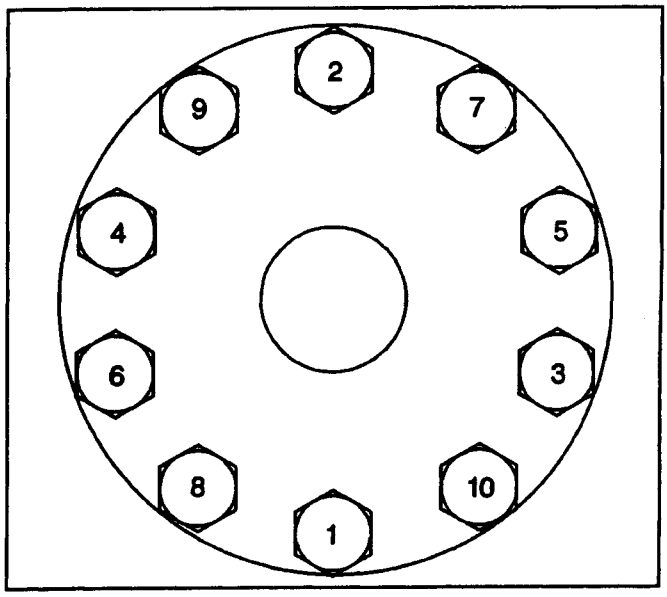
Important: Tighten the wheel nuts progressively using the first specification; then retighten the nuts using the second specification.

6. For 8-hole wheels, install the wheel nuts.
   Tighten
   - Tighten the wheel nuts to 100 N.m (74 lb ft) in the sequence shown.
   - Tighten the wheel nuts to 520–580 N.m (383–427 lb ft) in the sequence shown.

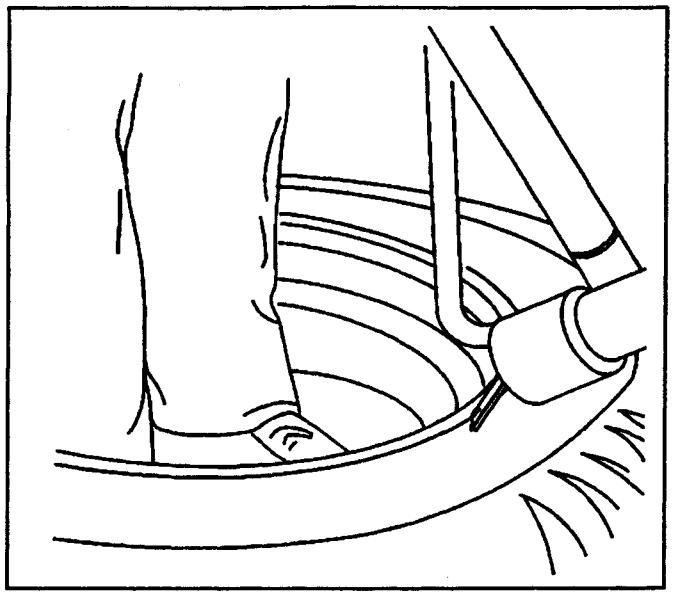


203172

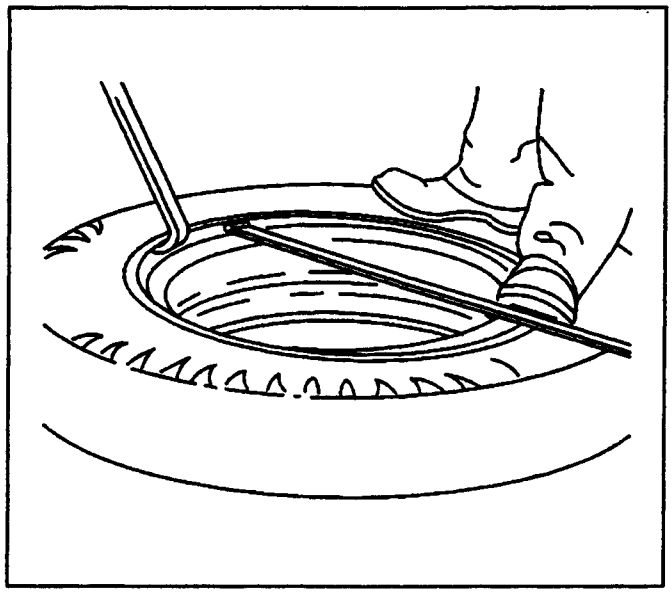
7. For 10-hole wheels, install the wheel nuts.
   Tighten
   - Tighten the wheel nuts to 225 N.m (166 lb ft) in the sequence shown.
   - Tighten the wheel nuts to 610–678 N.m (450–500 lb ft) in the sequence shown.



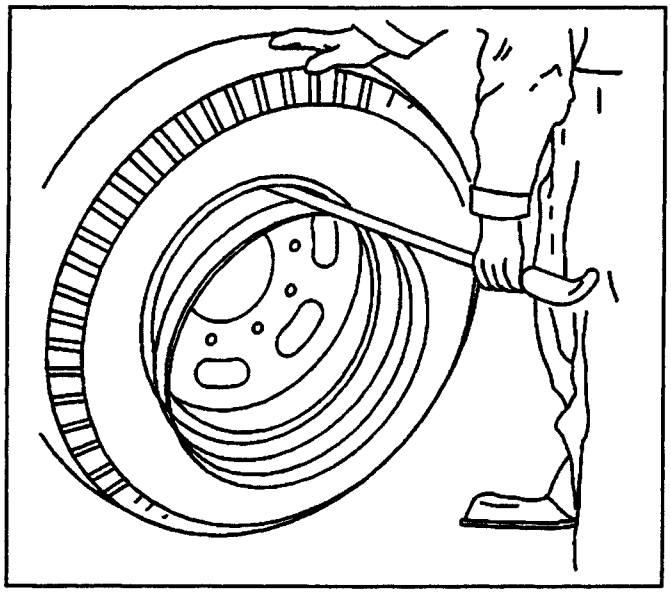
203173



214470



214473



214475

Tire Mounting and Dismounting

Removal Procedure

Caution: To avoid eye injury, use approved safety lenses, goggles, or face shield to prevent eye injury when deflating tires.

1. Completely deflate the tire prior to demounting. If either the rim or the rings are damaged, or if the ring appears to be unseated, deflate the tire prior to removing the assembly from the vehicle. Reduce the pressure by pushing in the valve stem, or remove the entire core. Keep your eyes away from the valve.
2. Loosen both beads from the rim by driving the flat end of the tire tool between the tire bead and the rim flange. Straighten the tool to a vertical position and hammer downward in order to pry the tire from the rim. Repeat this step at approximately 200 mm (8 in) intervals around the flanges until you free the beads from the rim.
3. Place the wide side of the rim down.
4. Lubricate the tire bead and the rim.
5. Insert the curved end of both tools and step on the tire opposite the valve in order to direct the first bead into the rim well. Hold one tool in position with your foot, and pull the second tool toward the center of the rim. Progressively work the first bead off of the rim.
6. Stand the wheel on the tire tread with the valve near the top.
7. Lubricate the second bead and the rim.
8. Insert the straight end of the tool between the tire bead and the back rim flange. Hook the tool over the second flange. Lean the tire assembly toward the tool and provide a rocking or a bouncing action in order to pry the rim out of the tire.

   Caution: To avoid eye injury, use approved safety lenses, goggles, or face shield when using buffing and cleaning equipment.

9. Clean the rim of dirt, corrosion and light rust. If you mount the tires on dirty or corroded rims, or if you do not properly center the tires on their rims, then the tire bead may bind on the rim and refuse to seat. Replace any rims that are corroded and weakened:
   - Remove surface rust and other foreign material from the rim.
   - Verify that rim flanges and the bead ledge areas are smooth and clean, especially around the hump and the radius.
   - Remove the following foreign materials using a wire brush:
     - Dried tire mounting lubricant
     - Surface rust
     - Heavy paint
   - Paint steel wheels that show bare metal using a good grade of aluminum paint or equivalent, in order to prevent rust.
10. Inspect the rim for the following conditions:
    - Cracks
    - Bends
    - Corrosion which results in heavy pitting
    - Rust
    - Distortion
11. Replace damaged rims.

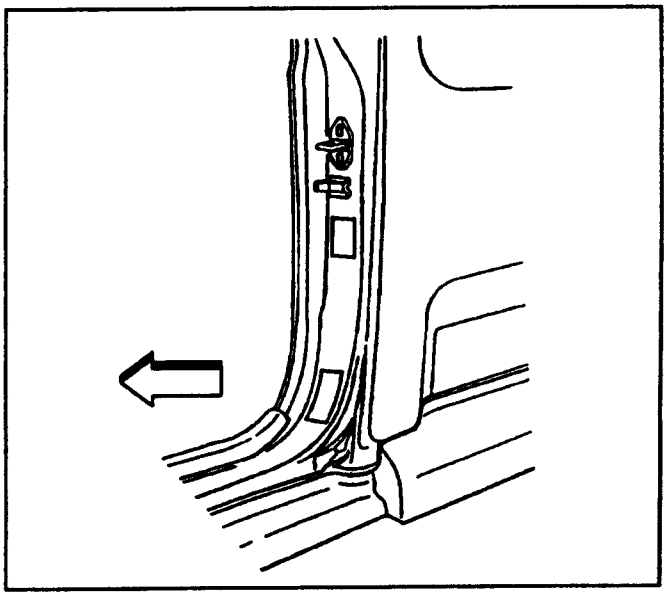
Installation Procedure

Caution: Only use mounting equipment tools specifically designed for tire mounting. Do not use improvised tools. Failure to observe this precaution could cause serious injury to you or other personnel in the area.

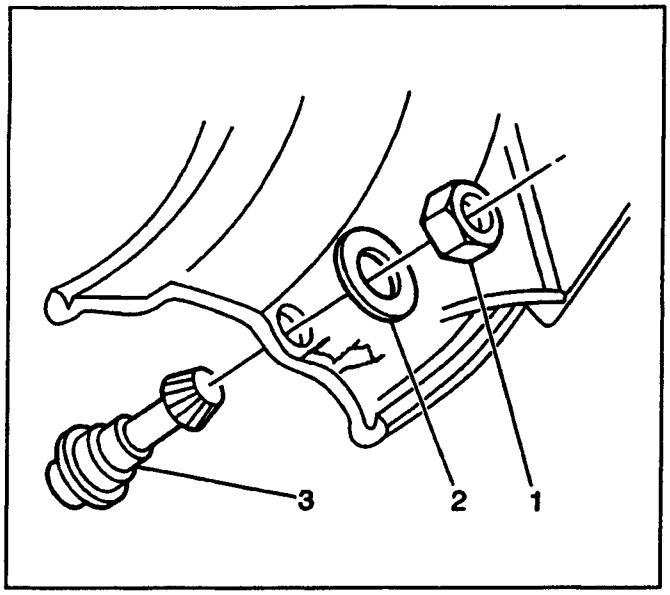
Notice: Use an approved tire mounting compound such as Ru-Glyde®, Frey Lube II® or equivalent. Do not use silicone-base compounds or corrosive-type compounds. Silicone-base compounds can cause the tire to slip on the rim. Corrosive-type compounds can cause tire and/or rim deterioration.

Important: Use only proper size rims. Do NOT exceed the recommended air pressures as specified on the vehicle certification label.

1. Select tires and rims which are the correct size.



205890



203179

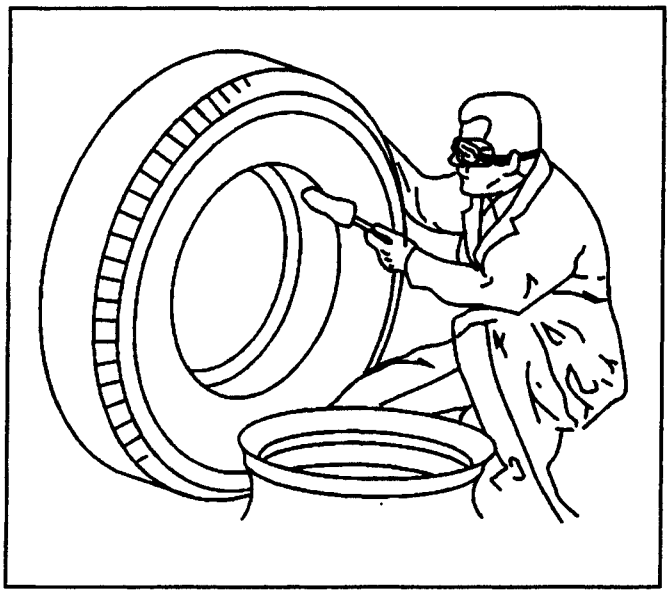
2. Place the valve stem with the rubber washer through the valve hole from the tire side of the rim.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Screw on the valve nut from the opposite side. Center the rubber bushing, the metal collar, and the nut snugly in the valve hole.

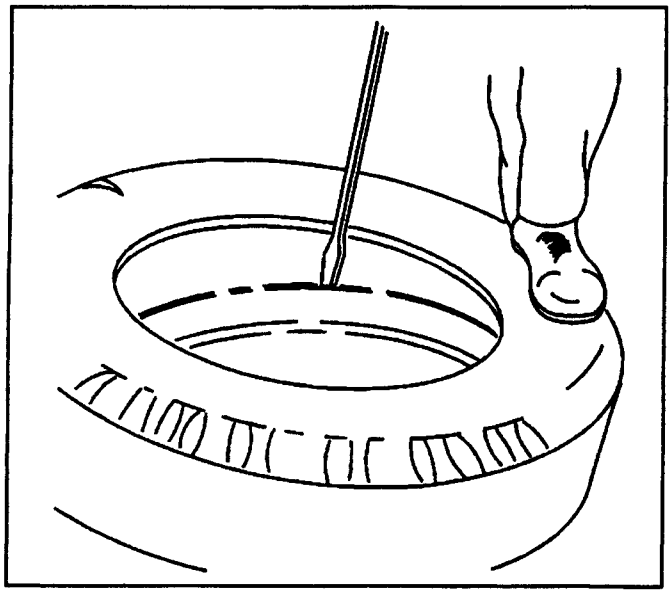
   Tighten

   Tighten the valve stem nut to 6 N·m (53 lb in).



203180

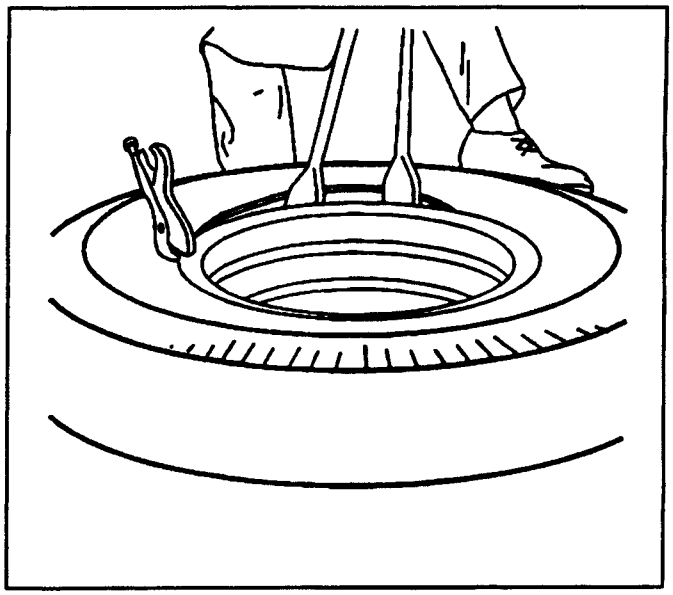
4. Use an approved tire mounting compound such as RU-Glyde®, Frey Lube II® or equivalent in order to lubricate the following areas:
   - The tire beads
   - The rim flanges
   - The bead ledge areas



214479

5. Place the rim on the floor with the wide end side down.
6. Push the first bead over the flange and into the rim well.
7. Using the straight end of a tool (with the stop resting on the flange of the rim), take small bites in order to work the remaining section of the bead onto the rim.

8. Stand on the tire in order to start the second bead over the rim flange into the well.
9. Use the spoon end of a tire iron, with the stop toward the rim. Work progressively around the bead using small bites until the bead slips over the flange onto the rim base.



214482

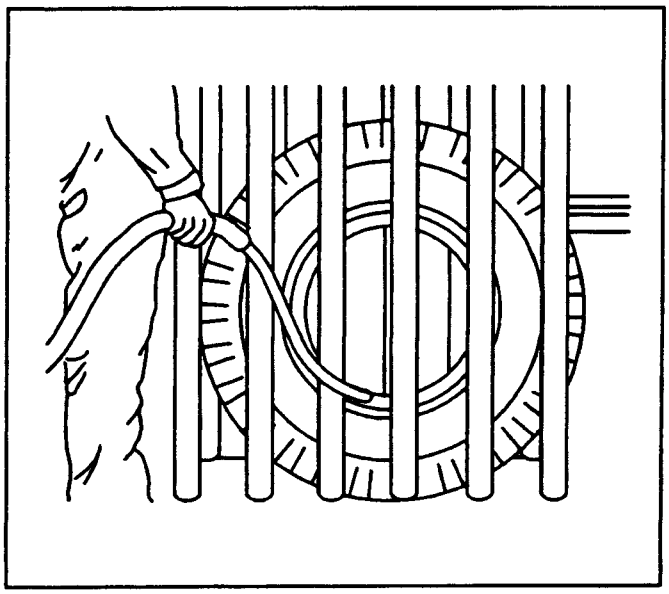
Caution: Be careful not to drop tire and wheel assemblies on your hands and feet. Lift properly, using your legs as well as your body. Tires and wheels are heavy and can cause injury if not handled correctly.

Caution: Allowing pressure to continue to build up within a tire in an attempt to seat the bead is a dangerous practice that can result in a broken tire bead and possible serious injury to the technician.

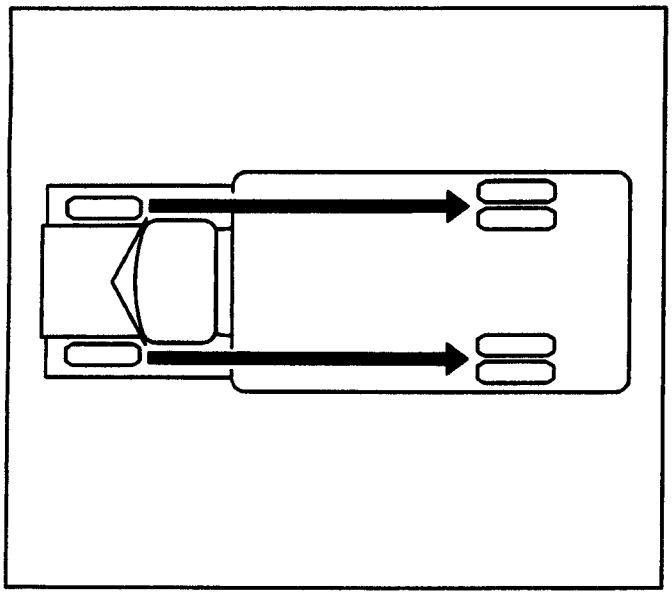
Important:

- Use dry air for tire inflation. Use moisture traps on the air lines leading from the air compressor.
- Do NOT overload the tires. Verify that the load and the vehicle weights do not exceed the rated load of the tires used on the vehicle. The rims are designed in order to sustain the maximum rated load of the maximum tire size that is recommended for that rim. Refer to the *Vehicle Certification Label Description* in General Information for recommended rated load and tire size.
- Do not exceed the maximum inflation pressures. Inflation pressures are determined by the size and the ply rating of the tire. Refer to the manufacturer's specification for proper inflation. Equally inflate both tires of a dual assembly in order to equally distribute the weight.

10. Inflate the tire in a safety cage using an extension hose equipped with an air gage and a chuck. Confirm that you have seated the bead properly by referencing any circumferential design element on the tire and on the top of the rim flange. These design elements should be equally spaced around the tire.



203182



203209

Tire Rotation

The movement of the tires from the front of the vehicle to various rear wheel positions depends on the type of unit being operated. Use tires with good non-skid tread design on the drive wheels.

Notice: Never rotate a drive-type tread tire to the front axle. When rotating tires, only rotate tires that have the same tire tread type. When a drive-type tread tire is placed on the front axle, improper vehicle handling and tire damage may result. Following these instructions can help you avoid damage to parts and the steering system.

Rotate the tires from the front wheel to the rear wheels when the tread depth is 3.2 mm (0.13 in). If the front wheel tire wear is uneven, then rotate the tires and check the vehicle for mechanical irregularities.

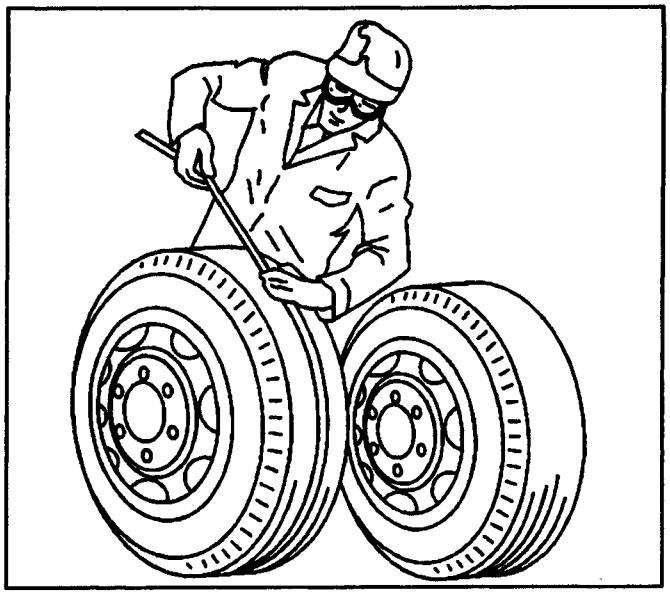
Tire Matching

1. Mismatched tires on tandem drive units will cause the following conditions:
   - Tire wear
   - Scuffing
   - Possible damage to the drive units
2. Match the tires to within 3 mm (0.125 in) of the same rolling radius and 19 mm (0.75 in) of the same rolling circumference.

   Notice: The four largest tires should never be installed on one driving axle or the four smallest tires on the other driving axle. Such tire mounting will cause an inter-axle bind and unusually high axle lubricant temperatures that result in premature lubricant breakdown and possible costly axle damage.
3. Ensure that the total tire circumference of one driving axle matches the total tire circumference of the other driving axle as nearly as possible. This will result in higher tire mileage. This will also maintain satisfactory temperatures of tandem axle lubricants which lengthen the drive unit service.

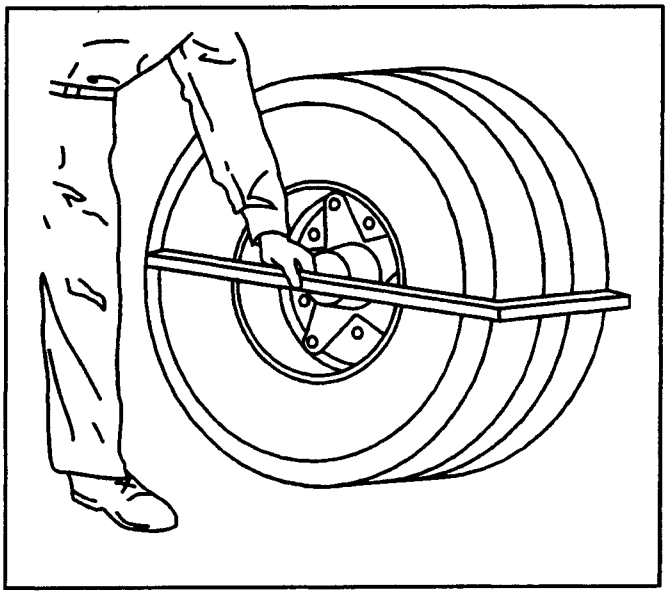
4. Park the vehicle on a level floor, carrying an evenly rated capacity load. Verify that all of the tires are the same size. Measure new tires in order to be sure that the tires will be correctly matched.
5. Inflate all tires to the same recommended pressure:

- Measure the rolling circumference of each tire using a steel tape after you have inflated the tires and placed the tires on their rims, but before you have installed the tires on a vehicle. This is the most accurate method. This procedure allows for any irregularities in wear.

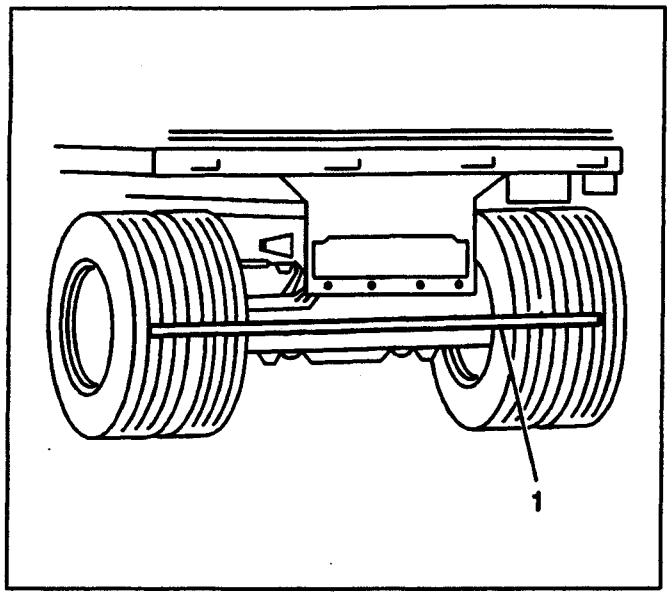


203195

- In order to check the tires already installed on the vehicle use a large square.

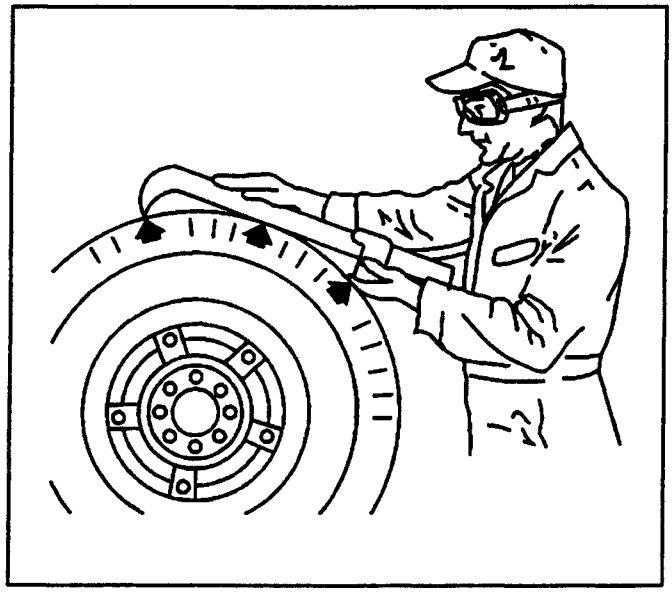


203202



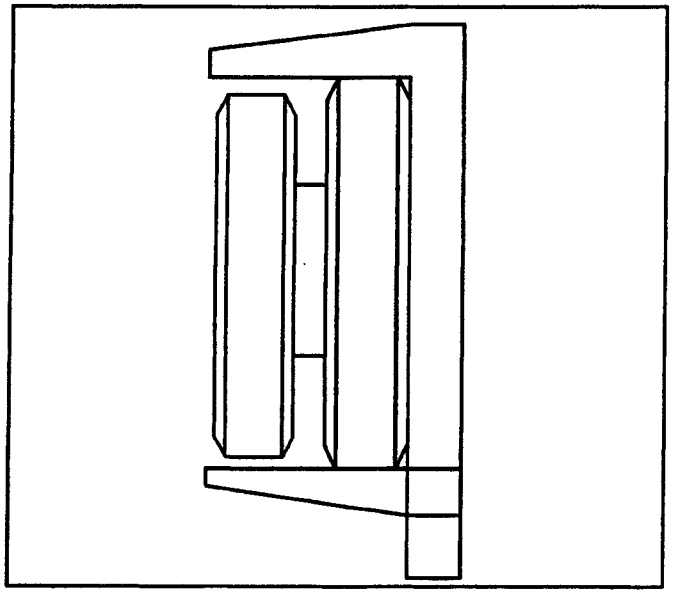
203199

- Check the tires using a string gage (1).



203204

- Check the tires using a large caliper.

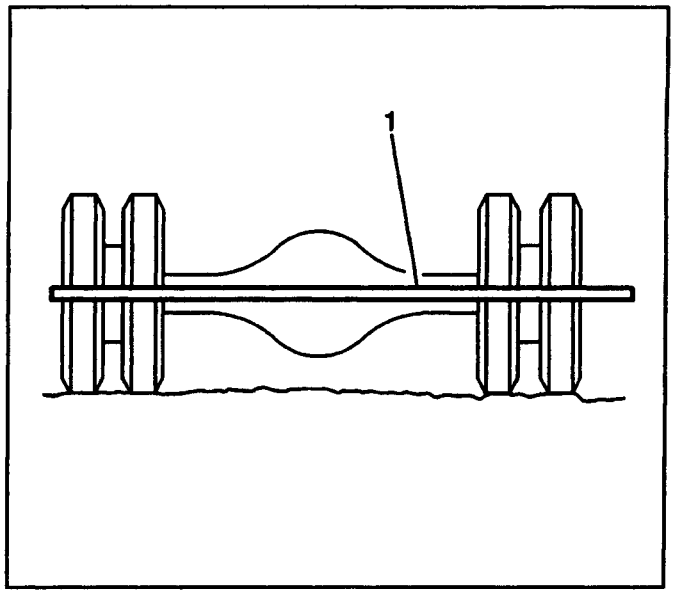


203205

- Check the tires using a matching stick.

- Check using a wooden straightedge (1) long enough to lie across the treads of all four tires.

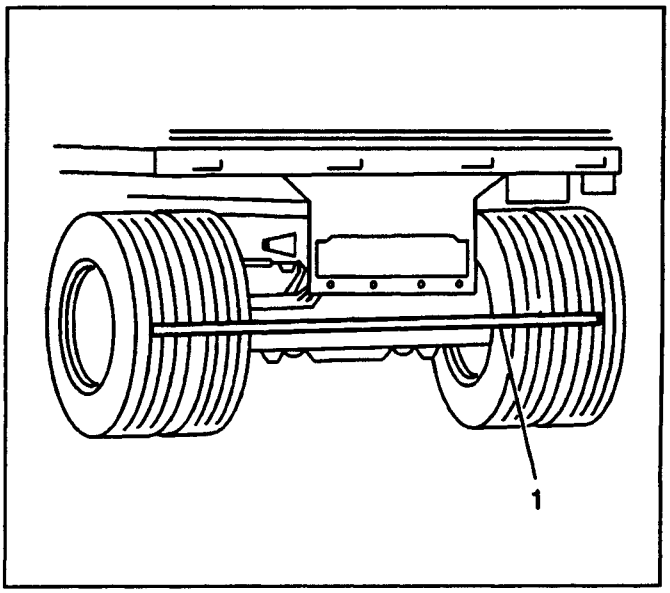
  Mark the size on each tire with chalk and arrange the tires in order of size, largest to smallest.



203207

Installation Procedure

1. Install the two largest tires on one side of one axle.
2. Install the two smallest tires on the opposite side of the same axle.
3. Install four other tires on each of the other axles as described in steps 1 and 2.
4. Inspect the rear axle lubricant temperature readings.
   - Run the vehicle for accurate readings.
   - Vary the tire air pressure, within the tire manufacturer's recommended range, in order to ensure that the lubricant temperature of both axles is within 17°C (30°F) of each other and not in excess of 104°C (220°F). This will result in uniform tire loading and will assure good tire life.



203199

Tire Measuring

Overall Diameter (5): Overall diameter is the diameter of the tire measured from the opposite outer tread surfaces, without carrying a load.

Free Radius (3): The free radius is one-half of the overall diameter.

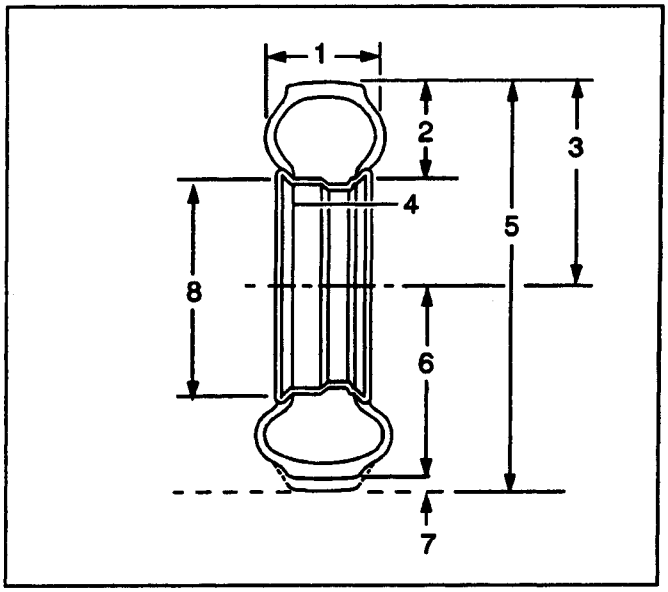
Section Height (2): Section height is the distance from the rim seat (4) to the outer tread surface of the tire without carrying a load.

Section Width (1): Section width is the distance between the outside of the sidewalls of the inflated tire.

Loaded Radius (6): Loaded radius is the distance from the wheel axle centerline to the supporting surface under a tire, properly inflated for its load.

Deflection (7): The deflection of a tire is the free radius (3) minus the loaded radius (6).

Revolutions Per Mile: Revolutions per mile is the measured number of revolutions for a tire traveling one mile. This measurement can vary with load inflation.



203275

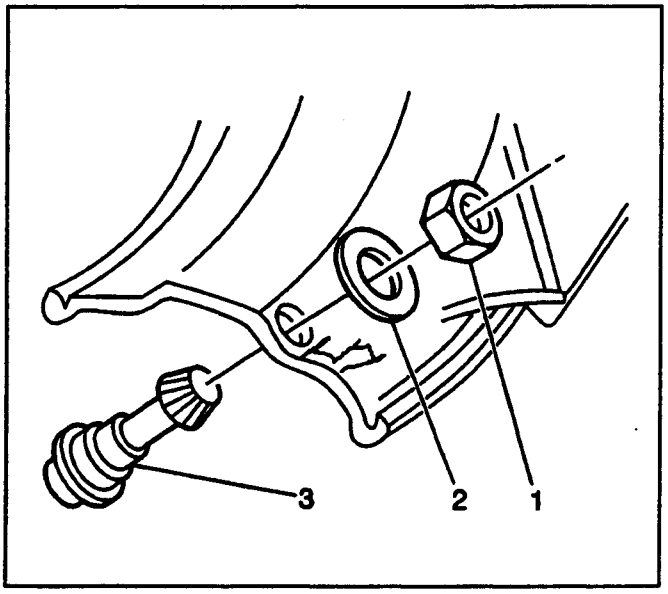
Loads Per Axle and Inflation Pressures: The carrying capacity of each tire size is determined by various inflation pressures for a single application (two tires) axle load and for a dual application (four tires) axle load.

Wear Bars: Truck tires contain wear bars in the grooves of the tire tread that show when only 1.6 mm (0.0625 in) or less of tread is remaining. When the wear bars show, replace the tires. The tires on the front axles must have at least 3.2 mm (0.13 in) of tread depth.

Load Range/Ply Rating: Load range is a letter that corresponds to the numerical ply rating. Refer to Load Range/Ply Rating Description.

Valve Core and Cap Replacement

The valve core (3) is a spring-loaded check valve in the valve stem. The valve core allows inflation or deflation of the tube or the tire. This check valve is intended to hold air during operation. The valve cap keeps dirt and foreign material away from the valve core. Use valve caps at all times.



203179

Description and Operation

Tires Description

Caution: Do not mix bias-ply and radial tires on the vehicle except in emergencies, because vehicle handling could be affected and may result in the loss of control.

Radial tires are constructed of the following material:

- Casing plies which run perpendicular to the tread direction
- Several layers of steel or fabric tread-reinforcing plies just under the tread area

This construction permits flexing of the tire sidewall with the following advantages:

- A minimum of tread distortion
- Better traction
- A softer ride

Tubeless radial tires are recommended for this vehicle.

When inspecting the tires, check the valve stem cores for leakage. Also check around the tires for embedded steel, rock, or glass. If these objects remain in the tread, these objects may eventually cause a failure. In some cases a puncture will occur, and removal of the foreign object will cause the tire or the tube to lose pressure.

Overloading causes many kinds of cord body breaks. Overloading is due to abnormal flexing or overworking of the cord body of the tire. Overload flex breaks occur in the sidewall or in the shoulder of a tire. These breaks run with the circumference of the tire. Sometimes the breaks are only 51–76 mm (2–3 in) long. Other times these breaks will extend partly around the tire. These breaks may cause a blowout or a pinched tube that allows the tire to go flat.

Normal flexing of a tire can go on for long periods of time without causing any great damage to the cords. If the tire is overworked or overflexed abnormal heat is generated, and the cords may become weak and will break.

The following conditions may cause flex breaks:

- Underinflation
- Sprung axles
- Mismatched dual tires
- Poor load distribution

You may avoid this condition by using proper size and type of tires and rims which are large enough to carry the load. Do not attempt to increase the rated carrying capacity of a tire by inflating the tire beyond the maximum recommended pressure. For information on bias-ply tire inflation, refer to the manufacturer's information.

Tire Repair Description

Caution: Do not mix bias-ply and radial tires on the vehicle except in emergencies, because vehicle handling could be affected and may result in the loss of control.

Inspect the valve stem cores for leakage. Refer to *Valve Core and Cap Replacement*. Inspect around the tires for embedded steel, rock, or glass. In some cases the tube of an inflated tire may already be punctured, and pressure will be lost only when the object is removed.

Overloading is the cause of many kinds of cord body breaks. Such breaks are due to abnormal flexing or overworking of the cord body of the tire. Overload flex breaks occur in the sidewall or the shoulder of a tire. These breaks run with the circumference of the tire. Sometimes the breaks are only 51–76 mm (2–3 in) long. Other times the breaks will extend partly around the tire, resulting either in a blowout or a pinched tube that allows the tire to go flat.

Normal flexing of a tire can go on for long periods of time without causing any great damage to the cords. If the tire is overworked or overflexed from overload, then abnormal heat is generated, and the cords become weak and the cords break.

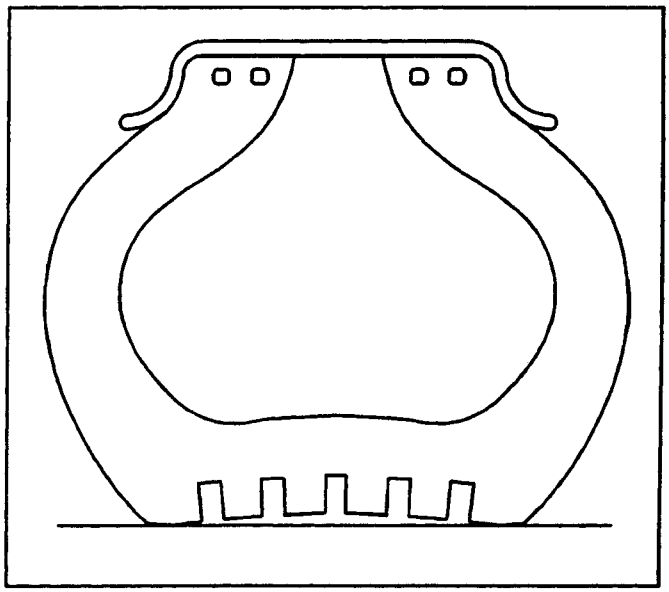
Underinflation will cause the same result. In addition, spring axles, mismatched duals, and poor load distribution tend to cause flex breaks. This can be avoided if vehicles are equipped with the tires and the rims of the proper size and type, large enough to carry the load. Inflating the tire beyond the maximum recommended pressure will not increase the rated carrying capacity of a tire. Refer to the manufacturer's specifications for load and pressure recommendations.

Tire Inflation Description

The following tire qualities are designed in order to obtain maximum length of service under normal operating conditions:

- The fabric
- The rubber
- The bead
- The contour
- The size of tires used on these vehicles

The tires are made in order to operate efficiently only on a specified amount of air. Unless the driver of the vehicle maintains the correct air pressure, the tires will not function as intended.

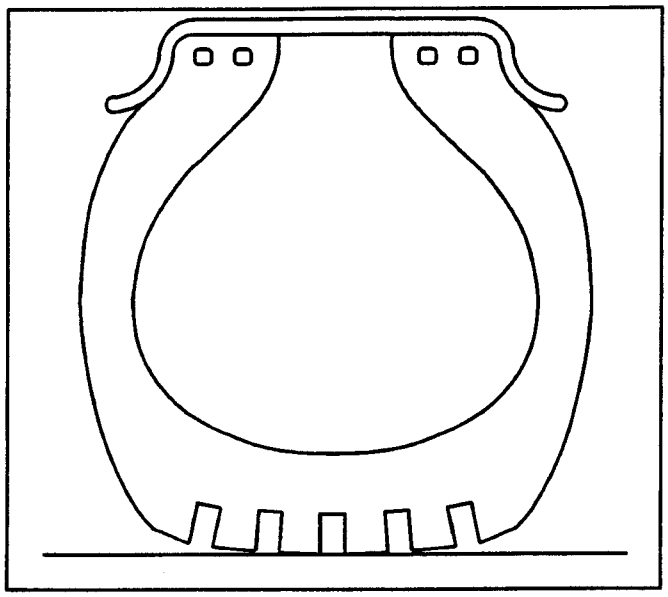


203217

An underinflated tire may cause the vehicle to operate in the following manners:

- Runs sluggishly
- Heats up quickly because of the greater flexing
- Bruises more often

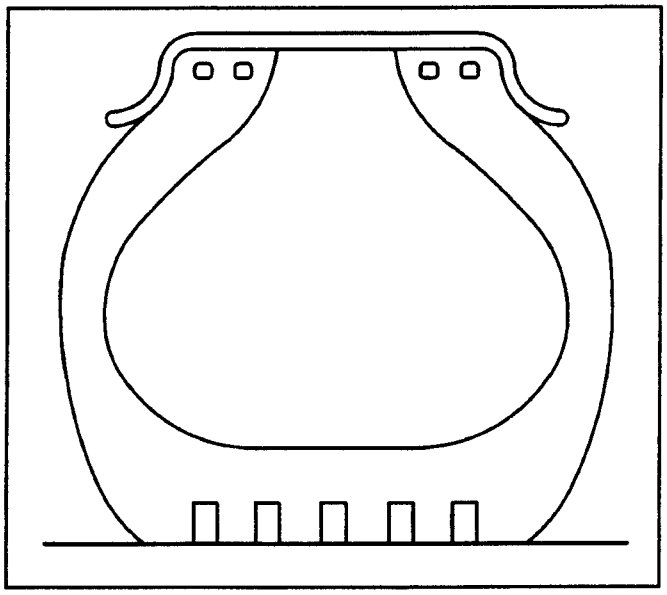
In dual tire mounting, loss of pressure in one tire could cause the rim to slip on the wheel.



203219

Overinflation may weaken the tire, causing a blow-out. Improperly inflated tires will affect the following conditions:

- Steering
- Riding comfort
- Safe driving



203215

Inflate the tires as indicated by the manufacturer's recommendation:

- For greater riding comfort
- For longer tire life
- To reduce vehicle chassis wear

Ensure that the combined front and rear tire load do not exceed the maximum recommended load.

Inflate the tires to the recommended pressure when the tires are cool. If the tires are always carrying less than the recommended maximum load, reduce the air pressure to correspond with the actual load carried.

Never bleed the tires in order to relieve pressure buildup. Tire temperature and air pressure will increase when the tire is in service. Tire design allows for this buildup in pressure. Tire temperature and air pressure will stay within limits that are not harmful to the tire when used with the recommended load and air pressure.

The followings conditions may be responsible for high pressure buildup:

- Overload
- Underinflation
- Speed
- A combination of these

Use the size and type of tire that has the capacity to carry the load at a recommended cold starting pressure.

Pressure Loss

At periodic intervals, use an accurate gage in order to check each tire for pressure loss. If you notice a pressure loss in any of the tires, complete the following steps:

1. Make an inspection.
2. Determine the cause of the pressure loss.
3. Correct the problem.

Balanced Inflation

All tires on the same axle should always carry the same air pressure. Although a difference in air pressure of the rear and the front tires may be allowed, within certain limitations, you should not tolerate a difference in pressures between the right and the left tires on the same axle.

A 34 kPa (5 psi) underinflated tire can lower the efficiency of most brakes. Balanced tire inflation contributes to the following conditions:

- Easier steering
- Riding comfort
- Driving safety
- Minimum fuel use
- Maximum tire mileage

Tire Overheat

As a tire becomes heated, the air in the tire expands and the air pressure rises. This is a normal condition, unless the pressure buildup is excessive. Increased tire pressure over 138 kPa (20 psi) is excessive. Increased tire pressure indicates the following conditions:

- Underinflation
- Overload
- Too much speed
- Too small a tire
- More often, a combination of these factors

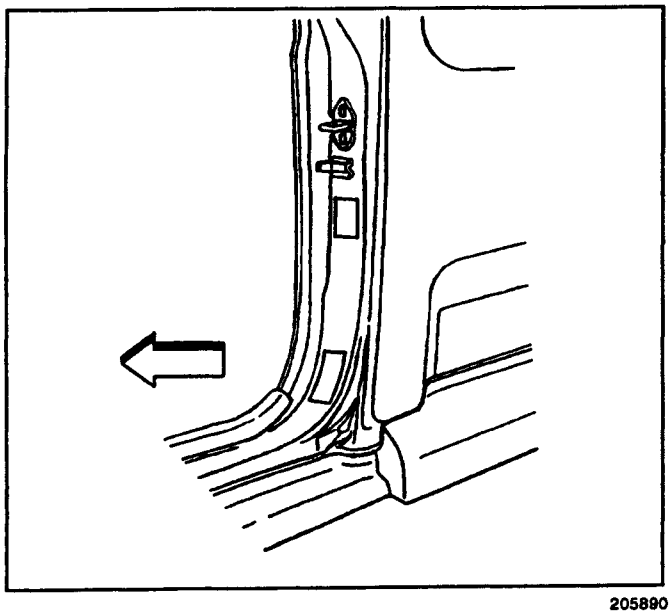
Investigate pressure buildups of over 138 kPa (20 psi) in order to determine the cause of the buildups. Take proper corrective action. Normal pressure buildups, not over 138 kPa (20 psi), reduce flexing.

Heat balance is defined as the temperature at which the rate of heating equals the rate of cooling. Normal pressure buildup reaches this heat balance at a lower temperature than by frequently bleeding the air in order to maintain the inflation pressure. Never bleed the tires. When the pressure builds up excessively, reduce the speed or the load.

Load Range/Ply Rating Description

Load Range	Ply Rating
A	2
B	4
C	6
D	8
E	10
F	12
G	14
H	16
J	18
L	20
M	22
N	24

Vehicle Certification Label Description

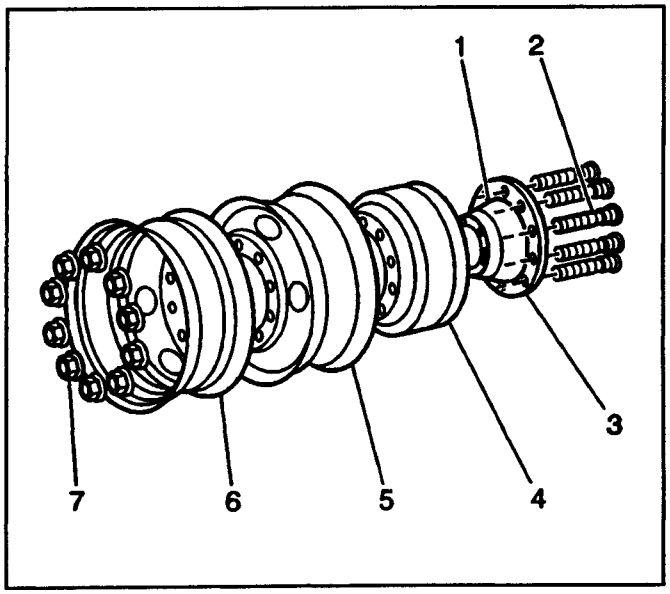


205890

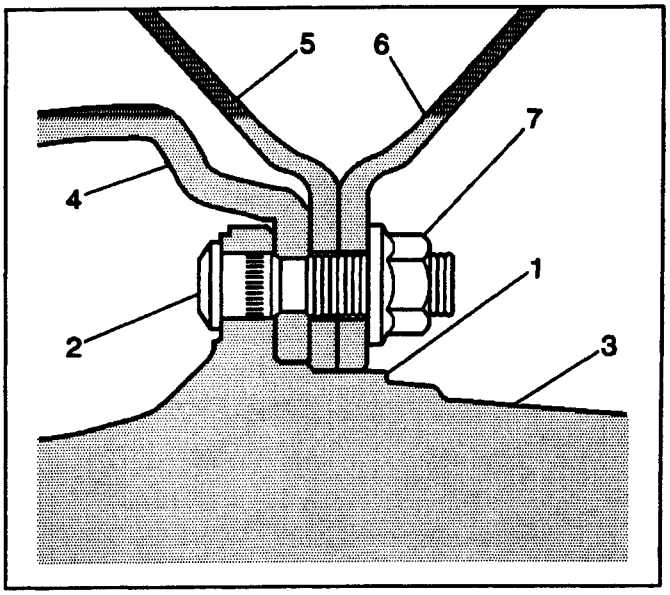
The vehicle certification label shows the originally equipped tire size and the recommended inflation pressures. The label is located on the driver side door sill.

Wheels Description

The wheels are all of a hub-piloted design. "Hub-piloted" refers to the way that the rim trues (centers) itself on the hub by the use of hub pads. A hub pad (1) is the cast and machined ears of the hub (3) that comes into contact with the rim (5,6) during installation. The wheel is attached to the hub by two-piece flange nuts (7).



203156



203157

The wheels are made of aluminum or steel. The steel type wheel utilizes a two-piece steel construction, making the wheel and the rim an integral unit. The aluminum wheel is a one-piece cast aluminum component.

BLANK

Air Suspension

Specifications

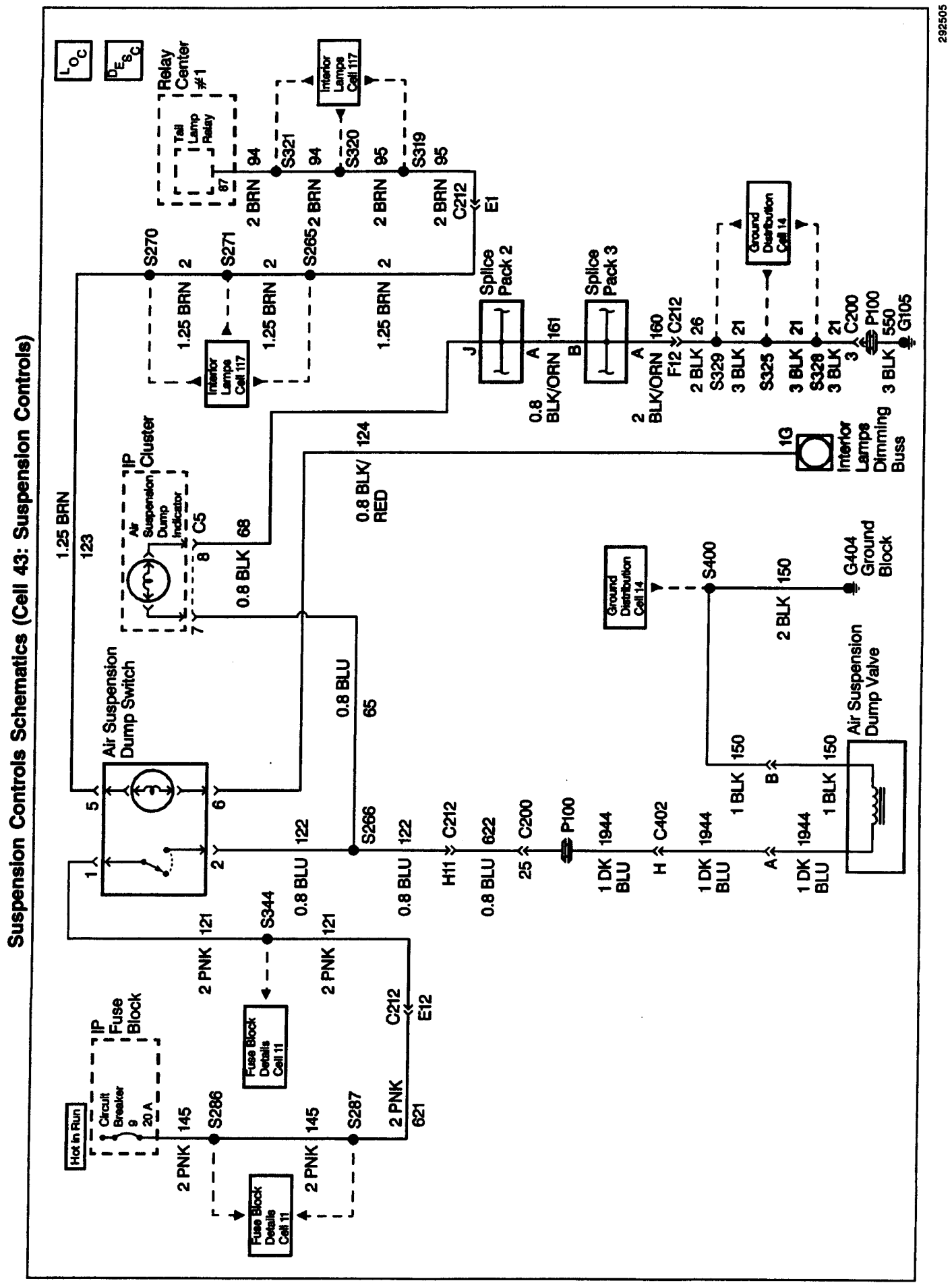
Fastener Tightening Specifications

Application	Specification	
	Metric	English
Air Spring Frame Hanger to Frame Locknut	300–360 N.m	221–266 lb ft
Air Spring to Air Spring Frame Hanger Locknut	27–41 N.m	20–30 lb ft
Air Suspension Relief Valve Bolt	15–20 N.m	11–15 lb ft
Cross Channel to Main Support Beam Locknut	330 N.m	243 lb ft
Leveling Valve Arm on Leveling Valve Locknut	21–25 N.m	15–18 lb ft
Leveling Valve Mounting Locknut-Models Without RPO-GPG	82–108 N.m	60–80 lb ft
Leveling Valve Mounting Locknut-Models With RPO-GPG	68–95 N.m	50–70 lb ft
Rebound Bolt Locknut	68–95 N.m	50–70 lb ft
Shock Absorber to Mounting Bracket Locknut	68–95 N.m	50–70 lb ft
Transverse Rod Bar Pin Nut-Models Without RPO-GPG	285–310 N.m	210–229 lb ft
Transverse Rod Taper Pin Locknut-Models With RPO-GPG	474–542 N.m	350–400 lb ft
Torque Bar Rod Pin Locknut	203–278 N.m	150–205 lb ft
Torque Rod Locknut	203–278 N.m	150–205 lb ft
Torque Rod Locknut at Axle End of Torque Rod	203–278 N.m	150–205 lb ft
10 mm (0.375") Hex Head Self-Tapping Screw	34 N.m	25 lb ft

Schematic and Routing Diagrams

Suspension Controls Schematic References

Reference on Schematic	Section Number - Subsection Name
Fuse Block Details Cell 11	8—Wiring Systems
Ground Distribution Cell 14	8—Cruise Control
Interior Lamps Cell 117	8—Lighting Systems


Suspension Controls Schematics (Cell 43: Suspension Controls)
292505
LOC
DESC
Relay Center #1
Tail Lamp Relay
87
Interior Lamps Cell 117
S321
S320
S319
94
95
2 BRN
C212
E1
S270
S271
S265
2
1.25 BRN
Splice Pack 2
Splice Pack 3
J
A
B
161
160
F12
C212
26
0.8 BLK/ORN
2 BLK/ORN
2 BLK
S329
3 BLK
21
S325
S328
3 C200
P100
550
G105
Ground Distribution Cell 14
1G
Interior Lamps Dimming Buss
IP Cluster
Air Suspension Dump Indicator
C5
8
7
68
0.8 BLK
123
1.25 BRN
124
0.8 BLK/ RED
Air Suspension Dump Switch
5
6
1
2
65
0.8 BLU
122
S266
H11
C212
622
C200
25
P100
1944
1 DK BLU
H
C402
A
S400
150
1 BLK
B
G404 Ground Block
2 BLK
Air Suspension Dump Valve
121
S344
2 PNK
C212
E12
621
S287
S286
145
Hot In Run
Circuit Breaker
9
20 A
IP Fuse Block
Fuse Block Details Cell 11

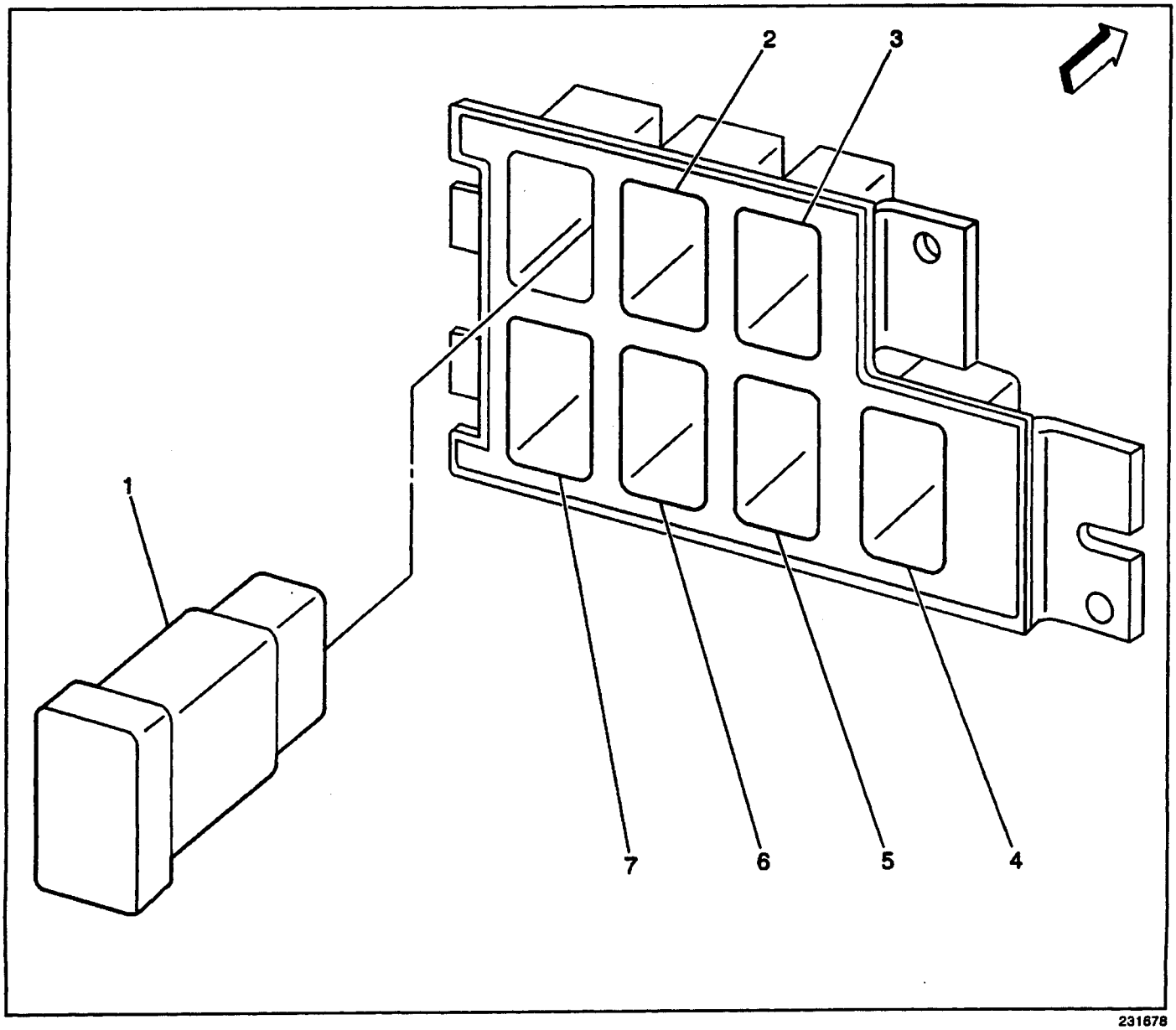
Component Locator

Suspension Controls Components

Name	Location	Locator View	Connector End View
Air Suspension Dump Switch	Center of the I/P	*Suspension Controls Component Views*	*Suspension Controls Connector End Views*
Air Suspension Dump Valve	Inboard RH frame rail, rear of the shock absorber crossmember	—	*Suspension Controls Connector End Views*

Suspension Controls Component Views

Instrument Panel Switches, Center Forward View



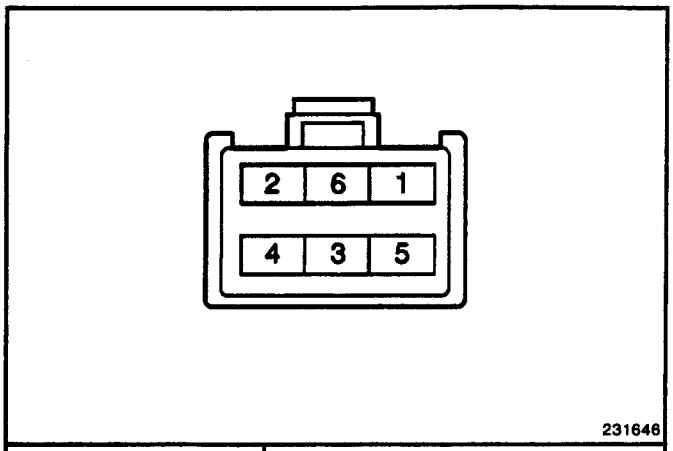
231678

Legend

(1) Exhaust Brake Switch
(2) Fast Idle Switch
(3) Heated Mirror Switch
(4) Two Speed Rear Axle Shift Switch (Automatic Transmission)
(5) Air Suspension Dump Switch
(6) Differential Lock Switch
(7) Clearance Lamps Switch

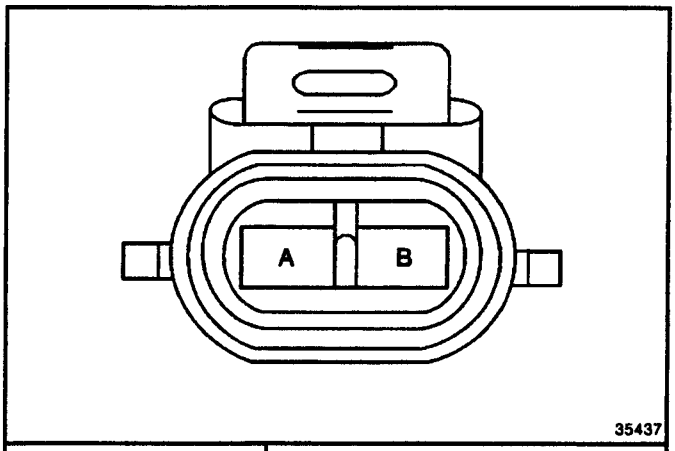
Suspension Controls Connector End Views

Air Suspension Dump Switch



Connector Part Information	• 6 Way • Female		
Pin	**Wire Color**	**Circuit No.**	**Function**
1	PNK	121	Fuse Output-Ignition
2	BLU	122	Air Suspension Dump Valve Solenoid Feed
3-4	—	—	Not Used
5	BRN	123	Illumination
6	BLK/RED	124	Interior lamp Dimming Buss

Air Suspension Dump Valve Solenoid



Connector Part Information	• 12052641 • 2 Way F Metri-Pack 150 Series (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	DK BLU	1944	Suspension Dump Valve Solenoid Feed
B	BLK	150	Ground

Diagnostic Information and Procedures

Rear Air Springs Do Not Deflate

Step	Action	Value(s)	Yes	No
1	• Turn the ignition switch to RUN. • Disconnect the air suspension dump switch. Does the Air Suspension Dump Solenoid Valve disengage?	—	*Go to Step 2*	*Go to Step 3*
2	Replace the air suspension dump solenoid valve switch. Is the Air Suspension Valve engaged at all times?	—	*Go to Step 3*	System OK
3	1. Disconnect the air suspension dump solenoid valve harness connector. 2. Connect a test lamp between terminals A and B of the Air Suspension Dump Valve connector. Does the test lamp light?	—	*Go to Step 4*	*Go to Step 5*
4	Locate and repair short to voltage in BLU (122, 65, 622, or 1944) circuit between the Air Suspension Dump Switch, the I/P Cluster, and the Air Suspension Dump Valve. Is the Air Suspension Dump Valve engaged at all times?	—	—	System OK
5	Replace the air suspension dump valve. Is the Air Suspension Dump Valve engaged at all times?	—	—	System OK

Air Suspension Dump Indicator Inoperative

Step	Action	Value(s)	Yes	No
1	Activate the air suspension dump valve solenoid. Does the air suspension dump solenoid valve energize?	—	*Go to Step 2*	Refer to Air Suspension Dump Valve Does Not Engage
2	1. Connect a test lamp from BLU (65) wire at 13 Way I/P Harness connector (terminal E7) to ground. 2. Place the Ignition Switch in RUN. 3. Turn the air suspension dump switch ON. Does the test lamp light?	—	*Go to Step 4*	*Go to Step 3*
3	Locate and repair open in BLU (65) circuit between the I/P Harness connector and S266. Dos the Air Suspension Dump Indicator Lamp function?	—	System OK	*Go to Step 4*
4	Connect a test lamp from BLU (65) wire (terminal E7) to BLK (68) wire (terminal E8) at 13 Way I/P Harness connector. Does the test lamp light?	—	*Go to Step 5*	*Go to Step 6*
5	Replace the Instrument Cluster. Does the Air Suspension Dump Indicator Lamp function?	—	System OK	—
6	Locate and repair open in BLK (68) circuit between the I/P Cluster and ground. Does the Air Suspension Dump Indicator Lamp function?	—	System OK	—

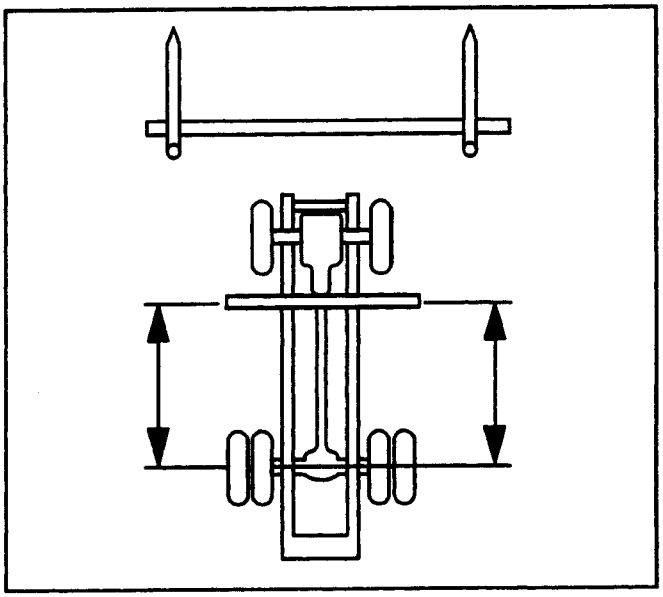
Repair Instructions

Suspension Alignment

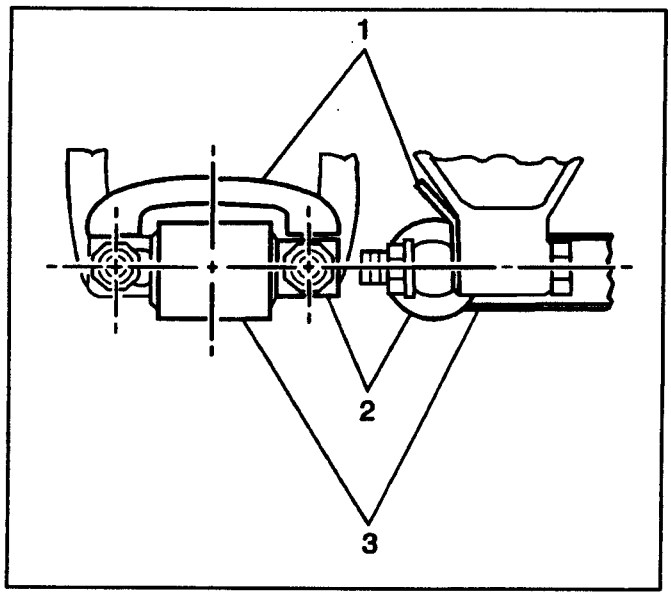
Perform the following procedure after all of the repairs are completed and all of the suspension fasteners have been tightened to the specified torque values.

1. Place the vehicle on a level floor area. Free and center all of the suspension joints by slowly moving the vehicle back and forth several times without using the brakes.
2. Block the front wheels. Ensure that the vehicle breaks are released.
3. Securely clamp a nine foot piece of straight bar stock or angle iron across the frame using C-clamps.

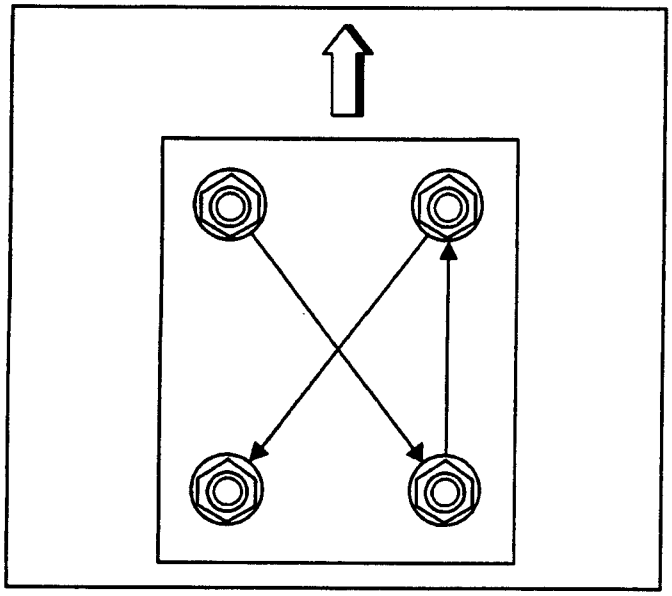
   Select a location as far forward of the drive axle as possible.
4. Use a square in order to align a straight edge to the frame.



200638



200644


200648

5. Use a trammel bar or its equivalent in order to measure from a straight edge to the center line of the drive axle on both sides of the vehicle.
   5.1. If both sides measure within 4.8 mm (0.1875 in) of being equal, alignment of the rear axle is acceptable.
   5.2. If both side measurements differ by more than 4.8 mm (0.1875 in), complete the following steps:
      5.2.1. Loosen the rebound bolt locknut
      5.2.2. Adjust the rear drive axle by loosening the torque rod bar pin locknuts on the spring hanger and add drop-in shims.
6. Mount the torque rod bar pin (2) adjacent to the forward face of the spring hanger legs. Do not use more than four shims (1) or 6.0 mm (0.25 in) total thickness.
7. Install the torque rod bar pin locknuts. Do not torque the locknuts to specification.
8. Follow the alignment of the drive axle and move the vehicle back and forth several times prior to removing the straight edge from the frame.
9. Reinspect the alignment in order to confirm the adjustments.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
10. Tighten the torque bar rod pin locknuts.
    Tighten

    Tighten the torque bar rod pin locknuts to 203–278 N·m (150–205 lb ft).
11. Tighten the rebound bolt locknuts.
    Tighten

    Tighten the rebound bolt locknuts to 68–95 N·m (50–70 lb ft).

Preventive Maintenance

Use the following procedure when servicing a vehicle with a Hendrickson Suspension model HAS air suspension:

Notice: Check for proper seating of components to eliminate gaps or misalignment.

Notice: If the tightening torques recommended are not achieved and maintained, metal surfaces can work and wear the spring seats, axle bottom caps and possibly other components related in the total assembly.

1. Torque the U-bolt nuts at preparation for delivery.
2. Retorque the U-bolt locknuts at 3 000 km (2,000 miles).
3. Inspect and retorque the U-bolt locknuts at regular intervals. Do not exceed 10 400 km (6,500 miles) between inspection intervals.

4. Use the following procedure in order to replace the U-bolts or other components:

   Notice: Refer to *Fastener Notice* in Cautions and Notices.

   4.1. Evenly torque the U-bolt locknuts.

   Tighten

   Tighten the locknuts in 37 N·m (50 lb ft) increments in order to achieve uniform bolt tension and correct (level) attitude of the main support beam, the spring seat, and the axle bottom cap at the final torque.

   Notice: Check for proper seating of components to eliminate gaps or misalignment.

   4.2. Drive the vehicle in order to seat the components.

   4.3. After the road test, retorque the U-bolt locknuts to the specified torque.

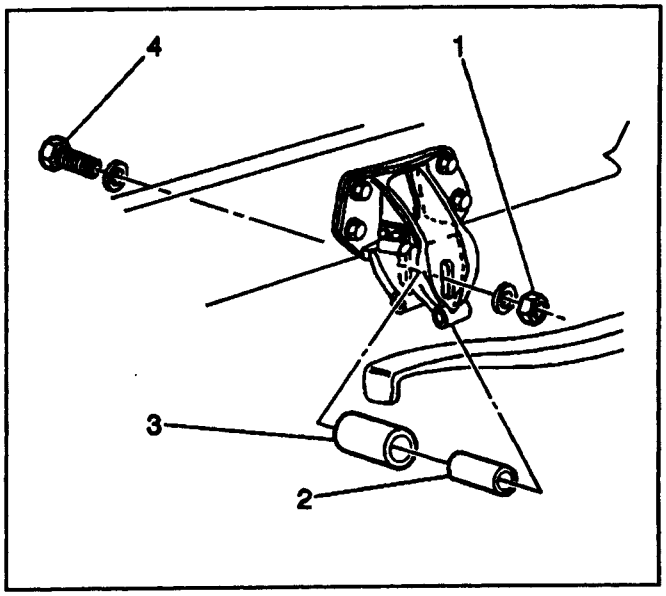
   4.4. Retorque the U-bolt locknuts at 3 000 km (2,000 miles) following service.

   4.5. Inspect and retorque the U-bolt locknuts at regular intervals. Do not exceed 10 400 km (6,500 miles) between inspection intervals.

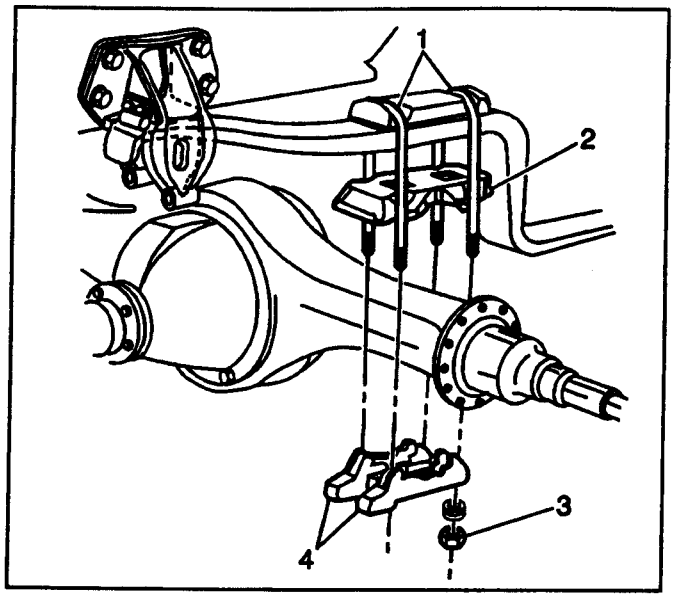
Main Support Beam

Removal Procedure

1. Block the wheels of the axle.
2. Support the axle using jack stands.
3. Drain the air pressure from the air springs.
4. Remove the height control valve link from the valve.
5. Remove the following components from the spring hanger:
   - The rebound bolt (4)
   - The locknut (1)
   - The washers
   - The spacer tube (2)
   - The rebound roller (3)
6. Raise the rear of the frame far enough in order to remove the load from the main support beam.

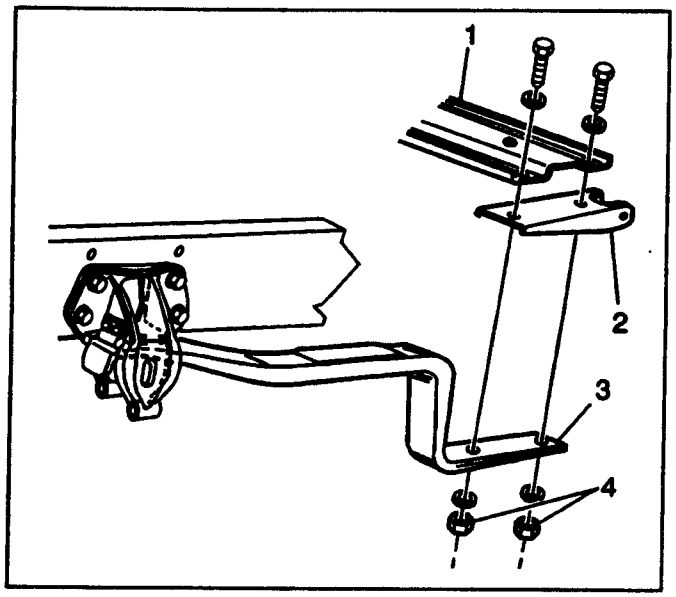


200651



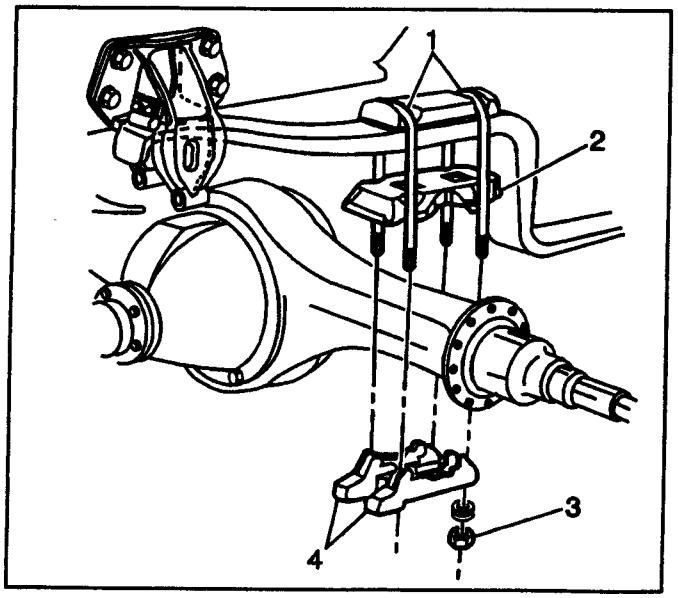
200654

7. Remove the U-bolt locknuts (3) and the washers.
8. Remove the following components:
   - The U-bolts (1)
   - The bottom pads (4)
   - The top pad (2)



200660

9. Remove the locknuts (4) and the washers that connect the cross channel (1) to both of the main support beams (3).
10. Lift the cross channel off of the main support beam using jacks.
11. Remove the main support beam assembly.



200654

Installation Procedure

Important: The Delrin liner must be positioned on the top side of the main support beam.

1. Position the main support beam on the axle seat with the main support beam center dowel pin. Pilot the main support beam into the hole of the axle seat or the spacer plate.

   Important: Do not tighten the U-bolts at this time. Position the torque rod mounting bolts of the spring seats toward the front of the vehicle.
2. Install the following components:
   - The top pad (2)
   - The U-bolts (1)
   - The bottom cap (4)
   - The washers
   - The locknuts (3)

3. Lower the air spring and the cross channel mounting bolts into the main support beams (3).

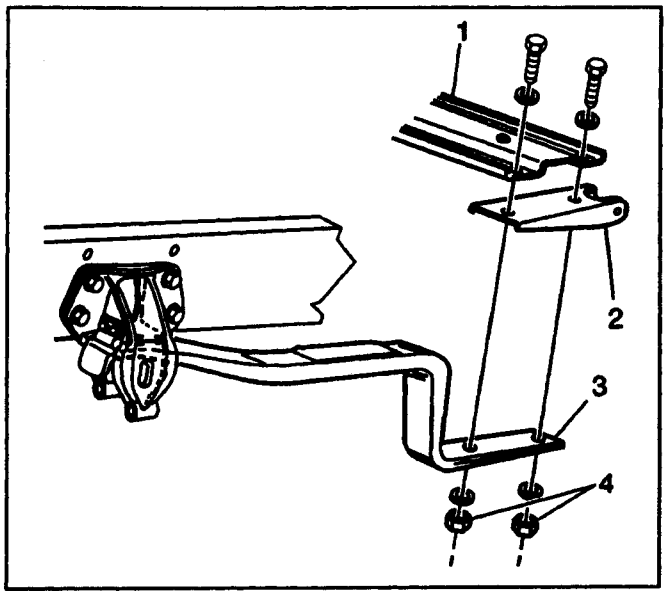
   Notice: Refer to *Fastener Notice* in Cautions and Notices.

4. Install the washers and the locknuts (4) that connect the cross channel (1) to the main support beam (3).

   Tighten

   Tighten the locknuts in 37 N·m (50 lb ft) increments to 330 N·m (243 lb ft).

5. Lower the frame in order to ensure that the spring hangers engage the main support beam.
6. Refill air into the system.
7. Center the tip of the main support beam between the spring hanger legs.



200660

Important: Do not exceed the specified torque on the U-bolt locknuts.

8. Tighten the U-bolt nuts.

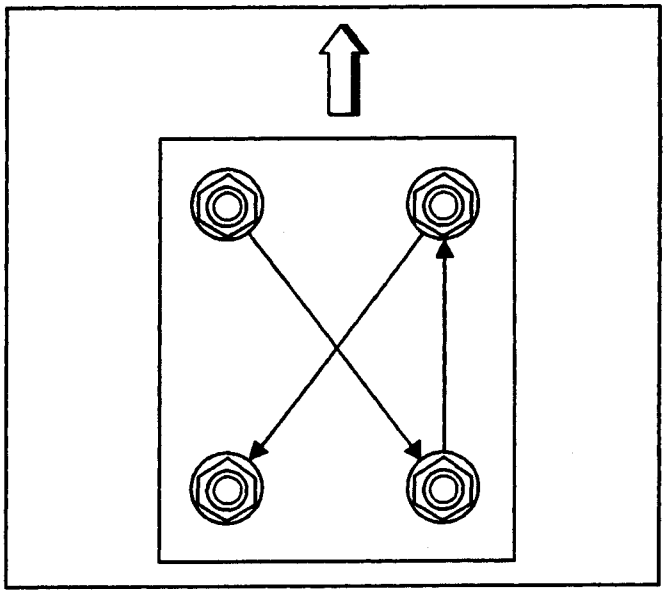
   Tighten

   Tighten the U-bolt nuts in 37 N·m (50 lb ft) increments to 353–434 N·m (260–320 lb ft).

9. Hit the top of the U-bolts using a hammer.. Retighten the U-bolt nuts.

   Tighten

   Retighten the U-bolt nuts in 37 N·m (50 lb ft) increments to 353–434 N·m (260–320 lb ft).



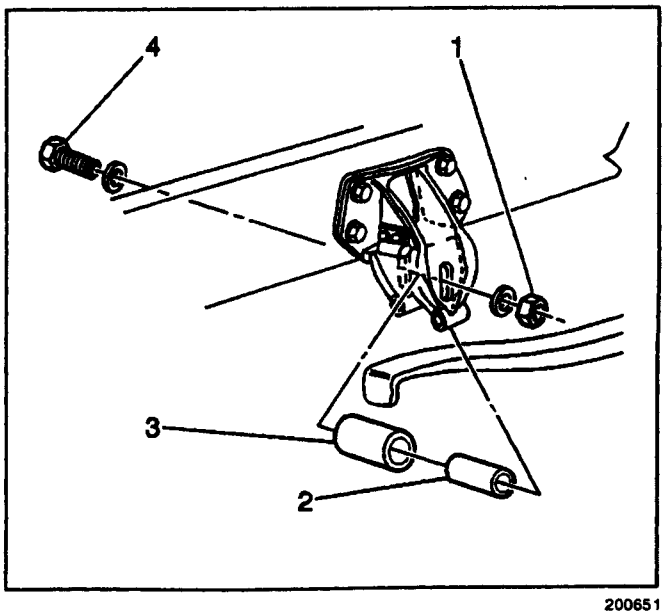
200648

10. Install the following components in the hangers:
    - The rebound bolt (4)
    - The spacer tube (2)
    - The rebound roller (3)
    - The washers
    - The locknuts (1)

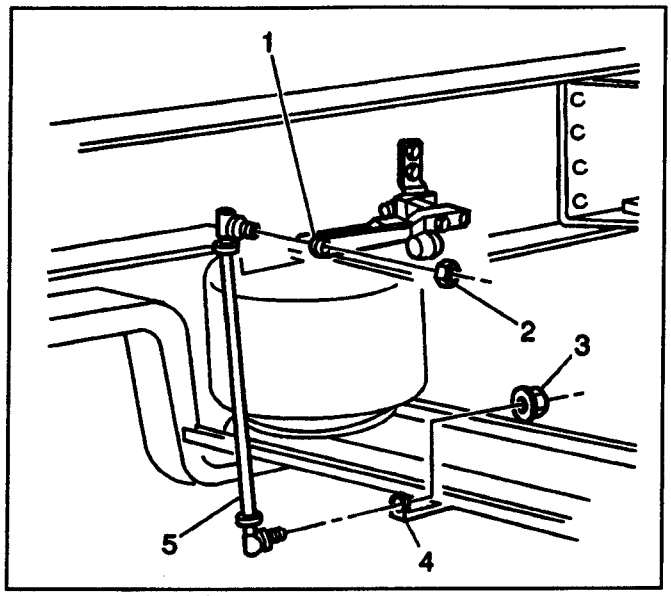
    Tighten

    Tighten the rebound bolt locknut to 68–95 N·m (50–70 lb ft).

11. Unblock the wheels.
12. Inspect the alignment after installing the new main support beams.



200651

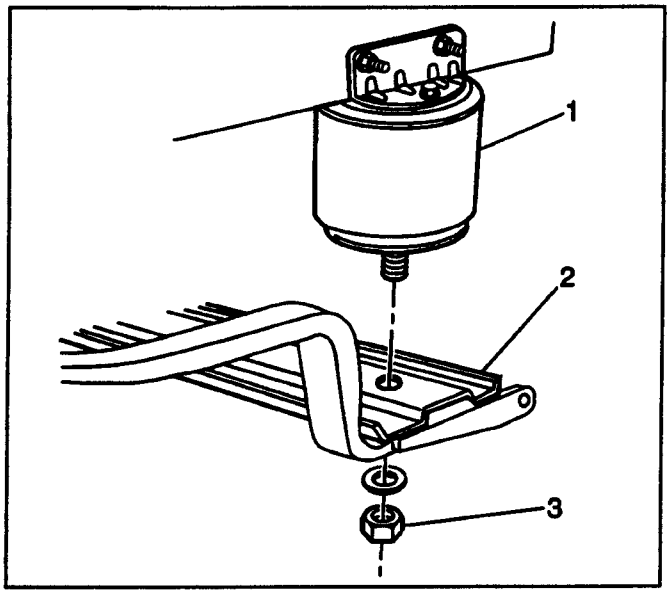


200667

Cross Channel Replacement

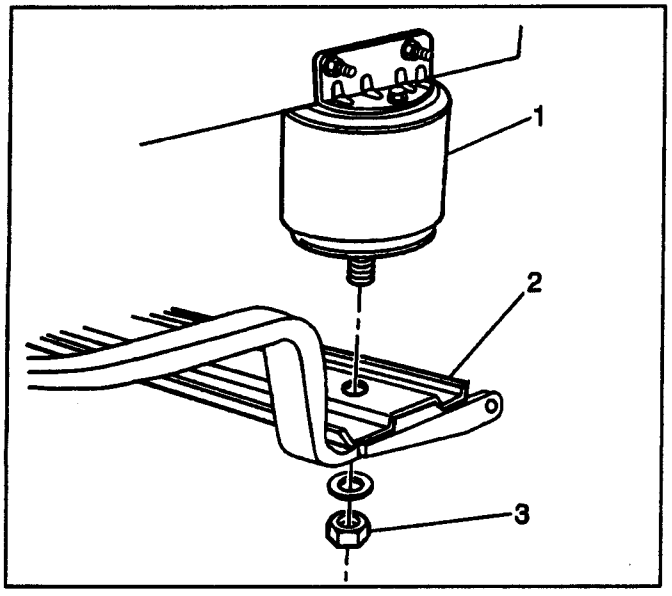
Removal Procedure

1. Block the wheels of the axle.
2. Remove the locknuts (2,3) and the washer that connects the height control valve link (5) to the valve (1).
3. Remove the height control valve link (5) from the control valve (1).
4. Drain the air pressure from the air springs.
5. Raise the frame of the vehicle in order to remove the load from the suspension.
6. Support the frame using jack stands.



200663

7. Remove the locknut (3) and the washer that connect the air spring (1) to the cross channel (2) and to both of the main support beams.
8. Raise the cross channel using jacks, if required.



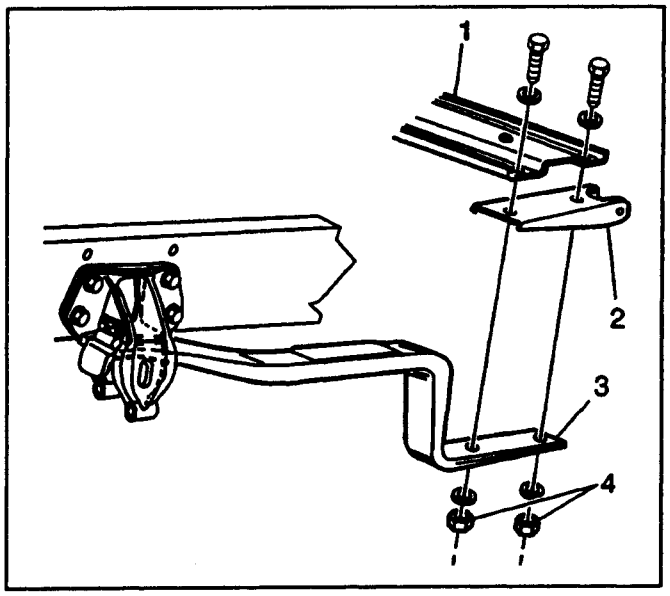
200663

Installation Procedure

1. Connect the cross channel (2) to both of the air springs (1).
2. Lower the frame.
3. Pilot the bolt holes onto the main support beam.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

4. Install the washers and the locknuts (4) that connect the cross channel (1) to the main support beam (3).
   Tighten
   Tighten the locknuts in 37 N·m (50 lb ft) increments to 330 N·m (243 lb ft).
5. Refill the system with air.
6. Unblock the wheels.

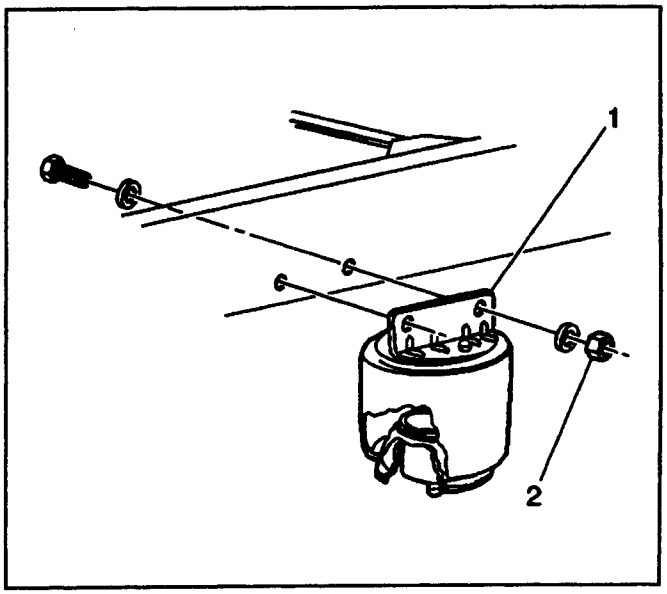


200660

Air Spring Frame Hanger Replacement

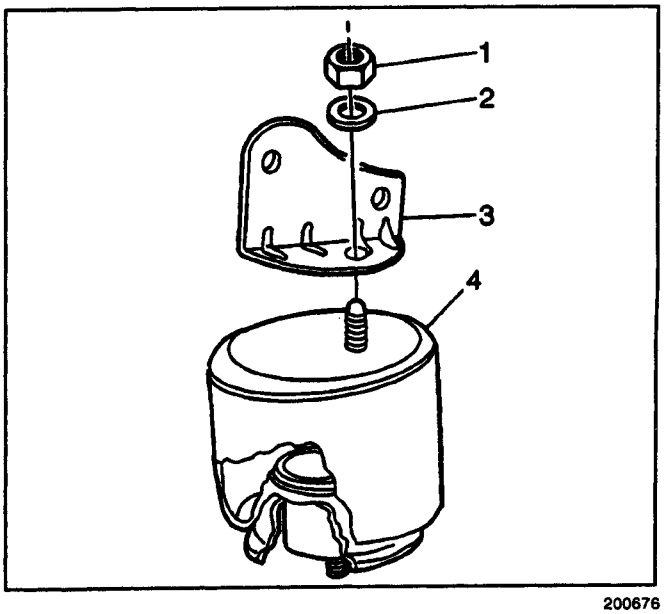
Removal Procedure

1. Block the front wheels.
2. Drain the air pressure from the air springs.
3. Raise the frame of the vehicle in order to remove the load from the suspension.
4. Remove the air lines that connect to the air spring.
5. Remove the brass air fittings from the air spring.
6. Remove the locknuts (2) and the washers that connect the air spring (1) bracket to the frame side rail.

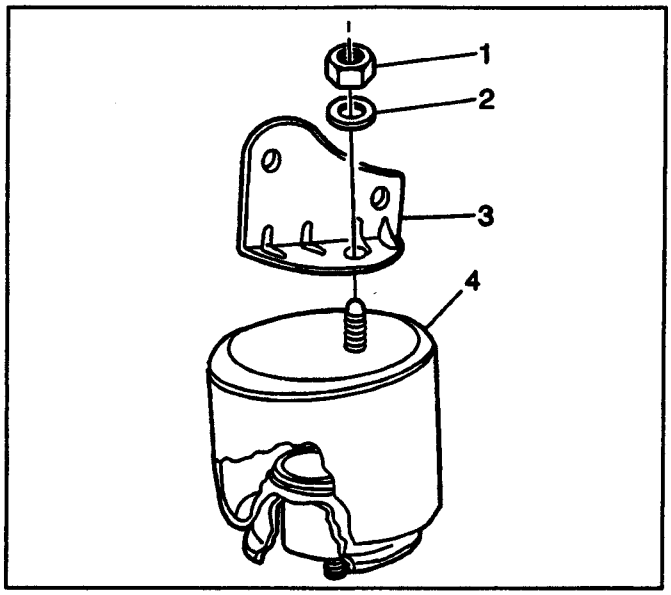


200665

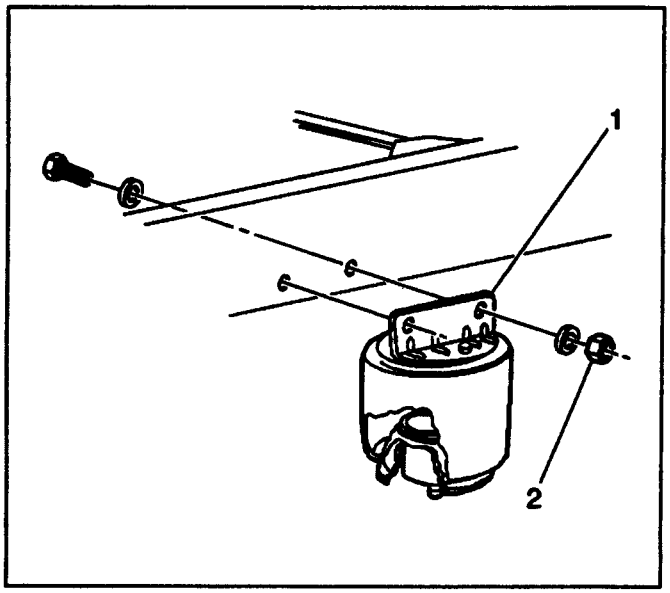
7. Remove the locknut (1) and the washer (2) that connect the air spring (4) to the air spring frame hanger (3).
8. Remove the air spring frame hanger (3).



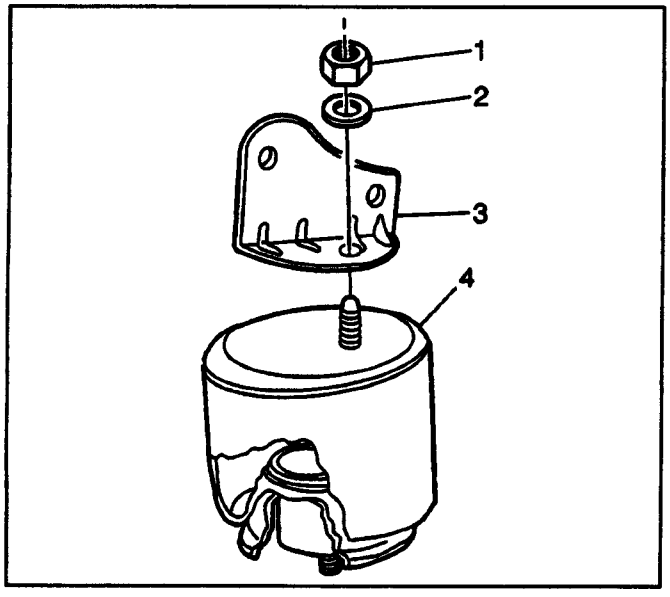
200676



200676



200665



200676

Installation Procedure

1. Connect the air spring frame hanger (3) to the top of the air spring (4).

Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the following components that connect the air spring frame hanger (1) to the frame:
   - The bolts
   - The washers
   - The locknuts (2)

   Tighten

   Tighten the locknuts in 37 N·m (50 lb ft) increments to 300–360 N·m (221–266 lb ft).

3. Install the washer (2) and the locknut (1) that connect the air spring (4) to the air spring frame hanger (3).

   Tighten

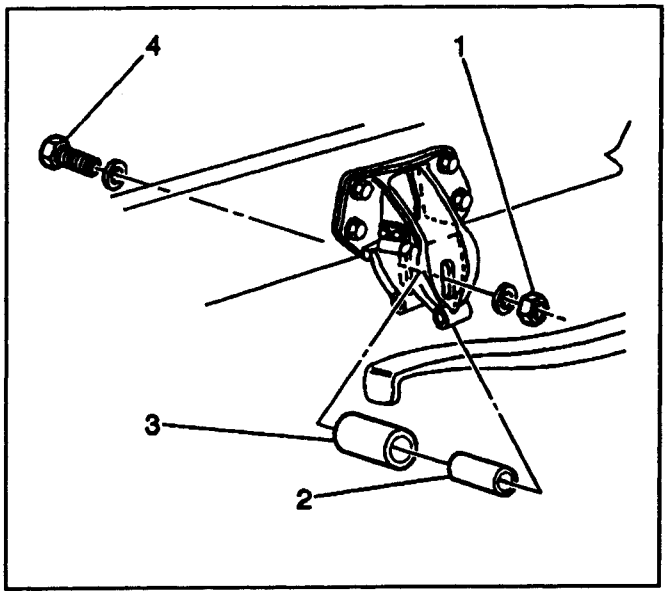
   Tighten the air spring to air spring frame hanger locknut to 27–41 N·m (20–30 lb ft).
4. Install the brass air fitting to the air spring using a Teflon® thread seal.
5. Unblock the wheels.
6. Refill the system with air.

Spring Hanger Bracket Insulator Replacement

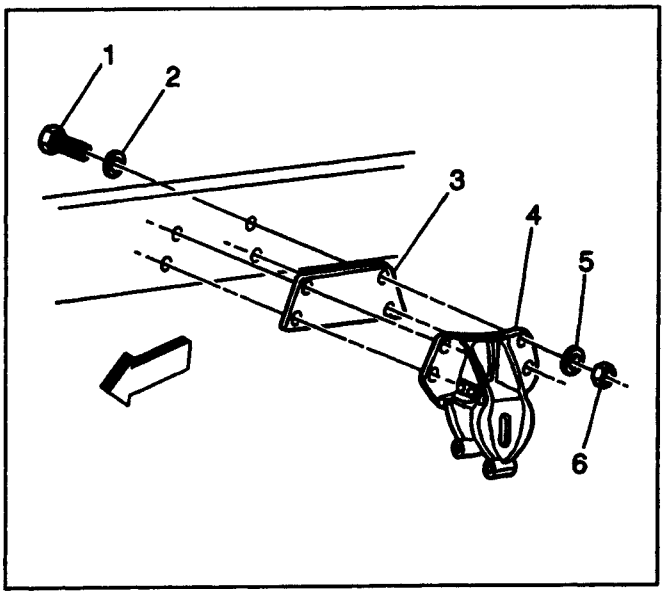
Removal Procedure

1. Block the wheels of all of the axles.
2. Support the frame using frame stands.
3. Support the axles using jack stands.
4. Drain the air pressure from the air springs.
5. Remove the following components:
   - The rebound bolt (4)
   - The locknut (1)
   - The washers
   - The spacer tube (2)
   - The rebound roller (3)

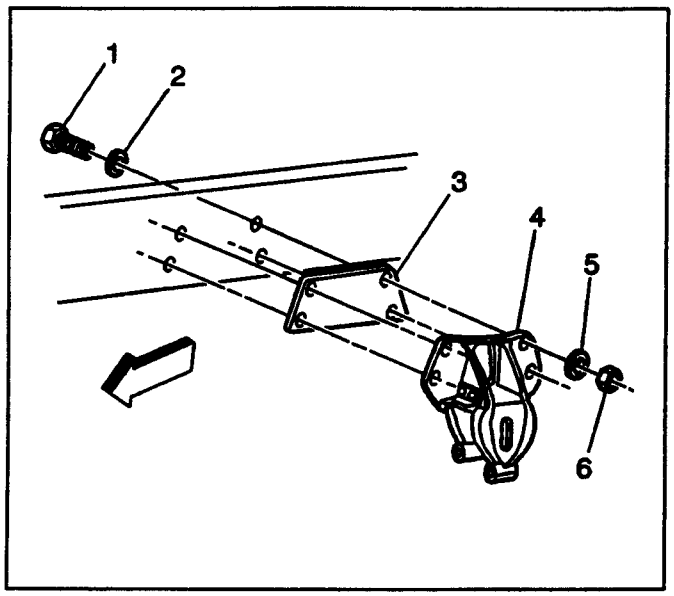
   Important: The torque rods may remain in place.
6. Apply an upward force on the cross tube or lower air spring brackets using a jack or a pry bar. The tips of the main support beams will drop away from the cam surface of the spring hanger brackets.
7. Remove the following components:
   - The insulator fasteners (1,2,5,6)
   - The reinforcement plates
   - The insulator pads (3)



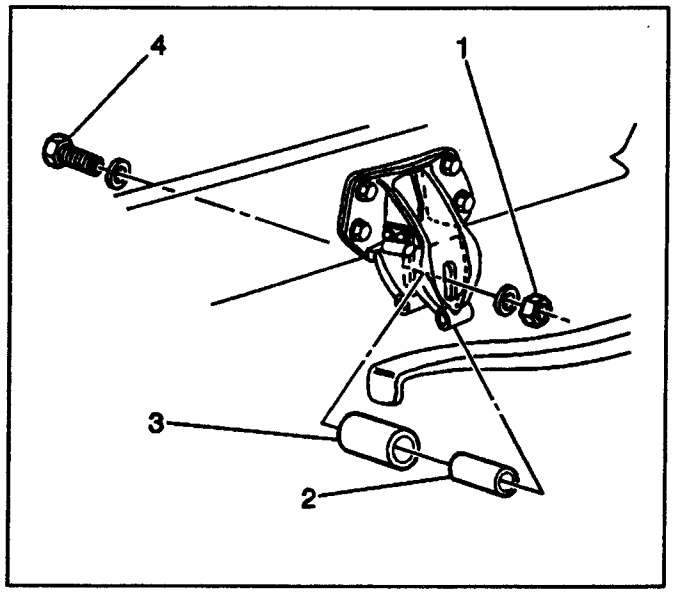
200651



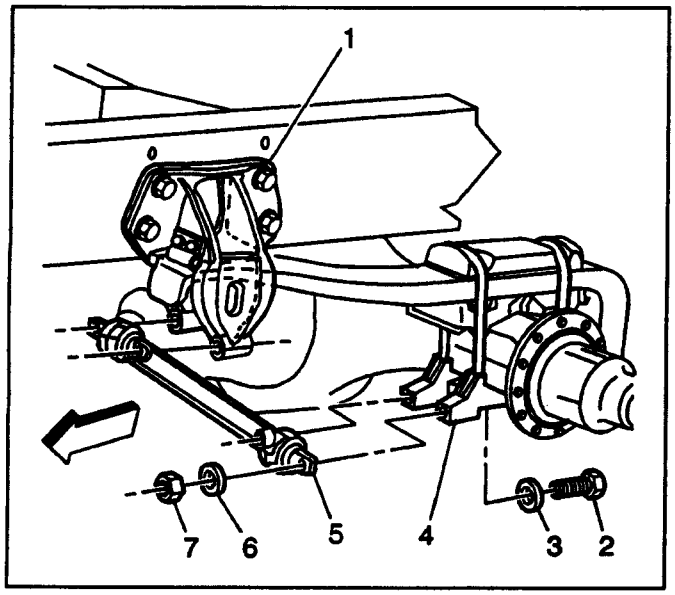
200684



200684



200651



200685

Installation Procedure

1. Place a new insulator pad on the spring hanger (4).

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Place the retainer plate over the insulator pad.

   Tighten

   Tighten the 10 mm (0.375 in) hex head self-tapping screws to 34 N.m (25 lb ft).
3. Release the jack or pry bar on the cross tube or on the lower air spring brackets. Allow the main support beams to come up to the new insulator pads.
4. Install the following components:
   - The rebound rollers (3)
   - The spacers (2)
   - The rebound bolts (4)
   - The washers
   - The locknuts (1)

   Tighten

   Tighten the rebound bolt locknuts to 68–95 N.m (50–70 lb ft).
5. Unblock the wheels.

Torque Rod Replacement

Removal Procedure

1. Block the wheels of the drive axles.
2. Remove the torque rod bar pin locknuts (7) and the washers (6) at the axle end of the torque rod (5).
3. Loosen the rebound bolt locknut in the spring hanger (1).

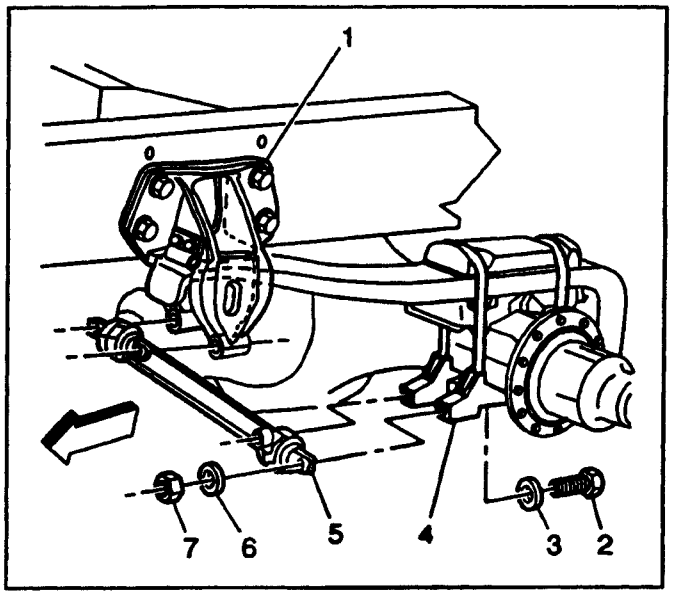
   Important: Note the number of shims. Reinstall the shims in the same manner in order to avoid affecting the alignment.
4. Remove the following components at the spring hanger ends of the torque rod:
   - The torque rod bar pin locknuts (7)
   - The bolts
   - The washers (6)
   - The alignment shims

Installation Procedure

1. Position the new or rebushed torque rod into the spring seat (4).
2. Install the washers (6) and the torque rod locknuts (7). Tighten the locknuts by hand.
3. Position the torque rod on the forward face of the spring hanger legs.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
4. Install the following components:
   - The bolts
   - The washers
   - The alignment shims
   - The locknuts

   Tighten
   - Tighten the torque rod locknuts to 203–278 N·m (150–205 lb ft).
   - Tighten the rebound bolt locknuts to 68–95 N·m (50–70 lb ft).
   - Tighten the torque rod locknuts, at the axle end of the torque rod, to 203–278 N·m (150–205 lb ft).
5. Unblock the wheels.



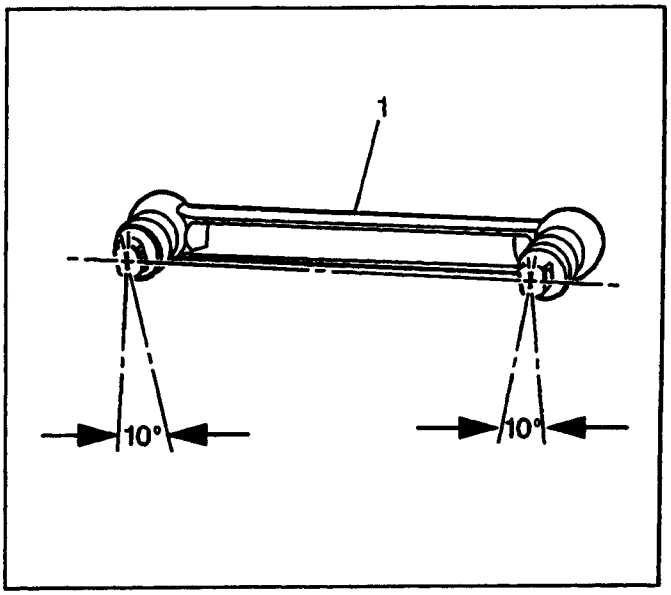
200685

Torque Rod Bushing Replacement

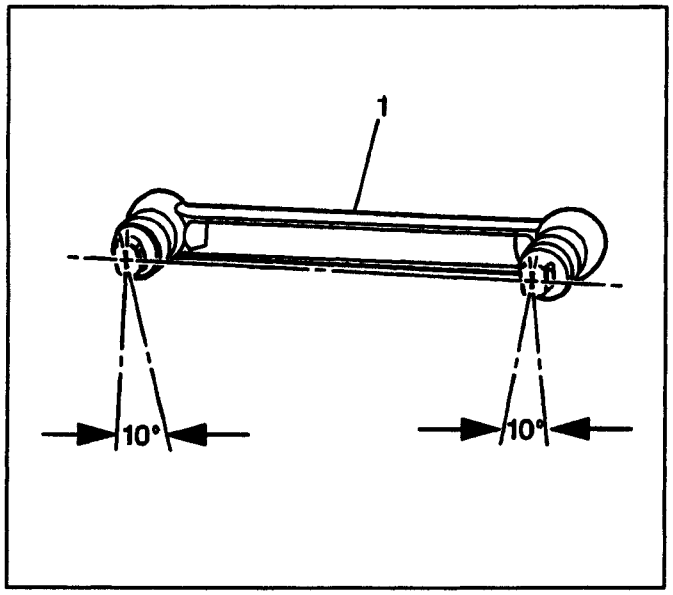
Removal Procedure

1. Use a press with a minimum capacity of 10 tons.
2. Support the torque rod (1) on a piece of 6 mm (0.25 in) wall steel tubing that is 127 mm (5 in) long with an inside diameter of 50.8 mm (2 in).

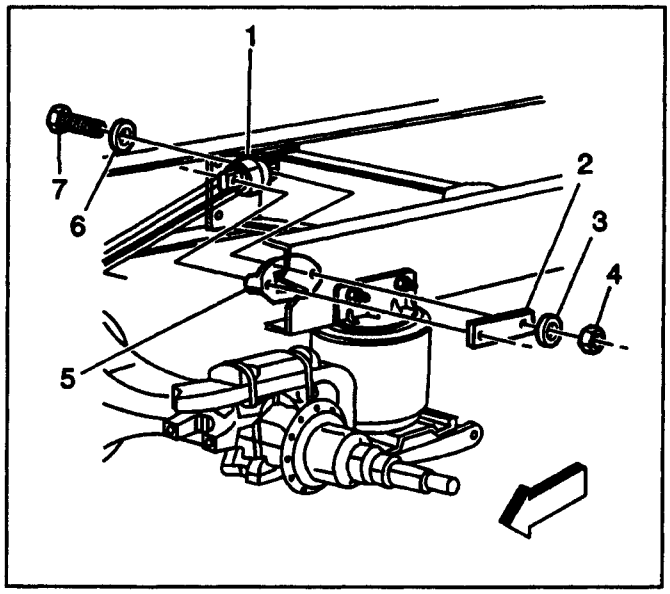
   Notice: Do not use heat or a cutting torch to remove the bushings from the torque rod. The use of heat will adversely affect the strength of the torque rod.
3. Remove the bushing from the torque rod by pushing directly on the bar pin of the bushing.
4. Inspect the inside diameter of the ends of the torque rods.
5. Remove any nicks and small scratches from the bore of the torque rod. Use an emery cloth.



200687



200687



200688

Installation Procedure

Important: Do not use a petroleum or a soap base lubricant.

1. Lubricate the inside diameter of the torque rod (1) and the new bushing using a vegetable base oil, such as cooking oil.

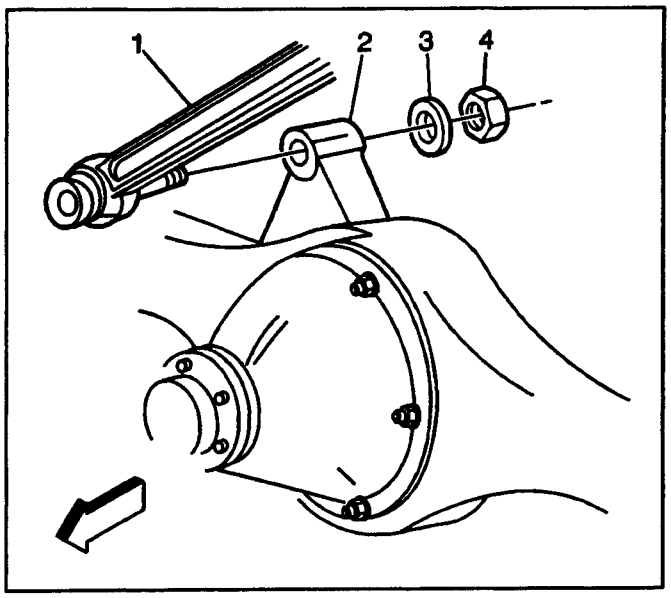
   Notice: If the tightening torques recommended are not achieved and maintained, metal surfaces can work and wear the spring seats, axle bottom caps and possibly other components related in the total assembly.
2. Support the torque rod on a piece of steel tubing during assembly. Center the bore of the torque rod in the tubing.
3. Place the bushing in the bore of the torque rod in order to position the mounting flats of the bar pin 10 degrees counterclockwise to the shank of the rod.
4. Press the bushing into the torque rod in order to extend the bushing 4.8 mm (0.1875 in) on the opposite side of the torque rod.
5. Turn the torque rod over and press on the bar pin in order to center the bushing into the bore of the torque rod.

Transverse Rod Replacement (with RPO-GPG)

Removal Procedure

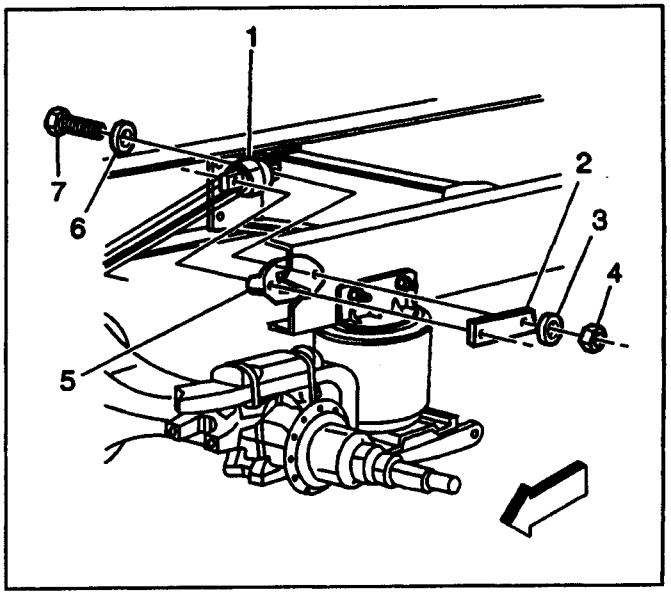
1. Remove the locknuts (4) and the washers (3) that connect the transverse rod (1) to the frame.

2. Remove the locknuts (4) and the washers (3) that fasten the transverse rod (1) to the axle housing (2).
3. Remove the transverse rod (1).



200692

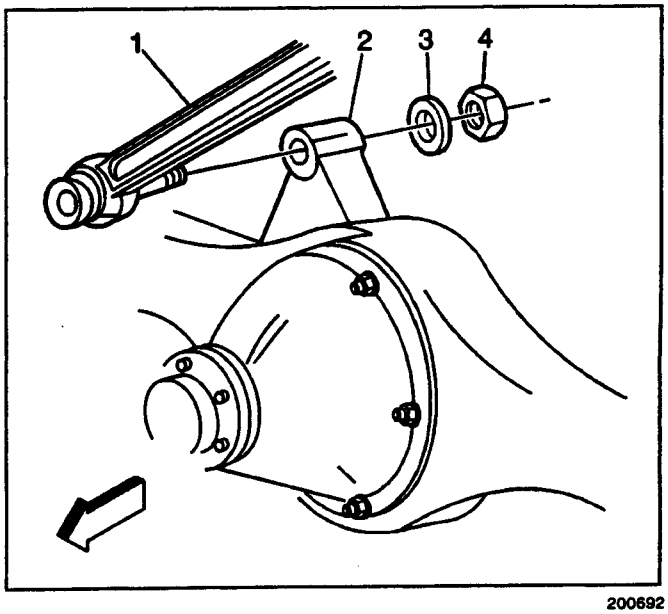
4. Remove the transverse rod bracket from the frame.
5. Inspect the transverse rod bushings. If the transverse rod bushings are worn or damaged, remove the bushing from the transverse rod (1).



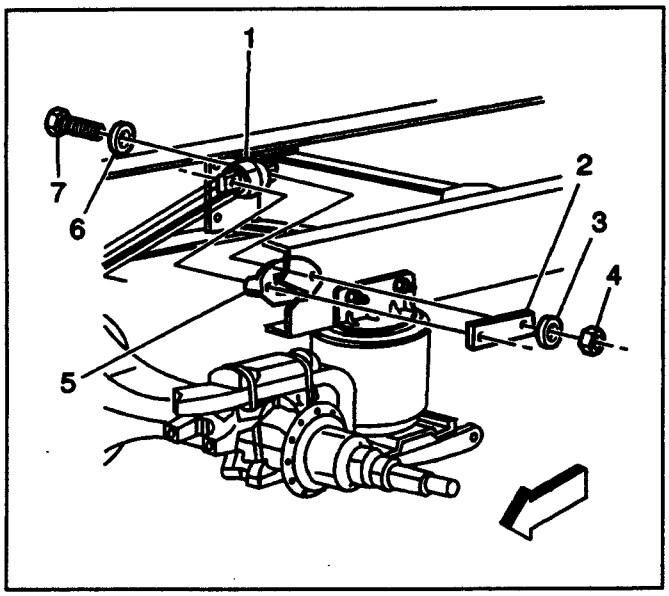
200688

Installation Procedure

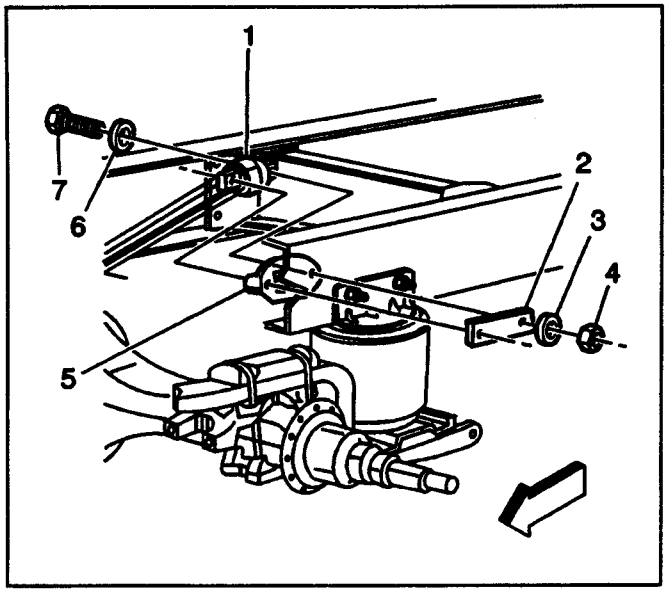
1. Install the bushings in the transverse rod.
2. Position the transverse rod (1) in the bracket on the axle housing (3).



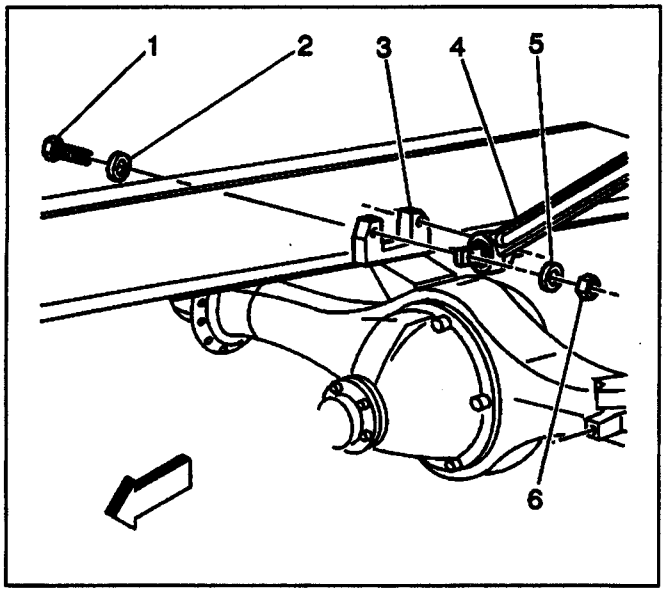
200692



200686



200688



200691

Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the following components:
   - The transverse rod bolt (7)
   - The washers (6)
   - The locknuts (4) that fasten the rod to the bracket

   Tighten

   Tighten the locknut to 474–542 N.m (350–400 lb ft) for models with RPO-GPG.
4. Install the following components:
   - The reinforcement bolts
   - The washers
   - The locknuts that fasten the torque rod and the bracket to the frame

   Tighten

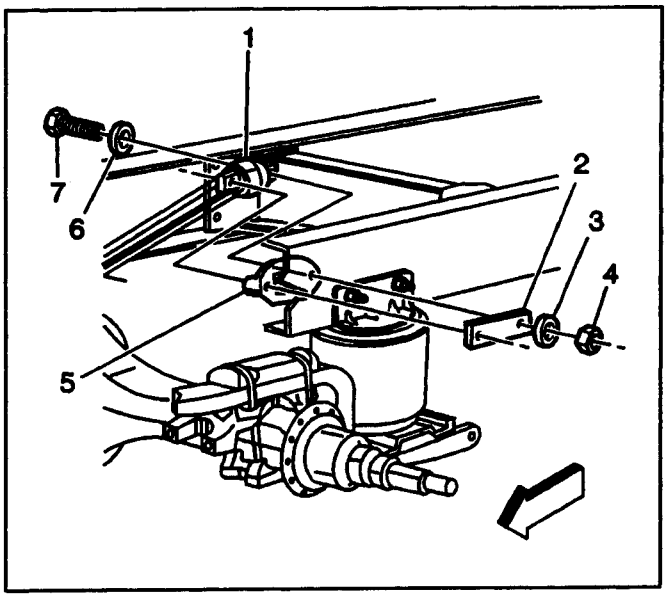
   Tighten the rod bar pin nuts to 285–310 N.m (210–229 lb ft).

Transverse Rod Replacement (without RPO-GPG)

Removal Procedure

1. Remove the locknuts (4) and the washers (3) that connect the transverse rod (1) to the frame.
2. Remove the locknuts (6) and the washers (2,5) that fasten the transverse rod (4) to the axle housing (3).
3. Remove the transverse rod (4).

4. Remove the transverse rod bracket from the frame.
5. Inspect the transverse rod bushings. If the transverse rod bushings are worn or damaged, remove the bushing from the transverse rod (5).



200688

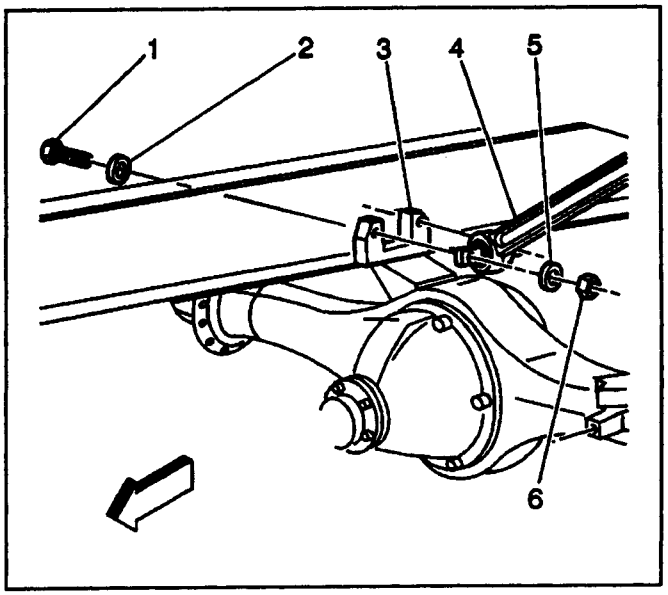
Installation Procedure

1. Install the bushings in the transverse rod.
2. Position the transverse rod (1) in the bracket on the axle housing (2).

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
3. Install the following components:
   - Transverse rod bolts (1)
   - The washers (2)
   - The locknuts (6) that fasten the rod to the bracket

   Tighten

   Tighten the locknut on the transverse rod taper pin to 285–310 N·m (210–229 lb ft) for models without RPO-GPG.

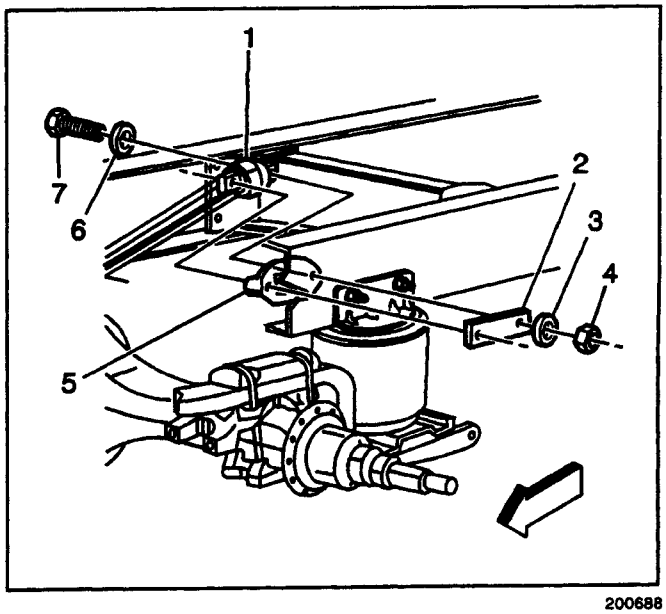


200691

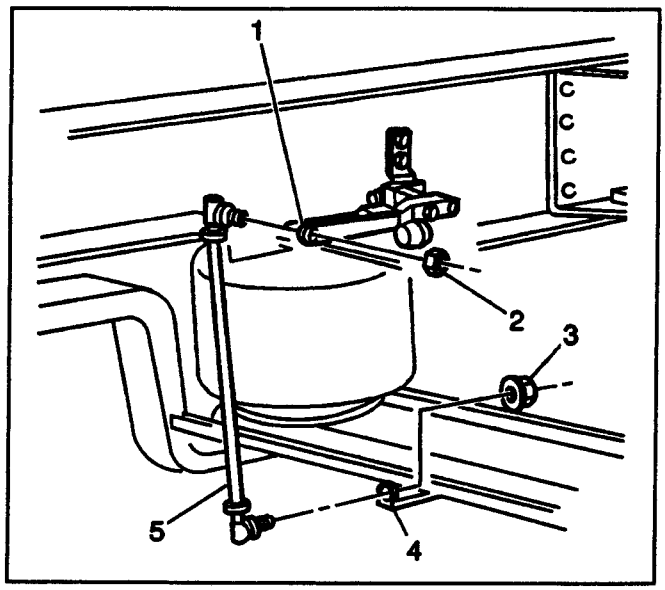
4. Install the following components:
   - The reinforcement bolts
   - The washers
   - The locknuts

   Tighten

   Tighten the pin nuts on the transverse rod bar to 285–310 N·m (210–229 lb ft).



200688

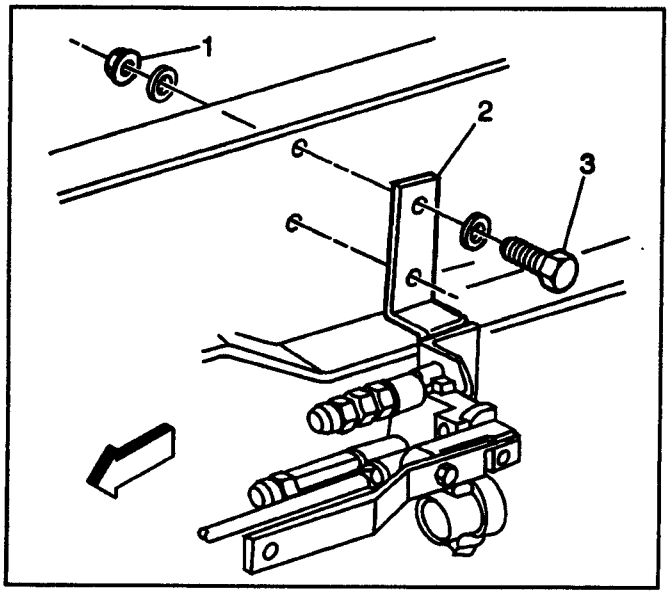


200667

Height Leveling Valve Replacement (with RPO-GPG)

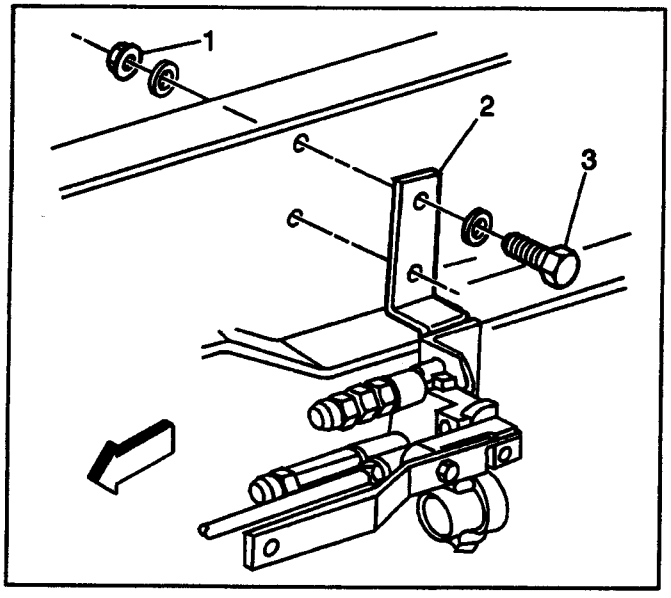
Removal Procedure

1. Drain all of the air from the air supply system.
2. Mark both of the air lines to the leveling valve.
3. Remove the valve locknut (2) that fastens the control valve link (5) to the control valve (1).



200696

4. Remove the following components:
   - The leveling valve locknuts (1)
   - The washers
   - The bolts (3)
5. Remove the height leveling valve (2).
6. Remove the brass air fittings from the height leveling valve.



200696

Installation Procedure

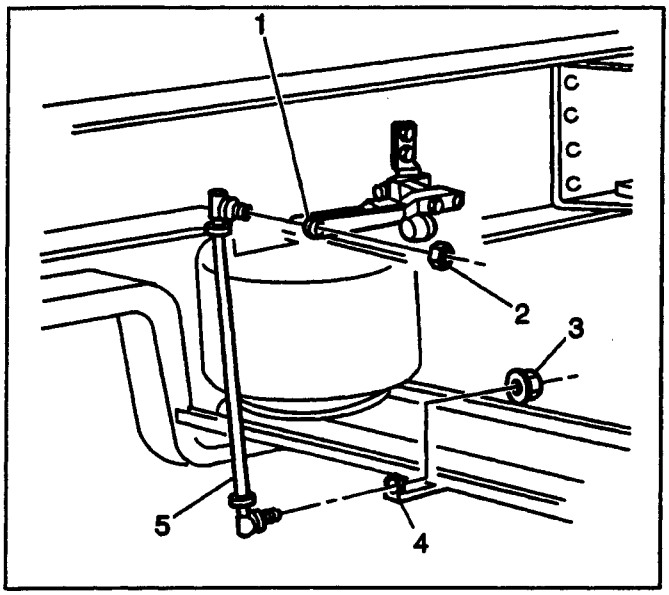
1. Install the brass air fitting on the leveling valve.
2. Connect the leveling valve in position on the frame.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
3. Install the following components:
   - The leveling valve locknuts (1)
   - The washers
   - The bolts (3)

   Tighten

   Tighten the leveling valve mounting locknuts to 68–95 N·m (50–70 lb ft) for models with RPO-GPG.
4. Connect the leveling valve air lines to the correct ports on the leveling valve.

5. Connect the control valve link (5) to the control valve (1).
6. Install the locknut that connects the control valve link to the control valve.
   Tighten
   Tighten the locknut on the control valve link to 21–25 N.m (15–18 lb ft).
7. Apply air pressure and inspect the valve for leaks.

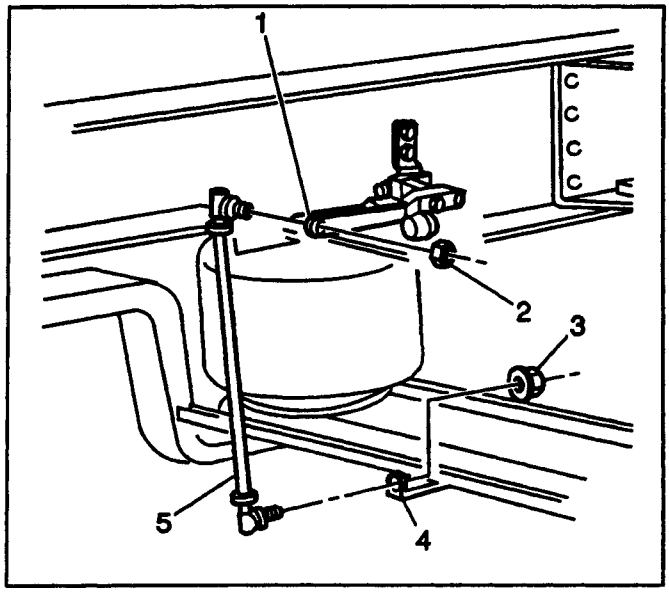


200667

Height Leveling Valve Replacement (without RPO-GPG)

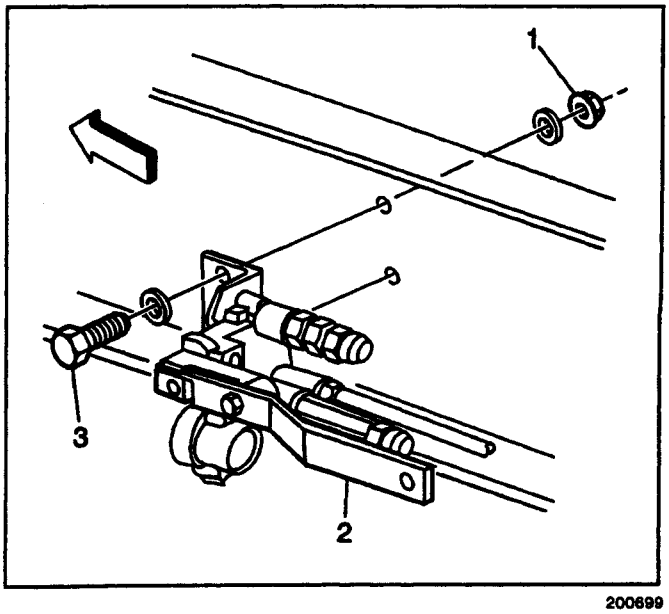
Removal Procedure

1. Drain all of the air from the air supply system.
2. Mark both of the air lines to the leveling valve.
3. Remove the valve locknut (2) that fastens the control valve link (5) to the control valve (1).

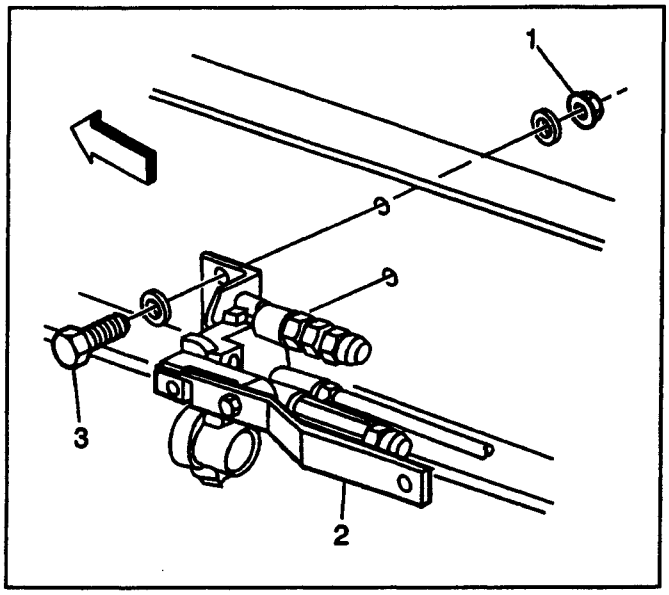


200667

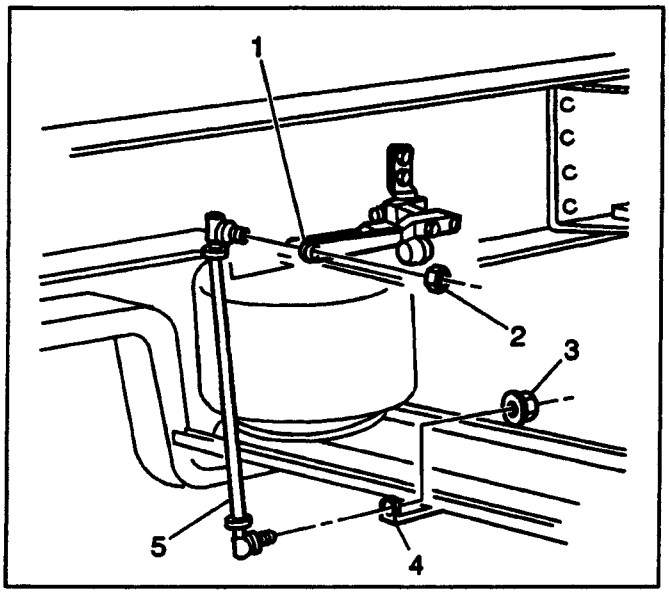
4. Remove the following components:
   - The leveling valve locknuts (1)
   - The washers
   - The bolts (3)
5. Remove the height leveling valve (2).
6. Remove the brass air fittings from the height leveling valve.



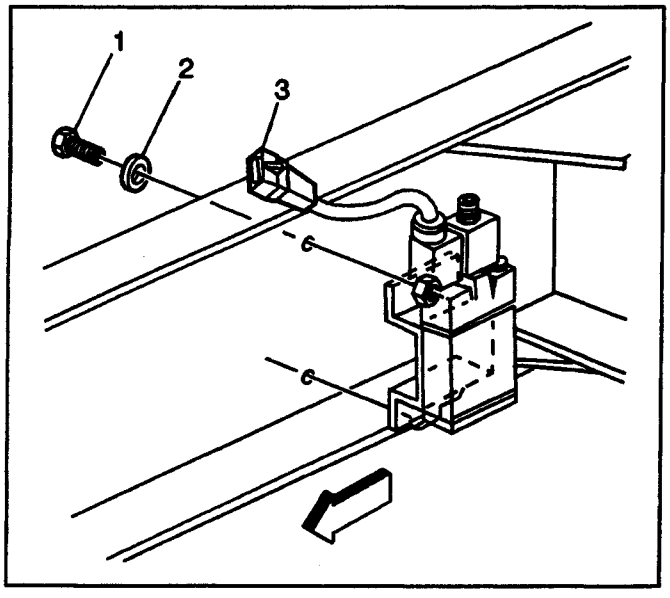
200699



200699



200667



200700

Installation Procedure

1. Install the brass air fitting on the leveling valve.
2. Connect the leveling valve in position on the frame.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
3. Install the following components:
   - The leveling valve locknuts (1)
   - The washers
   - The bolts (3)

   Tighten

   Tighten the leveling valve mounting locknuts to 82–108 N.m (60–80 lb ft) for models without RPO-GPG.
4. Connect the leveling valve air lines to the correct ports on the leveling valve.
5. Connect the control valve link (5) on the control valve (1).
6. Install the locknut that connects the control valve link to the control valve.

   Tighten

   Tighten the locknut to 21–25 N.m (15–18 lb ft).
7. Apply air pressure. Inspect the valve for leaks.

Air Suspension Relief Valve Replacement

Removal Procedure

1. Drain all of the air from the air supply system.
2. Mark the lines to the air suspension relief valve.
3. Disconnect the electrical connector (3) at the air suspension relief valve.
4. Remove the following components:
   - The air suspension relief valve mounting bolts (1)
   - The washers (2)
   - The air suspension relief valve

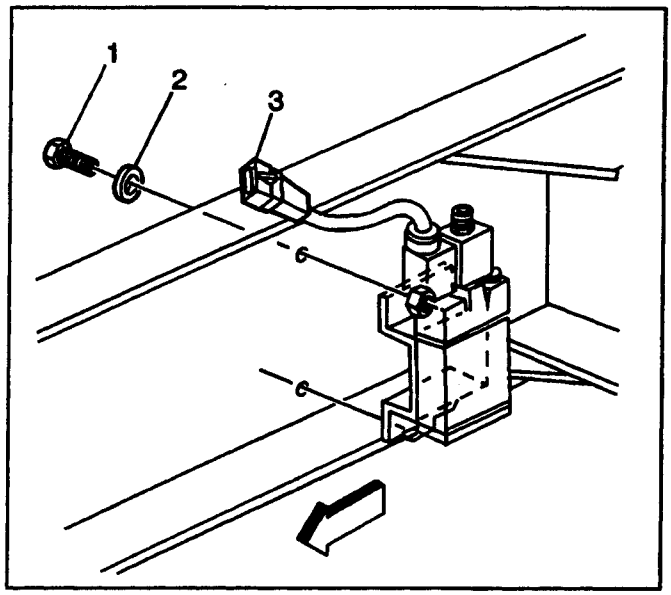
Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the following components:
   - The air suspension relief valve
   - The washers (2)
   - The air suspension relief valve mounting bolts (1)

   Tighten

   Tighten the bolts to 15–20 N·m (11–15 lb ft).
2. Connect the electrical connector (3) to the air suspension relief valve.
3. Connect the air lines of the air suspension relief valve to the correct ports on the air suspension relief valve.
4. Operate the vehicle in order to charge the air supply system and to ensure that the valve does not leak.

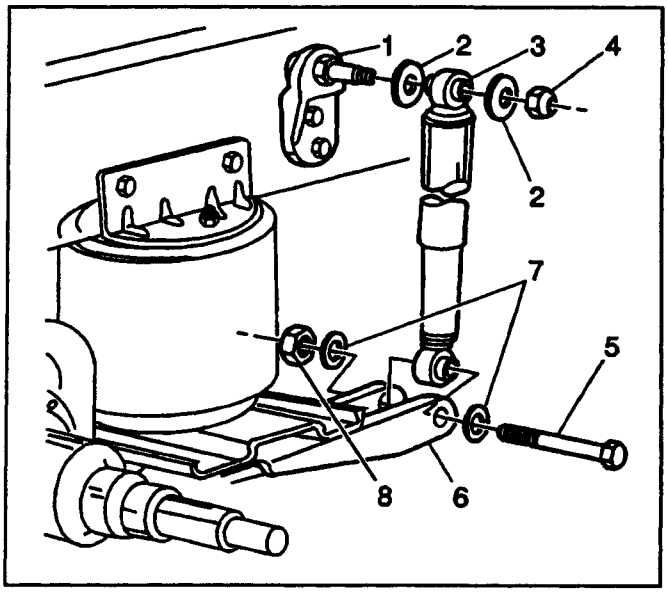


200700

Shock Absorber Replacement

Removal Procedure

1. Remove the locknut (4) and the washers (2) that connect the shock absorber (3) to the shock absorber outboard frame hanger bracket (1).
2. Remove the following components that connect the shock absorber (3) to the lower shock absorber bracket (6):
   - The locknut (8)
   - The washers (7)
   - The bolt (5)
3. Remove the shock absorber (3).



200680

Installation Procedure

1. Install the shock absorber (3).

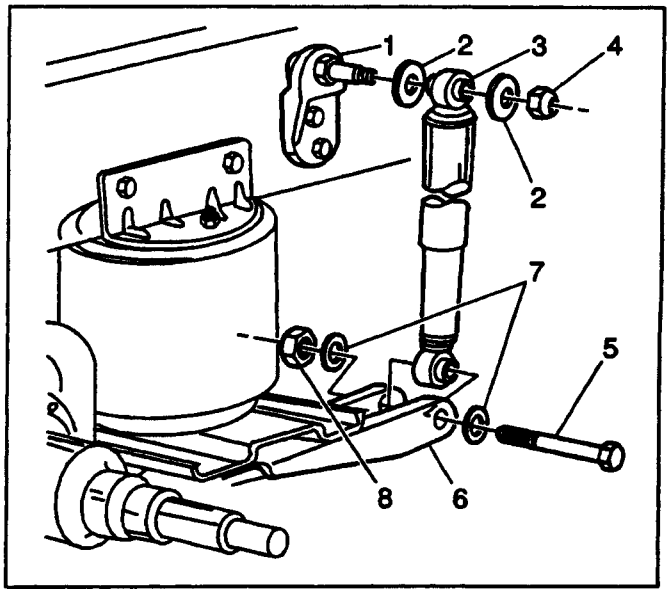
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the washers (2) and the locknut (4) that connect the shock absorber (3) to the upper shock absorber mounting bracket.

   Tighten

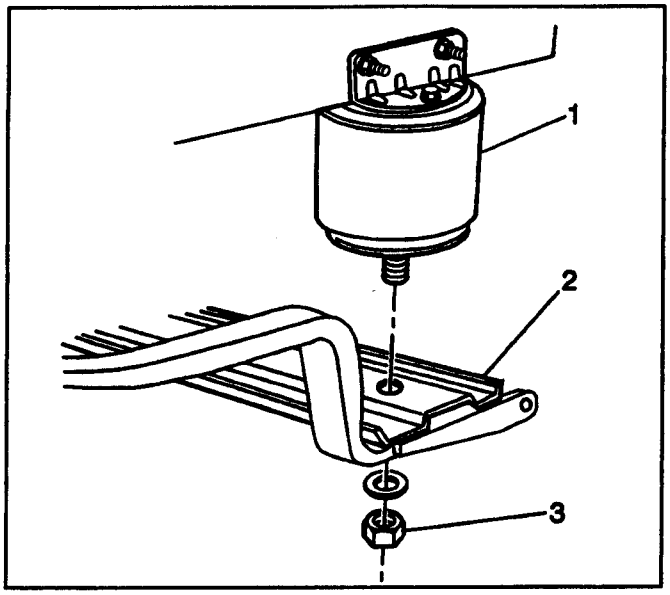
   Tighten the locknut to 68–95 N·m (50–70 lb ft).
3. Install the following components that connect the shock absorber (3) to the lower shock absorber bracket (6):
   - The bolt (5)
   - The washers (7)
   - The locknut (8)

   Tighten

   Tighten the locknut to 68–95 N·m (50–70 lb ft).



200680

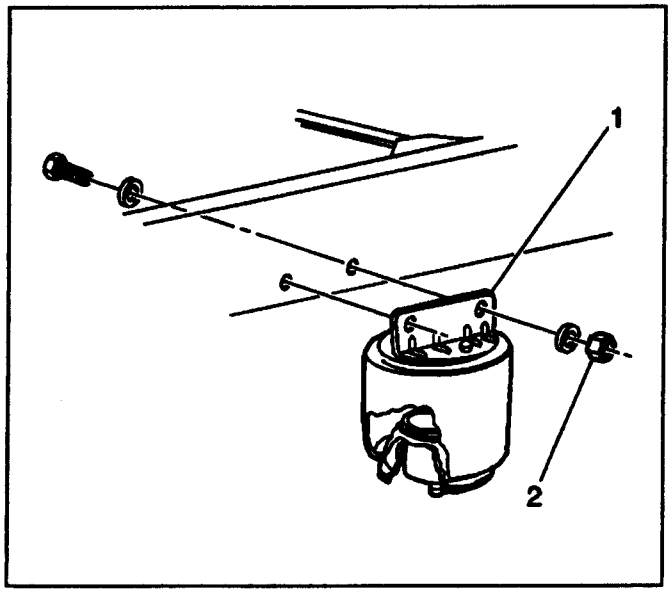


200663

Air Spring Replacement

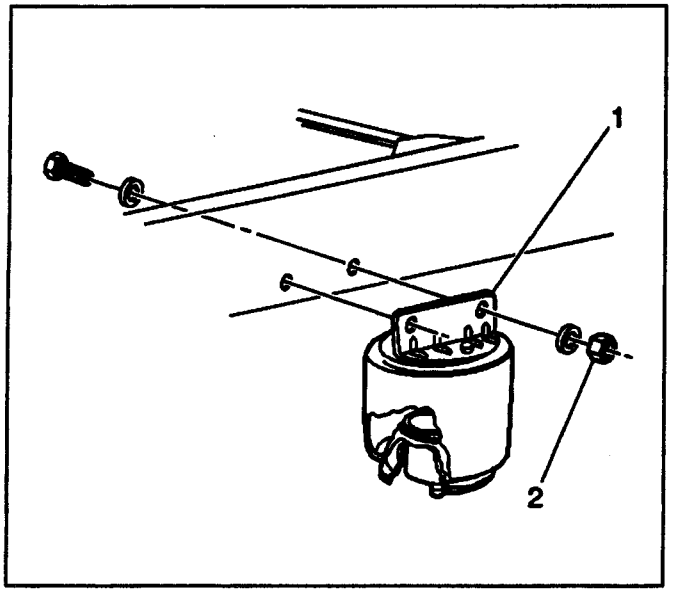
Removal Procedure

1. Block the wheels of the axle.
2. Drain the air pressure from the air springs.
3. Raise the frame of the vehicle in order to remove the load from the suspension.
4. Support the frame using jack stands.
5. Remove the locknuts (3) and the washers that connect the air spring (1) to the cross channel (2).
6. Remove the air line that connects to the air spring (1).
7. Remove the brass air fittings from the air spring (1).



200665

8. Remove the locknuts (2) and the washers that connect the air spring (1) to the upper frame hanger.
9. Remove the air spring (1).



200665

Installation Procedure

1. Connect the air spring (1) to the air spring frame hanger.

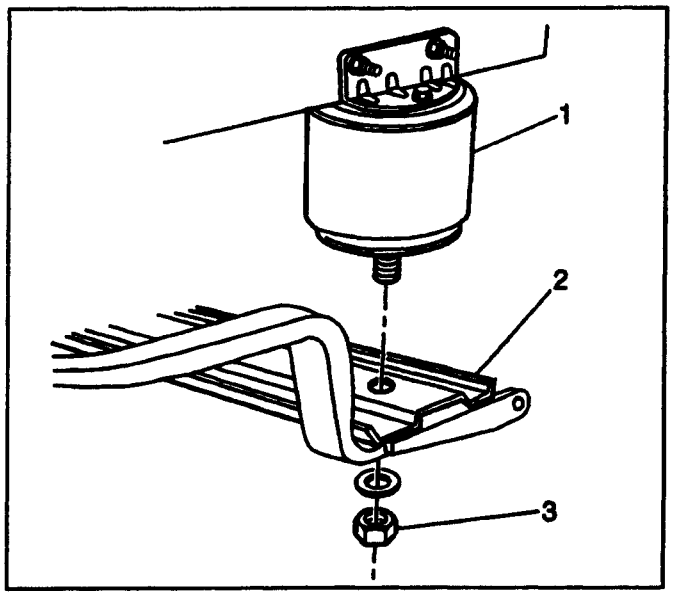
2. Connect the air spring (1) to the cross channel (2).

   Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the washers and the locknuts (3) that connect the air spring to the cross channel.

   Tighten

   Tighten the locknuts to 27–41 N.m (20–30 lb ft).



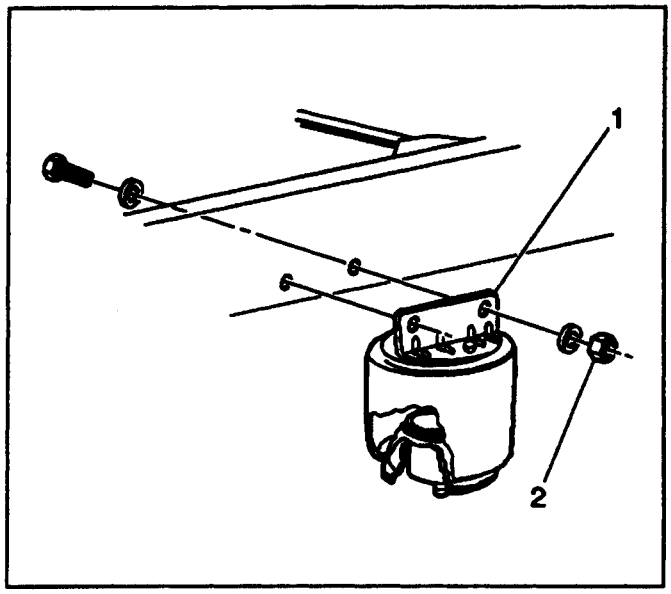
200663

4. Install the washers and the locknuts (2) that connect the air spring (1) to the air spring frame hanger.

   Tighten

   Tighten the locknuts to 27–41 N.m (20–30 lb ft).

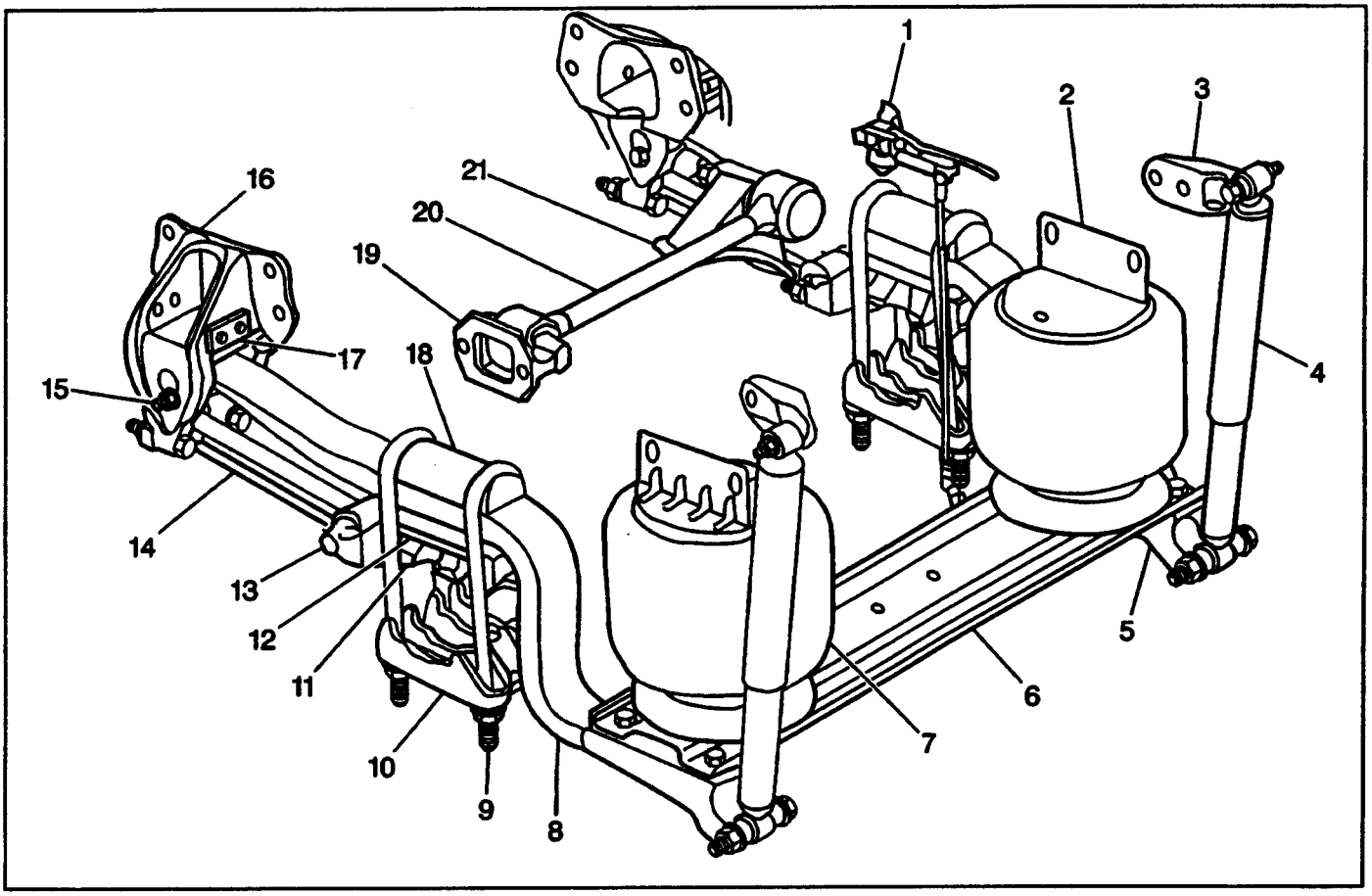
5. Install the brass air fitting to the air spring using a Teflon® thread seal.
6. Connect the air lines to the air springs.
7. Lower the frame of the vehicle.
8. Unblock the wheels.
9. Refill air into the system.



200665

Description and Operation

Rear Air Suspension



200633

The Hendrickson HAS Series single axle air suspension is made up of two air springs (7). The air springs are supported on main support beams (8), which are fastened to the axle and to the frame. A torque rod (14) from the frame bracket to the spring seat (11) or bottom axle cap (10) provides stability. Additional stability is provided by a transverse torque rod (20) from the frame to the axle housing. The shock absorbers (4) help to control jounce and rebound during vehicle operation.

Air Control System

The suspension air control system uses air drawn from the vehicle air system in order to pressurize the air spring assemblies through the height leveling valve.

The correct vehicle ride height is maintained through use of a frame-mounted height leveling valve.

The pressure protection valve is located on the front service reservoir. The pressure protection valve protects the air supply to the brakes if a failure occurs in the air suspension system. If a loss of air occurs forward (upstream) of the protection valve, air pressure within the air spring system will be partially maintained until repairs can be made. If a loss of air occurs rearward (downstream) of the protection valve, the air in the brake system will be protected but the air pressure in the air springs will be lost.

Height Leveling Valve

The height leveling valve is located on the frame. The height leveling valve attaches to the cross channel by a fixed link. The valve senses changes in the ride height due to varying loads. The valve either will add air or exhaust air from the air springs until the correct ride height is reached.

Air Suspension Relief Valve

The air suspension relief valve permits deflation of the rear suspension air springs. The air suspension relief valve is manually operated by the control valve switch located on the dash panel. The supply port on the relief valve closes when the control valve switch is actuated. This allows the air from the air springs to exhaust and the springs to deflate. The exhaust port closes and the supply air is directed to the air springs when the control valve switch is deactivated. The air springs are then allowed to inflate to normal ride height.

Suspension Controls Circuit Description

Circuit Operation

Voltage is applied to the Air Suspension Dump Switch when the Ignition Switch is in RUN. When the switch is manually closed, voltage is then applied to the Air Suspension Dump Valve. Since this valve is permanently grounded at G404, the valve will energize until the switch is manually opened.

Section 4
Driveline/Axle

Propeller Shaft 4-3
Specifications 4-3
Fastener Tightening Specifications 4-3
Diagnostic Information and Procedures 4-3
Roughness or Vibration (Diagnosis) 4-3
Roughness or Vibration (Propeller Shaft Runout) 4-6
Roughness or Vibration (Propeller Shaft Visual Inspect) 4-6
Ping, Snap, or Click Noise 4-7
Repair Instructions 4-8
Driveline Angle Adjustment 4-8
One-Piece Propeller Shaft Replacement (Full Yoke/229) 4-10
One-Piece Propeller Shaft Replacement (Full Yoke/305) 4-12
One-Piece Propeller Shaft Replacement (Half Yoke/229) 4-14
One-Piece Propeller Shaft Replacement (Half Yoke/305) 4-16
One-Piece Propeller Shaft Replacement (Outboard Slip/229) 4-18
One-Piece Propeller Shaft Replacement (Outboard Slip/305) 4-20
One-Piece Propeller Shaft Replacement (Inboard Flange/229) 4-22
One-Piece Propeller Shaft Replacement (Inboard Flange/305) 4-24
One-Piece Propeller Shaft Replacement (Inboard Full Yoke/305) 4-26
Two-Piece Propeller Shaft Replacement (Inboard Slip Joint and Flange) 4-28
Two-Piece Propeller Shaft Replacement (Inboard Slip Joint and Full) 4-30
Two-Piece Propeller Shaft Replacement (Outboard Slip Joint and Half) 4-33
Two-Piece Propeller Shaft Replacement (Center Bearing, Half Yoke) 4-35
Two-Piece Propeller Shaft Replacement (Center Bearing, Full Yoke) 4-38
Three-Piece Propeller Shaft Replacement (Center Bearing, Full Yoke) 4-40
Three-Piece Propeller Shaft Replacement (Inboard Slip Joint, Full Yoke) 4-43
Three-Piece Propeller Shaft Replacement (Inboard Slip Joint, Flange) 4-45
Three-Piece Propeller Shaft Replacement (Outboard Slip Joint, Half) 4-48
Propeller Shaft Assembly Component Lubrication 4-51
Slip Joint Replacement 4-52
Center Bearing Replacement 4-54
Yoke Replacement 4-56
Universal Joints Replacement 4-58
Description and Operation 4-60
Propeller Shaft Description 4-60
Propeller Shaft Phasing Description 4-61
Universal Joint Description 4-61
Center Bearing Description 4-62
Special Tools and Equipment 4-62
Special Tools 4-62
Rear Drive Axle 4-63
Specifications 4-63
Fastener Tightening Specifications 4-63
Diagnostic Information and Procedures 4-63
Determining Type of Noise 4-63
Noise Diagnosis 4-66
General Information (Axle Housing Alignment Diagnos) 4-67
General Information (Bent Axle Housing Check) 4-67
Repair Instructions 4-68
Lubricant Change 4-68
Differential Replacement 4-70
Axle Shaft Replacement 4-72
Drive Pinion Yoke Replacement (Input Yoke) 4-74
Vent Hose Replacement 4-76
Rear Hub and Bearing Replacement (Hub and Bearing) 4-77
Rear Hub and Bearing Replacement (Wheel Bearing Cup) 4-80
Rear Hub and Bearing Replacement (Wheel Bearing Seal) 4-81
Axle Housing Replacement 4-82
Wheel Bearing Adjustment 4-84
Wheel Hub Bolt Replacement 4-86

Description and Operation 4-86
Rear Axle Description (Single-Speed Axles) ...4-86
Rear Axle Description (Two-Speed Axles).....4-87
Rear Axle Description (Tandem Axles)..... 4-87
Rear Axle Description (Overhaul - Dana/Spicer) 4-87
Rear Axle Description (Overhaul - Eaton).....4-87
Special Tools and Equipment 4-87
Special Tools..... 4-87
Rear Axle Controls..... 4-89
Specifications 4-89
Fastener Tightening Specifications 4-89
Schematic and Routing Diagrams..... 4-89
Rear Axle Schematic References..... 4-89
Rear Axle Schematic Icons..... 4-89
Two Speed Rear Axle Schematics (Two-Speed Rear Axle Schematic) 4-90
Two Speed Rear Axle Schematics (Vehicle Speed Sensor Schematic)..... 4-91
Component Locator..... 4-92
Rear Axle Components..... 4-92
Rear Axle Connector End Views..... 4-93
Diagnostic Information and Procedures.....4-94
Two Speed Rear Axle System Check..... 4-94
Two Speed Rear Axle Shift Motor Diagnosis (High Speed Inoperative) 4-94
Two Speed Rear Axle Shift Motor Diagnosis (Low Speed Inoperative) 4-95
Repair Instructions 4-97
Two Speed R/Axle Shift Control Switch Replacement..... 4-97
Two Speed Rear Axle Shift Motor Relay Replacement..... 4-97
Two Speed Rear Axle Shift Motor Replacement..... 4-99
Description and Operation 4-101
Two Speed Rear Axle Shift System Description 4-101
Two Speed Rear Axle Circuit Description 4-102

Propeller Shaft

Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Center Bearing Bolts	60/81 N.m	44/59 lb ft
Propeller Shaft Hanger Bracket Nuts	101 N.m	75 lb ft
Propeller Shaft Hanger Nuts	70 N.m	52 lb ft
Propeller Shaft to Transmission Flange With 4 Nuts	75 N.m	55 lb ft
Propeller Shaft to Transmission Flange With 8 Nuts	38 N.m	28 lb ft
Universal Joint Bearing Strap Bolts Series 1480, 1550, 1610	54 N.m	40 lb ft
Universal Joint Bearing Strap Bolts Series 1710, 1710HD	136 N.m	100 lb ft
Universal Joint Cap Screws	44 N.m	33 lb ft
Yoke Nut Series 1480	779 N.m	575 lb ft
Yoke Nut Series 1550	216 N.m	160 lb ft
Yoke Nut Series 1610, 1710	983 N.m	725 lb ft

Diagnostic Information and Procedures

Roughness or Vibration (Diagnosis)

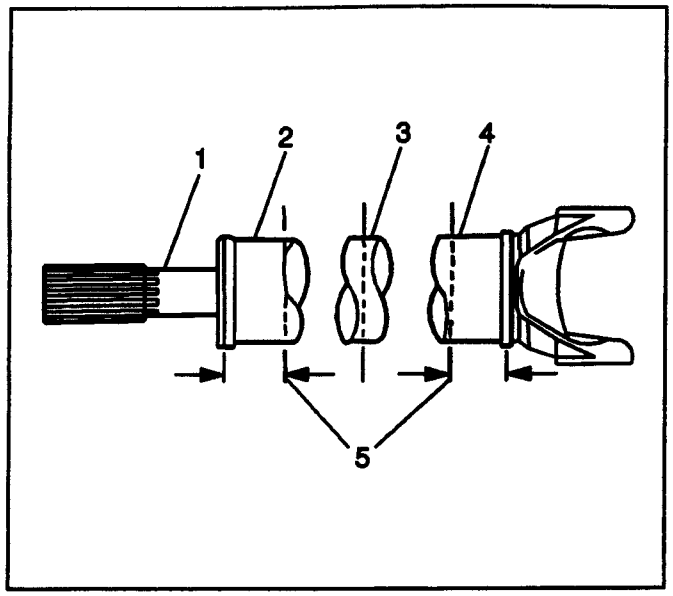
Step	Action	Value(s)	Yes	No
1	Inspect the center bearing. Is the bearing worn?	—	Go to *Step 2*	Go to *Step 3*
2	Replace the center bearing. Is roughness or vibration still evident?	—	Go to *Step 3*	System OK
3	Inspect the hanger. Is the hanger worn?	—	Go to *Step 4*	Go to *Step 5*
4	Replace the hanger. Is roughness or vibration still evident?	—	Go to *Step 5*	System OK
5	Inspect the universal joints. Are the universal joints worn?	—	Go to *Step 6*	Go to *Step 7*
6	Replace the bearings. Is roughness or vibration still evident?	—	Go to *Step 7*	System OK
7	Inspect the universal joints. Do the universal joints require lubrication?	—	Go to *Step 8*	Go to *Step 9*
8	Lubricate the universal joints. Is roughness or vibration still evident?	—	Go to *Step 9*	System OK
9	Inspect the flange bolts. Are the bolts loose?	—	Go to *Step 10*	Go to *Step 11*
10	Tighten the flange bolts to specification. Refer to *Fastener Tightening Specifications.* Is roughness or vibration still evident?	—	Go to *Step 11*	System OK
11	Inspect the propeller shaft. Is the propeller shaft bent or dented?	—	Go to *Step 12*	Go to *Step 13*

Roughness or Vibration (Diagnosis) (cont'd)

Step	Action	Value(s)	Yes	No
12	Replace the propeller shaft. Is roughness or vibration still evident?	—	Go to *Step 13*	System OK
13	Inspect the propeller shaft. Is there dirt or debris on the propeller shaft?	—	Go to *Step 14*	Go to *Step 15*
14	Clean the propeller shaft. Is roughness or vibration still evident?	—	Go to *Step 15*	System OK
15	Inspect the tires. Are the tires out of balance?	—	Go to *Step 16*	Go to *Step 17*
16	Balance or replace the tires as necessary. Is roughness or vibration still evident?	—	Go to *Step 17*	System OK
17	Inspect the U-bolt torque. Is the torque excessive?	—	Go to *Step 18*	Go to *Step 19*
18	Correct the torque according to specifications. Refer to *Fastener Tightening Specifications.* Is roughness or vibration still evident?	—	Go to *Step 19*	System OK
19	Inspect the universal joints. Are the universal joints tight?	—	Go to *Step 20*	Go to *Step 21*
20	1. Impact the yokes using a hammer in order to loosen the yokes. 2. Overhaul the universal joint if one of the following conditions exist: • You are unable to loosen the universal joint. • The joint feels rough when rotated by hand. Is roughness or vibration still evident?	—	Go to *Step 21*	System OK
21	Inspect the universal joints. Are the universal joints worn?	—	Go to *Step 22*	Go to *Step 23*
22	1. Overhaul the universal joints. 2. Replace worn parts as necessary. Is roughness or vibration still evident?	—	Go to *Step 23*	System OK
23	Inspect the companion flange. Are there burrs or gouges on the companion flange?	—	Go to *Step 24*	Go to *Step 25*
24	1. Inspect the snap ring locating surfaces on the flange yoke. 2. Rework or replace the companion flange. Is roughness or vibration still evident?	—	Go to *Step 25*	System OK
25	Inspect the propeller shaft. Is the propeller shaft unbalanced?	—	Go to *Step 26*	Go to *Step 27*
26	1. Inspect the propeller shaft for a missing balance weight. 2. Remove the propeller shaft. 3. Install the propeller shaft to the companion flange 180° from the original position. Is roughness or vibration still evident?	—	Go to *Step 27*	System OK
27	Inspect the parking brake drum, if used. Is the parking brake drum unbalanced?	—	Go to *Step 28*	Go to *Step 29*
28	Repair or replace the parking brake drum. Is roughness or vibration still evident?	—	Go to *Step 29*	System OK

Roughness or Vibration (Diagnosis) (cont'd)

Step	Action	Value(s)	Yes	No
29	Inspect the companion flange. Is the companion flange unbalanced?	—	Go to *Step 30*	Go to *Step 31*
30	Repair or replace the companion flange. Is roughness or vibration still evident?	—	Go to *Step 31*	System OK
31	Inspect the rear joint angle. Is the angle too large or too small?	—	Go to *Step 32*	Go to *Step 33*
32	1. Check the trim height at curb weight. 2. Correct the trim height, if necessary. 3. Check the rear joint angle. 4. Correct the rear joint angle. Is roughness or vibration still evident?	—	Go to *Step 33*	System OK
33	Inspect the slip yoke spline. Is the slip yoke spline excessively loose?	—	Go to *Step 34*	Go to *Step 35*
34	Replace the parts as necessary. Is roughness or vibration still evident?	—	Go to *Step 35*	System OK
35	Inspect the yokes. Are the yokes distorted or damaged?	—	Go to *Step 36*	Go to *Step 37*
36	Install the new yokes. Is roughness or vibration still evident?	—	Go to *Step 37*	System OK
37	Inspect the yokes. Are the yokes out of parallel to each other?	—	Go to *Step 38*	—
38	Change the propeller shaft. Is roughness or vibration still evident?	—	—	System OK
For additional vibration diagnosis, refer to Vibration Diagnosis in General Information.				



198579

Use a dial indicator in order to inspect each shaft at several locations for excessive runout. Ensure that the readings at each location are within the limits as specified:

Roughness or Vibration (Propeller Shaft Runout)

Application	Specification	
	Metric	English
Splined Shaft (1)	1.30 mm	0.005 in
Front (2)	3.0 mm	0.015 in
Center (3)		
Shafts to 762 mm (30 in)	3.0 mm	0.015 in
Shafts over 762 mm (30 in)	2.5 mm	0.010 in
Rear (4)	3.0 mm	0.015 in
Front to Rear (5)	75.0 mm	3.0 in

Roughness or Vibration (Propeller Shaft Visual Inspect)

An unbalanced propeller shaft and universal joint assembly may be caused by one or more of the following conditions:

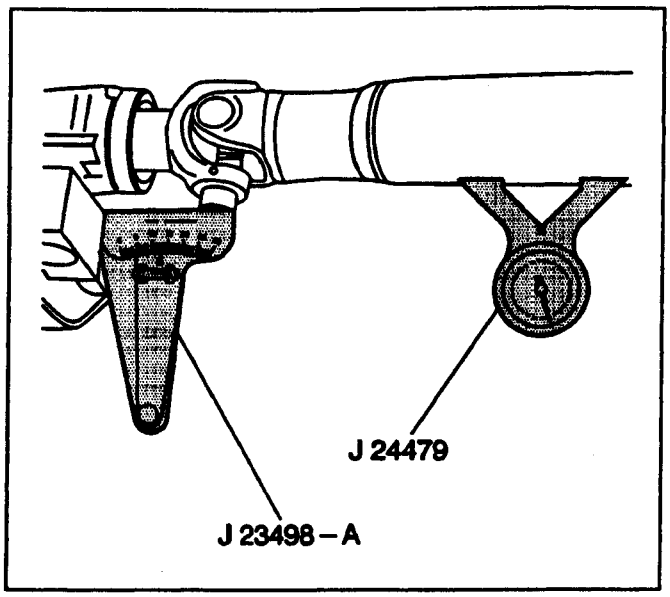
- Missing balance weights
- Bent, dented, or damaged tubing
- Worn slip spline (inboard type)
- Foreign material on the propeller shaft tubing or the end yokes
- Improperly installed propeller shaft and universal joint assembly

1. Clean all foreign material from the shaft or tube and the end yokes.
2. Inspect the assembly. If necessary, remove and repair the assembly as required.

Do not replace missing balance weights or straighten a bent tube without the proper tools. Refer to a service outlet that specializes in such work.

Ping, Snap, or Click Noise

Step	Action	Value(s)	Yes	No
1	Inspect the upper control arm bushing bolts at the rear axle. Are the bolts loose?	—	Go to *Step 2*	Go to *Step 3*
2	Tighten the bolts to specification. Refer to *Fastener Tightening Specifications.* Is the ping, snap or click noise still evident?	—	Go to *Step 3*	System OK
3	Inspect the lower control arm bushing bolts at the rear axle. Are the bolts loose?	—	Go to *Step 4*	Go to *Step 5*
4	Tighten the bolts to specification. Refer to *Fastener Tightening Specifications.* Is the ping, snap or click noise still evident?	—	Go to *Step 5*	System OK
5	Inspect the companion flange. Is the companion flange loose?	—	Go to *Step 6*	—
6	1. Remove the companion flange. 2. Turn the companion flange 180° from the original position. 3. Lubricate the splines. 4. Install the companion flange. 5. Tighten the pinion to the specified torque. Refer to *Fastener Tightening Specifications.* Is the ping, snap or click noise still evident?	—	—	System OK
For additional vibration diagnosis, refer to Vibration Diagnosis in General Information.				



198591

Repair Instructions

Driveline Angle Adjustment

Tools Required

- *J 23498-A* Inclinometer
- *J 24479* Inclinometer

Correct driveline angles are necessary in order to prevent torsional vibration. There must be at least a 1/2 degree angle in adjacent components of the propeller shaft in order to promote longer universal joint life.

On some vehicles, adjustable auxiliary transmission mountings are provided for adjusting the angle of the various driveline components. On vehicles that do not have adjustable auxiliary transmission mountings, use spacers or shims at the hanger bracket in order to achieve proper adjustment of the angle of the driveline components. The following procedure covers the checking and adjusting of driveline angles on the vehicles.

Refer to *Driveline Angles Layout* for measurements and angle specifications.

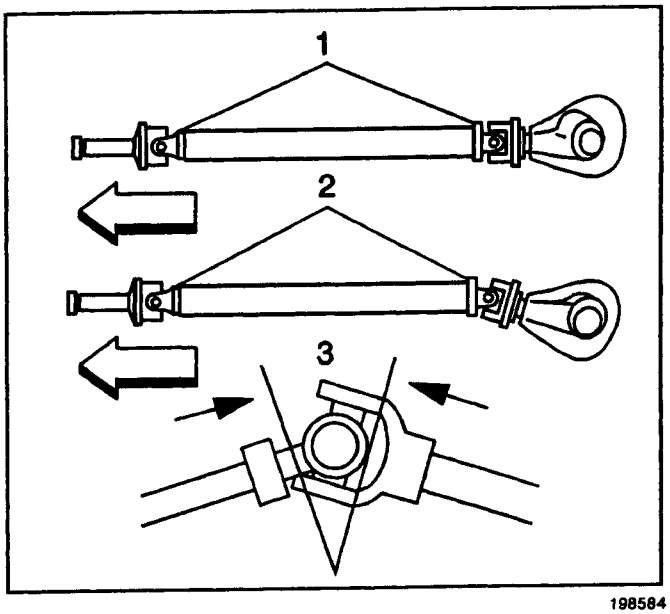
Driveline Angles Inspection

Inspect the driveline angles when the vehicle is unloaded, and again when the vehicle is loaded. Ensure that the vehicle is in its normal operating position, with a full tank of gasoline. Safely block the wheels.

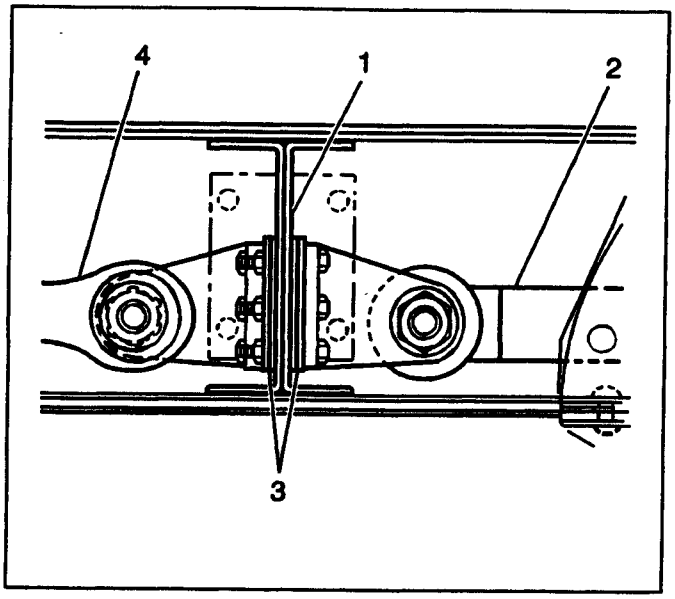
1. Ensure that all of the parts are clean. The parts must be free of dirt or other foreign material in order to obtain an accurate measurement.
2. Measure the tire air pressure. Ensure that the air pressures are at normal operating levels.
3. Measure the ground surface for level. Take the measurements from both front to rear and from side to side.
4. Place the *J 23498-A* or the *J 24479* on the rear propeller shaft bearing cap.
5. Center the bubble in the sight glass and record the measurement. Ensure that the bearing cap is straight up and down.
6. Rotate the propeller shaft 90 degrees. Place the *J 23498-A* or the *J 24479* on the front slip spline yoke bearing cap.
7. Center the bubble on the sight glass and record the measurement.
8. Ensure that the bearing cap is straight up and down.
9. Place the *J 23498-A* or the *J 24479* on the rear propeller shaft bearing cap. Ensure that the bearing cap is straight up and down.
10. Center the bubble in the sight glass and record the measurement.
11. Rotate the propeller shaft 90 degrees. Place the *J 23498-A* or the *J 24479* on the front slip spline yoke bearing cap.
12. Center the bubble on the sight glass and record the measurement.
13. Subtract the smaller figure from the larger figure in order to obtain the rear universal joint angle.

14. Place the *J 23498-A* or the *J 24479* on the front propeller shaft bearing cap.
15. Center the bubble in the sight glass and record the measurement.
16. Rotate the propeller shaft 90 degrees. Place the *J 23498-A* or the *J 24479* on the front slip spline yoke bearing cap.
17. Center the bubble on the sight glass and record the measurement.
18. Subtract the smaller figure from the larger figure in order to obtain the rear universal joint angle.
19. Place the *J 23498-A* or the *J 24479* on the front propeller shaft bearing cap.
20. Center the bubble in the sight glass and record the measurement.
21. Rotate the propeller shaft 90 degrees. Place the *J 23498-A* or the *J 24479* on the front slip spline yoke bearing cap.
22. Center the bubble on the sight glass and record the measurement.
23. Subtract the smaller figure from the larger figure in order to obtain the front universal joint angle.

    The recorded measurements determine if the journal cross operating angles of each propeller shaft set is more than 3 degrees. The working angles should not exceed 3 degrees (3). Ensure that the operating angle is greater than 1/2 degree in order to prevent brinelling of the bearing.



198584



198581

Auxiliary Transmission and Propeller Shaft Angle

Adjust the propeller shaft by raising or lowering the front or rear of the transmission using one of the following components:

- The adjustable mounting bolts
- The adding or removing shims
- The plates
- The washers, etc.

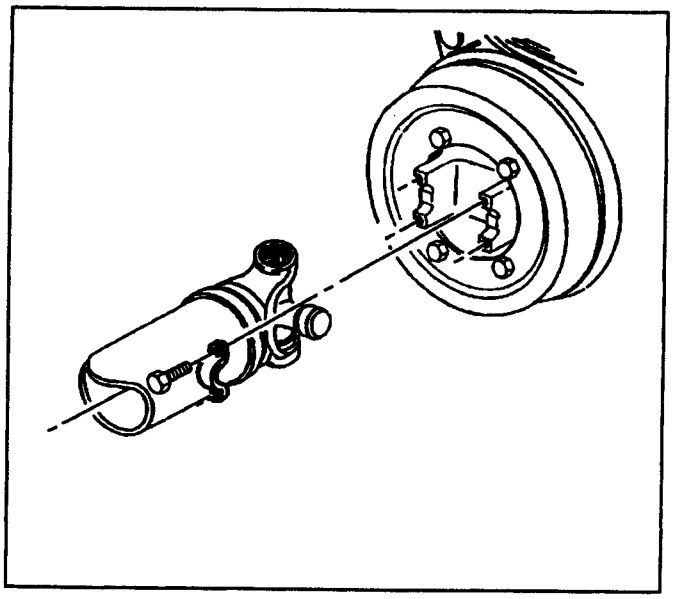
In order to change the transmission angle, raise or lower one end of the transmission more than the other end.

Torque Rod Shimming

The addition or removal of shims (3) from the rear axle torque rod (2) will change the angle of the interaxle drive shaft. Verify the interaxle drive shaft angle and the rear yoke angle measurements after each adjustment is made in order to determine the journal operating angle.

Short Coupled Universal Joints

Install the short coupled universal joints to the front and rear universal joints. Ensure that the angles do not exceed 3 degrees.



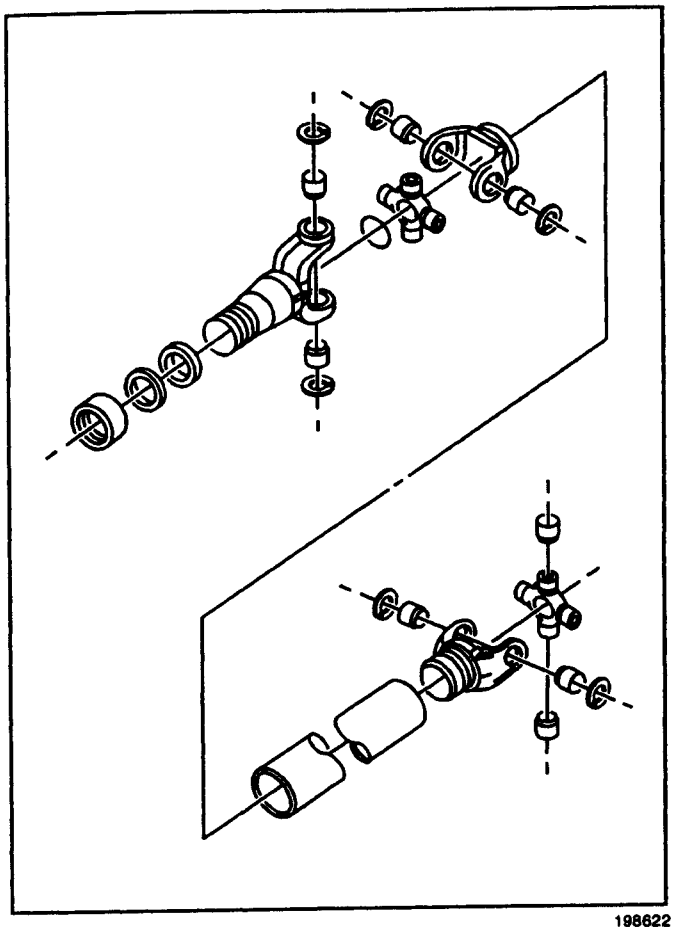
198564

One-Piece Propeller Shaft Replacement (Full Yoke/229)

Removal Procedure

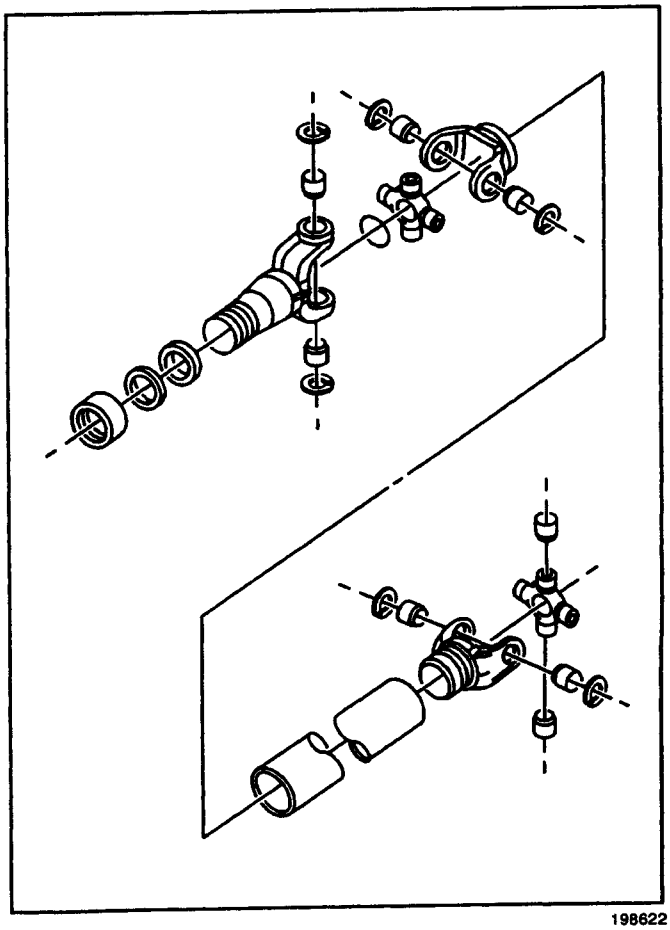
1. Block the wheels.
2. Support the propeller shaft.
3. Mark the universal joints and slip joints with alignment marks.
4. Remove the propeller shaft guards, if equipped.
5. Remove the propeller shaft mounting from the 229 mm (9 in) brake drum.

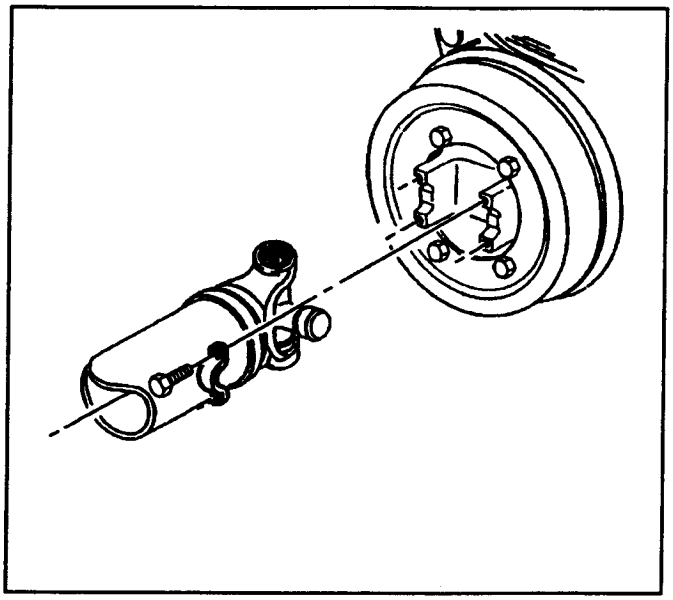
6. Remove the propeller shaft 1480 or 1550 series with outboard slip joint and half round end yoke.
7. Remove the universal joints. Refer to *Universal Joints Replacement.*


198622

Installation Procedure

1. Install the universal joints to the propeller shaft. Refer to *Universal Joints Replacement.*
2. Support the propeller shaft sections in the installed position.
3. Install the slip yoke to the installed propeller shaft splined end.

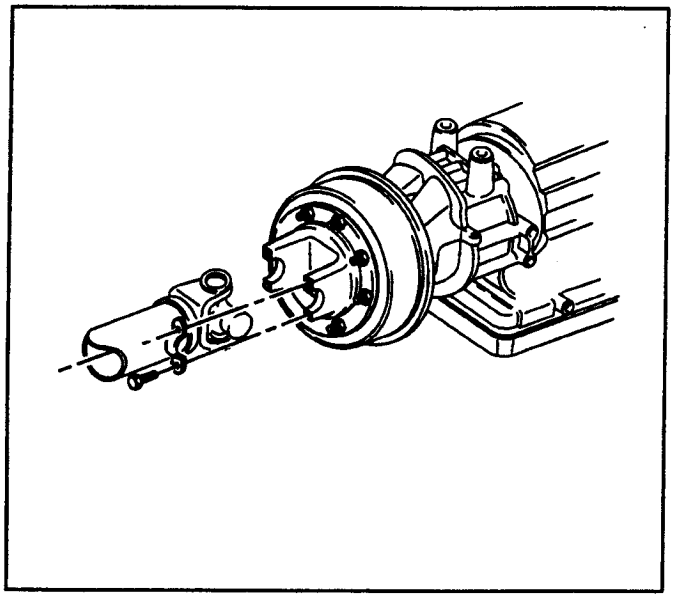

198622



198564

4. Install the front propeller shaft to the 229 mm (9 in) brake drum. Keep the alignment marks together.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
5. Inspect the propeller shaft for alignment and phasing.
6. Install and tighten the propeller shaft half round end yoke bolts. Refer to *Fastener Tightening Specifications.*
7. Install the propeller shaft guards, if equipped.
8. Lubricate the universal joints and the slip joints. Refer to *Propeller Shaft Assembly Component Lubrication.*



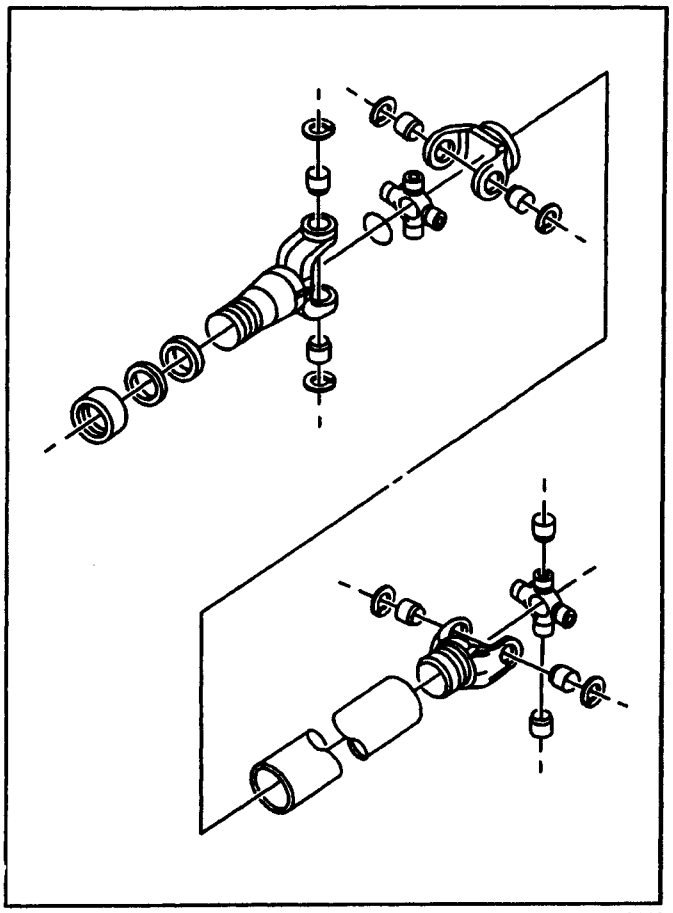
198559

One-Piece Propeller Shaft Replacement (Full Yoke/305)

Removal Procedure

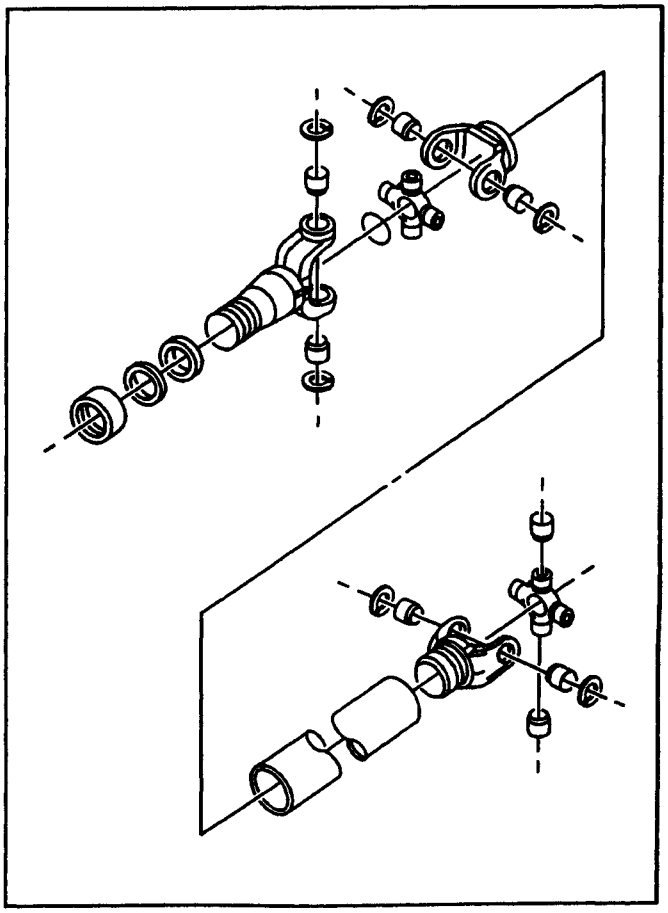
1. Block the wheels.
2. Support the propeller shaft.
3. Mark the universal joints and slip joints with alignment marks.
4. Remove the propeller shaft guards, if equipped.
5. Remove the propeller shaft mounting from the 305 mm (12 in) brake drum.

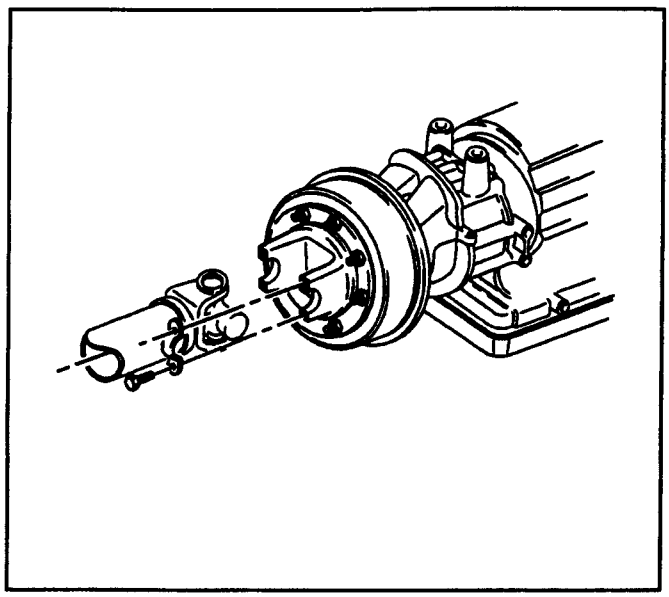
6. Remove the propeller shaft 1480 or 1550 series with outboard slip joint and half round end yoke.
7. Remove the universal joints. Refer to *Universal Joints Replacement.*


198622

Installation Procedure

1. Install the universal joints to the propeller shaft. Refer to *Universal Joints Replacement.*
2. Support the propeller shaft sections in the installed position.
3. Install the slip yoke and the center bearing assembly to the installed propeller shaft splined end.

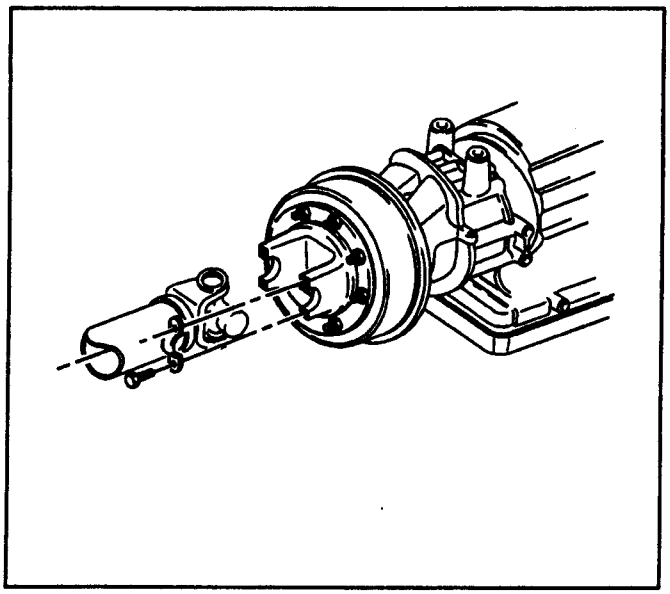

198622



198559

4. Install the front propeller shaft to the 305 mm (12 in) brake drum. Keep the alignment marks together.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
5. Inspect the propeller shaft for alignment and phasing.
6. Install and tighten the propeller shaft half round end yoke bolts. Refer to *Fastener Tightening Specifications.*
7. Install the propeller shaft guards, if equipped.
8. Lubricate the universal joints and the slip joints. Refer to *Propeller Shaft Assembly Component Lubrication.*



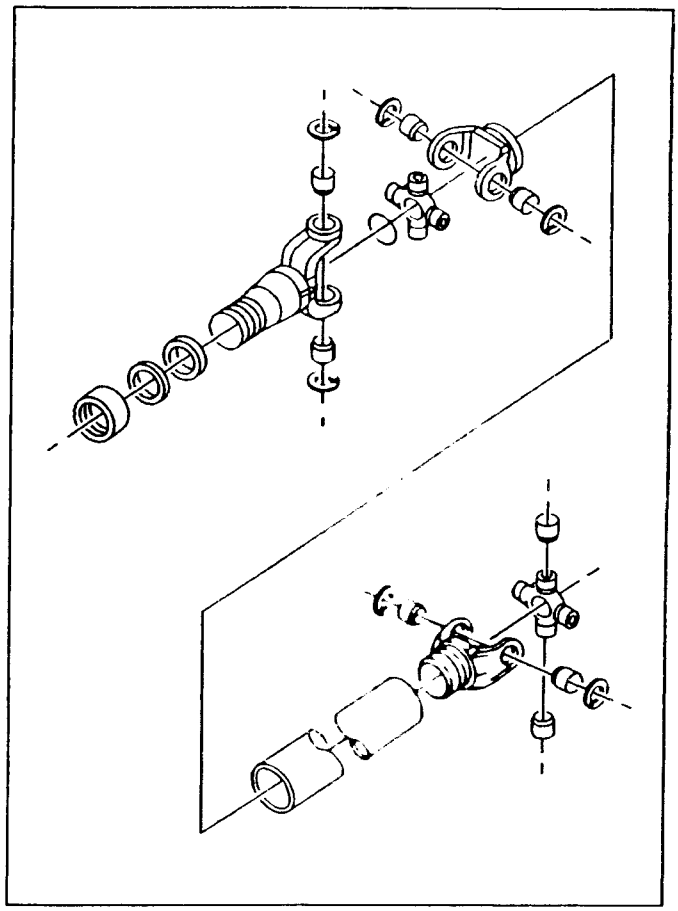
198559

One-Piece Propeller Shaft Replacement (Half Yoke/229)

Removal Procedure

1. Block the wheels.
2. Support the propeller shaft.
3. Mark the universal joints and slip joints with alignment marks.
4. Remove the propeller shaft guards, if equipped.
5. Remove the propeller shaft mounting from the 305 mm (12 in) brake drum.

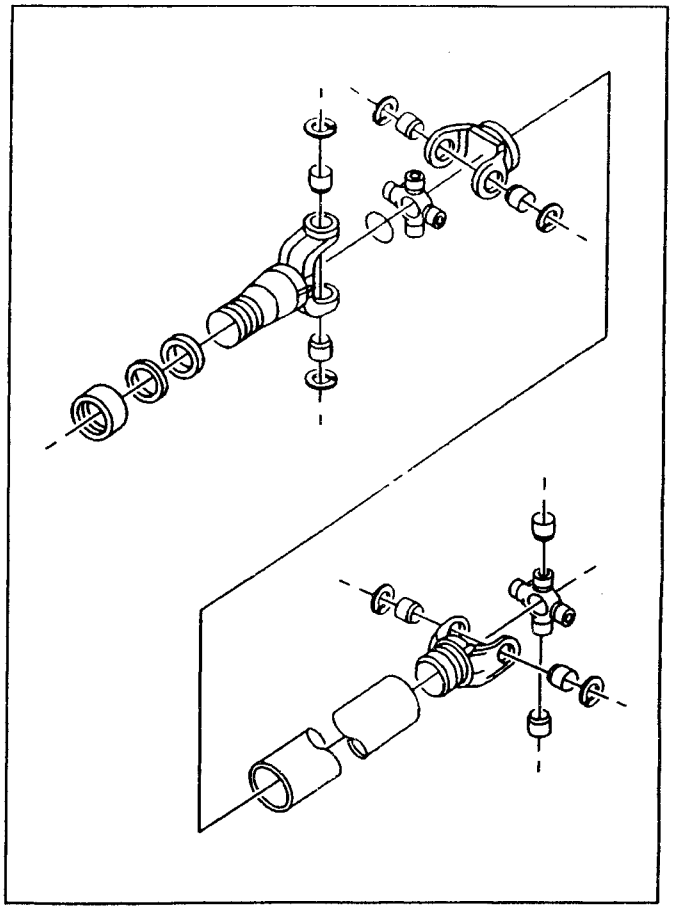
6. Remove the propeller shaft 1480 or 1550 series half round end yoke.
7. Remove the universal joints. Refer to *Universal Joints Replacement.*



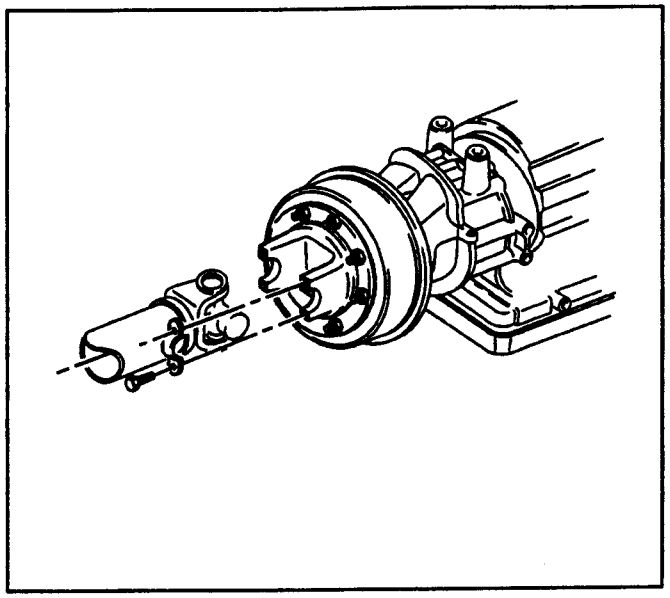
198622

Installation Procedure

1. Install the universal joints to the propeller shaft. Refer to *Universal Joints Replacement.*
2. Support the propeller shaft sections in the installed position.
3. Install the slip yoke assembly to the installed propeller shaft splined end.



198622

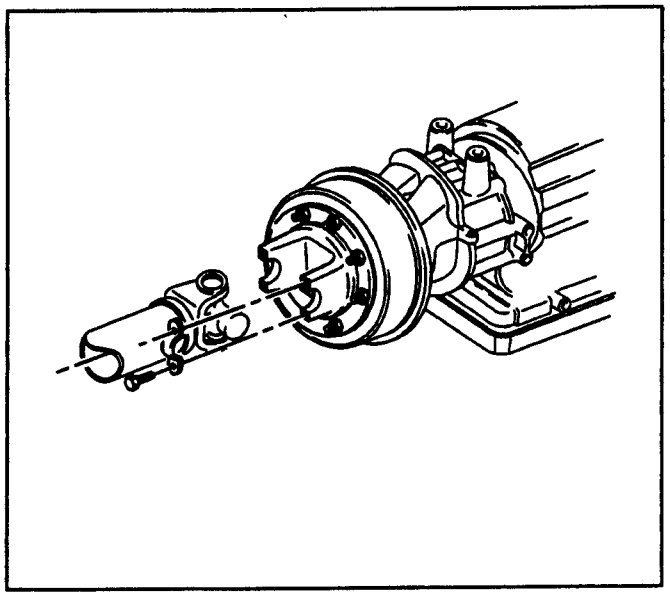


198559

4. Install the front propeller shaft to the 305 mm (12 in) brake drum. Keep the alignment marks together.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Install and tighten the propeller shaft full or half round end yoke bolts. Refer to *Fastener Tightening Specifications.*
6. Install the rear propeller shaft to the universal joints.
7. Install the propeller shaft guards, if equipped.
8. Lubricate the universal joints and the slip joints. Refer to *Propeller Shaft Assembly Component Lubrication.*



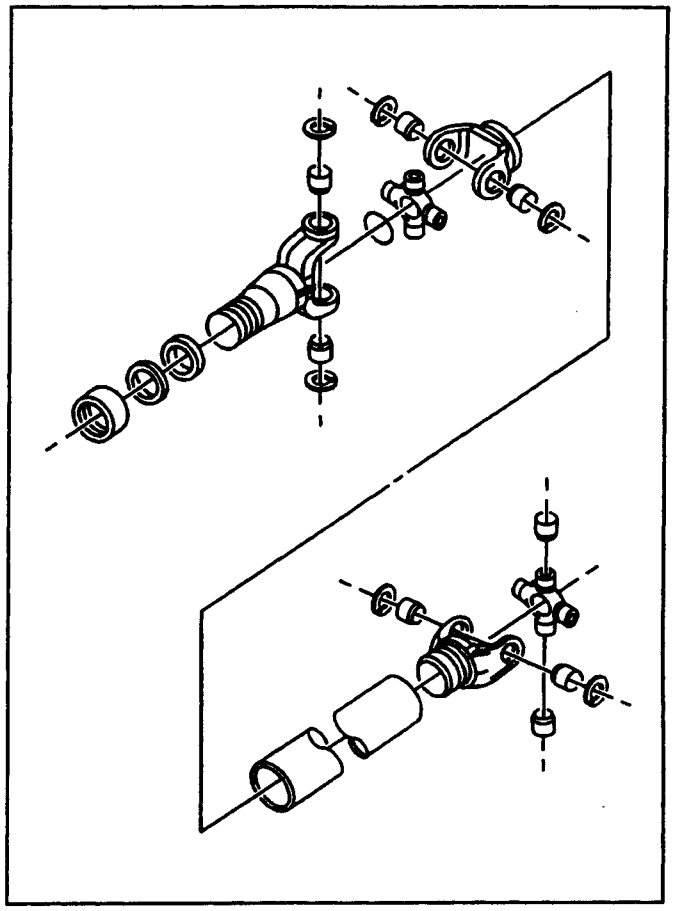
198559

One-Piece Propeller Shaft Replacement (Half Yoke/305)

Removal Procedure

1. Block the wheels.
2. Support the propeller shaft.
3. Mark the universal joints and slip joints with alignment marks.
4. Remove the propeller shaft guards, if equipped.
5. Remove the propeller shaft mounting from the 305 mm (12 in) brake drum.

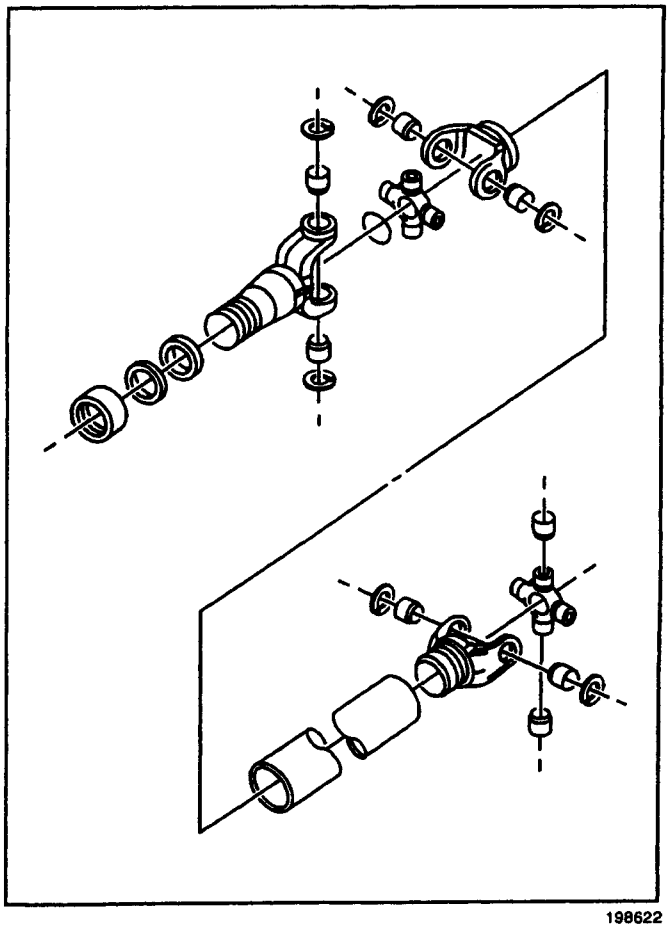
6. Remove the propeller shaft 1480 or 1550 series with outboard slip joint and half round end yoke.
7. Remove the universal joints. Refer to *Universal Joints Replacement.*



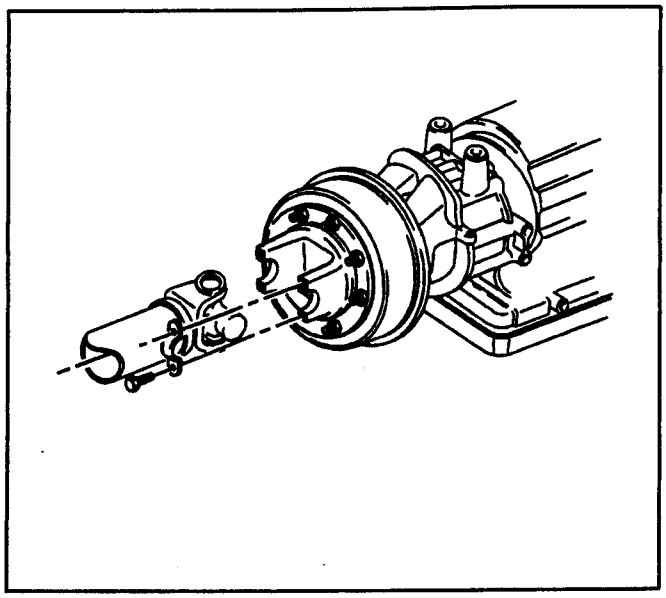
198622

Installation Procedure

1. Install the universal joints to the propeller shaft. Refer to *Universal Joints Replacement.*
2. Support the propeller shaft sections in the installed position.
3. Install the slip yoke and the center bearing assembly to the installed propeller shaft splined end.



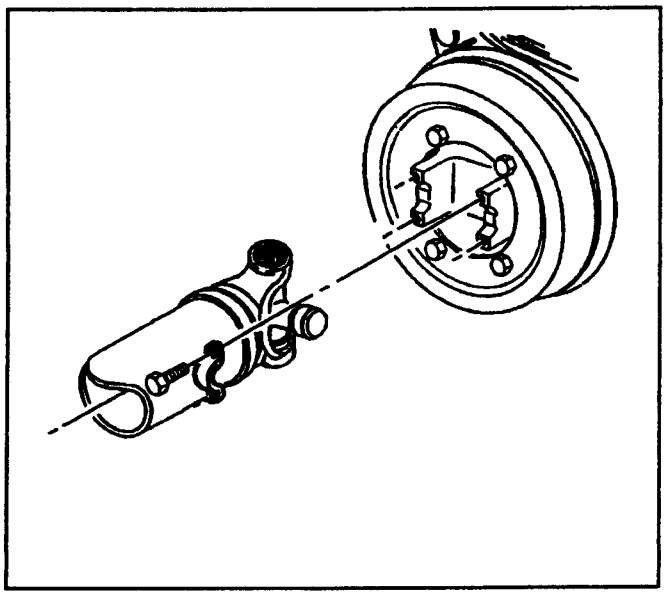
198622



198559

4. Install the front propeller shaft to the 305 mm (12 in) brake drum. Keep the alignment marks together.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
5. Inspect the propeller shaft for alignment and phasing.
6. Install and tighten the propeller shaft half round end yoke bolts. Refer to *Fastener Tightening Specifications.*
7. Install the propeller shaft guards, if equipped.
8. Lubricate the universal joints and the slip joints. Refer to *Propeller Shaft Assembly Component Lubrication.*



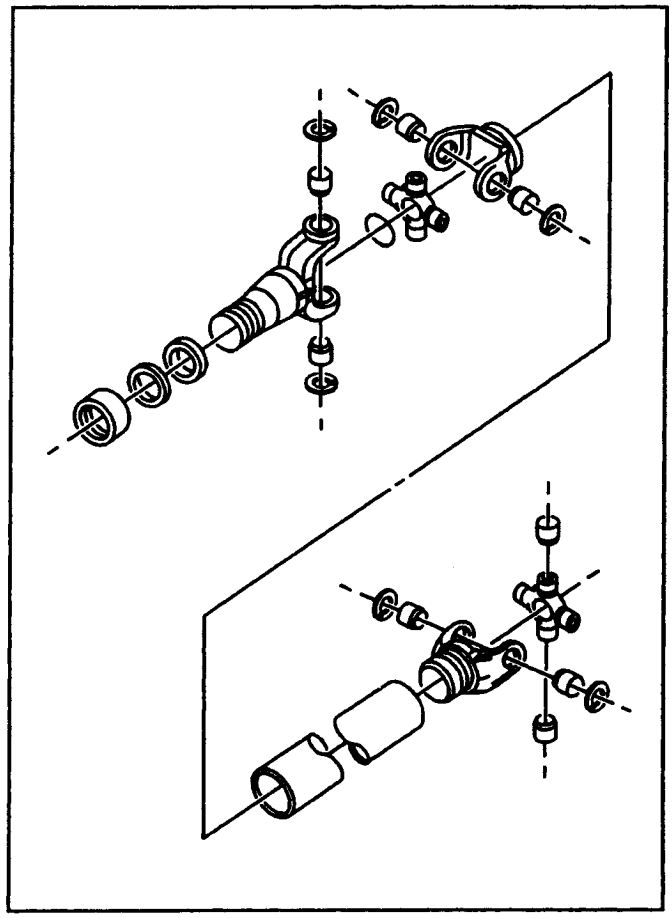
198564

One-Piece Propeller Shaft Replacement (Outboard Slip/229)

Removal Procedure

1. Block the wheels.
2. Support the propeller shaft.
3. Mark the universal joints and slip joints with alignment marks.
4. Remove the propeller shaft guards, if equipped.
5. Remove the propeller shaft mounting from the 229 mm (9 in) brake drum.

6. Remove the propeller shaft 1480 or 1550 series half round end yoke.
7. Remove the universal joints. Refer to *Universal Joints Replacement.*

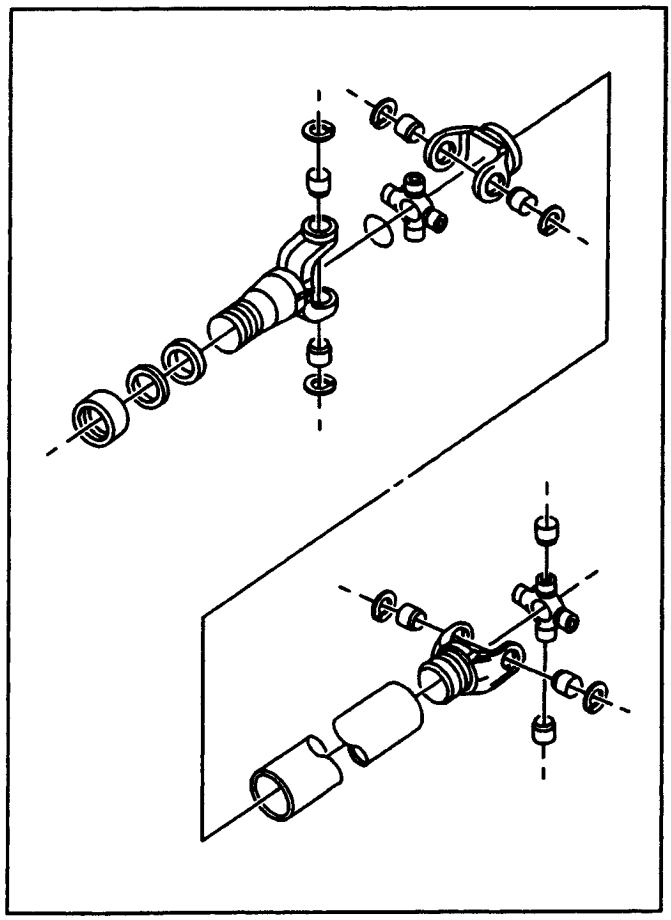


198622

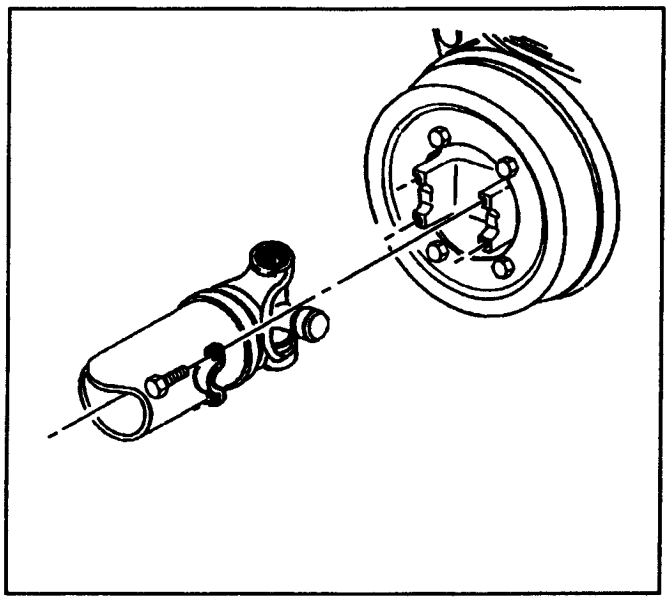
Installation Procedure

1. Install the universal joints to the propeller shaft. Refer to *Universal Joints Replacement.*
2. Support the propeller shaft sections in the installed position.
3. Install the slip yoke assembly to the installed propeller shaft splined end.
4. Install the front propeller shaft to the 229 mm (9 in) brake drum.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
5. Keep the alignment marks together.



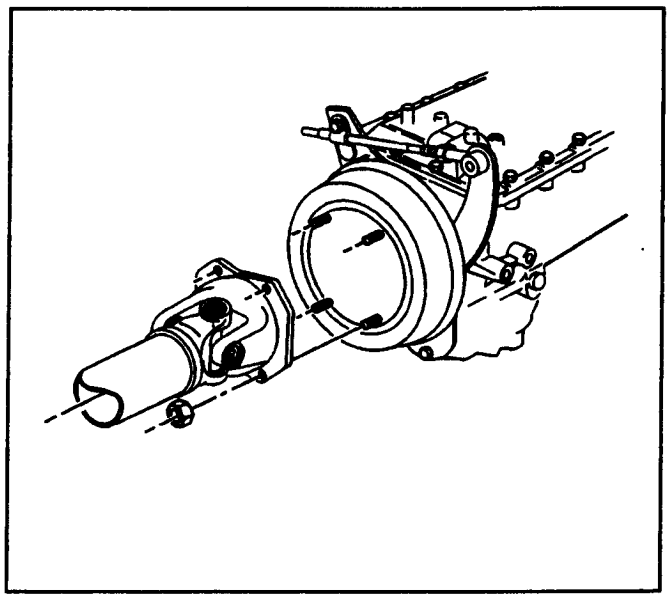
198622



198564

6. Install and tighten the propeller shaft half round end yoke bolts

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
7. Inspect the propeller shaft for alignment and phasing.
8. Install the propeller shaft guards, if equipped.
9. Lubricate the universal joints and the slip joints. Refer to *Propeller Shaft Assembly Component Lubrication.*



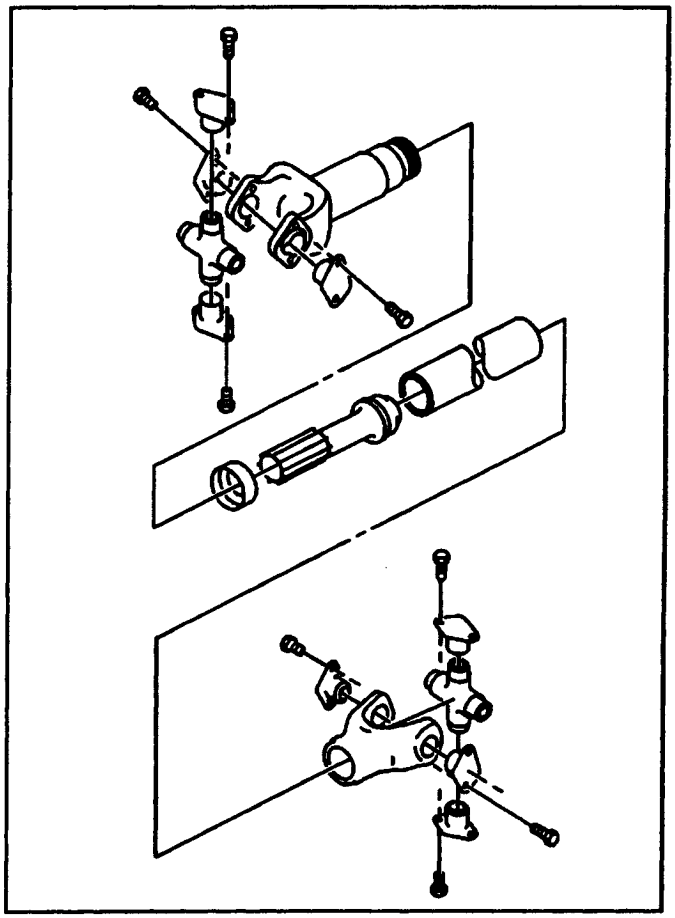
198510

One-Piece Propeller Shaft Replacement (Outboard Slip/305)

Removal Procedure

1. Block the wheels.
2. Support the propeller shaft.
3. Mark the universal joints and slip joints with alignment marks.
4. Remove the propeller shaft guards, if equipped.
5. Remove the propeller shaft from the Yoke Flange (4 nut) mounting.

6. Remove the propeller shaft 16N, 17N, 18N, 1710 or 1760 series full round end yoke.
7. Remove the universal joints. Refer to *Universal Joints Replacement*

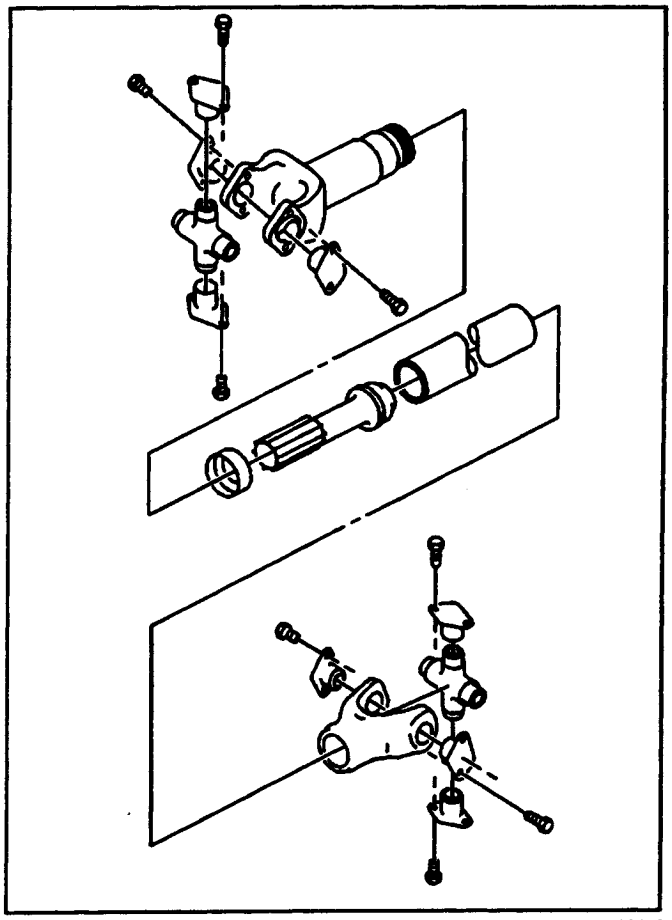


198610

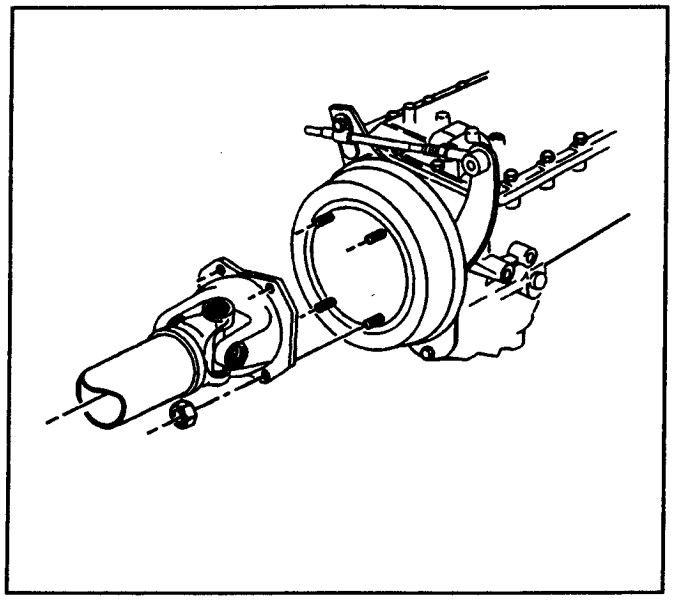
Installation Procedure

1. Install the universal joints to the propeller shaft. Refer to *Universal Joints Replacement.*
2. Support the propeller shaft sections in the installed position.
3. Install the slip yoke assembly to the installed propeller shaft splined end.
4. Install the front propeller shaft to the Yoke Flange (4 nut) mounting. Keep the alignment marks together.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
5. Install and tighten the propeller shaft full or half round end yoke bolts. Refer to *Fastener Tightening Specifications.*



198610

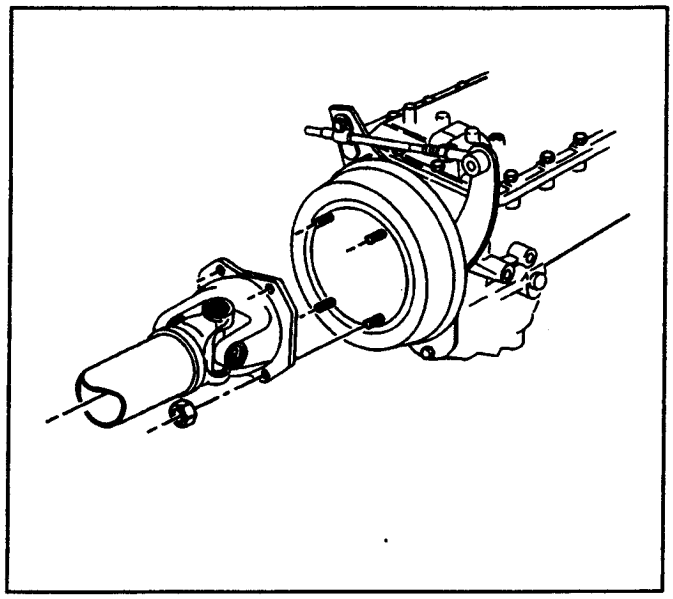


198510

6. Install the propshaft to the yoke flange.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.

7. Inspect the propeller shaft for alignment and phasing.
8. Install the propeller shaft guards, if equipped.
9. Lubricate the universal joints and the slip joints. Refer to *Propeller Shaft Assembly Component Lubrication.*



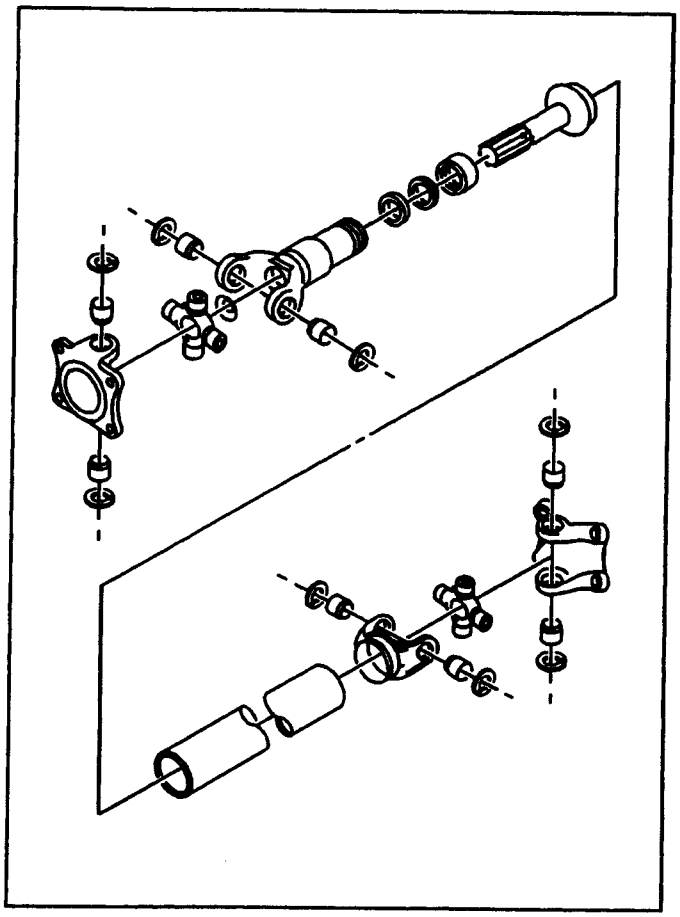
198510

One-Piece Propeller Shaft Replacement (Inboard Flange/229)

Removal Procedure

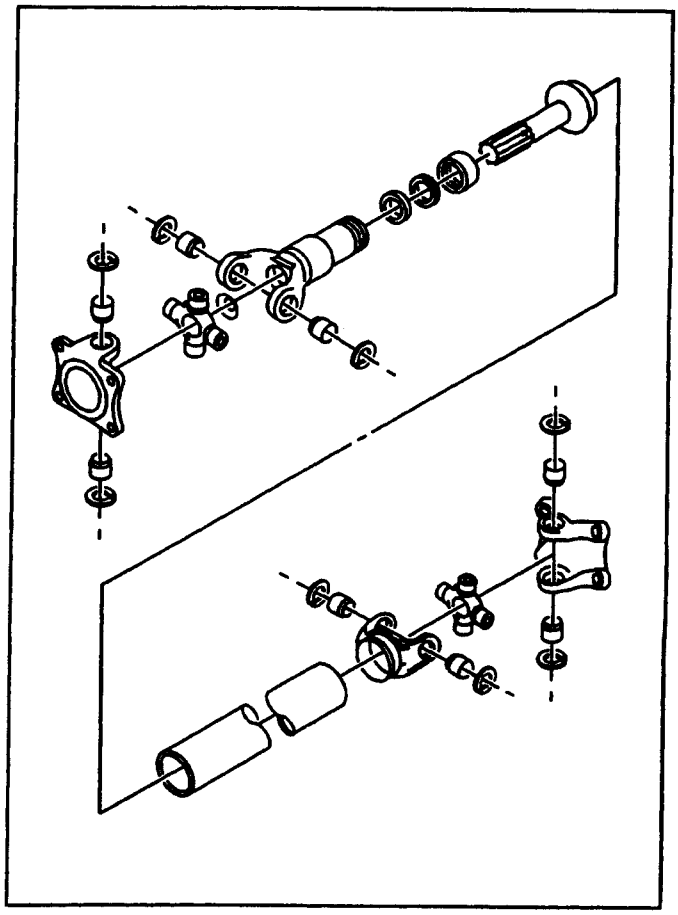
1. Block the wheels.
2. Support the propeller shaft.
3. Mark the universal joints and slip joints with alignment marks.
4. Remove the propeller shaft guards, if equipped.
5. Remove the propeller shaft mounting from the 229 mm (9 in) brake drum.

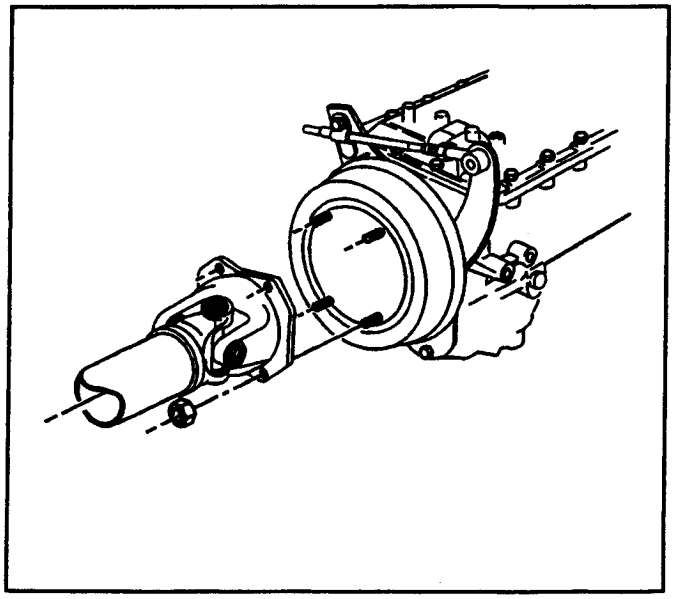
6. Remove the propeller shaft 1480 or 1550 series with inboard slip joint and flange yoke.
7. Remove the universal joints. Refer to *Universal Joints Replacement.*


198617

Installation Procedure

1. Install the universal joints to the propeller shaft. Refer to *Universal Joints Replacement.*
2. Support the propeller shaft sections in the installed position.
3. Install the slip yoke assembly to the installed propeller shaft splined end. Refer to *Propeller Shaft Assembly Component Lubrication.*

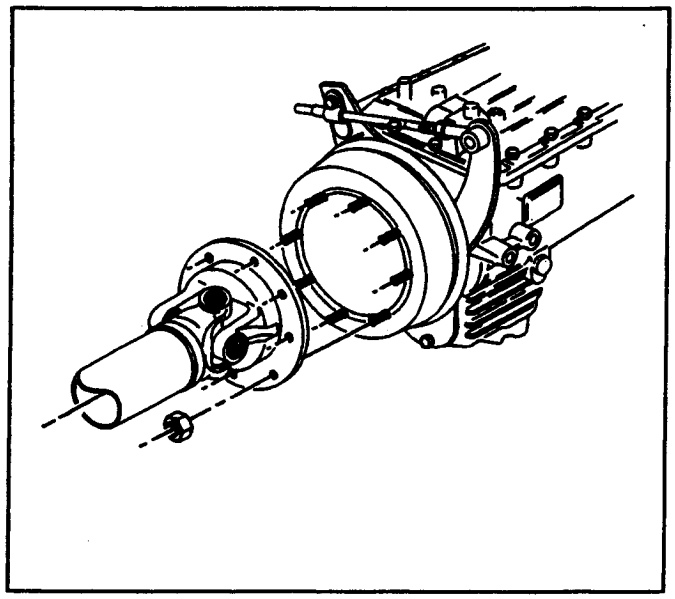

198617



198510

4. Install the front propeller shaft to the 229 mm (9 in) brake drum. Keep the alignment marks together.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
5. Inspect the propeller shaft for alignment and phasing.
6. Install and tighten the propeller shaft inboard slip joint and yoke flange yoke bolts. Refer to *Fastener Tightening Specifications.*
7. Install the propeller shaft guards, if equipped.
8. Lubricate the universal joints and the slip joints. Refer to *Propeller Shaft Assembly Component Lubrication.*



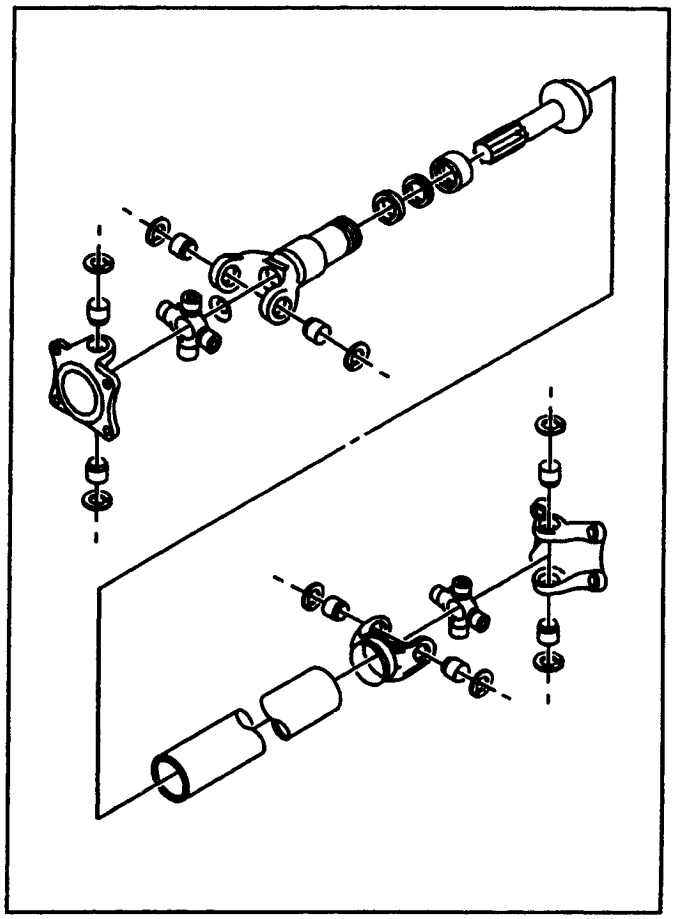
198506

One-Piece Propeller Shaft Replacement (Inboard Flange/305)

Removal Procedure

1. Block the wheels.
2. Support the propeller shaft.
3. Mark the universal joints and slip joints with alignment marks.
4. Remove the propeller shaft guards, if equipped.
5. Remove the propeller shaft mounting from the Yoke Flange (8 nut) mounting.

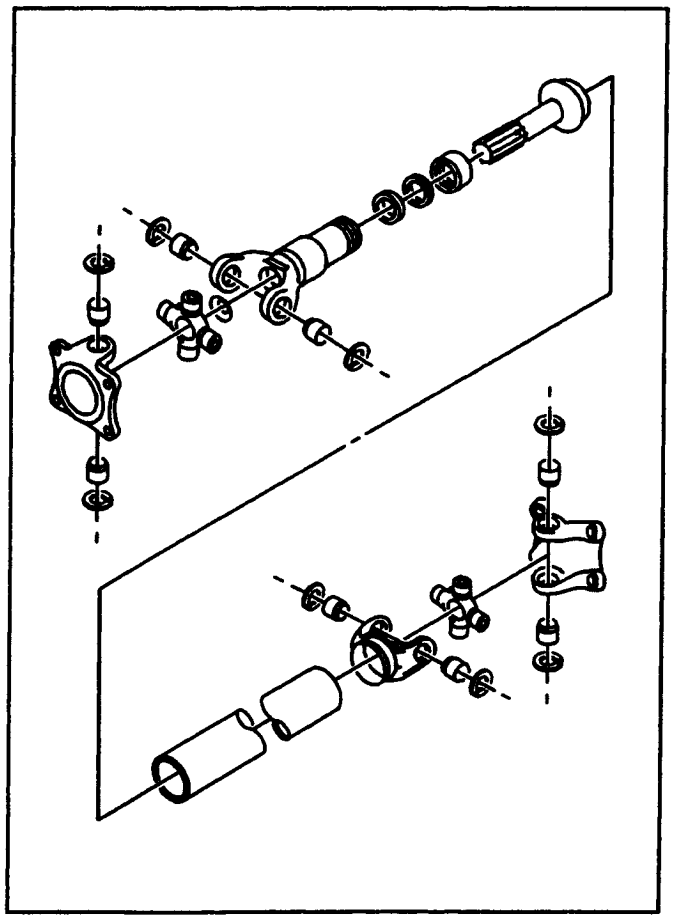
6. Remove the propeller shaft 1480 or 1550 series with inboard slip joint and flange yoke.
7. Remove the universal joints. Refer to *Universal Joints Replacement.*



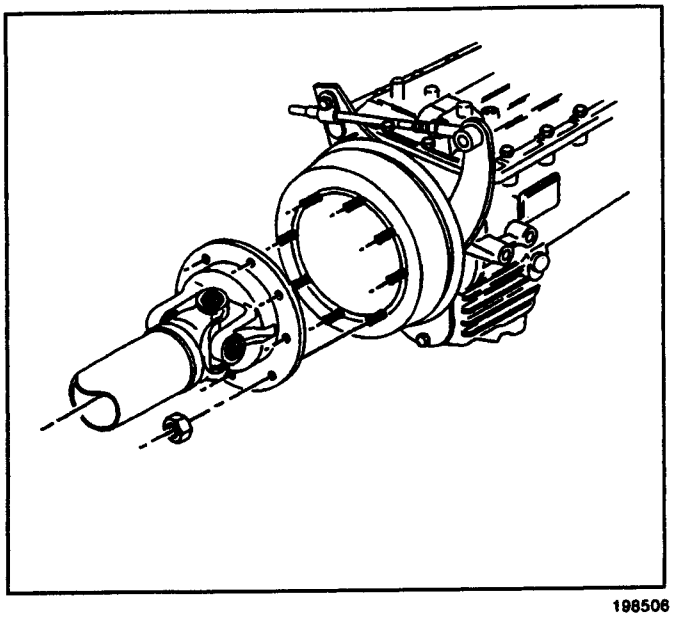
198617

Installation Procedure

1. Install the universal joints to the propeller shaft. Refer to *Universal Joints Replacement.*
2. Support the propeller shaft sections in the installed position.
3. Install the slip yoke to the installed propeller shaft splined end.



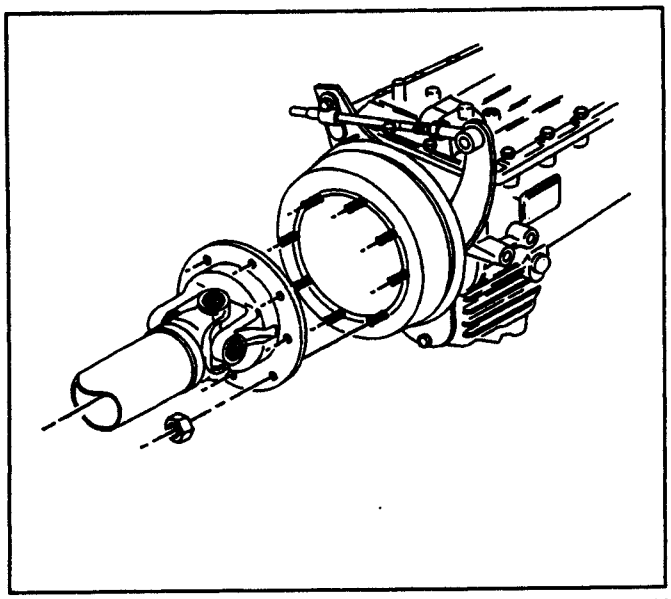
198617



198506

4. Install the front propeller shaft to the Yoke Flange (8 nut) mounting. Keep the alignment marks together.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
5. Inspect the propeller shaft for alignment and phasing.
6. Install and tighten the propeller shaft Inboard Slip Joint Flange yoke bolts. Refer to *Fastener Tightening Specifications.*
7. Install the propeller shaft guards, if equipped.
8. Lubricate the universal joints and the slip joints. Refer to *Propeller Shaft Assembly Component Lubrication.*



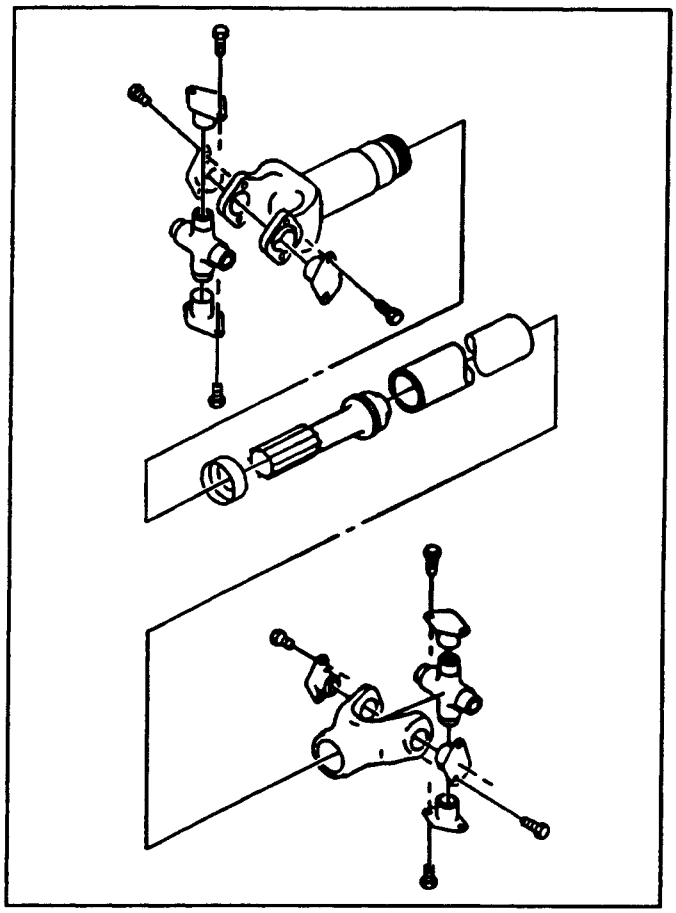
198506

One-Piece Propeller Shaft Replacement (Inboard Full Yoke/305)

Removal Procedure

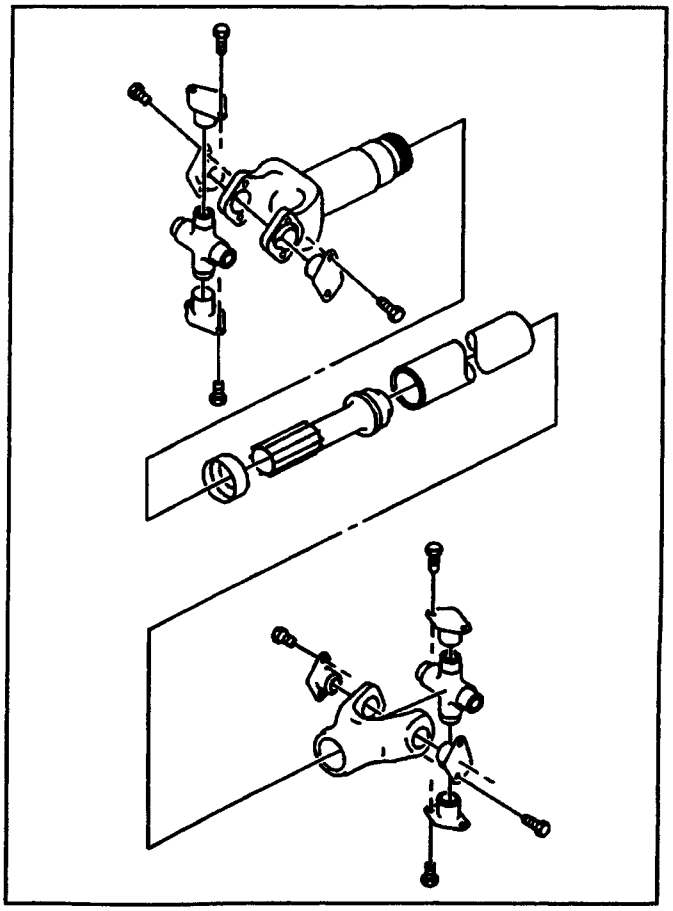
1. Block the wheels.
2. Support the propeller shaft.
3. Mark the universal joints and slip joints with alignment marks.
4. Remove the propeller shaft guards, if equipped.
5. Remove the propeller shaft from the Yoke Flange (8 nut) mounting.

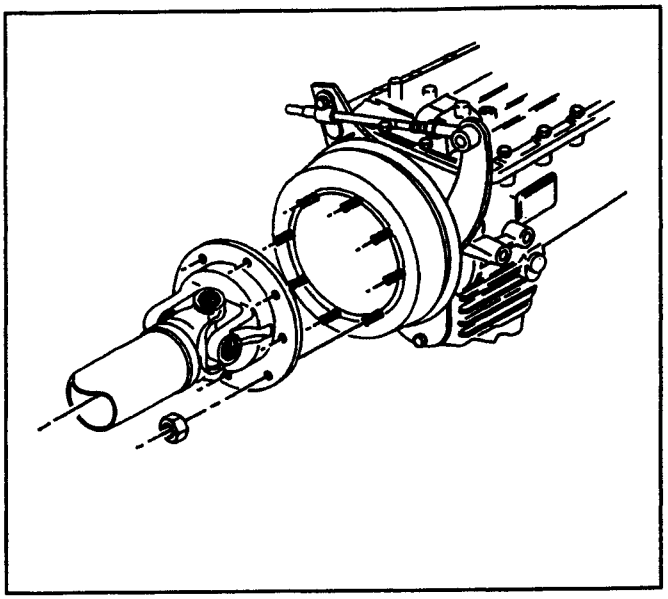
6. Remove the propeller shaft 16N, 17N, 18N, 1710 or 1760 series with inboard slip joint and full round end yoke.
7. Remove the universal joints. Refer to *Universal Joints Replacement.*


198610

Installation Procedure

1. Install the universal joints to the propeller shaft. Refer to *Universal Joints Replacement.*
2. Support the propeller shaft sections in the installed position.
3. Install the slip yoke to the installed propeller shaft splined end.

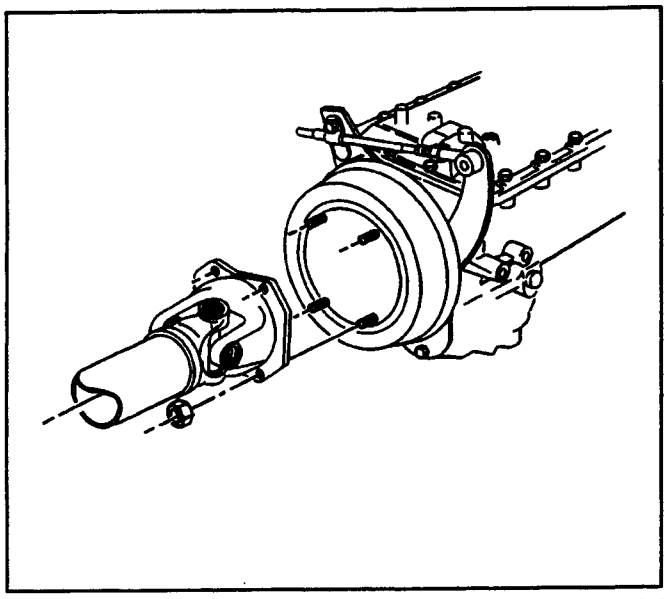

198610



198506

4. Install the front propeller shaft to the Yoke Flange (8 nut) mounting. Keep the alignment marks together.
5. Install and tighten the propeller shaft inboard slip joint flange full round end yoke bolts. Refer to *Fastener Tightening Specifications.*

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
6. Inspect the propeller shaft for alignment and phasing.
7. Install the propeller shaft guards, if equipped.
8. Lubricate the universal joints and the slip joints. Refer to *Propeller Shaft Assembly Component Lubrication.*

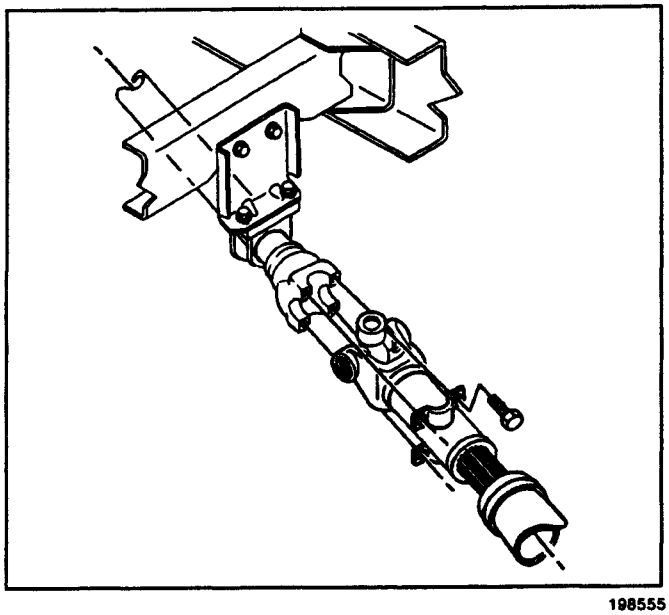


198510

Two-Piece Propeller Shaft Replacement (Inboard Slip Joint and Flange)

Removal Procedure

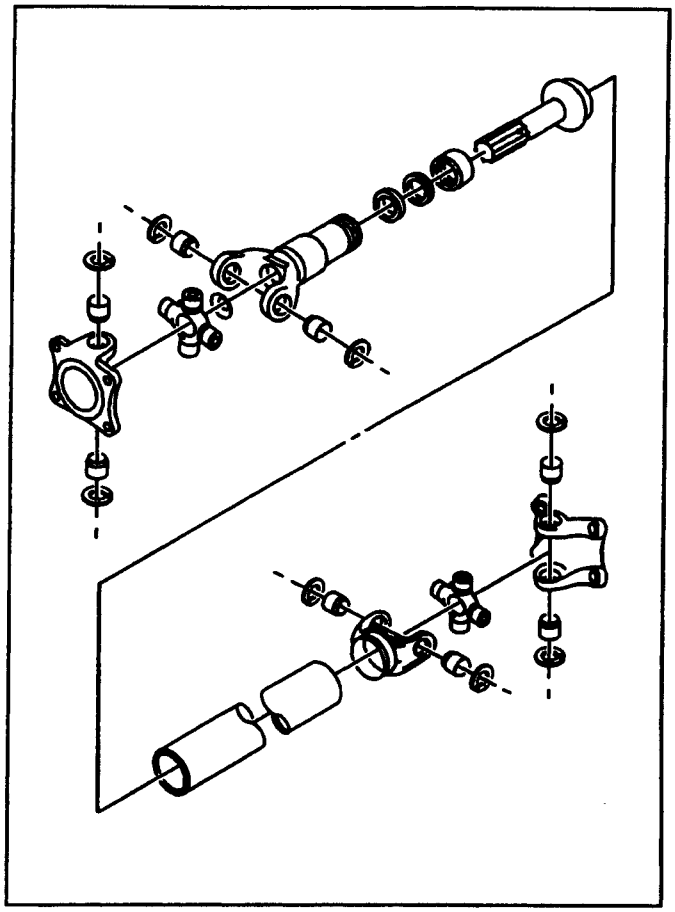
1. Block the wheels.
2. Support the propeller shaft.
3. Mark the universal joints and slip joints with alignment marks.
4. Remove the propeller shaft guards, if equipped.
5. Remove the propeller shaft from the Yoke Flange (4 nut) mounting.
6. Remove the center bearing assembly, if equipped, from the cross member. Refer to *Center Bearing Replacement.*



198555

7. Remove the two piece propeller shaft mounting.
8. Remove the universal joint. Refer to *Universal Joints Replacement.*

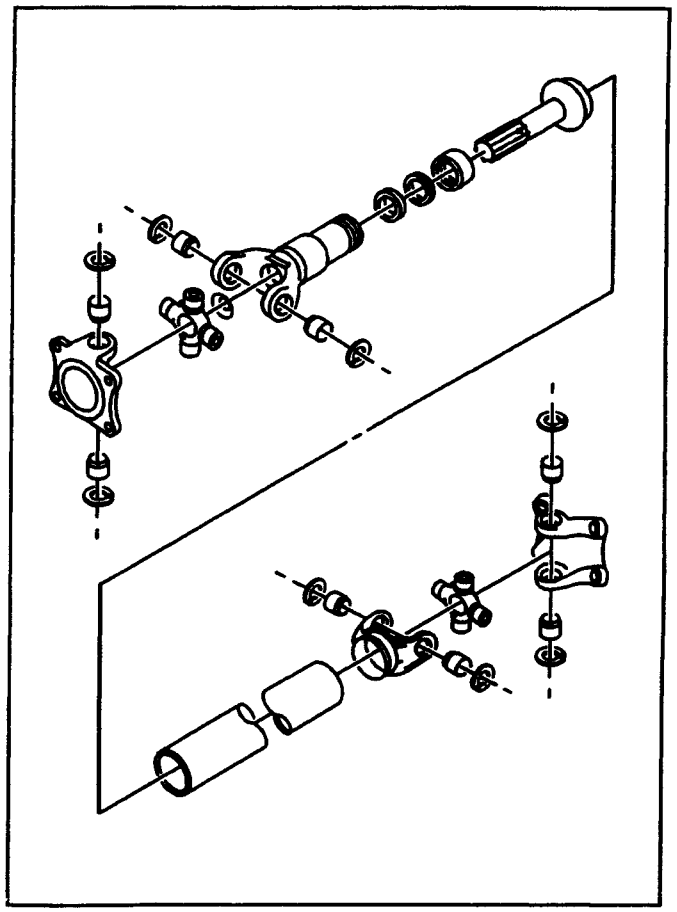
9. Remove the propeller shaft 1480 or 1550 series with inboard slip joint and flange yoke.



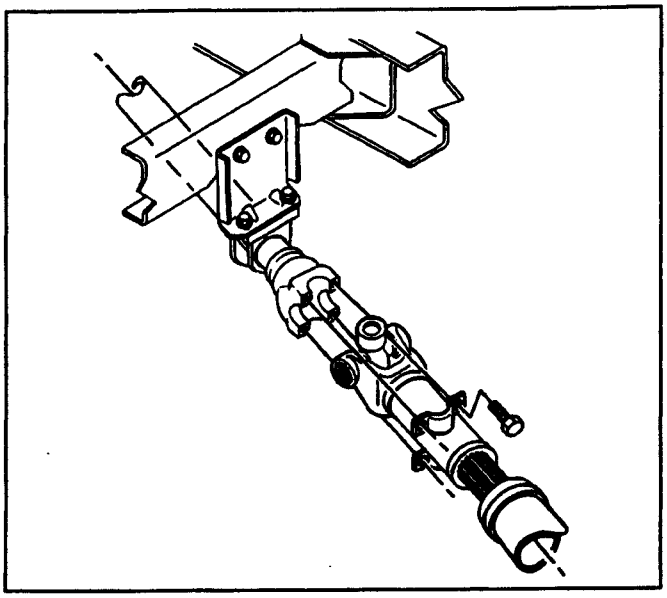
198617

Installation Procedure

1. Install the universal joints to the propeller shaft. Refer to *Universal Joints Replacement.*
2. Support the propeller shaft sections in the installed position.
3. Install the slip yoke and the center bearing assembly to the installed propeller shaft splined end. Refer to *Center Bearing Replacement.*



198617



198555

4. Install the front propeller shaft to the Yoke Flange (4 nut) mounting. Keep the alignment marks together.

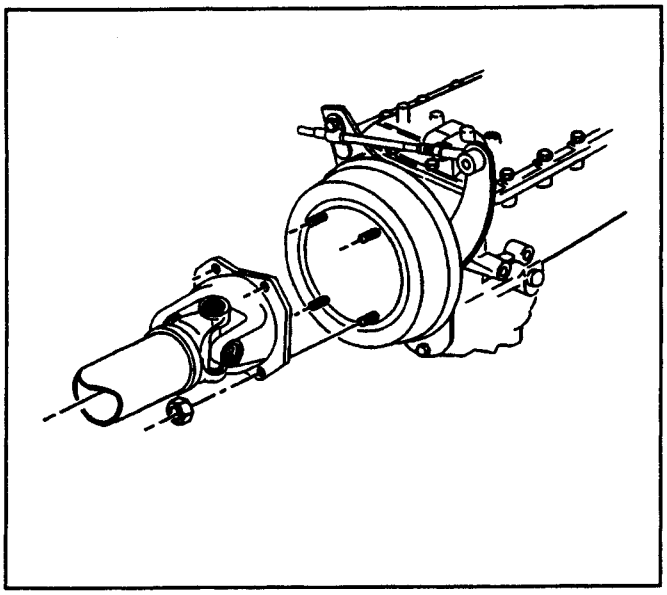
   Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Install and tighten the propeller shaft inboard slip joint and flange yoke bolts. Refer to *Fastener Tightening Specifications.*

   Tighten

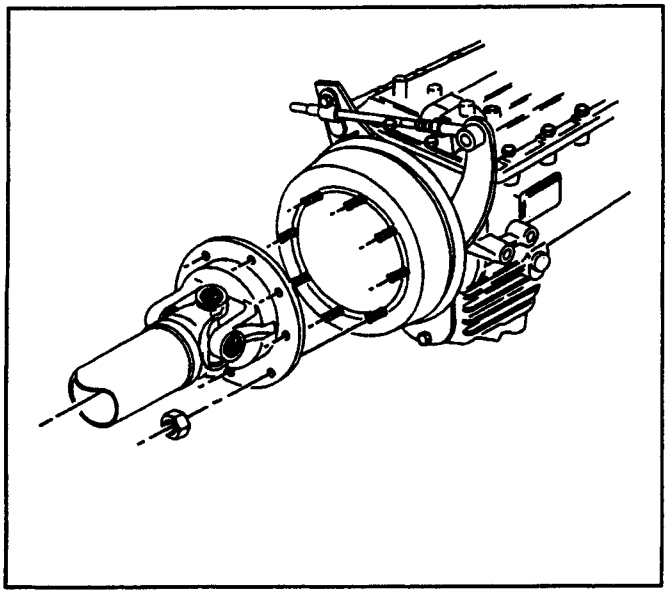
   Tighten the center bearing mounting bolts to 71 N.m (52 lb ft).

6. Install the rear propeller shaft to the center bearing assembly.



198510

7. Install the center bearing assembly to the cross frame. Refer to *Center Bearing Replacement.*
8. Install the propeller shaft guards, if equipped.
9. Lubricate the universal joints and the slip joints. Refer to *Propeller Shaft Assembly Component Lubrication.*



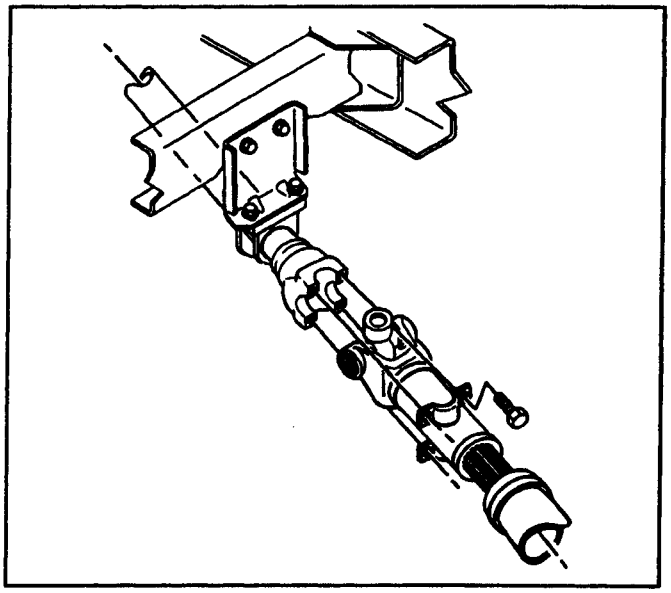
198506

Two-Piece Propeller Shaft Replacement (Inboard Slip Joint and Full)

Removal Procedure

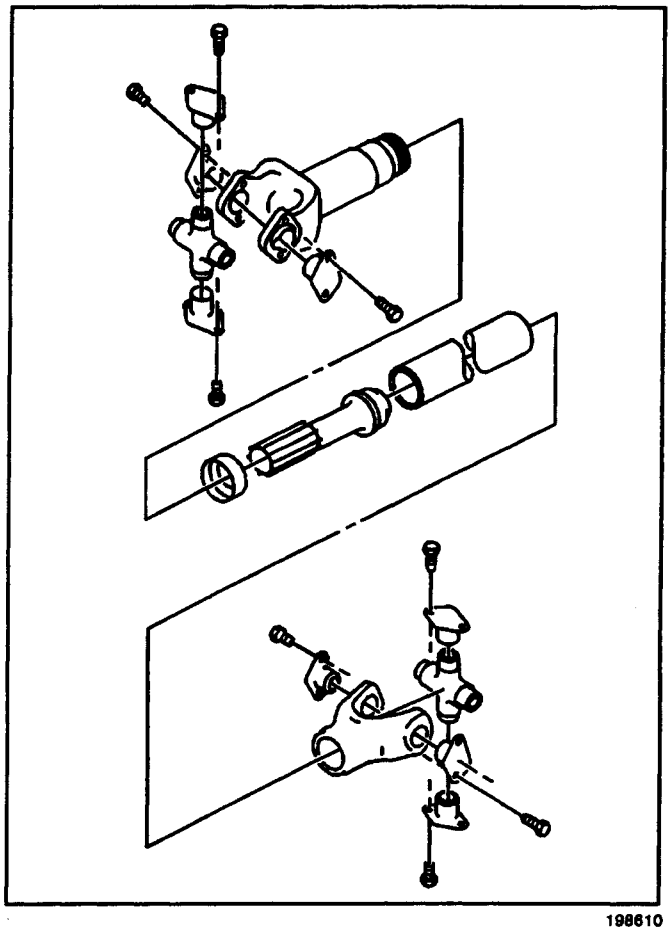
1. Block the wheels.
2. Support the propeller shaft.
3. Mark the universal joints and slip joints with alignment marks.
4. Remove the propeller shaft guards, if equipped.
5. Remove the propeller shaft from the Yoke Flange (8 nut) mounting.
6. Remove the center bearing assembly from the cross member. Refer to *Center Bearing Replacement.*

7. Remove the two piece propeller shaft mounting.

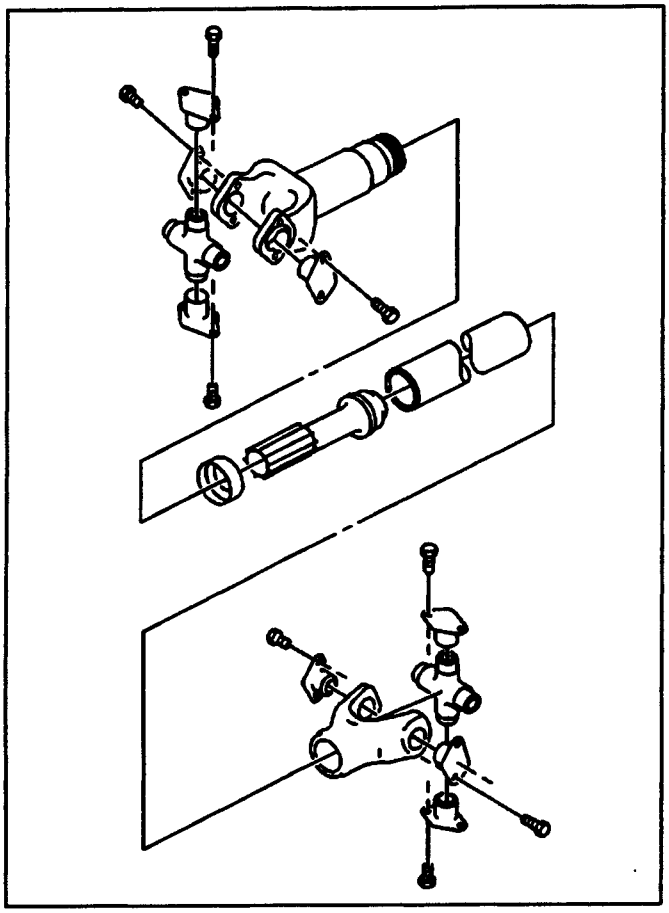


198555

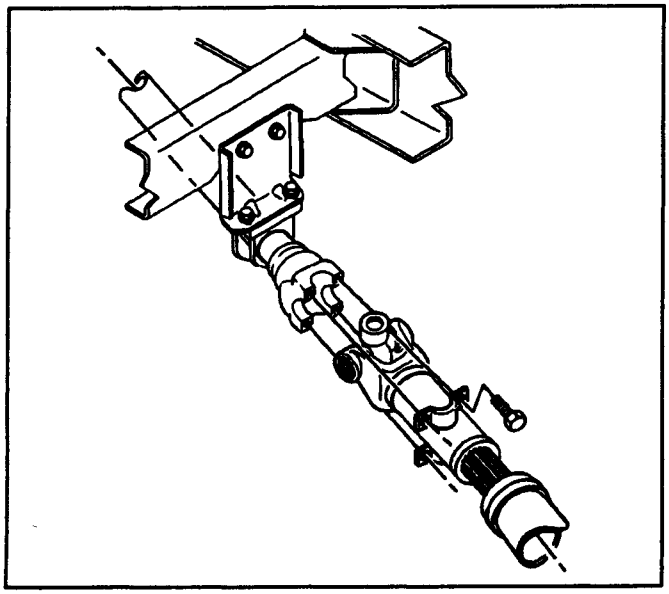
8. Remove the universal joints. Refer to *Universal Joints Replacement.*
9. Remove the propeller shaft 16N, 17N, 18N, 1710 or 1760 series with inboard slip joint and flange yoke.



198610



198610



198555

Installation Procedure

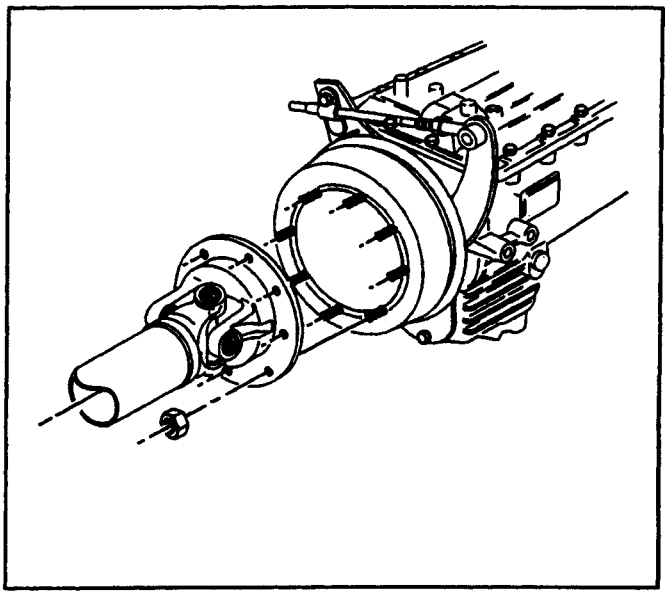
1. Install the universal joints to the propeller shaft. Refer to *Universal Joints Replacement.*
2. Support the propeller shaft sections in the installed position.
3. Install the slip yoke and the center bearing assembly to the installed propeller shaft splined end. Refer to *Propeller Shaft Assembly Component Lubrication.*
4. Install the front propeller shaft to the Yoke Flange (8 nut) mounting. Keep the alignment marks together.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
5. Install and tighten the propeller shaft inboard slip joint and full round end yoke bolts. Refer to *Fastener Tightening Specifications.*

   Tighten

   Tighten the center bearing mounting bolts to 71 N·m (52 lb ft).

6. Install the rear propeller shaft to the center bearing assembly.
7. Install the center bearing assembly to the cross frame. Refer to *Center Bearing Replacement.*
8. Install the propeller shaft guards, if equipped.
9. Lubricate the universal joints and the slip joints. Refer to *Propeller Shaft Assembly Component Lubrication.*

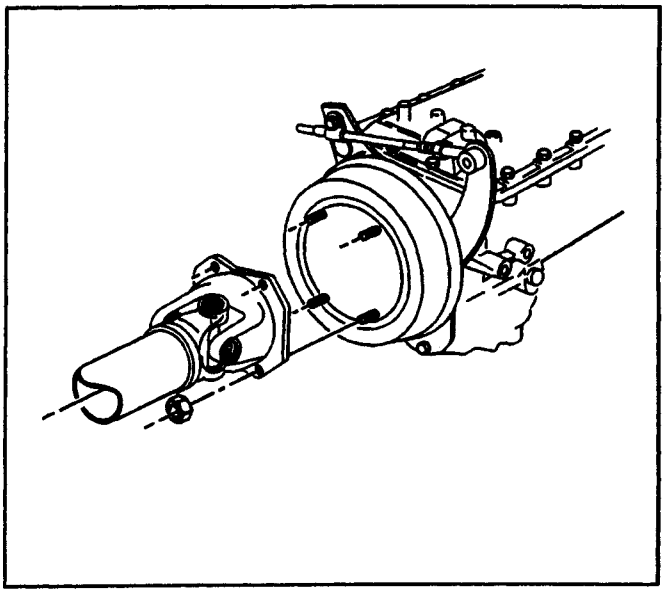


198506

Two-Piece Propeller Shaft Replacement (Outboard Slip Joint and Half)

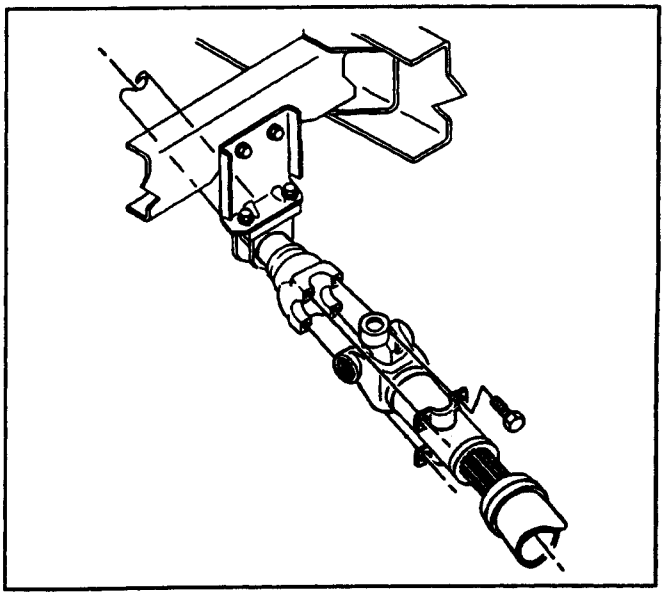
Removal Procedure

1. Block the wheels.
2. Support the propeller shaft.
3. Mark the universal joints and slip joints with alignment marks.
4. Remove the propeller shaft guards, if equipped.
5. Remove the propeller shaft from the Yoke Flange (4 nut) mounting.
6. Remove the center bearing assembly from the cross member. Refer to *Center Bearing Replacement.*

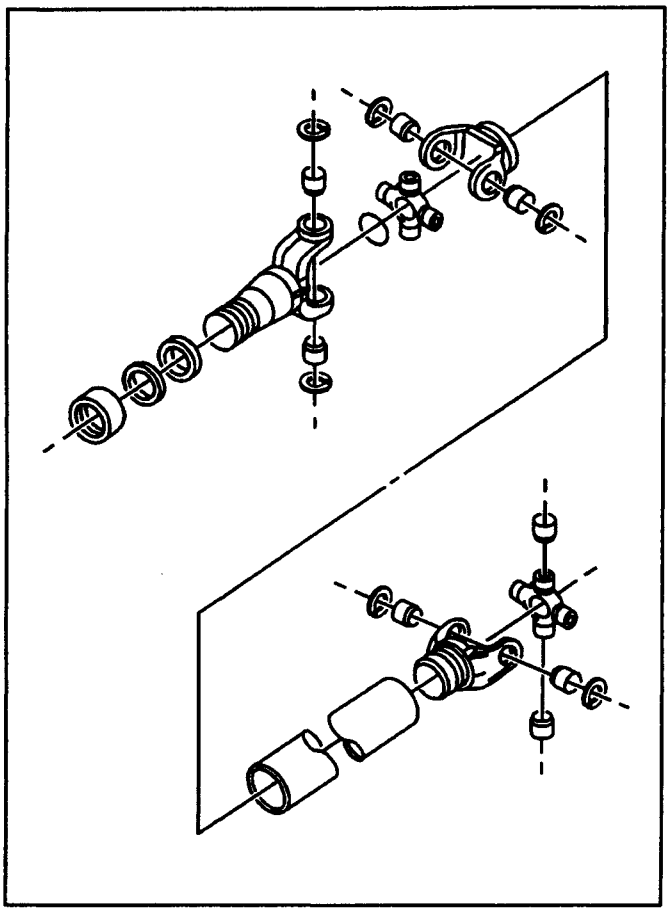


198510

7. Remove the two piece propeller shaft mounting.

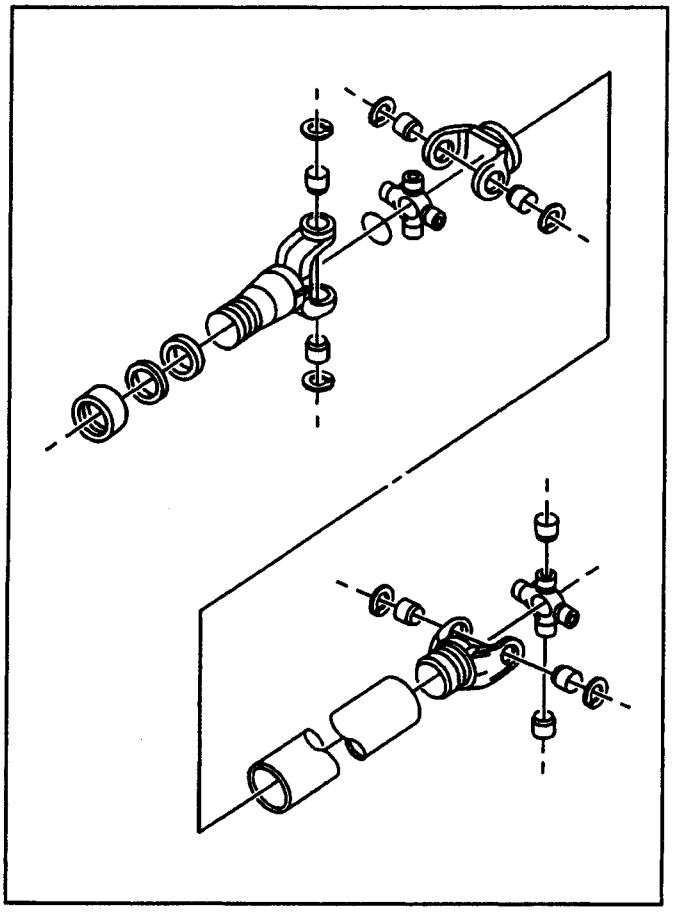


198555



198622

8. Remove the universal joints. Refer to *Universal Joints Replacement.*
9. Remove the propeller shaft 1480 or 1550 series with outboard slip joint and half round end yoke.



198622

Installation Procedure

1. Install the universal joints to the propeller shaft. Refer to *Universal Joints Replacement.*
2. Support the propeller shaft sections in the installed position.
3. Install the slip yoke and the center bearing assembly to the installed propeller shaft splined end. Refer to *Propeller Shaft Assembly Component Lubrication.*

4. Install the front propeller shaft to the Yoke Flange (4 nut) mounting. Keep the alignment marks together.

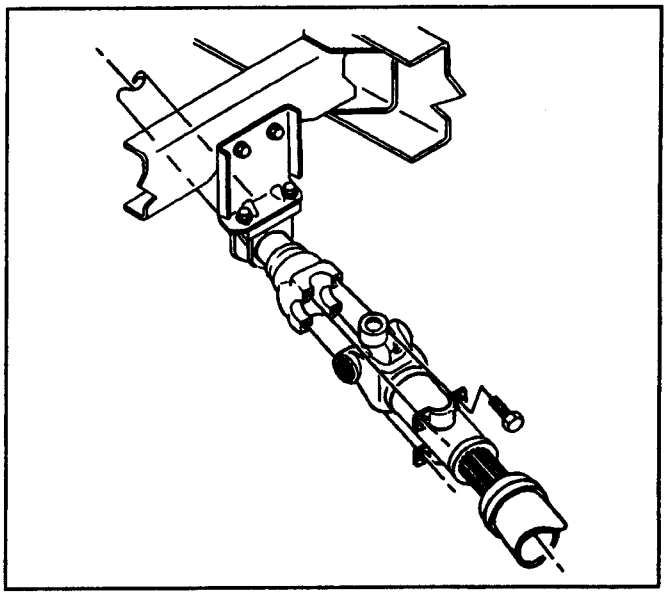
   Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Install and tighten the propeller shaft outboard slip joint and half round end yoke bolts. Refer to *Fastener Tightening Specifications.*

   Tighten

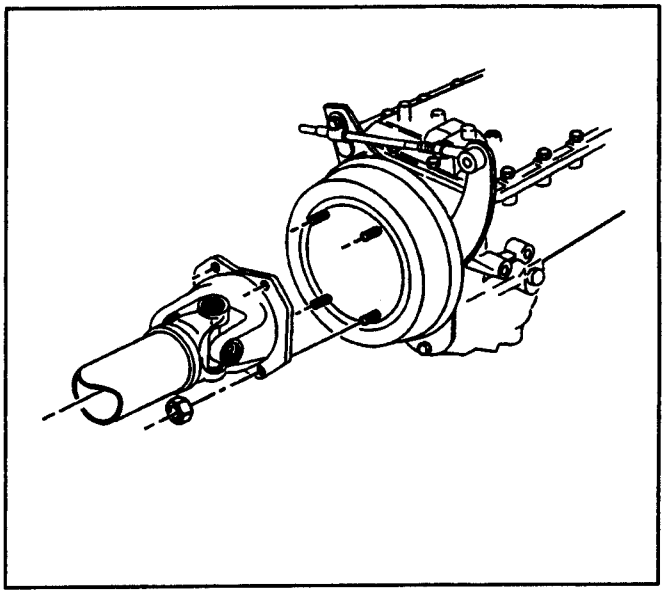
   Tighten the center bearing mounting bolts to 71 N.m (52 lb ft).

6. Install the rear propeller shaft to the center bearing assembly.



198555

7. Install the center bearing assembly to the cross frame. Refer to *Center Bearing Replacement.*
8. Install the propeller shaft guards, if equipped.
9. Lubricate the universal joints and the slip joints. Refer to *Propeller Shaft Assembly Component Lubrication.*

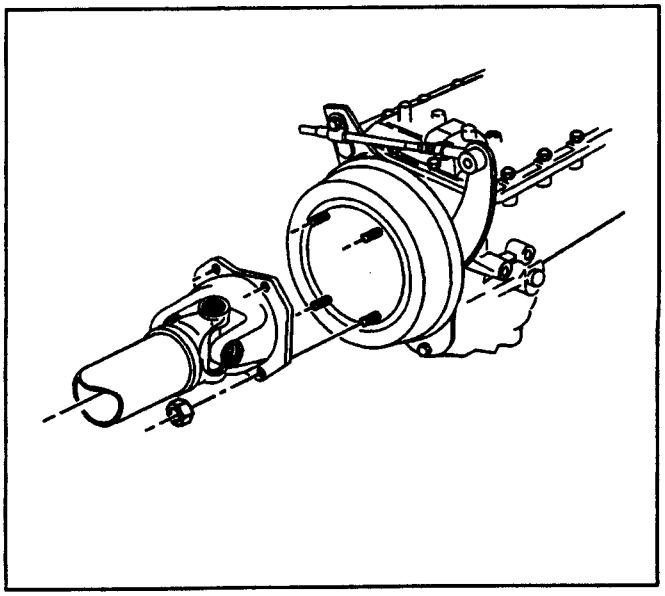


198510

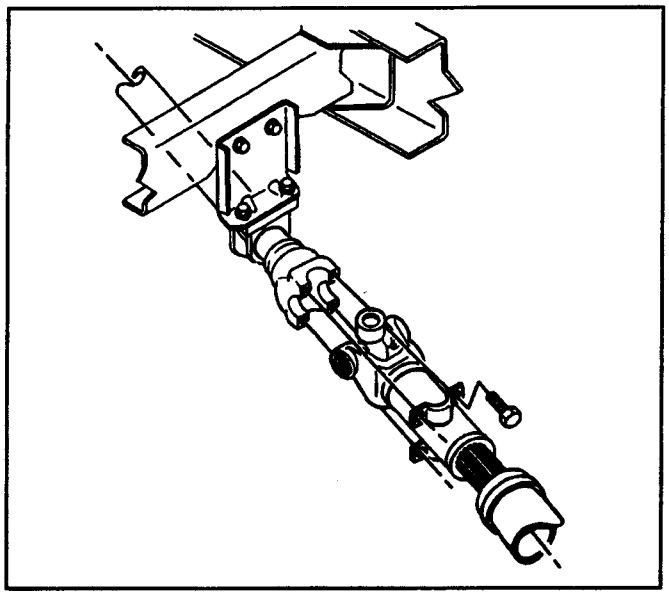
Two-Piece Propeller Shaft Replacement (Center Bearing, Half Yoke)

Removal Procedure

1. Block the wheels.
2. Support the propeller shaft.
3. Mark the universal joints and slip joints with alignment marks.
4. Remove the propeller shaft guards, if equipped.
5. Remove the propeller shaft from the Yoke Flange (4 nut) mounting.
6. Remove the center bearing assembly from the cross member. Refer to *Center Bearing Replacement.*

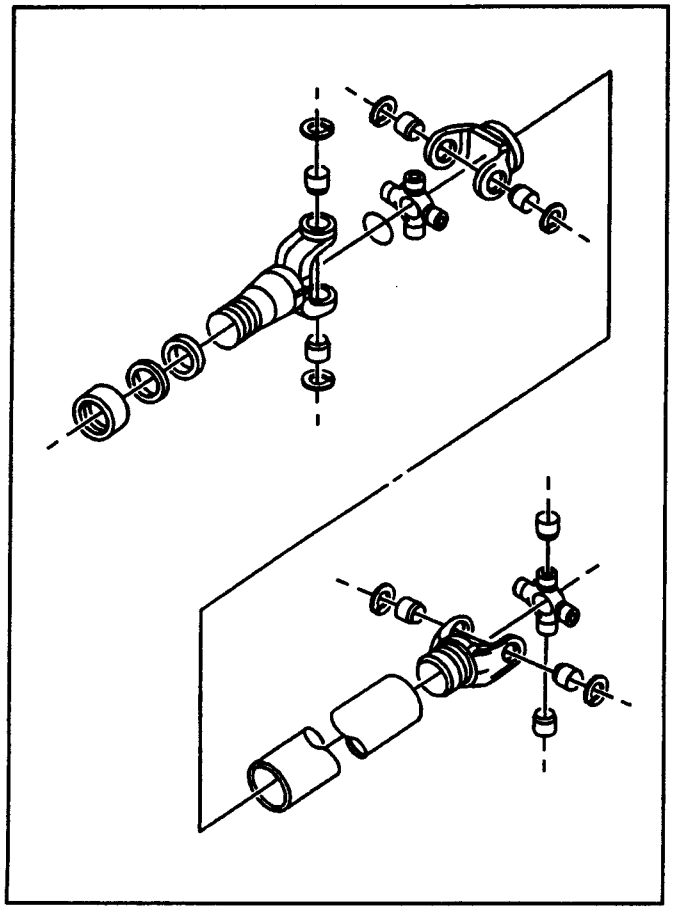


198510



198555

7. Remove the two piece propeller shaft mounting.
8. Remove the universal joints. Refer to *Universal Joints Replacement.*

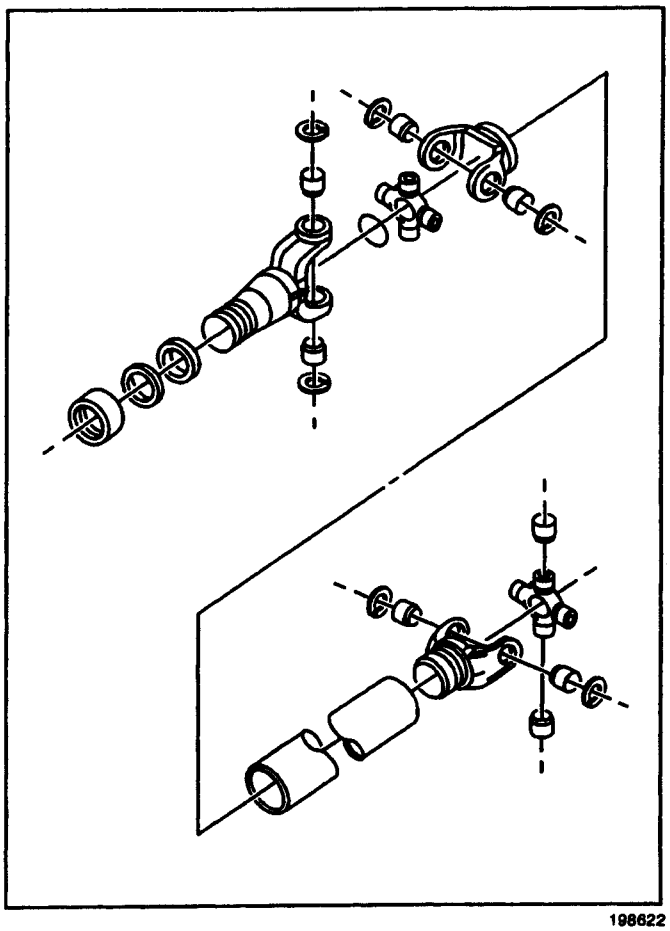


198622

9. Remove the propeller shaft 1480 or 1550 series with outboard slip joint and half round end yoke.

Installation Procedure

1. Support the propeller shaft sections in the installed position.
2. Install the slip yoke and the center bearing assembly to the installed propeller shaft splined end.
3. Install the front propeller shaft to the Yoke Flange (4 nut) mounting. Keep the alignment marks together.



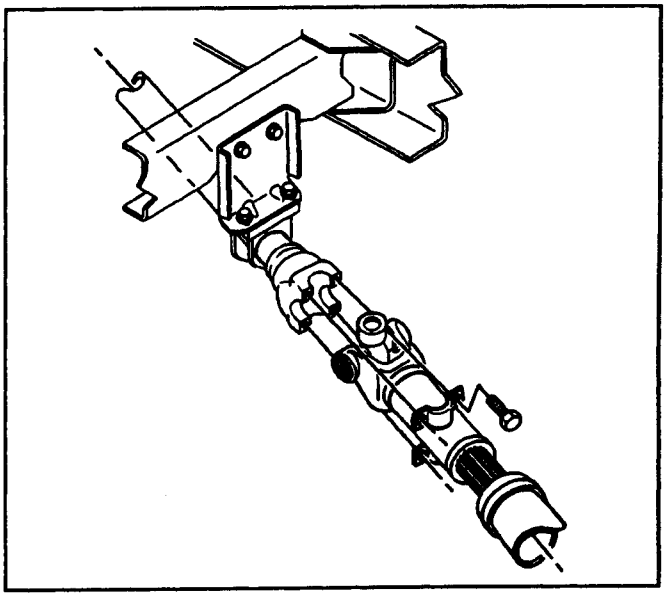
198622

Notice: Refer to *Fastener Notice* in Cautions and Notices.

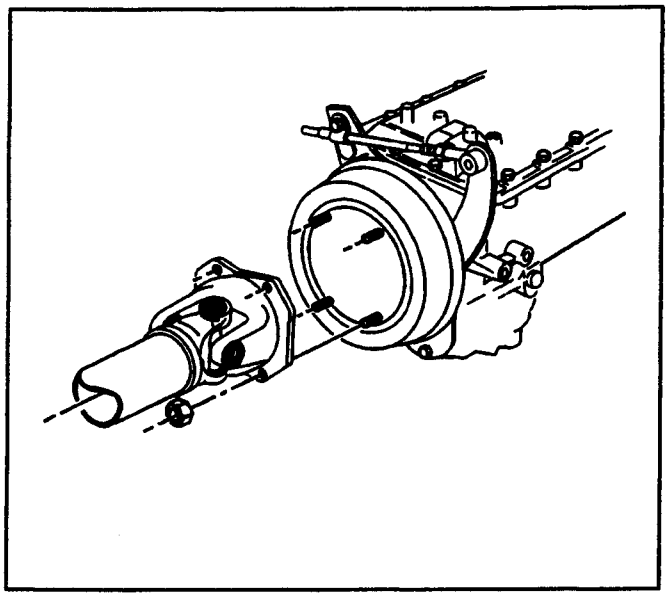
4. Install and tighten the propeller shaft half round end yoke bolts. Refer to *Fastener Tightening Specifications.*

   Tighten

   Tighten the center bearing mounting bolts to 71 N·m (52 lb ft).
5. Install the rear propeller shaft to the center bearing assembly.

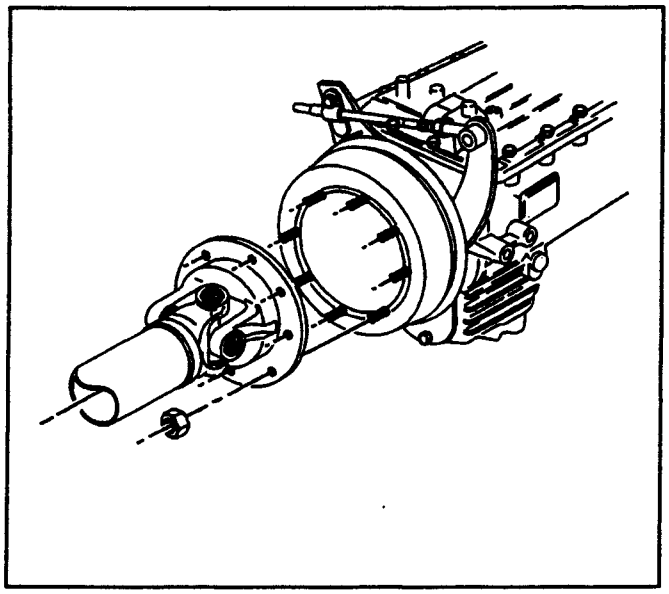


198555



198510

6. Install the center bearing assembly to the cross frame. Refer to *Center Bearing Replacement.*
7. Install the propeller shaft guards, if equipped.
8. Lubricate the universal joints and the slip joints. Refer to *Propeller Shaft Assembly Component Lubrication.*

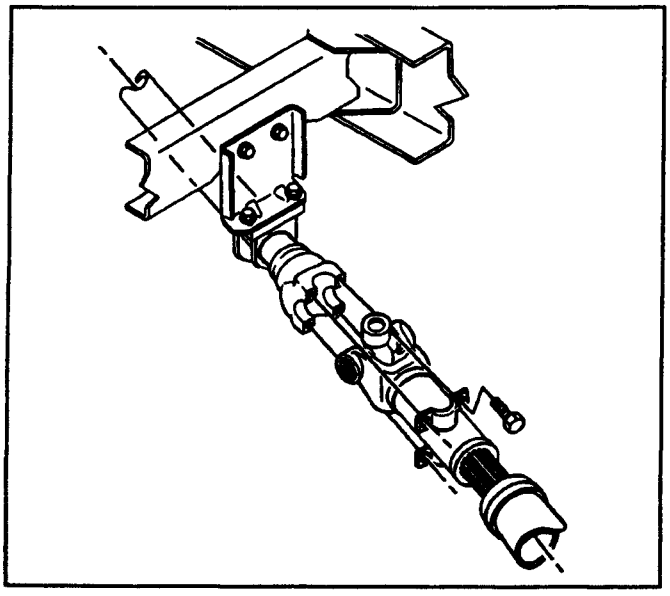


198506

Two-Piece Propeller Shaft Replacement (Center Bearing, Full Yoke)

Removal Procedure

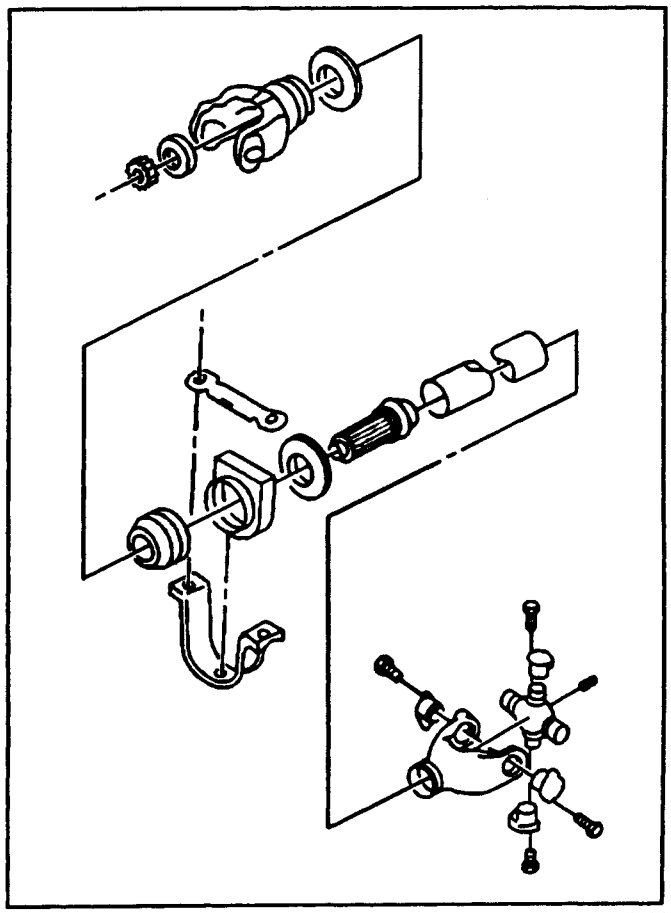
1. Block the wheels.
2. Support the propeller shaft.
3. Mark the universal joints and slip joints with alignment marks.
4. Remove the propeller shaft guards, if equipped.
5. Remove the propeller shaft from the Yoke Flange (8 nut) mounting.
6. Remove the center bearing assembly from the cross member. Refer to *Center Bearing Replacement.*



198555

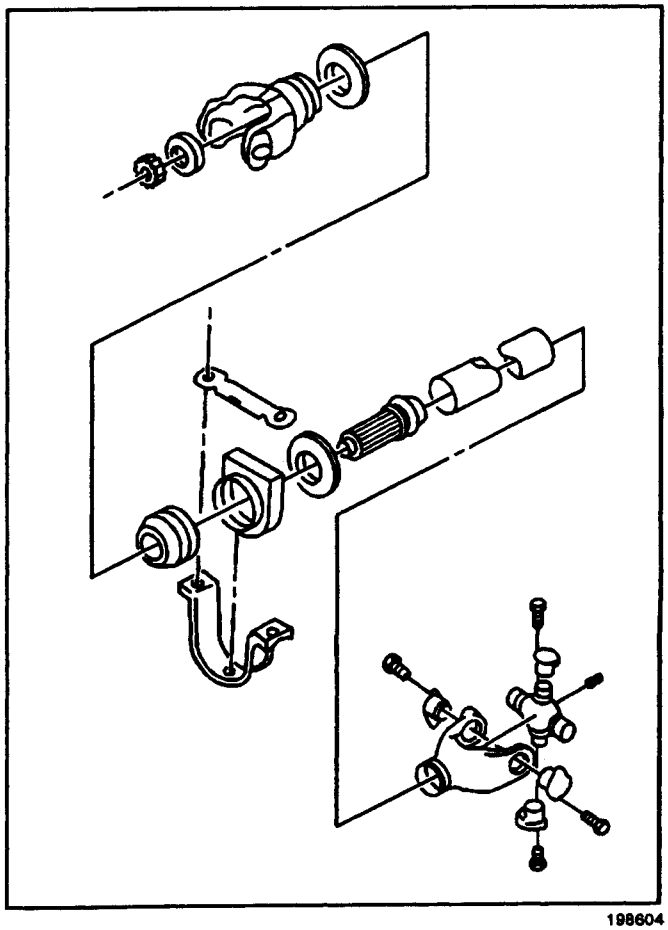
7. Remove the two-piece propeller shaft mounting.

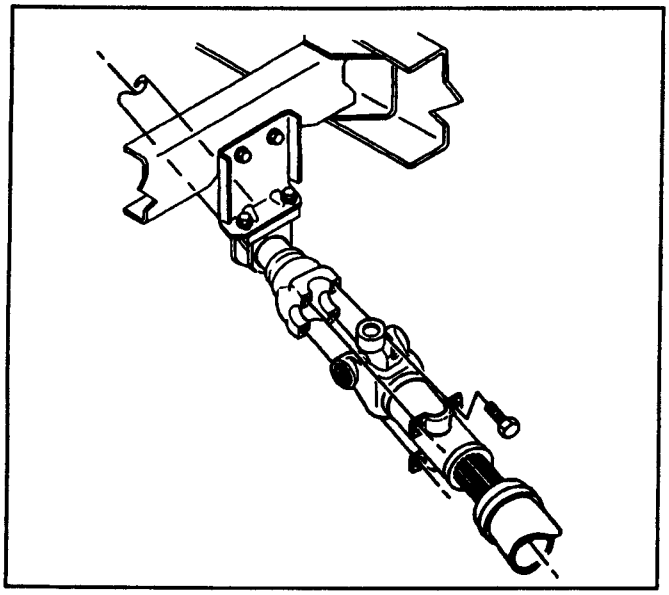
8. Remove the universal joint. Refer to *Universal Joints Replacement.*
9. Remove the propeller shaft 16N, 17N, 18N, 1710, or 1760 series with center bearing and full round or end yoke.


198604

Installation Procedure

1. Install the universal joints to the propeller shaft. Refer to *Universal Joints Replacement.*
2. Support the propeller shaft sections in the installed position.
3. Install the slip yoke and the center bearing assembly to the installed propeller shaft splined end.


198604

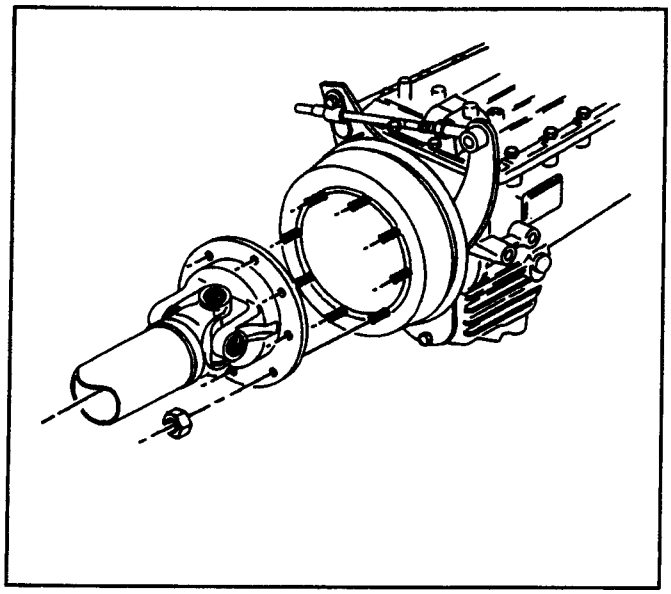


198555

4. Install the front propeller shaft to the Yoke Flange (8 nut) mounting. Keep the alignment marks together.
5. Install and tighten the propeller shaft full round end yoke bolts. Refer to *Fastener Tightening Specifications.*

   Tighten

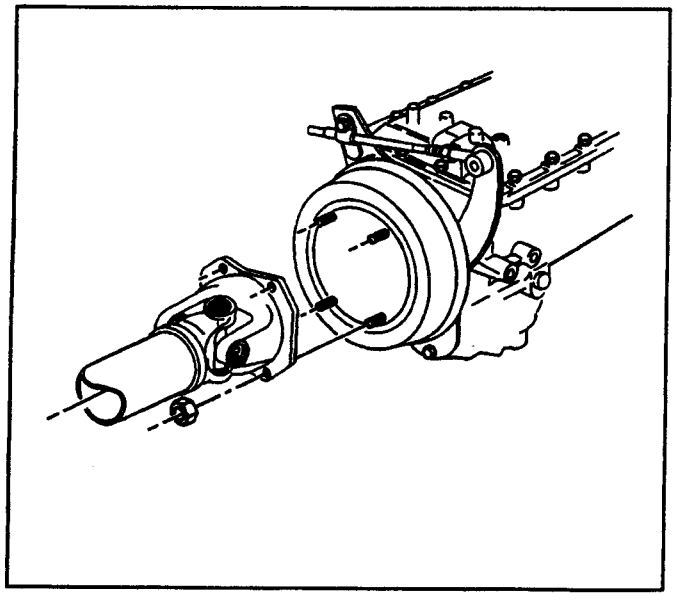
   Tighten the center bearing mounting bolts to 71 N·m (52 lb ft).
6. Install the rear propeller shaft to the center bearing assembly.



198506

7. Install the center bearing assembly to the cross frame. Refer to *Center Bearing Replacement.*

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
8. Inspect the propeller shaft for alignment and phasing.
9. Install the propeller shaft guards, if equipped.
10. Lubricate the universal joints and the slip joints. Refer to *Propeller Shaft Assembly Component Lubrication.*



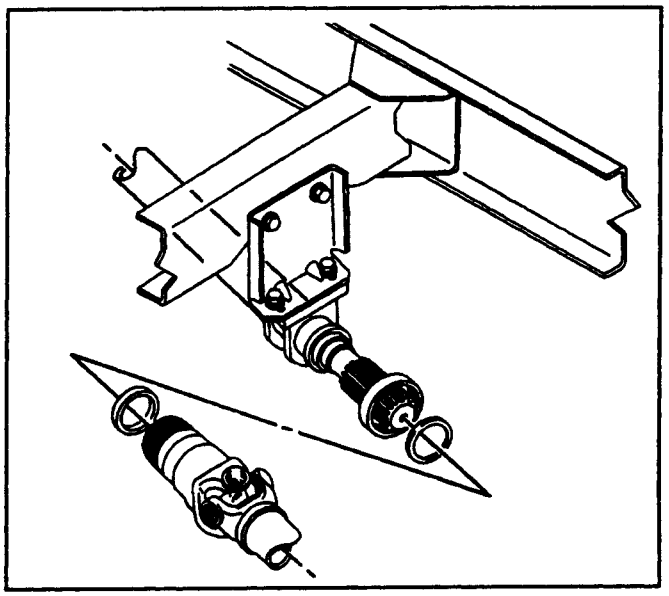
198510

Three-Piece Propeller Shaft Replacement (Center Bearing, Full Yoke)

Removal Procedure

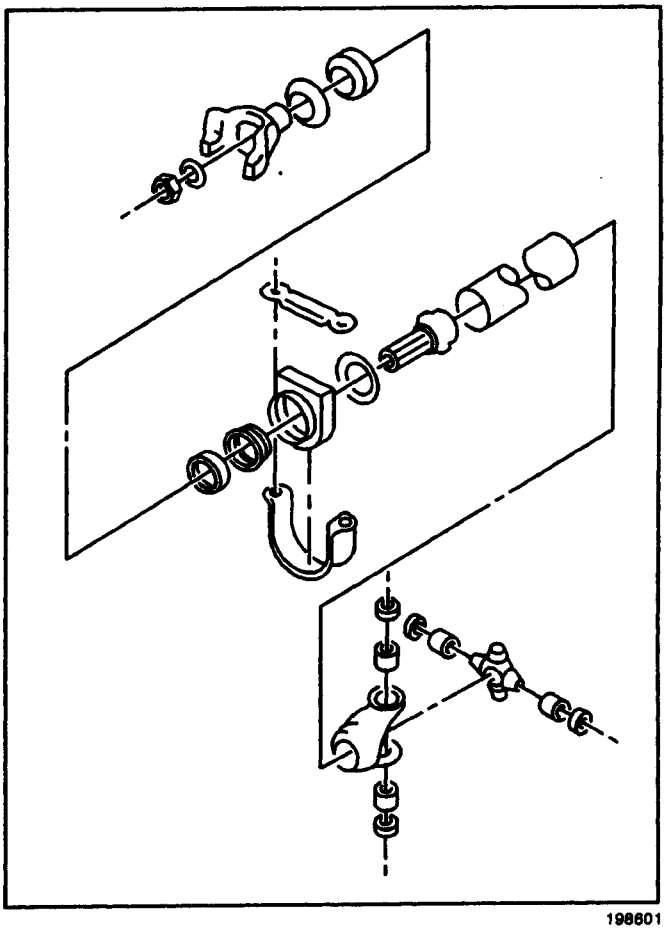
1. Block the wheels.
2. Support the propeller shaft.
3. Mark the universal joints and slip joints with alignment marks.
4. Remove the propeller shaft guards, if equipped.
5. Remove the propeller shaft from the Yoke Flange (4 nut) mounting.
6. Remove the center bearing assembly from the cross member. Refer to *Center Bearing Replacement.*

7. Remove the three-piece propeller shaft with tandem axle mounting.
8. Remove the universal joints. Refer to *Universal Joints Replacement.*

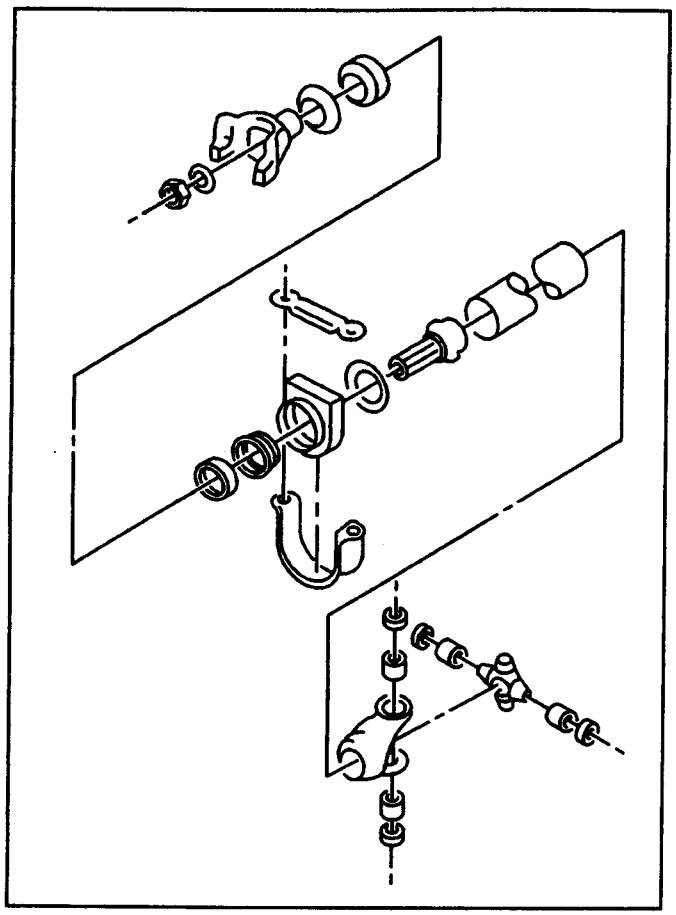


198535

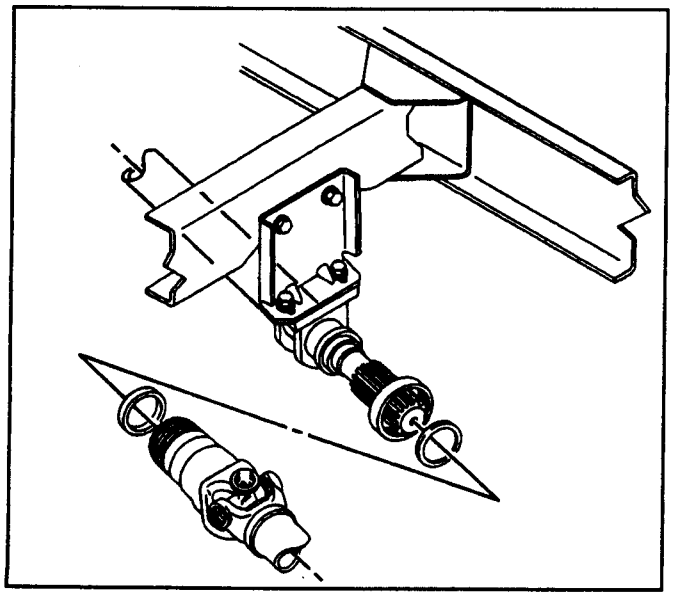
9. Remove the propeller shaft 1480 or 1550 series with center bearing and full round or end yoke.



198601



198601



198535

Installation Procedure

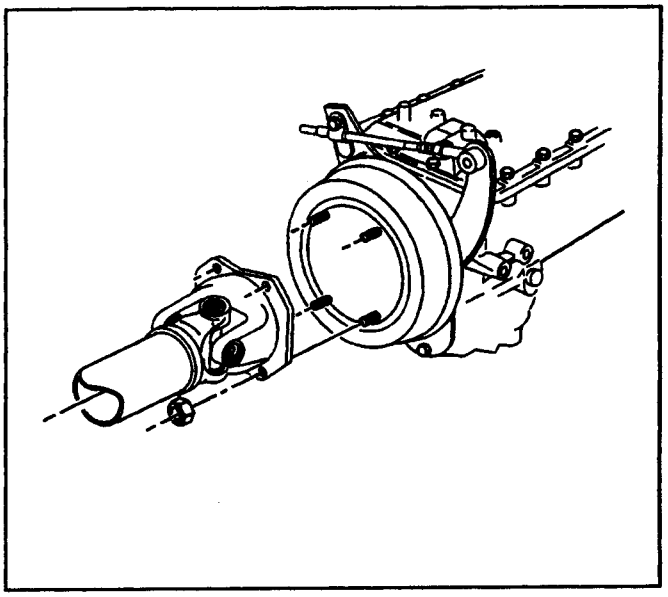
1. Install the universal joints to the propelled shaft. Refer to *Universal Joints Replacement.*
2. Support the propeller shaft sections in the installed position.
3. Install the slip yoke and the center bearing assembly to the installed propeller shaft splined end.
4. Install the front propeller shaft to the Yoke Flange (4 nut) mounting. Keep the alignment marks together.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
5. Install and tighten the propeller shaft half round end yoke bolts. Refer to *Fastener Tightening Specifications.*

   Tighten

   Tighten the center bearing mounting bolts to 71 N·m (52 lb ft).

6. Install the rear propeller shaft to the center bearing universal joint, if equipped.
7. Install the center bearing assembly to the cross frame. Refer to *Center Bearing Replacement.*
8. Install the propeller shaft guards, if equipped.
9. Lubricate the universal joints and the slip joints. Refer to *Propeller Shaft Assembly Component Lubrication.*

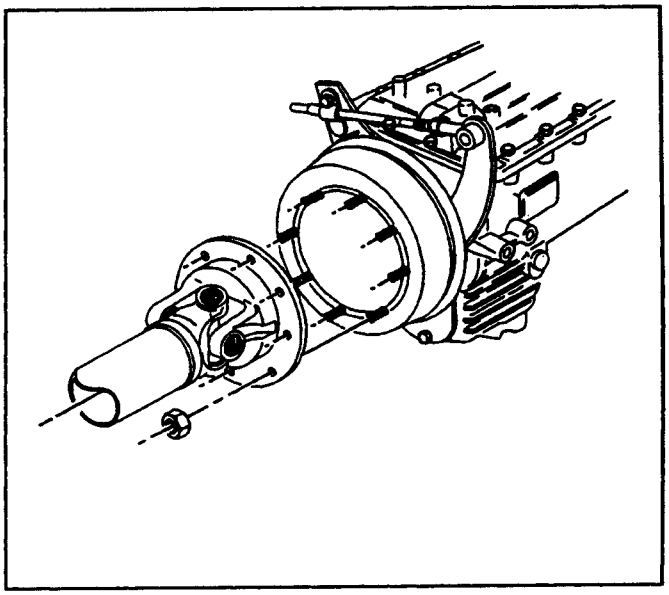


198510

Three-Piece Propeller Shaft Replacement (Inboard Slip Joint, Full Yoke)

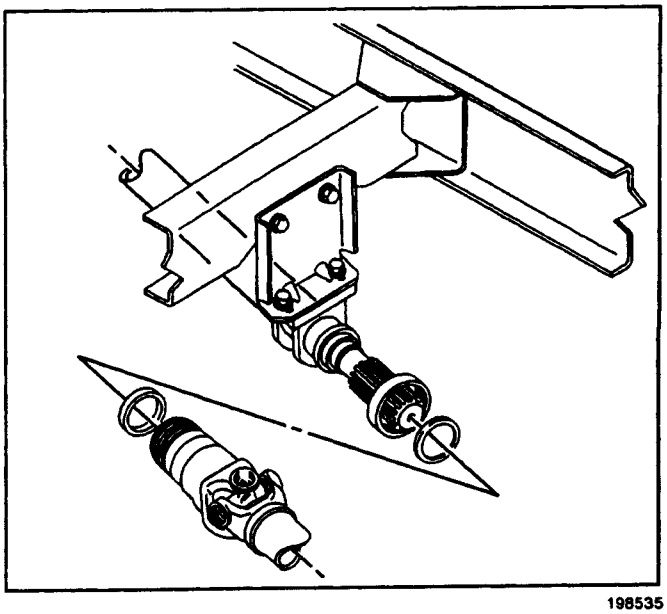
Removal Procedure

1. Block the wheels.
2. Support the propeller shaft.
3. Mark the universal joints and slip joints with alignment marks.
4. Remove the propeller shaft guards, if equipped.
5. Remove the propeller shaft bolts from the Yoke Flange (8 nut) mounting.

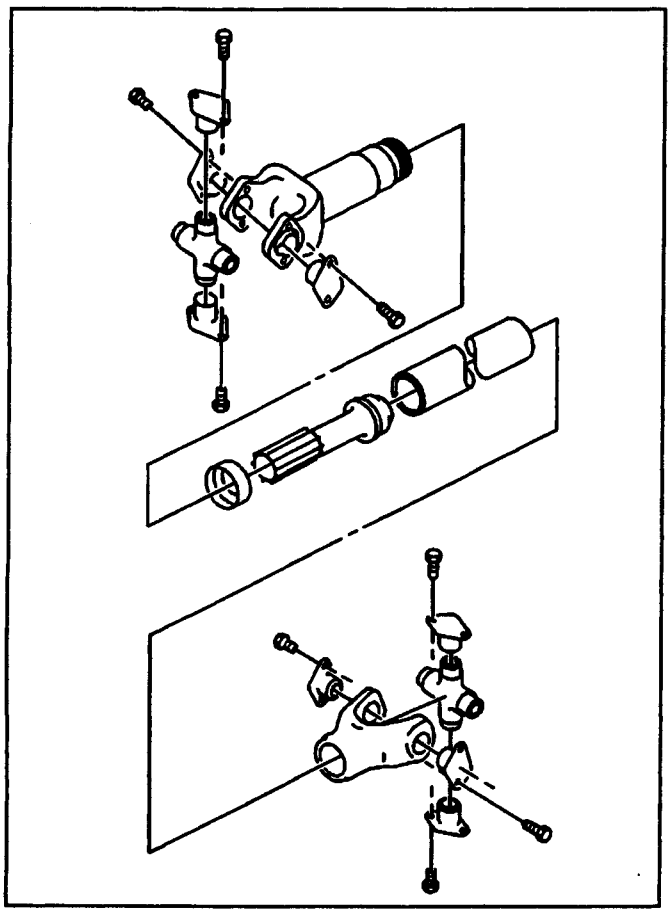


198506

6. Remove the three-piece propeller shaft with tandem axle mounting.

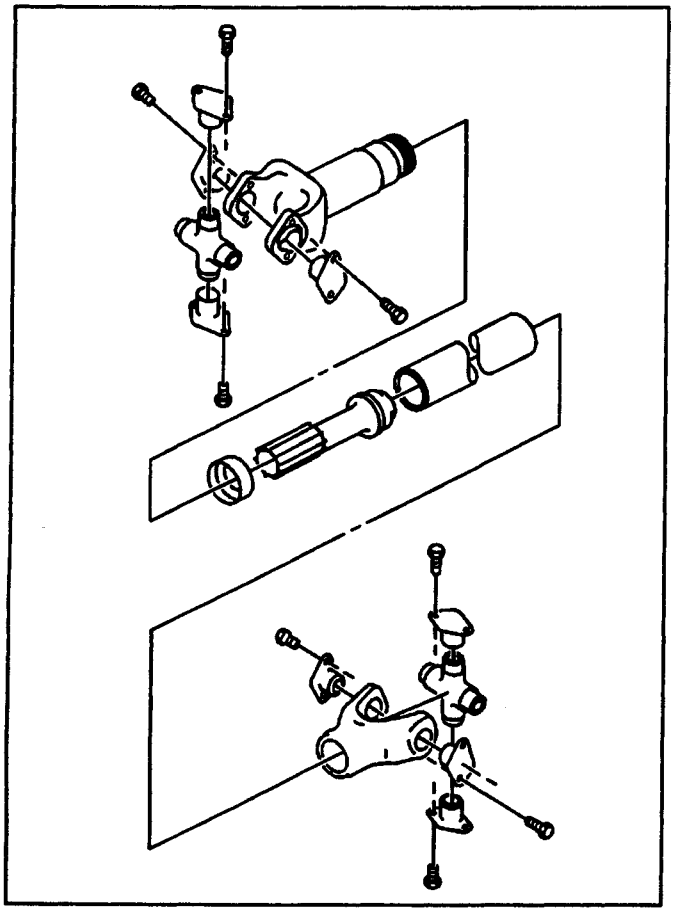


198535



198610

7. Remove the propeller shaft 16N, 17N, 18N, 1710 or 1760 series with inboard slip joint and full round end yoke.
8. Remove the universal joints. Refer to *Universal Joints Replacement.*

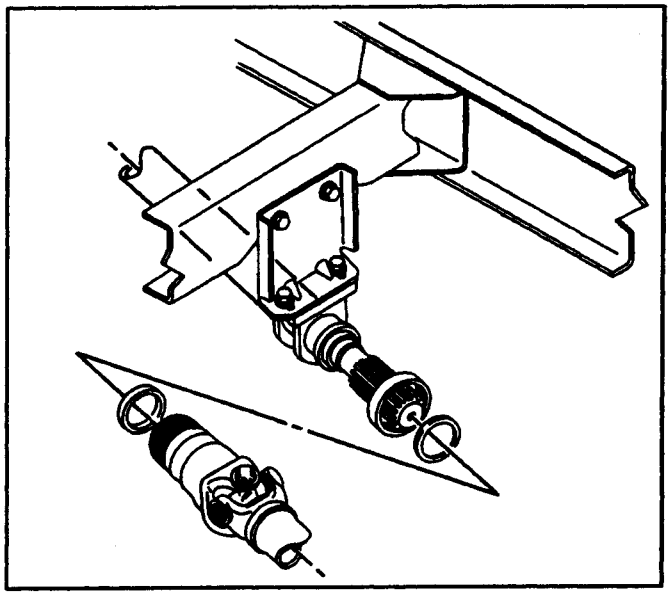


198610

Installation Procedure

1. Install the universal joints to the propeller shaft. Refer to *Universal Joints Replacement.*
2. Support the propeller shaft sections in the installed position.
3. Install the slip yoke and the center bearing assembly to the installed propeller shaft splined end. Refer to *Propeller Shaft Assembly Component Lubrication.*

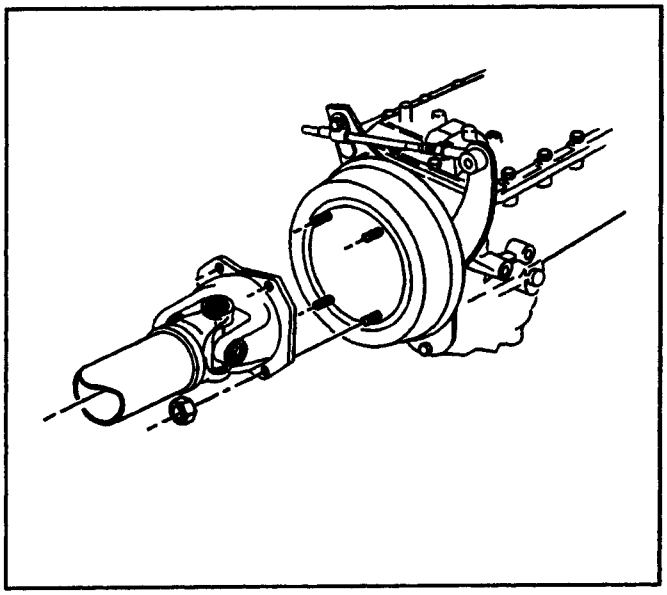
4. Install the front propeller shaft to the Yoke Flange (8 nut) mounting. Keep the alignment marks together.
5. Install and tighten the propeller shaft full or half round end yoke bolts. Refer to *Fastener Tightening Specifications.*



198535

Notice: Refer to *Fastener Notice* in Cautions and Notices.

6. Inspect the propeller shaft for alignment and phasing.
7. Install the propeller shaft guards, if equipped.
8. Lubricate the universal joints and the slip joints. Refer to *Propeller Shaft Assembly Component Lubrication.*

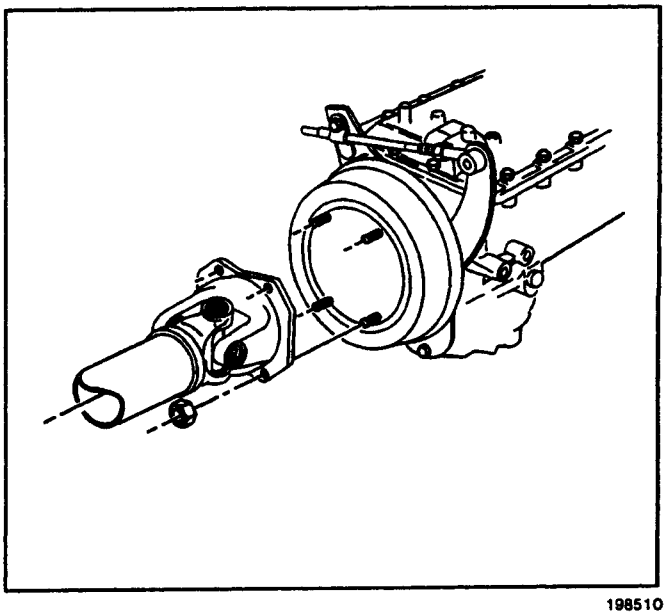


198510

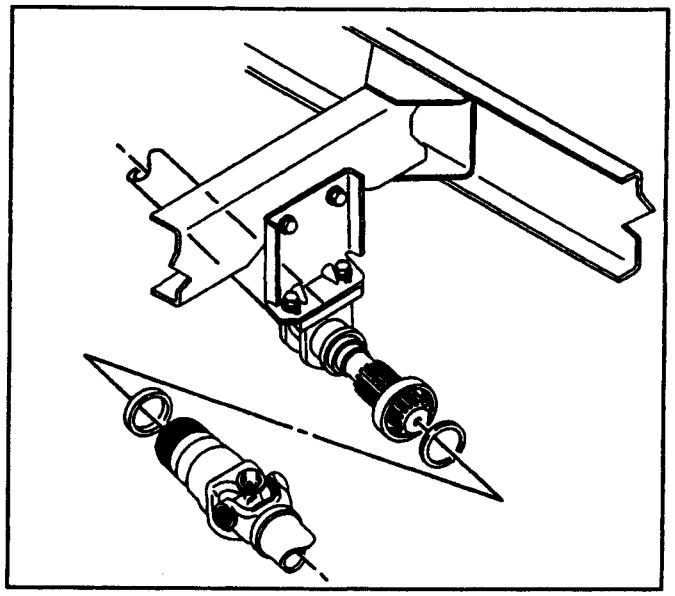
Three-Piece Propeller Shaft Replacement (Inboard Slip Joint, Flange)

Removal Procedure

1. Block the wheels.
2. Support the propeller shaft.
3. Mark the universal joints and slip joints with alignment marks.
4. Remove the propeller shaft guards, if equipped.
5. Remove the propeller shaft bolts from the Yoke Flange (4 nut) mounting.

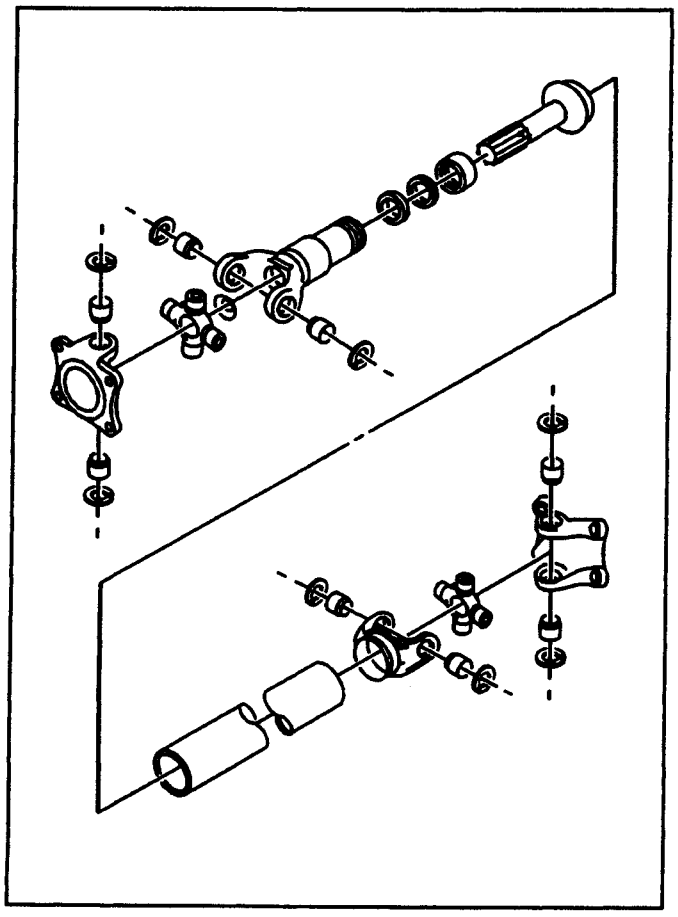


198510



198535

6. Remove the three-piece propeller shaft with tandem axle mounting.

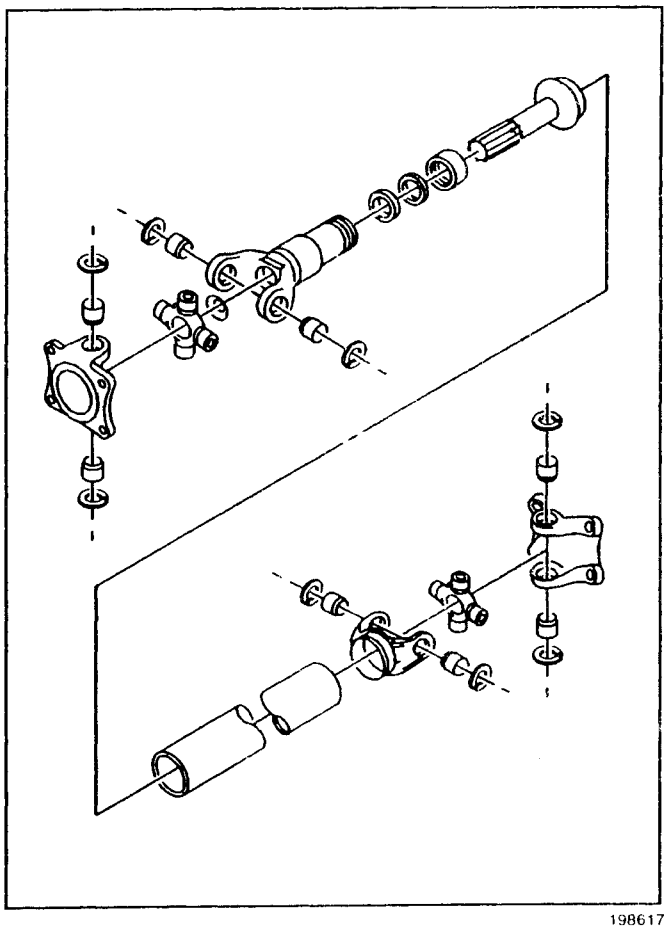


198617

7. Remove the propeller shaft 1480 or 1550 series with inboard slip joint and flange yoke.
8. Remove the universal joints. Refer to *Universal Joints Replacement.*
9. Remove the center bearing assembly from the cross member. Refer to *Center Bearing Replacement.*

Installation Procedure

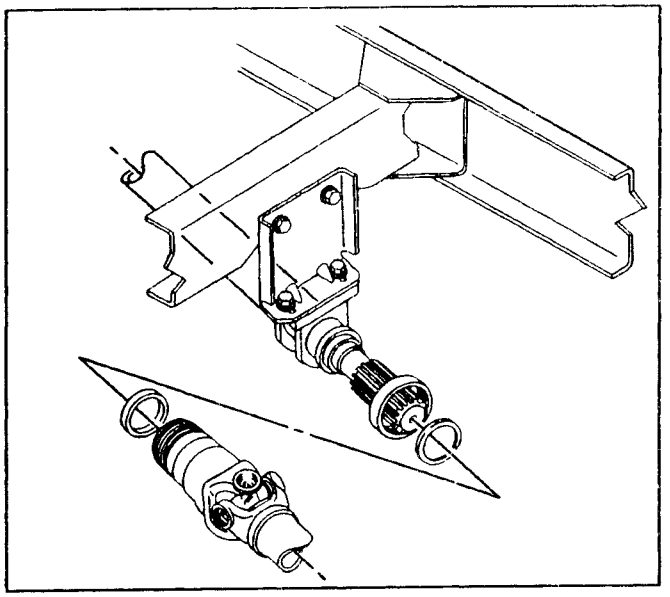
1. Install the universal joints to the propeller shaft. Refer to *Universal Joints Replacement.*
2. Support the propeller shaft sections in the installed position.
3. Install the slip yoke and the center bearing assembly to the installed propeller shaft splined end. Refer to *Propeller Shaft Assembly Component Lubrication.*



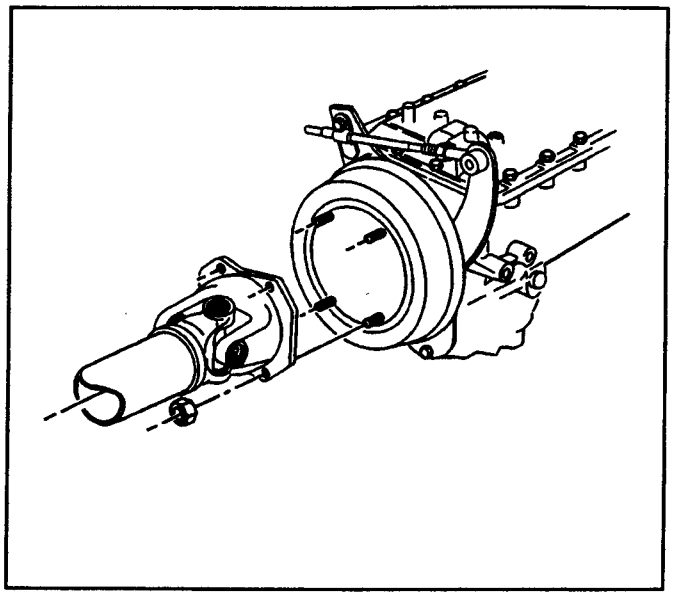
198617

4. Install the front propeller shaft to the Yoke Flange (4 nut) mounting. Keep the alignment marks together.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
5. Inspect the propeller shaft for alignment and phasing.
6. Install and tighten the propeller shaft flange yoke bolts. Refer to *Fastener Tightening Specifications.*

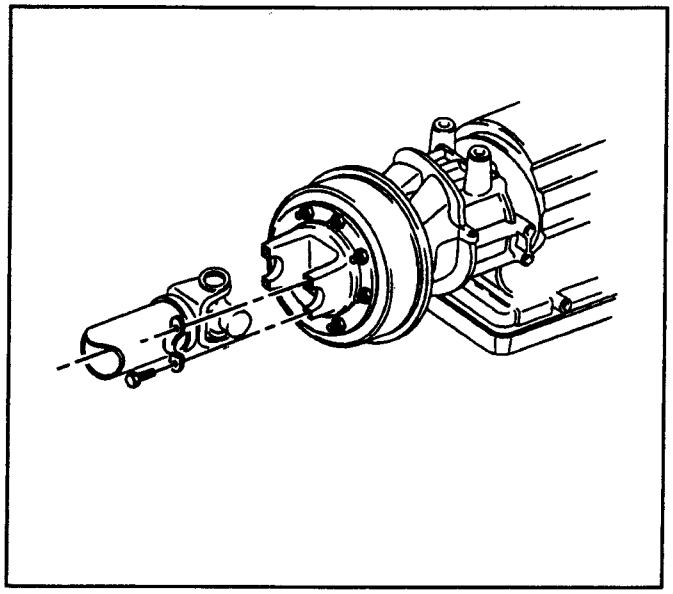


198535



198510

7. Install the propeller shaft guards, if equipped.
8. Lubricate the universal joints and the slip joints. Refer to *Propeller Shaft Assembly Component Lubrication.*

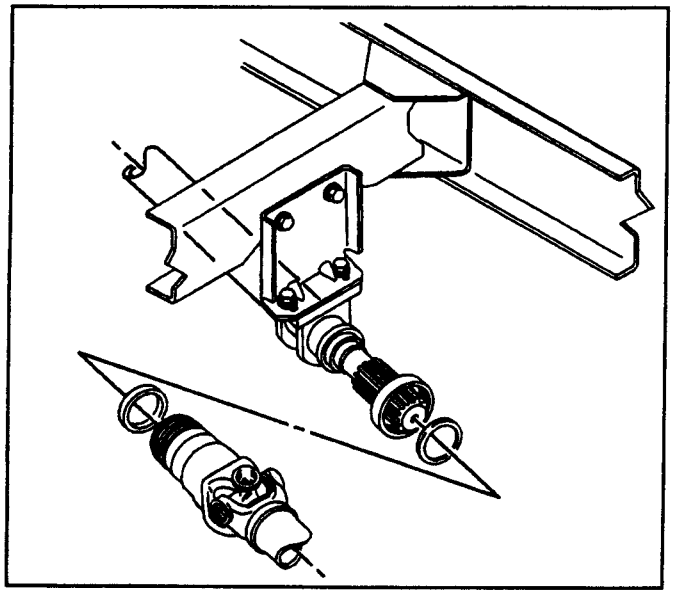


198559

Three-Piece Propeller Shaft Replacement (Outboard Slip Joint, Half)

Removal Procedure

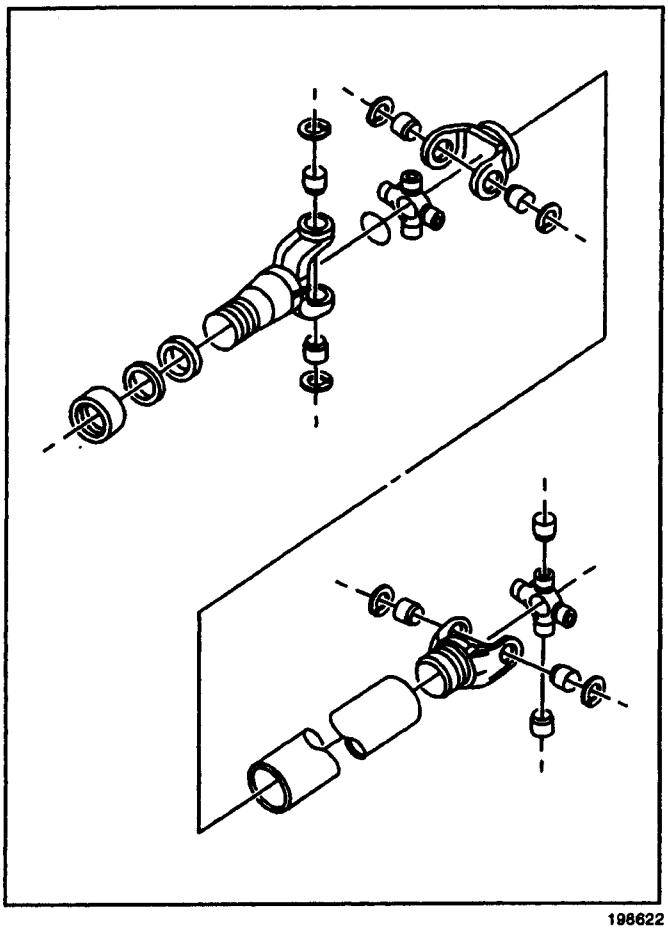
1. Block the wheels.
2. Support the propeller shaft.
3. Mark the universal joints and slip joints with alignment marks.
4. Remove the propeller shaft guards, if equipped.
5. Remove the propeller shaft from the 305 mm (12 in) brake drum.



198535

6. Remove the three-piece propeller shaft with tandem axle mounting.

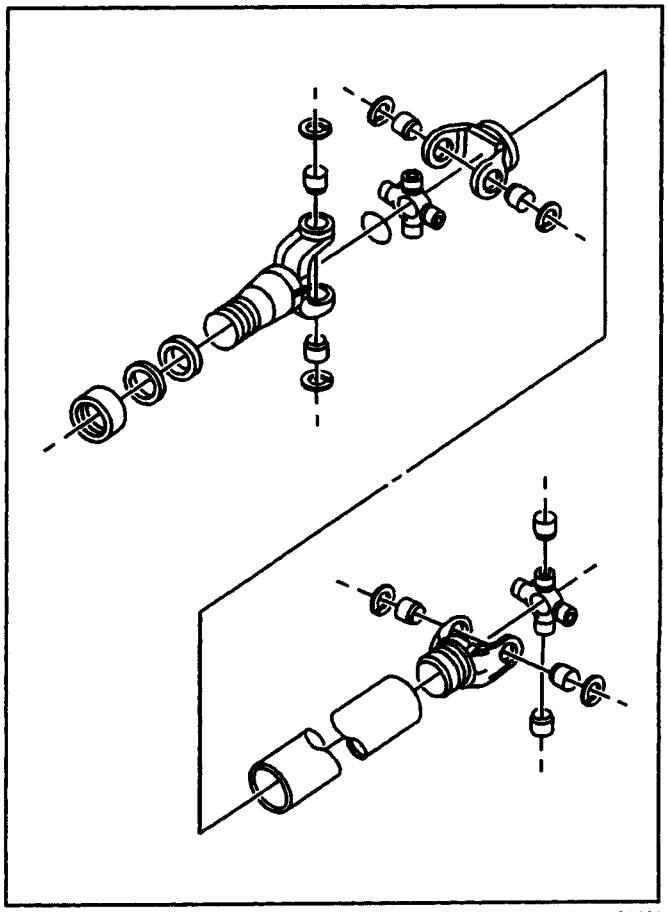
7. Remove the propeller shaft 1480 or 1550 series with outboard slip joint and half round end yoke.
8. Remove the universal joints. Refer to *Universal Joints Replacement.*
9. Remove the center bearing assembly from the cross member. Refer to *Center Bearing Replacement.*



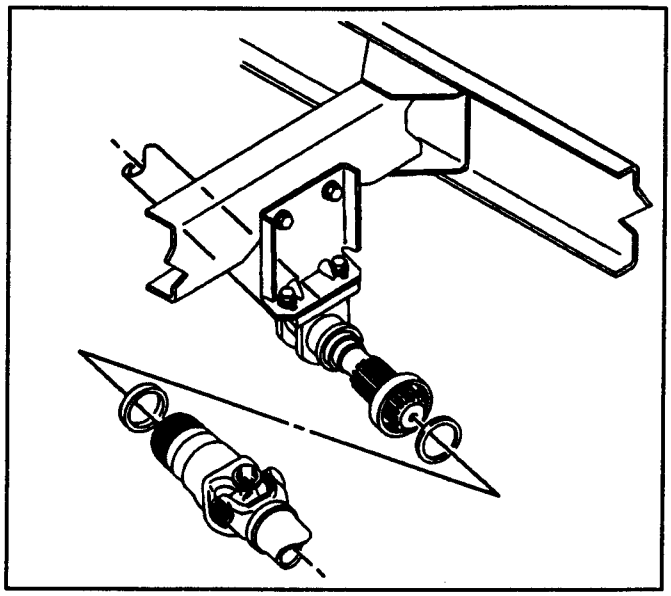
198622

Installation Procedure

1. Install the universal joints propeller shaft. Refer to *Universal Joints Replacement.*
2. Support the propeller shaft sections in the installed position.
3. Install the slip yoke and the center bearing assembly to the installed propeller shaft splined end. Refer to *Propeller Shaft Assembly Component Lubrication.*

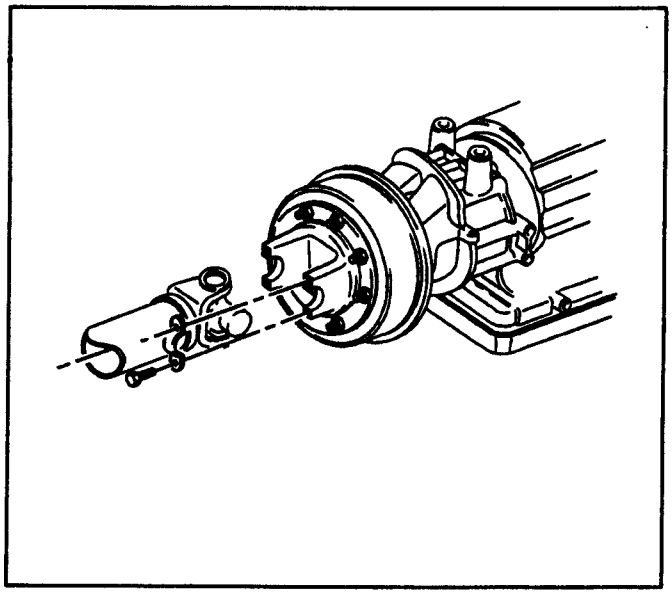


198622



198535

4. Install the front propeller shaft to the 305 mm (9 in) brake drum. Keep the alignment marks together.
5. Install and tighten the propeller shaft half round end yoke bolts. Refer to *Fastener Tightening Specifications.*



198559

Notice: Refer to *Fastener Notice* in Cautions and Notices.

6. Inspect the propeller shaft for alignment and phasing.
7. Install the propeller shaft guards, if equipped.
8. Lubricate the universal joints and the slip joints. Refer to *Propeller Shaft Assembly Component Lubrication.*

Propeller Shaft Assembly Component Lubrication

Universal Joints

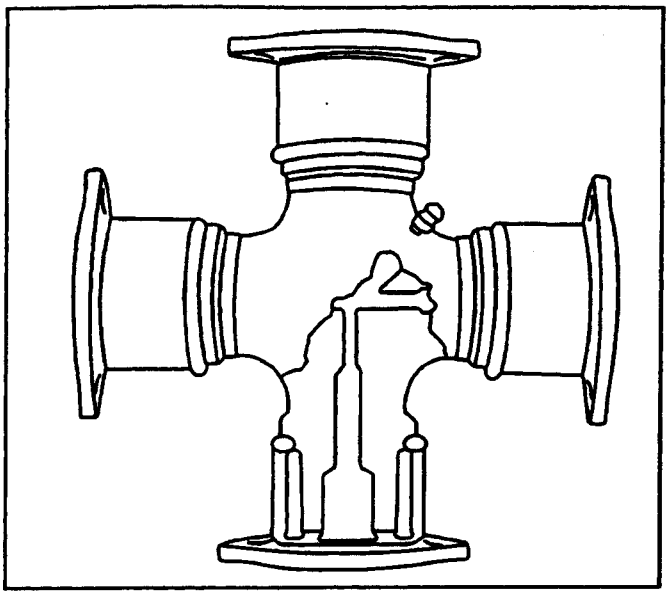
The journals of the universal joints are drilled and provided with lubrication fittings. Lubricant travels through the fittings to all four oil reservoirs, through a small hole inside of each reservoir, direct to the needle bearings. The seals protect the needle bearings against lubricant leakage, dirt and debris.

1. Lubricate with chassis lubricant. Refer to *Fluid and Lubricant Recommendations* in Maintenance and Lubrication.
2. When greasing the joint, ensure that a flow of grease at all four trunnion seals is visible in order to ensure the lubrication of the joint.
3. If grease does not appear at all four trunnion seals, rotate the universal joint trunnion in all four directions while applying the lubricant under pressure in order to relieve any air lock inside of the joint. Air lock would prevent the lubricant from reaching the bearing area.
4. Loosen the cap bolts and cap enough in order to allow a flow of grease, as necessary.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
5. Tighten the bolts.

   Tighten

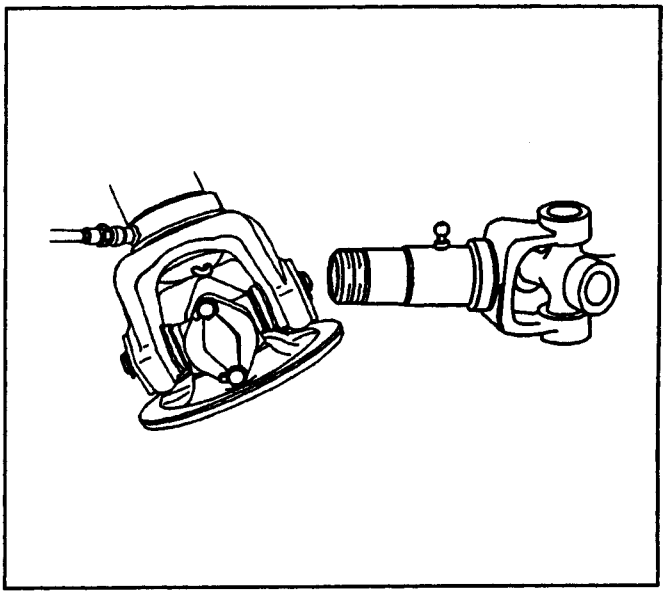
   Tighten the bolts to 44 N.m (33 lb ft).



175626

Slip Joint

1. Splines of the slip joint are lubricated through a lubrication fitting installed in the slip yoke. Apply grease gun pressure to the lubrication fitting until the lubricant appears at the pressure relief hole.
2. Cover the pressure relief hole.
3. Apply pressure until the grease appears at the sleeve yoke seal.
4. Lubricate the universal joints and slip yoke splines at the specified periods. Refer to *Maintenance Schedule* in General Information.

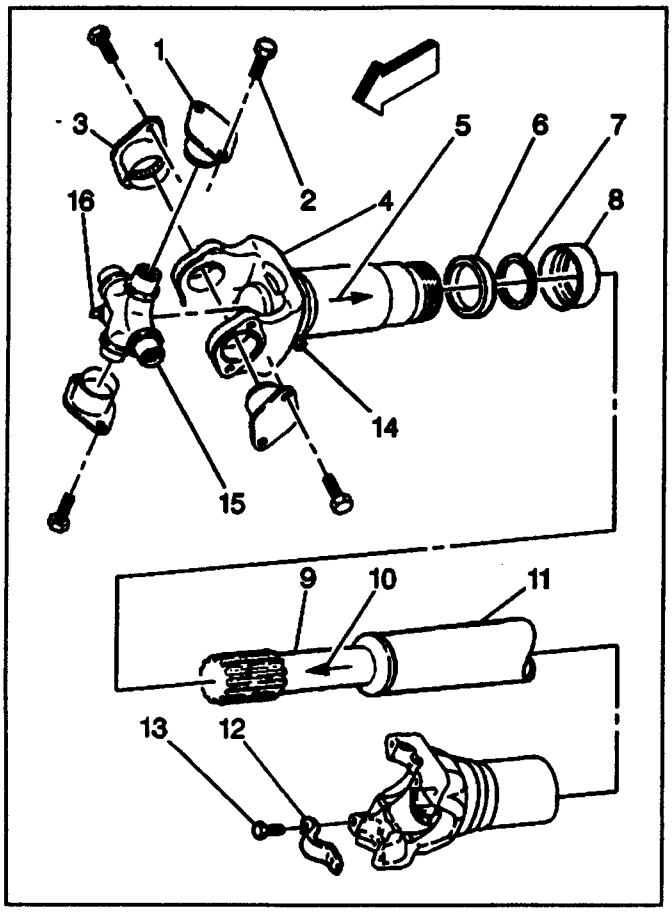


175624

Center Bearing

This bearing is permanently lubricated. Do not attempt to add or change grease within the bearing.

When installing a new center bearing, fill the entire cavity with chassis grease. Ensure that the quantity is sufficient enough in order to fill the cavity to the extreme edge of the slinger surrounding the bearing. This will shield the bearing from water and contaminants.



198531

Slip Joint Replacement

Removal Procedure

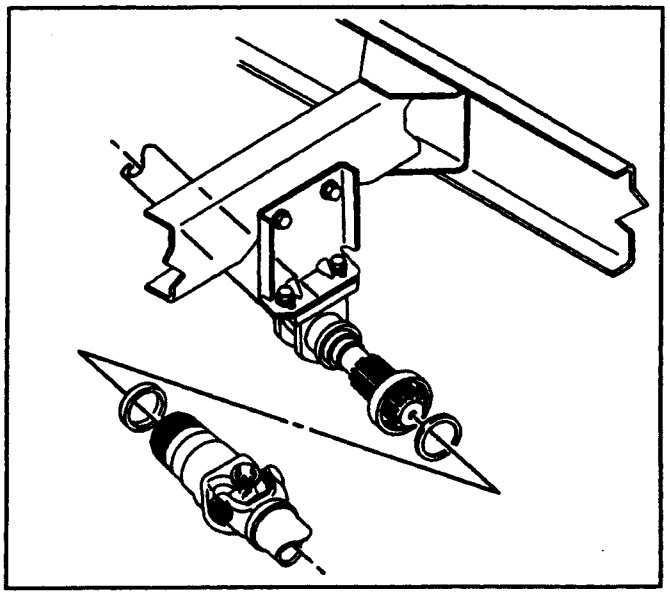
1. Inspect the alignment marks (5) on the propeller shaft and the slip yoke. Punch mark both of the members if the marks are not present.
2. Remove the propeller shaft. Use the following list in order to determine which assembly is to be referenced:
   - If the propeller shaft is a one-piece, refer to *One-Piece Propeller Shaft Replacement (Full Yoke/229)*
   - *One-Piece Propeller Shaft Replacement (Full Yoke/305).*
   - *One-Piece Propeller Shaft Replacement (Half Yoke/229).*
   - *One-Piece Propeller Shaft Replacement (Half Yoke/305).*
   - *One-Piece Propeller Shaft Replacement (Outboard Slip/229).*
   - *One-Piece Propeller Shaft Replacement (Outboard Slip/305).*
   - *One-Piece Propeller Shaft Replacement (Inboard Flange/229).*
   - *One-Piece Propeller Shaft Replacement (Inboard Flange/305).*
   - *One-Piece Propeller Shaft Replacement (Inboard Full Yoke/305)* or
   - If the propeller shaft is a two-piece, refer to *Two-Piece Propeller Shaft Replacement (Inboard Slip Joint and Flange).*
   - *Two-Piece Propeller Shaft Replacement (Inboard Slip Joint and Full).*
   - *Two-Piece Propeller Shaft Replacement (Outboard Slip Joint and Half).*
   - *Two-Piece Propeller Shaft Replacement (Center Bearing, Half Yoke).*
   - *Two-Piece Propeller Shaft Replacement (Center Bearing, Full Yoke).*
   - If the propeller shaft is a three-piece, refer to *Three-Piece Propeller Shaft Replacement (Center Bearing, Full Yoke).*
   - *Three-Piece Propeller Shaft Replacement (Inboard Slip Joint, Full Yoke).*
   - *Three-Piece Propeller Shaft Replacement (Inboard Slip Joint, Flange).*
   - *Three-Piece Propeller Shaft Replacement (Outboard Slip Joint, Half).*
3. Remove the dust cap (8) from the slip yoke tube.
4. Remove the shaft (9).
5. Remove the cork (or felt) seal (6), if used.
6. Remove the steel ring (7), if used.
7. Remove the dust cap (8) from the shaft (9). The dust cap may have an integral rubber seal. If the rubber seal is present there will be no steel ring, cork, or felt seal.
8. Remove the lubrication fitting (14).

9. Clean the slip yoke (4).
10. Clean the slip yoke splines.
11. Clean the shaft splines.
12. Inspect the slip yoke splines for wear or twist.
13. Inspect for backlash between the slip yoke and the shaft. Replace the slip joint if the backlash is excessive.

Installation Procedure

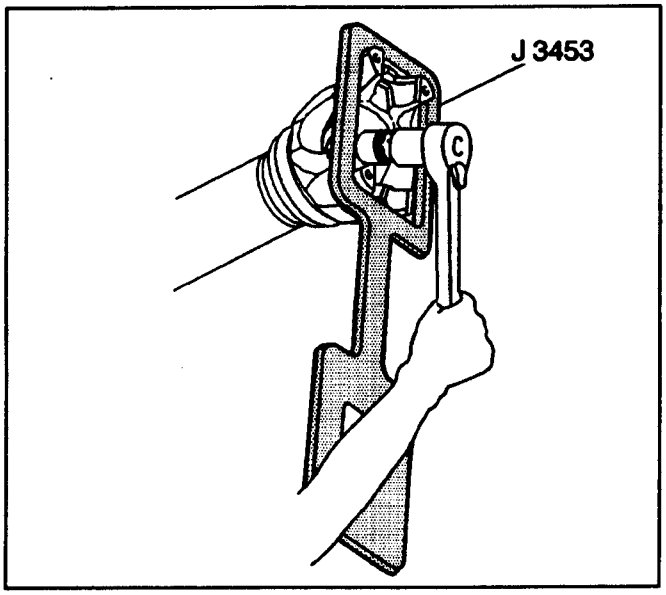
1. Connect the dust cap on to the shaft.
2. Install the steel ring on the shaft, if equipped.
3. Install the new cork (or felt) seal on the shaft, if equipped.
4. Lubricate the shaft splines. Refer to *Propeller Shaft Assembly Component Lubrication.*

   Notice: The journal crosses must be in the same plane (in Phase), or serious vibration will occur, with resultant damage to the propeller shaft and components.
5. Install the shaft into the slip yoke. Ensure that the yokes are aligned.
6. Install the dust cap onto the slip yoke. Hand tighten the dust cap.
7. Install the lubrication fitting in the slip yoke.
8. Lubricate the slip joint. Refer to *Propeller Shaft Assembly Component Lubrication.*
9. Install the propeller shaft. Use the following list in order to determine which assembly is to be referenced:
   - If the propeller shaft is a one-piece, refer to *One-Piece Propeller Shaft Replacement (Full Yoke/229).*
   - *One-Piece Propeller Shaft Replacement (Full Yoke/305).*
   - *One-Piece Propeller Shaft Replacement (Half Yoke/229).*
   - *One-Piece Propeller Shaft Replacement (Half Yoke/305).*
   - *One-Piece Propeller Shaft Replacement (Outboard Slip/229).*
   - *One-Piece Propeller Shaft Replacement (Outboard Slip/305).*
   - *One-Piece Propeller Shaft Replacement (Inboard Flange/229).*
   - *One-Piece Propeller Shaft Replacement (Inboard Flange/305).*
   - *One-Piece Propeller Shaft Replacement (Inboard Full Yoke/305)* or
   - If the propeller shaft is a two-piece, refer to *Two-Piece Propeller Shaft Replacement (Inboard Slip Joint and Flange).*
   - *Two-Piece Propeller Shaft Replacement (Inboard Slip Joint and Full).*
   - *Two-Piece Propeller Shaft Replacement (Outboard Slip Joint and Half).*
   - *Two-Piece Propeller Shaft Replacement (Center Bearing, Half Yoke).*



198535

- *Two-Piece Propeller Shaft Replacement (Center Bearing, Full Yoke).*
- If the propeller shaft is a three-piece, refer to *Three-Piece Propeller Shaft Replacement (Center Bearing, Full Yoke).*
- *Three-Piece Propeller Shaft Replacement (Inboard Slip Joint, Full Yoke).*
- *Three-Piece Propeller Shaft Replacement (Inboard Slip Joint, Flange).*
- *Three-Piece Propeller Shaft Replacement (Outboard Slip Joint, Half).*



198518

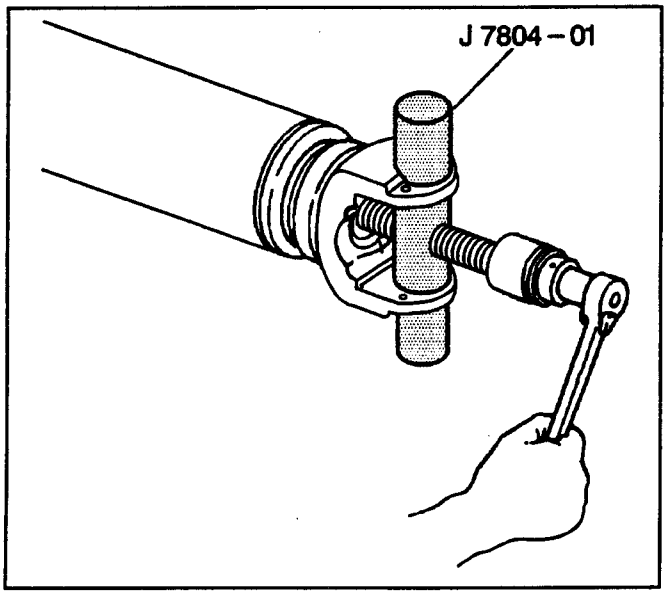
Center Bearing Replacement

Removal Procedure

Tools Required

- *J 3453* Holding Bar
- *J 7804-01* Puller

1. Support the propeller shaft assembly.
2. Remove the universal joint from the yoke. Refer to *Universal Joints Replacement.*
3. Remove the bracket mounting bolts and nuts.
4. Remove the bracket and the retainer.
5. Remove the yoke nut using the *J 3453.*

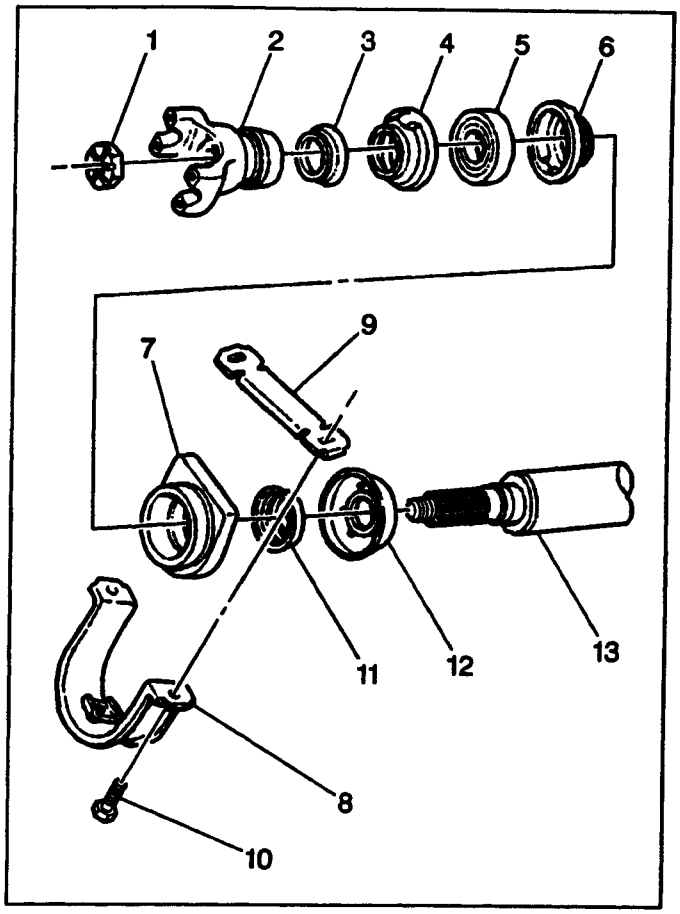


198515

6. Remove the yoke from the propeller shaft using the *J 7804-01.*
7. Remove the slinger.
8. Remove the grease retainer, if equipped.

9. Remove the center bearing (5).
10. Remove the grease retainer (4 and 6), if equipped.
11. Remove the rubber cushion (7).
12. Remove the slinger (11) and dust shield (12), if used.

    Notice: Clean bearings in clean mineral spirits paint thinner, or equivalent. Do not spin dry bearings. Bearings can be damaged by use of wrong cleaning solvents and rough handling.
13. Clean the following components:
    - The slingers
    - The grease retainers
    - The center bearing
    - The rubber cushion
14. Inspect the following components for wear or damage:
    - The center bearing
    - The rubber cushion
    - The slingers
    - The grease retainers



198520

Installation Procedure

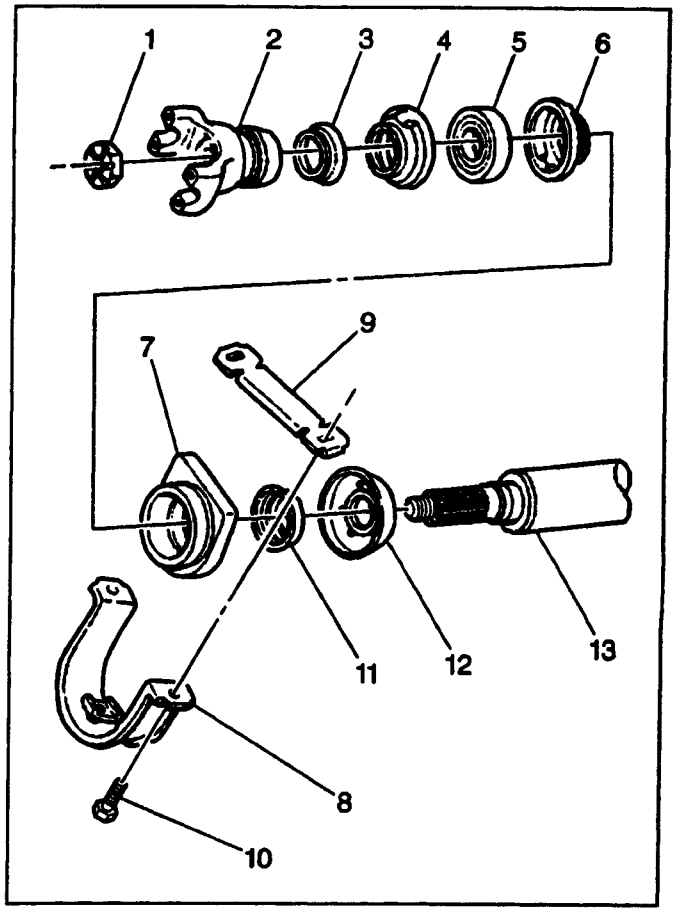
Tools Required

J 3453 Holding Bar

1. Install the lubricant into the grease retainers, if equipped. Refer to *Propeller Shaft Assembly Component Lubrication.*
2. Install the grease retainers (4, 6), if equipped, to the center bearing (5).
3. Install the center bearing (5) into the rubber cushion (7).
4. Install the dust shield (12), if used.
5. Install the slinger (11).
6. Install the center bearing (5) on the propeller shaft (13).
7. Install the slinger (11) on the propeller shaft (13).
8. Install the yoke (2).

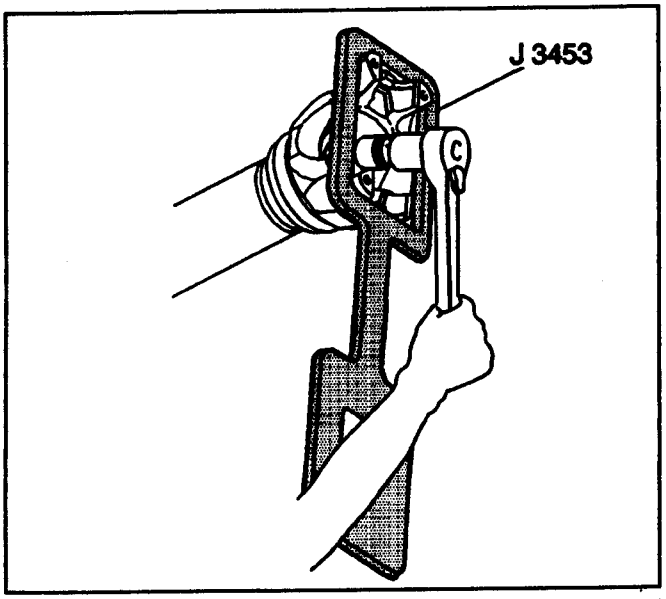
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
9. Install the yoke nut (1) using the *J 3453.*

   Tighten
   - Tighten the series 1480 nut to 779 N·m (575 lb ft).
   - Tighten the series 1550 bolt to 216 N·m (160 lb ft).
   - Tighten the series 1610 or 1710 nut to 983 N·m (725 lb ft).



198520

10. Install the bracket (8) and the retainer (9) to the rubber cushion (7).
11. Install the mounting bolts (10) and nuts.
    Tighten
    Tighten the propeller shaft hanger nuts to 70 N.m (52 lb ft).
12. Install the universal joint. Refer to *Universal Joints Replacement.*



198518

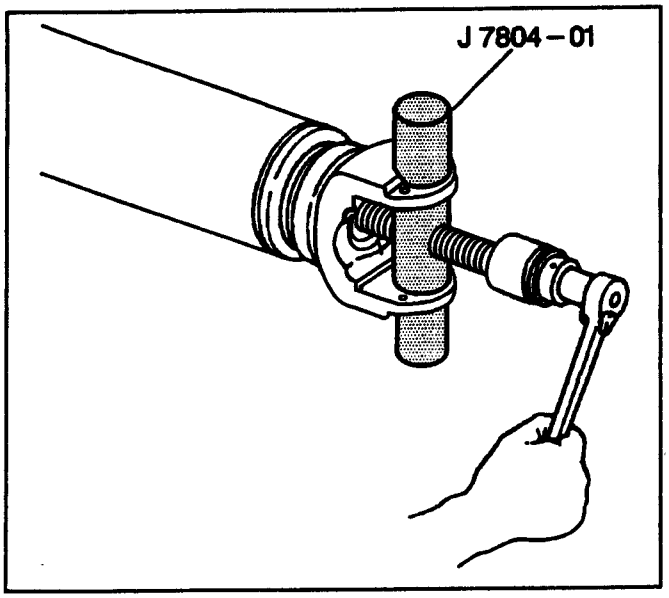
Yoke Replacement

Removal Procedure

Tools Required

- *J 3453* Holding Bar
- *J 7804-01* Puller

1. Remove the universal joints. Refer to *Universal Joints Replacement.*
2. Remove the yoke nut or bolt and the washers. Use the *J 3453.*



198515

3. Remove the yoke using the *J 7804-01.*

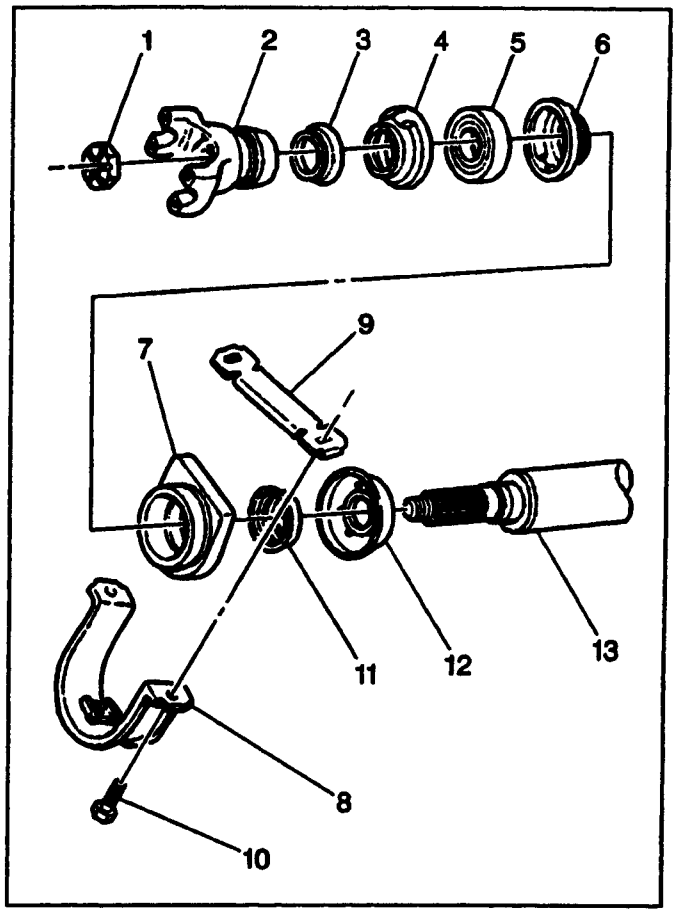
Installation Procedure

Tools Required
J 3453 Holding Bar

Important:

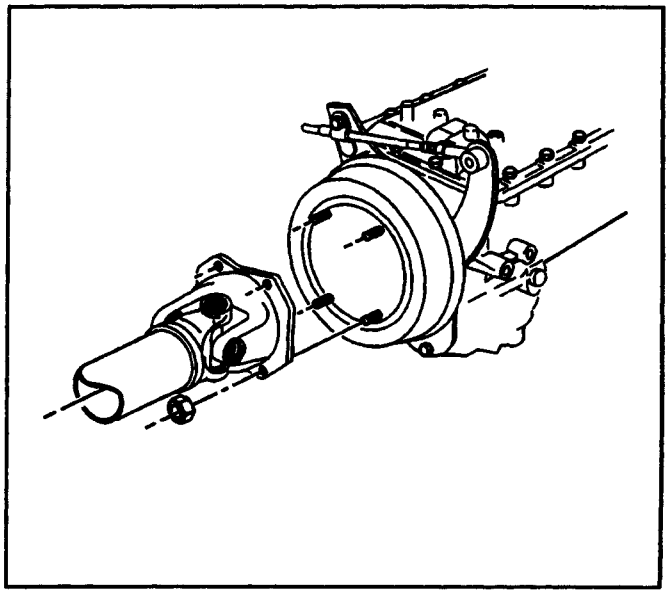
- Ensure that the splines are aligned and the yokes are in phase.
- Tap on the yoke in order to ensure that the yoke is completely seated against the propeller shaft.

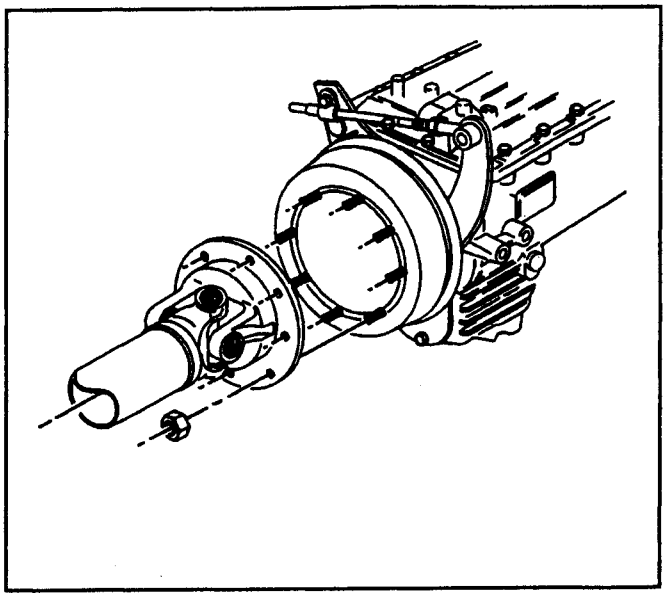
1. Install the yoke (2).



198520

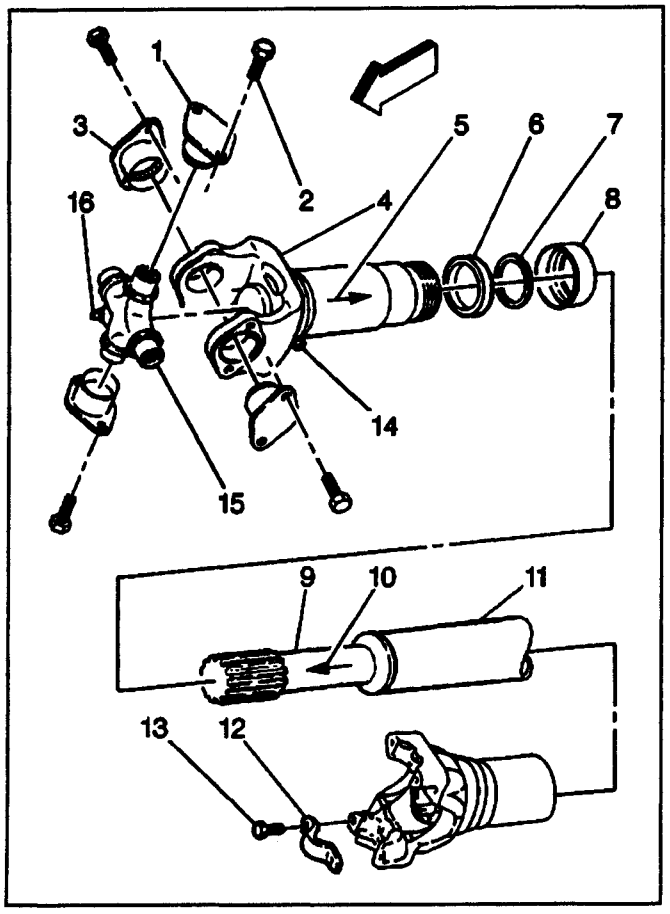
2. Install the yoke nut or bolt and washers with the 4 nut mounting.


198510



198506

3. Install the yoke nut or bolt and washers with the 8 nut mounting, if used.
4. Install the universal joint. Refer to *Universal Joints Replacement.*



198531

Universal Joints Replacement

Removal Procedure

1. Remove the bolts (13).
2. Remove the bearing straps (12).
3. Remove the cap screws (2).
4. Remove the bearing assemblies (1), as required.
5. Remove the journal (15) from the yoke (4).
6. Remove the lubrication fitting (14, 16).
7. Clean the lubricant passages in the journal cross.

   Notice: Clean bearings in clean mineral spirits paint thinner, or equivalent. Do not spin dry bearings. Bearings can be damaged by use of wrong cleaning solvents and rough handling.
8. Clean the needle bearings and the cages.
9. Inspect the bearings for excessive looseness or brinelling. Replace the journal (15) and the bearings, if the bearings are worn, damaged or brinelled.
10. Inspect the yokes for the following conditions:
    - Nicks
    - Burrs
    - Damaged threads
11. Remove the nicks and burrs using a fine file or stone. Chase damaged threads using a bottoming tap.
12. Inspect the bearing cage seals for wear or damage.

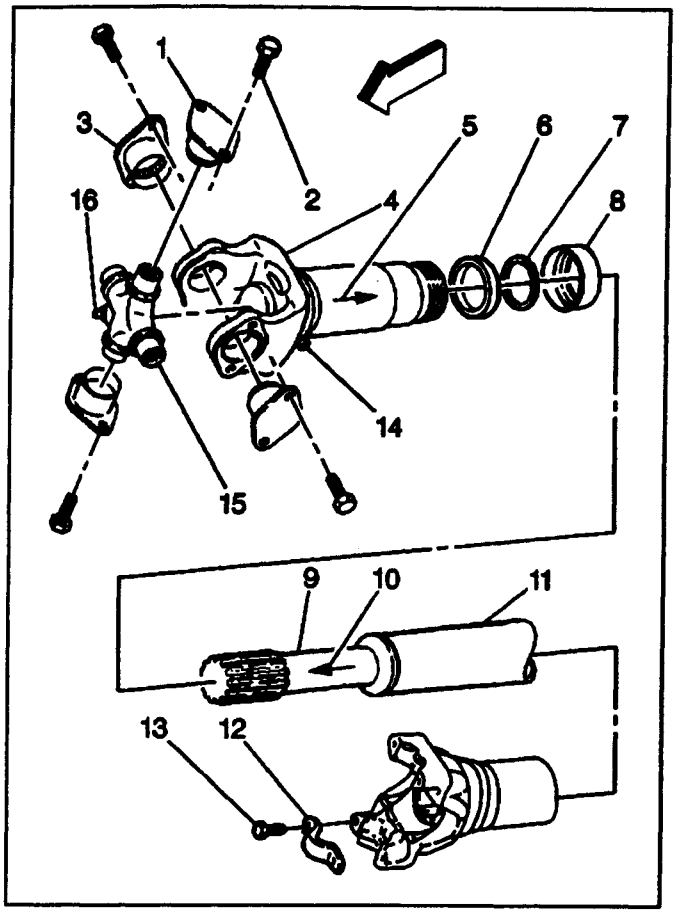
Installation Procedure

1. Install the journal (15) into the yoke (4).
2. Install the bearing assemblies (1), if required.
3. Install the bolts (13).
4. Install the bearing straps (12).

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
5. Install the universal joint cap screws (2), if equipped.

   Tighten

   - For series 1480, 1550, and 1610, tighten the bolts to 54 N·m (40 lb ft).
   - For series 1710 and 1710 HD, tighten the bolts to 136 N·m (100 lb ft).
   - Tighten the cap screws to 44 N·m (33 lb ft).
6. Install the new lubrication fitting (14, 16).
7. Apply lubricant through the new lubrication fitting. Refer to *Propeller Shaft Assembly Component Lubrication.*

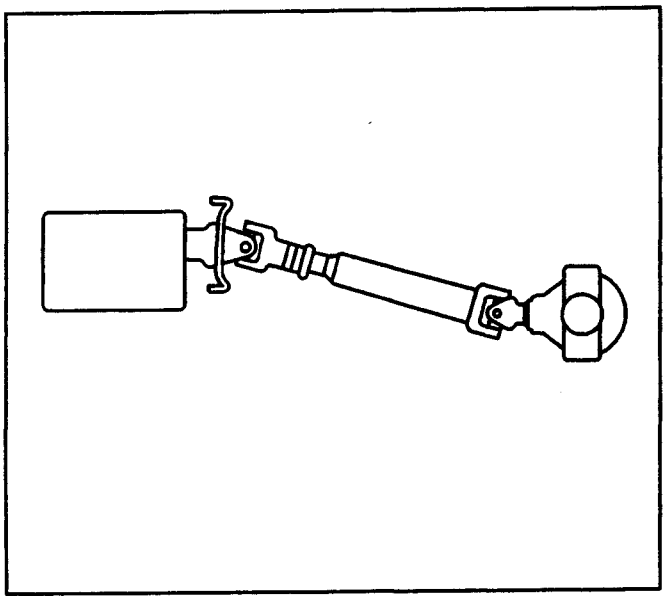


198531

Description and Operation

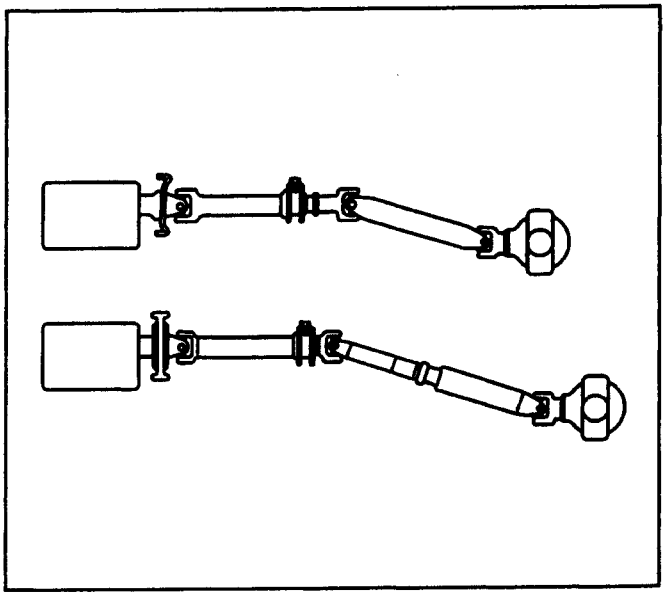
Propeller Shaft Description

The following propeller shafts are available on this vehicle:



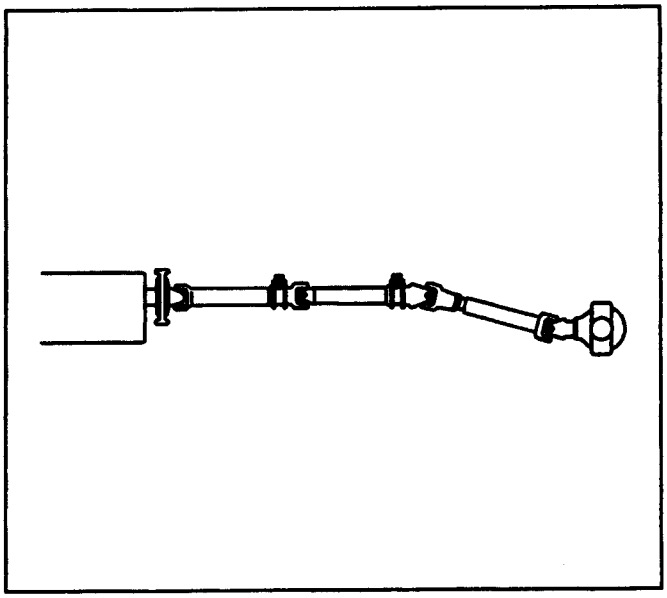
198670

- Single propeller shaft



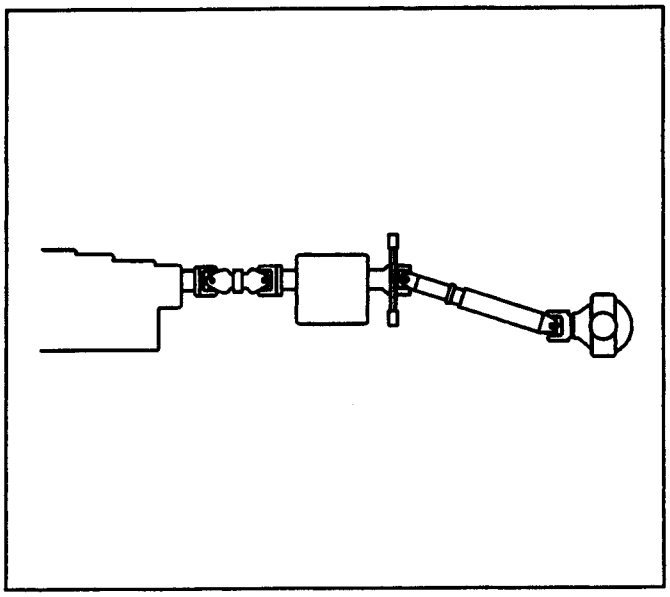
198636

- Dual propeller shafts



198633

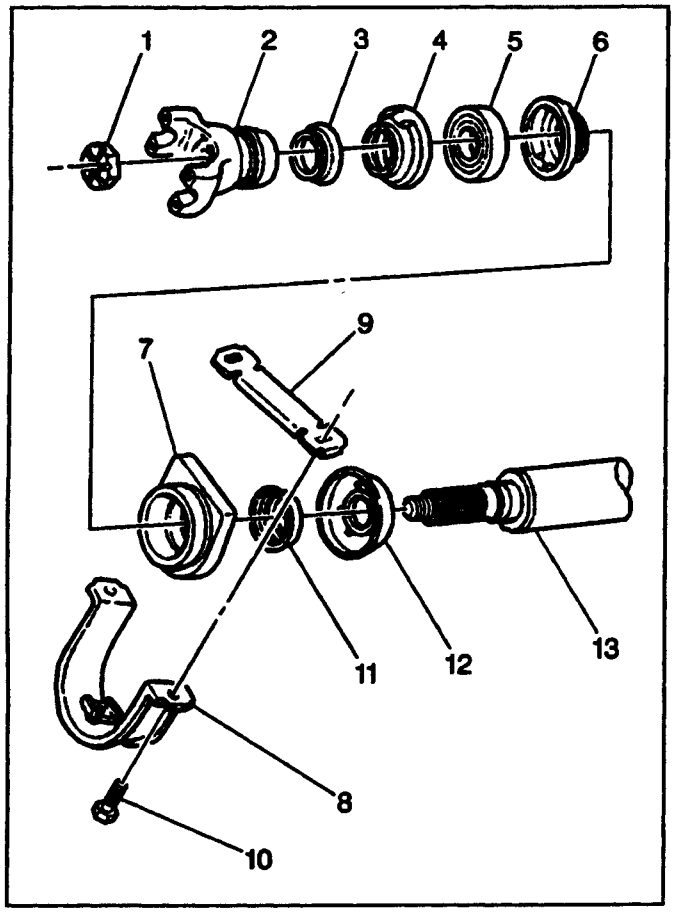
- Multi-propeller shafts



198630

- Propeller shaft with an auxiliary transmission

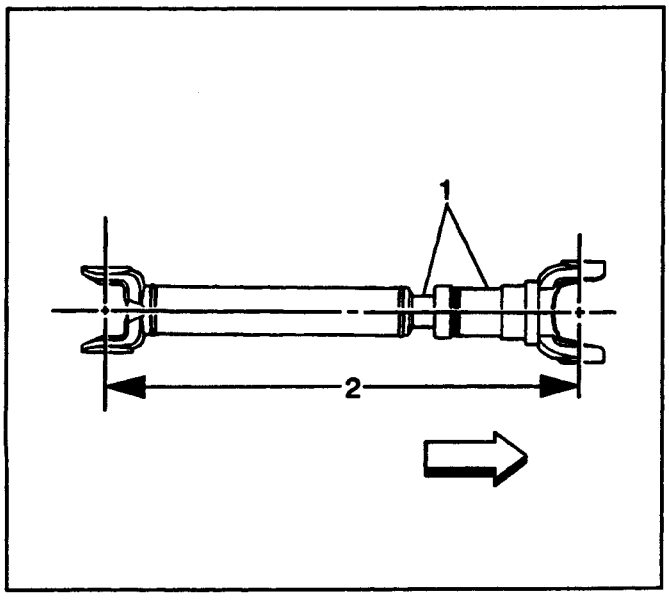
Torque is transmitted from the transmission to the rear axle through one or more propeller shafts and universal joint assemblies. The propeller shaft and universal joint installations and assemblies used on the vehicles are covered in this service manual. The number of propeller shafts and universal joint assemblies varies with vehicle wheelbases and the combinations or transmission and rear axle equipment.



198520

All propeller shafts (13) are balanced tubular type. A splined slip joint is provided in each drive line. The slip joint is at the forward end of the rear shaft.

Propeller Shaft Phasing Description

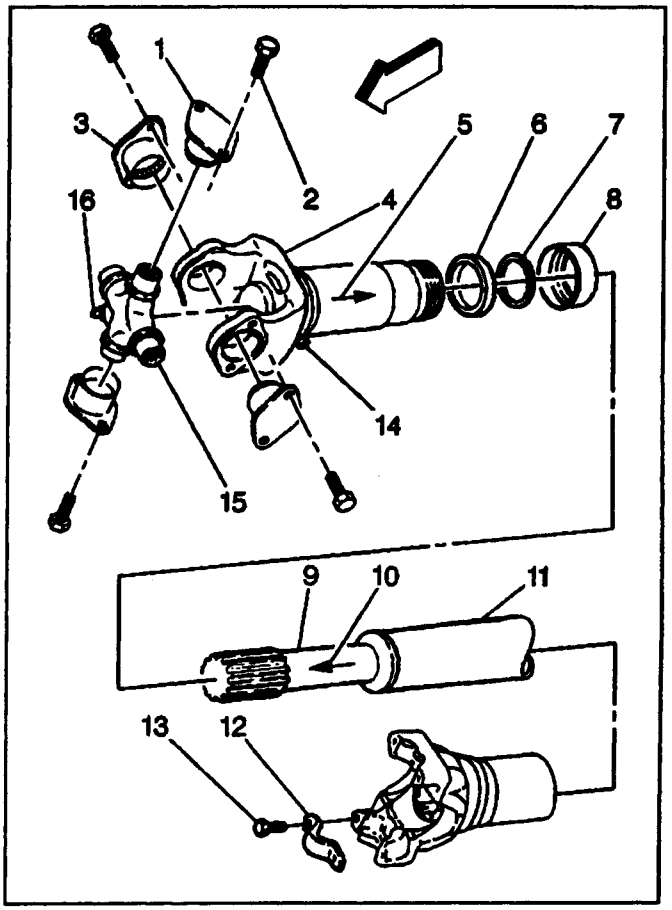


198598

All propeller shafts are designed and built with the yoke lugs (ears) in line with each other. This condition is called phasing. Phasing produces the smoothest running shaft possible.

An out-of-phase propeller shaft may cause phasing. The shaft will absorb the vibration from the speeding up and slowing down each time the universal joint rotates. Phasing in a propeller shaft is similar to two people snapping a rope at the same time and watching the wave reaction flow to the other end. This is similar to the universal joints on a propeller shaft. The cancellation produces a smooth flow of power to the wheels. Mark the propeller shafts when disassembling, in order to assure proper assembly alignment. Some propeller shafts have alignment arrows stamped on them at the time of production.

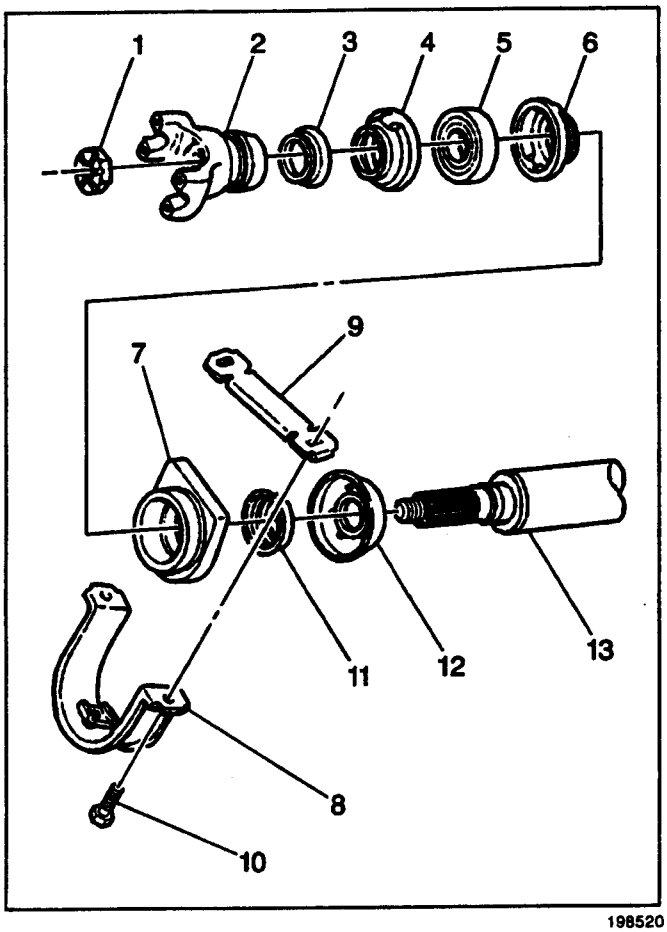
Universal Joint Description



198531

The needle bearings are installed in the bearing cages. The bearing cages are retained in the yoke (4) using bolts (13) with bearing straps (12).

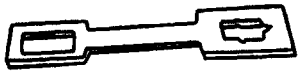
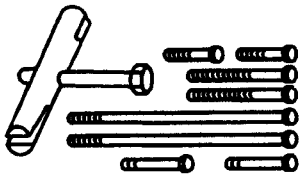
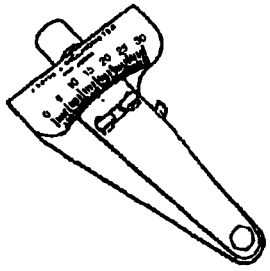
Center Bearing Description



198520

Center bearings (5) are used in order to support the center portion of the driveline when two or more propeller shafts (13) are used. The bearing (5) is a ball type. The bearing is mounted in a rubber cushion (7) that is attached to a frame cross member. The bearing is prelubricated by the manufacturer.

Special Tools and Equipment

Illustration	Tool Number/ Description
 36470	J 3453 Holding Bar
 36471	J 7804-01 Puller
 8224	J 23498-A Inclinometer
 198640	J 24479 Inclinometer

Rear Drive Axle

Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Axle Shaft Mounting Nut		
12 Stud Axle	77 N·m	57 lb ft
8 Stud Axle	155 N·m	114 lb ft
Axle Vent Assembly	14 N·m	124 lb in
Differential Carrier to Axle Housing Bolt		
Dana/Spicer® Model S150-S	150 N·m	111 lb ft
Eaton® Models 15040S and 19050S	128 N·m	94 lb ft
Eaton® Models 19050T	143 N·m	105 lb ft
Eaton® Models 19060S, 19060T, 21060S, 21060T, 22060S, 22060T, 23080S, 23080T and 23105S	227 N·m	167 lb ft
Drain Plug	70 N·m	52 lb ft
Drive Pinion Nut		
Dana Spicer® Model S150-S	1088 N·m	802 lb ft
Eaton® Models 15040S, 19050S, and 19050T	568 N·m	419 lb ft
Eaton® Models 15060S, 21060S, and 22060S	867 N·m	639 lb ft
Eaton® Models 15060T, 21060T, and 22060T	1025 N·m	755 lb ft
Eaton® Model 23080T	1190 N·m	877 lb ft
Eaton® Models 23080S and 23105S	1262 N·m	930 lb ft
Rear Wheel Pinion Outer Nut	169 N·m	125 lb ft
Top-off Plug	67 N·m	49 lb ft

Diagnostic Information and Procedures

Determining Type of Noise

Any gear-driven unit produces a certain amount of noise. This includes an automotive drive axle where engine torque multiplication occurs at a 90 degree turn in the driveline. Perform an interpretation for each vehicle in order to determine whether the noise is normal or if a problem exists. Expect a certain amount of noise that cannot be eliminated by conventional repairs or adjustments.

Normal rear axle noise is a slight noise that is only heard at a certain speed or under unusual or remote conditions. Noise tends to reach a peak at speeds from 64–97 km/H (40–60 mph) depending on the road and load conditions or on the gear ratio and the tire size. This type of noise is not indicative of trouble in the rear axle.

The following vehicle noises are often mistaken for rear axle noise:

- Tires
- Propeller shaft
- Transmission
- Universal joints
- Front wheel bearings
- Rear wheel bearings

The following practices will aid in locating the source of rear axle noises:

- Raise the tire pressure in order to eliminate tire noise. Raising the tire pressure will not silence the tread noise of some of the tread patterns.
- Listen for the noise at varying speeds and road surfaces (drive, float and coast).

Isolate the noise to a specific driveline component. Do not make a random guess. Random guessing may be a costly waste of time.

External Noise

If you suspect that a rear axle is noisy, perform a thorough test in order to determine whether the noise originates from one of the following locations:

- The tires
- The road surface
- The front wheel bearings
- The engine
- The transmission
- The rear axle

Rear axle parts adjustment or replacement will not correct noise that originates in other locations.

Road Noise

Driving on the following road surfaces causes noise which may be mistaken for rear axle noise:

- Brick
- Rough-surfaced concrete

Driving on one of the following different types of road surface will quickly show whether the road surface is the cause of the noise:

- Smooth asphalt
- Dirt

Road noise is usually the same on drive or on coast.

Tire Noise

Tire noise may easily be mistaken for rear axle noise, even though the noisy tires may be located on the front wheels. Tires that exhibit the following conditions are usually noisy and may produce vibrations which seem to originate elsewhere in the vehicle:

- Uneven wear
- Non-skid division surfaces that are worn in saw-tooth fashion (particularly true with low tire pressure)

Tire Noise Test

Tire noise changes according to different road surfaces, but rear axle noise does not. Temporarily inflating the tires to the maximum recommended pressure, for test purposes only, will materially alter the tire noise. Temporarily inflating the tires will not affect the noise caused by the rear axle. Rear axle noise usually stops when coasting at speeds under 48 km/h (30 mph). Tire noise may continue at a lower tone as you reduce the vehicle speed. Rear axle noise usually changes when comparing the pull and the coast conditions. The tire noise remains about the same.

Engine and Transmission Noise

Sometimes a noise which seems to originate in the rear axle is actually caused by the engine or transmission. In order to determine which unit is causing the noise, complete the following steps:

1. Observe the approximate vehicle speeds and conditions under which the noise is most pronounced.
2. Stop the vehicle in a quiet place in order to avoid interfering noises.
3. Place the vehicle in Neutral.
4. Run the engine slowly up and down through the engine speeds that correspond to the vehicle speed at which the noise is most pronounced.

If a similar noise is produced with the vehicle standing, the noise is caused by the engine or the transmission and not the rear axle.

Front Wheel Bearing Noise

Do not confuse loose or rough front wheel bearing noise with rear axle noise. Front wheel drive noise does not change when comparing pull and coast conditions. Light application of the brake, while holding the vehicle speed steady, will often cause the front vehicle noise to diminish. This light application of the brake takes some weight off of the bearing. Inspect the front wheel bearings for noise. Complete the following steps:

1. Raise and spin the front wheels.
2. Shake the front wheels in order to determine if the front wheel bearings are excessively loose.

Body Boom Noise or Vibration

An unbalanced propeller shaft may cause an objectionable body boom noise or vibration at 89–105 km/h (55–65 mph). Excessive looseness at the propeller shaft spline may contribute to the imbalance. The following items also contribute to the noise problem:

- Undercoating or mud on the propeller shaft — causing an imbalance
- Propeller shaft or companion flange balance weights missing
- Propeller shaft damage — such as bends, dents, or nicks
- Rough tires — switch the tires from a known good vehicle in order to determine a tire fault.

After completing a comprehensive check of the vehicle, if all indications point to the rear axle, further diagnostic steps are necessary in order to determine the rear axle components are at fault. True rear axle noise generally falls into the following two categories:

- Gear noise
- Bearing noise

Rear Axle Noise

If a careful test of the vehicle shows that the noise is not caused by external items, the rear axle is the cause of the noise. Test the rear axle on a smooth level road in order to avoid road noise. Do not test the rear axle for noise by running the vehicle with the rear wheels raised.

Noise in the rear axle may be caused by one of the following conditions:

- A faulty propeller shaft
- Faulty rear wheel bearings
- Misalignment between two universal joints
- Worn differential side gears and pinions
- A mismatched differential drive pinion and ring gear set
- An improperly adjusted differential drive pinion and ring gear set
- A scored differential drive pinion and ring gear set

Rear Wheel Bearing Noise

A rough rear wheel bearing produces a vibration or a growl which continues while the vehicle is coasting and the transmission is in Neutral. A brinelled rear wheel bearing causes a knock or click approximately every two revolutions of the rear wheel. This occurs because the bearing rollers do not travel at the same speed as the rear axle and the rear wheel. Raise the rear wheels and spin the rear wheels by hand. Listen at the rear wheel hubs for evidence of a rough or brinelled rear wheel bearing.

Differential Side Gear and Pinion Noise

Differential side gear movement is relatively slight on straight ahead driving and may seldom cause noise. Noise from the gears is most pronounced during turns.

In order to determine pinion bearing failures compare the bearings rotation at higher speeds to the differential side bearings and axle shaft bearings.

Rough or brinelled pinion bearings produce a continuous low-pitched whirring or scraping noise starting at a low speed.

Side bearings produce a constant rough noise pitched lower than pinion bearing noise. Side bearing noise may also fluctuate in the previous rear wheel bearing test.

Gear Noise

There are two basic types of gear noise. Broken, bent or damaged gear teeth produce the first type of noise. The gear noise is usually audible over the entire speed range and does not present a problem in diagnosis. Hypoid gear tooth scoring generally results from the following conditions:

- Insufficient lubricant
- Improper break-in
- Incorrect lubricant
- Insufficient gear backlash
- Improper differential drive pinion gear and ring gear alignment
- Loss of differential drive pinion gear nut torque

The scoring will progressively lead to the complete erosion of the gear tooth, or the gear tooth pitting. Fracture of the gear tooth will eventually occur if the scoring condition is not corrected.

Other causes of the hypoid tooth fracture include the following items:

- Extended overloading of the gear set — produces fatigue fracture
- Shock loading — results in sudden malfunction

Differential pinion gear and side gears normally do not fail. Common causes of differential malfunctions include the following conditions:

- Shock loading
- Extended overloading
- Seizure of the differential pinion gears to the cross shaft resulting from too much wheel spin and consequent lubrication breakdown

The second type of gear noise pertains to the mesh pattern of the gear teeth. This form of abnormal gear noise produces a cycling pitch (whine). The gear noise will be very pronounced at the speed range at which the noise occurs. This pitch (whine) appears under the following conditions:

- Drive
- Float — Lightly step on the accelerator pedal in order to keep the vehicle from driving the engine.

  The vehicle slows down gradually, but the engine still pulls slightly.
- Coast — Allows the vehicle to roll down the road without accelerating.

  Gear noise exhibits the following conditions:
  - Peaks in a narrow range or ranges
  - Remains in constant pitch

Bearing noise will vary in pitch with the vehicle speeds.

Noise Diagnosis

Noise in Drive

Problem	Action
The drive pinion to the ring gear has excessive backlash.	Adjust the drive pinion to ring backlash.
The drive pinion and the ring gear are worn.	Replace the drive pinion and ring set.
The drive pinion bearings are worn.	Replace the bearings.
The drive pinion bearings are loose.	Adjust the bearings.
The drive pinion has excessive end play.	Adjust the drive pinion end play.
The differential bearings are worn.	Replace the differential bearings.
The differential bearings are loose.	Adjust the bearings.
The rear axle lubricant is low.	Fill with synthetic rear axle lubricant.
The wrong rear axle lubricant is being used.	Replace the rear axle lubricant with the proper synthetic lubricant.
The rear axle housing is bent.	Replace the rear axle housing.

Noisy When Coasting

Problem	Action
Rear axle noises heard on drive will usually be heard also on coasting, although not as loud.	Adjust or replace the drive pinion and ring gear set.
The drive pinion gear and ring are too tight. Noise is audible when slowing down and disappears when driving.	Adjust the drive pinion to ring gear backlash.

Intermittent Noise

Problem	Action
The ring gear is warped.	Replace the differential drive pinion gear and ring gear set.
The differential case bolts are loose.	Tighten the differential case bolts.

Constant Noise

Problem	Action
A flat spot is on the drive gear or on the ring gear teeth.	Replace the differential drive pinion gear and ring gear set.
A flat spot is on the bearing.	Replace the bearing.
The differential drive pinion gear splines are worn.	Replace the differential drive pinion gear and ring gear set.
The rear axle (shaft) housing cover locator holes are worn.	Replace the rear axle shaft.
The wheel hole studs are worn.	Replace the wheel hub studs.
The rear axle shaft is bent.	Replace the rear axle shaft.

Noisy on Turns

Problem	Action
The differential side gears and the pinion gears are worn.	Replace the worn parts.
The differential spider is worn.	Replace the worn parts.
The rear axle shaft splines are worn.	Replace the rear axle shafts.

Two Speed Axle Fails to Shift into High or Low Range

Problem	Action
The electrical circuit is inoperative.	Repair the circuit.
The shift motor assembly is inoperative.	Repair or replace the shift motor assembly.

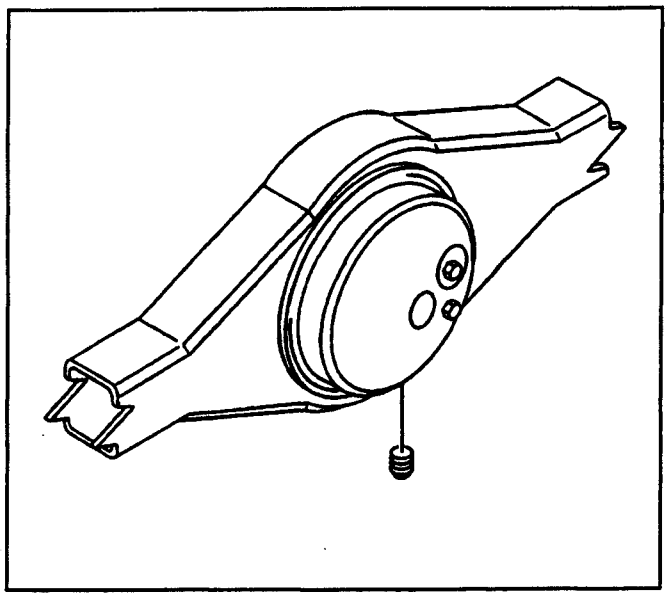
General Information (Axle Housing Alignment Diagnos)

For rear wheel bearing diagnosis information, refer to Wheel Bearing Test in Front Suspension.

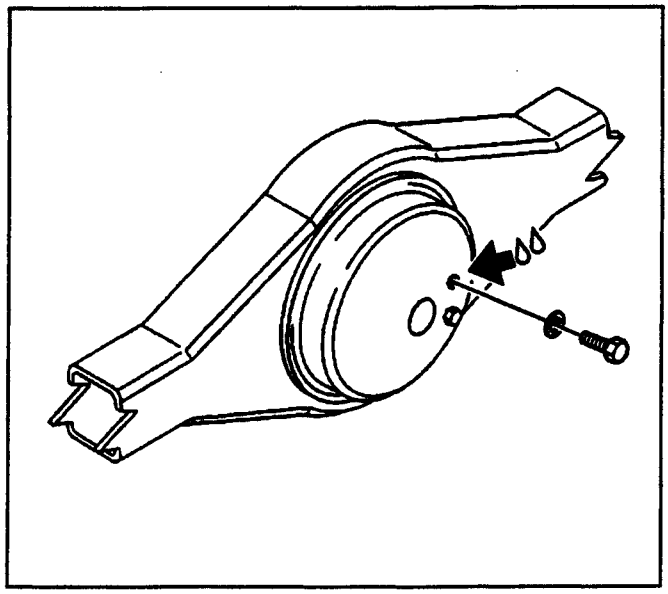
Replace the rear axle if any damage exists which affects the misalignment or the structural integrity of the rear axle housing. Do not weld or straighten the rear axle housing. This process may affect the rear axle housing metallurgy, and cause the rear axle housing to fail completely when under load.

General Information (Bent Axle Housing Check)

1. Block the front wheels.
2. Raise and support the rear axle housing using suitable jackstands.
3. Inspect the rear wheel bearing adjustment and the rear wheel mounting. Refer to *Wheel Bearing Adjustment.*
4. Place a chalk mark in the following locations:
   - On the outer side wall of both the outside rear tires.
   - At the bottom of the rear tires near the ground.
5. Measure across the rear tires at the chalk mark using a toe-in gauge. Record the reading.
6. Rotate the rear wheels in order to position the chalk marks at the top of the rear wheels.
7. Measure across the rear tires at the chalk mark using a toe-in gauge. Record the reading.
8. Compare the top measurement with the bottom measurement. Ensure that the measurements are the same within 3.2 mm (0.125 in).
   - If the top measurement is more than 3.2 mm (0.125 in) larger than the bottom measurement, the rear axle is bent at the ends.
   - If the top measurement is more than 3.2 mm (0.125 in) smaller than the bottom measurement, the rear axle housing has sagged.
9. Turn the rear wheels in order to position the chalk marks on both rear wheels are parallel to the ground (level with the rear axle housing) and facing toward the rear of the vehicle.
10. Measure across the rear tires at the chalk mark using a toe-in gauge. Record the reading.
11. Turn the rear wheels half way around in order to position the chalk marks are positioned parallel to the ground (level with the rear axle housing) and facing toward the front of the vehicle.
12. Measure across the rear tires at the chalk mark using the toe-in gauge. Record the reading.
13. Compare the front and rear readings. Ensure that the readings are the same within 3.2 mm (0.125 in).
    - If the rear measurement is more than 3.2 mm (0.125 in) greater than the front measurement, the rear axle housing is bent forward.
    - If the rear measurement is 3.2 mm (0.125 in) less than the front measurement, the rear axle housing is bent to the rear.



198572



198575

Repair Instructions

Lubricant Change

Removal Procedure

1. Apply the parking brake.
2. Block the wheels.

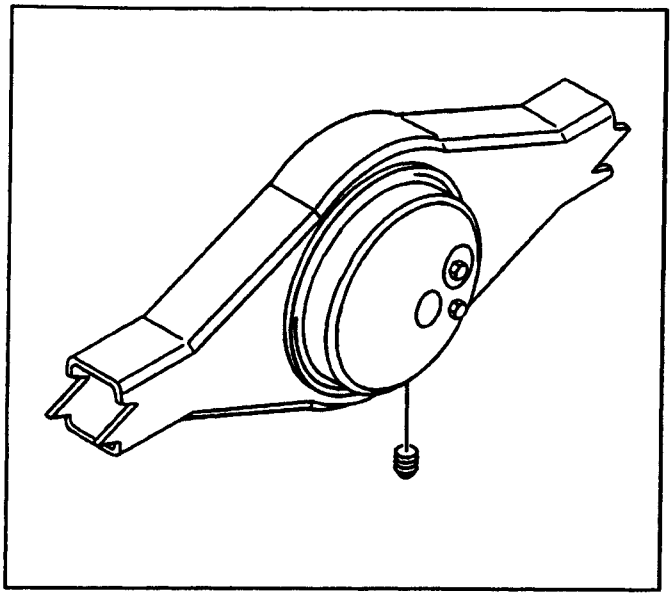
   Important:

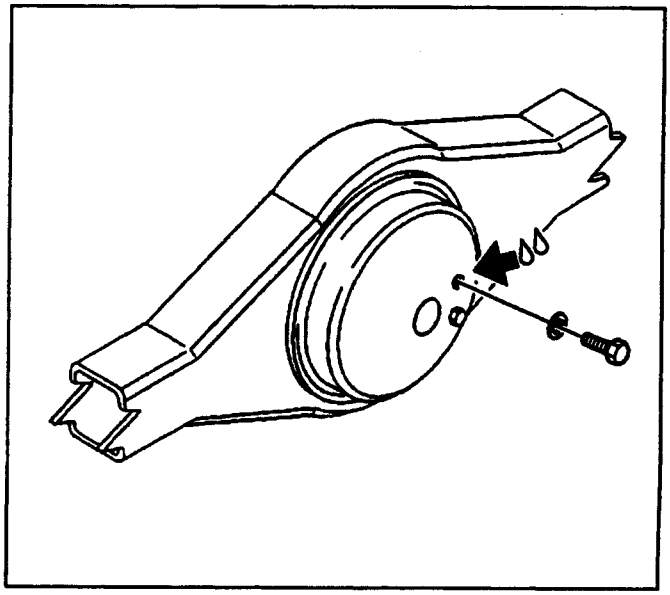
   - Drain the rear axle lubricant at normal operating temperature.
   - Drain the rear axle lubricant into a suitable container.
3. Remove the rear axle drain plug.
4. Inspect the rear axle housing drain plug for excessive metal particle accumulation. This accumulation is symptomatic of extreme wear.
5. Clean the drain plug.
6. Remove the rear axle housing top-off plug.

Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the rear axle housing drain plug.
   Tighten
   Tighten the rear axle housing drain plug to 70 N.m (52 lb ft).
   Notice: In cases where wheel equipment is being installed, either new or after maintenance activity, the rear wheel hub cavities are empty. Rear wheel bearings and seals must be manually supplied with adequate rear axle lubricant or they will be severely damaged before normal motion of the vehicle can supply the rear axle lubricant to the rear wheel hub cavities. To avoid the risk of premature damage to the rear wheel bearings and the rear wheel hub seals, they must be filled with rear axle lubricant any time the wheel equipment is being installed.
   Important: Ensure that the rear axle housing is level.
2. Install the rear axle lubricant. Refer to *Approximate Fluid Capacities* in General Information.
   - Fill the rear axle housing using rear axle lubricant until the lubricant is level with the bottom of the rear axle housing filler hole.
   - If the service has been performed at the rear wheels, fill the rear wheel hub cavities. Perform step 4 through step 10 if the rear wheel equipment has been serviced.
3. Install the rear axle housing top-off plug.
   Tighten
   Tighten the rear axle housing top-off plug to 67 N.m (49 lb ft).
4. Hand tighten the rear axle housing top-off plug.
5. Raise the left side of the rear axle housing a minimum of 152.4 mm (6 in). Maintain this position for one minute in order to allow the rear axle lubricant to flow into the right side rear axle hub cavity.
6. Lower the rear axle housing.
7. Raise the right side of the rear axle housing a minimum of 152.4 mm (6 in). Maintain this position for one minute in order to allow the rear axle lubricant to flow into the left side rear axle hub cavity.
8. Lower the rear axle housing.


198572


198575

9. Fill the rear axle housing using rear axle lubricant until the lubricant is level with the bottom of the rear axle housing filler hole.

   The rear axle housing requires approximately 1.5 L (1.58 qt) of additional rear axle lubricant.

10. Install the rear axle housing top-off plug.

    Tighten

    Tighten the rear axle housing top-off plug to 67 N.m (49 lb ft).

11. Remove the wheel blocks.

Differential Replacement

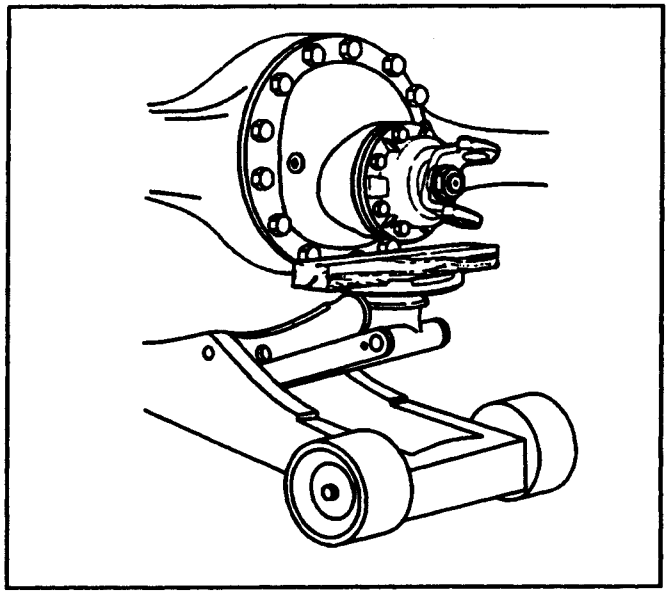
Removal Procedure

1. Inspect the rear axle housing for leaks and damage.
2. Clean the rear axle housing with steam.

   Important: Shift the two speed rear axle into LOW range, if equipped.

3. Apply the parking brake.
4. Block the wheels.
5. Remove the rear axle housing drain plug. Refer to *Lubricant Change*.
6. Remove the propeller shaft. Refer to the following list in order to select the correct replacement procedure:
   - If the propeller shaft is a one-piece 1410, 1480, or 1550 series with an Outboard Slip Joint, refer to *One-Piece Propeller Shaft Replacement (Full Yoke/229)*.
   - If the propeller shaft is a one-piece 1410, 1480, or 1550 series with an Inboard Slip Joint, refer to *One-Piece Propeller Shaft Replacement (Full Yoke/305)*.
   - If the propeller shaft is a one-piece 16N, 17N, 18N, 1710, 1760, or 1810 series with an Inboard Slip Joint, refer to *One-Piece Propeller Shaft Replacement (Half Yoke/229)*.
   - If the propeller shaft is a one-piece 16N, 17N, 18N, 1710, 1760, or 1810 series with a center bearing, refer to *One-Piece Propeller Shaft Replacement (Half Yoke/305)*.
   - If the propeller shaft is a one-piece 1480 or 1550 series with a center bearing, refer to *One-Piece Propeller Shaft Replacement (Outboard Slip/305)*.
   - If the propeller shaft is a one-piece 1410 series with a center bearing, refer to *One-Piece Propeller Shaft Replacement (Outboard Slip/229)*.
7. Remove the rear axle shafts. Refer to *Axle Shaft Replacement*.
8. Remove the shift motor assembly, if equipped. Refer to *Two Speed Rear Axle Shift Motor Replacement* in Rear Axle Controls.

9. Remove the following components from the differential carrier. DO NOT remove the top two fasteners.
   - The washers
   - The bolts
   - The stud nuts, if equipped.
10. Remove the differential carrier assembly.
    10.1. Support and secure the differential carrier to a floor jack.
    10.2. Remove the top two fasteners.
11. Clean the rear axle housing and the differential carrier mating surfaces.
12. Clean the rear axle housing bowl interior.
13. Dry the rear axle housing bowl immediately using clean cloths. Then dry the rear axle housing bowl using compressed air.
14. Inspect the rear axle housing for the following conditions:
    - Cracks
    - Loose studs
    - Nicks
    - Burrs



198566

Installation Procedure

Important:

- Apply a 3.17 mm (0.125 in) diameter bead completely around the rear axle housing differential carrier mating surface and around each threaded hole and stud.
- Install the differential carrier and fasteners within 20 minutes (before the silicone sealer sets).

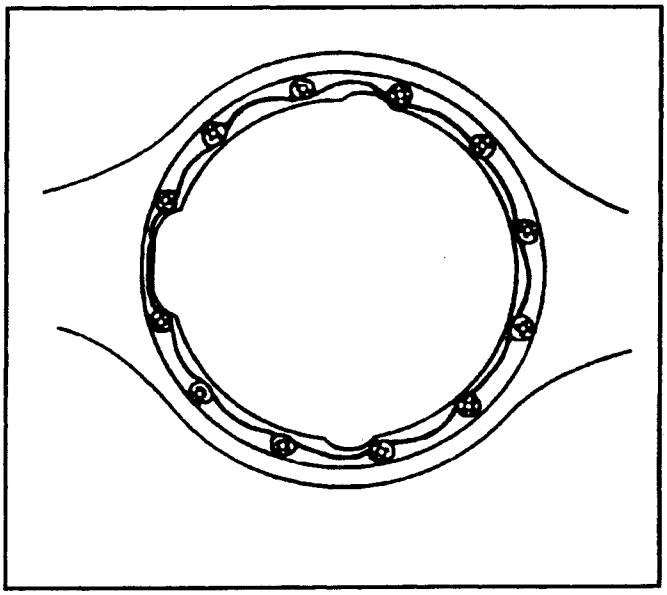
1. Install the Silicone Sealer (RTV).
2. Install the four temporary alignment studs, if needed.
3. Install the differential carrier.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.

   Important:
   - Ensure that the threads are clean and free of grease.
   - Apply 272 Threadlocker GM P/N 12345493 or equivalent to the threads of each differential carrier bolt.
4. Install the following components to the differential carrier:
   - The washers
   - The bolts
   - The nuts, if equipped.

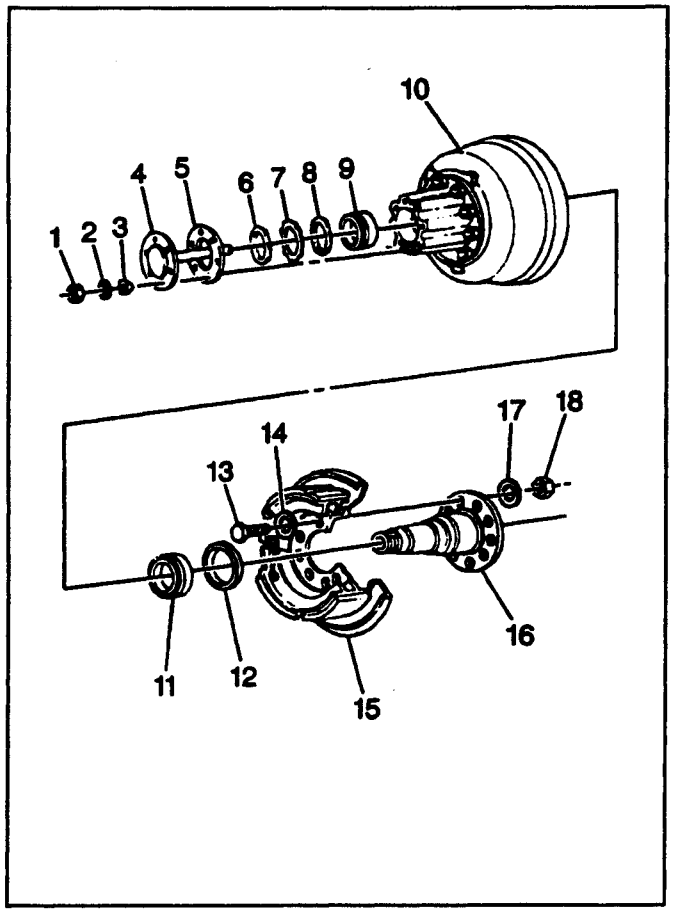
   Tighten

   Tighten the differential carrier bolts and nuts to the torques listed in Fastener Tightening Specifications.



198568

5. Install the propeller shaft.
6. Install the shift motor assembly, if equipped.
7. Install the rear axle shafts.
8. Install the rear axle lubricant. Refer to *Lubricant Change.*
9. Remove the wheel blocks.



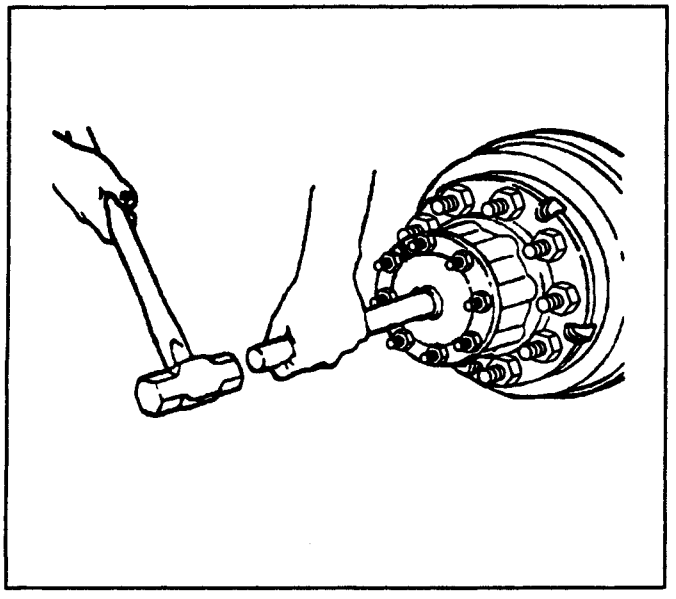
198550

Axle Shaft Replacement

Removal Procedure

1. Remove the nuts (1,18).
2. Remove the flat washers (2,17).

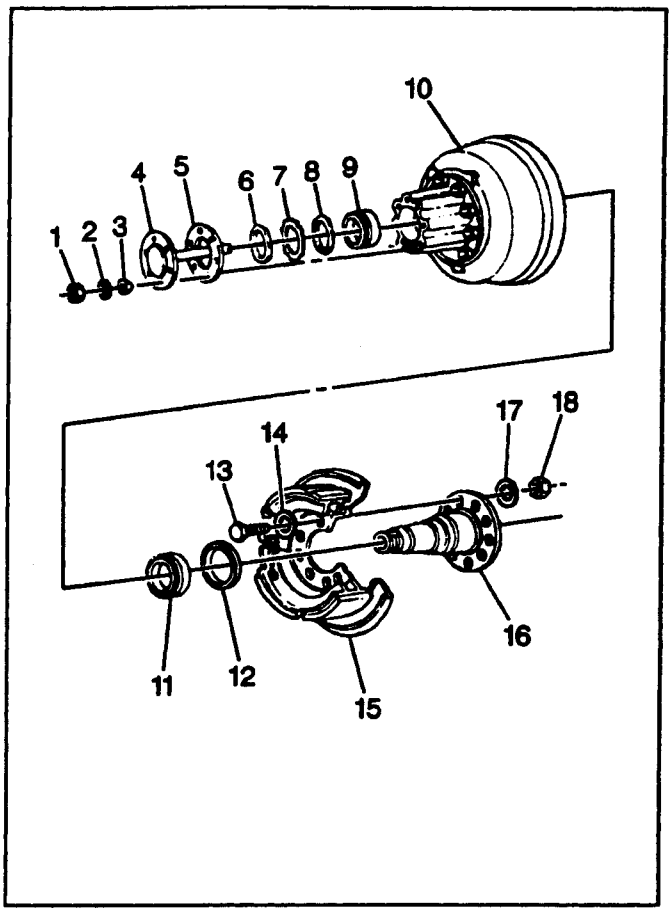
   Notice: Do not strike the axle shaft flange with a hammer. This may damage the shaft. Do not use a chisel or a wedge to loosen the shaft or locators. This will damage the hub, the shaft and the rear wheel bearing seals.
3. Remove the locators (3).



198557

4. Hold a brass drift against the center of the axle shaft flange.
5. Strike he drift a blow using a 2.3 kg (5 lb) hammer.

6. Remove the rear axle shaft (4).
7. Remove the gasket (5).



198550

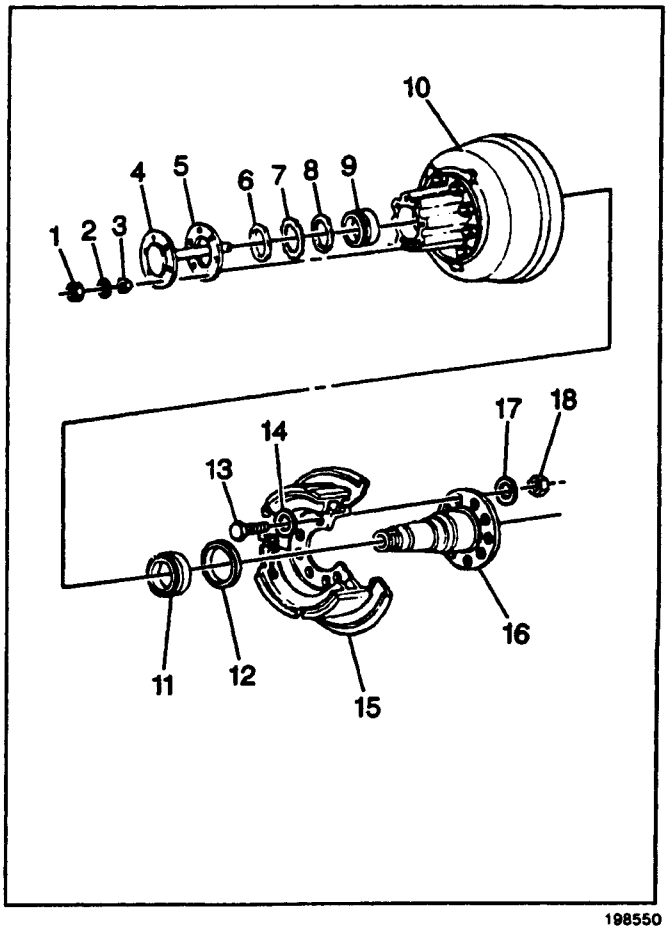
Installation Procedure

1. Install the new gasket (5).
2. Install the axle shaft (4).
   2.1. Dip the splined end in synthetic lubricant before installing. Refer to *Approximate Fluid Capacities* in Maintenance and Lubrication.
   2.2. Rotate the axle shaft as needed in order to align the axle shaft flange holes with the studs.
3. Install the locators (3).
4. Install the flat washers (2).

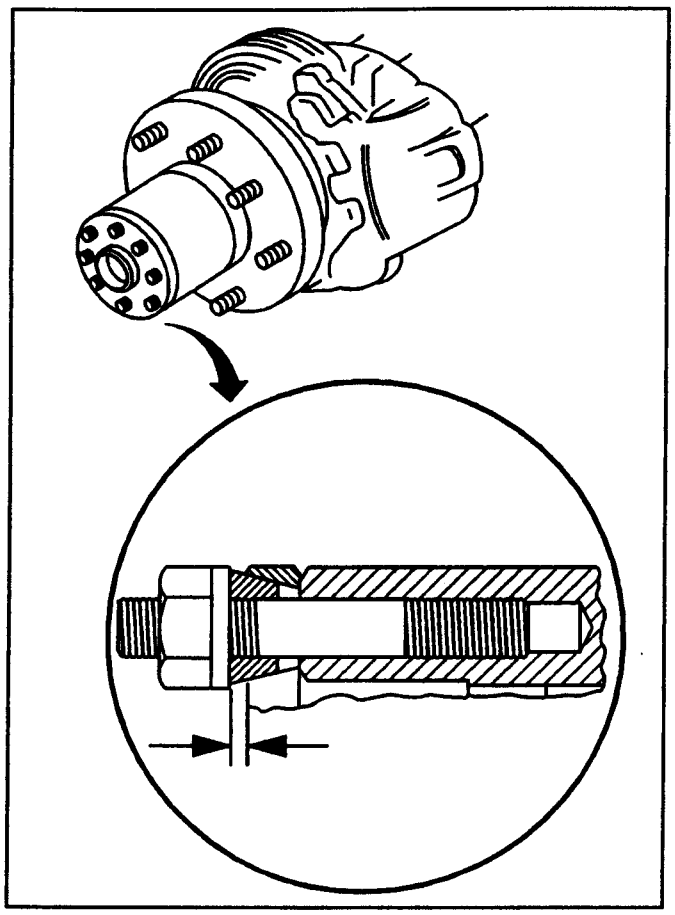
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
5. Install the nuts (1,18).

   Tighten

   - Tighten the nuts (12 stud rear axle) to 77 N.m (57 lb ft).
   - Tighten the nuts (8 stud rear axle) to 155 N.m (114 lb ft).



198550



198562

Important: Ensure that clearance is present between the flat washers and the axle flange. If the flat washers contact the axle flange, remove the axle shaft. Inspect and replace the faulty parts.

6. Inspect for clearance between the axle shaft flange and the flat washers.

Drive Pinion Yoke Replacement (Input Yoke)

Removal Procedure

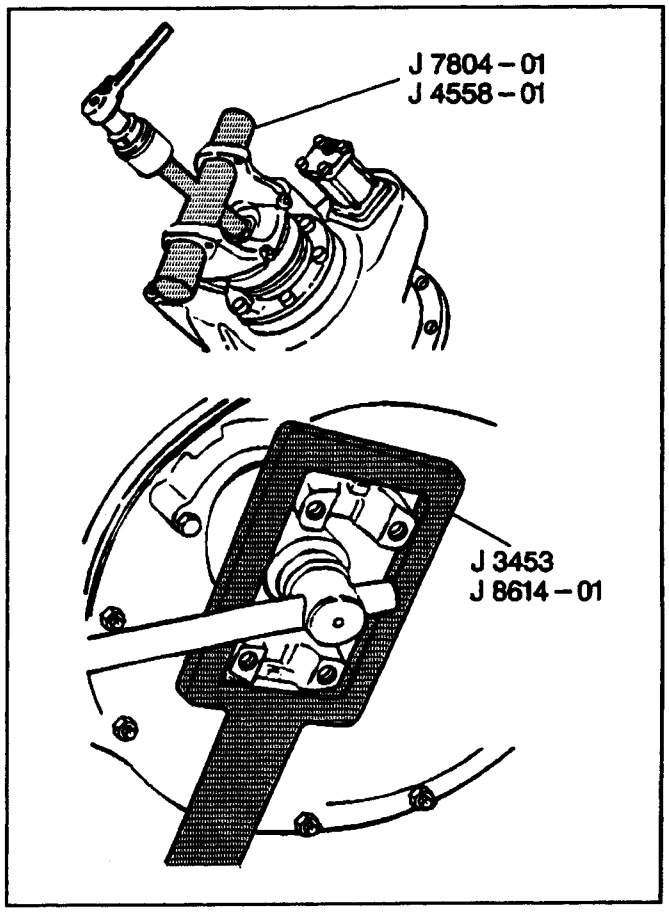
Tools Required

- *J 7804-01* or *J4558-01* Puller
- *J 3453* or *J 8614-01* Holding Bar

1. Remove the rear axle propeller shaft.
2. Refer to the following list in order to select the correct replacement procedure:
   - If the propeller shaft is a one-piece 1410, 1480, or 1550 series with an Outboard Slip Joint, refer to *One-Piece Propeller Shaft Replacement (Full Yoke/229)*.
   - If the propeller shaft is a one-piece 1410, 1480, or 1550 series with an Inboard Slip Joint, refer to *One-Piece Propeller Shaft Replacement (Full Yoke/305)*.
   - If the propeller shaft is a one-piece 16N, 17N, 18N, 1710, 1760, or 1810 series with an Inboard Slip Joint, refer to *One-Piece Propeller Shaft Replacement (Half Yoke/229)*.
   - If the propeller shaft is a one-piece 16N, 17N, 18N, 1710, 1760, or 1810 series with a center bearing, refer to *One-Piece Propeller Shaft Replacement (Half Yoke/305)*.

- If the propeller shaft is a one-piece 1480 or 1550 series with a center bearing, refer to *One-Piece Propeller Shaft Replacement (Outboard Slip/305).*
- If the propeller shaft is a one-piece 1410 series with a center bearing, refer to *One-Piece Propeller Shaft Replacement (Outboard Slip/229).*

3. Remove the inter-axle differential input shaft nut and washer, if equipped.
4. Remove the input yoke.
5. Remove the drive pinion seal.
6. Inspect the input yoke seal surface for damage or scoring. If the seal surface is damaged, replace the input yoke.

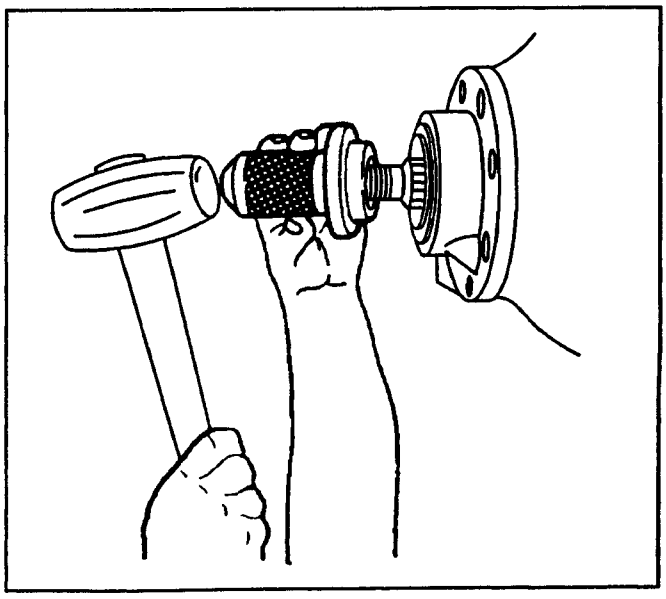


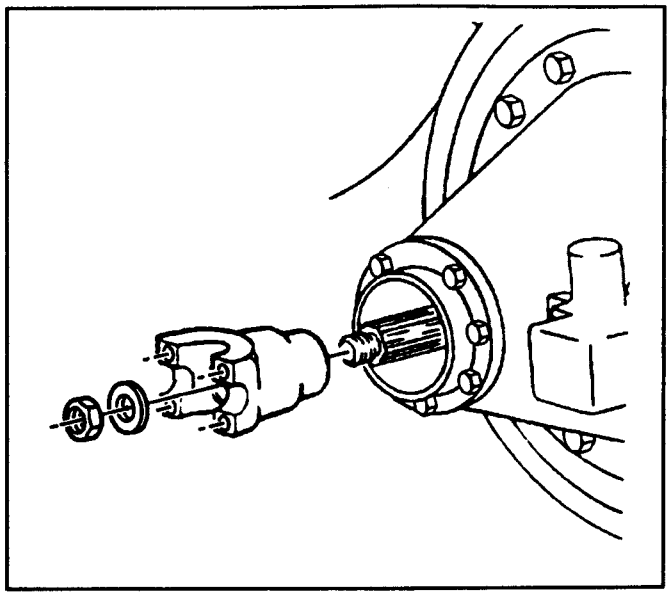
198583

Installation Procedure

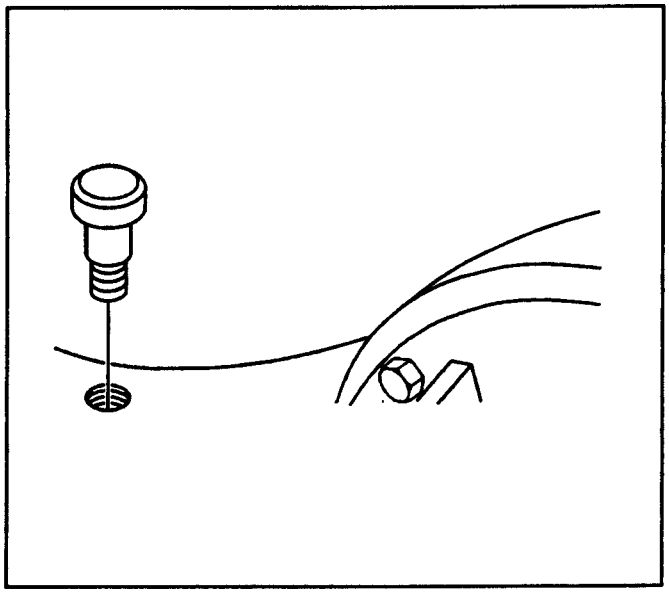
Important: Lubricate the new inter-axle differential input shaft seal lip with the rear axle lubricant. For rear axle lubricant specifications, refer to *Fluid and Lubricant Recommendations* in Maintenance and Lubrication.

1. Install the drive pinion seal.


198589



198587



198678

2. Install the input yoke.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.

   Important:

   - Ensure that the threads are clean and free of grease.
   - Apply 272 Threadlocker GM P/N 12345493 or equivalent to the threads of the inter-axle differential input shaft nut.

3. Install the washer, if equipped, and the new inter-axle differential input shaft nut.

   Tighten

   Tighten the drive pinion nut to the torque listed in *Fastener Tightening Specifications.*

4. If a new inter-axle differential input shaft nut with pre-applied threadlocker is unavailable, reuse the original inter-axle differential input shaft nut under the following conditions:
   - The nut is in good condition.
   - The threadlocker is applied.
5. Remove the wheel blocks.

Vent Hose Replacement

Removal Procedure

Remove the rear axle vent.

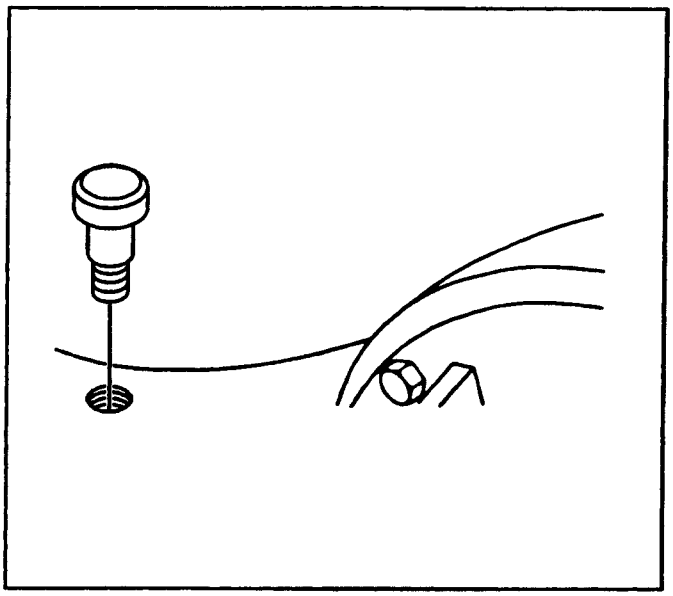
Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

Install the rear axle vent.

Tighten

Tighten the rear axle vent to 14 N·m (124 lb in).



198678

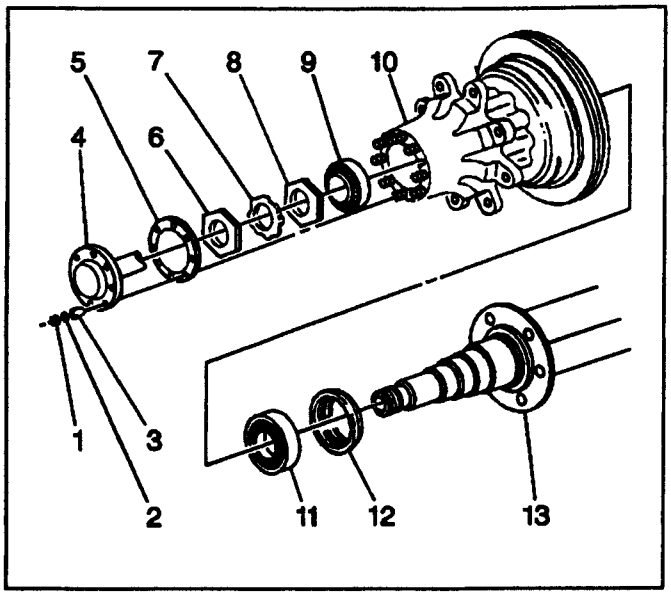
Rear Hub and Bearing Replacement (Hub and Bearing)

Removal Procedure

Caution: When servicing brake parts, do not create dust by grinding or sanding brake pads, by cleaning brake parts with a dry brush or with compressed air. Many earlier models or aftermarket brake parts may contain asbestos fibers which can become airborne if dust is created during servicing. Breathing dust containing asbestos fibers may cause serious bodily harm. A water dampened cloth or water based solution should be used to remove any dust on brake parts. Equipment is commercially available to perform this washing function. These methods will prevent fibers from becoming airborne.

Important: Ensure that the vehicle rear wheel on the service side is off of the floor.

1. Block the front wheels.
2. Raise the rear axle and place the supports under the frame rails. Ensure that the vehicle rear wheels are off the floor.
3. Release the parking brake.
4. Remove the rear tire and wheel assembly. Refer to *Wheel Removal (Dual/Rear)* in Tires and Wheels.
5. Remove the rear axle shaft. Refer to *Differential Replacement.*
6. Remove the rear brake drum, if equipped.



198681

7. Remove the following components from the rear wheel bearing:
   - The outer nut (6)
   - The nut lock (7)
   - The rear bearing inner nut (8)
8. Remove the rear hub assembly or hub/rotor assembly (10).
9. Remove the rear wheel bearing outer cone assembly (9).
10. Remove the following components:
    - The rear wheel bearing seal (12)
    - The rear wheel bearing inner cone assembly (11)

    Notice: Clean rear wheel bearing cones in clean mineral spirits. Do not spin-dry. Rear wheel bearing cones can be damaged by use of wrong cleaning solvents and rough handling.
11. Clean the rear wheel bearing cones and the rear hub using clean mineral spirits.
12. Clean the rear brake rotor, if equipped, and the rear axle housing spindle. Use Brake Parts Cleaner GM P/N 12345754 or equivalent.
13. Inspect the rear wheel hub. Replace the hub, if damaged.
14. Inspect the rear wheel stud for looseness and damaged threads.
15. Inspect the rear wheel bearing for the following conditions:

    Refer to *Wheel Hub, Bearing, and Seal Replacement (Drum Brakes)* in Front Suspension.
    - Wear
    - Chipped edges
    - Flat spots
16. Inspect the rear wheel bearing cups for cracks and pits. Refer to *Wheel Hub, Bearing, and Seal Replacement (Drum Brakes)* in Front Suspension.
17. Inspect the rear axle spindle for damage.
18. Inspect the rear wheel hub bearing seal retainer. Replace the retainer, if damaged. Refer to *Wheel Hub, Bearing, and Seal Replacement (Drum Brakes)* in Front Suspension.
19. Inspect the rear axle (shaft) flange studs for damaged threads and bends.
20. Inspect the rear brake rotor or rear drum brake for scoring. Refer to Brake Rotor Tolerance or Brake Drum Inspection in Brakes.

Installation Procedure

- *J41107* Oil Seal Installation Kit
- *J 8092* Driver Handle
- *551-5386* or *551-5318* Fleet Hub Tool

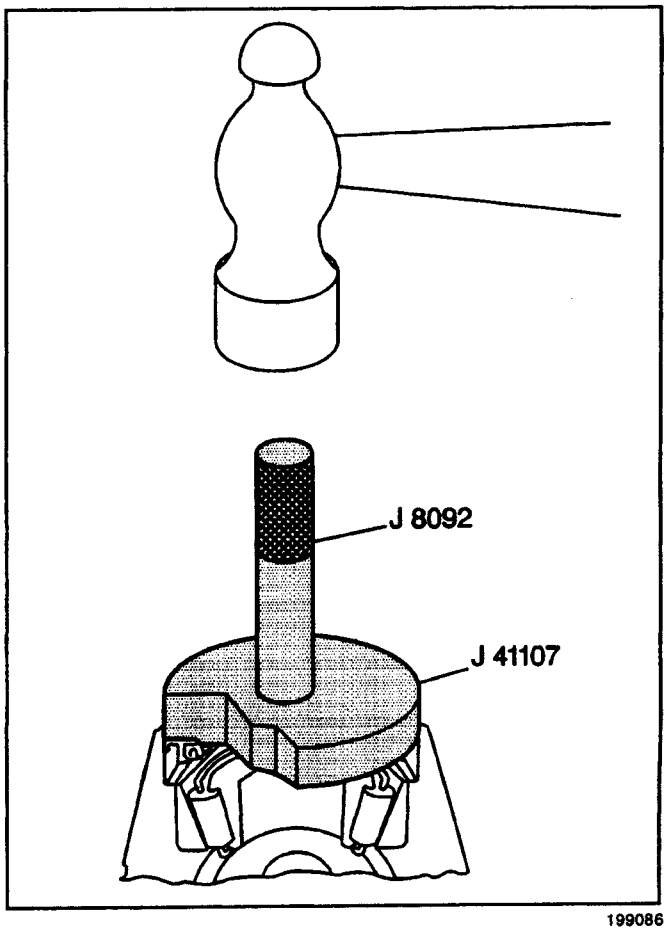
1. Install the synthetic lubricant in the following locations:
   - The bearings
   - The rear axle housing tube
   - The inside of the wheel hub
   - The rear wheel hub bearing seal lip
   - The rear axle spindle seal lip contact surface
   - The rear wheel hub bearing inner cone assembly

   Important: When installing the new rear wheel bearing inner cone, always replace the rear wheel bearing inner cup.
2. Install the rear wheel bearing inner cone. Refer to *Rear Hub and Bearing Replacement (Wheel Bearing Cup).*
3. Apply Silicone Sealer (RTV) or equivalent to the OD of the rear wheel bearing seal. The silicone sealer will overcome minor faults in the rear wheel bearing seal bore.

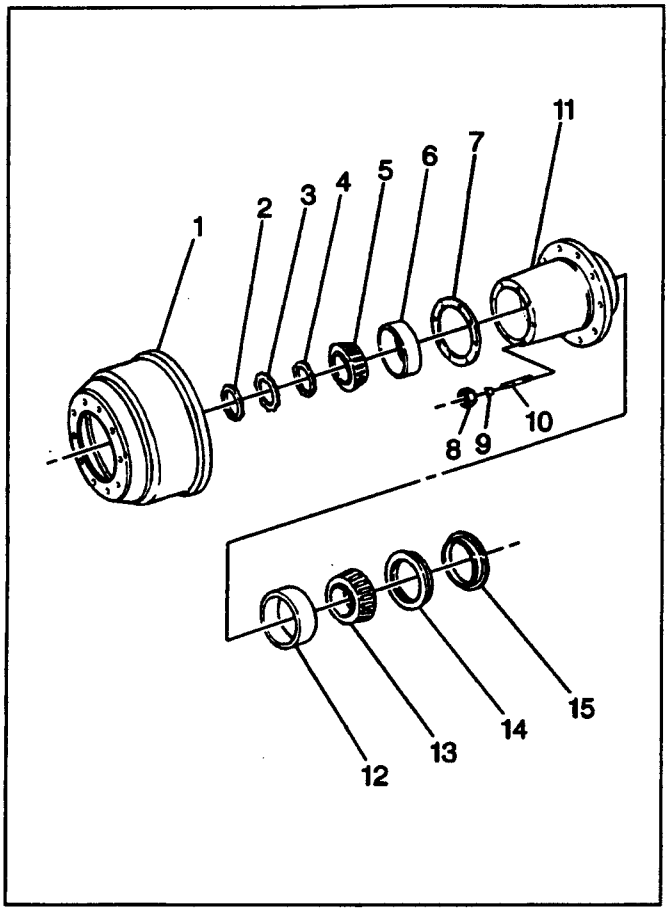
Notice: Do not continue to hammer after rear wheel hub bearing seal has bottomed evenly all around, as this will cause damage to the rear wheel hub bearing seal.

4. Install the rear wheel bearing seal. Perform the following steps:
   - 4.1. Ensure that the rear wheel hub bearing seal lip faces inward.
   - 4.2. Use the *J41107* and the *J 8092* on the standard rear wheel hub bearing seal.
   - 4.3. Use the *551-5386* or the *551-5318* on the G98 rear wheel hub bearing seal option.
   - 4.4. Hold the tool handle vertical. Strike a sharp blow with the hammer in order to start the rear wheel hub bearing seal into the rear wheel hub bore.
   - 4.5. Tap the rear wheel hub bearing seal down into place.
5. Install the rear hub assembly. Do not damage the rear wheel bearing seal.

   Important: When installing a new rear wheel bearing outer cone, always replace the rear wheel bearing outer cup. Refer to *Rear Hub and Bearing Replacement (Wheel Bearing Cup).*
6. Install the rear wheel bearing outer cone. Push the cone firmly into place.

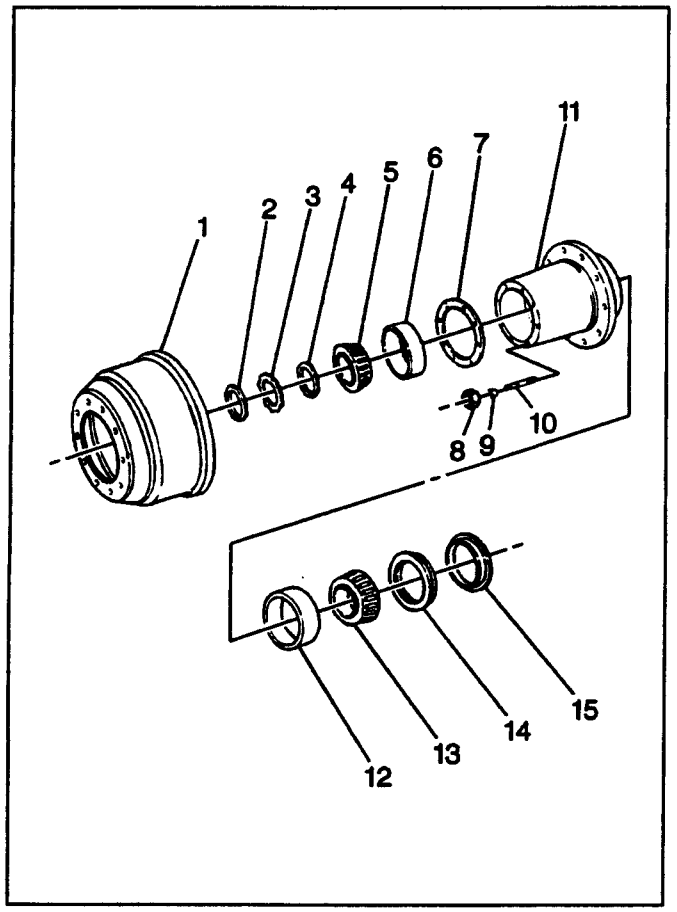


199086



199065

7. Install the following rear wheel bearing components:
   7.1. The inner adjust nut.
   7.2. The adjust nut lock.
   7.3. The outer adjust nut.
8. Install the rear brake drum, if equipped.
9. Install the rear tire and wheel assembly.
10. Adjust the rear wheel bearings. Refer to *Wheel Bearing Adjustment.*
11. Install the rear axle shaft.
12. Adjust the drum brakes, if equipped. Refer to Air Drum Brake Adjustment in Brakes.



199065

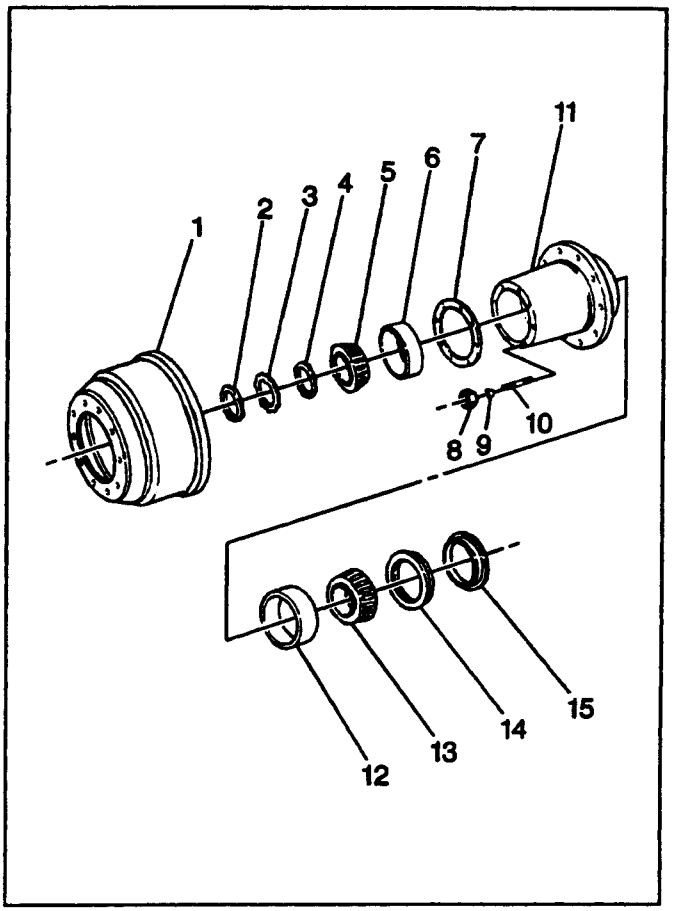
Rear Hub and Bearing Replacement (Wheel Bearing Cup)

Removal Procedure

1. Remove the rear wheel hub. Refer to *Rear Hub and Bearing Replacement (Hub and Bearing).*
2. Remove the rear wheel bearing cup (12).
   Alternately tap on the opposite sides of the rear wheel bearing cup inner edge until the bearing cup is free from the wheel hub. Use a brass drift and a small hammer.

Installation Procedure

1. Install the rear wheel bearing cup. Position the rear wheel bearing cup in the rear wheel hub.
2. Alternately tap on the opposite sides of the rear wheel bearing cup in order to drive the bearing cup in squarely. Use a brass drift and a small hammer.
3. Ensure that the rear wheel bearing cup seats firmly against the hub shoulder.
4. Install the rear wheel hub.



199065

Rear Hub and Bearing Replacement (Wheel Bearing Seal)

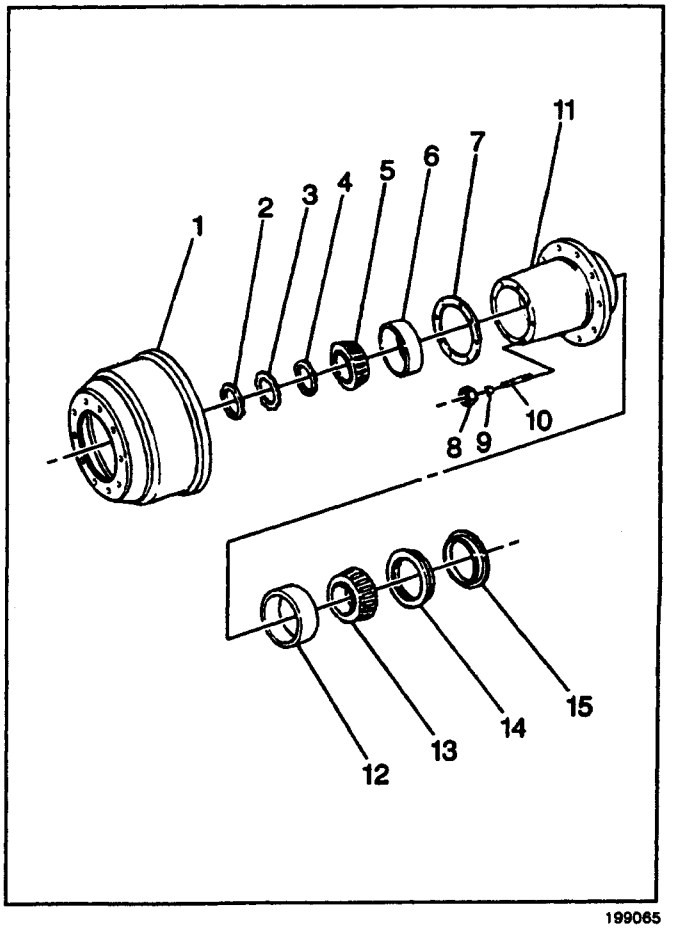
For on-vehicle service of the rear wheel hub bearing seal.

Removal Procedure

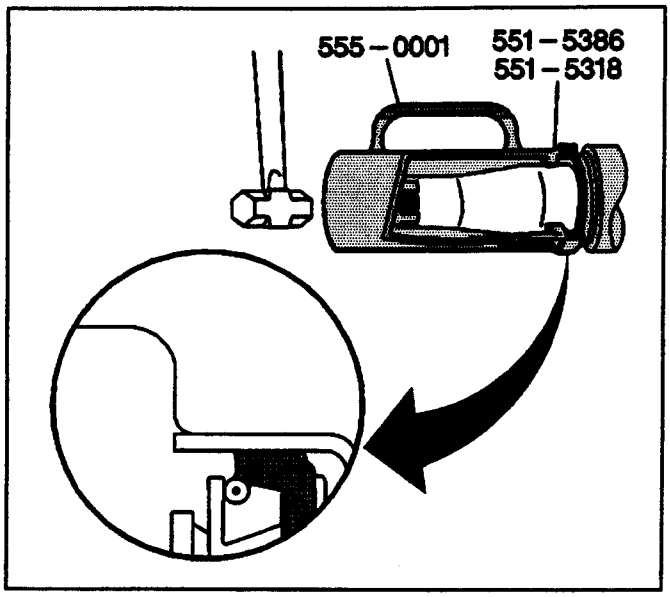
Tools Required

- *555-0001* Universal Tool Body
- *551-5386* or *555-5076* Tool Head

1. Remove the rear wheel hub (11). Refer to *Rear Hub and Bearing Replacement (Hub and Bearing).*
2. Remove the rear wheel hub bearing seal retainer (15).
   2.1. Tap around the outside diameter of the seal retainer (15) with a hammer in order to stretch the metal.
   2.2. Use a blunt chisel in order to cut into the rear wheel bearing seal retainer inner flange. The rear wheel bearing seal retainer will be loose enough for removal.
3. Clean the spindle shoulder and threads. Use Brake Parts Cleaner.
4. Remove the burrs from the spindle shoulder.



199065



199089

Installation Procedure

1. Apply Silicone Sealer (RTV) to the spindle shoulder.
2. Install the new rear wheel bearing seal retainer onto the spindle shoulder.
   2.1. Place the rear wheel bearing seal retainer and tool on to the rear axle spindle.
   2.2. Tap the end of the tool until the rear wheel bearing seal retainer contacts the rear axle spindle shoulder.
   2.3. Rotate the tool and tap several times in order to ensure complete bottoming of the rear wheel bearing seal retainer.
   2.4. Wipe off the excess sealer.
3. Ensure that the edge of the rear wheel bearing seal retainer is parallel and flush with the rear axle spindle shoulder face.
4. Install the rear wheel hub.

Axle Housing Replacement

Removal Procedure

Caution: When servicing brake parts, do not create dust by grinding or sanding brake pads, by cleaning brake parts with a dry brush or with compressed air. Many earlier models or aftermarket brake parts may contain asbestos fibers which can become airborne if dust is created during servicing. Breathing dust containing asbestos fibers may cause serious bodily harm. A water dampened cloth or water based solution should be used to remove any dust on brake parts. Equipment is commercially available to perform this washing function. These methods will prevent fibers from becoming airborne.

1. Block the front wheels.
2. Raise and support the vehicle under the frame rails. Ensure that the vehicle rear wheels are off the floor.
3. Release the parking brake.
4. Remove the rear tire and wheel assemblies. Refer to *Wheel Removal (Dual/Rear)* in Tires and Wheels.
5. Remove the rear axle lubricant. Refer to *Lubricant Change.*
6. Remove the propeller shaft. Refer to the following list in order to select the correct replacement procedure:
   - If the propeller shaft is a one-piece 1410, 1480, or 1550 series with an Outboard Slip Joint, refer to *One-Piece Propeller Shaft Replacement (Full Yoke/229).*
   - If the propeller shaft is a one-piece 1410, 1480, or 1550 series with an Inboard Slip Joint, refer to *One-Piece Propeller Shaft Replacement (Full Yoke/305).*

- If the propeller shaft is a one-piece 16N, 17N, 18N, 1710, 1760, or 1810 series with an Inboard Slip Joint, refer to *One-Piece Propeller Shaft Replacement (Half Yoke/229)*.
- If the propeller shaft is a one-piece 16N, 17N, 18N, 1710, 1760, or 1810 series with a center bearing, refer to *One-Piece Propeller Shaft Replacement (Half Yoke/305)*.
- If the propeller shaft is a one-piece 1480 and 1550 series with a center bearing, refer to *One-Piece Propeller Shaft Replacement (Outboard Slip/305)*.
- If the propeller shaft is a one-piece 1410 series with a center bearing, refer to *One-Piece Propeller Shaft Replacement (Outboard Slip/229)*.

7. Remove the rear air brake lines, if equipped. Refer to Air Brakes in Brakes.
8. Remove the shift motor assembly, if equipped. Refer to *Two Speed Rear Axle Shift Motor Replacement* in Rear Axle Controls.
9. Cage the spring brake chambers, if equipped. Refer to Leaf Spring Removal in Brakes.
10. Remove the rear brake drum, if equipped.
11. Remove the rear hub assemblies. Refer to *Rear Hub and Bearing Replacement (Hub and Bearing)*.
12. Remove the rear brake caliper mounting plate, if equipped.
13. Remove the rear cam brake assembly, if equipped. Refer to Air Brakes in Brakes.
14. Remove the wiring attached to the rear axle housing.
15. Remove the rear axle tie rod, if equipped. Refer to Rear Suspension.
16. Remove the rear axle control arms (air suspension only). Refer to Air Suspension.
17. Remove the rear shock absorber from the rear shock absorber lower bracket. Refer to *Shock Absorber Replacement* in Rear Suspension.
18. Remove the following components:
    - The nuts
    - The washers
    - The U-bolts
19. Remove the rear shock absorber lower bracket, if equipped. Refer to *Shock Absorber Replacement* in Rear Suspension.
20. Remove the rear spring anchor plate bracket. Refer to *Leaf Spring Replacement* in Rear Suspension.
21. Remove the rear axle housing from the suspension.
    21.1. Support the axle. Use a hydraulic transmission dolly with adapters in order to properly handle the axle housing.
    21.2. Fasten a chain over the top of the housing and to both sides of the dolly.
22. Remove the differential carrier. Complete the following steps:
    22.1. Set the rear axle housing on an axle stand with the differential carrier facing up.
    22.2. Remove the following differential carrier components:
    - The bolts
    - The nuts, if equipped
    - The washers

    22.3. Strike the differential carrier housing using a rubber mallet in order to break the seal.
    22.4. Lift the differential carrier from the rear axle housing. Use a chain lift or equivalent.
23. Clean the differential carrier seal surface.
24. Clean the rear brake drum or rear bake rotor, and rear brake assemblies using brake parts cleaner.
25. Clean the rear wheel bearings. Refer to *Rear Hub and Bearing Replacement (Hub and Bearing)*.
26. Inspect the new rear axle housing for the following conditions:
    - Damaged threads
    - Cracked welds
    - Damaged flanges

Installation Procedure

1. Install the differential carrier. Refer to *Differential Replacement*.
    - Lift the differential carrier, then lower the carrier onto the rear axle housing.
    - Use a chain lift or equivalent.
2. Install the rear axle assembly to the suspension.
    - Support the rear axle housing using a hydraulic transmission dolly with adapters in order to properly handle the rear axle housing.
    - Fasten a chain over the top of the rear axle housing and to both sides of the dolly.
3. Install the rear spring anchor plate bracket.
4. Install the rear shock absorber lower bracket, if equipped.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
5. Install the following components:
    - The U-bolts
    - The washers
    - The nuts

    Tighten

    For U-bolt tightening procedures, refer to *Fastener Tightening Specifications*.
6. Install the rear shock absorber to the rear shock absorber lower bracket.

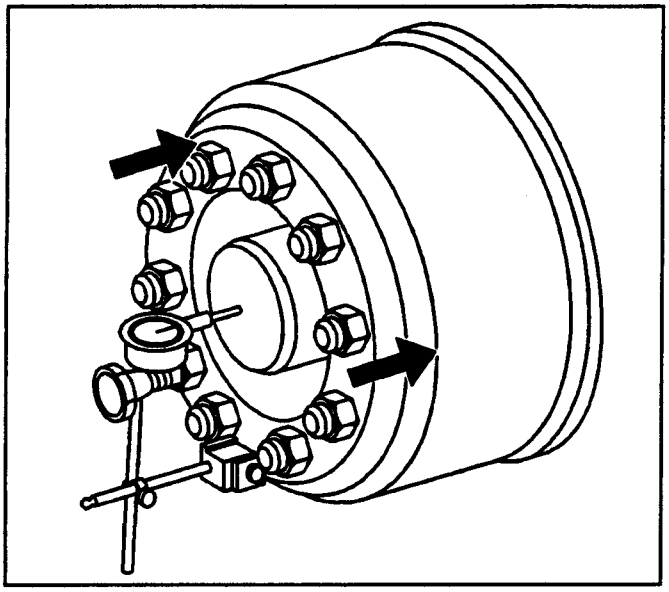
7. Install the rear suspension control arms (air suspension only).
8. Install the rear axle tie rod, if equipped.
9. Install the wiring to the rear axle housing.
10. Install the rear cam brake assembly, if equipped.
11. Install the rear brake caliper mounting plates, if equipped.
12. Install the rear hub assemblies.
13. Install the rear brake drum, if equipped.
14. Uncage the spring brake chambers, if equipped.
15. Install the differential lock air line, if equipped.
16. Install the shift motor assembly, if equipped.
17. Install the air brake lines, if equipped.
18. Install the propeller shafts.

    Important: Add 0.94 liters (1 quart) to the power divider of the tandem axle front unit, if equipped.
19. Install the rear axle lubricant. Refer to *Lubricant Change*.
20. Install the rear tire and wheel assemblies.
21. Inspect for air leaks. Refer to Air Leak Test in Brakes.
22. Verify proper brake operation.
23. Remove the wheel blocks.

Wheel Bearing Adjustment

Removal Procedure

1. Block the front wheels.
2. Raise the rear axle and place the jack stands under the frame rails. Ensure that the vehicle rear wheels are off the of the floor.
3. Release the parking brake.
4. Remove the axle shafts. Refer to *Axle Shaft Replacement*.
5. Use a pry bar in order to move the tire assembly up and down. Observe the following notes:
   - If the rear wheel bearings are properly adjusted, the rear wheel bearing end play should be 0.025–0.178 mm (0.001–0.007 in).
   - The movement of the rear wheel hub in relation to the backing plate or spider assembly will be barely noticeable and the rear wheel will turn freely.
   - If the adjustment is within specification, go to step 3 of the Installation procedure.
   - If the movement is excessive, adjust the rear wheel bearings using all of the following steps.
6. Remove the rear wheel bearing (outer) adjust nut and the rear wheel bearing adjust nut lock.



199108

7. Loosen the rear wheel bearing (inner) adjust nut.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.

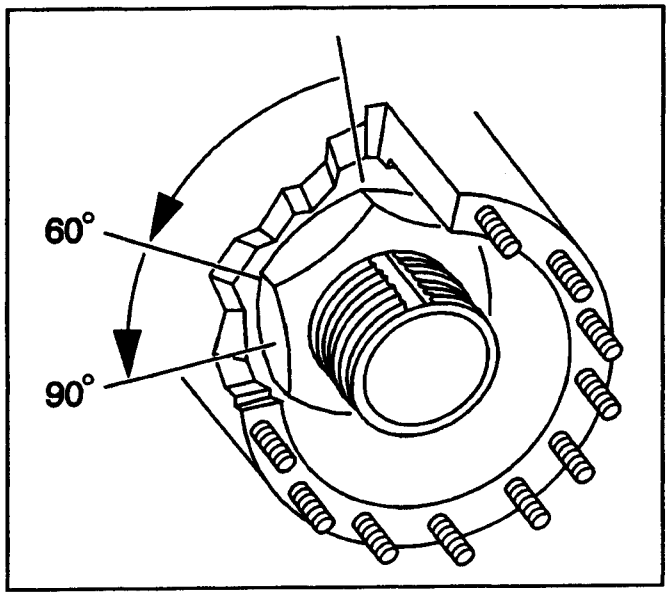
   Important: Rotate the rear tire and wheel assembly while tightening the rear wheel bearing (inner) adjust nut in order to ensure proper seating of the rear wheel bearings.

8. Rotate the rear tire and wheel assembly.

   Tighten

   Tighten the rear wheel bearing (inner) adjust nut to 68 N·m (50 lb ft).

9. Back off the rear wheel bearing (inner) adjust 60–90 degrees (1/6 to 1/4 turn).



199114

Installation Procedure

1. Install the rear wheel bearing adjust nut lock.

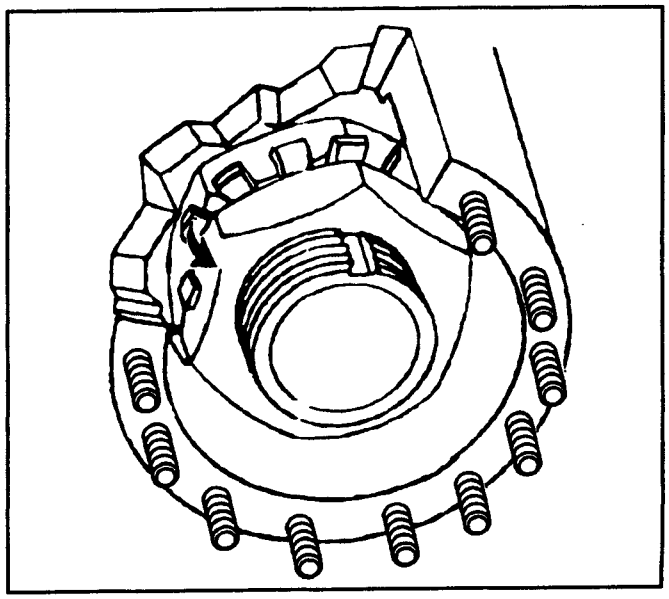
   Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the rear wheel bearing (outer) adjust nut.

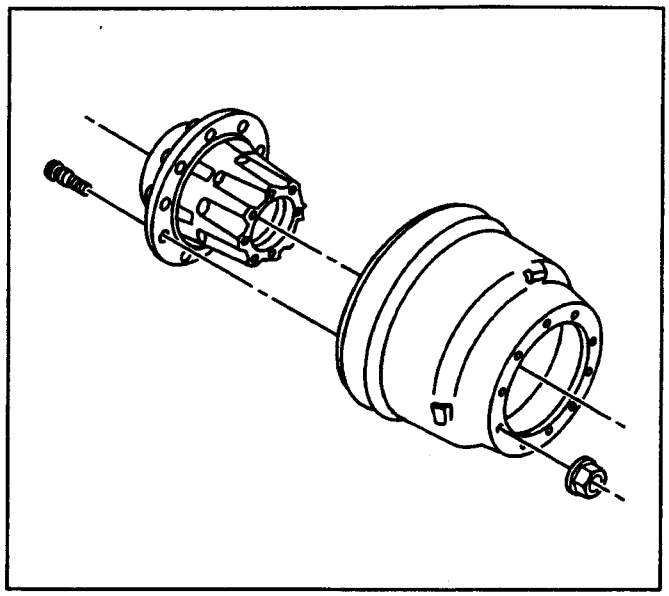
   Tighten

   Tighten the rear wheel bearing (outer) adjust nut to 169 N·m (125 lb ft).

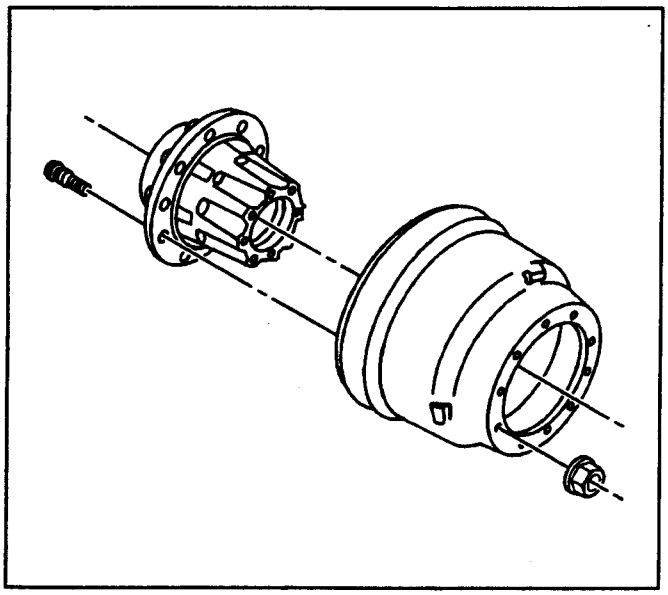
3. Bend one tang of the rear wheel bearing adjust nut lock over the flat of each rear wheel bearing adjust nut.
4. Lower the rear axle housing.
5. Install the rear axle shafts.



199117



199099



199099

Wheel Hub Bolt Replacement

Removal Procedure

Caution: If any wheel stud is damaged, all wheel studs should be replaced. A loose running wheel may cause only one wheel stud to break, but the other wheel studs could have internal fatigue. Replace only the broken wheel stud and remounting the wheel may cause further damage and personal injury. If the wheel stud holes in the wheels have become enlarged or distorted, replace the wheel.

1. Remove the rear wheel hub. Refer to *Rear Hub and Bearing Replacement (Hub and Bearing)*.
2. Remove the rear wheel hub bolts using a suitable press.

Installation Procedure

1. Install the rear wheel hub bolts using a suitable press.
2. Press the new rear wheel hub bolt threads into place during installation.
3. Do not damage the rear wheel hub bolt threads during installation.

   Ensure that the wheel hub bolts are a tight fit into the rear wheel hub.

Description and Operation

Rear Axle Description (Single-Speed Axles)

The single speed rear axles are composed of the following two main components:

- The rear axle housing
- The differential carrier assembly

The banjo-type rear axle housing carries the weight of the vehicle. The rear axle housing provides a machined spindle surface for the rear wheel bearings. The rear wheel hubs rotate on the rear wheel bearings, allowing the rear axle shafts to float within the rear axle housing.

The differential carrier assembly performs the following two functions:

- Changes the driving force 90 degrees from the propeller shaft
- Allows the rear wheels to turn at different speeds

The differential carrier assembly consists of the following components:

- The differential drive pinion gear
- The input yoke (drive pinion)
- The ring gear
- The differential carrier
- The differential case
- The side gears
- The differential gears
- All related bearings

The complete carrier assembly may be removed from the vehicle without removing the rear axle assembly.

Rear Axle Description (Two-Speed Axles)

The two speed rear axle contains two different gear ratios or ranges. The two speed rear axles operate in the same way as the single speed rear axles. The driver selects the range using a control switch on the instrument panel.

A two speed rear axle shift actuator mounted on the rear carrier engages a shift fork. The shift fork selects the range chosen by the driver.

The two speed rear axle shift actuator is electric powered.

The shift fork will perform one of the following functions:

- Slide a collar onto the sun gear of a planetary gear set.
- Slide the entire sun gear assembly in or out of the gear set

Two possible gear ratios may originate from the same gear axle.

Rear Axle Description (Tandem Axles)

A tandem rear axle increases the amount of payload a vehicle may carry. The tandem rear axle increases the traction factor when both rear axles are locked together. A tandem rear axle consists of the following components:

- A rear axle front unit
- A rear axle rear unit

The rear axle front unit has a power divider with an inter-axle differential. The power divider sends power to the individual axle differentials. The power divider allows inter-axle differential action between the two rear axles.

The tandem rear axles have the ability to be locked together, providing power to both the rear axles without the inter-axle differential action.

The inter rear axle differential air shift chamber has the following characteristics:

- Is part of the power divider
- Is mounted to the rear axle front unit differential carrier

The inter rear axle differential air shift chamber controls the tandem rear axles.

The driver controls the electric or air operated inter-axle differential lock system using one of the following items:

- An inter-axle differential lock switch
- An inter-axle differential lock control valve

All the rear axles have a removable differential carrier. The tandem rear axles operate in the same way as the single speed rear axles.

Rear Axle Description (Overhaul - Dana/Spicer)

For complete rear axle identification information, refer to *Rear Axle Identification* in General Information.

For unit repair information of the Dana/Spicer® differential carrier assembly, contact the Spicer® Support Line at 1-800-666-8688.

Rear Axle Description (Overhaul - Eaton)

For complete rear axle identification information, refer to *Rear Axle Identification* in General Information.

For unit repair information of the Eaton® differential carrier assembly or the power divider, contact Eaton® Roadranger® Service at 1-800-826-HELP (1-800-826-4357).

Special Tools and Equipment

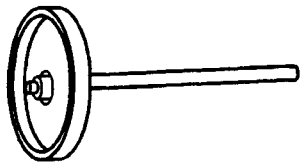
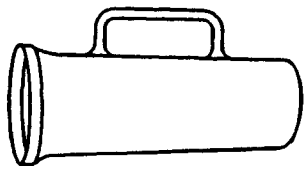
Illustration	Tool Number/ Description
 202853	551-5386 or 551-5318 Fleet Hub Tool
 202857	555-0001 Universal Tool Body

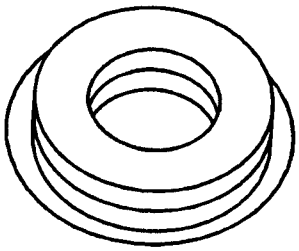
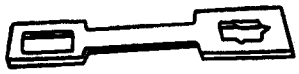
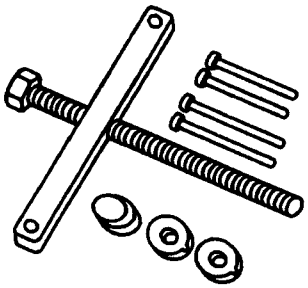
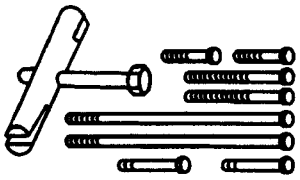
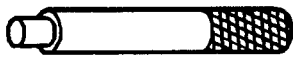
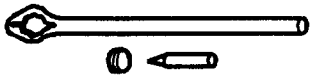
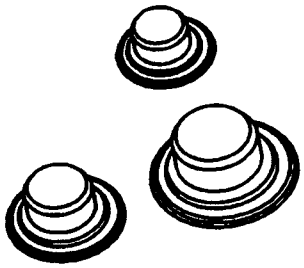
Illustration	Tool Number/ Description
 202855	555-5074 or 555-5076 Tool Head
 36470	J 3453 Holding Bar
 202849	J 4558-01 Puller
 36471	J 7804-01 Puller

Illustration	Tool Number/ Description
 2015	J 8092 Driver Handle
 1507	J 8614-01 Holding Bar
 202860	J 41107 Axle Seal Installer Kit

Rear Axle Controls

Specifications

Fastener Tightening Specifications

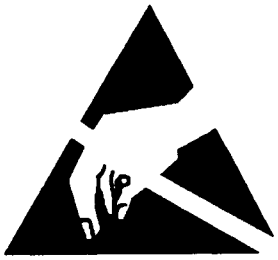
Application	Specification	
	Metric	English
Rear Axle Motor Mounting Stud Nut	54 N·m	40 lb ft
Wiring Harness Clip Nut	1.9 N·m	17 lb in

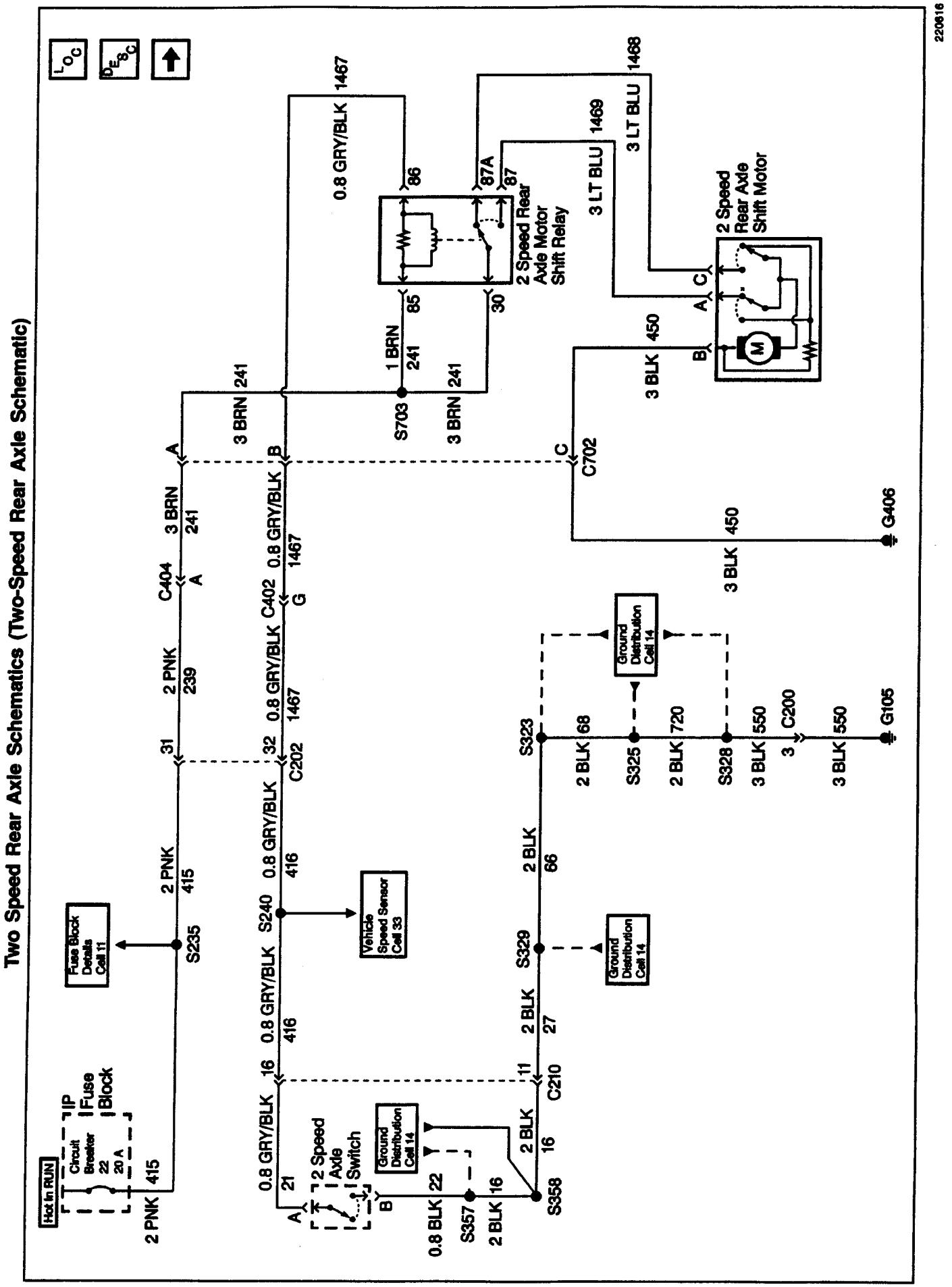
Schematic and Routing Diagrams

Rear Axle Schematic References

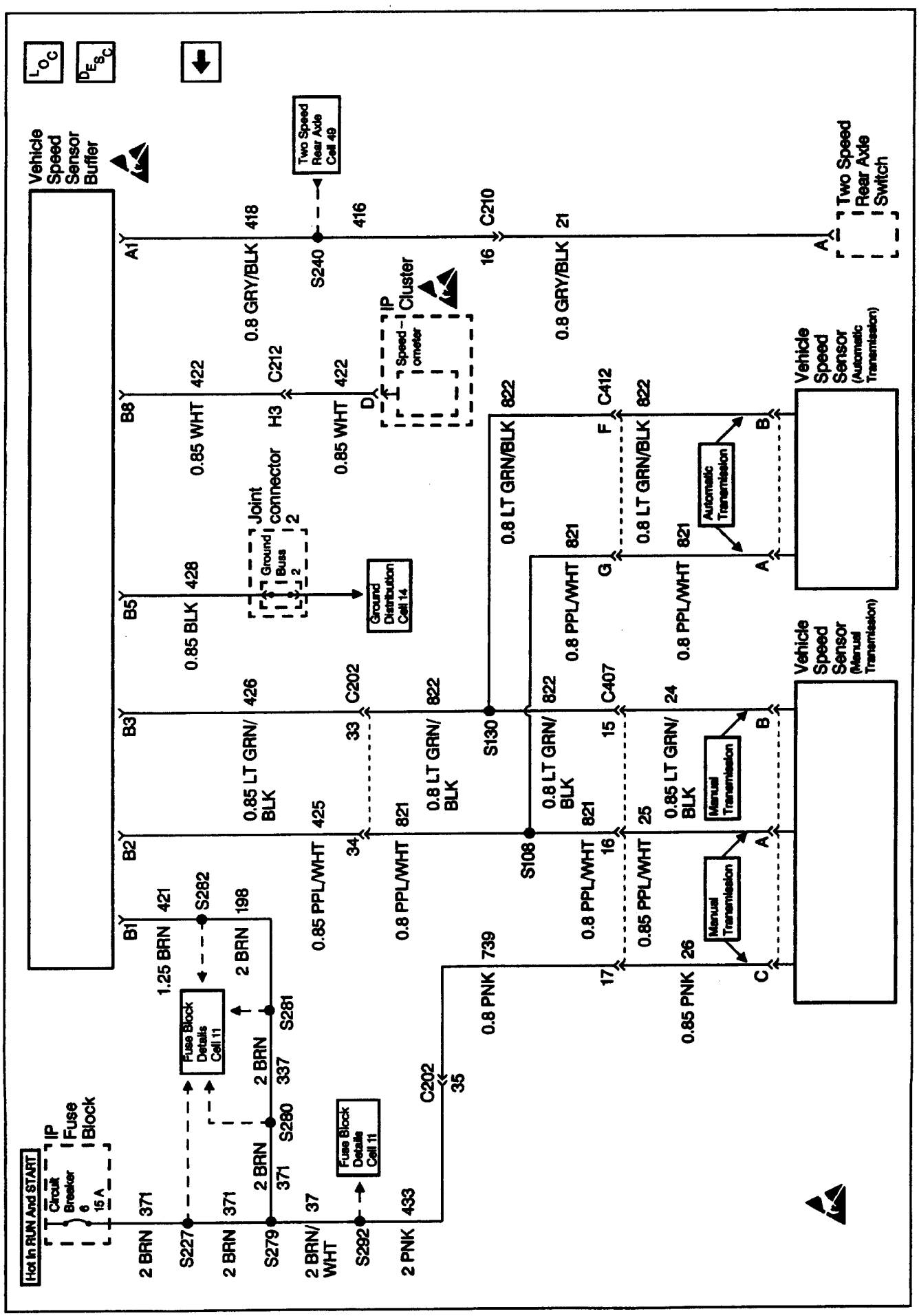
Reference on Schematic	Section Number - Subsection Name
Fuse Block Details Cell 11	8 — Wiring Systems
Ground Distribution Cell 14	8 — Wiring Systems

Rear Axle Schematic Icons

Icon	Icon Definition
 19384	Refer to *ESD Notice* in Cautions and Notices.


Two Speed Rear Axle Schematics (Two-Speed Rear Axle Schematic)
220616
LOC
DESC
Hot In RUN
IP Fuse Block
Circuit Breaker 22 20 A
2 PNK 415
Fuse Block Details Cell 11
S235
2 PNK 415
0.8 GRY/BLK 16
0.8 GRY/BLK 416
S240
Vehicle Speed Sensor Cell 33
0.8 GRY/BLK 21
2 Speed Axle Switch
Ground Distribution Cell 14
0.8 BLK 22
S357
2 BLK 16
S358
2 BLK 16
C210 11
2 BLK 27
S329
2 BLK 66
S323
2 BLK 68
S325
2 BLK 720
S328
3 BLK 550
C200 3
3 BLK 550
G105
Ground Distribution Cell 14
Ground Distribution Cell 14
C202 32
0.8 GRY/BLK 1467
C402 G
0.8 GRY/BLK 1467
C404 A
3 BRN 241
2 PNK 239
31
A
B
3 BRN 241
0.8 GRY/BLK 1467
86
87A
87
30
85
1 BRN 241
S703
3 BRN 241
2 Speed Rear Axle Motor Shift Relay
3 LT BLU 1469
3 LT BLU 1468
C
C702
3 BLK 450
B
A C
2 Speed Rear Axle Shift Motor
M
3 BLK 450
G406

Two Speed Rear Axle Schematics (Vehicle Speed Sensor Schematic)



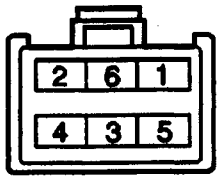
Component Locator

Rear Axle Components

Name	Location	Locator View	Connector End View
IP Fuse Block	On the RH top of the IP, under the access panel	—	—
Two-Speed Rear Axle Shift Motor	On the front of the rear axle housing	—	—
Two-Speed Rear Axle Shift Relay	Mounted on the crossmember forward of the rear axle	—	—
Two-Speed Rear Axle Shift Switch (Automatic Transmission)	In the center of the IP	—	—
Two-Speed Rear Axle Shift Switch (Manual Transmission)	On the transmission shift lever	—	—
C200 (56 cavities)	In the lower IP harness to the front chassis harness, left center of the cab, in the cab interface connector housing	—	—
C210 (16 cavities)	In the lower IP to the floor harness	—	—
C402 (8 cavities)	In the front chassis harness, to the rear chassis and taillamps harness, inside the RH frame rail, inboard of the batteries	—	—
C404 (3 cavities)	In the front chassis harness, to the rear chassis and taillamps harness, inside the RH frame rail, inboard of the batteries	—	—
C702 (3 cavities)	On the RH frame rail forward of the rear axle	—	—
G406 (Two-Speed Rear Axle and Air Brake Dryer)	In the rear chassis and taillamps harness, inboard the RH frame rail, in the ground block (part of the negative battery cable)	—	—
S235	In the lower IP harness, in the main harness at the HVAC and turn/hazard flasher module harness breakout	—	—
S323	In the lower IP harness	—	—
S325	In the lower IP harness	—	—
S328	In the lower IP harness	—	—
S329	In the lower IP harness	—	—
S357	In the floor harness	—	—
S358	In the floor harness	—	—
S703	In the two-speed axle control harness, approximately 5.0 cm (2.0 in) before the relay breakout	—	—

Rear Axle Connector End Views

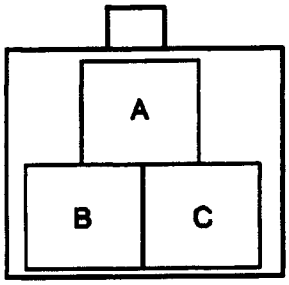
Two Speed Axle Switch (Auto)



237080

Connector Part Information	• 6 Way • Female		
Pin	Wire Color	Circuit No.	Function
1	BLK	152	Two Speed Axle Switch
2	GRA/BLK	151	Two Speed Axle Switch
3	—	—	Not Used
4	BLK/RED	154	Rheostatt
5	BRN	153	Illumination
6	—	—	Not Used

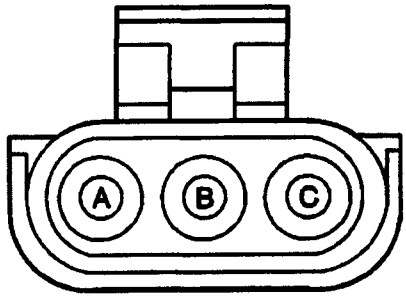
Two Speed Rear Axle Switch (Manual)



339122

Connector Part Information	• 3 Way • Female		
Pin	Wire Color	Circuit No.	Function
A	GRA/BLK	21	Two Speed Rear Axle Input
B	BLK	22	Two Speed Rear Axle Input
C	—	—	Not Used

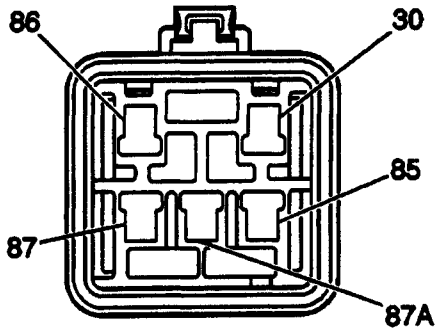
Two Speed Rear Axle Shift Motor (Electric)



309547

Connector Part Information	• 12020737 • 3 Way M Weather Pack (BRN)		
Pin	Wire Color	Circuit No.	Function
A	LT BLU	1469	Two Speed Rear Axle Shift Motor Feed-High
B	BLK	450	Ground
C	LT GRN	1468	Two Speed Rear Axle Shift Motor Feed-Low

Two Speed Rear Axle Shift Motor Relay



39685

Connector Part Information	• 12110539 • 5 Way F Metri-Pack 280 Series Flexlock, Sealed (BLK)		
Pin	Wire Color	Circuit No.	Function
30	BRN	241	Fuse Output-Ignition
85	BRN	241	Fuse Output-Ignition
86	GRA/BLK	1467	Two Speed Rear Axle Shift Motor Relay Output-Coil
87	LT BLU	1469	Two Speed Rear Axle Shift Motor Feed-High
87A	LT GRN	1468	Two Speed Rear Axle Shift Motor Feed-Low

Diagnostic Information and Procedures

Two Speed Rear Axle System Check

1. Inspect Circuit Breaker #22 to determine if it is open. If an open condition exists, Locate and repair the cause of the overload and replace the circuit breaker.
2. Inspect grounds G 105 and G 406 to make certain that they are clean and tight.
3. Inspect for broken (or partially broken) wire inside the insulation. This condition could cause system malfunction but prove to test good in a continuity or voltage test with the system disconnected. These circuits may be intermittent or resistive when in operation. If possible test for a voltage drop when the system is operational.
4. Inspect for proper installation of aftermarket electronic equipment which may affect the integrity of other systems.

Two Speed Rear Axle Shift Motor Diagnosis (High Speed Inoperative)

Step	Action	Value(s)	Yes	No
1	1. Move the two-speed rear axle switch to HIGH. 2. Connect a DVM from CKT 241 (BRN) at the two-speed rear axle motor shift relay to the chassis ground. Did the DVM read a battery voltage?	—	Go to *Step 3*	Go to *Step 2*
2	Locate and repair the open in CKT 241 (BRN). Is the two-speed rear axle HIGH speed still inoperative?	—	Go to *Step 3*	System OK
3	Connect a DVM between the two-speed rear axle motor shift relay CKT 1469 (LT BLU) and the chassis ground. Did the DVM read a battery voltage?	—	Go to *Step 13*	Go to *Step 4*
4	Connect a DVM between the two-speed rear axle motor shift relay CKT 1468 (LT BLU) and the chassis ground. Did the DVM read a battery voltage?	—	Go to *Step 6*	Go to *Step 5*
5	Replace the two-speed rear axle motor shift relay. Is the two-speed rear axle HIGH speed still inoperative?	—	Go to *Step 6*	System OK
6	1. Disconnect the two-speed rear axle motor shift relay. 2. Connect an ohmmeter across the two-speed rear axle motor shift relay socket terminal 86 and the chassis ground. Did the ohmmeter detect continuity?	—	Go to *Step 7*	Go to *Step 8*
7	Replace the two-speed rear axle motor shift relay. Is the two-speed rear axle HIGH speed still inoperative?	—	Go to *Step 8*	System OK
8	1. Disconnect the two-speed axle switch. 2. Connect an ohmmeter across the two-speed axle switch terminal A and the chassis ground. Did the ohmmeter detect continuity?	—	Go to *Step 10*	Go to *Step 9*
9	Locate and repair the open in one or more of the following circuits: • CKT 21 (GRN/BLK or GRY/BLK) • CKT 416 (GRN/BLK or GRY/BLK) • CKT 1467 (GRN/BLK or GRY/BLK) Is the two-speed rear axle HIGH speed still inoperative?	—	Go to *Step 10*	System OK
10	Connect an ohmmeter across the two-speed axle switch terminal B and the chassis ground. Did the ohmmeter detect continuity?	—	Go to *Step 11*	Go to *Step 12*
11	Replace the two-speed axle switch. Is the two-speed rear axle HIGH speed still inoperative?	—	Go to *Step 13*	System OK

Two Speed Rear Axle Shift Motor Diagnosis (High Speed Inoperative) (cont'd)

Step	Action	Value(s)	Yes	No
12	Locate and repair the open in one or more of the following circuits: • CKT 22 (BLK) • CKT 16 (BLK) • CKT 27 (BLK) • CKT 66 (BLK) • CKT 68 (BLK) • CKT 720 (BLK) • CKT 550 (BLK) Is the two-speed rear axle HIGH speed still inoperative?	—	Go to *Step 13*	System OK
13	Connect a DVM from CKT 1469 (LT BLU) at the two-speed rear axle shift motor to the chassis ground. Did the DVM read a battery voltage?	—	Go to *Step 15*	Go to *Step 14*
14	Locate and repair the open in CKT 1469 (LT BLU). Is the two-speed rear axle HIGH speed still inoperative?	—	Go to *Step 15*	System OK
15	1. Disconnect the two-speed rear axle shift motor. 2. Connect a self-powered test lamp from CKT 450 (BLK) at the connector and the chassis ground. Did the test lamp light?	—	Go to*Step 16*	Go to *Step 17*
16	Replace the two-speed rear axle motor shift relay. Is the replacement procedure complete?	—	System OK	—
17	Locate and repair the open in CKT 450 (BLK). Is the repair complete?	—	System OK	—

Two Speed Rear Axle Shift Motor Diagnosis (Low Speed Inoperative)

Step	Action	Value(s)	Yes	No
1	1. Move the two-speed rear axle switch to LOW. 2. Connect a DVM from CKT 241 (BRN) at the two-speed rear axle motor shift relay to the chassis ground. Did the DVM read a battery voltage?	—	Go to *Step 3*	Go to *Step 2*
2	Locate and repair the open in the CKT 241 (BRN). Is the two-speed rear axle LOW speed still inoperative?	—	Go to *Step 3*	System OK
3	Connect a DVM between the two-speed rear axle motor shift relay CKT 1468 (LT BLU) and the chassis ground. Did the DVM read a battery voltage?	—	Go to *Step 11*	Go to *Step 4*
4	Connect a DVM between the two-speed rear axle motor shift relay CKT 1469 (LT BLU) and the chassis ground. Did the DVM read a battery voltage?	—	Go to *Step 6*	Go to *Step 5*
5	Replace the two-speed rear axle motor shift relay. Is the two-speed rear axle LOW speed still inoperative?	—	Go to *Step 6*	System OK
6	1. Disconnect the two-speed rear axle motor shift relay. 2. Connect an ohmmeter across the two-speed rear axle motor shift relay socket terminal 86 and the chassis ground. Did the ohmmeter detect continuity?	—	Go to *Step 8*	Go to *Step 7*
7	Replace the two-speed rear axle motor shift relay. Is the two-speed rear axle LOW speed still inoperative?	—	Go to *Step 8*	System OK

Two Speed Rear Axle Shift Motor Diagnosis (Low Speed Inoperative) (cont'd)

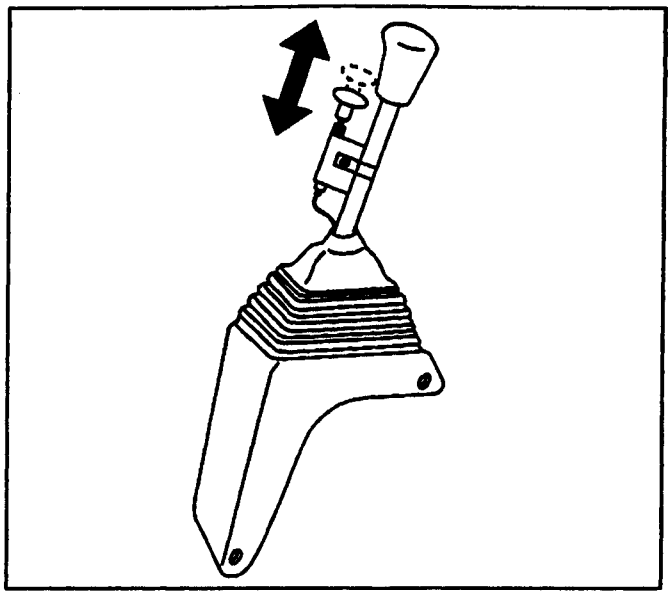
Step	Action	Value(s)	Yes	No
8	1. Disconnect the two-speed axle switch. 2. Connect the ohmmeter across the two-speed axle switch terminal A and the chassis ground. Did the ohmmeter detect continuity?	—	Go to *Step 9*	Go to *Step 10*
9	Locate and repair the short to the ground in one or more of the following circuits: • CKT 21 (GRN/BLK or GRY/BLK) • CKT 416 (GRN/BLK or GRY/BLK) • CKT 1467 (GRN/BLK or GRY/BLK) Is the two-speed rear axle LOW speed still inoperative?	—	Go to *Step 11*	System OK
10	Replace the two-speed axle switch. Is the two-speed rear axle LOW speed still inoperative?	—	Go to *Step 11*	System OK
11	Connect a DVM from CKT 1468 (LT BLU) at the two-speed rear axle shift motor to the chassis ground. Did the DVM read a battery voltage?	—	Go to *Step 13*	Go to *Step 12*
12	Locate and repair the open in CKT 1468 (LT BLU). Is the two-speed rear axle LOW speed still inoperative?	—	Go to *Step 13*	System OK
13	1. Disconnect the two-speed rear axle shift motor. 2. Connect a self-powered test lamp from CKT 450 (BLK) at the connector and the chassis ground. Did the test lamp light?	—	Go to *Step 14*	Go to *Step 15*
14	Replace the two-speed rear axle motor shift relay. Is the replacement procedure complete?	—	System OK	—
15	Locate and repair the open in CKT 450 (BLK). Is the repair complete?	—	System OK	—

Repair Instructions

Two Speed R/Axle Shift Control Switch Replacement

Removal Procedure

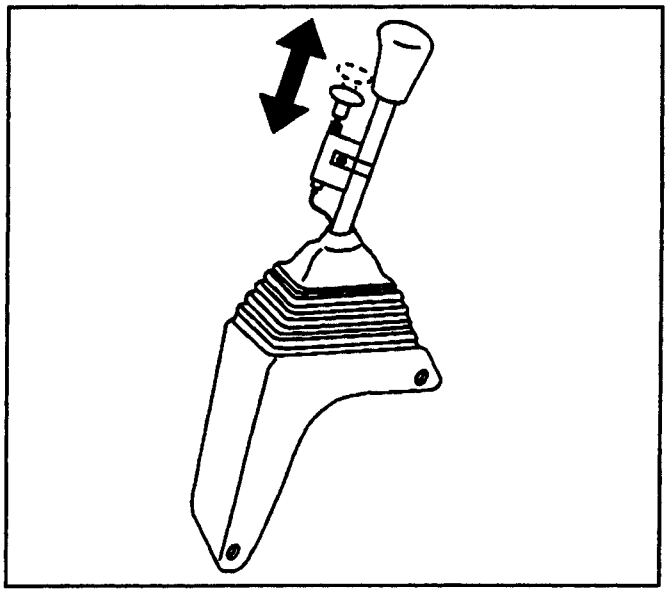
1. Remove the electrical connector.
2. Remove the screw.
3. Remove the clamp.
4. Remove the switch.



216280

Installation Procedure

1. Install the switch.
2. Install the screw.
3. Install the clamp.
4. Install the electrical connector.



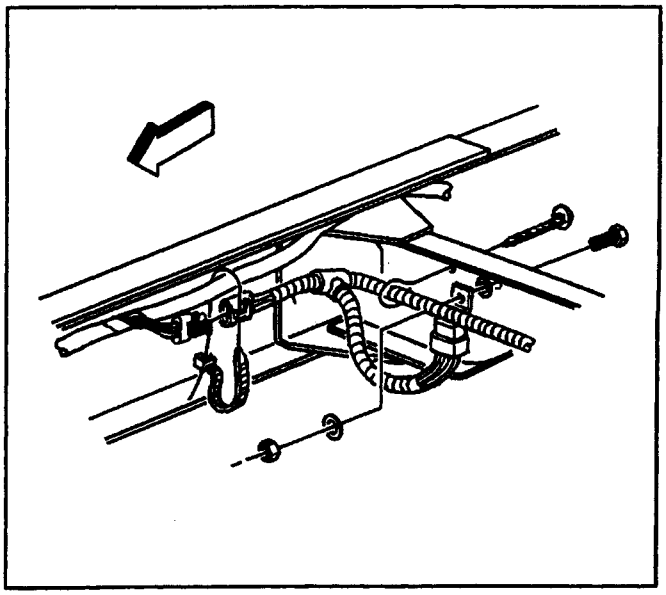
216280

Two Speed Rear Axle Shift Motor Relay Replacement

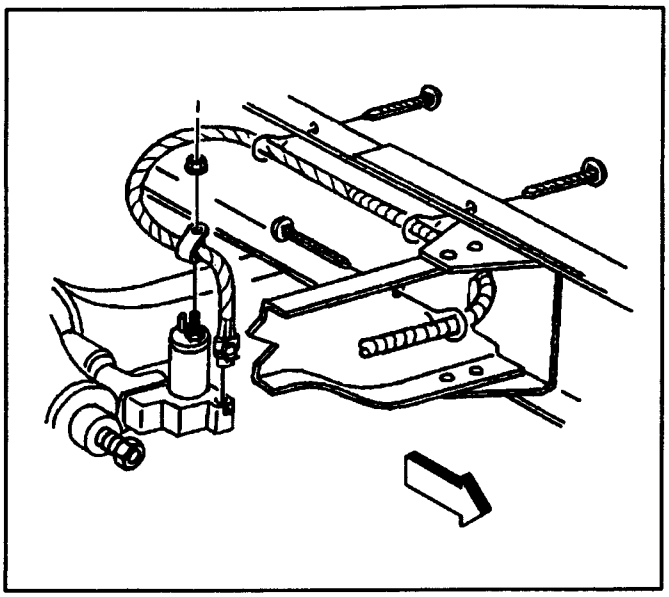
Removal Procedure

Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the negative battery cable.
2. Remove the electrical connector from the relay.

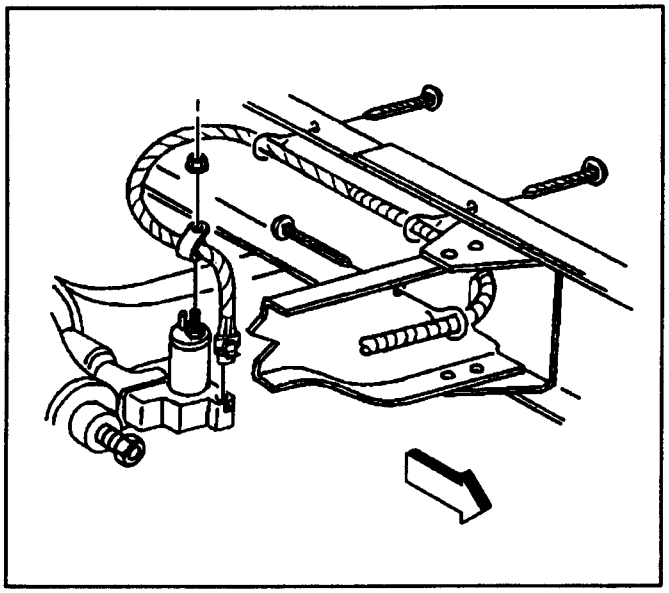


216273



216282

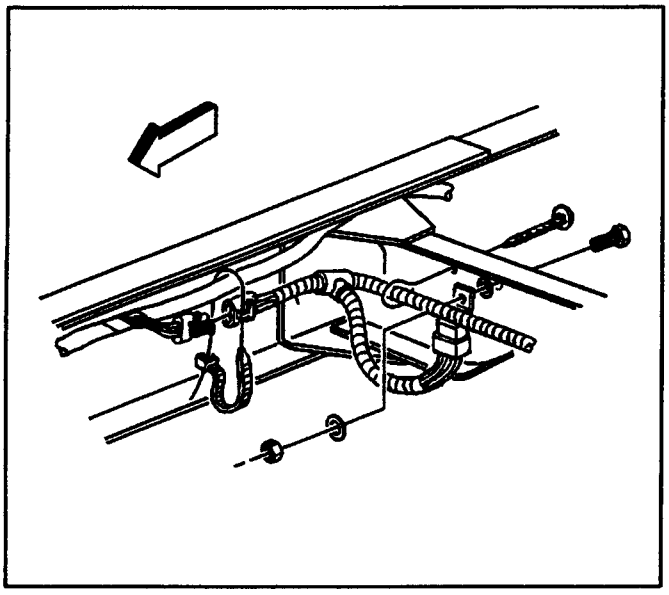
3. Remove the following from the chassis:
   - The nut
   - The washer
   - The bolt



216282

Installation

1. Install the following from the chassis:
   - The bolt
   - The washer
   - The nut



216273

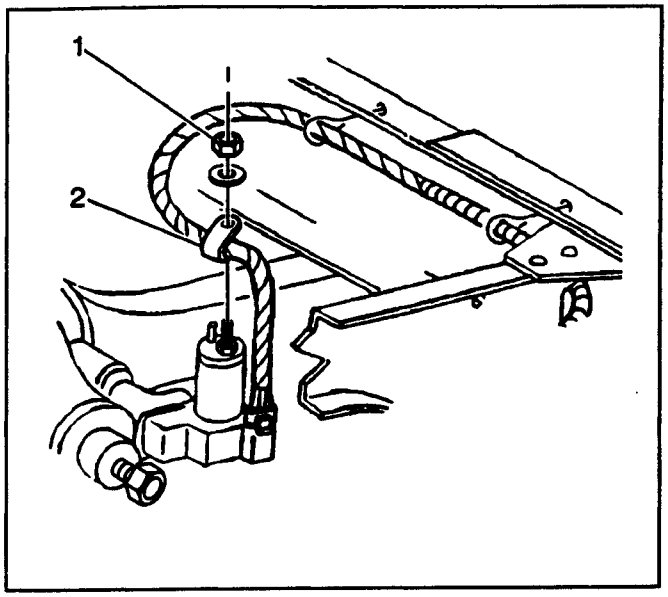
2. Install the electrical connector from the relay.
3. Connect the negative battery cable. Refer to Engine Electrical.

Two Speed Rear Axle Shift Motor Replacement

Removal Procedure

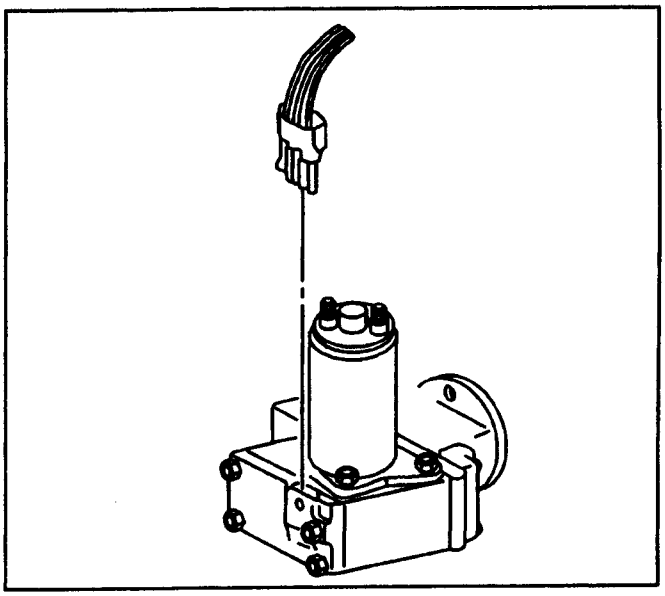
Important: Shift the axle control switch to the LOW range.

1. Remove the wiring harness clip nut (1).
2. Remove the wiring harness clip (2) from the stud.

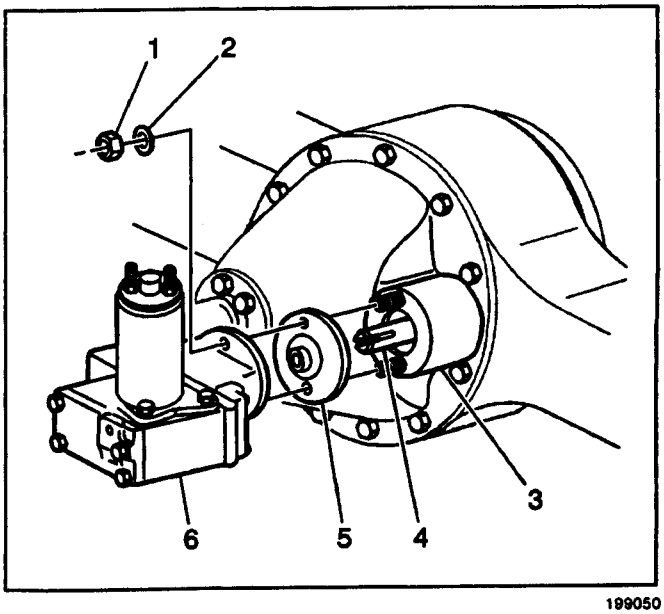


199043

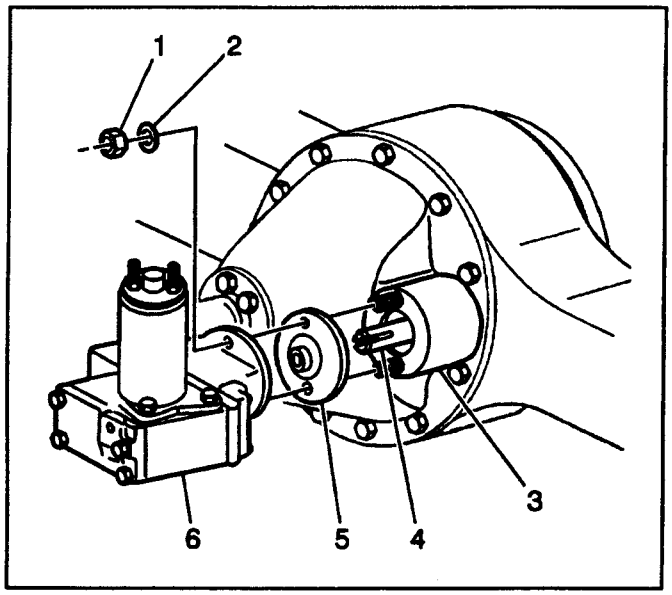
3. Disconnect the wiring harness connector.


199122

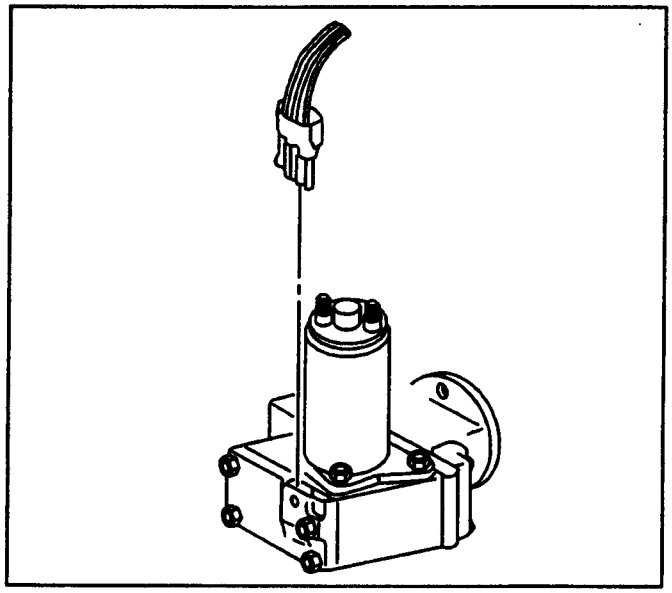
4. Remove the shift motor mounting stud nuts (1).
5. Remove the washers (2).
6. Remove the shift motor (6).
7. Remove the spring from the shift fork (4).
8. Remove the seal (5) from the differential carrier housing (3).



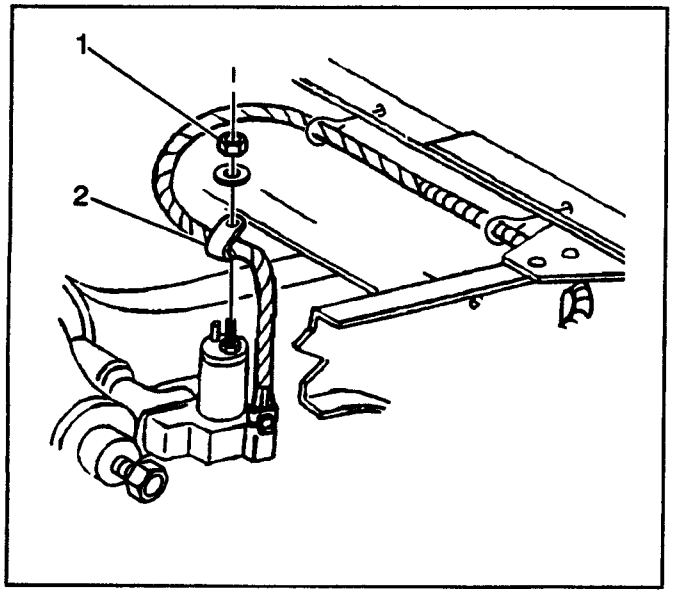
199050



199050



199122



199043

Installation Procedure

1. Install the seal (5) onto the differential carrier housing (3).
2. Install the spring onto the shift fork (4).

   Important: Ensure that the actuator lever engages with the shift fork (4).
3. Install the shift motor (6) onto the mounting studs.
4. Install the washers (2).

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
5. Install the shift motor mounting stud nuts (1).

   Tighten

   Tighten the nuts (1) to 54 N·m (40 lb ft).
6. Connect the wiring harness connector to the shift motor.
7. Install the wiring harness clip (2) onto the stud.
8. Install the wiring harness clip nut (1).

   Tighten

   Tighten the nut (1) to 1.9 N·m (17 lb in).
9. Turn the ignition switch to the ON position.
10. Verify proper operation of the system.

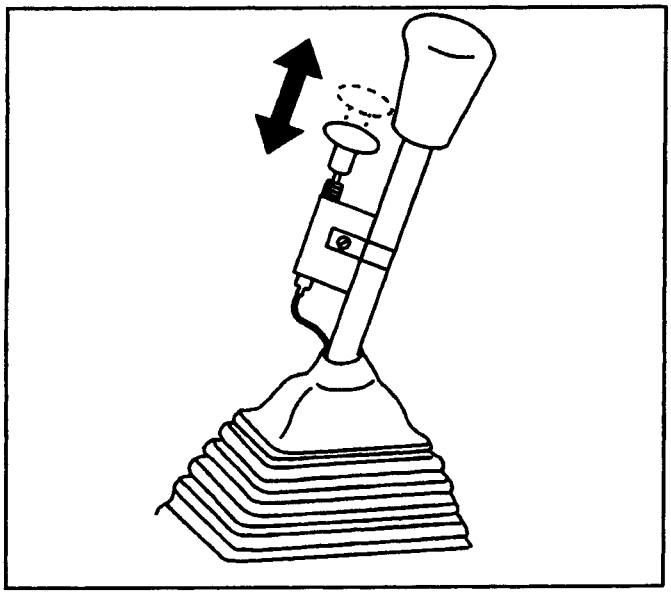
Description and Operation

Two Speed Rear Axle Shift System Description

The electric shift control system includes the following components:

- A control switch
- A speedometer adapter assembly
- A shift motor assembly
- A relay
- A wiring harness

Control Switch

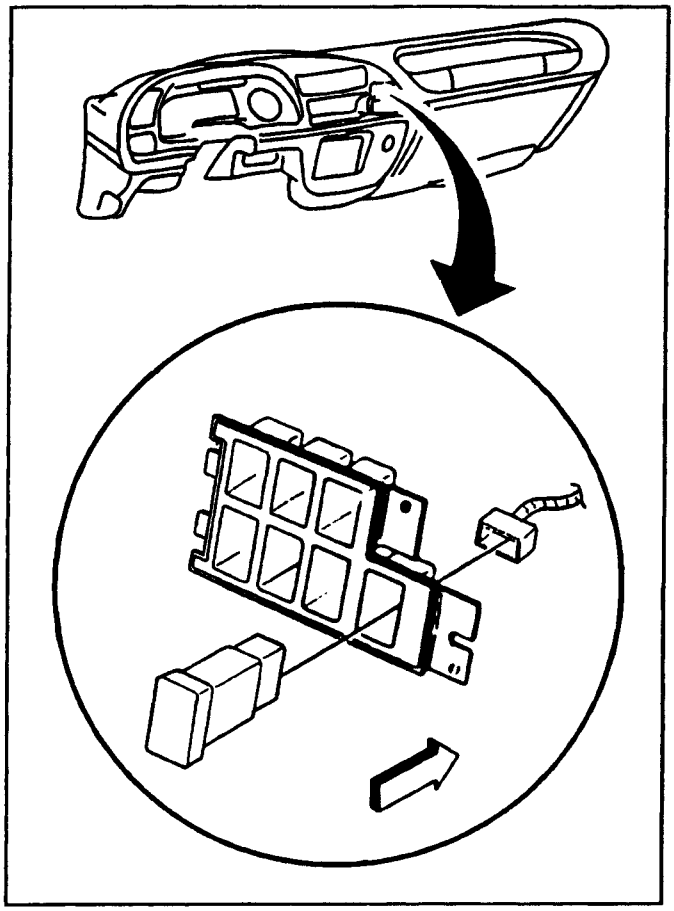


202537

In manual transmission models, the two speed rear axle control switch is mounted on the manual transmission shift lever.

The control switch consists of a shift button that is positioned by the driver in order to operate the two speed shift motor assembly at the rear axle.

The driver selects the axle speed by moving the shift mounted control switch down or up in order to select the LOW or HIGH axle range.



202542

In automatic transmission models, the two speed rear axle control switch is mounted in the instrument panel.

The driver selects the axle speed by pushing the switch for the LOW or HIGH axle range.

Relay

The relay is mounted to the crossmember in front of the rear axle.

When the control switch is in the HIGH position a ground is supplied to the relay. This condition actuates the shift motor to the HIGH speed range.

When the control switch is returned to the LOW position the relay is de-energized. This condition returns the shift motor to the LOW speed range.

Shift Motor Assembly

The shift motor assembly is mounted on the differential carrier.

The shift motor shifts the axle into the LOW or HIGH speed range.

Speedometer Adapter Assembly

A speedometer adapter assembly matches the ratio of the speedometer to the ratio of the rear axle.

The adapter gives an accurate speedometer reading when the axle is shifted from one ratio to the other.

The speedometer adapter assembly is electrically connected to the rear axle control switch.

When the shift control switch is placed in the LOW position, an electric signal changes the speedometer adapter assembly to the LOW ratio in order to match the rear axle.

When the shift control switch is placed in the HIGH position, the electric signal is removed and the speedometer adapter assembly reads the HIGH ratio of the rear axle.

Two Speed Rear Axle Circuit Description

The two-speed axle electric shift system consists of the following components:

- A switch
- A relay
- A two-speed rear axle motor

When the two-speed rear axle switch is closed (HIGH speed range), a ground is supplied to the two-speed rear axle motor shift relay. Voltage is applied to the two-speed rear axle shift motor through CKT 1469 (LT BLU). This action moves the control spring to the HIGH range position. When the load on the axle gear is relieved, the axle shifts to the HIGH speed range. The automatic switch in the motor unit moves to a position that opens the input on CKT 1469 (LT BLU) and closes the input on CKT 1468 (LT BLU).

When the two-speed switch is opened (LOW speed range), the two-speed rear axle motor shift relay is de-energized. Battery voltage is supplied through CKT 1468 (LT BLU) to the two-speed rear axle motor. This action moves the control spring to the LOW position. When the load on the axle is relieved, the axle shifts to the LOW range.

Voltage is available at all times to the two-speed rear axle motor shift relay coil and contacts, from circuit breaker #22 through CKT 415, CKT 239, or CKT 241 (PNK or BRN). When the two-speed axle switch is actuated, the switch contacts close. This action connects the ground to the coil of the two-speed rear axle motor shift relay through CKT 21, CKT 416, or CKT 1467 (GRN/BLK or GRY/BLK). The two-speed rear axle shift motor is grounded through CKT 450 (BLK) to G450.

Section 5
Brakes

Hydraulic Brakes 5-7
Specifications 5-7
Fastener Tightening Specifications 5-7
Schematic and Routing Diagrams 5-7
Hydraulic Brakes Schematic References 5-7
Hydraulic Brakes Schematic Icons 5-7
Brake Warning System Schematics 5-8
Component Locator 5-11
Hydraulic Brakes Components 5-11
Hydraulic Brakes Component Views 5-12
Hydraulic Brakes Connector End Views 5-15
Diagnostic Information and Procedures 5-16
Brake Warning Indicator Inoperative 5-16
AUX BRAKE Indicator and Alarm On w/Engine Running 5-17
AUX BRAKE Indicator Inoperative 5-18
External Conditions that Affect Brake Performance 5-19
Brake System Diagnosis 5-19
Brake Pedal Excessive Effort with Engine Off (Brake Light On) 5-19
Brake Pedal Excessive Effort with Engine Off (Brake Light Off) 5-20
Brake Pedal Excessive Effort to Stop 5-20
Brake Fluid Leaks 5-20
EH Pump and Booster Mating Surface Oil Leak 5-21
EH Pump End Plate Oil Leak 5-21
EH Pump Motor Oil Leak 5-21
EH Pump Noise 5-21
Master Cylinder Diagnosis 5-21
Hydraulic System Fluid Loss 5-21
Hydraulic Booster Noise Diagnosis 5-22
Repair Instructions 5-22
Master Cylinder Reservoir Filling 5-22
Master Cylinder Replacement 5-23
Master Cylinder Bench Bleeding 5-24
Master Cylinder Fluid Level Sensor Replacement 5-24
Brake Pedal Replacement 5-25
Pipe Replacement 5-25
Master Cylinder Hose Replacement (Front) 5-26
Master Cylinder Hose Replacement (Rear) 5-27
ISO Flares Replacement 5-28
Brake Hose Replacement - Front 5-29
Brake Hose Replacement - Rear 5-30
Hydraulic Brake System Bleeding (Manual) 5-32
Hydraulic Brake System Bleeding (Pressure) 5-33
Hydraulic Brake System Flushing 5-34
Hydraulic Brake Booster Replacement 5-35
Electrohydraulic Pump Replacement 5-37
Fluid Flow Switch Replacement 5-38
Stoplamp Switch Replacement 5-38
Description and Operation 5-38
Hydraulic Brake Booster Description 5-38
Brake Warning System Circuit Description (Primary Brake Lamp Description) 5-39
Brake Warning System Circuit Description (Auxiliary Brake Lamp Descripti) 5-39
Special Tools and Equipment 5-40
Special Tools 5-40
Disc Brakes 5-41
Specifications 5-41
Fastener Tightening Specifications 5-41
Brake Lathe Specifications (Accuturn) 5-41
Brake Lathe Specifications (Ammco) 5-41
Component Specifications 5-41
Diagnostic Information and Procedures 5-42
Brake Rotor Thickness Variation Check 5-42
Brake Rotor Lateral Runout Check 5-42
Brake Rotor Tolerance 5-43
Repair Instructions 5-43
Brake Pad Inspection 5-43
Brake Pads Replacement (Front, Bendix) 5-44
Brake Pads Replacement (Front, Dayton-Walther) 5-45
Brake Pads Replacement (Rear, Bendix Rail Slider) 5-47

Brake Pads Replacement (Rear, Dayton-Walther Rail Slider) 5-49
Burnishing Pads and Rotors 5-51
Brake Caliper Replacement (Front, Bendix) 5-51
Brake Caliper Replacement (Front, Dayton-Walther) 5-54
Brake Caliper Replacement (Rear, Rail Slider) 5-58
Brake Caliper and Anchor Plate Wear Adjustment (Front, Bendix) 5-62
Brake Caliper and Anchor Plate Wear Adjustment (Rear, Bendix) 5-64
Brake Caliper and Anchor Plate Wear Adjustment (Front, Dayton-Walther) 5-66
Brake Caliper and Anchor Plate Wear Adjustment (Rear, Dayton-Walther) 5-68
Brake Caliper Overhaul (Bendix Rail Slider) 5-70
Brake Caliper Overhaul (Dayton-Walther Rail Slider) 5-73
Brake Caliper Overhaul (Bendix) 5-75
Brake Caliper Overhaul (Dayton-Walther) 5-78
Brake Caliper Mounting Plate Replacement (Front, Bendix) 5-81
Brake Caliper Mounting Plate Replacement (Front, Dayton-Walther) 5-82
Brake Caliper Mounting Plate Replacement (Rear, Bendix Rail Slider) 5-83
Brake Caliper Mounting Plate Replacement (Rear, Dayton-Walther) 5-84
Description and Operation 5-86
Disc Brakes System Description (Front) 5-86
Disc Brakes System Description (Rear) 5-87
Park Brake 5-89
Specifications 5-89
Fastener Tightening Specifications (Electric/Hydraulic) 5-89
Repair Instructions 5-89
Park Brake Shoe Replacement (Bendix 229 mm - 9 in) 5-89
Park Brake Shoe Replacement (Bendix 254 mm - 10 in) 5-90
Park Brake Shoe Inspection 5-93
Park Brake Shoe Adjustment (Bendix 254 mm - 10 in) 5-94
Park Brake Lubrication Procedure 5-96
Park Brake Lever Replacement (Mechanical) 5-97
Park Brake Lever Adjustment 5-98
Park Brake Warning Lamp Switch Replacement 5-98
Park Brake Cable Replacement 5-99
Park Brake Cable Inspection 5-101
Brake Drum Replacement (Bendix 254 mm - 10 in) 5-101
Brake Drum Replacement (Bendix 229 mm - 9 in) 5-103
Brake Drum Inspection 5-105
Park Brake Support Replacement 5-106
Park Brake Bellcrank and Cam Lever Replacement 5-107
Description and Operation 5-110
Park Brake System Description 5-110
Park Brake System Operation 5-112
Air Brakes 5-113
Specifications 5-113
Fastener Tightening Specifications 5-113
Schematic and Routing Diagrams 5-114
Air Brake System Schematics 5-114
Air Brake Dryer Schematic 5-132
Air Brake Park Brake Control Schematic 5-133
Air Brake Park Brake Schematic 5-134
Air Brake System Schematic References 5-135
Air Brake System Schematic Icons 5-135
Brake Warning System Schematics 5-136
Component Locator 5-137
Air Brake System Components 5-137
Air Brake System Component Views 5-140
Air Brake System Connector End Views 5-142
Diagnostic Information and Procedures 5-143
Air Brakes Inoperative 5-143
Air Brakes Not Operating Properly 5-143
Air Brakes Application Slow 5-143
Pressure Loss w/Eng. Off - Brakes Released 5-144
Pressure Loss w/Eng. Off - Brakes Applied 5-144
Air Brake Safety Valve Blows Off 5-144
Braking Uneven - Front to Rear 5-144
Braking Uneven - Side to Side 5-145
Air Brakes Make Grinding Sound When Applied 5-145
Air Brakes Drag 5-145
Air Brake Dryer Constantly Cycling or Purging 5-145
Air Brake Reservoirs Contain Water 5-146
Air Brake Dryer Safety Valve Exhausting Air 5-146
Air Brake Dryer Purge Valve Exhausting Air 5-146

Air Brake Dryer Does Not Purge or Exhaust Air....5-147
Desiccant Being Expelled From Purge Valve Exhaust....5-147
Air Brake System Testing (Operational Check)....5-148
Air Brake System Testing (Leakage Test)....5-148
Primary Brake Indicator or Alarm Inoperative....5-148
Primary Brake Indicator or Alarm Always On....5-149
Low Air Pressure Switch Diagnosis....5-149
Stoplamp Switch Diagnosis....5-149
Trailer Stoplamp Switch Diagnosis....5-150
Air Brake Dryer Testing....5-150
Air Brake System Leak Test....5-150
IP Mounted Air Brake Park Control Valve Test (Operational Check)....5-151
IP Mounted Air Brake Park Control Valve Test (Leakage Test)....5-152
Parking Control Valve Test (Operational Check)....5-152
Parking Control Valve Test (Leakage Test)....5-153
Trailer Brake Supply Valve Test (Operational Check)....5-153
Trailer Brake Supply Valve Test (Leakage Test)....5-154
Reservoir Check Valve Test (Operational Check)....5-155
Reservoir Check Valve Test (Leakage Test)....5-155
Air Brake Double Check Valve Test (Operational Check)....5-156
Air Brake Double Check Valve Test (Leakage Test)....5-157
Air Brake Application Valve Test (Operational Check)....5-158
Air Brake Application Valve Test (Leakage Test)....5-158
Front Air Brake Limit Valve Test (Operational Check)....5-158
Front Air Brake Limit Valve Test (Leakage Test)....5-159
Front Axle Serv Rsvr Air Supply Valve Test (Operational Check)....5-159
Front Axle Serv Rsvr Air Supply Valve Test (Leakage Test)....5-159
Moisture Ejector Valve Test (Operational Check)....5-160
Moisture Ejector Valve Test (Leakage Test)....5-160
Pressure Protection Valve Test (Operational Check)....5-160
Pressure Protection Valve Test (Leakage Test)....5-161
Reservoir Drain Valve Test....5-161
Air Brake Quick Release Valve Test (Operational Check)....5-161
Air Brake Quick Release Valve Test (Leakage Test)....5-161
Rear Air Brk Quick Release Double Check Valve Test (Operational Check)....5-162
Rear Air Brk Quick Release Double Check Valve Test (Leakage Test)....5-162
Rear Air Brake Relay Valve Test (Operational Check)....5-163
Rear Air Brake Relay Valve Test (Leakage Test)....5-163
Rear Air Brake Relay Double Check Valve Test (Operational Check)....5-163
Rear Air Brake Relay Double Check Valve Test (Leakage Test)....5-163
Primary Air Brake Supply Rsvr Safety Valve Test (Operational Check)....5-164
Primary Air Brake Supply Rsvr Safety Valve Test (Leakage Test)....5-165
Chassis Mounted Air Brake Park Control Valve Test (Operational Check)....5-165
Chassis Mounted Air Brake Park Control Valve Test (Leakage Test)....5-165
Towing Vehicle Protection Valve Test (Operational Check)....5-165
Towing Vehicle Protection Valve Test (Leakage Test)....5-166
Trailer Brake Control Valve Test (Operational Check)....5-166
Trailer Brake Control Valve Test (Leakage Test)....5-167
Air Dryer/Moisture Ejector System Check....5-167
Air Dryer and Moisture Ejector Do Not Work....5-168
Air Dryer or Moisture Ejector Does Not Work....5-168
Repair Instructions....5-169
Draining Reservoirs....5-169
Filling Reservoirs....5-170
Applying Pipe Sealant....5-170
Air Brake Pedal Replacement....5-171
Stoplamp Switch Replacement....5-173
Trailer Stoplamp Switch Replacement....5-174
Hose and Line Replacement (Nylon and Metal - Compression)....5-174
Hose and Line Replacement (Nylon - Push-In)....5-176
Hose and Line Replacement (Flexible)....5-177
Hose and Line Replacement (Trailer Brake Coupling)....5-179

Hose and Line Replacement (Trailer Brake Dummy Cap) 5-180
Reservoir Replacement (Supply) 5-181
Reservoir Replacement (Front Service) 5-182
Reservoir Replacement (Truck Rear Service) 5-184
Reservoir Support Replacement (Front Axle) 5-185
Reservoir Support Replacement (Primary Air Brake) 5-186
Reservoir Support Replacement (Rear Axle) 5-186
Reservoir Drain Valve Replacement (Manual Type) 5-187
Reservoir Drain Valve Replacement (Automatic Type) 5-188
Low Air Pressure Switch Replacement 5-189
Air Dryer Replacement 5-190
IP Mounted Air Brake Park Cont Valve Replacement 5-192
Trailer Brake Supply Valve Replacement 5-193
Reservoir Check Valve Replacement 5-194
Air Brake Double Check Valve Replacement 5-195
Air Brake Application Valve Replacement 5-196
Front Air Brake Limit Valve Replacement 5-198
Front Axle Serv Rsvr Air Supply Valve Replacement 5-198
Reservoir Drain Valve Replacement 5-199
Pressure Protection Valve Replacement 5-200
Air Brake Quick Release Valve Replacement 5-200
Air Brake Quick Rel Dbl Check Valve Replacement-RR 5-202
Air Brake Relay Valve Replacement - Rear 5-203
Air Brake Relay Dbl Check Valve Replacement - Rear 5-204
Primary Air Brk Sply Rsvr Safety Valve Replacement 5-205
Chas Mount Air Brk Park Control Valve Replacement 5-205
Towing Vehicle Protection Valve Replacement 5-206
Trailer Brake Control Valve Replacement 5-207
Description and Operation 5-208
Air Brake System Description 5-208
Air Brake System Operation 5-209
Air Brake Component Description 5-209
Air Brake Component Operation 5-210
Air Brake Dryer System Description 5-212
Air Brake Dryer System Operation 5-212
Air Brake Valves Description 5-212
Air Brake Valves Operation 5-218
Air Dryer/Moisture Ejector Circuit Description 5-225
Air Drums 5-227
Specifications 5-227
Fastener Tightening Specifications 5-227
Air Drum Brake Component Specifications (Dimensional) 5-227
Air Drum Brake Component Specifications (Front Brakes) 5-228
Air Drum Brake Component Specifications (Rear Brakes) 5-228
Diagnostic Information and Procedures 5-229
Air Drum Brake System Diagnosis 5-229
Repair Instructions 5-229
Air Drum Brake System Inspection 5-229
Brake Drum Replacement 5-230
Brake Drum Inspection 5-231
Brake Drum Refinishing 5-232
Cam Brake Assembly Replacement (Front) 5-233
Cam Brake Assembly Replacement (Rear) 5-234
Brake Shoe Inspection 5-235
Brake Shoe Replacement 5-236
Brake Camshaft Replacement 5-243
Air Brake Automatic Slack Adjuster Replacement (Rockwell) 5-247
Air Brake Automatic Slack Adjuster Replacement (Eaton) 5-253
Air Brake Chamber Clevis Replacement (Rockwell) 5-258
Air Brake Chamber Clevis Replacement (Eaton) 5-262
Air Brake Chamber Replacement (Front) 5-264
Air Brake Chamber Replacement (Rear) 5-265
Air Brake Chamber Replacement - Front (With Rockwell Slack Adjuster) 5-265
Air Brake Chamber Replacement - Front (With Eaton Slack Adjuster) 5-266
Air Brake Chamber Overhaul (Service) 5-267
Air Brake Chamber Overhaul (Spring) 5-274
Caging the Rear Air Brake Chamber 5-282
Air Drum Brake Adjustment (Pushrod Stroke Measurement) 5-284
Air Drum Brake Adjustment (Normal Wear Adjustment) 5-285
Description and Operation 5-286
Air Drum Brakes System Description 5-286
Air Compressor 5-287
Specifications 5-287
Fastener Tightening Specifications 5-287

Air Compressor Mechanical Specifications 5-287
Air Compressor Gov Valve Adjustment Specifications 5-287
Diagnostic Information and Procedures 5-288
Air Compressor Diagnosis (Air Compressor Not Unloading) 5-289
Air Compressor and Governor Valve Diagnosis 5-289
Repair Instructions 5-290
Air Compressor Replacement 5-290
Air Compressor Overhaul (Disassembly/Assembly) 5-294
Air Compressor Overhaul (Cleaning and Inspection) 5-298
Air Compressor Overhaul (Tests after Overhaul) 5-298
Air Compressor Governor Valve Replacement 5-299
Air Compressor Governor Valve Adjustment 5-300
Description and Operation 5-301
Air Compressor Description 5-301
Air Compressor Operation 5-301
Air Compressor Governor Valve Description 5-302
Air Compressor Governor Valve Operation 5-302
Antilock Brake System 5-303
Specifications 5-303
Fastener Tightening Specifications 5-303
Schematic and Routing Diagrams 5-304
BPMV Hydraulic Flow Chart 5-304
Antilock Brakes System Schematic References 5-309
Antilock Brakes System Schematic Icons 5-309
Antilock Brake System Schematics (Hydraulic Brake) 5-310
Component Locator 5-313
Antilock Brakes System Components 5-313
Antilock Brakes System Component Views 5-316
Antilock Brakes System Connector End Views 5-323
Diagnostic Information and Procedures 5-325
Self-Diagnostics 5-325
Displaying DTCs 5-325
Clearing DTCs 5-325
Intermittents and Poor Connections 5-325
Scan Tool Diagnosis 5-325
Diagnostic System Check 5-326
DTC List 5-329
DTC C0221 RF Wheel Speed Sensor Circuit Open 5-330
DTC C0222 RF Wheel Speed Signal Missing 5-333
DTC C0223 RF Wheel Speed Signal Erratic 5-336
DTC C0225 LF Wheel Speed Sensor Circuit Open 5-339
DTC C0226 LF Wheel Speed Signal Missing 5-342
DTC C0227 LF Wheel Speed Signal Erratic 5-345
DTC C0231 RR Wheel Speed Signal Circuit Open 5-348
DTC C0232 RR Wheel Speed Signal Missing 5-351
DTC C0233 RR Wheel Speed Signal Erratic 5-354
DTC C0235 LR Wheel Speed Signal Circuit Open 5-357
DTC C0236 LR Wheel Speed Signal Circuit Missing 5-360
DTC C0237 LR Wheel Speed Signal Erratic 5-363
DTC C0238 Wheel Speed Mismatch 5-366
DTC C0241-C0258 EBCM Control Valve Circuit 5-368
DTC C0265 or C0266 EBCM Relay Circuit 5-370
DTC C0267 or C0268 Pump Motor Circuit Open/Shorted 5-372
DTC C0269 or C0274 Excessive Dump/Isolation Time 5-375
DTC C0271-C0273 EBCM Malfunction 5-377
DTC C0279 Trim Level Not Selected 5-378
DTC C0281 Brake Switch Circuit 5-380
DTC C0286 ABS Indicator Lamp Circuit Shorted to B+ 5-383
ABS Indicator Off No DTC Set 5-385
ABS Indicator On No DTC Set 5-387
Repair Instructions 5-389
ABS Bleed Procedure 5-389
Electronic Brake Control Module Replacement 5-390
Brake Pressure Modulator Valve Replacement 5-390
Wheel Speed Sensor Replacement - Front 5-392
Wheel Speed Sensor Replacement - Rear 5-393
Tube Adapter Replacement 5-394
Description and Operation 5-394
Service Precautions 5-394
General System Description 5-394
Abbreviations and Definitions 5-394

Basic Knowledge Required 5-395
ABS System Description 5-395
ABS System Operation 5-396
Special Tools and Equipment 5-398
Special Tools 5-398
Air Antilock Brake System 5-399
Specifications 5-399
Fastener Tightening Specifications 5-399
Schematic and Routing Diagrams 5-400
Air Antilock Brakes System Schematic References 5-400
Air Antilock Brakes System Schematic Icons 5-400
Air Antilock Brakes System Schematics 5-401
Component Locator 5-405
Air Antilock Brakes System Components 5-405
Air Antilock Brakes System Component Views 5-408
Visual Identification 5-415
Air Antilock Brakes System Connector End Views 5-415
Diagnostic Information and Procedures 5-419
Self-Diagnostics 5-419
Intermittents and Poor Connections 5-420
Air ABS Diagnostic System Check 5-421
Status Lamps Illuminated - Left, Front, and Sens 5-426
Status Lamps Illuminated - Right, Front and Sens 5-429
Status Lamps Illuminated - Left, Rear, and Sens 5-432
Status Lamps Illuminated - Right, Rear and Sens 5-435
Status Lamps Illuminated - Left, Front, and Mod 5-438
Status Lamps Illuminated - Right, Front and Mod 5-441
Status Lamps Illuminated - Left, Rear, and Mod 5-444
Status Lamps Illuminated - Right, Rear and Mod 5-446
Repair Instructions 5-448
Electronic Brake Control Module Replacement 5-448
Modulator Valve Replacement - Rear 5-448
Modulator Valve Replacement - Front 5-449
Wheel Speed Sensor Replacement - Front 5-450
Wheel Speed Sensor Replacement - Rear 5-451
Description and Operation 5-452
Service Precautions 5-452
General System Description 5-453
Abbreviations and Definitions 5-453
Basic Knowledge Required 5-453
Air ABS System Description 5-454
Air ABS System Operation 5-454
Special Tools and Equipment 5-455
Special Tools 5-455

Hydraulic Brakes

Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Booster Pump Rod Nut	68 N.m	50 lb ft
Brake Booster Mounting Nuts	36 N.m	27 lb ft
Master Cylinder Bracket Nut	45 N.m	33 lb ft

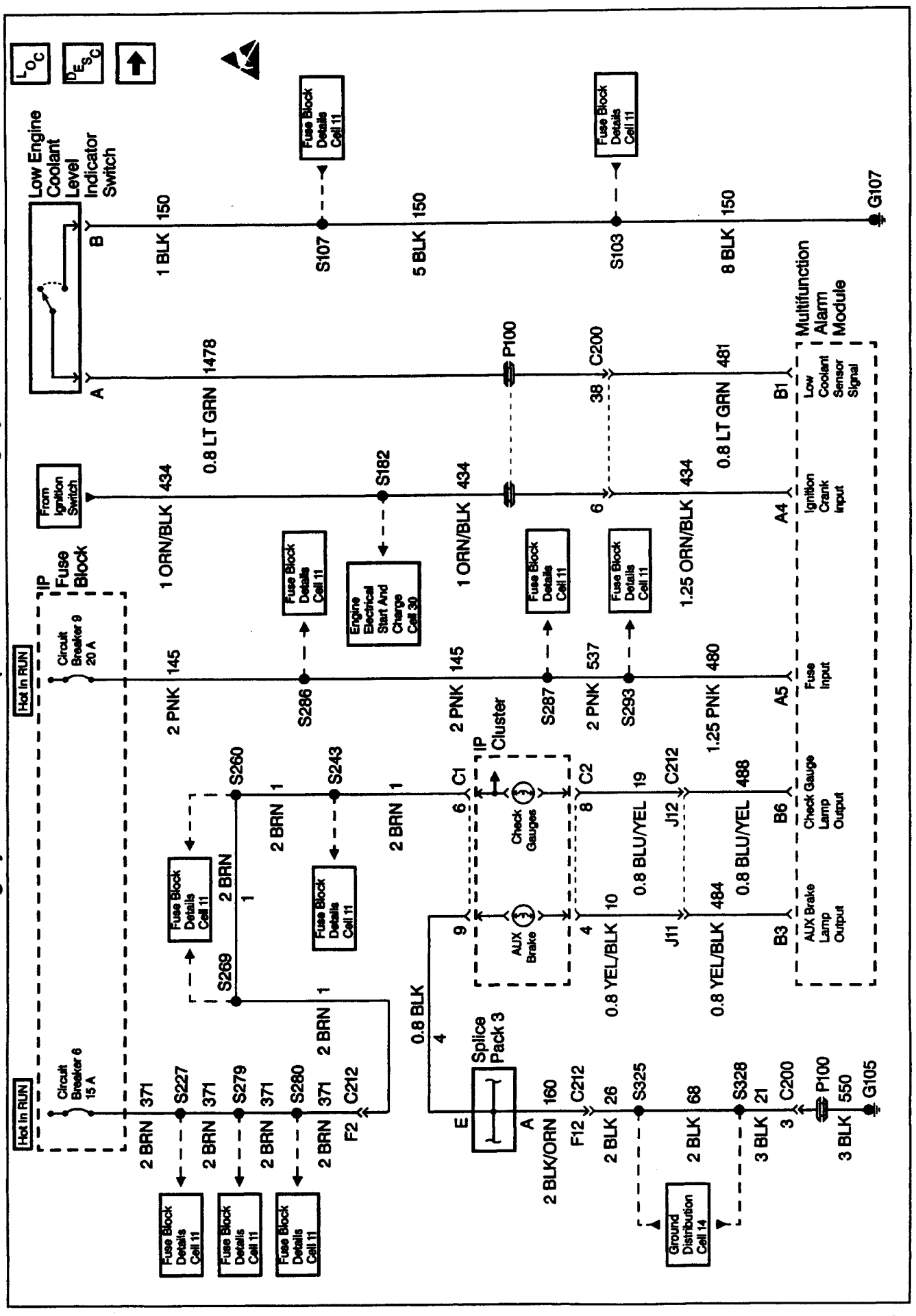
Schematic and Routing Diagrams

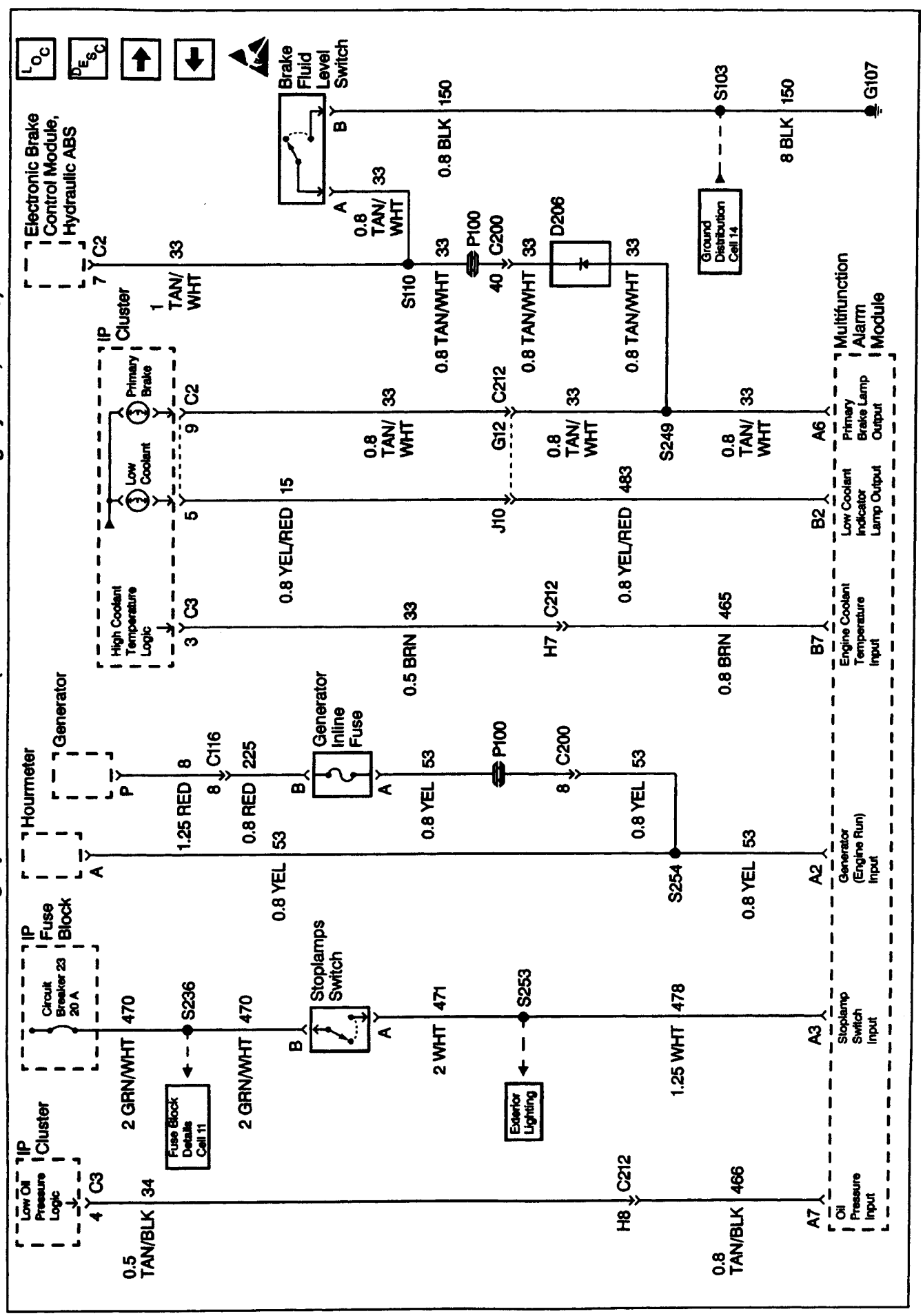
Hydraulic Brakes Schematic References

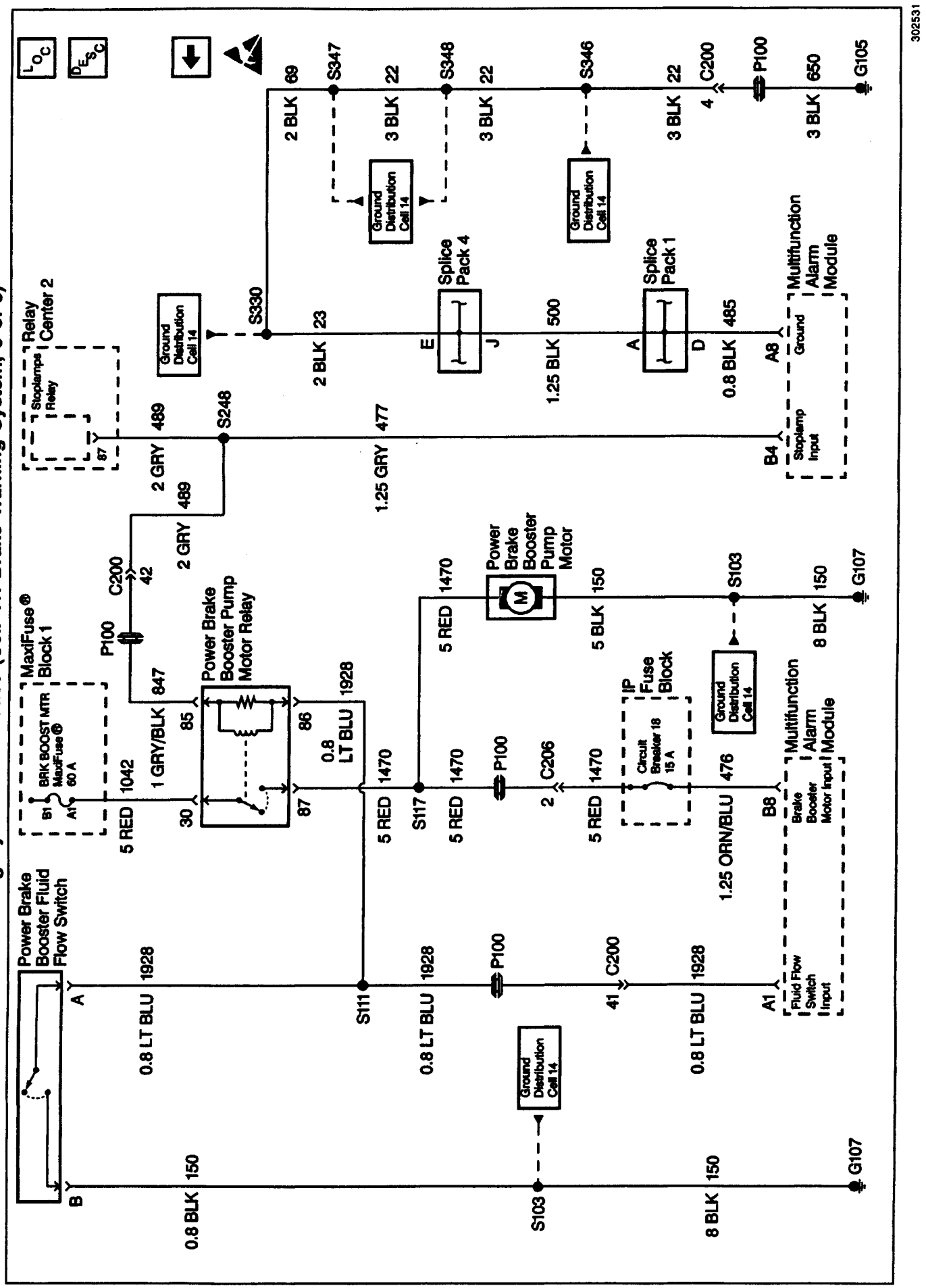
Reference on Schematic	Section Number - Subsection Name
Power Distribution Cell 10	8—Wiring Systems
Fuse Block Details Cell 11	8—Wiring Systems
Ground Distribution Cell 14	8—Wiring Systems

Hydraulic Brakes Schematic Icons

Icon	Icon Definition
 19384	Refer to *ESD Notice* in Cautions and Notices.


Brake Warning System Schematics (Cell 41: Brake Warning System, 1 of 3)
302528
LOC
DESC
Low Engine Coolant Level Indicator Switch
B
A
1 BLK 150
S107
5 BLK 150
S103
8 BLK 150
G107
Fuse Block Details Cell 11
Fuse Block Details Cell 11
Multifunction Alarm Module
Low Coolant Sensor Signal
B1
481
0.8 LT GRN 1478
P100
C200
38
From Ignition Switch
S182
Engine Electrical Start And Charge Cell 30
1 ORN/BLK 434
6
434
0.8 LT GRN
A4
Ignition Crank Input
Hot In RUN
Circuit Breaker 9 20 A
IP Fuse Block
2 PNK 145
S286
145
S287
537
S293
480
1.25 PNK
A5
Fuse Input
1.25 ORN/BLK
2 PNK
IP Cluster
C1
6
C2
8
Check Gauges
S260
S243
2 BRN 1
2 BRN 1
S269
1
2 BRN
Fuse Block Details Cell 11
Fuse Block Details Cell 11
AUX Brake
9
4
0.8 BLK
4
Splice Pack 3
E
A
2 BLK/ORN 160
C212
F12
26
0.8 YEL/BLK 10
0.8 BLU/YEL 19
J12
C212
J11
484
0.8 BLU/YEL
488
B6
Check Gauge Lamp Output
B3
AUX Brake Lamp Output
0.8 YEL/BLK
S325
68
2 BLK
Ground Distribution Cell 14
S328
21
3 BLK
C200
3
P100
550
3 BLK
G105
Hot In RUN
Circuit Breaker 6 15 A
371
2 BRN
S227
S279
S280
C212
F2
Fuse Block Details Cell 11
Fuse Block Details Cell 11
Fuse Block Details Cell 11


Brake Warning System Schematics (Cell 41: Brake Warning System, 2 of 3)
302530
Electronic Brake Control Module, Hydraulic ABS
Brake Fluid Level Switch
IP Cluster
Hourmeter
Generator
IP Fuse Block
Circuit Breaker 23 20 A
Generator Inline Fuse
High Coolant Temperature Logic
Low Coolant
Primary Brake
Stoplamps Switch
Fuse Block Details Cell 11
Exterior Lighting
Ground Distribution Cell 14
Multifunction Alarm Module
Low Oil Pressure Logic
Oil Pressure Input
Generator (Engine Run) Input
Stoplamp Switch Input
Engine Coolant Temperature Input
Low Coolant Indicator Lamp Output
Primary Brake Lamp Output
C2
C3
C116
C212
C200
P100
D206
S110
S103
S236
S253
S254
S249
G107
J10
G12
H7
H8
A2
A3
A6
A7
B2
B7
0.8 TAN/WHT
0.8 BLK
0.8 TAN/BLK
0.8 TAN/WHT
0.8 YEL/RED
0.5 BRN
0.8 BRN
0.8 YEL
1.25 RED
0.8 RED
2 GRN/WHT
2 WHT
1.25 WHT
8 BLK


Brake Warning System Schematics (Cell 41: Brake Warning System, 3 of 3)
302531
Power Brake Booster Fluid Flow Switch
MaxiFuse® Block 1
BRK BOOST MTR MaxiFuse® 60 A
Power Brake Booster Pump Motor Relay
Relay Center 2
Stoplamps Relay
Power Brake Booster Pump Motor
IP Fuse Block
Circuit Breaker 18 15 A
Ground Distribution Cell 14
Splice Pack 4
Splice Pack 1
Multifunction Alarm Module
Brake Booster Motor Input
Fluid Flow Switch Input
Stoplamp Input
Ground
P100
C200
C206
S103
S111
S117
S248
S330
S346
S347
S348
G105
G107
0.8 BLK 150
0.8 LT BLU 1928
1 GRY/BLK 847
1042
2 GRY 489
5 RED 1470
1.25 GRY 477
2 BLK 23
1.25 BLK 500
0.8 BLK 485
2 BLK 69
3 BLK 22
4
42
41
2
30
85
86
87
87A
A
B
A1
B1
A8
B4
B8
E
J
A
D
1.25 ORN/BLU 476
5 BLK 150
8 BLK 150
3 BLK 650

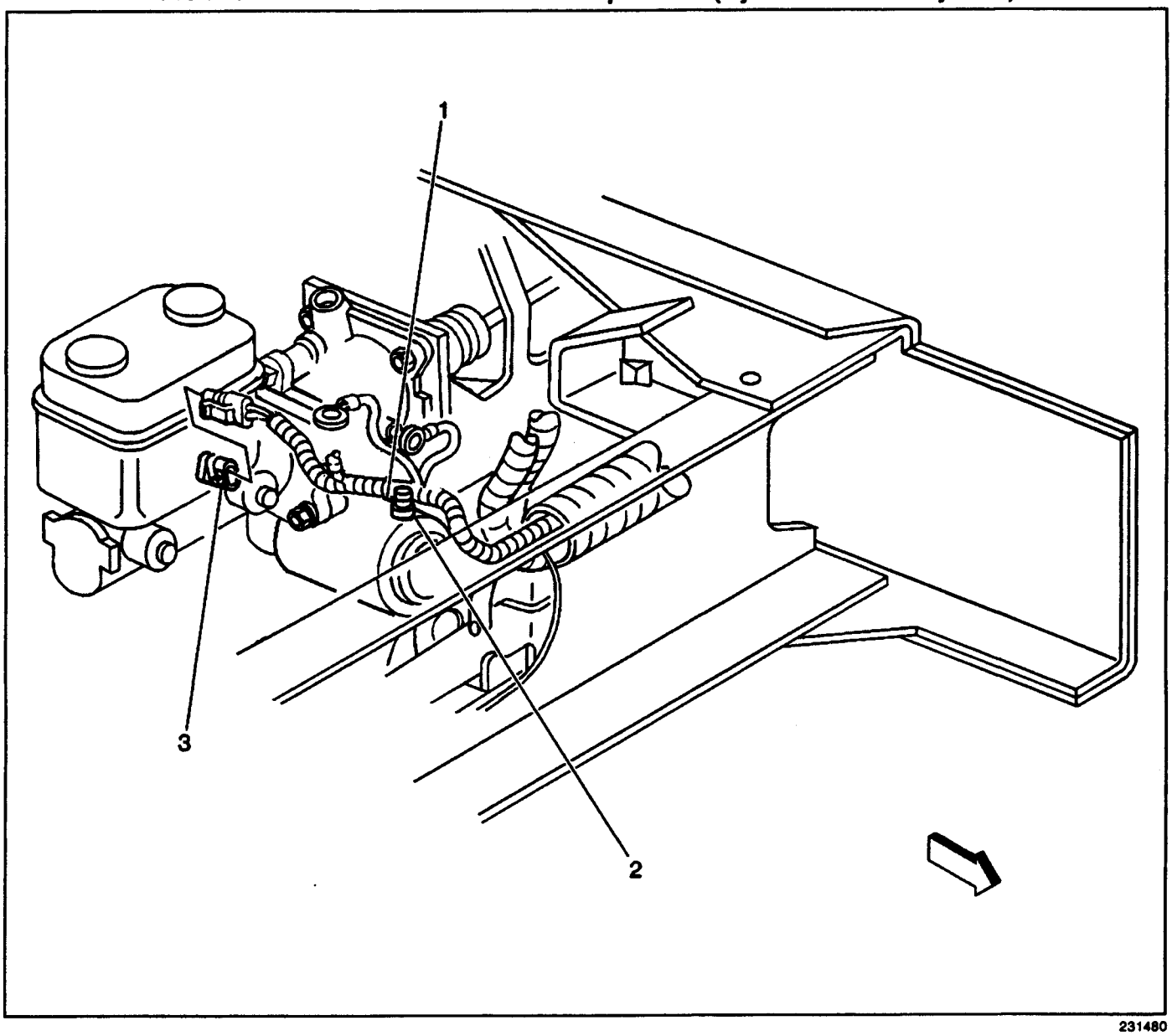
Component Locator

Hydraulic Brakes Components

Name	Location	Locator View	Connector End View
Brake Fluid Level Indicator Switch	Behind the left side of the front crossmember on the front of the brake master cylinder reservoir.	Refer to *Hydraulic Brakes Component Views*	Refer to *Hydraulic Brakes Connector End Views*
Power Brake (P/B) Booster Fluid Flow Switch (Hydraulic Brakes)	Right side of the power brake booster pump housing left of the brake master cylinder.	Refer to *Hydraulic Brakes Component Views*	Refer to *Hydraulic Brakes Connector End Views*
Power Brake (P/B) Booster Pump Motor (Hydraulic Brakes)	Left side front frame rail, behind the front crossmember at the brake master cylinder.	Refer to *Hydraulic Brakes Component Views*	Refer to *Hydraulic Brakes Connector End Views*
Power Brake (P/B) Booster Pump Motor Relay (Hydraulic Brakes)	Under the MaxiFuse.rtm block cover.	Refer to *Hydraulic Brakes Component Views*	Refer to *Hydraulic Brakes Connector End Views*

Hydraulic Brakes Component Views

Front Chassis Harness to Brake Components (Hydraulic Brake System)

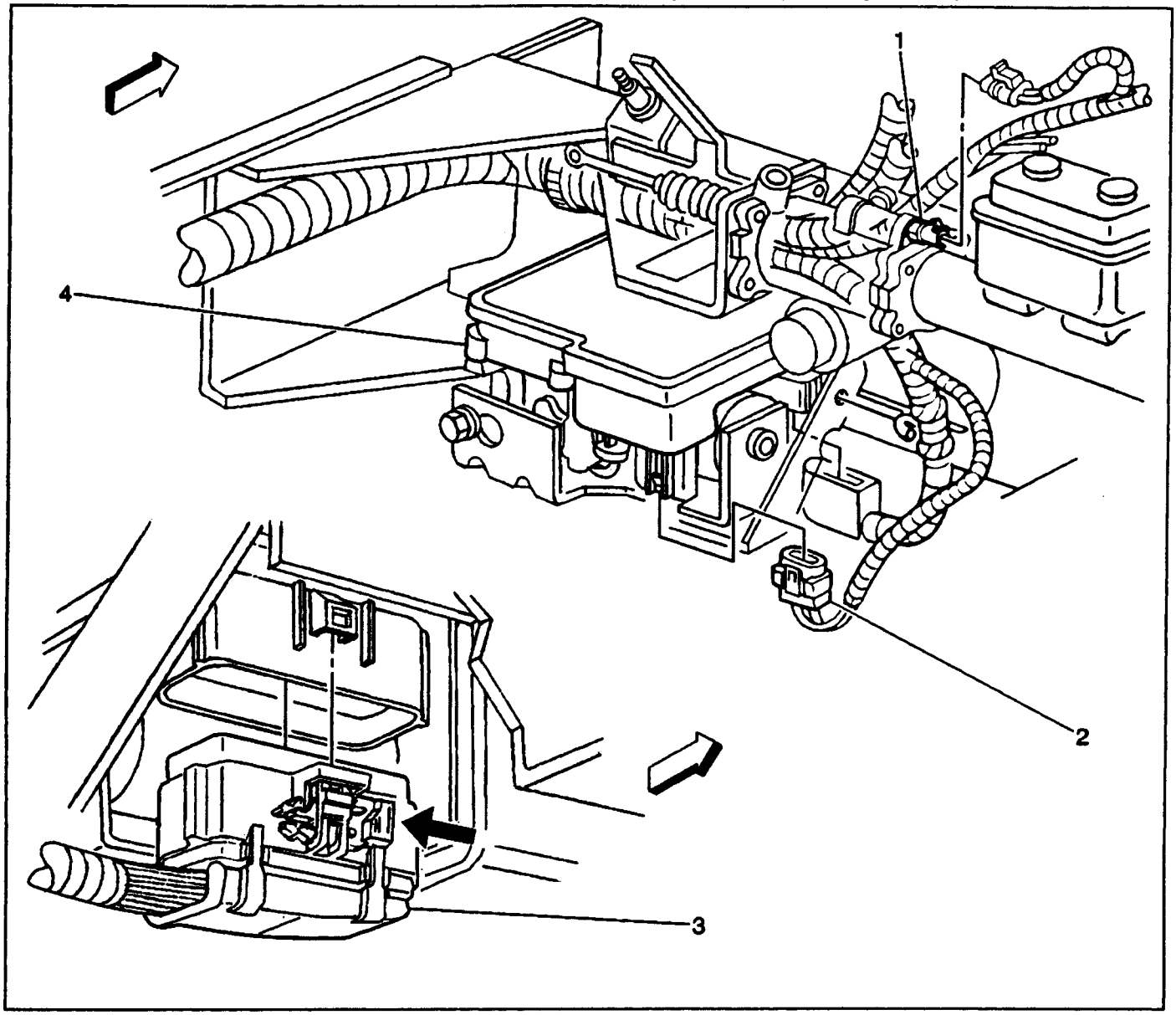


231480

Legend

(1) Power Brake Booster Pump
(2) Power Brake Booster Pump Motor
(3) Brake Fluid Level Indicator Switch

Front Chassis Harness to Brake Components (ABS-Hydraulic)

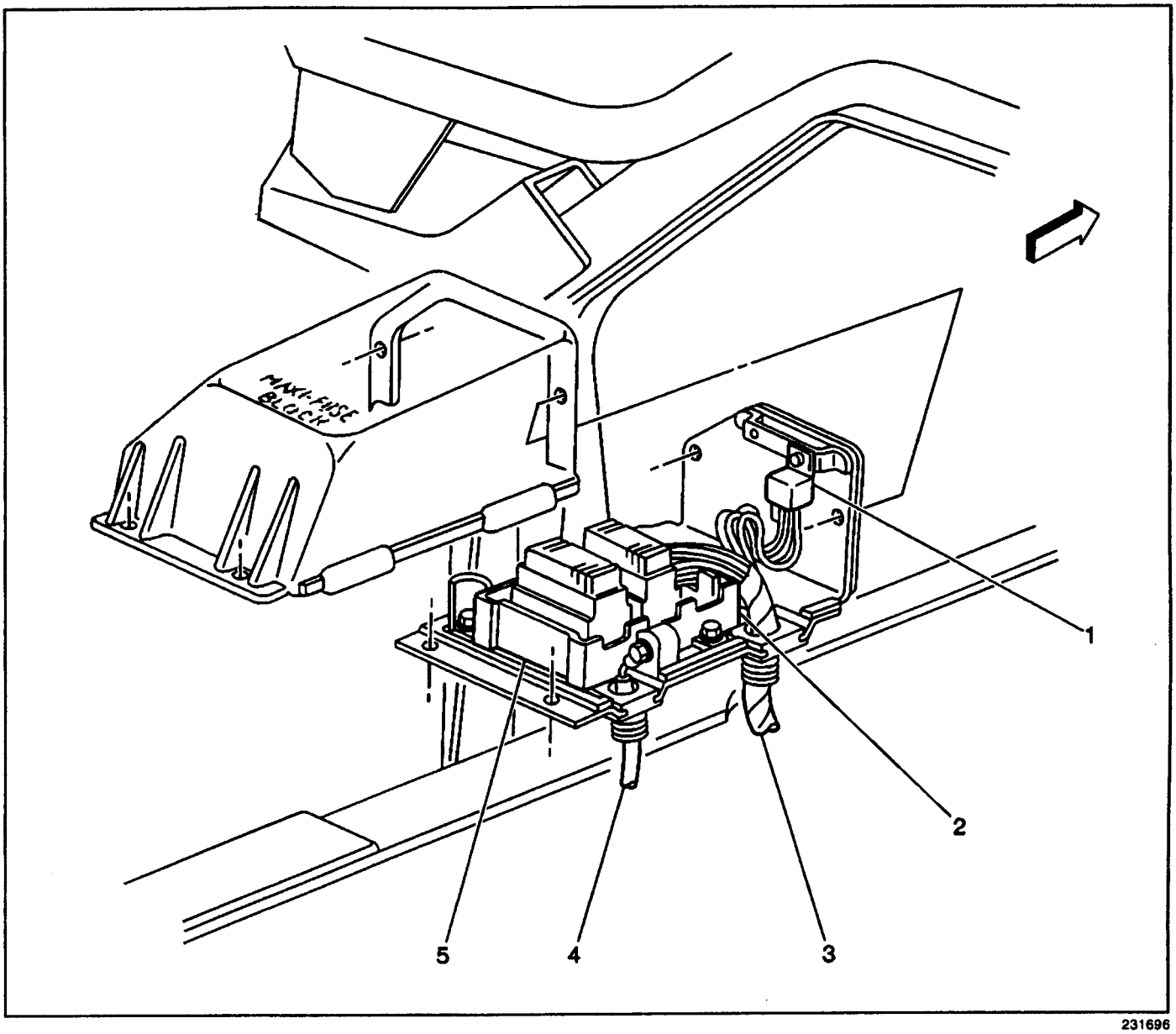


231487

Legend

(1) Brake Fluid Flow Switch
(2) Electronic Brake Control Module (EBCM) (ABS-Hydraulic) Connecor C2 (2 cavities)
(3) Electronic Brake Control Module (EBCM) (ABS-Hydraulic) Connector C1 (24 cavities)
(4) Electronic Brake Control Module (EBCM) (ABS-Hydraulic) Connector C2 (2 cavities)

MaxiFuse® Blocks



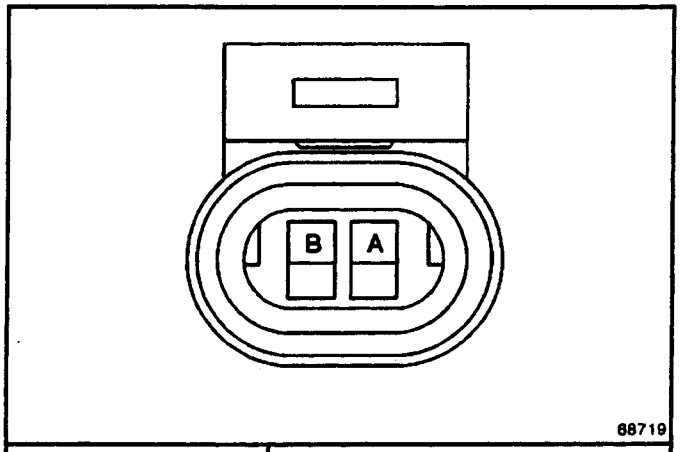
231696

Legend

(1) Power Brake Booster Pump Motor Relay
(2) MaxiFuse® Block 2
(3) Front Chassis Harness
(4) Positive Battery Cable Feed
(5) Maxifuse® Block 1

Hydraulic Brakes Connector End Views

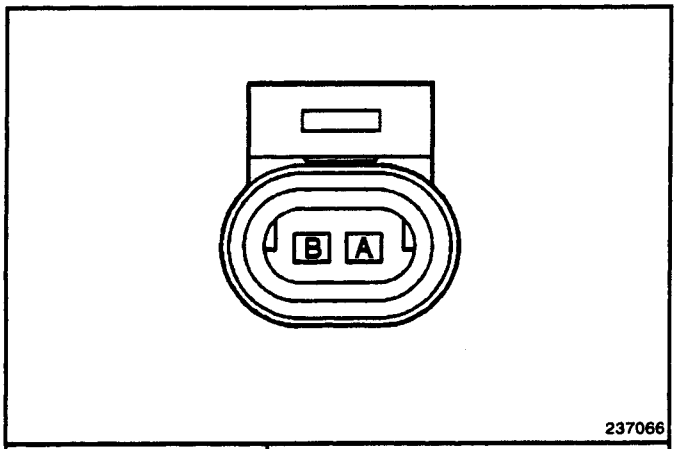
Power Brake Booster Brake Fluid Flow Switch



68719

Connector Part Information	• 12162198 • ASM 2F Metri Pack 150.2 Series Pull To Seat, Sealed (GRY)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	LT BLU	1928	Brake Booster Fluid Flow Switch Feed
B	BLK	150	Ground

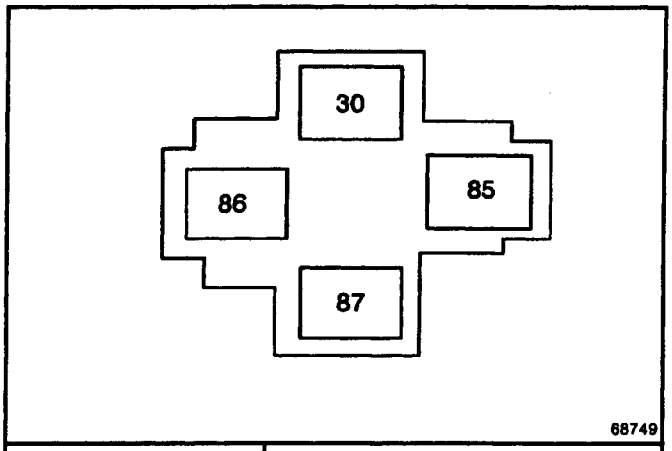
Brake Fluid Level Switch



237066

Connector Part Information	• 12162194 • ASM 2F Metri Pack 150.2 Series Pull To Seat, Sealed (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	TAN/WHT	33	Brake Warning Lindicator Lamp Output
B	BLK	150	Ground

Power Brake Booster Pump Motor Relay



68749

Connector Part Information	• 12124169 • ASM 4F Mixed (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
30	RED	1042	Fuse Output Battery
85	GRY/BLK	847	Brake Pedal Switch Output ExtendedTravel
86	LT BLU	1928	Brake Booster Fluid Flow Switch Feed
87	RED	1470	Power Brake Booster Pump Motor Feed

Diagnostic Information and Procedures

Brake Warning Indicator Inoperative

Step	Action	Value(s)	Yes	No
1	1. Backprobe the multifunction alarm module with a *J 39200* Digital Multimeter (DMM) from terminal A8 to B+ 2. Measure the voltage. Is the voltage greater than the specified value?	10.0 volts	Go to *Step 2*	Go to *Step 3*
2	1. Turn the ignition switch to the RUN position. 2. Backprobe the multifunction alarm module with a *J 39200* (DMM) from terminal A5 to ground. 3. Measure the voltage. Is the voltage greater than the specified value?	10.0 volts	Go to *Step 4*	Go to *Step 5*
3	Repair the open in CKT 485 (BLK) between the multifunction alarm module and the lower ground buss 1. Is the repair complete?	—	System OK	—
4	1. Backprobe the multifunction alarm module with a *J 39200* (DMM) from terminal A4 to ground while cranking the engine. 2. Measure the voltage. Is the voltage greater than the specified value?	10.0 volts	Go to *Step 6*	Go to *Step 7*
5	Repair the open in CKT 145, 522 and 625 (PNK) between the instrument panel fuse block and the multifunction alarm module. Is the repair compete?	—	System OK	—
6	1. Turn the ignition switch to the LOCK position. 2. Disconnect the multifunction alarm module. 3. Start the engine. 4. Connect a test lamp from the multifunction alarm module connector terminal A2 to ground. Was the test lamp lit?	—	Go to *Step 8*	Go to *Step 9*
7	Repair the open in CKT 434 and 487 (ORN/BLK) between S182 and the multifunction alarm module. Is the repair complete?	—	System OK	—
8	Replace the multifunction alarm module. Refer to *Multifunction Alarm Module Replacement* in Instrument Panel, Gauges and Console. Is the repair complete?	—	System OK	—
9	Backprobe the inline fuse with a test lamp to ground. Was the test lamp lit?	—	Go to *Step 10*	Go to *Step 11*
10	Repair the open in CKT 53, 37 and 468 (YEL) between the inline fuse and the multifunction alarm module. Is the repair complete?	—	System OK	—
11	Inspect for an open in CKT 8 and 255 (RED) between the generator line and the inline fuse. Did you find an open?	—	—	Refer to Engine Electrical for Generator Diagnosis.
12	Repair the open. Is the repair complete?	—	System OK	—

AUX BRAKE Indicator and Alarm On w/Engine Running

Step	Action	Value(s)	Yes	No
1	1. Disconnect the multifunction alarm module connector. 2. Connect a test lamp from terminal A5 to terminal A1 at the multifunction alarm module. 3. Start the engine and run the engine for 30 seconds. Does the test lamp light?	—	Go to *Step 2*	Go to *Step 4*
2	1. Disconnect the brake fluid flow switch connector with the engine running. 2. Leave the test lamp connected as described in Step 1. Does the test lamp light?	—	Go to *Step 3*	Go to *Step 11*
3	Repair the short to ground in CKT 475 and CKT 1928 (LT BLU) between the following components: – The multifunction alarm module – The brake fluid flow switch – The hydraulic brake relay Is the repair complete?	—	System OK	—
4	1. Connect the test lamp between CKT 480 (PNK) and CKT 476 (ORN) at the multifunction alarm module. 2. Start the engine and run the engine. Does the test lamp light?	—	Go to *Step 9*	Go to *Step 5*
5	1. Turn the engine OFF. 2. Disconnect the power brake booster motor connector. 3. Install a fused jumper wire between CKT 150 (BLK) and CKT 1470 (RED) at the power brake booster motor connector. 4. Keep the test lamp connected at the multifunction alarm module connector. 5. Place the ignition switch in the RUN position. Does the test lamp light?	—	Go to *Step 6*	Go to *Step 7*
6	Replace the power brake booster pump motor. Refer to *Hydraulic Brake Booster Replacement.* Is the repair complete?	—	System OK	—
7	Connect a self-powered test lamp from CKT 150 (BLK) at the power brake booster pump motor to B+. Does the test lamp light?	—	Go to *Step 8*	Go to *Step 12*
8	Repair the open in CKT 476 (ORN/BLU) or CKT 474 and CKT 1470 (RED) between the power brake booster pump motor and the multifunction alarm module. Is the repair complete?	—	System OK	—
9	1. Connect a test lamp between CKT 150 (BLK) terminal A8 and CKT 847 (GRY) terminal B4 at the multifunction alarm module connector. 2. Apply the service brakes. Does the test lamp light?	—	Go to *Step 10*	Refer to *Stop Lamps Inoperative - All (Hydraulic Brakes)* in Lighting Systems
10	Replace the multifunction alarm module. Refer to *Multifunction Alarm Module Replacement* in Instrument Panels, Gauges and Console. Is the repair complete?	—	System OK	—

AUX BRAKE Indicator and Alarm On w/Engine Running (cont'd)

Step	Action	Value(s)	Yes	No
11	Replace the brake fluid flow switch. Refer to *Fluid Flow Switch Replacement.* Is the repair complete?	—	System OK	—
12	Repair the open in CKT 150 (BLK) between the power brake booster motor and ground. Is the repair correct?	—	System OK	—

AUX BRAKE Indicator Inoperative

Step	Action	Value(s)	Yes	No
1	1. Turn the ignition switch to the START position. 2. Observe the AUX BRK indicator lamp. Does the indicator lamp light for four seconds after the engine is cranked?	—	System OK	Go to *Step 2*
2	1. Remove the connector at the brake fluid flow switch. 2. Connect a self powered test lamp between the switch terminals. 3. Start the engine. 4. Observe the test lamp. Was the lamp lit?	—	Go to *Step 3*	Go to *Step 4*
3	Replace the flow switch. Refer to *Fluid Flow Switch Replacement.* Is the repair complete?	—	System OK	—
4	1. Connect a test lamp from CKT 1470 (RED) at the power brake booster pump motor relay to chassis ground. 2. Crank the engine. 3. Observe the test lamp. The test lamp will only light for four seconds. Was the lamp lit?	—	Go to *Step 5*	Go to *Step 6*
5	1. Backprobe the multifunction alarm module with a digital multimeter *J 39200* from terminal A3 to chassis ground. 2. Measure the voltage while applying the service brakes. Is the voltage more than the specification?	10.0 volts	Go to *Step 7*	Refer to *Stop Lamps Inoperative - All (Hydraulic Brakes)* in Lighting Systems
6	Replace the power brake booster pump motor relay. Refer to *Hydraulic Brake Booster Replacement.* Is the repair complete?	—	System OK	—
7	1. Remove the connector from the power brake booster pump motor. 2. Connect a self powered test lamp between the motor terminals. Was the lamp lit?	—	Go to *Step 8*	Go to *Step 11*
8	1. Remove the connectors at the multifunction alarm module and the 9 way instrument panel harness connector. 2. Connect a self powered test lamp from the instrument panel harness connector (terminal B4) to CKT 484 (YEL/BLK) at the multifunction alarm module (terminal B3). Was the lamp lit?	—	Go to *Step 9*	Go to *Step 10*

AUX BRAKE Indicator Inoperative (cont'd)

Step	Action	Value(s)	Yes	No
9	Replace the multifunction alarm module. Refer to *Multifunction Alarm Module Replacement* in Instrument Panels, Gauges and Console. Is the repair complete?	—	System OK	—
10	Repair the open in CKT 10 and CKT 484 (YEL/BLK) between the instrument panel harness connector and the multifunction alarm module. Is the repair complete?	—	System OK	—
11	Replace the power brake booster pump motor. Refer to *Hydraulic Brake Booster Replacement.* Is the repair complete?	—	System OK	—

External Conditions that Affect Brake Performance

- Tires — Tires with unequal contact and grip on the road cause unequal braking. The inflation and the tread pattern of the right and the left tires should be equal.
- Vehicle Loading — The most heavily loaded wheels on the vehicle require more braking force when the loading is unequal.
- Front Wheel Bearings — Loose front wheel bearings permit the rotor to tilt. Loose front wheel bearings also cause the rotor to have spotty contact with the linings. A tilted rotor that has spotty contact with the lining causes erratic braking.
- Front End Alignment — Misalignment of the following components will cause the brakes to pull to one side of the vehicle:
  - The front end
  - The camber
  - The caster

Brake System Diagnosis

Important: A vehicle that pulls to one side during braking may need a front end alignment. Do not assume that the reason the vehicle pulls to one side is a brake related condition. Ensure that the alignment is correct.

Test the brakes on a dry, clean, reasonably smooth and level roadway. The accuracy of the brake performance cannot be determined if the following road conditions exist:

- Wet roadway
- Greasy roadway
- Roadway covered with loose dirt

The road conditions prevent the tires from gripping the road equally. Crowned roadways affect brake testing by throwing the weight of the vehicle toward the wheels on one side of the vehicle. Rough roadways cause the wheels to bounce. Bouncing wheels affect the test accuracy.

Test the brakes at different vehicle speeds with light and heavy pressure. Do not lock the wheels and slide the tires on the roadway. Locked wheels and sliding tires do not indicate brake efficiency. Heavily braked, turning wheels will stop the vehicle in less distance than locked wheels. More tire-to-road friction is present with heavily braked, turning tires than with sliding tires.

Brake Pedal Excessive Effort with Engine Off (Brake Light On)

Problem	Action
DEFINITION: Excessive pedal pressure is required to stop with the engine OFF and BRAKE lamp ON.	
Low or no voltage exists at the Electrohydraulic (EH) pump motor connection of the wiring harness.	1. Inspect for an open circuit between the battery and the EH pump. 2. Repair the circuit as necessary.
A loose, dirty, or disconnected connection exists between the EH pump motor lead wire and the wiring harness.	Clean and secure the connection.
A poor ground exists between the EH pump and the booster.	Repair the circuit as necessary.
The EH pump is not functioning.	Replace the pump. Refer to *Electrohydraulic Pump Replacement.* Electrohydraulic Pump Replacement.

Brake Pedal Excessive Effort with Engine Off (Brake Light Off)

Problem	Action
DEFINITION: Excessive pedal pressure is required to stop with the engine OFF and BRAKE lamp OFF.	
The flow switch is malfunctioning.	Replace the flow switch. Refer to *Fluid Flow Switch Replacement* Fluid Flow Switch Replacement.
Little or no voltage exists to the following locations: • The ignition side of the coil relay • The battery connection to the relay • The electrohydraulic terminal on the relay	Clean the connections or replace the relay.
An open condition exists in the ignition diode.	Replace the diode.

Brake Pedal Excessive Effort to Stop

Problem	Action
DEFINITION: Excessive pedal pressure required to stop (Hard Pedal)	
The power steering pump is loose or broken.	1. Tighten the belt and the mounting hardware. 2. Replace the power steering pump. Refer to Power Steering Pump Replacement in Steering.
The brake power steering pump output pressure is low.	Install the gauge in the inlet line to the booster. The gauge should read at least 4137 kPa (600 psi) before the pedal becomes hard to push.
The drive belt on the power steering pump is loose.	Tighten the belt. Refer to Power Steering System in Power Steering.
The fluid level in the power steering pump is low.	Fill the power steering pump to the proper level with power steering fluid. Refer to Bleeding Power Steering System in Steering.
Air is present in the fluid.	Locate the air leak and correct the leak. Bleed the system. Refer to Bleeding Power Steering System in Steering.
An internal booster or power steering pump problem exists.	1. Test the internal booster and the power steering pump. 2. Repair or replace the faulty unit.

Brake Fluid Leaks

Apply and hold constant foot pressure on the brake pedal with the engine at idle position. Ensure that the transmission is in the NEUTRAL position. The brake hydraulic system may have the following conditions if the brake pedal gradually loses foot pressure:

- External leakage
- Internal leakage
- Incorrect component adjustment

Perform a visual inspection of the hydraulic system.

Inspect the master cylinder fluid level. A slightly low brake fluid level in either reservoir can result from normal lining wear. An abnormally low fluid level indicates a leak in the system. A full master cylinder does not always indicate that there is no leakage. Slight leakage can occur and not appear as a fluid level condition.

Internal leakage may be the cause if no external leaks are found. Internal leakage is related to an internal master cylinder condition. Disassemble the master cylinder in order to accurately diagnose internal leakage. Refer to the instructions included with the service repair kit. Contact the Bendix® Helpline at 1-800-AIR-BRAK (1-800-247-2725) for additional overhaul information.

Brake Hose and Pipe Inspection

Inspect the brake hoses and the pipes at least twice a year for the following conditions:

- Road damage
- Cracks
- Chafing of the outer cover

Inspect the brake hoses and the pipe connections for fluid leaks and damage. Replace the brake hoses and the pipe connections if fluid leaks or damages are detected. Ensure that all of the mounting hardware is in place and secure. Repair the hoses or the pipe connections as needed.

EH Pump and Booster Mating Surface Oil Leak

Problem	Action
DEFINITION: Oil leaks at the booster and the electrohydraulic pump mating surface.	
The pressure port and/or return port has missing or damaged O-rings.	Replace both O-rings.

EH Pump End Plate Oil Leak

Problem	Action
DEFINITION: Oil leaks from the electrohydraulic pump end plate.	
The plate seal has a missing end or is damaged.	Replace the electrohydraulic pump assembly. Refer to *Electrohydraulic Pump Replacement.* Electrohydraulic Pump Replacement.

EH Pump Motor Oil Leak

Problem	Action
DEFINITION: Oil leaks from the electrohydraulic pump motor.	
The shaft seal is damaged.	Replace the electrohydraulic pump assembly. Refer to *Electrohydraulic Pump Replacement* Electrohydraulic Pump Replacement.

EH Pump Noise

Problem	Action
DEFINITION: Excessive electrohydraulic pump noise (gurgle, chatter, etc) is present.	
Air is trapped in the electrohydraulic pump.	1. Depress the brake pedal lightly for 30 seconds with the engine OFF. 2. Repeat the brake pedal depression after 3 minutes if the problem continues. The noise diminishes with the brake use under normal driving conditions.

Master Cylinder Diagnosis

1. Inspect the master cylinder for the following conditions:
   - Cracked casting
   - Brake fluid leaks around the master cylinder

   Brake fluid leaks are indicated if there is one drop of fluid. A damp condition is not abnormal.
2. Inspect the master cylinder for the following conditions:
   - Binding pedal linkage
   - Incorrect pushrod length
3. Disassemble the master cylinder if the following conditions exist:
   - No brake pedal binding
   - Improper brake pedal travel

   Refer to the instructions enclosed with the service repair kit.
4. Inspect the master cylinder for swollen or elongated primary piston seal(s).

Hydraulic System Fluid Loss

Notice: Do not run the engine without fluid in the power steering pump reservoir. Doing so could damage the pump bearing and seals. The belt that drives the power steering pump also drives the coolant pump and other components. Do not disconnect the belt and run the engine. A malfunctioning power steering pump and/or system still serves as an idler pulley for the belt. If the pump is allowed to run without fluid in it, the bearings will seize up and cause the coolant pump to stop. This can cause damage to the engine.

Before starting the vehicle if the hydraulic brake booster system fails due to the loss of fluid, ensure that the necessary repairs are performed. Fill and bleed the hydraulic brake booster system.

Clean and flush the hydraulic booster system when the power steering pump is replaced. Metal shavings from a worn hydraulic pump will contaminate the system. Disassemble and clean the booster head. Replace the seals and the O-ring seals. Remove the pipes and the hoses. Blow clean the pipes and hoses of all metal shavings. Refer to *Hydraulic Brake Booster Description.*

Hydraulic Booster Noise Diagnosis

Noise caused by the relief valve is normal when the brakes are applied. Firmly pressing the brake pedal when the vehicle is parked also causes noise. Air temporarily gets into the fluid when the brakes are applied.

Hydraulic pump noise can be confused with transmission, rear axle or generator noise.

Air in the fluid causes noise. Fill and bleed the system when a hose has been disconnected.

Use the following steps in order to locate and correct the noise problems:

- Inspect the fluid level.
- Adjust the fluid level as needed.
- Inspect the hoses at the places where the hoses contact other vehicle parts.
- Reposition the hoses as needed.
- Inspect the fluid for air. The following conditions may exist if air is present:
  - Bubbles
  - Milky appearance
  - Extremely noisy operation
- Bleed the brake booster system if air is present.
- Inspect the hydraulic brake booster pump pressure.

Repair Instructions

Master Cylinder Reservoir Filling

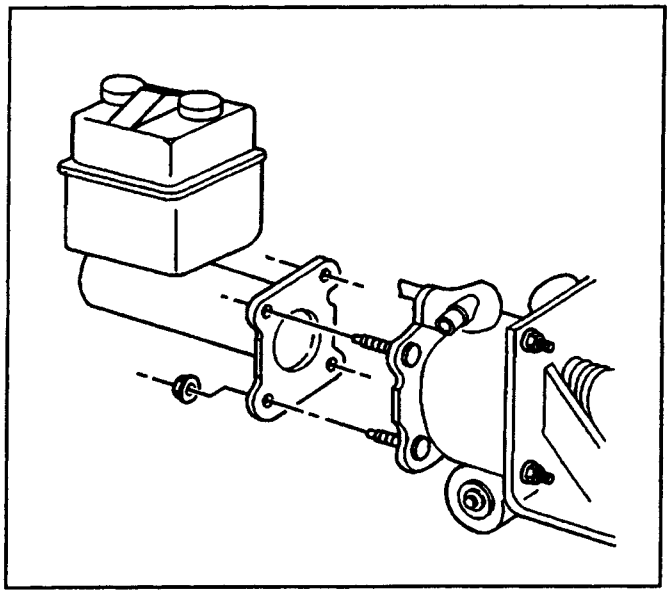
Keep the master cylinder reservoir filled in order to keep air out of the hydraulic system. Do not overfill the reservoir. The fluid expands due to heat from the brakes and the engine.

Clean the reservoir caps before opening the caps in order to keep out dirt. Add brake fluid to the reservoir until the brake fluid is even with the bottom of the filler neck or within 6 to 13 mm (1/4 to 1/2 in) of the top of the master cylinder reservoir.

Master Cylinder Replacement

Removal Procedure

1. Set the parking brake.
2. Block the drive wheels.
3. Place a suitable container under the master cylinder in order to catch the fluid.
4. Cap or plug the hydraulic pipes.
5. Remove the hydraulic pipes from the master cylinder.
6. Remove the low fluid level sensor connector.
7. Remove the mounting nuts.
8. Remove the master cylinder.



220733

Installation Procedure

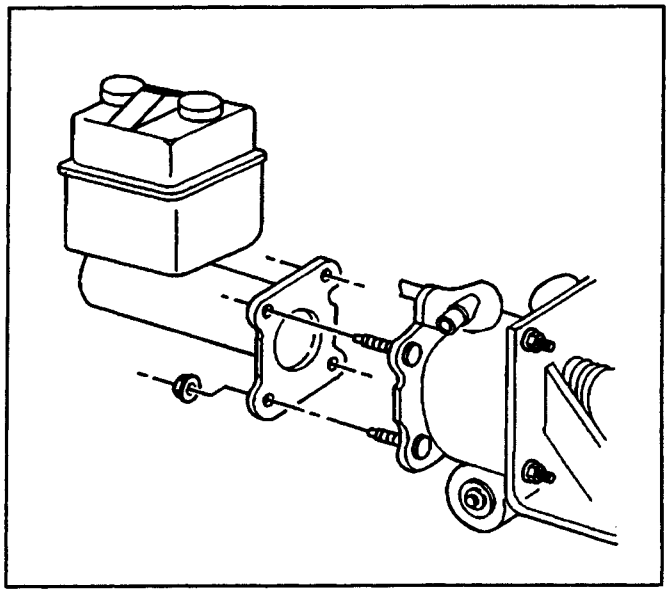
1. Install the master cylinder.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the mounting nuts.

   Tighten

   Tighten the mounting nuts to 36 N·m (27 lb ft).
3. Install the low fluid level sensor connector.
4. Install the hydraulic pipes to the master cylinder.
5. Bleed the brake system.

   Caution: After releasing the parking brake, be sure the vehicle will not roll forward or backwards when removing the wheel blocks. If the vehicle is not in gear, the vehicle may move possibly causing personal injury.
6. Remove the wheel blocks.
7. Release the parking brake.



220733

Master Cylinder Bench Bleeding

Bench bleeding removes the air from the master cylinder prior to the installation of the master cylinder. Bench bleeding reduces the amount of bleeding needed after the installation of the master cylinder onto the vehicle.

1. Plug the outlet ports.
2. Mount the master cylinder in a vise with the front end tilted slightly down.
3. Fill the reservoir with clean brake fluid.
4. Stroke the primary piston about 25 mm (1 in) several times using a smooth, rounded end tool. Resistance to the primary piston travel will not allow the full 25 mm (1 in) stroke when air is bled from the master cylinder.
5. Reposition the master cylinder in the vise with the front end tilted slightly up.
6. Repeat the stroke to the primary piston of about 25 mm (1 in) several times.
7. Reposition the master cylinder in the vise to the level position.
8. Loosen the plugs one at a time.
9. Push the piston into the bore in order to force the air from the cylinder.
10. Tighten the plug(s) before the piston returns to the original position in order to prevent air from being sucked into the cylinder.
11. Fill the reservoir.
12. Perform the normal bleeding procedure after the master cylinder is installed.

Master Cylinder Fluid Level Sensor Replacement

Removal Procedure

1. Remove the brake fluid from the master cylinder reservoir.
2. Remove the connector.
3. Remove the four bolts that hold the reservoir to the master cylinder.
4. Remove the reservoir.
5. Remove the fluid level switch from the reservoir. Use a pick or a thin tool in order to reach into the slot on the bottom of the reservoir. Compress the tabs while pulling out on the sensor.

Installation Procedure

1. Install the fluid level switch into the reservoir until the tabs click.
2. Install the reservoir.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
3. Install the bolts.

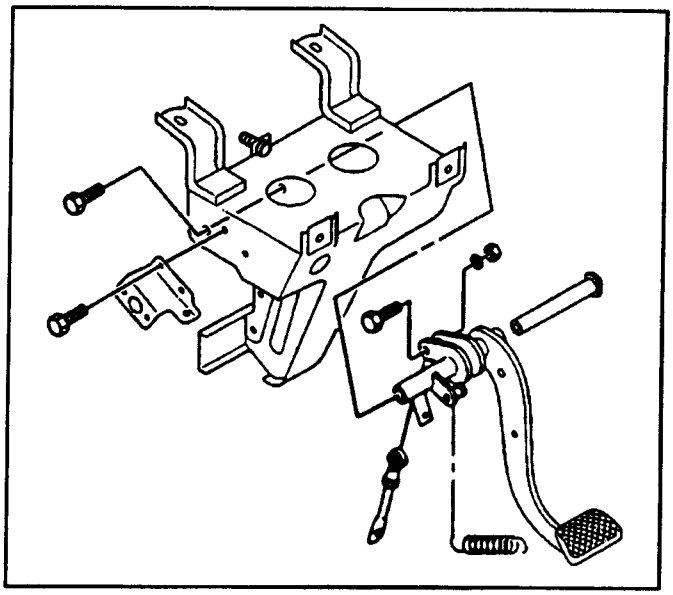
   Tighten

   Tighten the bolts to 22 N·m (16 lb ft).
4. Install the connector.
5. Fill the master cylinder with brake fluid.
6. Bleed the brake system.

Brake Pedal Replacement

Removal Procedure

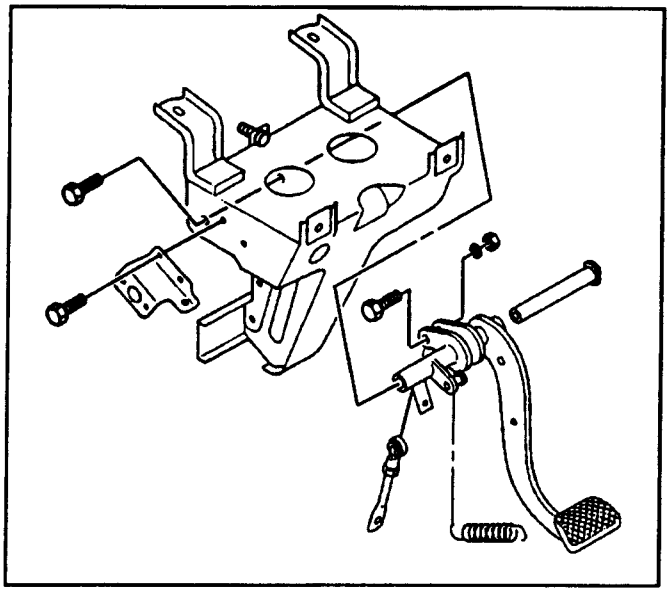
1. Set the parking brake.
2. Remove the steering shaft assembly.
3. Remove the instrument panel trim as necessary.
4. Remove the pushrod.
5. Remove the bracket.
6. Remove the return spring.
7. Remove the pedal shaft.
8. Remove the brake pedal.
9. Inspect the bushings for wear or deterioration. Replace the bushings if necessary.



220709

Installation Procedure

1. Install the brake pedal.
2. Install the pedal shaft.
3. Install the return spring.
4. Install the bracket.
5. Install the pushrod.
6. Install the instrument panel trim.
7. Install the steering shaft assembly.



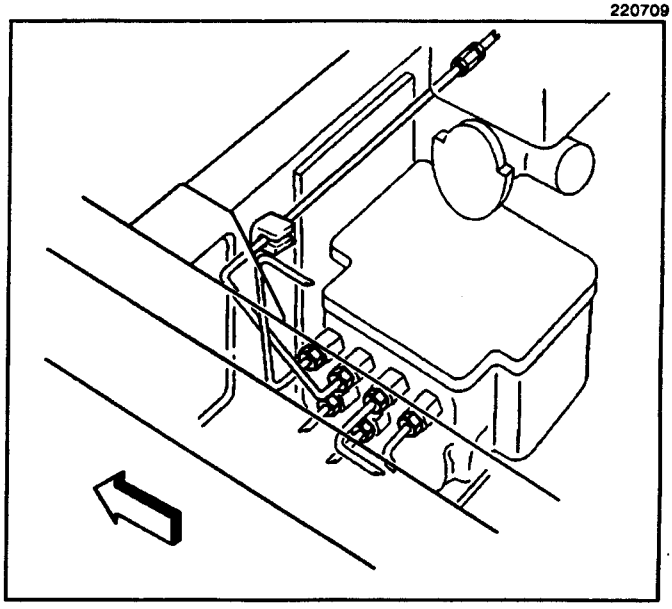
220709

Pipe Replacement

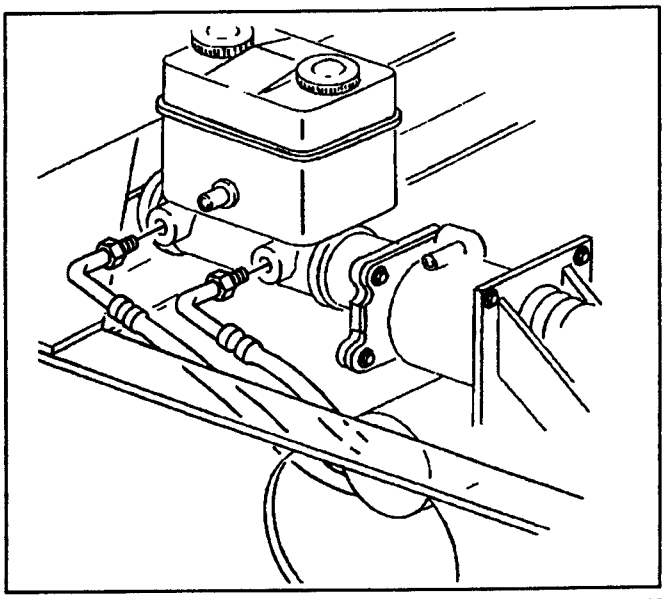
Pipe Replacement

Caution: Always use double-flared steel brake pipe when replacing brake pipes. The use of any other pipe is not recommended and may cause brake system failure. Carefully route and retain replacement brake pipes. Always use the correct fasteners and the original location for replacement brake pipes. Failure to properly route and retain brake pipes may cause damage to the brake pipes and lead to brake system failure.

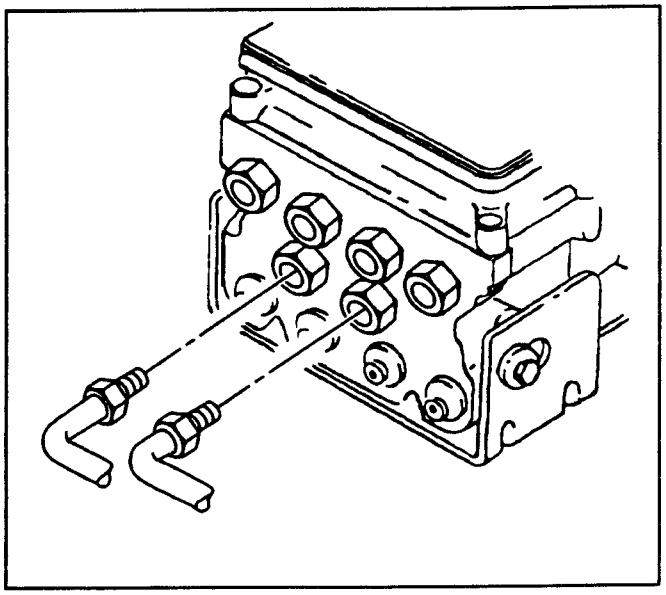
Brake pipes that run parallel to each other must maintain a 6 mm (1/4 in) clearance.



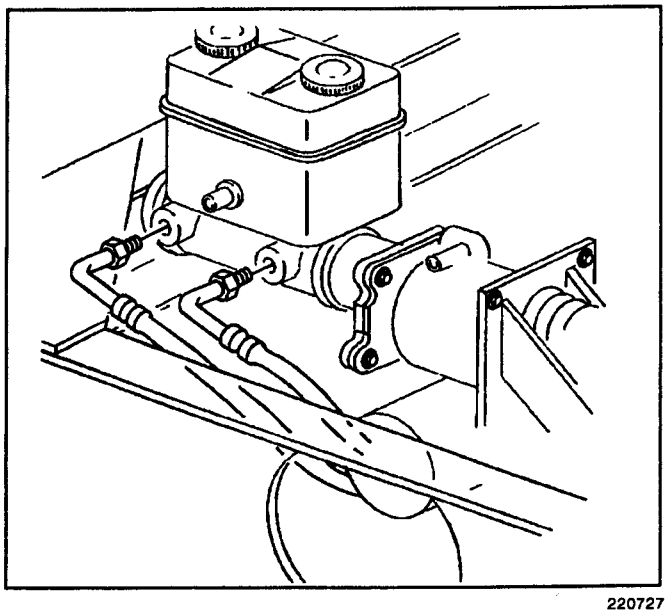
220712



220727



208878



220727

Master Cylinder Hose Replacement (Front)

Removal Procedure

Important: Clean the dirt, the grease and the foreign particles from the hose fitting at both ends before removing the master cylinder hose.

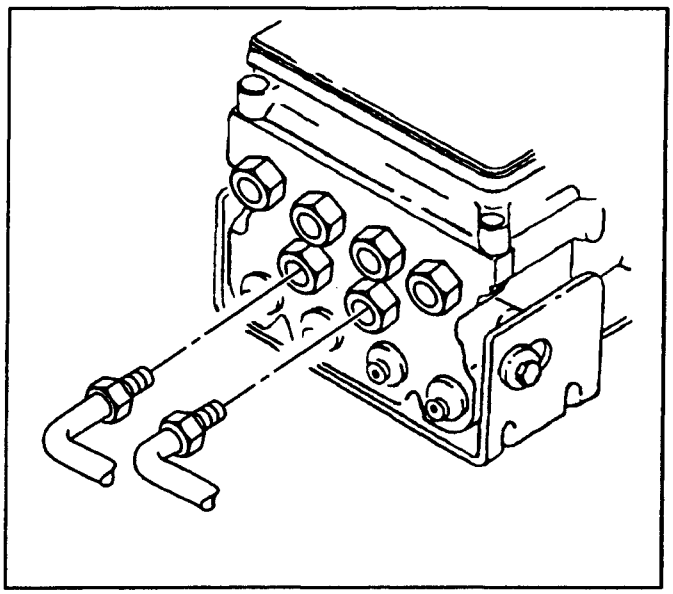
1. Remove the hose from the master cylinder.
2. Plug the front brake hose fitting.
3. Remove the hose from the electric hydraulic control unit.

Installation Procedure

1. Install the hose to the master cylinder.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the hose to the electric hydraulic control unit.
   Tighten
   Tighten the hose fittings to 19 N·m (14 lb ft).
3. Bleed the front brakes.



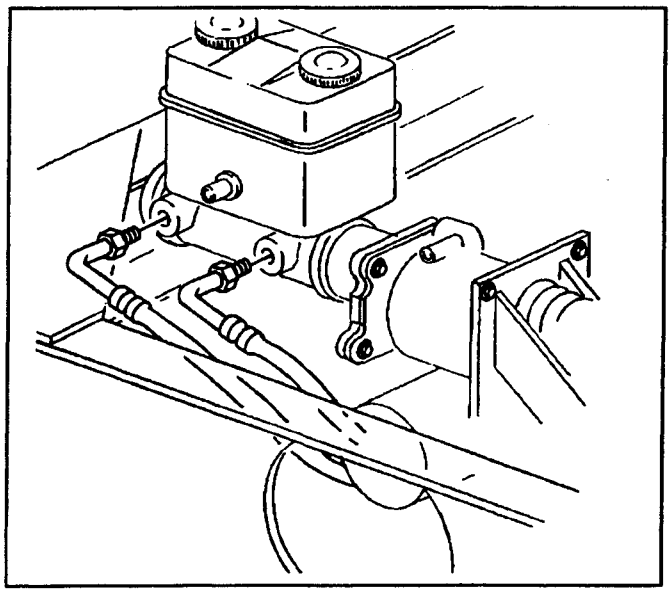
208878

Master Cylinder Hose Replacement (Rear)

Removal Procedure

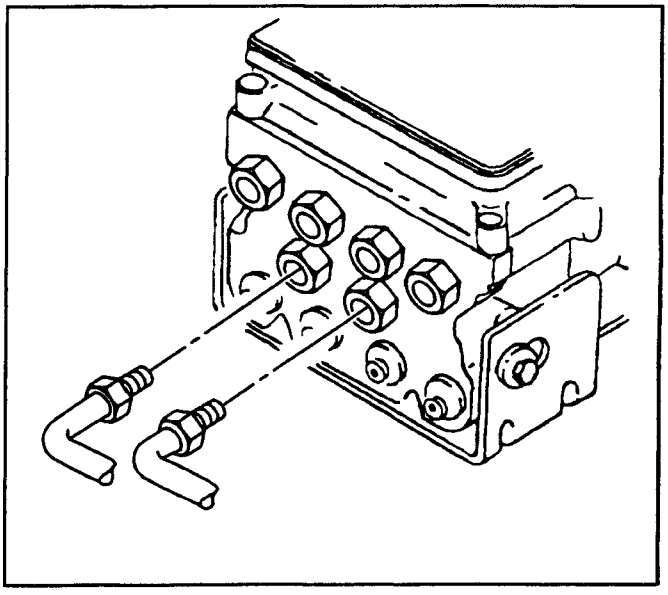
Important: Clean the dirt, the grease and the foreign particles from the hose fitting at both ends before removing the master cylinder hose.

1. Remove the hose from the master cylinder.

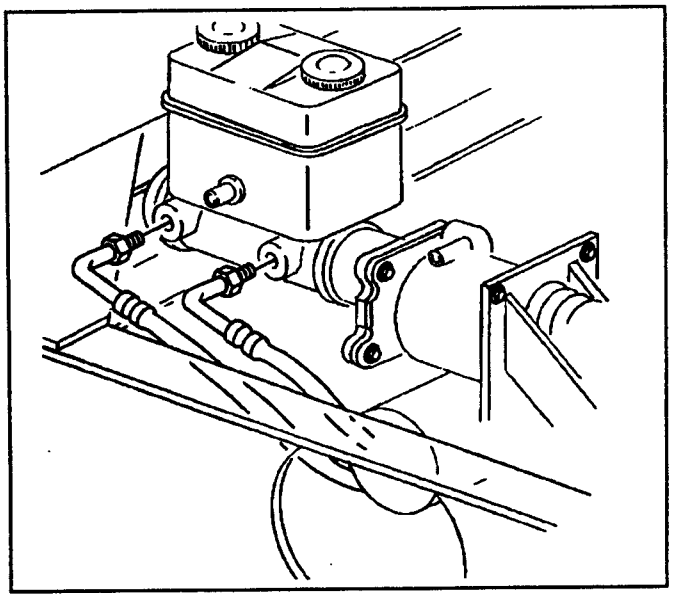


220727

2. Remove the hose from the electric hydraulic control unit.



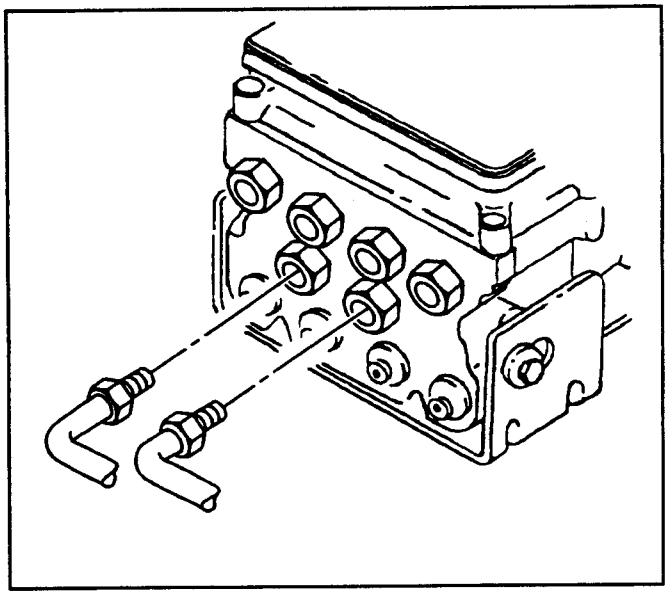
208878



220727

Installation Procedure

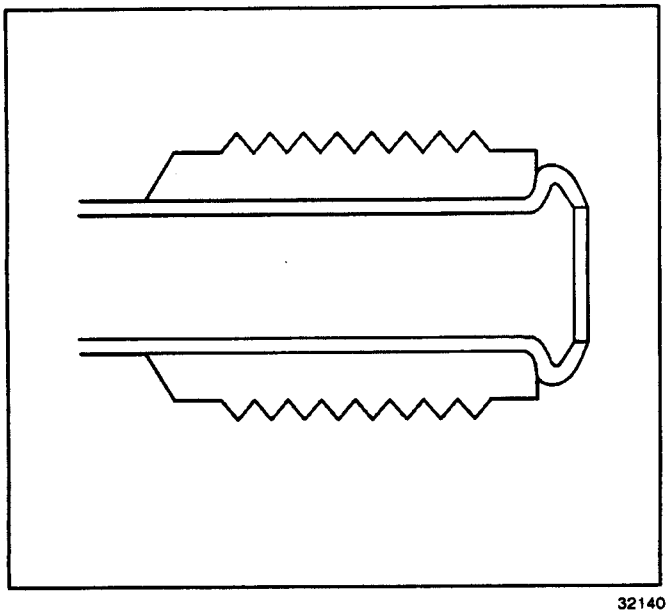
1. Install the hose to the master cylinder.



208878

Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the hose to the electric hydraulic control unit.
   Tighten
   Tighten the hose fittings to 19 N.m (14 lb ft).
3. Bleed the rear brakes.



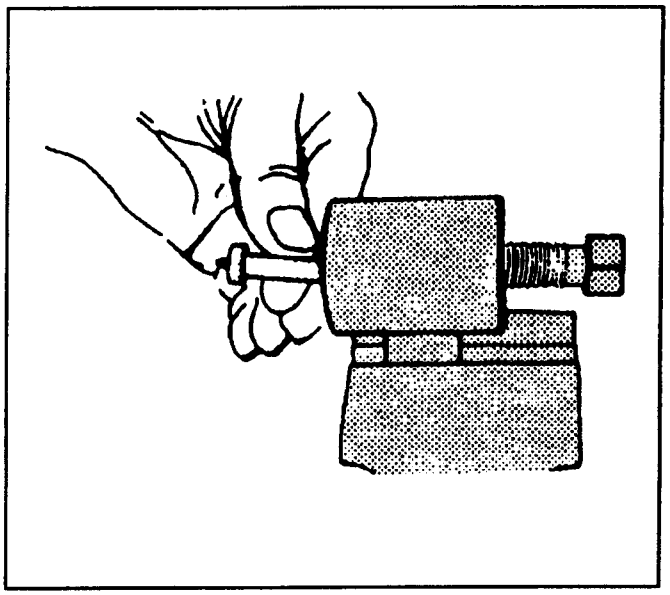
32140

ISO Flares Replacement

Tools Required
J 29803-A Flaring Kit

1. Use the correct size steel pipe and fittings.
   The outside diameter of the pipe specifies the size.
2. Cut the steel pipe to length. Add 3 mm (1/8) to the length for each flare.
3. Install the fittings on the pipe before starting the flare.
4. Chamfer the inside and the outside diameter of the steel pipe with a deburring tool.
5. Remove all traces of the lubricant from the brake pipe and the flaring tool.
6. Clamp the flaring tool body in a vise.

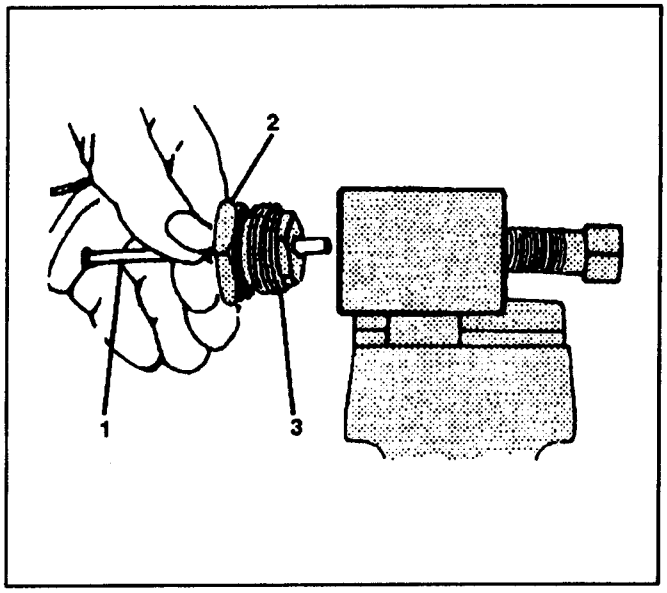
7. Select the correct size collet and the forming mandrel for the pipe size that is being used.
8. Insert the proper forming mandrel into the tool body.
9. Hold the mandrel in place with your finger. Thread the forcing screw in until the forcing screw makes contact and begins to move the forming mandrel.



32135

10. Slide the clamping nut over the brake pipe and into the correct collet. Leave about 19 mm (3/4 in) of the pipe extending out of the collet.
11. The brake pipe end must contact the face of the forming mandrel in order to insert the assembly into the tool body.
12. Tightly fasten the clamping nut into the tool body in order to prevent the pipe from pushing out.
13. Tighten the forcing screw with a wrench until the forcing screw bottoms. Do not over tighten the forcing screw. Over tightening the screw causes the flare to become oversized.
14. Take the clamping nut out of the tool body.
15. The flare is ready for use when the clamping nut and the collet assembly are disassembled.
16. Use a pipe bender in order to bend the pipe.

    Bending the pipe ensures a match to the old pipe.



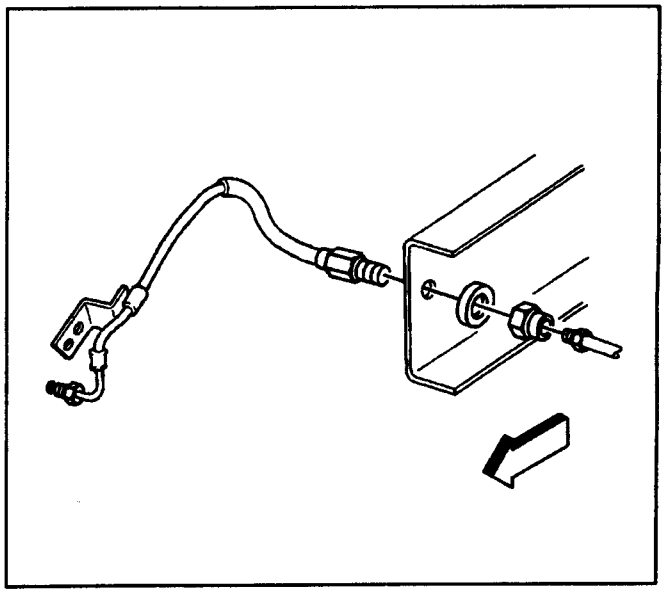
32136

Brake Hose Replacement - Front

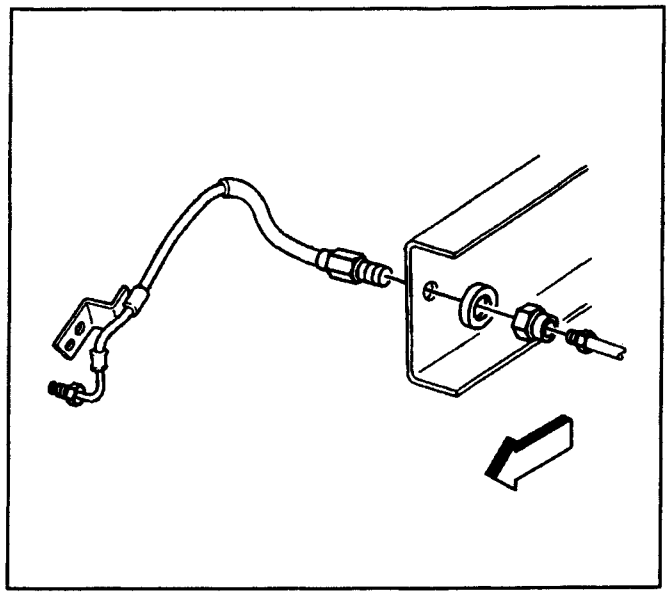
Removal Procedure

Important: Clean the dirt, the grease and the foreign particles from the hose fittings at both ends before removing the master cylinder hose.

1. Remove the mounting bolts and the washers.
2. Remove the hose fittings from the caliper.
3. Remove the steel pipe(s) from the hose junction block.
4. Bend the steel pipe(s) in a backward position in order to clear the junction block.
5. Cap the steel pipes.
6. Remove the nut and the washer.
7. Remove the hose.



220730



220730

Installation Procedure

1. Install the hose into the frame hole.
2. Install the washer.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
3. Install the front brake hose nut.

   Tighten

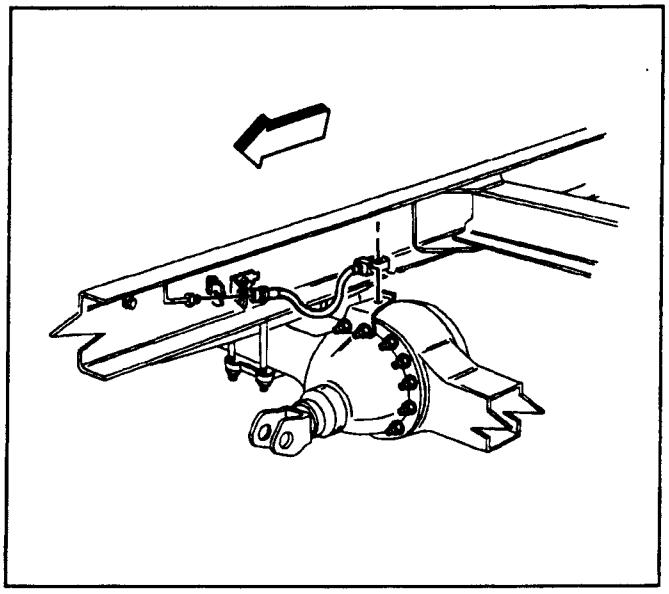
   Tighten the front brake hose nut to the 37 N·m (27 lb ft).
4. Install the steel pipe(s) to the junction block.

   Tighten

   Tighten the fitting(s) to 19 N·m (14 lb ft).
5. Ensure that the hose is not twisted in order to properly install the hose fitting to the caliper.
6. Install the bolts.

   Tighten

   - Tighten the fitting to 19 N·m (14 lb ft).
   - Tighten the bolts to 32 N·m (24 lb ft).
7. Install the washer.
8. Bleed the brakes.



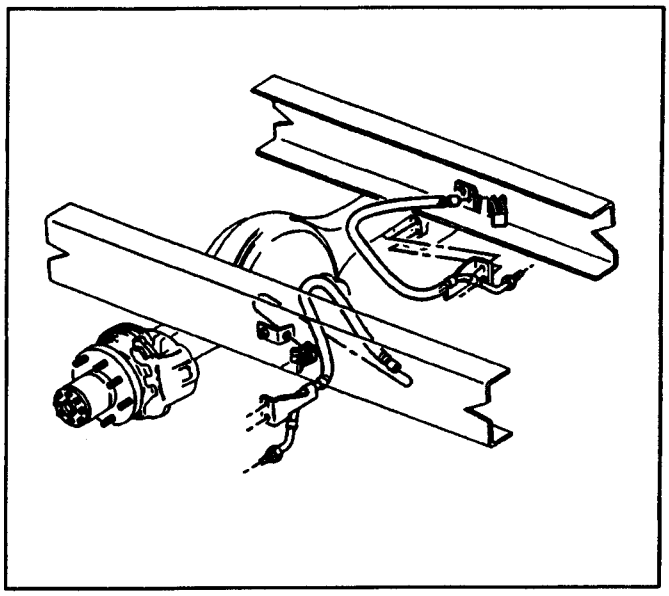
208913

Brake Hose Replacement - Rear

Removal Procedure

1. Remove the retainer.

2. Remove the brake hose from the chassis brake pipe.
3. Remove the brake pipes.
4. Plug the brake pipes.
5. Remove the mounting bolts.

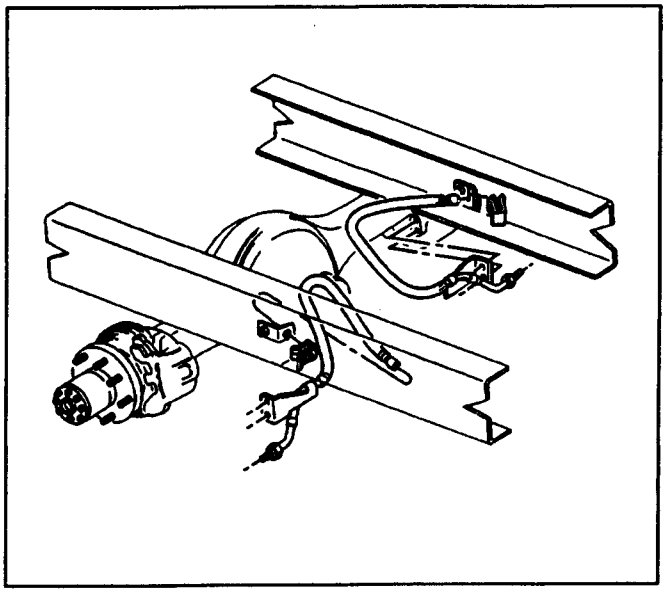


208909

Installation Procedure

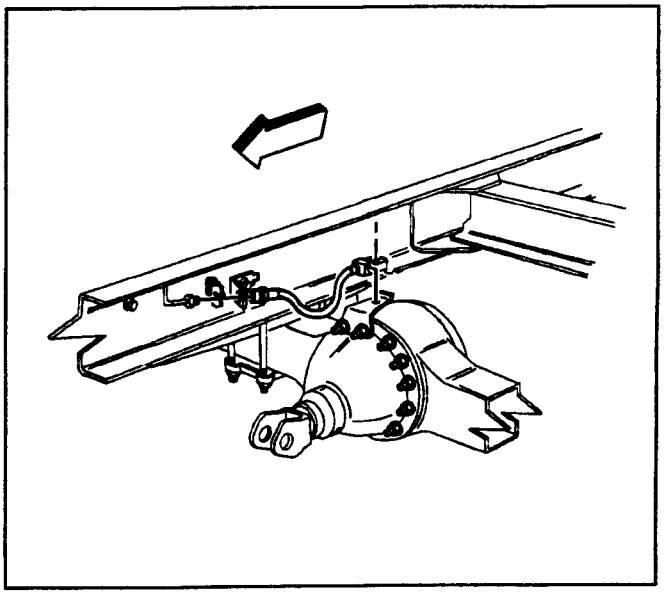
Notice: *Fastener Notice* in Cautions and Notices.

1. Install the mounting bolts.
   Tighten
   Tighten the mounting bolts to 32 N.m (24 lb ft).
2. Install the brake pipes.
   Tighten
   Tighten the brake pipe fittings to 19 N.m (14 lb ft).
3. Install the brake hose through the frame bracket.
4. connect the fitting to the brake hose.
   Tighten
   Tighten the fitting to 19 N.m (14 lb ft).

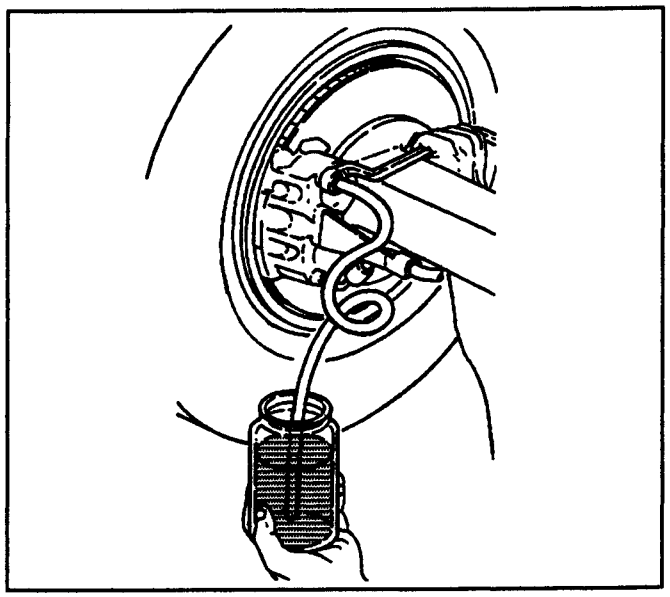


208909

5. Install the retainer.
6. Bleed the brakes.



208913



220731

Hydraulic Brake System Bleeding (Manual)

Bleeding the brake is necessary if air has entered the hydraulic brake system.

Bleed the system at all four wheels if a low fluid level has allowed air to enter the system or the brake pipes have been disconnected at the master cylinder. If a pipe is disconnected at one wheel, bleed only that wheel.

Bleed the master cylinder before you install the master cylinder into the vehicle. Bleeding the cylinder reduces the time required to bleed the hydraulic system when you remove the master cylinder.

Use the Hydraulic Brake System Bleeding procedure if the Electric Hydraulic Control Unit (EHCU) has not been replaced. If the EHCU has been replaced, refer to the ABS Bleeding Procedure in Antilock Brakes for the proper bleeding procedures.

Notice: Brake fluid will damage electrical connections and painted surfaces. Use shop cloths, suitable containers, and fender covers to prevent brake fluid from contacting these areas. Always re-seal and wipe off brake fluid containers to prevent spills.

1. Fill the master cylinder reservoirs with DOT 3 motor vehicle brake fluid. Maintain the fluid level during the bleeding procedure.
2. Perform the following procedure if you suspect the master cylinder has air in the bore:
   - 2.1. Bleed the master cylinder before bleeding any wheel cylinder brake caliper.
   - 2.2. Disconnect the forward brake pipe connection at the master cylinder.
   - 2.3. Allow the brake fluid to flow from the connector port.
   - 2.4. Connect the brake pipe.

     Do not tighten the brake pipe.
   - 2.5. Apply the brake pedal slowly.

     Allow the air to bleed from the loose fitting.
   - 2.6. Tighten the fitting before releasing the pedal.
   - 2.7. Wait 15 seconds.
   - 2.8. Repeat this sequence, including the 15 second wait, until the air is plunged from the bore.
   - 2.9. Repeat the procedure for the rear pipe after all of the air is removed from the forward connection.
3. Bleed the brake system in the following sequence:
   - 3.1. The right rear
   - 3.2. The left rear
   - 3.3. The right front
   - 3.4. The left front

4. Attach a hose to the caliper bleeder valve. Immerse the opposite end of the hose into a container that is partially filled with clean brake fluid.
5. Slowly apply the brake pedal one time and hold the brake pedal.
6. Loosen the bleeder valve in order to purge the air from the caliper.
7. Tighten the bleeder valve and slowly release the pedal.
8. Wait 15 seconds.
9. Repeat the sequence, including the 15 second wait, until all of the air is purged from the caliper.
10. Continue steps 4 through 9 at each wheel until the brake system has been bled.
11. Inspect the brake pedal for sponginess. Repeat the bleeding procedure if the brake is spongy.

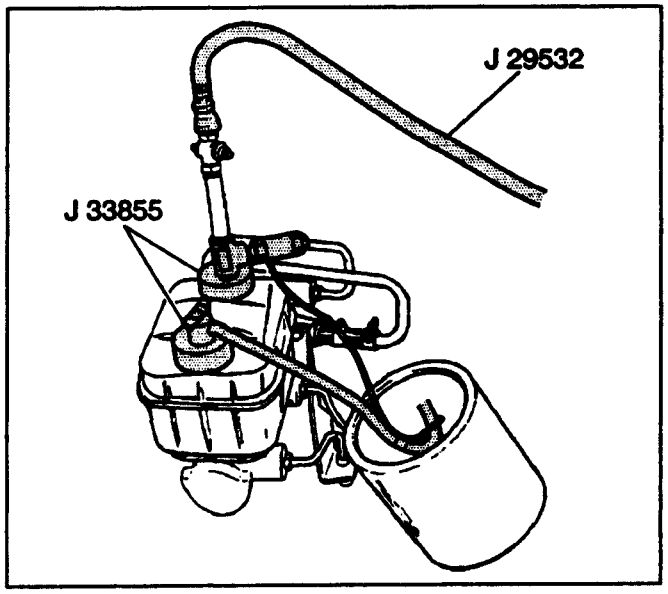
Hydraulic Brake System Bleeding (Pressure)

Bleeding is necessary if air has entered the hydraulic system.

Bleed the system at all four wheels if a low fluid level has allowed air to enter the system or the brake pipes has been disconnected at the master cylinder. If a pipe is disconnected at one wheel, then only bleed that wheel.

Bleed the master cylinder before you install the master cylinder into the vehicle.Bleeding the cylinder reduces the time required to bleed the hydraulic system when you remove the master cylinder.

Use the Hydraulic Brake System Bleeding procedure if the Electric Hydraulic Control Unit (EHCU) has not been replaced. If the EHCU has been replaced, refer to the ABS Bleed Procedure in Antilock Brakes for the proper bleeding procedures.



208940

Tools Required

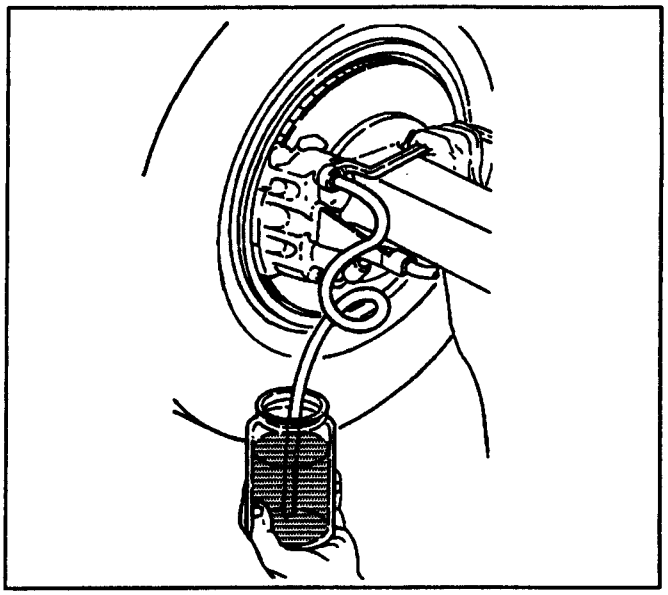
- *J 29532* Power Brake Bleeder
- *J 33855* Pressure Bleeder Adapter

Notice: Brake fluid will damage electrical connections and painted surfaces. Use shop cloths, suitable containers, and fender covers to prevent brake fluid from contacting these areas. Always re-seal and wipe off brake fluid containers to prevent spills.

Use a diaphragm type pressure bleeder. The bleeder must have a rubber diaphragm between the air supply and the brake fluid in order to prevent the following from contaminating the hydraulic system:

- Air
- Moisture
- Oil
- Other contaminants

1. Fill the pressure tank at least 2/3 full with the brake fluid. Bleed the bleeder each time the fluid is added.
2. Charge the bleeder to 140 to 170 kPa (20 to 25 psi).
3. Install the *J 33855* Pressure Bleeder Adapter on the master cylinder.
4. Connect the hose from the bleeder to the adapter.
5. Open the tank valve.
6. Bleed the brake system in the following sequence:
   - The right rear
   - The left rear
   - The right front
   - The left front
7. Attach the hose to the bleeder valve. Immerse the opposite end of the hose into a container that is partially filled with clean brake fluid.
8. Open the bleeder valve at lease 3/4 of a turn. Allow the fluid to flow until no air is found in the fluid.
9. Close the bleeder valve.
10. Repeat steps 7 through 9 at each wheel.
11. Inspect the brake pedal for sponginess. Repeat the entire bleeding procedure if the brake pedal is spongy.
12. Disconnect the line from the bleeder adapter.
13. Remove the bleeder adapter.
14. Fill the master cylinder to the proper fluid level. Refer to *Master Cylinder Reservoir Filling.*

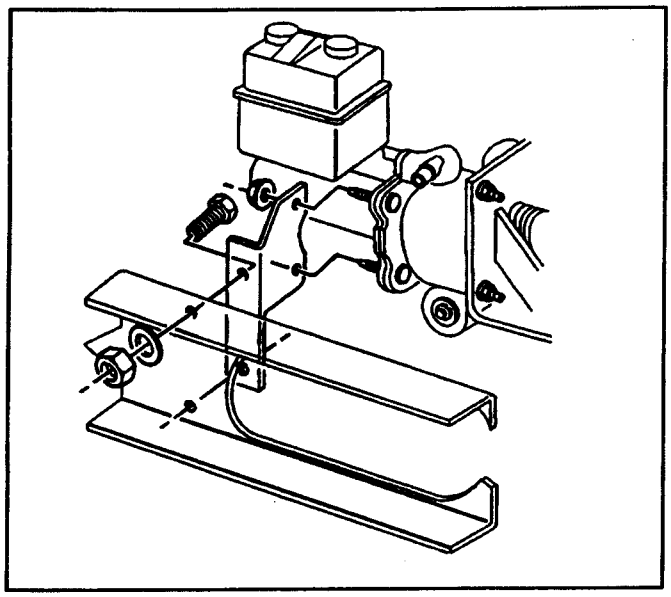


220731

Hydraulic Brake System Flushing

Notice: Do not use alcohol for flushing the system or cleaning assemblies where alcohol could be trapped and contaminate the brake fluid. The contaminated fluid can then cause the failure of the rubber components in the system.

(1) Flush at each bleeder valve. Flushing is similar to the bleeding procedure. The difference is that the bleeder valve is opened 1 1/2 turns. Fluid is forced through the lines and the bleeder valves until the fluid comes out clear in color. (2) Inspect the master cylinder fluid level after flushing each valve. (3) Refill the master cylinder fluid as required. Ensure that the master cylinder reservoir is filled to the proper level after flushing.



220749

Hydraulic Brake Booster Replacement

Removal Procedure

Flushing the system is required when dirt, sludge or water is found in the system. Flushing the system involves running clean fluid through the system until the draining fluid appears. Contaminated fluid in the booster system can cause the rubber parts to deteriorate.

Clean and flush the hydraulic booster system when the hydraulic pump is replaced. Metal shavings from a worn hydraulic pump contaminate the system.

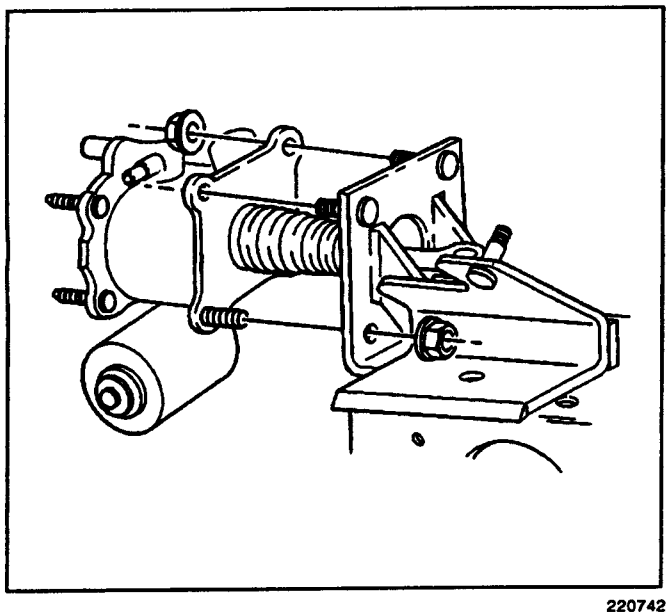
Disassemble the booster head. Clean the booster head. Replace all the seals and the o-ring seals.

Remove and blow clean the pipes and hoses of all metal shavings.

1. Block the vehicle wheels.

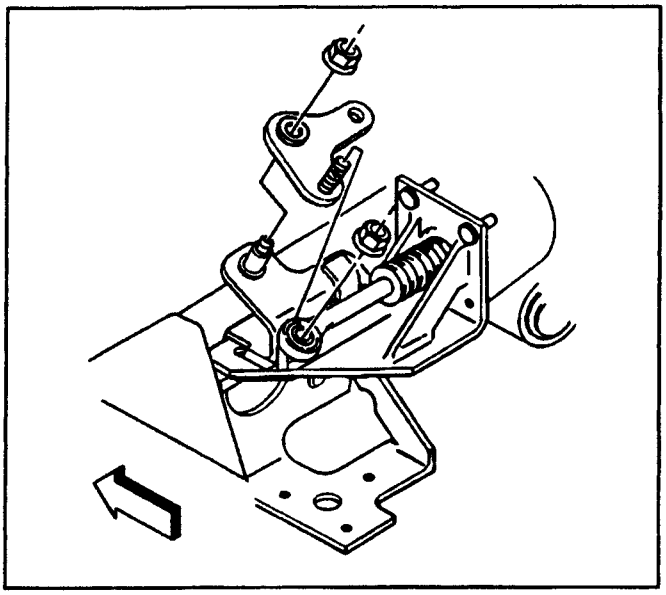
   Caution: Before servicing any electrical component, the ignition key must be in the OFF or LOCK position and all electrical loads must be OFF, unless instructed otherwise in these procedures. If a tool or equipment could easily come in contact with a live exposed electrical terminal, also disconnect the negative battery cable. Failure to follow these precautions may cause personal injury and/or damage to the vehicle or its components.

2. Disconnect the negative battery cable.
3. Tilt the cab. Refer to *Cab Tilting* in General Information.
4. Disconnect the electrical connectors from the electrohydraulic pump and the flow switch.
5. Remove the master cylinder bracket.
6. Remove the master cylinder. Position the master cylinder away from the booster head. Secure the master cylinder in an upright position.
7. Disconnect the hoses from the booster.



220742

8. Remove the booster pump rod nut from the lever.
9. Remove the nuts at the booster.
10. Remove the booster assembly.



220748

Installation Procedure

1. Install the booster assembly to the vehicle.

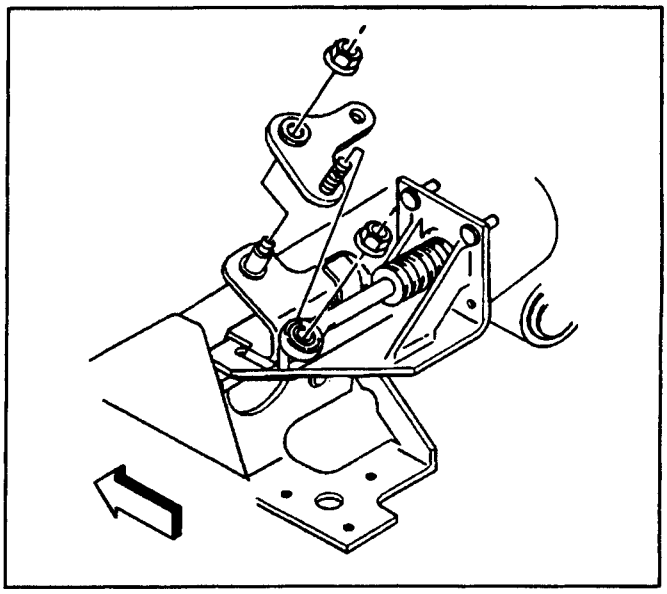
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the nuts at the booster.

   Tighten

   Tighten the nuts to 36 N.m (27 lb ft).
3. Install the booster pump rod to the lever.

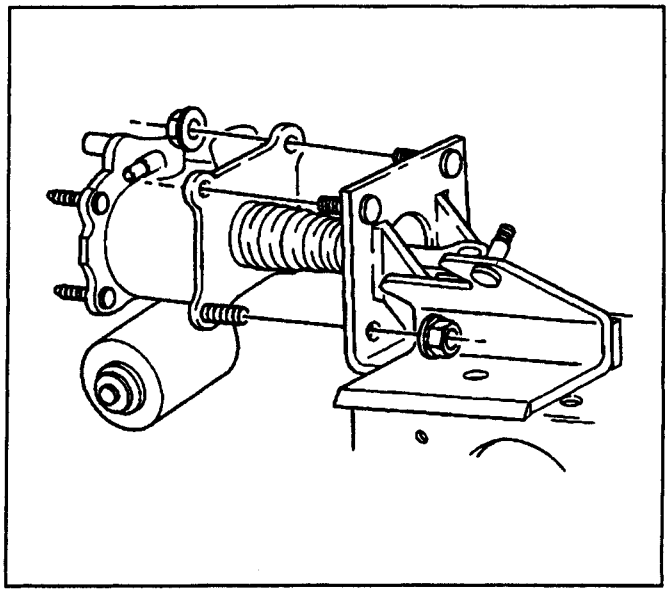
   Tighten

   Tighten the nuts to 68 N.m (50 lb ft).

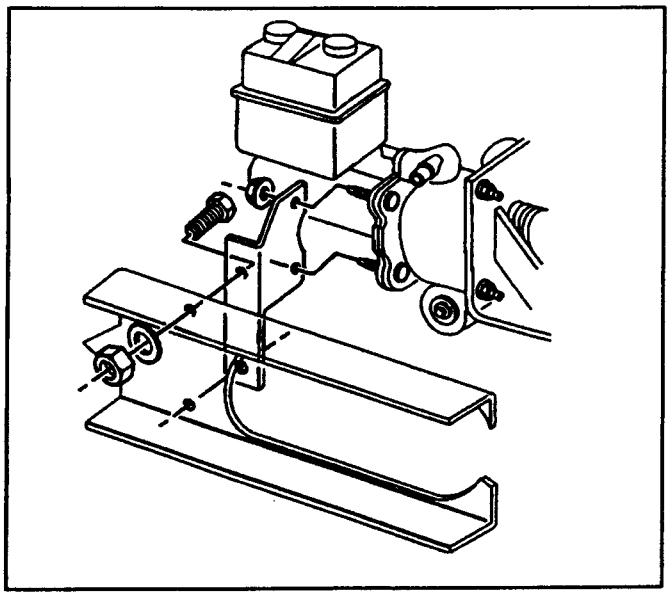


220748

4. Install the hoses to the booster.



220742



220749

5. Install the master cylinder.
6. Install the master cylinder bracket.
   Tighten
   Tighten the nuts to 45 N.m (33 lb ft).
7. Install the electrical connectors to the electrohydraulic pump and the flow switch.
8. Install the negative battery cable.
9. Fill the hydraulic pump reservoir.
10. Bleed the system.
11. Lower the cab. Refer to *Cab Tilting* in General Information.
12. Inspect the vehicle for the proper brake operation.
13. Remove the wheel blocks.

Electrohydraulic Pump Replacement

Removal Procedure

Notice: The EH pump operates on power steering fluid only. Do not service the EH pump in any brake servicing area. Be sure hands are clean of all brake fluid. Contamination can cause swelling and deterioration of rubber parts, brake damage, and the eventual loss of braking capability.

1. Block the vehicle wheels.
2. Tilt the cab. Refer to *Cab Tilting* in General Information.
3. Remove the booster assembly. Refer to *Hydraulic Brake Booster Replacement.*
4. Remove the bolt and the spring washer.
5. Position a container in order to catch the leaking fluid.
6. Remove the bolts and the spring washers.
7. Remove the electrohydraulic pump.
8. Remove the o-ring seals.
9. Remove the relief valve and the spring.

Installation Procedure

1. Install the relief valve with the slotted end towards the center of the booster body.
2. Install the spring.
3. Install the new o-ring seals.
4. Install the electrohydraulic pump.
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
5. Install the bolts and the spring washers.
   Tighten
   Tighten the bolts to 31 N.m (23 lb ft).
6. Install the identification tag.
7. Install the spring washer and the bolt.
   Tighten
   Tighten the bolt to 13 N.m (116 lb in).

8. Install the booster assembly. Refer to *Hydraulic Brake Booster Replacement.*
9. Fill the hydraulic pump reservoir.
10. Bleed the system.
11. Inspect the vehicle for proper brake operation.
12. Remove the wheel blocks.
13. Lower the cab. Refer to *Cab Tilting* in General Information.

Fluid Flow Switch Replacement

Removal Procedure

1. Block the vehicle wheels.
2. Tilt the cab. Refer to *Cab Tilting* in General Information.
3. Position a suitable container in order to catch the fluid from the flow switch and the hose. Do not re-use the old fluid.
4. Remove the electrical connector from the flow switch.

   Notice: Do not tighten the flow switch with a thick blade wrench. The flow switch may be damaged. Use a thin blade open end wrench.
5. Use an open wrench in order to remove the flow switch.
6. Remove the O-ring seal.

Installation Procedure

1. Install the new O-ring seal.

   Notice: Do not tighten the flow switch with a thick blade wrench. The flow switch may be damaged. Use a thin blade open end wrench.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Use an open end wrench in order to install the flow switch.

   Tighten

   Tighten the flow switch to 10 N.m (88 lb in).
3. Connect the electrical connector to the flow switch.
4. Fill the hydraulic pump reservoir.
5. Bleed the system.
6. Inspect the vehicle for proper brake operation.
7. Remove the wheel blocks.
8. Lower the cab. Refer to *Cab Tilting* in General Information.

Stoplamp Switch Replacement

Removal Procedure

Important: Refer to Lighting Systems in Body and Accessories for further information on the stoplamp switch electrical diagnosis.

1. Remove the electrical connectors.
2. Remove the retaining nut.
3. Remove the stoplamp switch.

Installation Procedure

1. Install the stoplamp switch.
2. Install the retaining nut.
3. Adjust the switch pin operating stroke to 2.4 mm.
4. Tighten the retaining nut.
5. Install the electrical connector.

Description and Operation

Hydraulic Brake Booster Description

Booster Assembly

The hydraulic booster applies force to the master cylinder when the brake pedal is applied. Brake pedal movement controls the fluid flowing through the booster head.

The fluid from the hydraulic brake booster pump enters the booster at the inlet port. The fluid flows through the control valve and the seat and exits through the outlet port and the flow switch before returning to the hydraulic brake booster pump.

The hydraulic booster cylinder rod attaches to a piston that contains the control valve seat. The assembly moves when pressure is applied to the brake pedal. As the control valve moves closer to the control valve seat in the piston, the fluid flow is restricted and the pressure builds on one side of the piston. The pressure overcomes the return spring and moves the piston to a balanced position. The piston is balanced when the pressure on each side of the return spring equals the pressure of the hydraulic fluid flowing through the control valve and the seat. The piston pushes the cylinder rod and applies pressure to the master cylinder as the piston moves.

A relief valve inside the booster head limits the pressure to 4826 kPa (700 psi). The limiting of the pressure in the booster head limits the brake line pressure at the master cylinder to 13455 kPa (1950 psi). The pressure level provides good braking without damaging the brake pipes or the hoses. The relief valve allows fluid to bypass the piston when actuated. Fluid constantly flows through the booster head when the engine is running.

Electrohydraulic Pump

The Electrohydraulic (EH) pump is used as a backup to the belt driven power steering pump. The EH pump turns on when the fluid stops flowing through the booster head. The EH pump is a small hydraulic pump that mounts to the bottom of the booster head.

The EH pump draws fluid from the low pressure side of the booster head piston. The EH pump delivers fluid to the high pressure side. The normal output of the EH pump is 2070–2415 kPa (300–500 psi) which is about half that of the power steering pump.

Flow Switch

A flow switch in the booster head outlet port senses the fluid flow. The flow switch controls a relay for the EH pump. A pedal switch also activates the EH pump when the brake pedal is applied and the engine is not running.

Pipes, Hoses, and Fittings

Stationary pipes and flexible hoses carry fluid throughout the hydraulic brake booster system. The stationary pipes and the flexible hoses connect the booster head to the hydraulic brake booster pump and the fluid reservoir.

Overhaul Information

Refer to the instructions enclosed with the service repair kit for overhaul information on the Bendix® brake booster. Contact the Bendix® Helpline at 1-800-AIR-BRAK (1-800-247-2725) for additional overhaul information.

Fluid and Fluid Handling

Notice: Hydraulic brake systems use two distinct and incompatible fluids. Power steering fluid is used in the hydraulic brake booster system. Brake fluid is used in the master cylinder and brake pipes. Use extreme care when selecting brake system fluids, or seal damage can result. Refer to General Information to select the correct fluid.

The hydraulic booster system uses no special fluids. However, ensure the use of the correct fluids. The master cylinder and the brake system use brake fluid. The hydraulic brake booster pump uses power steering fluid.

Substandard or Contaminated Brake Fluid

Contaminated fluid causes swelling and deterioration of the rubber parts. The swelling and deterioration leads to reduced brake performance and the loss of braking capability. Inspect the condition of the fluid at regular intervals and note any unusual consistency, color and signs of contaminants in the fluid.

Notice: Power steering fluid and brake fluid cannot be mixed. If brake seals contact power steering fluid or steering seals contact brake fluid, seal damage will result.

Do not reuse the brake system fluids Always discard the used fluid. Do not mix the power steering fluid with the hydraulic brake fluid. Flush the hydraulic booster system with clean power steering fluid if contamination occurs.

Do booster component bench servicing in a clean work area separate from the brake servicing area. Wash your hands before changing between the brake or the booster work area. Do not use the same containers for the fluids.

Brake Warning System Circuit Description (Primary Brake Lamp Description)

Primary Brake Lamp

The primary brake indicator lamp will light on vehicles equipped with hydraulic brakes and a continuous tone will sound if any of the following conditions occur:

- There is insufficient brake fluid in the reservoir.
- There is insufficient fluid flow in the hydro-boost system during braking.
- If the vehicle is equipped with antilock brakes, the Electronic Brake Control Module (EBCM) notices a fault.

The multifunction alarm module receives a ground signal from both the brake fluid level switch and the EBCM through CKT 33, 495 and 494 (TAN/WHT). The primary brake lamp is also connected through CKT 33, 495 and 494 (TAN/WHT) to the level switch, the EBCM and the alarm module. The brake fluid level switch is a float switch. The brake fluid level switch will close when the fluid in the reservoir drops below a minimum level. The EBCM will provide a ground path to the lamp and the alarm module if a diagnostic trouble code is set. The brake fluid flow switch is connected to the multifunction alarm module through CKT 475 and 1928 (LT BLU). If insufficient fluid flow is detected in the hydro-boost system the flow switch closes in order to provide a ground path to the alarm module.

Brake Warning System Circuit Description (Auxiliary Brake Lamp Descripti)

Auxiliary Brake Lamp

The AUX BRAKE indicator lamp will light on vehicles equipped with hydraulic brakes and a continuous tone will sound if any of the following conditions occur:

- There is fluid flow in the hydro-boost system within four seconds of the engine start.
- No input is received from the stoplamp relay during braking.

The brake fluid flow switch is connected to the multifunction alarm module through CKT 475 and 1928 (LT BLU). If insufficient fluid flow is detected in the hydro-boost system, the flow switch closes in order to provide a ground path to the alarm module. The switch should be open during the engine start. The multifunction alarm module receives the engine start voltage signal from the starter relay through CKT 434 and 487 (ORN/BLK). The multifunction alarm module receives the stoplamp relay voltage signal from the stoplamp relay through CKT 489 (GRY).

Special Tools and Equipment

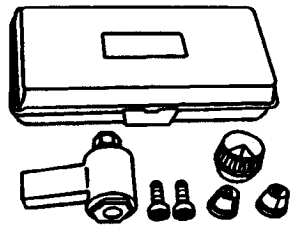
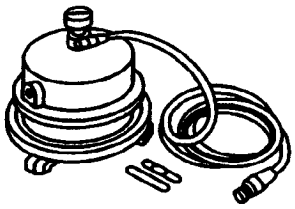
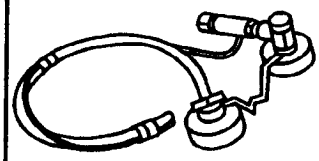
Illustration	Tool Number/ Description
 1089	J 29803-A Flaring Kit
 153125	J 29532 Power Brake Bleeder

Illustration	Tool Number/ Description
 218955	J 33855 Pressure Bleeder Adapter

Disc Brakes

Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Bleeder Valve	17 N.m	13 lb ft
Brake Caliper Brake Hose Bracket Bolt	32 N.m	24 lb ft
Brake Caliper Brake Hose Nut	19 N.m	14 lb ft
Brake Caliper Mounting Plate Bolt	280 N.m	206 lb ft
Brake Caliper Retainer Screw	40 N.m	29 lb ft
Brake Shield Bolt	32 N.m	24 lb ft
Brake Rotor to Hub Bolt 9/16" OD (10 Bolt Pattern)	152 N.m	112 lb ft
Brake Rotor to Hub Bolt 5/8" OD (5 Bolt Pattern)	256 N.m	189 lb ft

Brake Lathe Specifications (Accuturn)

Data	Cut Information
Spindle Speed	150 RPM
Tool Cross Feed (per revolution)	0.076 mm (0.003 in)
Tool Bit Nose Radius	0.396 mm (0.003 in)
Vibration Dampener	Yes
Swirl Pattern 120 Grit	Yes

Brake Lathe Specifications (Ammco)

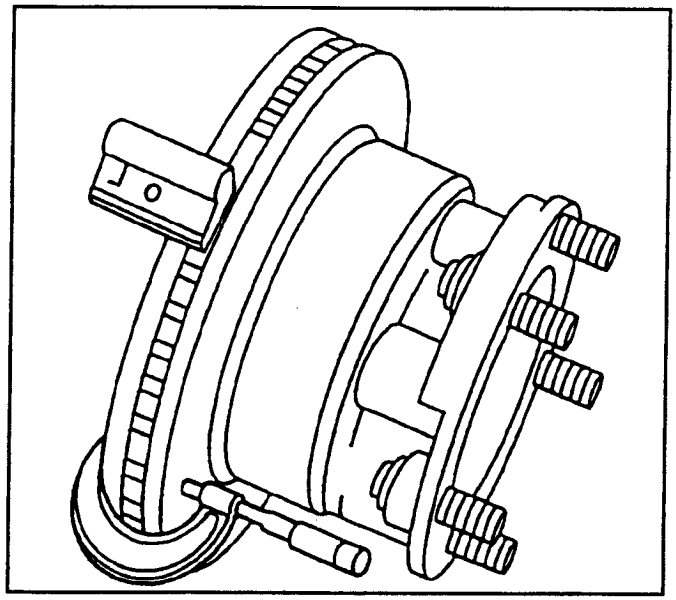
Data	Rough Cut	Finish Cut
Spindle Speed	150 RPM	150 RPM
Depth of Cut (per side)	0.127 mm (0.005 in)	0.051 mm (0.002 in)
Total Cross Feed (per revolution)	0.152–0.254 mm (0.006–0.01 in)	0.051 mm max. (0.002 in)
Vibration Dampener	Yes	Yes
Swirl Pattern 120 Grit	No	Yes

Component Specifications

Application	Specification	
	Metric	English
Brake Lining Replacement Thickness	1.60 mm	0.063 in
Brake Lining to Brake Rotor Maximum Clearance	0.13 mm	0.005 in
Brake Rotor OD Runout	0.76 mm	0.030 in
Brake Rotor Thickness Variation	0.05 mm	0.002 in
Brake Rotor Total Indicated Runout (TIR)	0.13 mm	0.005 in
Front Hub and Bearing Assembly Lateral Runout	0.040 mm	0.0016 in

Diagnostic Information and Procedures

Brake Rotor Thickness Variation Check



171512

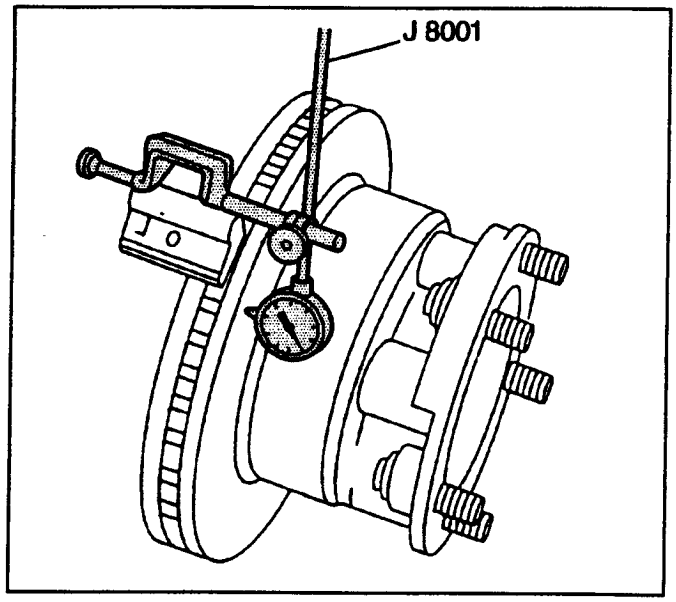
Check thickness variation by measuring the brake rotor thickness at four or more points around the circumference of the brake rotor. Use a micrometer calibrated in ten-thousands of an inch. Make all measurements about 25.4 mm (1 in) in from the edge of the brake rotor.

A brake rotor that varies in thickness by more than 0.05 mm (0.002 in) can cause brake pedal pulsation and/or front end vibration during brake applications. Refinish or replace a brake rotor that does not meet these specifications.

Brake Rotor Lateral Runout Check

Tools Required

J 8001 Dial Indicator Set



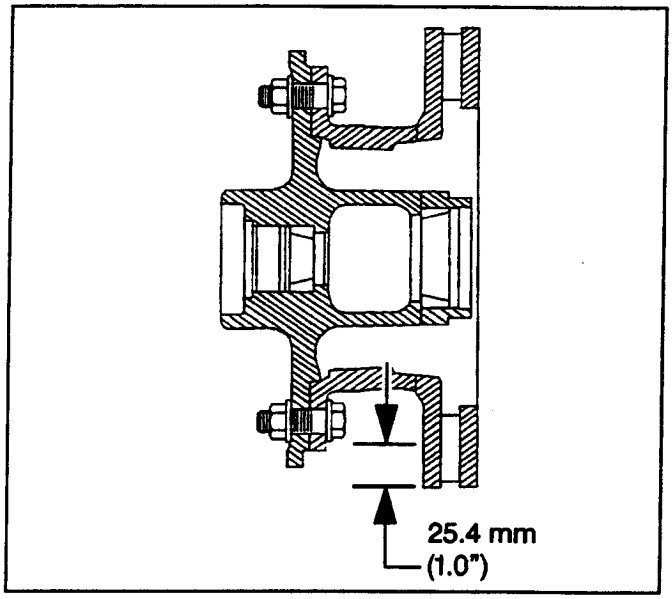
171514

Check the lateral runout with the wheels still installed on the vehicle. Keeping the wheels on the vehicle gives a much more accurate reading of the Total Indicated Runout (TIR) under real braking conditions. If the equipment is not available to perform the measurement with the wheels installed, measure with the wheels removed but with the brake caliper still installed.

In some cases, excessive lateral runout can be improved by indexing the brake rotor on the hub that is one or two bolt positions from the original position. If you cannot correct the lateral runout by indexing the brake rotor, check the hub and bearing assembly for excessive lateral runout or looseness. If the hub and bearing assembly lateral runout exceeds 0.040 mm (0.0016 in), replace the hub and/or bearing assembly as necessary. If the brake rotor's lateral runout is not within specifications, refinish or replace the rotor as necessary.

Measurement Procedure

1. Set the parking brake.
2. Block the vehicle wheels.
3. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
4. Support the vehicle with safety stands.
5. Remove the tires and wheels. Refer to *Wheel Bearing Adjustment*
6. Clean the brake rotor surface.
7. Tighten the wheel bearings to zero end play.



171510

8. Fasten a dial indicator to the steering knuckle so that the indicator button contacts the brake rotor surface about 25.4 mm (1 in) from the outer edge.
9. Set the dial indicator to zero.
10. Turn the wheel one complete revolution.
11. Observe the runout indicated on the dial.
12. The (TIR) must not exceed 0.13 mm (0.005 in).
13. Adjust the wheel bearings. Refer to *Wheel Bearing Adjustment* in Front Suspension.

Brake Rotor Tolerance

Rotor Tolerance And Surface Finish

Manufacturers closely hold brake rotor tolerances. These tolerances include flatness of the braking surfaces, parallelism, and lateral runout.

Maintaining the close tolerance on the shape of the braking surface prevents brake roughness or pulsation. The surface finish must be maintained at 60 Ra roughness or less.

Control the braking surface finish in order to avoid the following conditions:

- Hard pedal application
- Excessive brake fade
- Brake and steering pulls
- Erratic brake performance

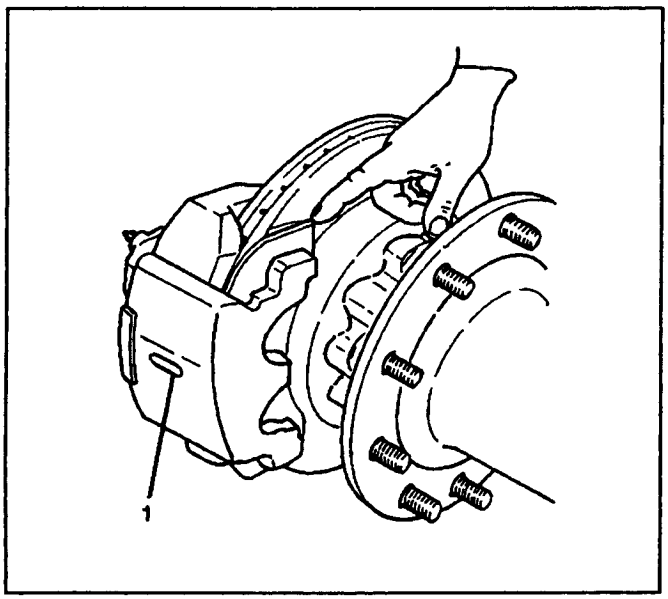
Controlled braking surface finish can prolong the life of the brake lining. Light scoring of the rotor braking surface not exceeding 1.5 mm (0.06 in) in depth is normal and will not damage the brake operation.

Repair Instructions

Brake Pad Inspection

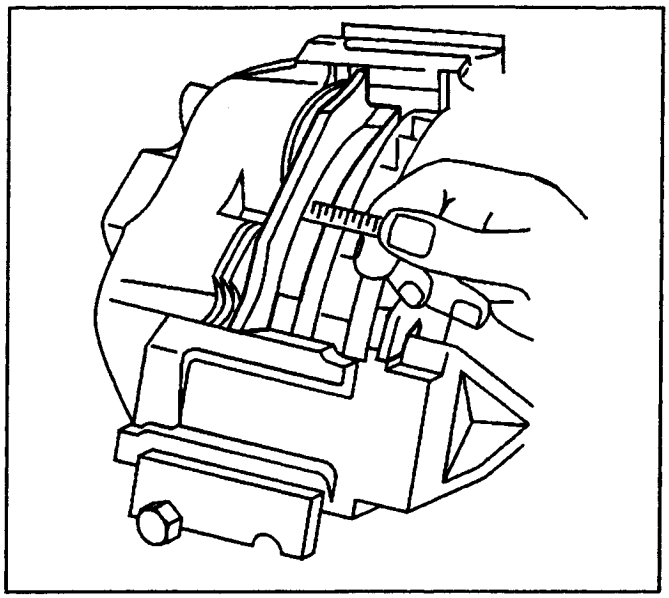
Lining Inspection

Inspect the brake linings every 9656 km (6,000 mi) and any time the wheels are removed (tire rotation, etc.). The preliminary inspection can be made with a mirror and flashlight. Remove the tire and wheel assembly in order to measure the linings.



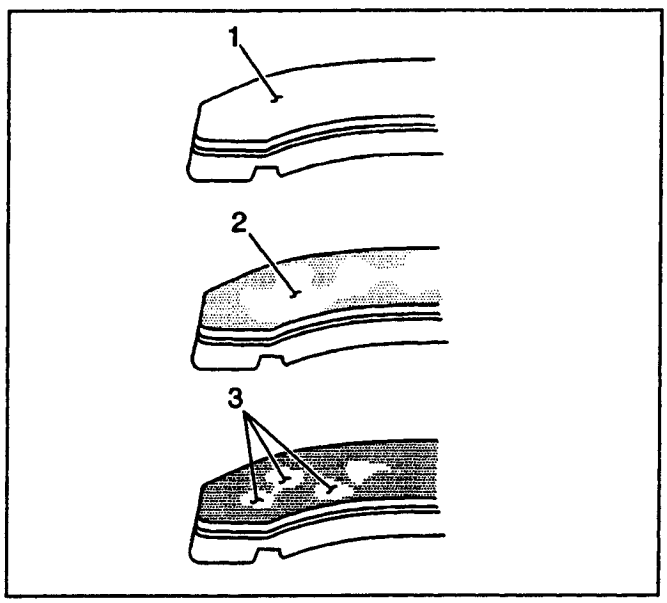
32117

Measure the linings with the brake caliper installed. The outer lining on brake calipers is exposed for easy inspection. The inner lining on Dayton-Walther brake calipers is also exposed. Inspect Bendix® inner linings through the inspection hole in the brake caliper housing. Replace the brake pad assemblies when the lining is worn to 1.6 mm (0.063 in). Measure the linings at their thinnest point.



200264

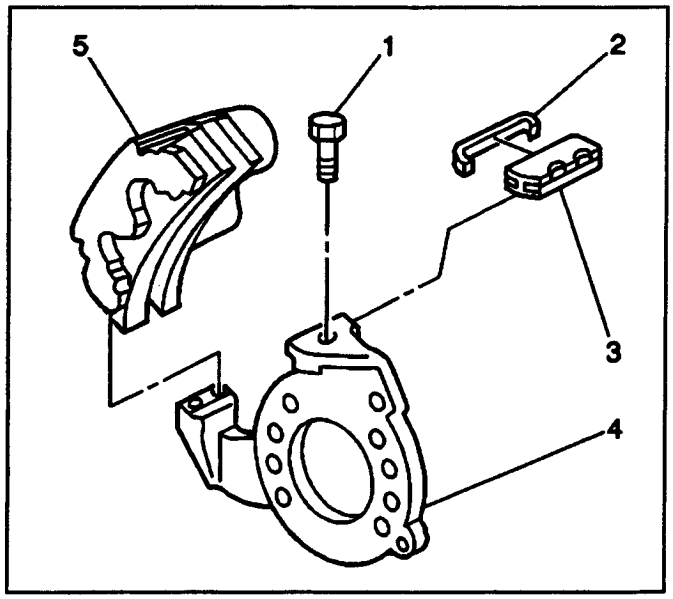
Brake linings should lightly contact the brake rotor or have no more than 0.13 mm (0.005 in) clearance. It is normal for the brakes to drag if the brakes were applied shortly before checking the brake clearance. If the brake linings are more than 0.13 mm (0.005 in) from the brake rotor, pump the brake pedal several times and recheck the lining clearance. If the lining clearance is still not within specifications, check for unevenly worn surfaces on the brake rotor, brake linings, or brake caliper pistons. New brake linings may have more clearance until they have worn to match the brake rotor. If the gap between either brake caliper piston face and the brake pad is more than 1.8 mm (0.071 in), overhaul the brake caliper.



171508

Remove the brake caliper in order to inspect the brake lining surface conditions. Refer to *Brake Caliper Replacement (Front, Bendix)* or *Brake Caliper Replacement (Front, Dayton-Walther)*. The brake linings must be free of grease and oil. The brake linings should show at least 70 percent wear (2) over the braking surface in order to indicate good lining contact.

Knock-back is a condition that occurs when a turning brake rotor pushes the brake linings and brake caliper pistons farther into the bores than normal. Excessive clearance results from the knock-back. The driver will notice increased pedal travel with the next brake application. Loose or worn suspension parts, especially the wheel bearings, can increase knock-back. Refer to Suspension Diagnosis.

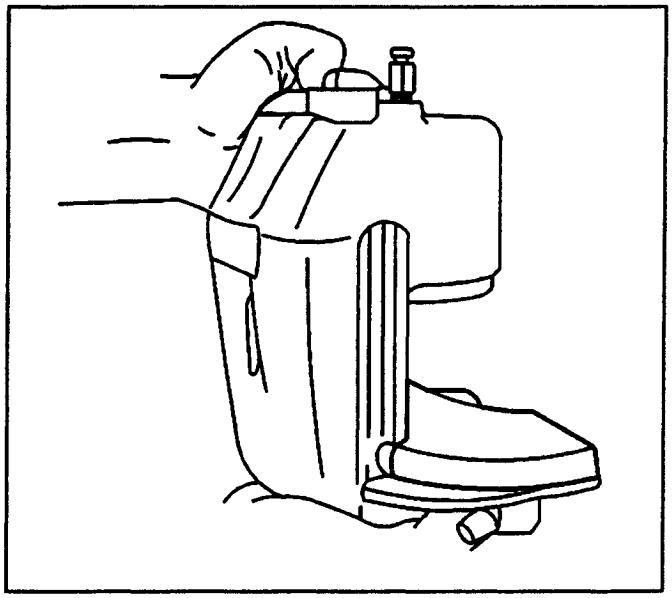


209267

Brake Pads Replacement (Front, Bendix)

Removal Procedure

1. Remove the brake caliper (5). Refer to *Brake Caliper Replacement (Front, Bendix)* or *Brake Caliper Replacement (Front, Dayton-Walther).*
2. Remove the inner brake pad from the brake caliper mounting plate (4).

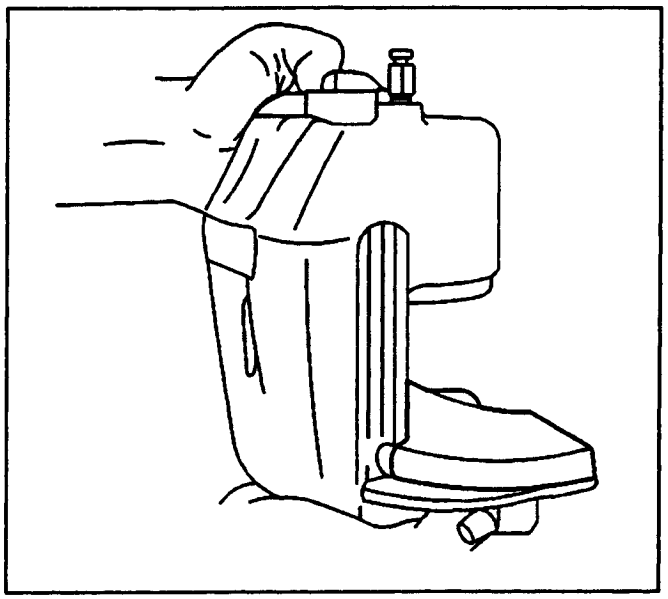


22104

3. Slide the outer brake pad along the rail in the brake caliper housing to the notches.
4. Remove the outer brake pad.
5. Inspect the brake caliper. Refer to *Brake Caliper Replacement (Front, Bendix).*

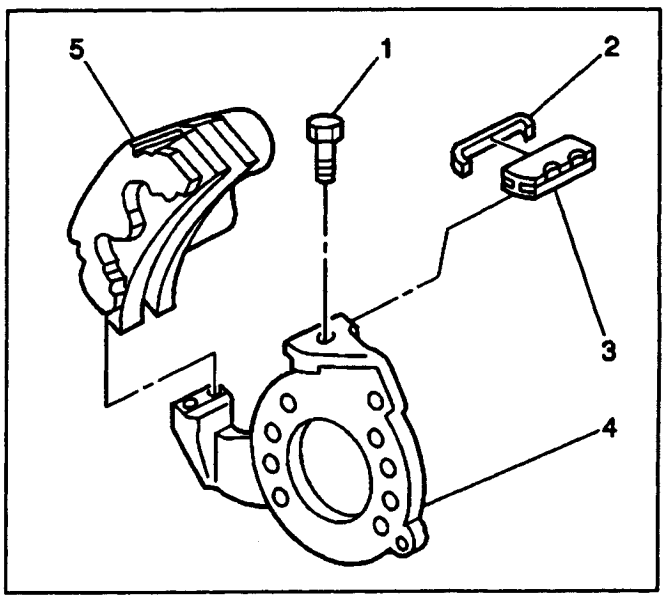
Installation Procedure

1. Install the outer brake pad into the brake caliper housing.
2. Install the inner brake pad onto the brake caliper mounting plate.



22104

3. Install the brake caliper (5). Refer to *Brake Caliper Replacement (Front, Bendix).*

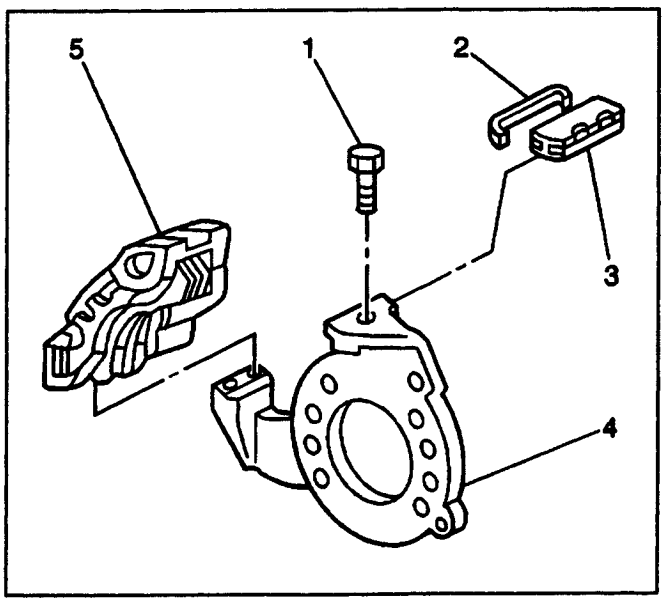


209267

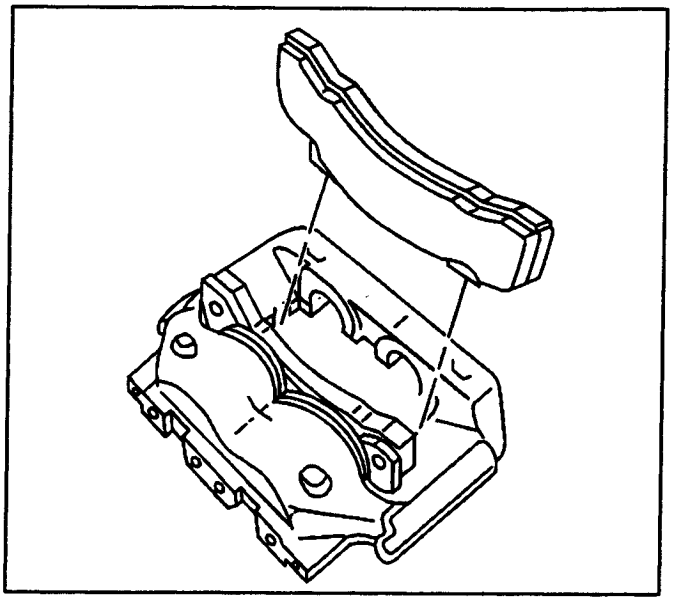
Brake Pads Replacement (Front, Dayton-Walther)

Removal Procedure

1. Remove the brake caliper (5). Refer to *Brake Caliper Replacement (Front, Bendix) Brake Caliper Replacement (Front, Dayton-Walther).*

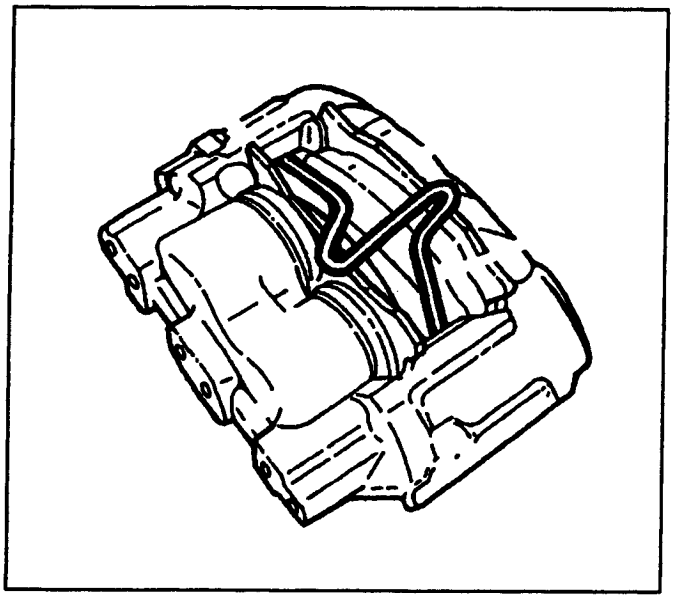


209264



200256

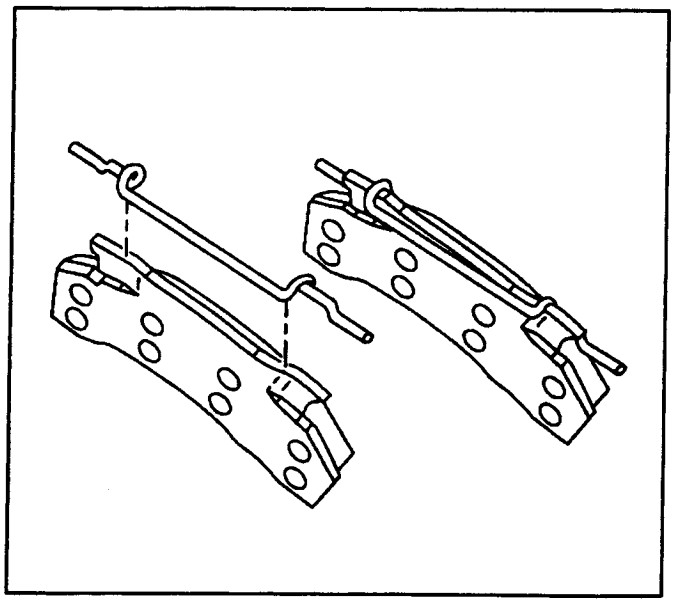
2. Slide the outer brake pad along the rail in the brake caliper housing to the notches.
3. Remove the outer brake pad.
4. Slide the inner brake pad along the rail in the brake caliper housing to the notches.
5. Remove the inner brake pad.



22102

Important: Either remove one factory installed Z spring from the brake caliper or remove two service kit springs from the brake pads, if equipped.

6. Remove the retainer spring(s).
7. Inspect the brake caliper. Refer to *Brake Caliper Replacement (Front, Bendix)* or *Brake Caliper Replacement (Front, Dayton-Walther).*

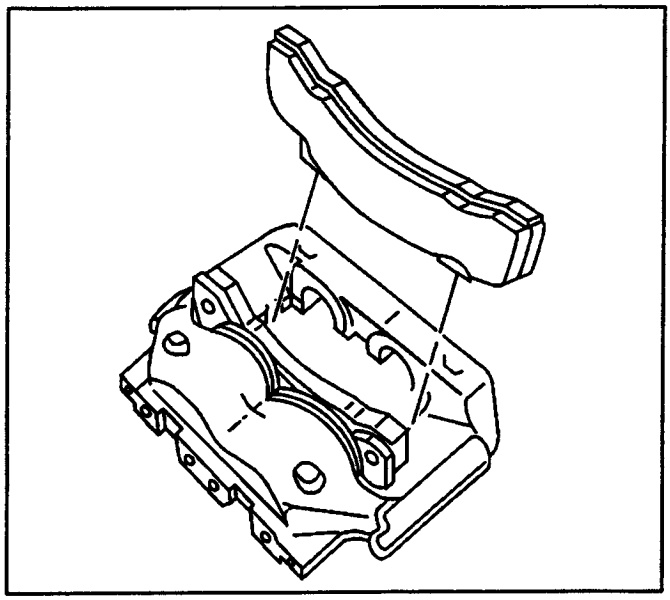


237231

Installation Procedure

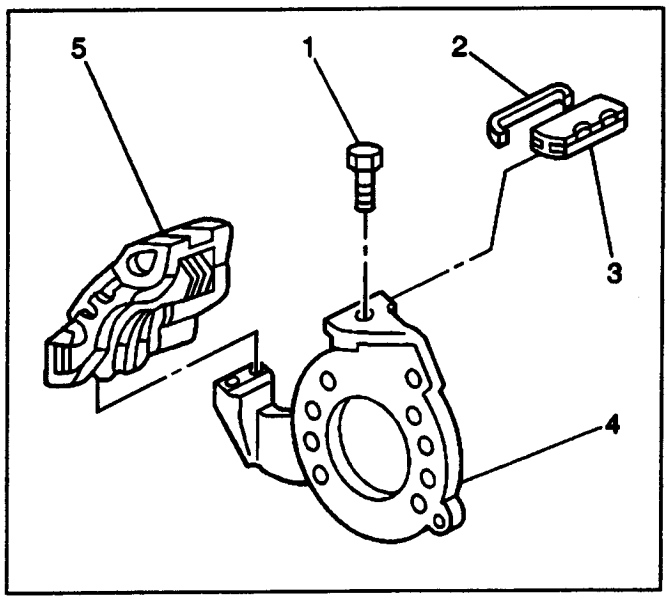
1. Install one service kit brake pad retainer spring on each brake pad.
2. Reuse the Z spring if the Z spring is undamaged. Descard the service springs if the Z spring is used.

3. Install the inner brake pad.
4. Install the outer brake pad.



200256

5. Install the brake caliper (5). Refer to *Brake Caliper Replacement (Front, Bendix) Brake Caliper Replacement (Front, Dayton-Walther).*

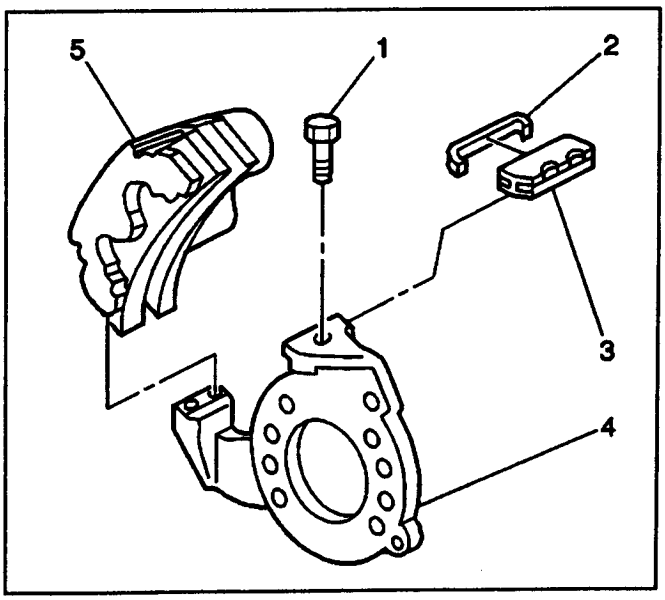


209264

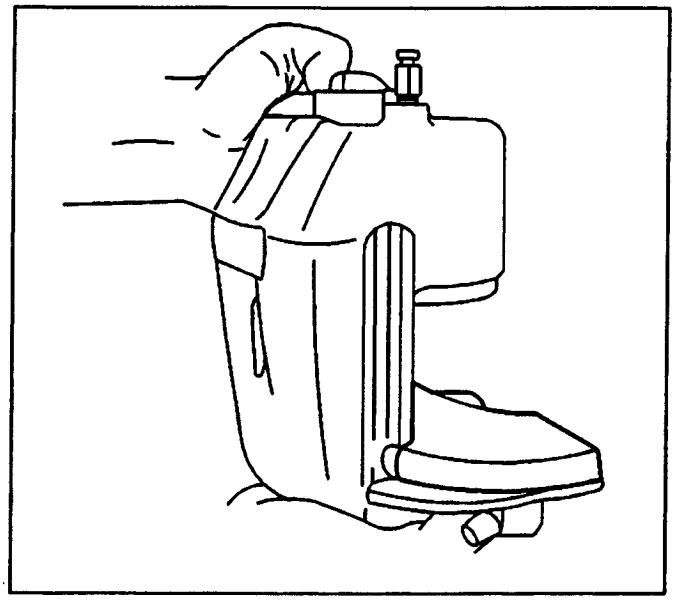
Brake Pads Replacement (Rear, Bendix Rail Slider)

Removal Procedure

1. Remove the brake caliper (5). Refer to *Brake Caliper Replacement (Rear, Rail Slider).*
2. Remove the inner brake pad from the brake caliper mounting plate (4).

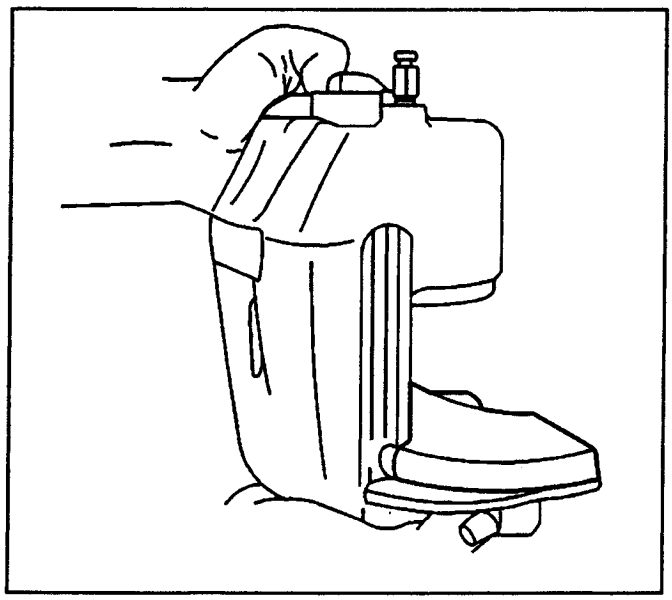


209267



22104

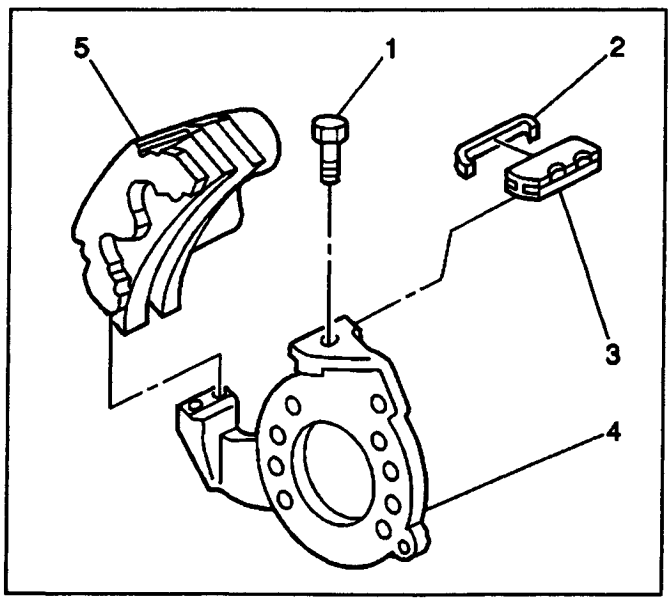
3. Slide the outer brake pad along the rail in the brake caliper housing to the notches.
4. Remove the outer brake pad.
5. Inspect the brake caliper. Refer to *Brake Caliper Replacement (Rear, Rail Slider)*



22104

Installation Procedure

1. Install the outer brake pad into the brake caliper housing.
2. Install the inner brake pad onto the brake caliper mounting plate.



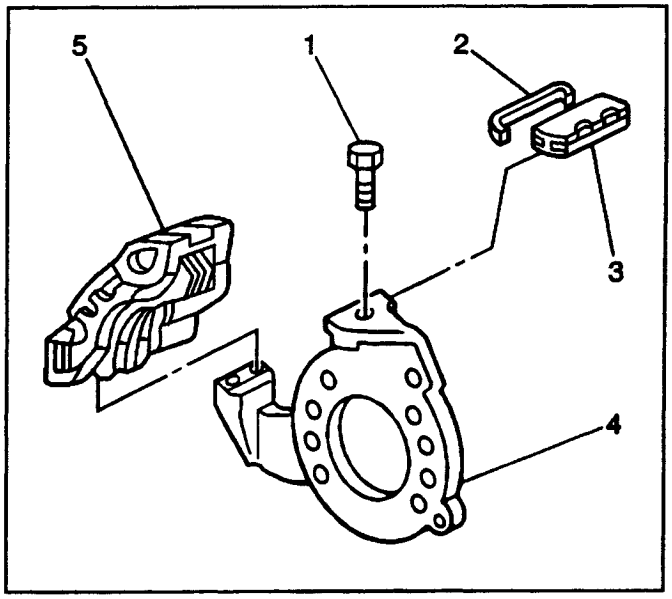
209267

3. Install the brake caliper (5). Refer to *Brake Caliper Replacement (Rear, Rail Slider).*

Brake Pads Replacement (Rear, Dayton-WaltherRailSlider)

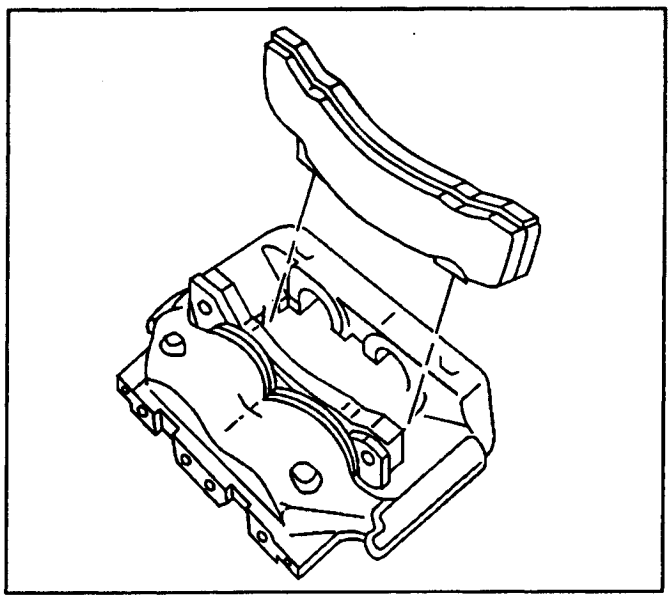
Removal Procedure

1. Remove the brake caliper (5). Refer to *Brake Caliper Replacement (Rear, Rail Slider).*



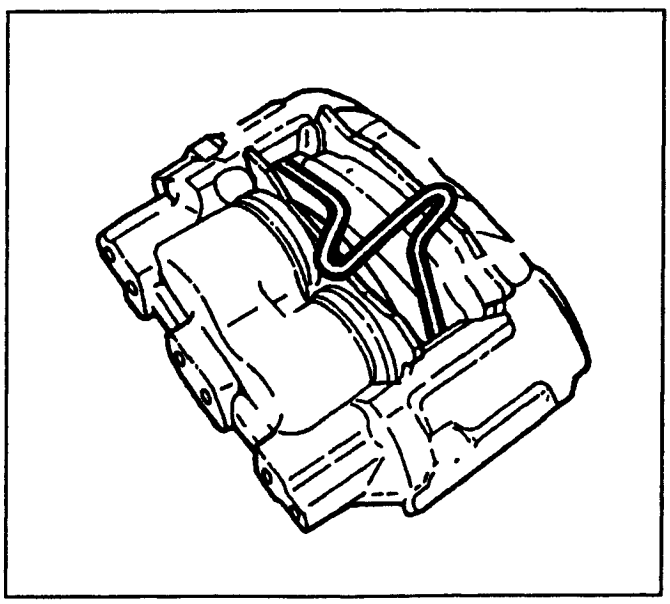
209264

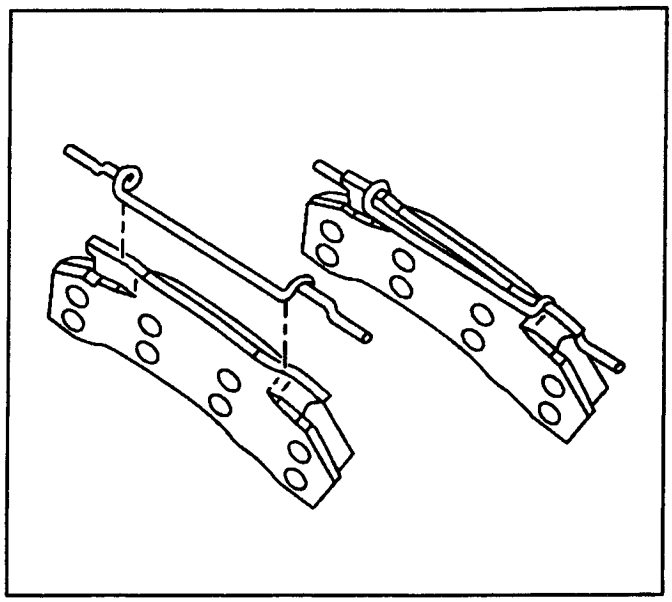
2. Slide the outer brake pad along the rail in the brake caliper housing to the notches.
3. Remove the outer brake pad.
4. Slide the inner brake pad along the rail in the brake caliper housing to the notches.
5. Remove the inner brake pad.


200256

Important: Either remove one factory installed Z spring from the brake caliper or remove two service kit springs from the brake pads, if equipped.

6. Remove the brake pad retainer spring.
7. Inspect the brake caliper. Refer to *Brake Caliper Replacement (Rear, Rail Slider).*

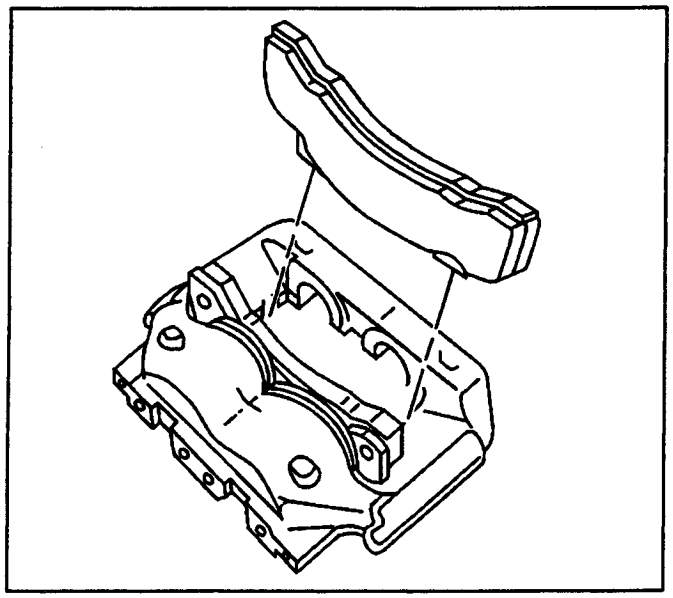

22102



237231

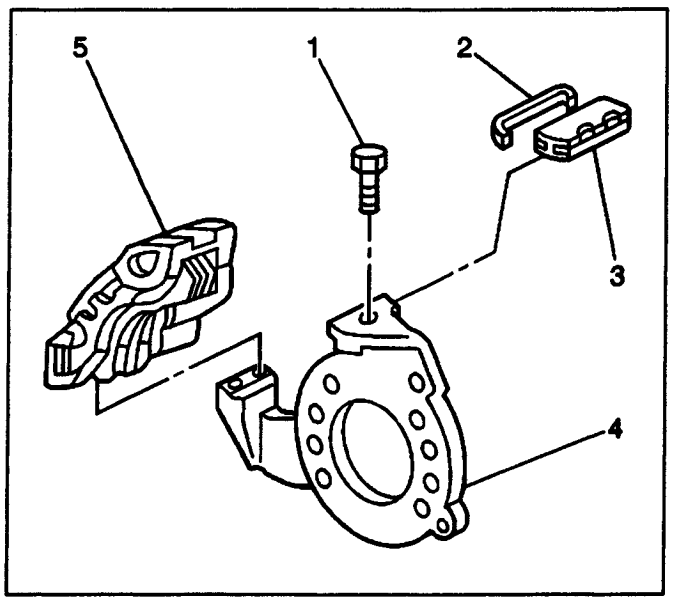
Installation Procedure

1. Install one service kit brake pad retainer spring on each brake pad.
2. Reuse the Z spring if the Z spring is undamaged. Descard the service springs if the Z spring is used.



200256

3. Install the inner brake pad.
4. Install the outer brake pad.



209264

5. Install the brake caliper (5). Refer to *Brake Caliper Replacement (Rear, Rail Slider).*

Burnishing Pads and Rotors

Burnish the linings and rotors under the following conditions:

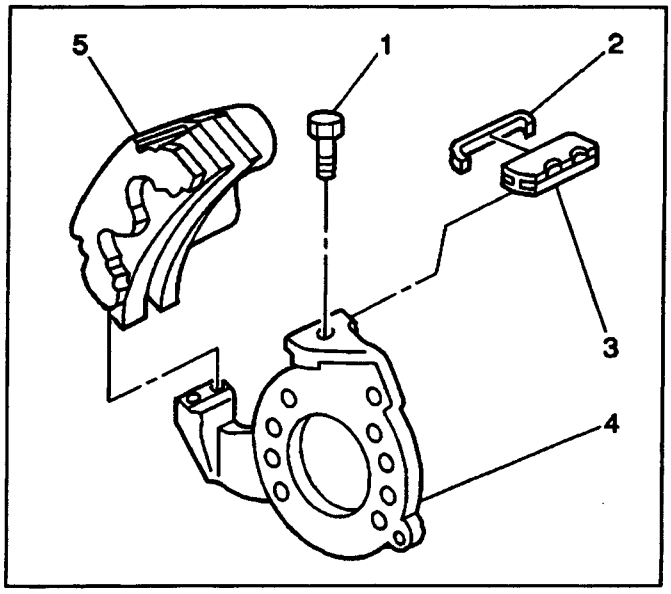
- You replaced the brake linings.
- You refinished the brake rotors.

Stop 20 times from 48 km/h (30 mph) using medium to firm brake pedal pressure. Do not overheat the brakes.

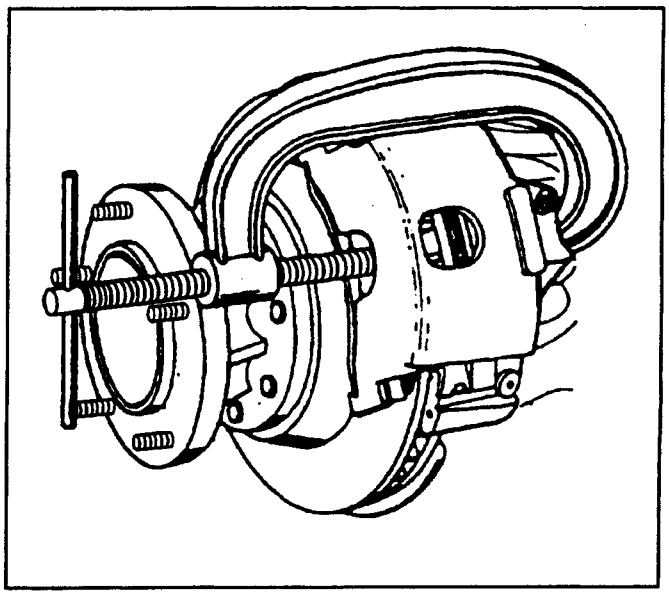
Brake Caliper Replacement (Front, Bendix)

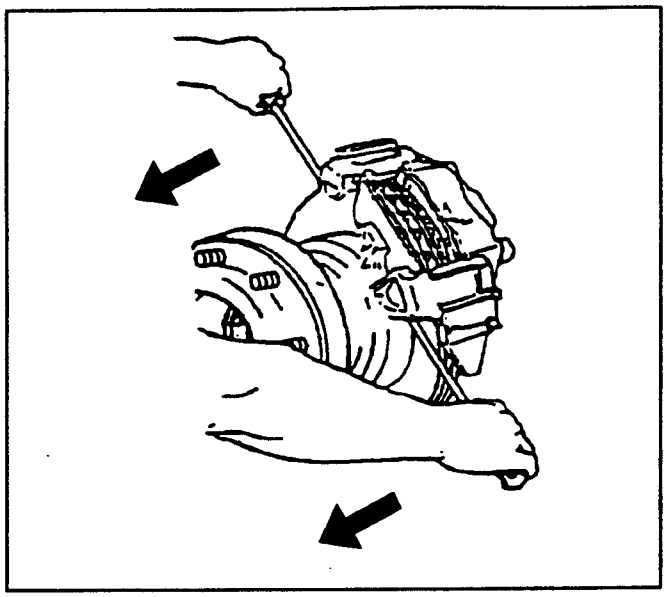
Removal Procedure

1. Apply the parking brake.
2. Block the vehicle wheels.
3. Tilt the cab.
4. Remove about 2/3 of the brake fluid from the master cylinder reservoir.
   - Do not completely drain the master cylinder reservoir.
   - Drain the fluid from the brake caliper bleeder valve.
   - Drain the fluid into a suitable container. Discard the fluid.
5. Raise the vehicle. Support the vehicle with safety stands. Refer to *Lifting and Jacking the Vehicle*
6. Remove the tires and wheels. Refer to *Wheel Removal (Front).*
7. Remove the brake caliper retainer screw (1).
8. Remove the brake caliper retainer (3) and the brake caliper spring (2) using a brass punch.
9. Compress the pistons, using one of the following methods:
10. Use a C-clamp between the inner brake caliper housing and the outer brake pad.



209267


156331

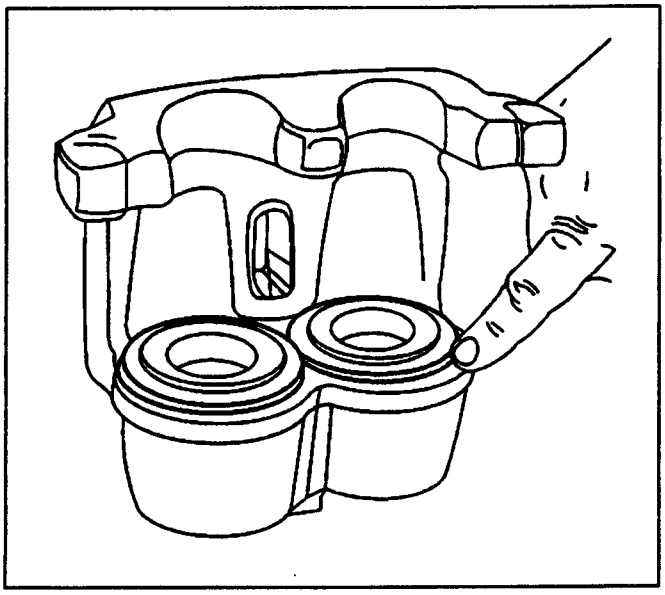


171517

11. Use screwdrivers in order to pry between the outer brake caliper housing and the outer brake pad.
12. While compressing the pistons, watch the reservoir for possible brake fluid overflow. The inner brake pad may stay on the brake caliper mounting plate (Bendix® caliper).
13. Remove the wheel speed sensor. Refer to in Wheel Speed Sensor Replacement in Antilock Brakes.
14. Disconnect the brake hose.
15. Cap or tape the brake hose fitting in order to prevent contamination.

    Notice: Do not allow calipers to hang from the flexible hoses. Doing so can damage the hoses.
16. Remove the front brake hose.

    Important:
    - Do not let the brake caliper hang from the brake hose. Suspend the brake caliper with a wire or cord.
    - It is not always necessary to remove the brake hose from the brake caliper when replacing the brake pad assemblies.
    - Clean the area around the brake hose on the brake caliper.
    - Cap or tape the fitting in order to prevent dirt from entering the brake hose.
17. Remove the brake caliper.



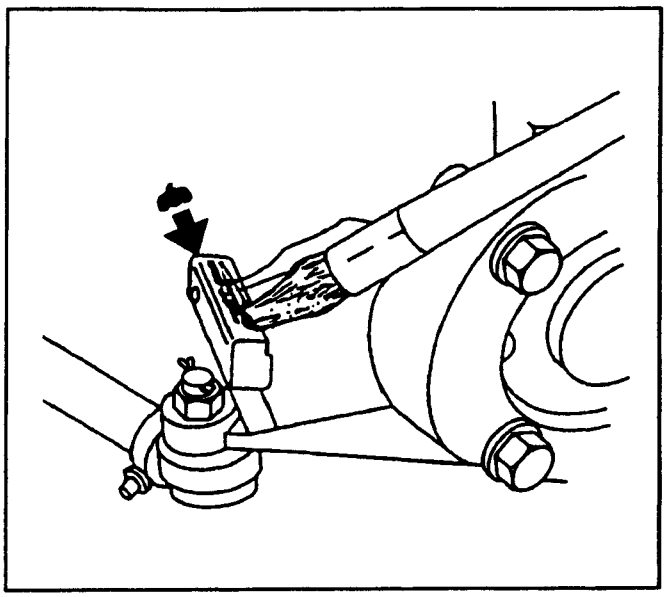
22105

Inspection Procedure

1. Inspect the inside of the brake caliper for brake fluid leaks. If you find a leak, overhaul the brake caliper. Refer to *Brake Caliper Overhaul (Bendix Rail Slider)*.
2. Inspect the piston seal for leaks and brake fluid around the dust boot, the heat shield, and the inboard brake pad.
3. Inspect the dust boots for any damage. If you find damage, overhaul the brake caliper. Refer to *Brake Caliper Overhaul (Bendix Rail Slider)*
4. Inspect the support rail surfaces on the brake caliper.
5. Inspect the support rail surfaces on the brake caliper mounting plate.
6. Inspect the V-way surfaces on the brake caliper and the support rail surfaces on the brake caliper mounting plate.
7. Inspect the heat shields. If the heat shields are loose, replace the shields.
8. Inspect under the dust boots for leakage. If you find leakage, overhaul the brake caliper. Refer to *Brake Caliper Overhaul (Bendix Rail Slider)*.

Installation Procedure

1. Clean the support rail surfaces of the brake caliper with a wire brush. File smooth any deep nicks or gouges.
2. Clean the support rail surfaces of the brake caliper mounting plate with a wire brush. File smooth any deep nicks or gouges.
3. Apply a thin coat of Brake Caliper Lubricant to the brake caliper mounting plate support rail surfaces.



171530

Important: Never drive the pistons into the bores with a mallet or metal tools.

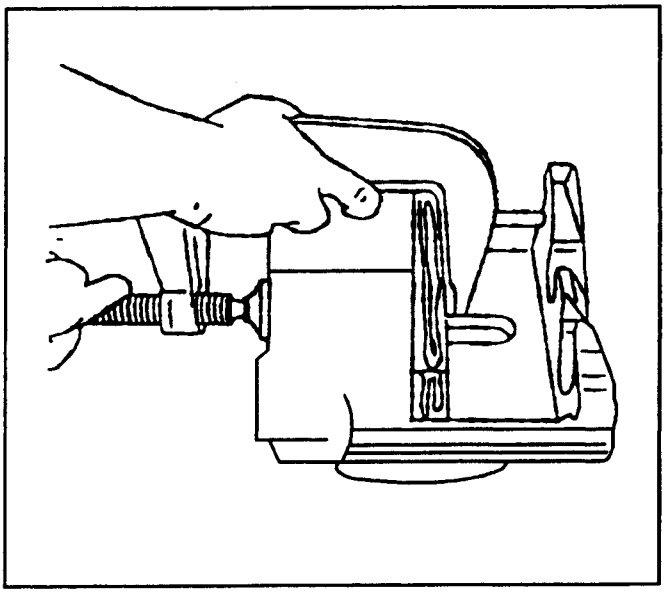
4. Install the brake caliper pistons to the bottom of the bores. If the piston cannot be pushed by hand, place a small block of wood over the pistons and the boots. Use a C-clamp around the wood block and brake caliper housing in order to push in the pistons.
5. Install the brake caliper.

   Notice: Make sure the brake hose is not twisted or kinked after installation. Damage to the hose could result.
6. Loosely assemble the brake hose nut to the brake caliper.

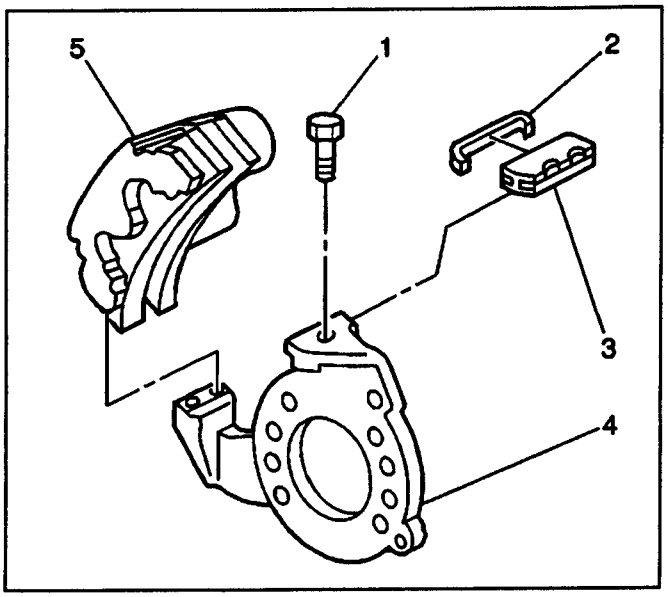
   Notice: Refer to *Fastener Notice.*
7. Loosely assemble the brake hose bracket to the brake caliper.

   Tighten

   - Tighten the brake hose nut to 19 N·m (14 lb ft).
   - Tighten the brake hose bracket bolts to 32 N·m (24 lb ft).
8. Install the wheel speed sensor. Refer to in Wheel Speed Sensor Replacement in Antilock Brakes.
9. Select a shim. Refer to *Brake Caliper and Anchor Plate Wear Adjustment (Front, Bendix).*
10. Apply a thin coat of Brake Caliper Lubricant to the brake caliper retainer and the brake caliper spring.



171534



209267

11. Tap the brake caliper retainer and brake caliper spring into place using a brass punch and a light weight hammer. The hose in the brake caliper retainer should line up with the threaded hole in the brake caliper mounting plate.

    Important: The brake caliper retainer bolt boss must fit in the circular hole in the brake caliper retainer.

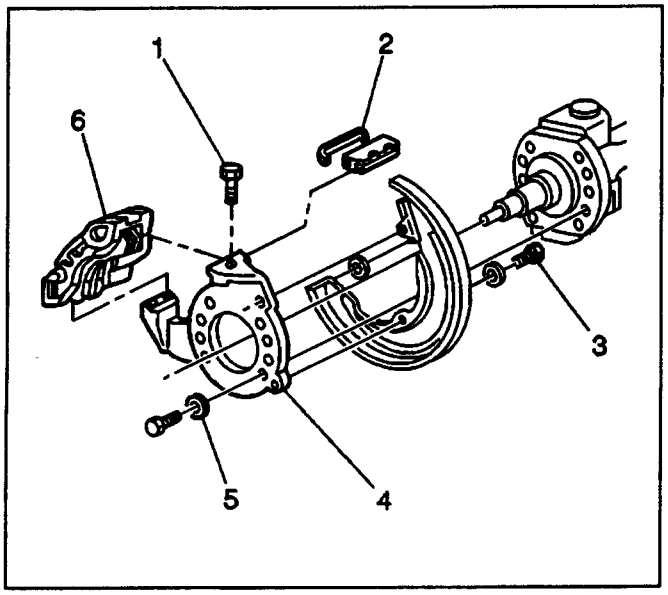
    Important: Do not reuse the brake caliper retainer bolt more than 4 times.
12. Install the brake caliper retainer bolt.

    Tighten

    Tighten the brake caliper retainer bolt to 40 N.m (29 lb ft).
13. Fill the master cylinder reservoir with brake fluid. Refer to in Hydraulic Brakes.
14. Bleed the hydraulic brake system. Refer to Hydraulic Brakes.

    Important: Check the fluid level in the master cylinder reservoir after pumping the brake pedal.
15. Pump the brake pedal several times in order to ensure that the pedal is firm and the brake linings are adjusted.
16. Install the tires and wheels. Refer to *Wheel Removal (Front).*
17. Lower the vehicle. Refer to *Lifting and Jacking the Vehicle.*

    Caution: Do not move the vehicle until a firm brake pedal is obtained. Air in the brake system can cause the loss of brakes with possible personal injury.
18. Remove the blocks.



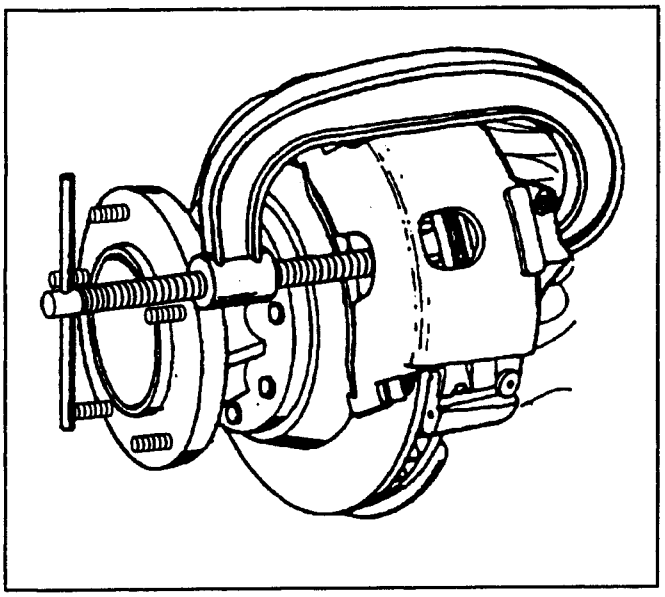
260919

Brake Caliper Replacement (Front, Dayton-Walther)

Removal Procedure

1. Apply the parking brake.
2. Block the vehicle wheels.
3. Remove about 2/3 of the brake fluid from the master cylinder reservoir.
   - Do not completely drain the master cylinder reservoir.
   - Drain the fluid from the brake caliper bleeder valve.
   - Drained the fluid into a suitable container. Discard the fluid.
4. Raise the vehicle. Support the vehicle with safety stands. Refer to *Lifting and Jacking the Vehicle.*
5. Remove the tires and wheels. Refer to *Wheel Removal (Front).*

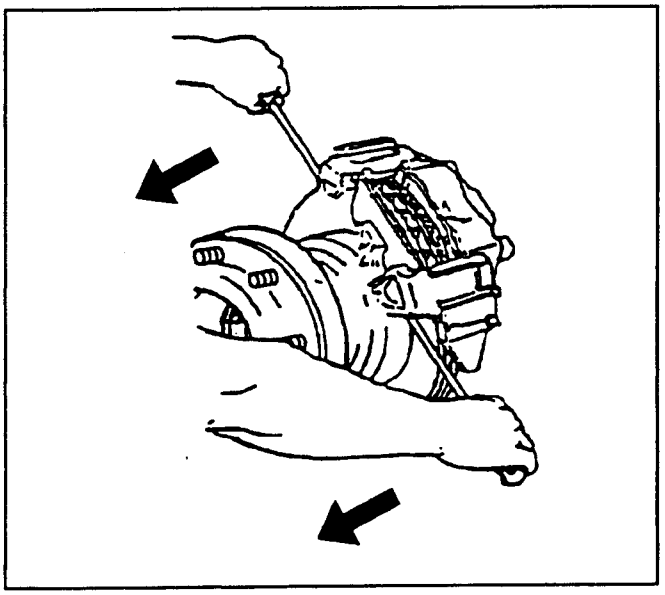
6. Remove the brake caliper retainer bolt (1).
7. Remove the brake caliper retainer (6) and brake caliper spring (2) using a brass punch.
8. Compress the pistons.
9. Use a C-clamp between the inner brake caliper housing and the outer brake pad.



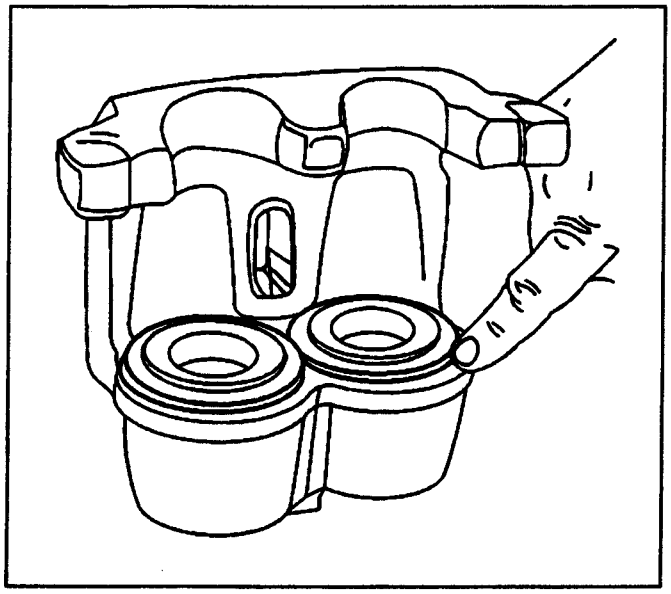
156331

10. Use screwdrivers to pry between the outer brake caliper housing and the outer brake pad.
11. While compressing the pistons, watch the reservoir for possible brake fluid overflow.
12. Remove the wheel speed sensor. Refer to Wheel Speed Sensor Replacement in Antilock Brakes.
13. Disconnect the brake hose.
14. Cap or tape the brake hose fitting in order to prevent contamination.

    Notice: Do not allow calipers to hang from the flexible hoses. Doing so can damage the hoses.
15. Remove the brake caliper.



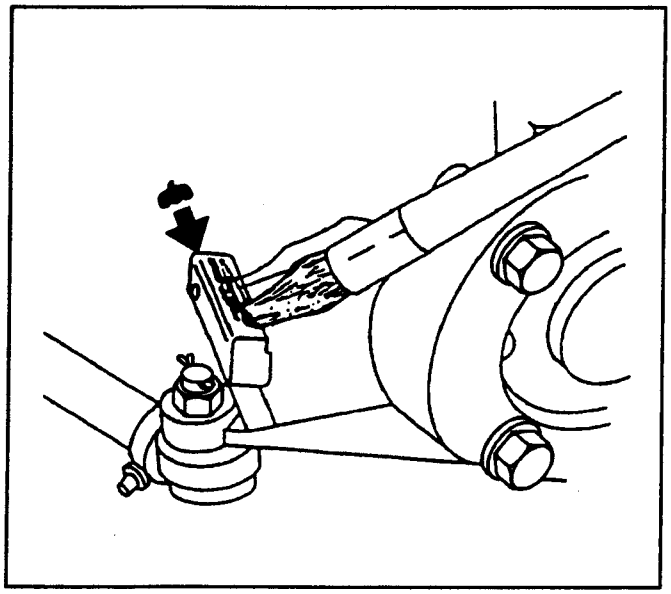
171517



22105

Inspection Procedure

1. Clean the area around the brake hose on the brake caliper. Use Brake Parts cleaner.
2. Inspect the inside of the brake caliper for brake fluid leaks. If you find a leak, overhaul the brake caliper. Refer to *Brake Caliper Overhaul (Dayton-Walther Rail Slider).*
3. Inspect the piston seal for leaks and brake fluid around the dust boot, the heat shield, and the inboard brake pad.
4. Inspect the dust boots for any damage. If you find damage, overhaul the brake caliper. Refer to *Brake Caliper Overhaul (Dayton-Walther Rail Slider).*
5. Inspect the V-way surfaces on the brake caliper.
6. Inspect the V-way surfaces on the brake caliper mounting plate.
7. Inspect the heat shields. If the heat shields are loose, replace the shields.
8. Inspect under the dust boots for leakage. If you find leakage, overhaul the brake caliper. Refer to *Brake Caliper Overhaul (Dayton-Walther Rail Slider).*



171530

Installation Procedure

1. Clean the V-way surfaces of the brake caliper with a wire brush. File smooth any deep nicks or gouges.
2. Clean the support rail surfaces of the brake caliper mounting plate with a wire brush. File smooth any deep nicks or gouges.
3. Apply a thin coat of Brake Caliper Lubricant to the brake caliper mounting plate support rail surfaces.

Important: Never drive the pistons into the bores with a mallet or metal tools.

4. Install the pistons into the bottom of the caliper bores.

   If you cannot push the completely pistons into the bores by hand, place a small block of wood over the pistons and dust boots. Use a C-clamp around the wooden block and brake caliper housing in order to push in the pistons.

5. Install the brake caliper.

   Notice: Make sure the brake hose is not twisted or kinked after installation. Damage to the hose could result.

6. Install the brake hose.
7. Loosely assemble the brake hose nut to the brake caliper.

   Notice: Refer to *Fastener Notice*

8. Loosely assemble the brake hose bracket to the brake caliper.

   Tighten

   - Tighten the brake hose nut to 19 N.m (14 lb ft).
   - Tighten the brake hose bracket bolts to 32 N.m (24 lb ft).

9. Install the wheel speed sensor. Refer to in Wheel Speed Sensor Replacement in Antilock Brakes.
10. Refer to *Brake Caliper and Anchor Plate Wear Adjustment (Front,Dayton-Walther).*
11. Apply a thin coat of Brake Caliper Lubricant to the brake caliper retainer and the brake caliper spring.
12. Tap the brake caliper retainer (6) and brake caliper spring (2) into place using a brass punch and a light weight hammer. The hose in the brake caliper retainer should line up with the threaded hole in the brake caliper mounting plate (4).

    Important: The brake caliper retainer bolt boss must fit in the circular hole in the brake caliper retainer.

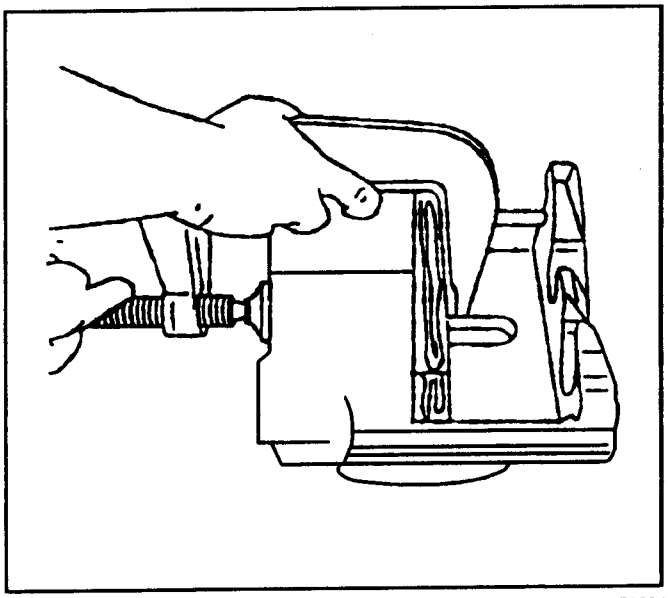
    Important: Do not reuse the brake caliper retainer bolt more than 4 times.

13. Install the brake caliper retainer bolt.

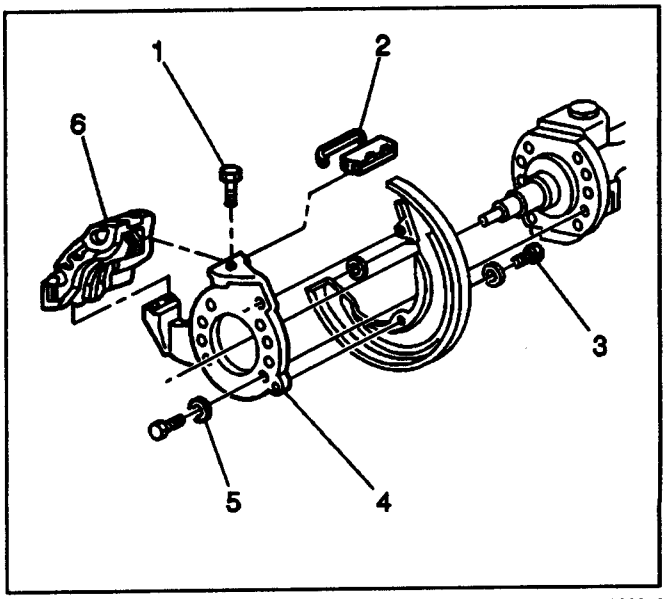
    Tighten

    Tighten the brake caliper retainer bolt to 40 N.m (29 lb ft).

14. Fill the master cylinder reservoir with brake fluid. Refer to Hydraulic Brakes.



171534



260919

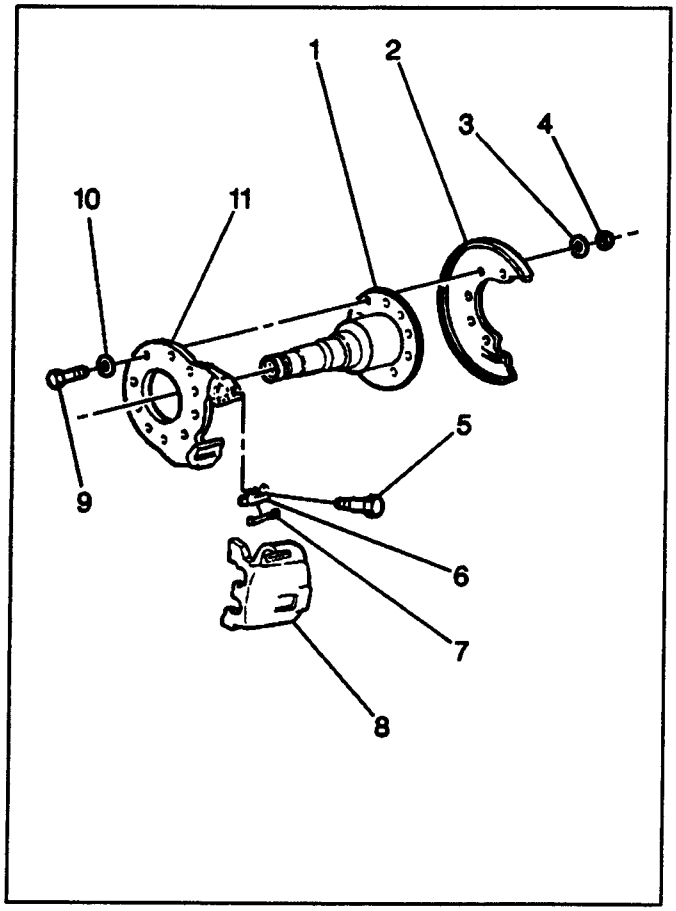
15. Bleed the hydraulic brake system. Refer to Hydraulic Brakes.

    Important: Check the fluid level in the master cylinder reservoir after pumping the brake pedal.

16. Pump the brake pedal several times in order to ensure that the pedal is firm and the brake linings are adjusted.
17. Install the tires and wheels. Refer to *Wheel Removal (Front).*
18. Lower the vehicle. Refer to *Lifting and Jacking the Vehicle.*

    Caution: Do not move the vehicle until a firm brake pedal is obtained. Air in the brake system can cause the loss of brakes with possible personal injury.

19. Remove the blocks.
20. Release the parking brake.



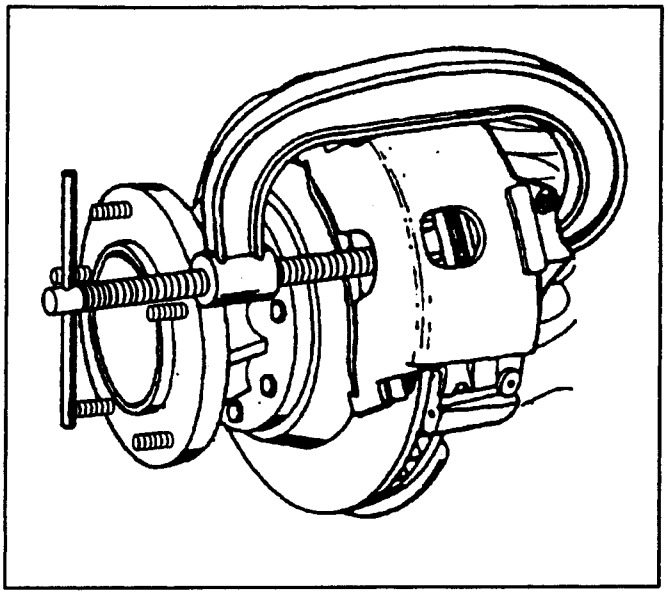
237274

Brake Caliper Replacement (Rear, Rail Slider)

Removal Procedure

1. Apply the parking brake.
2. Block the vehicle wheels.
3. Tilt the cab.
4. Remove about 2/3 of the brake fluid from the master cylinder reservoir.
   - Do not completely drain the master cylinder reservoir.
   - Drain the fluid from the brake caliper bleeder valve.
   - Drain the fluid into a suitable container. Discard the fluid.
5. Raise the vehicle. Support the vehicle with safety stands. Refer to *Lifting and Jacking the Vehicle.*
6. Remove the tires and wheels. Refer to *Wheel Removal (Front).*
7. Remove the brake caliper retainer screw.
8. Remove the brake caliper retainer and the brake caliper spring (11) using a brass punch.
9. Compress the pistons.

10. Use a C-clamp between the inner brake caliper housing and the outer brake pad.

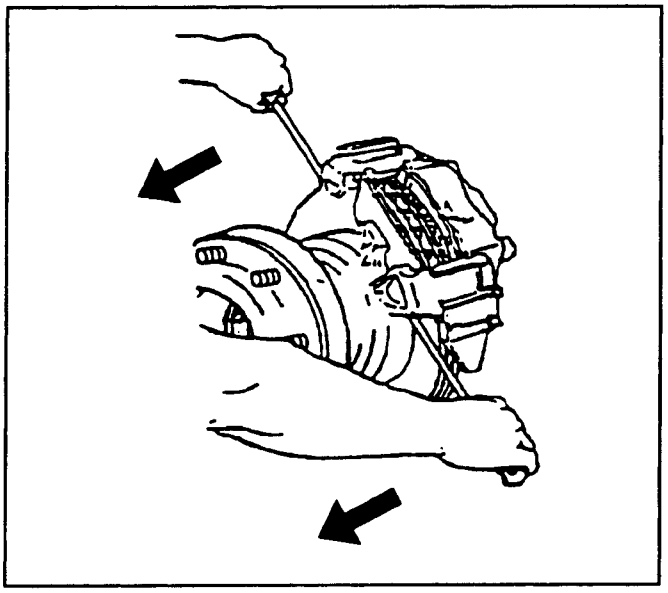


156331

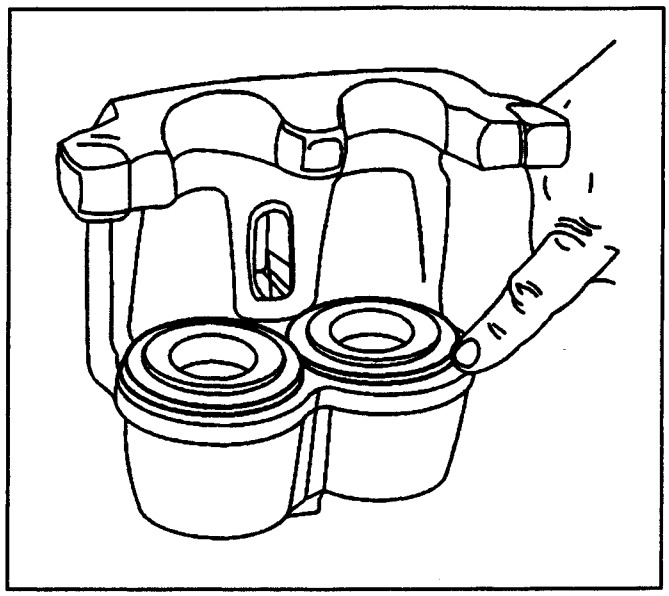
11. Use screwdrivers in order to pry between the outer brake caliper housing and the outer brake pad.
12. While compressing the pistons, watch the reservoir for possible brake fluid overflow. The inner brake pad may stay on the brake caliper mounting plate (Bendix® caliper).
13. Remove the wheel speed sensor. Refer to in Wheel Speed Sensor Replacement in Antilock Brakes.
14. Disconnect the brake hose.

    Notice: Do not allow calipers to hang from the flexible hoses. Doing so can damage the hoses.
15. Remove the brake hose.

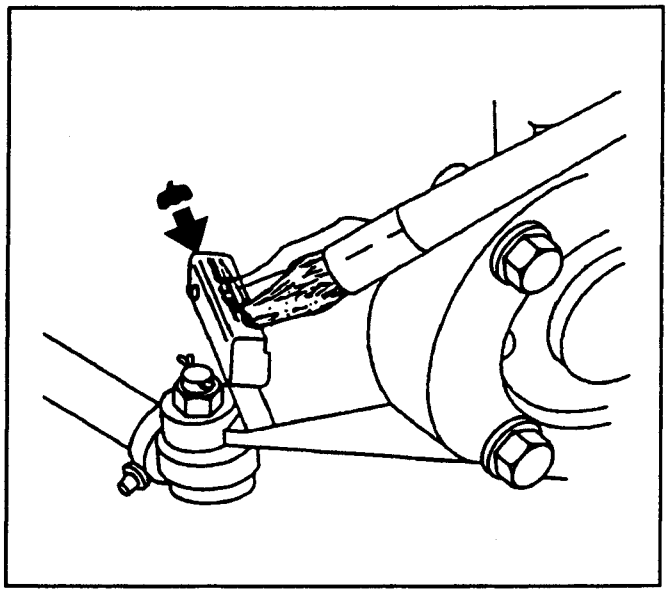
    Important:
    - Do not let the brake caliper hang from the brake hose. Suspend the brake caliper with a wire or cord.
    - Removing the brake hose from the brake caliper when replacing the brake pad assemblies is not always necessary.
    - Clean the area around the brake hose on the brake caliper.
    - Cap or tape the fitting in order to prevent dirt from entering the brake hose.
16. Remove the brake caliper.



171517



22105



171530

Inspection Procedure

1. Inspect the inside of the brake caliper for brake fluid leaks. If you find a leak, overhaul the brake caliper. Refer to *Brake Caliper Overhaul (Dayton-Walther Rail Slider).*
2. Inspect the piston seal for leaks and brake fluid around the dust boot, the heat shield, and the inboard brake pad.
3. Inspect the dust boots for any damage. If you find damage, overhaul the brake caliper. Refer to *Brake Caliper Overhaul (Dayton-Walther Rail Slider).*
4. Inspect the V-way surfaces on the brake caliper.
5. Inspect the V-way surfaces on the brake caliper mounting plate.
6. Inspect the dust shields. If the dust shields are loose, replace the shields.
7. Inspect under the dust boots for leakage. If you find leakage, overhaul the brake caliper. Refer to *Brake Caliper Overhaul (Dayton-Walther Rail Slider).*

Installation Procedure

1. Clean the V-way surfaces of the brake caliper with a wire brush. File smooth any deep nicks or gouges.
2. Clean the V-way surfaces of the brake caliper mounting plate with a wire brush. File smooth any deep nicks or gouges.
3. Apply a thin coat of Brake Caliper Lubricant to the brake caliper mounting plate support rail surfaces.

Important: If the piston cannot be pushed by hand, place a small block of wood over the pistons and boots. Use a C-clamp around the wood block and brake caliper housing in order to push in the pistons.

Important: Never drive the pistons into the bores with a mallet or metal tools.

4. Install the brake caliper pistons to the bottom of the bores.
5. Install the brake caliper.

   Notice: Make sure the brake hose is not twisted or kinked after installation. Damage to the hose could result.
6. Install the brake hose.
7. Loosely assemble the brake hose nut to the brake caliper.

   Notice: Refer to *Fastener Notice.*
8. Loosely assemble the brake hose bracket to the brake caliper.

   Tighten

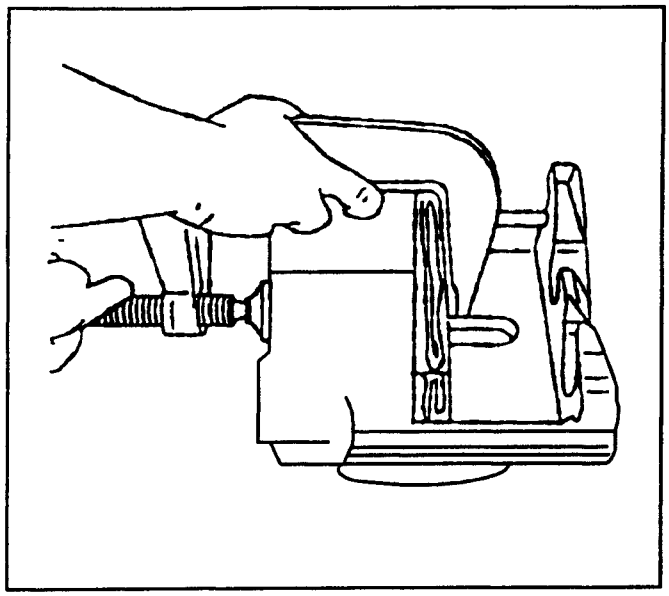
   - Tighten the brake hose nut to 19 N.m (14 lb ft).
   - Tighten the brake hose bracket bolts to 32 N.m (24 lb ft).
9. Install the wheel speed sensor. Refer to Wheel Speed Sensor Replacement in Antilock Brakes.
10. Install the brake caliper.
11. Install the brake caliper retainer spring in the support rail.
12. Select an appropriate shim. Refer to *Brake Caliper and Anchor Plate Wear Adjustment (Rear, Bendix).*
13. Apply a thin coat of Brake Caliper Lubricant to the brake caliper retainer and the brake caliper spring.
14. Tap the brake caliper retainer (3) and brake caliper spring (2) into place using a brass punch and a light weight hammer. The hose in the brake caliper retainer should line up with the threaded hole in the brake caliper mounting plate.
15. Install the brake caliper retainer screw.

    Important: The brake caliper retainer bolt boss must fit in the circular hole in the brake caliper retainer.

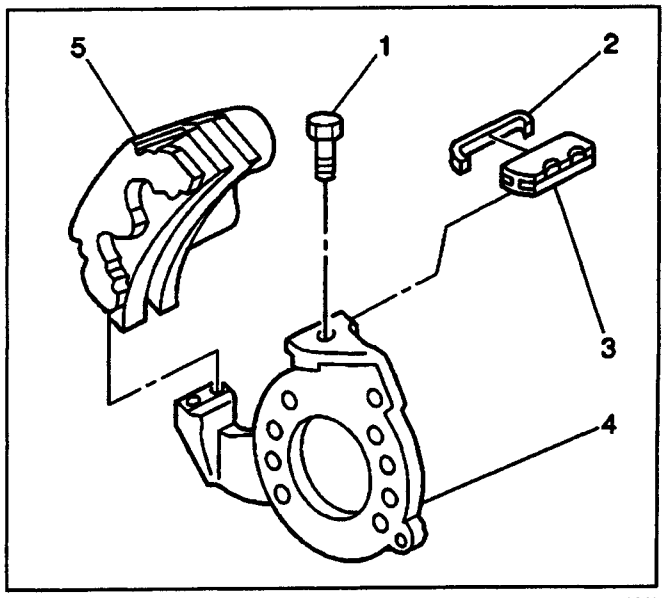
    Important: Do not reuse the brake caliper retainer bolt more than 4 times.
16. Install the brake caliper retainer bolt.

    Tighten

    Tighten the brake caliper retainer bolt to 40 N.m (29 lb ft).
17. Fill the master cylinder reservoir with brake fluid. Refer to Hydraulic Brakes.



171534



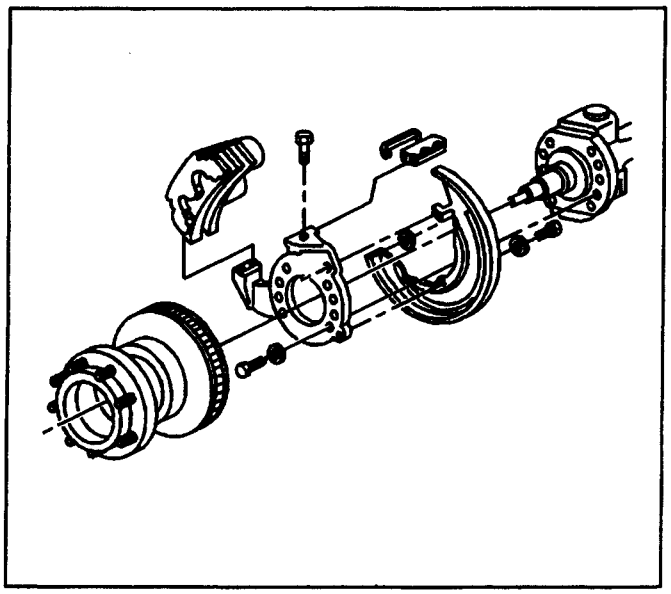
209267

18. Bleed the hydraulic brake system. Refer to Hydraulic Brakes.

    Important: Check the fluid level in the master cylinder reservoir after pumping the brake pedal.

    Pump the brake pedal several times in order to ensure that the pedal is firm and the brake linings are adjusted.
19. Install the tires and wheels. Refer to *Wheel Removal (Front).*
20. Lower the vehicle.

    Caution: Do not move the vehicle until a firm brake pedal is obtained. Air in the brake system can cause the loss of brakes with possible personal injury.
21. Remove the blocks.



237266

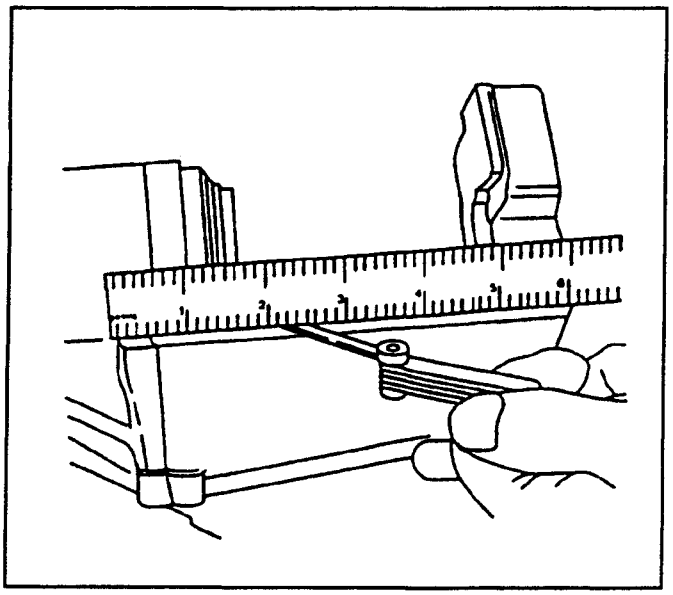
Brake Caliper and Anchor Plate Wear Adjustment (Front, Bendix)

Shim Selection

1. Remove the brake caliper retainer screw.
2. Tap out the brake caliper retainer and the brake caliper retainer spring.
3. Remove the brake caliper. Refer to *Brake Caliper Replacement (Front, Bendix).*
4. Clean the V-way surfaces of the brake caliper with a wire brush.

   File smooth any nicks and gouges.
5. Clean the support rail surfaces of the brake caliper mounting plate with a wire brush.

   File smooth any nicks and gouges.

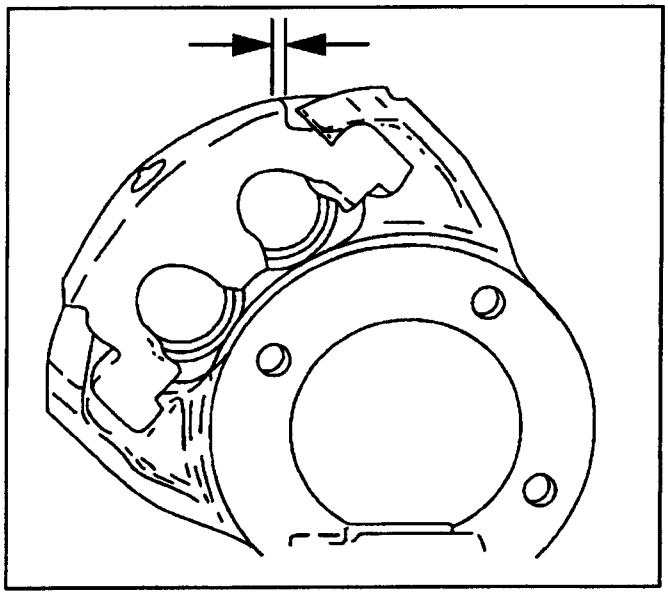


171507

6. Lay a straight edge across the brake caliper V-way surfaces.
7. Measure the maximum depth of the brake caliper V-way surfaces.
8. If the brake caliper V-way surfaces are worn to a depth of 1.27 mm (0.050 in) or more, replace the brake caliper.
9. Temporarily mount the brake caliper on the brake caliper mounting plate.
10. Install a new brake caliper retainer.
11. Install the brake caliper retainer bolt.

    Important:
    - Do not install the spring at this time.
    - Make sure that the tool is equally distant from each edge of the brake caliper.
12. Insert a screwdriver between the brake caliper and the brake caliper retainer.
13. Pry firmly in order to ensure that the brake caliper is seated against all three slide surfaces.

14. Measure the bumper gap with the largest feeler gage (or stack of gages) that fit in the gap on either side of the screwdriver.
15. Select the correct size shim.
    - If the gap measurement is 0.0–1.47 mm (0.0–0.058 in), no shim is required.
    - If the gap measurement is 1.50–2.57 mm (0.059–0.101 in), use a shim thickness of 0.64 mm (0.025 in).
    - If the gap measurement is 2.59–3.68 mm (0.102–0.145 in), use a shim thickness of 1.14 mm (0.045 in).
16. If the gap exceeds 3.68 mm (0.145 in), replace with a new brake caliper.
17. Re-measure the gap.
18. If the bumper gap with the new brake caliper is 1.49–3.68 mm (0.059–0.145 in), Insert a screwdriver between the brake caliper and the brake caliper retainer, and pry firmly in order to ensure that the brake caliper is seated against all three slide surfaces.
19. If the bumper gap with the new brake caliper exceeds 3.68 mm (0.145 in), replace the brake caliper mounting plate.



237228

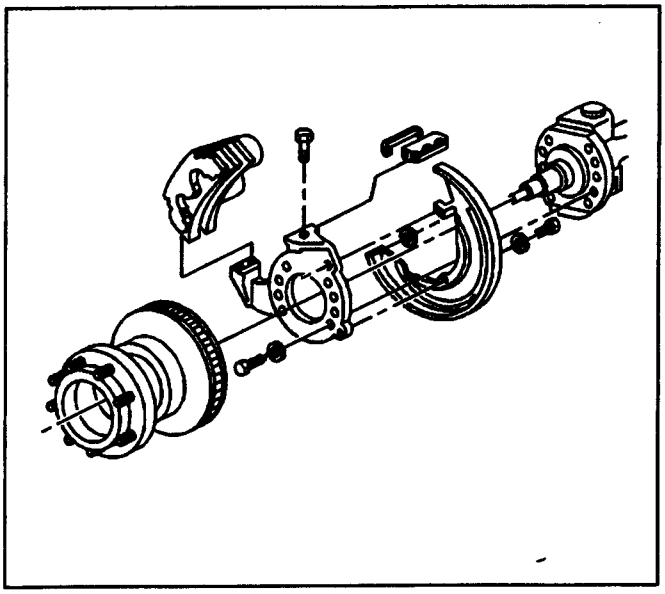
Important: Use a new brake caliper retainer and brake caliper retainer spring in order to assemble the new components.

20. Remove the brake caliper.
21. Install the selected shim on the brake caliper mounting plate support rail opposite to the brake caliper retainer and spring V-way.
22. Install the brake caliper.

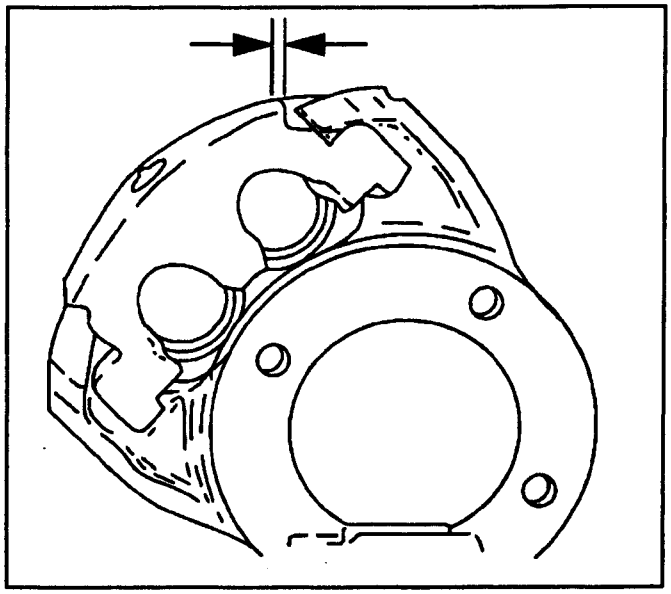
    Notice: Refer to *Fastener Notice*
23. Install the brake caliper retainer screw.

    Tighten

    Tighten the screw to 40 N·m (29 lb ft).

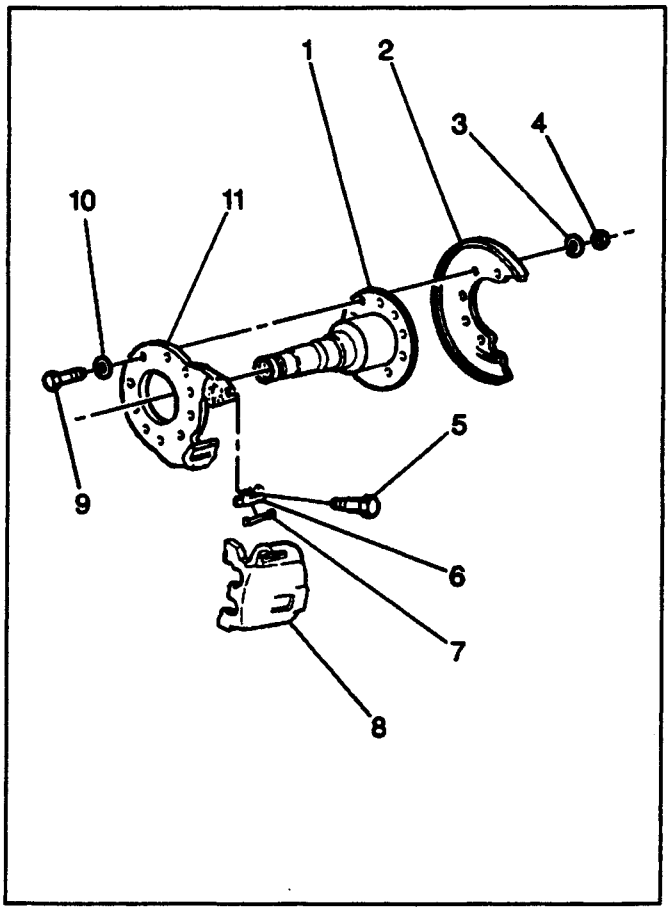


237266



237228

24. Marie the bumper gap.
25. If the gap exceeds 1.47 mm (0.058 in), install a thicker shim or replace the components as necessary.



237274

Brake Caliper and Anchor Plate Wear Adjustment (Rear, Bendix)

Shim Selection

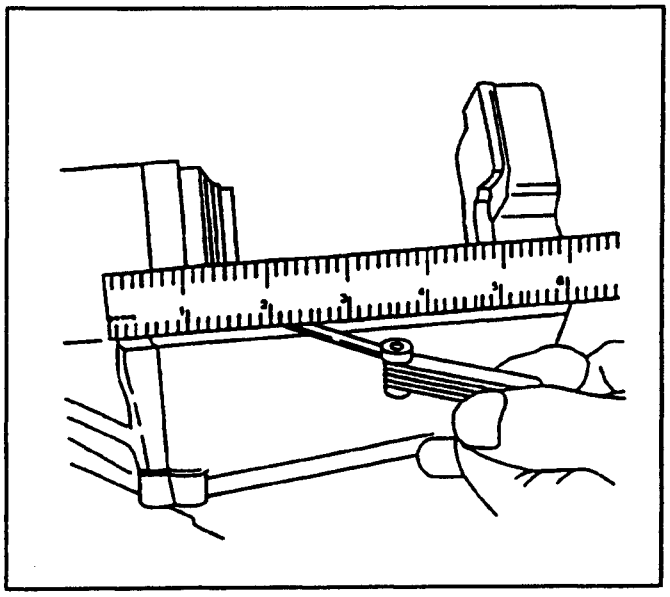
1. Remove the brake caliper retainer screw (5).
2. Tap out the brake caliper retainer (6) and the brake caliper retainer spring (7).
3. Remove the brake caliper. Refer to *Brake Caliper Replacement (Front, Bendix)*
4. Clean the V-way surfaces of the brake caliper with a wire brush.

   File smooth any nicks and gouges.
5. Clean the support rail surfaces of the brake caliper mounting plate with a wire brush.

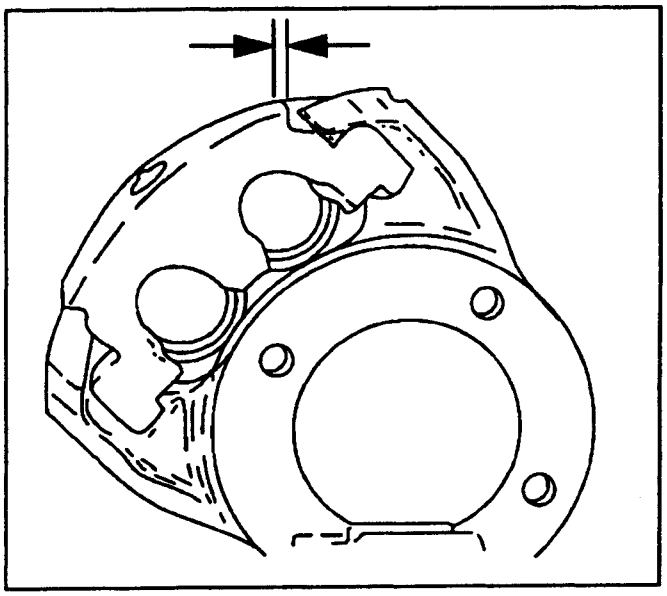
   File smooth any nicks and gouges.

6. Lay a straight edge across the brake caliper V-way surfaces.
7. Measure the maximum depth of the brake caliper V-way surfaces.
8. If the brake caliper V-way surfaces are worn to a depth of 1.27 mm (0.050 in) or more, replace the brake caliper.
9. Temporarily mount the brake caliper on the brake caliper mounting plate.
10. Install a new brake caliper retainer.
11. Install the brake caliper retainer bolt.

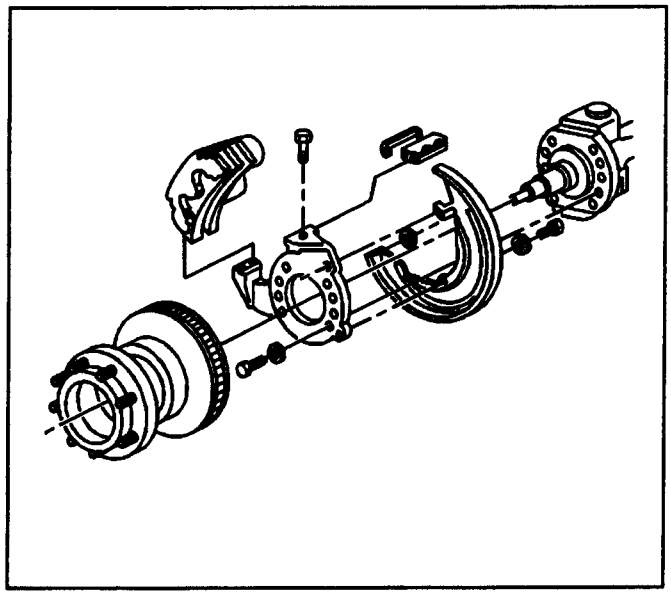
    Important:
    - Do not install the spring at this time.
    - Make sure that the tool is equally distant from each edge of the brake caliper.
12. Insert a screwdriver between the brake caliper and the brake caliper retainer.
13. Pry firmly in order to ensure that the brake caliper is seated against all three slide surfaces.
14. Measure the bumper gap with the largest feeler gage (or stack of gages) that fit in the gap on either side of the screwdriver.
15. Select the correct size shim.
    - If the gap measurement is 0.0–1.47 mm (0.0–0.058 in), no shim is required.
    - If the gap measurement is 1.50–2.57 mm (0.059–0.101 in), use a shim thickness of 0.64 mm (0.025 in).
    - If the gap measurement is 2.59–3.68 mm (0.102–0.145 in), use a shim thickness of 1.14 mm (0.045 in).
16. If the gap exceeds 3.68 mm (0.145 in), replace with a new brake caliper.
17. Re-measure the gap.
18. If the bumper gap with the new brake caliper is 1.49–3.68 mm (0.059–0.145 in), Insert a screwdriver between the brake caliper and the brake caliper retainer, and pry firmly in order to ensure that the brake caliper is seated against all three slide surfaces.
19. If the bumper gap with the new brake caliper exceeds 3.68 mm (0.145 in), replace the brake caliper mounting plate.



171507



237228



237266

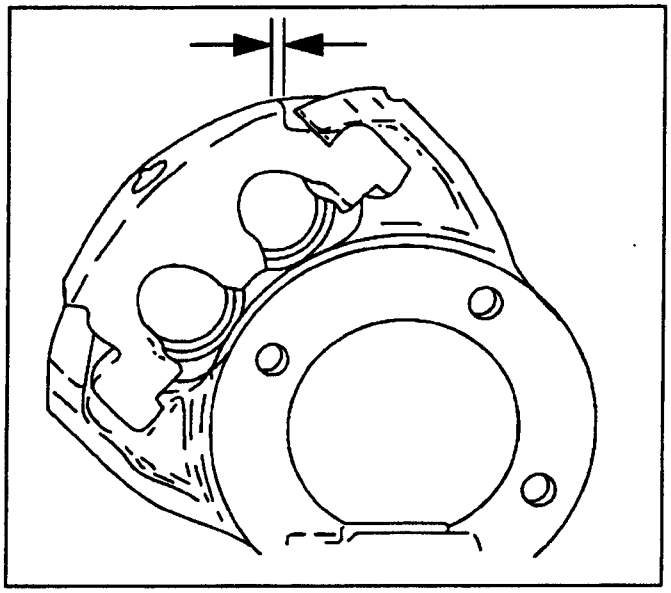
Important: Use a new brake caliper retainer and brake caliper retainer spring in order to assemble the new components.

20. Remove the brake caliper.
21. Install the selected shim on the brake caliper mounting plate support rail opposite to the brake caliper retainer and spring V-way.
22. Install the brake caliper.

    Notice: Refer to *Fastener Notice*
23. Install the brake caliper retainer screw.

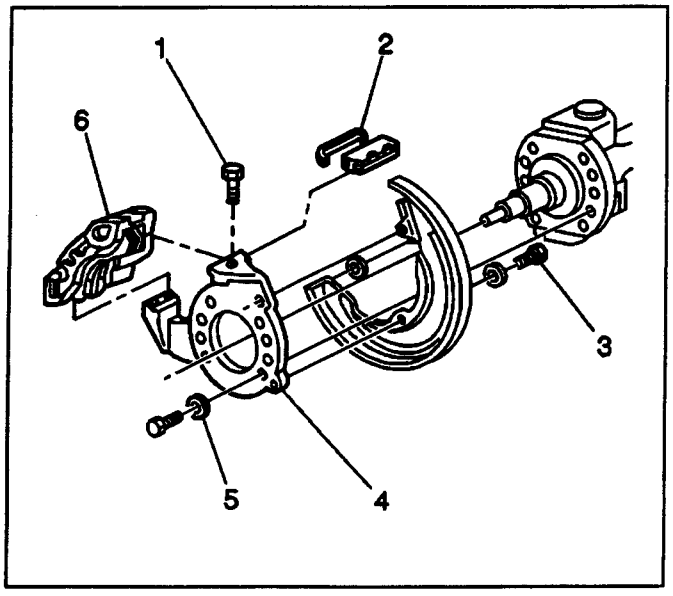
    Tighten

    Tighten the screw to 40 N.m (29 lb ft).



237228

24. Measure the bumper gap.
25. If the gap exceeds 1.47 mm (0.058 in), install a thicker shim or replace the components as necessary.



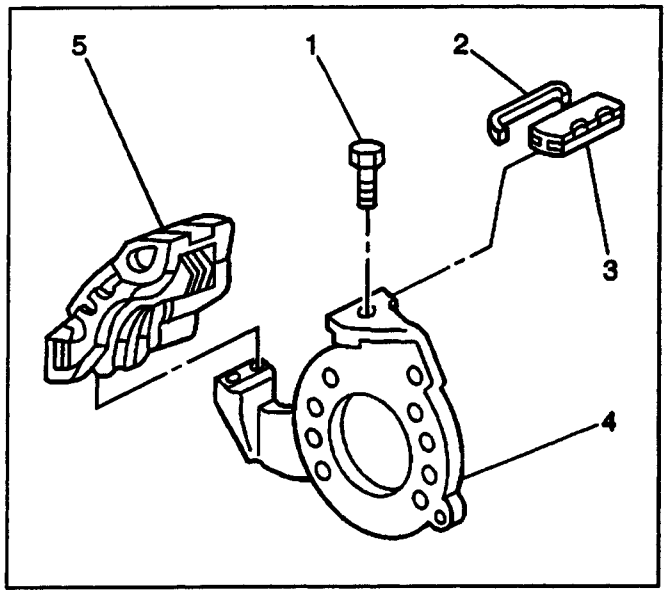
260919

Brake Caliper and Anchor Plate Wear Adjustment (Front, Dayton-Walther)

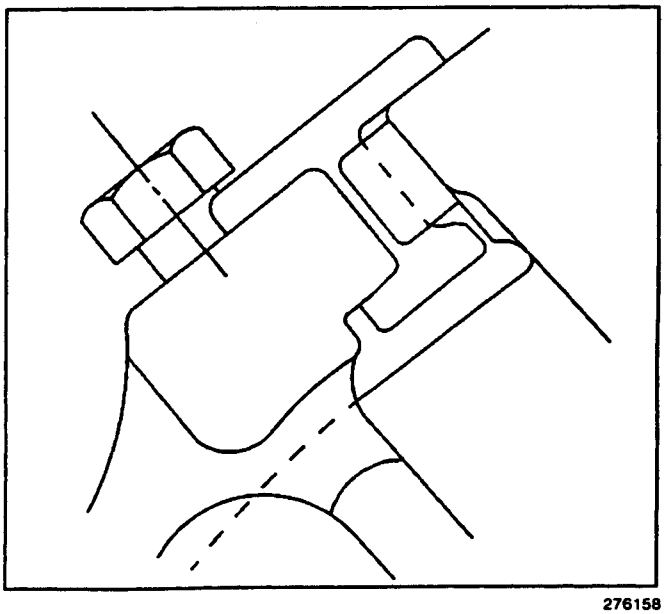
The brake caliper V-ways and brake caliper mounting plate support rails will wear and eventually cause the brake caliper to fit loosely. Dayton-Walther brakes use shims to adjust for this wear. Follow these steps when replacing the linings.

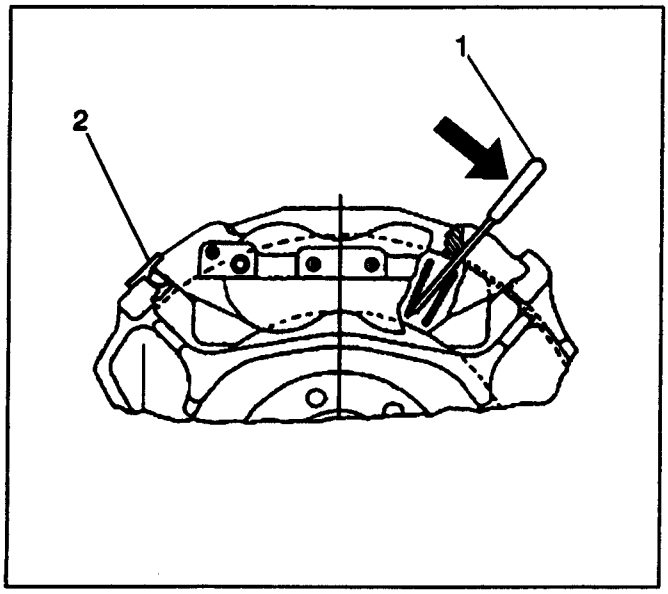
1. Remove the brake caliper retainer screw (1).
2. Tap out the brake caliper retainer (4) and the brake caliper retainer spring (2).
3. Remove the brake caliper (6). Refer to *Brake Caliper Replacement (Front, Dayton-Walther).*

4. Clean the V-way surfaces of the brake caliper (5) with a wire brush.
   File smooth any nicks and gouges.
5. Clean the support rail surfaces of the brake caliper mounting plate (4) with a wire brush.
   File smooth any nicks and gouges.
6. Temporarily mount the brake caliper on the brake caliper mounting plate.
7. Install a new brake caliper retainer (3).
8. Install the brake caliper retainer bolt (1).
9. Use a screwdriver in order to turn the vanes of the brake rotor in the forward direction. This will jam the brake caliper support rail in contact with the brake caliper mounting plate support rail.
10. Measure the brake caliper retainer gap with a feeler gauge laid full length in the gap.
    - If the gap is 0.89 mm (0.035 in), or less then no shim is needed.
    - If the gap is more than 0.89 mm (0.035 in), continue with step 10.
    - If the gap is greater than 2.92 mm (0.115 in), replace the brake caliper mounting plate. Refer to *Brake Caliper Replacement (Front, Dayton-Walther)*.
11. Select the correct size shim.
    - If the gap measurement is 0.91–1.40 mm (0.036–0.055 in), use a shim thickness of 0.51 mm (0.020 in).
    - If the gap measurement is 1.42–1.91 mm (0.056–0.075 in), use a shim thickness of 1.07 mm (0.042 in).
    - If the gap measurement is 1.93–2.41 mm (0.076–0.095 in), use a shim thickness of 1.47 mm (0.058 in).
    - If the gap measurement is 2.44–2.92 mm (0.096–0.115 in), use a shim thickness of 1.83 mm (0.072 in).
12. Remove the brake caliper retainer bolt.
13. Remove the brake caliper retainer.
14. Remove the brake caliper spring.



209264


276158

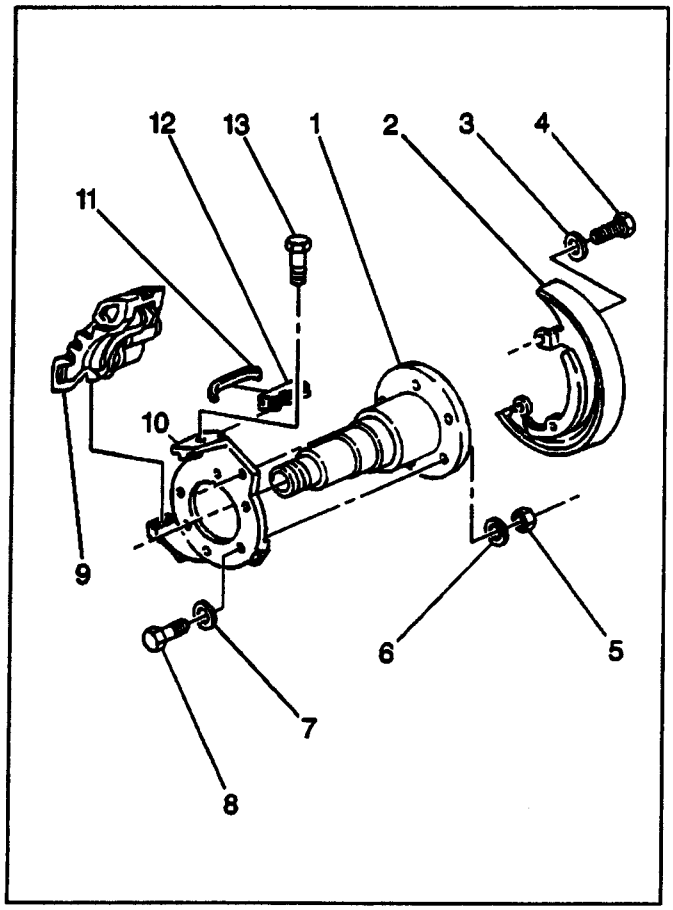


22098

15. Lift the forward (1) end of the brake caliper enough in order to provide clearance between the brake caliper and the brake caliper mounting plate support rail.

    This permits installation of the shim.

    Important: Place the shim with the widest side of the shim fitting against the widest surface of the brake caliper mounting plate.
16. Lower the brake caliper to the caliper's original position with the shim in place.
17. Install the brake caliper. Refer to *Brake Caliper Replacement (Front, Dayton-Walther).*



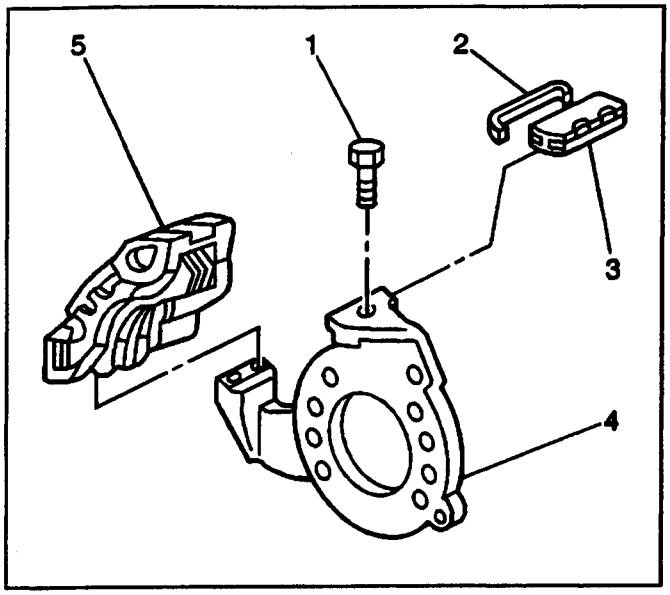
237280

Brake Caliper and Anchor Plate Wear Adjustment (Rear, Dayton-Walther)

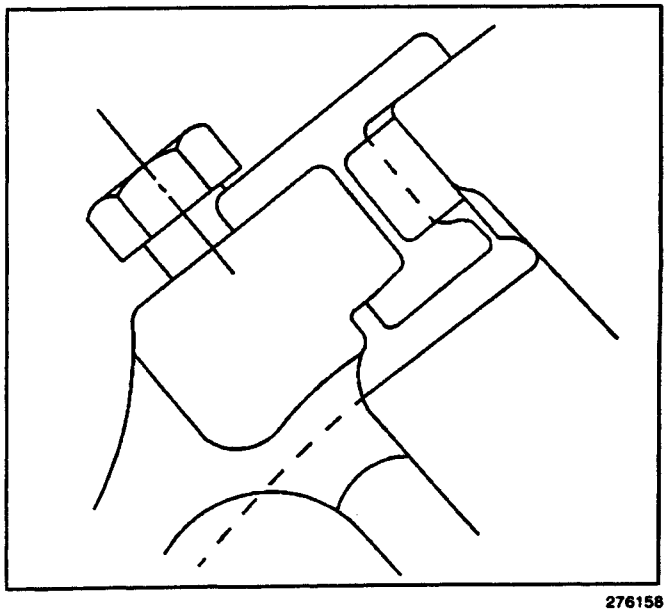
The brake caliper V-ways and brake caliper mounting plate support rails will wear and eventually cause the brake caliper to fit loosely. Dayton-Walther brakes use shims to adjust for this wear. Follow these steps when replacing the linings.

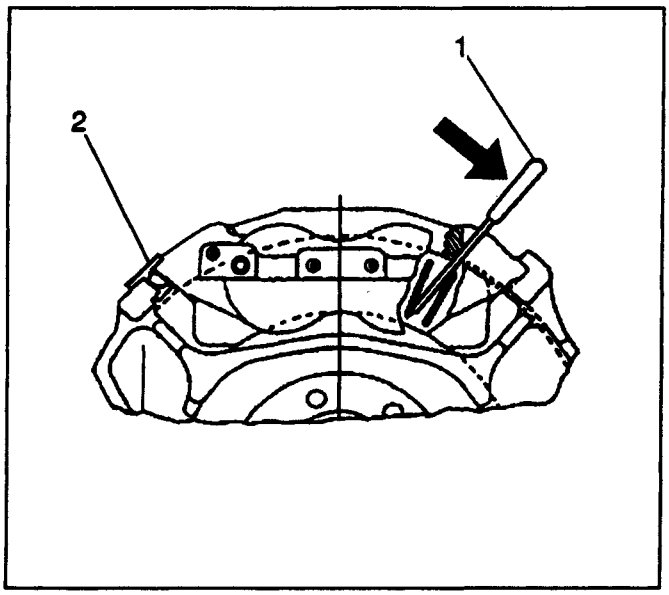
1. Remove the brake caliper retainer screw (8).
2. Tap out the brake caliper retainer (12) and the brake caliper retainer spring (11).
3. Remove the brake caliper. Refer to *Brake Caliper Replacement (Rear, Rail Slider).*

4. Clean the V-way surfaces of the brake caliper (5) with a wire brush.
   File smooth any nicks and gouges.
5. Clean the support rail surfaces of the brake caliper mounting plate (4) with a wire brush.
   File smooth any nicks and gouges.
6. Temporarily mount the brake caliper on the brake caliper mounting plate.
7. Install a new brake caliper retainer (3).
8. Install the brake caliper retainer bolt (1).
9. Use a screwdriver in order to turn the vanes of the brake rotor in the forward direction. This will jam the brake caliper support rail in contact with the brake caliper mounting plate support rail.
10. Measure the brake caliper retainer gap with a feeler gauge laid full length in the gap.
    - If the gap is 0.89 mm (0.035 in), or less then no shim is needed.
    - If the gap is more than 0.89 mm (0.035 in), continue with step 10.
    - If the gap is greater than 2.92 mm (0.115 in), replace the brake caliper mounting plate. Refer to *Brake Caliper Replacement (Rear, Rail Slider)*.
11. Select the correct size shim.
    - If the gap measurement is 0.91–1.40 mm (0.036–0.055 in), use a shim thickness of 0.51 mm (0.020 in).
    - If the gap measurement is 1.42–1.91 mm (0.056–0.075 in), use a shim thickness of 1.07 mm (0.042 in).
    - If the gap measurement is 1.93–2.41 mm (0.076–0.095 in), use a shim thickness of 1.47 mm (0.058 in).
    - If the gap measurement is 2.44–2.92 mm (0.096–0.115 in), use a shim thickness of 1.83 mm (0.072 in).
12. Remove the brake caliper retainer bolt.
13. Remove the brake caliper retainer.
14. Remove the brake caliper spring.



209264


276158

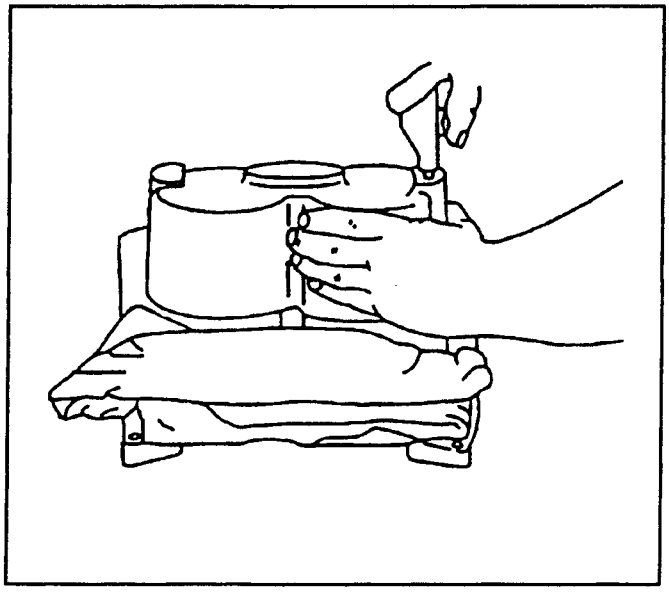


22098

15. Lift the forward end of the brake caliper enough in order to provide clearance between the brake caliper and the brake caliper mounting plate support rail.

    This permits installation of the shim.

    Important: Place the shim with the widest side of the shim fitting against the widest surface of the brake caliper mounting plate.
16. Lower the brake caliper to the caliper's original position with the shim in place.
17. Install the brake caliper. Refer to *Brake Caliper Replacement (Rear, Rail Slider).*



171564

Brake Caliper Overhaul (Bendix Rail Slider)

Disassembly Procedure

1. Remove the brake fluid from the brake caliper.
2. Clean the exterior of the brake caliper.

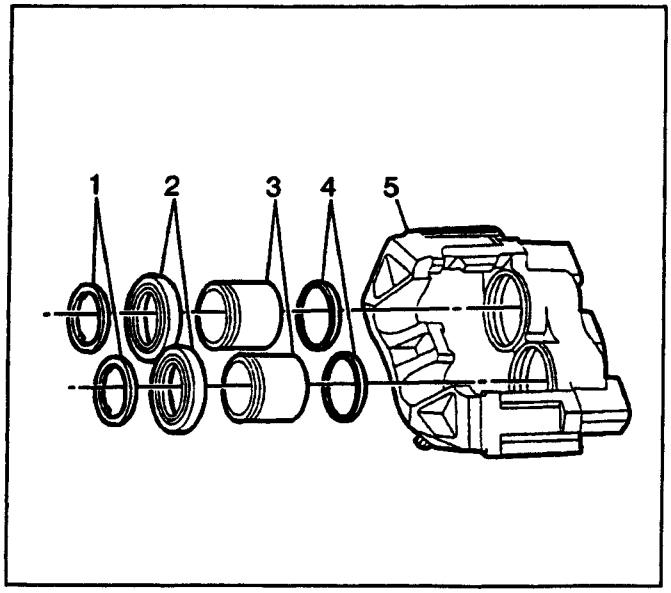
   Caution: Do not place your fingers in front of the piston in order to catch or protect the piston while applying compressed air. This could result in serious injury.

   Notice: Use only enough air to ease the piston out of the bore. If the piston is blown out, even with the padding, it can be damaged.
3. Remove the pistons from the bore by directing compressed air in to the caliper brake fluid inlet in order to remove the pistons from the caliper bore.
4. Pad the exterior of the brake caliper with a clean shop towel.

Important:

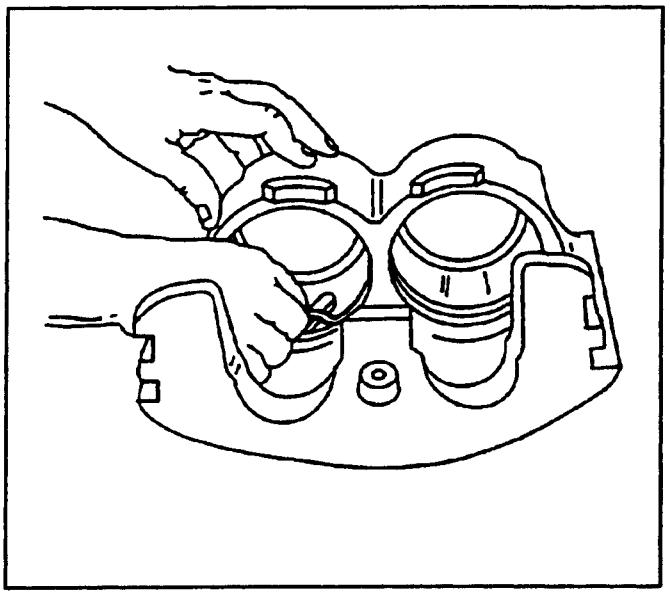
- Use just enough air pressure in order to ease the pistons out of the bore.
- If only one piston is blown loose, it may be necessary to reinsert the piston part way and block it in position.
- Apply air pressure in order to free the remaining piston.

5. Remove the heat shields (1).
6. Remove the dust boots (2).



171587

7. Remove the piston seals from the groove in the caliper bore using a pointed piece of wood or plastic.
8. Remove the brake caliper bleeder valve.



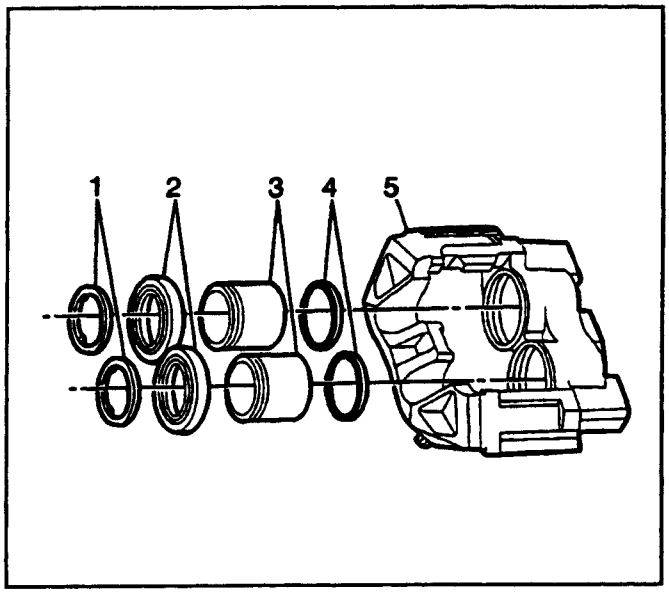
171589

Notice: Do not use mineral base cleaning solvents such as gasoline, kerosene, carbon tetrachloride, acetone, or paint thinner to clean the brake caliper. These solvents will cause rubber parts to become soft and swollen in an extremely short time.

9. Clean all of the parts in Brake Parts Cleaner.
10. Blow out all of the passages in the brake caliper housing (5) and the brake caliper bleeder valve.

    Use dry, filtered, unlubricated compressed air.
11. Clean the brake caliper support rail surfaces with a wire brush.
12. Inspect the support rail surfaces for rust or corrosion.
13. Inspect the brake caliper housing for cracks or other damage. Replace the caliper housing if necessary.
14. Inspect the outside diameter of the pistons for the following conditions:
    - Scoring
    - Nicks
    - Corrosion
    - Wear
    - Any other damage

    Important: The outside diameter of the piston is the primary sealing surface of the brake caliper. The piston diameter is manufactured to very close tolerances. Do not refinish the piston diameter. Do not use abrasives on the piston diameter.
15. If you find any surface faults, replace the piston.

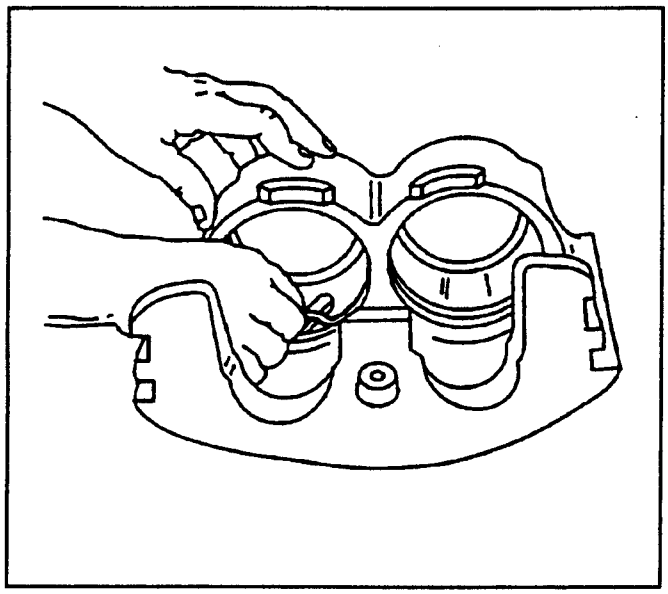


171587

16. Inspect the caliper bore for the following conditions:
    - Scoring
    - Nicks
    - Corrosion
    - Wear
    - Any other damage

    Important: Do not use any abrasive on the caliper bore, including emery cloth.
17. Polish out stains and minor corrosion from the caliper bore with crocus cloth.

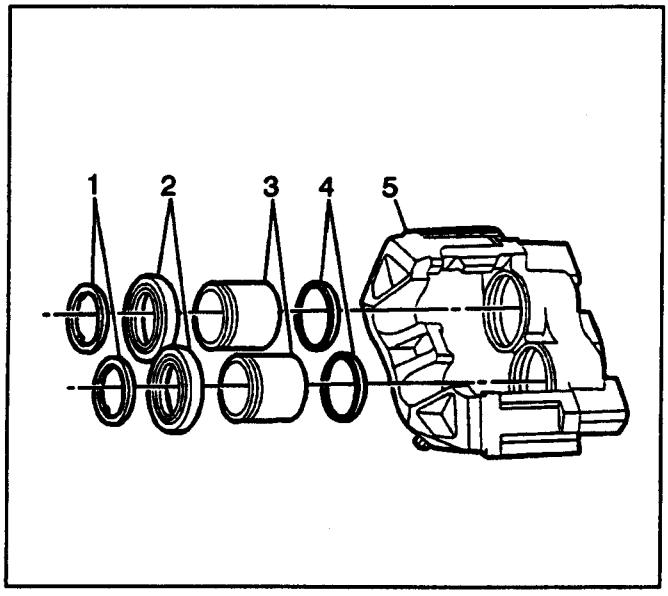
    If you cannot remove the stains and corrosion with crocus cloth, replace the caliper.
18. Clean the caliper bore after using the crocus cloth.



171569

Assembly Procedure

1. Place the brake caliper housing on a clean work bench with the open ends of the caliper bores facing up.
2. Dip the new piston seal in Brake Fluid.
3. Gently work the piston seal around the caliper bore with a finger until the seal seats in the piston seal groove.
4. Ensure that the piston seal is not twisted or rolled in the groove.
5. Lubricate the piston and the caliper bore with Brake Fluid.
6. Gently push the piston into the caliper bore.
7. Rotate the piston slightly in order to prevent dislodging the piston seal.



171587

8. Press the dust boot (2) into the counterbore in the brake caliper housing (5).

   The dust boot fits in a counterbore in the brake caliper housing, and overlaps the stepped edge of the piston.
9. Install a new heat shield (1) on the piston (3). The shield's chamfer faces out.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
10. Install the brake caliper bleeder valve.

    Tighten

    Tighten the brake caliper bleeder valve to 17 N·m (13 lb ft).

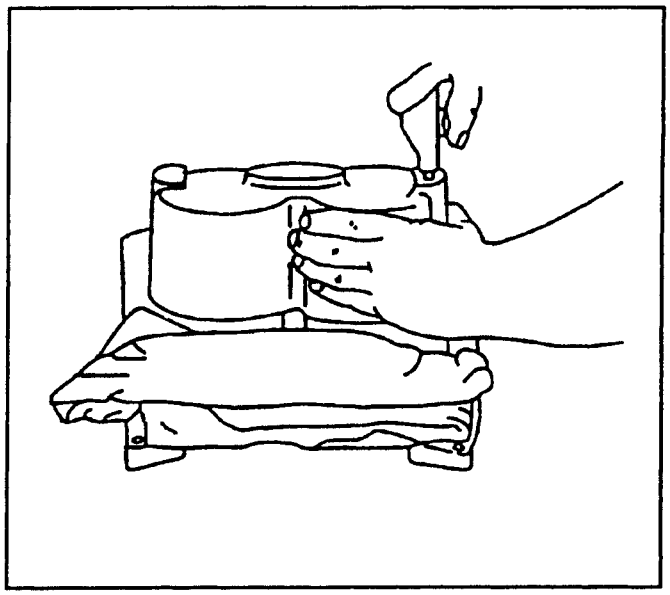
Brake Caliper Overhaul (Dayton-Walther Rail Slider)

Disassembly Procedure

1. Remove the brake fluid from the brake caliper.
2. Clean the exterior of the brake caliper.

   Caution: Do not place your fingers in front of the piston in order to catch or protect the piston while applying compressed air. This could result in serious injury.

   Notice: Use only enough air to ease the piston out of the bore. If the piston is blown out, even with the padding, it can be damaged.
3. Remove the pistons from the bore by directing compressed air in to the caliper brake fluid inlet in order to remove the pistons from the caliper bore.
4. Pad the exterior of the brake caliper with a clean shop towel.

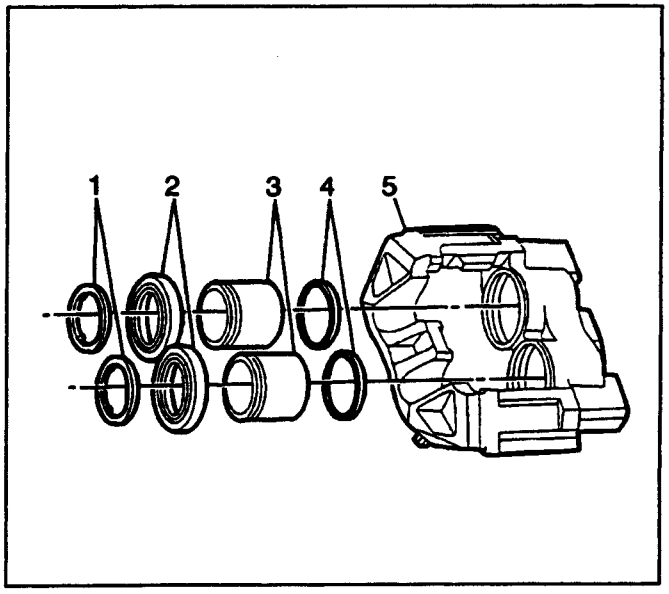


171564

Important:

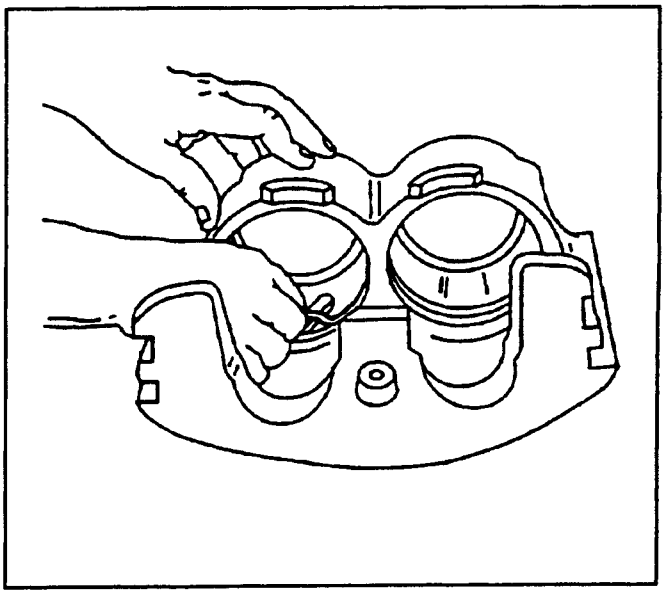
- Use just enough air pressure in order to ease the pistons out of the bore.
- If only one piston is blown loose, it may be necessary to reinsert the piston part way and block it in position.
- Apply air pressure in order to free the remaining piston.

5. Remove the heat shields (1).
6. Remove the dust boots (2).

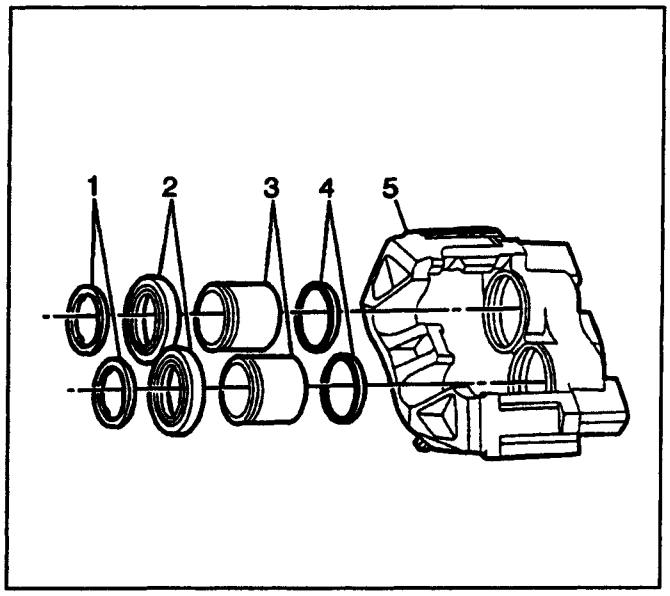


171587

7. Remove the piston seals from the groove in the caliper bore using a pointed piece of wood or plastic.
8. Remove the brake caliper bleeder valve.



171569



171587

Notice: Do not use mineral base cleaning solvents such as gasoline, kerosene, carbon tetrachloride, acetone, or paint thinner to clean the brake caliper. These solvents will cause rubber parts to become soft and swollen in an extremely short time.

9. Clean all of the parts in Brake Parts Cleaner.
10. Blow out all of the passages in the brake caliper housing (5) and the brake caliper bleeder valve.

    Use dry, filtered, unlubricated compressed air.
11. Clean the brake caliper support rail surfaces with a wire brush.
12. Inspect the support rail surfaces for rust or corrosion.
13. Inspect the brake caliper housing for cracks or other damage. Replace the caliper housing if necessary.
14. Inspect the outside diameter of the pistons for the following conditions:
    - Scoring
    - Nicks
    - Corrosion
    - Wear
    - Any other damage

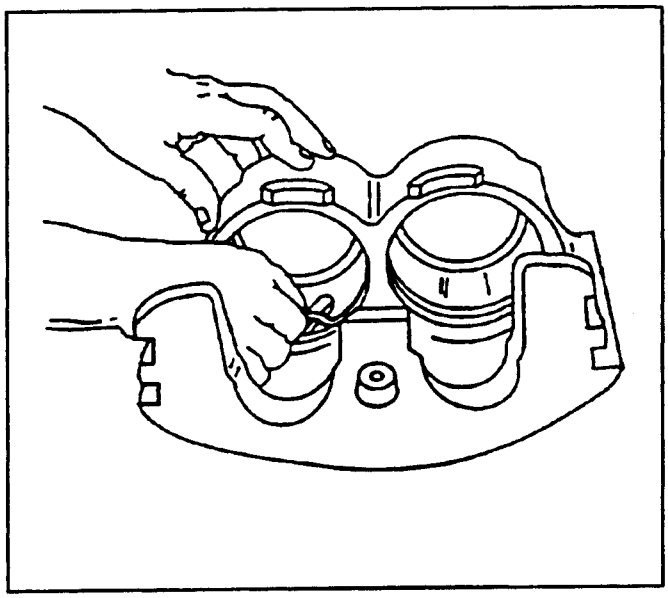
    Important: The outside diameter of the piston is the primary sealing surface of the brake caliper. The piston diameter is manufactured to very close tolerances. Do not refinish the piston diameter. Do not use abrasives on the piston diameter.
15. If you find any surface faults, replace the piston.
16. Inspect the caliper bore for the following conditions:
    - Scoring
    - Nicks
    - Corrosion
    - Wear
    - Any other damage

    Important: Do not use any abrasive on the caliper bore, including emery cloth.
17. Polish out stains and minor corrosion from the caliper bore with crocus cloth.

    If you cannot remove the stains and corrosion with crocus cloth, replace the caliper.
18. Clean the caliper bore after using the crocus cloth.

Assembly Procedure

1. Place the brake caliper housing on a clean work bench with the open ends of the caliper bores facing up.
2. Dip the new piston seal in Brake Fluid.
3. Lubricate the caliper bore with Brake Fluid.
4. Gently work the piston seal (4) into the caliper bore piston seal groove until the seal seats properly.
5. Ensure that the piston seal is not twisted or rolled in the groove.



171569

6. Install a new dust boot (2) into the caliper bore.

   Important:

   - Apply even force and slightly rotate the piston (3). This avoids cocking the piston in the caliper bore and dislodging the piston seal.
   - The dust boot will slide into the piston.
   - Ensure that the dust boot seats evenly into the piston groove.

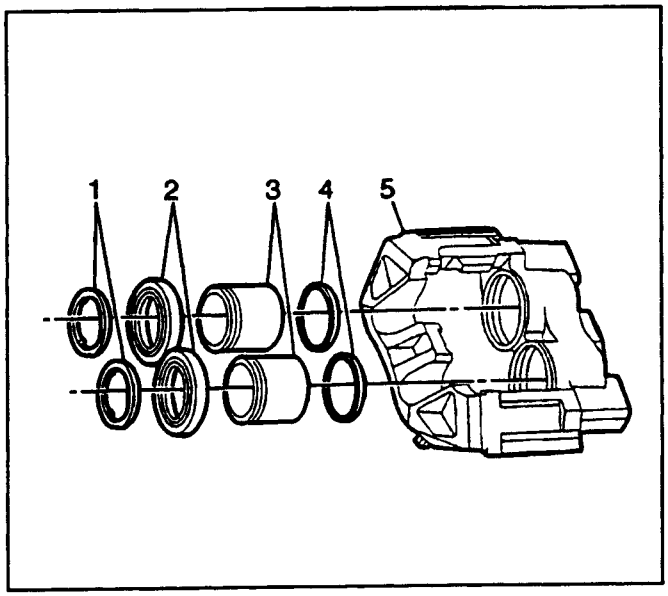
7. Install the piston through boot and into the bore.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.

8. Install the brake caliper bleeder valve.

   Tighten

   Tighten the brake caliper bleeder valve to 17 N.m (13 lb ft).



171587

Brake Caliper Overhaul (Bendix)

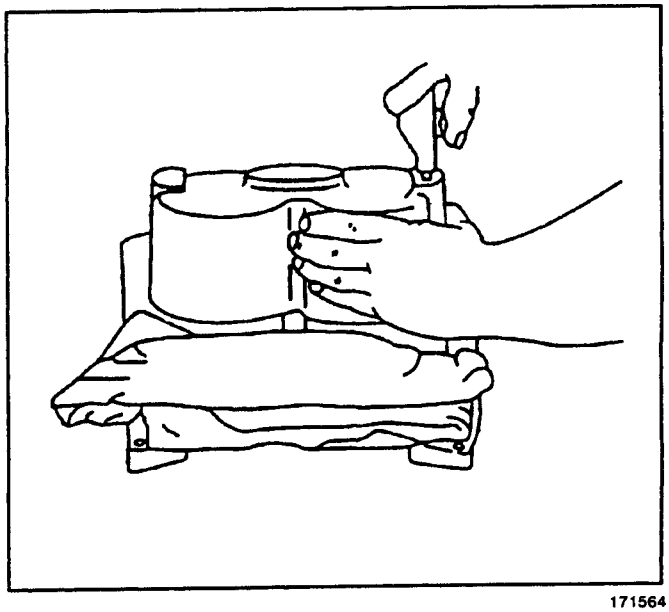
Disassembly Procedure

1. Remove the brake fluid from the brake caliper.
2. Clean the exterior of the brake caliper.

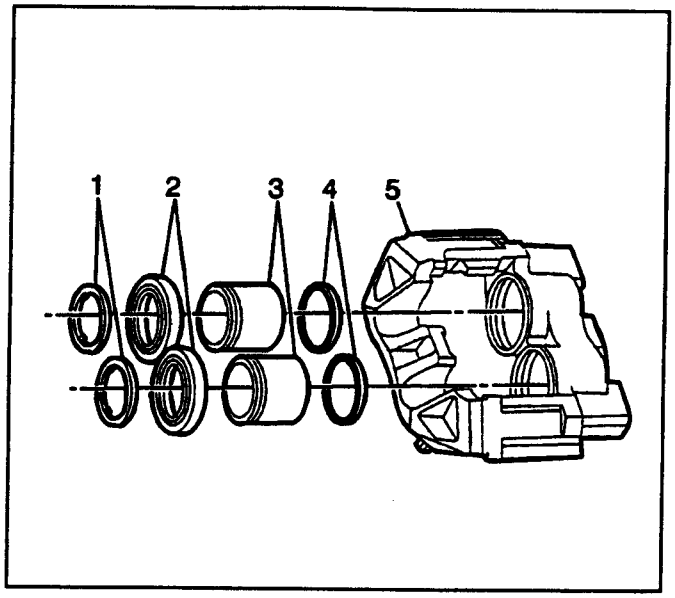
   Caution: Do not place your fingers in front of the piston in an attempt to catch or protect it when applying compressed air. This could result in serious injury.

   Notice: Use only enough air to ease the piston out of the bore. If the piston is blown out, even with the padding, it can be damaged.

3. Remove the pistons from the bore by directing compressed air in to the caliper brake fluid inlet in order to remove the pistons from the caliper bore.
4. Pad the exterior of the brake caliper with a clean shop towel.



171564

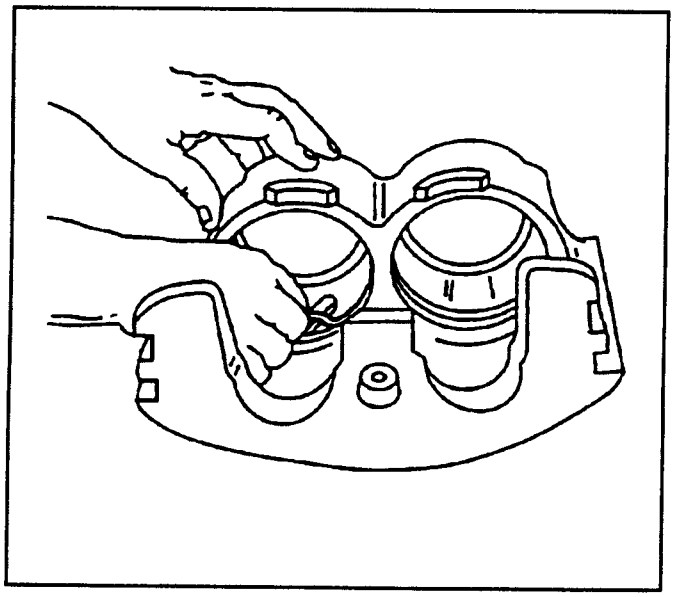


171587

Important:

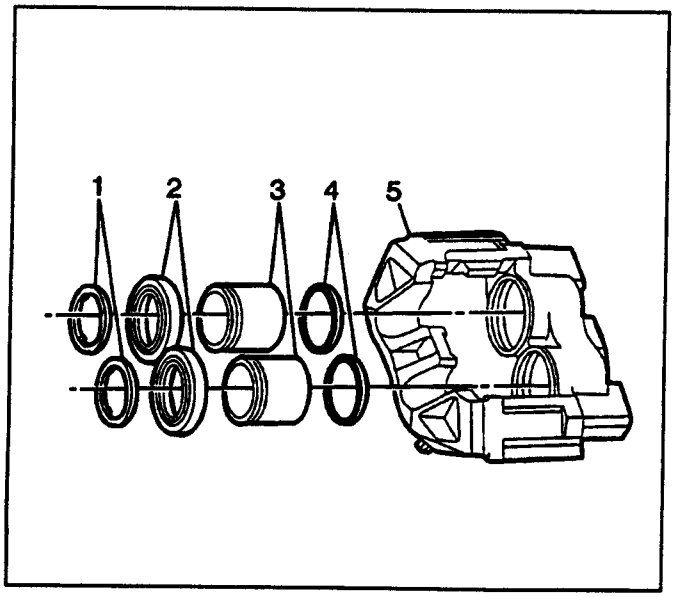
- Use just enough air pressure in order to ease the pistons out of the bore.
- If only one piston is blown loose, it may be necessary to reinsert the piston part way and block it in position.
- Apply air pressure in order to free the remaining piston.

5. Remove the heat shields (1).
6. Remove the dust boots (2).



171569

7. Remove the piston seals from the groove in the caliper bore using a pointed piece of wood or plastic.
8. Remove the brake caliper bleeder valve.



171587

Notice: Do not use mineral base cleaning solvents such as gasoline, kerosene, carbon tetrachloride, acetone, or paint thinner to clean the brake caliper. These solvents will cause rubber parts to become soft and swollen in an extremely short time.

9. Clean all of the parts in Brake Parts Cleaner.
10. Blow out all of the passages in the brake caliper housing (5) and the brake caliper bleeder valve.

    Use dry, filtered, unlubricated compressed air.
11. Clean the brake caliper support rail surfaces with a wire brush.
12. Inspect the support rail surfaces for rust or corrosion.
13. Inspect the brake caliper housing for cracks or other damage. Replace the caliper housing if necessary.

14. Inspect the outside diameter of the pistons for the following conditions:
    - Scoring
    - Nicks
    - Corrosion
    - Wear
    - Any other damage

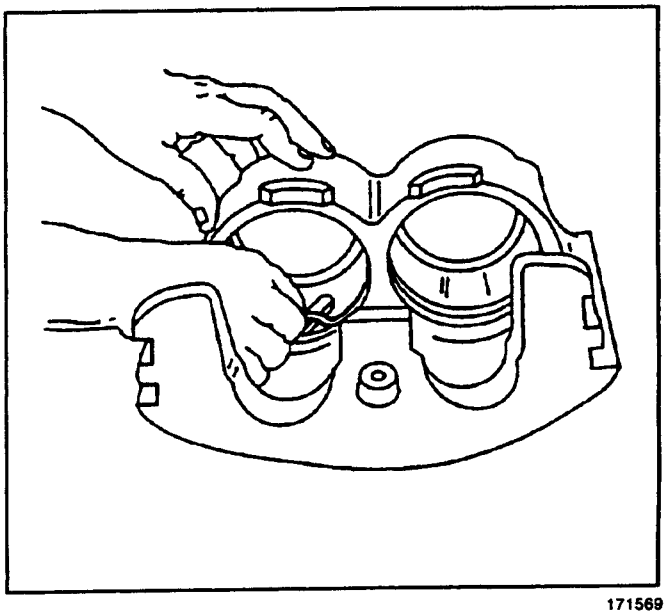
    Important: The outside diameter of the piston is the primary sealing surface of the brake caliper. The piston diameter is manufactured to very close tolerances. Do not refinish the piston diameter. Do not use abrasives on the piston diameter.
15. If you find any surface faults, replace the piston.
16. Inspect the caliper bore for the following conditions:
    - Scoring
    - Nicks
    - Corrosion
    - Wear
    - Any other damage

    Important: Do not use any abrasive on the caliper bore, including emery cloth.
17. Polish out stains and minor corrosion from the caliper bore with crocus cloth.

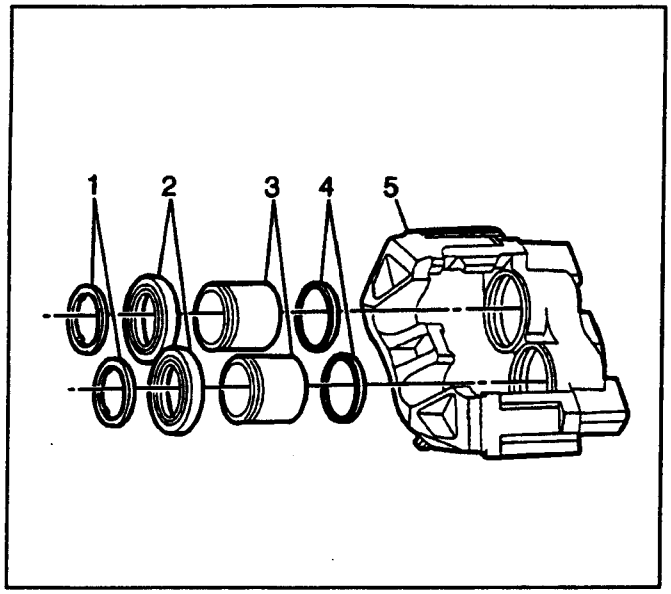
    If you cannot remove the stains and corrosion with crocus cloth, replace the caliper.
18. Clean the caliper bore after using the crocus cloth.

Assembly Procedure

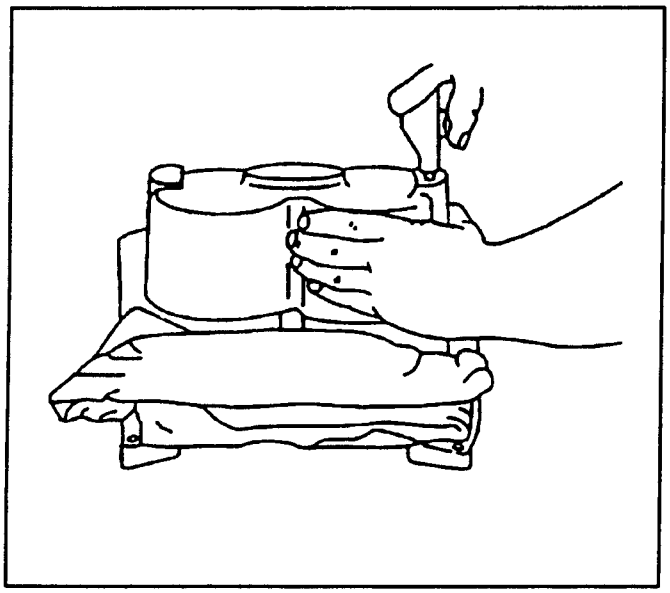
1. Place the brake caliper housing on a clean work bench with the open ends of the caliper bores facing up.
2. Dip the new piston seal in Brake Fluid.
3. Gently work the piston seal around the caliper bore with a finger until the seal seats in the piston seal groove.
4. Ensure that the piston seal is not twisted or rolled in the groove.
5. Lubricate the piston and the caliper bore with Brake Fluid.
6. Gently push the piston into the caliper bore.
7. Rotate the piston slightly in order to prevent dislodging the piston seal.



171569



171587



171564

8. Press the dust boot (2) into the counterbore in the brake caliper housing (5).

   The dust boot fits in a counterbore in the brake caliper housing, and overlaps the stepped edge of the piston.

9. Install a new heat shield (1) on the piston (3). The shield's chamfer faces out.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.

10. Install the brake caliper bleeder valve.

    Tighten

    Tighten the brake caliper bleeder valve to 17 N·m (13 lb ft).

Brake Caliper Overhaul (Dayton-Walther)

Disassembly Procedure

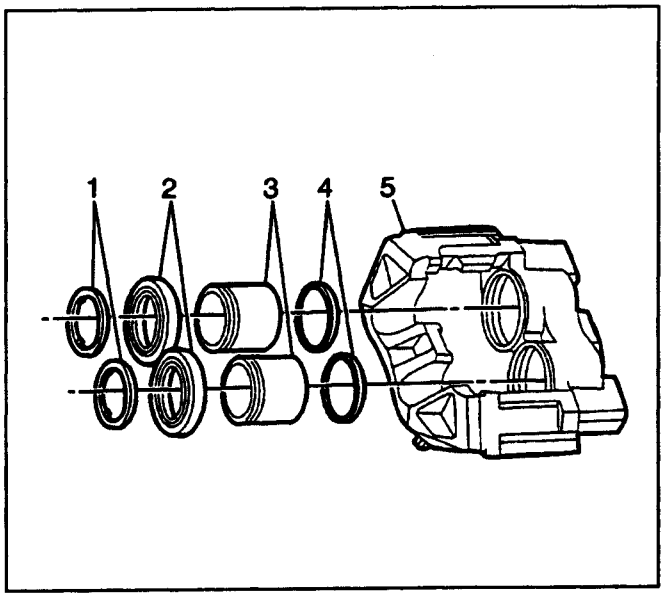
1. Remove the brake fluid from the brake caliper.
2. Clean the exterior of the brake caliper.
3. Pad the exterior of the brake caliper with a clean shop towel.

   Caution: Do not place your fingers in front of the piston in order to catch or protect the piston while applying compressed air. This could result in serious injury.

   Notice: Use only enough air to ease the piston out of the bore. If the piston is blown out, even with the padding, it can be damaged.

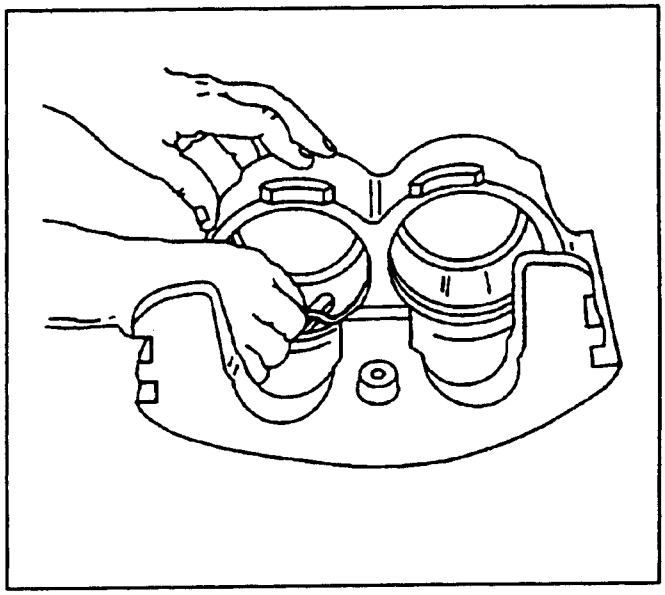
4. Direct compressed air in to the caliper brake fluid inlet in order to remove the pistons from the caliper bore.
   - 4.1. If only one piston leaves the bore, reinsert the piston part-way.
   - 4.2. Block the reinserted piston in place.
   - 4.3. Apply air pressure again. This should free the remaining piston.

5. Remove the heat shields (1).
6. Remove the dust boots (2).



171587

7. Remove the piston seals from the groove in the caliper bore using a pointed piece of wood or plastic.
8. Remove the brake caliper bleeder valve.

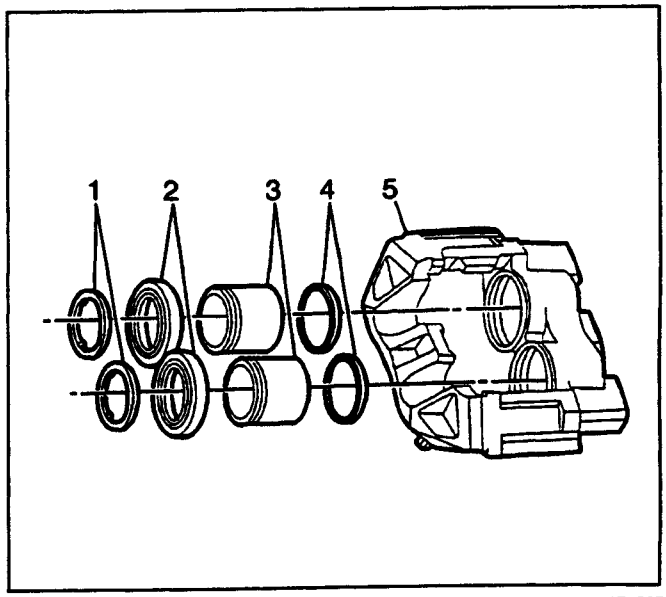


171569

Notice: Do not use mineral base cleaning solvents such as gasoline, kerosene, carbon tetrachloride, acetone, or paint thinner to clean the brake caliper. These solvents will cause rubber parts to become soft and swollen in an extremely short time.

9. Clean all of the parts in Brake Parts Cleaner.
10. Blow out all of the passages in the brake caliper housing (5) and the brake caliper bleeder valve.

    Use dry, filtered, unlubricated compressed air.
11. Clean the brake caliper support rail surfaces with a wire brush.
12. Inspect the support rail surfaces for rust or corrosion.
13. Inspect the brake caliper housing for cracks or other damage. Replace the caliper housing if necessary.



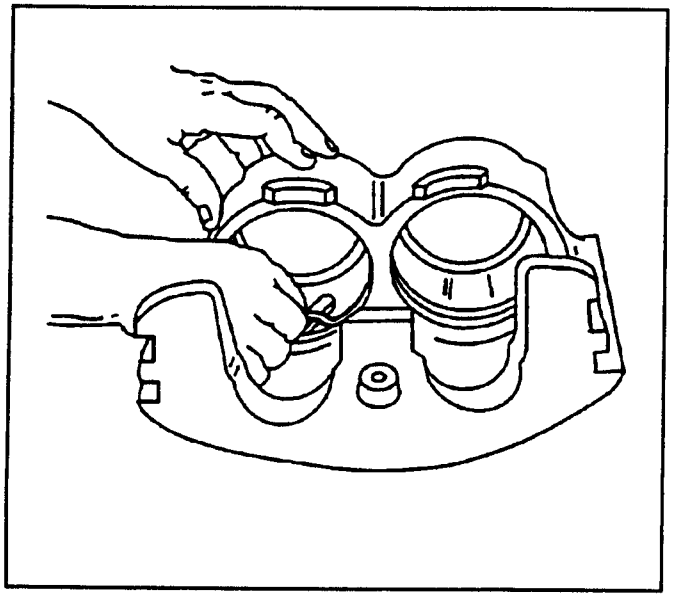
171587

14. Inspect the outside diameter of the pistons for the following conditions:
    - Scoring
    - Nicks
    - Corrosion
    - Wear
    - Any other damage

    Important: The outside diameter of the piston is the primary sealing surface of the brake caliper. The piston diameter is manufactured to very close tolerances. Do not refinish the piston diameter. Do not use abrasives on the piston diameter.
15. If you find any surface faults, replace the piston.
16. Inspect the caliper bore for the following conditions:
    - Scoring
    - Nicks
    - Corrosion
    - Wear
    - Any other damage

    Important: Do not use any abrasive on the caliper bore, including emery cloth.
17. Polish out stains and minor corrosion from the caliper bore with crocus cloth.

    If you cannot remove the stains and corrosion with crocus cloth, replace the caliper.
18. Clean the caliper bore after using the crocus cloth.

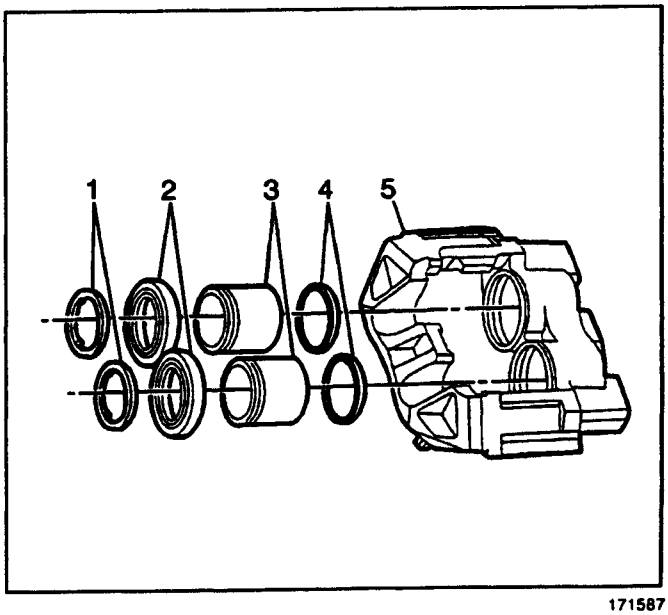


171569

Assembly Procedure

1. Place the brake caliper housing on a clean work bench with the open ends of the caliper bores facing up.
2. Dip the new piston seal in Brake Fluid.
3. Gently work the piston seal around the caliper bore with a finger until the seal seats in the piston seal groove.
4. Ensure that the piston seal is not twisted or rolled in the groove.
5. Lubricate the piston and the caliper bore.
6. Gently push the piston into the caliper bore.
7. Rotate the piston slightly in order to prevent dislodging the piston seal.

8. Press the dust boot (2) into the counterbore in the brake caliper housing (5).
   The dust boot overlaps the stepped edge of the piston.
9. Install a new heat shield (1) on the piston (3). The shield's chamfer faces out.
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
10. Install the brake caliper bleeder valve.
    Tighten
    Tighten the brake caliper bleeder valve to 17 N.m (13 lb ft).



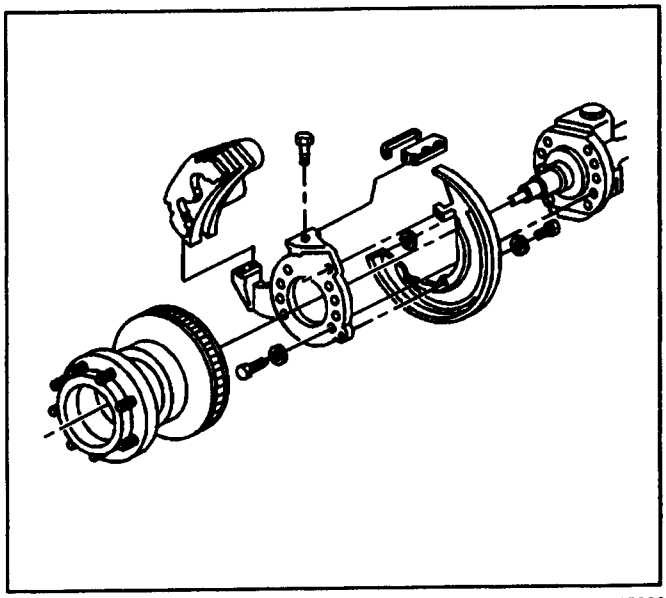
171587

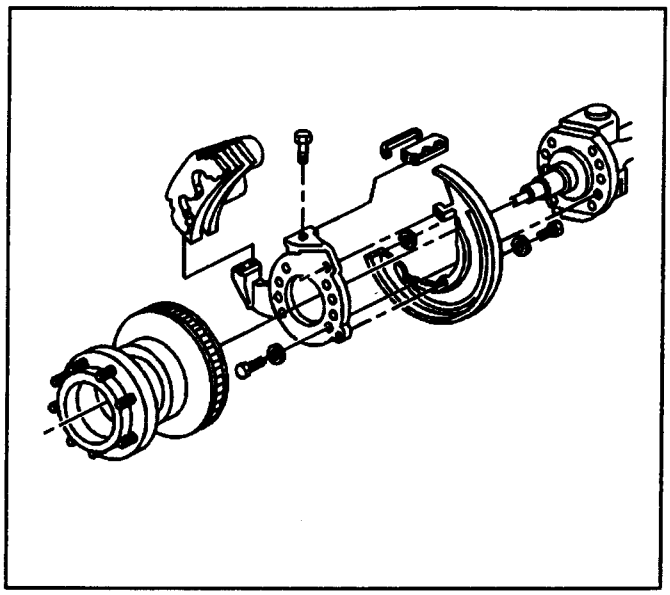
Brake Caliper Mounting Plate Replacement (Front, Bendix)

Use the brake caliper mounting plate in order to mount all of the stationary brake components. An L or R following the part number cast on the back of the plates indicates left or right side mounting. Some plates may also have an L or R painted on the front.

Removal Procedure

1. Apply the parking brake.
2. Block the wheels.
3. Remove the brake caliper. Refer to *Brake Caliper Replacement (Front, Bendix).*
4. Remove the hub and brake rotor assembly. Refer to the proper procedure in Front Suspension:
   - *Wheel Hub, Bearing, and Seal Replacement (Drum Brakes)*
   - *Wheel Hub, Bearing, and Seal Replacement (Disc Brakes)*
5. Remove the bolts and washers.
6. Remove the brake caliper mounting plate .
7. Inspect the support rails for rust, corrosion, and wear.
8. Clean the support rails with a wire brush.
9. Inspect the brake caliper mounting plate for cracks or elongated bolt holes.
   Replace the mounting plate if necessary.


237266



237266

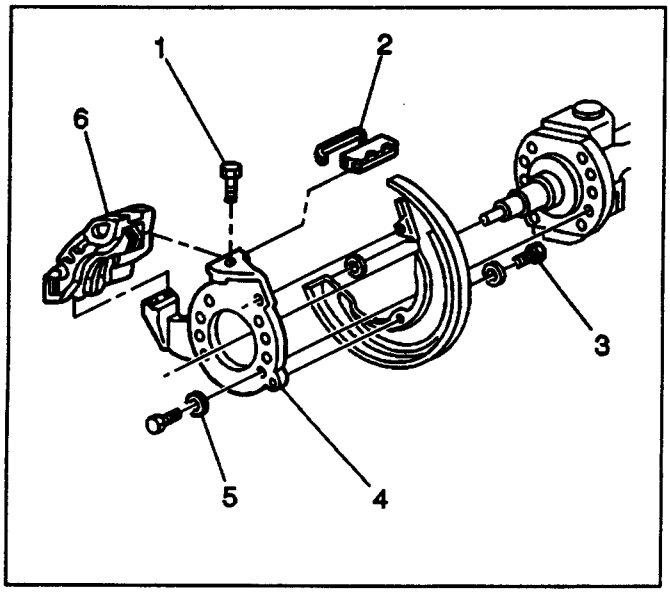
Installation Procedure

1. Install the brake caliper mounting plate to the steering knuckle.

   Important: Ensure that the threads are clean and greaseless before applying threadlocker.
2. Apply 272 Threadlocker to the threads of each brake caliper mounting plate bolt.

   Notice: Refer to *Fastener Notice.*
3. Install the bolts and washers.

   Tighten
   - Tighten the brake shield bolts to 32 N·m (24 lb ft).
   - Tighten the brake caliper mounting plate bolts to 280 N·m (206 lb ft).
4. Install the hub and brake rotor assembly. Refer to the proper procedure in Front Suspension:
   - *Wheel Hub, Bearing, and Seal Replacement (Drum Brakes)*
   - *Wheel Hub, Bearing, and Seal Replacement (Disc Brakes)*
5. Install the brake caliper. Refer to *Brake Caliper Replacement (Front, Bendix).*
6. Remove the blocks.



260919

Brake Caliper Mounting Plate Replacement (Front, Dayton-Walther)

Use the brake caliper mounting plate in order to mount all of the stationary brake components. An L or R following the part number cast on the back of the plates indicates left or right side mounting. Some plates may also have an L or R painted on the front.

Removal Procedure

1. Apply the parking brake.
2. Block the wheels.
3. Remove the brake caliper (6). Refer to *Brake Caliper Replacement (Front, Dayton-Walther)*
4. Remove the hub and brake rotor assembly. Refer to the proper procedure in Front Suspension:
   - *Wheel Hub, Bearing, and Seal Replacement (Drum Brakes)*
   - *Wheel Hub, Bearing, and Seal Replacement (Disc Brakes)*
5. Remove the bolts and washers (3,5).
6. Remove the brake caliper mounting plate (4).
7. Inspect the support rails for rust, corrosion, and wear.
8. Clean the support rails with a wire brush.
9. Inspect the brake caliper mounting plate (4) for cracks or elongated bolt holes.

   Replace the mounting plate if necessary.

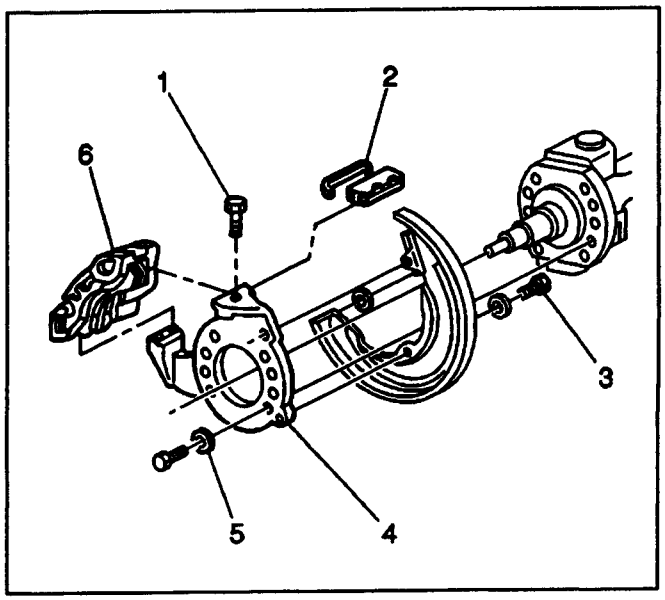
Installation Procedure

1. Install the brake caliper mounting plate (4) to the steering knuckle.

   Important: Ensure that the threads are clean and greaseless before applying threadlocker.
2. Apply 272 Threadlocker to the threads of each brake caliper mounting plate bolt.

   Notice: Refer to *Fastener Notice.*
3. Install the bolts and washers (3, 5).

   Tighten
   - Tighten the brake shield bolts to 32 N.m (24 lb ft).
   - Tighten the brake caliper mounting plate bolts to 280 N.m (206 lb ft).
4. Install the hub and brake rotor assembly. Refer to the proper procedure in Front Suspension:
   - *Wheel Hub, Bearing, and Seal Replacement (Drum Brakes)*
   - *Wheel Hub, Bearing, and Seal Replacement (Disc Brakes)*
5. Install the brake caliper (6). Refer to *Brake Caliper Replacement (Front, Dayton-Walther).*
6. Remove the blocks.



260919

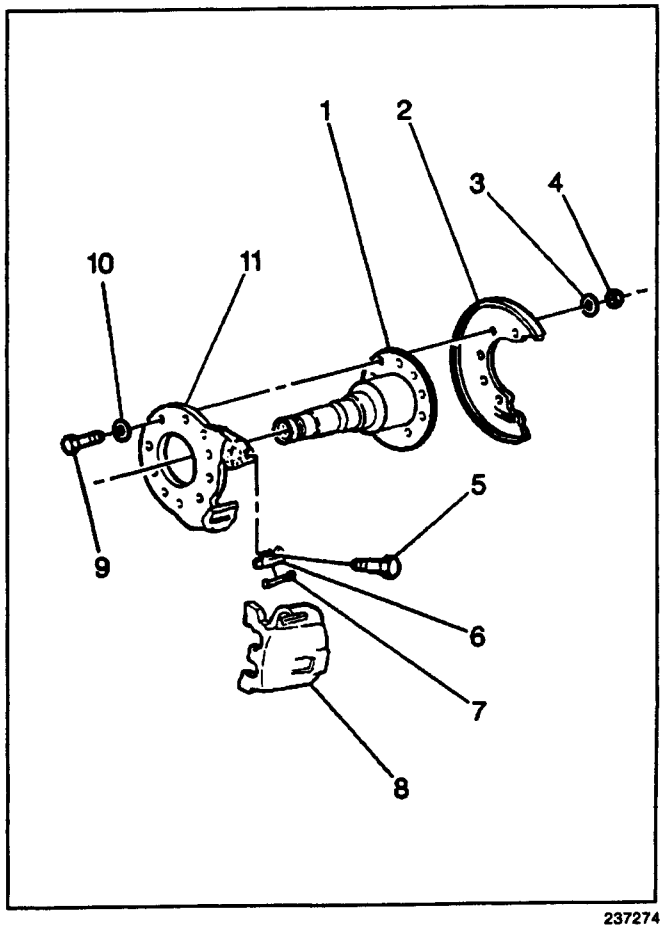
Brake Caliper Mounting Plate Replacement (Rear, Bendix Rail Slider)

Use the brake caliper mounting plate in order to mount all of the stationary brake components. An L or R following the part number cast on the back of the plates indicates left or right side mounting. Some plates may also have an L or R painted on the front.

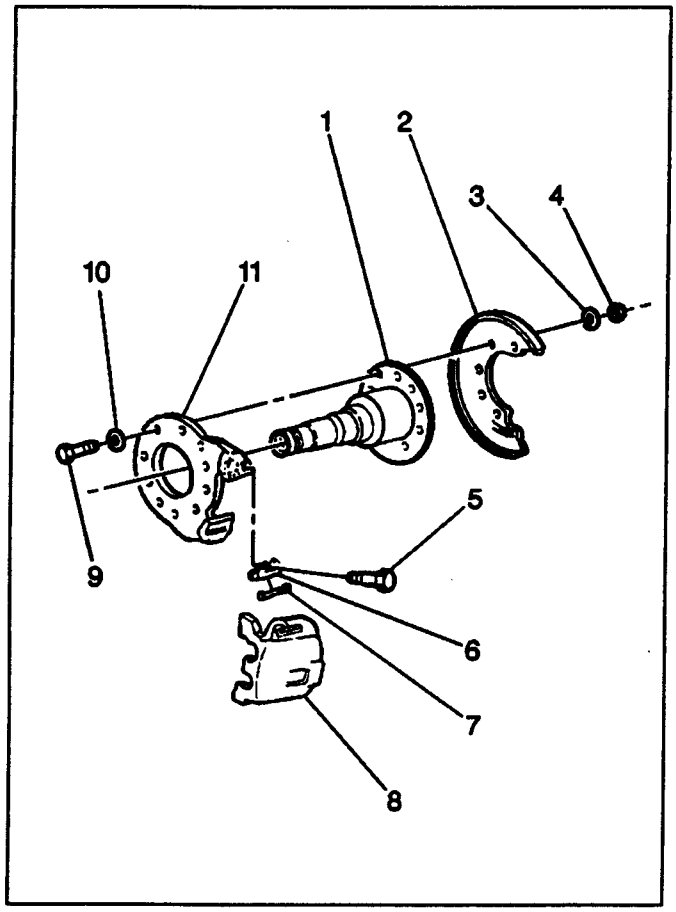
Removal Procedure

1. Apply the parking brake.
2. Block the wheels.
3. Remove the brake caliper (5). Refer to *Brake Caliper Replacement (Rear, Rail Slider).*
4. Remove the hub and brake rotor assembly. Refer to the proper procedure in Front Suspension:
   - *Wheel Hub, Bearing, and Seal Replacement (Drum Brakes)*
   - *Wheel Hub, Bearing, and Seal Replacement (Disc Brakes)*
5. Remove the bolts and washers.
6. Remove the brake caliper mounting plate (4).
7. Inspect the support rails for rust, corrosion, and wear.
8. Clean the support rails with a wire brush.
9. Inspect the brake caliper mounting plate for cracks or elongated bolt holes.

   Replace the mounting plate if necessary.



237274



237274

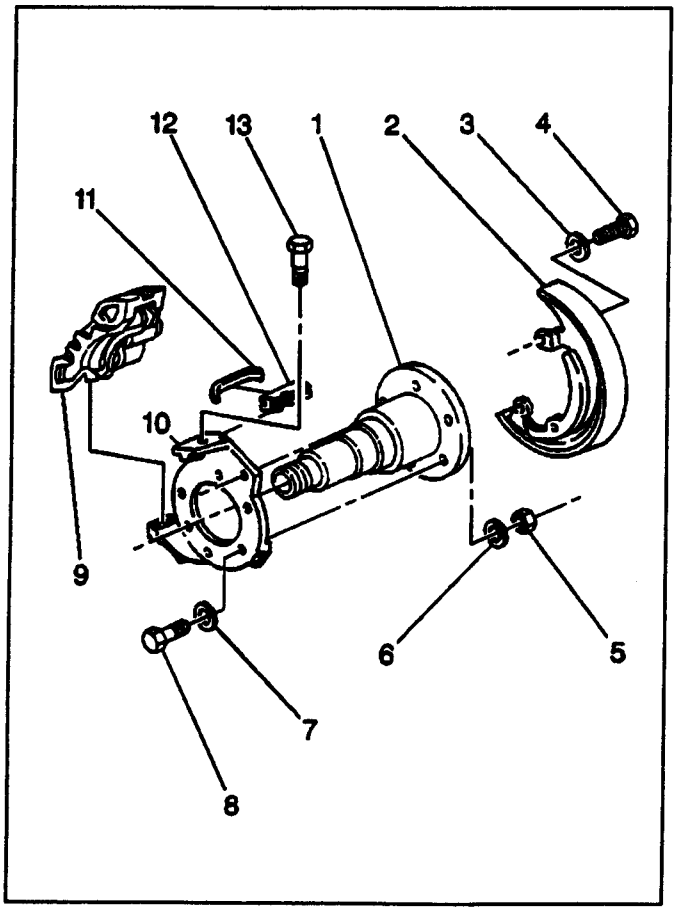
Installation Procedure

1. Install the brake caliper mounting plate (4) to the steering knuckle.

   Important: Ensure that the threads are clean and greaseless before applying threadlocker.
2. Apply 272 Threadlocker to the threads of each brake caliper mounting plate bolt.

   Notice: Refer to *Fastener Notice.*
3. Install the bolts and washers.

   Tighten
   - Tighten the brake shield bolts to 32 N·m (24 lb ft).
   - Tighten the brake caliper mounting plate bolts to 280 N·m (206 lb ft).
4. Install the hub and brake rotor assembly. Refer to the proper procedure in Front Suspension:
   - *Wheel Hub, Bearing, and Seal Replacement (Drum Brakes)*
   - *Wheel Hub, Bearing, and Seal Replacement (Disc Brakes)*
5. Install the brake caliper. Refer to *Brake Caliper Replacement (Rear, Rail Slider).*
6. Remove the blocks.



237280

Brake Caliper Mounting Plate Replacement (Rear, Dayton-Walther)

Use the brake caliper mounting plate in order to mount all of the stationary brake components. An L or R following the part number cast on the back of the plates indicates left or right side mounting. Some plates may also have an L or R painted on the front.

Removal Procedure

1. Apply the parking brake.
2. Block the wheels.
3. Remove the brake caliper (5). Refer to *Brake Caliper Replacement (Rear, Rail Slider).*
4. Remove the hub and brake rotor assembly. Refer to the proper procedure in Front Suspension:
   - *Wheel Hub, Bearing, and Seal Replacement (Drum Brakes)*
   - *Wheel Hub, Bearing, and Seal Replacement (Disc Brakes)*
5. Remove the bolts and washers.
6. Remove the brake caliper mounting plate (4).
7. Inspect the support rails for rust, corrosion, and wear.
8. Clean the support rails with a wire brush.
9. Inspect the brake caliper mounting plate for cracks or elongated bolt holes.

   Replace the mounting plate if necessary.

Installation Procedure

1. Install the brake caliper mounting plate (4) to the steering knuckle.

   Important: Ensure that the threads are clean and greaseless before applying threadlocker.

2. Apply 272 Threadlocker to the threads of each brake caliper mounting plate bolt.

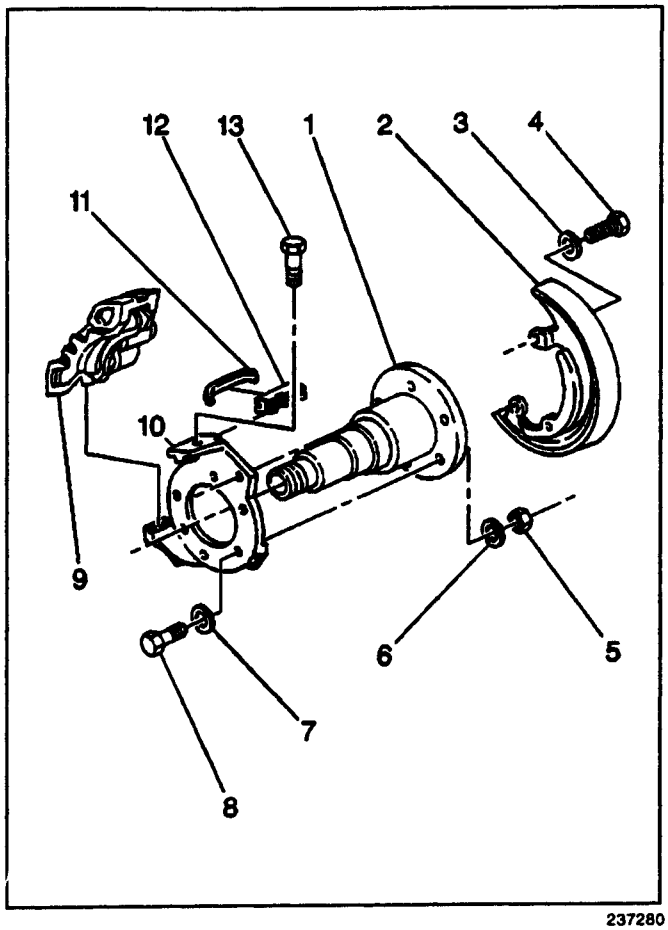
   Notice: Refer to *Fastener Notice.*

3. Install the bolts and washers.

   Tighten

   - Tighten the brake shield bolts to 32 N.m (24 lb ft).
   - Tighten the brake caliper mounting plate bolts to 280 N.m (206 lb ft).

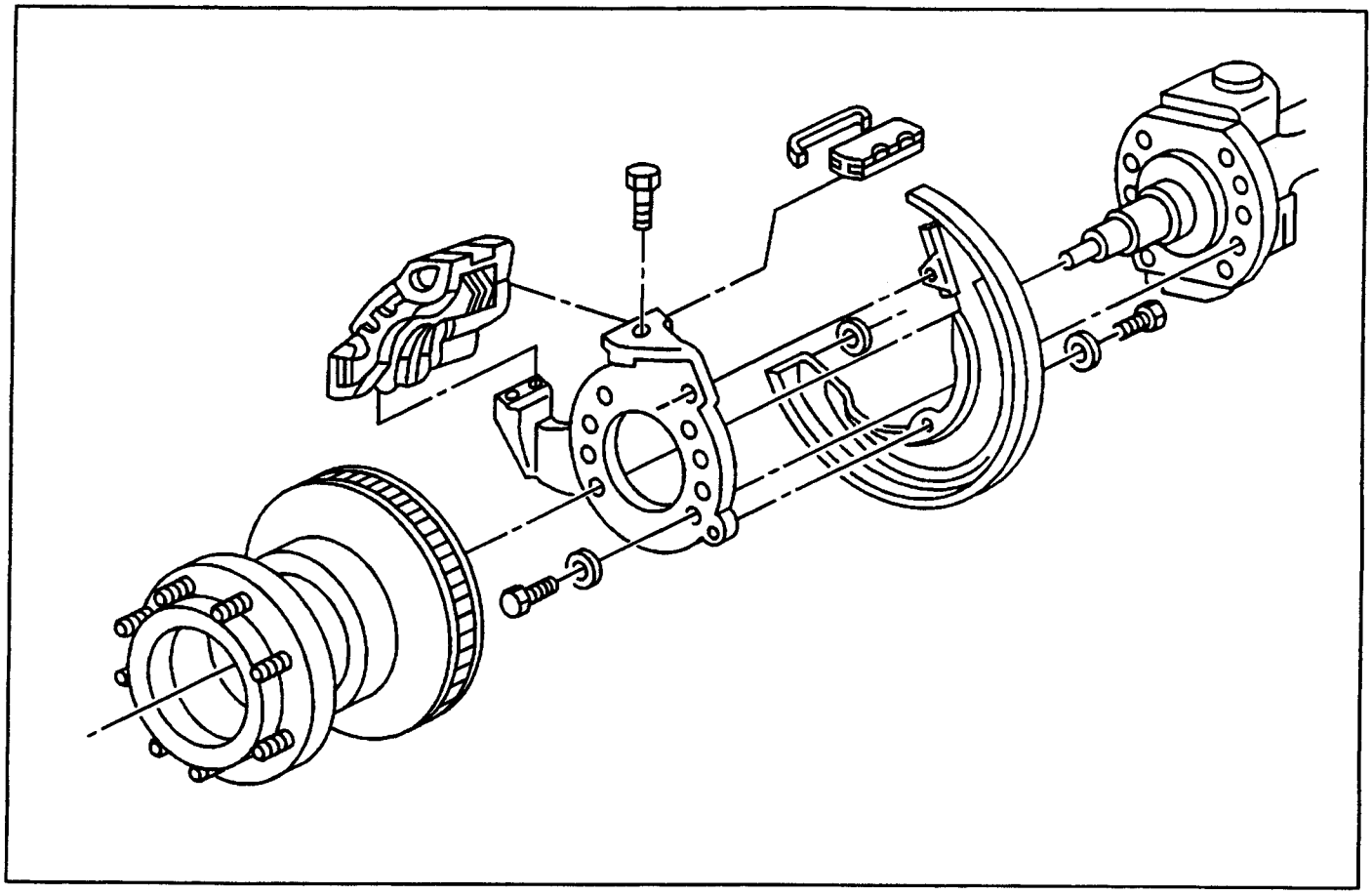
4. Install the hub and brake rotor assembly. Refer to the proper procedure in Front Suspension:
   - *Wheel Hub, Bearing, and Seal Replacement (Drum Brakes)*
   - *Wheel Hub, Bearing, and Seal Replacement (Disc Brakes)*
5. Install the brake caliper. Refer to *Brake Caliper Replacement (Rear, Rail Slider).*
6. Remove the blocks.



237280

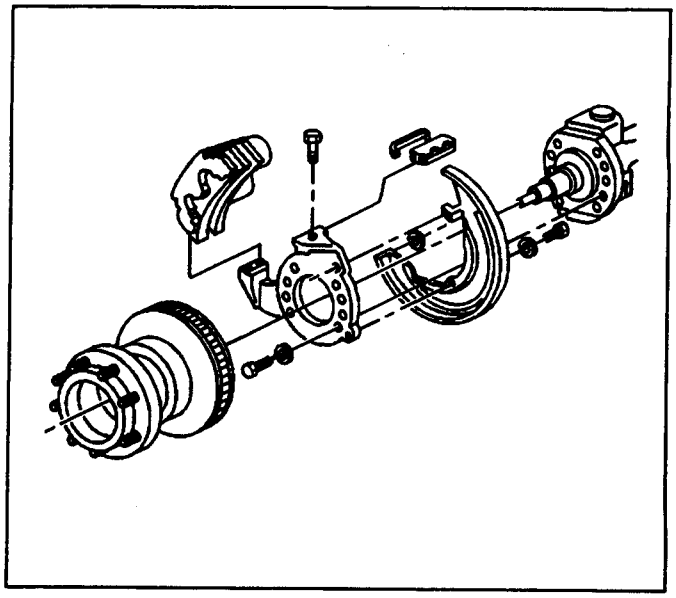
Description and Operation

Disc Brakes System Description (Front)



237270

All hydraulic foundation brakes are disc brake type. The Dayton-Walther rail slider type disc brake caliper is used on the 8,100 lb front axle. All other axles use the Bendix® rail slider type disc brake caliper.



237266

The front and rear disc brake assembly consists of the following components:

- The brake caliper
- The brake rotor (with a hub, or with a wheel)
- Brake pads
- The brake caliper mounting plate
- The brake shield

The brake rotor is bolted to the front hub or wheel. The rotor turns with the tire and wheel assembly. The brake caliper housing has machined bores and pistons. A seal in a groove of the wall in each bore provides a hydraulic seal and retracts the piston when fluid pressure is relieved. A dust boot keeps the piston bore clean. A metal heat shield protects the dust boot from the heat caused by braking friction. The brake caliper is mounted by a brake caliper retainer and the brake caliper retainer spring to the stationary brake caliper mounting plate. The brake caliper mounting plate and the brake shield is bolted to the steering knuckle.

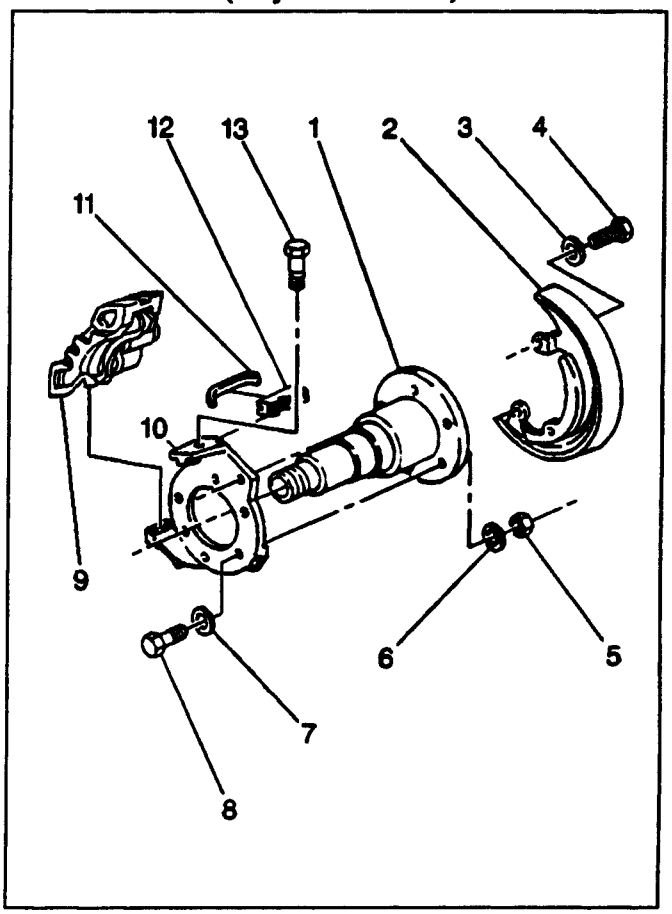
The brake pad assemblies are held in place on each side of the brake rotor. The outer brake pad moves with the brake caliper housing. Depending on axle size, the inner brake pad is held in place by either the brake caliper mounting plate or the brake caliper housing. All original equipment brake pad linings are asbestos free.

Applying the brake pedal causes hydraulic pressure to move the brake caliper pistons. This causes the brake pads to clamp the brake rotor. The brake caliper adjusts its clamping position by sliding laterally in the support rails on the brake caliper mounting plate.

Releasing the brake pedal relieves the pressure applied to the brake caliper pistons. The pistons are pulled back in the bore by the action of the square cut piston seals returning to their original shape. This allows for a running clearance between the brake pad linings and the brake rotor.

Disc Brakes System Description (Rear)

Rear Disc Brake Components (Dayton-Walther)

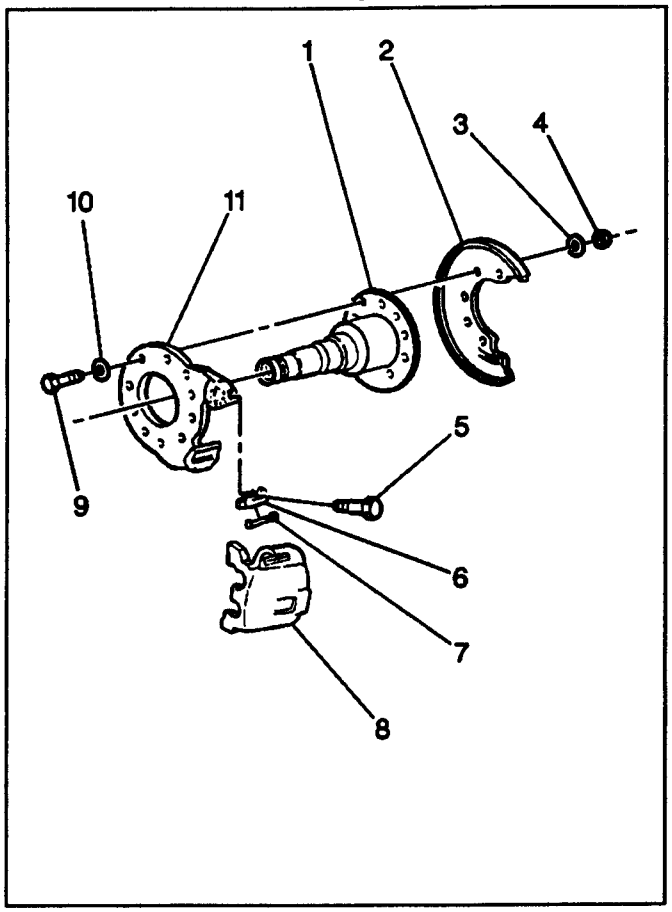


237280

Legend

(1) Rear Axle
(2) Brake Shield
(3) Washer
(4) Bolt
(5) Nut
(6) Washer
(7) Washer
(8) Brake Caliper Mounting Plate Bolt
(9) Brake Caliper
(10) Brake Caliper Mounting Plate
(11) Brake Caliper Retainer Spring
(12) Brake Caliper Retainer
(13) Brake Caliper Retainer Screw

Rear Disc Brake Components (Bendix®)



237274

Legend

(1) Rear Axle
(2) Brake Shield
(3) Washer
(4) Nut
(5) Brake Caliper Retainer Screw
(6) Brake Caliper Retainer
(7) Brake Caliper Retainer Spring
(8) Brake Caliper
(9) Brake Caliper Mounting Plate Bolt
(10) Washer
(11) Brake Caliper Mounting Plate

All hydraulic foundation brakes are disc brake type. The Dayton-Walther rail slider type disc brake caliper is used on the 15,000 lb rear axle. All other axles use the Bendix® rail slider type disc brake caliper.

The front and rear disc brake assembly consists of the following components:

- The brake caliper
- The brake rotor (with a hub, or with a wheel)
- Brake pads
- The brake caliper mounting plate
- The brake shield

The brake rotor is bolted to the front hub or wheel. The rotor turns with the tire and wheel assembly. The brake caliper housing has machined bores and pistons. A seal in a groove of the wall in each bore provides a hydraulic seal and retracts the piston when fluid pressure is relieved. A dust boot keeps the piston bore clean. A metal heat shield protects the dust boot from the heat caused by braking friction. The brake caliper is mounted by a brake caliper retainer and the brake caliper retainer spring to the stationary brake caliper mounting plate. The brake caliper mounting plate and the brake shield is bolted to the steering knuckle.

The brake pad assemblies are held in place on each side of the brake rotor. The outer brake pad moves with the brake caliper housing. Depending on axle size, the inner brake pad is held in place by either the brake caliper mounting plate or the brake caliper housing. All original equipment brake pad linings are asbestos free.

Applying the brake pedal causes hydraulic pressure to move the brake caliper pistons. This causes the brake pads to clamp the brake rotor. The brake caliper adjusts its clamping position by sliding laterally in the support rails on the brake caliper mounting plate.

Releasing the brake pedal relieves the pressure applied to the brake caliper pistons. The pistons are pulled back in the bore by the action of the square cut piston seals returning to their original shape. This allows for a running clearance between the brake pad linings and the brake rotor.

Park Brake

Specifications

Fastener Tightening Specifications (Electric/Hydraulic)

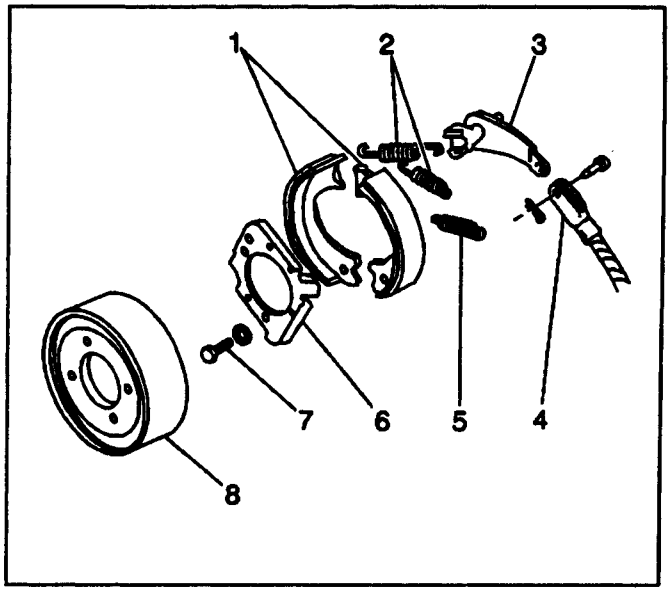
Application	Specification	
	Metric	English
Companion Flange Bolt (Bendix®)	140 N·m	103 lb ft
Propeller Shaft Nut	38 N·m	27 lb ft
Support Plate Bolt (Bendix®) Manual Transmission	86 N·m	63 lb ft
Support Plate Bolt (Bendix®) Automatic Transmission	46 N·m	34 lb ft
Bellcrank Pivot Nut (Bendix®) with Bellcrank Bracket	38 N·m	28 lb ft
Bellcrank Pivot Nut (Bendix®) on Transmission Boss	46 N·m	34 lb ft
Cover Bolt (ISUZU)	127 N·m	94 lb ft
Flange Nut (ISUZU)	784 N·m	579 lb ft

Repair Instructions

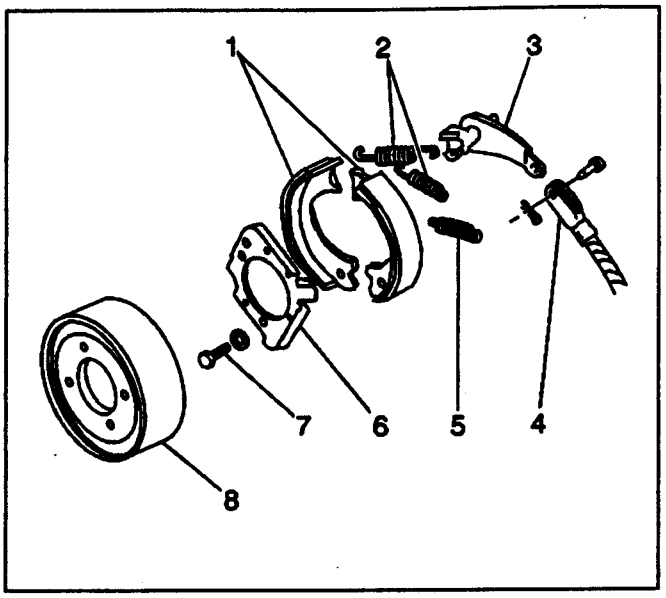
Park Brake Shoe Replacement (Bendix 229 mm - 9 in)

Removal Procedure

1. Remove the drum (6). Refer to *Brake Drum Replacement (Bendix 229 mm - 9 in).*
2. Remove the return springs (2).
3. Remove the anchor springs (5).
4. Remove the linings (1).
5. Spread the brake shoes apart.
6. Inspect the linings (1) for contamination.
7. Inspect the linings (1) for excessive wear.
   The minimum thickness (with bonded linings) is 1.52 mm (0.60 in).
   Replace the linings (1) as a set, if necessary.
8. Inspect the springs for distortion.
   Replace the springs, if necessary.
9. Inspect the springs for a loss of tension.
   Replace the springs, if necessary.
10. Inspect the cam lever (3) for grooves at the brake shoe contact points.
    Replace the cam lever (3), if necessary.



29070



29070

Installation Procedure

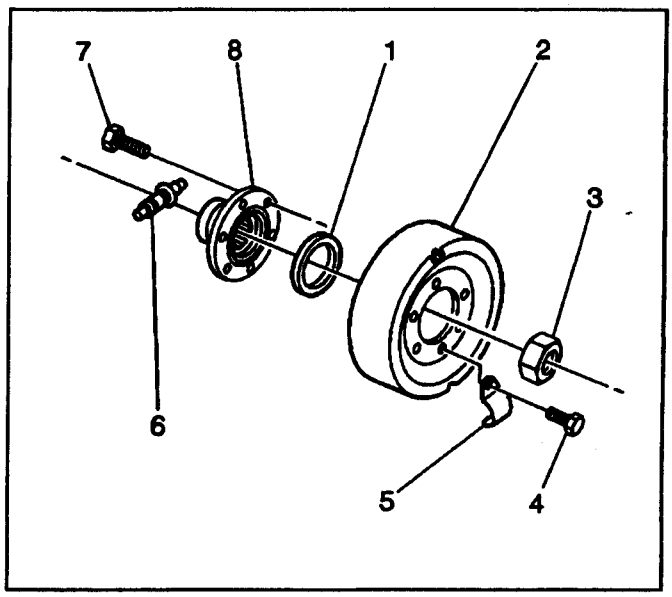
1. Install the linings (1).
   Place the cam lever (3) in position with the two fingers between the shoe webs.
2. Install the anchor spring (5).
   Lubricate the points where the brake shoes contact the support plate (6).
3. Install the return springs (2).
4. Install the drum (8). Refer to *Brake Drum Replacement (Bendix 229 mm - 9 in).*
5. Adjust the parking brake. Refer to Parking Brake Adjustment.

Park Brake Shoe Replacement (Bendix 254 mm - 10 in)

Removal Procedure

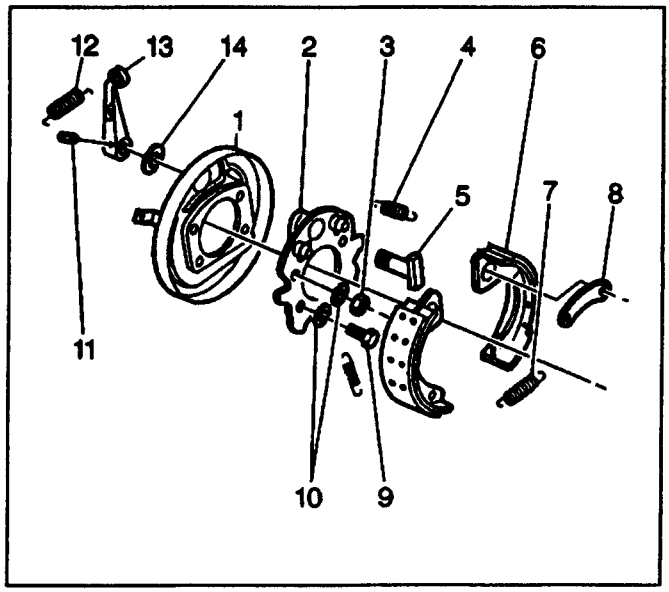
1. Block the wheels of the vehicle.
2. Release the parking brake.
3. Remove the propeller shaft. Refer to the appropriate replacement procedure in Propeller Shaft:
   - *One-Piece Propeller Shaft Replacement (Full Yoke/229)*
   - *One-Piece Propeller Shaft Replacement (Full Yoke/305)*
   - *One-Piece Propeller Shaft Replacement (Half Yoke/229)*
   - *One-Piece Propeller Shaft Replacement (Half Yoke/305)*
   - *One-Piece Propeller Shaft Replacement (Outboard Slip/229)*
   - *One-Piece Propeller Shaft Replacement (Outboard Slip/305)*
   - *Two-Piece Propeller Shaft Replacement (Inboard Slip Joint and Flange)*
   - *Three-Piece Propeller Shaft Replacement (Center Bearing, Full Yoke)*

4. Remove the flange nut (3).
5. Remove the drum (2) and flange (8).
6. Disconnect the O-ring seal (1) in the flange bore.



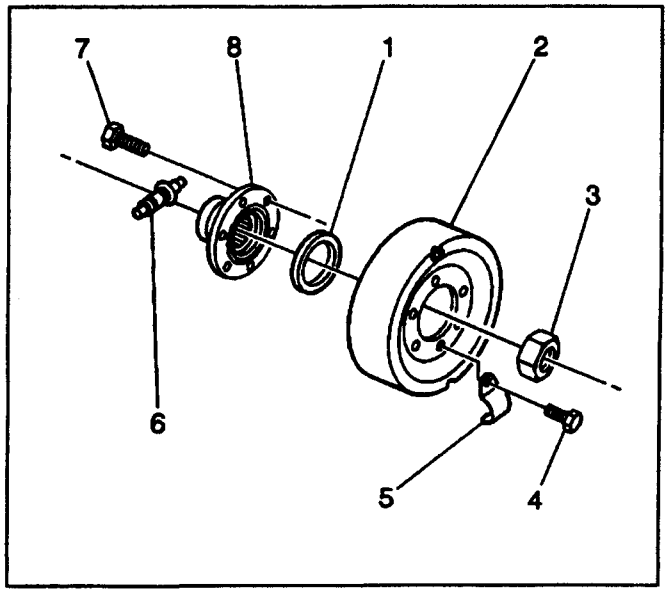
229424

7. Remove the springs (4, 7).

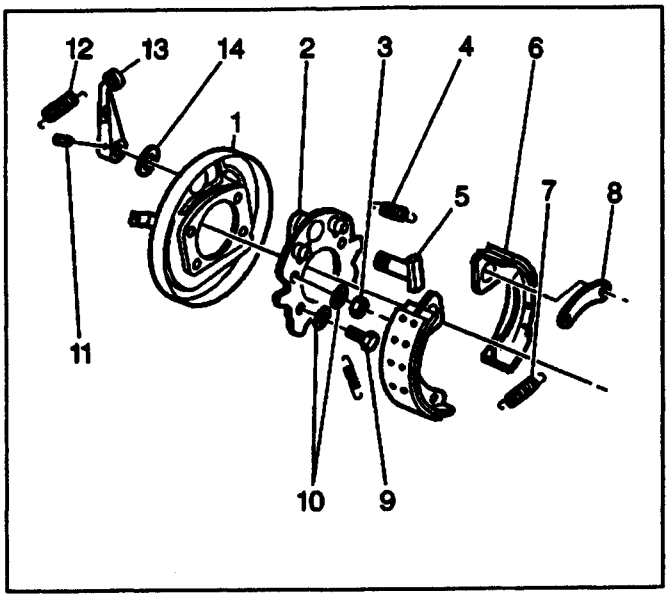


229425

8. Remove the adjuster (6).

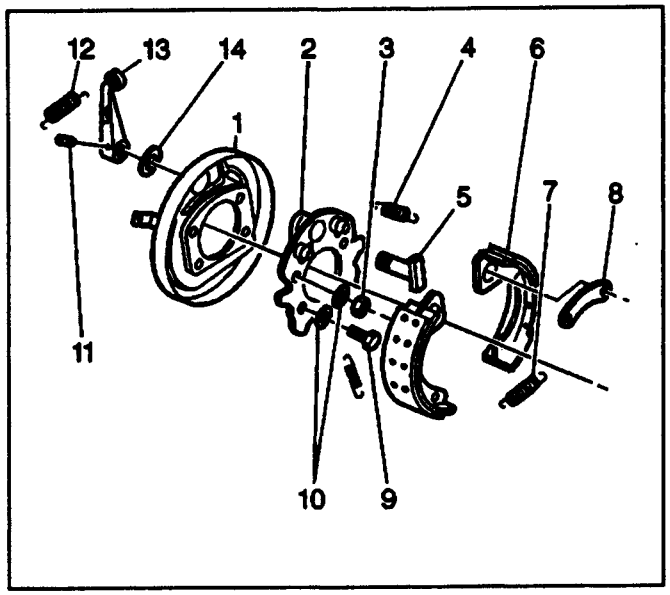


229424



229425

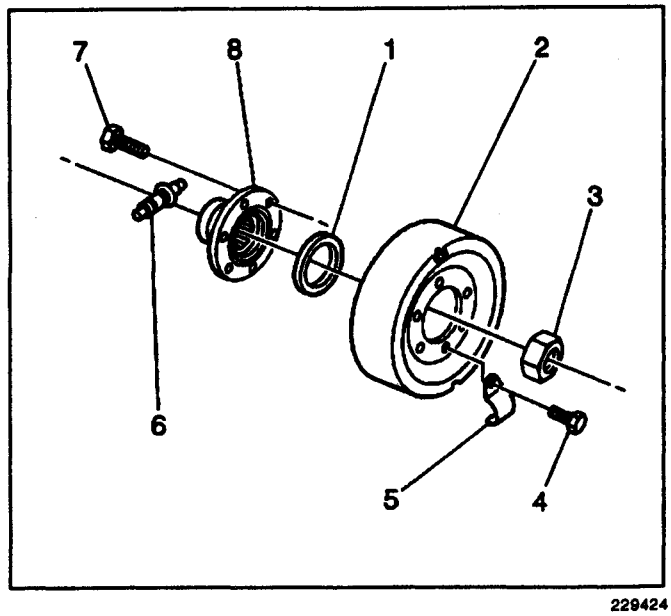
9. Remove the shoes (6).
10. Inspect the return spring. Ensure that the free length is 68 mm (2.68 in).
11. Inspect the shoes (6).
    - Replace the shoes if the web at the point of the cam contact is severely worn.
    - Replace the shoes if the riveted lining is 0.2 mm (0.008 in) from the rivet heads or on bonded shoes when worn to 2.0 mm (0.08 in).



229425

Installation Procedure

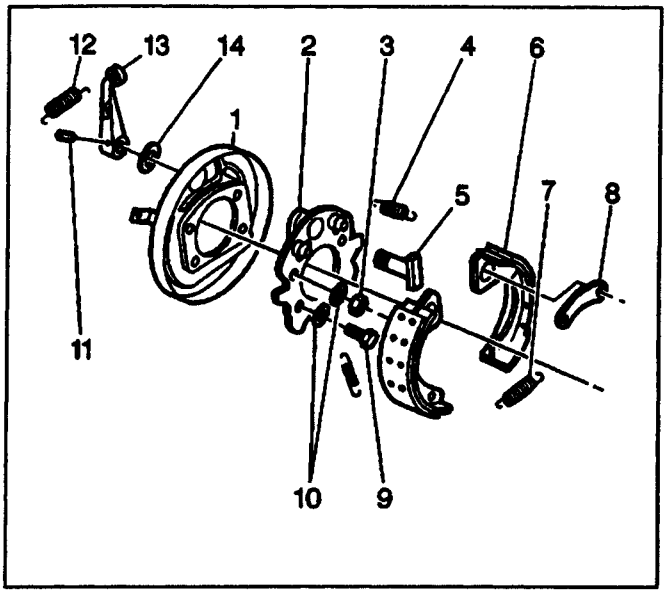
1. Install the shoes (6).



229424

2. Install the adjuster (6).

3. Install the springs (4, 7).



229425

4. Install the drum (2) and the flange (8).

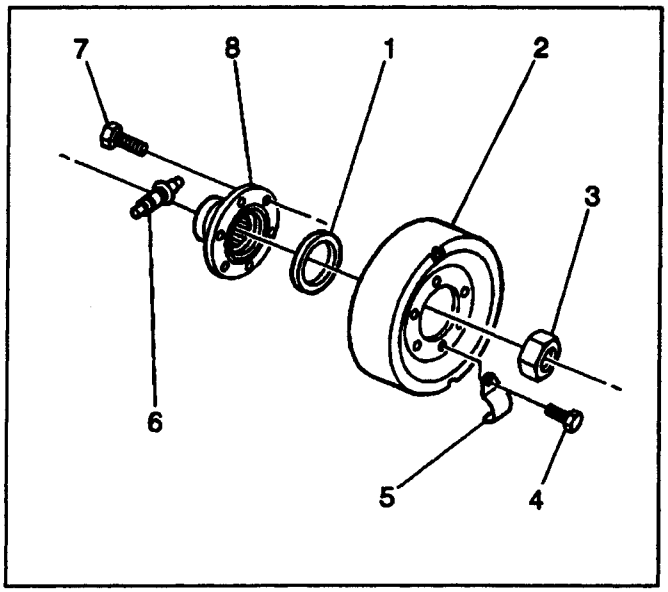
   Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Install the flange nut (3).

   Tighten

   Tighten the flange nut to 784 N.m (579 lb ft).

6. Stake the nut in two places, 180 degrees apart.
7. Install the propeller shaft.
8. Adjust the brake shoes.
9. Verify that the brakes are functioning correctly.

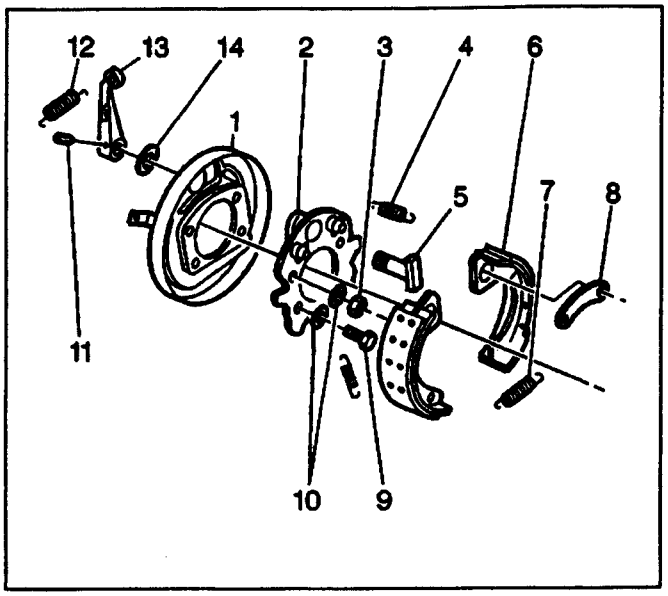


229424

Park Brake Shoe Inspection

Replace the brake shoe and lining assemblies whenever the thickness of any lining is worn within 0.76 mm (0.030 inch) of the shoe.

Replace riveted shoe and lining assemblies when the lining is worn within 0.76 mm (0.030 inch) of any rivet head.



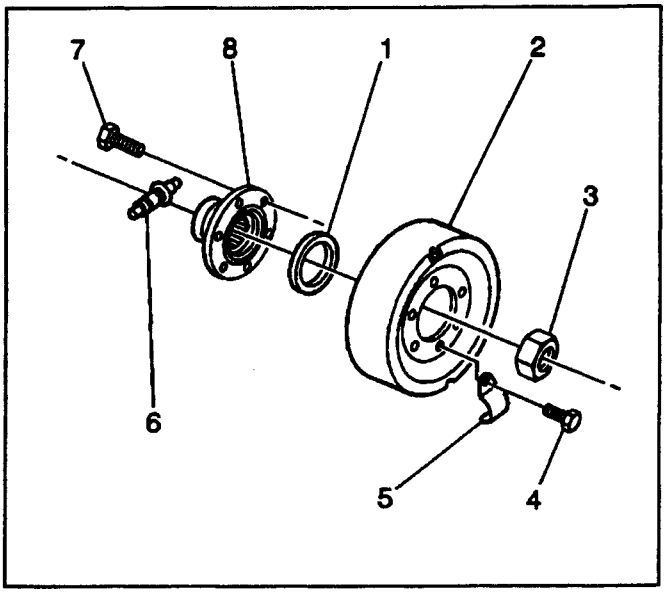
229425

Park Brake Shoe Adjustment (Bendix 254 mm - 10 in)

Removal Procedure

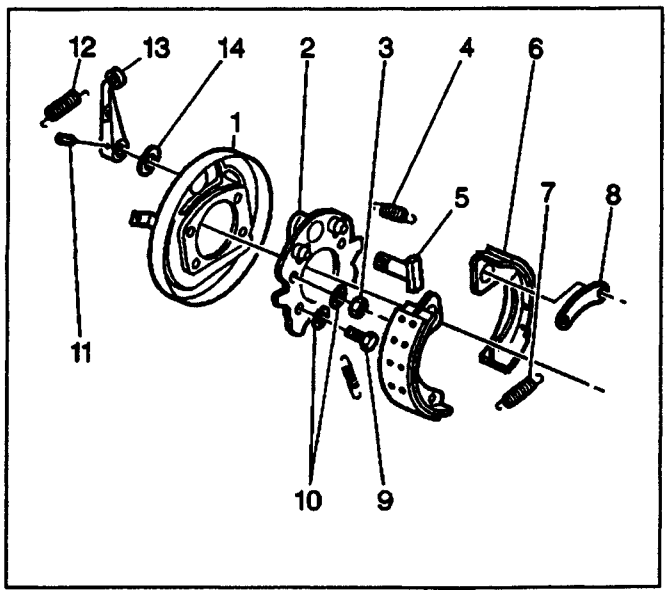
Park the vehicle on a level surface before performing service on the parking brake.

1. Block the wheels of the vehicle.
2. Release the parking brake.
3. Raise the rear axle until the tires are off of the ground.
4. Remove the cable at the lever (13).



229424

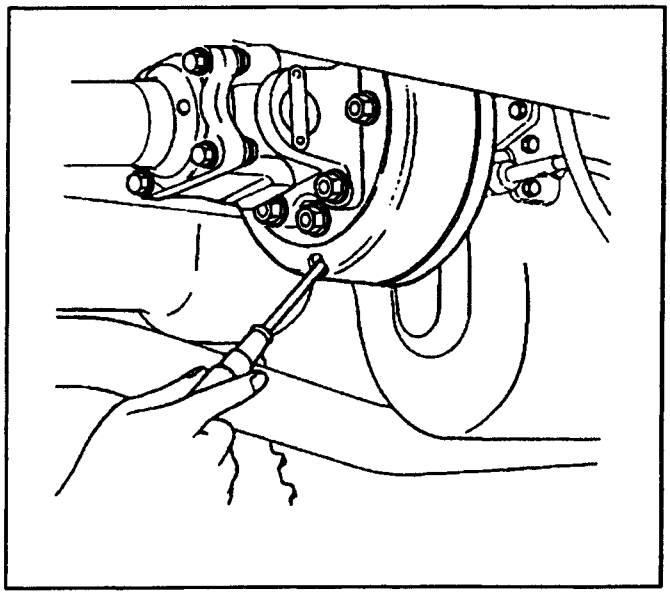
5. Rotate the drum (2) in order to align an access hole with the adjuster (6).
6. Remove the bolt (4).
7. Remove the cover (5).



229425

8. Move the lever (13) side to side several times in order to center the shoes (6).

9. Insert a screwdriver in the access hole and rotate the adjuster upward until the shoes drag on the drum.
10. Move the adjuster back 13 notches.
11. Measure the gap at the middle of the shoe lining in order to ensure that the gap has a 0.23 mm (0.009 in) measurement.

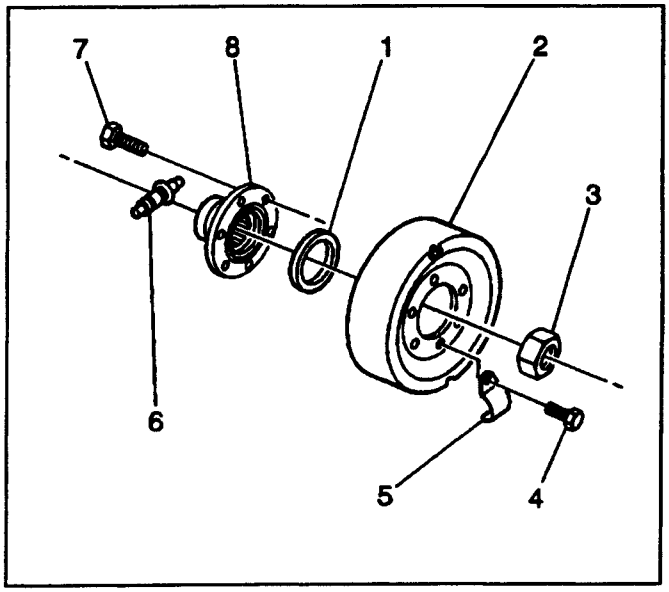


229428

Installation Procedure

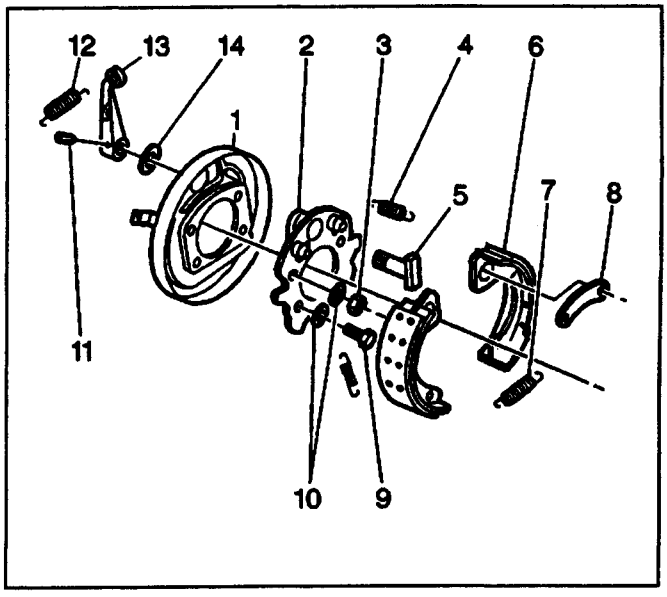
Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the cover (5).
2. Install the bolt (4).

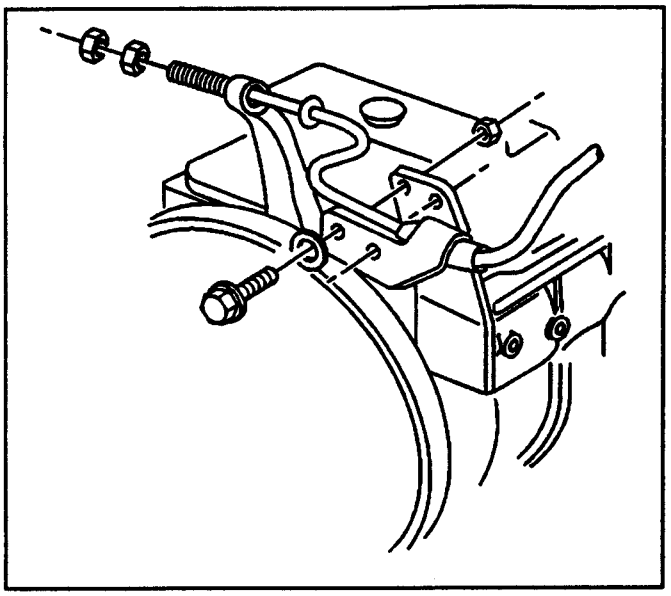


229424

3. Connect the cable to the lever (13).
4. Verify the parking brake operation.



229425



229422

Lever Adjustment

1. Block the wheels of the vehicle.
2. Release the parking brake.
3. Loosen the jamb nut.
4. Loosen the adjusting nut.
5. When connecting the cable with the cam lever, use the adjusting nut in order to remove any clearance between the cam and the shoe.
6. Lock the adjust nut with the locknut.
7. Remove the blocks from the wheels.

Park Brake Lubrication Procedure

Clean and lubricate the parking brake assembly and the cables. Do not allow the lubricant to contact the drum or the lining surfaces.

Notice: Frequent parking brake operation will require lubrication more often than once a month.

In order to reduce the amount of assembly wear, lubricate the following items monthly:

- The lever assembly pivot pin
- The slot clevis pin
- The slots
- The parking brake cable to the transmission clevis pin

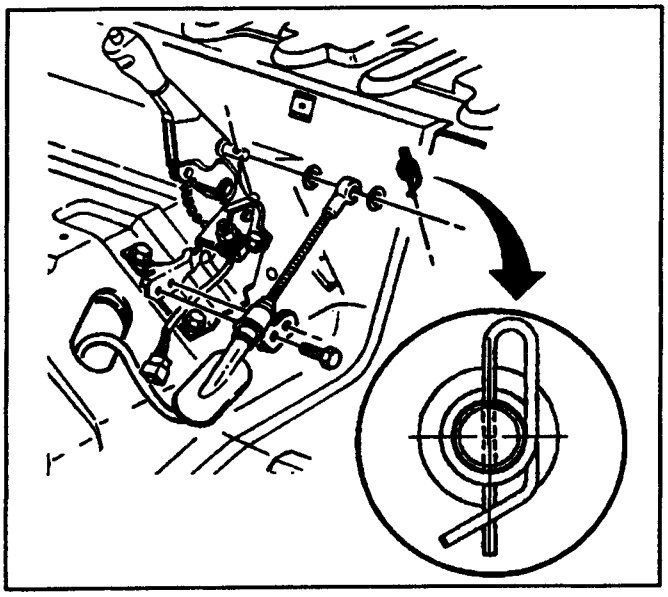
Use the following method in order to lubricate the parking brake assembly:

1. Apply a light coating of lubricant to the following areas:
   - The parking brake lever pivot pin
   - The right-hand side of the slot clevis
   - The left-hand side of the slot clevis
2. Apply a light coating of the same lubricant to the parking brake cable clevis pin which is located at the transmission brake.
3. Check the adjustment of the parking brake.
4. Adjust the parking brake if necessary.

Park Brake Lever Replacement (Mechanical)

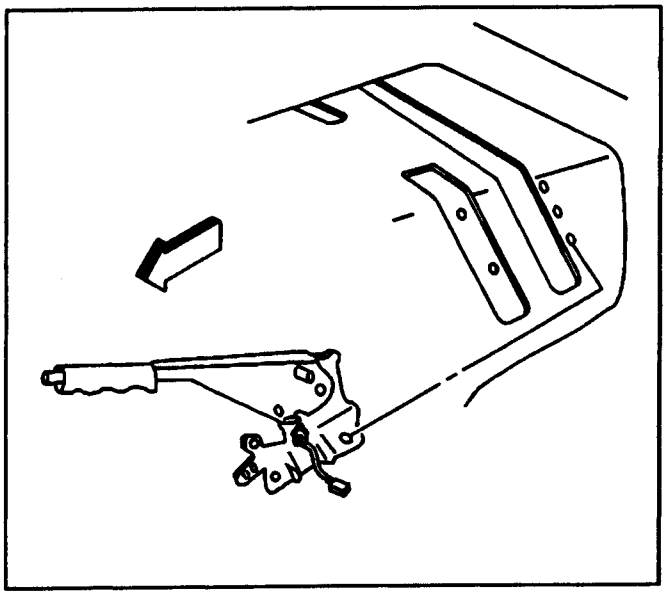
Removal Procedure

1. Remove the console assembly.
2. Remove the mounting bolts.
3. Disconnect the cable from the lever.



221274

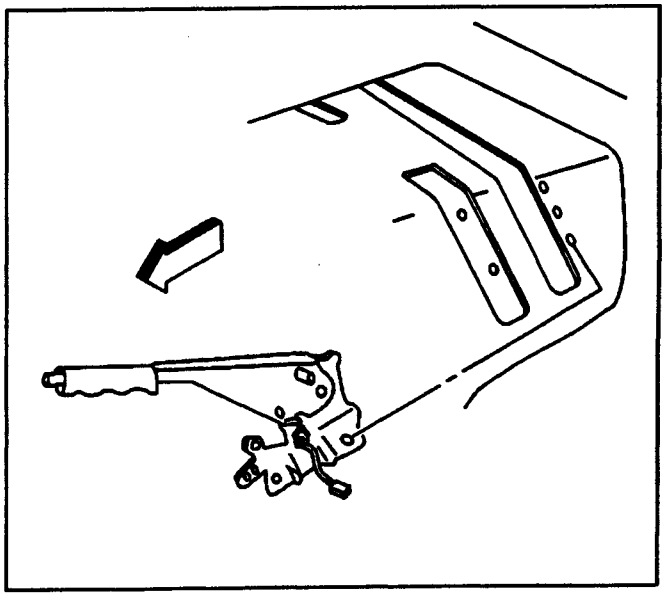
4. Remove the wiring harness.
5. Remove the parking brake lever.



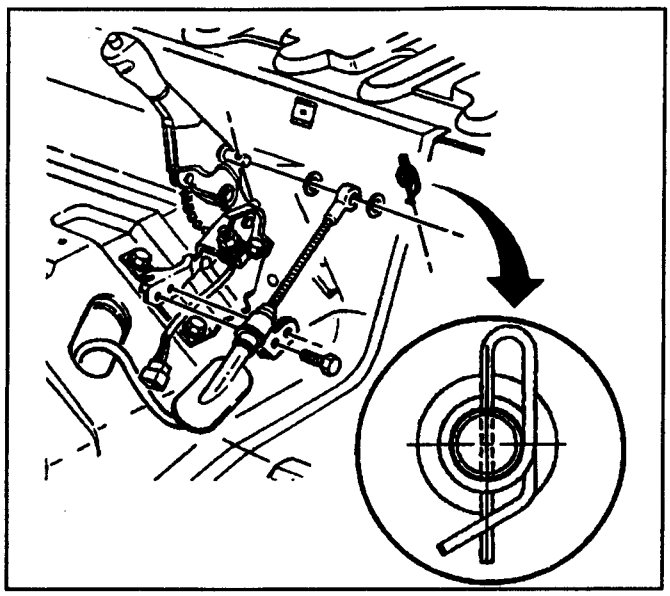
221273

Installation Procedure

1. Connect the parking brake lever to the cab.
2. Install the wiring harness.



221273



221274

3. Connect the cable to the lever.
4. Install the mounting bolts.
5. Install the console assembly.

Park Brake Lever Adjustment

1. Block the wheels of the vehicle.
2. Place the hand lever in the OFF position.
3. Perform the lining wear and linkage adjustments. Refer to the appropriate procedure:
   - *Park Brake Shoe Replacement (Bendix 229 mm - 9 in)*
   - *Park Brake Shoe Adjustment (Bendix 254 mm - 10 in)*
4. Place the hand lever in the ON position.
5. Inspect the parking brake's operating and holding ability.
6. Unblock the wheels.

Park Brake Warning Lamp Switch Replacement

Removal Procedure

1. Remove the parking brake lever. Refer to *Park Brake Lever Replacement (Mechanical)*.
2. Remove the mounting bolt.
3. Remove the wiring harness.
4. Remove the switch.

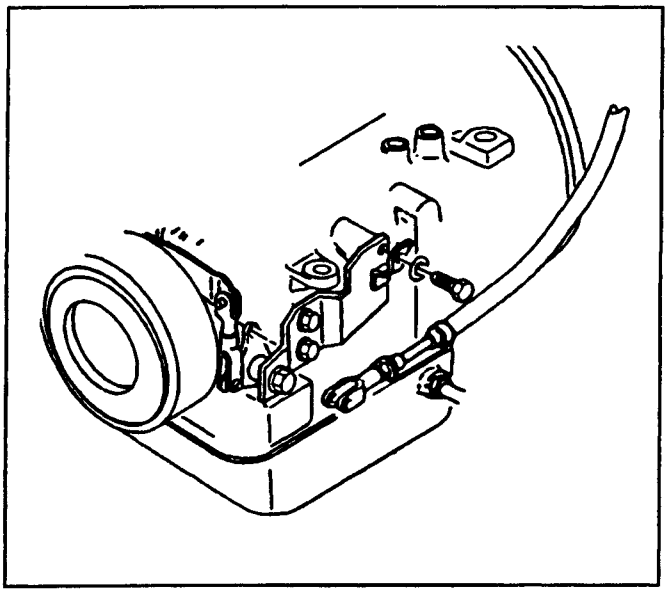
Installation Procedure

1. Install the switch.
2. Install the wiring harness.
3. Install the mounting bolt.
4. Install the parking brake lever. Refer to *Park Brake Lever Replacement (Mechanical)* in Cautions and Notices.

Park Brake Cable Replacement

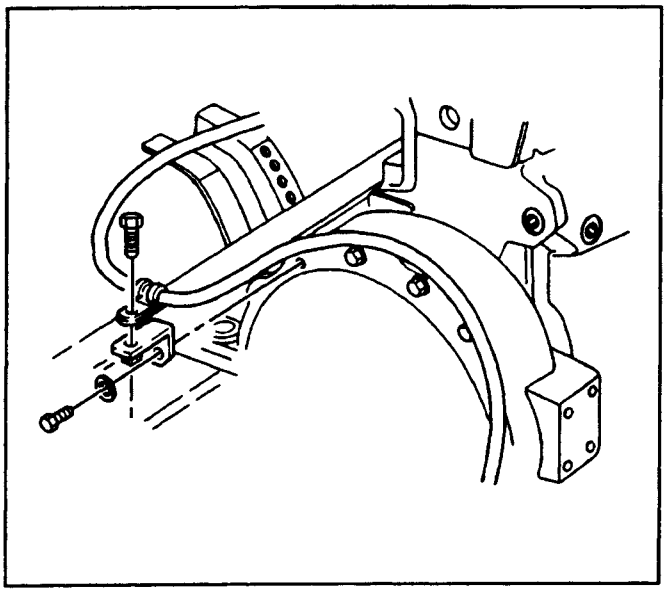
Removal Procedure

1. Block the vehicle wheels.
2. Remove the lock nut on the actuator end of the cable at the 2 piece fitting.
3. Remove the end fitting.
4. Remove the cotter pin and the cable clevis pin.
5. Remove the fastener from the transmission bracket clip.
6. Remove the fastener from the transmission housing bracket.



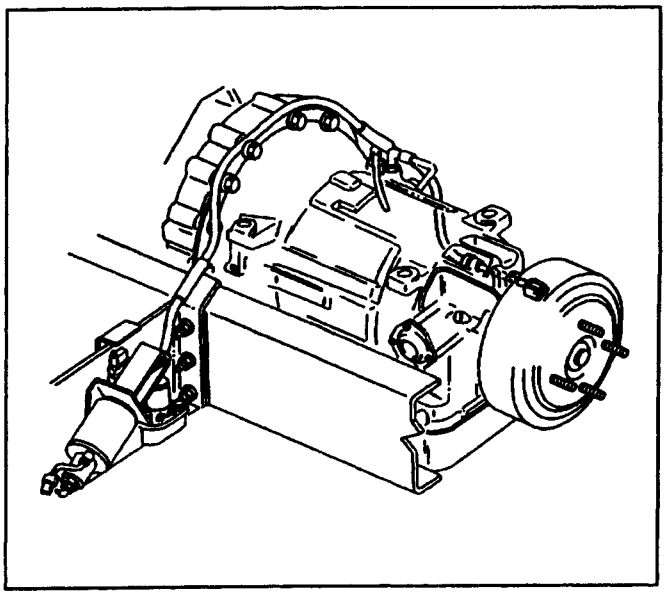
199980

7. Remove the fastener from the frame bracket.
8. Remove the strap.

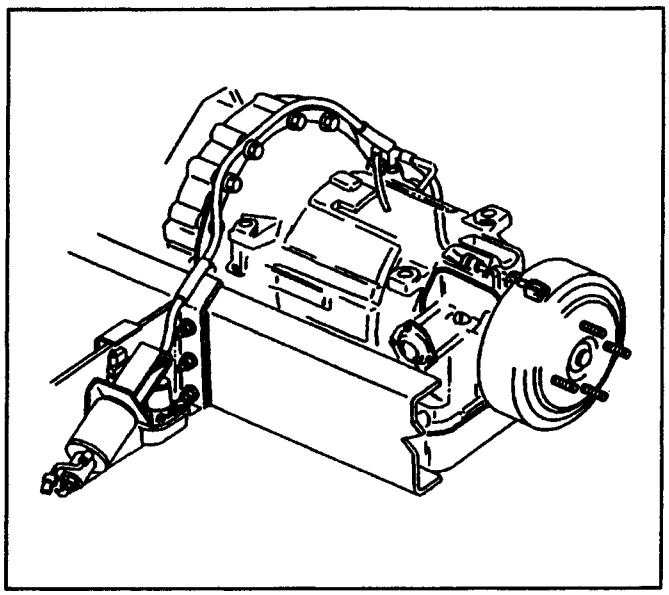


199978

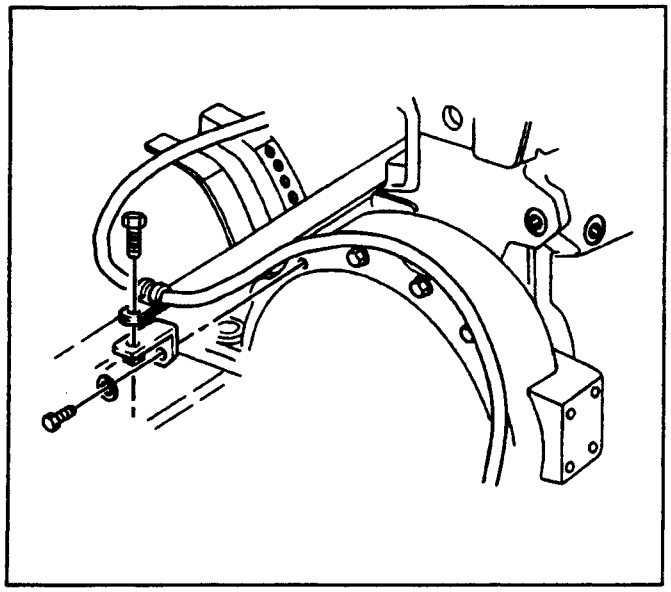
9. Remove the cable assembly.



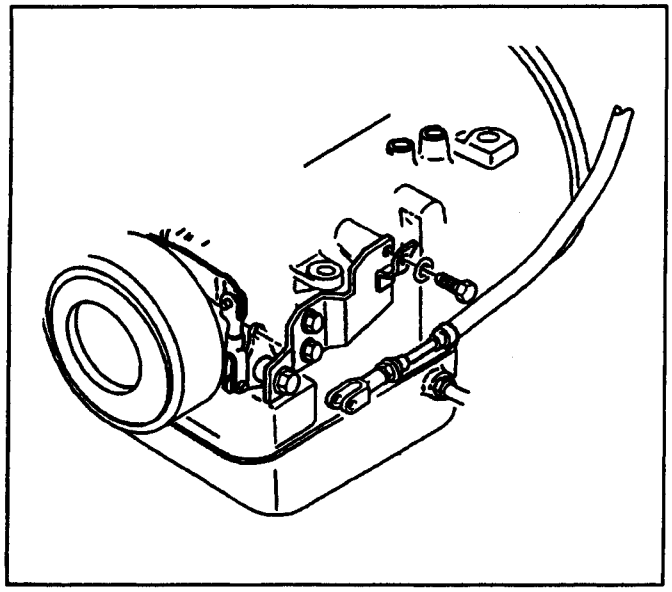
199973



199973



199978



199980

Installation Procedure

1. Install the new cable assembly.
2. Install the strap.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
3. Install the fastener from the frame bracket.

   Tighten

   Tighten the fastener from the frame bracket to 50 N.m (37 lb ft).
4. Install the fastener from the transmission housing bracket.

   Tighten

   Tighten the fastener from the transmission housing bracket to 35 N.m (26 lb ft).

   Notice: Make sure that the clip has the bolt hole facing forward. If the clip is out of position, it may cause a binding condition in the parking brake released position.
5. Install the fastener from the transmission bracket clip.

   Tighten

   Tighten the fastener from the transmission bracket clip to 64 N.m (47 lb ft).

6. Install the small and the large ends of the two-piece cable fitting at the actuator. The small fitting should bottom on both the actuator and the large half of the 2 piece fitting.
   Tighten
   Tighten the 2 pieces of the fitting together to 54 N.m (40 lb ft).
7. Install the lock nut to the two-piece fitting.
   Tighten
   Tighten the lock nut to 45 N.m (33 lb ft).
8. Perform the drum adjustment. Refer to the following list for the appropriate brake:
   - *Brake Drum Replacement (Bendix 254 mm - 10 in)*
   - *Brake Drum Replacemen (Bendix 229 mm - 9 in)*

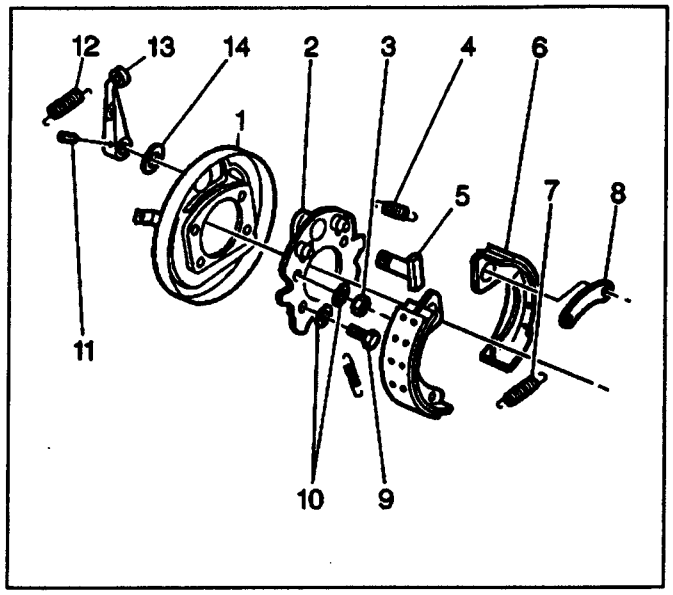
Park Brake Cable Inspection

Check the parking brake for free operation. The brake lever must return to the released position without sticking or binding. If a problem is present, check the cable routings for kinks or binding.

Brake Drum Replacement (Bendix 254 mm - 10 in)

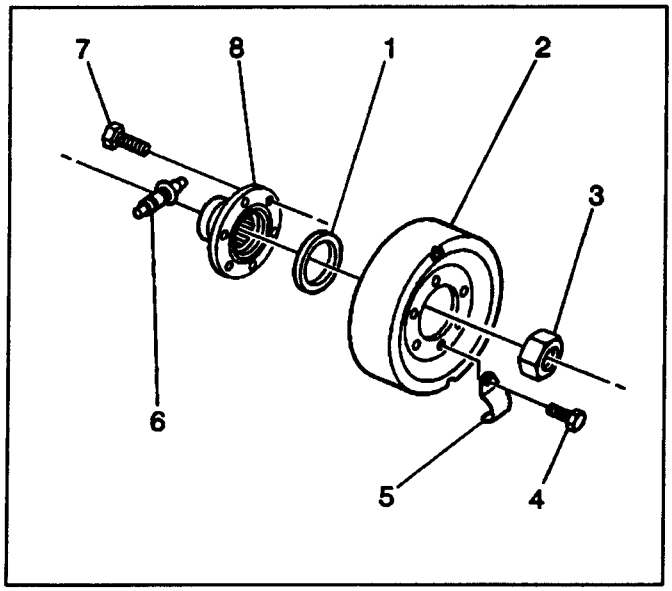
Removal Procedure

1. Block the wheels of the vehicle.
2. Release the parking brake.
3. Remove the propeller shaft. Refer to the appropriate replacement procedure in Propeller Shaft:
   - *One-Piece Propeller Shaft Replacement (Full Yoke/229)*
   - *One-Piece Propeller Shaft Replacement (Full Yoke/305)*
   - *One-Piece Propeller Shaft Replacement (Half Yoke/229)*
   - *One-Piece Propeller Shaft Replacement (Half Yoke/305)*
   - *One-Piece Propeller Shaft Replacement (Outboard Slip/229)*
   - *One-Piece Propeller Shaft Replacement (Outboard Slip/305)*
   - *Two-Piece Propeller Shaft Replacement (Inboard Slip Joint and Flange)*
   - *Three-Piece Propeller Shaft Replacement (Center Bearing, Full Yoke)*



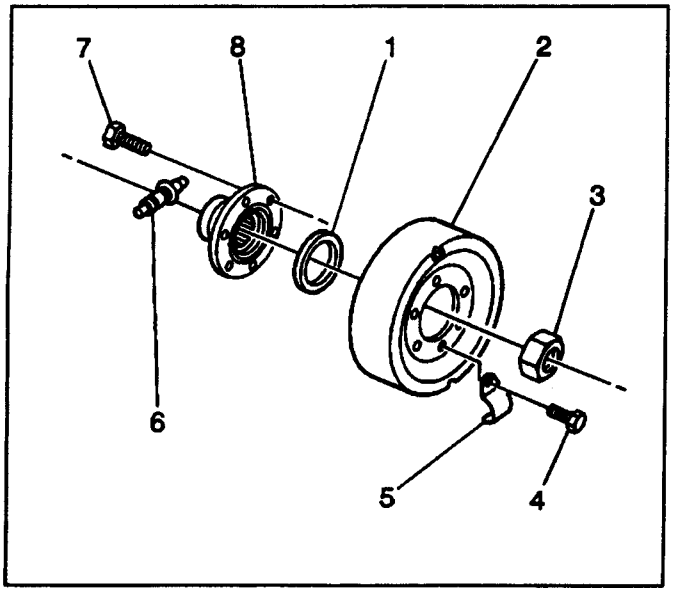
229425

4. Remove the bolts (9).
5. Remove the washers (10).



229424

6. Remove the covers (5).
7. Remove the drum (2).
8. Measure the drum diameter.
9. Replace the drum if the ID is more than 256 mm (10.08 in).
10. Measure the drum run-out.
11. Replace the drum if the run-out varies by more than 0.05 mm (0.002 in).

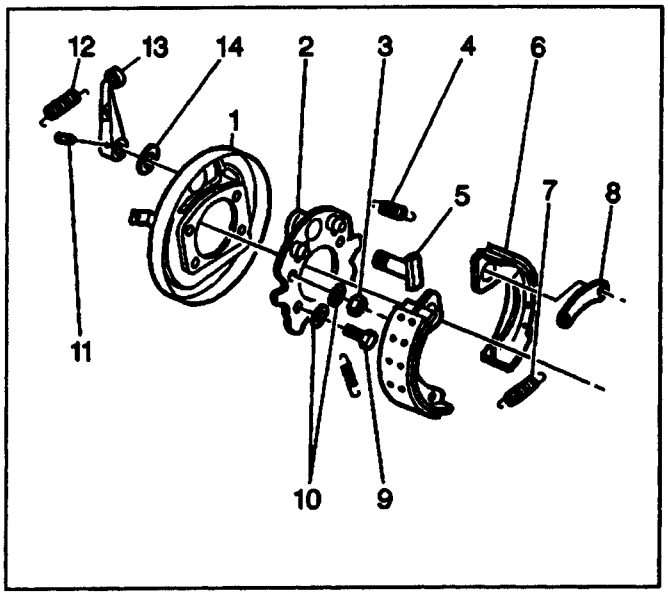


229424

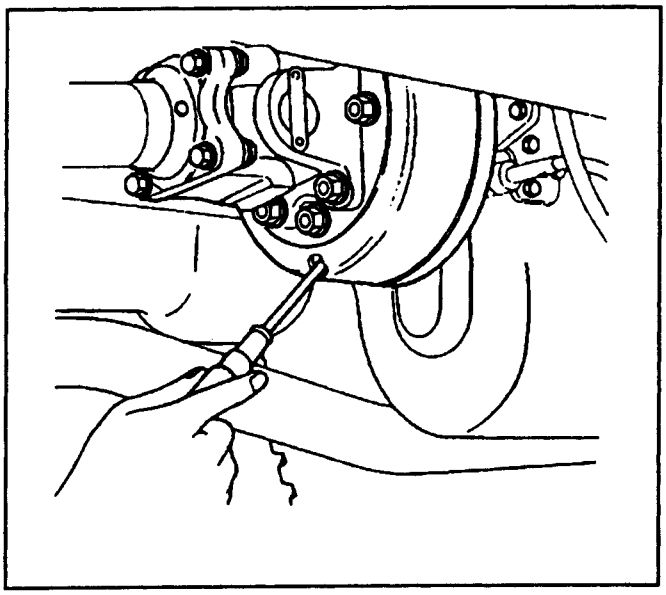
Installation Procedure

1. Install the drum (2).
2. Install the covers (5).

3. Install the bolts (9).
4. Install the washers (10).
5. Align the drum holes with the flange holes.
6. Install the propeller shaft. Refer to the appropriate replacement procedure in Propeller Shaft:
   - *One-Piece Propeller Shaft Replacement (Full Yoke/229)*
   - *One-Piece Propeller Shaft Replacement (Full Yoke/305)*
   - *One-Piece Propeller Shaft Replacement (Half Yoke/229)*
   - *One-Piece Propeller Shaft Replacement (Half Yoke/305)*
   - *One-Piece Propeller Shaft Replacement (Outboard Slip/229)*
   - *One-Piece Propeller Shaft Replacement (Outboard Slip/305)*
   - *Two-Piece Propeller Shaft Replacement (Inboard Slip Joint and Flange)*
   - *Three-Piece Propeller Shaft Replacement (Center Bearing, Full Yoke)*
7. Adjust the brake linings.
8. Verify the operation of the parking brake.



229425

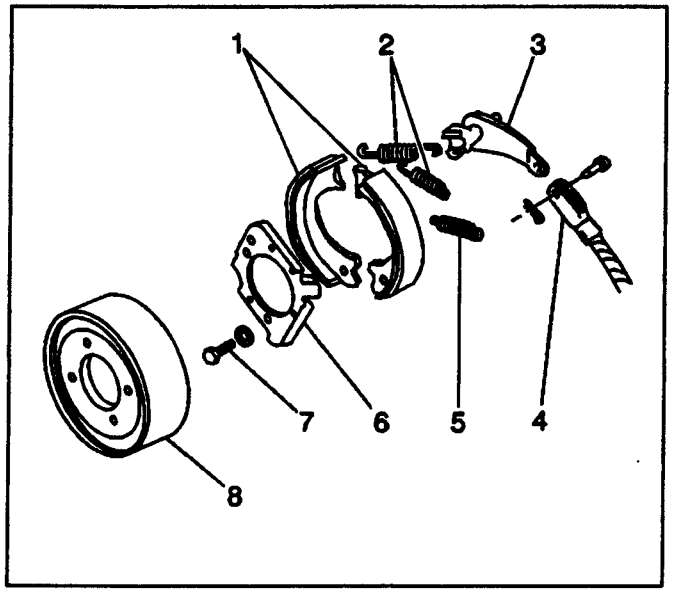

229428

Brake Drum Replacement (Bendix 229 mm - 9 in)

Removal Procedure

1. Block the vehicle wheels.
2. Remove the propeller shaft. Refer to the appropriate replacement procedure in Propeller Shaft:
   - *One-Piece Propeller Shaft Replacement (Full Yoke/229)*
   - *One-Piece Propeller Shaft Replacement (Full Yoke/305)*

- *One-Piece Propeller Shaft Replacement (Half Yoke/229)*
- *One-Piece Propeller Shaft Replacement (Half Yoke/305)*
- *One-Piece Propeller Shaft Replacement (Outboard Slip/229)*
- *One-Piece Propeller Shaft Replacement (Outboard Slip/305)*
- *Two-Piece Propeller Shaft Replacement (Inboard Slip Joint and Flange)*
- *Three-Piece Propeller Shaft Replacement (Center Bearing, Full Yoke)*



29070

3. Remove the following items from the center of the yoke:
   - The companion flange bolt
   - The washer
   - The retainer
4. Straighten the lock tab on the washer.
5. Remove the brake drum (8) and the yoke assembly from the transmission.
6. Remove the bolts that hold the drum (8) to the yoke.

   Important: Closely examine all mounting bolt holes in the drum for stress cracks.
7. Inspect the drum (8) for the following:
   - Cracks
   - Scoring
   - Pitting
   - Grooves
   - Overheating damage
8. Repair the drum as needed.
9. Inspect the linings (1) for contamination and excessive wear. The minimum lining thickness (with bonded linings) is 1.52 mm (0.060 in).
10. If replacement is necessary, replace the linings as a set.
11. Inspect the brake mechanism for proper operation.
12. Repair the brake mechanism as needed.

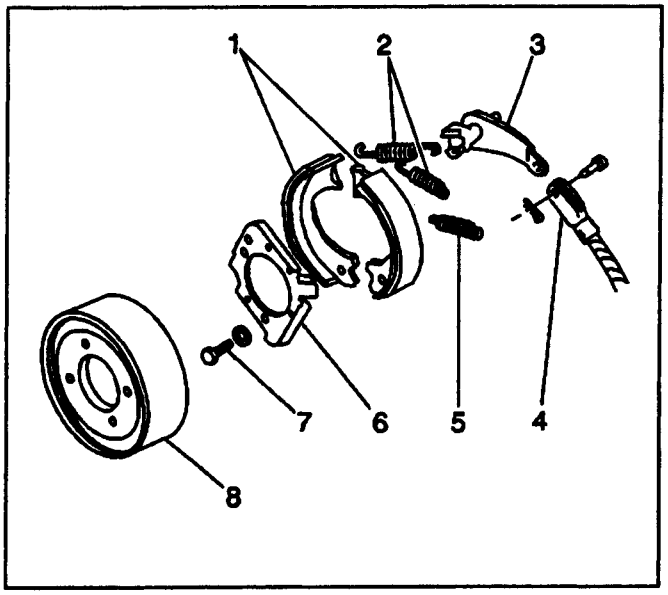
Installation Procedure

1. Install the bolts that hold the drum (8) to the yoke.
2. Install the drum and yoke assembly to the transmission.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
3. Install the companion flange bolt and a new washer to the transmission mainshaft at the center of the yoke.

   Tighten

   Tighten the companion flange bolt to 140 N.m (103 lb ft).
4. Install the propeller shaft. Refer to the appropriate replacement procedure in Propeller Shaft:
   - *One-Piece Propeller Shaft Replacement (Full Yoke/229)*
   - *One-Piece Propeller Shaft Replacement (Full Yoke/305)*
   - *One-Piece Propeller Shaft Replacement (Half Yoke/229)*
   - *One-Piece Propeller Shaft Replacement (Half Yoke/305)*
   - *One-Piece Propeller Shaft Replacement (Outboard Slip/229)*
   - *One-Piece Propeller Shaft Replacement (Outboard Slip/305)*
   - *Two-Piece Propeller Shaft Replacement (Inboard Slip Joint and Flange)*
   - *Three-Piece Propeller Shaft Replacement (Center Bearing, Full Yoke)*
5. Adjust the parking brake. Refer to *Park Brake Shoe Replacement (Bendix 229 mm - 9 in).*



29070

Brake Drum Inspection

When removing the parking brake drum, thoroughly clean and inspect the drum for the following conditions:

- Cracks
- Scores
- Deep grooves
- Out-of-round

Surface Finish

Clean slight scoring with a fine emery cloth. Heavy or extensive scoring causes excessive brake lining wear. The drum braking surface will need machining in order to remove these scores.

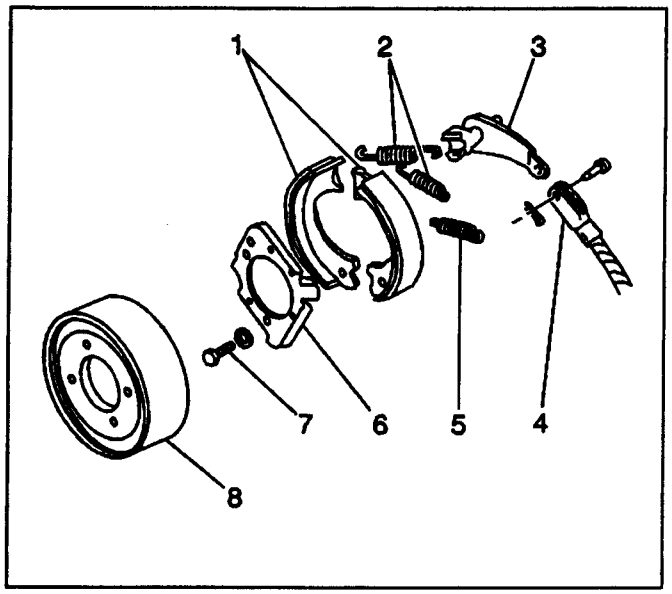
Do not machine the drum if the drum is grooved and the brake linings are slightly worn. Polish the drum braking surface with a fine emery cloth. Eliminating all of the drum grooves and ridges on the lining requires removing too much metal lining material. If the grooves and ridges match, leaving the drums alone is satisfactory service.

Inside Diameter Check

Measure the inside of the brake drum at two or more places around the circumference of the braking surface. Perform the measurements at the same distance in from the edge of the drum.

Taper Check

Measuring the drum for taper involves taking measurements at the inner and the outer edges of the machined surface at two or more places around the drum.

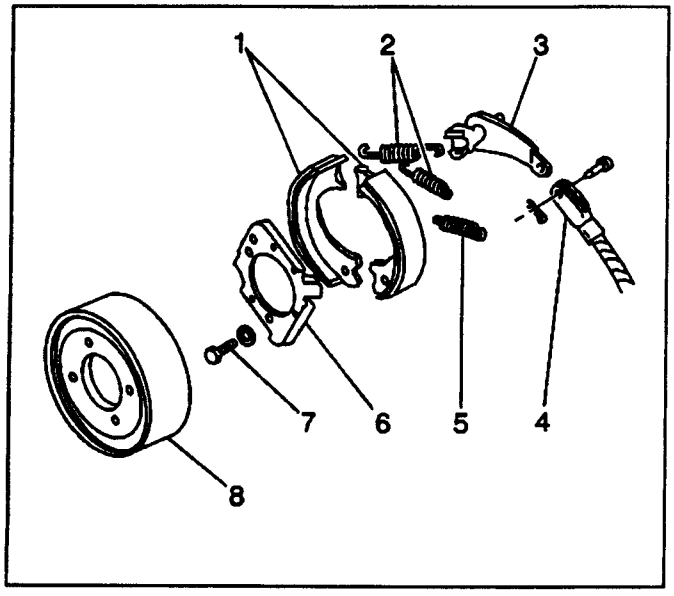


29070

Park Brake Support Replacement

Removal Procedure

1. Remove the drum (8). Refer to *Brake Drum Replacement (Bendix 229 mm - 9 in).*
2. Remove the linings. Refer to *Park Brake Shoe Replacement (Bendix 229 mm - 9 in).*
3. Remove the bolts (7).
4. Remove the support plate (6).
5. Inspect the support plate for damage or distortion.
6. Replace the support plate, if necessary.
7. Inspect the support plate for corrosion.
8. Remove corrosion from the shoe contact surfaces with a fine emery cloth.



29070

Installation Procedure

1. Install the support plate (8).

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the bolts (7).

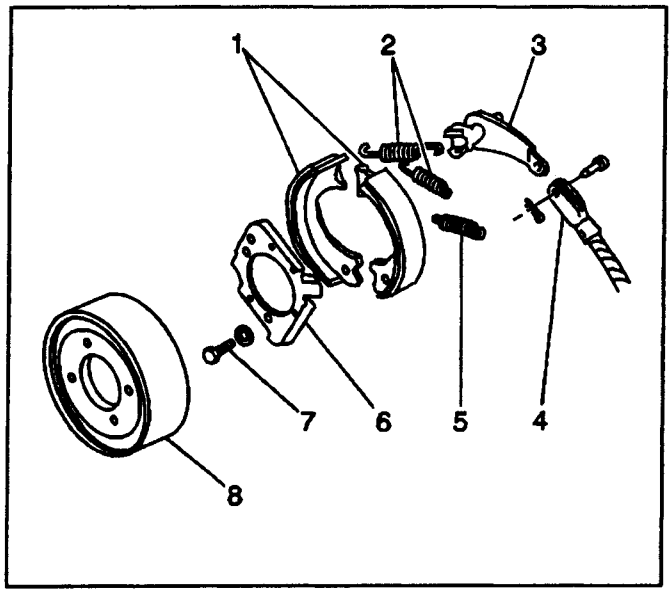
   Tighten

   - For vehicles with manual transmission, tighten the bolts to 86 N·m (63 lb ft).
   - For vehicles with automatic transmission, tighten the bolts to 46 N·m (34 lb ft).
3. Install the linings. Refer to *Park Brake Shoe Replacement (Bendix 229 mm - 9 in).*
4. Install the drum (6). Refer to *Brake Drum Replacement (Bendix 229 mm - 9 in).*

Park Brake Bellcrank and Cam Lever Replacement

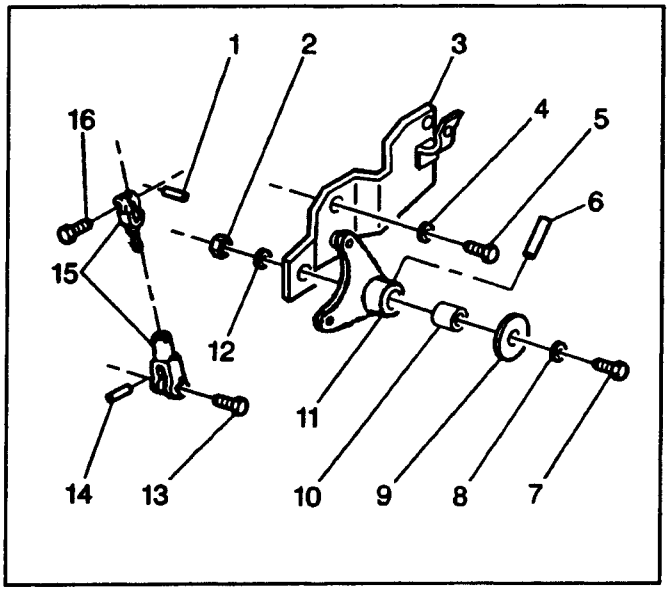
Removal Procedure

1. Remove the drum (6). Refer to *Brake Drum Replacement (Bendix 254 mm - 10 in).*
2. Remove the linings (1). Refer to *Park Brake Shoe Replacement (Bendix 229 mm - 9 in).*



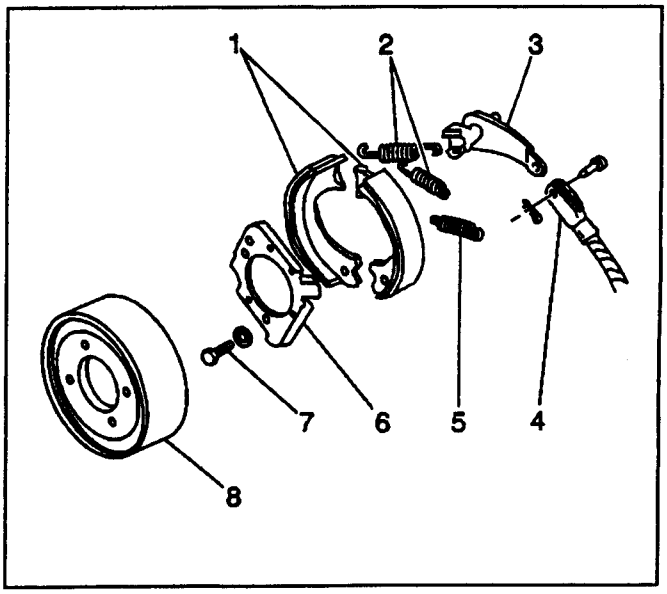
29070

3. Remove the two cotter pins (1, 14).
4. Remove the two clevis pins (13, 16).

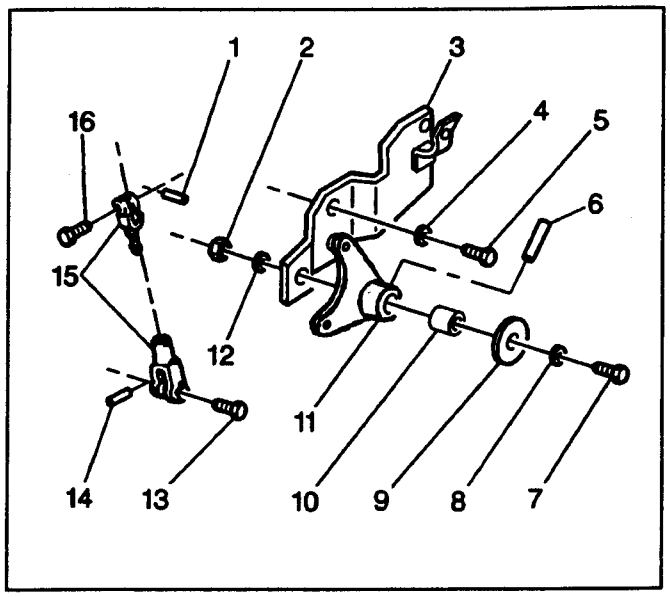


199959

5. Remove the cam lever (3).
6. Loosening the support plate mounting bolts (7) may be necessary.



29070



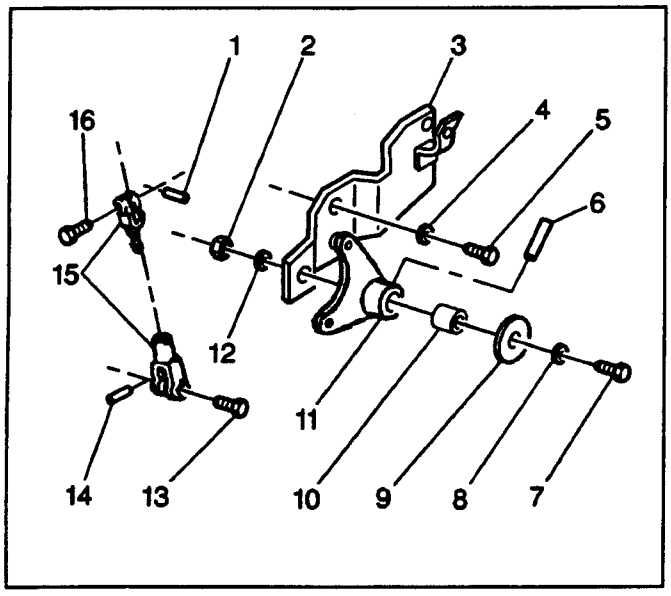
199959

7. Remove the cotter pin and the clevis pin at the control cable arm of the bellcrank.

   Loosening the clevis jam nut (2) may be necessary in order to relieve binding of the pin in the clevis.
8. Remove the bellcrank bracket (3), if equipped.
9. Remove the following components:
   - Two bracket bolts (5)
   - The spring washers (4)
   - The bellcrank and bracket assembly (3)
10. Remove the bellcrank pivot nut (2) and the spring washer, if equipped.
11. Remove the bellcrank pivot bolt (5) and the two washers (4).
12. Remove the bellcrank (11).
13. Remove the bellcrank bushing (10).
14. Inspect the bellcrank bushing for wear.

    Replace the bellcrank bushing, if necessary.
15. Inspect the following components:
    - The washers
    - The levers
    - The clevises
16. Replace the components in the previous step if the following conditions exist:
    - Wear
    - Cracks
    - Damage
17. Inspect the bellcrank bracket (3) for damage, if equipped.

    Replace the bellcrank bracket, if necessary.



199959

Installation Procedure

1. Install the bellcrank bushing (10).
2. Connect the bellcrank (11) to the bracket (3), if equipped, or directly to the transmission boss.
3. Install the bellcrank pivot bolt (7) and the two washers (8, 9).

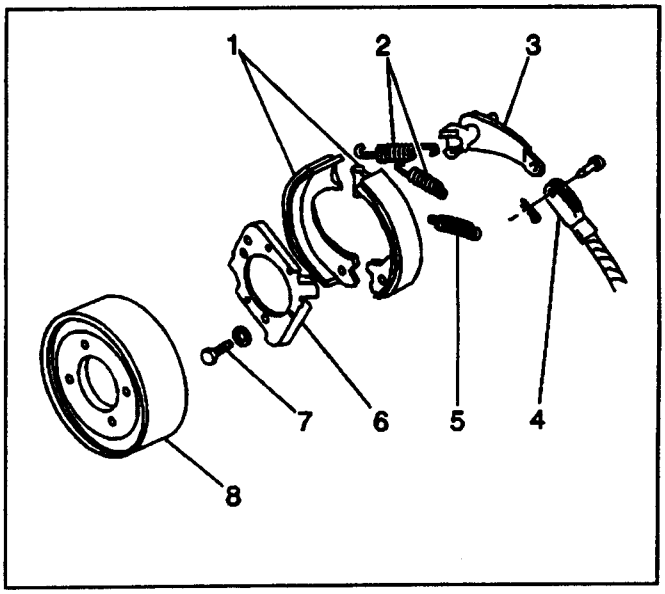
   Tighten

   Tighten the bolt on assemblies mounted directly to the transmission boss to 98 N·m (72 lb ft).
4. Install the bellcrank pivot nut (2) and the spring washer (12), if equipped.

   Tighten

   Tighten the nut on assemblies with a bellcrank bracket to 38 N·m (28 lb ft).
5. Install the bellcrank bracket (3), if equipped, with the assembled bellcrank to the transmission housing.

6. Install the two bracket bolts (5) and the spring washers (4), if equipped.
   Tighten
   Tighten the bolts (5) to 30 N.m (22 lb ft).
7. Connect the control cable to the bellcrank (11).
8. Insert the bellcrank arm into the slot in the control cable clevis.
9. Insert the clevis pin.
10. Install a new cotter pin.
11. Tighten the control cable clevis lock nut, if the lock nut is loosened.
12. Install the cam lever (15).
13. Lubricate the socket in the transmission case boss.
14. Install the two clevis pins (13, 16).
15. Install the two new cotter pins (1, 14).
16. Install the linings (1). Refer to *Park Brake Shoe Replacement (Bendix 229 mm - 9 in).*
17. Install the drum (5). Refer to *Brake Drum Replacement (Bendix 254 mm - 10 in).*
18. Adjust the parking brake. Refer to *Park Brake Shoe Adjustment (Bendix 254 mm - 10 in).*



29070

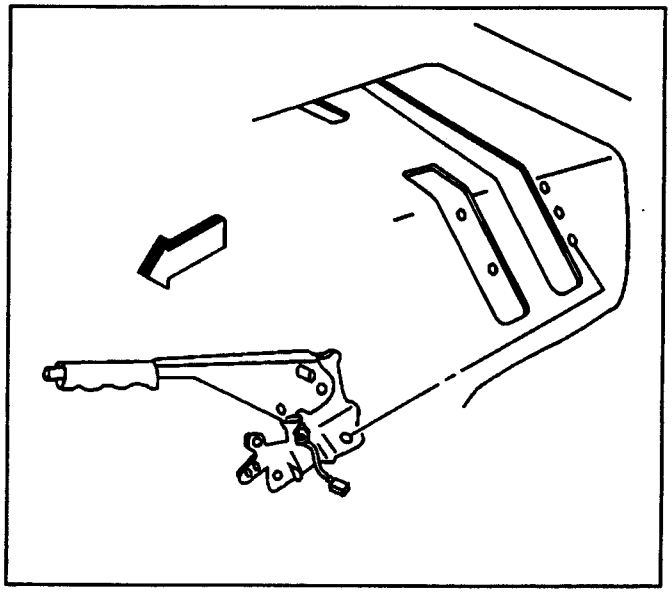
Description and Operation

Park Brake System Description

The parking brake is not designed for use in place of service brakes. Apply the parking brake only after the vehicle is brought to a complete stop, except in an emergency. Mechanically actuated parking brakes are internal-expanding drum-and-shoe type. The parking brakes are identified by their drum diameters and manufacturers. The transmission in the vehicle determines which parking brake is used.

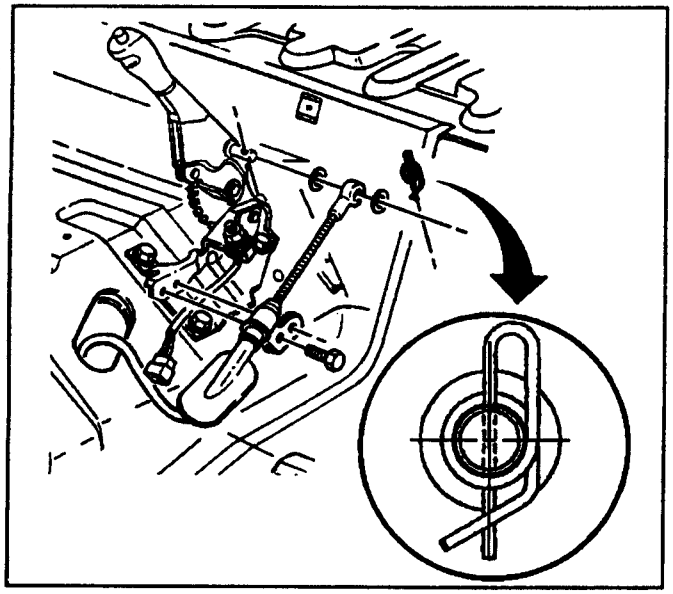
Lever

Parking Brake Lever



221273

Cable to Lever Attachment



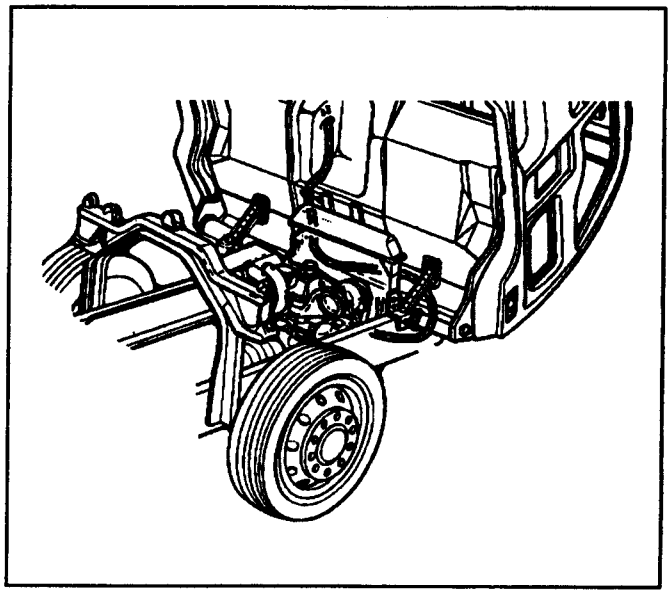
221274

The parking brake hand lever is mounted next to the driver's seat. The parking brake hand lever connects to the parking brake by a flexible cable. The cable end at the parking brake may have the following components in order to connect with the brake mechanism:

- A clevis
- A rod eye
- A pin

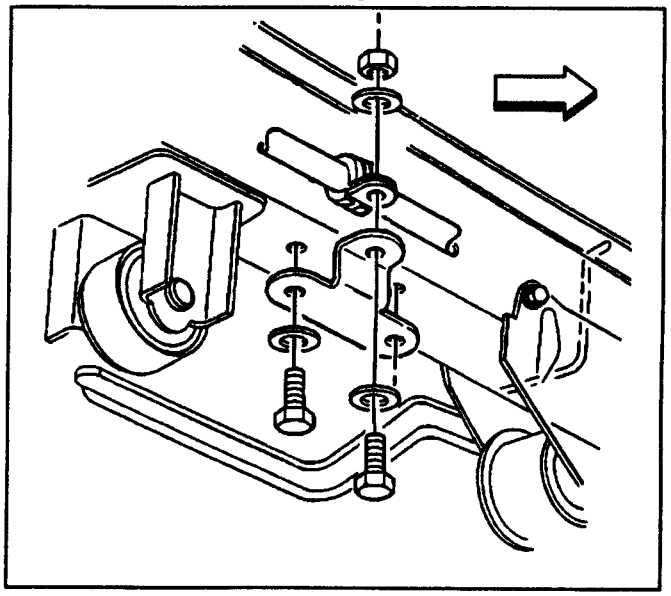
Cable System

Cable Routing on the Cab



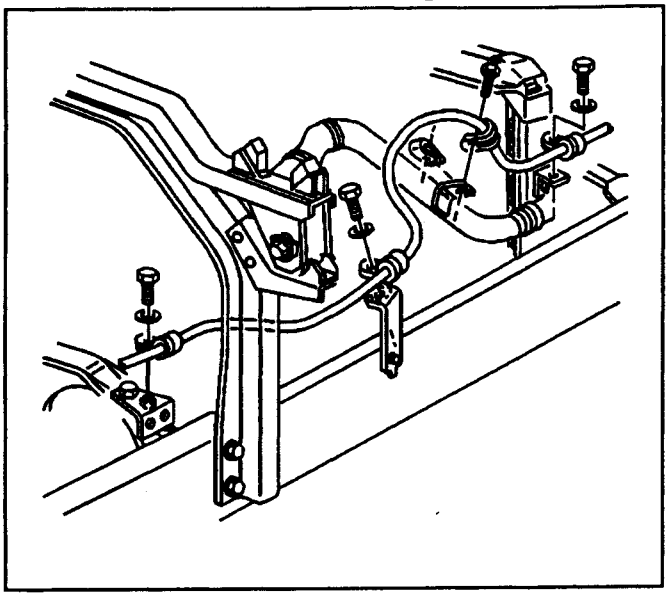
221276

Cable Mounting to the Cab



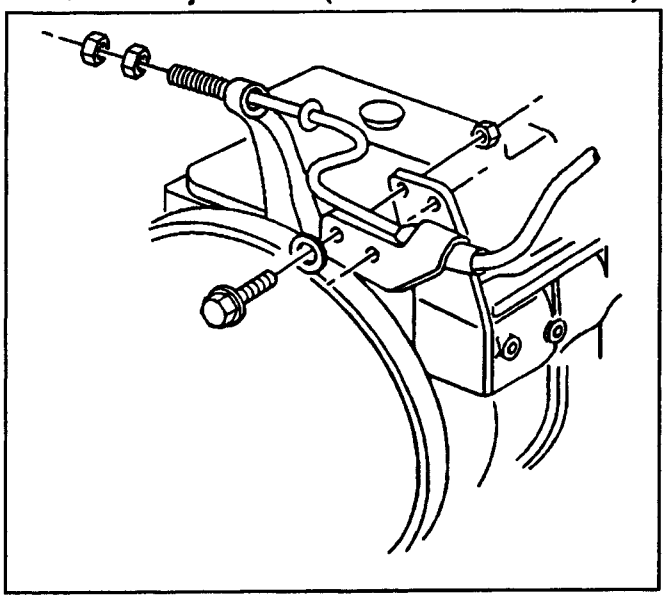
221277

Cable Routing



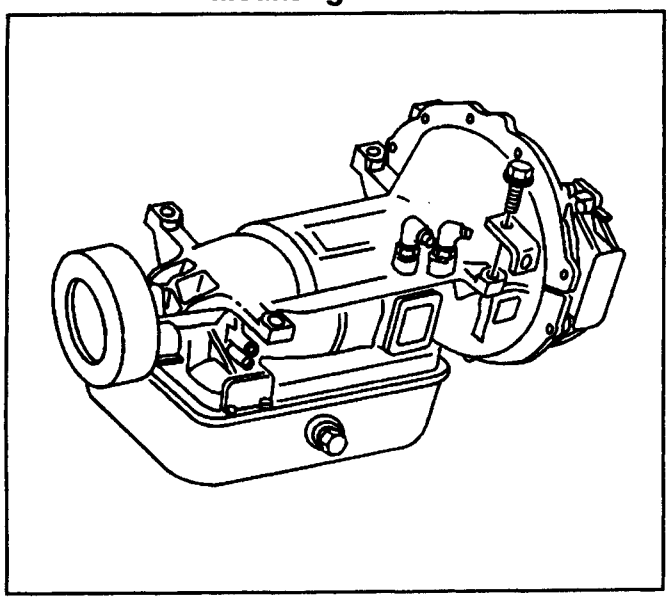
229417

Bracket Adjustment (Manual Transmission)



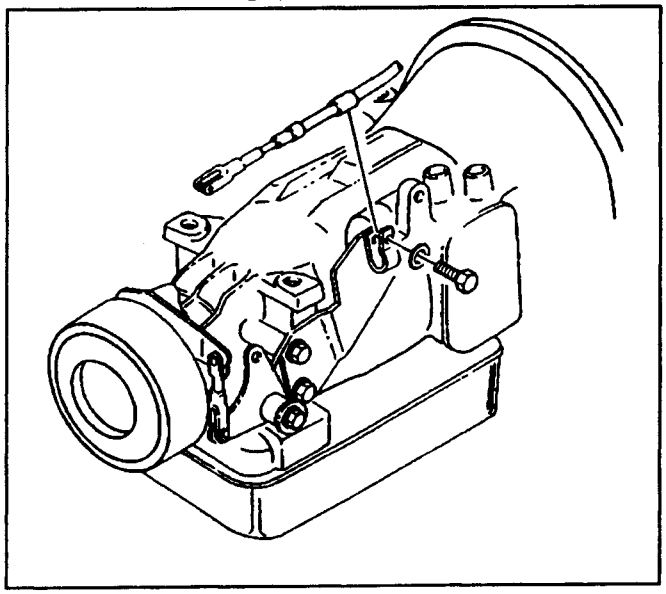
229422

Mounting Bracket



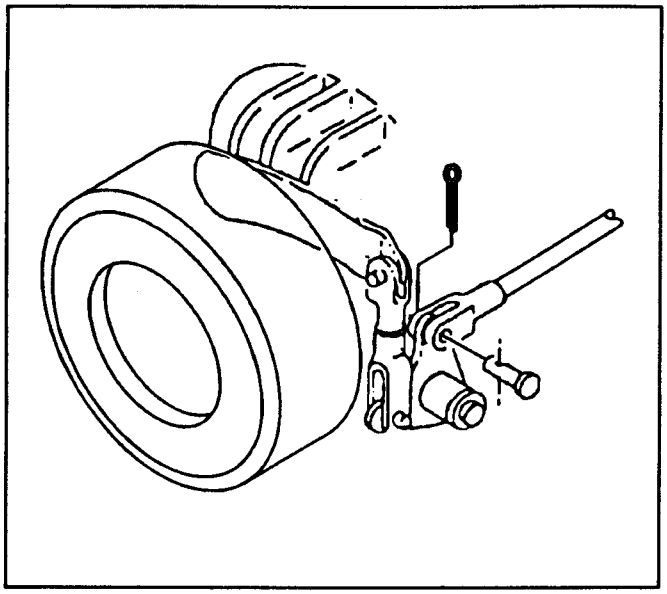
229421

Cable Mounting (Automatic Transmission)



221282

Bracket Adjustment (Automatic Transmission)



199944

A cable connects the lever to the propeller shaft-mounted parking brake. Coated parking brake cable assemblies are used on these vehicles. The wire strand is coated with a nylon material that slides through plastic seals inside the conduit end fittings. The nylon material protects the cable from corrosion and reduces parking brake effort.

Notice: Handling of the parking brake cables during service requires extra care. Damage to the nylon coating reduces the corrosion protection. If the damaged area passes through the seal, increased parking brake effort could result. Avoid contacting the coating with sharp-edged tools, or the sharp surfaces of the vehicle underbody.

In order to prevent damage to the threaded parking brake adjusting rod when servicing the parking brake, complete the following steps:

- Before turning the adjusting yoke, clean the exposed threads on each side of the yoke.
- Lubricate the threads of the adjusting rod before turning the yoke.

Brake Lamp

The BRAKE warning lamp on the instrument cluster turns ON when you apply the parking brake. The BRAKE lamp can also be turned ON by the switch in the combination valve and the antilock brake system.

Parking Brake Switch

The parking brake switch is located on the lever assembly. The switch turns ON the BRAKE lamp when you apply the parking brake and turns OFF the BRAKE lamp when you release the parking brake.

Daytime Running Lamps

This vehicle uses a daytime running lamp (DRL) system. This system uses the parking brake switch in order to turn OFF the DRL when the ignition switch is ON and the parking brake is applied. Refer to *DRL Circuit Description* in Body and Accessories for more information on DRL.

Park Brake System Operation

Push in on the dash park brake switch in order to release the park brake. The Park Brake Control Module (PBCM) turns ON the park brake pump motor in order to supply hydraulic pressure to the park brake actuator. The park brake actuator has a large spring on the inside that applies the park brake. When running, the park brake pump motor supplies hydraulic pressure behind a piston in the actuator which overcomes opposing spring tension. The actuator moves when the spring compresses. This movement transfers over to the park brake through the park brake cable.

The pump shuts OFF after the park brake is released. The PBCM then monitors the system pressure. The PBCM turns ON the pump in order to maintain the system pressure if the pressure drops too low.

The park brake solenoid is de-energized when the dash park brake switch is pulled out. This allows the fluid to dump back into the hydraulic reservoir. The spring tension in the actuator moves against the piston as the pressure drops. The actuator applies the park brake through the movement of the park brake cable.

Vehicles with a steering column-mounted transmission shifter include a feature that applies the park brake when the shifter is placed in the PARK position. This feature operates in conjunction with the dash park brake switch to apply the park brake.

Air Brakes

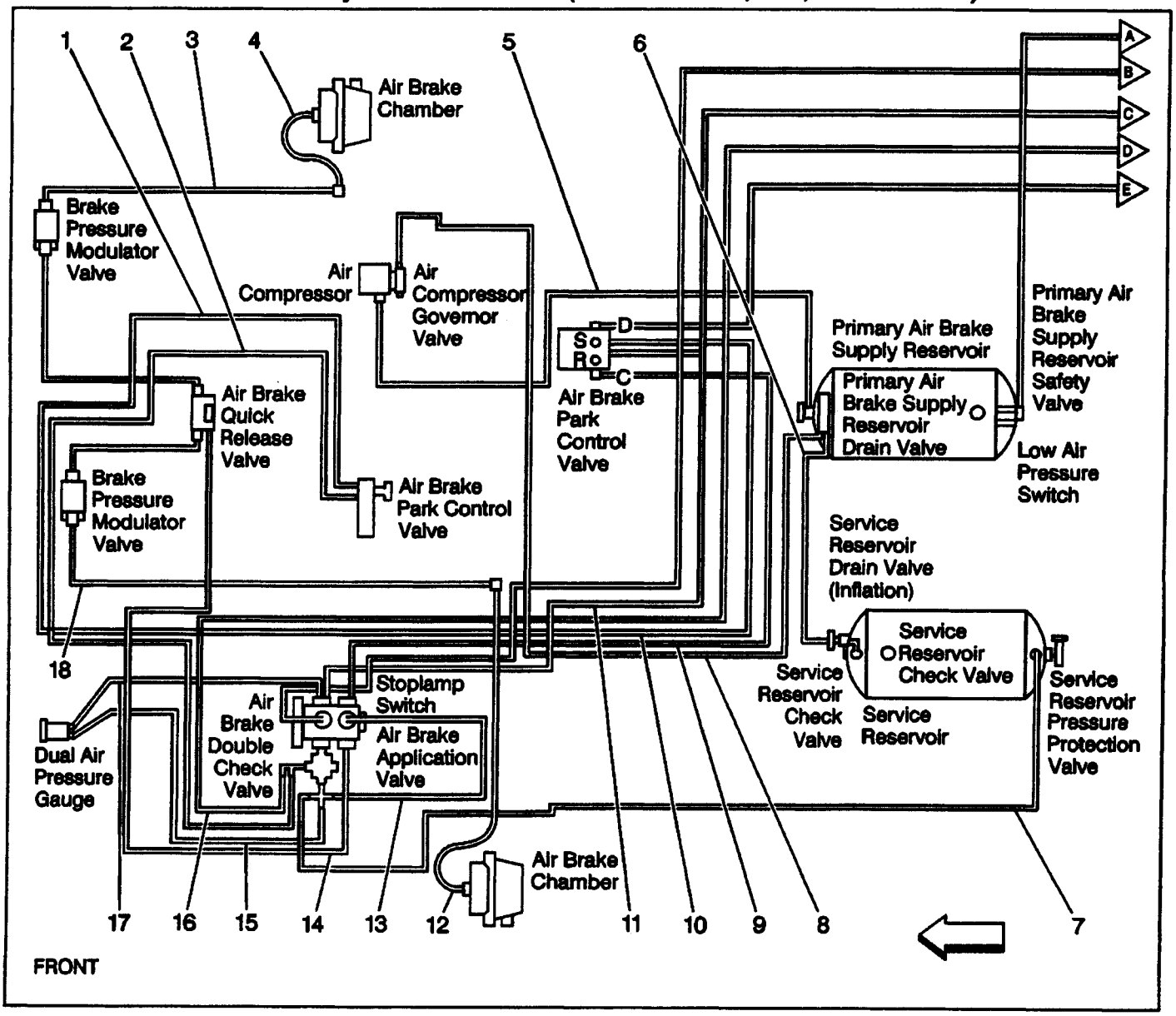
Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Air Dryer Delivery Port Elbow*	35 N·m	26 lb ft
Air Dryer Governor Port Elbow*	20 N·m	15 lb ft
Air Dryer Nut	45 N·m	33 lb ft
Air Dryer Supply Port Elbow*	35 N·m	26 lb ft
Air Reservoir Plug (All)	50 N·m	37 lb ft
Air Reservoir Support Bolt	53 N·m	39 lb ft
Brake Pedal Bracket Bolt (6 mm)	8 N·m	71 lb in
Brake Pedal Bracket Bolt (8 mm)	19 N·m	14 lb ft
Brake Pedal Joint Lock Nut	62 N·m	46 lb ft
Double Check Valve	28 N·m	21 lb ft
Dual Application Valve Mounting Bolt	40 N·m	29 lb ft
Elbow* (Air Brake Coupling Stud Nut)	20 N·m	15 lb ft
Inflation Valve	20 N·m	15 lb ft
Low Air Pressure Switch	12 N·m	106 lb in
Park Control Valve Nut (Cab Mounted)	6 N·m	53 lb in
Park Control Valve Nut (Chassis Mounted)	22 N·m	16 lb ft
Parking Control Valve Nut	6 N·m	53 lb in
Pressure Protection Valve	30 N·m	22 lb ft
Quick Release Valve (Double Check Type) Bolt	52 N·m	38 lb ft
Quick Release Valve Nut	22 N·m	16 lb ft
Relay Valve Bolt	52 N·m	38 lb ft
Relay Valve (Double Check Type) Bolt	52 N·m	38 lb ft
Reservoir Drain Valve	50 N·m	37 lb ft
Reservoir Drain Valve (Manual Type)	50 N·m	37 lb ft
Safety Valve	30 N·m	22 lb ft
Single Check Valve	50 N·m	37 lb ft
Stoplamp Switch	11 N·m	97 lb in
Strap Nut (All except Rear Axle)	28 N·m	21 lb ft
Strap Nut (Rear Axle)	23 N·m	17 lb ft
Stud Nut	45 N·m	33 lb ft
Towing Vehicle Protection Valve	22 N·m	16 lb ft
Trailer Air Brake Control Valve Bolt	40 N·m	29 lb ft
Trailer Air Brake Coupling	35 N·m	26 lb ft
Trailer Air Brake Dummy Coupling Nut	30 N·m	22 lb ft
Trailer Air Brake Stoplamp Switch	7 N·m	62 lb in
*Tighten the elbow to the specified torque, and then rotate a maximum of 360 degrees until the proper orientation is achieved.		

Schematic and Routing Diagrams

Air Brake System Schematics (F6/7B042 RQ2, JE4, JE5 w/o JYV)



283080

Legend

(1) Front Air Brake Chamber to Front Air Brake Chamber Supply Tube Elbow (Black) O.D. 19 mm, 0.750 in

(2) Air Brake Park Control Valve Supply Tube Connector to Air Brake Park Control Valve (I/P Mounted) (Blue) O.D. 16 mm, 0.625 in

(3) Front Brake Pressure Modulator Valve to Front Air Brake Chamber supply Tube Elbow (Black) O.D. 13 mm, 0.50 in

(4) Front Air Brake Chamber to Front Air Brake Chamber Supply Tube Elbow (Black) O.D. 19 mm, 0.750 in

(5) Air Compressor to Primary Air Brake Supply Reservoir (Copper) O.D. 16 mm, 0.625 in

(6) Primary Air Brake Supply Reservoir to Front Axle Service Reservoir (Black) O.D. 13 mm, 0.50 in

(7) Air Brake Double Check Valve to Front Axle Service Reservoir (Blue) O.D. 13 mm, 0.50 in

(8) Air Compressor Governor Valve to Primary Air Brake Supply Reservoir (Black) O.D. 10 mm, 0.375 in

(9) Air Brake Application Valve to Air Brake Park Control Valve (Chassis Mounted) (Blue) O.D. 6 mm, 0.250 in

(10) Air Brake Park Control Valve (Chassis Mounted) to Air Brake Park Control Valve (I/P Mounted) Delivery Tube Connector (Red) O.D. 10 mm, 0.375 in

(11) Air Brake Application Valve to Air Brake Park Control Valve (Chassis Mounted) (Green) O.D. 13 mm, 0.50 in

(12) Front Air Brake Chamber to Front Air Brake Chamber Supply Tube Elbow (Black) O.D. 19 mm, 0.750 in

(13) Air Brake Application Valve to Air Brake Double Check Valve (Blue) O.D. 13 mm, 0.50 in

(14) Air Brake Application Valve to Front Air Brake Quick Release Valve (Blue) O.D. 13 mm, 0.50 in

(15) Air Brake Double Check Valve to Dual Air Pressure Gauge (Blue) O.D. 6 mm, 0.250 in

(16) Air Brake Double Check Valve to Air Brake Park Control Valve (I/P Mounted) Supply Tube Connector (Brown) O.D. 10 mm, 0.375 in

(17) Air Brake Application Valve to Dual Air Pressure Gauge (Green) O.D. 6 mm, 0.250 in

(18) Front Brake Pressure Modulator Valve to Front Air Brake Chamber supply Tube Elbow (Black) O.D. 13 mm, 0.50 in

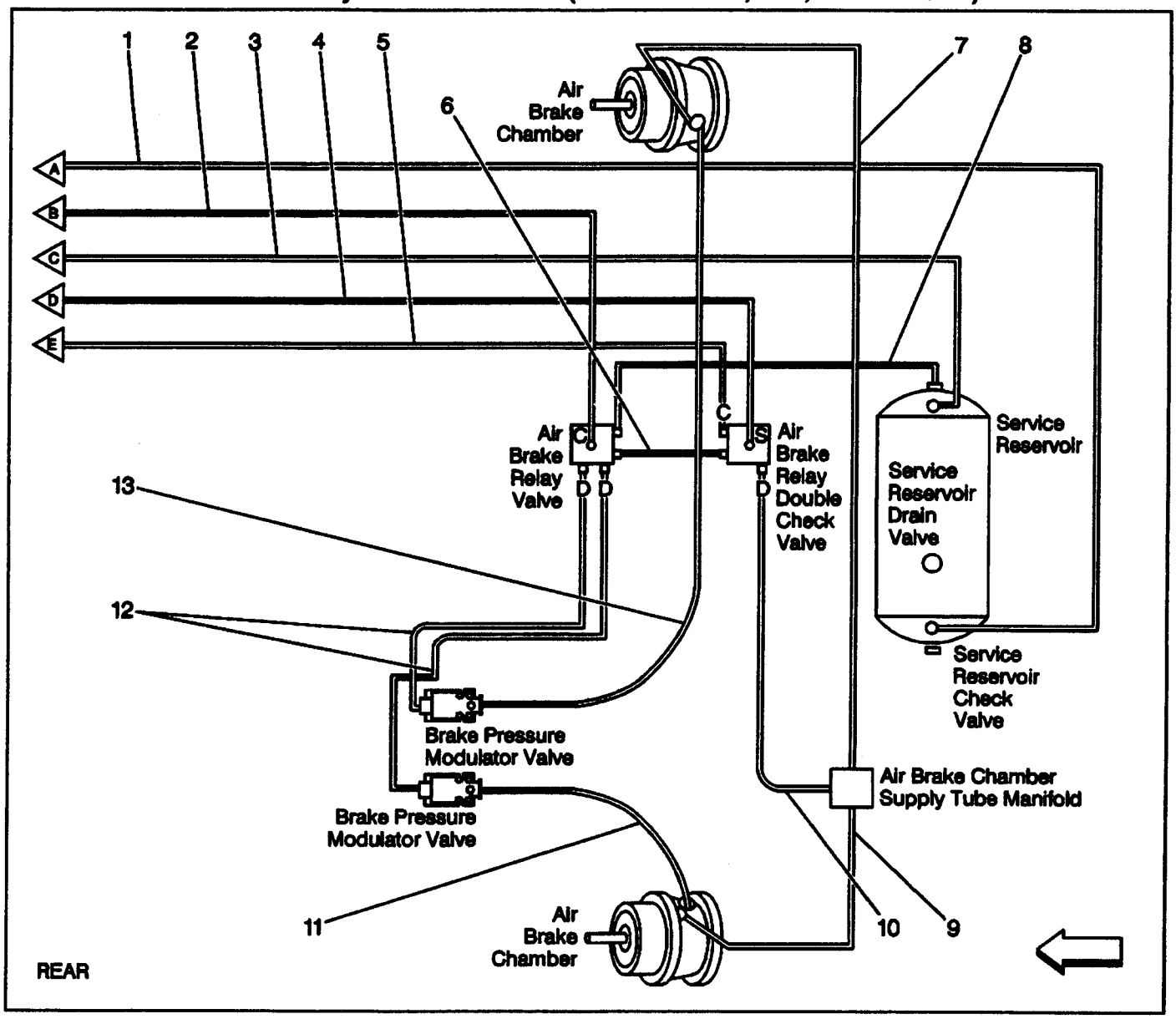
(c) Control Port

(d) Delivery Port

(r) Rear Reservoir Port

(s) Supply Port

Air Brake System Schematics (F6/7B042 RQ2, JE4, JE5 w/o JYV)



Legend

(1) Primary Air Brake Supply Reservoir to Rear Axle Service Reservoir (Black) O.D. 13 mm, 0.50 in

(2) Air Brake Application Valve to Rear Air Brake Relay Valve (Green) O.D. 13 mm, 0.50 in

(3) Rear Axle Service Reservoir to Air Brake Park Control Valve (Chassis Mounted) (Green) O.D. 13 mm, 0.50 in

(5) Air Brake Double Check Valve to Rear Air Brake Relay Double Check Valve (Red) O.D. 13 mm, 0.50 in

(6) Air Brake Park Control Valve (Chassis Mounted) to Air Brake Relay Double Check Valve (Black) O.D. 10 mm, 0.375 in

(7) Rear Air Brake Chamber Supply Tube Manifold to Rear Air Brake Chamber (Service Port) (Red) O.D. 13 mm, 0.50 in

(8) Rear Air Brake Relay Valve to Rear Axle Service Reservoir (Green) O.D. 13 mm, 0.50 in

(9) Rear Air Brake Chamber Supply Tube Manifold to Rear Air Brake Chamber (Service Port) (Red) O.D. 13 mm, 0.50 in

(10) Rear Air Brake Quick Release Double Check Valve to Rear Air Brake Chamber Supply Tube Manifold (Black) O.D. 27 mm, 1.06 in

(11) Rear Brake Pressure Modulator Valve to Rear Air Brake Chamber (Emergency Port) (Black) O.D. 27 mm, 1.06 in

(12) Rear Air Brake Relay Valve to Rear Brake Pressure Modulator Valve (Green) O.D. 19 mm, 0.750 in

(13) Rear Brake Pressure Modulator Valve to Rear Air Brake Chamber (Emergency Port) (Black) O.D. 27 mm, 1.06 in

(c) Control Port

(c1) Control Port

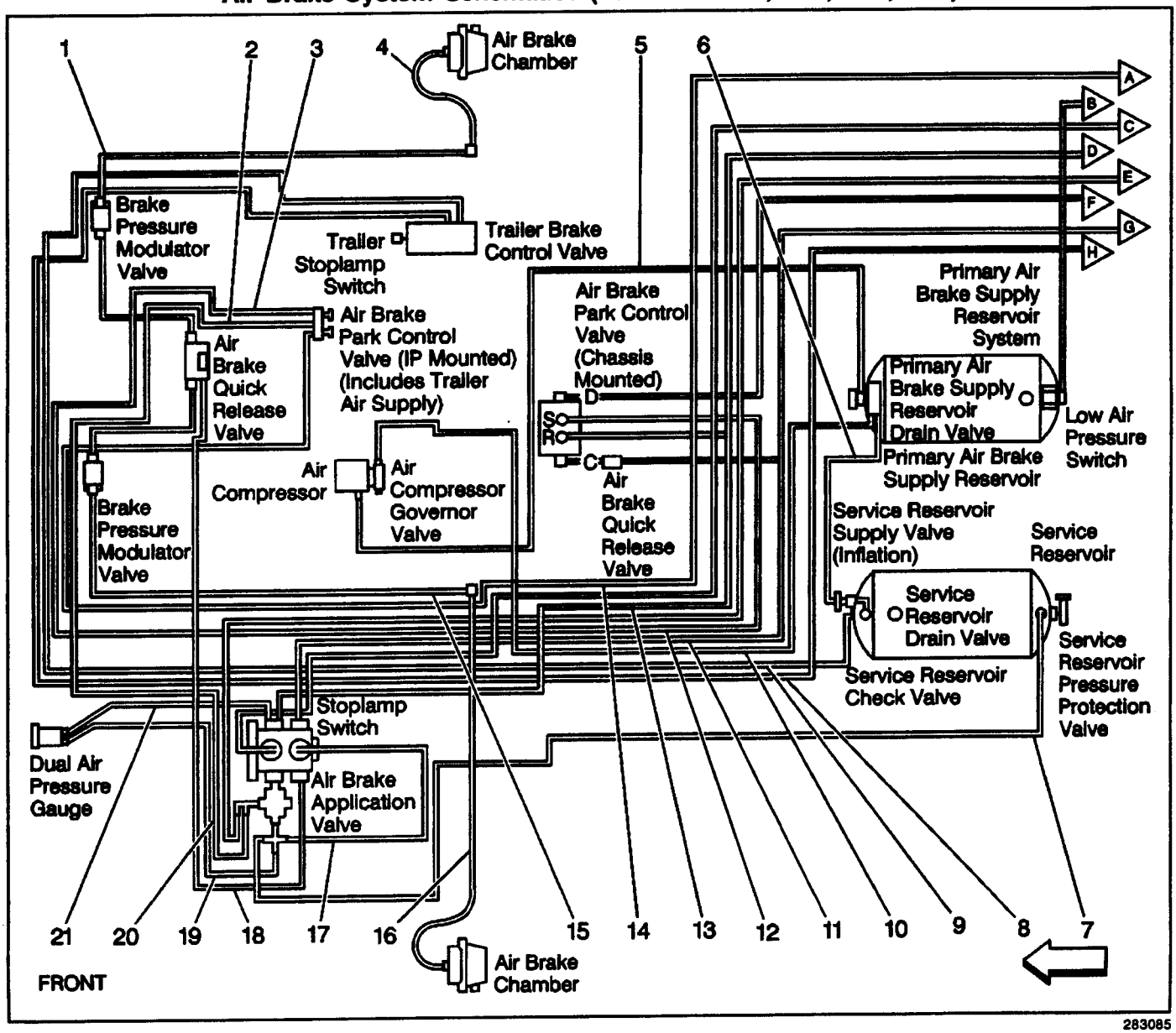
(d) Delivery Port

(d1) Delivery Port

(d2) Delivery Port

(s) Supply Port

Air Brake System Schematics (F6/7B042 RQ2, JE4, JE5, JYV)



283085

Legend

(1) Front Brake Pressure Modulator Valve to Front Air Brake Chamber Supply Tube Elbow (Black) O.D. 13 mm, 0.50 in

(2) Air Brake Park Control Valve Supply Tube Connector to Air Brake Park Control Valve (I/P Mounted) (Blue) O.D. 16 mm, 0.625 in

(3) Air Brake Park Control Valve Delivery Tube Connector to Air Brake Park Control Valve (I/P Mounted) (Orange) O.D 16 mm, 0.625 in

(4) Front Air Brake Chamber to Front Air Brake Chamber Supply Tube Elbow (Black) O.D. 19 mm, 0.750 in

(5) Air Compressor to Primary Air Brake Supply Reservoir (Copper) O.D. 16 mm, 0.625 in

(6) Primary Air Brake Supply Reservoir to Front Axle Service Reservoir (Black) O.D. 13 mm, 0.50 in

(7) Air Brake Double Check Valve to Front Axle Service Reservoir (Blue) O.D. 13 mm, 0.50 in

(8) Trailer Brake Control Valve Delivery Tube Connector to Air Brake Towing Vehicle Protection Valve (Yellow) O.D. 10 mm, 0.375 in

(9) Front Axle Service Reservoir to Trailer Brake Control Valve Supply Tube Connector (Blue) O.D 10 mm, 0.375 in

(10) Air Compressor Governor Valve to Primary Air Brake Supply Reservoir (Black) O.D. 10 mm, 0.375 in

(11) Air Brake Application Valve to Air Brake Park Control Valve (Chassis Mounted) (Blue) O.D. 6 mm, 0.250 in

(12) Air Brake Park Control Valve (Chassis Mounted) to Air Brake Park Control Valve (I/P Mounted) Delivery Tube Connector (Red) O.D. 10 mm, 0.375 in

(13) Air Brake Application Valve to Air Brake Park Control Valve (Chassis Mounted) (Green) O.D. 13 mm, 0.50 in

(14) Trailer Air Supply Tube Connector to Air Brake Towing Vehicle Protection Valve (Yellow) O.D. 10 mm, 0.375 in

(15) Front Brake Pressure Modulator Valve to Front Air Brake Chamber Supply Tube Elbow (Black) O.D. 13 mm, 0.50 in

(16) Front Air Brake Chamber to Front Air Brake Chamber Supply Tube Elbow (Black) O.D. 19 mm, 0.750 in

(17) Air Brake Application Valve to Air Brake Park Control Valve (Chassis Mounted) (Blue) O.D. 6 mm, 0.250 in

(18) Air Brake Application Valve to Front Air Brake Quick Release Valve (Blue) O.D. 13 mm, 0.50 in

(19) Air Brake Double Check Valve to Dual Air Pressure Gauge (Blue) O.D. 6 mm, 0.250 in

(20) Air Brake Double Check Valve to Air Brake Park Control Valve (I/P Mounted) Supply Tube Connector (Brown) O.D. 10 mm, 0.375 in

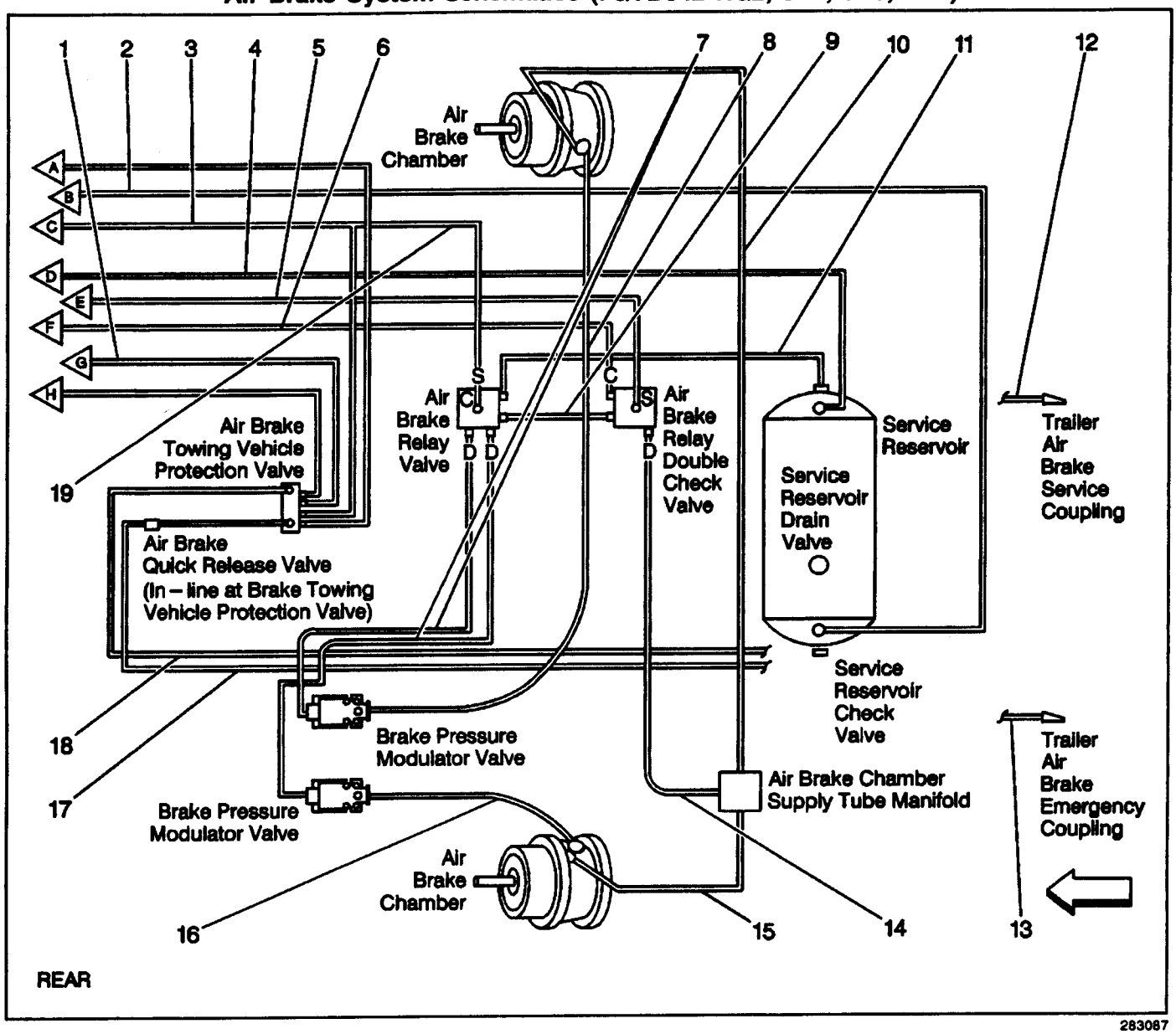
(21) Air Brake Application Valve to Dual Air Pressure Gauge (Green) O.D. 6 mm, 0.250 in

(c) Control Port

(r) Rear Reservoir Port

(s) Supply Port

Air Brake System Schematics (F6/7B042 RQ2, JE4, JE5, JYV)



283087

Legend

(1) Park Brake Control Valve (Chassis Mounted) to Air Brake Towing Vehicle Protection Valve (Blue) O.D. 13 mm, 0.50 in

(2) Primary Air Brake Supply Reservoir to Rear Axle Service Reservoir (Black) O.D. 13 mm, 0.50 in

(3) Air Brake Application Valve to Air Brake Towing Vehicle Protection Valve (Green) O.D. 13 mm, 0.50 in

(4) Rear Axle Service Reservoir to Rear Air Brake Park Control Valve (Chassis Mounted) (Green) O.D. 13 mm, 0.50 in

(5) Air Brake Double Check Valve to Rear Air Brake Relay Double Check Valve (Red) O.D. 13 mm, 0.50 in

(6) Air Brake Park Control Valve (Chassis Mounted) to Air Brake Relay double Check Valve (Black) O.D. 10 mm, 0.375 in

(7) Rear Air Brake Relay Valve to Rear Brake Pressure Modulator Valve (Green) O.D. 19 mm, 0.750 in

(8) Rear Brake Pressure Modulator Valve to Rear Air Brake Chamber (Emergency Port) (Black) O.D. 27 mm, 1.06 in

(9) Rear Air Brake Relay Valve to Rear Air Brake Relay Double Check Valve (Green) O.D. 6 mm, 0.250 in

(10) Rear Air Brake Chamber Supply Tube Manifold to Rear Air Brake Chamber (Service Port) (Red) O.D. 13 mm, 0.50 in

(11) Rear Air Brake Relay Valve to Rear Axle Service Reservoir (Green) O.D. 13 mm, 0.50 in

(12) Air Brake Towing Vehicle Protection Valve to Trailer Air Brake Service Coupling (Blue) O.D. 13 mm, 0.50 in

(13) Rear Air Brake Quick Release Valve (In-line at Air Brake Towing Vehicle Protection Valve) to Trailer Air Brake Emergency Coupling (Red) O.D. 13 mm, 0.50 in

(14) Rear Air Brake Relay Double Check Valve to Rear Air Brake Park Chamber Supply Tube Manifold (Black) O.D. 27 mm, 1.06 in

(15) Rear Air Brake Chamber Supply Tube Manifold to Rear Air Brake Chamber (Service Port) (Red) O.D. 13 mm, 0.50 in

(16) Rear Air Brake Chamber Supply Tube Manifold to Rear Air Brake Chamber (Emergency Port) (Green) O.D. 13 mm, 0.50 in

(17) Rear Air Brake Quick Release Valve (In-line at Air Brake Towing Vehicle Protection Valve) to Trailer Air Brake Emergency Coupling (Red) O.D. 13 mm, 0.50 in

(18) Air Brake Towing Vehicle Protection Valve to Trailer Air Brake Service Coupling (Blue) O.D. 13 mm, 0.50 in

(19) Air Brake Application Valve to Air Brake Towing Vehicle Protection Valve (Green) O.D. 13 mm, 0.50 in

(c) Control Port

(c1) Control Port

(d) Delivery Port

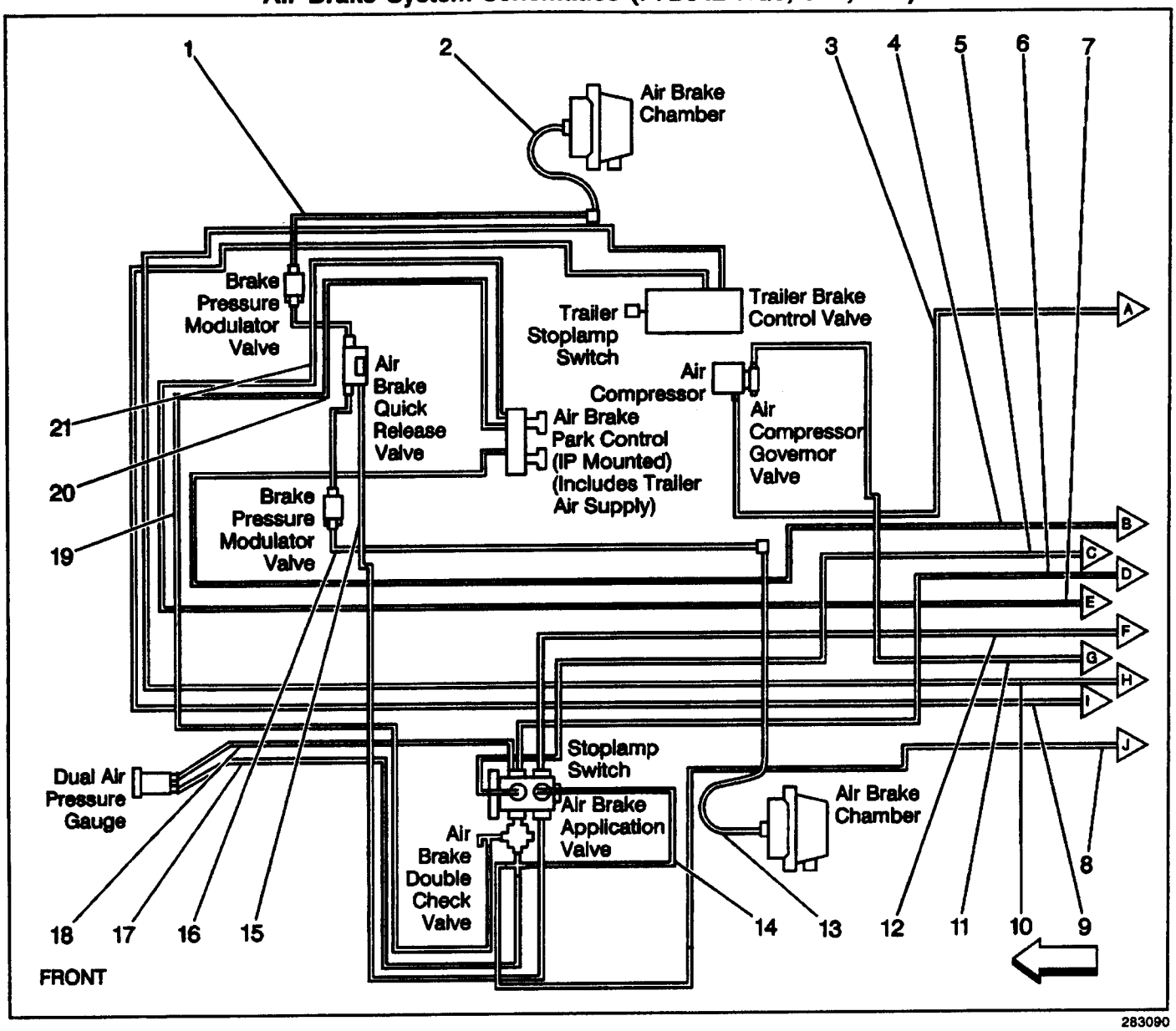
(d1) Delivery Port

(d2) Delivery Port

(s) Supply Port

(s1) Supply Port

Air Brake System Schematics (F7B042 RQ3, JE4, JE5)



Legend

(1) Front Brake Pressure Modulator Valve to Front Air Brake Chamber Supply Tube Elbow (Black) O.D. 13 mm, 0.50 in

(2) Front Air Brake Chamber to Front Air Brake Chamber Supply Tube Elbow (Black) O.D. 19 mm, 0.750 in

(3) Air Compressor to Primary Air Brake Supply Reservoir (Copper) O.D. 16 mm, 0.625 in

(4) Trailer Air Supply Tube Connector to Air Brake Towing Vehicle Protection Valve (Yellow) O.D. 10 mm, 0.375 in

(5) Air Brake Application Valve to Air Brake Towing Vehicle Protection Valve (Green) O.D. 13 mm, 0.50 in

(6) Air Brake Application Valve to Rear Axle Service Reservoir (Green) O.D. 16 mm, 0.625 in

(7) Air Brake Park Control Valve Delivery Tube Connector to Rear Air Brake Quick Release Double Check Valve (Red) O.D. 10 mm, 0.375 in

(8) Air Brake Double Check Valve to Front Axle Service Reservoir (Blue) O.D. 13 mm, 0.50 in

(9) Trailer Brake Control Valve Delivery Tube Connector to Air Brake Towing Vehicle Protection Valve (Yellow) O.D. 13 mm, 0.50 in

(10) front Axle Service Reservoir to Trailer Brake Control Valve Supply Tube Connector (Blue) O.D. 10 mm, 0.375 in

(11) Air Compressor Governor Valve to Primary Air Brake Supply Reservoir (Black) O.D. 10 mm, 0.375 in

(12) Air Brake Application Valve to Air Brake Towing Vehicle Protection Valve (Blue) O.D. 13 mm, 0.50 in

(13) Front Air Brake Chamber to Front Air Brake Chamber Supply Tube Elbow (Black) O.D. 19 mm, 0.750 in

(14) Air Brake Application Valve to Air Brake Double Check Valve (Blue) O.D. 13 mm, 0.50 in

(15) Air Brake Application Valve to Front Air Brake Quick Release Valve (Blue) O.D. 13 mm, 0.50 in

(16) Front Brake Pressure Modulator Valve to Front Air Brake Chamber Supply Tube Elbow (Black) O.D. 13 mm, 0.50 in

(17) Air Brake Double Check Valve to Dual Air Pressure Gauge (Blue) O.D. 6 mm, 0.250 in

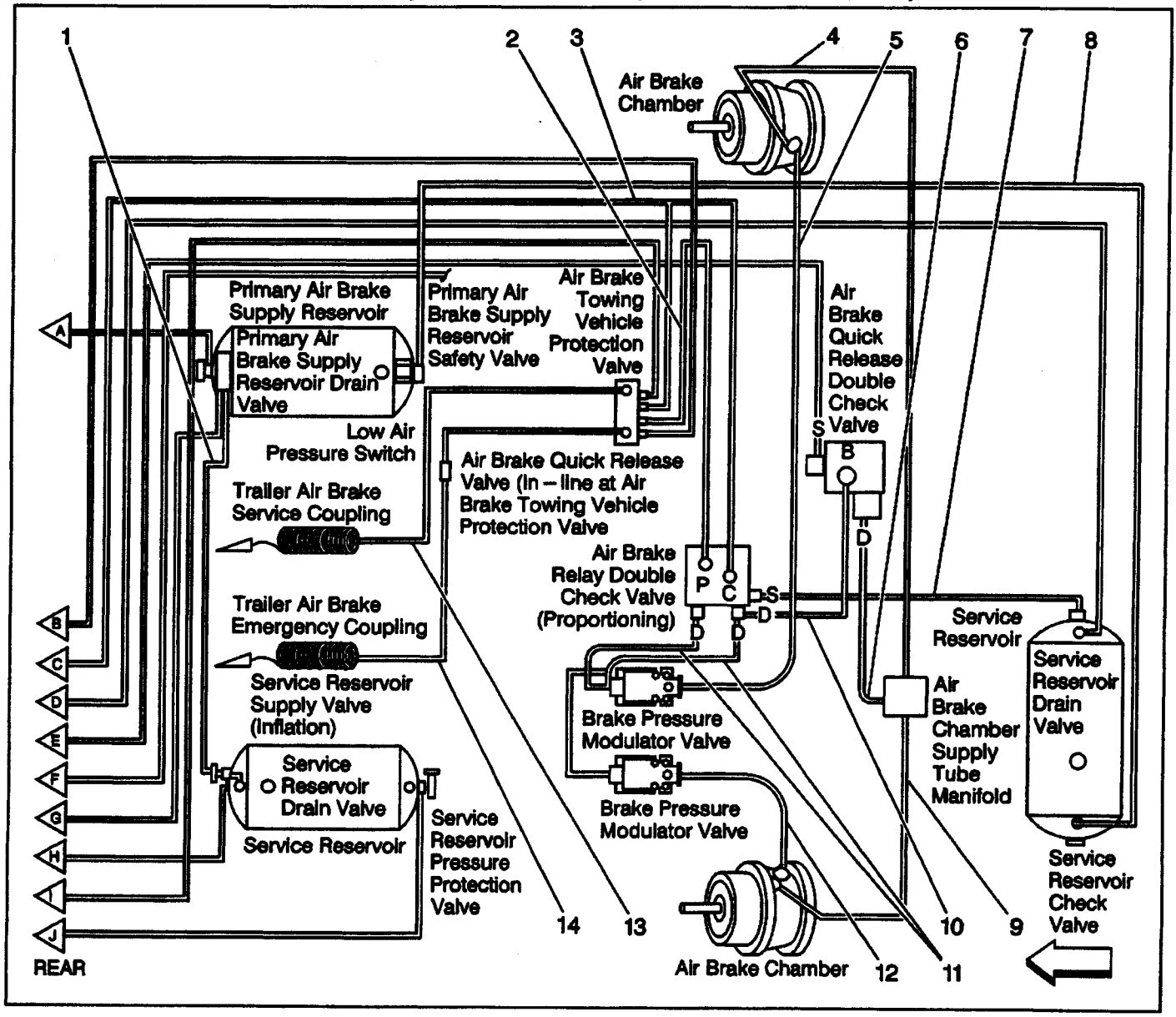
(18) Air Brake Application Valve to Dual Air Pressure Gauge (Green) O.D. 6 mm, 0.250 in

(19) Air Brake Double Check Valve to Air Brake Park Control Valve (I/P Mounted) Supply Tube Connector (Brown) O.D. 10 mm, 0.375 in

(20) Air Brake Park Control Valve Supply Tube Connector to Air Brake Park Control Valve (I/P Mounted) (Blue) O.D. 16 mm, 0.625 in

(21) Air Brake Park Control Valve Delivery Tube Connector to Air Brake Park Control Valve (I/P Mounted) (Copper) O.D. 16 mm, 0.625 in

Air Brake System Schematics (F7B042 RQ3, JE4, JE5)



283091

Legend

(1) Primary Air Brake Supply Reservoir To Front Axle Service Reservoir (Black) O.D. 13 mm, 0.50 in

(2) Air Brake Towing Vehicle Protection Valve to Rear Air Brake Relay Double Check Valve (Proportioning) (Yellow) O.D. 6 mm, 0.250 in

(3) Air Brake Towing vehicle Protection Valve to Rear Air Brake Relay Double Check Valve (Proportioning) (Green) O.D. 6 mm, 0.250 in

(4) Rear Air Brake Chamber Supply Tube Manifold to Rear Air Brake Chamber (Service Port) (Red) O.D. 13 mm, 0.50 in

(5) Rear Brake Pressure Modulator Valve to Rear Air Brake Chamber (Emergency Port) (Black) O.D. 27 mm, 1.06 in

(6) Rear Air Brake Quick Release Double Check Valve to Rear Air Brake Chamber Supply Tube Manifold (Black) O.D. 27 mm, 1.06 in

(7) Rear Air Brake Quick Release Double Check Valve to Rear Axle Service Reservoir (Green) O.D. 13 mm, 0.50 in

(8) Primary Air Brake Supply Reservoir to Rear Axle Service Reservoir (Black) O.D. 13 mm, 0.50 in

(9) Rear Air Brake Chamber Supply Tube Manifold to Rear Air Brake Chamber (Service Port) (Red) O.D. 13 mm, 0.50 in

(10) Rear Air Brake Relay Double Check Valve (Proportioning) to Rear Air Brake quick Release Double Check Valve (Green) O.D. 13 mm, 0.50 in

(11) Rear Air Brake Relay Valve to Rear Brake Pressure Modulator Valve (Green) O. D. 13 mm, 0.50 in

(12) Rear Brake Pressure Modulator Valve to Rear Air Brake Chamber (Emergency Port) (Black) O.D. 27 mm, 1.06 in

(13) Air Brake Towing Vehicle Protection Valve to Trailer Air Brake Service Coupling (Blue) O.D. 13 mm, 0.50 in

(14) Rear Air Brake Quick Release Valve (In-line at Air Brake Towing Vehicle Protection Valve) to Trailer Air Brake Emergency Coupling (Red) O.D. 13 mm, 0.50 in

(b) Balance Port

(c) Control Port

(d) Delivery Port

(d1) Delivery Port

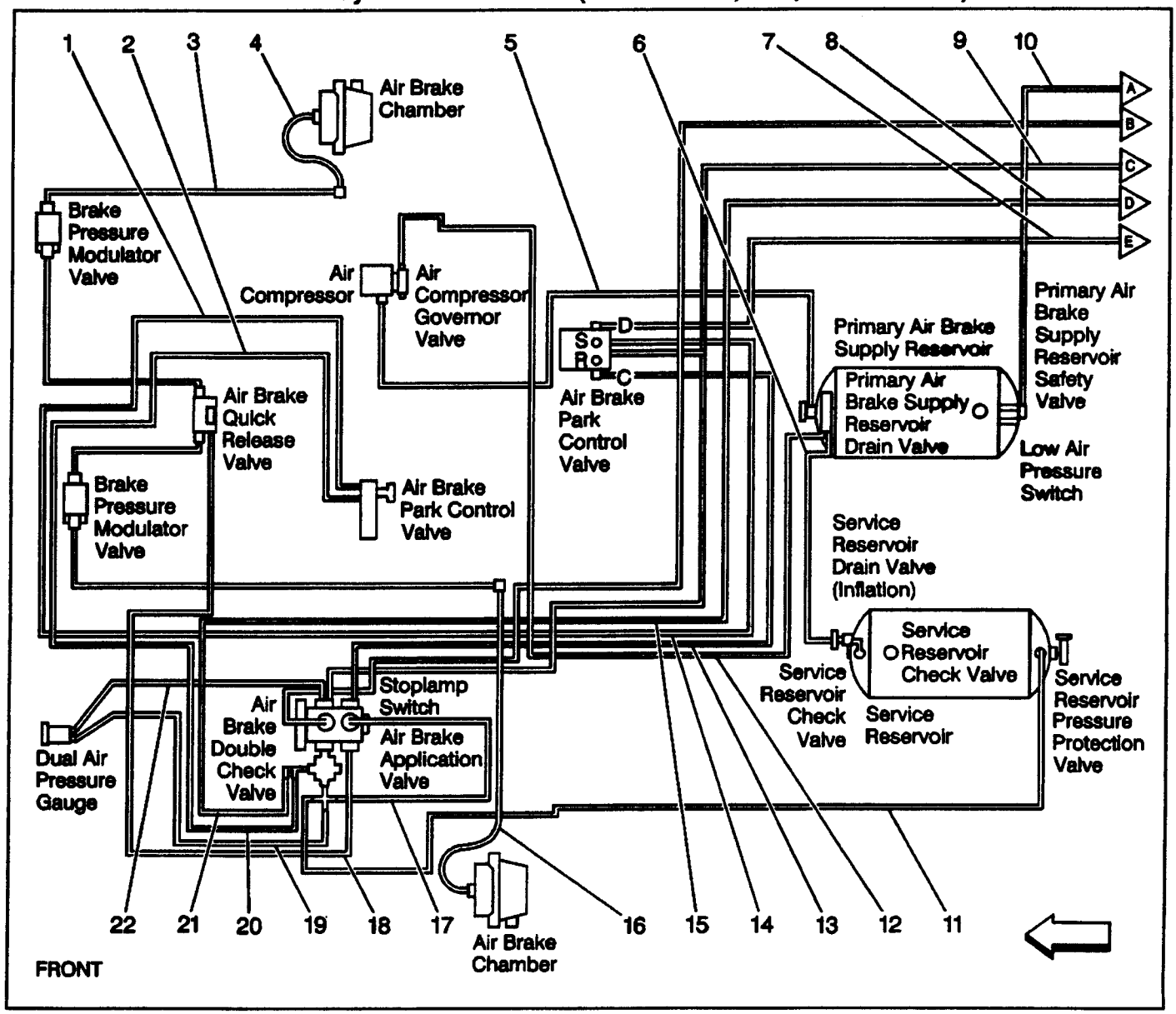
(d2) Delivery Port

(d3) Delivery Port

(s) Supply Port

(s1) Supply Port

Air Brake System Schematics (F7B064 RQ2, JE4, JE5 w/o JYV)



283082

Legend

(1) Air Brake Park Control Valve Delivery Tube Connector to Air Brake Park Control Valve (I/P Mounted) (Orange) O.D 16 mm, 0.625 in

(2) Air Brake Park Control Valve Supply Tube Connector to Air Brake Park Control Valve (I/P Mounted) (Blue) O.D. 16 mm, 0.625 in

(3) Front Brake Pressure Modulator Valve to Front Air Brake Chamber Supply Tube Elbow (Black) O.D. 13 mm, 0.50 in

(4) Front Air Brake Chamber to Front Air Brake Chamber supply Tube Elbow (Black) O.D. 19 mm, 0.750

(5) Air Compressor to Primary Air Brake Supply Reservoir (Copper) O.D. 16 mm, 0.625 in

(6) Primary Air Brake Supply Reservoir to Front Axle Service Reservoir (Black) O.D. 13 mm, 0.50 in

(7) Air Brake Park Control Valve (Chassis Mounted) to Air Brake Relay Double Check Valve (Black) O.D. 10 mm, 0.375 in

(8) Air Brake Double Check Valve to Rear Air Brake Relay Double Check Valve (Red) O.D. 13 mm, 0.50 in

(9) Air Brake Park Control Valve (Chassis Mounted) to Rear Axle Service Reservoir (Front Unit) (Green) O.D. 13 mm, 0.50 in

(10) Primary Air Brake Supply Reservoir to Rear Axle Service Reservoir (Black) O.D. 13 mm, 0.50 in

(11) Air Brake Double Check Valve to Front Axle Service Reservoir (Blue) O.D. 13 mm, 0.50 in

(12) Air Compressor Governor Valve to Primary Air Brake Supply Reservoir (Black) O.D. 10 mm, 0.375 in

(13) Air Brake Application Valve to Air Brake Park Control Valve (Chassis Mounted) (Blue) O.D. 6 mm, 0.250 in

(14) Air Brake Park Control Valve (Chassis Mounted) to Air Brake Park Control Valve (I/P Mounted) Delivery Tube Connector (Red) O.D. 10 mm, 0.375 in

(15) Air Brake Double Check Valve to Rear Air Brake Relay Double Check Valve (Red) O.D. 13 mm, 0.50 in

(16) Front Air Brake Quick Release Valve to Front Air Brake Chamber Supply Tube Elbow (Black) O.D. 19 mm, 0.750 in

(17) Air Brake Application Valve to Air Brake Double Check Valve (Blue) O.D. 13 mm, 0.50 in

(18) Air Brake Application Valve to Front Air Brake Quick Release Valve (Blue) O.D. 13 mm, 0.50 in

(19) Air Brake Double Check Valve to Dual Air Pressure Gauge (Blue) O.D. 6 mm, 0.250 in

(20) Air Brake Double Check Valve to Air Brake Park Control Valve (I/P Mounted) Supply Tube Connector (Brown) O.D. 10 mm, 0.375 in

(21) Air Brake Double Check Valve to Rear Air Brake Relay Double Check Valve (Red) O.D. 13 mm, 0.50 in

(22) Air Brake Application Valve to Dual Air Pressure Gauge (Green) O.D. 6 mm, 0.250 in

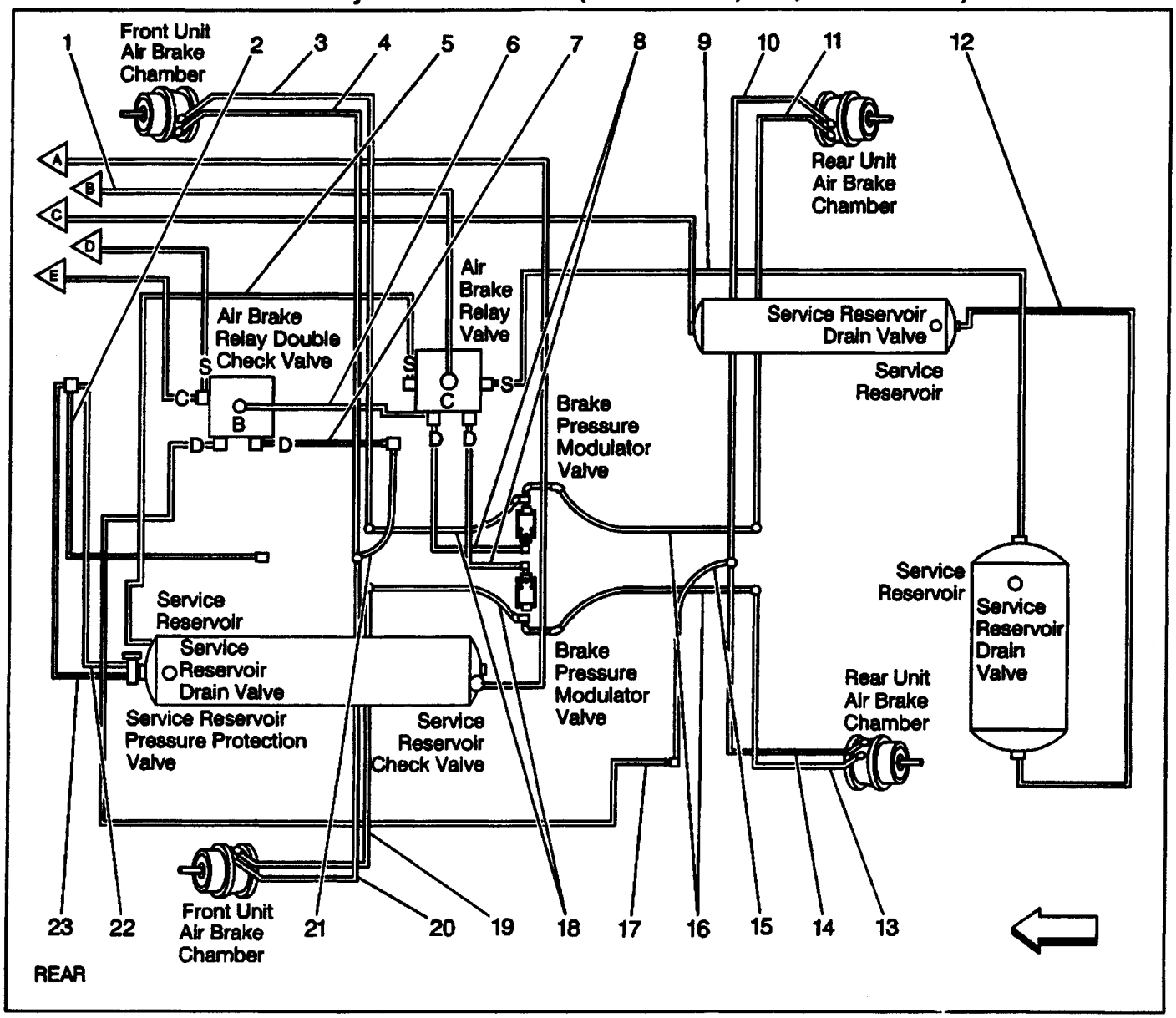
(c) Control Port

(d) Delivery Port

(r) Rear Reservoir Port

(s) Supply Port

Air Brake System Schematics (F7B064 RQ2, JE4, JE5 w/o JYV)



Legend

(1) Air Brake Application Valve to Rear Air Brake Relay Valve (Green) O.D. 10 mm, 0.375 in

(2) Differential Lock Control Valve to Rear Axle Differential Lockout Air Shift Cylinder (Black) O.D. 6 mm, 0.250 in

(3) Rear Air Brake Chamber Supply Tube Manifold to Rear Air Brake Chamber (Emergency Port) (Green) O.D. 13 mm, 0.50 in

(4) Rear Air Brake Chamber Supply Tube Manifold to Rear Air Brake Chamber (Service Port) (Red) O.D. 13 mm, 0.50 in

(5) Rear Axle Service Reservoir (Front Unit) to rear Air Brake Relay Valve (Rear Axle Front Unit) (Green) O.D. 13 mm, 0.50 in

(6) Rear Air Brake Relay Double Check Valve to Rear Air Brake Relay Valve (Rear Axle Front Unit) (Green) O.D. 6 mm, 0.250 in

(7) Rear Air Brake Relay Double Check Valve to Rear Air Brake Park Supply Tube Manifold (Rear Axle Front Unit) (Red) O.D. 19 mm, 0.750 in

(8) Rear Air Brake Relay Valve to Rear Brake Pressure Modulator Valve (Green) O.D. 19 mm, 0.750 in

(9) Rear Air Brake Relay Valve to Rear Axle Service Reservoir (Green) O.D. 13 mm, 0.50 in

(10) Rear Air Brake Chamber Supply Tube Manifold to Rear Air Brake Chamber (Service Port) (Red) O.D. 13 mm, 0.50 in

(11) Rear Air Brake Chamber Supply Tube Manifold to Rear Air Brake Chamber (Emergency Port) (Green) O.D. 13 mm, 0.50 in

(12) Rear Axle Service Reservoir (Rear Unit) to Rear Axle Service Reservoir (Green) O.D. 13 mm, 0.50 in

(13) Rear Air Brake Chamber Supply Tube Manifold to Rear Air Brake Chamber (Emergency Port) (Green) O.D. 13 mm, 0.50 in

(14) Rear Air Brake Chamber Supply Tube Manifold to Rear Air Brake Chamber (Service Port) (Red) O.D. 13 mm, 0.50 in

(15) Rear Air Brake Park Supply Tube Manifold to Rear Air Brake Chamber Supply Tube Manifold (Black) O.D. 27 mm, 1.06 in

(16) Rear Brake Pressure Modulator Valve to Rear Air Brake Chamber Supply Tube Manifold (Black) O.D. 27 mm, 1.06 in

(17) Rear Air Brake Relay Double Check Valve to Rear Air Brake Park Supply Tube Manifold (Rear Axle Front Unit) (Red) O.D. 19 mm, 0.750 in

(18) Rear Brake Pressure Modulator Valve to Rear Air Brake Chamber Supply Tube Manifold (Black) O.D. 27 mm, 1.06 in

(19) Rear Air Brake Chamber Supply Tube Manifold to Rear Air Brake Chamber (Emergency Port) (Green) O.D. 13 mm, 0.50 in

(20) Rear Air Brake Chamber Supply Tube Manifold to Rear Air Brake Chamber (Service Port) (Red) O.D. 13 mm, 0.50 in

(21) Rear Air Brake Park Supply Tube Manifold to Rear Air Brake Chamber Supply Tube Manifold (Black) O.D. 27 mm, 1.06 in

(22) Differential Lock Control Valve to Rear Axle Service Reservoir (Front Unit) Pressure Protection Valve (Black) O.D. 6 mm, 0.250 in

(23) Rear Axle Service Reservoir (Front Unit) Pressure Protection Valve to Differential Lock Control Valve (Black) O.D. 6 mm, 0.250 in

(c) Control Port

(c1) Control Port

(d) Delivery Port

(d1) Delivery Port

(d2) Delivery Port

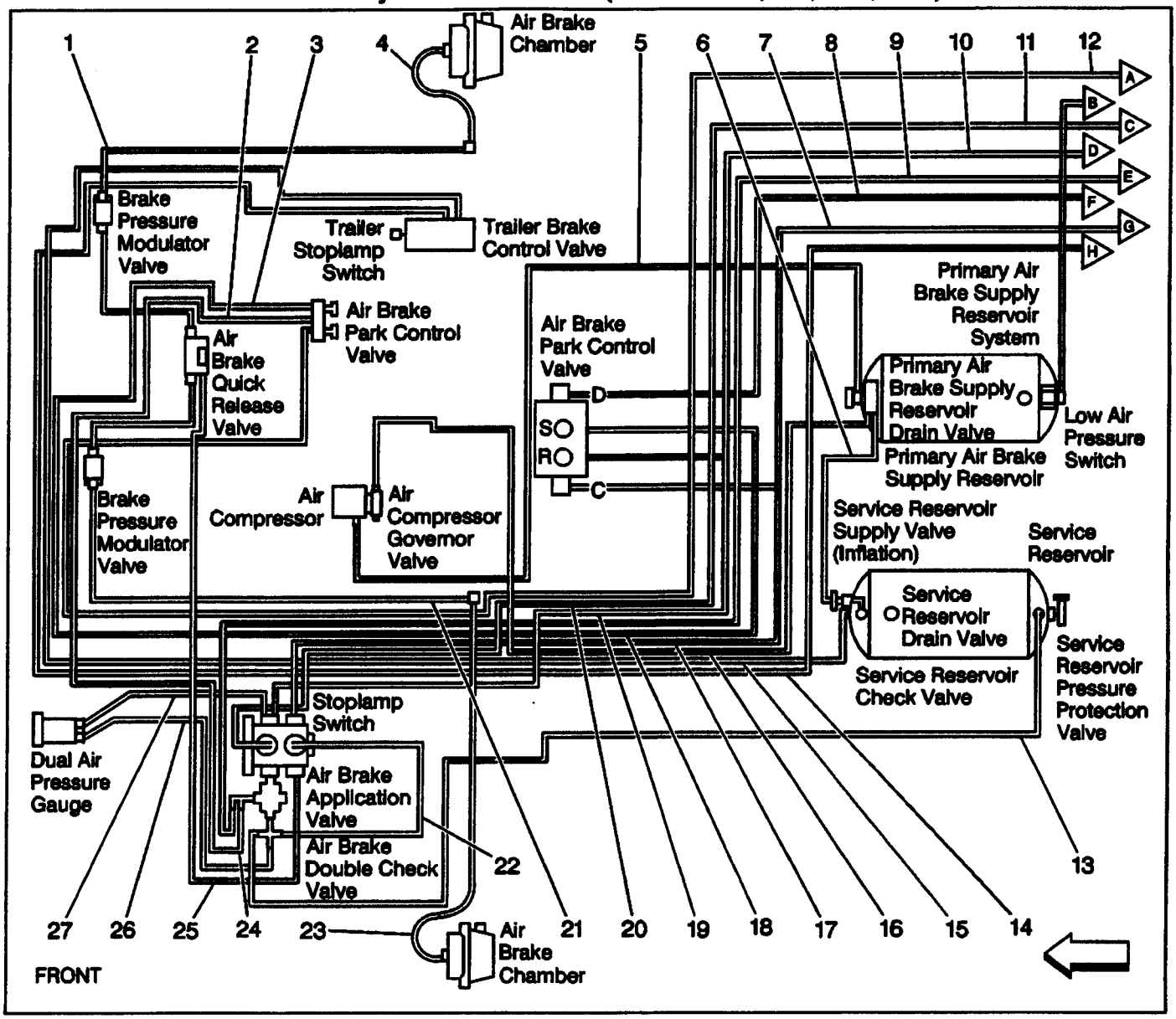
(d3) Delivery Port

(s) Supply Port

(s1) Supply Port

(s2) Supply Port

Air Brake System Schematics (F7B064 RQ2,JE4, JE5, JYV)



283088

Legend

(1) Front Brake Pressure Modulator Valve to Front Air Brake Chamber Supply Tube Elbow (Black) O.D. 13 mm, 0.50 in

(2) Air Brake Park Control Valve Supply Tube Connector to Air Brake Park Control Valve (I/P Mounted) (Blue) O.D. 16 mm, 0.625 in

(3) Air Brake Park Control Valve Delivery Tube Connector to Air Brake Park Control Valve (I/P Mounted) (Orange) O.D 16 mm, 0.625 in

(4) Front Air Brake Chamber to Front Air Brake Chamber Supply Tube Elbow (Black) O.D. 19 mm, 0.750 in

(5) Air Compressor to Primary Air Brake Supply Reservoir (Copper) O.D. 16 mm, 0.625 in

(6) Primary Air Brake Supply Reservoir to Front Axle Service Reservoir (Black) O.D. 13 mm, 0.50 in

(7) Park Brake Control Valve (Chassis Mounted) to Air Brake Towing Vehicle Protection Valve (Blue) O.D. 13 mm, 0.50 in

(8) Air Brake Park Control Valve (Chassis Mounted) to Air Brake Relay Double Check Valve (Black) O.D. 10 mm, 0.375 in

(9) Air Brake Double Check Valve to Rear Air Brake Relay Double Check Valve (Red) O.D. 13 mm, 0.50 in

(10) Air Brake Park Control Valve (Chassis Mounted) to Rear Axle Service Reservoir (Front Unit) (Green) O.D. 13 mm, 0.50 in

(11) Air Brake Application Valve to Air Brake Towing Vehicle Protection Valve (Green) O.D. 13 mm, 0.50 in

(12) Trailer Air Supply Tube Connector to air Brake Towing Vehicle Protection Valve (Yellow) O.D. 10 mm, 0.375 in

(13) Air Brake Double Check Valve to Front Axle Service Reservoir (Blue) O.D. 13 mm, 0.50 in

(14) Trailer Brake Control Valve Delivery Tube Connector to Air Brake Towing Vehicle Protection Valve (Yellow) O.D. 10 mm, 0.375 in

(15) Front Axle Service Reservoir to Trailer Brake Control Valve Supply Tube Connector (Blue) O.D. 10 mm, 0.375 in

(16) Air Compressor Governor Valve to Primary Air Brake Supply Reservoir (Black) O.D. 10 mm, 0.375 in

(17) Air Brake Application Valve to Air Brake Park Control Valve (Chassis Mounted) (Blue) O.D. 6 mm, 0.250 in

(18) Air Brake Park Control Valve (Chassis Mounted) to Air Brake Park Control Valve (I/P Mounted) Delivery Tube Connector (Red) O.D. 10 mm, 0.375 in

(19) Air Brake Application Valve to Air Brake Park Control Valve (Chassis Mounted) (Blue) O.D. 6 mm, 0.250 in

(20) Air Brake Application Valve to Air Brake Towing Vehicle Protection Valve (Green) O.D. 13 mm, 0.50 in

(21) Front Brake Pressure Modulator Valve to Front Air Brake Chamber Supply Tube Elbow (Black) O.D. 13 mm, 0.50 in

(22) Air Brake Application Valve to Air Brake Double Check Valve (Blue) O.D. 13 mm, 0.50 in

(23) Front Air Brake Chamber to Front Air Brake Chamber Supply Tube Elbow (Black) O.D. 19 mm, 0.750 in

(24) Air Brake Double Check Valve to Air Brake Park control Valve (I/P Mounted) Supply Tube Connector (Brown) O.D. 10 mm, 0.375 in

(25) Air Brake Application Valve to Front Air Brake Quick Release Valve (Blue) O.D. 13 mm, 0.50 in

(26) Air Brake Application Valve to Dual Air Pressure Gauge (Blue) O.D. 6 mm, 0.250 in

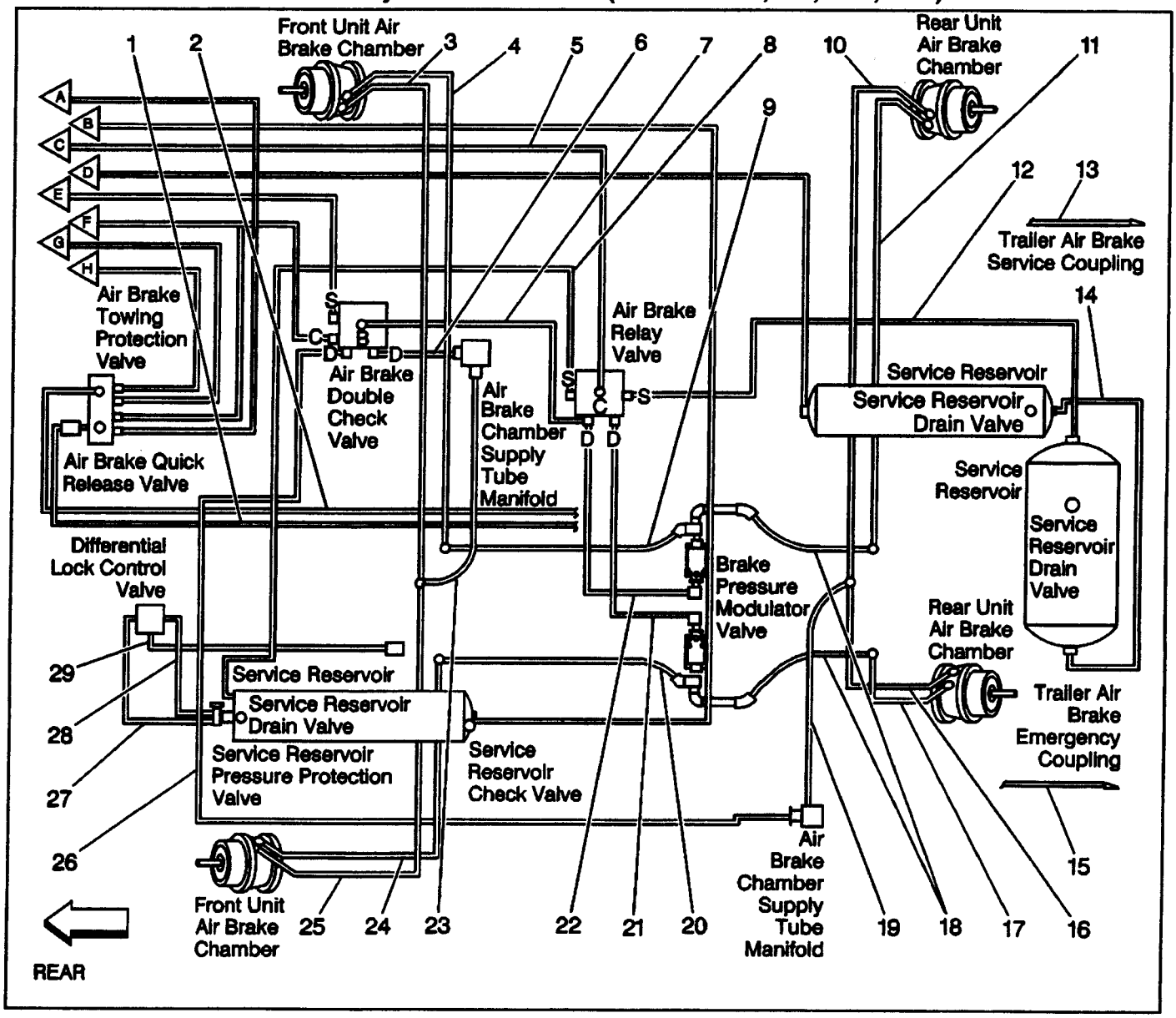
(27) Air Brake Application Valve to Dual Air Pressure Gauge (Green) O.D. 6 mm, 0.250 in

(c) Control Port

(r) Rear Reservoir Port

(s) Supply Port

Air Brake System Schematics (F7B064 RQ2,JE4, JE5, JYV)



283089

Legend

(1) Rear Air Brake Quick Release Valve (In-line at Air Brake Towing Vehicle Protection Valve) to Trailer Air Brake Emergency Coupling (Red) O.D. 13 mm, 0.50 in

(2) Air Brake Towing Vehicle Protection Valve to Trailer Air Brake Service Coupling (Blue) O.D. 13 mm, 0.50 in

(3) Rear Air Brake Chamber Supply Tube Manifold to Rear Air Brake Chamber (Service Port) (Red) O.D. 13 mm, 0.50 in

(4) Rear Air Brake Chamber Supply Tube Manifold to Rear Air Brake Chamber (Service Port) (Red) O.D. 13 mm, 0.50 in

(5) Air Brake Towing Vehicle Protection Valve to Rear Air Brake Relay Valve (Green) O.D. 13 mm, 0.50 in

(6) Rear Air Brake Relay Double Check Valve to rear Air Brake Park Supply Tube Manifold (Rear Axle Front Unit) (Red) O.D. 19 mm, 0.750 in

(8) Rear Axle Service Reservoir (Front Unit) to Rear Air Brake Relay Valve (Rear Axle Front Unit) (Green) O.D. 13 mm, 0.50 in

(9) Rear Brake Pressure Modulator Valve to Front Air Brake Chamber Supply Tube Manifold (Black) O.D. 27 mm, 1.06 in

(10) Rear Air Brake Chamber Supply Tube Manifold to Rear Air Brake Chamber (Service Port) (Red) O.D. 13 mm, 0.50 in

(11) Rear Air Brake Chamber Supply Tube Manifold To Rear Air Brake Chamber (Emergency Port) (Green) O.D. 13 mm, 0.50 in

(12) Rear Air Brake Relay Valve to Rear Axle Service Reservoir (Green) O.D. 13 mm, 0.50 in

(13) Rear Brake Pressure Valve to Rear Air Brake Chamber (Emergency Port) (Black) O.D. 27 mm, 1.06 in

(14) Rear Axle service Reservoir (Rear Unit) to Rear Axle Service Reservoir (Green) O.D. 13 mm, 0.50 in

(15) Rear Air Brake Quick Release Valve (In-line at Air Brake Towing Vehicle Protection Valve) to Trailer Air Brake Emergency Coupling (Red) O.D. 13 mm, 0.50 in

(16) Rear Air Brake Chamber Supply Tube Manifold to Rear Air Brake Chamber (Service Port) (Red) O.D. 13 mm, 0.50 in

(17) Rear Air Brake Chamber Supply Tube Manifold to Rear Air Brake Chamber (Emergency Port) (Green) O.D. 13 mm, 0.50 in

(18) Rear Park Brake Pressure Modulator Valve to rear Air Brake Chamber Supply Tube Manifold (Black) O.D. 27 mm, 1.06 in

(19) Rear Air Brake Park Supply Tube Manifold to rear Air Brake Chamber Supply Tube Manifold (Black) O.D. 27 mm, 1.06 in

(20) Rear Brake Pressure Modulator Valve to Front Air Brake Chamber Supply Tube Manifold (Black) O.D. 27 mm, 1.06 in

(21) Rear Air Brake Relay Valve to Rear Brake Pressure Modulator Valve (Green) O.D. 19 mm, 0.750 in

(22) Rear Air Brake Relay Valve to Rear Brake Pressure Modulator Valve (Green) O.D. 19 mm, 0.750 in

(23) Rear Air Brake Park Supply Tube Manifold to rear Air Brake Chamber Supply Tube Manifold (Black) O.D. 27 mm, 1.06 in

(24) Rear Air Brake Chamber Supply Tube Manifold to Rear Air Brake Chamber (Emergency Port) (Green) O.D. 13 mm, 0.50 in

(25) Rear Air Brake Chamber Supply Tube Manifold to Rear Air Brake Chamber (Service Port) (Red) O.D. 13 mm, 0.50 in

(26) Rear Air Brake Relay Double Check Valve to Rear Air Brake Park Supply Tube Manifold (Rear Axle Rear Unit) (Red) O.D. 19 mm, 0.750 in

(27) Rear Axle Service Reservoir (Front Unit) Pressure Protection Valve to Differential Lock Control Valve (Black) O.D. 6 mm, 0.250 in

(28) Differential Lock control Valve to Rear Axle Service Reservoir (Front Unit) Pressure Protection Valve (Black) O.D. 6 mm, 0.250 in

(29) Differential Lock Control Valve to Rear Axle Differential Lockout Air Shift cylinder (Black) O.D. 6 mm, 0.250 in

(b) Balance Port

(c) Control Port

(c1) Control Port

(d) Delivery Port

(d1) Delivery Port

(d2) Delivery Port

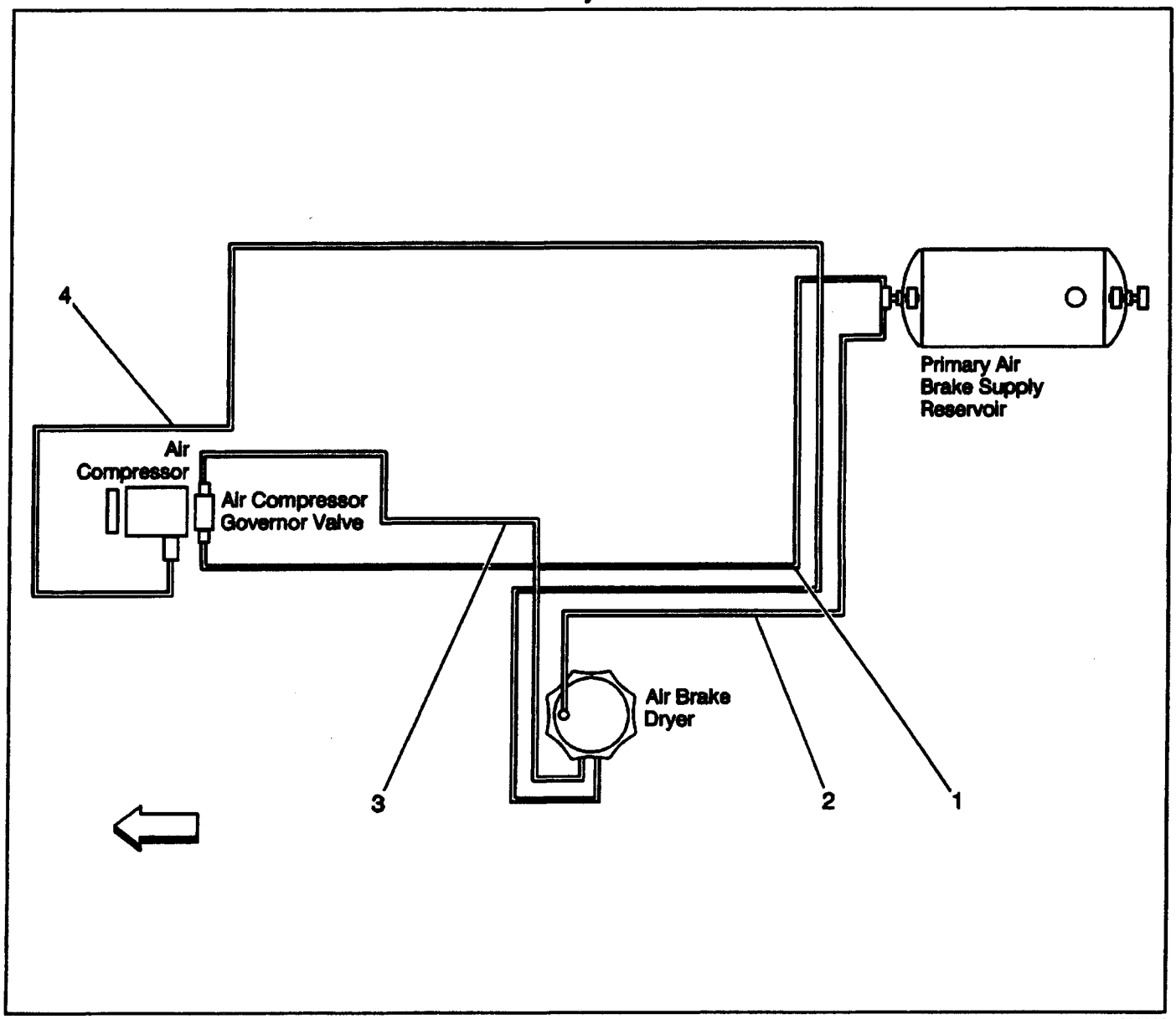
(d3) Delivery Port

(s) Supply Port

(s1) Supply Port

(s2) Supply Port

Air Brake Dryer Schematic



Legend

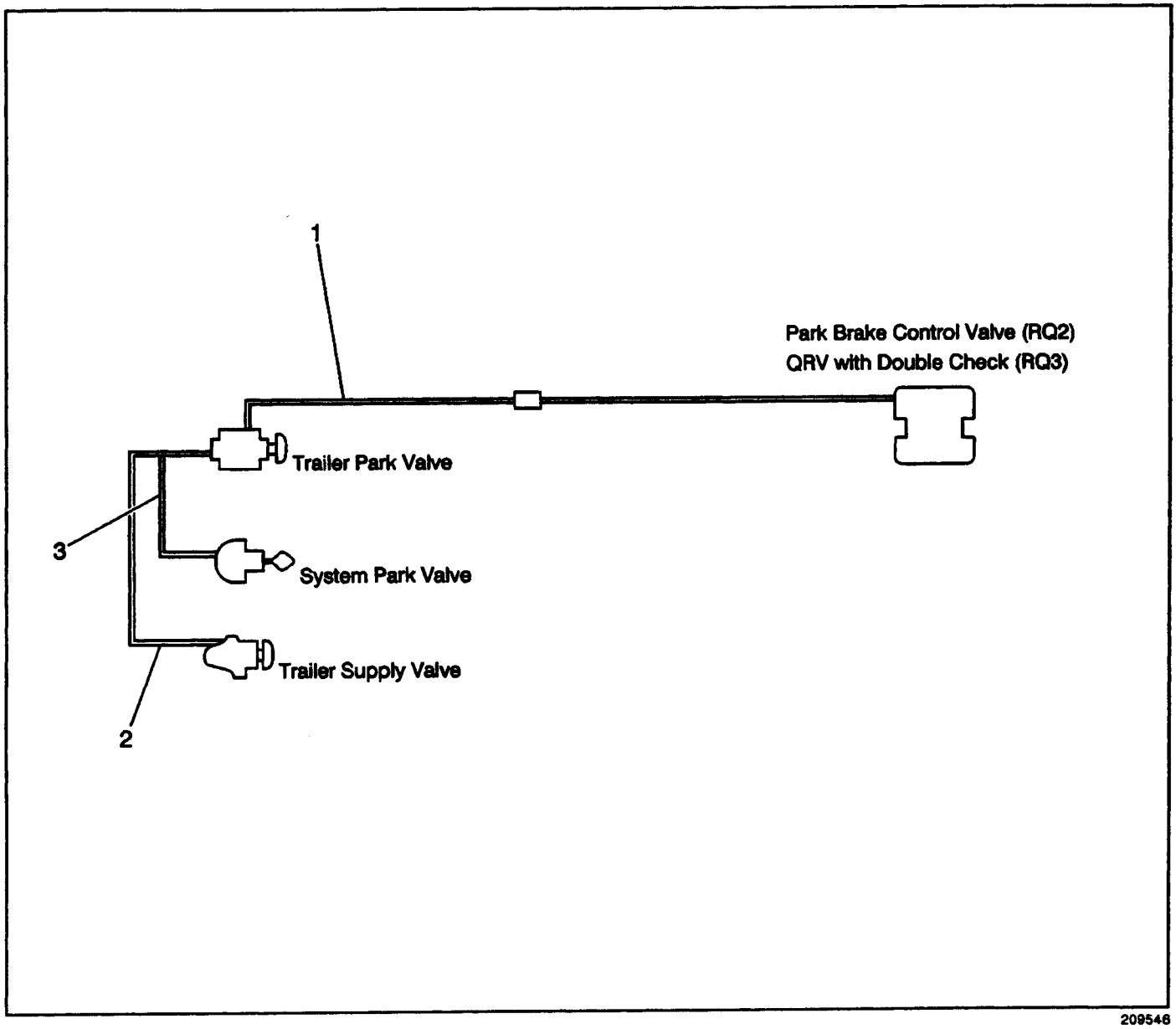
(1) Air Line (Air Compressor Governor Valve to Primary Air Brake Supply Reservoir)

(2) Air Line (Air Brake Dryer to Primary Air Brake Supply Reservoir)

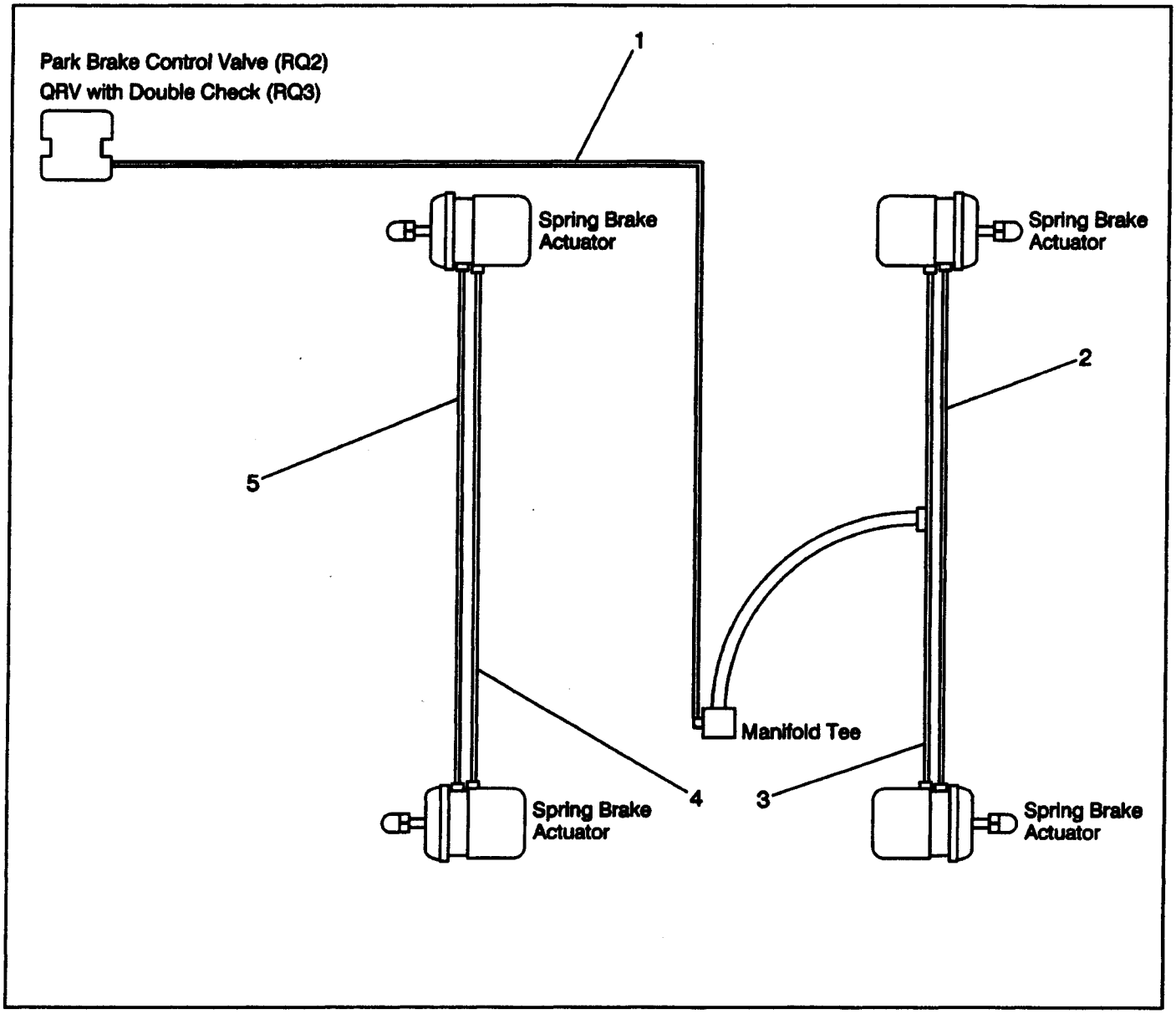
(3) Air Line (Air Compressor Governor Valve to Air Brake Dryer)

(4) Air Line (Air Compressor to Air Brake Dryer)

Air Brake Park Brake Control Schematic



Air Brake Park Brake Schematic

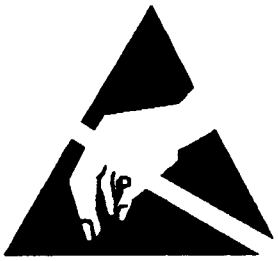


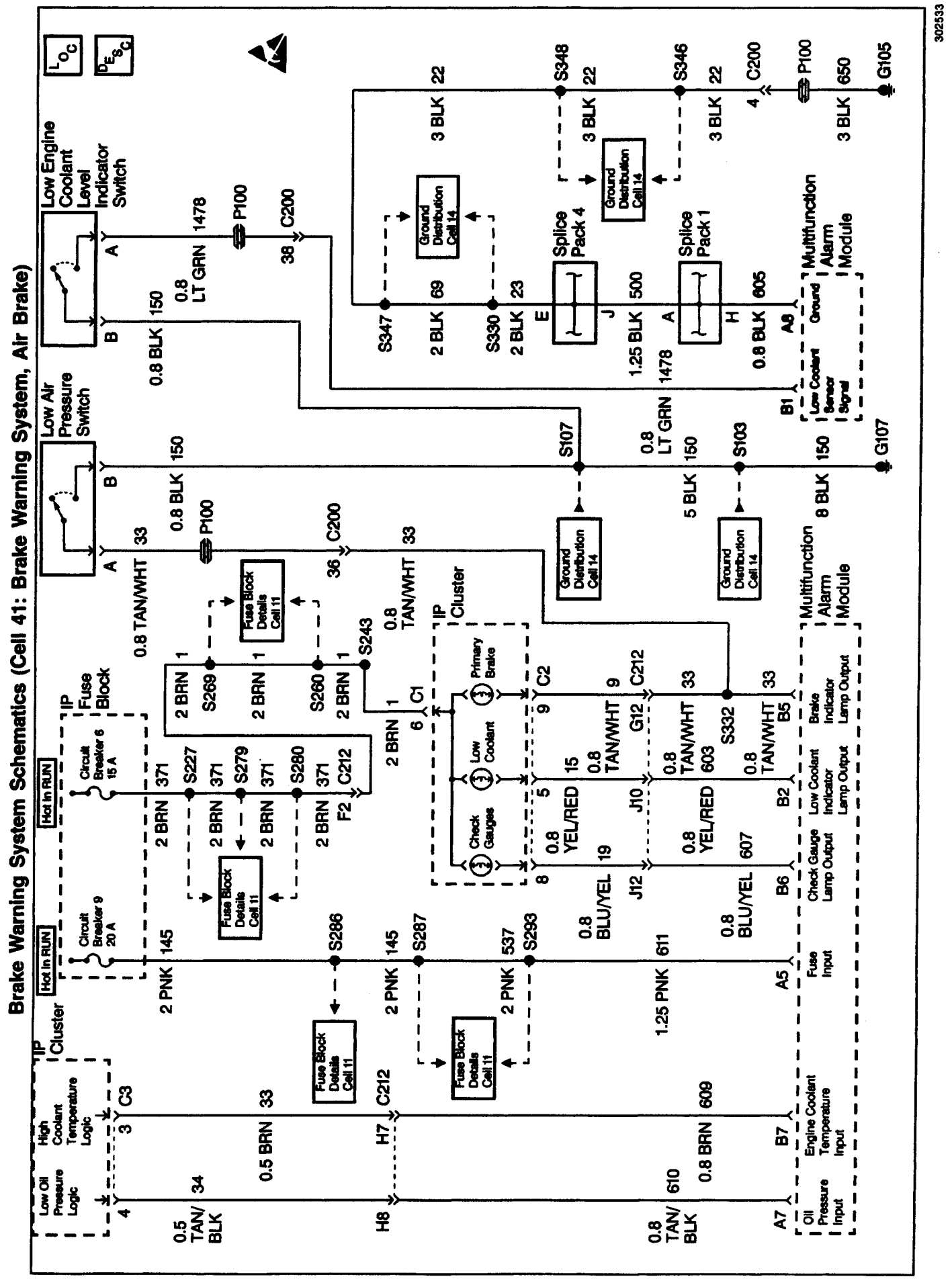
209552

Air Brake System Schematic References

Reference on Schematic	Section Number - Subsection Name
Fuse Block Details Cell 11	8—Wiring Systems
Ground Distribution Cell 14	8—Wiring Systems

Air Brake System Schematic Icons

Icon	Icon Definition
 19384	Refer to *ESD Notice* in Cautions and Notices.


Brake Warning System Schematics (Cell 41: Brake Warning System, Air Brake)
302533
Low Engine Coolant Level Indicator Switch
Low Air Pressure Switch
Multifunction Alarm Module
Splice Pack 4
Splice Pack 1
Ground Distribution Cell 14
Fuse Block Details Cell 11
IP Fuse Block
IP Cluster
Circuit Breaker 6 15 A
Circuit Breaker 9 20 A
Hot In RUN
Primary Brake
Low Coolant
Check Gauges
Low Coolant Brake Indicator Lamp Output
Check Gauge Lamp Output
Low Oil Pressure Logic
High Coolant Temperature Logic
Oil Pressure Input
Engine Coolant Temperature Input
Fuse Input
Low Coolant Sensor Signal
Ground
S107
S103
S243
S269
S260
S227
S279
S280
S286
S287
S293
S332
S347
S330
S348
S346
P100
C200
C212
C1
C2
C3
G105
G107
J10
J12
G12
H7
H8
A5
A7
B1
B2
B5
B6
B7
A9
F2
1998 - MD-Isuzu

Component Locator

Air Brake System Components

Name	Location	Locator View	Connector End View
Air Brake Dryer	On the left side of the frame in the component box	*Air Brake System Component Views* in Air Brakes	*Air Brake System Connector End Views* in Air Brakes
Engine Coolant Temperature (ECT) Switch (Cat® Diesel)	On the right side of the engine, on the upper rear of the coolant outlet	—	*Engine Controls Connector End Views* in Engine Controls-7.8L (Isuzu)
Engine Oil Pressure (EOP) Indicator Switch (Cat® Diesel and Engine Alarm)	On the left side of the engine block, on a tee fitting pointing up	—	*Engine Controls Connector End Views* in Engine Controls-7.8L (Isuzu)
Instrument Panel Cluster (IPC) C1 (15 cavities)	In the upper IP harness to the IPC	—	*Instrument Cluster Connector End Views* in Instrument Panel, Gauges and Console
Instrument Panel Cluster (IPC) C2 (9 cavities)	In the upper IP harness to the IPC	—	*Instrument Cluster Connector End Views* in Instrument Panel, Gauges and Console
IP Fuse Block	On the right top side of the IP, under the access panel	*Power and Grounding Component Views* in Wiring Systems	—
Low Air Pressure Switch (ABS-Air)	On the top rear of the primary air reservoir, at the right frame rail	*Air Antilock Brakes System Component Views* in Air Brakes	*Air Antilock Brakes System Connector End Views* in Air Brakes
Low Engine Coolant Level Indicator Switch (Isuzu Diesel w/ Automatic Engine Shutdown)	On the left cab bridge, on the bottom of the radiator surge tank	—	*Engine Controls Connector End Views* in Engine Controls-7.8L (Isuzu)
Moisture Ejector Heater (Air Brakes)	On the bottom if the primary air tank, between the frame rails	*Air Brake System Component Views* in Air Brakes	*Air Brake System Connector End Views* in Air Brakes
Multifunction Alarm Module (MFAM) (Air) C1 (16 cavities)	In the lower IP harness to the MFAM	*Air Brake System Component Views* in Air Brakes	*Air Brake System Connector End Views* in Air Brakes
C125 (38 cavities) (Isuzu Diesel)	On the front chassis harness to the engine harness at the left rear of the engine	—	*Inline Harness Connector End Views* in Wiring Systems
C200 (56 cavities) (Isuzu Diesel)	On the lower IP harness, to the front chassis harness, left center of the cab, in the cab interface connector.	—	*Inline Harness Connector End Views* in Wiring Systems
C212 (84 cavities)	On the lower IP harness to the upper IP harness, left center of the IP at the floor	—	*Inline Harness Connector End Views* in Wiring Systems
C404 (3 cavities)	On the front chassis harness, to the rear chassis and taillamps harness, inside the right frame rail, inboard of the batteries	—	*Inline Harness Connector End Views* in Wiring Systems

Air Brake System Components (cont'd)

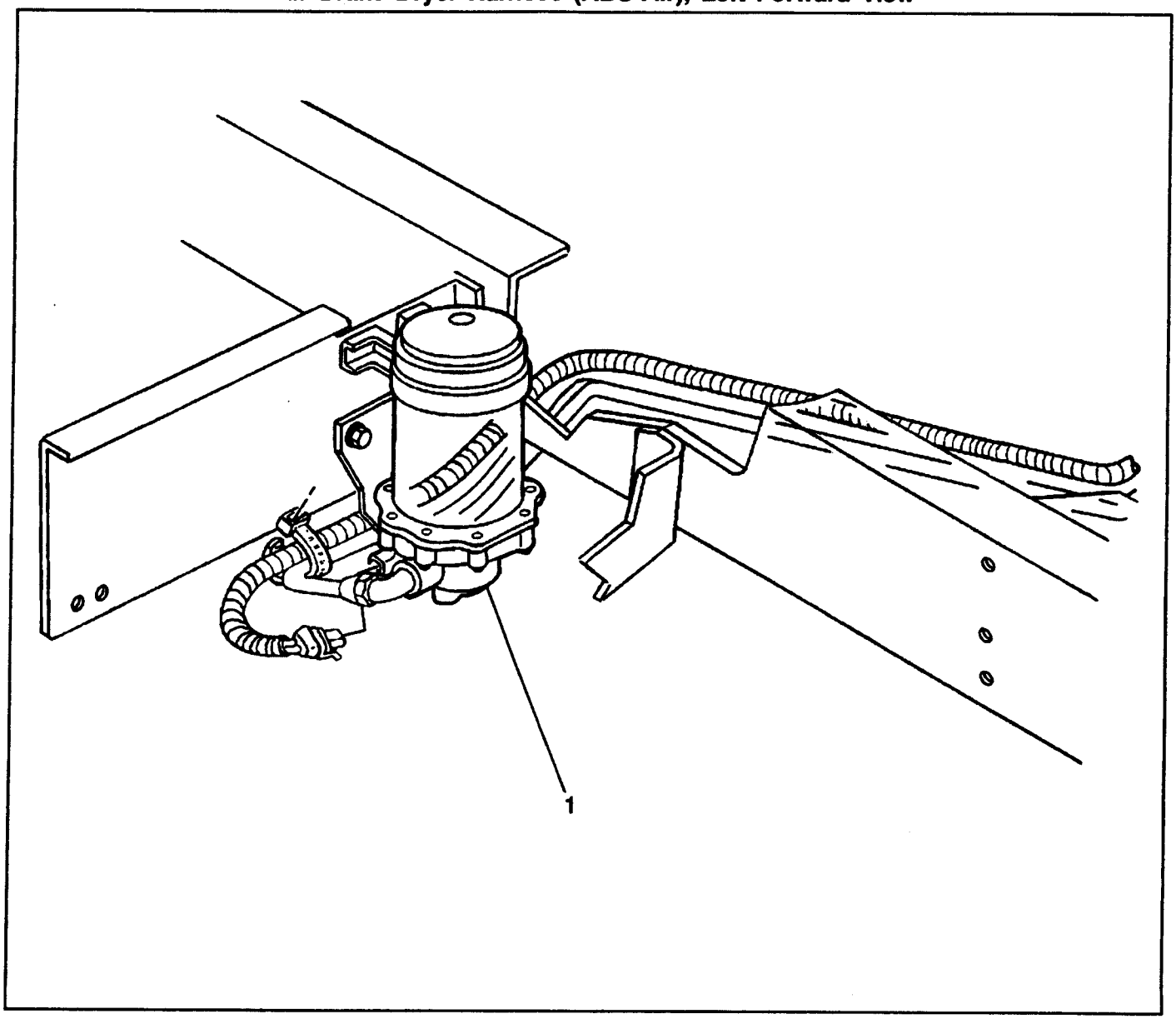
Name	Location	Locator View	Connector End View
C408 (2 cavities) (Long Wheelbase)	On the rear chassis and taillamps harness, to the air brake moisture ejector valve, approximately 15 cm from the ground connectors breakout	—	*Inline Harness Connector End Views* in Wiring Systems
G105	On the left front of the #1 crossmember	—	—
G107	On the front chassis harness, on the left frame rail, approximately 25 cm (9.9 in) rear of the front shock absorber	—	—
G404	On the rear chassis and taillamps harness, inboard the right frame rail, in the ground block (part of the negative battery cable)	—	—
P100	In the front chassis harness, underhood, center of the bulkhead, in the cab interface connector housing	—	—
Splice Pack 1	On the lower IP harness, below the left side of the IP, to the right of the steering column, joint connector 1, row 2, terminals 2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2J and 2L	—	—
Splice Pack 4	In the upper IP harness, under the crash pad, on the top of the IP, joint connector 1, row 2, terminals 2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2J and 2L	—	—
S103	In the front chassis harness, approximately 7 cm (2.8 in) rear of the main harness breakout	—	—
S107 (Cat® Diesel)	In the front chassis harness, approximately 10 cm (3.9 in) forward of the MaxiFuse® block breakout	—	—
S109	In the front chassis harness, approximately 4 cm (1.6 in) rear of the engine harness breakout	—	—
S183 (Cat® Diesel)	In the front chassis harness, approximately 16 cm (6.3 in) from the G107 ground breakout	—	—
S227	In the upper IP harness, under the IP, approximately 6 cm (2.4 in) left of the fuse block breakout	—	—
S243	In the upper IP harness, approximately 13 cm (5.1 in) from the IP connector toward the main harness	—	—
S260	In the upper IP harness, the main harness at the speedometer breakout	—	—
S269	In the upper IP harness, the main harness, approximately 21 cm (8.3 in) from the upper IP connector C212 (84 cavities)	—	—
S279	In the lower IP harnes, below the IP, approximately 5 cm (2.0 in) right of the relay center 1 harness breakout	—	—

Air Brake System Components (cont'd)

Name	Location	Locator View	Connector End View
S280	In the lower IP harness, in the main harness at the frame harness breakout	—	—
S286	In the lower IP harness, in the main harness at the fuse block harness breakout	—	—
S287	In the lower IP harness, in the main harness, approximately 22 cm (8.7 in) right of the fuse block harness breakout	—	—
S295	In the lower IP harness, in the main branch, at the C200 (56 cavities) and C202 (56 cavities) breakout	—	—
S330	In the lower IP harness	—	—
S332	In the lower IP harness	—	—
S346	In the lower IP harness	—	—
S347	In the lower IP harness	—	—
S348	In the lower IP harness	—	—
S363	In the lower IP harness	—	—
S400	In the rear chassis and taillamps harness, approximately 30 cm (11.8 in) from the engine harness connectors	—	—
S400 (Long Wheelbase)	In the rear chassis and taillamps harness, at the main branch, approximately 10 cm (3.9 in) from the ground connectors breakout	—	—
S400 (Low Profile)	In the rear chassis and taillamps harness, at the main branch, approximately 10 cm (3.9 in) from the ground connectors breakout	—	—
S401	In the rear chassis and taillamps harness, approximately 20 cm (7.9 in) from the engine harness connectors	—	—
S401 (Long Wheelbase)	In the rear chassis and taillamps harness, at the main branch, approximately 5 cm (2.0 in) from C410	—	—
S701	In the moisture ejector and air dryer harness, approximately 10 cm (3.9 in) after the air brake dryer breakout	—	—
S702	In the moisture ejector and air dryer harness, approximately 30 cm (11.8 in) after the air brake dryer breakout	—	—

Air Brake System Component Views

Air Brake Dryer Harness (ABS-Air), Left Forward View

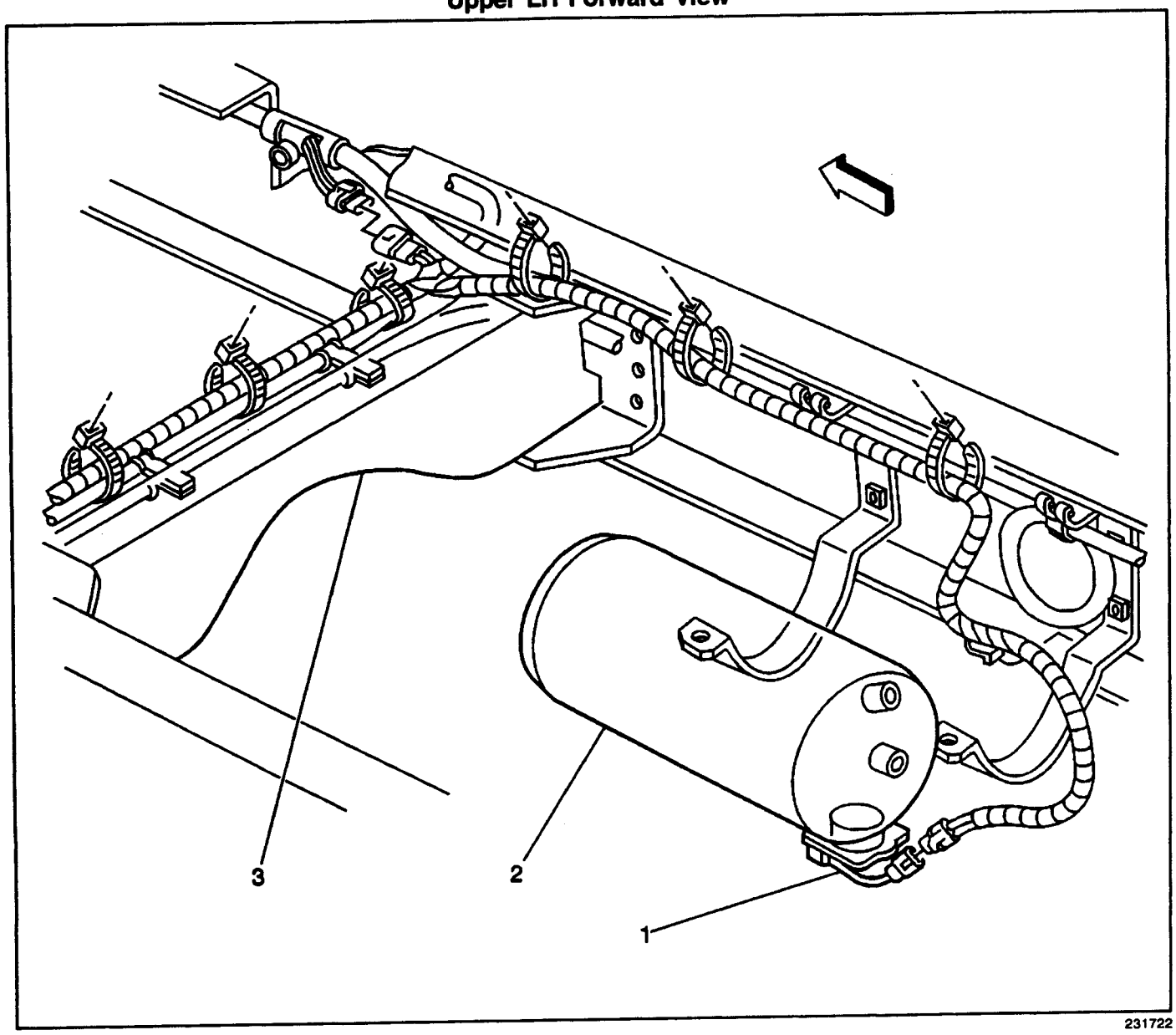


231721

Legend

(1) Air Brake Dryer

Air Dryer and Moisture Ejector Harness (ABS-Air) to Primary Air Reservoir; Upper LH Forward View

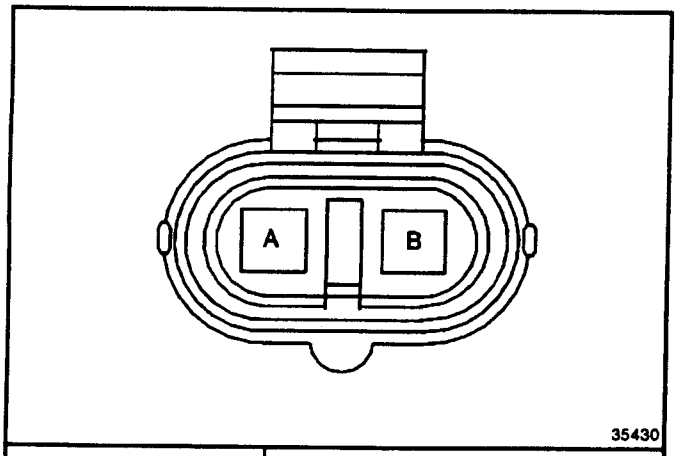


Legend

(1) Moisture Ejector Valve
(2) Primary Air Reservoir
(3) Back-of-Cab (BOC) Crossmember

Air Brake System Connector End Views

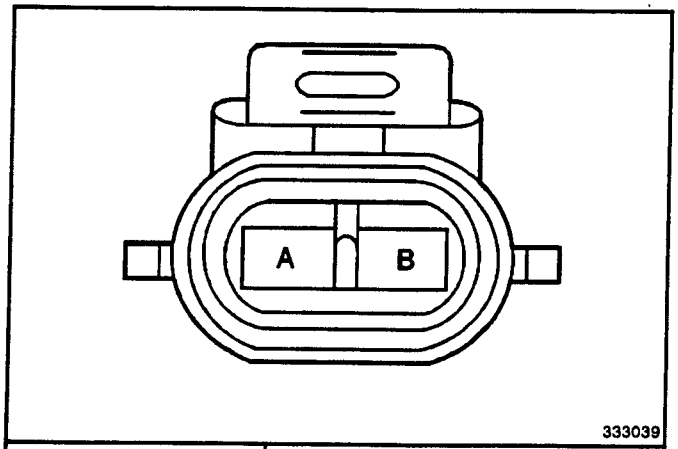
Air Brake Dryer



35430

Connector Part Information	• 12020599 • 2 Way F Metri-Pack 280 Series, Sealed (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BRN	341	Fuse Output-Ignition
B	BLK	150	Ground

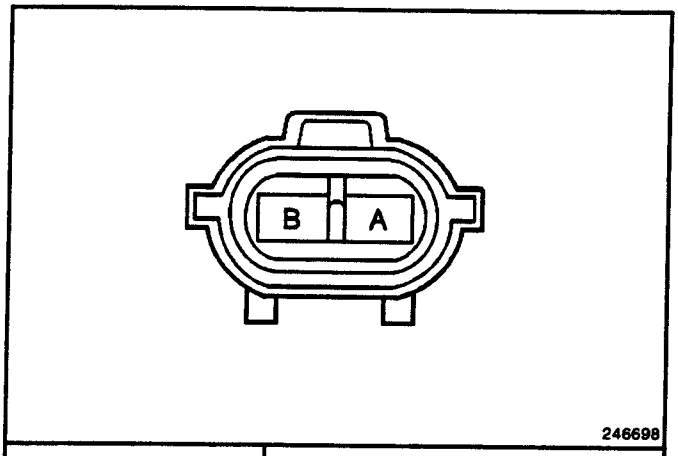
Moisture Ejector Heater



333039

Connector Part Information	• 12052644 • 2 Way F Metri-Pack 150 Series (LT GRY)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BRN	341	Fuse Output-Ignition
B	BLK	150	Ground

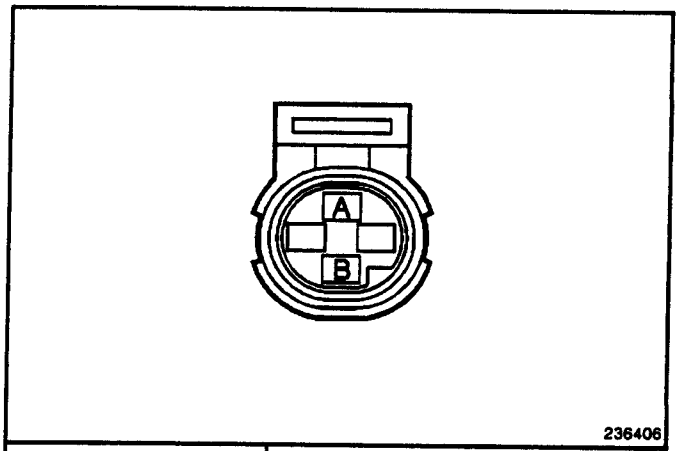
Park Brake Switch, Daytime Running Lamps (Air Brakes)



246698

Connector Part Information	• 2 Way M • (GRY)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	LT BLU	744	Daytime Running Lamps (DRL) Off Relay Air Brake
B	BLK	746	Park Brake Switch Air Brake

Low Air Pressure Switch



236406

Connector Part Information	• 12065400 • 2 Way F Metri-Pack 150 Series, Sealed (GRN)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	TAN/WHT	33	Brake Warning Indicator Lamp Output
B	BLK	150	Ground

Diagnostic Information and Procedures

Air Brakes Inoperative

Checks	Action
Check the air compressor for proper operation.	Refer to *Air Brake System Testing (Operational Check).*
Check the line or hose for restrictions.	Repair ir replace the line.
Check the air brake valve.	Refer to *Front Air Brake Limit Valve Test (Operational Check).*
Check for ice in the air system.	Refer to *Air Dryer/Moisture Ejector System Check.*
Check if the brakes are out of adjustment.	Refer to *Air Drum Brake Adjustment (Normal Wear Adjustment).*

Air Brakes Not Operating Properly

Checks	Action
Check the line or hose for a restriction.	Replace or repair the line.
Check if the brakes are out of adjustment.	Refer to *Air Drum Brake Adjustment (Normal Wear Adjustment).*
Check for air line leaks.	Refer to *Air Brake System Leak Test.*
Check for service chamber diaphragm leaks.	Refer to *Air Brake System Leak Test.*
Check if the governor cut-out adjustment is too low.	Refer to *Air Compressor Governor Valve Adjustment.*
Check for worn linings or drums.	Refer to *Air Drum Brake System Inspection.*
Check for a safety valve malfunction.	Refer to *Air Compressor Diagnosis (Air Compressor Not Unloading).*

Air Brakes Application Slow

Checks	Action
Check for a restricted line or hose.	Replace or repair the line.
Check for a faulty air brake valve.	Refer to *Air Brake Application Valve Test (Operational Check).*
Check if the brakes are out of adjustment.	Refer to *Air Drum Brake Adjustment (Normal Wear Adjustment).*
Check for air line leaks.	Refer to *Low Air Pressure Switch Diagnosis.*
Check if the governor cut-out adjustment is too low.	Refer to *Air Compressor Governor Valve Adjustment.*
Check for worn linings or drums.	Refer to *Air Drum Brake System Inspection.*
Check for brake pedal linkage binding.	Refer to *Air Brake Pedal Replacement.*
Check for brake shoe binding.	Refer to *Brake Shoe Inspection.*
Check for camshaft bushing binding.	Refer to *Air Drum Brake Adjustment (Normal Wear Adjustment).*
Check for a safety valve malfunction.	Refer to *Air Brake Dryer Safety Valve Exhausting Air.*

Pressure Loss w/Eng. Off - Brakes Released

Checks	Action
Check for a faulty air brake valve.	Refer to *Air Brake Application Valve Test (Operational Check).*
Check the air line for leaks.	Refer to *Air Brake System Leak Test.*
Check the compressor or the governor for leaking.	Refer to *Air Compressor and Governor Valve Diagnosis.*
Check the single check valve for leakage.	Refer to *Reservoir Check Valve Test (Operational Check).*
Check the spring brake chamber hose for leakage.	Refer to *Air Brake System Leak Test.*
Check the spring brake chamber diaphragm for leakage.	Refer to *Air Brake System Leak Test.*
Check if the reservoir drain valve is open or is leaking.	Refer to *Air Brake Reservoirs Contain Water.*

Pressure Loss w/Eng. Off - Brakes Applied

Checks	Action
Check for a faulty air brake valve.	Refer to *Air Brake Application Valve Test (Operational Check).*
Check if the air line leaks.	Refer to *Air Brake System Leak Test.*
Check the spring brake chamber hose for leaks.	Refer to *Air Brake System Leak Test.*
Check the compressor and the governor for leaks.	Refer to *Air Compressor Diagnosis (Air Compressor Not Unloading).*

Air Brake Safety Valve Blows Off

Checks	Action
Check for a safety valve malfunction.	Refer to *Air Brake Dryer Safety Valve Exhausting Air.*
Check if the governor cut-out adjustment is too high.	Refer to *Air Compressor Diagnosis (Air Compressor Not Unloading).*

Braking Uneven - Front to Rear

Checks	Action
Check for a restricted line or hose.	Replace or repair the line.
Check for a faulty air brake valve.	Refer to *Air Brake Application Valve Test (Operational Check).*
Check for ice in the air system.	Refer to *Air Dryer/Moisture Ejector System Check.*
Check if the brakes are out of adjustment.	Refer to *Air Drum Brake Adjustment (Normal Wear Adjustment).*
Check for air line leaks.	Refer to *Air Brake System Leak Test.*
Check for service chamber diaphragm leaks.	Refer to *Air Brake System Leak Test.*
Check for worn linings or drums.	Refer to *Air Drum Brake System Inspection.*
Check for brake shoe binding.	Refer to *Brake Shoe Inspection.*
Check for camshaft bushing binding.	Refer to *Air Drum Brake Adjustment (Normal Wear Adjustment).*

Braking Uneven - Side to Side

Checks	Action
Check for a restricted line or hose.	Replace or repair the line.
Check for a faulty air brake valve.	Refer to *Front Air Brake Limit Valve Test (Operational Check).*
Check if the brakes are out of adjustment.	Refer to *Air Drum Brake Adjustment (Normal Wear Adjustment).*
Check for air line leaks.	Refer to *Air Brake System Leak Test.*
Check for brake shoe binding.	Refer to *Air Drum Brake Adjustment (Normal Wear Adjustment).*
Check for camshaft bushing binding.	Refer to *Air Drum Brake Adjustment (Normal Wear Adjustment).*

Air Brakes Make Grinding Sound When Applied

Checks	Action
Check for worn out brake shoe linings.	Refer to *Brake Shoe Replacement.*

Air Brakes Drag

Checks	Action
Check if the brakes are out of adjustment.	Refer to *Air Drum Brake Adjustment (Normal Wear Adjustment).*
Check for brake pedal linkage binding.	Refer to *Air Brake Pedal Replacement.*
Check for brake shoe binding.	Refer to *Brake Shoe Inspection.*
Check for camshaft bushing binding.	Refer to *Air Drum Brake Adjustment (Normal Wear Adjustment).*

Air Brake Dryer Constantly Cycling or Purging

Problem	Action
Excessive system leakage is evident.	Inspect for system leakage. Repair the system.
Excessive leakage is evident in one or more of the following components: • The fittings • The hoses • The tubing connected to the compressor • The air brake dryer • The main supply reservoir	1. Test the system for leakage at the following components: • The fittings • The reservoir drain valve (automatic type), if equipped • The safety valve in the supply reservoir 2. Repair or replace as needed.
The internal check valve is faulty.	1. Remove the check valve from the assembly from the end cover. 2. Apply air pressure to the delivery side of the valve. 3. Apply a soap solution at the opposite end. 4. Inspect for leakage. Permissible leakage is a 25 mm (1 in) bubble in five seconds. If the leakage is excessive, replace the check valve.
The governor is faulty.	1. Inspect the governor for proper cut-in and cut-out pressures. 2. Inspect the governor for excessive leakage in both positions. Refer to *Air Compressor and Governor Valve Diagnosis*

Air Brake Dryer Constantly Cycling or Purging (cont'd)

Problem	Action
The purge valve in the air brake dryer is leaking.	1. Open the supply port. 2. Apply 827 kPa (120 psi) at the control port. 3. Apply a soap solution to the supply port and the exhaust port (in the purge valve seat area). Permissible leakage is a 25 mm (1 in) bubble in five seconds. If the leakage is excessive, replace the purge valve.
The compressor unloader mechanism is leaking.	1. Remove the air inlet hose and the fitting from the air compressor inlet cavity. 2. Inspect for leakage in the unloader piston while the air compressor is unloaded. Slight leakage is permissible.

Air Brake Reservoirs Contain Water

Problem	Action
The air brake dryer desiccant cartridge requires replacement.	Replace the desiccant cartridge.
The air system was charged from an external air source. Air is not passing through the air brake dryer.	Decrease use of the inflation valve in order to charge the system.
The air brake dryer is not purging.	Refer to *Air Brake Dryer Testing.*
The purge (air exhaust) time is too short because of excessive system leakage.	Refer to *Air Brake Dryer Testing.*

Air Brake Dryer Safety Valve Exhausting Air

Problem	Action
The air brake desiccant cartridge is plugged or saturated with contaminants.	Replace the desiccant cartridge.
The internal check valve is faulty.	1. Remove the check vale from the assembly from the end cover. 2. Apply air pressure to the delivery side of the valve. 3. Apply a soap solution at the opposite end. 4. Inspect for leakage. A permissible leakage is a 25 mm (1 in) bubble in five seconds. If the leakage is excessive, replace the check valve.
The fittings or the tubing between the air brake dryer and the supply reservoir are faulty.	Determine if air is reaching the supply reservoir. Inspect the reservoir for kinked tubing or for restricted tube fittings.

Air Brake Dryer Purge Valve Exhausting Air

Problem	Action
Excessive air brake dryer purge valve leakage is evident.	Inspect for excessive leakage with the air compressor loaded. Apply a soap solution on the purge valve exhaust. If the leakage is excessive, overhaul or replace the air brake dryer.
The governor is faulty.	1. Inspect the governor for proper cut-in and cut-out pressures. 2. Inspect the governor for excessive leakage in both positions. Refer to *Air Compressor and Governor Valve Diagnosis.*
The purge control line is connected to one of the following components: • The reservoir • The exhaust port • The governor	Connect the control line to the unloader port of the governor.

Air Brake Dryer Purge Valve Exhausting Air (cont'd)

Problem	Action
The heater and thermostat or wiring are faulty. A fuse is blown.	Test the electrical circuit. *Air Brake Dryer Testing*
The inlet and the outlet air connections are reversed.	Connect the lines properly.
The check valve between the air brake dryer and the supply reservoir is faulty.	1. Test the check valve for proper operation. Remove the check valve from the assembly from the end cover. 2. Apply air pressure to the delivery side of the valve. 3. Apply a soap solution at the opposite end. 4. Inspect for leakage. Permissible leakage is 25 mm (1 in) bubble in five seconds. If leakage is excessive, replace the check valve.
The discharge line is kinked or blocked.	Clean or replace the line as needed.
Excessive bends in the discharge line cause the water to collect and freeze.	Correct the discharge line routing.
Excessive system leakage is evident.	Inspect for system leakage. Repair or replace parts as needed.

Air Brake Dryer Does Not Purge or Exhaust Air

Problem	Action
The purge control line exhibits one of following conditions: • Broken • Kinked • Frozen • Plugged • Disconnected	Determine if the air flows through the purge control line when the air compressor is unloaded.
The air brake dryer purge valve is faulty.	Replace the purge valve.

Desiccant Being Expelled From Purge Valve Exhaust

Problem	Action
The air brake dryer is not securely mounted, allowing too much vibration.	Tighten the air brake dryer mounting hardware.
The desiccant cartridge is faulty.	Replace the desiccant cartridge.
The air compressor piston ring is leaking.	Overhaul or replace the air compressor.
The air compressor is passing too much oil.	Overhaul or replace the air compressor.

Air Brake System Testing (Operational Check)

If the vehicle pulls to one side during braking, check the front wheels. Do not assume this is a brake related condition. Check the wheel alignment first.

Test the brakes on a dry, clean, reasonably smooth, and level roadway. Do not test the brake performance when the roadway is wet, greasy, or covered with loose dirt. These conditions prevent the tires from gripping the road equally. A crowned roadway also affects brake testing. This condition throws the weight of the vehicle toward the wheels on one side. Results are also affected when the roadway is rough enough to cause the wheels to bounce.

Test the brakes at different vehicle speeds with light and heavy pressure. Do not lock the wheels or slide the tires on the roadway. Heavily braked wheels will stop the vehicle in less distance than locked wheels. There is more friction present with a heavily braked tire than with a sliding tire.

External Conditions That Affect Brake Performance

- Uneven breaking is caused when tires have uneven contact and grip on the road. Check that the tires are equally inflated and that the tread pattern on the right and the left tires are approximately equal.
- Load the vehicle evenly. Uneven loading creates uneven braking. The most heavily loaded tires require the most braking force.
- Loose front wheel bearings allow the brake drum and the wheel to tilt. This causes inconsistent contact with the brake linings and erratic braking action.
- Misalignment of the front wheels, the camber and the caster settings, causes the brakes to pull to one side.

Air Brake System Testing (Leakage Test)

System Tests

1. Inspect the air lines and tubing for kinks, twists, or dents.
2. Inspect the hoses for wear, drying or overheating. The hoses should not rub against or touch anything with sharp edges.
3. Inspect the tubing clamps and the clips. The tubing should be firmly held in place and not sag or vibrate.
4. Inspect the nylon lines. Keep the nylon lines away from extreme heat sources.
5. Inspect the reservoir support bolts, the straps and the strap nuts. Tighten the components if necessary.
6. Inspect the air line connections. Tighten the connections if necessary.

Primary Brake Indicator or Alarm Inoperative

Step	Action	Value(s)	Yes	No
1	1. Backprobe the low air pressure switch with a DVM from terminal B to B+. 2. Measure the voltage. Is the voltage less than the specified value?	10.0 V	Go to *Step 2*	Go to *Step 3*
2	Repair the open in CKT 150 (BLK) between the low air pressure switch and G107. Is the primary brake indicator lamp or the continuous tone inoperative?	—	Go to *Step 3*	System OK
3	1. Disconnect the low air pressure switch. 2. Connect a fused jumper from low air pressure switch connector terminal A to B. 3. Turn the ignition switch to RUN. 4. Observe the lamp. Did the test lamp light?	—	Go to *Step 4*	Go to *Step 4*
4	Replace the low air pressure switch. Is the primary brake indicator lamp or the continuous tone inoperative?	—	Go to *Step 5*	System OK
5	1. Leave the jumper connected. 2. Backprobe the multifunction alarm module with a DVM from terminal B5 to B+. 3. Measure the voltage. Is the voltage less than the specified value?	10.0 V	Go to *Step 6*	Go to *Step 7*

Primary Brake Indicator or Alarm Inoperative (cont'd)

Step	Action	Value(s)	Yes	No
6	Repair the open in CKT 33 (TAN) and CKT 602 (WHT) between the low air pressure switch, the instrument cluster, and the multifunction alarm module. Is the primary brake indicator lamp or the continuous tone inoperative?	—	—	System OK
7	Replace the multifunction alarm module. Is the primary brake indicator lamp or the continuous tone inoperative?	—	—	System OK

Primary Brake Indicator or Alarm Always On

Step	Action	Value(s)	Yes	No
1	Disconnect the low air pressure switch. Do the lamp and tone remain on?	—	Go to *Step 2*	Go to *Step 3*
2	Inspect for a short to ground in CKT 33 (TAN) and CKT 602 (WHT) between the low air pressure switch, the instrument cluster, and the multifunction alarm module. Is there a short to ground?	—	Go to *Step 4*	Go to *Step 5*
3	Replace the low air pressure switch. Do the lamp and the tone remain on?	—	—	System OK
4	Repair the short to ground in CKT 33 (TAN) and CKT 602 (WHT) between the low air pressure switch, the instrument cluster, and the multifunction alarm module. Do the lamp and tone remain on?	—	—	System OK
5	Replace the low air pressure switch. Do the lamp and tone the remain on?	—	—	System OK

Low Air Pressure Switch Diagnosis

1. Apply the parking brake.
2. Drain all of the reservoirs. Refer to *Draining Reservoirs.*
3. Start the engine and run the engine at a fast idle.
4. Verify that the low pressure tone alarm is on.
   - If the tone alarm is not on when first charging the system, test the brake warning system.
   - For diagnosis of the brake warning system, refer to Brake Warning System Check.
5. The low pressure tone alarm should turn off when the dual air pressure gauge indicates 470–510 kPa (68–74 psi).
   - If the tone alarm does not turn off, test the brake warning system.
   - For diagnosis of the brake warning system, refer to Brake Warning System Check.

Stoplamp Switch Diagnosis

Stoplamp Switch Mechanical Test, Service and Trailer Air Brake

1. Connect the trailer air lines, if equipped, to a known operating trailer.
2. Block the vehicle wheels.
3. Start the engine.
4. Charge the air system to the governor cut-out point.
5. Apply the system park control, the trailer air supply, and the tractor park controls, if equipped.
6. Turn the engine to OFF.
7. Ensure the following:
   - The brake lamps should illuminate when either the foot brake or the trailer air brake control is applied.
   - The trailer air brake control and the foot brake should operate the trailer service brakes when applied individually.
   - If either of these switches does not function, replace the faulty stoplamp switch.

Trailer Stoplamp Switch Diagnosis

Trailer Stoplamp Switch Mechanical Test

1. Connect the trailer air lines, if equipped, to a known operating trailer.
2. Block the wheels.
3. Start the engine.
4. Charge the system air pressure to the governor cut-out point.
5. Apply the system park control, the trailer air supply, and the tractor park controls, if equipped.
6. Stop the engine.
7. Check that the brake lamps illuminate when you apply the foot brake or the trailer air brake control. If the switch does not function, replace the switch.
8. Check that the trailer air brake control and the foot brake operates the trailer service brakes when you apply the controls individually. If the switch does not function, replace the switch.
9. Remove the wheel blocks.

Air Brake Dryer Testing

1. Set the vehicle parking brake.
2. Drain all of the air reservoirs. Refer to *Draining Reservoirs*.
3. Start the engine.
4. Charge the air system to the governor cut-out point.
5. Verify that a discharge of air occurs at the air dryer exhaust port. This is the air dryer purge cycle.

   If the air dryer does not cycle properly, inspect the air dryer system for leaks. Refer to Air Brake System Schematics. Overhaul or replace the air dryer as necessary.

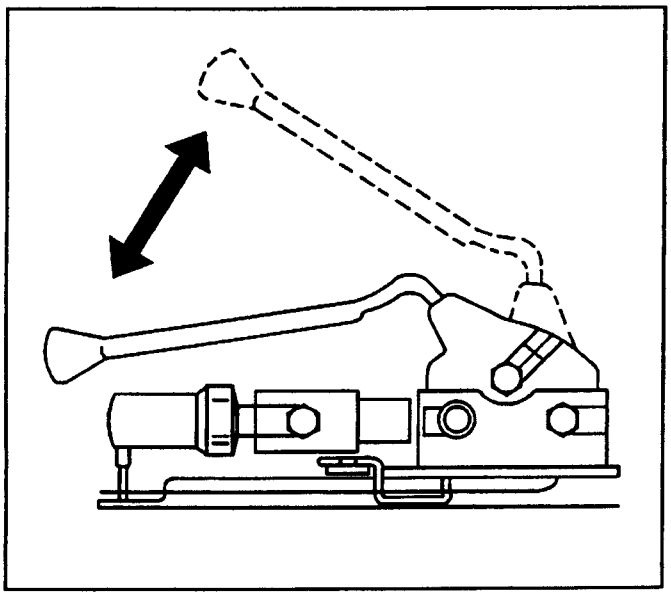
Air Brake System Leak Test

Air leakage is defined as measuring the size of a bubble formed over a specified period of time. A 25.4 mm (1 in) bubble formed over 5 seconds is equivalent to 100 standard cubic centimeters per minute (sccm). A 25.4 mm (1 in) bubble formed over 3 seconds is equivalent to 175 sccm.

Use a soap solution in order to perform all air leakage tests. This allows a bubble to form at the site of the air leak, giving a visual aid for diagnosing the air loss rate.

1. Inspect all tubing for kinks or dents.
2. Inspect all hoses for signs of wear, drying out, or overheating.
3. Inspect the suspension of all of the tubing. Support he tubing in order to eliminate vibration.
4. Inspect the suspension of all of the hoses. Position the hoses in a manner that will avoid the following conditions:
   - Abrasion
   - Overheating
5. Apply the parking brake.
6. Start the engine.
7. Charge the air system to the governor cut-out point.
8. Stop the engine.
9. Apply and release the service brakes.
10. Check the air leakage.
    - Check that the dual air pressure gauge on vehicles without trailer controls does not drop more than 28 kPa (4 psi) in 2 minutes.
    - Check that the dual air pressure gauge on vehicles with trailer controls does not drop more than 41 kPa (6 psi) in 2 minutes.
    - If the dual air pressure gauge reading drops more than specified, check for leaks at the following locations:
      - The air line connections
      - The application valve
      - The trailer control valve
      - The relay valve
      - The park brake control valve
      - The governor
      - Any other components on the supply side of the application valve
11. Start the engine.
12. Charge the system to the governor cut-out point.
13. Stop the engine.
14. Firmly apply the brakes and hold the brakes.
15. Check the air leakage.
    - If the air pressure drops 10% or more, check the air foundation brake adjustment at each wheel for excessive lining and brake drum wear. Refer to Air Foundation Brakes.
    - Check that the dual air pressure gauge on vehicles without trailer controls does not drop more than 41 kPa (6 psi) in 2 minutes.
    - Check that the dual air pressure gauge on vehicles with trailer controls does not drop more than 55 kPa (8 psi) in 2 minutes.
    - If the dual air gauge reading drops more than specified, test for leaks at the following locations. Double check the valves, the quick release valve, the relay valve and the other parts on the delivery side of the application valve.
      - The air line connections
      - The valves
      - The quick release valve
      - The relay valve
      - Any other components on the delivery side of the application valve

16. Start the engine.
17. Charge the air system to the governor cut-out point.
18. Stop the engine.



227705

19. On vehicles with trailer provisions, move the trailer air brake control valve handle up to the full ON position.
20. If air leakage is less than 41 kPa (6 psi), check for leakage at the following locations:air line fittings, trailer air brake control valve, towing vehicle protection valve, and any valves on the trailer.
    - The air line fitting
    - The trailer air brake control valve
    - The towing vehicle protection valve
    - Any valves on the trailer.

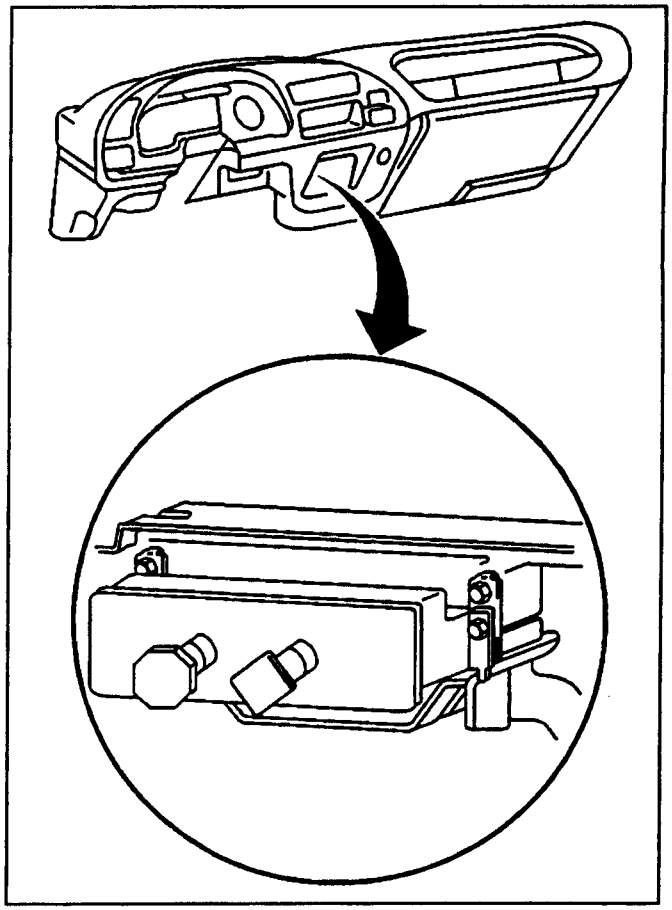
Reservoir Drain Valve

Test the reservoir drain valve periodically for leakage. Leakage is not permissible. Replace the reservoir drain valve if necessary.

1. Set the parking brake.
2. Start the engine.
3. Charge the air system to the governor cut-out point.
4. Apply a soap solution in order to cover the reservoir drain valve.
5. If bubbles appear indicating air leaks, replace the reservoir drain valve.

IP Mounted Air Brake Park Control Valve Test (Operational Check)

1. Block the wheels.
2. Start the engine.
3. Charge the system to the air compressor governor cut-out point.
4. Stop the engine.



227847

5. Pull out the park control valve (cab mounted) knob and release the brake pedal.
6. Verify that the spring brake chamber assemblies are applied.
7. Push in the park control valve (cab mounted) knob.
8. Verify that the spring brake chamber assemblies are fully released.
9. Drain the front service air reservoir.
10. Observe the dual air pressure gauge while the rear air reservoir is draining.
11. Verify that the park control valve (cab mounted) pops out when the air pressure drops below 276 kPa (40 psi) on models without trailer provisions.

    For models with trailer provision, refer to *Parking Control Valve Test (Operational Check)*

    If the park control valve knob does not pop out, overhaul or replace the park control valve (cab mounted).
12. Remove the wheel blocks.

IP Mounted Air Brake Park Control Valve Test (Leakage Test)

1. Block the wheels.
2. Start the engine.
3. Charge the system to the air compressor governor cut-out point.
4. Stop the engine.
5. Pull out the park control valve (cab mounted) knob and release the brake pedal.
6. Inspect the exhaust port for air leakage. The air leakage should not exceed 25.4 mm (1 in) bubble in 5 seconds.

   If air leakage is excessive, overhaul or replace the park control valve (cab mounted).
7. Inspect the plunger stem for air leakage. The air leakage should not exceed 25.4 mm (1 in) bubble in 5 seconds.

   If air leakage is excessive, overhaul or replace the park control valve (cab mounted).
8. Inspect the upper and lower valve body for air leakage.

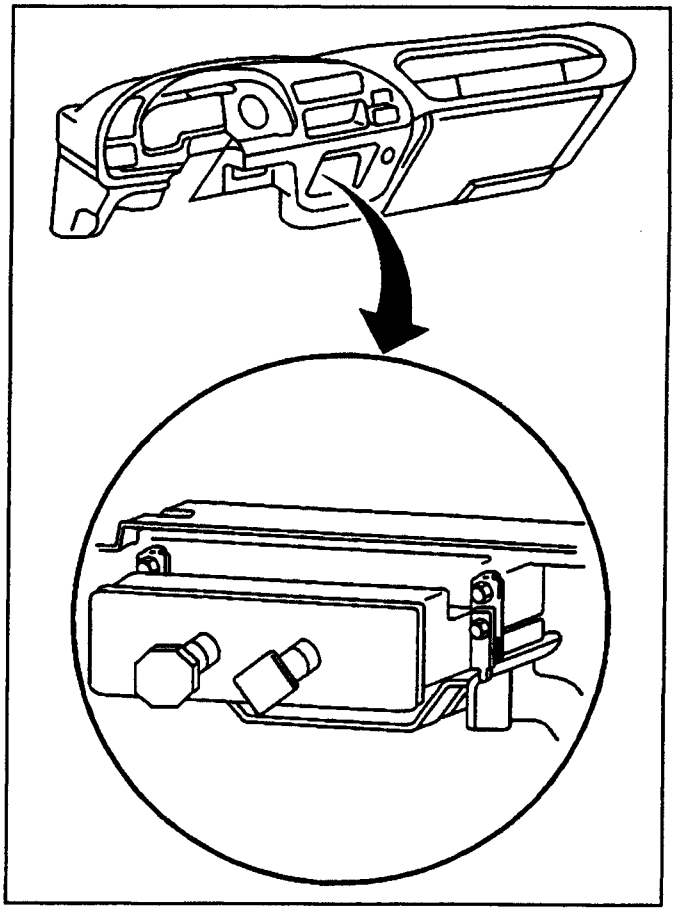
   No air leakage should occur between the upper and lower valve body. If air leakage occurs, overhaul or replace the park control valve (cab mounted).
9. Push in the system park knob.
10. Inspect the exhaust port for air leakage. Air leakage should not exceed a 25.4 mm (1 in) bubble in 3 seconds.

    If air leakage is excessive, overhaul or replace the park control valve (cab mounted).
11. Inspect the plunger stem for air leakage. Air leakage should not exceed a 25.4 mm (1 in) bubble in 3 seconds.

    If air leakage is excessive, overhaul or replace the park control valve (cab mounted).
12. Remove the wheel blocks.

Parking Control Valve Test (Operational Check)

1. Block the wheels.
2. Start the engine and charge the system to the air compressor governor cut-out point.
3. Stop the engine.



227847

4. Push in the trailer air supply knob.

   If the trailer air supply knob does not remain in, overhaul or replace the parking control valve.

   Important: The park control valve must not pop out before the trailer air supply knob. If the park control valve knob pops out first, overhaul or replace the parking control valve.
5. Slowly reduce the pressure in the air reservoirs.

   The trailer air supply knob must pop out when the air pressure is reduced to approximately 241-310 kPa (35-45 psi).
6. Hold in the trailer air supply knob and continue to reduce the pressure in all of the air reservoirs.

   Air must start to escape from the exhaust port when the trailer air supply line pressure reaches 138-241 kPa (20-35 psi).
7. Release the trailer air supply knob.
8. Start the engine.
9. Charge the system to the air compressor governor cut-out point.
10. Stop the engine.

11. Push in the control valve knob.
    If the park control valve does not remain in, overhaul or replace the parking control valve.
12. Pull out the trailer air supply knob.
13. Reduce the air pressure in all reservoirs. The park brake control knob must pop out at 138-209 kPa (20-30 psi). If the park control knob does not pop out at the specified pressure, overhaul or replace the parking control valve.
14. Start the engine.
15. Charge the system to the air compressor governor cut-out point.
16. Stop the engine.
17. Pull out the trailer air supply knob.
    If the park control knob does not remain in, overhaul or replace the parking control valve.
18. Push in the trailer supply knob.
19. Pull out the park control knob. The trailer air supply knob must pop out almost instantaneously. If the trailer air supply knob does not pop out as specified, overhaul or replace the parking control valve.
20. Remove the wheel blocks.

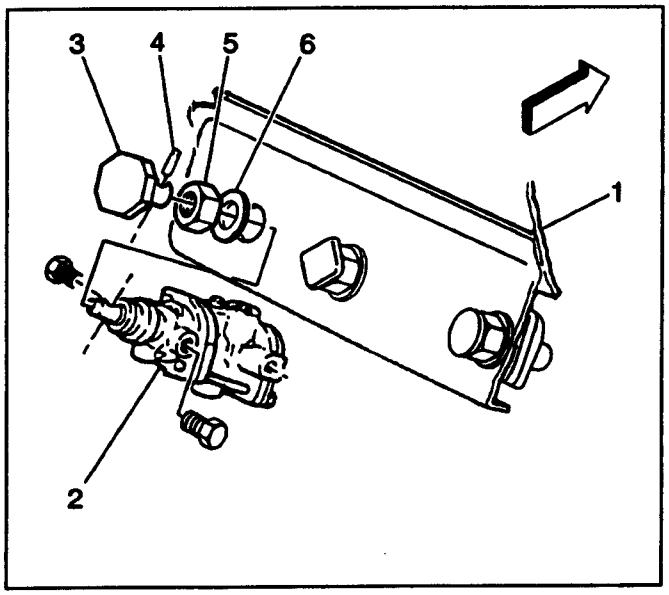
Parking Control Valve Test (Leakage Test)

1. Block the wheels.
2. Start the engine.
3. Charge the system to the air compressor governor cut-out point.
4. Stop the engine.
5. Inspect for air leakage between the valve body and cover plate. Air leakage at the exhaust port must not exceed a 25.4 mm (1 in) bubble in 5 seconds.
   If air leakage is excessive, overhaul or replace the parking control valve.
6. Push in the trailer air supply knob.
7. Inspect the exhaust port for air leakage. Air leakage at the exhaust port must not exceed a 25.4 mm (1 in) bubble in 5 seconds.
   If air leakage is excessive, overhaul or replace the parking control valve.
8. Start the engine.
9. Charge the system to the air compressor governor cut-out point.
10. Stop the engine.
11. Push in the park control knob.
12. Inspect the exhaust port for air leakage. Air leakage at the exhaust port must not exceed a 25.4 mm (1 in) bubble in 5 seconds.
    If air leakage is excessive, overhaul or replace the parking control valve.
13. Remove the wheel blocks.

Trailer Brake Supply Valve Test (Operational Check)

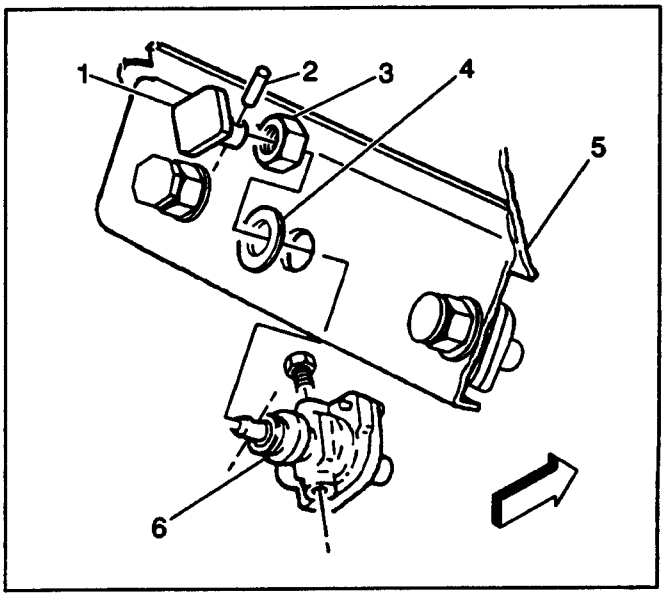
Operational Check

1. Block the vehicle wheels.
2. Check the vehicle dual air pressure gauge for accuracy with the test gauge.
3. Install the test gauge and hose coupling on the trailer supply coupling (tractor emergency hose coupling) at the rear of the cab.
4. Start the engine.
5. Charge the system air pressure to the governor cut-out point.



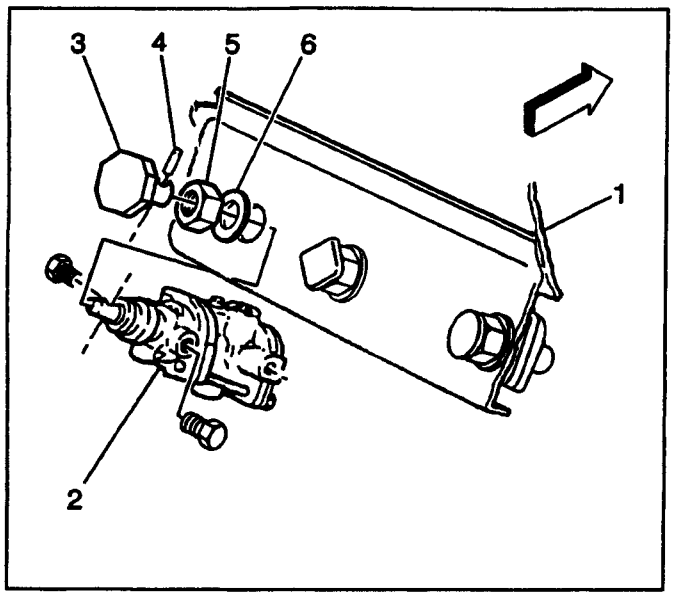
209561

6. Pull out the trailer air supply (3).



209563

7. Pull out the system park knob (1).
8. Verify the test gauge reads zero.

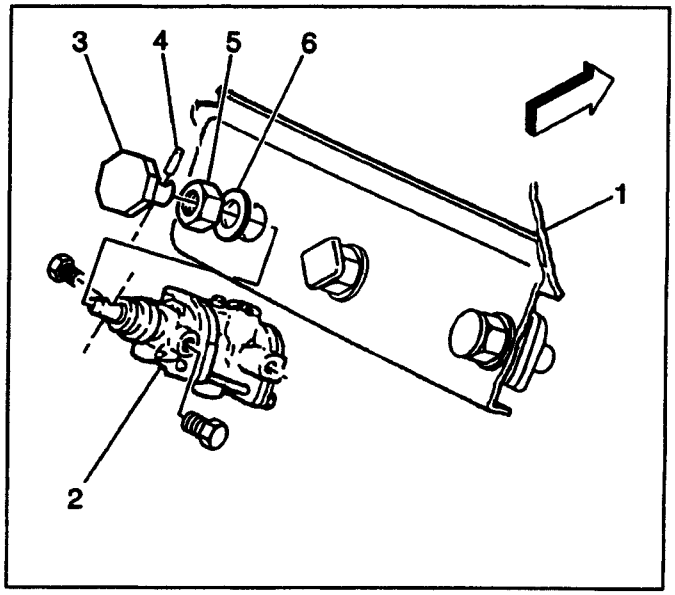


209561

9. Push in the trailer air supply knob (3).
10. Verify that the test gauge reads zero. If the gauge shows air pressure, repair or replace the valve (2). For repair information, refer to Air Brake Valve Unit Repair.
11. Push in the system park knob.
12. Verify that the test gauge reads about the same as the dual air pressure gauge.
13. If not, check for leaks or blockages in the air lines. If the air lines are not blocked or leaking, repair or replace the valve (2). For repair information, refer to Air Brake Valve Unit Repair.
14. Turn off the engine with the system at the governor cut-out point.
15. Disconnect the test gauge and the hose coupling from the trailer supply line coupling.
16. Verify that the valve knob (3) pops out.
17. Check that the supply pressure remaining is 276–448 kPa (40–65 psi) as indicated on the dual air pressure gauge.
18. If the remaining pressure is not within these limits, replace the valve (2) or repair the pressure sensing ports on the valve. For repair information, refer to Air Brake Valve Unit Repair.
19. Set the parking brake.
20. Remove the wheel blocks.

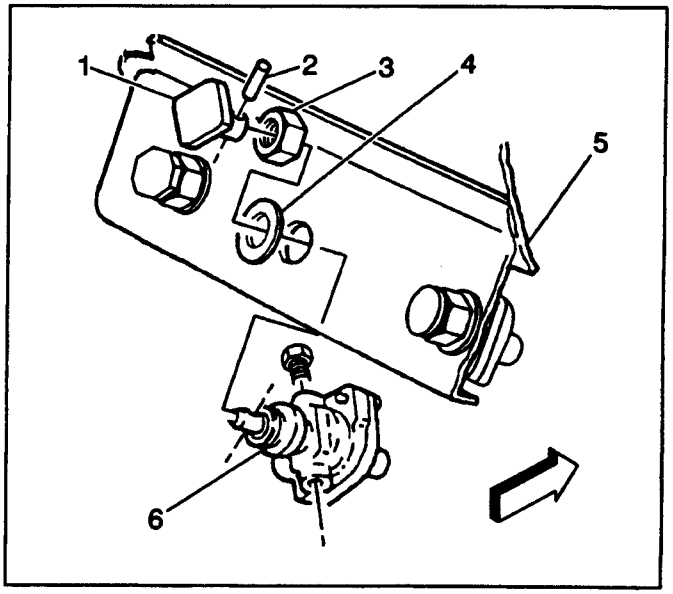
Trailer Brake Supply Valve Test (Leakage Test)

1. Block the vehicle wheels.
2. Start the engine.
3. Charge the system air pressure to the governor cut-out point.



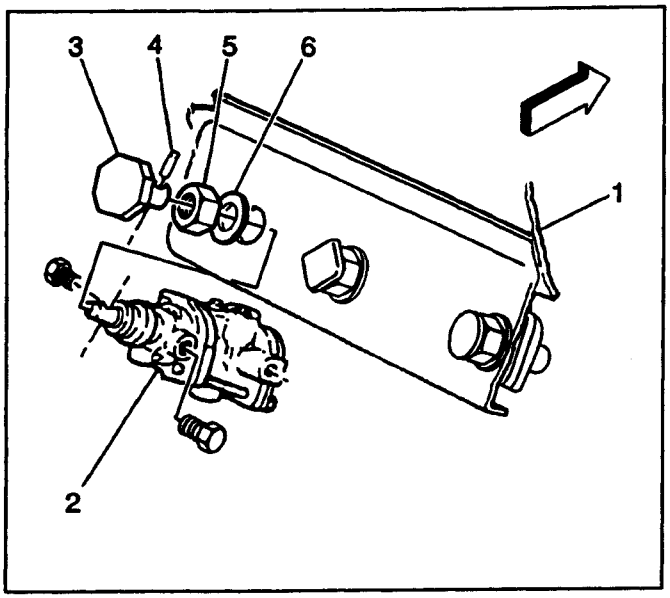
209561

4. Pull out the trailer air supply knob (3)



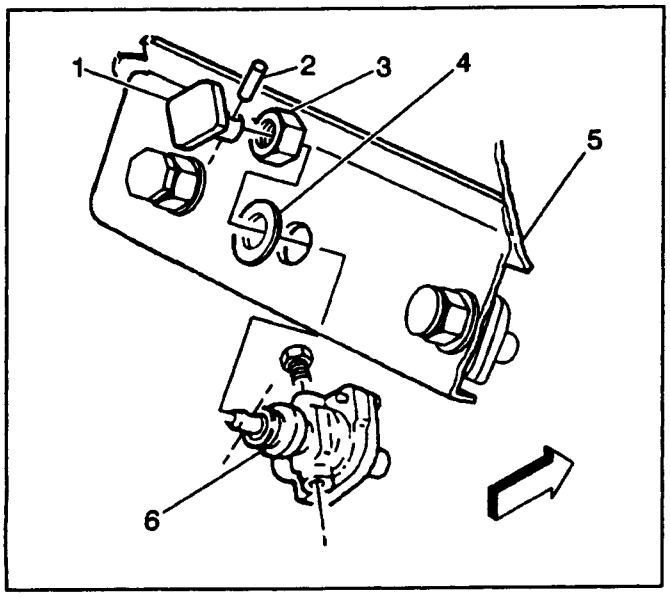
209563

5. Pull out the system park knob (1).



209561

6. Apply a soap solution to the exhaust vent and around the base of the trailer air supply knob (3).
7. Verify that leakage is less than a 25 mm (1 in) bubble in 5 seconds. If not, repair or replace the valve. For repair information, refer to Air Brake Valve Unit Repair.
8. If the leakage exceeds these limitations, repair or replace the valve. For repair information, refer to Air Brake Valve Unit Repair.
9. Push in the trailer air supply knob (3).



209563

10. Apply a soap solution to the exhaust port.
11. Check that the leakage is less than a 25 mm (1 in) bubble in 5 seconds.
12. If the leakage exceeds these limitations, repair or replace the valve. For repair information, refer to Air Brake Valve Unit Repair.
13. Set the parking brake.
14. Remove the wheel blocks.

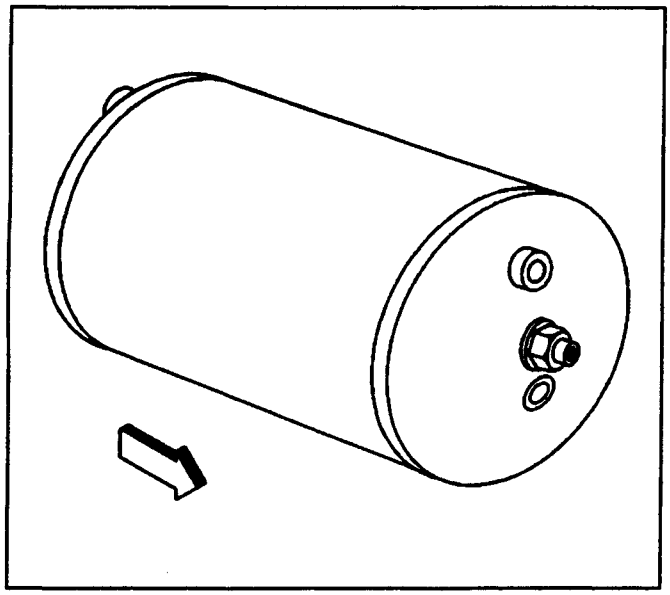
Reservoir Check Valve Test (Operational Check)

1. Apply the parking brake and block the vehicle wheels.
2. Start the engine.
3. Charge the system to the air compressor governor cut-out point.
4. Stop the engine.
5. Drain the air pressure from the supply air reservoir. Refer to *Draining Reservoirs.*

   Important: Applying and releasing the brakes repeatedly drains the supply air reservoir pressure. This can eventually cause the brakes to appear sluggish.
6. Ask an assistant to apply and release the brake pedal two times.
7. Verify that the front and rear slack adjusters move smoothly and promptly.
   - If the front brakes are sluggish or fail to move, overhaul or replace the single check valve at the front service air reservoir.
   - If the rear brakes are sluggish or fail to move, overhaul or replace the single check valve at the rear service air reservoir.
8. Start the engine.
9. Charge the system air pressure to the governor cut-out point.
10. Stop the engine.
11. Remove the wheel blocks.

Reservoir Check Valve Test (Leakage Test)

1. Apply the parking brake and block the vehicle wheels.
2. Start the engine.
3. Charge the system to the air compressor governor check-out point.
4. Stop the engine.
5. Drain the air pressure from the supply air reservoir. Refer to *Draining Reservoirs.*



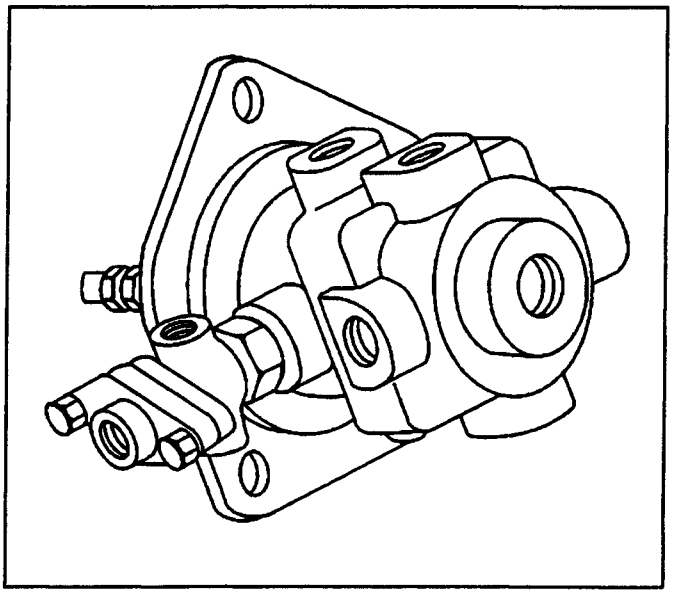
227883

6. Disconnect the air line on the supply side of the single check valve.
7. Inspect the single check valve for air leakage. Air leakage must not exceed a 25.4 mm (1 in) bubble in 5 seconds.

   If leakage is excessive, overhaul or replace the single check valve.
8. Connect the supply port air line.
9. Start the engine.
10. Charge the air system to the governor cut-out point.
11. Stop the engine.
12. Test the brake for proper operation.
13. Remove the wheel blocks.

Air Brake Double Check Valve Test (Operational Check)

1. If the vehicle has trailer provisions, connect the vehicle to a known operating trailer.
2. Block the vehicle wheels.
3. Start the engine.
4. Charge the air system to the governor cut-out point.



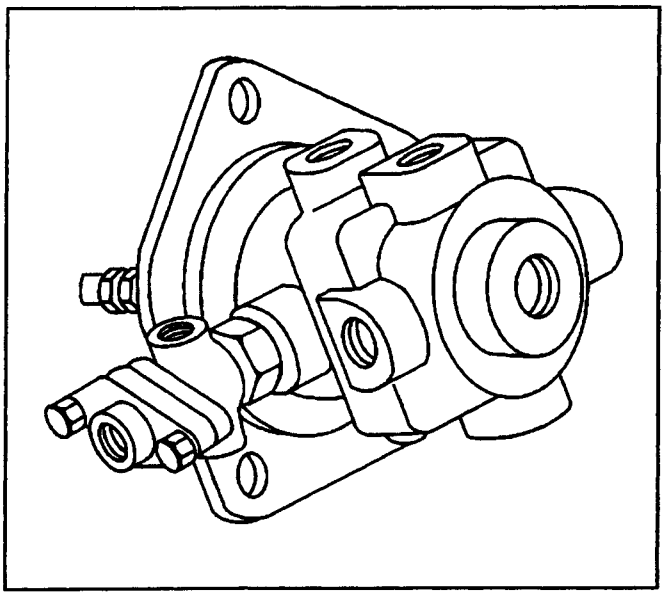
227886

5. Push in the park control knob and push in the trailer air supply knob, if equipped.
6. Stop the engine.
7. Drain the rear service air reservoir.

8. Verify the following items:
   - The park control knob and the trailer air supply knob should remain in the applied position and not pop out.
   - The spring brake chamber assemblies must remain in the released position. If the assemblies are not in the same position, overhaul or replace the double check valve.
   - For models with trailer provisions, the brake pedal should apply the trailer service brakes. If the brake pedal does not apply the trailer service brakes, check the trailer air brake control valve. If the control valve is operational, overhaul or replace the double check valve.
9. Start the engine.
10. Charge the air system to the air compressor governor cut-out point.
11. Push in the park control knob and push in the trailer air supply knob.
12. Stop the engine.
13. Drain the front service air reservoir.
14. Verify the following items:
    - The park control knob and the trailer air supply knob should remain in the applied position and not pop out.
    - The spring brake chamber assemblies must remain in the released position. If the assemblies are not in the same position, overhaul or replace the double check valve.
    - For models with trailer provisions, the brake pedal should apply the trailer service brakes. If the brake pedal does not apply the trailer service brakes, check the trailer air brake control valve. If the control valve is operational, overhaul or replace the double check valve.
15. If any of the items does not function properly, overhaul or replace the double check valve.
16. Start the engine.
17. Charge the air system to the air compressor governor cut-out point.
18. Check for proper brake operation.
19. Stop the engine.
20. Set the parking brake.
21. Remove the wheel blocks.

Air Brake Double Check Valve Test (Leakage Test)

1. Block the vehicle wheels.
2. Drain all of the air reservoirs. Refer to *Draining Reservoirs.*

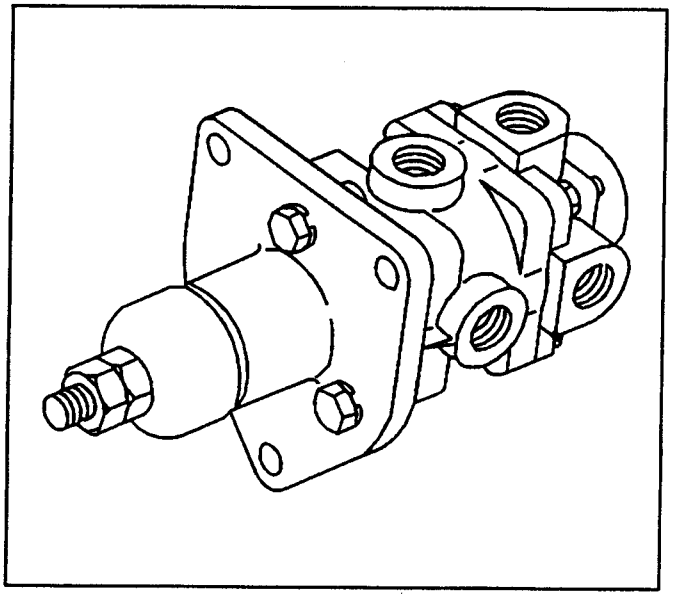


227886

3. Remove the double check valve. Refer to *Air Brake Double Check Valve Replacement.*
4. Plug the delivery port.
5. Connect an air supply to one of the supply ports. Apply approximately 861 kPa (125 psi) of air pressure.
6. Apply a soap solution to the opposite supply port.
7. Check that the leakage is less than a 25.4 mm (1 inch) bubble in 5 seconds. If the leakage exceeds these specifications, repair or replace the double check valve.
8. Disconnect the air supply and repeat Steps 4–6 on the other supply port.
9. Shut off and disconnect the air supply.
10. Unplug the delivery port.
11. Install the double check valve.
12. Start the engine.
13. Charge the air supply system to the air compressor governor cut-out point.
14. Stop the engine.
15. Check for proper brake operation.
16. Remove the wheel blocks.

Air Brake Application Valve Test (Operational Check)

1. Block the wheels.
2. Install accurate test gauges into the front and rear dual application valve circuits.
3. Start the engine.
4. Charge the air system to the air compressor *governor cut-out* point.
5. Stop the engine.



227888

6. Test the delivery air pressure in both the front circuis and the rear circuits.
   - 6.1. Depress the brake pedal to several positions between fully released and fully applied.
   - 6.2. Check the delivered air pressure on the test gauges in order to see that the pressure varies equally and proportionality with the movement of the brake pedal.

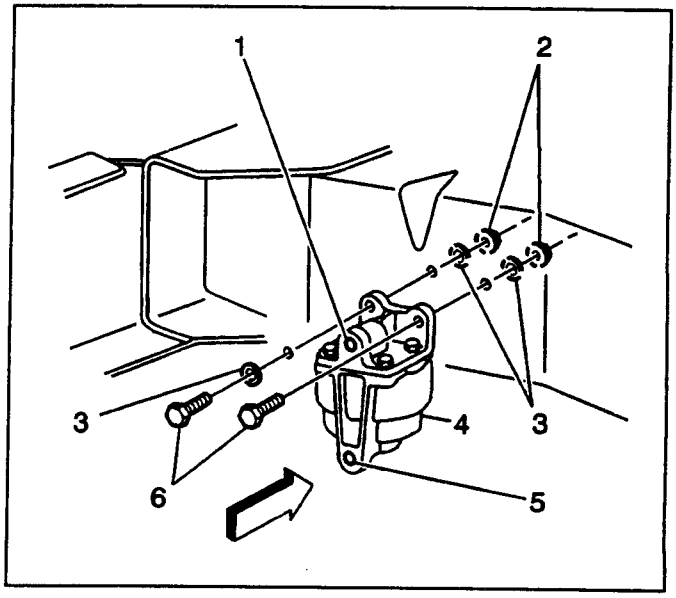
     After you release a full brake application, verify that the reading on the test gauges falls off to zero promptly. With both service air reservoirs at the same pressure, the rear brake circuit delivery air pressure will be about 14 kPa (2 psi) greater than the front brake delivery air pressure. This is a normal condition for this valve.
7. If the dual application valve does not operate as described, overhaul or replace the dual application valve.
8. Drain the air reservoirs.
9. Remove the test gauges.
10. Start the engine.
11. Charge the air system to the air compressor governor cut-out point.
12. Stop the engine.
13. Test the brake for proper operation.
14. Remove the wheel blocks.

Air Brake Application Valve Test (Leakage Test)

1. Block the wheels.
2. Tilt the cab. Refer to *Cab Tilting* in General Information.
3. Remove the upper inner fender panel. Refer to Body Front End.
4. Lower the cab.
5. Start the engine.
6. Charge the air system to the air compressor governor cut-out point.
7. Stop the engine.
8. Tilt the cab.
9. Ask an assistant to apply the brake pedal.
10. Inspect the exhaust port and the body of the dual application valve for air leakage. Air leakage of a 25.4 mm (1 in) bubble in 3 seconds is permitted.

    If air leakage is excessive, overhaul or replace the dual application air valve.
11. Install the upper inner fender panel.
12. Lower the cab.
13. Test the brake for proper operation.
14. Remove the wheel blocks.

Front Air Brake Limit Valve Test (Operational Check)



202582

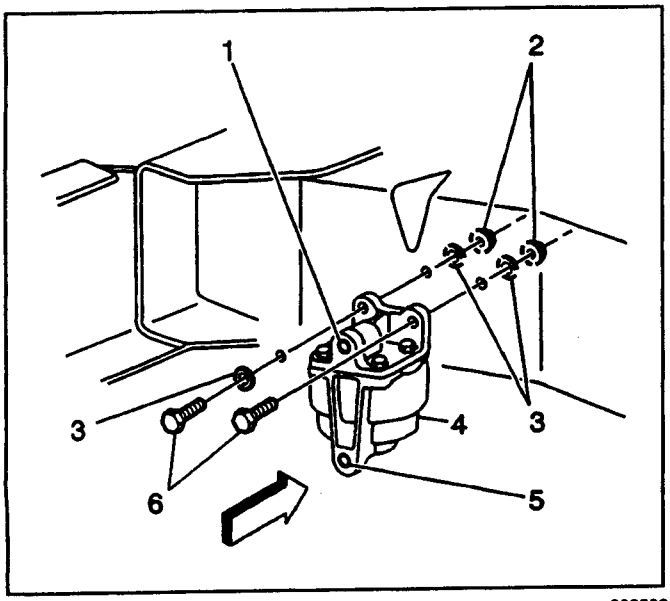
1. Install the test pressure gauges in the supply and the delivery lines of the limiting valve (4).
2. Start the engine.
3. Charge the system air pressure to the governor cut-out point.
4. Turn off the engine.
5. Apply the parking brake.
6. Apply the brake pedal slowly.

7. Check the pressure registered in the delivery line.

   The pressure should be approximately half of the supply line pressure. The 50 percent reduction should occur while the supply line pressure is below 275 kPa (40 psi). Repair or replace the valve (4) if this does not happen. Refer to Air Brake Valve Unit Repair.
8. Check that the delivery pressure catches up to the supply pressure when the supply line pressure exceeds 275 kPa (40 psi) but is less than 413 kPa (60 psi).
9. Check that the delivery line pressure is equal to the supply line pressure when the supply pressure exceeds 413 kPa (60 psi). Repair or replace the valve (4) if the pressure is not equal. Refer to Air Brake Valve Unit Repair.
10. Release the brakes.
11. Turn off the engine.
12. Remove the test air gauges.

Front Air Brake Limit Valve Test (Leakage Test)

1. Block the vehicle wheels.
2. Apply the parking brake.
3. Start the engine.
4. Charge the system air pressure to the governor cut-out point.
5. Have an assistant apply the brake pedal.
6. Apply a soap solution to the exhaust port and around the seam between the cover and the body.

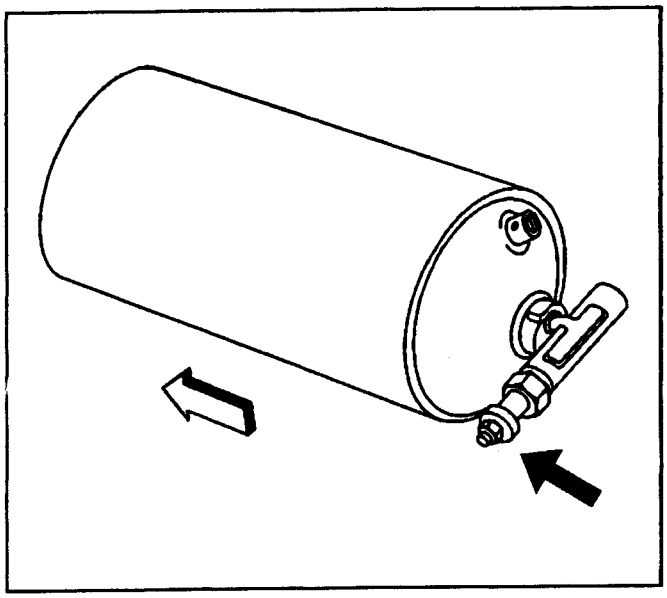


202582

7. Check that no bubbles appear around the seam.
8. Repair or replace the valve (4) if bubbles appear. Refer to *Air Brake Application Valve Replacement.*
9. Check that the exhaust port leakage is less than a 25 mm (1 in) bubble in 5 seconds.
10. Repair or replace the valve (4) if the leakage exceeds this amount. Refer to *Air Brake Application Valve Replacement*
11. Remove the wheel blocks.

Front Axle Serv Rsvr Air Supply Valve Test (Operational Check)

1. Block the wheels.
2. Bleed the air pressure from the supply air reservoir. Refer to *Draining Reservoirs.*



227891

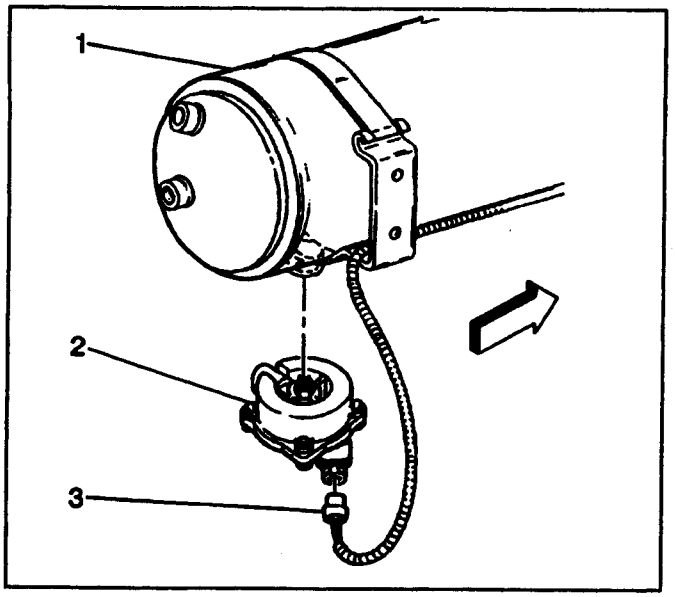
3. Connect a shop air hose to the inflation valve and fill the supply air reservoir.
4. Verify that the supply air reservoir fills.
5. Remove the wheel blocks.

Front Axle Serv Rsvr Air Supply Valve Test (Leakage Test)

1. Block the wheels.
2. Start the engine.
3. Charge the system to the air compressor governor cut-out point.
4. Stop the engine.
5. Apply a soap solution in order to cover the inflation valve. Leakage is not permissible.
   - If bubbles appear, install the valve core finger tightly and inspect the valve for leaks.
   - If leakage is still present, replace the inflation valve.
6. Remove the wheel blocks.

Moisture Ejector Valve Test (Operational Check)

1. Start the engine.
2. Charge the system air pressure to the governor cut-out point.
3. Have an assistant apply and release the brake pedal several times.

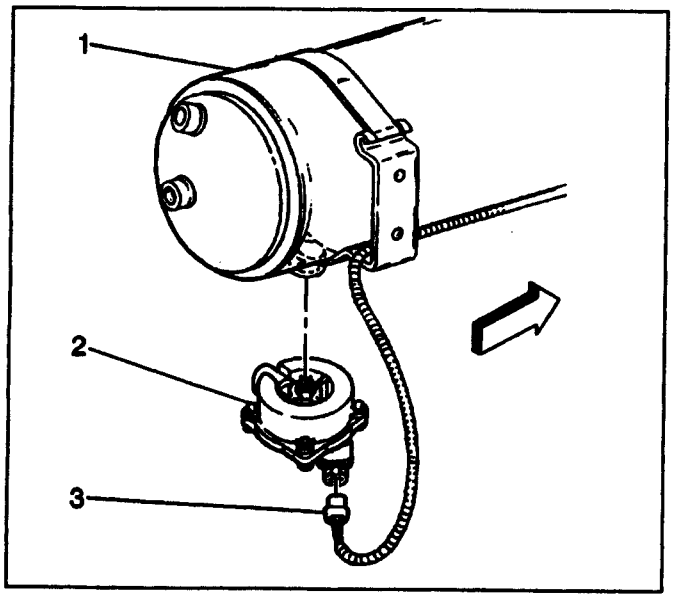


202605

4. Check that a spurt of air occurs at the exhaust port.
5. Clean or replace the valve (2) if there is no air at the exhaust port. Refer to Air Brake Valve Unit Repair.

Moisture Ejector Valve Test (Leakage Test)

1. Release the brake pedal.
2. Cover the exhaust port and the seams with a soap solution.

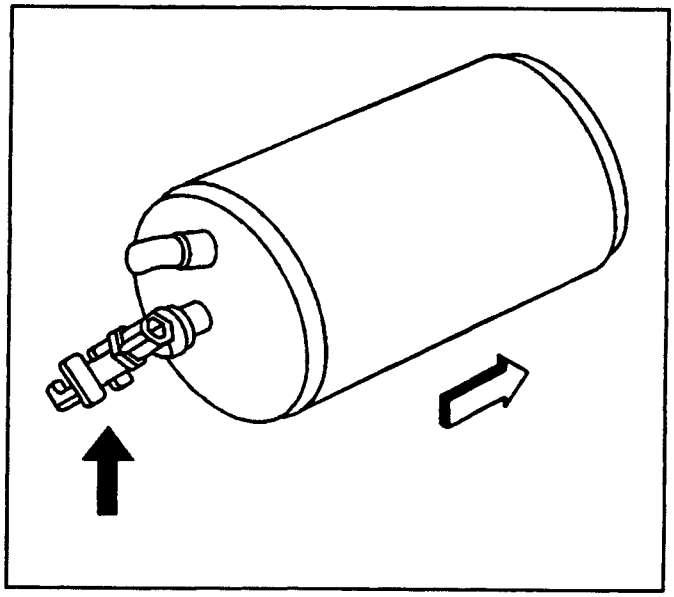


202605

3. Repair or replace the valve (2) if excessive leakage appears.

Pressure Protection Valve Test (Operational Check)

1. Block the wheels.
2. Apply the parking brake.
3. Drain all of the air reservoirs. Refer to *Draining Reservoirs.*



227894

4. Disconnect the air line from the pressure protection valve supply and the delivery ports.
5. Install test gauges and the drain valves onto the supply and delivery ports.
6. Start the engine.
7. Charge the system to the air compressor governor cut-out point.
8. Stop the engine.
9. While watching the test gauges, slowly exhaust pressure from the delivery side.
   - Both gauges will show a pressure loss until the pressure protection valve reaches its closing pressure.
   - The valve should close within 34 kPa (5 psi) of the rated pressure. If not replace the pressure protection valve.
10. Drain all of the air reservoirs.
11. Remove the drain valve and the test gauges.
12. Install the air lines.
13. Start the engine.
14. Charge the system to the air compressor governor cut-out point.
15. Stop the engine.
16. Inspect the system for air leakage.
17. Test the brakes for proper brake operation.
18. Remove the wheel blocks.

Pressure Protection Valve Test (Leakage Test)

1. Block the wheels.
2. Start the engine.
3. Charge the system to the air compressor governor cut-out point.
4. Stop the engine.
5. Inspect the pressure protection valve for air leakage. A 25.4 mm (1 in) bubble in 3 seconds or longer is acceptable.

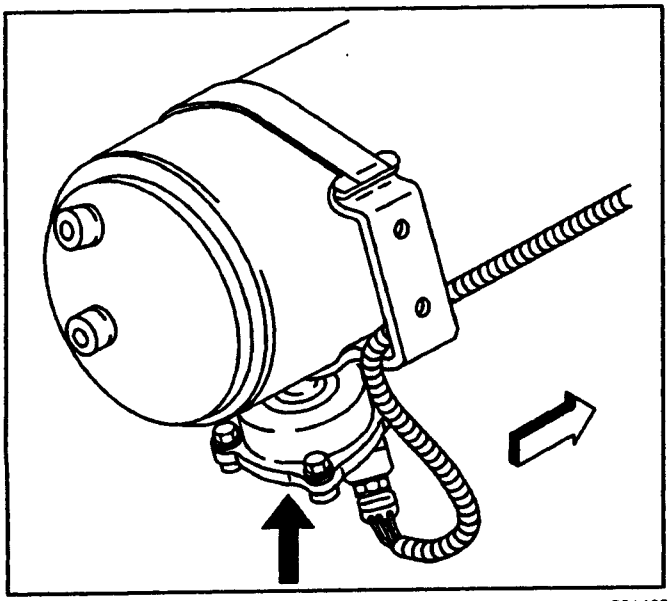
   If air leakage is excessive, replace the pressure protection valve.
6. Drain the air pressure from the delivery port and remove the air line connected to it.
7. Inspect the delivery port for leakage. A 25.4 mm (1 in) bubble in 5 seconds or longer is acceptable.

   If air leakage is excessive, replace the pressure protection valve.
8. Install the air line.
9. Remove the wheel blocks.

Reservoir Drain Valve Test

Operational Test

1. Block the wheels.
2. Start the engine.
3. Charge the system to the air compressor governor cut-out point.
4. Stop the engine.
5. Ask an assistant to apply and release the brake pedal several times.



201468

6. Verify that a discharge or air occurs at the reservoir drain valve (automatic type) exhaust port.

   If a discharge of air does not occur, clean, overhaul, or replace the reservoir drain valve (automatic type).
7. Remove the wheel blocks.

Air Leakage Test

1. Block the wheels.
2. Start the engine.
3. Charge the system to the air compressor governor cut-out point.
4. Stop the engine.
5. Cover the exhaust port and the seams with a soap solution. If air leakage appears, overhaul or replace the reservoir drain valve (automatic type).
6. Remove the wheel blocks.

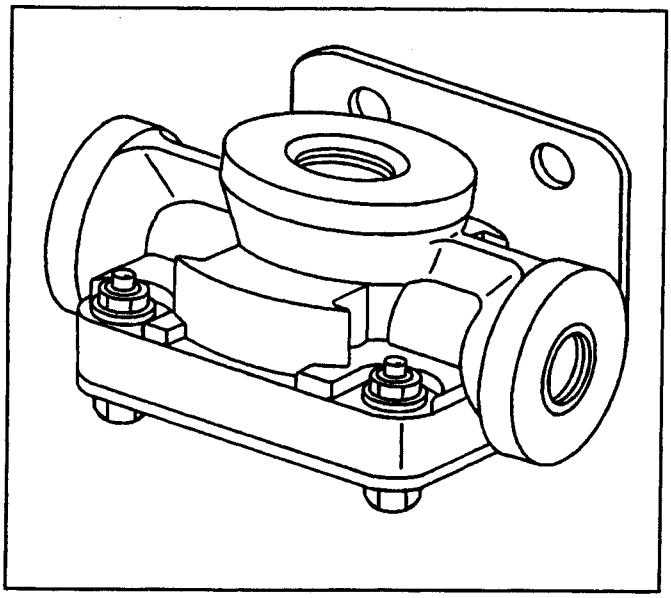
Air Brake Quick Release Valve Test (Operational Check)

1. Block the vehicle wheels.
2. Start the engine.
3. Charge the system air pressure to the governor cut-out point.
4. Stop the engine.
5. Ensure that the service brakes apply fully when you depress the brake pedal.
6. Verify that the brakes promptly release when you release the brake pedal.

   If the brakes are sluggish, check that air vents through the exhaust port when you release the brakes. If the brakes do not promptly release, repair or replace the quick release valve.
7. Remove the wheel blocks.

Air Brake Quick Release Valve Test (Leakage Test)

1. Block the vehicle wheels.
2. Start the engine.
3. Charge the system air pressure to the governor cut-out point.
4. Stop the engine.
5. Ask an assistant to apply the brake pedal.



202286

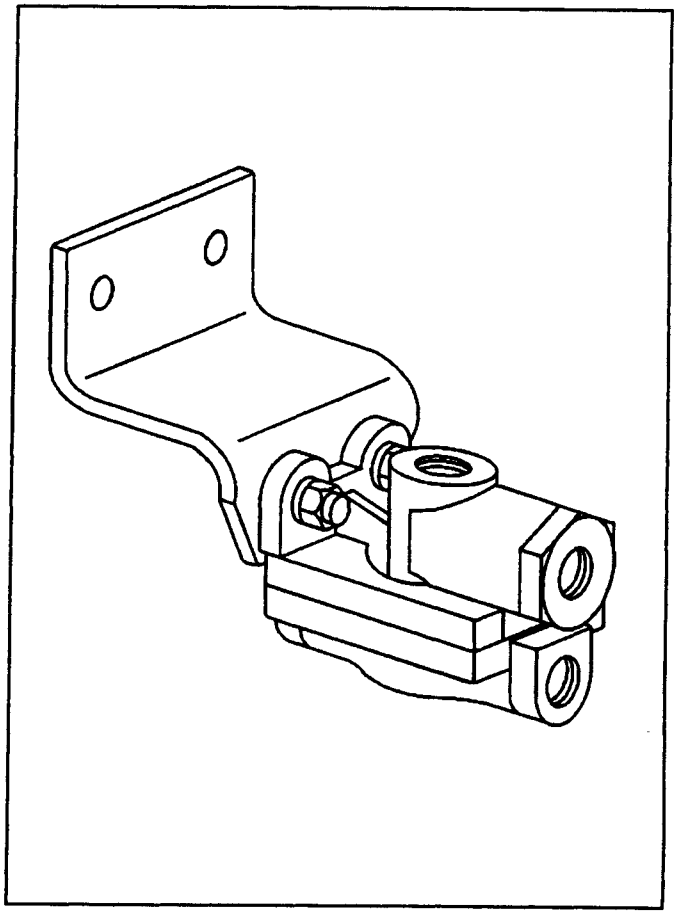
6. Inspect the exhaust port for air leakage. Air leakage of a 25.4 mm (1 inch) bubble in 3 seconds is acceptable. If the air leakage is excessive, overhaul or replace the quick release valve.
7. Inspect the upper and the lower valve body for air leakage. Air leakage is not permissable. If any bubbles appear, overhaul or replace the quick release valve.
8. Remove the wheel blocks.

Rear Air Brk Quick Release Double Check Valve Test (Operational Check)

1. Block the wheels.
2. Start the engine.
3. Charge the system air pressure to the governor cut-out point.
4. Stop the engine.
5. Release the brake pedal and push in the park control knob.
6. Verify that the spring brake chambers release promptly.
7. Pull out on the park control knob. Release the brake pedal.
8. Verify that a prompt exhaust of air occurs at the quick release valve (double check type) exhaust port.
9. Test the slack adjuster in order to verify that the spring brake is applied.
10. Remove the wheel blocks.

Rear Air Brk Quick Release Double Check Valve Test (Leakage Test)

1. Block the wheels.
2. Disconnect the air line from the balance port.
3. Start the engine.
4. Charge the air system to the air compressor governor cut-out point.
5. Stop the engine.
6. Push in the park control knob.



227875

7. Inspect the quick release valve (double check type) exhaust port and the balance port for air leakage. Air leakage less than 25.4 mm (1 in) bubble in 5 seconds is acceptable.

   If the air leakage is excessive, overhaul or replace the quick release valve (double check type).
8. Connect the air line to the balance port.
9. Pull out the park control knob.
10. Disconnect the air line from the supply port.
11. Ask an assistant to apply the brake pedal.
12. Inspect the supply port for air leakage. Air leakage less than 25.4 mm (1 in) bubble in 5 seconds is acceptable.

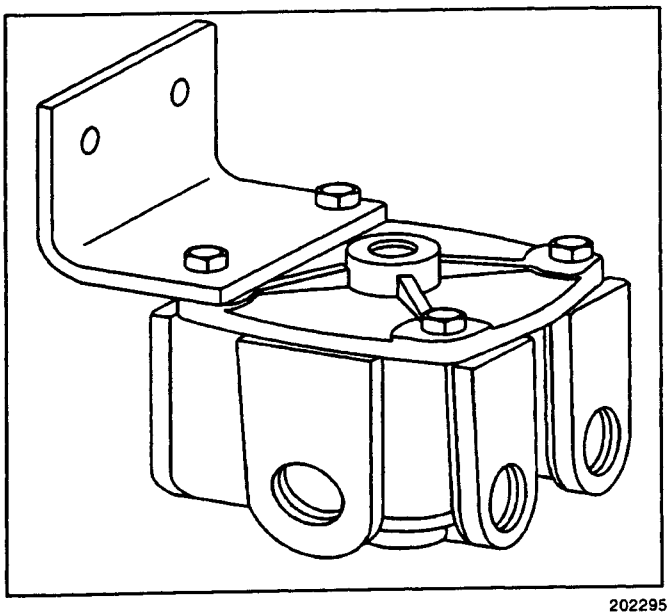
    If the air leakage is excessive, overhaul or replace the quick release valve (double check type).
13. Inspect the seam between the body and the cover for air leakage. Leakage is not permissable. If any bubbles appear, overhaul or replace the quick release valve (double check type).
14. Connect the air line at the supply port.
15. Inspect the air lines for leaks.
16. Remove the wheel blocks.

Rear Air Brake Relay Valve Test (Operational Check)

1. Block the wheels.
2. Start the engine.
3. Charge the air supply to the air compressor governor cut-out point.
4. Stop the engine.
5. While you check each wheel, ask an assistant to apply the brakes hard and then release the brakes several times.
   - Ensure that the brakes apply and release promptly at each wheel.
   - If the brakes do not apply and release promptly, overhaul or replace the relay valve.
6. Remove the wheel blocks.

Rear Air Brake Relay Valve Test (Leakage Test)

1. Block the wheels.
2. Start the engine.
3. Charge the air system to the air compressor governor cut-out point.
4. Stop the engine.
5. Release the brake pedal.



202295

6. Inspect the exhaust port and the area around the exhaust port retaining ring for air leakage. Air leakage less than a 25.4 mm (1 in) bubble in 3 seconds is acceptable.

   If air leakage is excessive, overhaul or replace the relay valve.
7. Ask an assistant to apply the brake pedal firmly.
8. Inspect the exhaust port for air leakage. Air leakage less than a 25.4 mm (1 in) bubble in 3 seconds is acceptable.

   If air leakage is excessive, overhaul or replace the relay valve.
9. Inspect the outside of the valve where the cover joins the valve body for air leakage. Air leakage is not pemissable.

   If any bubbles appear, overhaul or replace the relay valve.
10. Remove the wheel blocks.

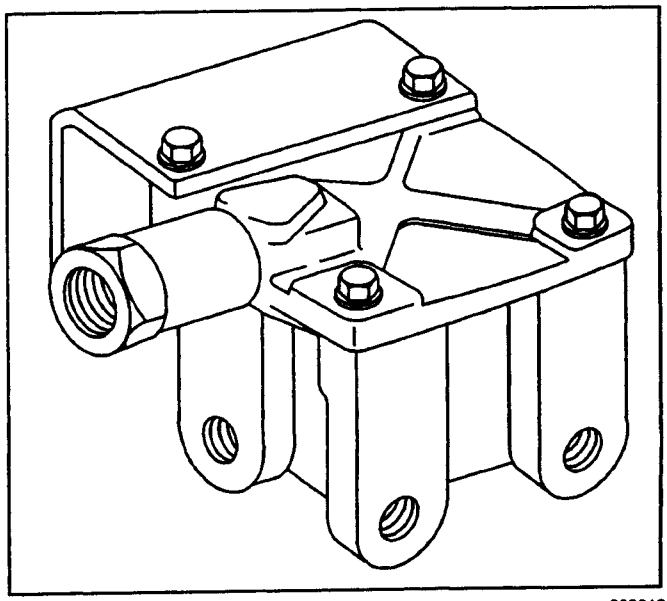
Rear Air Brake Relay Double Check Valve Test (Operational Check)

1. Block the wheels.
2. Start the engine.
3. Charge the air supply to the air compressor governor cut-out point.
4. Stop the engine.
5. While you check each wheel, ask an assistant to apply the brakes hard and then release the brakes several times.
6. Insure that the brakes apply and release promptly at each wheel.

   If the brakes do not apply and release promptly, overhaul or replace the relay valve (double check type).
7. Remove the wheel blocks.

Rear Air Brake Relay Double Check Valve Test (Leakage Test)

1. Start the engine.
2. Charge the air system to the air compressor governor cut-out point.
3. Stop the engine.
4. Release the brake pedal.
5. Pull out the park control knob.



202312

6. Inspect the exhaust port and inspect the area around the exhaust port retaining ring for air leakage. Air leakage less than a 25.4 mm (1 in) bubble in 3 seconds is acceptable.

   If air leakage is excessive, overhaul or replace the relay valve.

7. Push in the park control knob.
8. Inspect the exhaust port for air leakage. Air leakage less than a 25.4 mm (1 in) bubble in 3 seconds is acceptable.

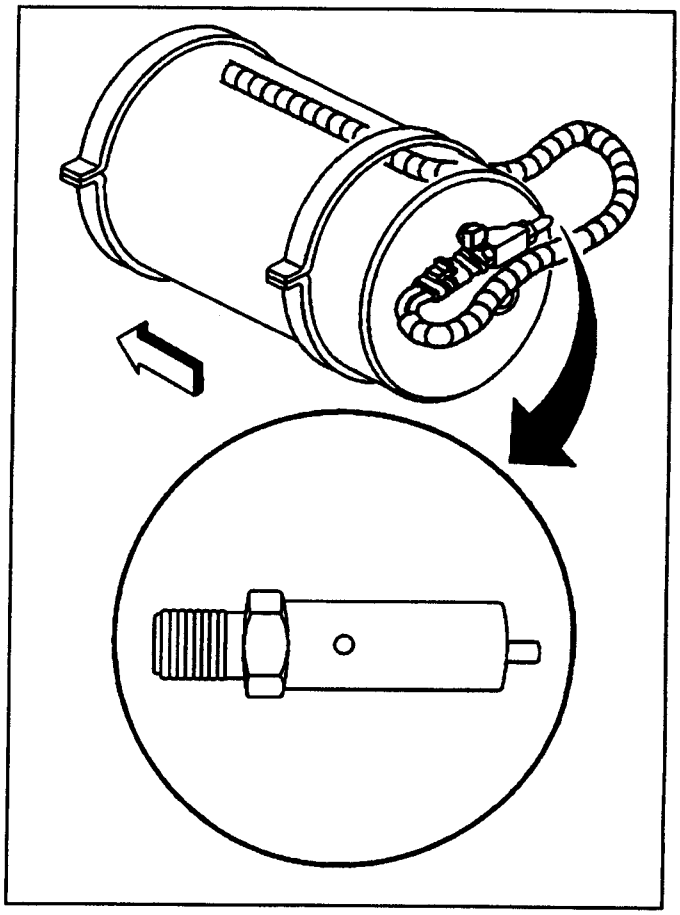
   If air leakage is excessive, overhaul or replace the relay valve (double check type).
9. Inspect the outside of the valve where the cover joins the valve body for air leakage. Air leakage is not permitted.

   If any bubbles appear, overhaul or replace the relay valve (double check type).
10. Disconnect the balance port air line.
11. Start the engine.
12. Charge the system to the air compressor governor cut-out point.
13. Stop the engine.
14. Inspect the balance port for air leakage. Air leakage less than a 25.4 mm (1 in) bubble in 3 seconds is acceptable.

    If air leakage is excessive, overhaul or replace the relay valve (double check type).
15. Connect the balance port air line.
16. Remove the wheel blocks.

Primary Air Brake Supply Rsvr Safety Valve Test (Operational Check)

1. Block the wheels.
2. Apply the parking brake.
3. Start the engine.
4. Charge the air system to the air compressor governor cut-out point.
5. Stop the engine.



227896

6. Pull out the exposed end of the valve stem. Air should exhaust from the safety valve exhaust port.

   If air does not exhaust from the safety valve exhaust port, replace the safety valve.
7. Release the valve stem. The air flow from the exhaust port should stop.

   If the air flow does not stop, replace the safety valve.
8. Remove the wheel blocks.

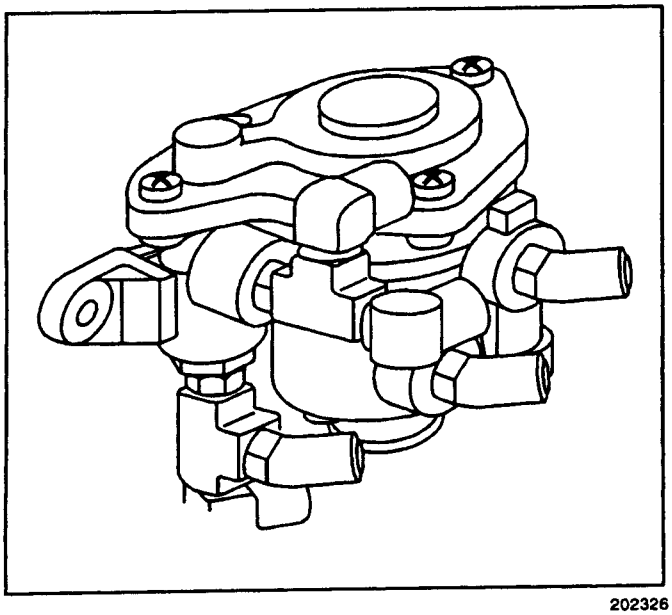
Primary Air Brake Supply Rsvr Safety Valve Test (Leakage Test)

1. Block the wheels.
2. Apply the parking brake.
3. Start the engine.
4. Charge the air system to the air compressor governor cut-out point.
5. Stop the engine.
6. Inspect the safety valve exhaust port for air leakage. Air leakage less than a 25.4 mm (1 in) bubble in 5 seconds is acceptable.

   If air leakage is excessive, replace the safety valve.
7. Remove the wheel blocks.

Chassis Mounted Air Brake Park Control Valve Test (Operational Check)

1. Block the wheels.
2. Start the engine.
3. Charge the system to the air compressor governor cut-out point.
4. Stop the engine.
5. Pull out the park control knob.
6. Verify that the spring brake chamber assemblies apply promptly.



202326

7. Install an accurate test air pressure gauge in the delivery port air line.
8. Push in the park control knob.
9. Verify that the spring brake chamber assemblies release fully.
10. Verify that the test gauge pressure reading is approximately 379 kPa (55 psi) or more. This is the rated spring hold-off pressure.

    If the pressure reading is not correct, overhaul or replace the park control valve (chassis mounted).
11. Pull out the park control knob.
12. Verify that the test gauge reading promptly falls to zero. If the reading does not fall to zero, overhaul or replace the park control valve (chassis mounted).
13. Push in the park control knob.
14. Drain the air from the rear service air reservoir(s).
15. Ask an assistant to apply and release the brake pedal repeatedly.
16. Verify that the pressure reading decreases each time your assistant applys the brake pedal.

    After several applications of the brakes, the pressure on the gauge will drop to the point where release of the spring brake chamber assemblies will no longer occur.
17. Remove the test air pressure gauge from the delivery port air line.
18. Start the engine.
19. Charge the system to the air compressor governor cut-out point.
20. Stop the engine.
21. Check the brakes for proper operation.
22. Remove the wheel blocks.

Chassis Mounted Air Brake Park Control Valve Test (Leakage Test)

1. Block the wheels.
2. Start the engine.
3. Charge the system to the air compressor governor cut-out point.
4. Stop the engine.
5. Push in the park control knob.
6. Inspect the exhaust port and around the valve cover for air leakage. Slight air leakage is permitted.

   If air leakage is excessive, overhaul or replace the park control valve (chassis mounted).
7. Remove the wheel blocks.

Towing Vehicle Protection Valve Test (Operational Check)

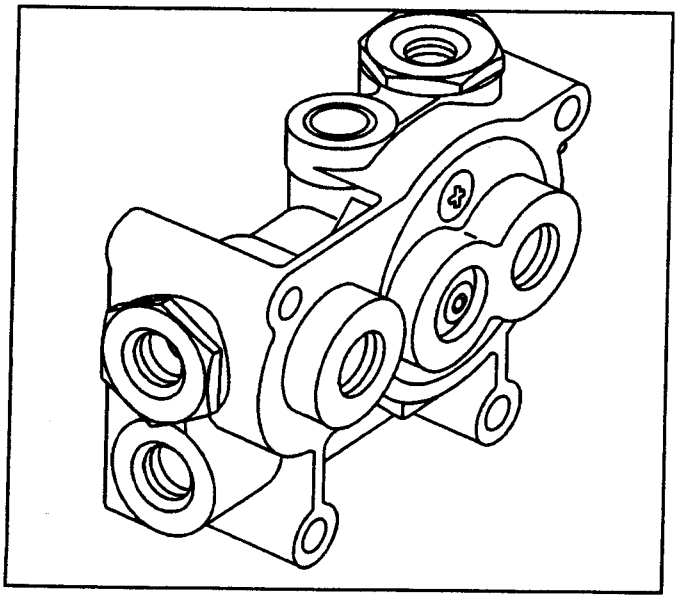
1. Block the wheels.
2. Start the engine.
3. Charge the system to the air compressor governor cut-out point.
4. Stop the engine.
5. Connect an air pressure test gauge to the trailer air supply service coupling.
6. Pull up the trailer air brake control lever to the fully applied position.
7. Verify that pressure occurs at the trailer service air line coupling.
8. Push down the trailer air brake control lever to the full released position.
9. Ask an assistant to apply the brake pedal firmly.

10. Inspect for air leakage at the exhaust port of the trailer air brake control valve. Excessive leakage indicates a faulty double check valve shuttle within the towing vehicle protection valve.

    If the leakage is excessive, overhaul or replace the towing vehicle protection valve.
11. Release the brake pedal.
12. Disconnect the air pressure test gauge from the trailer air supply service coupling.
13. Start the engine.
14. Charge the system to the air compressor governor cut-out point.
15. Stop the engine.
16. Check the brakes for proper operation.
17. Remove the wheel blocks.

Towing Vehicle Protection Valve Test (Leakage Test)

1. Block the wheels
2. Start the engine.
3. Charge the system to the air compressor governor cut-out point.
4. Stop the engine.
5. Pull out the trailer air supply knob.
6. Disconnect the trailer air service air line.
7. Pull up the trailer air brake control valve lever in order to fully apply the trailer service brakes.



202334

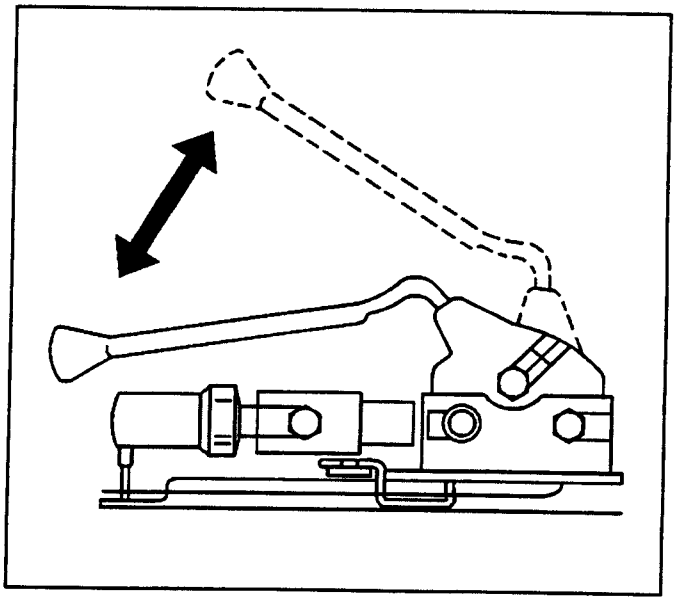
8. Hold a finger over the 1.6 mm (0.0625 in) vent hole in the valve.
9. Inspect the hose coupling and the exhaust port for leakage. If the air leakage is excessive, overhaul or replace the towing vehicle protection valve.
10. Release the trailer air brake hand control valve.
11. Connect an air pressure test gauge to the trailer air supply service coupling.
12. Pull up the trailer air brake control lever to the fully applied position.
13. Inspect for air leakage at the exhaust port. If the air leakage is excessive, overhaul or replace the towing vehicle protection valve.
14. Inspect the 1.6 mm (0.0625 in) vent hole in the valve for air leakage. Leakage is not permissible.

    If the air leakage is present, overhaul or replace the towing vehicle protection valve.
15. Push down the trailer air brake control lever.
16. Inspect the 1.6 mm (0.0625 in) vent hole in the valve for air leakage. Leakage is not permissible.

    If the air leakage is present, overhaul or replace the towing vehicle protection valve.
17. Drain all of the air from all of the lines and the air reservoirs.
18. Disconnect the air pressure test gauge from the trailer air supply service coupling.
19. Start the engine.
20. Charge the system to the air compressor governor cut-out point.
21. Stop the engine.
22. Check the brakes for proper operation.
23. Remove the wheel blocks.

Trailer Brake Control Valve Test (Operational Check)

1. Block the wheels.
2. Drain all of the air reservoirs. Refer to *Draining Reservoirs.*
3. Install a test air pressure gauge in the trailer air brake control valve delivery line.
4. Start the engine.
5. Charge the system to the air compressor governor cut-out point.
6. Stop the engine.



227705

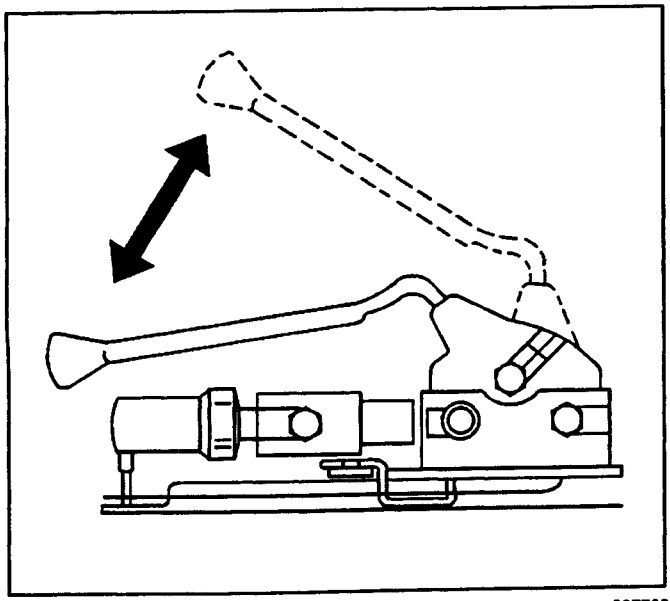
7. Push the trailer air brake control lever down to the full OFF position.
8. Verify that the test air pressure gauge indicates zero air pressure.

   If the gauge does not indicate zero air pressure, replace the trailer air brake control valve.
9. Pull up on the trailer air brake control lever to the full ON position.
10. Verify that the test air pressure gauge indicates the same air pressure as the the dual air pressure gauge.

    If the test air presssure gauge and the dual air pressure gauge do not have the same air pressure reading then replace the trailer air brake control valve.
11. Move the lever to several intermediate positions.
12. Verify that the test air pressure gauge indicates intermediate air pressures consistent with the handle position.
13. Drain all of the air reservoirs.
14. Remove the test air pressure gauge.
15. Start the engine.
16. Charge the system to the air compressor governor cut-out point.
17. Stop the engine.
18. Check for proper brake operation.
19. Remove the wheel blocks.

Trailer Brake Control Valve Test (Leakage Test)

1. Block the wheels.
2. Start the engine.
3. Charge the system to the air compressor governor cut-out point.
4. Stop the engine.



227705

5. Push down the trailer air brake control valve lever to the full OFF position.
6. Inspect the valve body and the exhaust port for air leakage. Air leakage is not permissible.

   If air leakage is present, replace the trailer air brake control valve.
7. Pull up the trailer air brake control lever to the full ON position.
8. Inspect the valve body and the exhaust port for air leakage. Air leakage is not permissible.

   If air leakage is present, replace the trailer air brake control valve.
9. Remove the wheel blocks.

Air Dryer/Moisture Ejector System Check

1. Check condition of circuit breaker #9. If circuit breaker is open, locate and repair cause of overload. Replace circuit breaker if necessary.
2. Check that G404 is clean and tight.
3. The air brake dryer and moisture ejector heater are both thermostatically controlled. The thermostat will activate the heating element when the valve body reaches a temperature of approximately 7°C (45°F). The heating elements will deactivate when the valve body is warmed to approximately 26°C (85°F).
4. If either the air brake dryer or the moisture ejector heater remain engaged above 26°C (85°F), replace the malfunctioning component.
5. Check for a broken or partially broken wire inside the insulation which could cause system malfunction but prove good in a continuity/voltage check with the system disconnected. These circuits may be interrmittent or resistive when loaded, and if possible, shoild be checked by monitoring for a voltage drop with the system operational (under load).
6. Check for proper installation of aftermarket electronic equipment which may affect the integrity of other systems. Refer to *Checking Aftermarket Accessories.*

Air Dryer and Moisture Ejector Do Not Work

Step	Action	Value(s)	Yes	No
1	1. Turn the ignition switch to RUN. 2. Backprobe the air dryer with a test lamp from terminal A to the chassis ground. Did the test lamp light?	—	Go to *Step 2*	Go to *Step 3*
2	Repair the open in CKT 150 (BLK) between the IP fuse block and S701. Do both the air dryer and the moisture ejector heater operate?	—	System OK	—
3	Repair the open in CKT 341, 139, and 145 (BRN) between the IP fuse block and G404. Do both the air dryer and the moisture ejector heater operate?	—	System OK	—

Air Dryer or Moisture Ejector Does Not Work

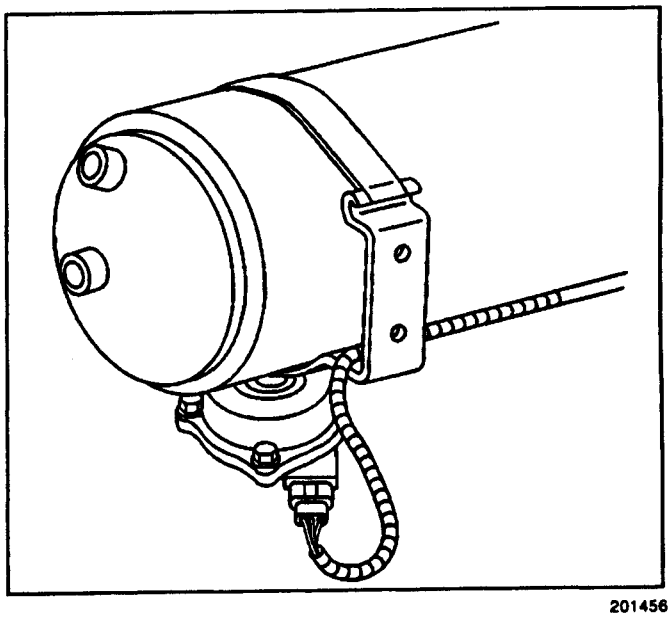
Step	Action	Value(s)	Yes	No
1	1. Turn the ignition switch to RUN. 2. Backprobe the inoperative component with a test lamp from terminal A to the chassis ground. Did the test lamp light?	—	Go to *Step 2*	Go to *Step 3*
2	Backprobe the inoperative component with a test lamp from terminal B to B+. Did the test lamp light?	—	Go to *Step 4*	Go to *Step 5*
3	Repair the open in CKT 341 (BRN) between S420 and the inoperative component. Does the air dryer or the moisture ejector heater operate?	—	System OK	—
4	Replace the inoperative component. Does the air dryer or the moisture ejector heater operate?	—	System OK	—
5	Repair the open in CKT 150 (BLK) between the inoperative component and G404. Does the air dryer or the moisture ejector heater operate?	—	System OK	—

Repair Instructions

Draining Reservoirs

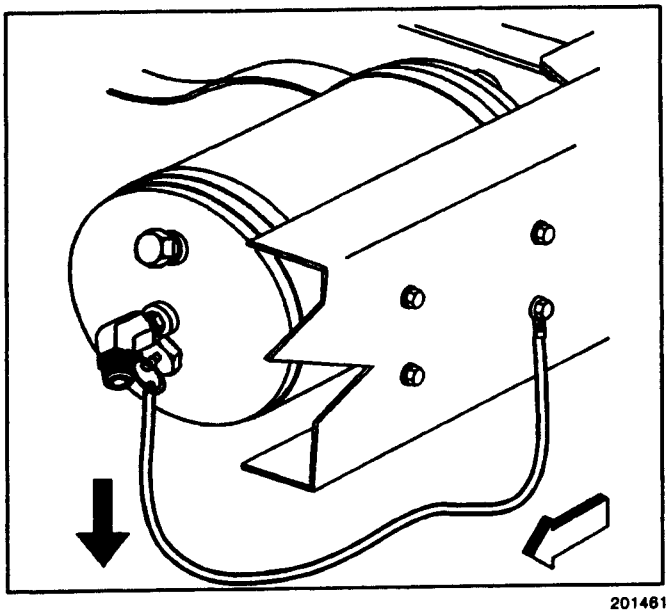
Daily Maintenance Draining

Water and contaminants should be drained from the primary air brake supply reservoir daily unless a reservoir drain valve (automatic type) is installed. Daily draining is not needed on reservoirs with the optional reservoir drain valve (automatic type). The reservoir drain valve (automatic type) automatically drains water and contaminants.



201456

1. Start the engine and charge the system with air.
2. Pull the cable attached to the reservoir drain valve (manual type) on the bottom of the supply reservoir.
3. After the water and contaminants stop draining, release the cable. The reservoir drain valve (manual type) will close.

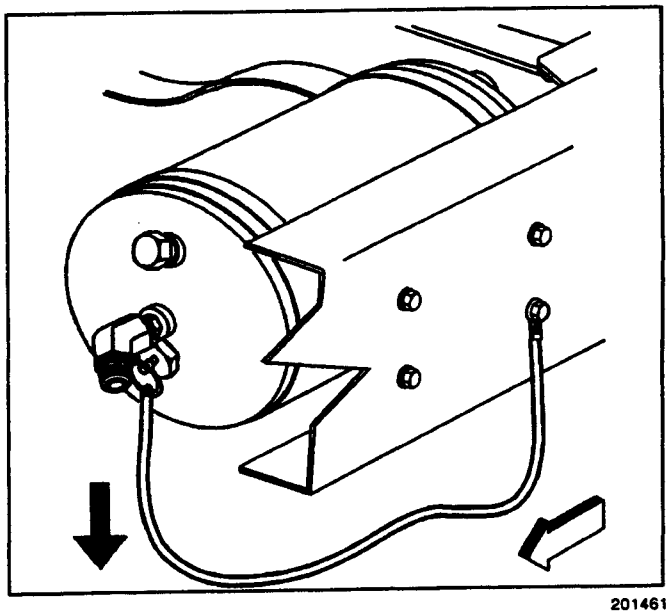


201461

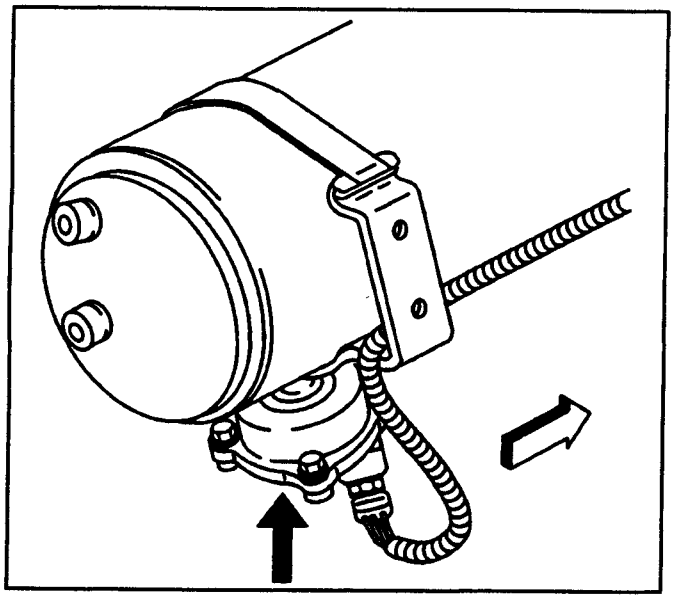
Complete Service Draining

1. Block the vehicle wheels.
2. Apply the parking brake.
3. Drain the supply reservoir.

   On reservoirs with a reservoir drain valve (manual type), pull the reservoir drain valve cable until the reservoir drain valve opens. Hold the cable until all the air is drained.

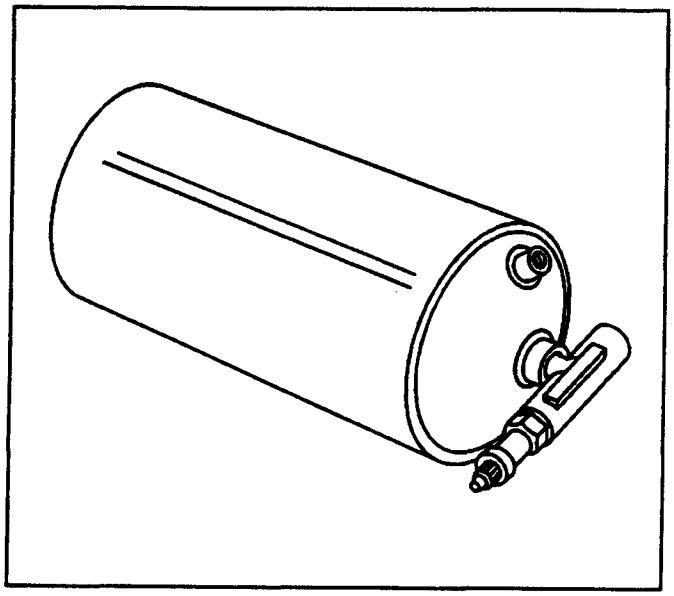


201461



201468

4. On reservoirs with a reservoir drain valve (automatic type), push upward on the wire in the exhaust port of the reservoir drain valve (automatic type) and hold until all the air is drained.
5. Open the reservoir drain valve (manual type) and drain the front service reservoir.
6. Open the reservoir drain valve (manual type) and drain the rear service reservoirs. Drain all of the rear service reservoirs.



227716

Filling Reservoirs

Standard Method

1. Charge the air system.

   Start the engine and allow the air compressor to fill the air system.
2. Remove the wheel blocks.

Optional Method

1. Connect a compressed air line to the inflation valve.
   - Ensure that the compressed air is free of moisture.
   - Do not fill the system with more than 861 kPa (125 psi) of air pressure.
2. Disconnect the compressed air line.
3. Remove the wheel blocks.

Applying Pipe Sealant

Apply pipe sealant, prior to the assembly procedure, to the following components:

- All male pipe threads not having pre-applied pipe sealant (burnt orange in color)
- Components with male pipe threads with pre-applied sealant that have been assembled and disassembled a maximum of five times must have pipe sealant applied before assembly

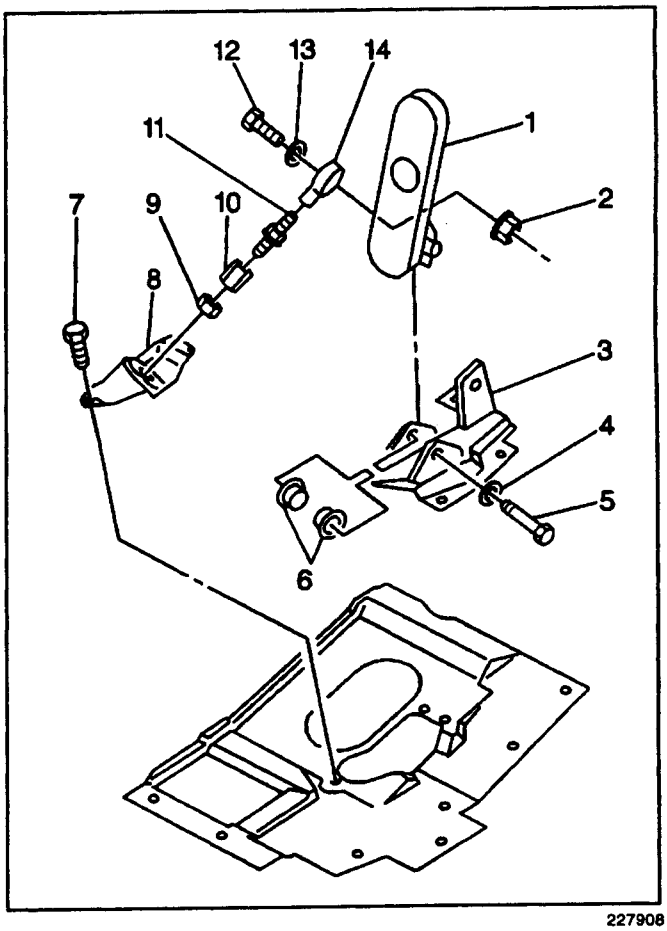
1. Clean the threads. Remove all grease and oil with a clean cloth.
2. Inspect the threads for damage. Replace any damaged threads.

   Important: Do not allow pipe thread sealant on any internal diameters.
3. Apply pipe sealant with Teflon® to the first few threads.

Air Brake Pedal Replacement

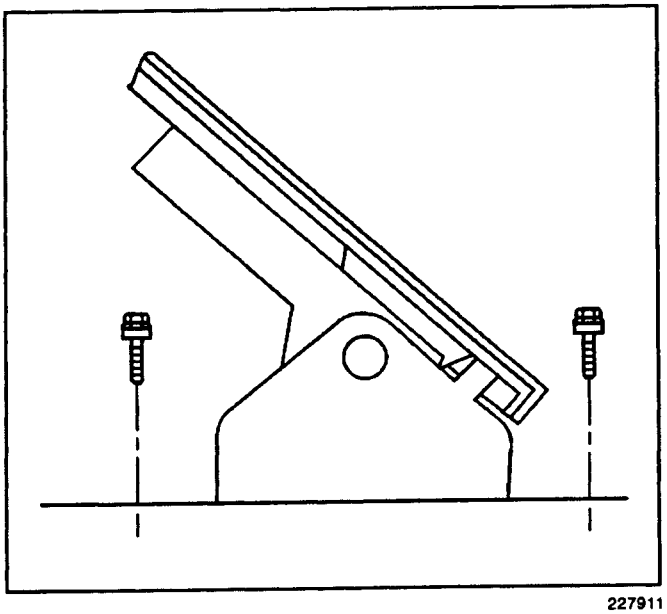
Removal Procedure

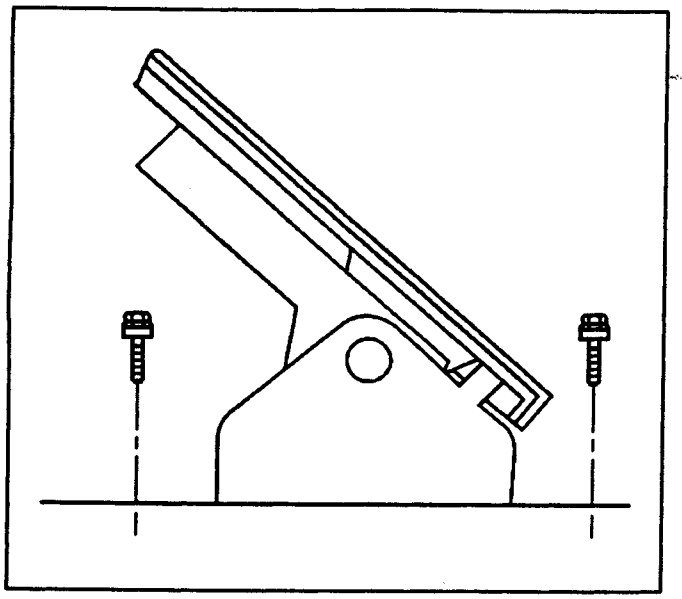
1. Block the wheels.
2. Remove the brake pedal bracket bolts (5) from the brake pedal bracket (3).
3. Tilt the cab. Refer to *Cab Tilting* in General Information.
4. Remove the left inner fender panel. Refer to Body Front End.
5. Loosen the brake pedal joint lock nut (9).
6. Turn the dual application valve push rod until it is free if the brake pedal joint nut (10).
7. Lower the cab.



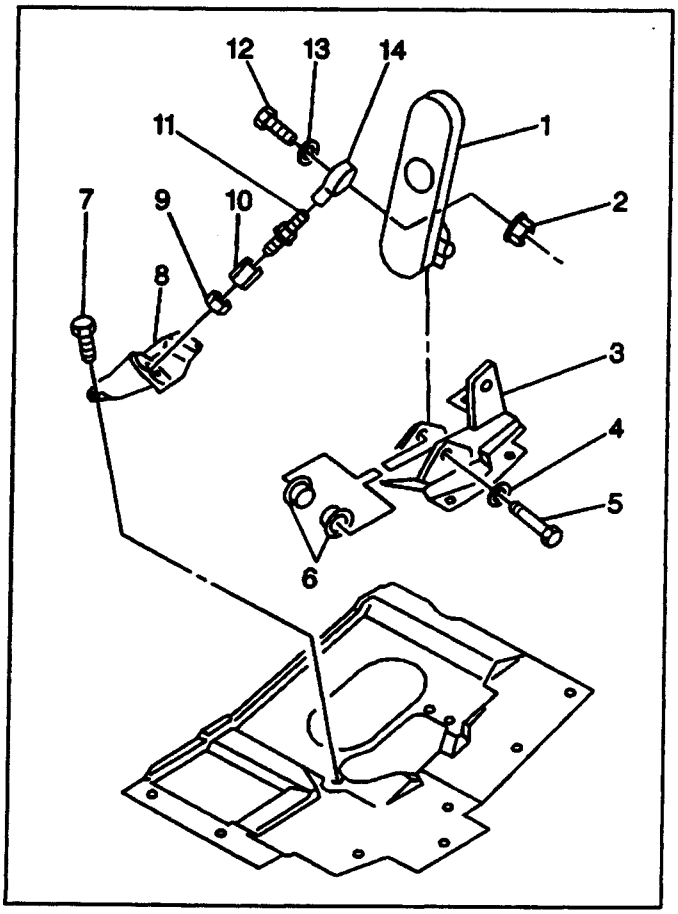
227908

8. Remove the brake pedal.


227911



227911



227908

Installation Procedure

1. Loosely fit the brake pedal into position.
2. Tilt the cab.
3. Loosely assemble the dual application valve push rod into the brake pedal joint nut (10).
4. Lower the cab.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
5. Install the brake pedal bracket bolts (5) to the brake pedal bracket (3).

   Tighten

   - Tighten the brake pedal bracket bolts (6 mm) to 8 N.m (71 lb in).
   - Tighten the brake pedal bracket bolts (8 mm) to 19 N.m (14 lb in).
6. Tilt the cab.
7. Pull up the top of the brake pedal until it is in contact with the stopper on the return side, while turning the brake pedal joint.

   Adjust the park pedal end play until 5.25– 5 mm (0.206 –0.182 in) end play is achieved.

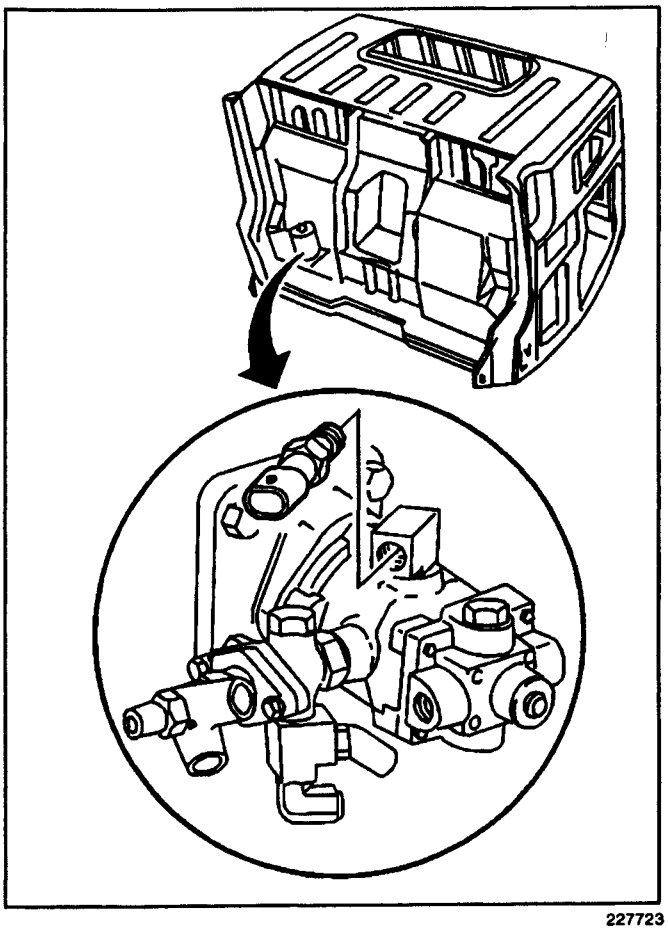
   Tighten

   Tighten the brake pedal joint lock nut to 62 N.m (46 lb ft).
8. Measure the end play 5.25–5 mm (0.206–0.182 in).
9. Install the left inner fender panel.
10. Lower the cab.
11. Perform the air leakage test. Refer to *Air Brake System Testing (Operational Check).*
12. Perform the operational test. Refer to *Air Brake System Testing (Operational Check).*

Stoplamp Switch Replacement

Removal Procedure

1. Block the vehicle wheels.
2. Set the parking brake.
3. Drain all of the air reservoirs. Refer to *Draining Reservoirs*.
4. Remove the wiring harness connector.
5. Remove the stoplamp switch.

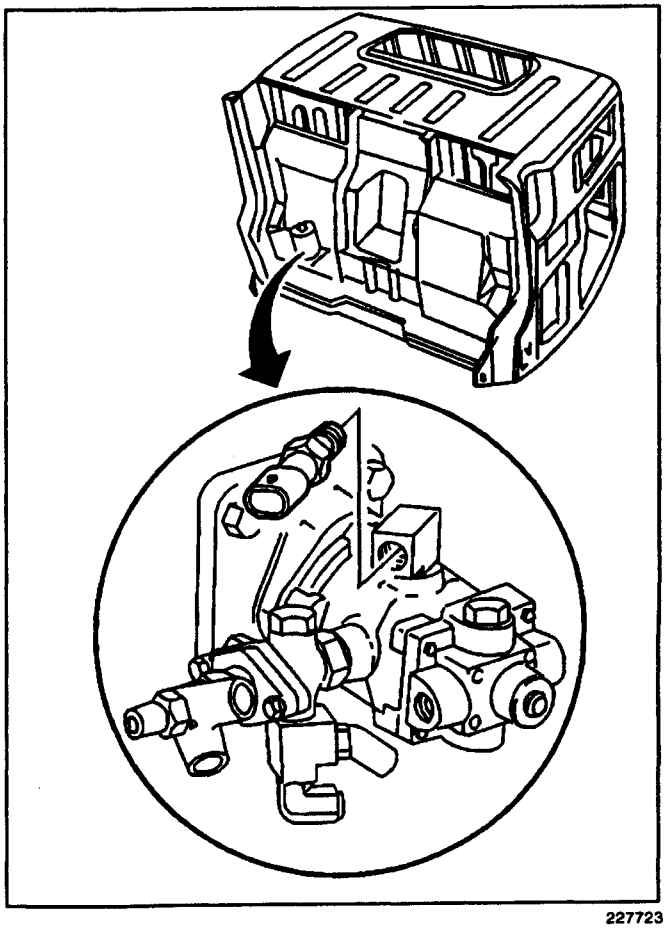


227723

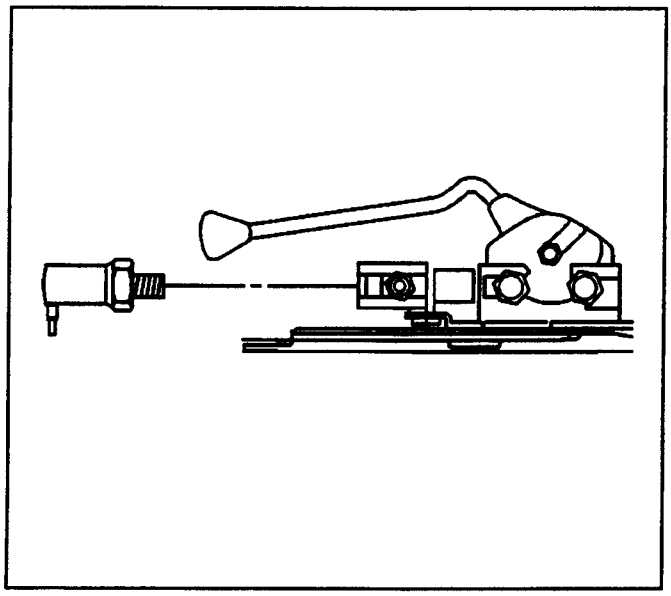
Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the stoplamp switch.
   Tighten
   Tighten the stoplamp switch to 11 N.m (97 lb in).
2. Install the wiring harness connector.
3. Start the engine and build up system air pressure.
4. Test the brakes for proper operation.
5. Remove the wheel blocks.



227723

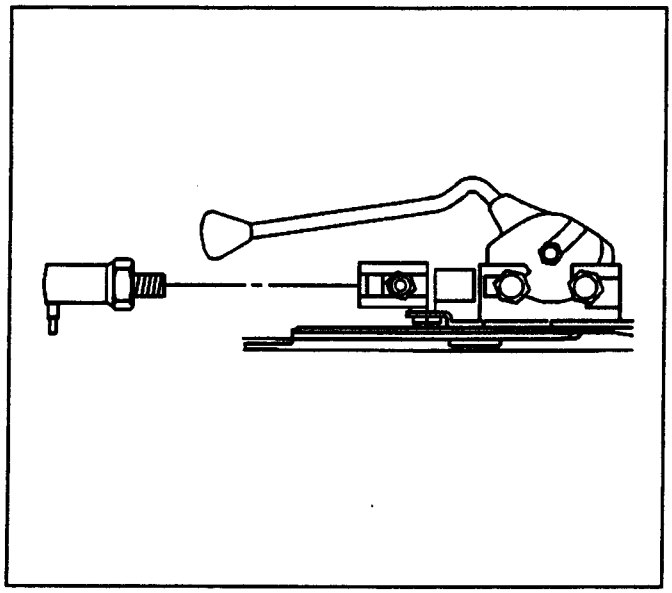


227732

Trailer Stoplamp Switch Replacement

Removal Procedure

1. Set the parking brake.
2. Block the vehicle wheels.
3. Drain all of the air reservoirs. Refer to *Draining Reservoirs.*
4. Remove the wiring harness connector.
5. Remove the trailer air brake stoplamp switch.

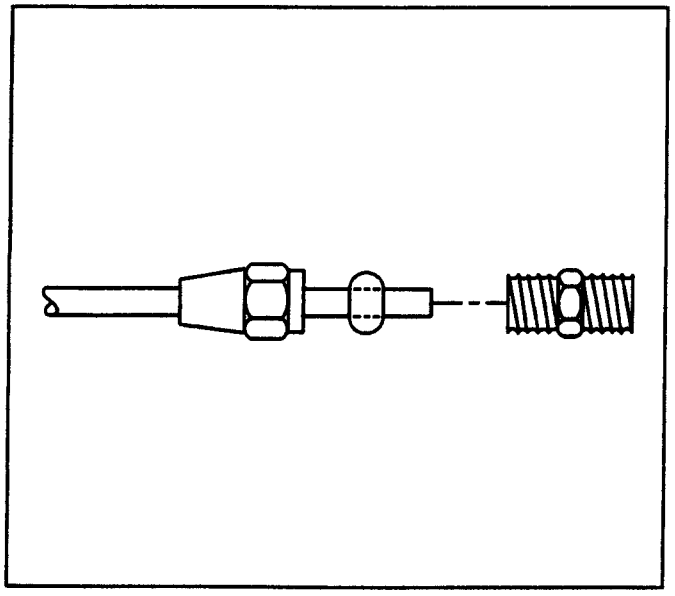


227732

Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the trailer air brake stoplamp switch.
   Tighten
   Tighten the trailer air brake stoplamp switch to 7 N.m (62 lb in).
2. Install the wiring harness connector.
3. Start the engine and build up the system air pressure.
4. Test the brakes for proper operation.
5. Remove the wheel blocks.



201481

Hose and Line Replacement (Nylon and Metal - Compression)

Removal Procedure

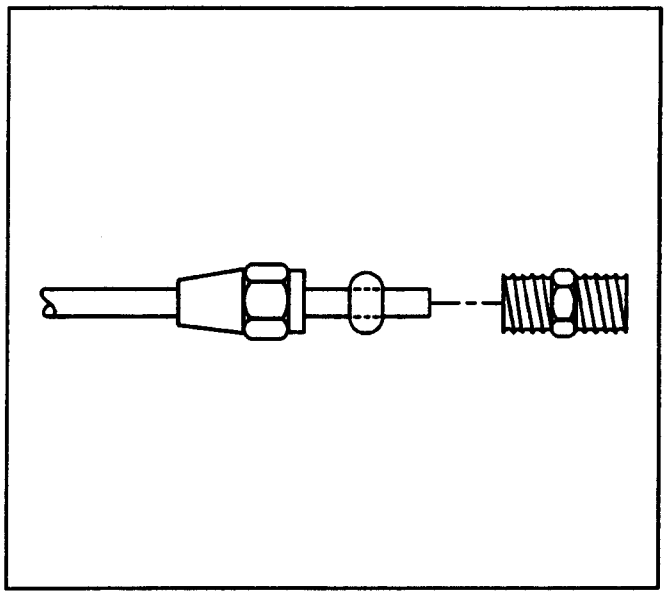
Notice: When replacing tubing, make sure that the tubing is free of burrs, cuttings, and dirt. While wearing safety glasses, use compressed air to blow out contaminants. Contaminants can destroy the air brake valve sealants.

Notice: Nylon air line should be used to replace existing nylon lines only. Do not route nylon air lines in areas where temperatures could exceed 93°C (200°F). Damage to the nylon lines could occur.

1. Apply the parking brake.
2. Block the wheels.
3. Remove the exhaust air from the lines. Refer to *Draining Reservoirs.*

Assembly and Disassembly Procedure

1. Remove the clips or the tubing clamps.
2. Remove the air line.
3. Remove the tube nuts from each fitting.
4. Remove the compression ring from the tube.
5. Clean the fittings and the tube nuts with a clean cloth.
6. Inspect the fittings and the tube nuts for the following conditions:
   - Nicks
   - Burrs
   - Wear Spots
7. Replace any damaged components.



201481

Important: Do not use the flared-type fittings in the air brake system. When replacing the air lines, use the end fitting kits to make new air line assemblies. Special tools are not required.

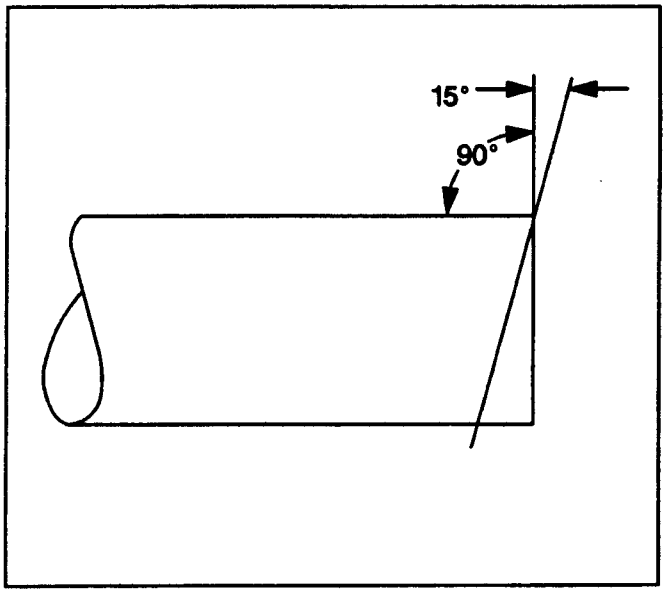
8. Cut the tube squarely at each end the same length as the old tube. Shape the metal tube to match the old tube.
9. Assemble the tube nut on the new tube.
10. Assemble the compression ring on the tube.

    Notice: Refer to *Fastener Notice* in Cautions and Notices.

    Important: Check that the tubing is completely inserted as far as it will go into the fitting.
11. Assemble the fitting and the tube.

    Tighten

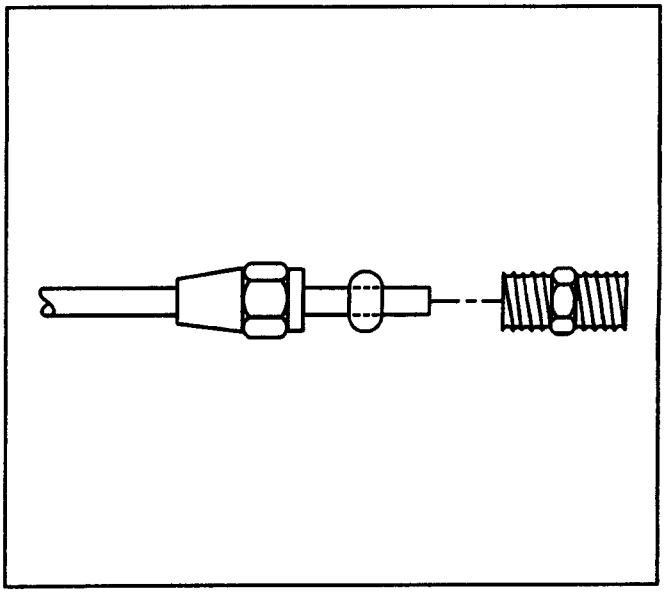
    Tighten the tube nut until 1 1/2 threads remain exposed between the tube nut and the fitting.



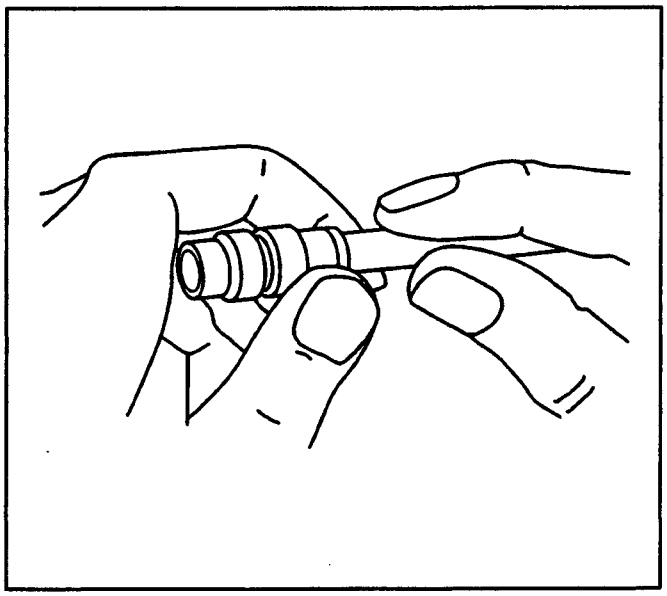
201499

Installation Procedure

1. Install the air line.
2. Install the clips or the tubing clamps.
3. Start the engine.
4. Charge the system air pressure to the governor cut-out point.
5. Check for leaks using a soap solution. Leaks are not permissible.
6. Check for the proper brake operation.
7. Remove the wheel blocks.



201481



201509

Hose and Line Replacement (Nylon - Push-In)

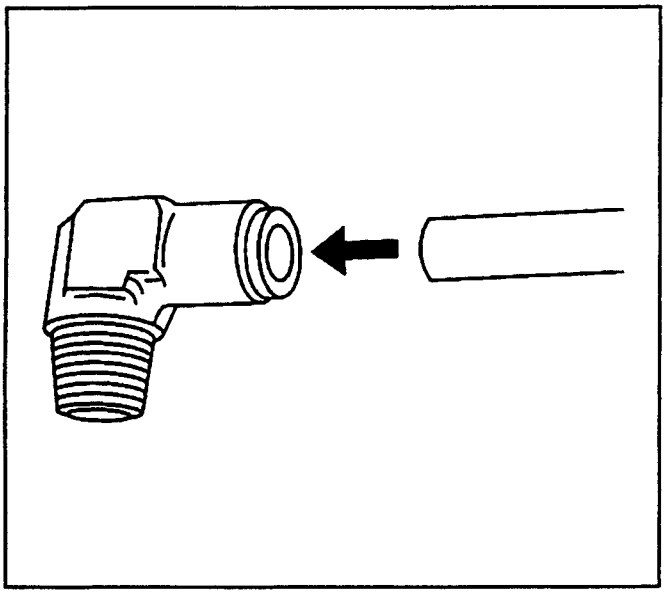
Removal Procedure

Notice: Nylon air line should be used to replace existing nylon lines only. Do not route nylon air lines in areas where temperatures could exceed 93°C (200°F). Damage to the nylon lines could occur.

Notice: When replacing air lines connected to the push-in type fittings, be certain that the nylon air line is pushed-in and seated in the fitting. Install the tube into the fitting until no tube color is visible between the gauge band and the fitting. The air line may blow out if the tube is not properly seated in the fitting.

1. Apply the parking brake.
2. Block the wheels.
3. Remove the exhaust air from the lines. Refer to *Draining Reservoirs.*
4. Remove the clips or the tubing clamps as needed.

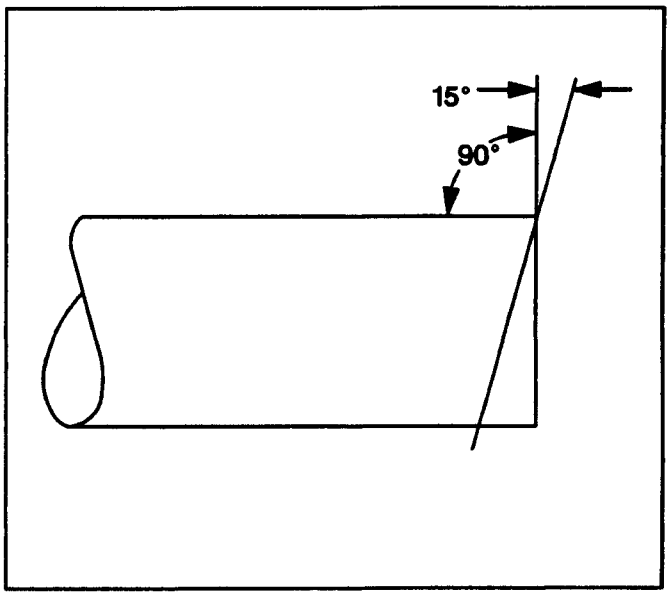
   Important: Once removed, the nylon tube can be reinserted up to five times before it must be replaced.



227738

5. Remove the nylon tube from the fitting using the following procedure:
   5.1. Push the nylon tube into the fitting until it bottoms on the tube stop.
   5.2. Depress the collet.
   5.3. Continue to depress the collet, while removing the tube from the fitting.
6. Inspect the fitting for the following conditions:
   - Nicks
   - Burrs
   - Wear spots
7. Replace the fitting if any of the aforementioned conditions exist.

8. Cut the nylon tube with a sharp tube cutter.

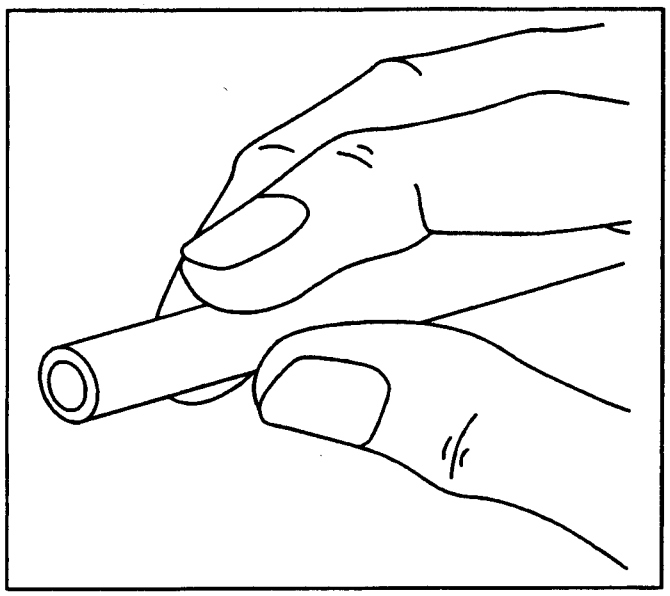


201499

9. Check that the nylon tube is cut square and is free of burrs.
10. Assemble the nylon tube into the fitting. Push the tube firmly into the fitting until it bottoms on the tube stop.

Installation Procedure

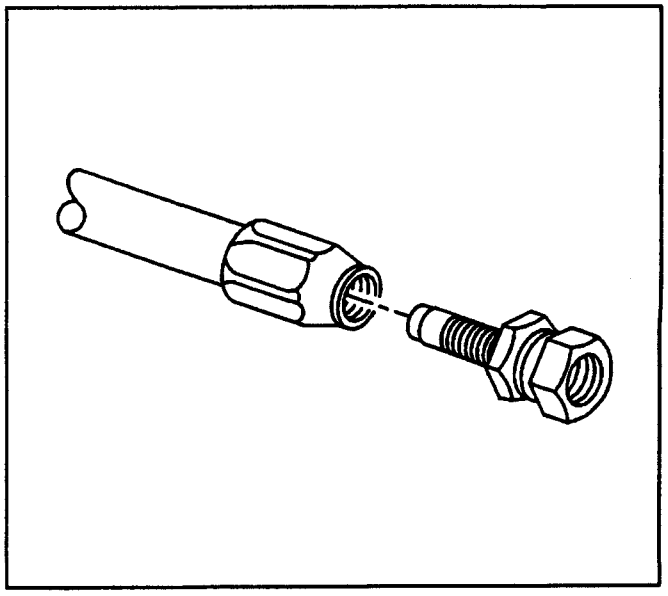
1. Place tape around the air line to bundle it with the other air lines.
2. Start the engine.
3. Charge the system air pressure to the governor cut-out point.
4. Check for leaks with a soap solution around the fittings. Leakage is not permissible.
5. Check for proper brake operation.
6. Remove the wheel blocks.

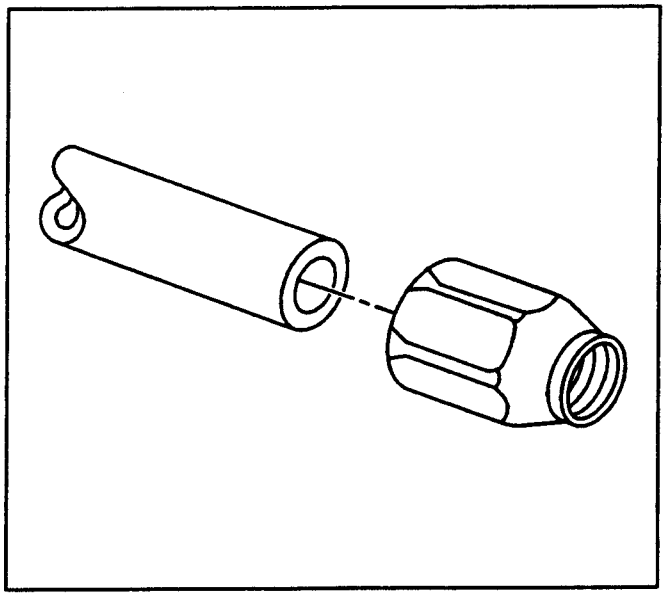

201515

Hose and Line Replacement (Flexible)

Removal Procedure

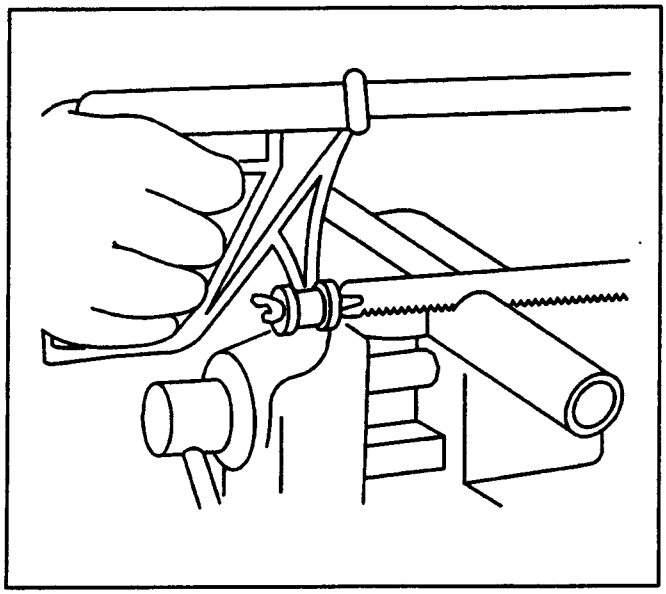
1. Apply the parking brake.
2. Block the wheels.
3. Exhaust the air from the lines. Refer to *Draining Reservoirs.*
4. Remove the air line.
5. Unscrew the nipple from the socket and the flexible hose.


228434



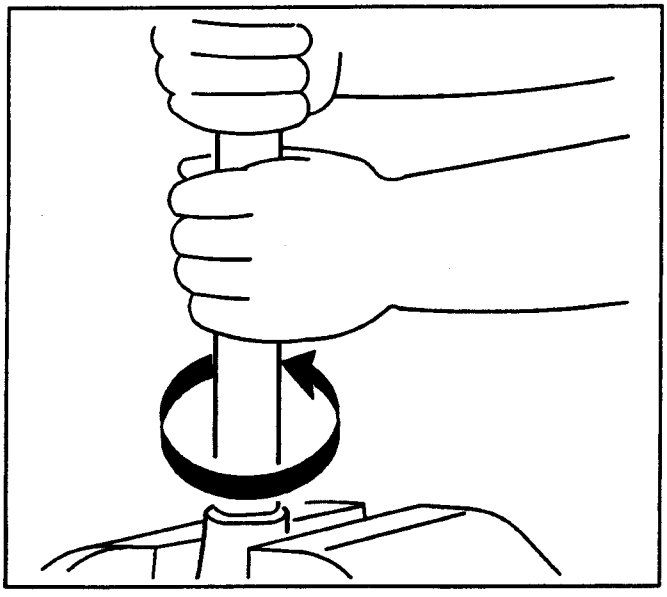
201523

6. Disassemble the flexible hose. Turn the hose clockwise in order to unscrew the hose from the socket.
7. Clean the nipple and the socket with a clean cloth.
8. Inspect the nipple and the socket for the following conditions:
   - Nicks
   - Burrs
   - Wear Spots
9. Replace any damaged components.



201546

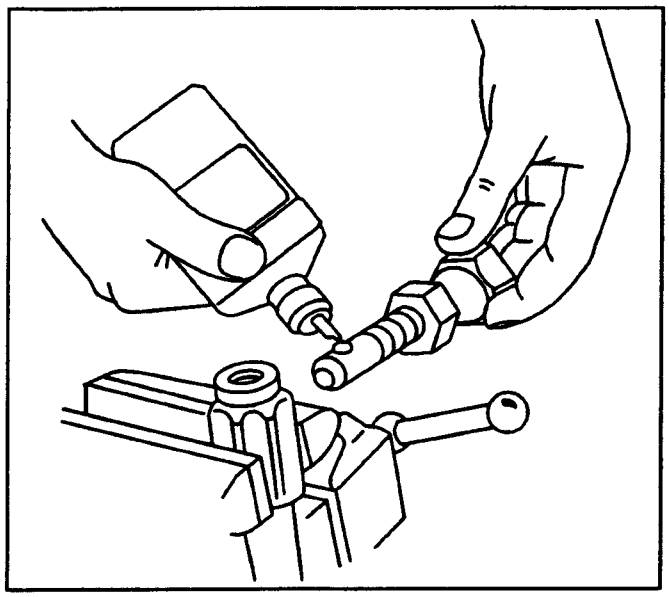
10. Use a fine tooth hacksaw or cutting wheel in order to cut the flexible hose squares the same length as the original part.



201555

11. Assemble the flexible hose into the socket. Turn the hose counterclockwise in the socket until it bottoms; then back off the flexible hose 1/4 turn.

12. Lubricate the nipple threads with clean engine oil.



201548

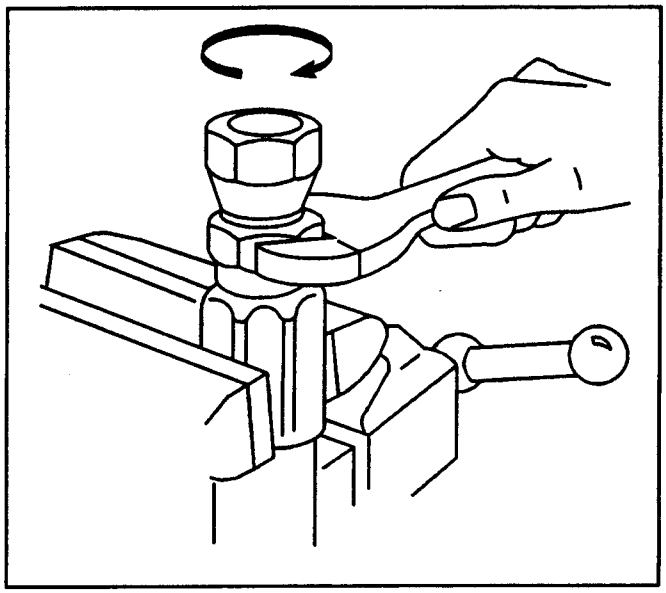
13. Assemble the nipple.

    Notice: Refer to *Fastener Notice* in Cautions and Notices.

14. Tighten the nipple.

    Tighten

    Tighten the nipple, leaving a 0.8 mm (0.03 in) clearance between the nipple hex and the socket.



201561

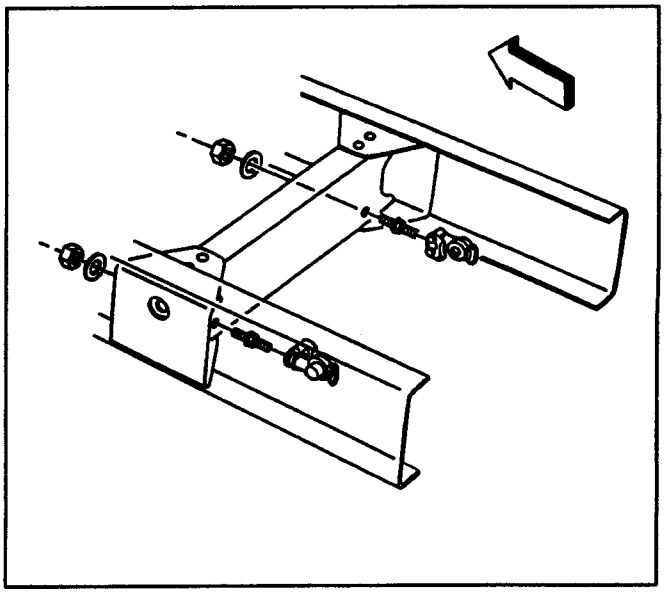
Installation Procedure

1. Install the air line.
2. Start the engine.
3. Charge the system air pressure to the governor cut-out point.
4. Check for leaks with a soap solution. No leakage is permissible.
5. Test the brakes for proper operation.
6. Remove the wheel blocks.

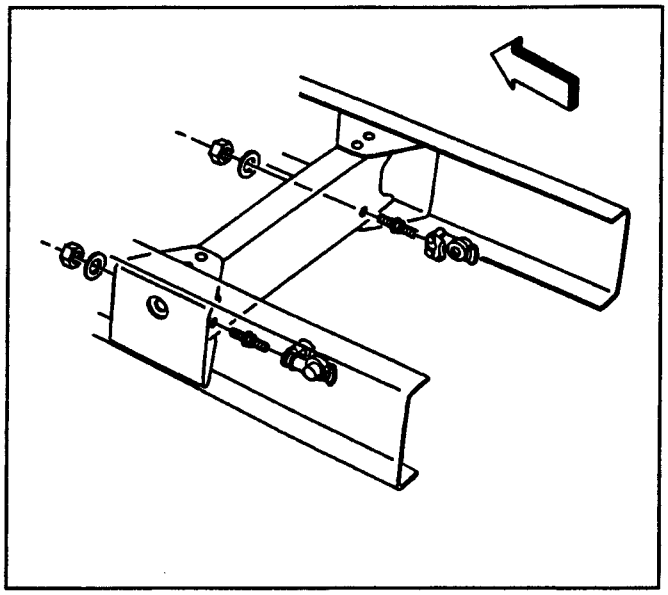
Hose and Line Replacement (Trailer Brake Coupling)

Removal Procedure

1. Set the parking brake.
2. Block the vehicle wheels.
3. Remove the trailer air brake coupling from the stud.



201579

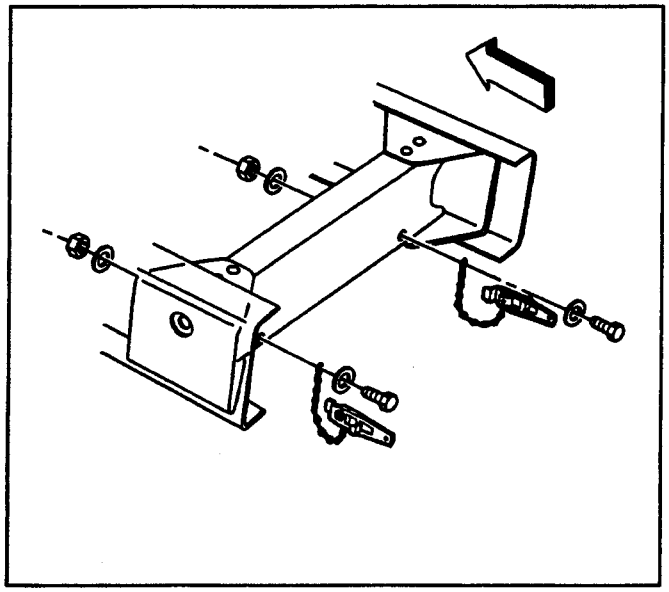


201579

Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the trailer air brake coupling to the stud.
   Tighten
   Tighten the trailer air brake coupling to 35 N·m (26 lb ft).
2. Remove the wheel blocks.

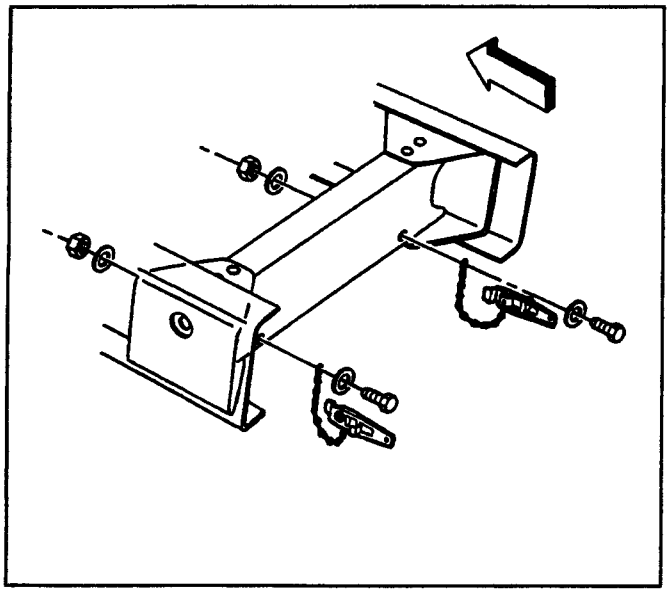


201619

Hose and Line Replacement (Trailer Brake Dummy Cap)

Removal Procedure

1. Block the vehicle wheels.
2. Apply the parking brake.
3. Remove the following components:
   3.1. The nut
   3.2. The washer
   3.3. The bolt
4. Remove the trailer air brake dummy coupling from the trailer air brake coupling.



201619

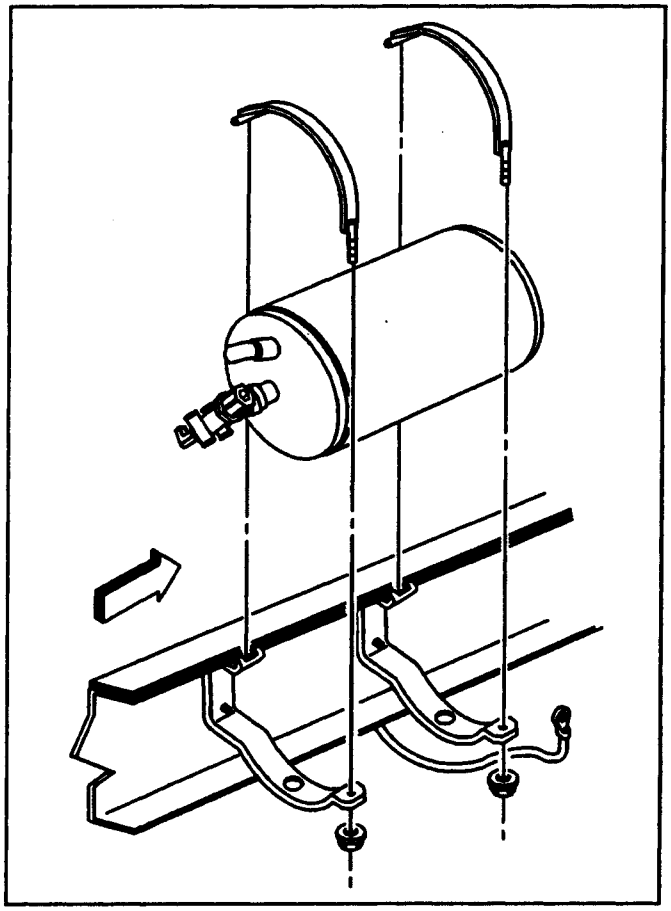
Installation Procedure

1. Install the trailer air brake dummy coupling to the trailer air brake coupling.
2. Install the following components:
   2.1. The bolt
   2.2. The washer
   Notice: Refer to *Fastener Notice.*
   2.3. The nut
   Tighten
   Tighten the nut to 30 N·m (22 lb ft).
3. Remove the wheel blocks.

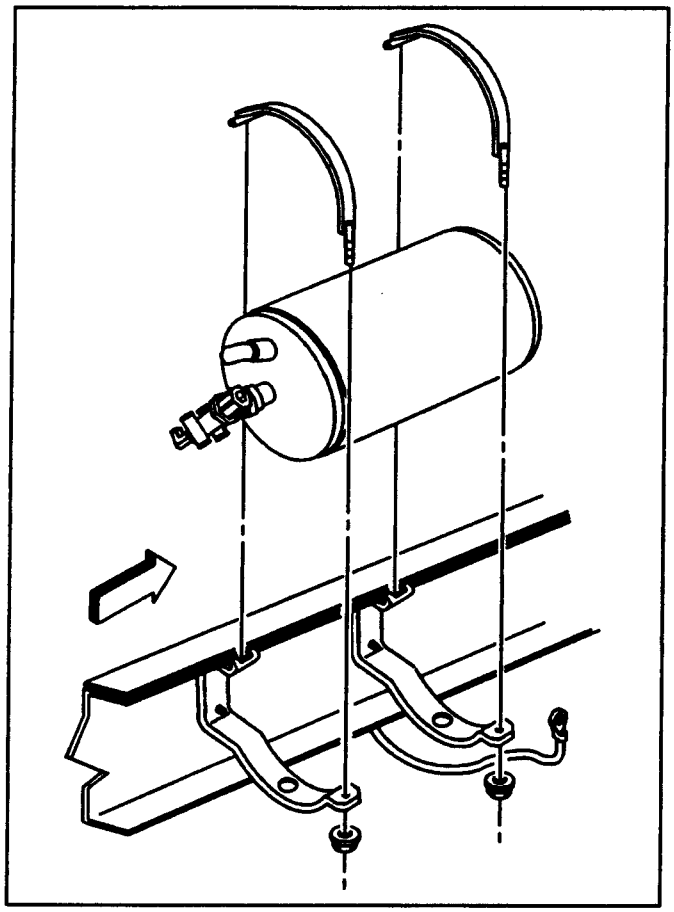
Reservoir Replacement (Supply)

Removal Procedure

1. Apply the parking brake.
2. Block the wheels.
3. Drain all the reservoirs. Refer to *Draining Reservoirs.*
4. Remove the air lines. Refer to the following procedures:
   - *Hose and Line Replacement (Nylon and Metal - Compression)*
   - *Hose and Line Replacement (Nylon - Push-In)*
   - *Hose and Line Replacement (Flexible)*
   - *Hose and Line Replacement (Trailer Brake Coupling)*
   - *Hose and Line Replacement (Trailer Brake Dummy Cap)*
5. Remove the strap nuts.
6. Remove the straps from the air reservoir supports.
7. Remove the air reservoir.
8. Clean the air lines clean and the fittings with a dry cloth.
9. Clean the inside reservoir with steam or hot water.
10. Inspect the air lines for the following conditions:
    - Damage
    - Cracks
    - Bulges
    - Wear
11. Replace any damaged, cracked, bulged, or worn air lines.
12. Inspect the air reservoir for corrosion or damage. Replace the reservoir if weakened.
13. Inspect the air reservoir supports and inspect the straps for damage. Replace the supports and the straps as needed.



201630



201630

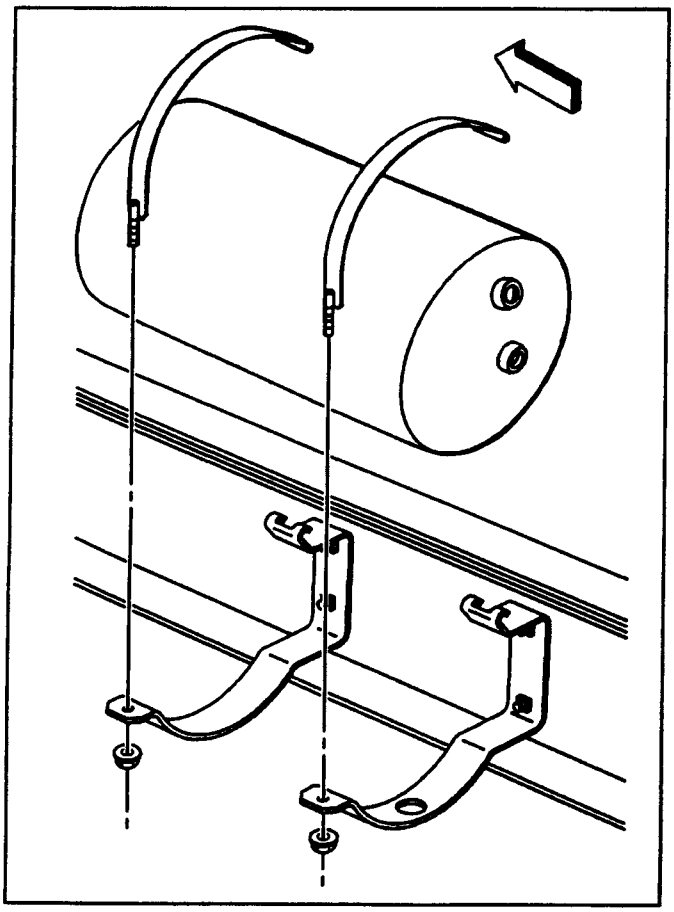
Installation Procedure

1. Install the air reservoir.
2. Install the straps to the air reservoir supports.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
3. Install the strap nuts.

   Tighten

   Tighten the strap nuts to 23 N·m (17 lb ft).
4. Install the air lines.
5. Start the engine.
6. Charge the system air pressure to the governor cut-out point.
7. Check for leaks with a soap solution. Leakage is not permissible.
8. Test the brakes for proper operation.
9. Remove the wheel blocks.



201628

Reservoir Replacement (Front Service)

Removal Procedure

1. Apply the parking brake.
2. Block the wheels.
3. Drain all the reservoirs. Refer to *Draining Reservoirs.*
4. Remove the air lines. Refer to the following procedures:
   - *Hose and Line Replacement (Nylon and Metal - Compression)*
   - *Hose and Line Replacement (Nylon - Push-In)*
   - *Hose and Line Replacement (Flexible)*
   - *Hose and Line Replacement (Trailer Brake Coupling)*
   - *Hose and Line Replacement (Trailer Brake Dummy Cap)*
5. Remove the strap nuts.
6. Remove the straps from the air reservoir supports.
7. Remove the air reservoir.
8. Clean the air lines clean and the fittings with a dry cloth.
9. Clean the inside reservoir with steam or hot water.

10. Inspect the air lines for the following conditions:
    - Damage
    - Cracks
    - Bulges
    - Wear
11. Replace any damaged, cracked, bulged, or worn air lines.
12. Inspect the air reservoir for corrosion or damage. Replace the reservoir if weakened.
13. Inspect the air reservoir supports and inspect the straps for damage. Replace as needed.

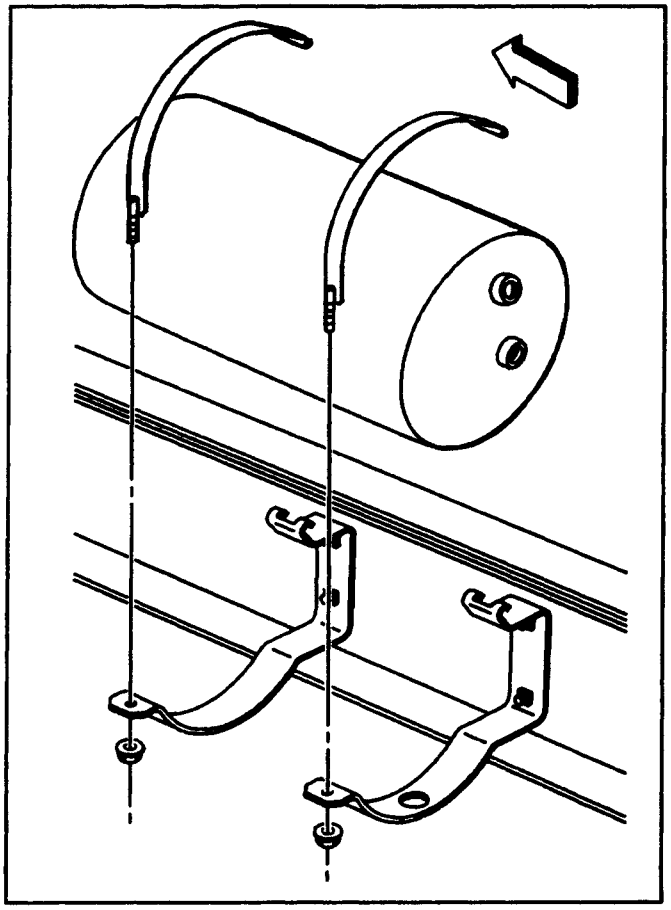
Installation Procedure

1. Install the air reservoir.
2. Install the straps to the air reservoir supports.

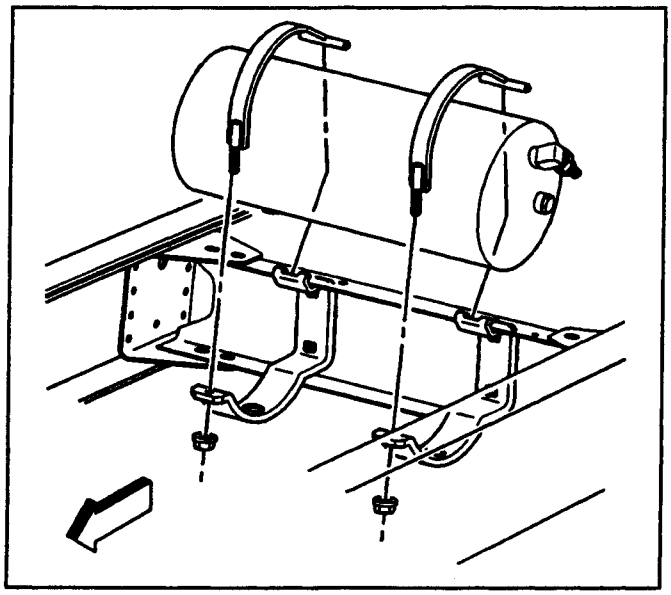
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
3. Install the strap nuts.

   Tighten

   Tighten the strap nuts to 40 N·m (29 lb ft).
4. Install the air lines.
5. Start the engine.
6. Charge the system air pressure to the governor cut-out point.
7. Check for leaks with a soap solution. Leakage is not permissible.
8. Test the brakes for proper operation.
9. Remove the wheel blocks.



201628



201670

Reservoir Replacement (Truck Rear Service)

Removal Procedure

1. Apply the parking brake.
2. Block the wheels.
3. Drain all the reservoirs. Refer to *Draining Reservoirs.*
4. Remove the air lines. Refer to the following procedures:
   - *Hose and Line Replacement (Nylon and Metal - Compression)*
   - *Hose and Line Replacement (Nylon - Push-In)*
   - *Hose and Line Replacement (Flexible)*
   - *Hose and Line Replacement (Trailer Brake Coupling)*
   - *Hose and Line Replacement (Trailer Brake Dummy Cap)*
5. Remove the strap nuts.
6. Remove the straps from the air reservoir supports.
7. Remove the air reservoir.
8. Clean the air lines clean and the fittings with a dry cloth.
9. Clean the inside reservoir with steam or hot water.
10. Inspect the air lines for the following conditions:
    - Damage
    - Cracks
    - Bulges
    - Wear
11. Replace any damaged, cracked, bulged, or worn air lines.
12. Inspect the air reservoir for corrosion or damage. Replace the reservoir if weakened.
13. Inspect the air reservoir supports and inspect the straps for damage. Replace the supports and the straps as needed.

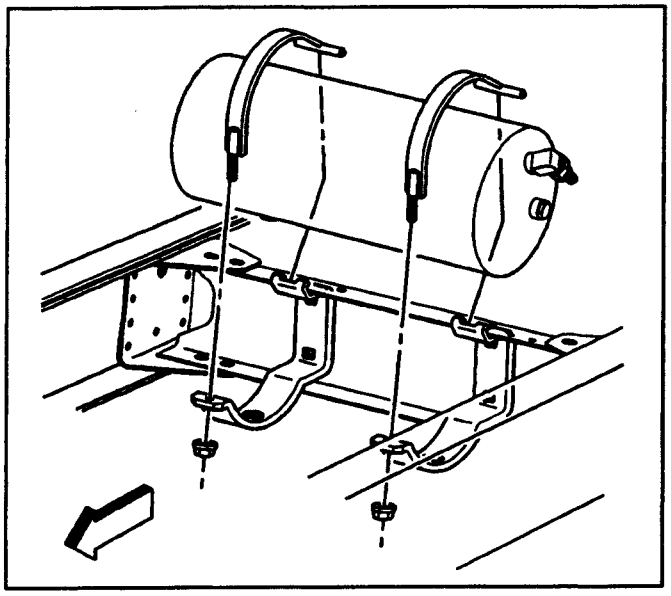
Installation Procedure

1. Install the air reservoir.
2. Install the straps to the air reservoir supports.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
3. Install the strap nuts.

   Tighten

   Tighten the strap nuts to 23 N.m (17 lb ft).
4. Install the air lines.
5. Start the engine.
6. Charge the system air pressure to the governor cut-out point.
7. Check for leaks with a soap solution. Leakage is not permissible.
8. Test the brakes for proper operation.
9. Remove the wheel blocks.

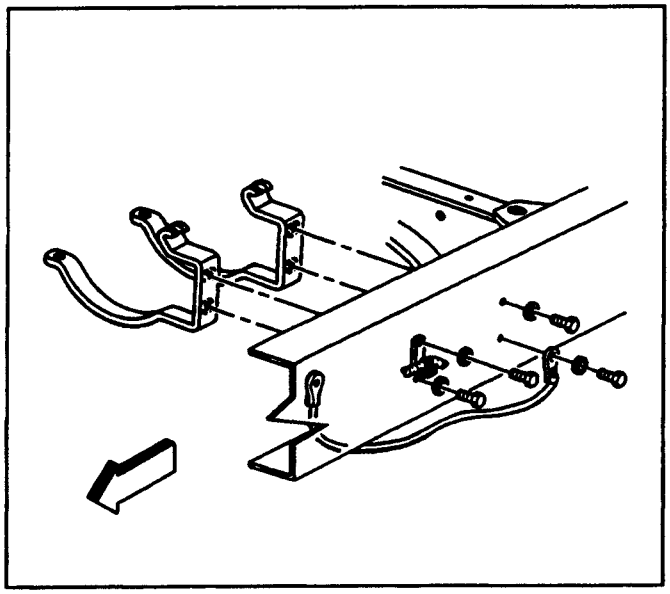


201670

Reservoir Support Replacement (Front Axle)

Removal Procedure

1. Apply the parking brake.
2. Block the wheels.
3. Remove the air reservoir. Refer to the following procedures:
   - *Reservoir Replacement (Supply)*
   - *Reservoir Replacement (Front Service)*
   - *Reservoir Replacement (Truck Rear Service)*
4. Remove the reservoir support bolts and the washers.
5. Remove the air reservoir supports.



201789

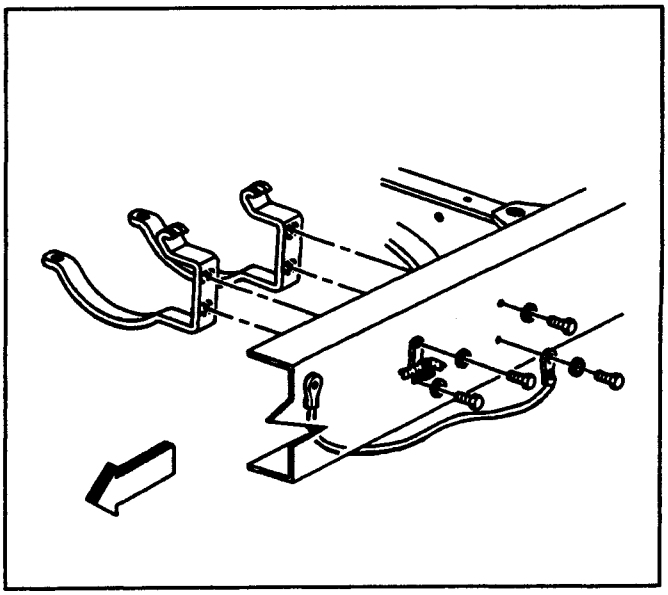
Installation Procedure

1. Install the air reservoir supports.

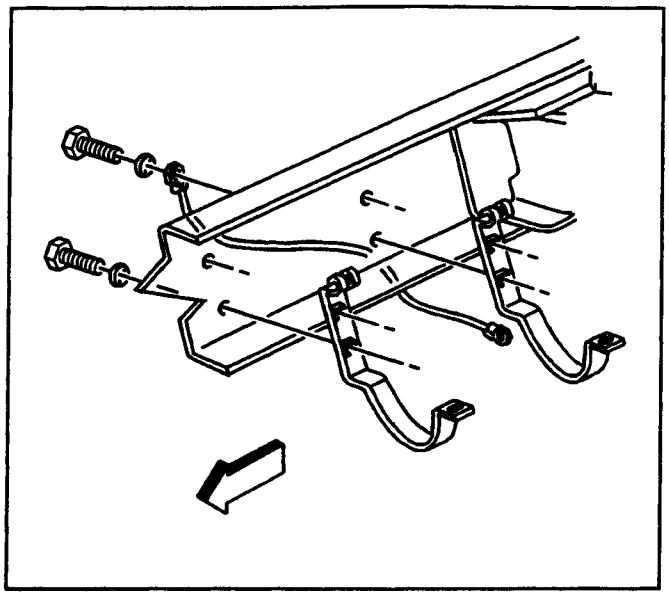
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the washers and bolts.

   Tighten

   Tighten the air reservoir support bolts to 53 N.m (39 lb ft).
3. Install the air reservoirs.



201789

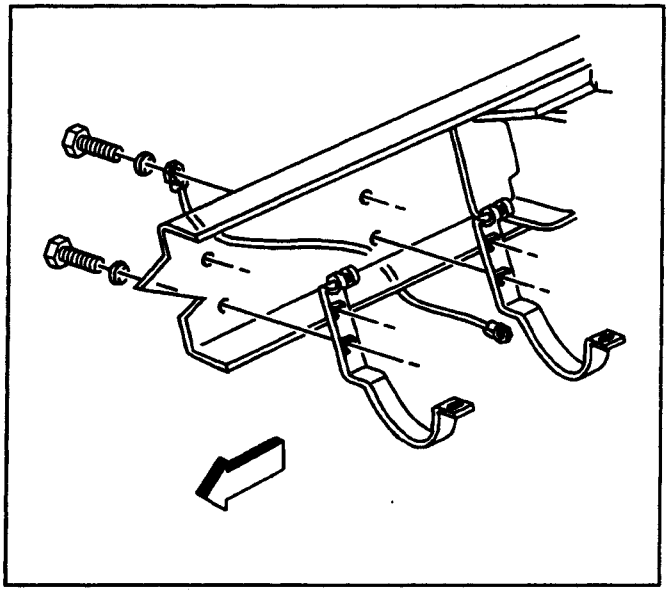


201794

Reservoir Support Replacement (Primary Air Brake)

Removal Procedure

1. Apply the parking brake.
2. Block the wheels.
3. Remove the air reservoir. Refer to the following procedures:
   - *Reservoir Replacement (Supply)*
   - *Reservoir Replacement (Front Service)*
   - *Reservoir Replacement (Truck Rear Service)*
4. Remove the reservoir support bolts and the washers.
5. Remove the air reservoir supports.



201794

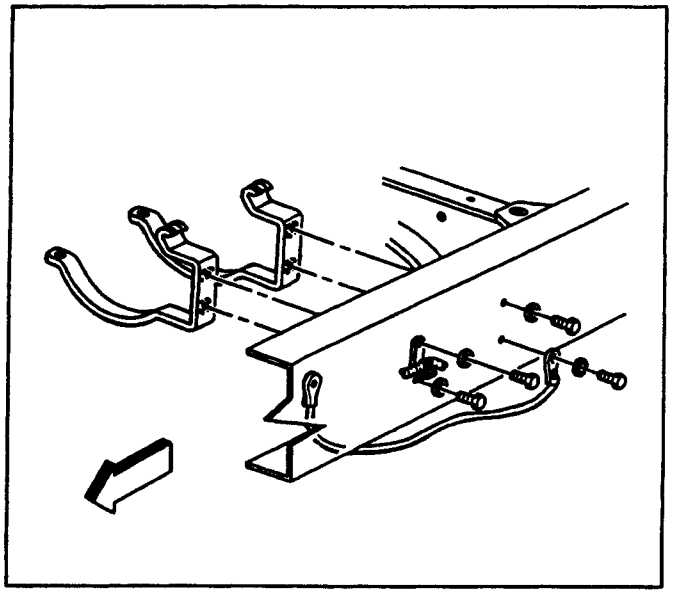
Installation Procedure

1. Install the air reservoir supports.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the washers and bolts.

   Tighten

   Tighten the air reservoir support bolts to 53 N·m (39 lb ft).
3. Install the air reservoirs.



201789

Reservoir Support Replacement (Rear Axle)

Removal Procedure

1. Apply the parking brake.
2. Block the wheels.
3. Remove the air reservoir. Refer to the following procedures:
   - *Reservoir Replacement (Supply)*
   - *Reservoir Replacement (Front Service)*
   - *Reservoir Replacement (Truck Rear Service)*
4. Remove the reservoir support bolts and the washers.
5. Remove the air reservoir supports.

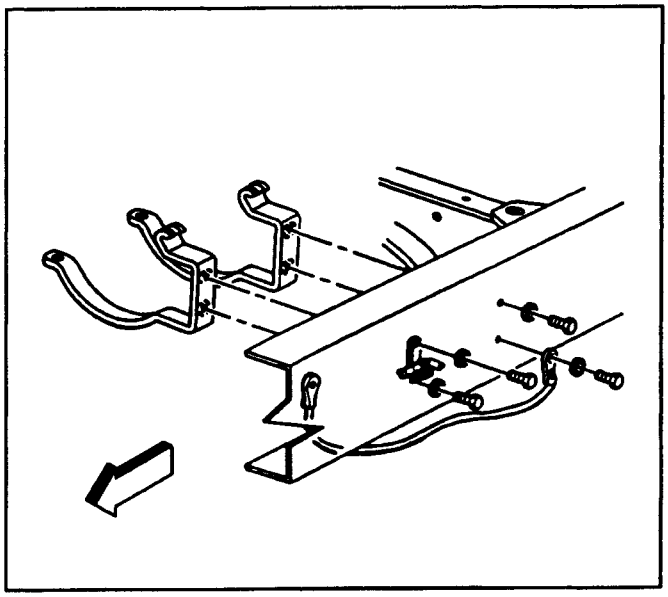
Installation Procedure

1. Install the air reservoir supports.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the washers and bolts.

   Tighten

   Tighten the air reservoir support bolts to 53 N.m (39 lb ft).
3. Install the air reservoirs.

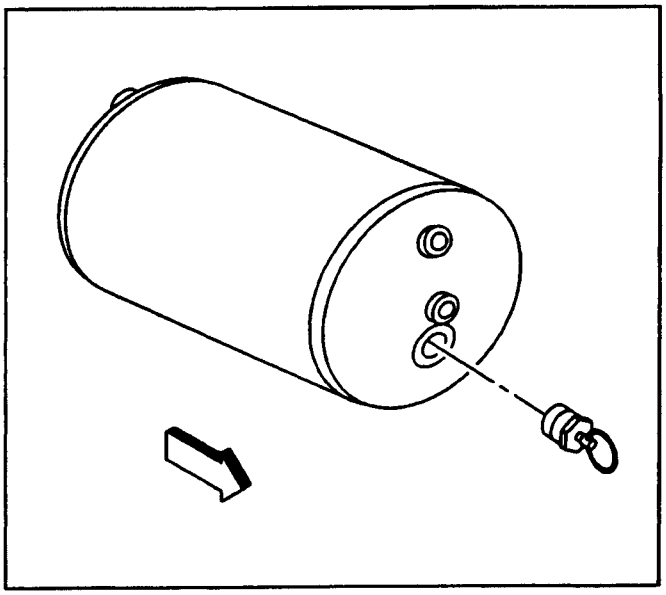


201789

Reservoir Drain Valve Replacement (Manual Type)

Removal Procedure

1. Apply the parking brake.
2. Block the wheels.
3. Drain all the reservoirs. Refer to *Draining Reservoirs*.
4. Remove the reservoir drain valve (manual type).



201690

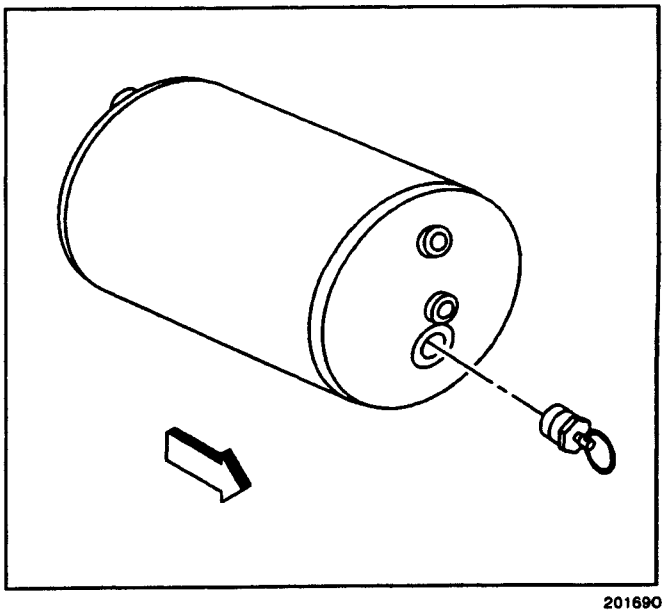
Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

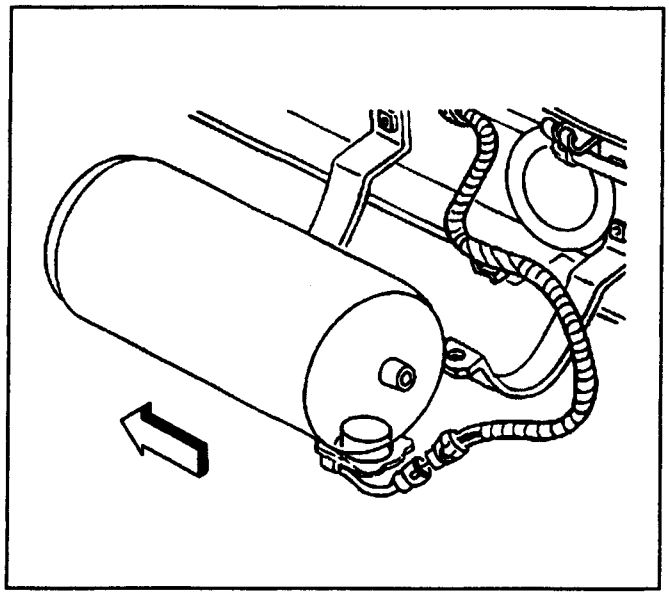
1. Install the reservoir drain valve (manual type).

   Tighten

   Tighten the primary air brake supply reservoir drain valve (manual type) to 50 N.m (37 lb ft).
2. Start the engine.
3. Charge the system air pressure to the governor cut-out point.
4. Check for leaks with a soap solution around the reservoir drain valve (manual type). Leakage is not permissible.
5. Remove the wheel blocks.



201690

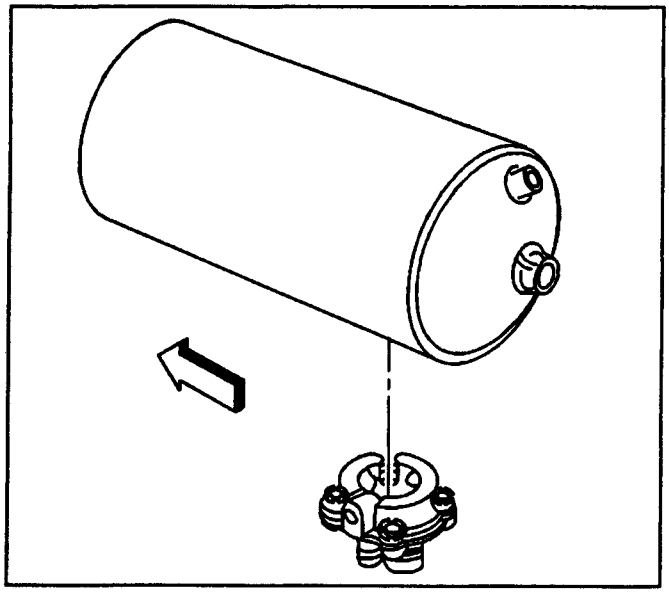


227919

Reservoir Drain Valve Replacement (Automatic Type)

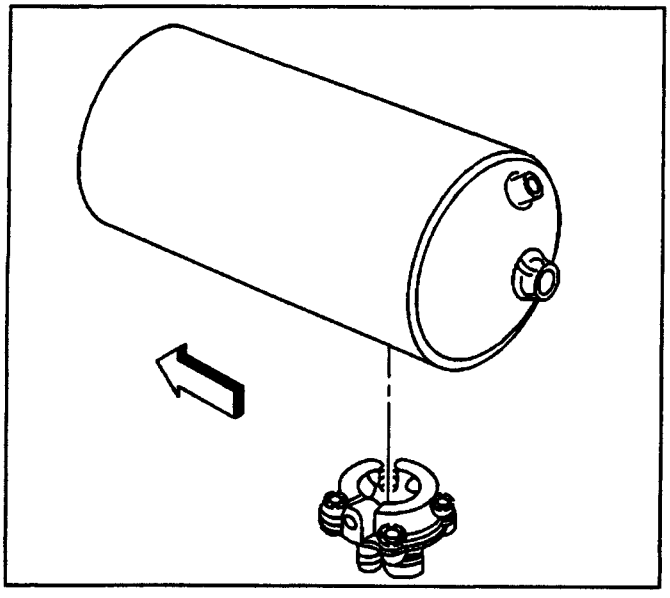
Removal Procedure

1. Block the wheels.
2. Drain all of the reservoirs. Refer to *Draining Reservoirs.*
3. Remove the reservoir drain valve (automatic type) wiring harness connector, if equipped.



227922

4. Remove the reservoir drain valve (automatic type).



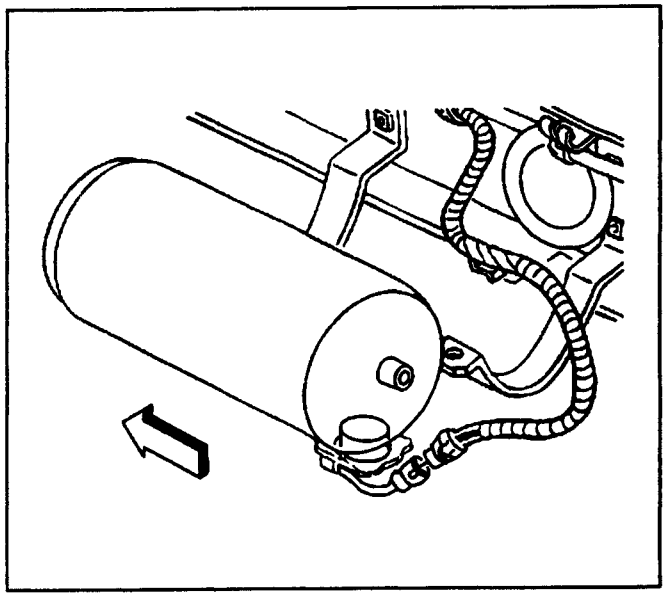
227922

Installation Procedure

Notice: Refer to *Fastener Notice* in Notices and Cautions.

1. Install the reservoir drain valve (automatic type).
   Tighten
   Tighten the reservoir drain valve (automatic type) to 50 N.m (37 lb ft).

2. Install the reservoir drain valve (automatic type) wiring harness connector, if equipped.
3. Perform the air leakage test. Refer to *Reservoir Drain Valve Test.*
4. Perform the operational test. Refer to *Reservoir Drain Valve Test.*

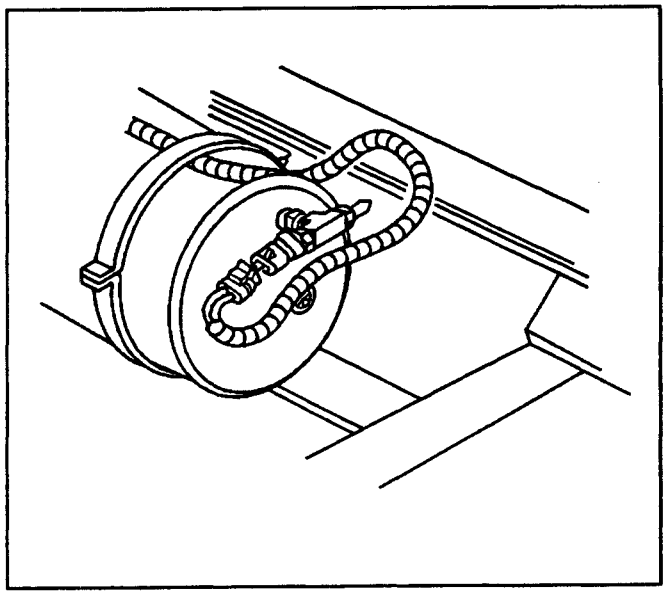


227919

Low Air Pressure Switch Replacement

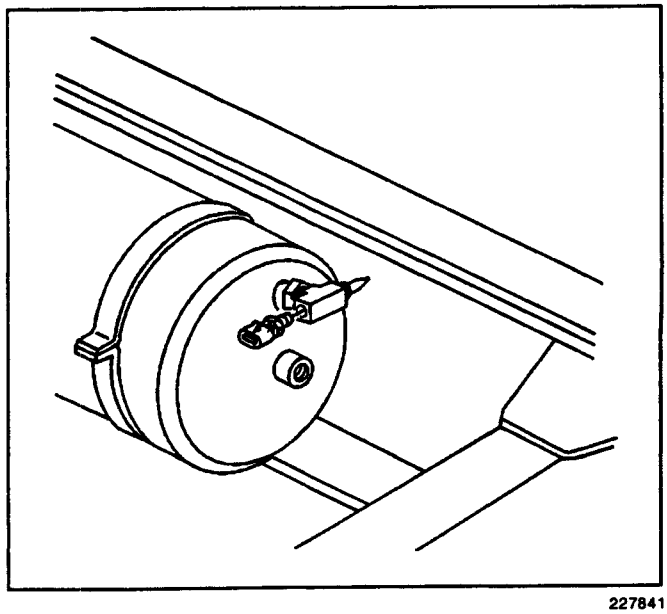
Removal Procedure

1. Apply the parking brake.
2. Block the wheels.
3. Drain all the reservoirs. Refer to *Draining Reservoirs.*
4. Remove the wiring harness connector.

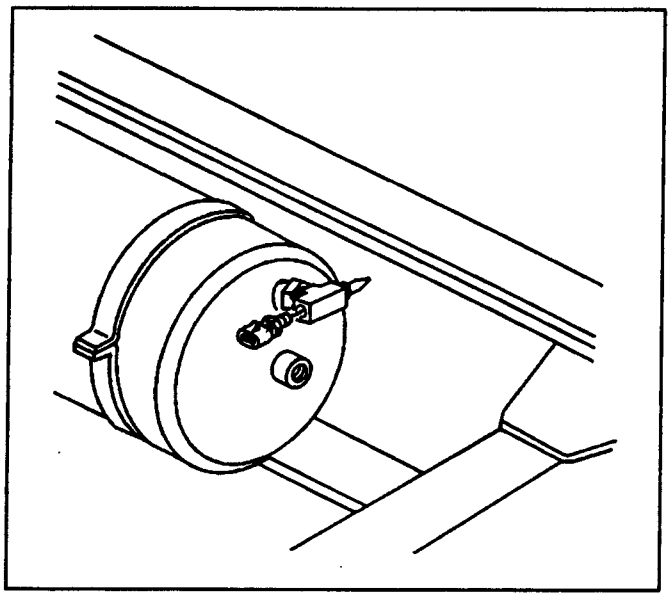


227835

5. Remove the low air pressure switch.



227841

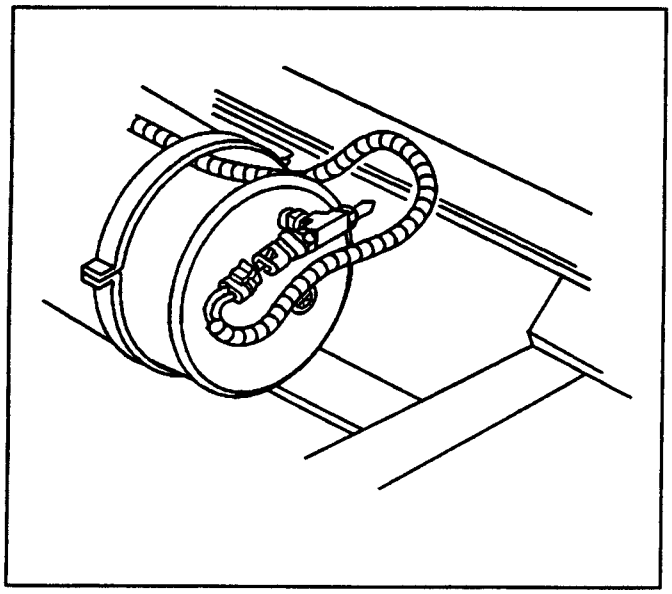


227841

Installation Procedure

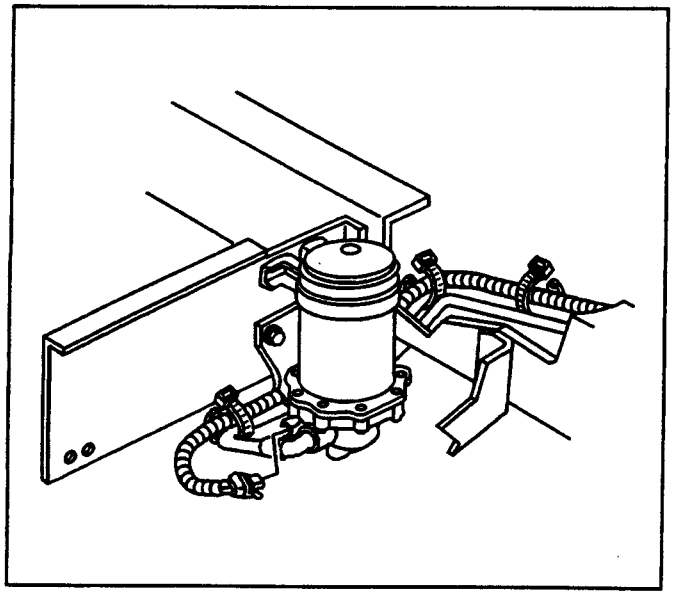
Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the low air pressure switch.
   Tighten
   Tighten the low air pressure switch to 12 N·m (106 lb in).



227835

2. Install the wiring harness connector.
3. Start the engine.
4. Charge the system air pressure to the governor cut-out point.
5. Check for leaks with a soap solution around the low air pressure switch. Leakage is not permissible.
6. Check for proper operation. Refer to *Low Air Pressure Switch Diagnosis.*
7. Remove the wheel blocks.



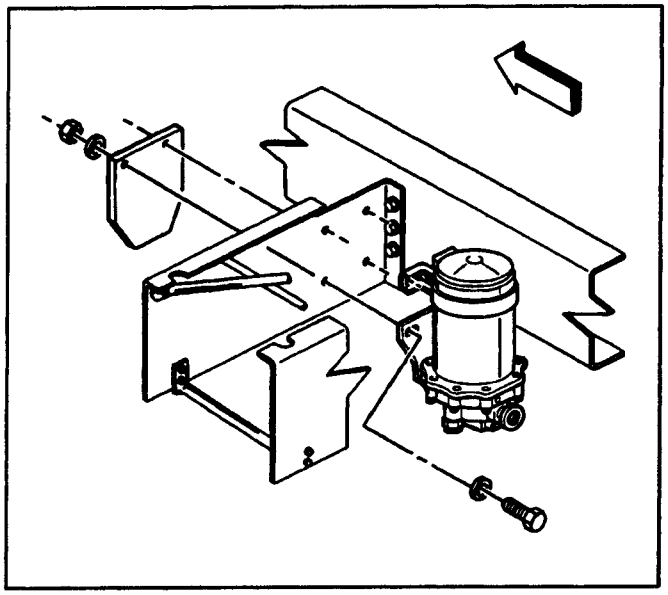
201587

Air Dryer Replacement

Removal Procedure

1. Apply the parking brake.
2. Block the wheels.
3. Drain the reservoirs. Refer to *Draining Reservoirs.*
4. Remove the air lines.
5. Remove the wiring harness connector.

6. Remove the nuts, the washers, and the bolts.
7. Remove the air dryer.



201592

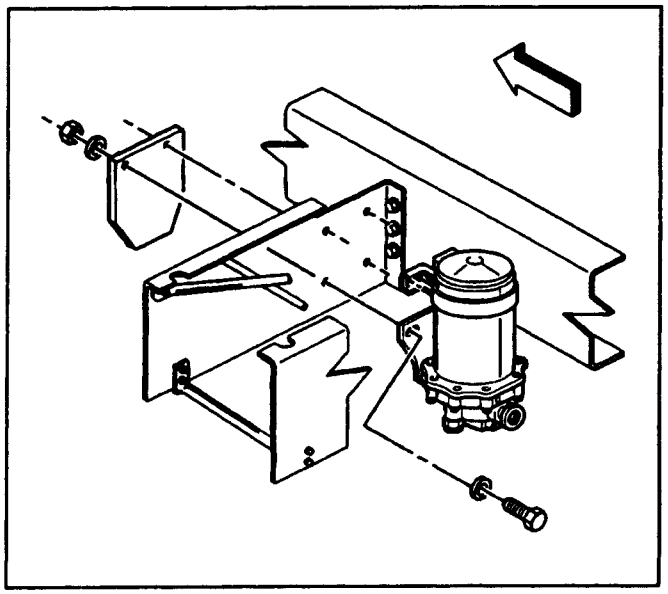
Installation Procedure

1. Install the air dryer.

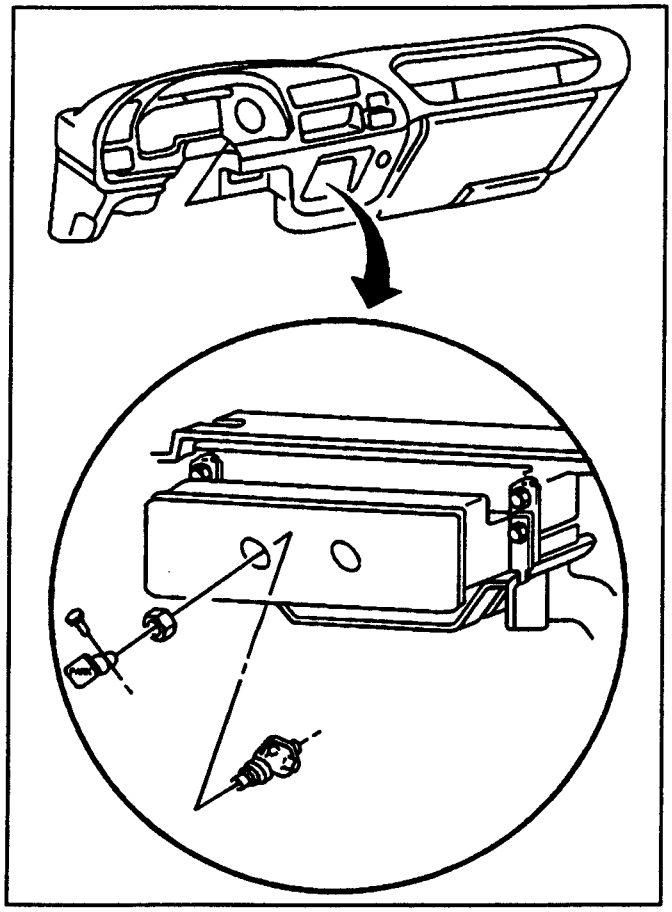
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the bolts, the washers and the nuts.

   Tighten

   Tighten the air dryer nuts to 45 N.m (33 lb ft).
3. Install the air lines.
4. Start the engine.
5. Charge the system air pressure to the governor cut-out point.
6. Check for air leaks with a soap solution. Leakage is not permissible.
7. Check for the proper brake operation.
8. Remove the wheel blocks.



201592



227898

IP Mounted Air Brake Park Cont Valve Replacement

Removal Procedure

1. Block the wheels.
2. Drain all of the air reservoirs. Refer to *Draining Reservoirs.*
3. Remove the air lines from the park control valve (cab mounted). Refer to the following procedures:

   Tag and label the air lines for later installation.

   - *Hose and Line Replacement (Nylon and Metal - Compression)*
   - *Hose and Line Replacement (Nylon - Push-In)*
   - *Hose and Line Replacement (Flexible)*
   - *Hose and Line Replacement (Trailer Brake Coupling)*
   - *Hose and Line Replacement (Trailer Brake Dummy Cap)*
4. Remove the pin.
5. Remove the knob.
6. Remove the park control valve (cab mounted) nut.
7. Remove the park control valve (cab mounted).
8. Inspect the air lines for the following conditions. Repair or replace the lines as necessary.
   - Damage
   - Kinks
   - Wear

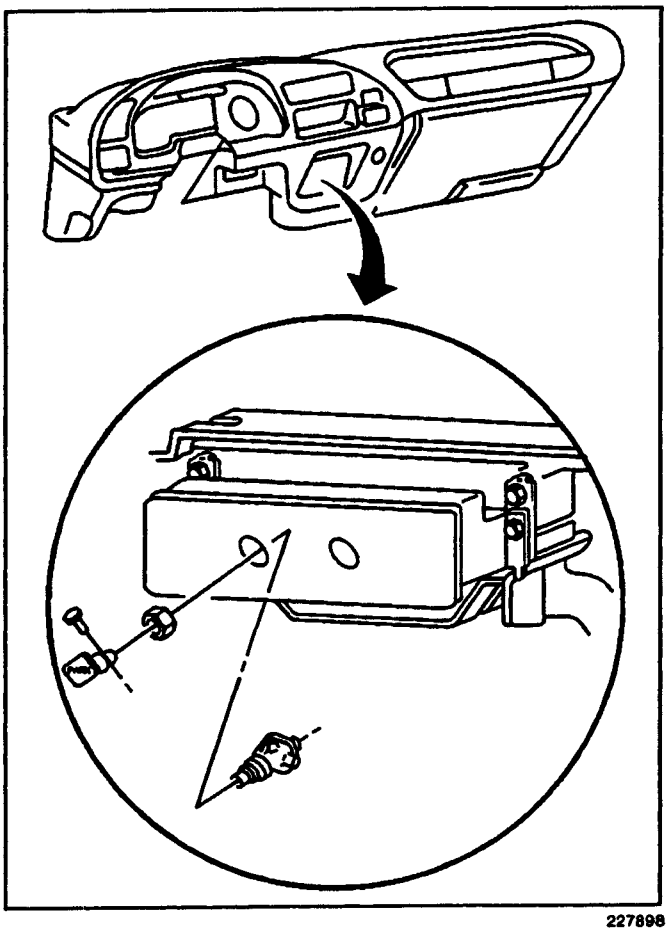
Installation Procedure

1. Install the park control valve (cab mounted).

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the park control valve (cab mounted) nut.

   Tighten

   Tighten the park control valve (cab mounted) nut to 6 N·m (53 lb in).
3. Install the knob.
4. Install the pin.
5. Install the air lines to the park control valve (cab mounted).
6. Perform the air leakage test. Refer to *IP Mounted Air Brake Park Control Valve Test (Leakage Test).*
7. Perform the operational test. Refer to *IP Mounted Air Brake Park Control Valve Test (Operational Check).*

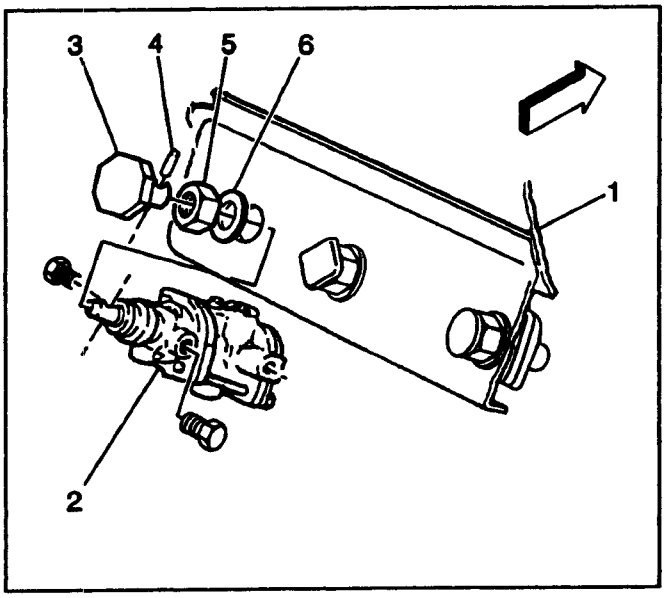


227898

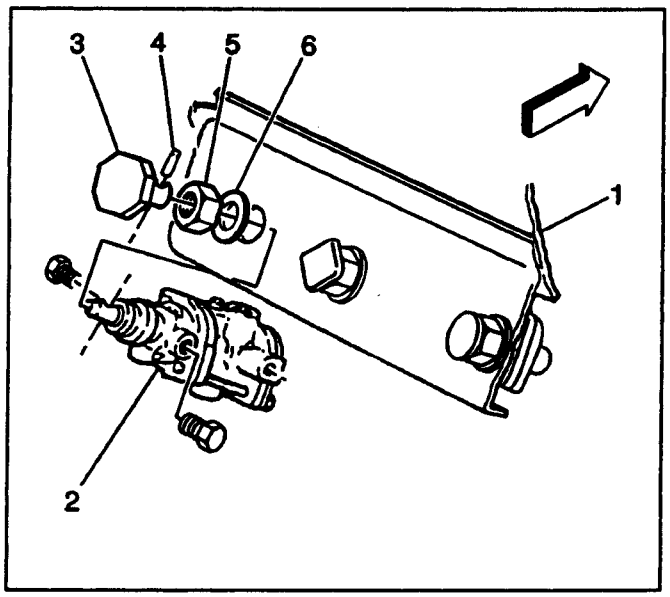
Trailer Brake Supply Valve Replacement

Removal Procedure

1. Apply the parking brake.
2. Block the wheels.
3. Drain all the reservoirs. Refer to *Draining Reservoirs.*
4. Disconnect the air lines from the valve.
5. Tag or label the air lines for later installation.
6. Remove the pin (4).
7. Remove the knob (3).
8. Remove the nut (5).
9. Remove the washer (6).
10. Remove the valve (2).
11. Inspect the air lines for damage or deterioration. Repair the air lines as needed.
12. Check the valve (2) for cracked, loose, or missing line clips or ties. Repair the line clips or the ties as needed.



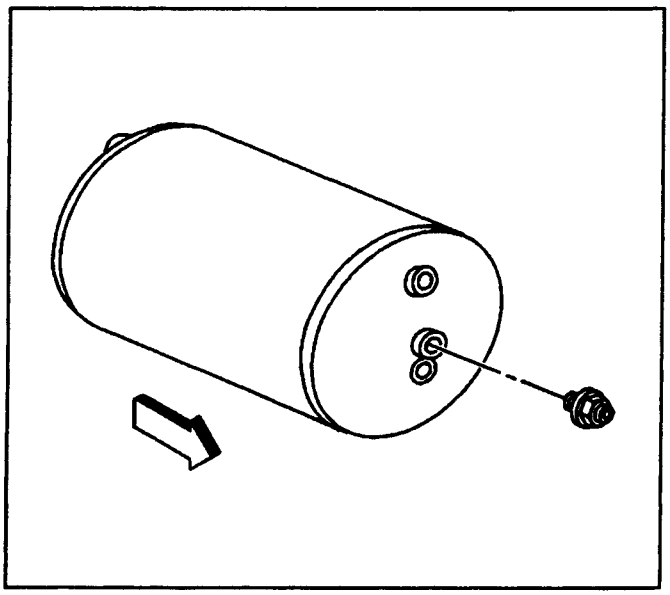
209561



209561

Installation Procedure

1. Install the valve (2).
2. Install the washer (6).
3. Install the nut (5).
4. Install the knob (3).
5. Install the pin (4).
6. Start the engine.
7. Charge the system air pressure to the governor cut-out point.
8. Stop the engine.
9. Check for air leaks using a soap solution.
10. Check for proper operation.
11. Remove the wheel blocks.

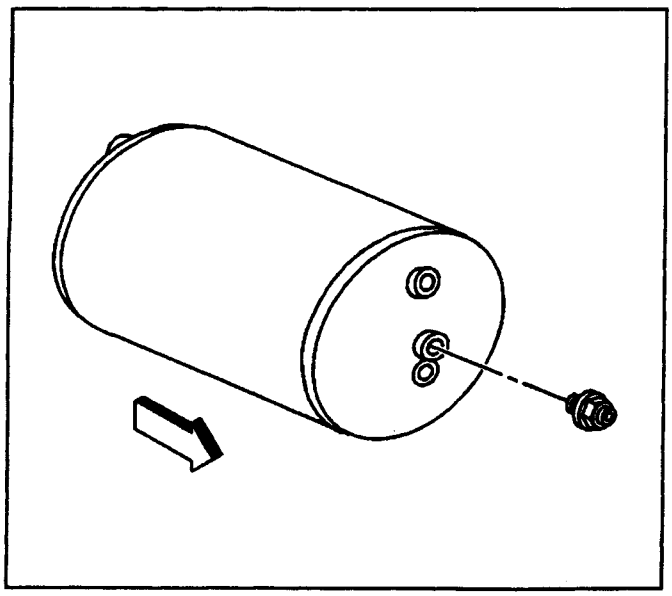


227901

Reservoir Check Valve Replacement

Removal Procedure

1. Block the wheels.
2. Drain all of the air reservoirs. Refer to *Draining Reservoirs.*
3. Remove the air line from the single check valve. Refer to the following procedures:
   - *Hose and Line Replacement (Nylon and Metal - Compression)*
   - *Hose and Line Replacement (Nylon - Push-In)*
   - *Hose and Line Replacement (Flexible)*
   - *Hose and Line Replacement (Trailer Brake Coupling)*
   - *Hose and Line Replacement (Trailer Brake Dummy Cap)*
4. Remove the single check valve.



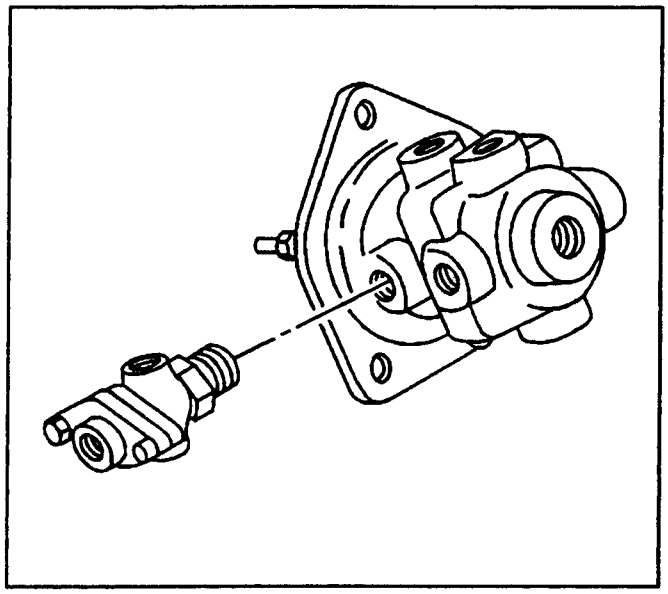
227901

Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the single check valve.
   Tighten
   Tighten the single check valve to 50 N·m (37 lb ft).
2. Install the air line to the single check valve.
3. Perform the air leakage test. Refer to *Reservoir Check Valve Test (Leakage Test).*
4. Perform the operational test. Refer to *Reservoir Check Valve Test (Operational Check).*

Air Brake Double Check Valve Replacement



227905

Removal Procedure

1. Block the wheels.
2. Tilt the cab. Refer to Cab Tilting in General Information.
3. Drain all of the air reservoirs. Refer to *Draining Reservoirs.*
4. Remove the upper inner fender panel. Refer to.
5. Remove the air lines from the double check valve. Refer to the following procedures:
   - *Hose and Line Replacement (Nylon and Metal - Compression)*
   - *Hose and Line Replacement (Nylon - Push-In)*
   - *Hose and Line Replacement (Flexible)*
   - *Hose and Line Replacement (Trailer Brake Coupling)*
   - *Hose and Line Replacement (Trailer Brake Dummy Cap)*
6. Remove the double check valve from the dual application valve.
7. Inspect the air lines for the following:
   - Damage
   - Kinks
   - Wear
8. Repair or replace the air lines as necessary.

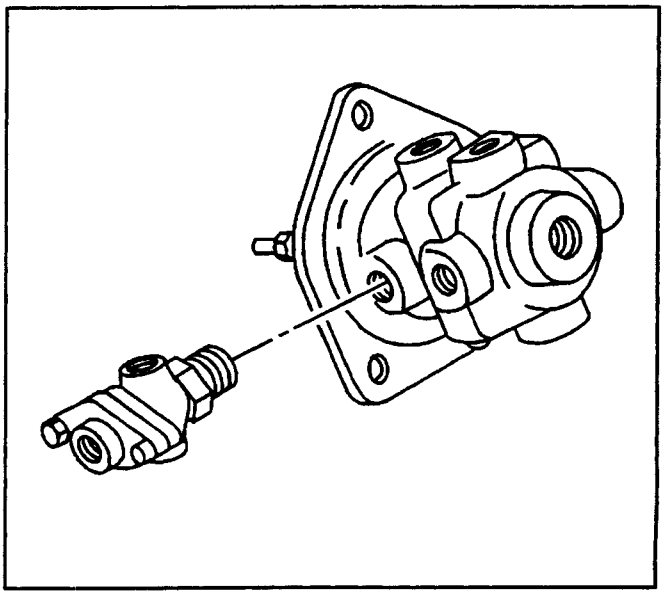
Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

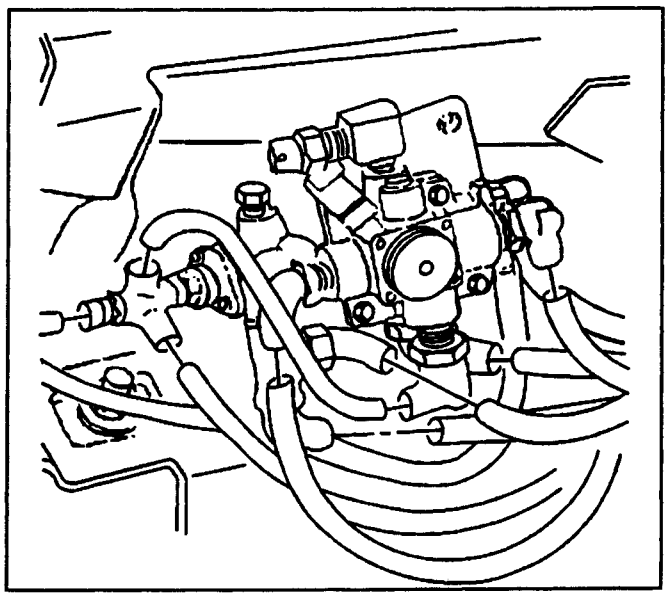
1. Install the double check valve to the dual application valve.

   Tighten

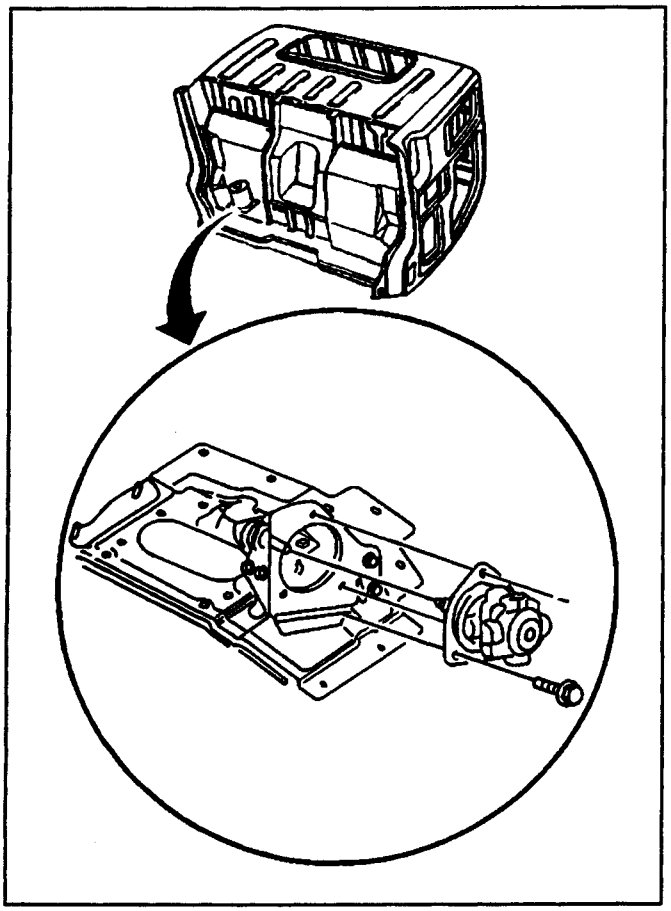
   Tighten the double check valve to 28 N·m (21 lb ft).
2. Install the air lines to the double check valve.
3. Perform the air leakage test. Refer to *Air Brake Double Check Valve Test (Leakage Test).*
4. Perform the operational test. Refer to *Air Brake Double Check Valve Test (Operational Check).*
5. Install the upper inner fender panel.
6. Lower the cab.
7. Remove the wheel blocks.



227905



227916



228756

Air Brake Application Valve Replacement

Removal Procedure

1. Block the wheels.
2. Tilt the cab. Refer to Cab Tilting in General Information.
3. Drain all of the air reservoirs. Refer to *Draining Reservoirs.*
4. Lift the inner fender panel.
5. Mark the air lines and connections in order to aid in installation.
6. Remove the wiring harness connector from the stoplamp switch.
7. Remove the air lines from the dual application valve.

   A double check valve and lines fittings are attached to the dual application valve. You can remove these fittings from the dual application valve or you can remove these fittings with the dual application valve as an assembly.
8. Remove the dual application valve mounting bolts.
9. Remove the dual application valve.
10. Inspect the air lines for the followings:
    - Damage
    - Kinks
    - Wear
11. Repair or replace the air lines as necessary.

Installation Procedure

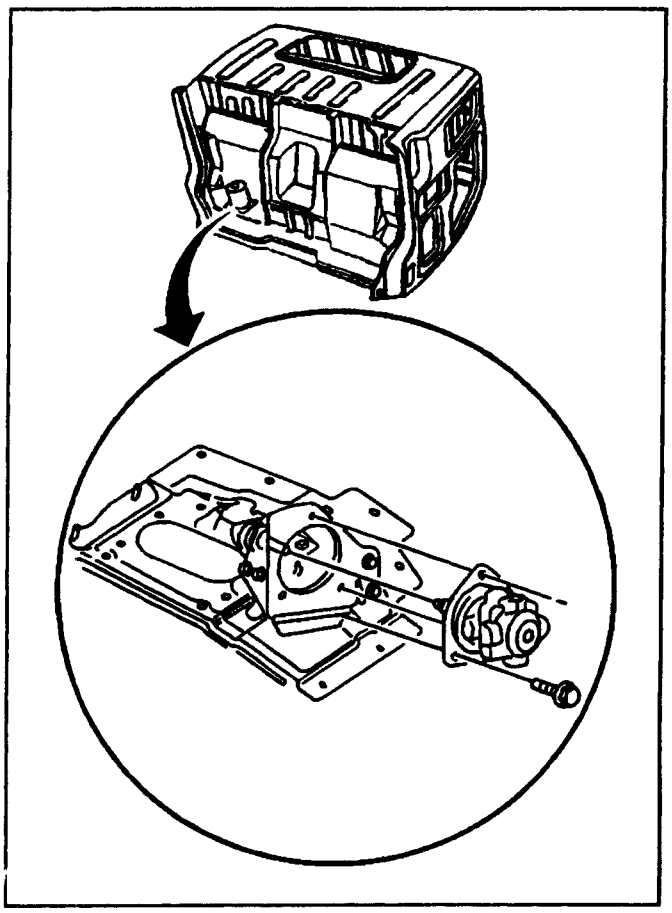
1. Install the dual application valve.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the dual application valve mounting bolts.

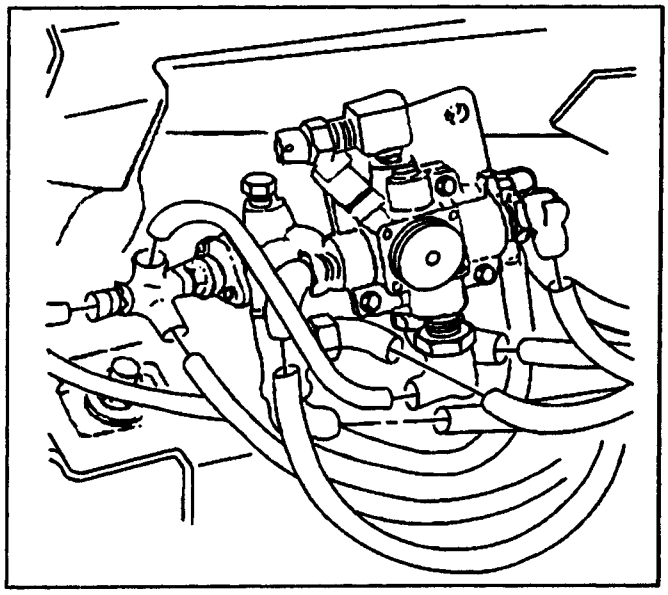
   Tighten

   Tighten the dual application mounting valves to 40 N·m (29 lb ft).

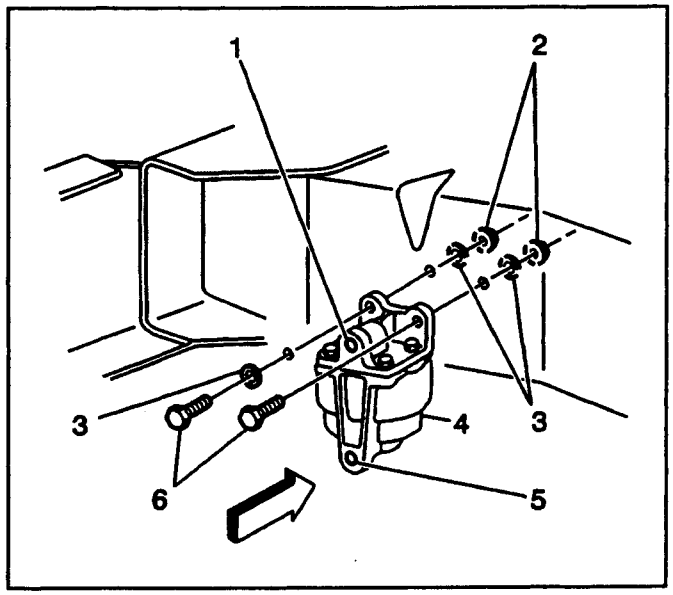


228756

3. Install the air lines to the dual application valve.
4. Check the brake pedal end play. Refer to Brake Pedal Replacement.
5. Perform the air leakage test. Refer to *Air Brake Application Valve Test (Leakage Test).*
6. Perform the operational test. Refer to *Air Brake Application Valve Test (Operational Check).*



227916

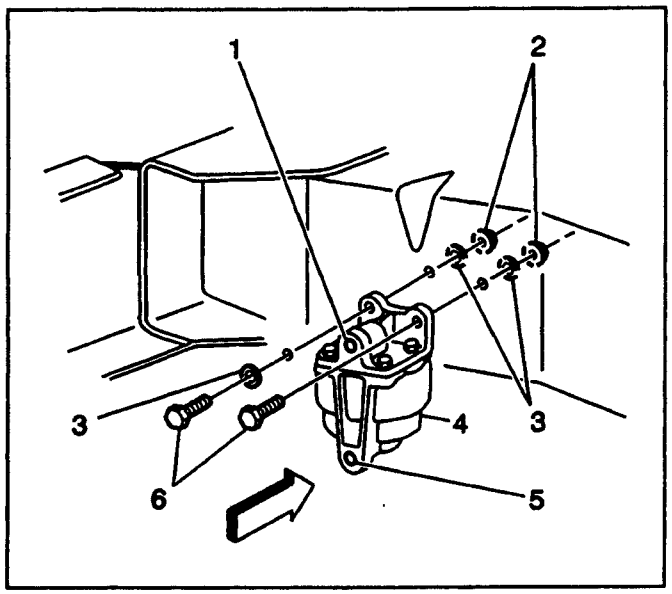


202582

Front Air Brake Limit Valve Replacement

Removal Procedure

1. Apply the parking brake.
2. Block the wheels.
3. Drain all the reservoirs. Refer to *Draining Reservoirs.*
4. Disconnect the air lines at the valve (4).
5. Remove the mounting bolts (6).
6. Remove the washers (3).
7. Remove the nuts (2).
8. Remove the front axle limiting (ratio) valve (4).



202582

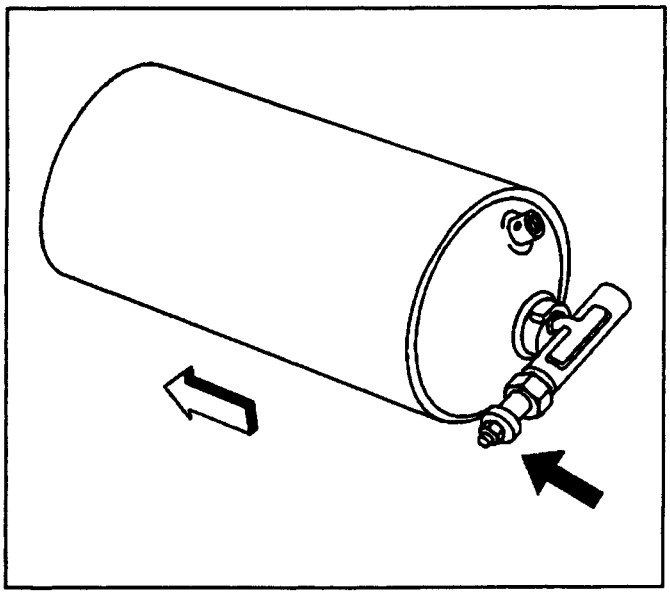
Installation Procedure

1. Install the front axle limiting (ratio) valve (4).
2. Install the bolts (6).
3. Install the washers (3).

   Notice: Refer to *Fastener Notice*
4. Install the nuts (2).

   Tighten

   Tighten the front axle limiting (ratio) valve nuts (2) to 22 N·m (16 lb ft).
5. Connect the air lines.
6. Start the engine.
7. Charge the system air pressure to the governor cut-out point.
8. Stop the engine.
9. Check for air leaks using a soap solution.
10. Check for proper operation.
11. Remove the wheel blocks.

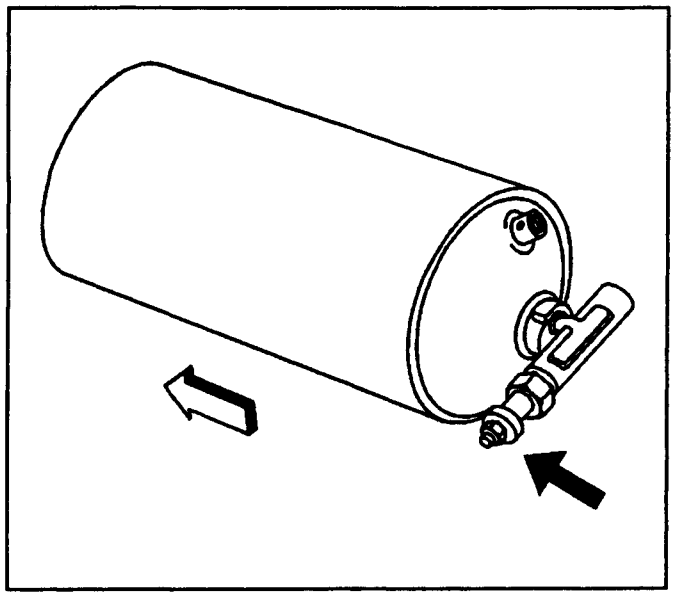


227891

Front Axle Serv Rsvr Air Supply Valve Replacement

Removal Procedure

1. Block the wheels.
2. Drain all of the air reservoirs. Refer to *Draining Reservoirs.*
3. Remove the inflation valve.



227891

Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the inflation valve.
   Tighten
   Tighten the inflation valve to 20 N.m (15 lb ft). The exhaust port should point down and face the rear of the vehicle.
2. Perform the air leakage test. Refer to *Front Axle Serv Rsvr Air Supply Valve Test (Leakage Test).*
3. Perform the operational test. Refer to *Front Axle Serv Rsvr Air Supply Valve Test (Operational Check).*

Reservoir Drain Valve Replacement

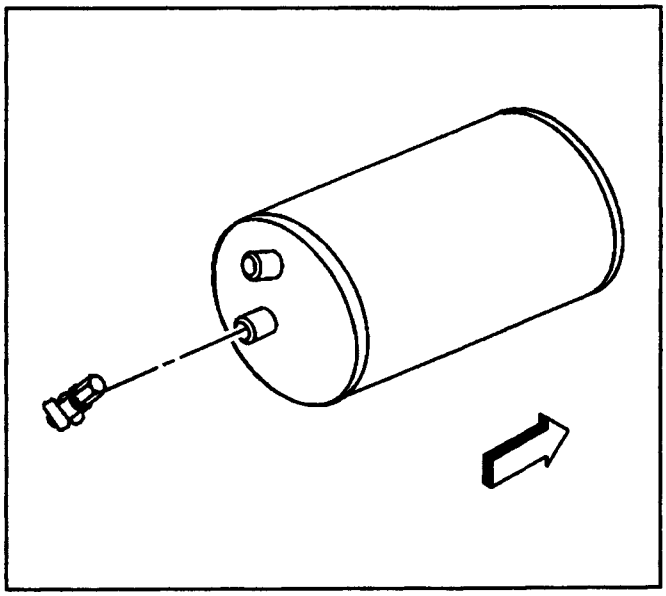
Removal Procedure

1. Apply the parking brake.
2. Block the wheels.
3. Drain all of the reservoirs. Refer to *Draining Reservoirs.*
4. Remove the reservoir drain valve (manual type).

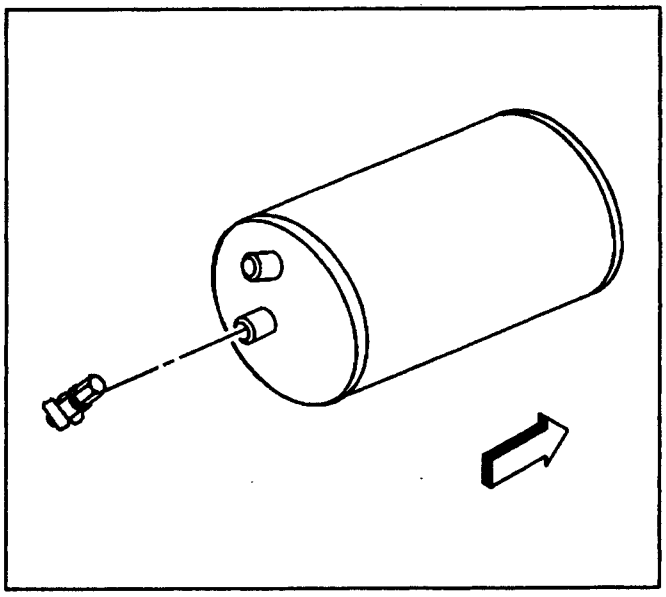
Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

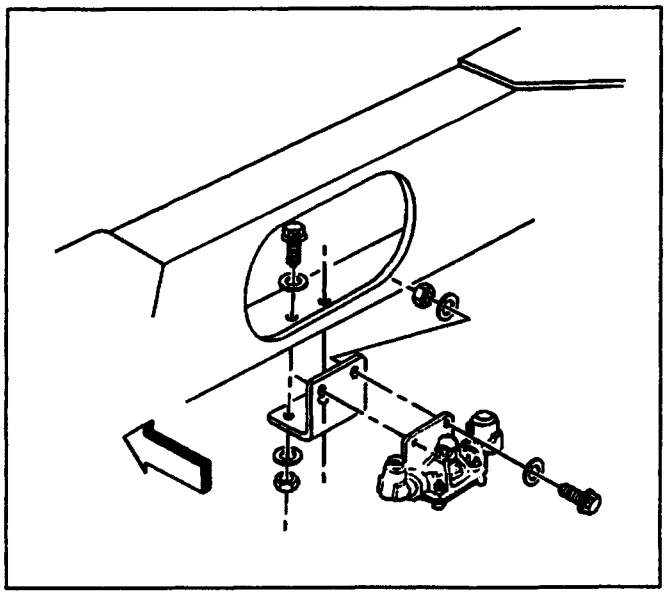
1. Install the reservoir drain valve (manual type).
   Tighten
   - Tighten the primary air brake supply reservoir drain valve (manual type) to 50 N.m (37 lb ft).
   - Tighten the front axle service reservoir drain valve (manual type) to 50 N.m (37 lb ft).
   - Tighten the rear axle service reservoir drain valve (manual type) to 50 N.m (37 lb ft).
2. Start the engine.
3. Charge the system air pressure to the governor cut-out point.
4. Inspect for leaks using a soap solution around the reservoir drain valve (manual type).
   No leakage is allowed.
5. Remove the wheel blocks.



227926



227926



227929

Pressure Protection Valve Replacement

Removal Procedure

1. Block the wheels.
2. Drain all the air reservoirs. Refer to *Draining Reservoirs.*
3. Remove the air line from the pressure protection valve. Refer to the following procedures:
   - *Hose and Line Replacement (Nylon and Metal - Compression)*
   - *Hose and Line Replacement (Nylon - Push-In)*
   - *Hose and Line Replacement (Flexible)*
   - *Hose and Line Replacement (Trailer Brake Coupling)*
   - *Hose and Line Replacement (Trailer Brake Dummy Cap)*
4. Remove the pressure protection valve.

Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the pressure protection valve.
   Tighten
   Tighten the pressure protection valve to 30 N.m (22 lb ft).
2. Install the air line to the pressure protection valve.
3. Perform the air leakage test. Refer to *Pressure Protection Valve Test (Leakage Test).*
4. Perform the operational test. Refer to *Pressure Protection Valve Test (Operational Check).*

Air Brake Quick Release Valve Replacement

Removal Procedure

1. Block the wheels.
2. Drain all of the air reservoirs. Refer to *Draining Reservoirs.*
3. Tilt the cab. Refer to Cab Tilting in General Information.

4. Remove the air lines. Refer to the following procedures:
   - *Hose and Line Replacement (Nylon and Metal - Compression)*
   - *Hose and Line Replacement (Nylon - Push-In)*
   - *Hose and Line Replacement (Flexible)*
   - *Hose and Line Replacement (Trailer Brake Coupling)*
   - *Hose and Line Replacement (Trailer Brake Dummy Cap)*
5. Remove the nuts, the washers, and the bolts.
6. Remove the quick release valve from the bracket.
7. Inspect the air lines for the following:
   - Damage
   - Kinks
   - Wear
8. Repair or replace the air lines as necessary.

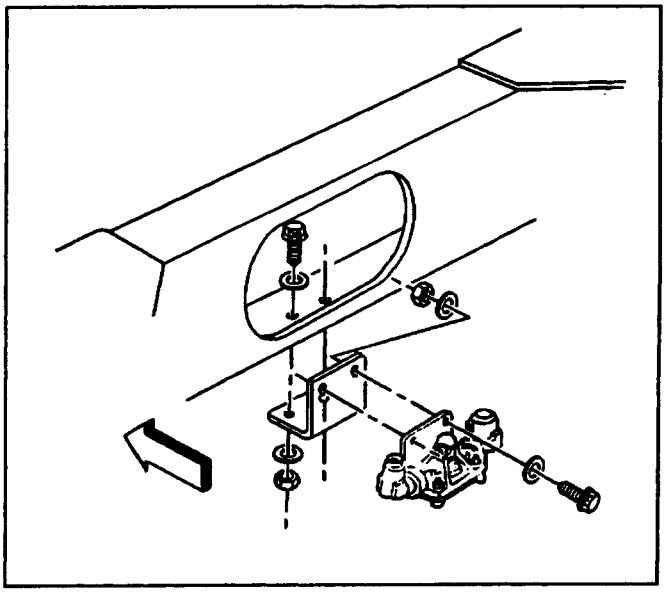
Installation Procedure

1. Install the quick release valve.

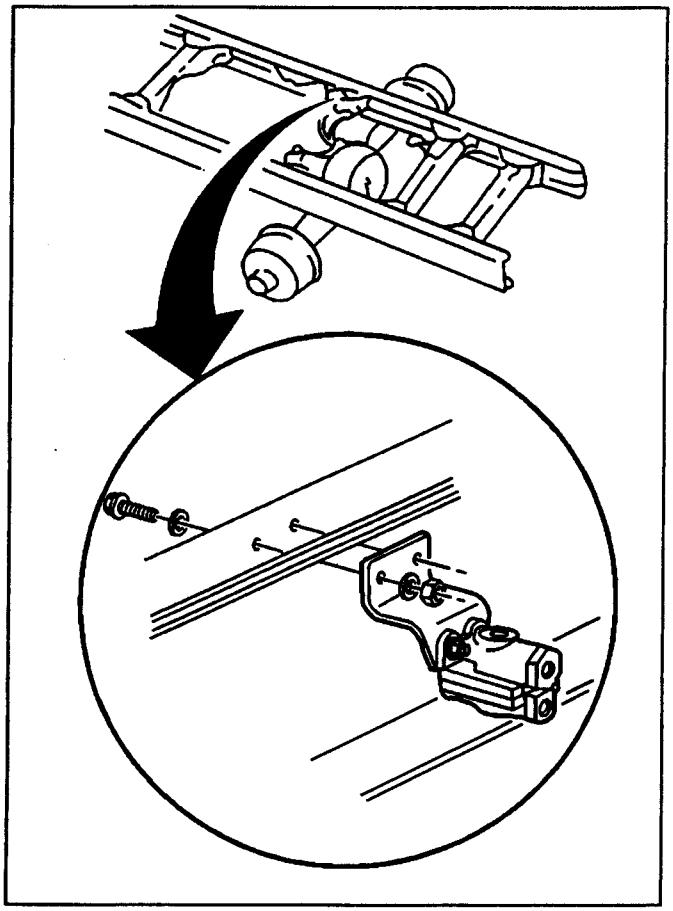
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the bolts, the washers, and the nuts.

   Tighten

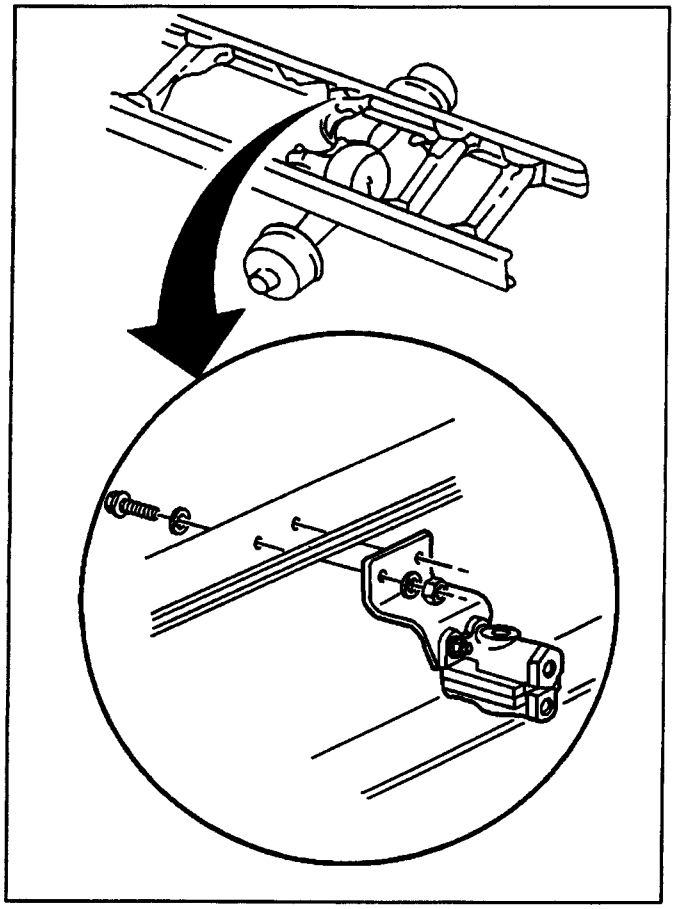
   Tighten the quick release valve nuts to 22 N·m (16 lb ft).
3. Install the air lines.
4. Perform the air leakage test. Refer to *Air Brake Quick Release Valve Test (Leakage Test).*
5. Perform the operational test. Refer to *Air Brake Quick Release Valve Test (Operational Check).*



227929



227931



227931

Air Brake Quick Rel Dbl Check Valve Replacement-RR

Removal Procedure

1. Block the vehicle wheels.
2. Drain all of the air reservoirs. Refer to *Draining Reservoirs.*
3. Remove the air lines from the quick release valve (double check type). Refer to the following procedures:
   - *Hose and Line Replacement (Nylon and Metal - Compression)*
   - *Hose and Line Replacement (Nylon - Push-In)*
   - *Hose and Line Replacement (Flexible)*
   - *Hose and Line Replacement (Trailer Brake Coupling)*
   - *Hose and Line Replacement (Trailer Brake Dummy Cap)*
4. Remove the nuts, the washers, and the bolts.
5. Remove the quick release valve (double check type).
6. Inspect the air lines for the following:
   - Damage
   - Kinks
   - Wear
7. Repair or replace the air lines as necessary.

Installation Procedure

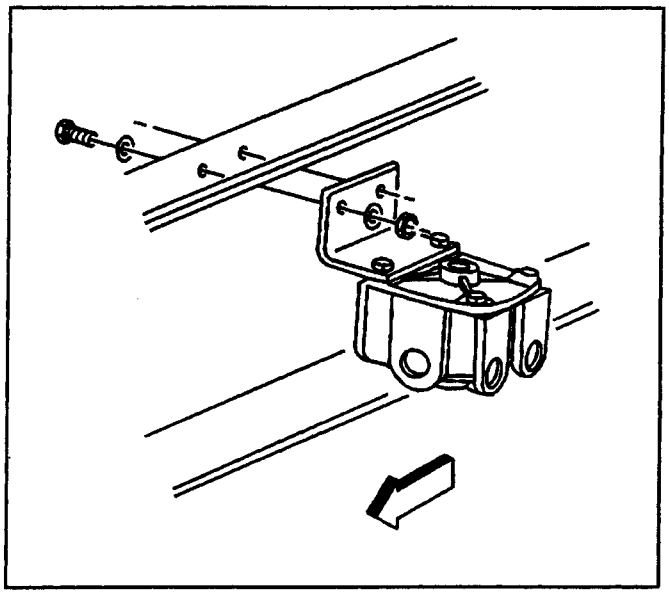
1. Install the quick release valve (double check type).

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the bolts, the washers, and the nuts.

   Tighten

   Tighten the quick release valve (double check type) bolts to 52 N·m (38 lb ft).
3. Install the air lines to the quick release valve (double check type).
4. Perform the air leakage test. Refer to *Rear Air Brk Quick Release Double Check Valve Test (Leakage Test).*
5. Perform the operational test. Refer to *Rear Air Brk Quick Release Double Check Valve Test (Operational Check).*

Air Brake Relay Valve Replacement - Rear



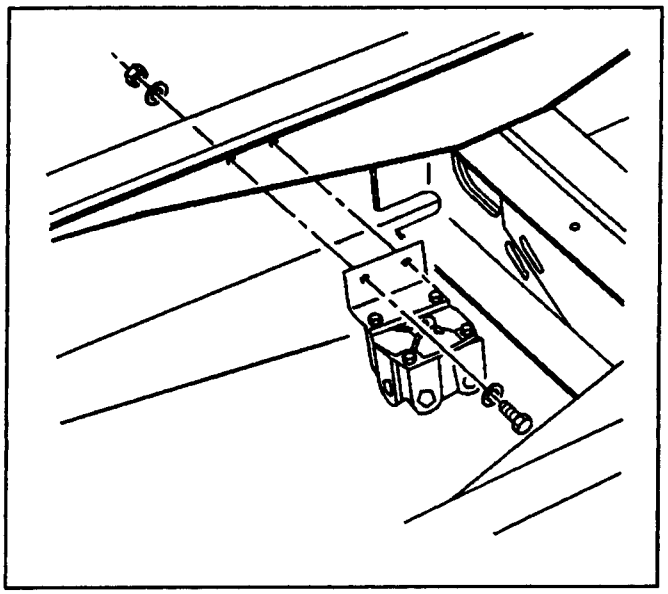
227932

Removal Procedure

1. Block the wheels.
2. Drain all of the air reservoirs. Refer to *Draining Reservoirs.*
3. Remove the air lines from the relay valve. Refer to the following procedures:

   Tag or label the air lines for installation.

   - *Hose and Line Replacement (Nylon and Metal - Compression)*
   - *Hose and Line Replacement (Nylon - Push-In)*
   - *Hose and Line Replacement (Flexible)*
   - *Hose and Line Replacement (Trailer Brake Coupling)*
   - *Hose and Line Replacement (Trailer Brake Dummy Cap)*
4. Remove the nuts, the washers, and the bolts.
5. Remove the relay valve.
6. Inspect the air lines for the following:
   - Damage
   - Kinks
   - Wear
7. Repair or replace the air lines as necessary.



227935

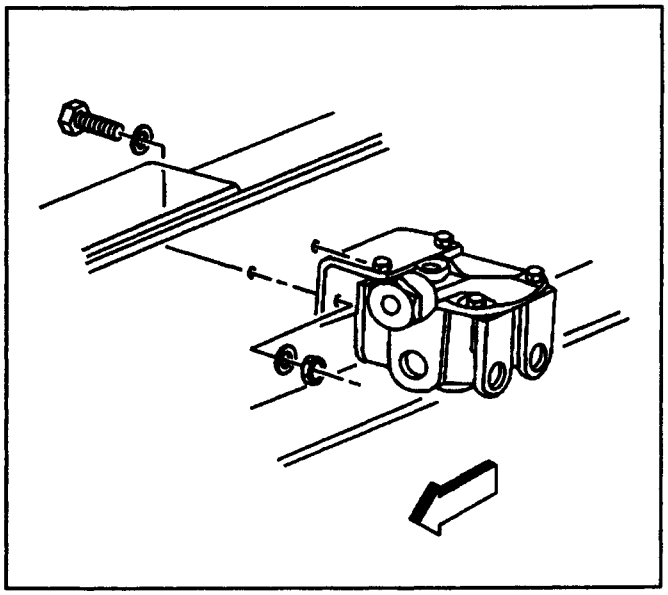
Installation Procedure

1. Install the relay valve to the bracket.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the bolts, the washers, and the nuts.

   Tighten

   Tighten the relay valve bolts to 52 N.m (38 lb ft).
3. Install the air lines to the relay valve.
4. Perform the air leakage test. Refer to *Rear Air Brake Relay Valve Test (Leakage Test).*
5. Perform the operational test. Refer to *Rear Air Brake Relay Valve Test (Operational Check).*



227936

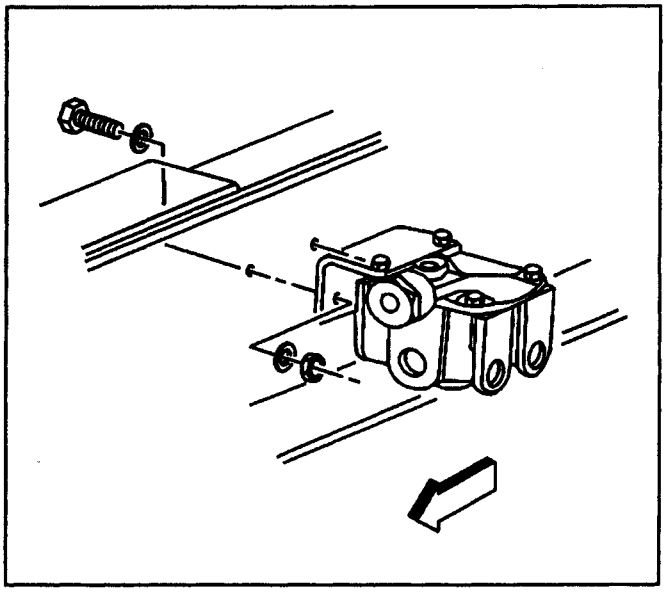
Air Brake Relay Dbl Check Valve Replacement - Rear

Removal Procedure

1. Block the wheels.
2. Drain all of the air reservoirs. Refer to *Draining Reservoirs.*
3. Remove the air lines from the relay valve (double check type). Refer to the following procedures:

   Tag or label the lines for installation.

   - *Hose and Line Replacement (Nylon and Metal - Compression)*
   - *Hose and Line Replacemen (Nylon - Push-In)*
   - *Hose and Line Replacement (Flexible)*
   - *Hose and Line Replacement (Trailer Brake Coupling)*
   - *Hose and Line Replacement (Trailer Brake Dummy Cap)*
4. Remove the nuts, the washers, and the bolts.
5. Remove the relay valve (double check type).
6. Inspect the air lines for the following:
   - Damage
   - Kinks
   - Wear
7. Repair or replace the air lines as necessary.



227936

Installation Procedure

1. Install the relay valve (double check type).

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the bolts, the washers, and the nuts.

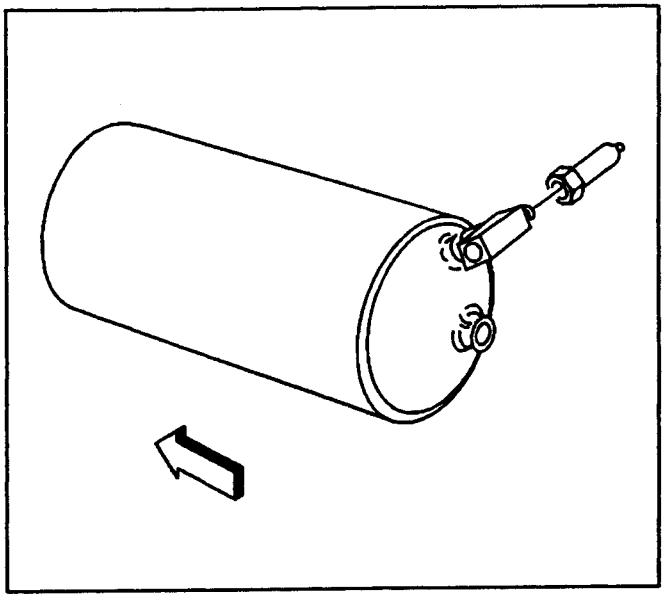
   Tighten

   Tighten the relay valve (double check type) bolts to 52 N·m (38 lb ft).
3. Install the air lines to the relay valve (double check type).
4. Perform the air leakage test. Refer to *Rear Air Brake Relay Double Check Valve Test (Leakage Test).*
5. Perform the operational test. Refer to *Rear Air Brake Relay Double Check Valve Test (Operational Check).*

Primary Air Brk Sply Rsvr Safety Valve Replacement

Removal Procedure

1. Block the wheels.
2. Drain the air reservoirs. Refer to *Draining Reservoirs.*
3. Remove the safety valve.

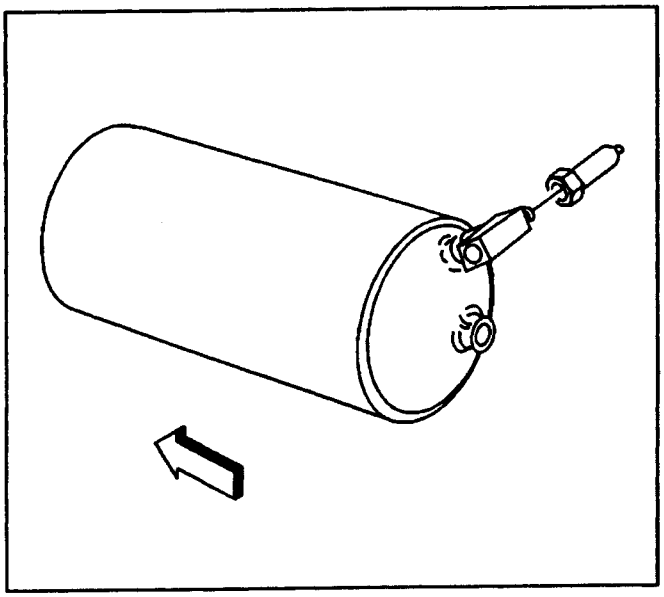


227937

Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the safety valve.
   Tighten
   Tighten the safety valve to 30 N.m (22 lb ft).
2. Perform the air leakage test. Refer to *Primary Air Brake Supply Rsvr Safety Valve Test (Leakage Test).*
3. Perform the operational test. Refer to *Primary Air Brake Supply Rsvr Safety Valve Test (Operational Check).*

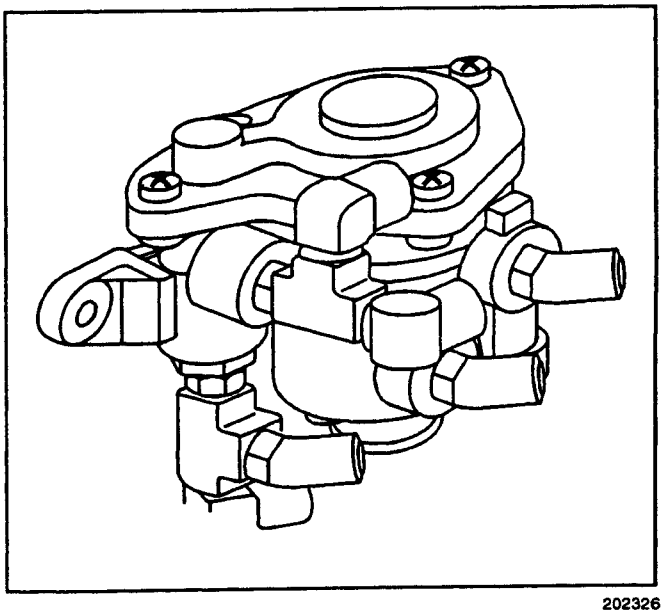


227937

Chas Mount Air Brk Park Control Valve Replacement

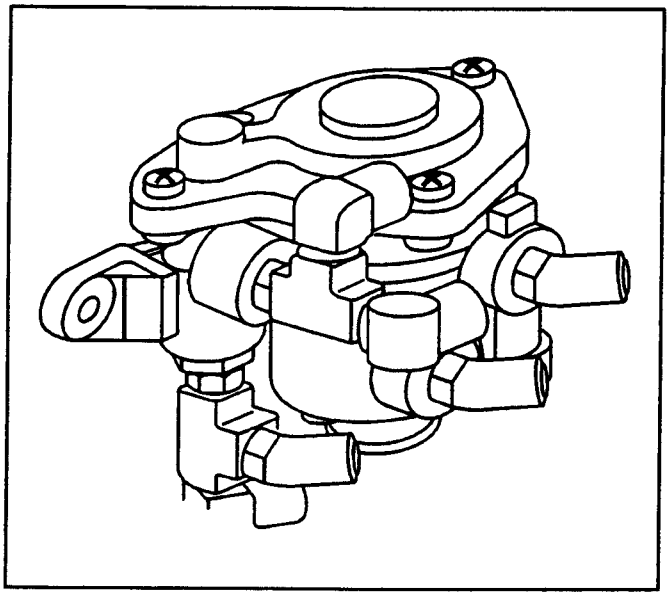
Removal Procedure

1. Block the wheels.
2. Drain the air reservoirs. Refer to *Draining Reservoirs.*
3. Remove the air lines from the valve. Refer to the following procedures:
   Tag or label the air lines for later installation.
   - *Hose and Line Replacement (Nylon and Metal - Compression)*
   - *Hose and Line Replacement (Nylon - Push-In)*
   - *Hose and Line Replacement (Flexible)*
   - *Hose and Line Replacement (Trailer Brake Coupling)*
   - *Hose and Line Replacement (Trailer Brake Dummy Cap)*



202326

4. Remove the nuts, the washers, and the bolts.
5. Remove the park control valve (chassis mounted) from the crossmember.
6. Inspect the air lines for the following:
   - Damage
   - Kinks
   - Wear
7. Replace or repair the air lines as necessary.



202326

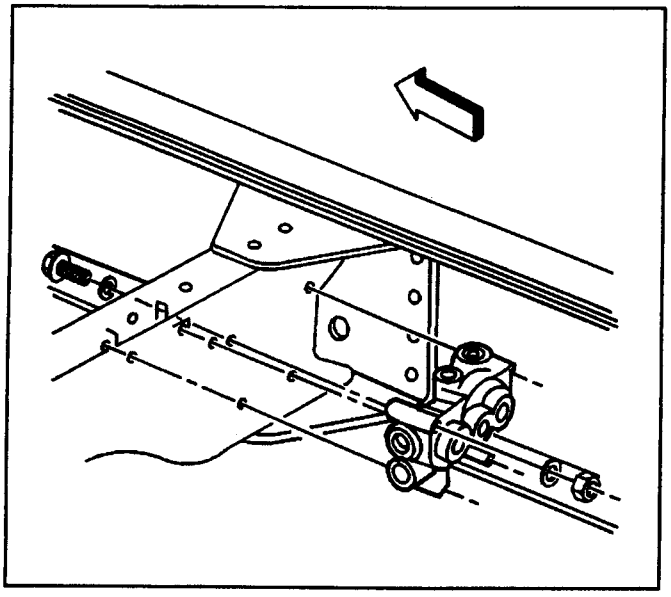
Installation Procedure

1. Install the park control valve (chassis mounted) to the crossmember.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the bolts, the washers, and the nuts.

   Tighten

   Tighten the park control valve (chassis mounted) nuts to 22 N.m (16 lb ft).
3. Install the air lines to the park control valve (chassis mounted).
4. Perform the air leakage test. Refer to *Chassis Mounted Air Brake Park Control Valve Test (Leakage Test).*
5. Perform the operational test. Refer to *Chassis Mounted Air Brake Park Control Valve Test (Operational Check).*



227940

Towing Vehicle Protection Valve Replacement

Removal Procedure

1. Block the wheels.
2. Drain the air reservoirs. Refer to *Draining Reservoirs.*
3. Remove the air lines from the towing vehicle protection valve. Refer to the following procedures:
   - *Hose and Line Replacement (Nylon and Metal - Compression)*
   - *Hose and Line Replacement (Nylon - Push-In)*
   - *Hose and Line Replacement (Flexible)*
   - *Hose and Line Replacement (Trailer Brake Coupling)*
   - *Hose and Line Replacement (Trailer Brake Dummy Cap)*
4. Remove the nuts, the washers, and the bolts.
5. Remove the towing vehicle protection valve.
6. Inspect the air lines for the following:
   - Damage
   - Kinks
   - Wear
7. Replace or repair the air lines as necessary.

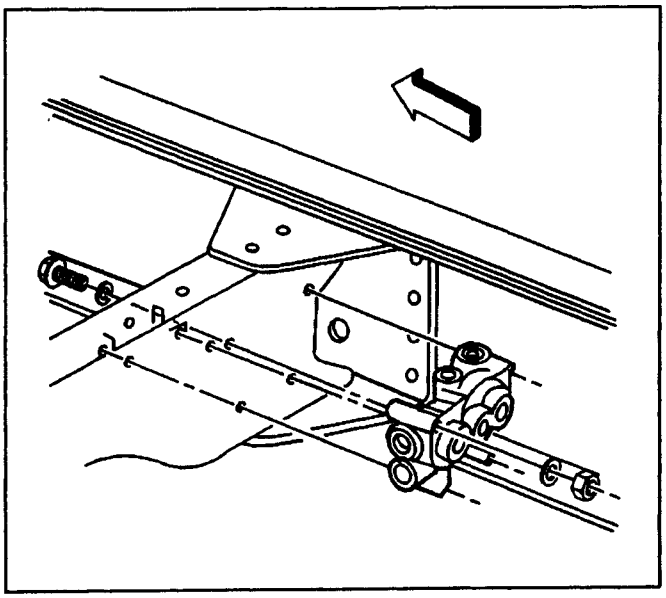
Installation Procedure

1. Install the towing vehicle protection valve.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the bolts, the washers, and the nuts.

   Tighten

   Tighten the towing vehicle protection valve nuts to 22 N.m (16 lb ft).
3. Install the air lines to the towing vehicle protection valve.
4. Perform the air leakage test. Refer to *Towing Vehicle Protection Valve Test (Leakage Test).*
5. Perform the operational test. Refer to *Towing Vehicle Protection Valve Test (Operational Check).*

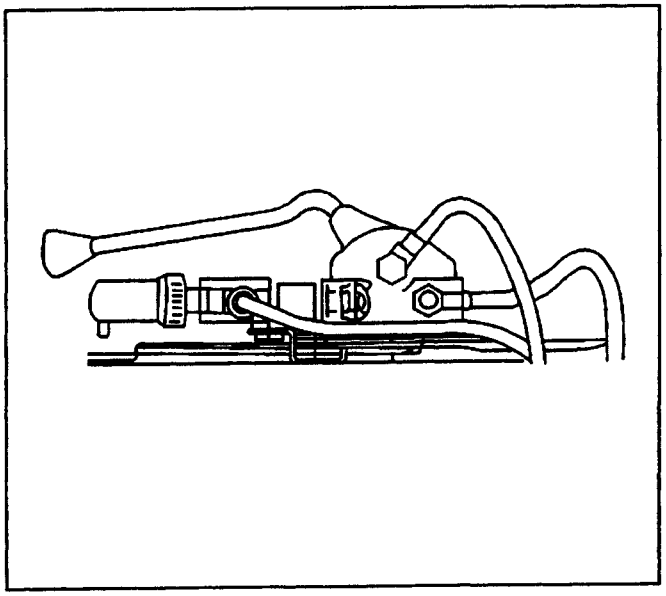


227940

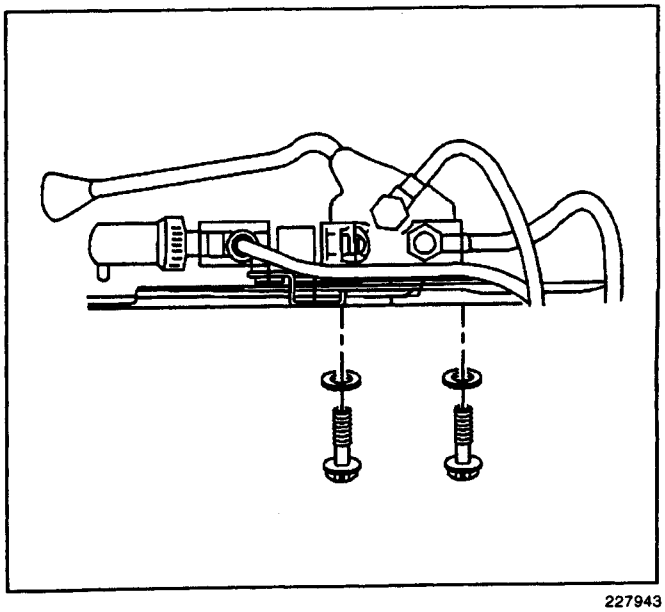
Trailer Brake Control Valve Replacement

Removal Procedure

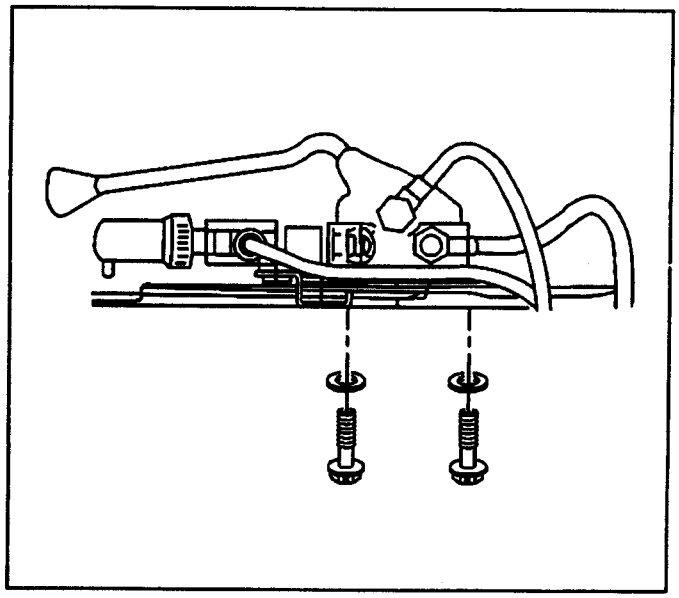
1. Block the wheels.
2. Drain the air reservoirs. Refer to *Draining Reservoirs.*
3. Remove the console assembly.
4. Remove the air lines from the trailer air brake control valve. Refer to the following procedures:
   - *Hose and Line Replacement (Nylon and Metal - Compression)*
   - *Hose and Line Replacement (Nylon - Push-In)*
   - *Hose and Line Replacement (Flexible)*
   - *Hose and Line Replacement (Trailer Brake Coupling)*
   - *Hose and Line Replacement (Trailer Brake Dummy Cap)*
5. Remove the nuts, the washers, and the bolts.
6. Remove the trailer air brake control valve.
7. Inspect the air lines for the following:
   - Damage
   - Kinks
   - Wear
8. Replace or repair the air lines as necessary.



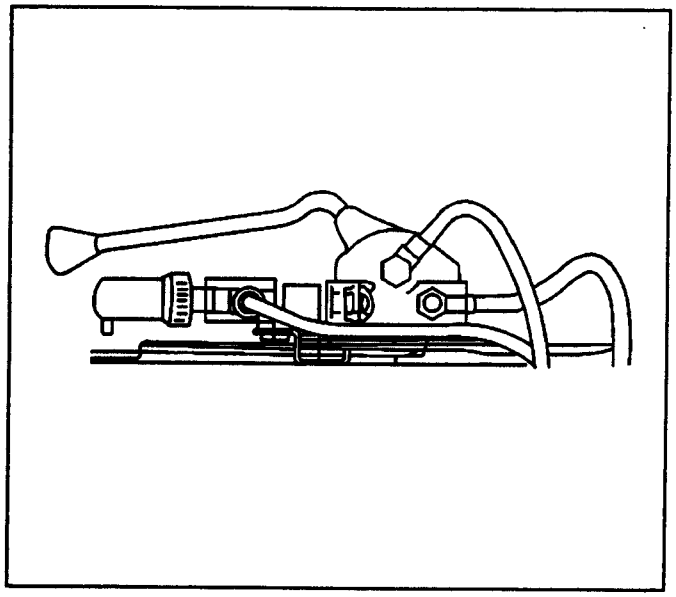
227942



227943



227943



227942

Installation Procedure

1. Instal the trailer air brake control valve.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the bolts, the washers, and the nuts.

   Tighten

   Tighten the trailer air brake control valve bolts to 40 N·m (29 lb ft).
3. Install the air lines to the trailer air brake control valve.
4. Perform the air leakage test. Refer to *Trailer Brake Control Valve Test (Leakage Test).*
5. Perform the operational test. Refer to *Trailer Brake Control Valve Test (Operational Check).*

Description and Operation

Air Brake System Description

The air brake valves include the following:

- Cab control valves
- Relay valves
- Automatic control valves
- Various safety valves

Air valves are pneumatic controls that route compressed air through hoses and lines to or from the air brake components. Air valves control the following:

- Service brake chambers
- Spring brake chamber assemblies
- Trailer supply
- Trailer service air lines

All air valves have air passages and internal moving parts. These moving parts direct the compressed air to the desired location. Each valve has the following components:

- At least one supply port to allow air to enter the valve
- One delivery port to allow air to exit the valve

Some valves have a control port that allows an air pressure source to control air flow through the valve. An exhaust port allows air to vent to the atmosphere. Some valves have special function control ports such as balance or reservoir ports. Refer to these valves for more discussion of the special ports.

Air brake valves operate either manually or automatically. Manual valves require the driver to move a knob, handle, or pedal in order to work the valve. Automatic valves use control ports or internal regulating parts in order to work.

Air Brake System Operation

The air brake system parts include the following:

- The air dryer
- The brake pedal
- The low air pressure switch
- The dual air pressure gauge
- Air lines
- Reservoirs
- Trailer air brake couplings
- A stoplamp switch
- The trailer air brake stoplamp switch

Air is supplied by a piston type air compressor. Refer to Air Compressor for on-vehicle service information of the air compressor equipment and controls.

Air flow is directed and controlled by air valves. Refer to specific portions of this section for on-vehicle service information of the air brake control valves.

The air foundation brakes are cam type. They are applied by the following:

- A camshaft
- A slack adjuster
- An air brake chamber

The parking brakes at the rear wheels are actuated by the spring brake chambers, which are controlled by the system park valve located in the cab. Refer to Air Compressor for on-vehicle service information of brake components located at the wheels.

Air Brake Component Description

Air Lines and Related Components

Notice: When replacing tubing, make sure that the tubing is free of burrs, cuttings, and dirt. While wearing safety glasses, use compressed air to blow out contaminants. Contaminants can destroy the air brake valve sealants.

The air lines deliver compressed air throughout the vehicle. The air lines are made from copper and nylon tubing.

Copper air lines consist of compression fittings with a diameter dimension of 19 mm (3/4 in).

Nylon air lines consist of push-in fittings in the following diameter dimensions:

- 4.8 mm (3/16 in)
- 6.4 mm (1/4 in)
- 9.5 mm (3/8 in)
- 12.7 mm (1/2 in)

The nylon air lines are color coded for system identification in the following ways:

Black: Accessory Equipment

Blue: Front System

Green: Rear System

Red: Parking Brake

Yellow: Trailer System

Blue: Trailer Supply

Nylon Air Lines

Notice: When replacing air lines connected to the push-in type fittings, be certain that the nylon air line is pushed-in and seated in the fitting. Install the tube into the fitting until no tube color is visible between the gauge band and the fitting. The air line may blow out if the tube is not properly seated in the fitting.

Notice: Nylon air line should be used to replace existing nylon lines only. Do not route nylon air lines in areas where temperatures could exceed 93°C (200°F). Damage to the nylon lines could occur.

All vehicles equipped with air brakes use a special push-in type fitting. These fittings are serviced as an assembly and should not be taken apart.

Flexible Hoses

Flexible hoses are used at the air brake chambers. These hoses connect the frame and axles with the trailer connections. Check the hoses for the following conditions:

- Chafed hoses
- Worn hoses
- Kinked flexible hoses

Replace the hoses as necessary.

Trailer and Brake Couplings
Vehicles equipped for trailer hauling have two flexible air lines that connect the truck or tractor and the trailer brake systems. One is the SERVICE air line and the other is the EMERGENCY air line. The EMERGENCY air line supplies constant air pressure to the trailer air system. The SERVICE air line delivers air to the trailer when braking is desired. Use either the foot brake pedal or the trailer brake control in order to apply the trailer brakes.

The flexible nylon air lines connect to the trailer through the couplings. When the couplings are connected, the pressure on two rubber gaskets makes an air-tight seal. Replace the rubber gaskets every 6 months. Uunder severe operating conditions, replace the gaskets more frequently.

The emergency coupling is located on the right side of the trailer air brake coupling hose bracket. This bracket is mounted on the cab and is tagged EMERGENCY. The service air line is located on the left side and is tagged SERVICE. When coupling the tractor and the trailer, connect the air lines properly. The corresponding couplings on the trailer are also tagged SERVICE and EMERGENCY.

Supporting Components
Maintain the following parts:

- Clips
- Ties
- Grommets
- Supporting brackets

Proper maintenance of these parts will prevent the following conditions:

- Unnecessary vibrations
- Loosening of the connections
- Separation of the connections

Check the air line routing and the support components regularly. Do not route the nylon lines near high heat sources such as the exhaust system.

Tabbed air line support brackets are used at some locations. A tab is positioned in a hole in the frame and retained with a single nut and bolt. The tab prevents the bracket from moving.

Use clamps on these brackets for holding bulky bundles of air lines and power cables. Verify that all clamps and brackets are be in place. Tighten all clamps and brackets securely.

The air line supports brace other components. Firmly mount the support in position. Do not allow the air lines to rub on the vehicle components.

The clamps and the band ties support and protect the air lines. Use the band ties in order to hold clusters of air lines and cables, when the use of clamps, brackets, or supports is not possible.

Heat Shields and Grommets
Grommets are used when air lines pass through frame members or sheet metal. The grommets prevent wear and cuts on the air lines. Check the grommets each time brake service is required.

Components must be in good condition and must be mounted correctly. The grommets should not be torn or bent. Replace all missing or damaged grommets.

In order to protect the air lines from heat, reinstall any heat shields which you removed during service.

Notice: When replacing air lines connected to the push-in type fittings, be certain that the nylon air line is pushed-in and seated in the fitting. Install the tube into the fitting until no tube color is visible between the gauge band and the fitting. The air line may blow out if the tube is not properly seated in the fitting.

Notice: Nylon air line should be used to replace existing nylon lines only. Do not route nylon air lines in areas where temperatures could exceed 93°C (200°F). Damage to the nylon lines could occur.

All vehicles equipped with air brakes use a special push-in type fitting. These fittings are serviced as an assembly and should not be taken apart.

Air Brake Component Operation

Air Lines and Related Components
The air lines deliver the compressed air throughout the vehicle. The air lines are made from copper and nylon tubing. Fittings are 4.8 mm (3/16 in), 6.4 mm (1/4 in), 9.5 mm (3/8 in), 12.7 mm (1/3 in) diameter push-in type for all nylon air lines, and 19 mm (3/4 in) diameter compression fittings for copper air lines.

The nylon air lines are color coded for system identification in the following ways:

- Black — Accessory Equipment
- Blue — Front System
- Green — Rear System
- Red — Parking Brake
- Yellow — Trailer System
- Blue — Trailer Supply

Nylon Air Lines

Notice: Nylon air line should be used to replace existing nylon lines only. Do not route nylon air lines in areas where temperatures could exceed 93°C (200°F). Damage to the nylon lines could occur.

Notice: When replacing air lines connected to the push-in type fittings, be certain that the nylon air line is pushed-in and seated in the fitting. Install the tube into the fitting until no tube color is visible between the gauge band and the fitting. The air line may blow out if the tube is not properly seated in the fitting.

All vehicles equipped with air brakes use a special push-in type fitting. These fittings are serviced as an assembly and should not be taken apart.

Flexible Hoses
Flexible hoses are used at the air brake chambers, between the frame and axles, and the trailer connections. Any chafed, worn, or kinked flexible hoses must be replaced.

Supporting Components

Maintain all air line clips, ties, grommets and supporting brackets to prevent unnecessary vibrations, and the loosening or separation of connections. Check the air line routing and support the components regularly. Do not route the nylon lines near high heat sources such as the exhaust system.

Tabbed air line support brackets are used at some locations. A tab is positioned in a hole in the frame and retained with a single nut and bolt. The tab prevents the bracket from moving.

Use clamps on these brackets for holding the air line and power cable bundles. All clamps and brackets must be in place and tightened securely.

The air line supports support other components. Firmly mount the support in position. Do not allow the air lines to rub on the vehicle components.

The clamps and the band ties support and protect the air lines. Use the band ties to hold clusters of air lines and cables where it is not possible to use clamps, brackets or supports.

Heat Shields and Grommets

Grommets are used when air lines pass through frame members or sheet metal. The grommets prevent wear and cuts on the air lines. Check the grommets each time brake service is required. Components must be in good condition and mounted correctly. The grommets should not be torn or bent. Replace the grommets if they are missing or damaged.

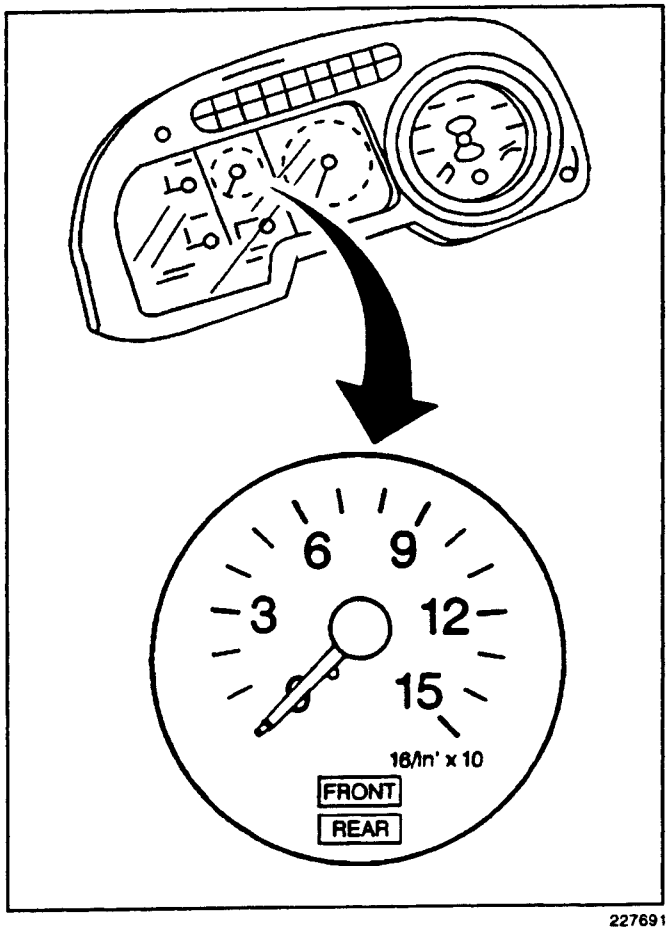
Any heat shields removed during service must be installed to protect the air lines from heat.

Reservoirs

Air reservoirs are the holding tanks for their respective systems. Each service system is a complete and separate air system. The service reservoirs isolate the front and the rear air brake systems. A front axle service reservoir stores compressed air for the front brakes. The rear service reservoirs store compressed air for the rear brakes. There is often more than 1 rear service reservoir. An in-line check valve at the inlet to each service reservoir prevents an air pressure loss from the service brakes if there is a leak in the supply air reservoir or the compressor discharge line. The service reservoirs are sometimes called dry tanks. The operator controls the air flow in both systems through a dual application valve.

The air supply reservoir holds heated air from the air compressor. As the air cools, water and contaminants collect in the supply reservoir. Drain this water at least once a day, unless the vehicle is equipped with an optional reservoir drain valve (automatic type).

Dual Air Pressure Gauge



227691

The dual air pressure gauge located in the instrument panel indicates the front and rear service system air pressures. Do not drive the vehicle when the front or rear gauge readings are below 450 kPa (65 psi). Check the dual air pressure gauge regularly with an accurate test gauge. Replace the dual air pressure gauge when the pressure reading varies by more than 27 kPa (4 psi), and there are no air leaks in the dual air pressure gauge circuit.

The dual air pressure gauge has 2 needles in contrasting colors. These needles show the front axle service and the rear axle service brake system air pressure. The dual air pressure gauge dial is marked from 0 to 15. Multiply the reading by 10 for the amount of psi.

The air pressure from the front and rear air brake systems is brought to the dual air pressure gauge through 2 nylon air lines. The 2 nylon air lines are routed from the instrument panel, through the floor, to the dual application valve. Inside the dual air pressure gauge, each nylon air line connects to a flattened, curved tube that straightens under internal pressure. The indicator needles are linked to the tubes and react to movement to indicate the air pressure.

Low Air Pressure Switch

The low air pressure switch is an air-controlled electrical switch that controls a cab tone alarm and warning light.

The low air pressure switch has a nominal pressure setting of 470 to 510 kPa (68 to 74 psi). If the low air pressure switch fails, replace the switch.

Air Brake Dryer System Description

The Bendix® AD-9 air brake dryer is a desiccant type (moisture absorbing) air dryer. The dryer consists of a die cast aluminum end cover secured to a cylindrical steel outer shell with eight cap screws and nuts. The end cover contains the following:

- A discharge check valve assembly
- A safety valve
- A purge valve housing assembly, which includes the following:
  - The heater
  - The thermostat assembly

The air brake dryer has three female pipe thread air connections. The ports and connections are identified as follows:

Air Brake Dryer System Description

Port Identification	Function/Connection
CON	Control Port (purge valve control and turbo cutoff)
SUP/11	Supply Port (air in)
DEL/2	Delivery Port (air out)

Air Brake Dryer System Operation

In the charge cycle, the compressed air flows into the air brake dryer through the supply port (SUP/11) where baffles change the direction of the air flow several times. This constant changing of air flow reduces the temperature and allows the contaminants to condense and drop to the bottom of the air brake dryer end cover. The air is then directed through a desiccant cartridge, where water, oil, and other contaminants first flow through an oil separator. The separator removes the water in liquid form as well as oil, oil vapor, and solid contaminates. Air then exits the oil separator and flows through the column of desiccant. The air becomes progressively dryer. The majority of the dry air exits through the internal check valve into the delivery port (DEL/2) and out to the supply reservoir.

In the purge cycle, the air compressor unloader port is connected to the air brake dryer control port (CON) which opens the purge valve in the bottom of the air brake dryer. This allows the water and contaminants to exit through the exhaust post in the bottom. Contaminants are blown out by air stored in the air brake dryer housing during the charge cycle. The complete purge cycle takes about 15–30 seconds.

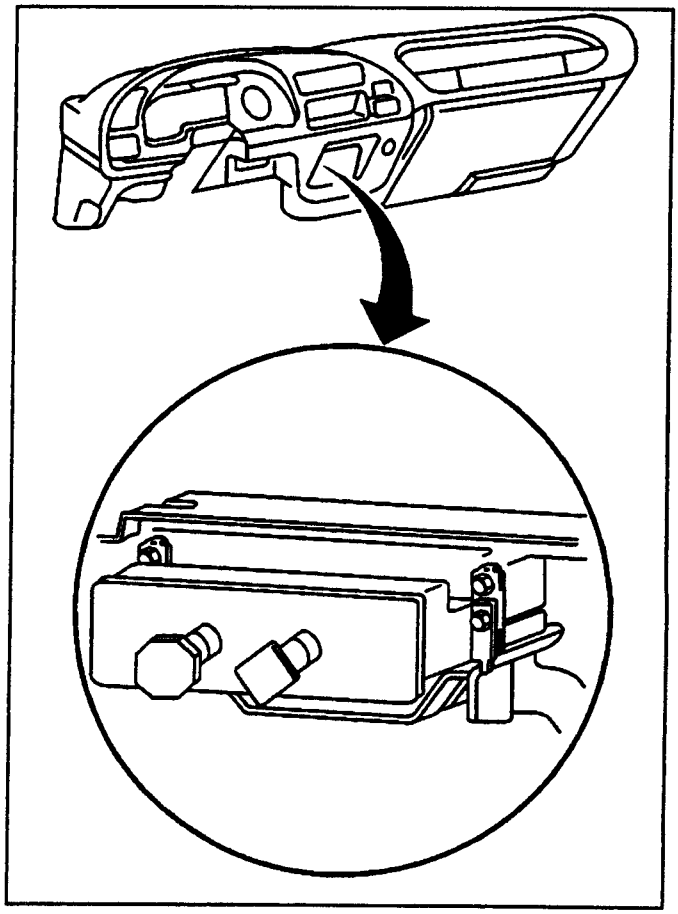
Air Brake Valves Description

The air brake valves include cab control valves, relay valves, automatic control valves, and various safety valves. Air valves are pneumatic controls that route compressed air through hoses and lines to or from the air brake components. They control service brake chambers, spring brake chamber assemblies, trailer supply, and trailer service air lines.

All air valves have air passages and internal moving parts. As the internal parts move, they direct the compressed air to the desired location. Each valve has at least one supply port to allow air to enter the valve and one delivery port to allow air to exit the valve. Some valves have a control port that allows an air pressure source to control when air can flow through the valve. An exhaust port allows air to vent to the atmosphere. Some valves have special function control ports such as balance or reservoir ports. The use of these special ports will be discussed on the valves that have them.

Air brake valves operate either manually or automatically. Manual valves require the driver to move a knob, handle, or pedal to work the valve. Automatic valves use control ports or internal regulating parts to work.

Park Control Valve, IP Mounted



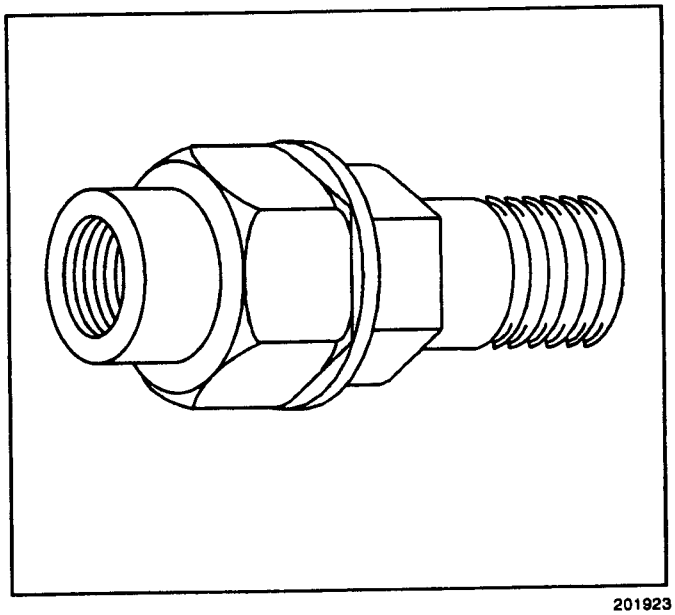
227847

The Bendix® PP-1 park control valve (cab mounted) is used on air brakes models without trailer provisions. The park control valve (cab mounted) is mounted in the instrument panel and has a yellow diamond-shaped control knob. The vehicle spring brakes are applied when the knob is pulled out. Pulling the knob out (exhaust position) allows the spring brake chamber assemblies to be activated. This applies the parking brakes.

Pushing the knob in (applied position) releases the parking brakes as long as the supply pressure is above 276 kPa (40 psi). When the supply pressure drops to 276 kPa (40 psi) and below, the internal spring causes the knob to pop out. This then returns the valve to the exhaust position, applying the parking brakes.

The park control valve (cab mounted) has a supply port. a delivery port, and an exhaust port. When the knob is pulled out, the supply port is blocked and the delivery port vents to the exhaust port. When the knob is pushed in, the exhaust port is blocked and supply air flows out of the delivery port.

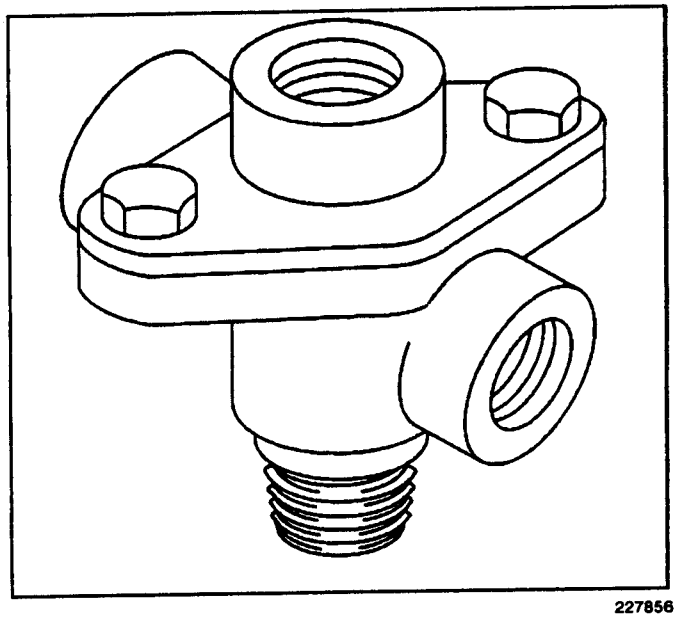
Single Check Valve



201923

A Bendix® SC-1 single check valve is installed at the inlet of each service air reservoir that is fed by the supply air reservoir. This valve prevents the loss of service brake air pressure if a leak occurs in the supply portion of the system. The single check valve has a supply port and a delivery port. Air flow in the normal direction moves the check valve disc from its seat and the air flow is unobstructed. Air flow in the reverse direction is prevented by the seating of the single check disc, which is caused by a drop in up-stream air pressure and is assisted by the spring.

Double Check Valve

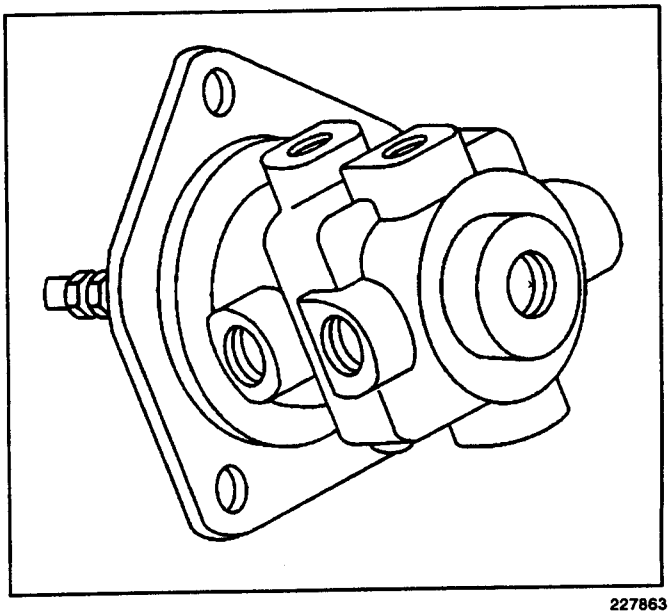


227856

The Bendix® DC-4 double check valve directs air from two supply lines into a common delivery line. The supply line with the highest air pressure will feed air to the delivery port while the lower pressure supply line is blocked. The valve isolates the supply ports.

The double check valve uses the front and rear service reservoirs to supply air to the spring brake chamber assemblies and the trailer air supply line. The trailer air brake control vale ties into the double check valve on models with trailer provisions.

Dual Application Valve

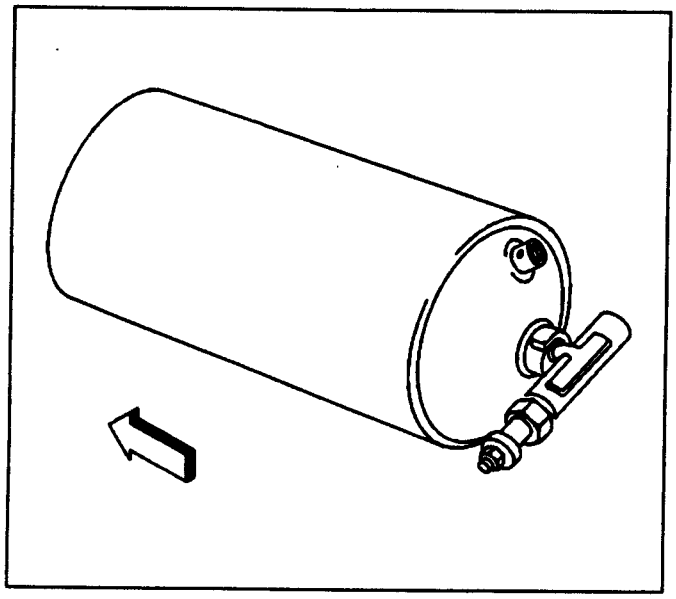


227863

The Bendix® E-6 dual application valve is a manual valve activated by the brake pedal. The dual application valve has two separate supply and delivery circuits for the front and the rear service brakes. Separating the circuits allows the driver to gradually apply and release the brakes.

The supply, the delivery, and the exhaust ports are identified by letters cast into the dual application valve body next to the ports. The primary supply and delivery ports are located in the dual application valve upper body portion and the secondary supply and the delivery ports are located in the lower body portion of the dual application valve. Both of the circuits serve as flow control valves. The flow of air directly relates to the travel of the brake pedal. The primary and secondary circuits use a common exhaust port protected by an exhaust diaphragm.

Inflation Valve

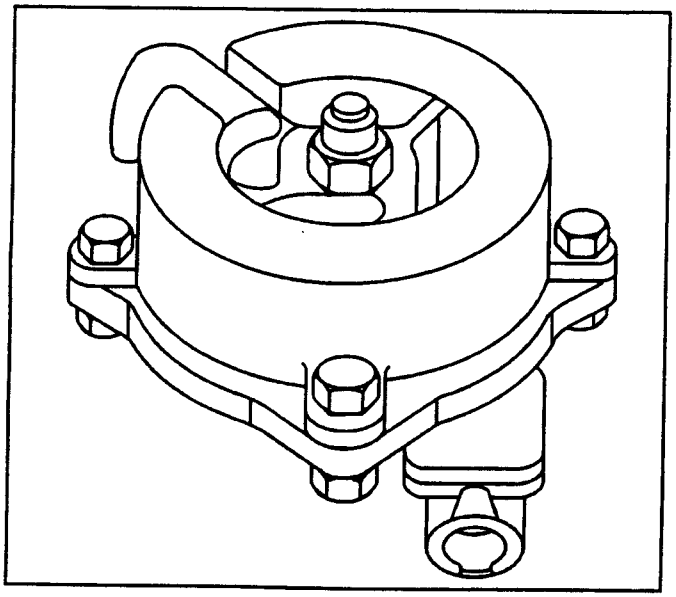


227870

The inflation valve is located on the air compressor governor. The inflation valve is used to fill the air system from an external source.

The inflation valve is a check valve and fitting for an external air hose connection. A cap is located on the valve stem to keep out dirt and other contaminants.

Reservoir Drain Valve, Automatic Type



202282

The Bendix® DV-2 reservoir drain valve (automatic type) is available as an option. It is also available with an optional heater and a thermostat cast into the cover.

The reservoir drain valve (automatic type) automatically drains moisture and contaminants from the supply reservoir. It mounts to the supply air reservoir at the valve supply port with the reservoir drain valve (automatic type) exhaust port pointing down.

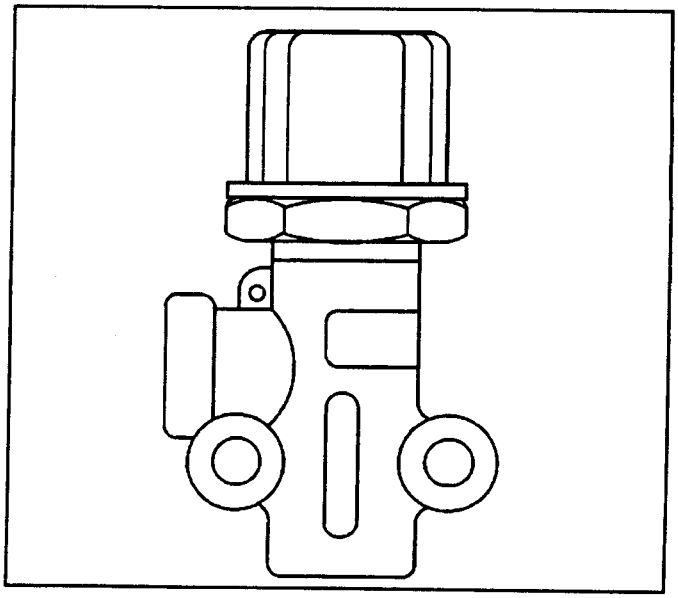
The supply and exhaust ports are normally closed. When the air compressor turns on to increase reservoir pressure, the supply port opens. This allows air and contaminants to collect in the sump of the reservoir drain valve (automatic type). The supply port remains open until the supply air reservoir pressure reaches the governor cut-out pressure. The valve spring then closes the supply port.

When the supply reservoir pressure drops about 14 kPa (2 psi), the sump cavity pressure opens the exhaust valve and allows the moisture and contaminants to be ejected from the sump cavity until the pressure in the sump cavity drops enough to close the exhaust valve. The length of time the exhaust valve remains open and the amount of moisture and contaminants ejected depends upon the sump pressure and the reservoir pressure drop that occurs each time air is used for the system.

The reservoir drain valve (automatic type) can be drained manually by moving the wire in the exhaust port upward, holding it in until the draining is complete.

The thermostat on the heated model will activate the heating element when the valve body reaches a temperature of approximately 7° C (45° F) and deactivates the heating element when the valve body is heated to approximately 29° C (85° F).

Pressure Protection Valve



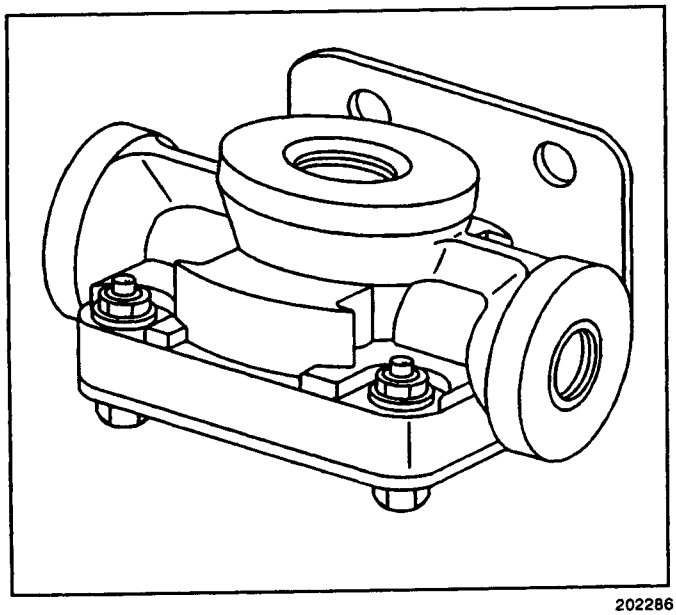
227873

The Bendix® PR-2 pressure protection valve is used on vehicles with air accessories or provisions for air accessories. The pressure protection valve is located on the front service air reservoir and the rear service air reservoir.

The pressure protection valve protects the air supply to the brakes if a failure occurs in the accessory equipment. The pressure protection valve has a supply port and a delivery port.

The pressure protection valve allows air to flow from the supply port to the delivery port as long as sufficient air pressure is available. If air pressure decreases below the specified closing pressure, the internal regulating spring moves the piston, closing the inlet valve. The remaining air pressure at the supply side is retained. The closing pressure is noted on the label attached to the pressure protection valve. The opening pressure is 103–238 kPa (15–20 psi) higher than the closing pressure.

Quick Release Valve



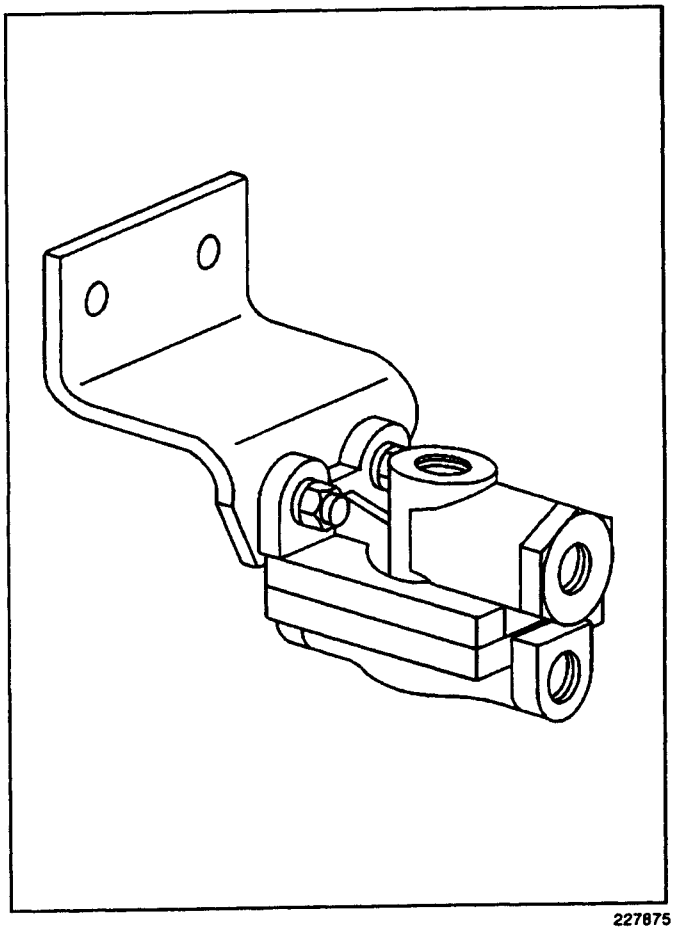
202286

The Bendix® QR-N quick release valve is mounted to a bracket on the front chassis crossmember.

When the brakes are applied, supply air flows through the quick release valve and out two delivery ports connected to the service brake chamber assemblies at the front wheels. When the foot brake is released, service brake chamber assembly air at the delivery ports is immediately vented through the exhaust port rather than the dual application valve. The quick release valve reduces the time required to exhaust service brake chamber assembly air, as compared to the time required to exhaust air through the dual application valve.

The quick release valve has an internal diaphragm. Air entering the supply port of the quick release valve causes the center portion of the diaphragm to seal the exhaust ports. Simultaneously, the outer edge of the diaphragm moves away from the sealing lip of the upper valve body, allowing air to flow from the supply port out the two delivery ports. Air then flows through the quick release valve to the service brake chamber assemblies until they are full. When air flow stops, the lip of the diaphragm seals the supply port. This sealing action causes the delivered air pressure to be slightly less than the supply pressure. The maximum differential air pressure is typically (1 psi). Releasing the brake pedal causes air from the service brake chamber assemblies to raise the diaphragm. This seals the supply port and opens the exhaust port, venturing the service brake chamber air pressure.

Quick Release Valve, Double Check Type



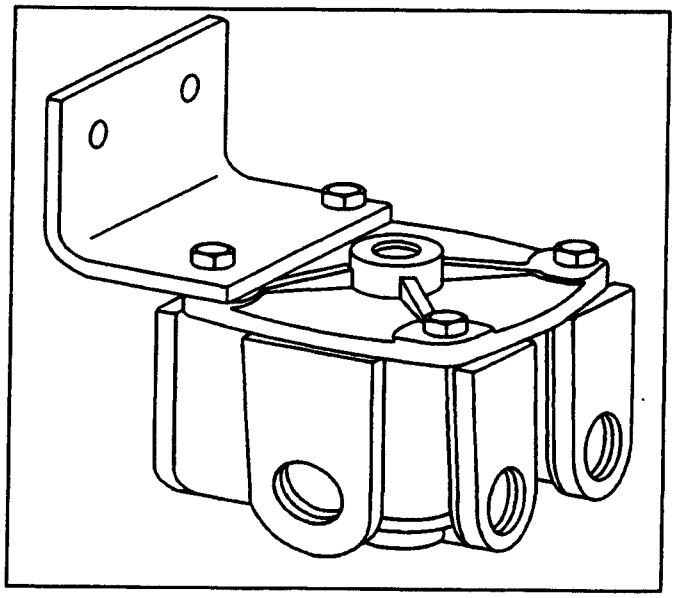
227875

The Bendix® QR-1C quick release valve (double check type) mounts to the right side frame rail near the rear axle assembly.

The quick release valve (double check type) is a dual function valve. The quick release valve's (double check type) primary function is to serve the emergency side of the spring brake chamber assemblies as a quick release valve. In addition, it functions as an anti-compound device. The quick release valve (double check type) prevents a service and emergency brake application from the occurring at the same time.

The quick release valve (double check type) has a supply port, a balance port, an exhaust port, and two delivery ports. Applying the park control valve (cab mounted) sends air into the supply port, out both delivery ports, and to the spring brake chamber assemblies. When the park control valve (cab mounted) pops out to apply the spring brake chamber assemblies, the supply and balance ports are sealed and the exhaust port opens. This vents the spring brake chamber assembly's air. Applying the brake pedal while the vehicle is parked causes service air to flow into the balance port, though the double check diaphragm, and out the delivery ports to the spring brake chamber assemblies.

Relay Valve



202295

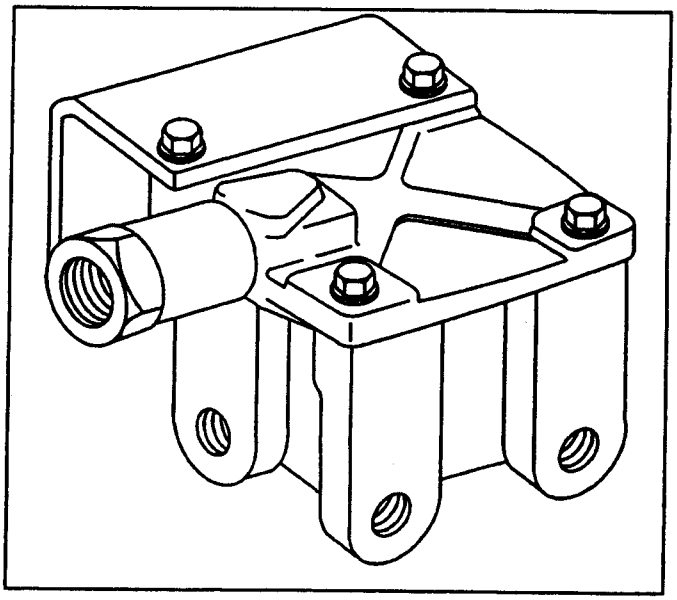
The Bendix® R-12 relay valve is mounted on a bracket to the frame side rail near the rear axle(s) to allow the shortest possible delivery lines to the rear service brake chamber assemblies.

The relay valve functions as a remote brake valve that delivers or releases air to the rear service brake chamber assemblies in response to control air from the dual application valve.

The relay valve has one control port, one supply port, two delivery ports, and one exhaust port. The control port connects to the rear service brake line from the dual application valve. The supply port connects to the rear axle service reservoir. The delivery ports connect to the rear service brake chamber assemblies.

As air pressure increases at the control port, an internal piston lowers to block the exhaust port and to gradually open the supply port in relation to piston travel. Supply air enters the cavity on the opposing face of the piston and flows out the delivery ports. With control and supply air on opposing faces, the piston balances to a position where the two pressures are equalized. Any change in control pressure then causes an equal change in delivery pressure. Releasing the brakes removes the control air. This causes the piston to rise, close the supply port, and open the exhaust port in the bottom of the relay valve. Service brake chamber assemblies air at the delivery ports then vent through the exhaust port.

Relay Valve, Double Check Type



202312

The Bendix® R-14 relay valve (double check type) is used on vehicles not built as tractors. It works with the parking brake control valve.

The relay vale (double check type) is mounted to the frame side rail near the rear axle(s) to allow the shortest possible delivery lines to the spring brake chamber assemblies.

The valve functions as a quick release valve that delivers or releases air to the spring brake chambers in response to the air pressure from the system park control valve (chassis mounted).

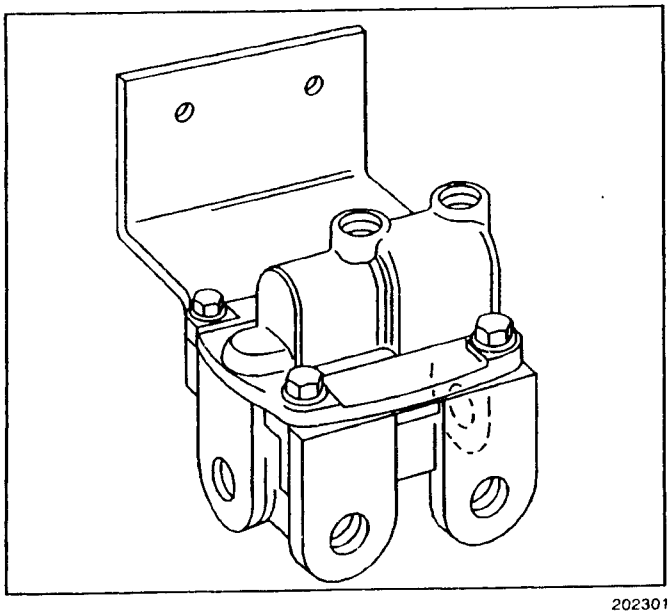
An internal double check diaphragm balances service brake line pressure and spring brake line pressure. This prevents the service brake chamber and the spring brake chamber from compounding their braking forces on the slack adjusters. When the service brake chambers and the spring brake chambers are applied at the same time, the double check diaphragm uses some air from the service brakes to partially release spring brake pressure from the slack adjuster. This balances the mechanical spring pressure with the service brake line pressure and keeps the slack adjusters from overloading.

The relay valve (double check type) has a control port, balance port, two supply ports, two delivery ports, and an exhaust port. The control port connects to the system park control valve (chassis mounted). The balance port connects to a relay valve delivery line. The control and balance lines are combined through an internal double check diaphragm to prevent brake compounding. One of the supply ports connects to the dual application valve, and the other is usually plugged. The delivery ports connect to the spring brake chamber assemblies.

When the dual application valve increases air pressure at the control port, an internal piston lowers to block the exhaust port and gradually open the supply port in relation to piston travel. Supply air enters the chamber on the opposing face of the piston and flows out the delivery ports. With control and supply air on the opposing faces, the piston balances to a position where the two pressures are equalized. Any change in control pressure then causes an equal change in delivery pressure.

When air pressure is released from the supply port and air pressure in the cavity above the relay piston is exhausted, air pressure under the piston lifts the relay piston and the exhaust seat moves away from the exhaust valve, opening the exhaust passage. With the exhaust passage open, the air pressure in the brake chamber assemblies is then permitted to exhaust through the exhaust port, releasing the brakes.

Relay Valve, Proportioning Type



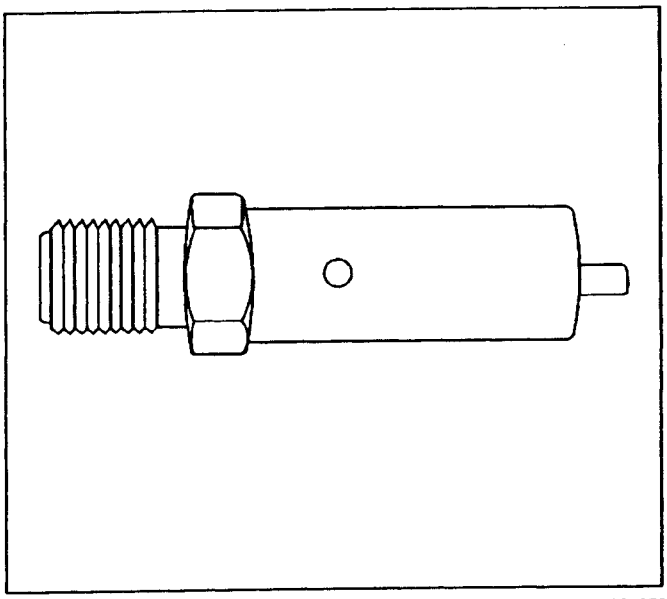
202301

The Bendix® BP-R1 relay valve (proportioning type) is only used on tractor applications. It is a combination of two individual valves in a single housing. The lower portion, or body, of the relay valve (proportioning type) contains a standard service brake relay valve. The upper portion, or cover, houses a brake proportioning valve to reduce normal service brake application pressure when the tractor is not towing a trailer.

The relay valve (proportional type) mounts to the right side frame rail. Air connections are identified by embossed letters. The relay valve (proportioning type) has a supply port connected to the rear service air reservoir, service port connected to the dual application valve, control port, and two delivery ports to allow air to flow to the service brake chamber assemblies.

When the tractor is pulling a trailer, it serves as a service brake relay valve to speed up apply and release time. When the tractor operates without a trailer, the relay valve (proportioning type) serves as service brake relay valve to speed up apply and release time. When the tractor operates without a trailer, the relay valve (proportioning type) reduces air pressure to the rear service brake chambers for improved control and reduced stopping distances.

Safety Valve

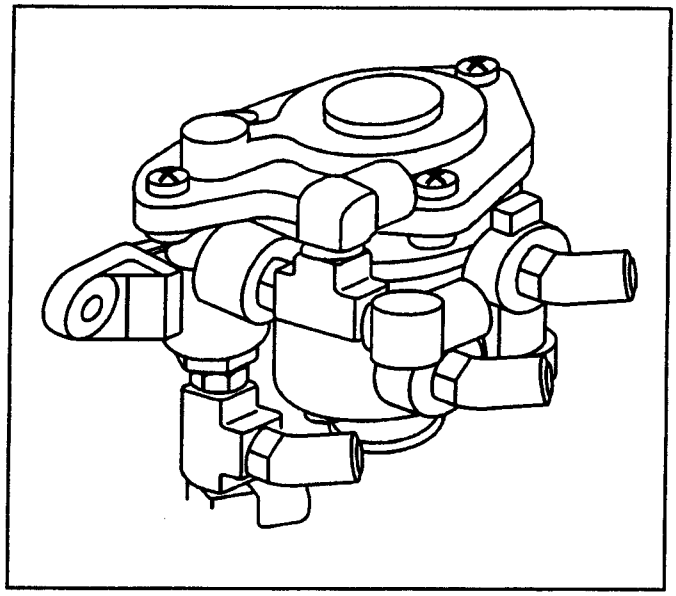


227879

A Bendix® ST-3 safety valve is installed in the air supply reservoir to stop air pressure buildup beyond a safe limit. The safety valve protects the reservoirs and lines in case of a governor malfunction. The safety valve is a spring-loaded type with a ball check valve and seat.

If the air pressure rises to approximately 1034 kPa (150 psi) it forces the ball check valve to unseat. This relieves air pressure through the exhaust vent in the spring cage. When the air pressure decreases sufficiently, the spring force seats the ball check valve, sealing off the supply air reservoir. This occurs at approximately 931 kPa (135 psi). The rated air pressure is attached to outside of the safety valve spring cage. The pressure setting on the safety valve is not adjustable.

Park Control Valve, Chassis Mounted



202326

The Bendix® SR-1 park control valve (chassis mounted) is used on all models that have spring brake chamber assemblies. The park control valve (chassis mounted) works with the relay valve. The park control valve (chassis mounted) allows the front brake service lines to modulate the spring brake chamber assemblies when the rear service air pressure fails.

The park control valve (chassis mounted) is mounted directly to the crossmember. The exhaust port always points down. The park control valve (chassis mounted) has a supply port connected to the park control valve (cab mounted), a delivery port connected to the front brake circuit on the dual application valve, a rear air reservoir port that senses rear service air reservoir pressure, and an exhaust port covered by a diaphragm. All of the ports are labeled with embossed letters.

The park control valve (chassis mounted) delivers a set air pressure to the delivery line as long as the supply and reservoir port pressures are 380 kPa (55 psi) or more. The air pressure is called the rated spring hold off pressure. The park control valve (chassis mounted) detects an air pressure loss in the rear service reservoir, through the reservoir port. When that happens, front brake service air at the control port of the park control valve modulates the spring brake chamber assemblies with the brake pedal as if they were service brakes. This allows the spring brake chamber assemblies to work in place of the service brakes during emergency situations.

When the park control valve (cab mounted) pulls out to the park position, supply port air is exhausted. This causes delivery port air to vent through the exhaust port.

Air Brake Valves Operation

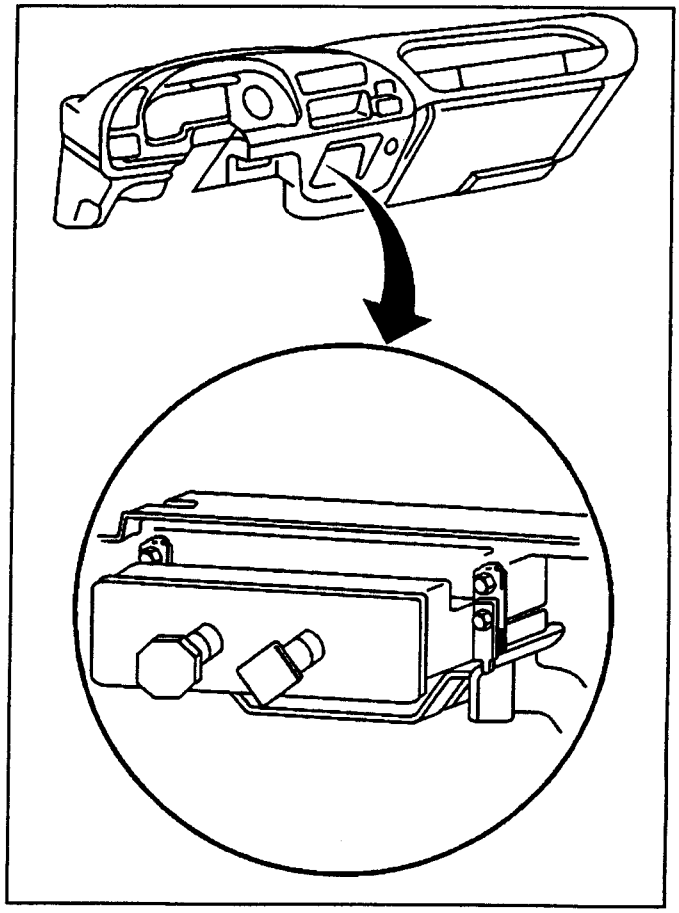
Air Brake Valves

The air brake valves include cab control valves, relay valves, automatic control valves, and various safety valves. Air valves are pneumatic controls that route compressed air through hoses and lines to or from the air brake components. They control service brake chambers, spring brake chamber assemblies, trailer supply, and trailer service air lines.

All air valves have air passages and internal moving parts. As the internal parts move, they direct the compressed air to the desired location. Each valve has at least one supply port to allow air to enter the valve and one delivery port to allow air to exit the valve. Some valves have a control port that allows an air pressure source to control when air can flow through the valve. An exhaust port allows air to vent to the atmosphere. Some valves have special function control ports such as balance or reservoir ports. The use of these special ports will be discussed on the valves that have them.

Air brake valves operate either manually or automatically. Manual valves require the driver to move a knob, handle, or pedal to work the valve. Automatic valves use control ports or internal regulating parts to work.

Park Control Valve, IP Mounted



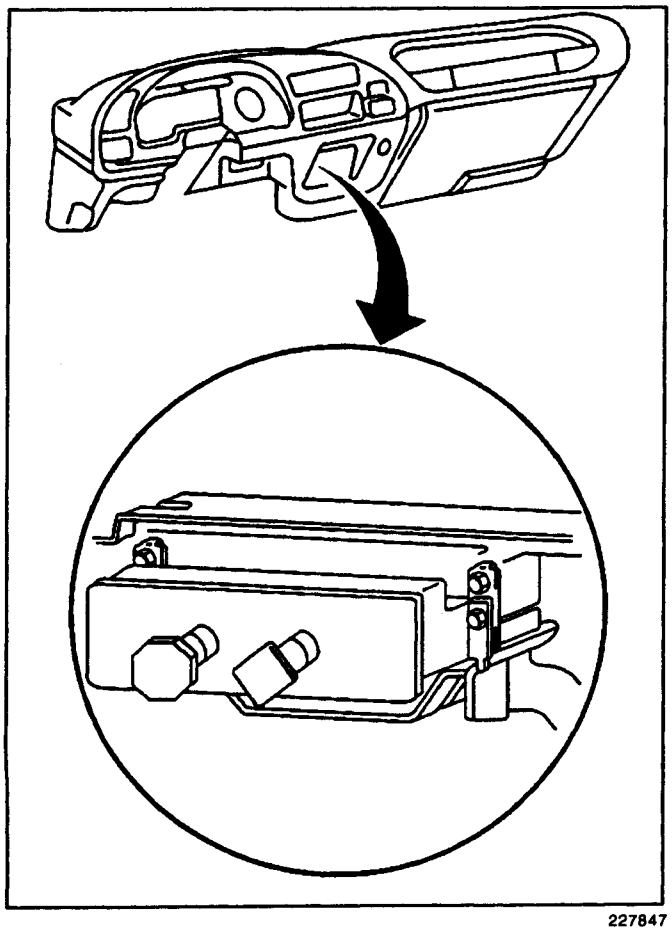
227847

The Bendix® PP-1 park control valve (cab mounted) is used on air brakes models without trailer provisions. The park control valve (cab mounted) is mounted in the instrument panel and has a yellow diamond-shaped control knob. The vehicle spring brakes are applied when the knob is pulled out. Pulling the knob out (exhaust position) allows the spring brake chamber assemblies to be activated. This applies the parking brakes.

Pushing the knob in (applied position) releases the parking brakes as long as the supply pressure is above 276 kPa (40 psi). When the supply pressure drops to 276 kPa (40 psi) and below, the internal spring causes the knob to pop out. This then returns the valve to the exhaust position, applying the parking brakes.

The park control valve (cab mounted) has a supply port. a delivery port, and an exhaust port. When the knob is pulled out, the supply port is blocked and the delivery port vents to the exhaust port. When the knob is pushed in, the exhaust port is blocked and supply air flows out of the delivery port.

Parking Control Valve



227847

The Bendix® MV-3 parking control valve is used on all models with trailer provisions. It is a two-knob control valve mounted in a single body, which includes a dual circuit supply valve and a check valve. The parking control is located in the instrument panel to the right of the driver. The parking control valve has a yellow diamond-shaped control knob for the park control, and a red octagon-shaped knob for the trailer air supply.

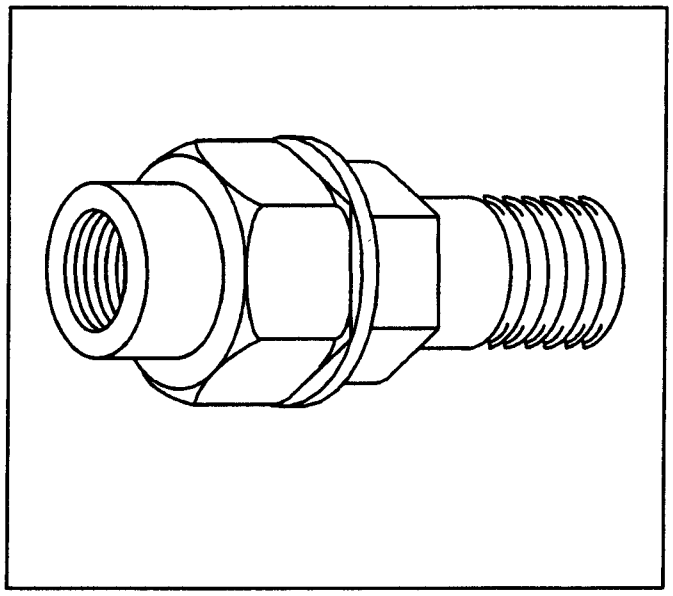
During the initial charge, with the system completely discharged, both knobs must be in the exhaust position (pulled out). When the air brake system pressure reaches 448 kPa (65 psi), the red knob (trailer air supply) may be pushed in, and should stay in, charging the trailer air brake system and releasing the trailer brakes. The yellow knob (park control) may now be pushed in, which will supply air to the spring brake chamber assemblies, releasing the parking brake.

In order to actuate the trailer parking brakes only, the red knob (trailer air supply) is pulled out, exhausting the trailer supply line. The trailer brakes are now applied either by the air emergency or the spring brake chamber assemblies, depending on the type of the trailer system. This mode is used while uncoupling the trailer. With both knobs pushed in for the normal run modes, the parking brakes on both the truck/tractor and trailer may be actuated by pulling the yellow knob (park control) out, which exhausts the air from the truck/tractor spring brake chamber assemblies, applying the parking brakes and simultaneously causes the the knob (trailer air supply) to pop out, applying the trailer brakes.

If both knobs are out when parking the combination vehicle and it is desired to recharge the trailer (leaving the truck/tractor parking brake applied), the red knob (trailer air supply) may be pushed in, re-pressurizing the trailer air supply line. This mode might also be used to park a combination vehicle with air actuated emergency brakes on the trailer to provide demonstrated parking capability with the truck/tractor spring brakes only.

With both knobs in (normal run configuration), if the air supply pressure to the parking control valve is reduced to approximately 241-310 kPa (35-45) psi), the red knob (trailer air supply) is held in manually and the pressure decreases to approximately 172 -241 kPa (25-35 psi), a tripper piston within the parking control valve will move upward, exhausting the trailer air supply, effecting the required non-override feature. The yellow knob (park control) will pop out at approximately 138 -210 kPa (20-30 psi).

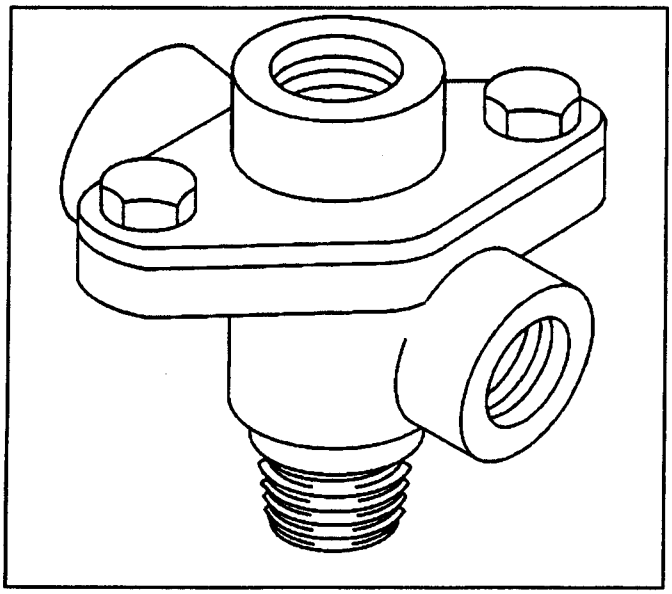
Single Check Valve



201923

A Bendix® SC-1 single check valve is installed at the inlet of each service air reservoir that is fed by the supply air reservoir. This valve prevents the loss of service brake air pressure if a leak occurs in the supply portion of the system. The single check valve has a supply port and a delivery port. Air flow in the normal direction moves the check valve disc from its seat and the air flow is unobstructed. Air flow in the reverse direction is prevented by the seating of the single check disc, which is caused by a drop in up-stream air pressure and is assisted by the spring.

Double Check Valve

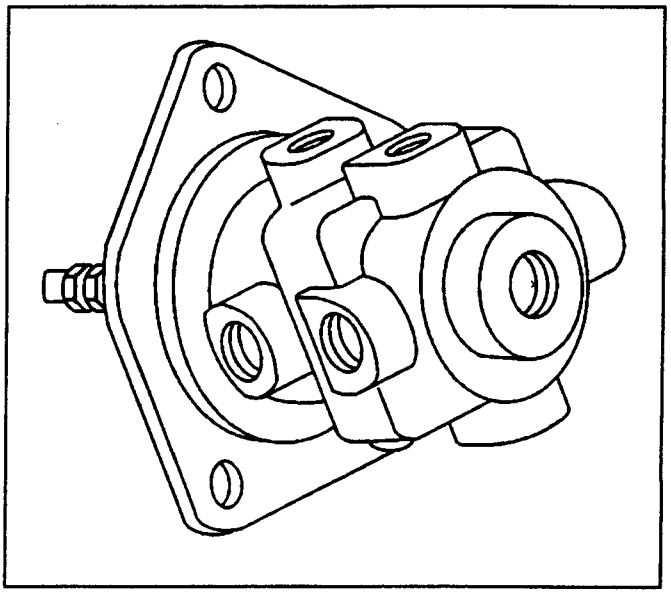


227856

The Bendix® DC-4 double check valve directs air from two supply lines into a common delivery line. The supply line with the highest air pressure will feed air to the delivery port while the lower pressure supply line is blocked. The valve isolates the supply ports.

The double check valve uses the front and rear service reservoirs to supply air to the spring brake chamber assemblies and the trailer air supply line. The trailer air brake control vale ties into the double check valve on models with trailer provisions.

Dual Application Valve

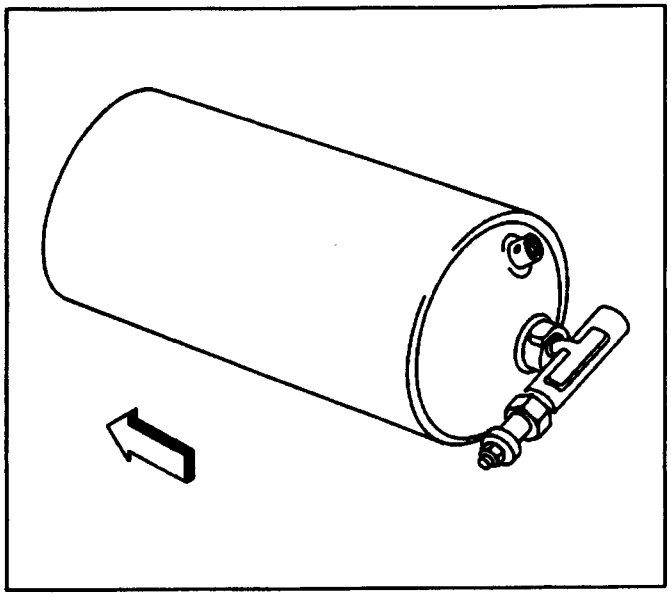


227863

The Bendix® E-6 dual application valve is a manual valve activated by the brake pedal. The dual application valve has two separate supply and delivery circuits for the front and the rear service brakes. Separating the circuits allows the driver to gradually apply and release the brakes.

The supply, the delivery, and the exhaust ports are identified by letters cast into the dual application valve body next to the ports. The primary supply and delivery ports are located in the dual application valve upper body portion and the secondary supply and the delivery ports are located in the lower body portion of the dual application valve. Both of the circuits serve as flow control valves. The flow of air directly relates to the travel of the brake pedal. The primary and secondary circuits use a common exhaust port protected by an exhaust diaphragm.

Inflation Valve

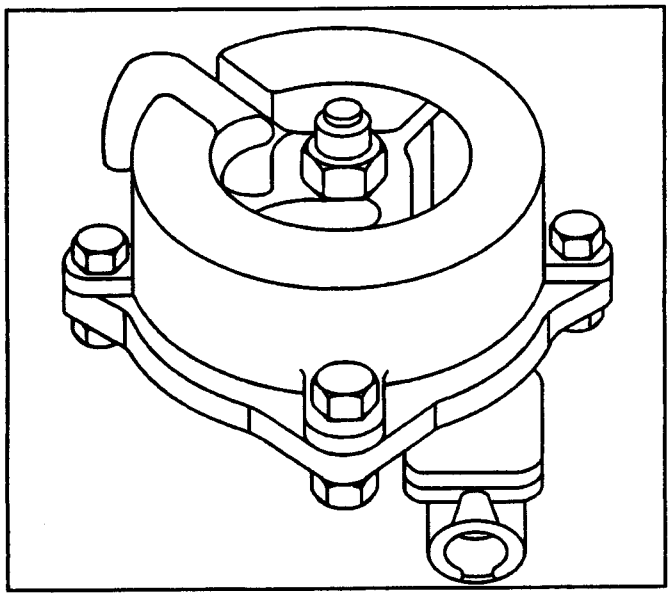


227870

The inflation valve is located on the air compressor governor. The inflation valve is used to fill the air system from an external source.

The inflation valve is a check valve and fitting for an external air hose connection. A cap is located on the valve stem to keep out dirt and other contaminants.

Reservoir Drain Valve, Automatic Type



202282

The Bendix® DV-2 reservoir drain valve (automatic type) is available as an option. It is also available with an optional heater and a thermostat cast into the cover.

The reservoir drain valve (automatic type) automatically drains moisture and contaminants from the supply reservoir. It mounts to the supply air reservoir at the valve supply port with the reservoir drain valve (automatic type) exhaust port pointing down.

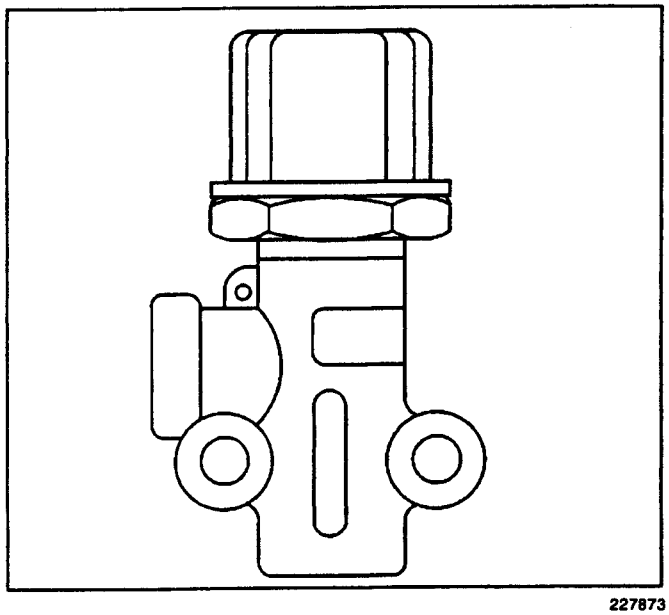
The supply and exhaust ports are normally closed. When the air compressor turns on to increase reservoir pressure, the supply port opens. This allows air and contaminants to collect in the sump of the reservoir drain valve (automatic type). The supply port remains open until the supply air reservoir pressure reaches the governor cut-out pressure. The valve spring then closes the supply port.

When the supply reservoir pressure drops about 14 kPa (2 psi), the sump cavity pressure opens the exhaust valve and allows the moisture and contaminants to be ejected from the sump cavity until the pressure in the sump cavity drops enough to close the exhaust valve. The length of time the exhaust valve remains open and the amount of moisture and contaminants ejected depends upon the sump pressure and the reservoir pressure drop that occurs each time air is used for the system.

The reservoir drain valve (automatic type) can be drained manually by moving the wire in the exhaust port upward, holding it in until the draining is complete.

The thermostat on the heated model will activate the heating element when the valve body reaches a temperature of approximately 7 °C (45 °F) and deactivates the heating element when the valve body is heated to approximately 29 °C (85 °F).

Pressure Protection Valve



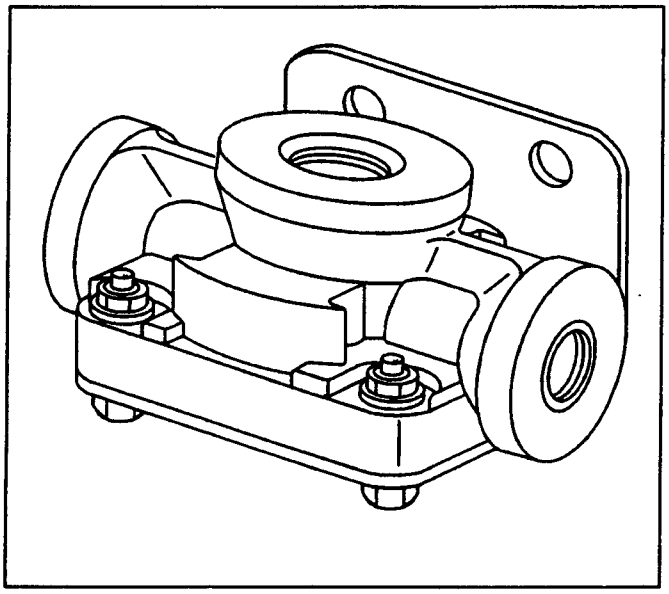
227873

The Bendix® PR-2 pressure protection valve is used on vehicles with air accessories or provisions for air accessories. The pressure protection valve is located on the front service air reservoir and the rear service air reservoir.

The pressure protection valve protects the air supply to the brakes if a failure occurs in the accessory equipment. The pressure protection valve has a supply port and a delivery port.

The pressure protection valve allows air to flow from the supply port to the delivery port as long as sufficient air pressure is available. If air pressure decreases below the specified closing pressure, the internal regulating spring moves the piston, closing the inlet valve. The remaining air pressure at the supply side is retained. The closing pressure is noted on the label attached to the pressure protection valve. The opening pressure is 103–238 kPa (15–20 psi) higher than the closing pressure.

Quick Release Valve



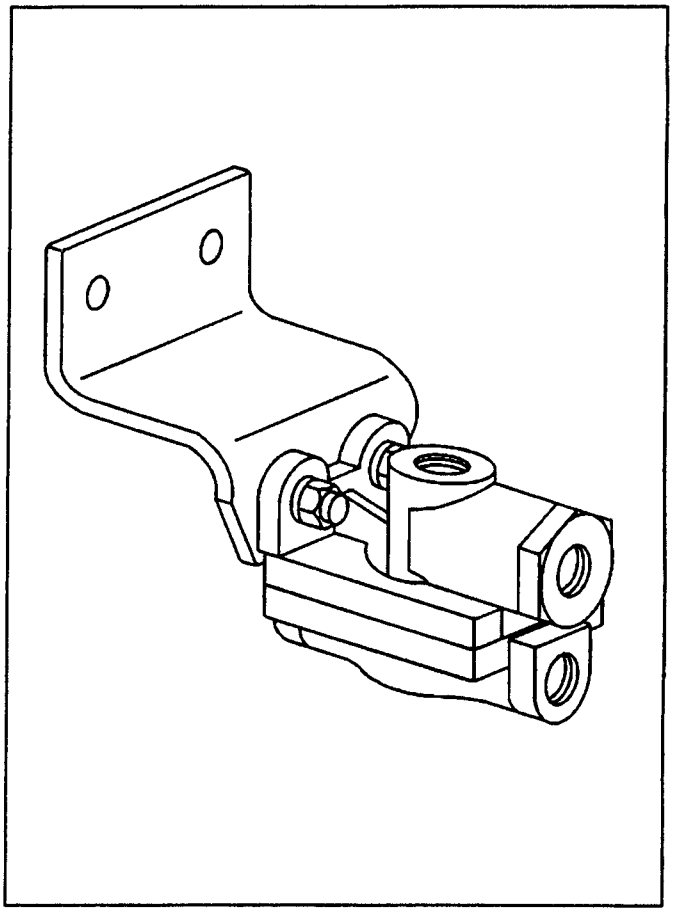
202286

The Bendix® QR-N quick release valve is mounted to a bracket on the front chassis crossmember.

When the brakes are applied, supply air flows through the quick release valve and out two delivery ports connected to the service brake chamber assemblies at the front wheels. When the foot brake is released, service brake chamber assembly air at the delivery ports is immediately vented through the exhaust port rather than the dual application valve. The quick release valve reduces the time required to exhaust service brake chamber assembly air, as compared to the time required to exhaust air through the dual application valve.

The quick release valve has an internal diaphragm. Air entering the supply port of the quick release valve causes the center portion of the diaphragm to seal the exhaust ports. Simultaneously, the outer edge of the diaphragm moves away from the sealing lip of the upper valve body, allowing air to flow from the supply port out the two delivery ports. Air then flows through the quick release valve to the service brake chamber assemblies until they are full. When air flow stops, the lip of the diaphragm seals the supply port. This sealing action causes the delivered air pressure to be slightly less than the supply pressure. The maximum differential air pressure is typically kPa (1 psi). Releasing the brake pedal causes air from the service brake chamber assemblies to raise the diaphragm. This seals the supply port and opens the exhaust port, venturing the service brake chamber air pressure.

Quick Release Valve, Double Check Type



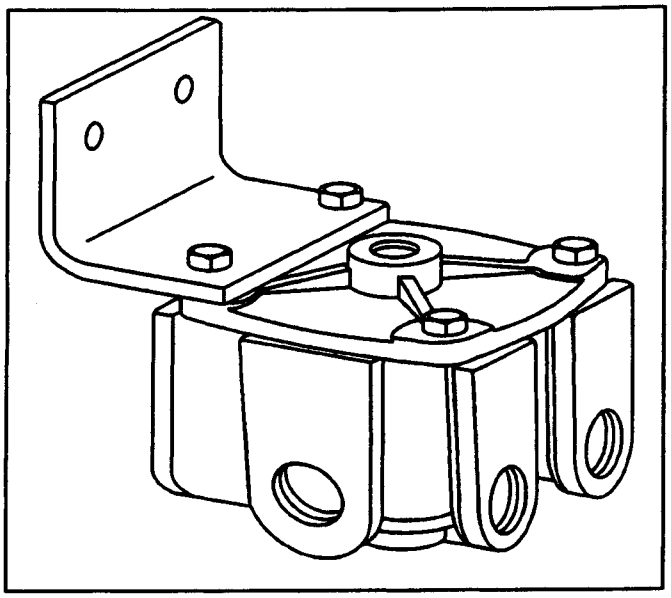
227875

The Bendix® QR-1C quick release valve (double check type) mounts to the right side frame rail near the rear axle assembly.

The quick release valve (double check type) is a dual function valve. The quick release valve's (double check type) primary function is to serve the emergency side of the spring brake chamber assemblies as a quick release valve. In addition, it functions as an anti-compound device. The quick release valve (double check type) prevents a service and emergency brake application from the occurring at the same time.

The quick release valve (double check type) has a supply port, a balance port, an exhaust port, and two delivery ports. Applying the park control valve (cab mounted) sends air into the supply port, out both delivery ports, and to the spring brake chamber assemblies. When the park control valve (cab mounted) pops out to apply the spring brake chamber assemblies, the supply and balance ports are sealed and the exhaust port opens. This vents the spring brake chamber assembly's air. Applying the brake pedal while the vehicle is parked causes service air to flow into the balance port, though the double check diaphragm, and out the delivery ports to the spring brake chamber assemblies.

Relay Valve



202295

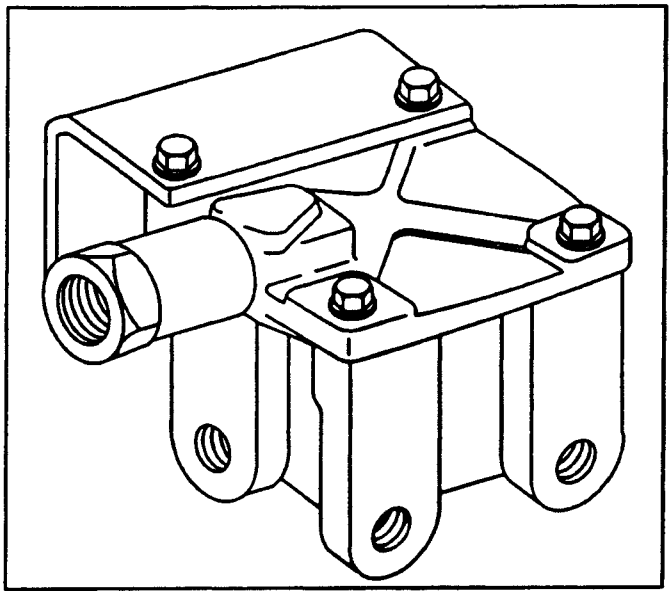
The Bendix® R-12 relay valve is mounted on a bracket to the frame side rail near the rear axle(s) to allow the shortest possible delivery lines to the rear service brake chamber assemblies.

The relay valve functions as a remote brake valve that delivers or releases air to the rear service brake chamber assemblies in response to control air from the dual application valve.

The relay valve has one control port, one supply port, two delivery ports, and one exhaust port. The control port connects to the rear service brake line from the dual application valve. The supply port connects to the rear axle service reservoir. The delivery ports connect to the rear service brake chamber assemblies.

As air pressure increases at the control port, an internal piston lowers to block the exhaust port and to gradually open the supply port in relation to piston travel. Supply air enters the cavity on the opposing face of the piston and flows out the delivery ports. With control and supply air on opposing faces, the piston balances to a position where the two pressures are equalized. Any change in control pressure then causes an equal change in delivery pressure. Releasing the brakes removes the control air. This causes the piston to rise, close the supply port, and open the exhaust port in the bottom of the relay valve. Service brake chamber assemblies air at the delivery ports then vent through the exhaust port.

Relay Valve, Double Check Type



202312

The Bendix® R-14 relay valve (double check type) is used on vehicles not built as tractors. It works with the parking brake control valve.

The relay vale (double check type) is mounted to the frame side rail near the rear axle(s) to allow the shortest possible delivery lines to the spring brake chamber assemblies.

The valve functions as a quick release valve that delivers or releases air to the spring brake chambers in response to the air pressure from the system park control valve (chassis mounted).

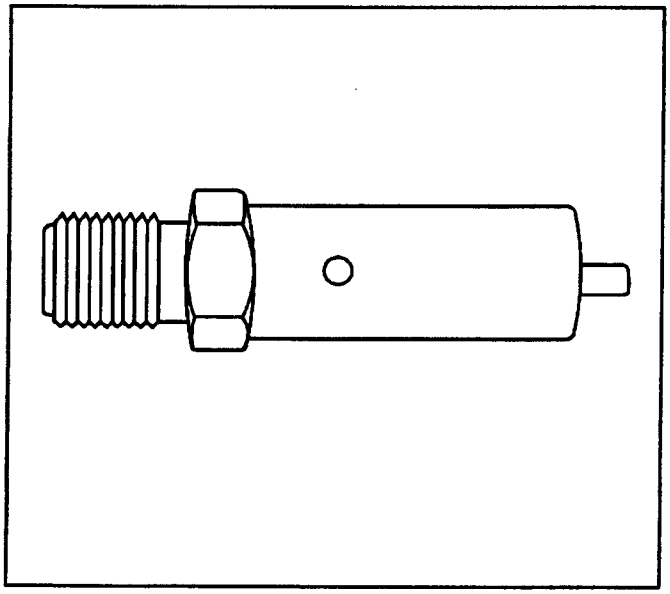
An internal double check diaphragm balances service brake line pressure and spring brake line pressure. This prevents the service brake chamber and the spring brake chamber from compounding their braking forces on the slack adjusters. When the service brake chambers and the spring brake chambers are applied at the same time, the double check diaphragm uses some air from the service brakes to partially release spring brake pressure from the slack adjuster. This balances the mechanical spring pressure with the service brake line pressure and keeps the slack adjusters from overloading.

The relay valve (double check type) has a control port, balance port, two supply ports, two delivery ports, and an exhaust port. The control port connects to the system park control valve (chassis mounted). The balance port connects to a relay valve delivery line. The control and balance lines are combined through an internal double check diaphragm to prevent brake compounding. One of the supply ports connects to the dual application valve, and the other is usually plugged. The delivery ports connect to the spring brake chamber assemblies.

When the dual application valve increases air pressure at the control port, an internal piston lowers to block the exhaust port and gradually open the supply port in relation to piston travel. Supply air enters the chamber on the opposing face of the piston and flows out the delivery ports. With control and supply air on the opposing faces, the piston balances to a position where the two pressures are equalized. Any change in control pressure then causes an equal change in delivery pressure.

When air pressure is released from the supply port and air pressure in the cavity above the relay piston is exhausted, air pressure under the piston lifts the relay piston and the exhaust seat moves away from the exhaust valve, opening the exhaust passage. With the exhaust passage open, the air pressure in the brake chamber assemblies is then permitted to exhaust through the exhaust port, releasing the brakes.

Safety Valve

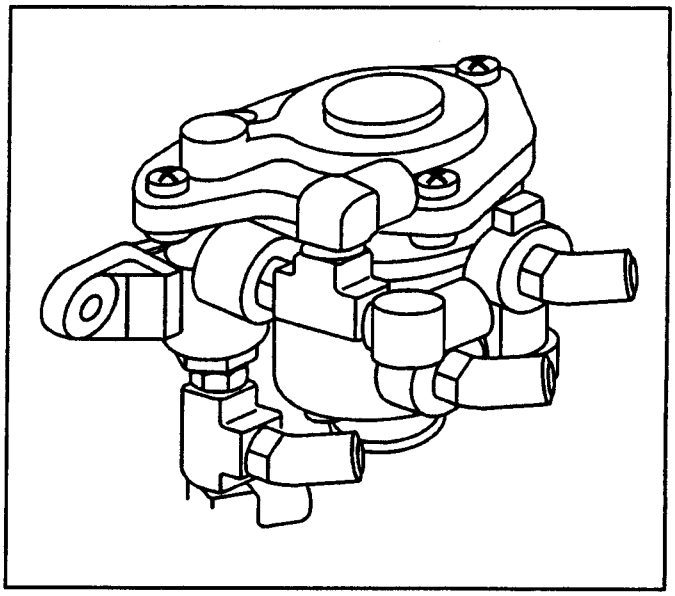


227879

A Bendix® ST-3 safety valve is installed in the air supply reservoir to stop air pressure buildup beyond a safe limit. The safety valve protects the reservoirs and lines in case of a governor malfunction. The safety valve is a spring-loaded type with a ball check valve and seat.

If the air pressure rises to approximately 1034 kPa (150 psi) it forces the ball check valve to unseat. This relieves air pressure through the exhaust vent in the spring cage. When the air pressure decreases sufficiently, the spring force seats the ball check valve, sealing off the supply air reservoir. This occurs at approximately 931 kPa (135 psi). The rated air pressure is attached to outside of the safety valve spring cage. The pressure setting on the safety valve is not adjustable.

Park Control Valve, Chassis Mounted



202326

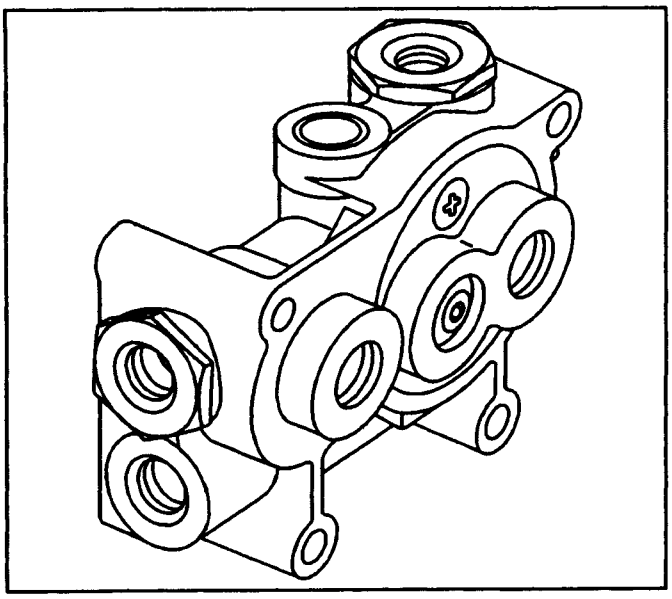
The Bendix® SR-1 park control valve (chassis mounted) is used on all models that have spring brake chamber assemblies. The park control valve (chassis mounted) works with the relay valve. The park control valve (chassis mounted) allows the front brake service lines to modulate the spring brake chamber assemblies when the rear service air pressure fails.

The park control valve (chassis mounted) is mounted directly to the crossmember. The exhaust port always points down. The park control valve (chassis mounted) has a supply port connected to the park control valve (cab mounted), a delivery port connected to the front brake circuit on the dual application valve, a rear air reservoir port that senses rear service air reservoir pressure, and an exhaust port covered by a diaphragm. All of the ports are labeled with embossed letters.

The park control valve (chassis mounted) delivers a set air pressure to the delivery line as long as the supply and reservoir port pressures are 380 kPa (55 psi) or more. The air pressure is called the rated spring hold off pressure. The park control valve (chassis mounted) detects an air pressure loss in the rear service reservoir, through the reservoir port. When that happens, front brake service air at the control port of the park control valve modulates the spring brake chamber assemblies with the brake pedal as if they were service brakes. This allows the spring brake chamber assemblies to work in place of the service brakes during emergency situations.

When the park control valve (cab mounted) pulls out to the park position, supply port air is exhausted. This causes delivery port air to vent through the exhaust port.

Towing Vehicle Protection Valve



202334

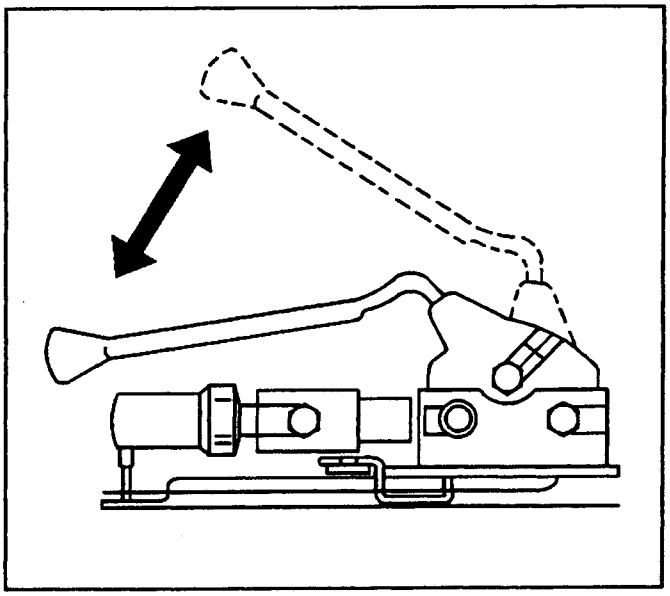
The Bendix® TP-5 towing vehicle protection valve is a combination quick release valve and a pressure sensing cutoff valve. The towing vehicle protection valve works with the trailer air supply valve in order to control trailer service brake lines in emergency situations.

The service brake and supply air lines are routed through this valve to the trailer. The towing vehicle protection valve protects the truck/tractor air brakes if there is a pressure loss in the trailer air system.

The towing vehicle protection valve is located on the crossmember. It has an internal service line shut off valve and a passage for the trailer supply air. The delivery line from the trailer air supply valve connects to the tractor emergency port. A delivery line from the dual application valve connects to the tractor service port. The trailer supply hose connects to the trailer emergency port. The trailer brake hose connects to the trailer service port.

When the supply pressure at the truck/tractor emergency port drops below 310 kPa (45psi), the towing vehicle protection valve closes the tractor service port.

Trailer Air Brake Control Valve



227705

The Bendix® TO-5 trailer air brake control valve is mounted on the floor, with the hand lever to the right of the driver's seat. It is used on models with trailer provisions.

Notice: The trailer air supply valve and trailer air system are not to be used as parking brakes at any time, under any circumstances. System air pressure could bleed off and release the brakes.

The trailer air brake control valve increases or decreases the delivered air pressure by the hand lever movement. The farther the handle is moved from the OFF toward the ON position, the greater the air pressure delivered to the trailer brakes. The hand lever stays in position until the lever is manually moved.

Air Dryer/Moisture Ejector Circuit Description

Voltage is applied to both the air dryer and the moisture ejector heater through circuit breaker 9 when the ignition switch is in RUN. Both the air dryer and the moisture ejector heater are equipped with thermal switches that will close whenever the outside temperature reaches 4°C (40°F) or lower. With these thermal switches closed, the air dryer and moisture ejector heater circuit will be complete. The heating elements will turn ON to warm the components and keep the air in the system from freezing. The air dryer and moisture heater will remain ON until the ambient temperature rises above 4°C (40°F), or the ignition switch is moved out of the RUN position.

BLANK

Air Drums

Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Front Air Brake Chamber Clevis Jam Nut (Type 16 Service Air Brake Chamber)	45 N·m	33 lb ft
Front Air Brake Chamber Clevis Jam Nut (Types 20 and 24 Service Air Brake Chamber)	78 N·m	57 lb ft
Front Cam Brake Assembly Bolt	280 N·m	206 lb ft
Rear Air Brake Chamber Clevis Jam Nut	76 N·m	56 lb ft
Rear Cam Brake Assembly Bolt	220 N·m	162 lb ft
Release Stud Nut (Maximum Torque for Caging the Spring Brake Chamber Assembly)	47 N·m	35 lb ft
Release Stud Nut (Tool Storage)	7 N·m	62 lb in
Service Brake Chamber Assembly Mounting Nut (Type 16)	39 N·m	29 lb ft
Service Brake Chamber Assembly Mounting Nut (Types 20 and 24)	109 N·m	80 lb ft
Service Brake Chamber Clamp Ring Assembly Nut	34 N·m	25 lb ft
Slack Adjuster Control Arm Nut	17 N·m	13 lb ft
Spring Brake Chamber Assembly Mounting Nut	108 N·m	80 lb in
Spring Brake Chamber Clamp Ring Assembly Nut	34 N·m	25 lb ft

Air Drum Brake Component Specifications (Dimensional)

Application	Specification	
	Metric	English
Brake Drums		
Maximum Discard Diameter	Marked on Brake Drum	
Out-of-Round Maximum Dimension	0.38 mm	0.015"
Taper or Barrel Shape Maximum Dimension	0.25 mm	0.010"
Brake Linings		
Replacement Thickness	6.35 mm	0.25"
Pushrod Stroke Dimensions Maximum Allowable Stroke at 550–620 kPa (80–90 psi)		
Air Brake Chamber Type 16	44.4 mm	1.75"
Air Brake Chamber Type 20	44.4 mm	1.75"
Air Brake Chamber Type 24	44.4 mm	1.75"
Air Brake Chamber Type 30	50.8 mm	2.00"
Brake Shoe		
Brake Shoe Anchor Pin Hole Diameter (16.5" Brake Shoe Only)	25.62 mm	1.009"
Brake Shoe Anchor Pin to Brake Shoe Roller Hole Span Distance	325 mm	12.779"

Air Drum Brake Component Specifications (Front Brakes)

Information	Brake Shoe - 381 x 102 mm (15" x 4")	Brake Shoe - 419 x 127 mm (16.5" x 5")
Air Brake Automatic Slack Adjuster (Distance Between Pivot Points)	140 mm (5.5")	140 mm (5.5")
Air Brake Chamber Clevis Setup	72 mm (2.83")	72 mm (2.83")
Brake Lining Thickness	19.1 mm (0.75")	19.1 mm (0.75")
Brake Lining Width	102 mm (4")	127 mm (5")
Manufacturer	Rockwell	Rockwell
Type	Q Plus ™	Q Plus ™

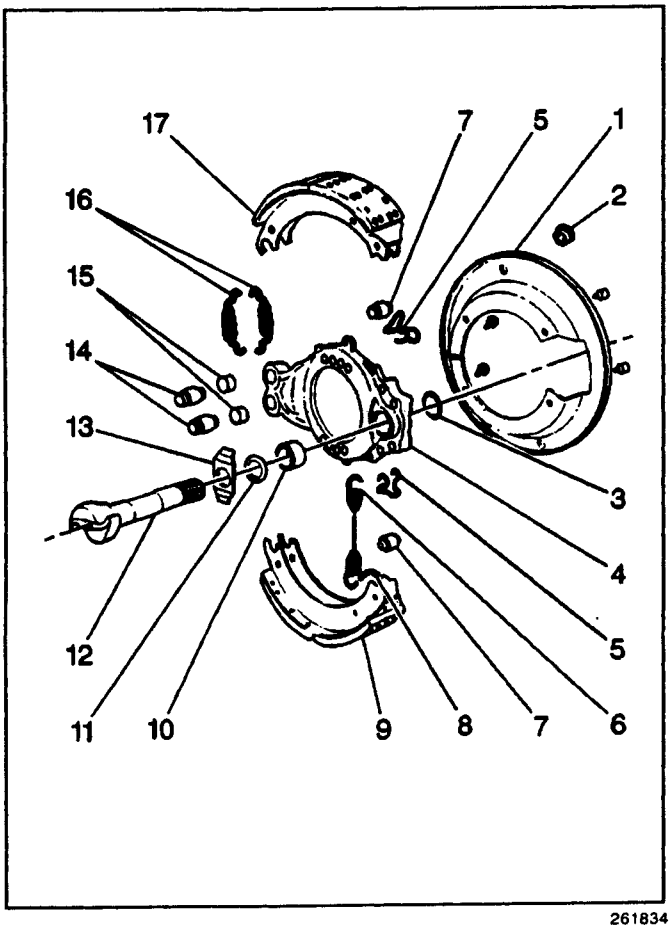
Air Drum Brake Component Specifications (Rear Brakes)

Information	Brake Shoe - 419 x 178 mm (16.5" x 7")	Brake Shoe - 419 x 178 mm (16.5" x 7")
Air Brake Automatic Slack Adjuster (Distance Between Pivot Points)	140 mm (5.5")	152 mm (6")
Air Brake Chamber Clevis Setup	68.5 mm (2.69")	68.5 mm (2.69")
Brake Lining Thickness	19.1 mm (0.75")	19.1 mm (0.75")
Brake Lining Width	178 mm (7")	178 mm (7")
Manufacturer	Rockwell	Rockwell
Type	Q Plus ™	Q Plus ™

Diagnostic Information and Procedures

Air Drum Brake System Diagnosis

1. Remove the brake drum.
2. Inspect the brake linings, the brake drums, and the camshaft. Refer to *Brake Drum Inspection.*



261834

3. Inspect the air brake anchor pins (14) for corrosion and wear.

   Replace the air brake anchor pins (14) if necessary.
4. Inspect the brake shoe rollers (7) for corrosion and wear.

   Replace the brake shoe rollers (7) if necessary.
5. Inspect the camshaft (12) for the following conditions:

   Replace the camshaft (12) as necessary.
   - Cracks
   - Wear
   - Corrosion
6. Inspect the brake chamber/camshaft support bracket (12) for the following conditions:

   Replace any damaged brackets.
   - Broken welds
   - Cracks
   - Misalignment

Repair Instructions

Air Drum Brake System Inspection

Front Air Brake Chamber

Front air brake chambers must be free to breathe through the pushrod opening and the four holes near the clamping flange.

Leakage Test

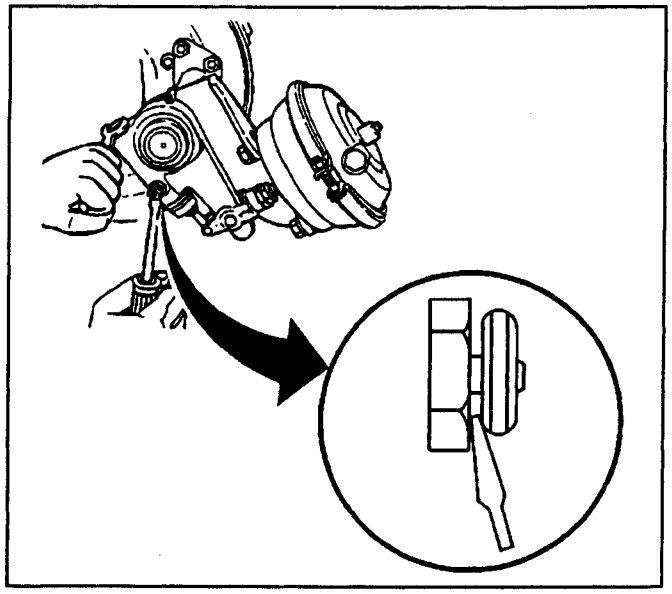
1. Block the wheels.
2. Start the engine.
3. Charge the air system to the air compressor governor valve cut-out point.
4. Stop the engine.
5. Have an assistant apply and hold the brake pedal.
6. Apply a soap solution around the front air brake chamber clamp and the breather holes.
7. Verify that no bubbles appear.
   - Lightly tap on the clamp and tighten the clamp bolts if bubbles appear.
   - Overhaul or replace the front air brake chamber if the bubbles continue. Refer to *Air Brake Chamber Overhaul (Service).*
8. Set the parking brake.
9. Remove the wheel blocks.

Rear Air Brake Chamber

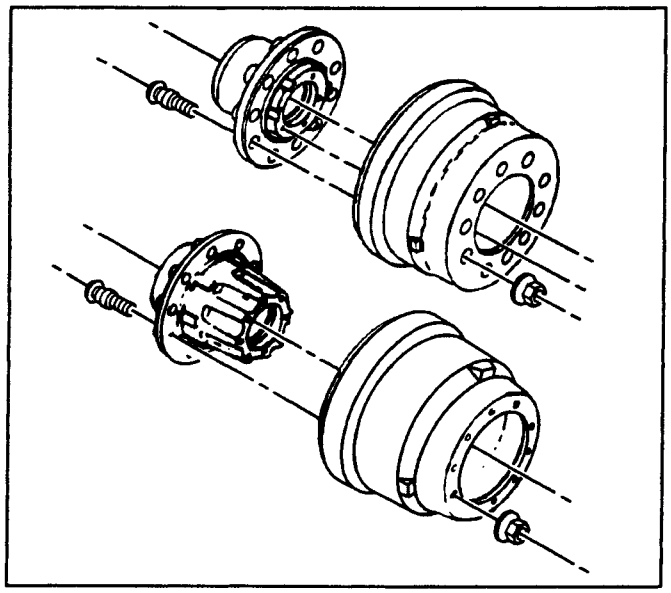
Rear air brake chambers must be free to breathe through the pushrod opening and four equally spaced holes near the clamping flange. Make sure these openings are clear.

Leakage Test

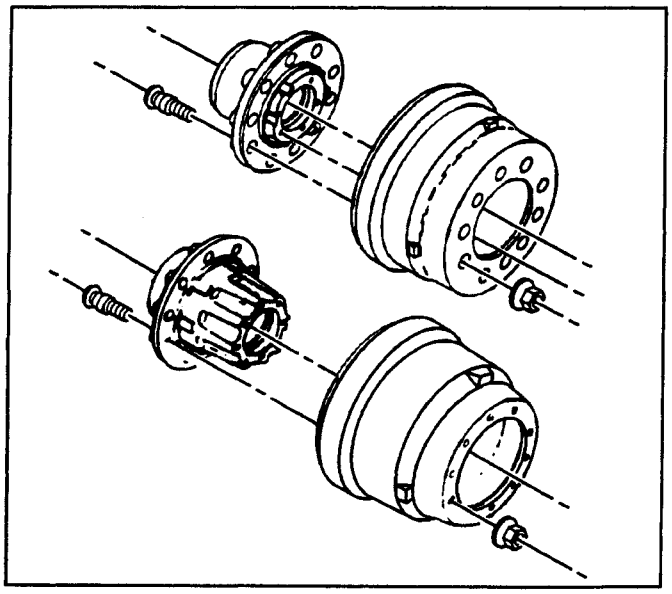
1. Block the wheels.
2. Start the engine.
3. Charge the air system to the air compressor governor valve cut-out point.
4. Stop the engine.
5. Have an assistant apply and hold the brake pedal.
6. Apply a soap solution around the air brake chamber clamp and the breather holes.
7. Verify that no bubbles appear.
   - Lightly tap on the clamp and tighten the clamp bolts if bubbles appear.
   - Overhaul or replace the rear air brake chamber if the bubbles continue. Refer to *Air Brake Chamber Overhaul (Spring).*
8. Set the parking brake.
9. Remove the wheel blocks.



201765



201685



201685

Brake Drum Replacement

Removal Procedure

1. Refer to *Brake drum protective coating removal* and *Lifting and Jacking the Vehicle* in General Information.
2. Remove the tire and wheel assembly. Refer to *Wheel Removal (Front)* in Tires and Wheels.
3. Cage the rear air brake chamber. Refer to *Caging the Rear Air Brake Chamber.*
4. Release the air brake automatic slack adjuster fully in order to retract the shoes, then the brake drum will clear the brake linings.
   - 4.1. Disengage the pawl with a screwdriver.
   - 4.2. Turn the air brake automatic slack adjuster adjusting nut until the brakes shoes are fully retracted.
   - 4.3. Release the pawl in order to snap the pawl into engagement after the brake shoes have retracted.
5. Slide the brake drum from the hub.
6. Clean the brake drum using brake component cleaner.
7. Inspect the brake drum. Refer to *Brake Drum Inspection.*

Installation Procedure

1. Slide the brake drum onto the hub.
2. Adjust the wheel bearings if needed. Refer to *Wheel Bearing Adjustment.*
3. Install the tire and wheel assembly.
4. Adjust the brakes. Refer to *Air Drum Brake Adjustment (Pushrod Stroke Measurement)* or *Air Drum Brake Adjustment (Normal Wear Adjustment).*
5. Remove the supports.
6. Lower the vehicle.
7. Check the brakes for proper operation.

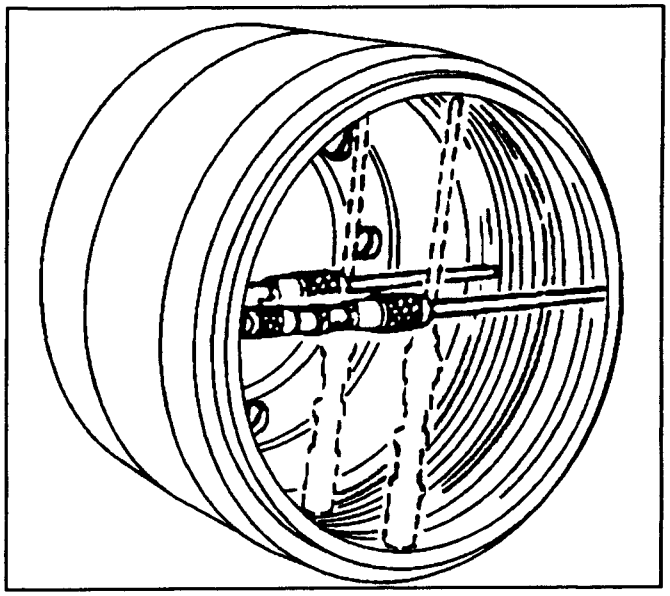
Brake Drum Inspection

Cracked, Scored or Grooved

A cracked brake drum is unsafe for further service. Replace a cracked brake drum. Do not attempt to weld a cracked brake drum. Smooth up any slight scores. Replace the brake drum if heavy or extensive scoring is present.

Polish the brake drum with a fine emery cloth. Do not refinish the brake drum if the brake linings are only slightly worn and the brake drum is only slightly grooved. Eliminating all grooves in the brake drum and smoothing the ridges on the brake lining would require removing too much metal and brake lining. If the components are left alone, the grooves and the ridges will match and should perform adequately.

Always replace a grooved brake drum when you are replacing the brake linings. Using a new brake lining with a grooved brake drum will cause brake lining wear and improper performance.



201762

Out-of-Round or Tapered Brake Drum

An out-of-round or tapered brake drum can cause the following conditions:

- Inaccurate brake shoe adjustment
- Excessive wear of other brake parts
- Severe and irregular tire tread wear
- A pulsating brake pedal

Out-of-round and tapered brake drums may be accurately assessed with an inside micrometer and extension rods. Take the measurements at the open and closed edges of the machined surface, at right angles to one other. Replace the brake drum when the brake drum exceeds the specification limits for taper and/or out-of-round.

Inside Diameter Check

Perform the following checks prior to major vehicle servicing:

1. Measure the braking surface for maximum allowable diameter.

   Fading or overheating brakes can be caused by an oversized brake drum.

   1.1. Measure the brake drum diameters at four equally-spaced points near the middle of the braking surface.

   1.2. Replace the brake drum if any diameter is at, or more than, the maximum discard diameter stamped into the brake drum.

2. Measure the braking surface for out-of-round.

   Chatter at the wheels can be caused by out-of-round brake drums.

   2.1. Measure the brake drum diameters at four equally-spaced points near the middle of the braking surface.

   2.2. Replace the brake drum if any diameter readings are more than 0.38 mm (0.015 inch) apart.

Taper Check

1. A tapered or barrel-shaped brake lining will cause uneven brake drum wear.
2. Measure the brake drum diameters at four equally-spaced points near the top of the braking surface.
3. Average the four measurements in order to obtain an average diameter near the top of the braking surface.
4. Measure and average four diameters at the middle of the braking surface.
5. Measure and average four diameters at the bottom of the braking surface.
6. Compare the four average diameters in order to determine if the brake drum is tapered or barrel shaped.
7. Replace the brake drum if any of the average diameters are more than 0.25 mm (0.010 in) apart.

New Replacement Brake Drum Refinishing

Do not refinish the braking surface when installing new brake drums. These components are already at the correct level of surface finish.

Balance

Weights are used in order to balance the brake drums during manufacturing. Do not remove the weights. Replace the brake drum if the weights are missing.

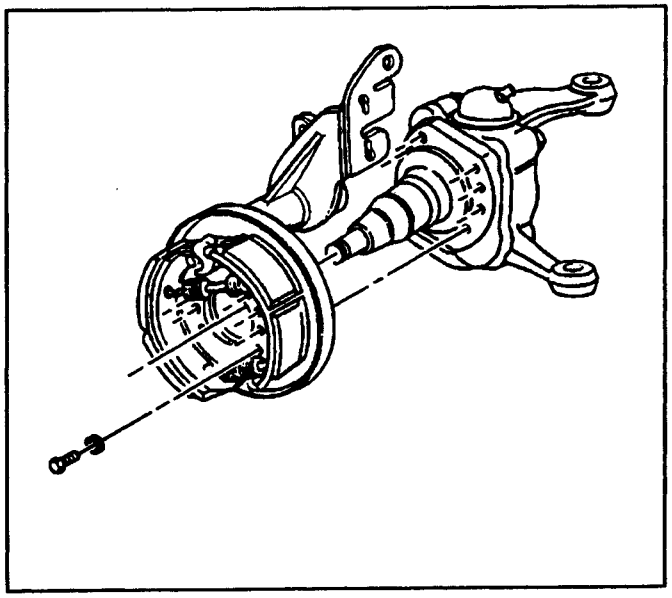
Brake Drum Refinishing

Do not rebore the brake face diameter. There is no way of knowing the number of heat cycles or severity of the cycles to which a brake drum has been subjected in actual usage.

Cam Brake Assembly Replacement (Front)

Removal Procedure

1. Block the rear wheels.
2. Drain the air reservoirs. Refer to *Draining Reservoirs* in Air Brakes.
3. Raise the front axle and support the front axle with safety stands. Refer to *Lifting and Jacking the Vehicle* in General Information.
4. Remove the tire and wheel assembly. Refer to *Wheel Removal (Front)* in Tires and Wheels.
5. Remove the brake drum. Refer to *Brake Drum Replacement.*
6. Remove the air line from the front air brake chamber. Refer to the following procedures in Air Drums:
   - *Hose and Line Replacement (Nylon and Metal - Compression)*
   - *Hose and Line Replacement (Nylon - Push-In)*
   - *Hose and Line Replacement (Flexible)* in Air Brakes.
7. Remove the wheel speed sensor (if equipped). Refer to Wheel Speed Sensor Replacement in Antilock Brakes.
8. Remove the bolts and the washers.
9. Remove the cam brake assembly from the knuckle.



201766

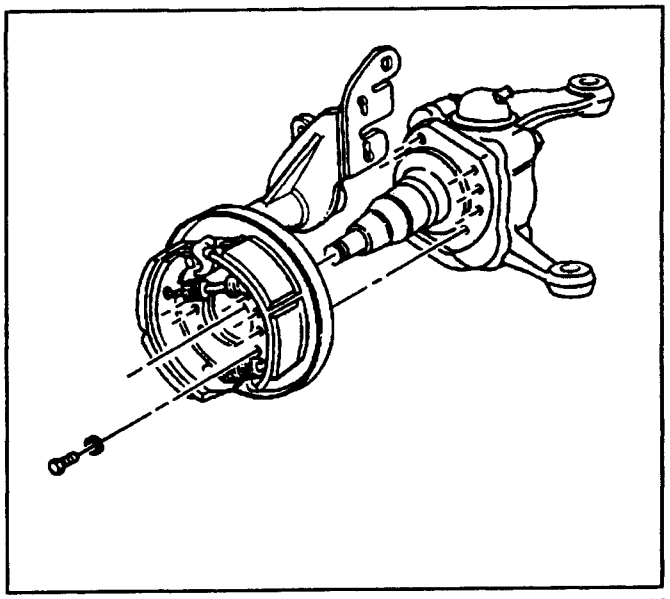
Installation Procedure

1. Install the cam brake assembly to the knuckle.

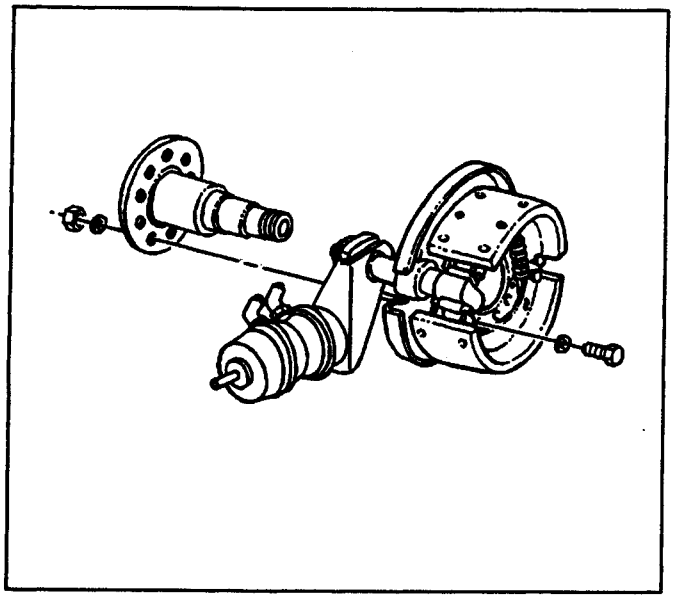
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the washers and the bolts.

   Tighten

   Tighten the front brake assembly bolts to 280 N·m (206 lb ft).
3. Install the wheel speed sensor (if equipped). Refer to Wheel Speed Sensor Replacement in Antilock Brakes.
4. Install the air line to the front air brake chamber. Refer to the following procedures in Air Drums:
   - *Hose and Line Replacement (Nylon and Metal - Compression)* or
   - *Hose and Line Replacement (Nylon - Push-In)* or
   - *Hose and Line Replacement (Flexible)* in Air Brakes.
5. Install the brake drum. Refer to *Brake Drum Replacement.*
6. Adjust the front wheel bearings (if needed). Refer to *Wheel Bearing Adjustment.*
7. Install the tire and wheel assembly.
8. Remove the safety stands and lower the vehicle.
9. Start the engine.



201766



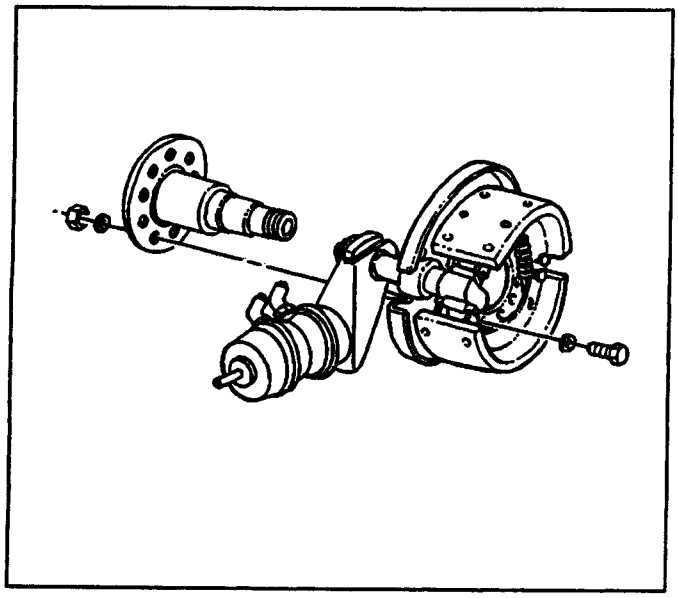
201768

10. Charge the air system to the air compressor governor valve cut-out point.
11. Check for proper brake operation.
12. Stop the engine.
13. Set the parking brake.
14. Remove the wheel blocks.

Cam Brake Assembly Replacement (Rear)

Removal Procedure

1. Block the rear wheels.
2. Drain all air reservoirs. Refer to *Draining Reservoirs* in Air Brakes.
3. Cage the rear air brake chamber. Refer to *Caging the Rear Air Brake Chamber.*
4. Raise the rear axle and support the rear axle with safety stands. Refer to *Lifting and Jacking the Vehicle* in General Information.
5. Remove the tire and wheel assembly. Refer to *Wheel Removal (Front)* in Tires and Wheels.
6. Remove the brake drum. Refer to *Brake Drum Replacement.*
7. Remove the air line from the rear air brake chamber. Refer to the following procedures in Air Drums:
   - *Hose and Line Replacement (Nylon and Metal - Compression)* or
   - *Hose and Line Replacement (Nylon - Push-In)* or
   - *Hose and Line Replacement (Flexible)* in Air Brakes.
8. Remove the wheel speed sensor (if equipped). Refer to Wheel Speed Sensor Replacement in Antilock Brakes.
9. Remove the bolts and the washers.
10. Remove the rear brake assembly from the rear axle.



201768

Installation Procedure

1. Install the rear cam brake assembly to the rear axle.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the bolts and the washers.

   Tighten

   Tighten the rear brake assembly bolts to 220 N·m (162 lb ft).
3. Install the wheel speed sensor (if equipped). Refer to Wheel Speed Sensor Replacement in Antilock Brakes.
4. Install the air line to the rear air brake chamber. Refer to the following procedures in Air Drums:
   - *Hose and Line Replacement (Nylon and Metal - Compression)* or
   - *Hose and Line Replacement (Nylon - Push-In)* or
   - *Hose and Line Replacement (Flexible)* in Air Brakes.

5. Install the brake drum. Refer to *Brake Drum Replacement.*
6. Adjust the rear wheel bearings (if needed). Refer to *Wheel Bearing Adjustment.*
7. Install the tire and wheel assembly.
8. Remove the safety stands and lower the vehicle.
9. Start the engine.
10. Charge the air system to the air compressor governor valve cut-out point.
11. Check for proper brake operation.
12. Stop the engine.
13. Set the parking brake.
14. Remove the wheel blocks.

Brake Shoe Inspection

Inspect the brake linings every 9656 km (6,000 miles) and any wheel removal, including tire rotation. Replace the brake linings before the rivet heads become exposed and score the brake drum. Replace the brake linings when the thickness of the brake lining is 6.3 mm (0.250 inches) at the thinnest point. Always replace the brake linings as a complete axle set.

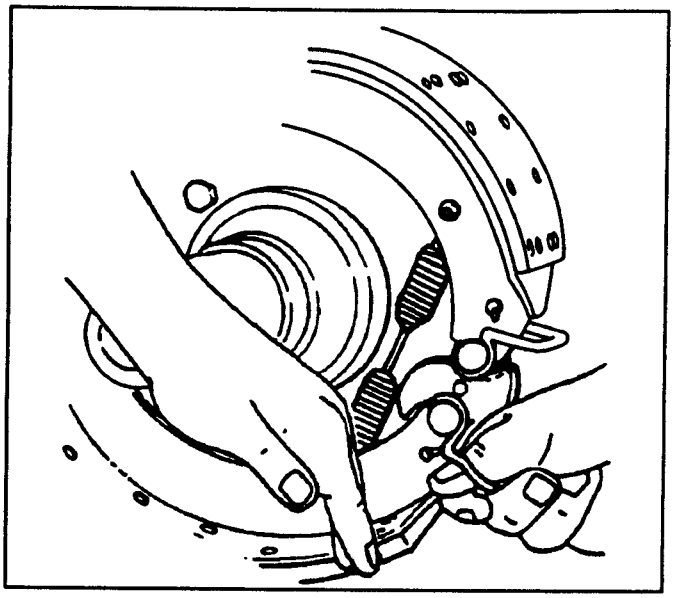
The brake linings should be free of grease and oil and show at least a 70 percent contact area over the braking surface, indicating satisfactory brake lining contact.

Caution: Avoid taking the following actions when you service wheel brake parts:

- ***Do not grind brake linings.***
- ***Do not sand brake linings.***
- ***Do not clean wheel brake parts with a dry brush or with compressed air.***

Some models or aftermarket brake parts may contain asbestos fibers which can become airborne in dust. Breathing dust with asbestos fibers may cause serious bodily harm. Use a water-dampened cloth in order to remove any dust on brake parts. Equipment is available commercially in order to perform this washing function. These wet methods prevent fibers from becoming airborne.

Remove any shiny glazed spots with an emery cloth while wearing a dust mask. Wipe the brake lining clean with a damp cloth.



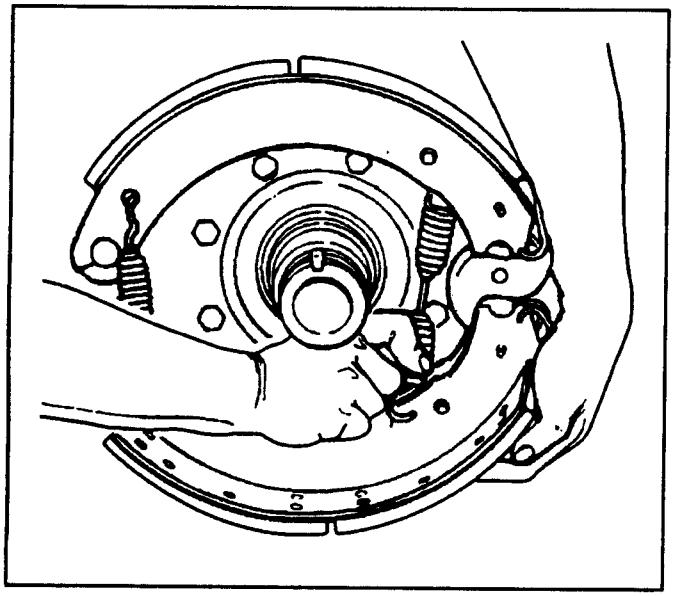
201773

Brake Shoe Replacement

Removal Procedure

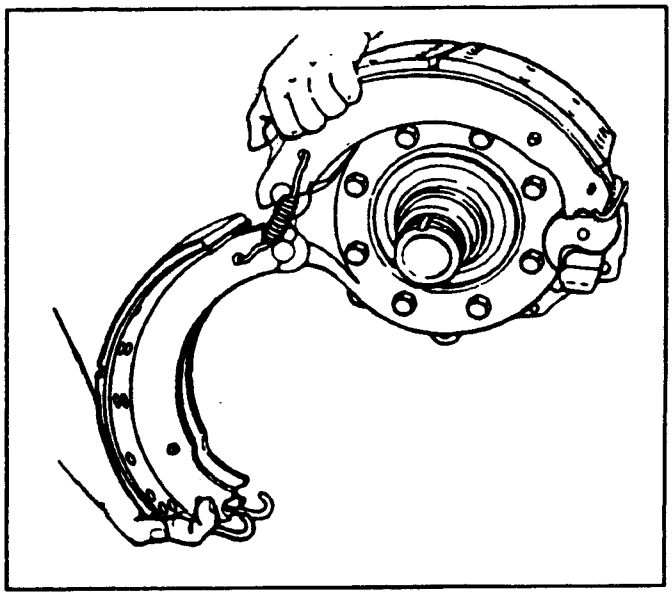
Replacement brake lining material is recommended for all vehicles in order to maintain the balance between the front and the rear brake performance. Replacement brake parts have been carefully selected in order to provide the proper brake balance in order to improve stopping distance and in order to provide brake control over the full range of the operating conditions. Installation of the front or the rear brake lining material with performance different from those of Replacement parts recommended for this vehicle can change the intended brake balance of this vehicle.

1. Block the wheels.
2. Drain all air reservoirs. Refer to *Draining Reservoirs* in Air Brakes.
3. Cage the rear air brake chambers. Refer to *Caging the Rear Air Brake Chamber.*
4. Raise the vehicle and support the vehicle with safety stands. Refer to *Lifting and Jacking the Vehicle* in General Information.
5. Remove the tire and wheel assembly. Refer to *Wheel Removal (Front)* in Tires and Wheels.
6. Remove the brake drums. Refer to *Brake Drum Replacement.*
7. Push down on the bottom brake shoe.
8. Pull on the brake shoe roll retainer in order to remove the bottom brake shoe roller.
9. Lift the bottom brake shoe in order to release the tension on the brake shoe return spring.
10. Remove the brake shoe return spring.



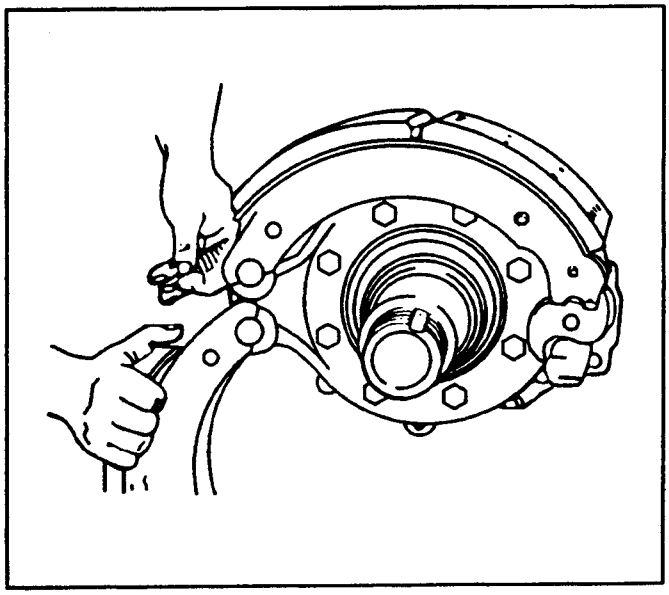
201776

11. Rotate the bottom brake shoe in order to release the tension on the two retaining springs.

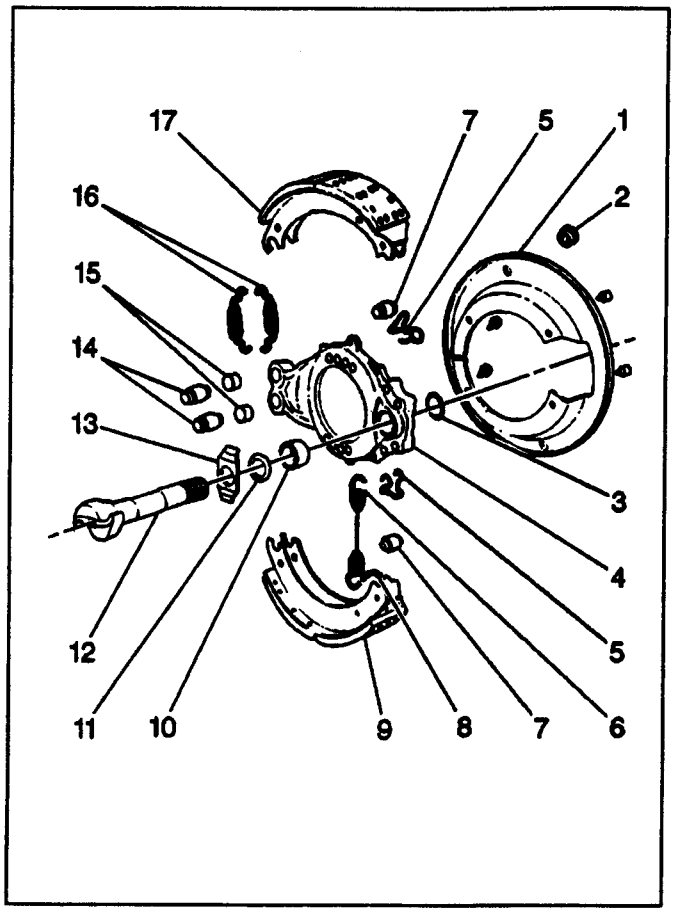


201779

12. Remove the retaining springs.
13. Remove the brake shoes.



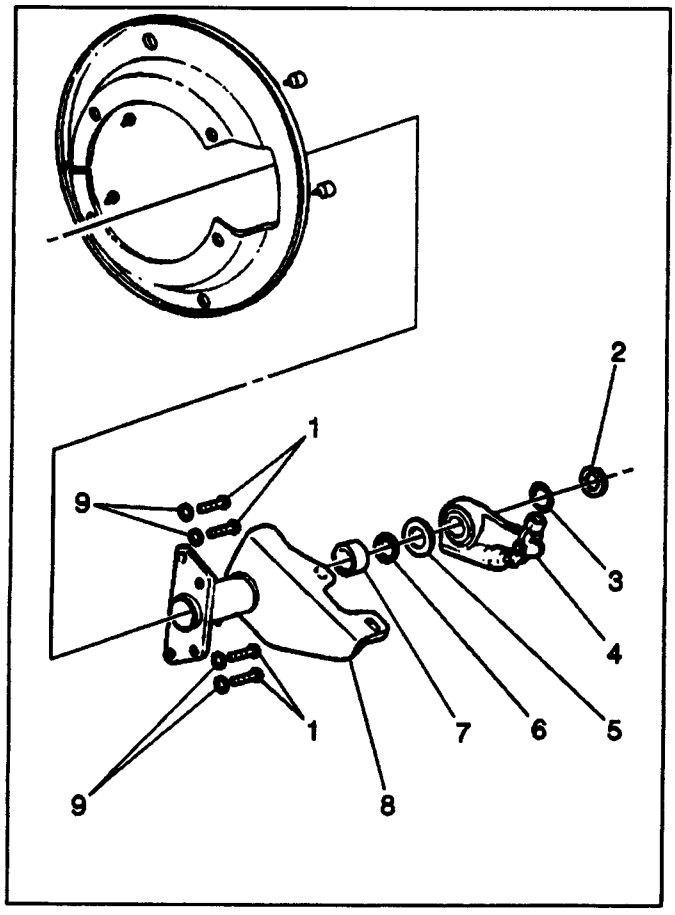
201781



261834

14. Inspect the brake spider (4) for expanded anchor pin holes and for cracks.

    Replace damaged brake spiders (4) and the anchor pin bushings (15).



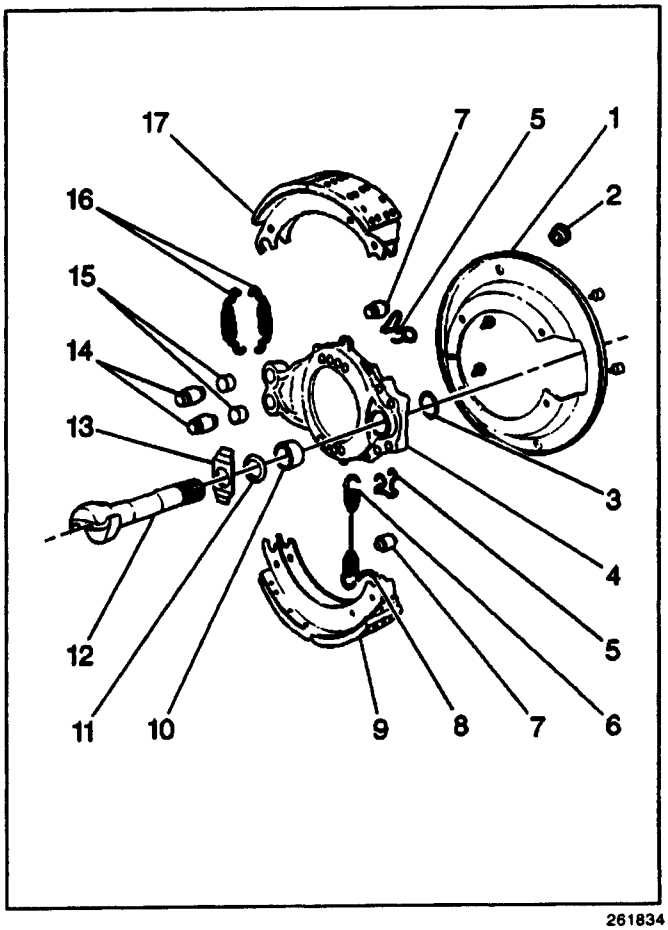
261832

15. Inspect the brake chamber/camshaft support bracket (8) for the following conditions:

    Replace damaged brake chamber/camshaft support brackets (8).

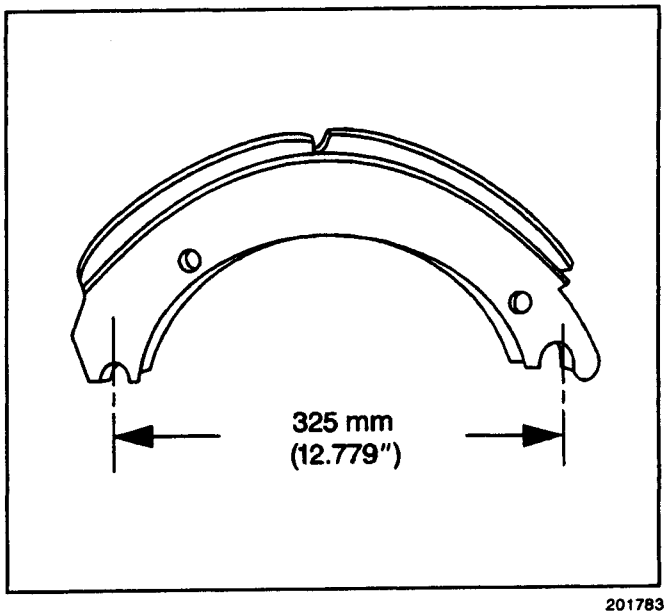
    - Broken welds
    - Cracks
    - Misalignment

16. Inspect the anchor pins (14) for corrosion and wear.
    Replace damaged anchor pins (14).
17. Inspect the camshaft (12) for the following conditions:
    Replace damaged camshafts (12).
    - Cracks
    - Wear
    - Corrosion
18. Inspect the brake drums. Refer to *Brake Drum Inspection.*

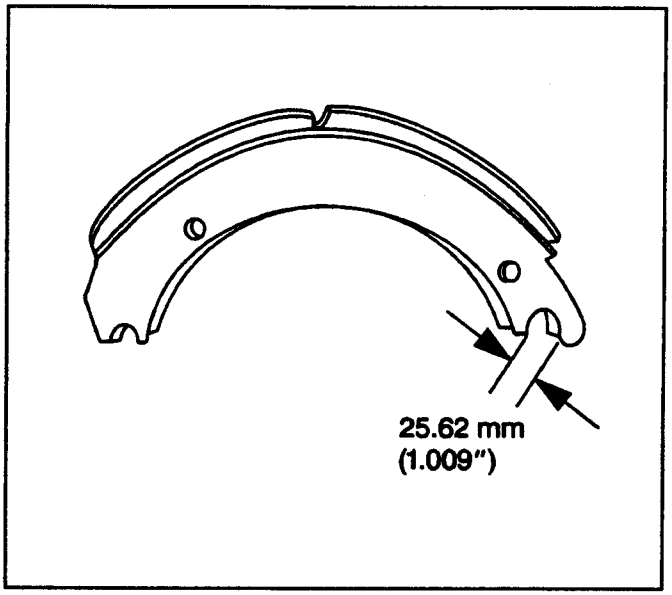


261834

19. Measure the brake shoe anchor pin to the brake shoe roller hole span distance on the 419 mm (16.5 in) diameter brake shoes.
20. Replace the brake shoe if the distance from the center of the brake shoe anchor pin slot to the center of the brake shoe roller slot is more than 325 mm (12.779 in).

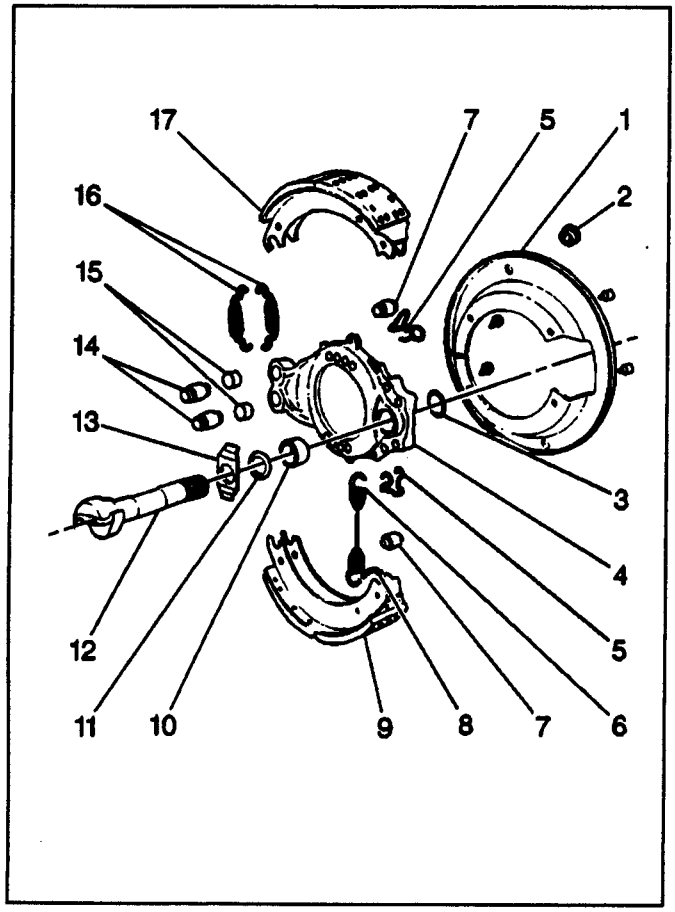


201783



201786

21. Measure the brake shoe anchor pin to the brake shoe roller hole span distance on the Rockwell 419 mm (16.5 in) diameter brake shoe.
22. Replace the brake shoe if the brake shoe anchor pin hole diameter is more than 25.62 mm (1.009 in).

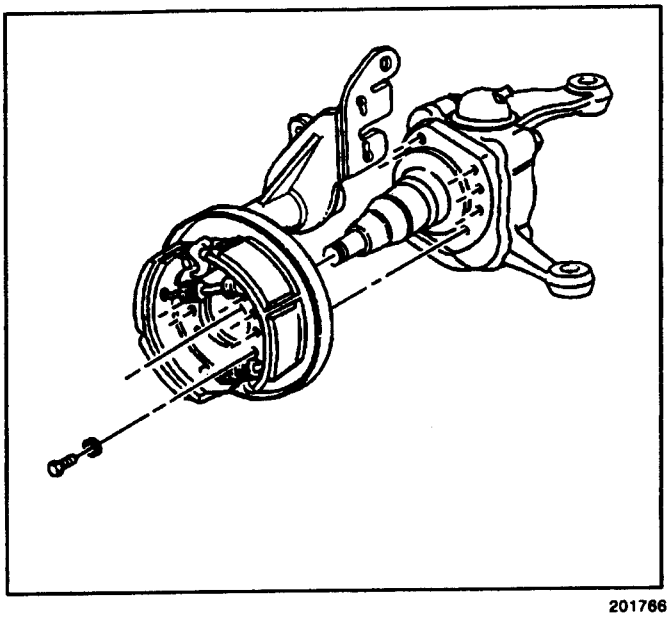


261834

23. Disassemble the brake lining (17) from the brake shoe.
24. Drill out the rivets.

Caution: Refer to Brake Dust Caution in Cautions and Notices.

25. Clean the burrs and the high spots from the brake shoe with a file.
26. Clean the brake shoe and the brake lining contact surfaces.



201766

Installation Procedure

1. Install the primary brake lining on the primary brake shoe.

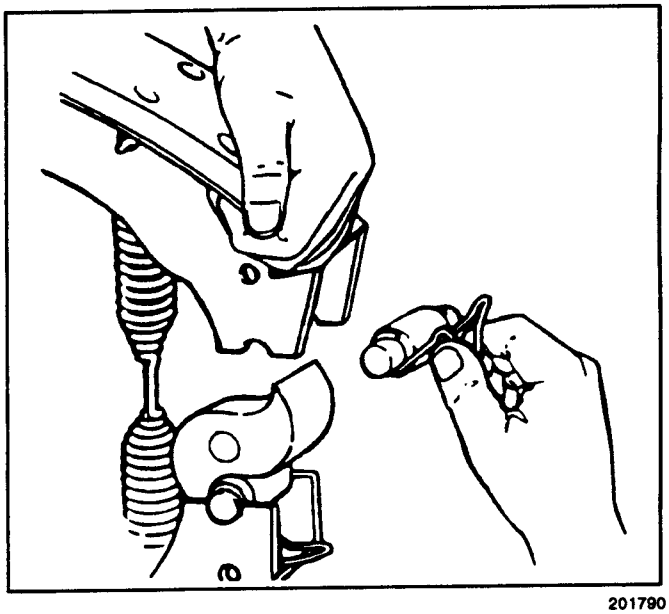
   The first brake shoe past the cam in the direction of the wheel rotation is the primary brake shoe. The primary and the secondary brake shoes may be in either position, depending on the location of the cam. If the cam is behind the axle, the top brake shoe is the primary brake shoe and the lower brake shoe is the secondary brake shoe. If the cam is in front of the axle, the lower brake shoe is the primary brake shoe.
2. Follow the rivet machine manufacturer's instructions.

   The brake lining to the brake shoe gap at both ends and both sides must not exceed 0.25 mm (0.010 in).

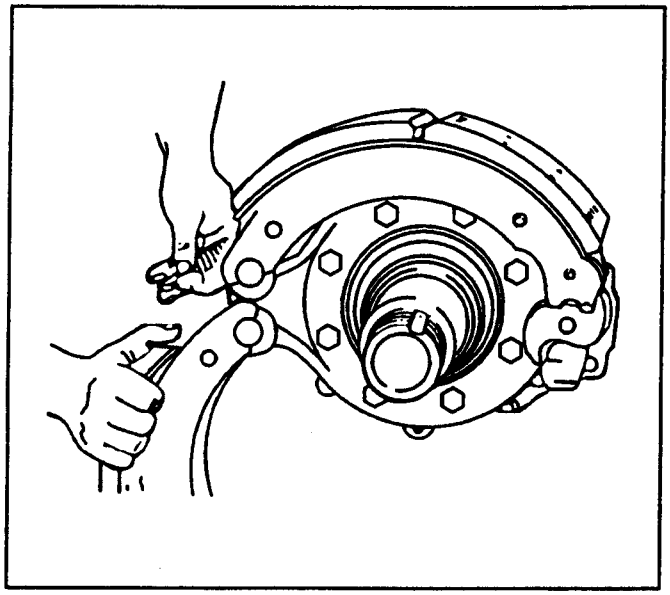
   The brake lining to the brake shoe gap between webs at both ends must not exceed 0.64 mm (0.025 in).
3. Assemble the new brake lining onto the brake shoe.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
4. Apply chassis to the anchor pins where the anchor pins touch the brake shoes.

   Important: Do not get grease on the part of the brake shoe roller that touches the camshaft.
5. Apply lubricant to the brake shoe rollers where the brake shoe rollers touch the brake shoes. Use a chassis lubricant.

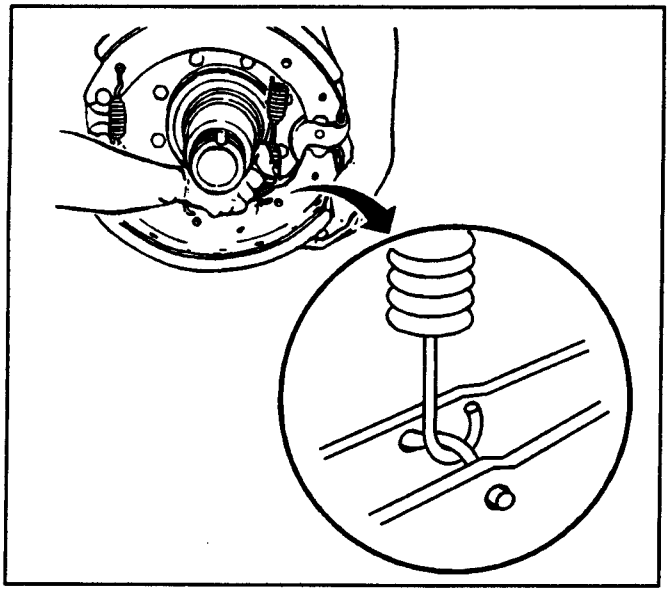


201790



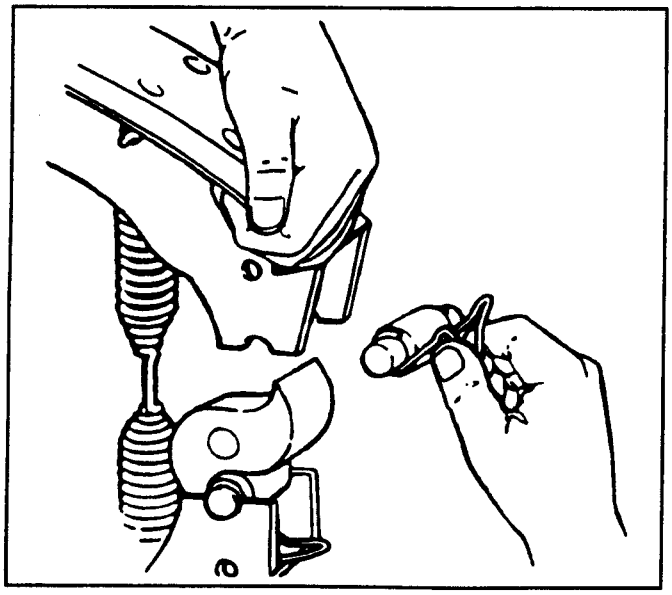
201781

6. Put the upper brake shoe in position on the top anchor pin.
7. Hold the lower brake shoe on the bottom anchor pin.
8. Install the two new brake shoe retaining springs.



201788

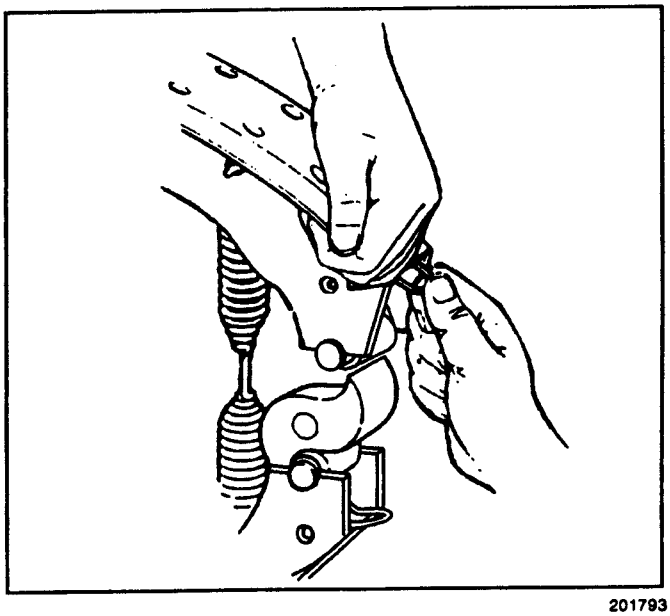
9. Rotate the lower brake shoe forward.
10. Install the new brake shoe return spring.
11. Install the open end of the return spring hooks toward the camshaft.



201790

12. Pull each brake shoe away from the camshaft in order to allow enough space for the brake shoe rollers and the brake shoe retainers.
13. Press the ears of the brake shoe retainer together in order to allow the brake shoe retainer to fit between the brake shoe webs.

14. Push the brake shoe retainer into the brake shoe web until the ears lock in the holes in the brake shoe webs.
15. Install the brake drums. Refer to *Brake Drum Replacement.*
16. Adjust the wheel bearings, if needed. Refer to *Wheel Bearing Adjustment.*
17. Install the tire and wheel assemblies. Refer to the following procedures in Tires and Wheels:
    - *Wheel Installation (Front)* in Tires and Wheels.
    - *Wheel Installation (Dual/Rear)* in Tires and Wheels.
18. Remove the safety stands and lower the vehicle.
19. Start the engine.
20. Charge the air system to the air compressor governor valve cut-out point.
21. Stop the engine.
22. Adjust the brakes. Refer to the following procedures:
    - *Air Drum Brake Adjustment (Pushrod Stroke Measurement).*
    - *Air Drum Brake Adjustment (Normal Wear Adjustment).*
23. Uncage the rear air brake chambers. Refer to *Caging the Rear Air Brake Chamber.*
24. Check for proper brake operation.
25. Set the parking brake.
26. Remove the wheel blocks.



201793

Brake Camshaft Replacement

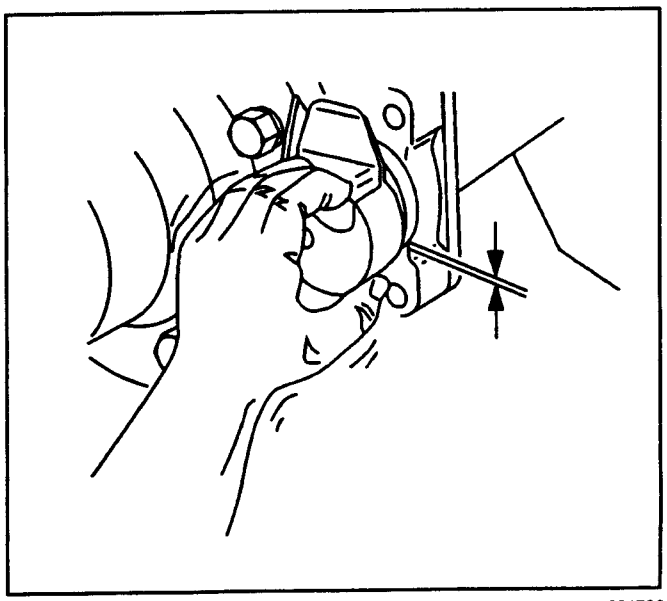
Removal Procedure

Lubricate the camshaft and check the camshaft for wear during brake realignment. The brake chamber/camshaft support bracket includes the following components:

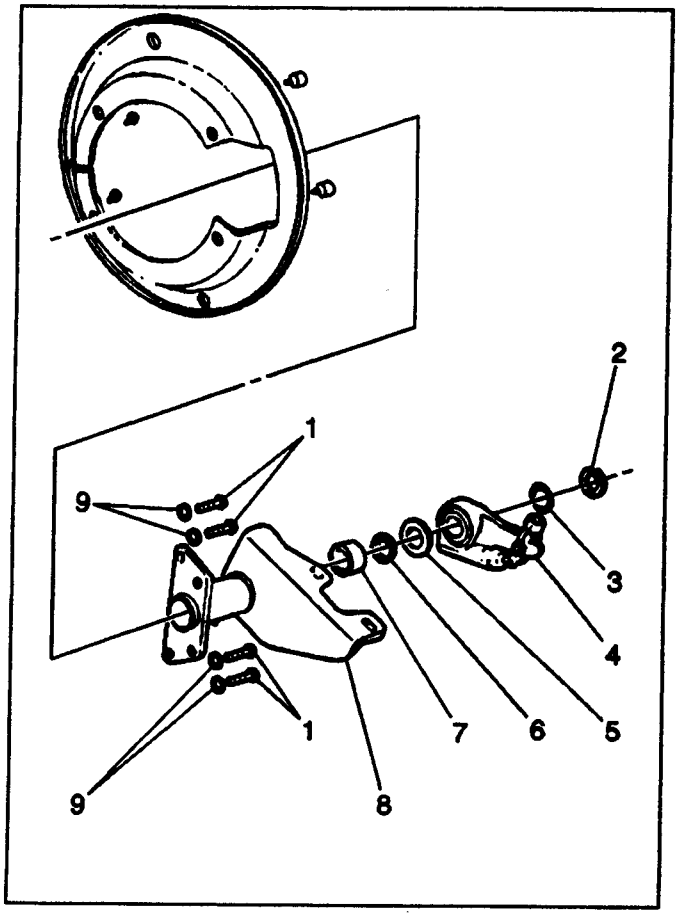
- Two bushings
- Two camshaft seals
- A lubrication fitting

The space between the bushings serves as the lubricant reservoir. Apply lubricant sparingly at the specified intervals. Refer to *Maintenance Schedule* in Maintenance and Lubrication.

1. Remove the brake linings. Refer to *Brake Shoe Replacement.*
2. Check the up-and-down and the side-to-side end play of the camshaft in order to determine if the camshaft bushings need replacement. Replace the camshaft bushings if the total movement is more than 0.76 mm (0.030 in).

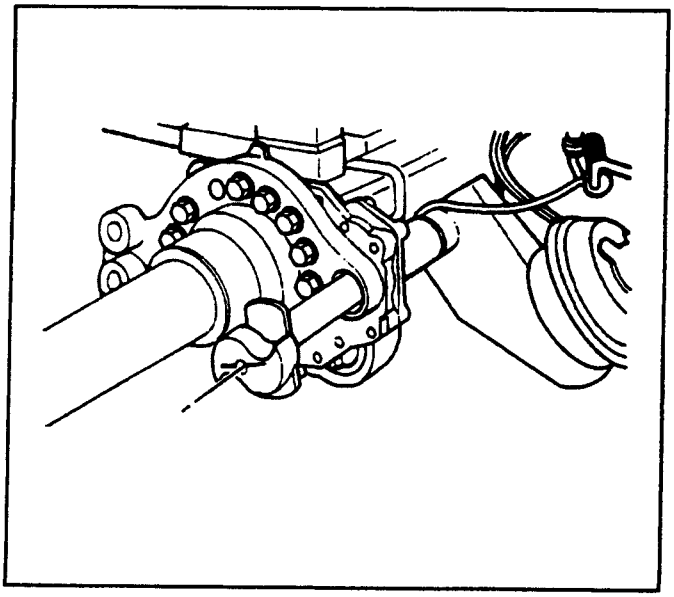


201796



261832

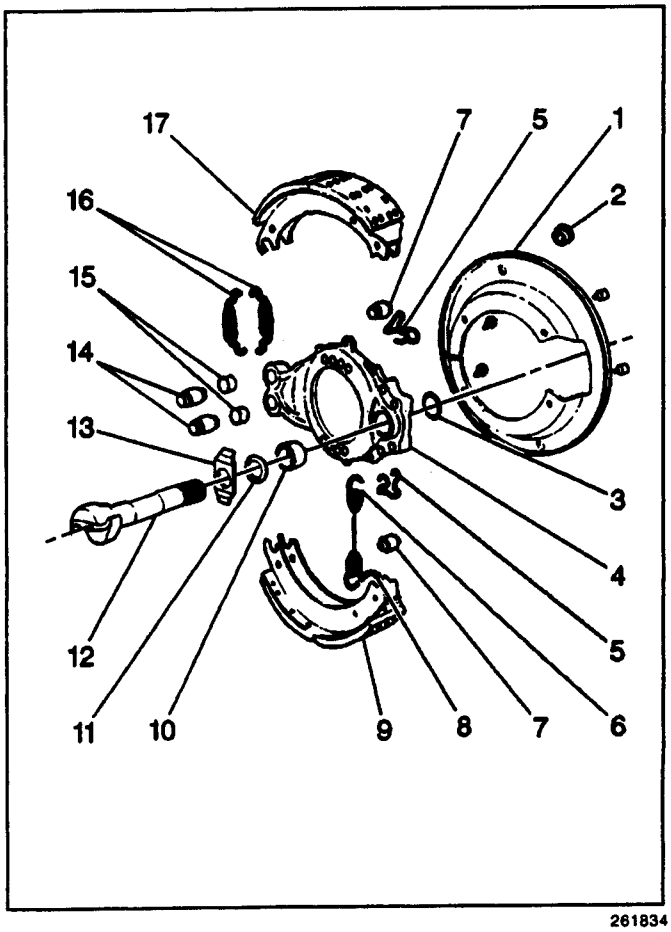
3. Remove the slack adjuster (4). Refer to *Air Brake Automatic Slack Adjuster Replacement (Rockwell)* or *Air Brake Automatic Slack Adjuster Replacement (Eaton).*



201797

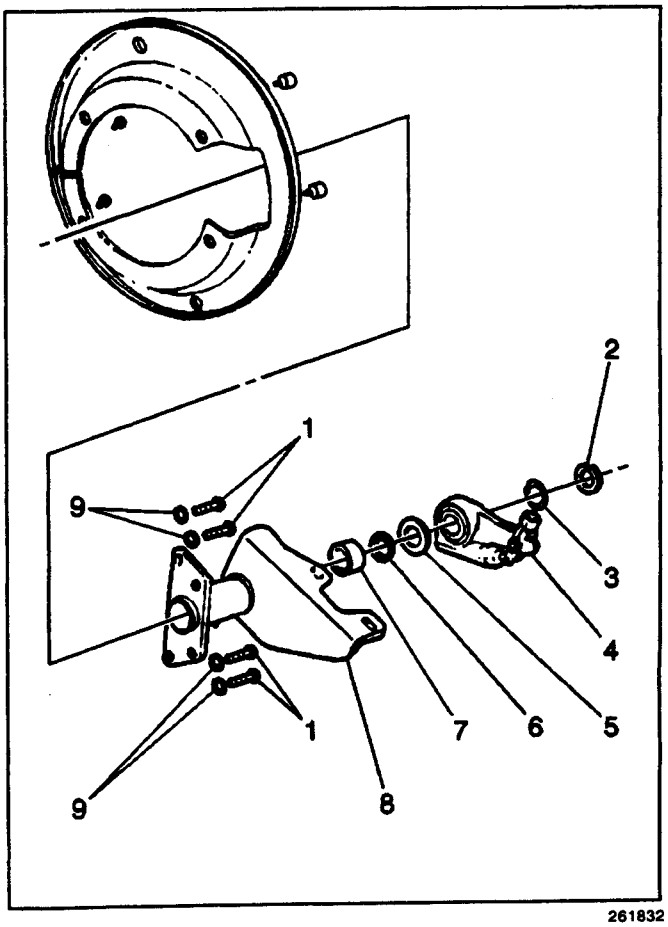
4. Pull the camshaft out from the brake chamber/camshaft support bracket.
5. Remove the camshaft.

6. Remove the camshaft seals (11).
7. Remove the camshaft bushings if needed (10).
8. Clean the old grease from the camshaft (12).

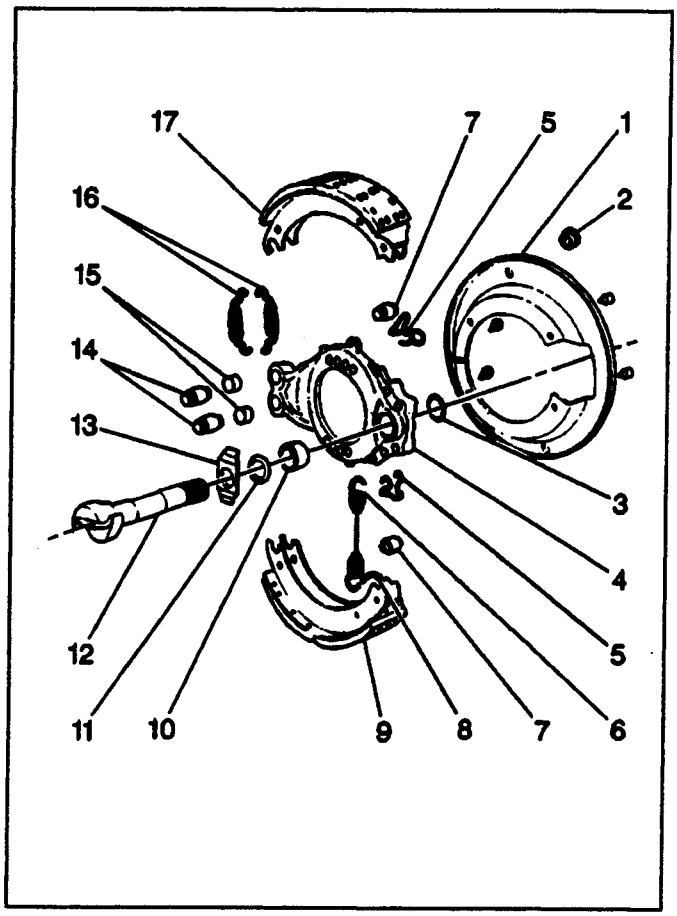


261834

9. Clean the old grease from the chamber/camshaft support bracket (8).



261832



261834

10. Inspect the camshaft bearing surface areas for wear and corrosion.

    Replace the camshaft (12) if the camshaft bearing surfaces show signs of wear or roughness.

11. Inspect the cam head for wear or flat spots on the roller surfaces.

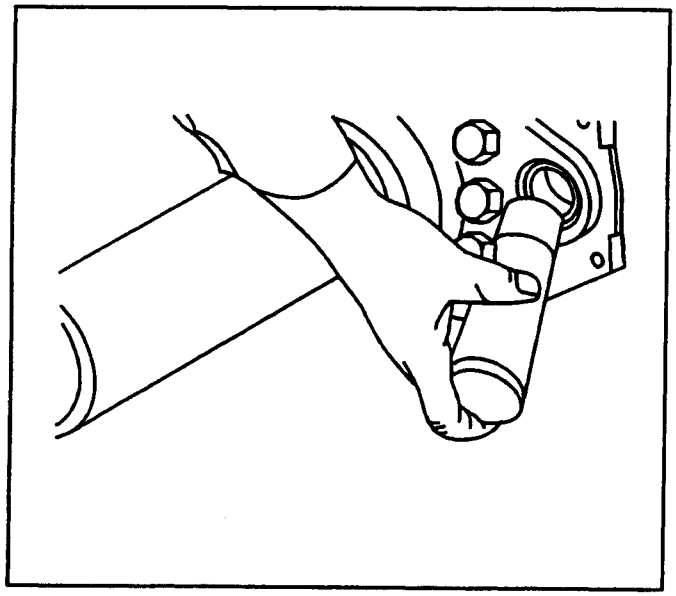
    Replace the camshaft (12) if any obvious wear or flat spots exist.

12. Inspect the camshaft splines for damage or wear.

    Replace the camshaft (12) if the camshaft splines are damaged.

13. Inspect the camshaft bushings (10) for deterioration.

    Replace the camshaft bushings (10) if needed.



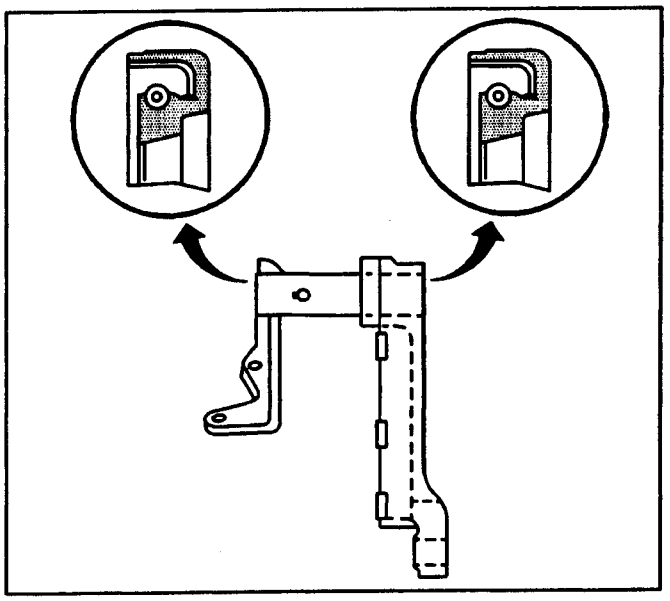
201800

Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

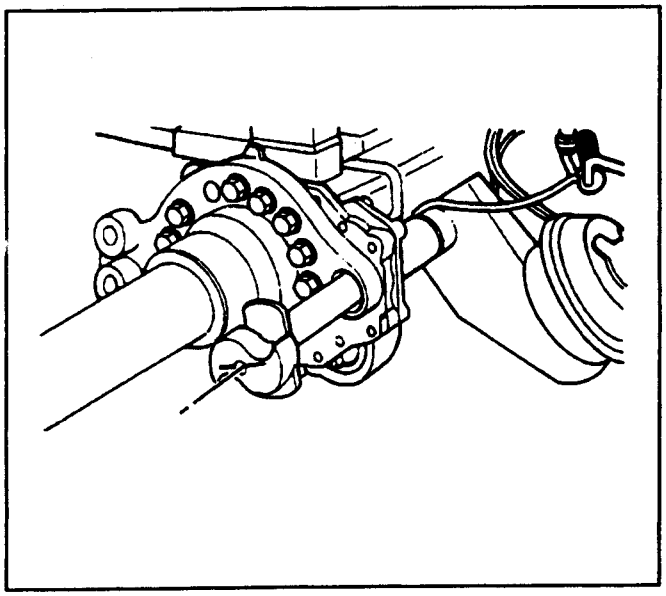
1. Install the camshaft bushings if needed.
2. Drive the camshaft bushings into the brake chamber/camshaft support bracket with a seal driver.

3. Install the new camshaft seals with the camshaft seal lips toward the slack adjuster.



201802

4. Apply a coat of grease to the camshaft bushings.
5. Install the camshaft.
6. Install the slack adjuster. Refer to the following procedures:
   - *Air Brake Automatic Slack Adjuster Replacement (Rockwell)* or
   - *Air Brake Automatic Slack Adjuster Replacement (Eaton).*
7. Install the brake linings. Refer to *Brake Shoe Replacement.*



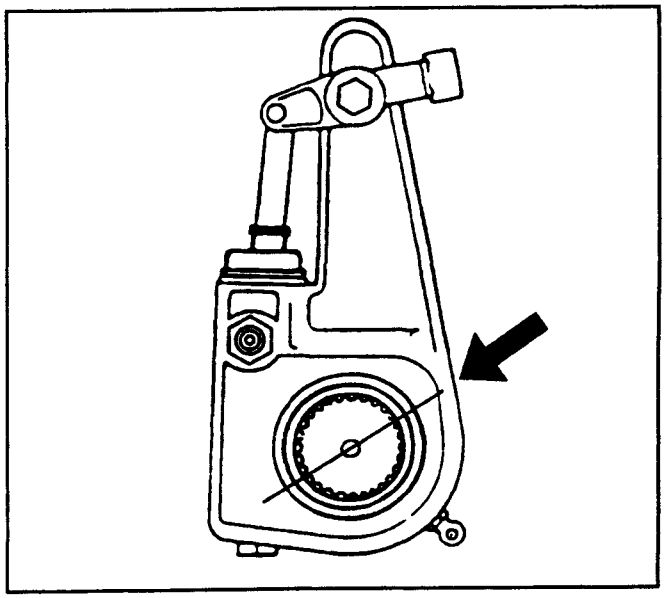
201797

Air Brake Automatic Slack Adjuster Replacement (Rockwell)

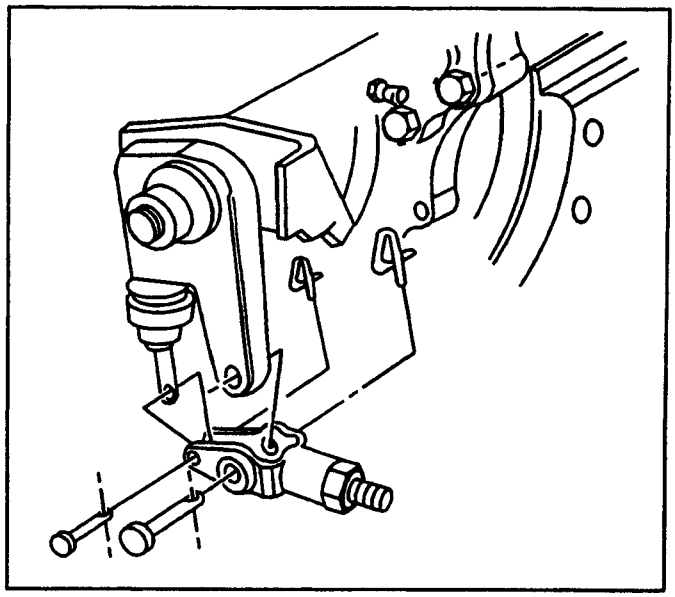
Removal Procedure

Important: For unit repair information on the Rockwell air brake automatic slack adjuster contact the Rockwell Field Support Center at 1–800–535–5560.

1. Block the wheels.
2. Cage the rear air brake chambers. Refer to *Caging the Rear Air Brake Chamber.*
3. Drain all of the air reservoirs. Refer to *Draining Reservoirs* in Air Brakes.
4. Raise the vehicle and support the vehicle with safety stands. Refer to *Lifting and Jacking the Vehicle* in General Information.
5. Mark the position of the slack adjuster to the camshaft by drawing a straight line on both components.

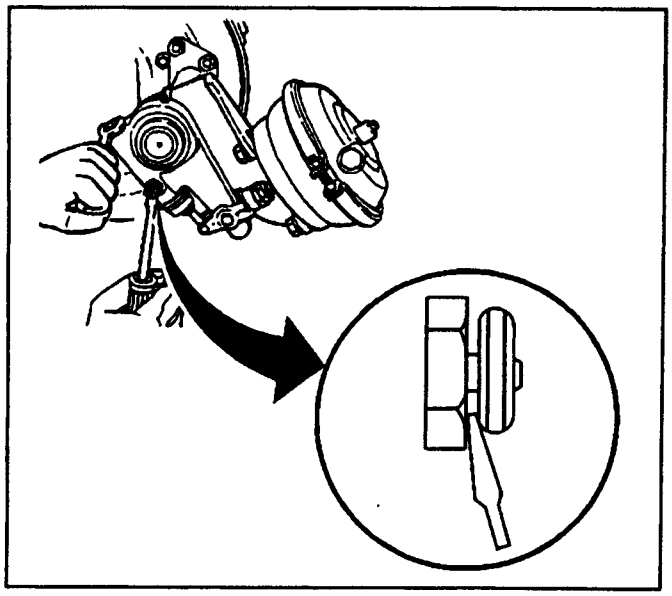


201804



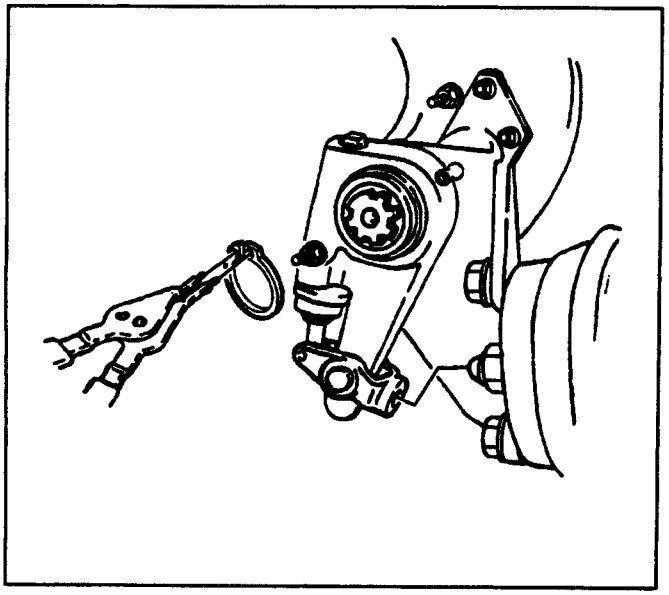
201809

6. Remove the retainers.
7. Remove the air brake chamber clevis pins.



201765

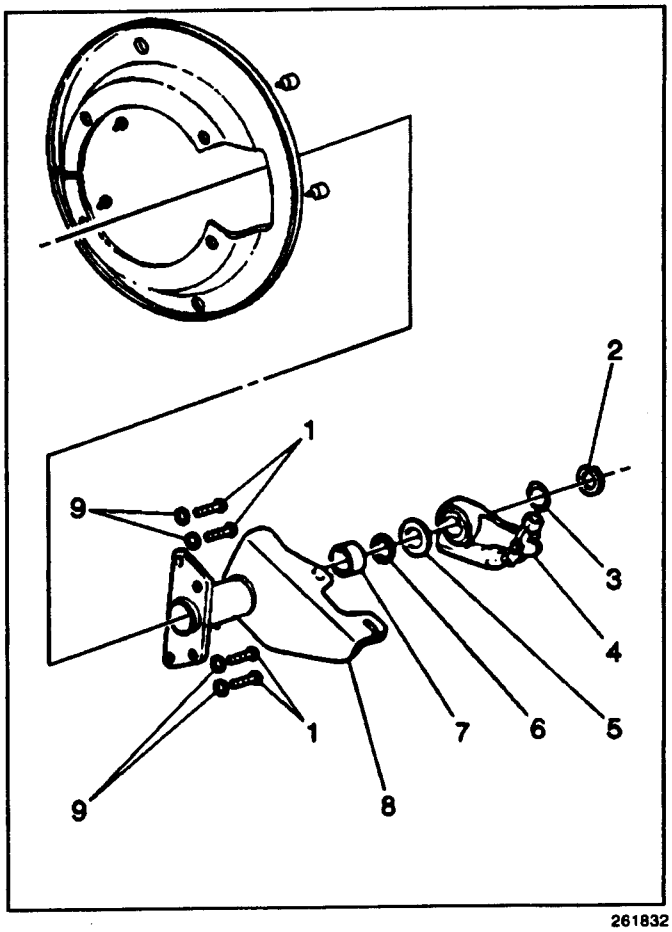
8. In order to fully release the air brake automatic slack adjuster, adhere to the following steps:
   - 8.1. Disengage the pawl with a screwdriver.
   - 8.2. Turn the slack adjuster adjusting nut until the air brake automatic slack adjuster is free from the air brake chamber clevis.
   - 8.3. Release the pawl so that the pawl snaps into engagement.



201813

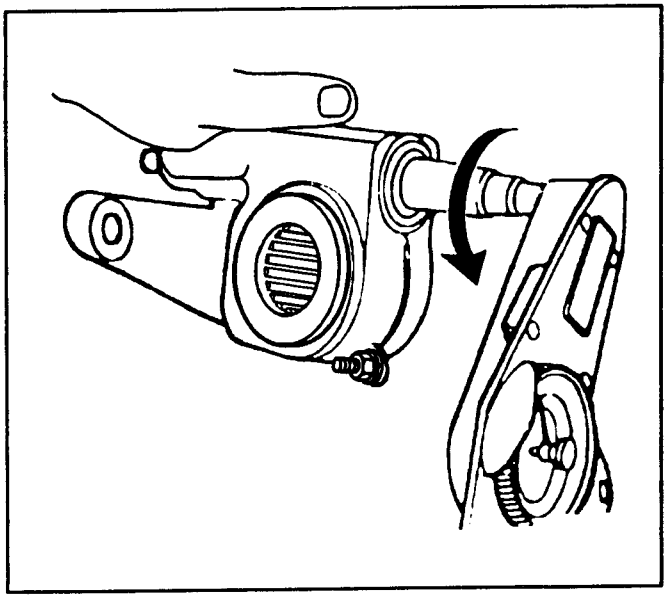
9. Remove the camshaft snap ring.

10. Remove the camshaft washer(s) (5).
11. Remove the slack adjuster (4).

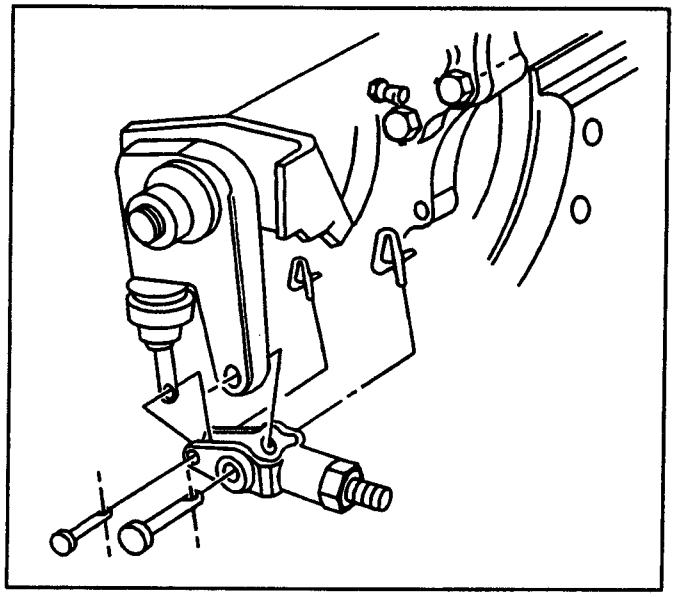


261832

12. In order to check the slack adjuster adjusting nut torque, adhere to the following steps:
    12.1. Use a pound inch torque wrench in order to rotate the air brake automatic slack adjuster adjusting nut counterclockwise.
    12.2. Turn the air brake automatic slack adjuster gear 360 degrees (22 rotations of the air brake automatic slack adjuster adjusting nut). The torque must remain less than 4.51 N.m (40 lb in). Overhaul or replace the air brake automatic slack adjuster if the torque specification is exceeded.

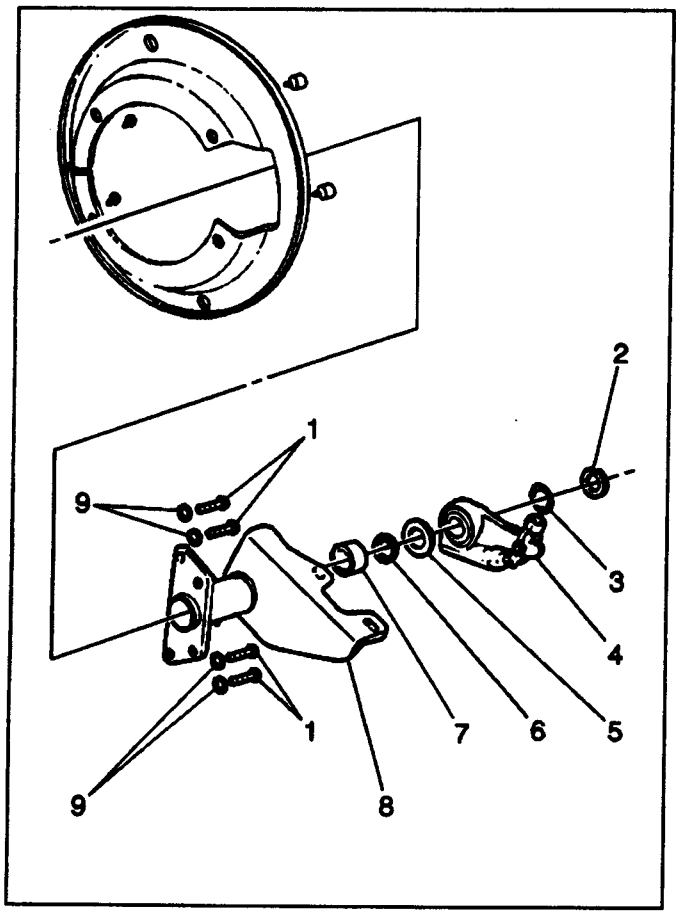


201816



201809

13. Inspect the air brake chamber clevis pins for wear or damage.
    Replace the air brake chamber clevis pins if necessary.

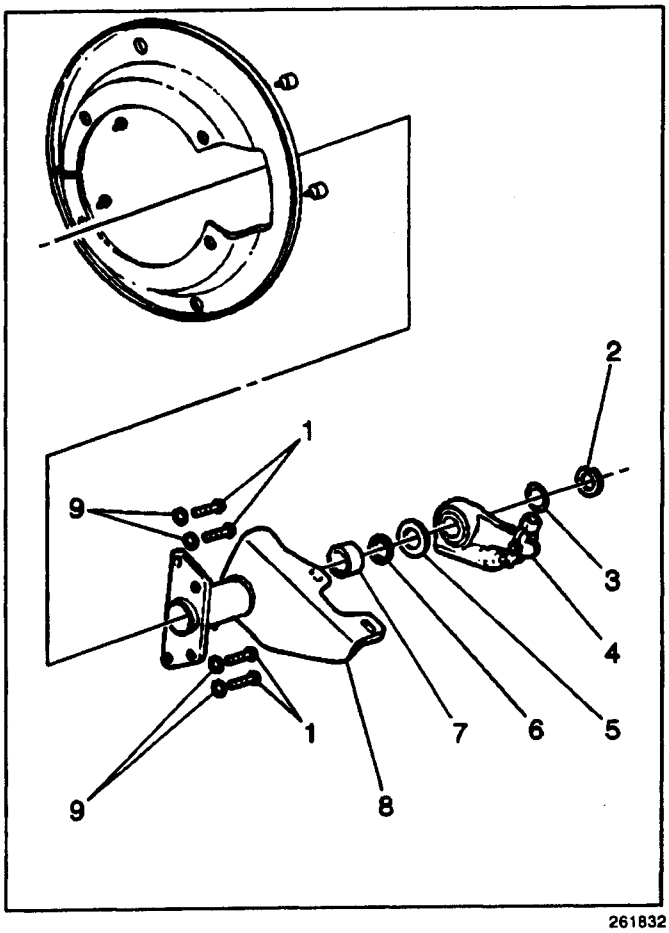


261832

14. Measure the bushing in the arm of the slack adjuster (4).
    Replace the bushings if the diameter exceeds 13.5 mm (0.531 in).

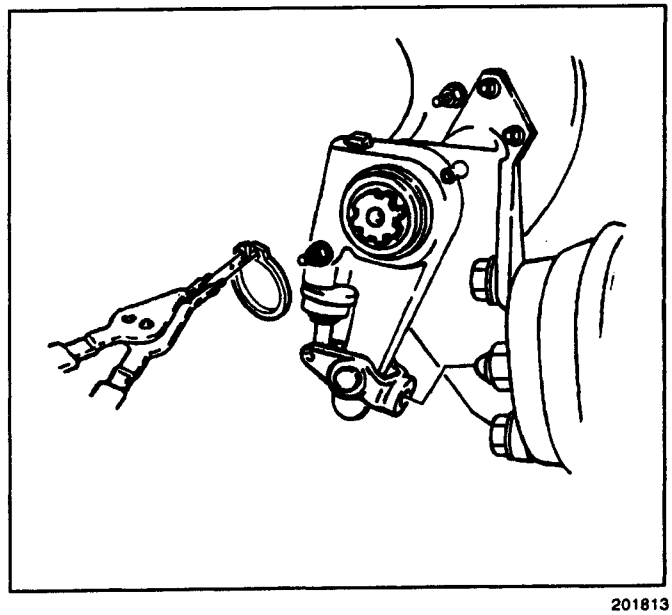
Installation Procedure

1. Install the slack adjuster (4) to the camshaft.
2. Install the camshaft washer(s) (5).

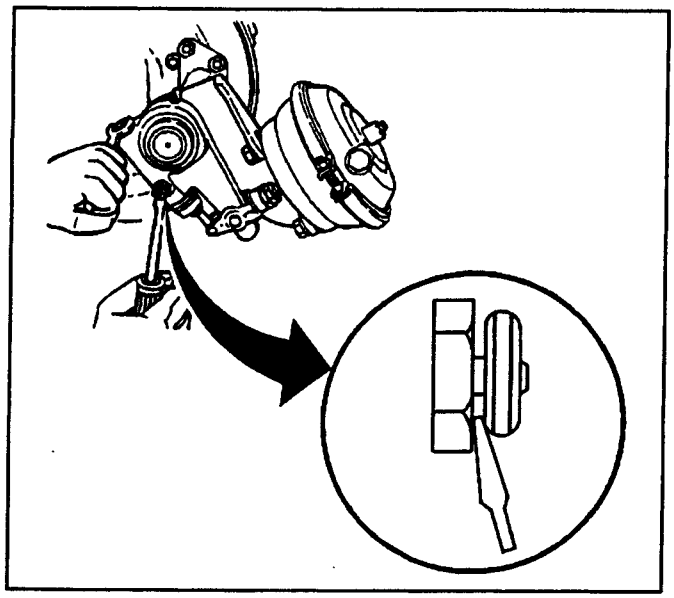


261832

3. Install the camshaft snap ring.

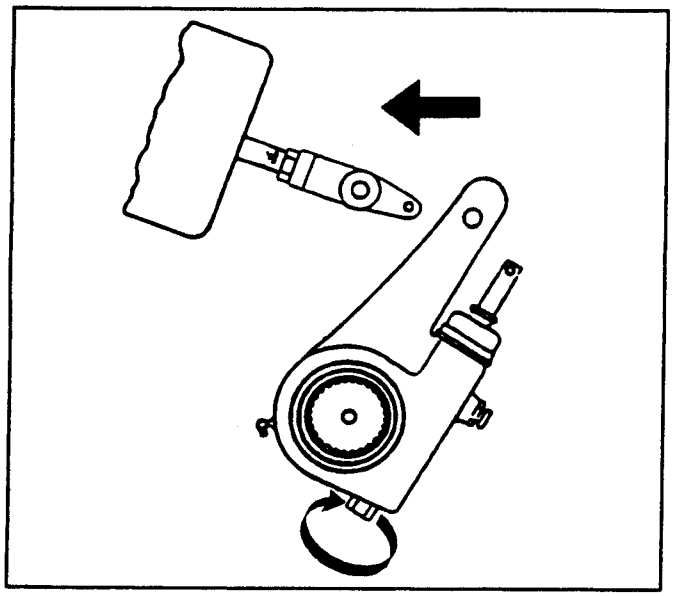


201813



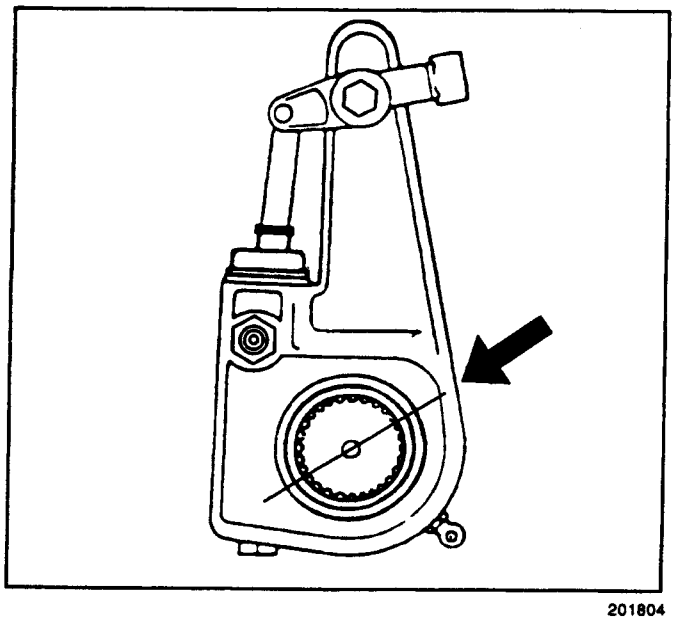
201765

4. Disengage the pawl assembly with a screwdriver.



201817

5. Turn the slack adjuster adjusting nut until the air brake automatic slack adjuster arm is properly aligned with the holes in the air brake chamber clevis.
6. Release the pawl so that the pawl snaps into engagement.

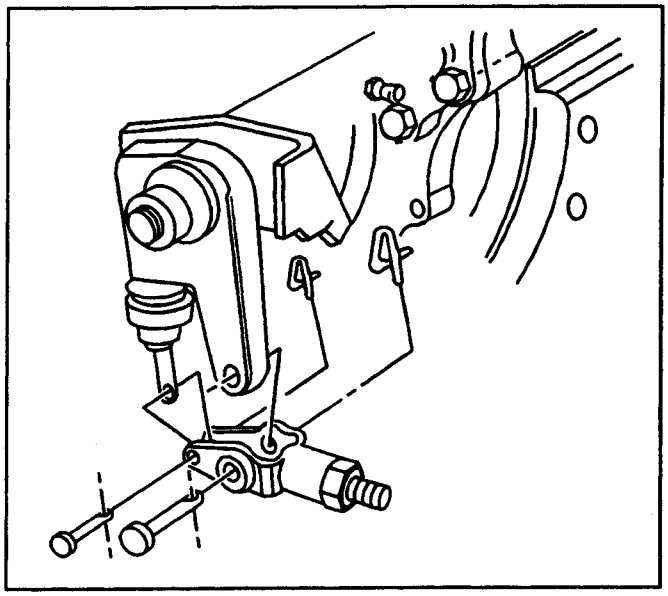


201804

7. Align the marks made on the slack adjuster and the camshaft.
8. Fully release the slack adjuster.

9. Install the air brake chamber clevis pins.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
10. Install the new retainers.
11. Adjust the brakes. Refer to the following procedures:
    - *Air Drum Brake Adjustment (Pushrod Stroke Measurement).*
    - *Air Drum Brake Adjustment (Normal Wear Adjustment).*
12. Remove the safety stands and lower the vehicle.
13. Uncage the rear air brake chambers. Refer to *Caging the Rear Air Brake Chamber.*
14. Check for proper brake operation.
15. Set the parking brake.
16. Remove the wheel blocks.



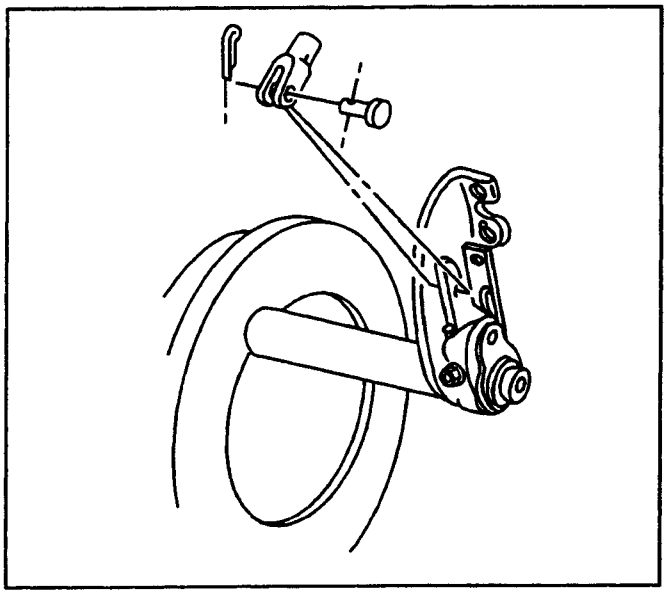
201809

Air Brake Automatic Slack Adjuster Replacement (Eaton)

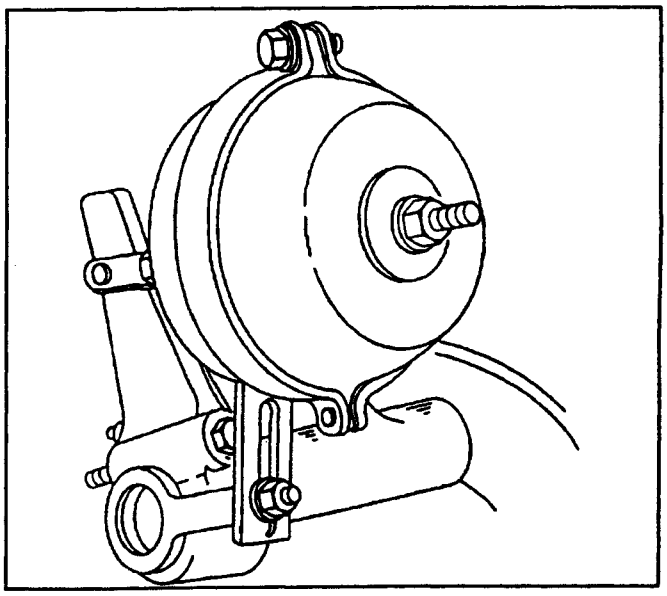
Removal Procedure

Important: The Eaton® air brake automatic slack adjuster is not serviceable. Replace any damaged Eaton air brake automatic slack adjusters.

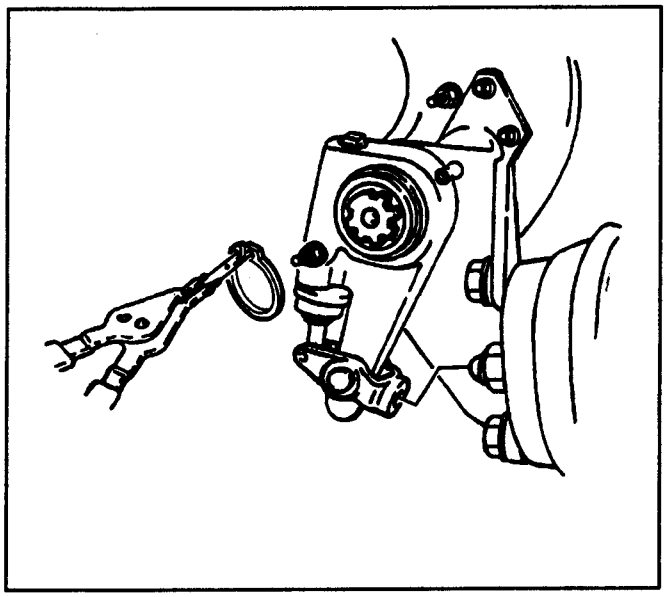
1. Block the wheels.
2. Cage the rear air brake chambers. Refer to *Caging the Rear Air Brake Chamber.*
3. Drain all air reservoirs. Refer to *Draining Reservoirs* in Air Brakes.
4. Remove the retainer.
5. Remove the air brake chamber clevis pin cotter pin.
6. Remove the air brake chamber clevis pin.
7. Fully release the slack adjuster by turning the slack adjuster counterclockwise until the slack adjuster arm is free from the air brake chamber clevis.
8. Remove the slack adjuster control arm nut and the washer.



201820

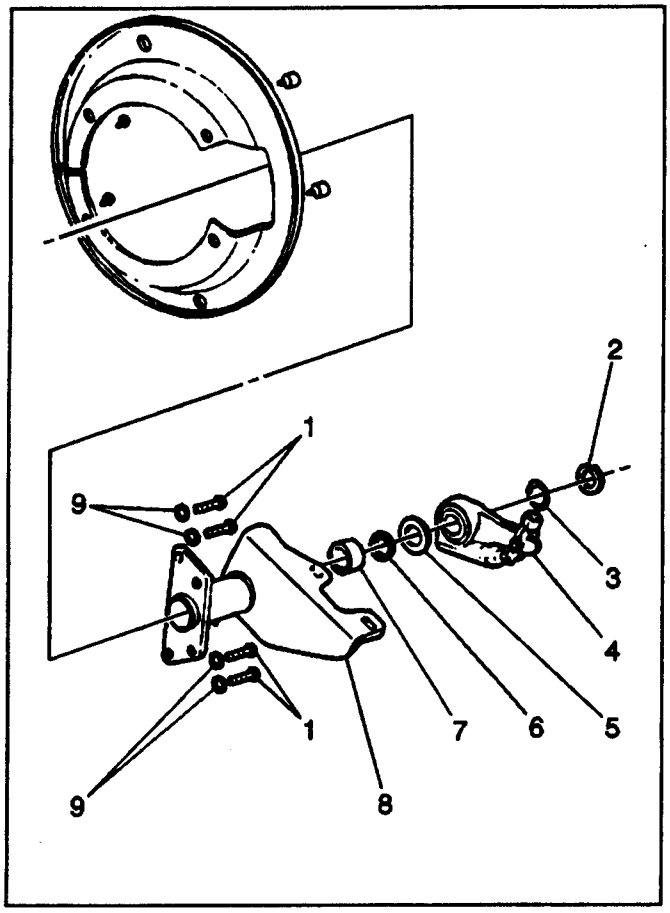


201833



201813

9. Remove the camshaft snap ring.



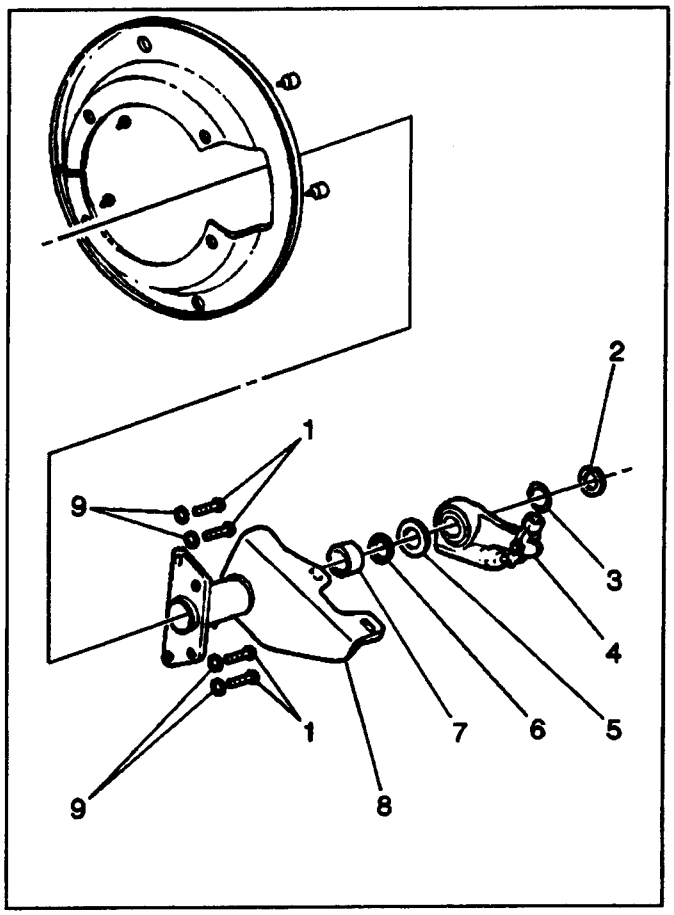
261832

10. Remove the camshaft washer(s) (5).
11. Remove the slack adjuster (4).
12. Inspect the slack adjuster (4) for damage or excessive wear.

    Replace the slack adjuster (4) if damage or excessive wear is present.

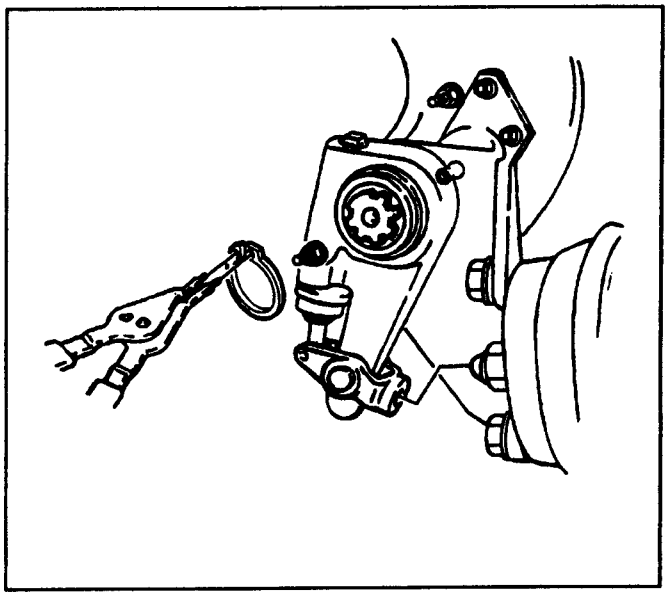
Installation Procedure

1. Lubricate the camshaft splines with anti-seize lubricant.
2. Install the slack adjuster (4) to the camshaft.
3. Install the camshaft washer(s) (5).

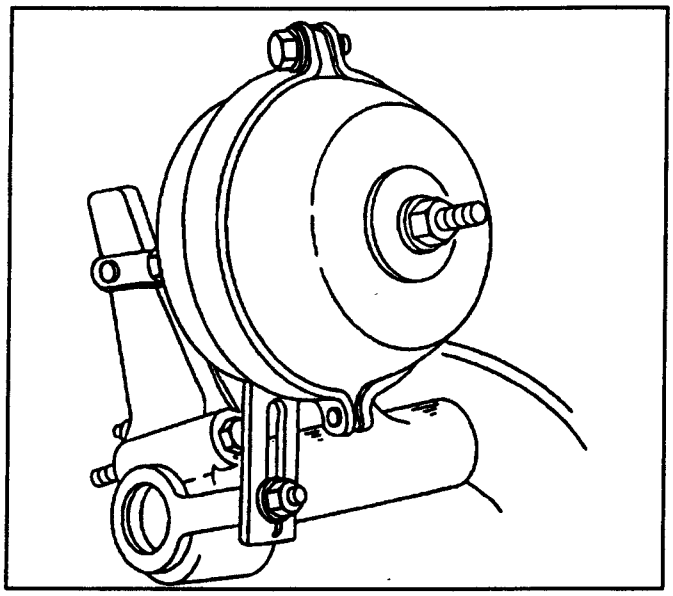


261832

4. Install the camshaft snap ring.

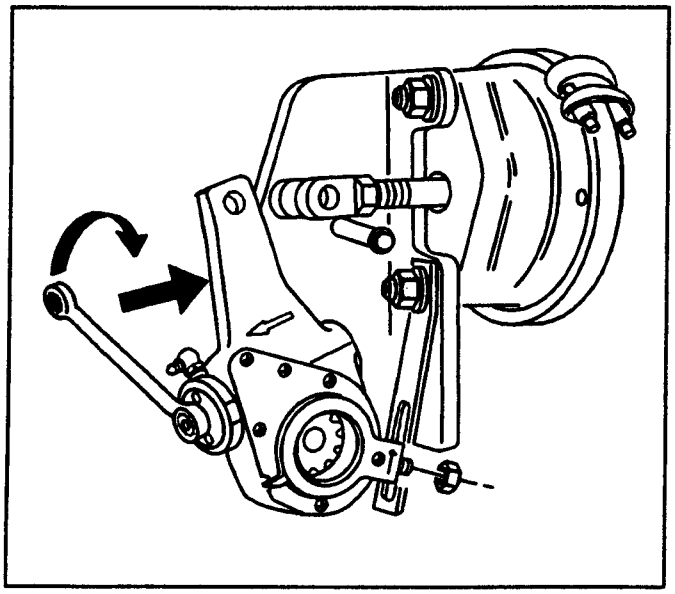


201813



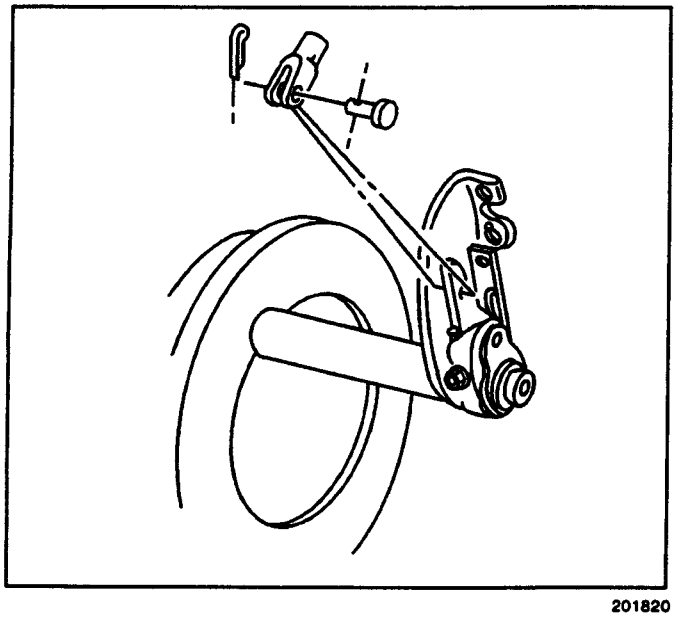
201833

5. Install the slack adjuster control arm washer.
6. Loosely install the slack adjuster control arm nut.



201826

7. Rotate the slack adjuster adjusting hex clockwise until the slack adjuster arm hole aligns with the air brake chamber clevis hole.



201820

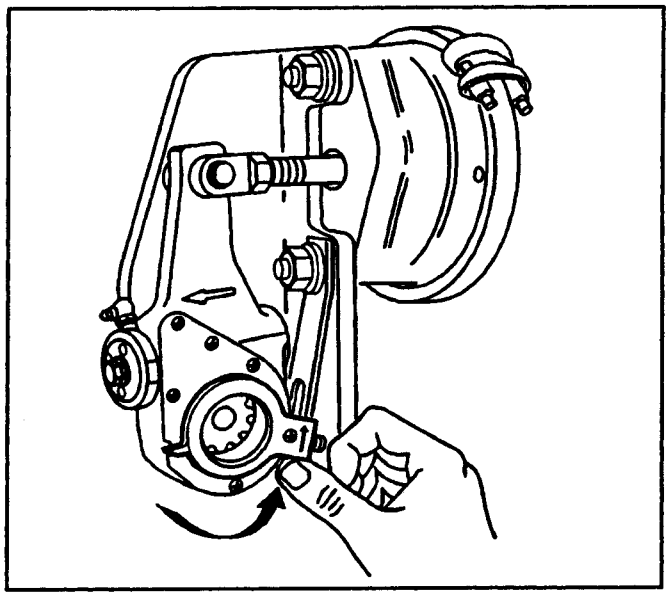
8. Install the air brake chamber clevis pin.
9. Do not install the retainer at this time.

   It may be necessary to remove the air brake chamber clevis pin later in order to check installation.

Notice: Excessive positioning force may damage the air brake automatic slack adjuster control arm. Most adjusters will be equipped with an installation indicator. The indicator must fall within the slot for proper installation. Incorrect air brake automatic slack adjuster control arm position can cause tight or dragging brakes.

10. Adjust the slack adjuster control arm. Rotate the control arm counterclockwise away from the slack adjuster adjusting hex. Continue the rotation towards the air brake chamber until the slack adjuster control arm comes to a definite internal stop.

    Use a plastic mallet in order to tap the slack adjuster control arm into position if necessary.
11. Install the slack adjuster control nut.



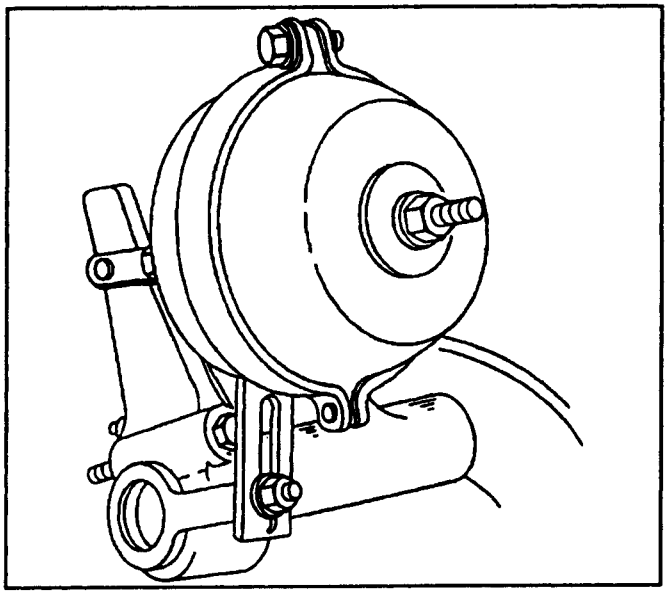
201829

Notice: Refer to *Fastener Notice* in Cautions and Notices.

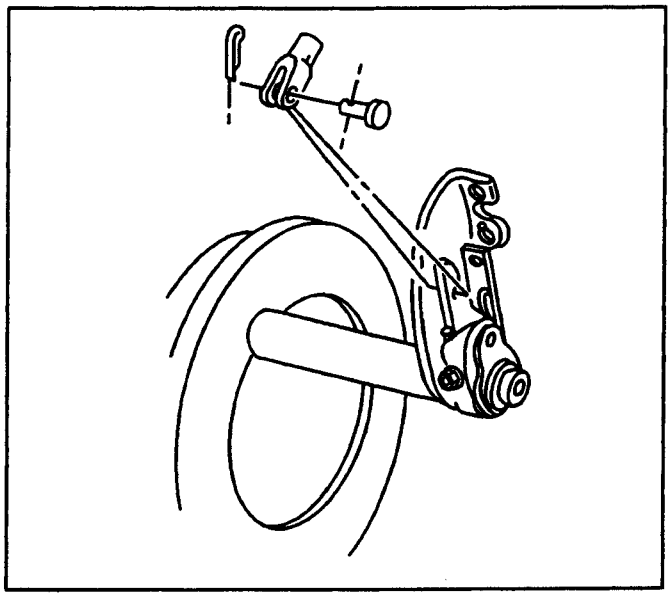
Important: Ensure that the slack adjuster control arm does not move from the correct position while tightening the slack adjuster control arm nut.

12. **Tighten**

    Tighten the slack adjuster control arm nut to 17 N·m (13 lb ft).
13. Adjust the brakes. Refer to the following procedures:
    - *Air Drum Brake Adjustment (Pushrod Stroke Measurement).*
    - *Air Drum Brake Adjustment (Normal Wear Adjustment).*
14. Start the engine.
15. Charge the system to the air compressor governor valve cut-out point.
16. Stop the engine.
17. Inspect the air brake automatic slack adjuster for proper installation.
18. Verify that the installation indicator is within the slot.

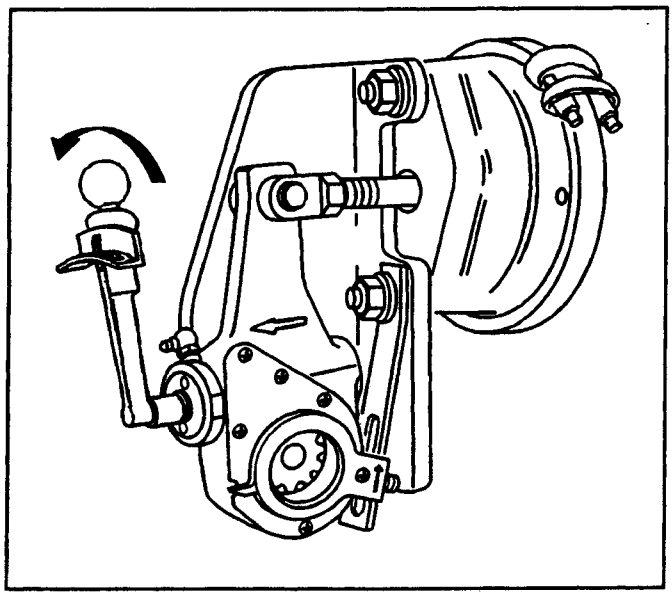


201833



201820

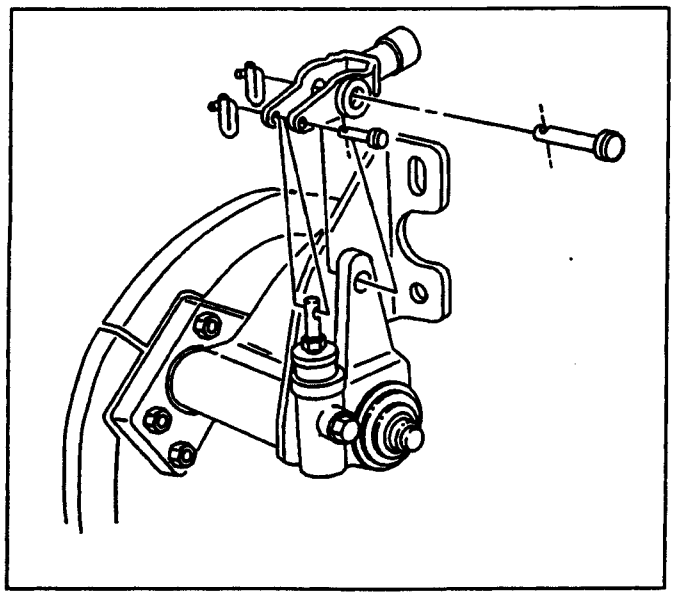
19. Remove the air brake chamber clevis pin.
20. Align the air brake chamber clevis hole and the slack adjuster arm hole.
21. Repeat steps 7–15 if the air brake chamber clevis retracts towards the air brake chamber when you remove the air brake chamber clevis pin.
22. Install the air brake chamber clevis pin.
23. Install the air brake chamber clevis pin cotter pin.



201843

24. Check the slack adjuster adjusting hex torque.
25. Use a pound inch torque wrench in order to rotate the slack adjuster adjusting hex counterclockwise.
26. The slack adjuster clutch should not slip at a torque less than 18 N.m (13 lb ft).

    A racheting sound occurs when the clutch slips. Replace the slack adjuster if the clutch slips at a lesser torque.
27. Start the engine.
28. Charge the system to the air compressor governor valve cut-out point.
29. Stop the engine.
30. Uncage the air brake chambers. Refer to *Caging the Rear Air Brake Chamber.*
31. Check for proper brake operation.
32. Set the parking brake.
33. Remove the wheel blocks.



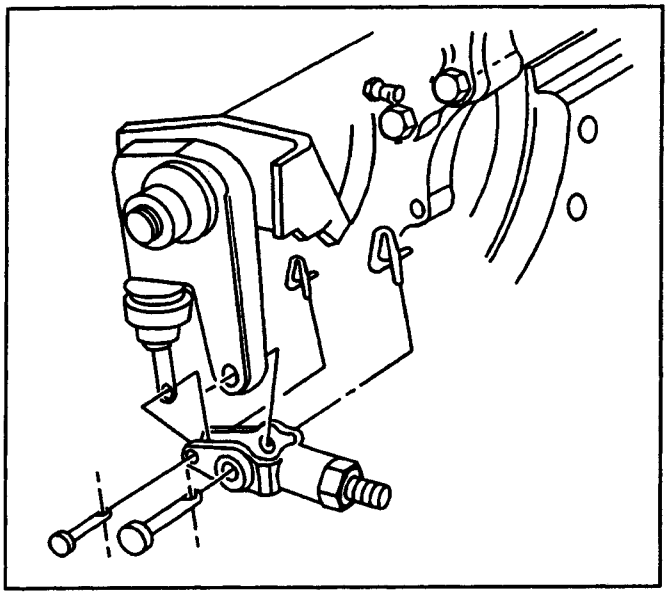
201846

Air Brake Chamber Clevis Replacement (Rockwell)

Removal Procedure

1. Block the wheels.
2. Cage the rear air brake chambers. Refer to *Caging the Rear Air Brake Chamber.*
3. Drain all air reservoirs. Refer to *Draining Reservoirs* in Air Brakes.
4. Mark the position of the slack adjuster to the camshaft by drawing a straight line on both parts.
5. Remove the front air brake chamber clevis pin retainers.
6. Remove the front air brake chamber clevis pins.

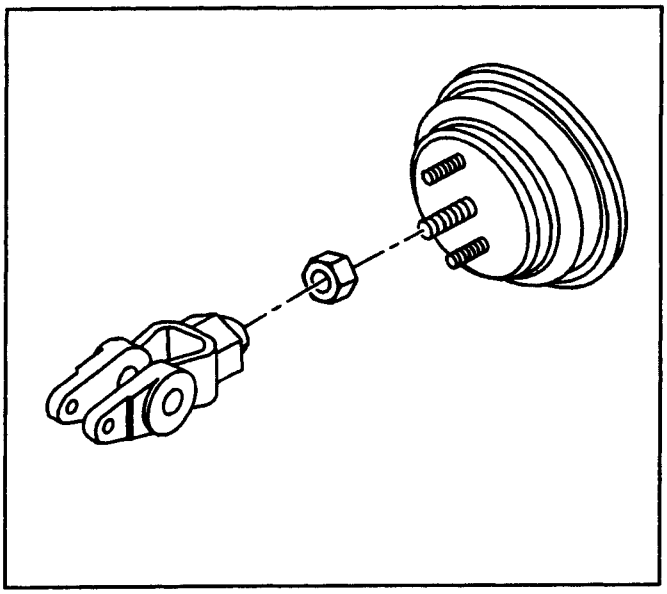
7. Remove the rear air brake chamber clevis pin retainers.
8. Remove the rear air brake chamber clevis pins.
9. Fully release the air brake automatic slack adjuster.
10. Disengage the pawl with a screwdriver.
11. Turn the slack adjuster adjusting nut until the slack adjuster is free from the air brake chamber clevis.
12. Release the pawl so that the pawl snaps into engagement.



201809

13. Loosen the jam nut.
14. Remove the air brake chamber clevis and the jam nut.
15. Inspect the service brake chamber pushrod for damage.

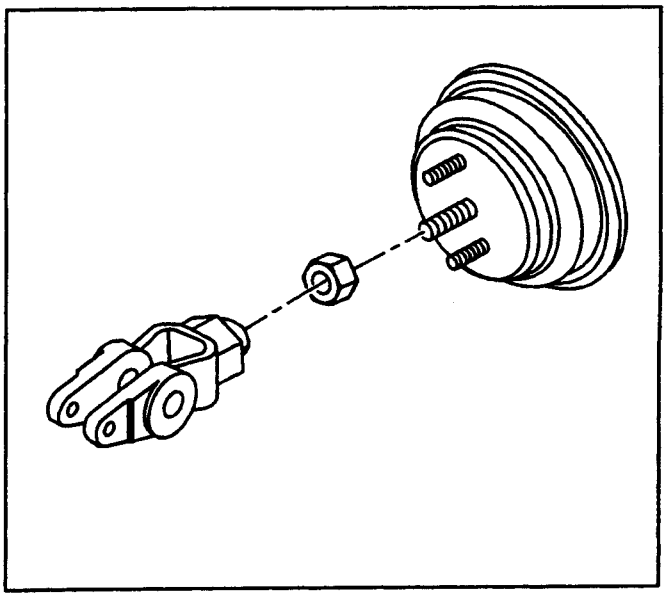
    Overhaul or replace the service brake chamber assembly if damaged.



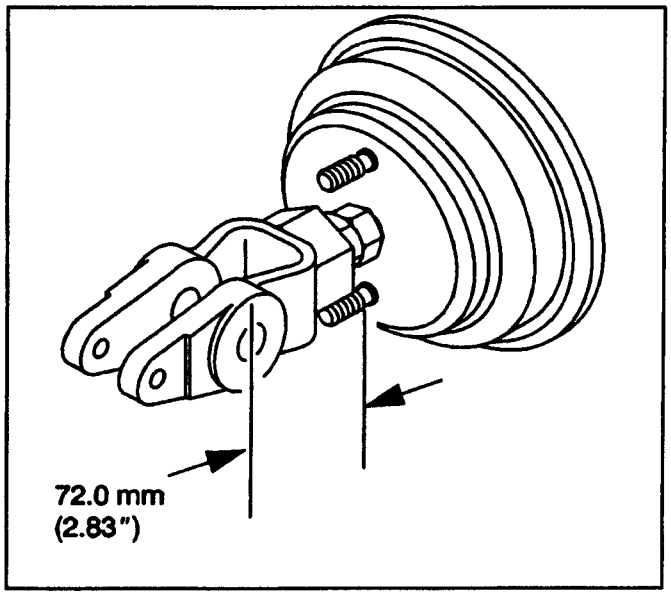
209228

Installation Procedure

1. Loosely assemble the jam nut and the air brake chamber clevis to the service brake chamber pushrod.
2. Adjust the air brake chamber clevis. Turn the air brake chamber clevis clockwise in order to decrease the distance. Turn the clevis counterclockwise in order to increase the distance.

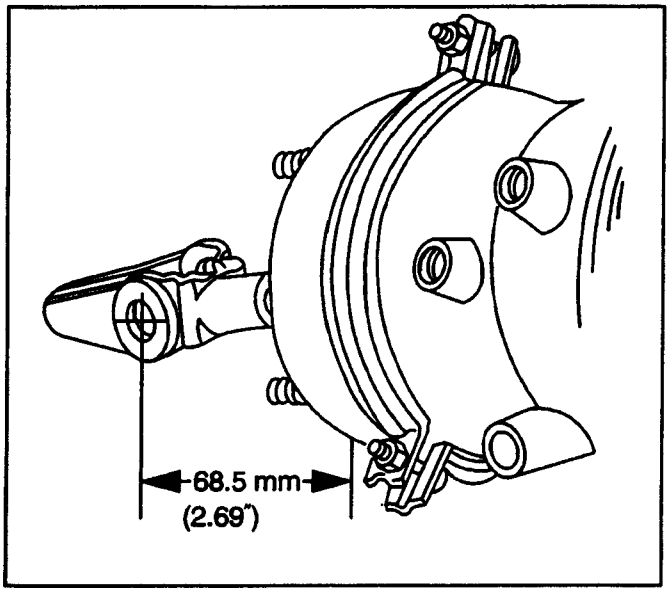


209228



201873

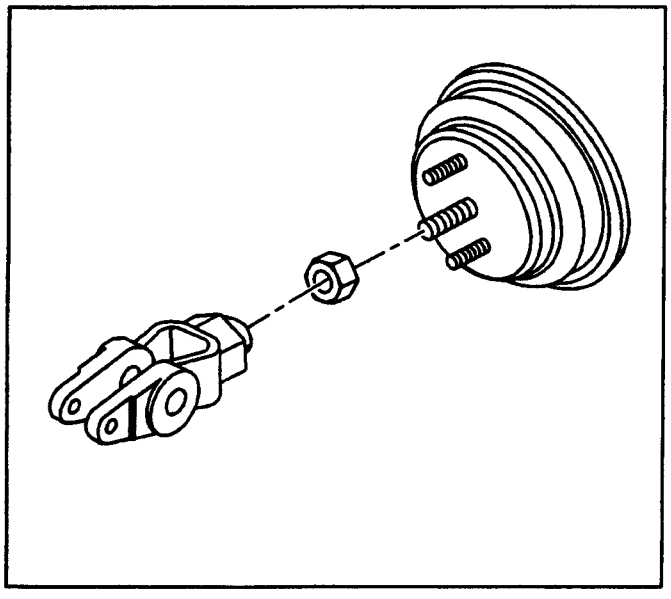
3. Adjust the front air brake chamber clevis to 72.0 mm (2.83 in) from the mounting surface of the service brake chamber to the center of the air brake chamber clevis pin mounting hole.



201877

Notice: Refer to *Fastener Notice* in Cautions and Notices.

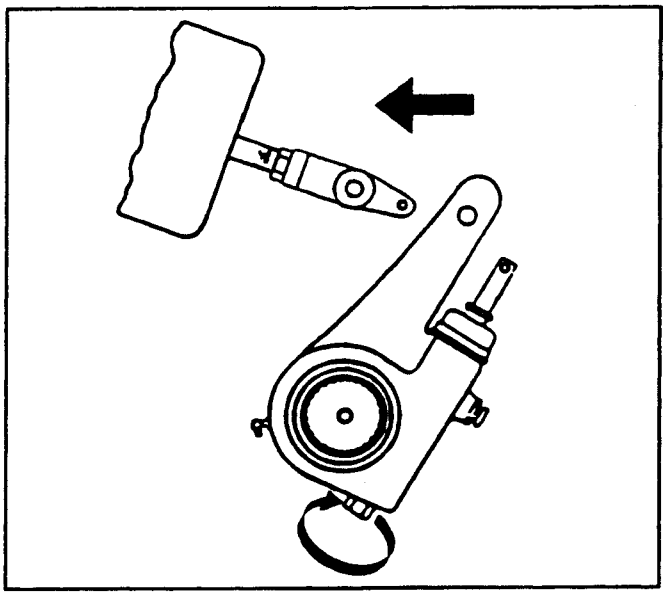
4. Adjust the rear air brake chamber clevis to 68.5 mm (2.69 in) from the mounting surface of the spring brake chamber to the center of the air brake chamber clevis pin mounting hole.
   Tighten
   - Tighten the front air brake chamber clevis jam nut (type 16 air brake chamber) to 45 N·m (33 lb ft).
   - Tighten the front air brake chamber clevis jam nut (types 20 and 24 air brake chamber) to 78 N·m (57 lb ft).
   - Tighten the rear air brake chamber clevis jam nut to 77 N·m (56 lb ft).



209228

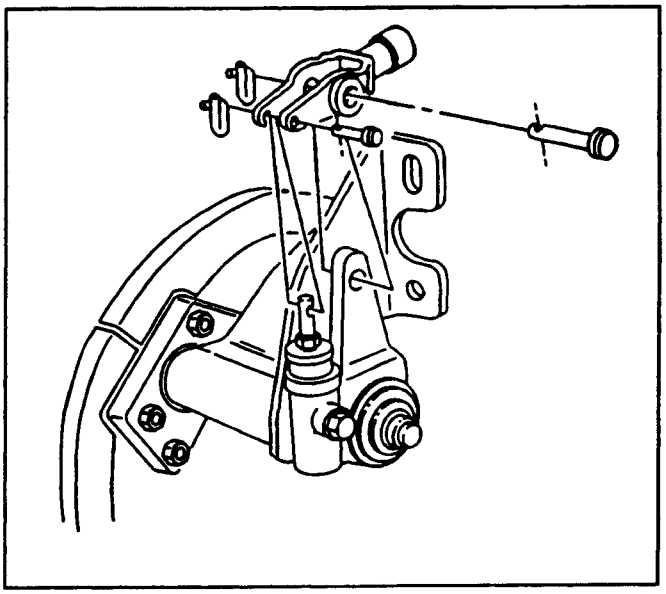
5. Fully release the slack adjuster.
6. Disengage the pawl with a screwdriver.

7. Turn the slack adjuster adjusting nut until the slack adjuster arm is properly aligned with the holes in the air brake chamber clevis.
8. Release the pawl so that the pawl snaps into engagement.



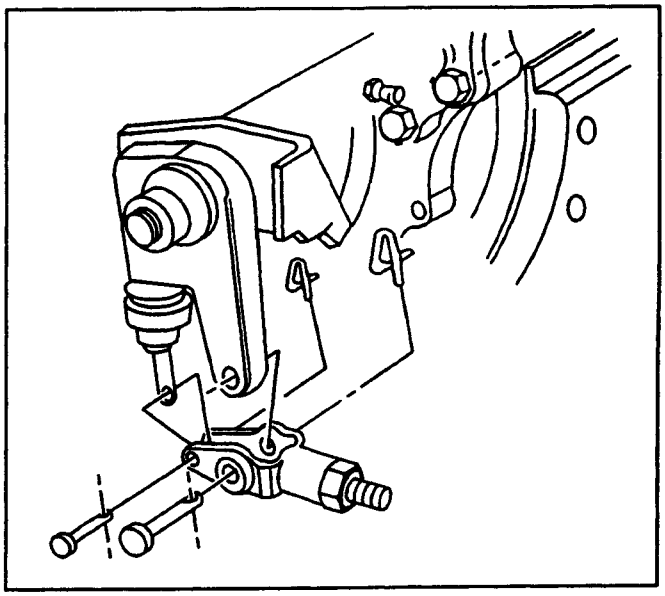
201817

9. Install the front air brake chamber clevis pins.
10. Install the new front air brake chamber clevis pin retainers.

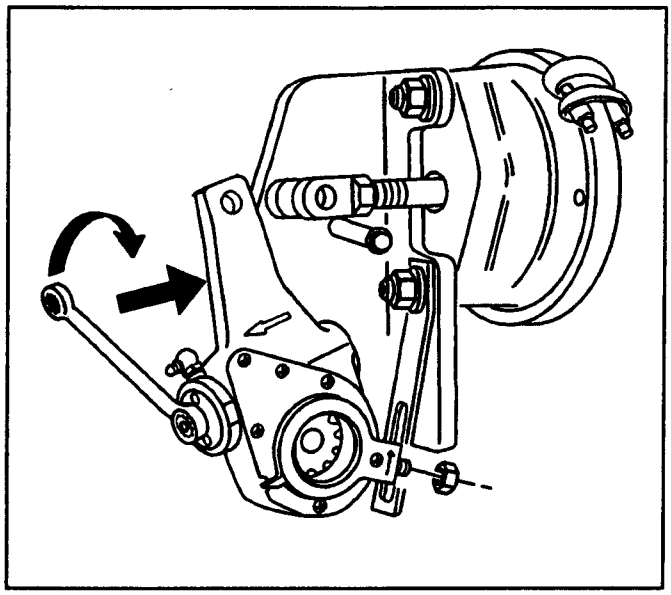


201846

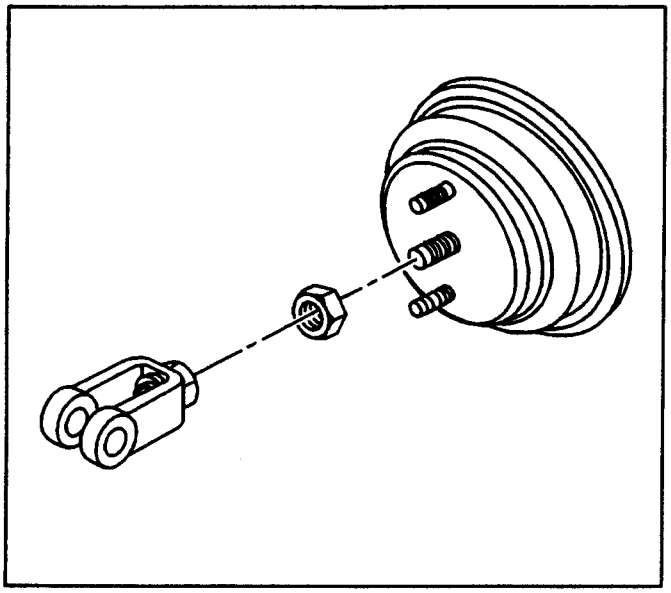
11. Install the rear air brake chamber clevis pins.
12. Install the new rear air brake chamber clevis pin retainers.
13. Adjust the brakes. Refer to the following procedures:
    - *Air Drum Brake Adjustment (Pushrod Stroke Measurement).*
    - *Air Drum Brake Adjustment (Normal Wear Adjustment).*
14. Start the engine.
15. Charge the system to the air compressor governor valve cut-out point.
16. Stop the engine.
17. Uncage the rear air brake chamber assemblies. Refer to *Caging the Rear Air Brake Chamber.*
18. Check for proper brake operation.
19. Set the parking brake.
20. Remove the wheel blocks.



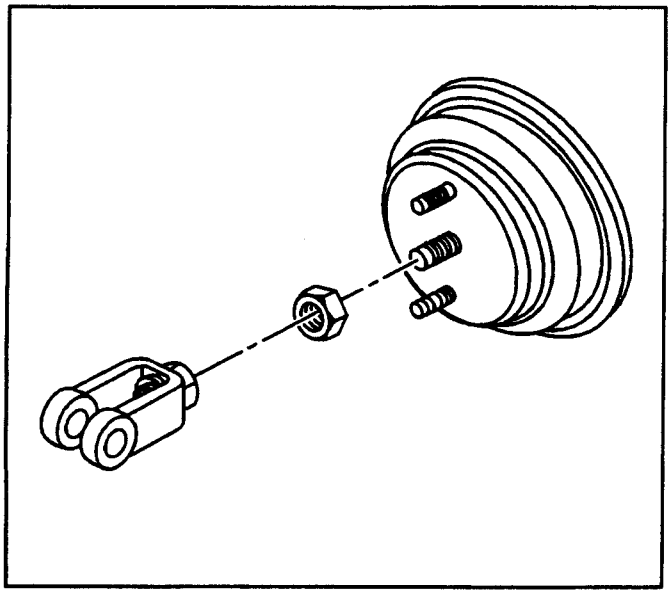
201809



201826



207511



207511

Air Brake Chamber Clevis Replacement (Eaton)

Removal Procedure

1. Block the wheels.
2. Cage the rear air brake chambers. Refer to *Caging the Rear Air Brake Chamber.*
3. Drain all air reservoirs. Refer to *Draining Reservoirs* in Air Brakes.
4. Remove the air brake chamber clevis pin cotter pin.
5. Remove the air brake chamber clevis pin.
6. Fully release the air brake automatic slack adjuster. Turn the air brake automatic slack adjuster counterclockwise until the slack adjuster arm is free from the air brake chamber clevis.
7. Loosen the jam nut.
8. Remove the air brake chamber clevis and the jam nut.
9. Inspect the service brake chamber pushrod for damage.

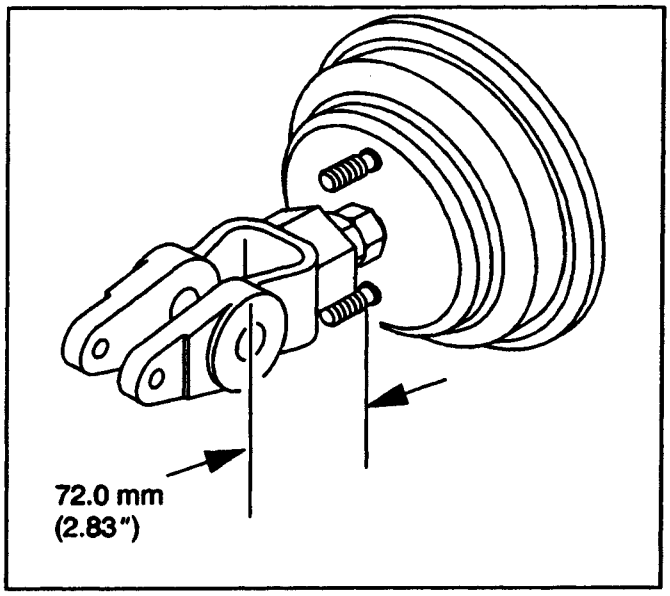
   Overhaul or replace the service brake chamber if damage exists.

Installation Procedure

1. Loosely assemble the jam nut and the air brake chamber clevis to the service brake chamber pushrod.
2. Adjust the air brake chamber clevis by turning the air brake chamber clevis clockwise in order to decrease the distance.

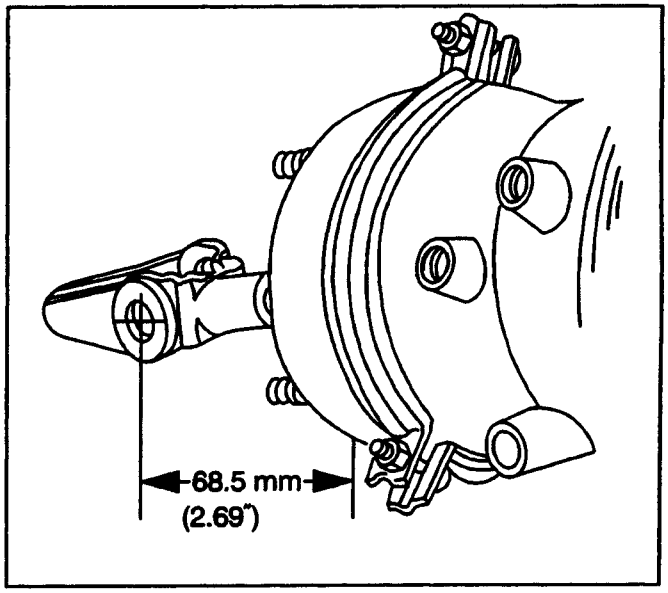
   Adjust the air brake chamber clevis. Turn the air brake chamber clevis counterclockwise.

3. Measure the front air brake chamber clevis to 72.0 mm (2.83 in) from the mounting surface of the service brake chamber to the center of the air brake chamber clevis pin mounting hole.



201873

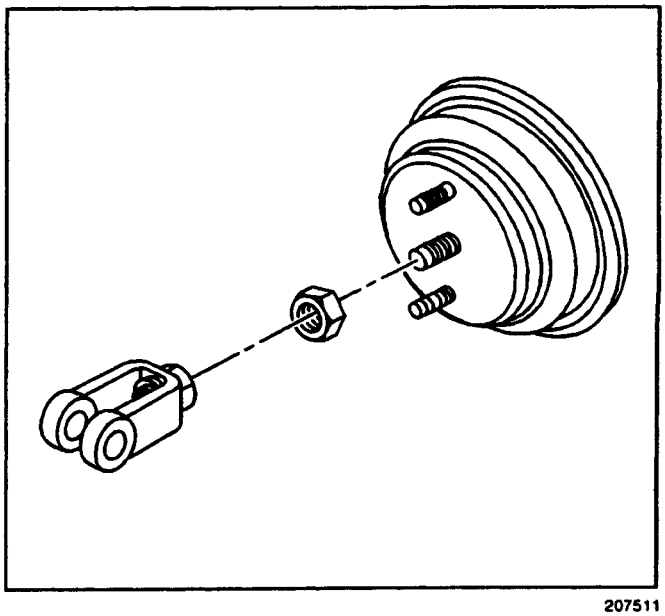
4. Measure the rear air brake chamber clevis to 68.5 mm (2.69 in) from the mounting surface of the spring brake chamber to the center of the air brake chamber clevis pin mounting hole.



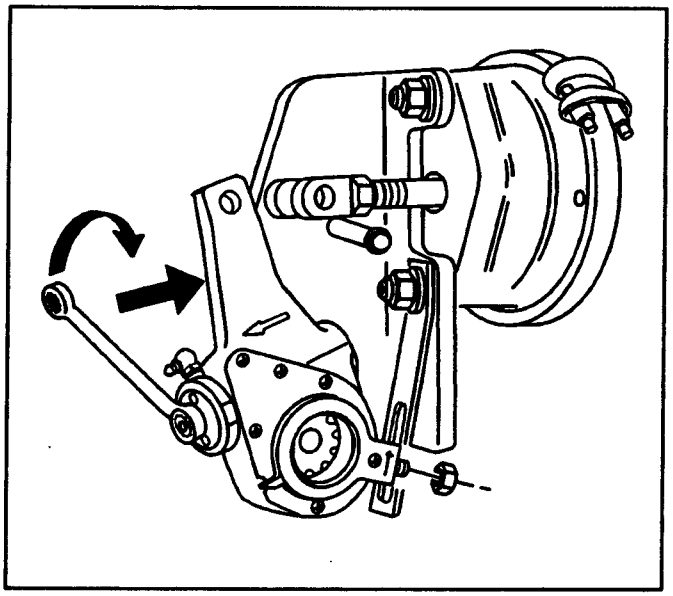
201877

Notice: Refer to *Fastener Notice* in Cautions and Notices.

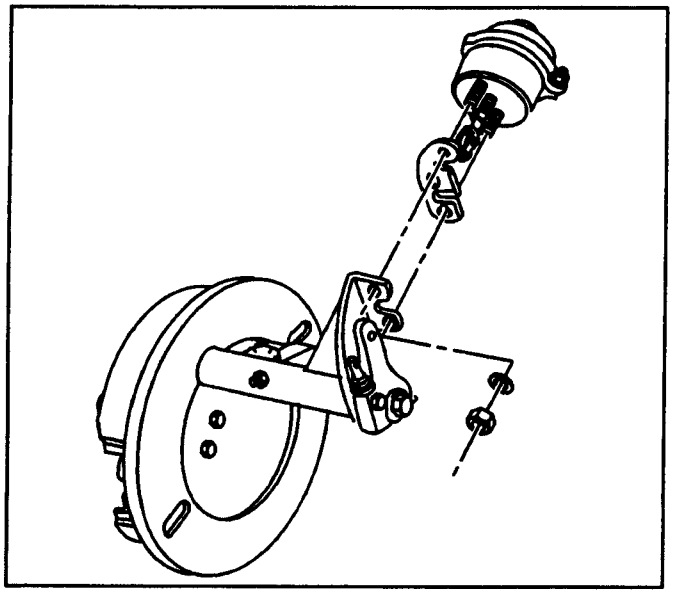
5. Install the front air brake chamber clevis jam nut.
   Tighten
   - Tighten the front air brake chamber clevis jam nut (type 16 air brake chamber) to 45 N.m (33 lb ft).
   - Tighten the front air brake chamber clevis jam nut (types 20 and 24 air brake chamber) to 78 N.m (57 lb ft).
   - Tighten the rear air brake chamber clevis jam nut to 77 N.m (56 lb ft).
6. Rotate the slack adjuster adjusting hex clockwise until the slack adjuster arm hole aligns with the air brake chamber clevis hole.



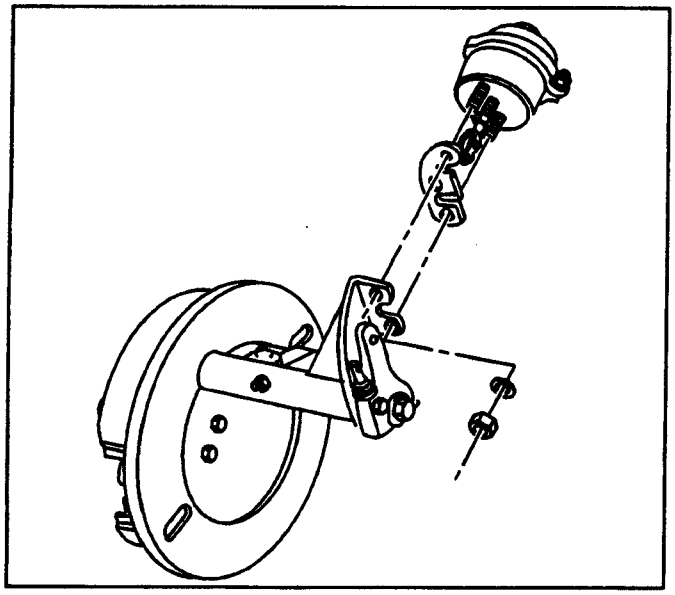
207511



201826



201884



201884

7. Install the air brake chamber clevis pin.
8. Install the air brake chamber clevis pin cotter pin.
9. Adjust the brakes. Refer to the following procedures:
   - *Air Drum Brake Adjustment (Pushrod Stroke Measurement).*
   - *Air Drum Brake Adjustment (Normal Wear Adjustment).*
10. Start the engine.
11. Charge the system to the air compressor governor valve cut-out point.
12. Stop the engine.
13. Uncage the rear air brake chambers. Refer to *Caging the Rear Air Brake Chamber.*
14. Check for proper brake operation.
15. Set the parking brake.
16. Remove the wheel blocks.

Air Brake Chamber Replacement (Front)

Removal Procedure

1. Remove the air brake chamber clevis. Refer to *Air Brake Chamber Clevis Replacement (Rockwell).*
2. Remove the air line from the air brake chamber assembly. Refer to the following procedures:
   - *Hose and Line Replacement (Nylon and Metal - Compression)* or
   - *Hose and Line Replacement (Nylon - Push-In)* or
   - *Hose and Line Replacement (Flexible)* in Air Brakes.
3. Remove the mounting nuts and the washers from the air brake chamber assembly.
4. Remove the air brake chamber assembly from the brake chamber/camshaft support bracket.

Installation Procedure

1. Install the air brake chamber assembly to the brake chamber/camshaft support bracket.

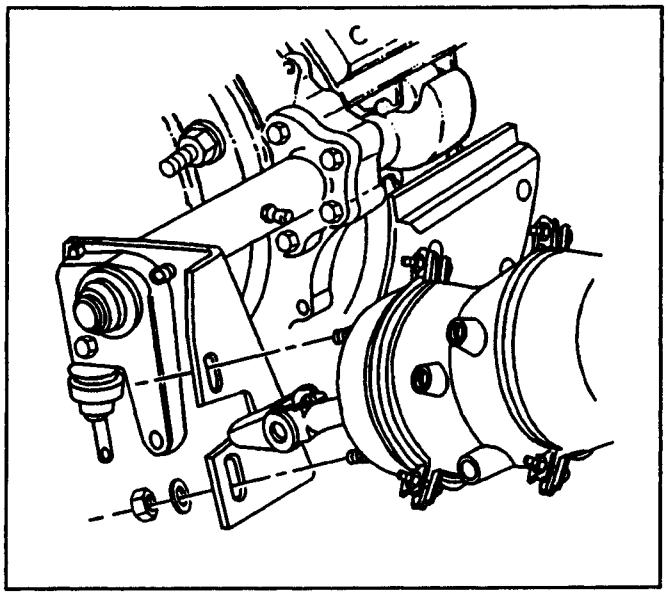
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the mounting washers and the nuts to the air brake chamber assembly.

   Tighten
   - Tighten the air brake chamber assembly (type 16) mounting nuts to 39 N·m (29 lb ft).
   - Tighten the air brake chamber assembly (type 20 and 24) mounting nuts to 74 N·m (55 lb ft).
3. Install the air brake chamber clevis. Refer to *Air Brake Chamber Clevis Replacement (Rockwell).*

Air Brake Chamber Replacement (Rear)

Removal Procedure

1. Remove the air brake chamber clevis. Refer to *Air Brake Chamber Clevis Replacement (Eaton).*
2. Remove the air line from the air brake chamber assembly. Refer to the following procedures:
   - *Hose and Line Replacement (Nylon and Metal - Compression)* or
   - *Hose and Line Replacement (Nylon - Push-In)* or
   - *Hose and Line Replacement (Flexible)* in Air Brakes.
3. Remove the mounting nuts and the washers from the air brake chamber assembly.
4. Remove the air brake chamber assembly from the brake chamber/camshaft support bracket.



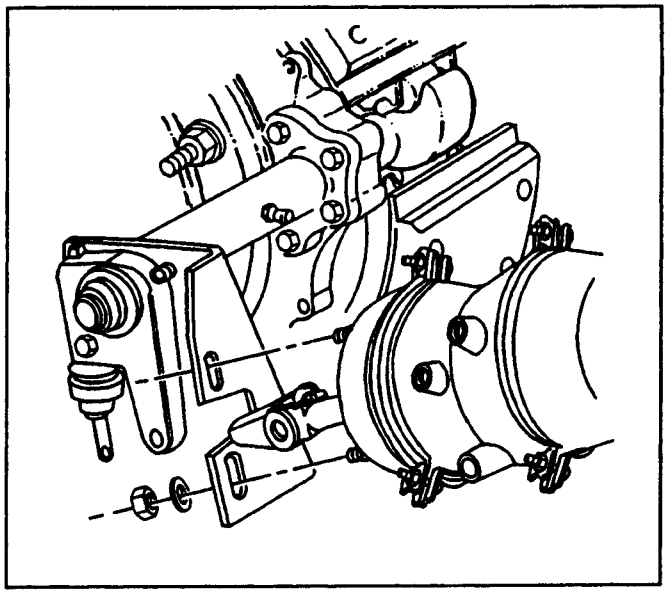
201891

Installation Procedure

1. Install the air brake chamber assembly to the brake chamber/camshaft support bracket.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the mounting washers and the nuts to the air brake chamber assembly.

   Tighten
   - Tighten the air brake chamber assembly (type 16) mounting nuts to 39 N·m (29 lb ft).
   - Tighten the air brake chamber assembly (type 20 and 24) mounting nuts to 74 N·m (55 lb ft).
3. Install the air brake chamber clevis. Refer to *Air Brake Chamber Clevis Replacement (Eaton).*

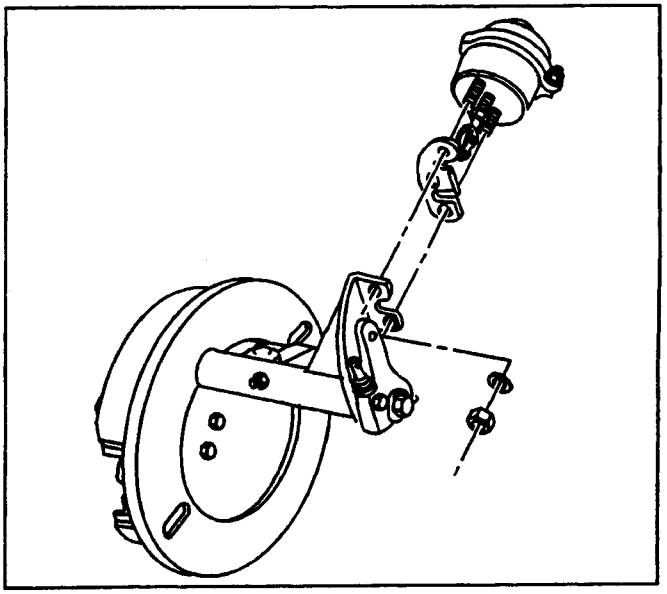


201891

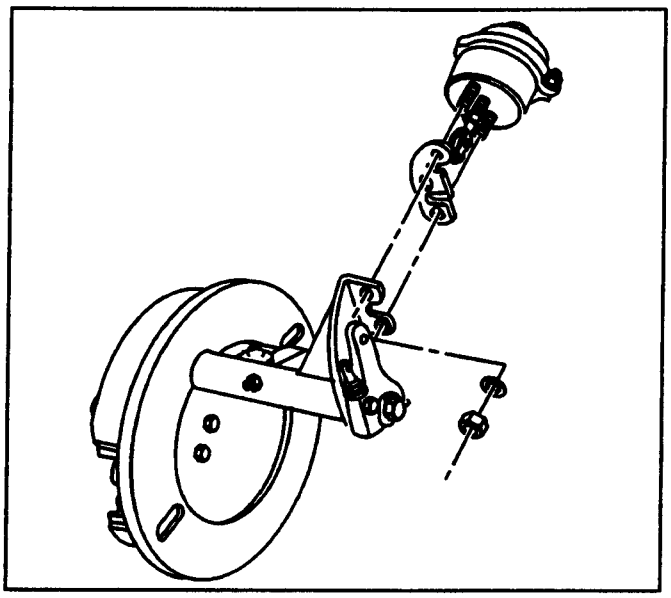
Air Brake Chamber Replacement - Front (With Rockwell Slack Adjuster)

Removal Procedure

1. Remove the air brake chamber clevis. Refer to *Air Brake Chamber Clevis Replacement (Rockwell).*
2. Remove the air line from the air brake chamber assembly. Refer to the following procedures:
   - *Hose and Line Replacement (Nylon and Metal - Compression)* or
   - *Hose and Line Replacement (Nylon - Push-In)* or
   - *Hose and Line Replacement (Flexible)* in Air Brakes.
3. Remove the mounting nuts and the washers from the air brake chamber assembly.
4. Remove the air brake chamber assembly from the brake chamber/camshaft support bracket.



201884



201884

Installation Procedure

1. Install the air brake chamber assembly to the brake chamber/camshaft support bracket.

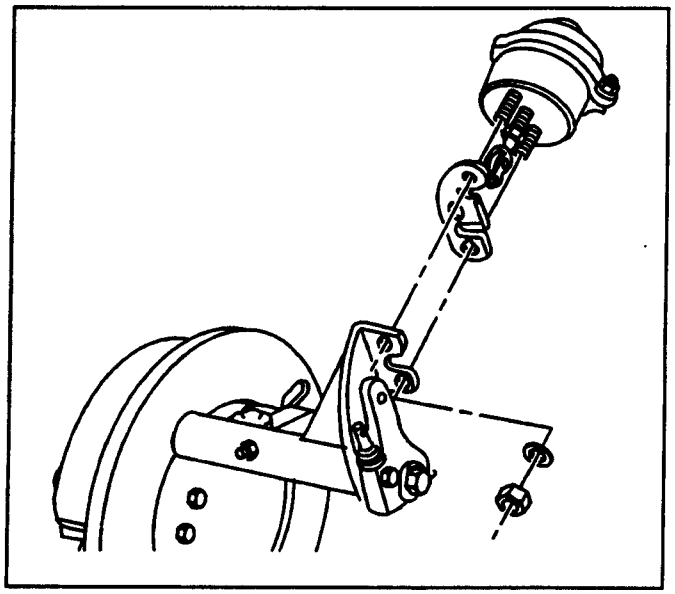
   Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the mounting washers and the nuts to the air brake chamber assembly.

   Tighten

   - Tighten the air brake chamber assembly (type 16) mounting nuts to 39 N.m (29 lb ft).
   - Tighten the air brake chamber assembly (type 20 and 24) mounting nuts to 74 N.m (55 lb ft).

3. Install the air brake chamber clevis. Refer to *Air Brake Chamber Clevis Replacement (Rockwell).*

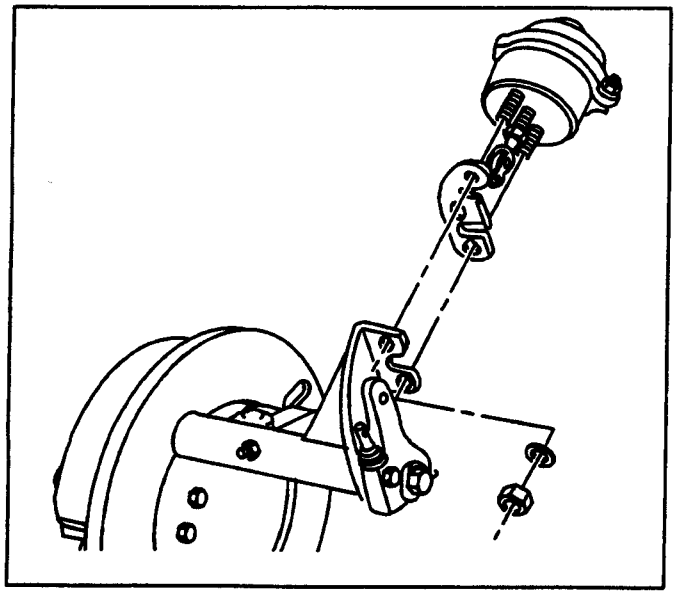


201888

Air Brake Chamber Replacement - Front (With Eaton Slack Adjuster)

Removal Procedure

1. Remove the air brake chamber clevis. Refer to *Air Brake Chamber Clevis Replacement (Eaton).*
2. Remove the air line from the air brake chamber assembly. Refer to the following procedures:
   - *Hose and Line Replacement (Nylon and Metal - Compression)* or
   - *Hose and Line Replacement (Nylon - Push-In)* or
   - *Hose and Line Replacement (Flexible)* in Air Brakes.
3. Remove the mounting nuts and the washers from the air brake chamber assembly.
4. Remove the air brake chamber assembly from the brake chamber/camshaft support bracket.



201886

Installation Procedure

1. Install the air brake chamber assembly to the brake chamber/camshaft support bracket.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the mounting washers and the nuts to the air brake chamber assembly.

   Tighten

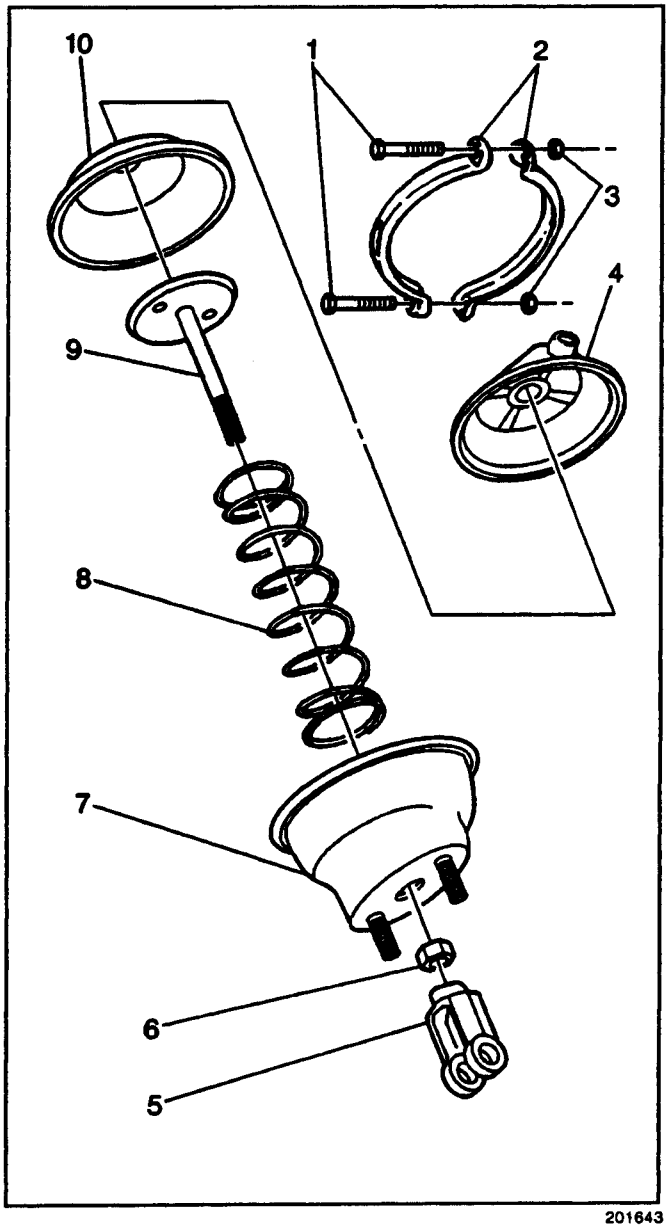
   - Tighten the air brake chamber assembly (type 16) mounting nuts to 39 N.m (29 lb ft).
   - Tighten the air brake chamber assembly (type 20 and 24) mounting nuts to 74 N.m (55 lb ft).

3. Install the air brake chamber clevis. Refer to *Air Brake Chamber Clevis Replacement (Eaton).*

Air Brake Chamber Overhaul (Service)

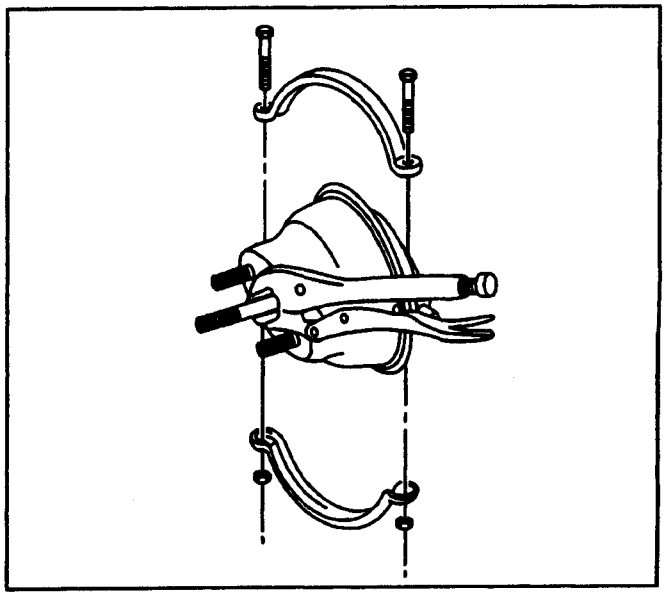
Disassembly Procedure

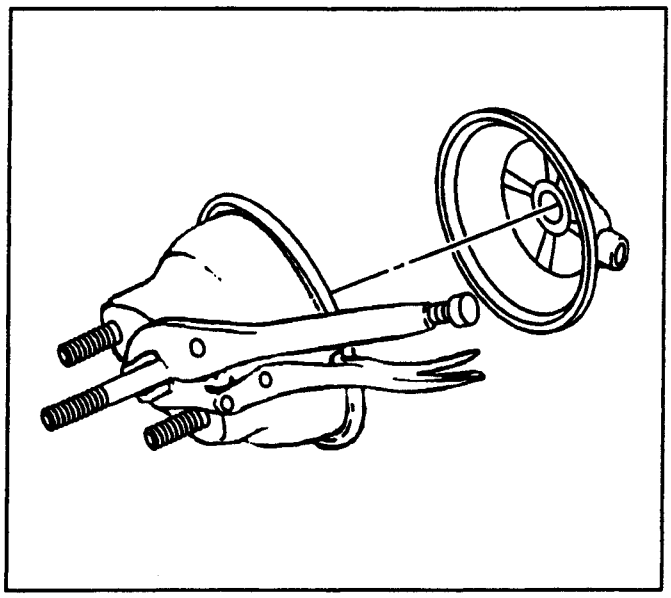
1. Mark the pressure cap (4) and the chamber assembly (7) in relation to the clamp ring assembly (2).
2. Remove the air brake chamber clevis (5) and the nut (6).
3. Pull out the pushrod (9).
4. Clamp the pushrod (9) using locking-type pliers.
5. Remove the nuts (3) and the bolts (1).



201643

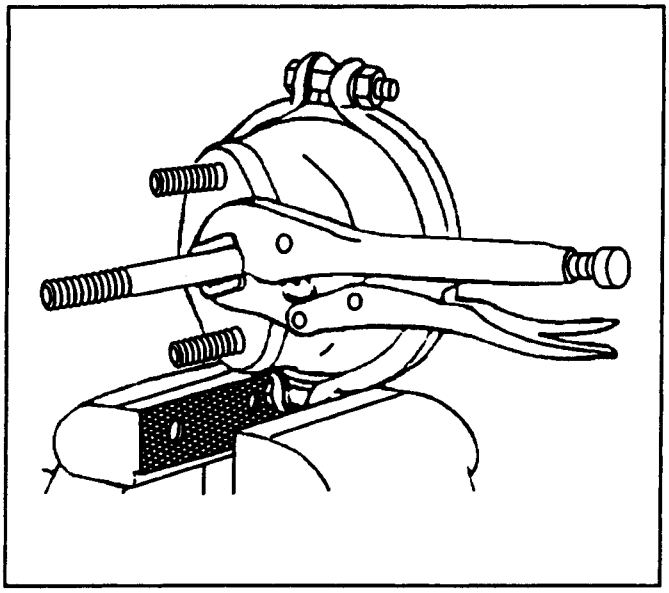
6. Remove the clamp ring assembly.


201666



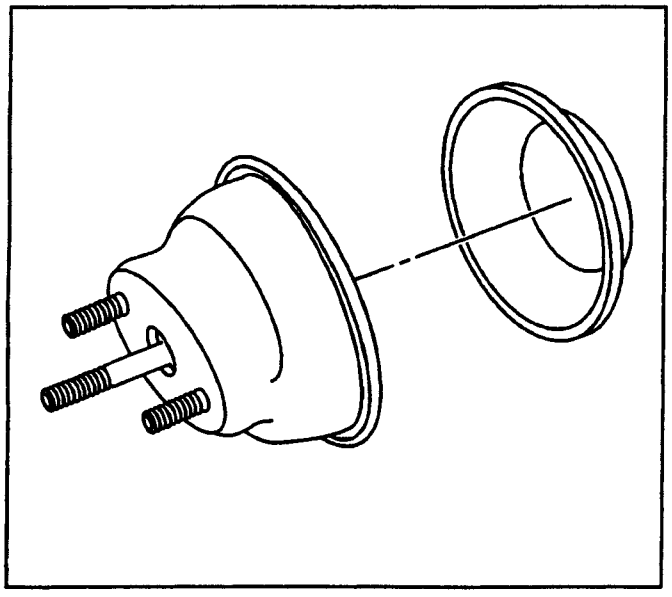
201671

7. Remove the pressure cap.



201669

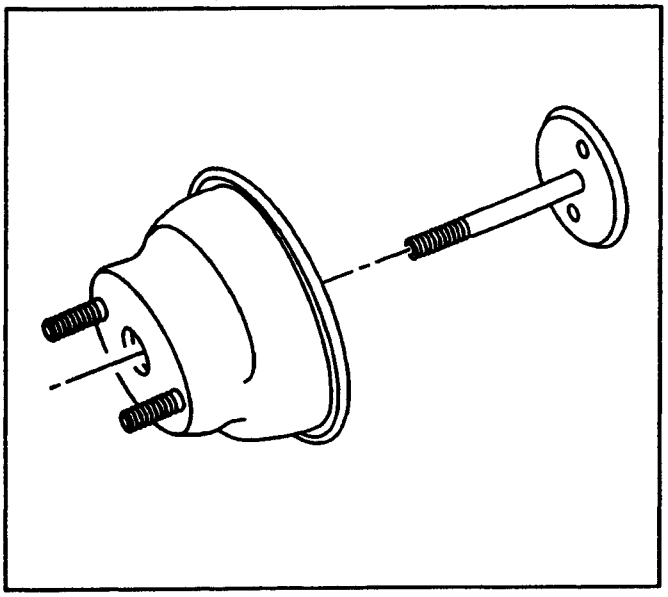
8. Release the locking-type pliers from the pushrod.



201673

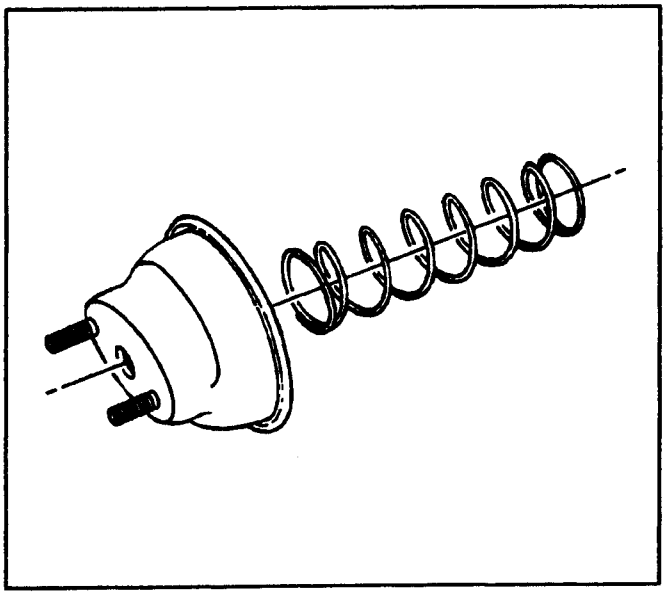
9. Remove the diaphragm.

10. Remove the pushrod.

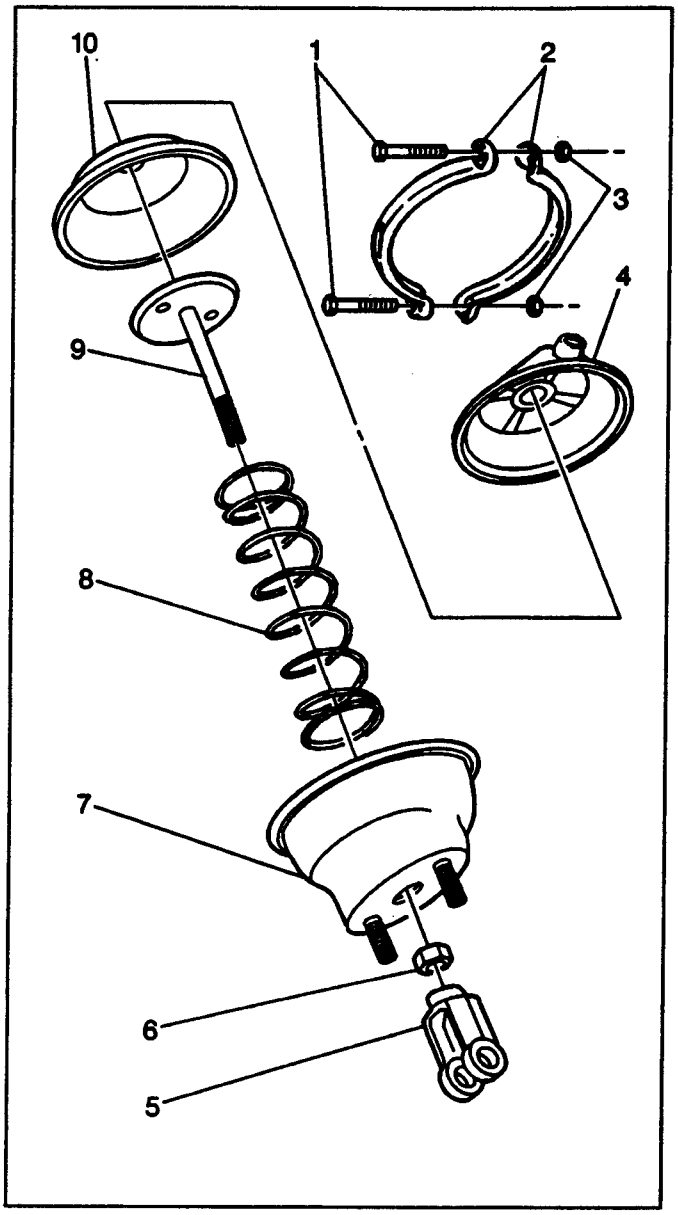


201674

11. Remove the return spring.

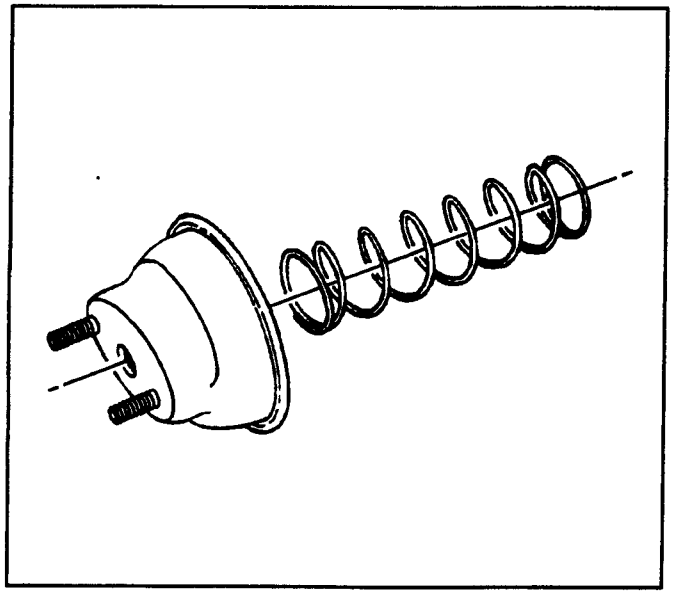


201676



201643

12. Replace all worn and/or damaged parts.
13. Inspect the inside of the chamber assembly (7) for corrosion.
14. Replace the chamber assembly (7) if you find corrosion.
15. Inspect the following components:
    - The return spring (8)
    - The pushrod (9)
    - The clamp ring assembly (2)



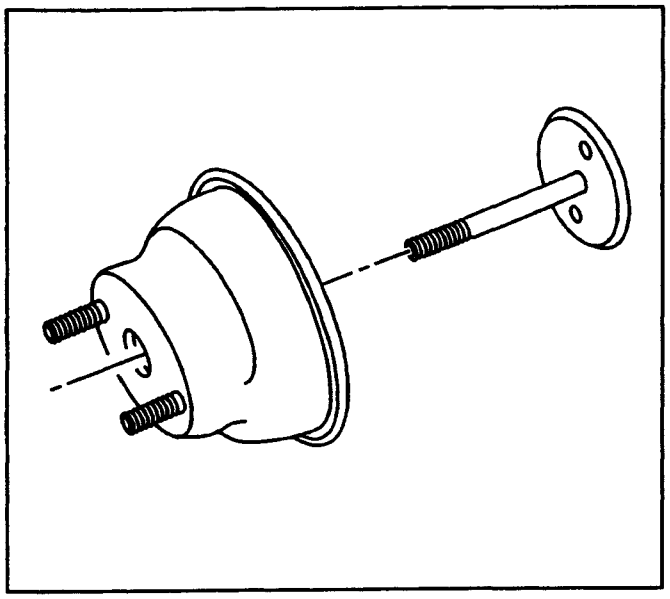
201676

Assembly Procedure

1. Install the return spring into the chamber assembly.

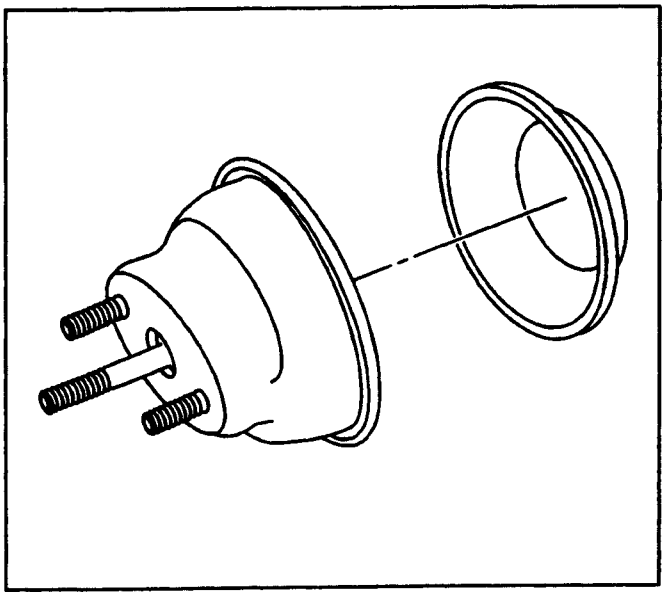
Important: Compress the return spring and clamp the pushrod in place with locking-type pliers.

2. Install the pushrod into the chamber assembly.



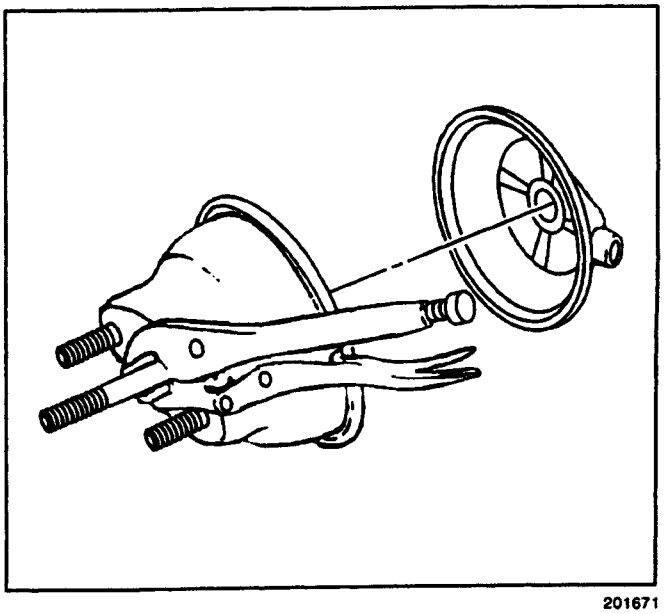
201674

3. Install the diaphragm into the chamber assembly.

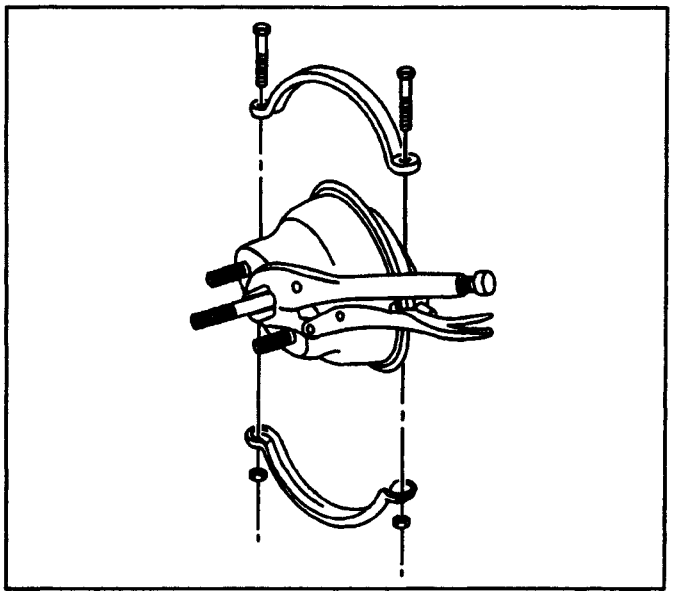


201673

4. Install the pressure cap onto the chamber assembly.

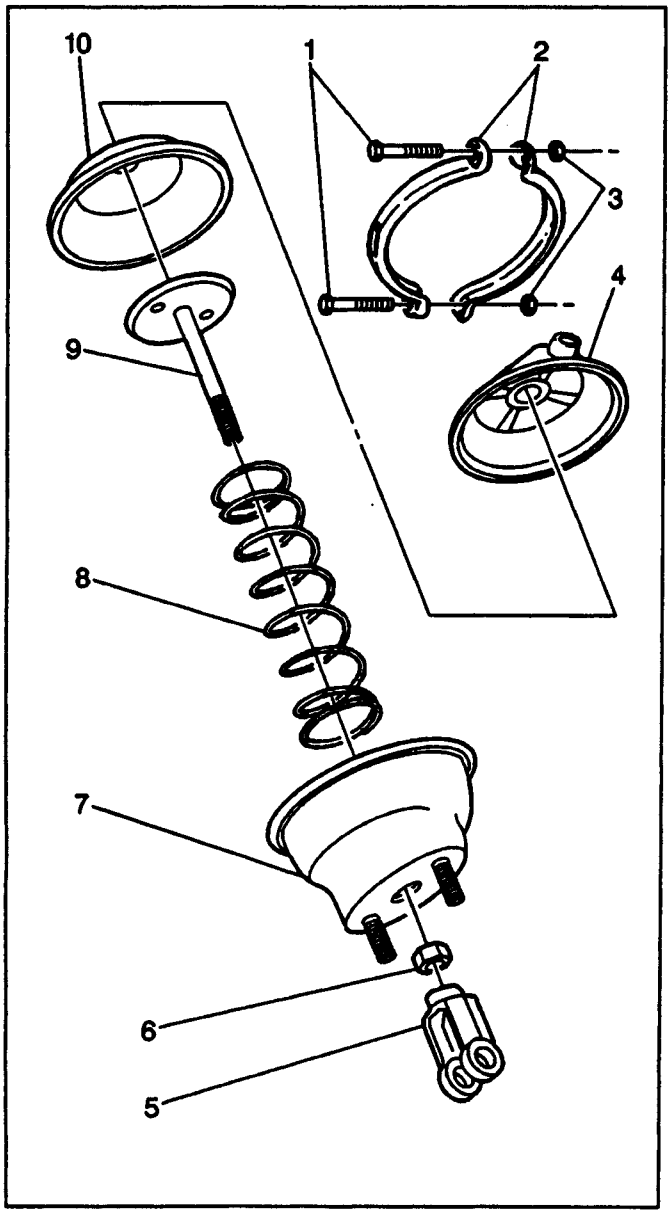


201671



201666

5. Install the clamp ring assembly.

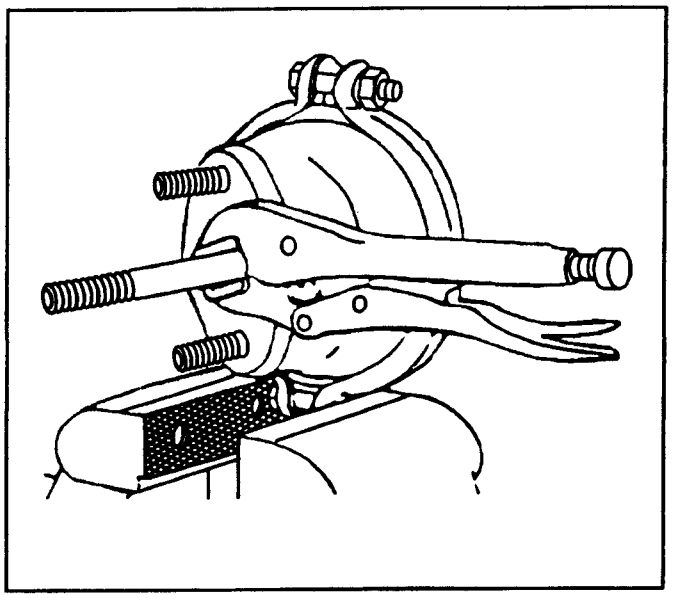


201643

Notice: Refer to *Fastener Notice* in Cautions and Notices.

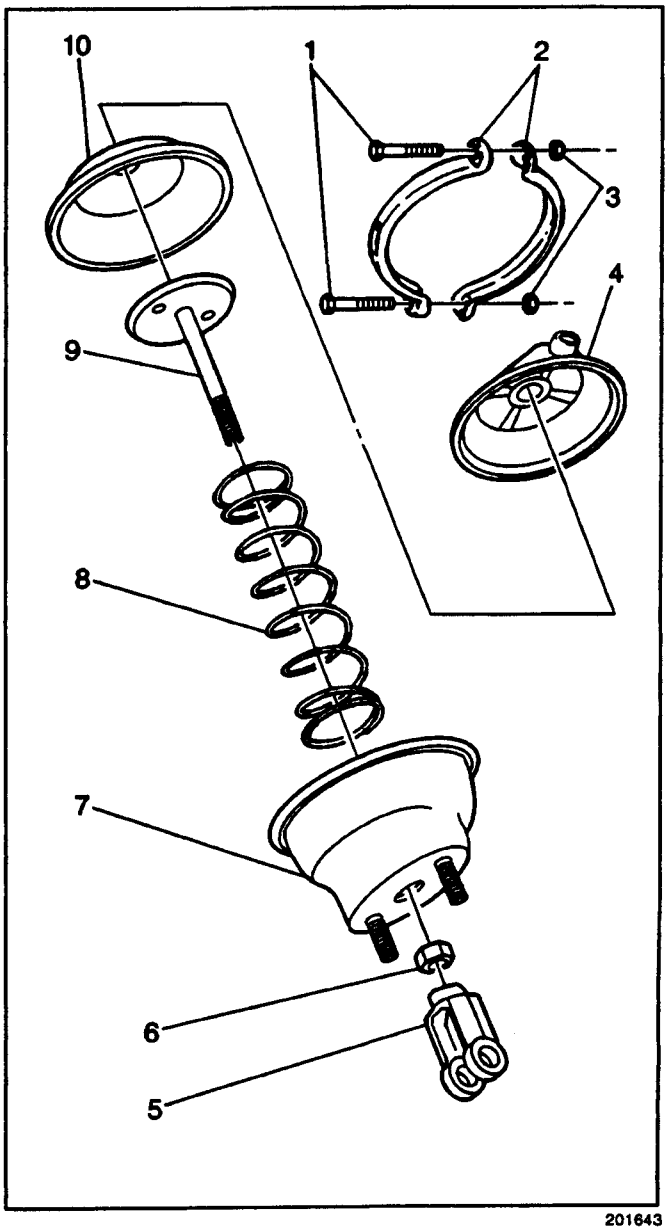
6. Align the marks made during the disassembly.
   Install the bolts (1) and the nuts (3).
   Tighten
   Tighten the nuts to 34 N.m (25 lb ft).

7. Release the locking-type pliers.

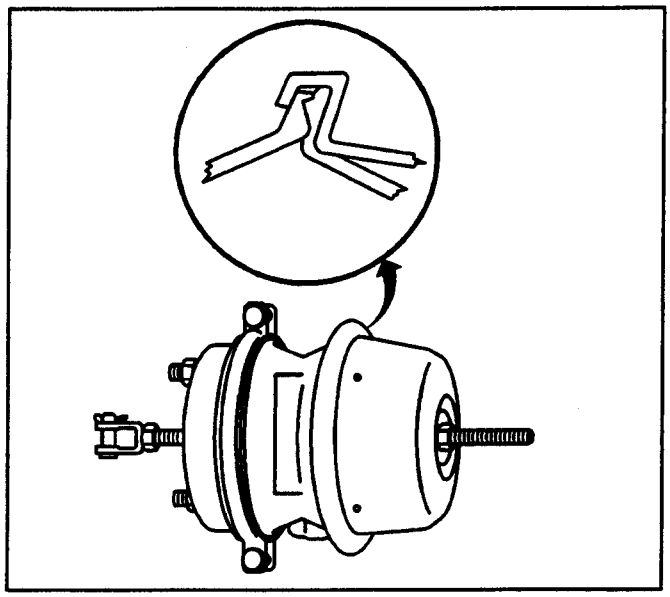


201669

8. Loosely fit the nut and the air brake chamber clevis to the pushrod. Refer to the following procedures:
   - *Air Brake Chamber Clevis Replacement (Rockwell)* or
   - *Air Brake Chamber Clevis Replacement (Eaton).*
9. Install the nut (6) and the air brake chamber clevis (5) to the pushrod (9).



201643

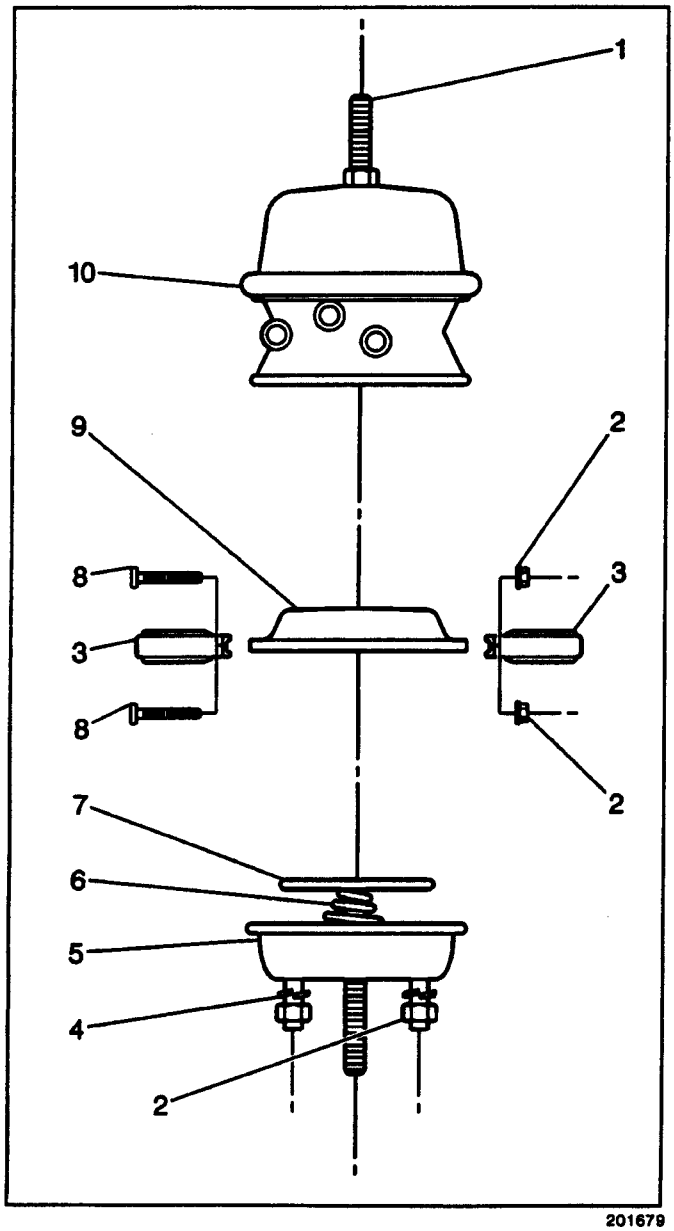


201678

Air Brake Chamber Overhaul (Spring)

Disassembly Procedure

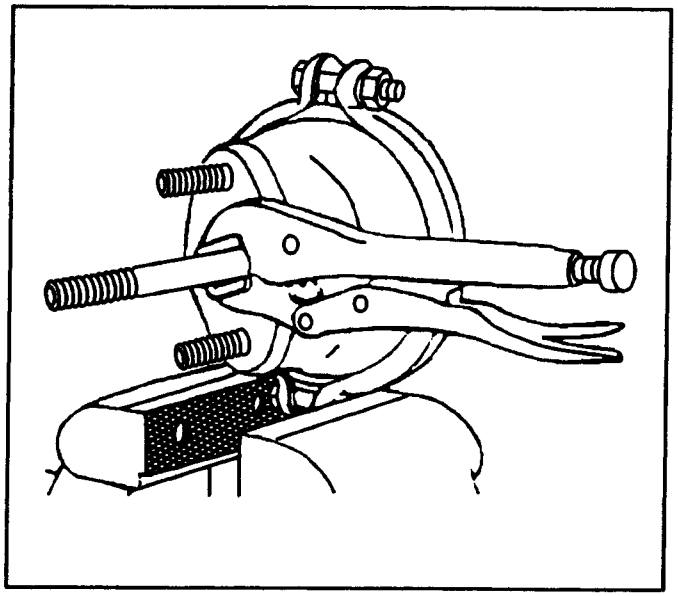
1. The spring brake chamber identification information is located on the adapter housing. The emergency side of the spring brake chamber uses a crimped safety seal and is not serviceable.



201679

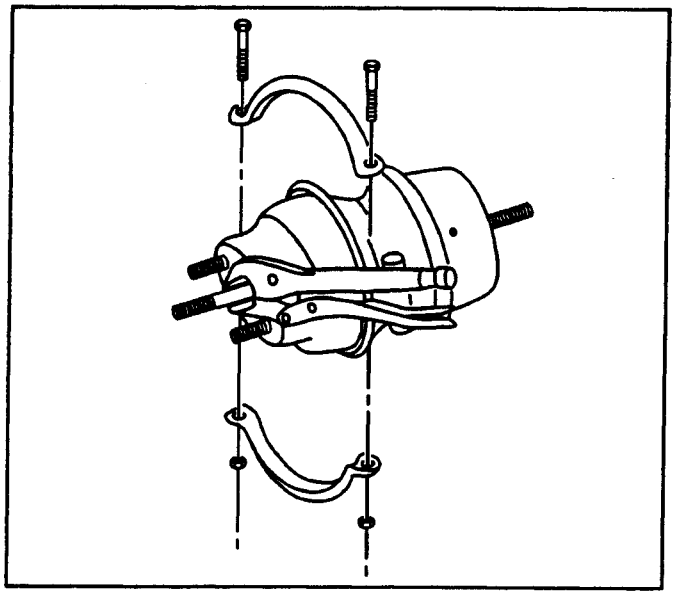
2. Mark the adapter (10) and the service housing (5) in relation to the clamp ring assembly (3).
3. Remove the air brake chamber clevis and the nut (2).

4. Pull out the pushrod and use locking-type pliers to clamp the pushrod.

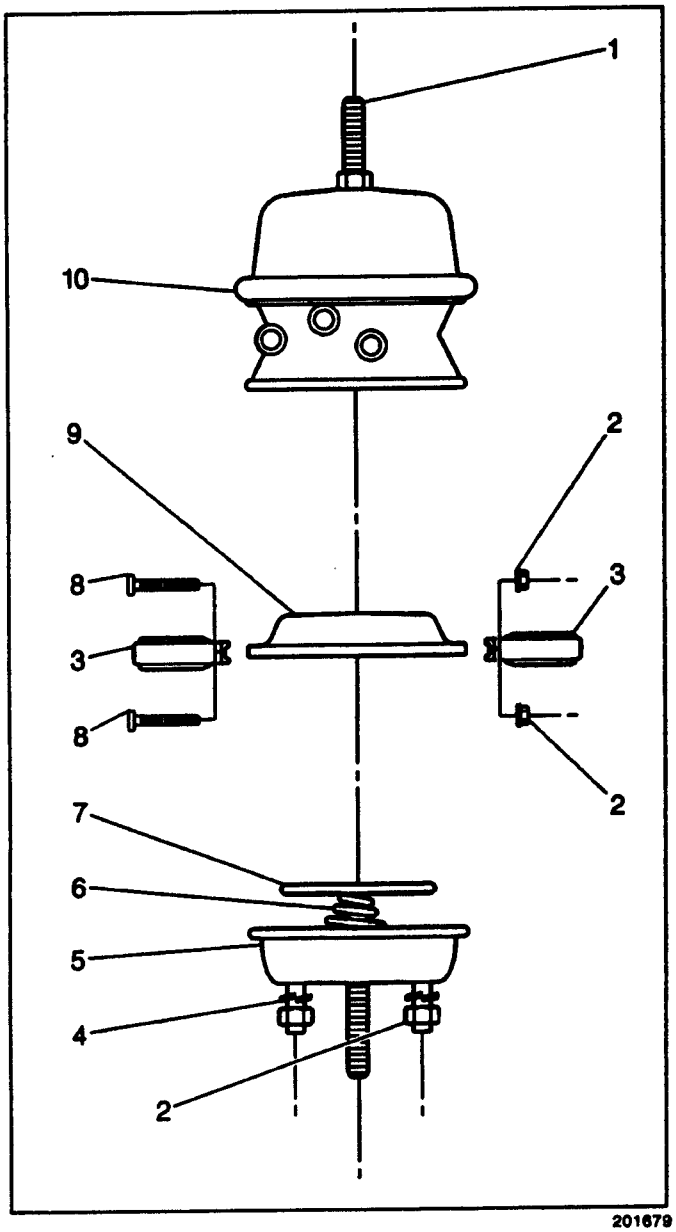


201669

5. Remove the nuts and the bolts.
6. Remove the clamp ring assembly.

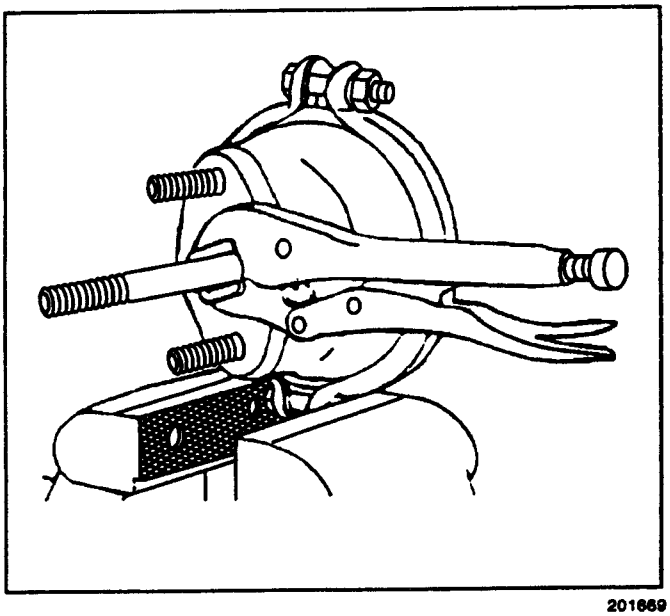


201682



201679

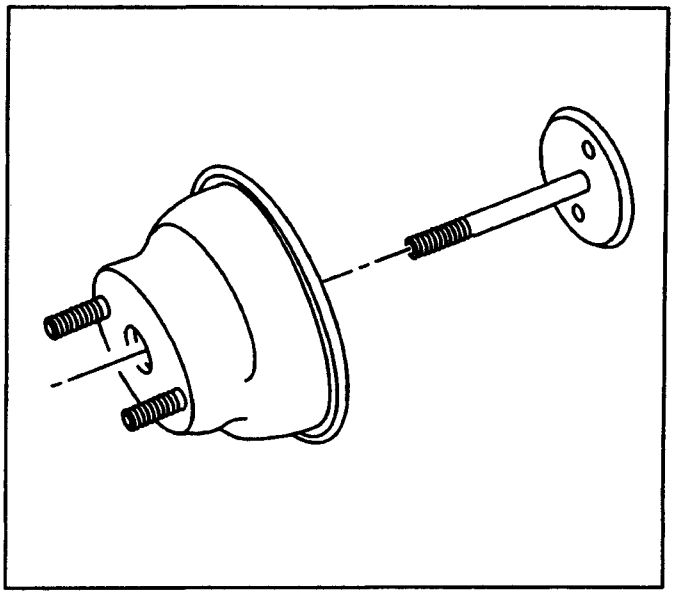
7. Remove the service housing (5) from the adapter (6).



201669

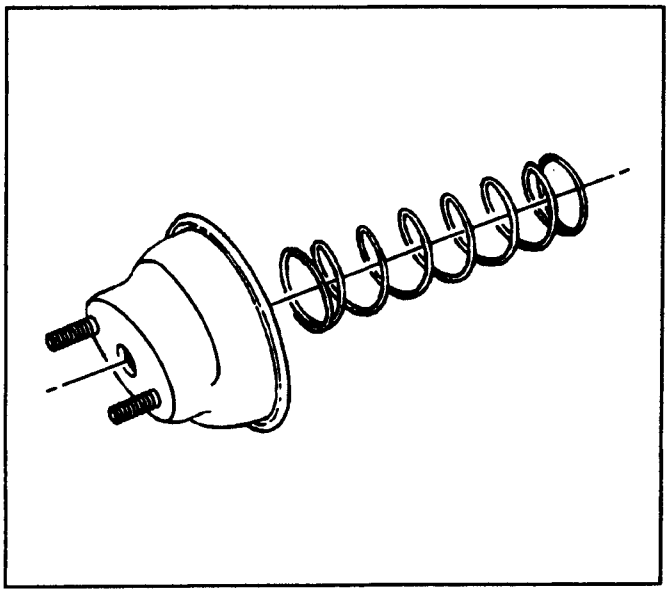
8. Release the locking-type pliers from the pushrod.

9. Remove the pushrod.



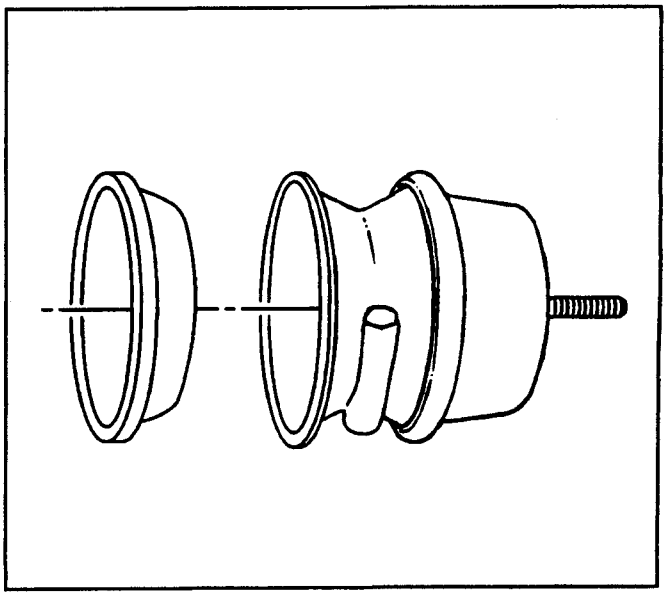
201674

10. Remove the return spring.

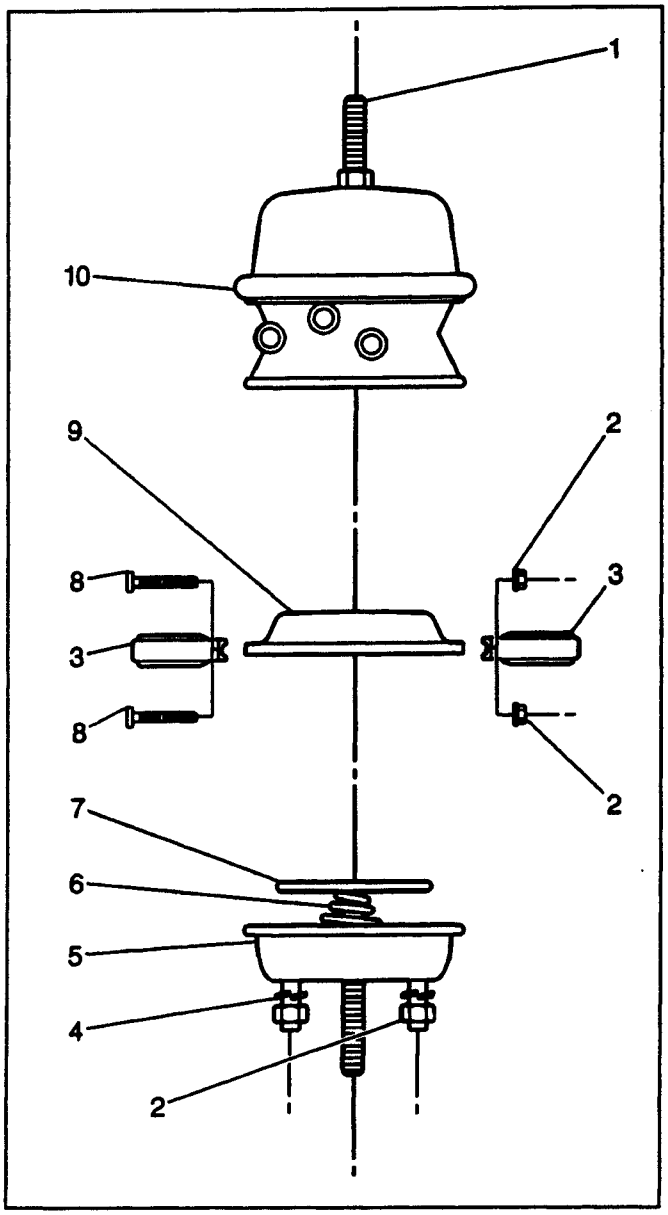


201676

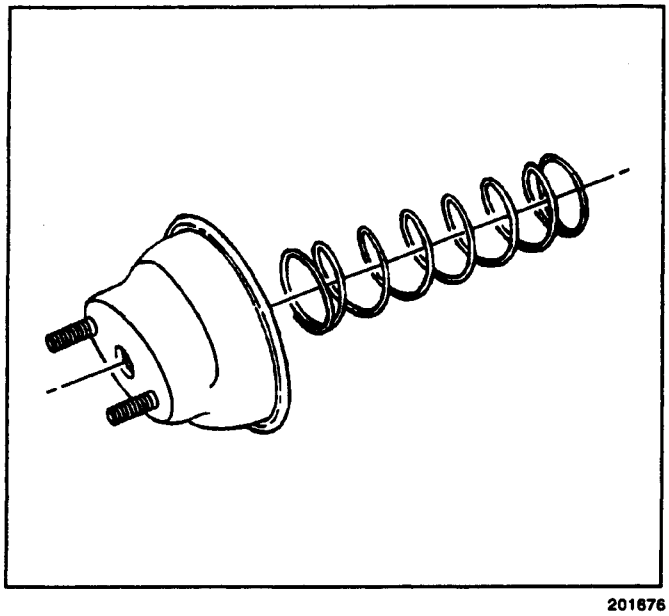
11. Remove the diaphragm from the adapter.



201683



201679



201676

Important: Replace all worn and/or damaged parts.

12. Inspect the inside of the service housing (5) for corrosion.

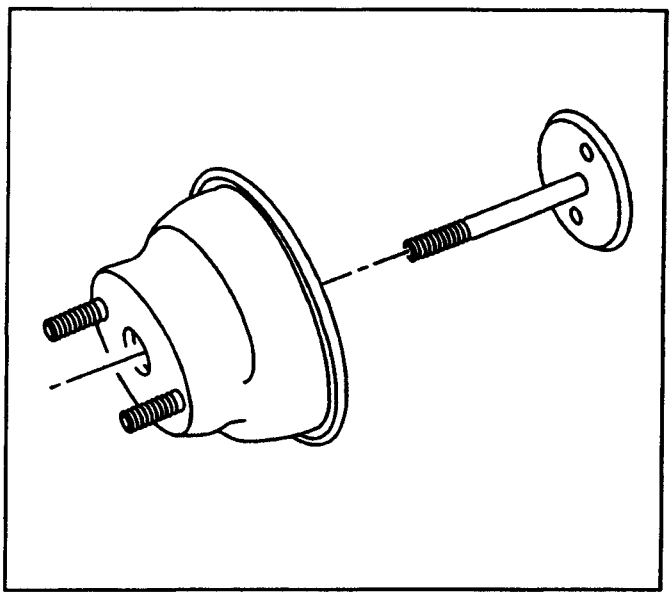
    Replace the service housing (5) if corrosion is found.
13. Inspect the adapter (10) wall and the lip.
14. Inspect the return spring (6).
15. Inspect the pushrod (7).
16. Inspect the clamp ring assembly (3).

Assembly Procedure

1. Install the return spring into the service housing.

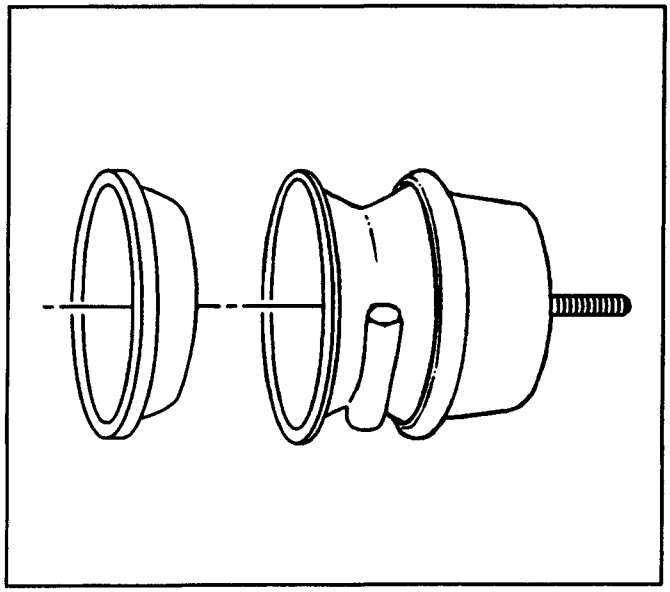
Important: Compress the return spring and clamp the pushrod in place with locking-type pliers.

2. Install the pushrod into the service housing.

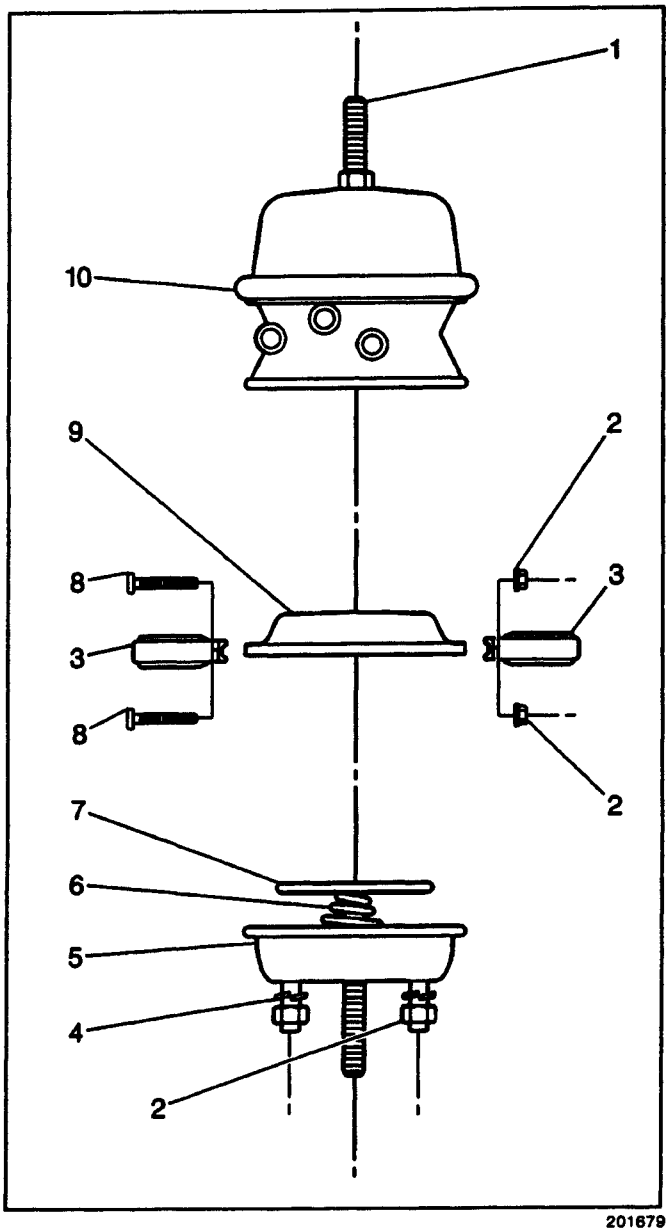


201674

3. Install the diaphragm into the adapter.

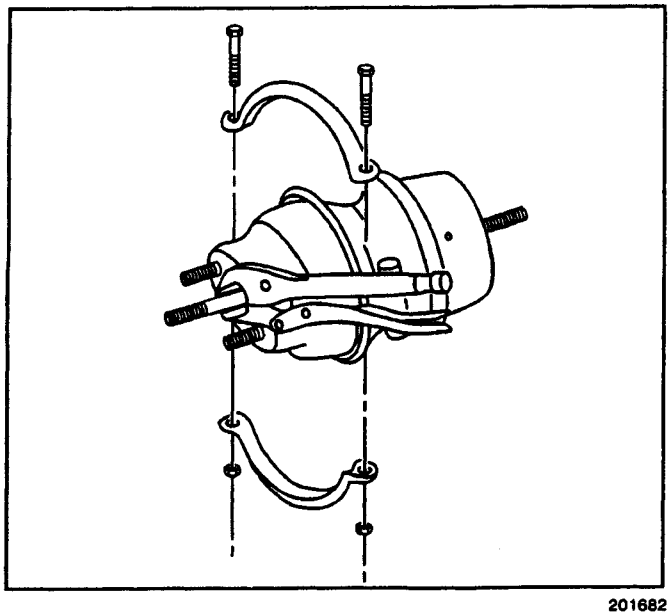


201683



201679

4. Install the service housing (5) onto the adapter (10).



201682

Important: Align the marks made during disassembly.

5. Install the clamp ring assembly.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.

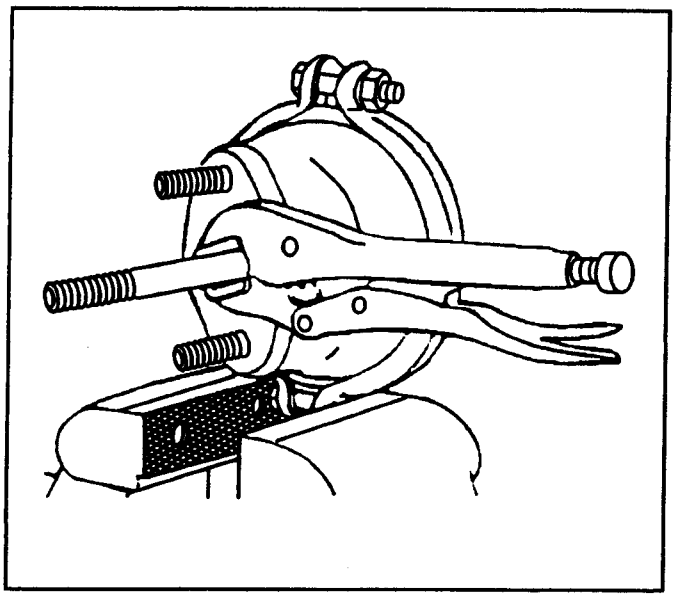
6. Install the bolts and the nuts.

   Tighten

   Tighten the nuts to 34 N.m (25 lb ft).

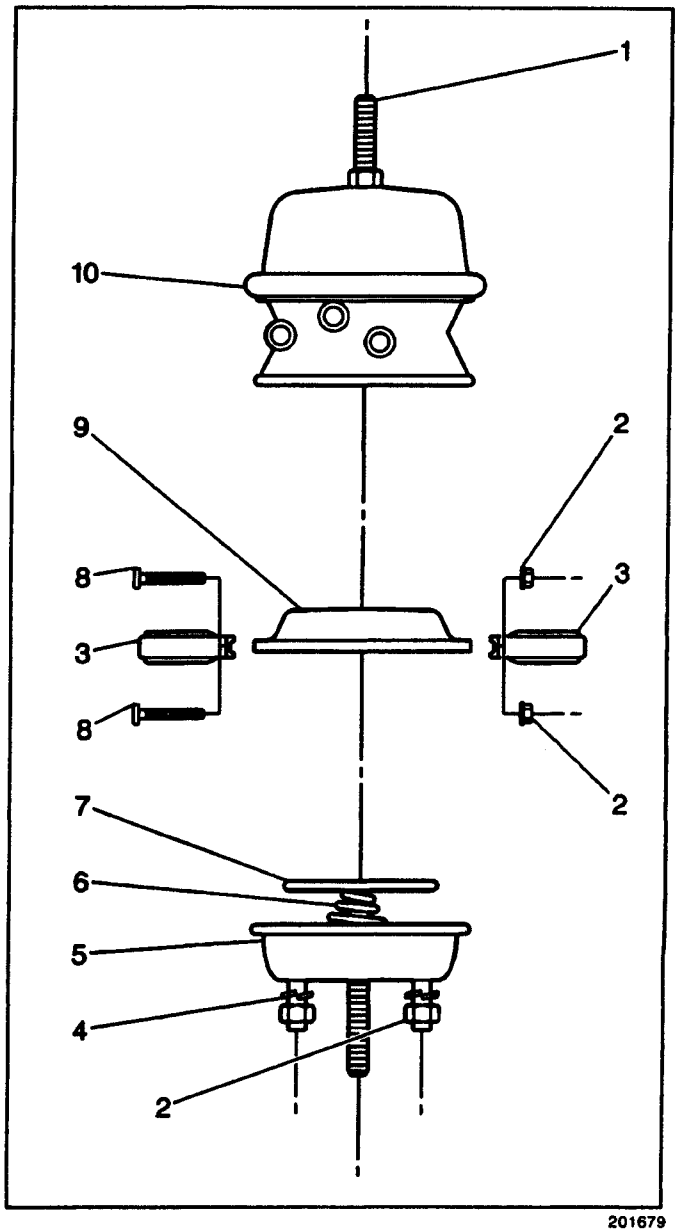
7. Inspect the clamp assembly for proper seating around the adapter and the service housing lip.

8. Release the locking-type pliers.

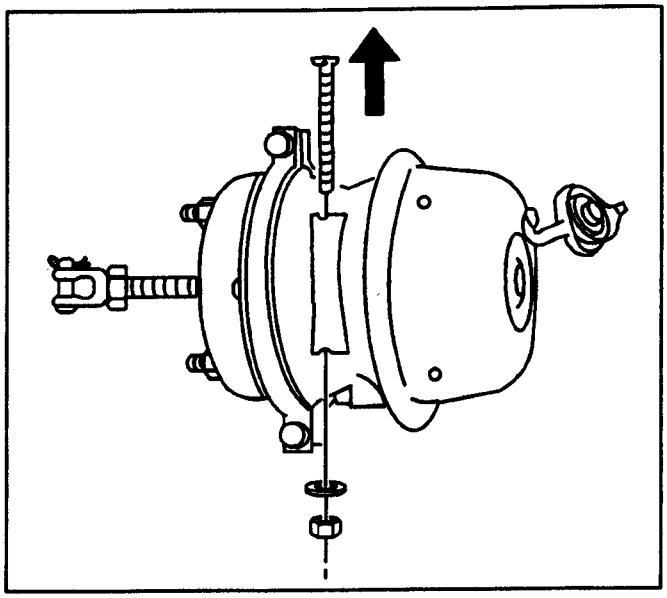


201669

9. Loosely fit the nut and the spring brake chamber clevis to the pushrod. Refer to the following procedures:
   - *Air Brake Chamber Clevis Replacement (Rockwell)* or
   - *Air Brake Chamber Clevis Replacement (Eaton).*
10. Install the nut (2) and the air brake chamber clevis to the pushrod (7).



201679



201893

Caging the Rear Air Brake Chamber

Caging Procedure

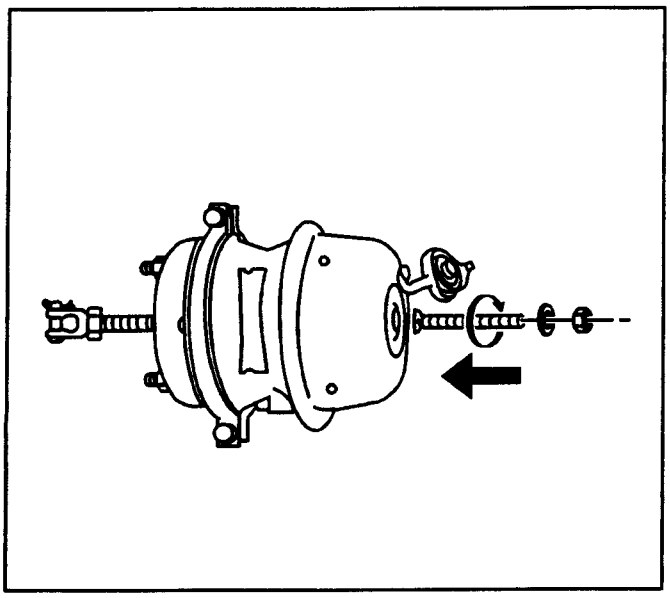
Caution: Do not attempt to cage the compression (power) spring when the rear air brake chamber shows structural damage. Caging the compression spring or disassembly of the spring brake chamber may result in the forceful release of the compression (power) spring and the chamber contents which may cause severe personal injury. Remove the entire rear air brake chamber if it has structural damage and replace with a new rear air brake chamber.

Caution: Do not drive the vehicle with the rear air brake chambers caged. Caging the rear air brake chambers disables the emergency and parking brakes. If a malfunction occurs with the service brakes, serious personal injury could result from not having any emergency brakes.

1. Block the wheels.
2. Start the engine.
3. Charge the system to the air compressor governor valve cut-out point.
4. Stop the engine.

   Important: Do not set the parking brake.
5. Inspect the rear air brake chamber for any structural damage.

   Do not try to cage the compression spring if there is any damage to the rear air brake chamber. Refer to the proper procedure:
6. Remove the dust plug from the release tool keyhole in the center of the rear air brake chamber.



201895

Caution: If air pressure is used to compress the compression spring, do not tighten the release nut more than finger tight. Torquing the release nut too tight may cause pressure plate damage resulting in the sudden release of the compression spring causing severe personal injury.

7. Remove the release tool assembly from the side pocket of the adapter.
8. Cage the rear air brake chambers.
   - 8.1. Insert the release stud through the keyhole in the rear air brake chamber (the spring brake chamber section) into the pressure plate.
   - 8.2. Turn the release stud 90 degrees (1/4 turn) clockwise.
   - 8.3. Pull on the release stud in order to ensure the release stud crosspin is properly seated in the pressure plate.

     Notice: Tighten the release stud nut no more than finger tight if air pressure is used to compress the compression (power) spring.
   - 8.4. Assemble the release stud washer and the nut on the release stud finger tight.

9. Measure the release stud length beyond the release stud nut.
10. Replace the rear air brake chamber if the stud length is less than 69.08 mm (2.72 in). Refer to the proper procedure:
    - Refer to *Air Brake Chamber Replacement (Front)* or
    - Refer to *Air Brake Chamber Replacement (Rear).*

    Caution: Do not torque the release stud more than the torque specified when caging the compression spring. If the specified release stud length cannot be obtained at the maximum allowed torque, there may be a broken compression spring. Do not attempt to disassemble any part of the spring brake chamber if the spring is broken. Replace the rear air brake chamber. Failure to observe this caution may result in sever personal injury.

    Notice: Do not use an impact wrench to tighten the release nut. Damage to the pressure plate and release stud can occur.

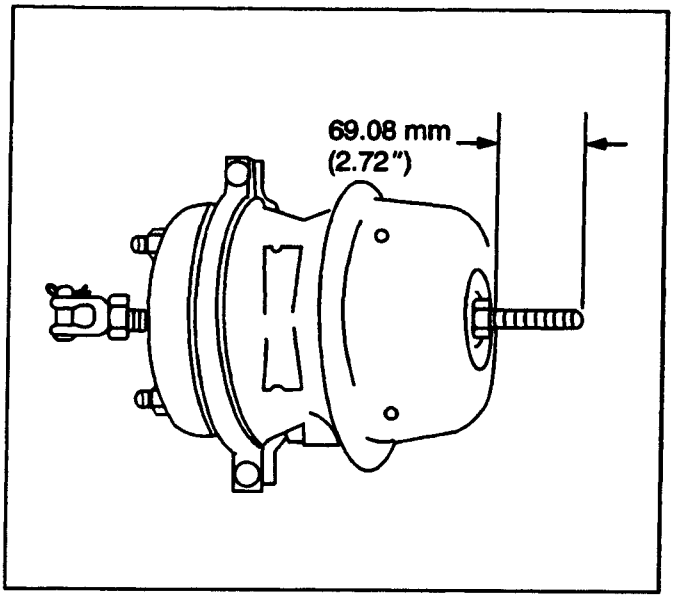
    Notice: Use the correct fastener in the correct location. Replacement fasteners must be the correct part number for that application. Fasteners requiring replacement or fasteners requiring the use of thread locking compound or sealant are identified in the service procedure. Do not use paints, lubricants, or corrosion inhibitors on fasteners or fastener joint surfaces unless specified. These coatings affect fastener torque and joint clamping force and may damage the fastener. Use the correct tightening sequence and specifications when installing fasteners in order to avoid damage to parts and systems.

    Important: Tighten the release stud nut only if the rear air brake chamber (spring brake chamber section) is not pressurized.
11. Tighten the release stud nut.

    Use a hand wrench with the air pressure exhausted from the rear air brake chamber (spring brake chamber section).

    Tighten

    Tighten the release stud nut to a maximum of 47 N.m (35 lb ft).
12. Ensure that the pushrod is retracting.
13. Ensure that the compression spring is completely caged.
14. Measure the release stud length beyond the release stud nut.
15. Replace the rear air brake chamber if the stud length is less than 69.08 mm (2.72 in). Refer to the proper procedure:
    - Refer to *Air Brake Chamber Replacement (Front)* or
    - Refer to *Air Brake Chamber Replacement (Rear).*



201898

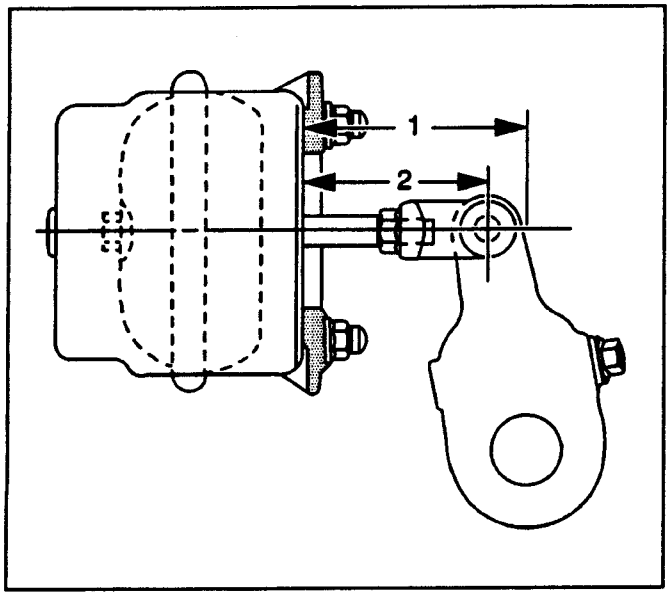
Uncaging Procedure

1. Unscrew the release stud nut and the washer from the release stud until the compression (power) spring pressure is completely relieved.
2. Turn the release stud 1/4 turn counterclockwise.
3. Remove the release stud from the keyhole in the rear air brake chamber.
4. Install the dust plug into the keyhole in the rear air brake chamber.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
5. Return the following components to the adapter storage pocket:
   - The release stud
   - The release stud nut
   - The washer

   Tighten

   Tighten the release stud nut to 7 N.m (62 lb in).
6. Start the engine.
7. Charge the system to the air compressor governor valve cut-out point.
8. Stop the engine.
9. Check for proper brake operation.
10. Set the parking brake.
11. Remove the wheel blocks.



201922

Air Drum Brake Adjustment (Pushrod Stroke Measurement)

Refer to *Maintenance Schedule* in Maintenance and Lubrication.

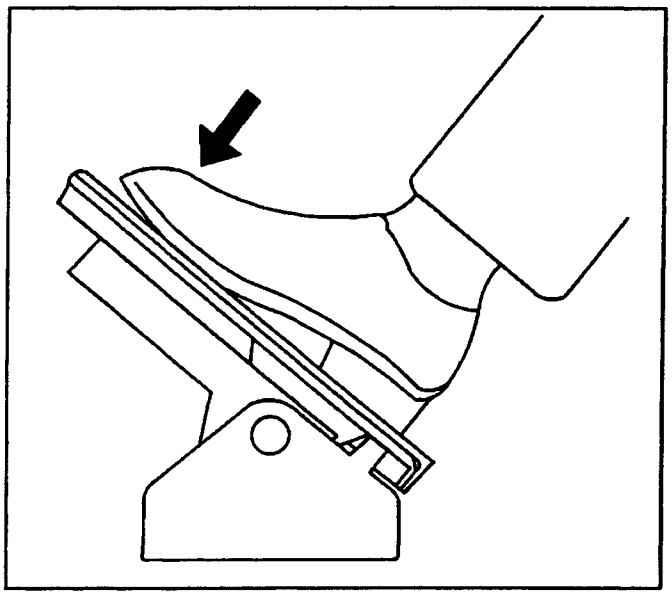
Measure the pushrod stroke in order to determine if the brakes are acceptably adjusted. The pushrod travel should be less than the maximum allowable stroke listed in the Dimensional Specifications Table. Refer to *Air Drum Brake Component Specifications (Dimensional)*.

Pushrod Stroke Measurement

The stroke is the difference between the released air brake automatic slack adjuster position and the applied air brake automatic slack adjuster position. The applied position must be measured at 550–620 kPa (80–90 psi) air pressure in the brake chamber assemblies when the brakes are fully applied.

1. Start the engine to increase the air pressure to 690 kPa (100 psi) if necessary.
2. Stop the engine.
3. Apply and release the brakes to decrease the air pressure to 690 kPa (100 psi) if necessary.

4. Check the duel air pressure gauge in order to ensure that the air pressure in the air reservoirs is 690 kPa (100 psi) with the engine off and that the rear air brake chambers (spring brake chamber section) is released.
5. Measure the distance between the brake chamber assembly mounting surface and the center of the air brake chamber clevis pin on all of the brakes.
6. Have an assistant apply and hold one full brake application.
7. Measure the distance between the brake chamber assembly mounting surface and the center of the air brake chamber clevis pin on all of the brakes with the brakes applied at 550–620 kPa (80–90 psi).
8. Release the brakes.
9. Calculate the adjusted air brake chamber stroke at each brake.
   - 9.1. Subtract the dimension in measurement number 1 from the dimension in measurement number 2.
   - 9.2. The difference between the two dimensions is the adjusted air brake chamber stroke. The adjusted air brake chamber stroke must not be greater than the stroke length shown in the Dimensional Specifications Table. Refer to *Air Drum Brake Component Specifications (Dimensional).*
   - 9.3. Adjust the brakes if the pushrod stroke is greater than the specifications. Refer to *Air Drum Brake Adjustment (Normal Wear Adjustment).*

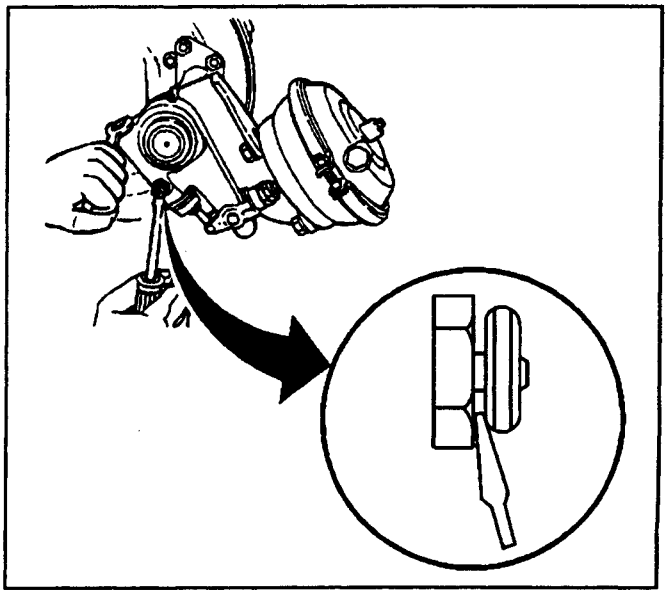


220963

Air Drum Brake Adjustment (Normal Wear Adjustment)

Air Brake Automatic Slack Adjuster (Rockwell)

1. Block the wheels.
2. Cage the rear air brake chambers. Refer to *Caging the Rear Air Brake Chamber.*
3. Raise the vehicle and support the vehicle with safety stands. Refer to *Lifting and Jacking the Vehicle* in General Information.
4. Adjust the brakes.
   - 4.1. Disengage the pawl assembly with a screwdriver.
   - 4.2. Turn the slack adjuster adjusting nut until the brake linings contact the brake drum.
   - 4.3. Rotate the slack adjuster adjusting nut 180 degrees (1/2 turn).
5. Release the pawl.
6. Measure the air brake chamber pushrod stroke. Refer to *Air Drum Brake Adjustment (Pushrod Stroke Measurement).*
7. Repeat step 4 and step 5 on each wheel until all of the brakes have been adjusted.
8. Lower the vehicle.



201765

9. Uncage the rear air brake chambers. Refer to *Caging the Rear Air Brake Chamber.*
10. Check for proper brake operation.
11. Set the parking brake.
12. Remove the wheel blocks.

Air Brake Automatic Slack Adjuster (Eaton)

1. Block the wheels.
2. Cage the rear air brake chambers. Refer to *Caging the Rear Air Brake Chamber.*
3. Raise the vehicle and support the vehicle with safety stands. Refer to *Lifting and Jacking the Vehicle* in General Information.
4. Turn the slack adjuster adjusting hex clockwise until the brake linings contact the brake drum.
5. Rotate the slack adjuster adjusting hex counterclockwise 180 degrees (1/2 turn).

   A minimum of 17.62 N.m (13 lb ft) is necessary in order to overcome the clutch. You will hear a racheting sound.
6. Measure the air brake chamber pushrod stroke. Refer to *Air Drum Brake Adjustment (Pushrod Stroke Measurement).*
7. Repeat Steps 4–6 on each wheel until all of the brakes have been adjusted.
8. Lower the vehicle.
9. Uncage the rear air brake chambers. Refer to *Caging the Rear Air Brake Chamber.*
10. Check for proper brake operation.
11. Set the parking brake.
12. Remove the wheel blocks.

Description and Operation

Air Drum Brakes System Description

This section covers the brake parts located at the wheels. For information on other air brake system components refer to Air Brakes or Air Compressor Brakes.

The air foundation brake assembly consists of the following components:

- The service brake chamber assembly
- The spring brake chamber assembly
- The slack adjuster
- The camshaft brake assembly
- The brake drum

Air Compressor

Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Air Inlet Pipe Bracket Nut	52 N.m	38 lb ft
Air Inlet Pipe Nut	63 N.m	46 lb ft
Air Compressor Mounting Bolt	73 N.m	54 lb ft
Air Compressor Mounting Nut	73 N.m	54 lb ft
Coolant Inlet Line Eye Bolt	41 N.m	30 lb ft
Coolant Outlet Line Eye Bolt	41 N.m	30 lb ft
Crankshaft Bearing Cover Bolt	8 N.m	71 lb in
Cylinder Body to Crankcase Bolt	29 N.m	21 lb ft
Cylinder Head to Cylinder Body Bolt	49 N.m	36 lb ft
Discharge Line Eye Bolt	63 N.m	46 lb ft
Governor Line Eye Bolt	41 N.m	30 lb ft
Governor Mounting Nut	22 N.m	16 lb ft
Oil Line Eye Bolt	30 N.m	22 lb ft

Air Compressor Mechanical Specifications

Application	Specification	
	Metric	English
Piston and Cylinder Bore	0.20 mm	0.008 in
Piston Pin and Piston Pin Hole	0.10 mm	0.004 in
Piston Ring Grooves and Piston Rings	0.15 mm	0.0059 in
Piston Ring Gap	1.00 mm	0.039 in
Piston Pin and Connecting Rod	0.10 mm	0.004 in
Crankshaft Journal and Connecting Rod	0.15 mm	0.0059 in

Air Compressor Gov Valve Adjustment Specifications

Application	Specification	
	Metric	English
Cut-in Pressure	725 kPa	105 psi
Cut-out Pressure	860 kPa	125 psi

Diagnostic Information and Procedures

Air Compressor Diagnosis (Air Compressor Not Unloading)

Problem	Action
The inlet valve plunger is damaged.	Replace any faulty parts.
There are intake cavity restrictions.	Remove the restrictions. Clean the cavity.
The governor is malfunctioning.	Overhaul or replace the governor. Refer to *Air Compressor Governor Valve Replacement.*
The unloader line or the cavity to the governor is restricted.	Remove the restriction.
The unloader mechanism is binding or sticking.	Overhaul or replace the cylinder head assembly. Refer to *Air Compressor Overhaul (Disassembly/Assembly).*

Air Compressor Diagnosis (Air Compressor Not Unloading)

Problem	Action
There is a restriction in the cylinder head or in the compressor.	Remove the restriction or clean the cylinder head and the discharge line.
The bearings are worn or burned out.	Replace the bearings.
The air compressor is not getting the proper lubrication.	Check the engine lubrication system and the oil supply hose. Repair or replace as necessary.
The air compressor is excessively worn.	Replace the air compressor. Refer to *Air Compressor Replacement.*

Air Compressor Diagnosis (Air Compressor Not Unloading)

Problem	Action
There is a restriction in the air compressor cylinder head intake cavities, the discharge cavities or in the discharge pipe.	Remove the restriction or clean the components.
There are leaking or broken discharge valves.	Replace the cylinder head assembly.
The air compressor is excessively worn.	Overhaul or replace the air compressor. Refer to *Air Compressor Overhaul (Disassembly/Assembly)* or *Air Compressor Replacement.*
The inlet valve is stuck open.	Replace the cylinder head assembly.
The inlet valves are worn.	Replace the cylinder head assembly.
There is excessive leakage in the system.	Check the system and repair as needed.

Air Compressor Diagnosis (Air Compressor Not Unloading)

Problem	Action
The governor is out of adjustment.	Adjust the governor. Refer to *Air Compressor Governor Valve Adjustment.*
The governor leaks.	Overhaul or replace the governor. Refer to *Air Compressor Governor Valve Replacement.*
The air compressor leaks.	Check the fittings, the bolts and the mating surfaces. Tighten or repair as needed.
The unloader is not functioning.	Overhaul the cylinder head assembly.
The governor is faulty.	Overhaul or replace the governor. Refer to *Air Compressor Governor Valve Replacement* or *Air Compressor Overhaul (Disassembly/Assembly).*

Air Compressor Diagnosis (Air Compressor Not Unloading)

Problem	Action
The air compressor is excessively worn.	Repair or replace the air compressor. Refer to *Air Compressor Replacement.*
The vacuum inlet is high.	Clean or repair the air compressor as necessary. Refer to *Air Compressor Replacement.*
The oil return line is small.	Install the proper size line.
There is excessive oil pressure.	Determine the cause of the condition and repair the condition.
The oil supply line to the air compressor is flooded.	Determine the cause of the condition. Repair the condition.
The oil seal rings in the crankcase cover are damaged.	Replace the seals.
The piston ring is not properly installed.	Install the piston ring properly.
There is back pressure from the engine crankcase.	Determine the cause of the pressure and repair the cause of the pressure.

Air Compressor and Governor Valve Diagnosis

Operation Test

1. Install a test gauge in the air compressor discharge line.
2. Start the engine and build up air pressure.
3. Check the reading on the test gauge when the air compressor cuts out.

   Compare the reading with the governor cut-out specification. Refer to *Air Compressor Gov Valve Adjustment Specifications.*
4. Slowly reduce the air pressure in the system.

   This is done by applying and releasing the brakes while the engine is running.
5. Check the reading on the test gauge when the air compressor cuts in.

   Compare the reading with the governor cut-in specification. Refer to *Air Compressor Gov Valve Adjustment Specifications.*
6. Adjust the governor if the cut-in or cut-out pressures are not within the specifications. Refer to *Air Compressor Gov Valve Adjustment Specifications.*

Leak Test

Run leakage tests on the Bendix® D-2 governor in both the cut-in and the cut-out positions.

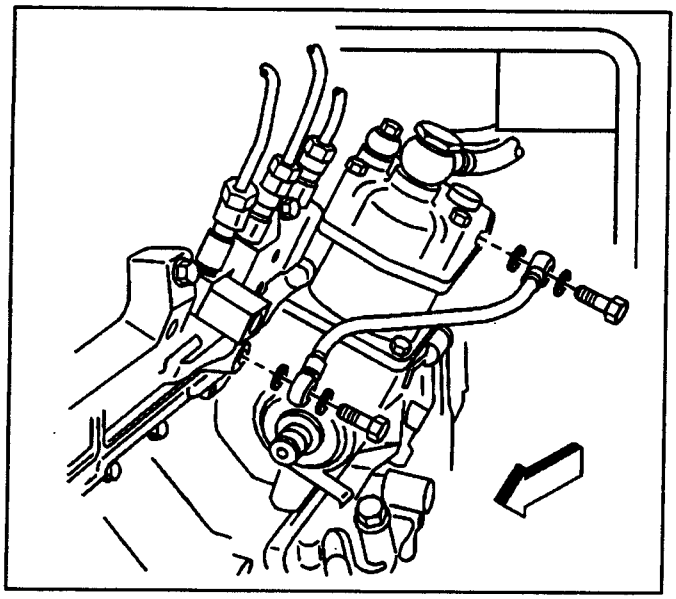
Cut-in Position

Apply a soap solution around the cover and the exhaust port. A slight bubble leakage is permitted. Excessive leakage indicates a faulty exhaust valve seat, exhaust stem O-ring, or O-ring at the top of the piston.

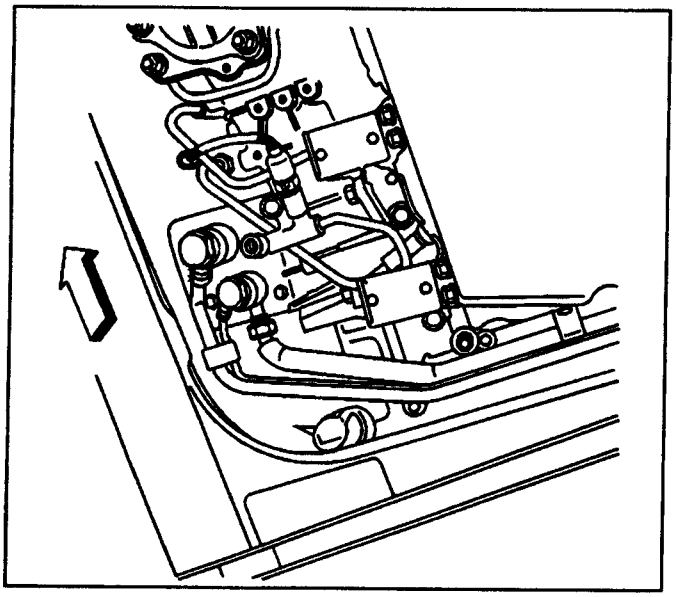
Cut-out Position

Apply a soap solution around the cover and to the exhaust port. A slight bubble leakage is permitted. Excessive leakage indicates a faulty exhaust valve seat, exhaust stem O-ring, or O-ring at the top of the piston.

If the governor does not function as described or if the leakage is excessive, overhaul or replace the governor. Refer to *Air Compressor Governor Valve Replacement.*



294385



294399

Repair Instructions

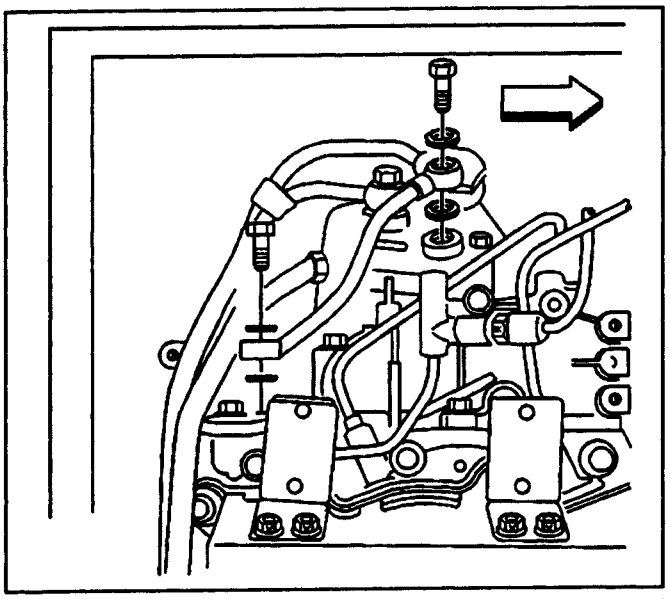
Air Compressor Replacement

Removal Procedure

1. Set the parking brake.
2. Block the vehicle wheels.
3. Tilt the cab. Refer to *Cab Tilting* in General Information.
4. Drain all of the air reservoirs. Refer to *Draining Reservoirs* in Air Brakes.
5. Drain the coolant to below the level of the air compressor. Refer to *Draining and Filling Cooling System (Draining)* in Engine Cooling.

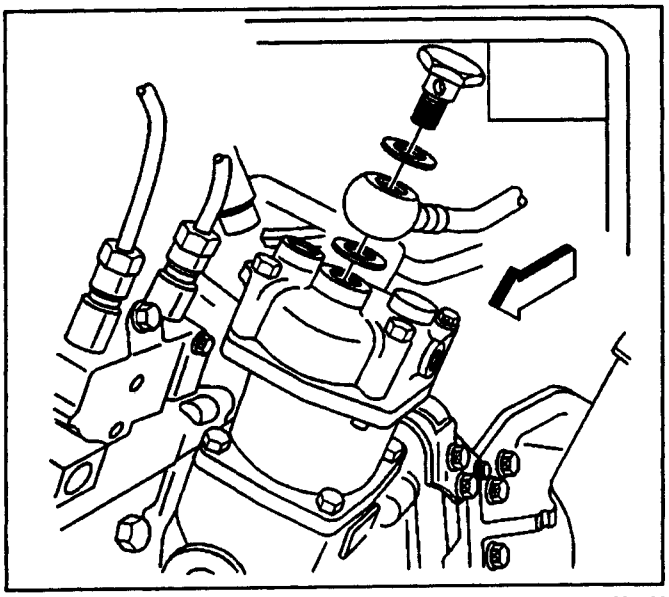
   Caution: Refer to Battery Disconnect Caution in Cautions and Notices.
6. Disconnect the negative battery cable.
7. Remove the fuel injector pump. Refer to the ISUZU service manual for this procedure.
8. Remove the coolant return pipe eye bolt, two gaskets connecting coolant return pipe to the air compressor. Discard all of the gaskets.
9. Disconnect the air inlet pipe at the air compressor.

10. Remove the two coolant inlet pipe eye bolts, four gaskets and the coolant inlet pipe from the air compressor and the engine. Discard all of the gaskets.



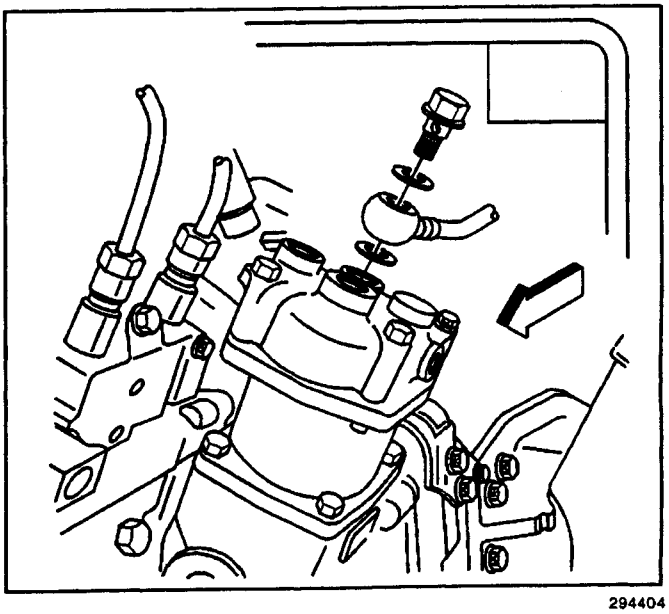
294400

11. Remove the discharge pipe eye bolt, two gaskets connecting discharge pipe to the air compressor. Discard all of the gaskets.

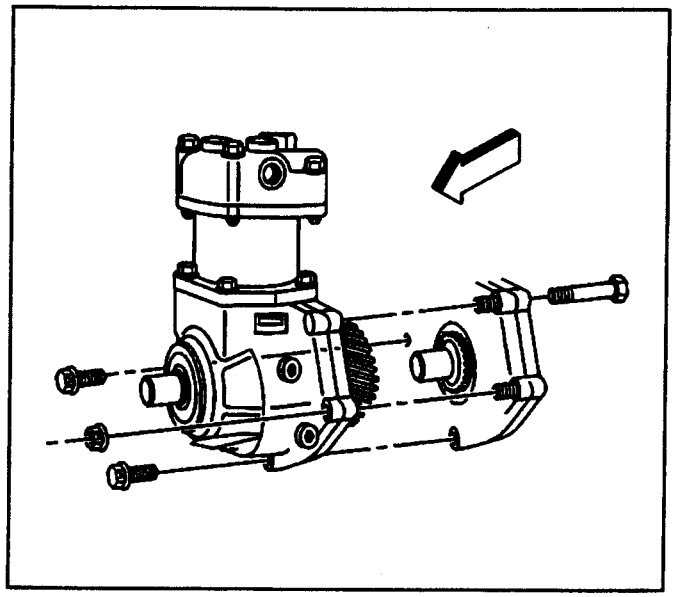


294403

12. Remove the governor pipe eye bolt, two gaskets connecting the governor pipe to the air compressor. Discard all of the gaskets.

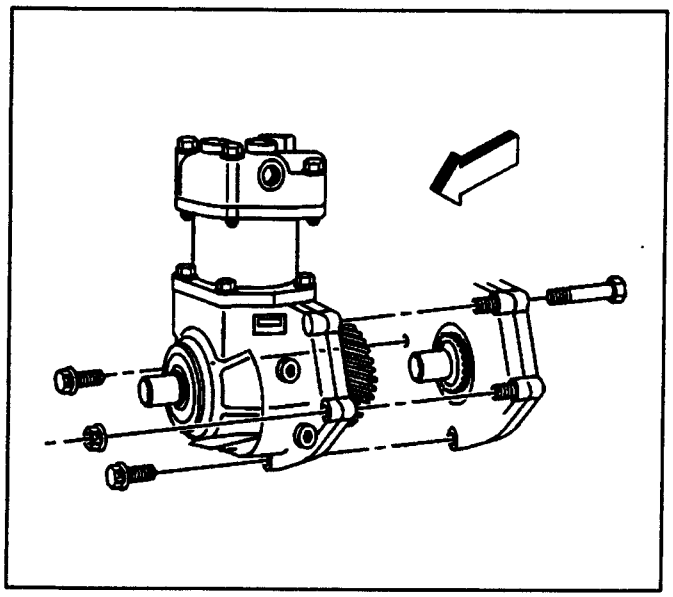


294404



294406

13. Remove the mounting bolts and the nut.
14. Remove the air compressor.
15. Remove the air compressor O-ring seal. Discard the O-ring.
16. Clean the exterior of the air compressor.
17. Clean any corroded lines.
18. Check for cracks on the following parts:
    - The air compressor crankcase
    - The mounting bosses
19. Ensure that the air compressor is in good condition and is not excessively worn.



294406

Installation Procedure

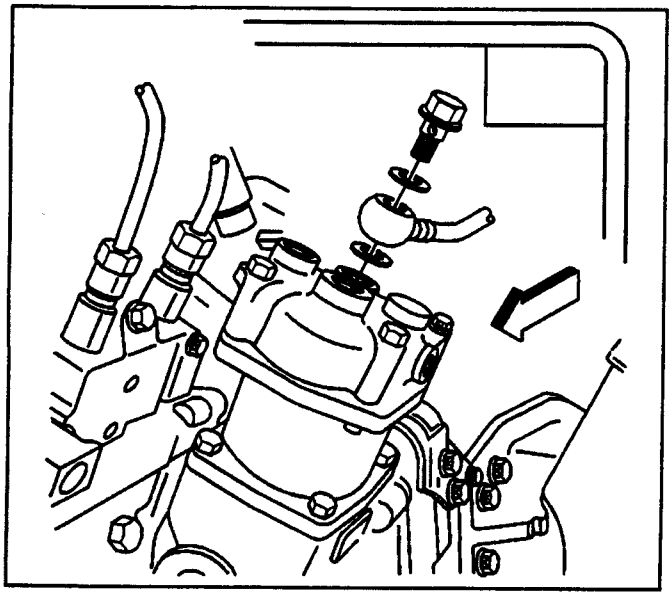
1. Install a new air compressor O-ring seal.
2. Install the air compressor.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
3. Install the mounting bolts and the nut.

   Tighten

   3.1. Tighten the bolt to 57 N.m (42 lb ft).

   3.2. Tighten the nut to 71 N.m (52 lb ft).



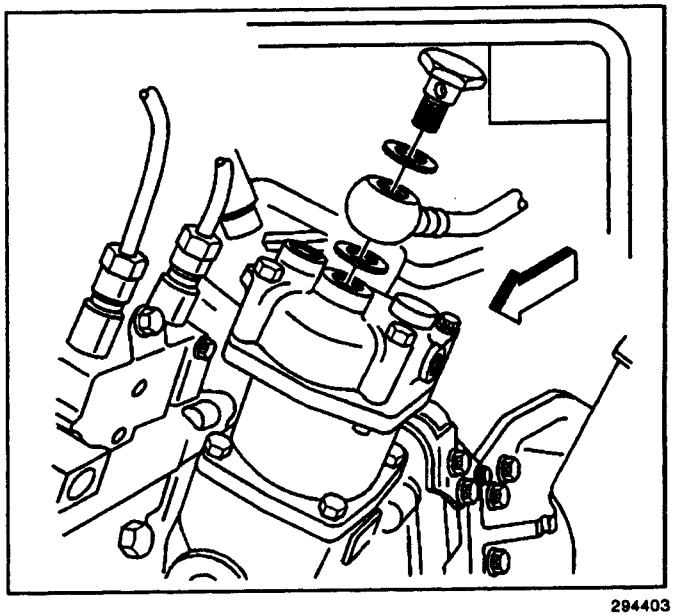
294404

4. Install the governor pipe at the air compressor using the governor pipe eye bolt and two new gaskets.

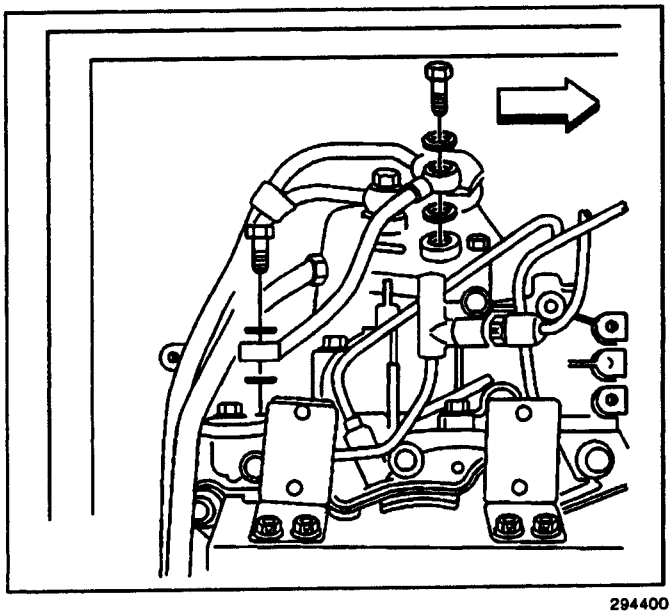
   Tighten

   Tighten the governor pipe eye bolt to 41 N.m (30 lb ft).

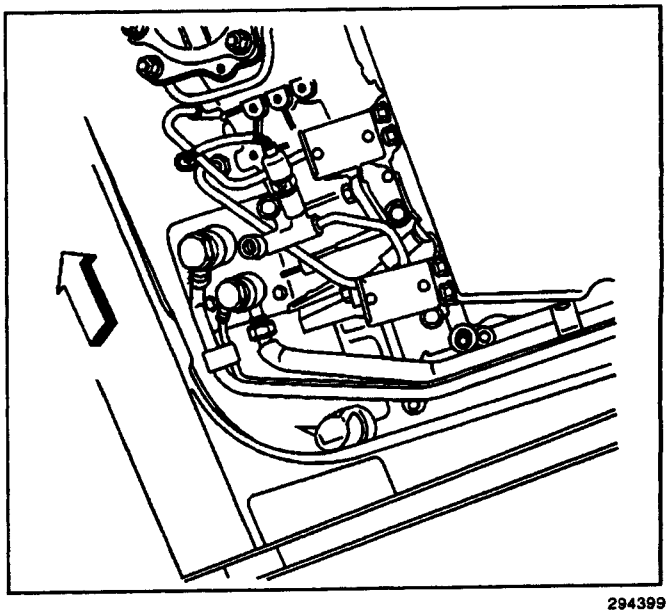
5. Install the air discharge pipe at the air compressor using the air discharge pipe eye bolt and two new gaskets.
   Tighten
   Tighten the air discharge pipe eye bolt to 63 N.m (46 lb ft).

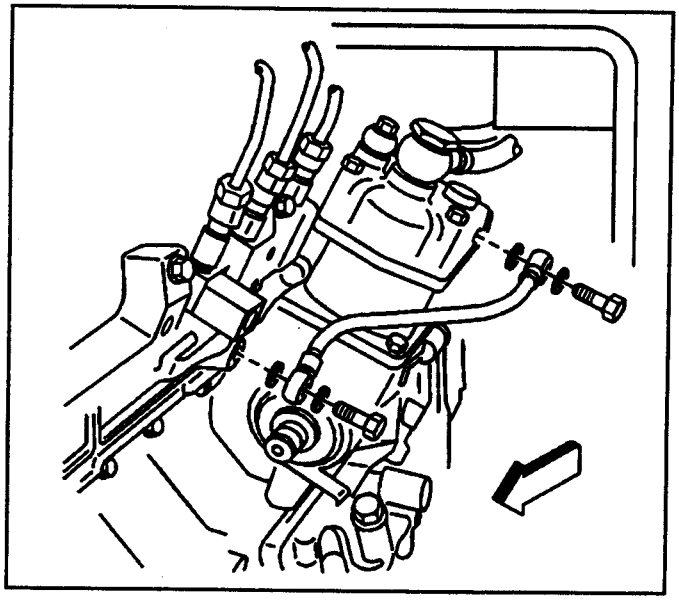

294403

6. Install the coolant inlet pipe at the air compressor using the coolant inlet pipe eye bolt and two new gaskets.
   Tighten
   Tighten the coolant inlet pipe eye bolt to 41 N.m (30 lb ft).


294400

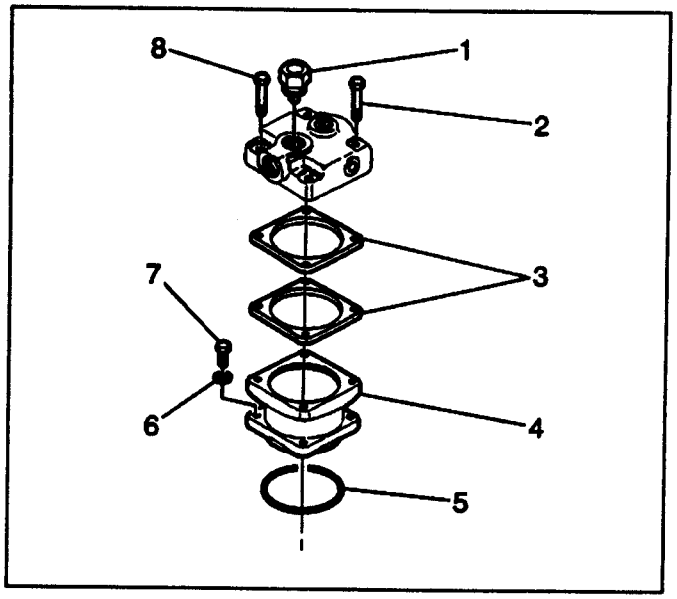
7. Install the air inlet pipe to the air compressor.
   Tighten
   Tighten the air inlet pipe to 63 N.m (46 lb ft).


294399



294385

8. Install the coolant return pipe using two coolant inlet pipe eye bolts and four new gaskets.
   Tighten
   Tighten the coolant return pipe eye bolt to 41 N·m (30 lb ft).
9. Install the fuel injector pump. Refer to the ISUZU service manual for this procedure.
10. Connect the negative battery cable.
11. Fill the cooling system. Refer to *Draining and Filling Cooling System (Filling)* in Engine Cooling.
12. Fill the engine with oil. Refer to *Fluid and Lubricant Recommendations* in Maintenance and Lubrication.
13. Lower the cab.



230294

Air Compressor Overhaul (Disassembly/Assembly)

Disassembly Procedure

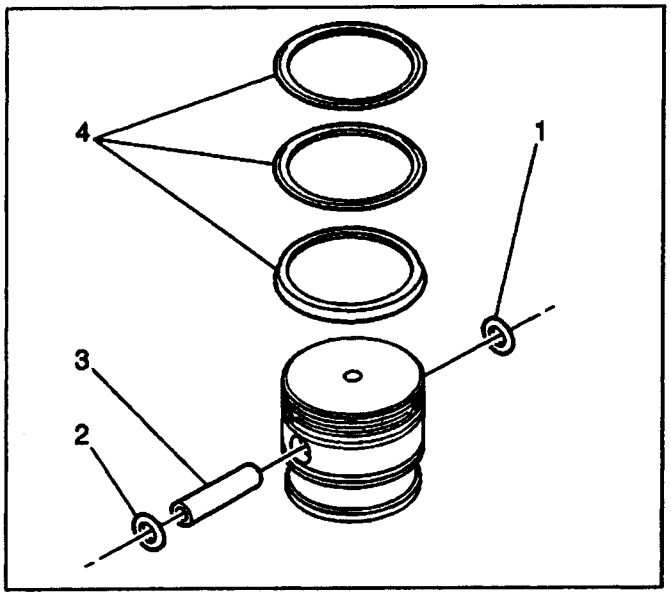
Important: Before you disassemble the compressor, mark the following components in order to show the relationships when you re-assemble the compressor:

- The cylinder head assembly to the cylinder body
- The cylinder body to the crankcase

1. Clean the compressor with engine degreaser.
2. Remove the cylinder head bolts (1, 2, 8).
   Tap the cylinder head with a soft faced mallet in order to break the gasket seal.
3. Remove the cylinder head gaskets (3).
4. Remove the air compressor cylinder body bolts (7).
   Use a wooden hammer in order to tap out the cylinder body from the crankcase.
5. Remove the air compressor cylinder body (4).
6. Remove the O-ring (5) from the cylinder body (4).

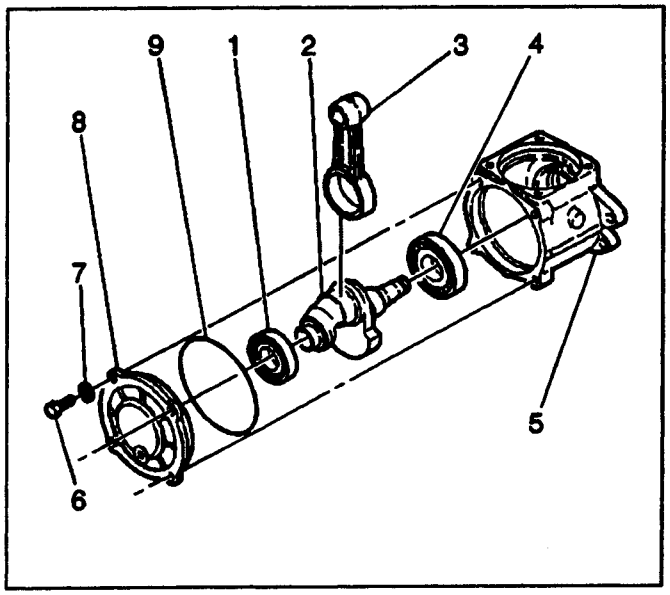
Important: Mark the relationship of the piston head to the connecting rod so that you can reassemble the parts later.

7. Remove the two piston pin snap rings (2).
8. Remove the piston pin (3).
9. Remove the piston.
10. Remove the piston ring assembly (4).
    Use piston rings pliers in order to remove the piston ring.



230296

11. Remove the crankshaft bearing cover bolts (6).
12. Remove the O-ring (9) from the crankshaft bearing cover (3).
13. Remove the front crankshaft bearing (1).
    Use a suitable bearing remover in order to remove the crankshaft bearing.
14. Remove the connecting rod (3).
    Lower the connecting rod (3) by rotating the crankshaft (2).
15. Remove the connecting rod (3) from the crankshaft (2).
16. Remove the crankshaft (2) and the rear crankshaft bearing (4).
    Use a suitable press in order to remove the crankshaft bearing.

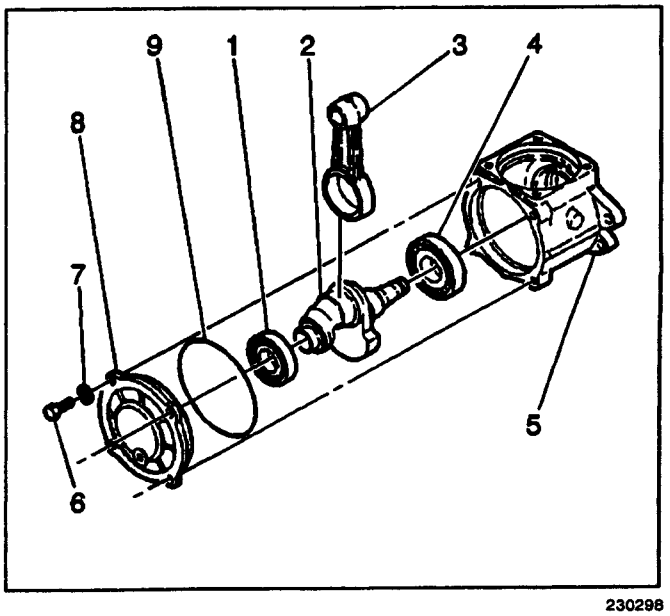


230298

Assembly Procedure

Cleanliness during assembly is important. Dirt causes premature wear of the overhauled air compressor. Lightly lubricate all of the moving parts with clean engine oil during assembly. Engine oil provides an initial lubricant when you start the engine.

1. Install the crankshaft rear bearing (4) onto the crankshaft.
   Use a suitable press and a suitable support in order to assemble the crankshaft rear bearing.
2. Install the crankshaft with the bearing into the crankcase (5).
3. Install the connecting rod (3) onto the crankshaft (2).



230298

4. Install the crankshaft front bearing (1) onto the crankshaft (2).

   Use a suitable press and a suitable sleeve in order to assemble the crankshaft front bearing.

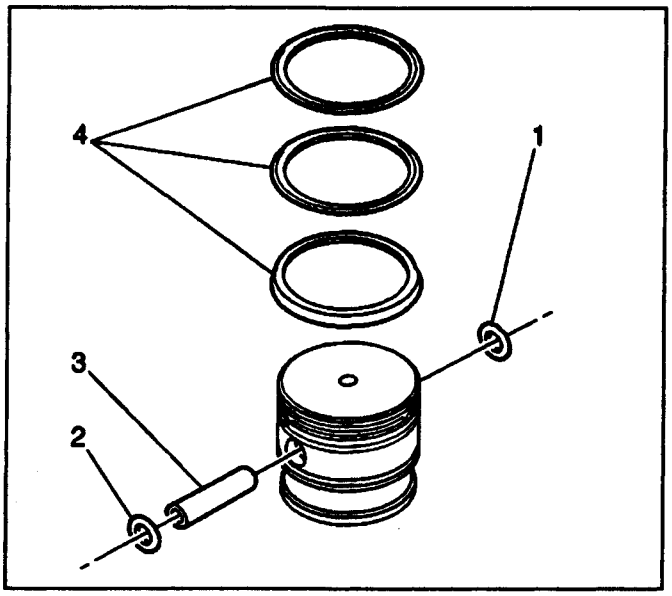
   Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Install the O-ring (9) and the crankshaft bearing cover (8).

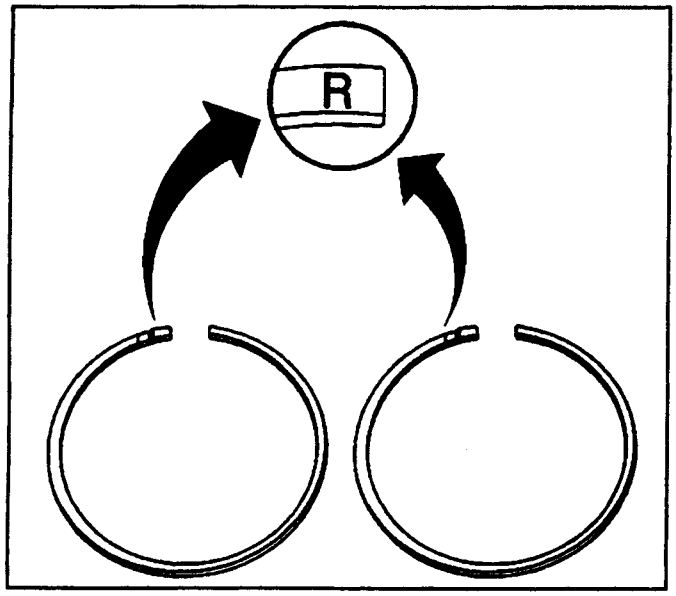
   Tighten

   Tighten the crankshaft bearing cover bolts to 8 N.m (71 lb in).

6. Install the piston ring assembly (4).



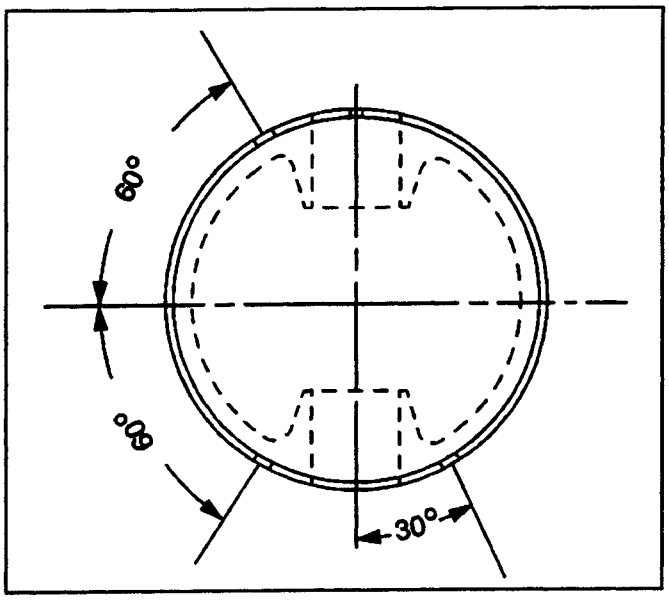
230296



230301

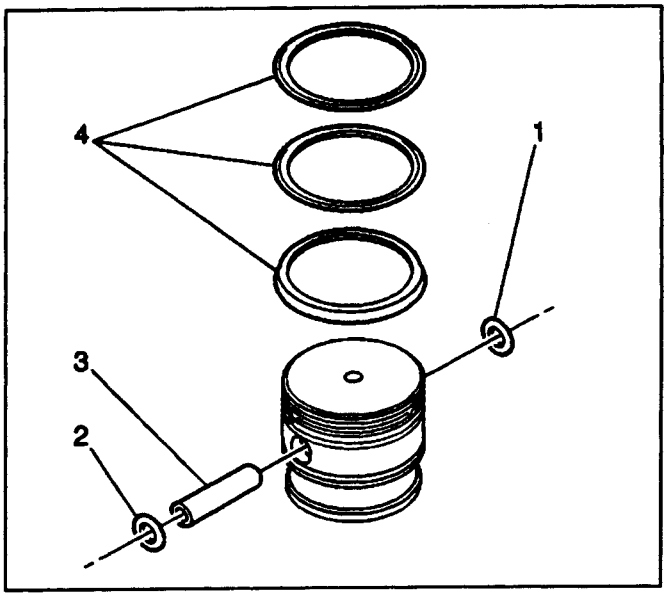
7. Install the first and the second rings with the R turned up.

8. Set the piston rings to the following recommended positions:
   8.1. Set the first compression ring at 30 degrees from the piston pin.
   8.2. Set the second compression ring at 60 degrees clockwise of the center line that is perpendicular to the piston pin center line.
   8.3. Set the expander ring at 60 degrees counter-clockwise of the center line that is perpendicular to the piston pin.



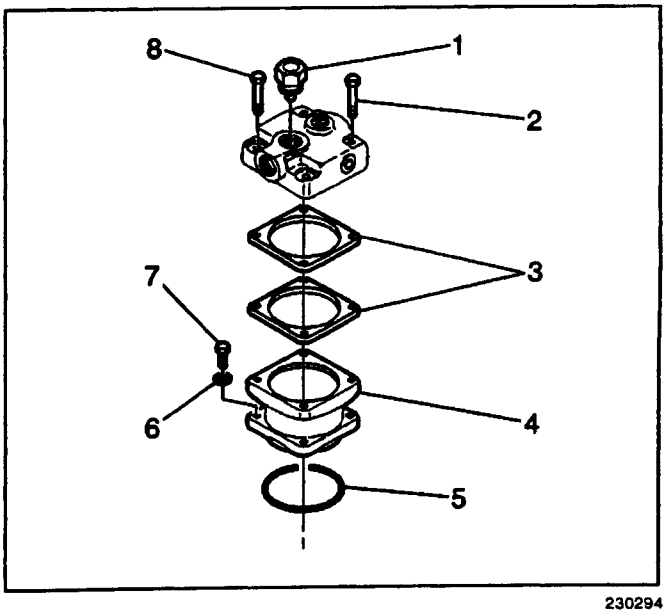
230303

9. Install the piston pin (3) into the piston.
10. Install the piston snap rings (2) into the piston.



230296

11. Install the cylinder body (4) and a new O-ring (5) into the crankcase.
    Tighten
    Tighten the bolts to 29 N.m (21 lb ft).
12. Install the new cylinder head gaskets (3) and a new cylinder head to the cylinder body.
    Tighten
    Tighten the bolts to 49 N.m (36 lb ft).



230294

Air Compressor Overhaul (Cleaning and Inspection)

Cleaning and Inspection

1. Clean all of the parts in parts cleaner.
   Dry the parts before you inspect the parts.
2. Remove the carbon deposits from the discharge cavities.
3. Remove the rust and the scale from the cooling cavities.
4. Scrape any foreign matter from the body surfaces.
   Use compressed air in order to remove dirt particles.
5. Clean the oil passages with a wire.
   Use compressed air in order to blow the loosened foreign matter out of the oil passages.
6. Inspect the crankcase surfaces for cracks and any other damage.
7. Inspect the tapered ends of the crankshaft and all of the machined parts for the following:
   - Wear
   - Scores
   - Damage
8. Inspect the cylinder bore for uneven wear.
9. Inspect the piston for the following conditions:
   - Scores
   - Cracks
   - Enlarged ring grooves

   Replace the piston if necessary.
10. Complete the following measurements:
    10.1. Measure the cylinder for uneven wear. The maximum limit is 0.1 mm (0.004 in).
    10.2. Measure the piston and the cylinder clearance. The maximum limit is 0.2 mm (0.008 in).
    10.3. Measure the piston ring groove and the piston ring clearance. The maximum limit is 0.15 mm (0.0059 in).
    10.4. Measure the piston ring gap. The maximum limit is 1.0 mm (0.039 in).
    10.5. Measure the piston pin and the piston hole clearance. The maximum limit is 0.1 mm (0.004 in).
    10.6. Measure the piston pin and the connecting rod small end clearance. The maximum limit is 0.1 mm (0.004 in).
    10.7. Measure the crankshaft journal and the connecting rod large end clearance. The maximum limit is 0.15 mm (0.0059 in).

Air Compressor Overhaul (Tests after Overhaul)

Important: Before you condemn or adjust the governor, check the dual air pressure gauge on the instrument panel. Use an accurate test gauge in order to verify the pressure that is shown on the dual air pressure gauge.

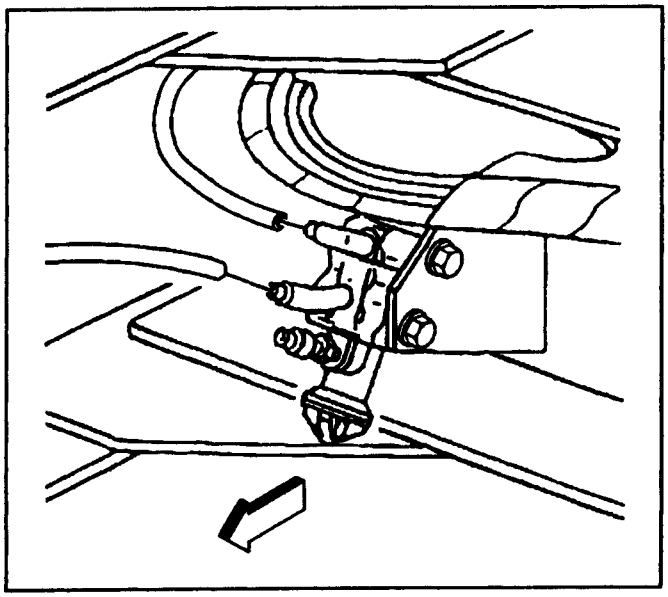
1. Start the engine.
2. Build up the air pressure.
3. Observe the reading on the dual air pressure gauge on the instrument panel when the governor cuts out. Refer to *Air Compressor Gov Valve Adjustment Specifications* for the cut-out pressure.
4. While the engine is still running, slowly reduce the air pressure. Apply and release the brakes in order to reduce the air pressure.
5. Observe the dual air pressure gauge when the governor cuts in. Refer to *Air Compressor Gov Valve Adjustment Specifications* for the cut-in pressure.
6. If you need to change the pressure settings, adjust the governor. Refer to *Air Compressor Governor Valve Adjustment.*

Air Compressor Governor Valve Replacement

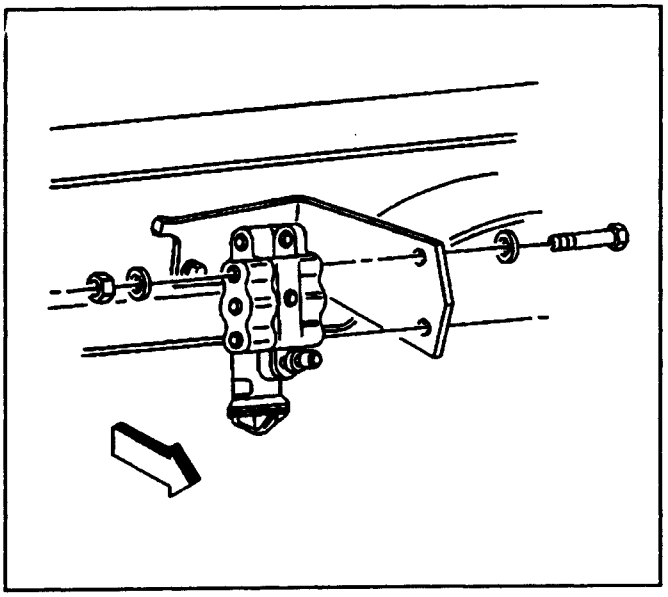
Removal Procedure

1. Block the wheels.
2. Set the parking brake.
3. Drain all of the air reservoirs. Refer to *Draining Reservoirs* in Air Brakes.

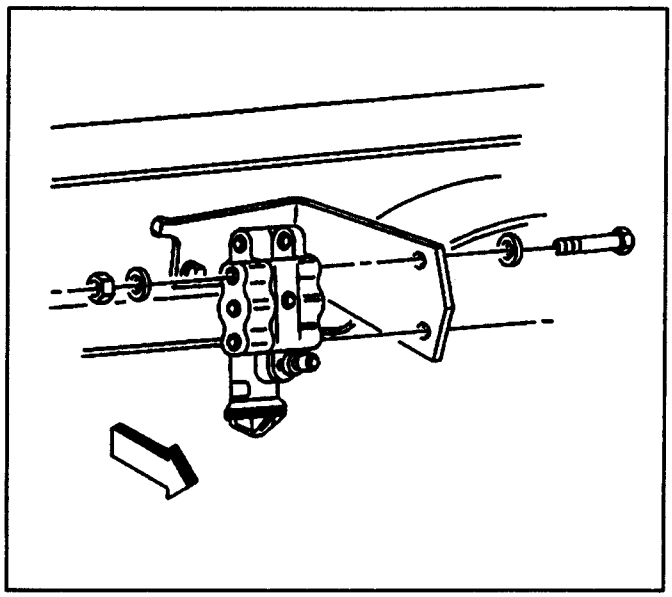
   Important: Tag or label the air lines for later installation.
4. Remove the air lines. Refer to the following procedures in Air Brakes:
   - *Hose and Line Replacement (Nylon and Metal - Compression)*
   - *Hose and Line Replacement (Nylon - Push-In)*
   - *Hose and Line Replacement (Flexible)*
   - *Hose and Line Replacement (Trailer Brake Coupling)*
   - *Hose and Line Replacement (Trailer Brake Dummy Cap)*
5. Remove the nuts.
6. Remove the bolts.
7. Remove the washers.
8. Remove the governor.



230283



230286



230286

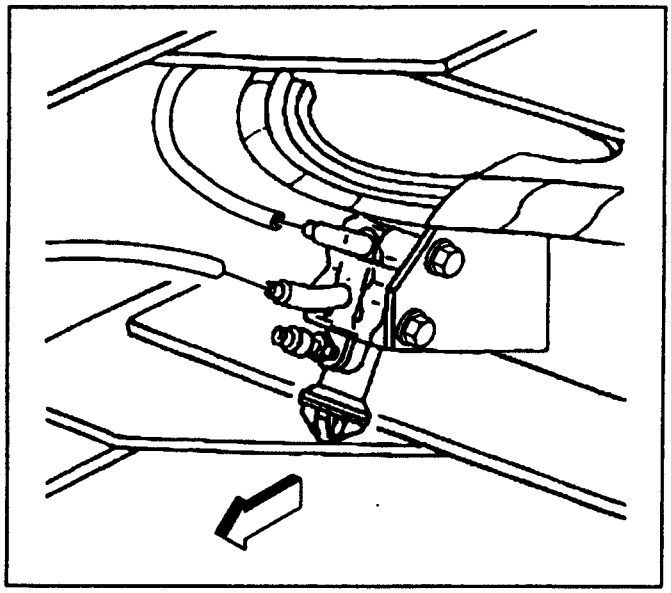
Installation Procedure

1. Install the governor.
2. Install the bolts.
3. Install the washers.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
4. Install the nuts.

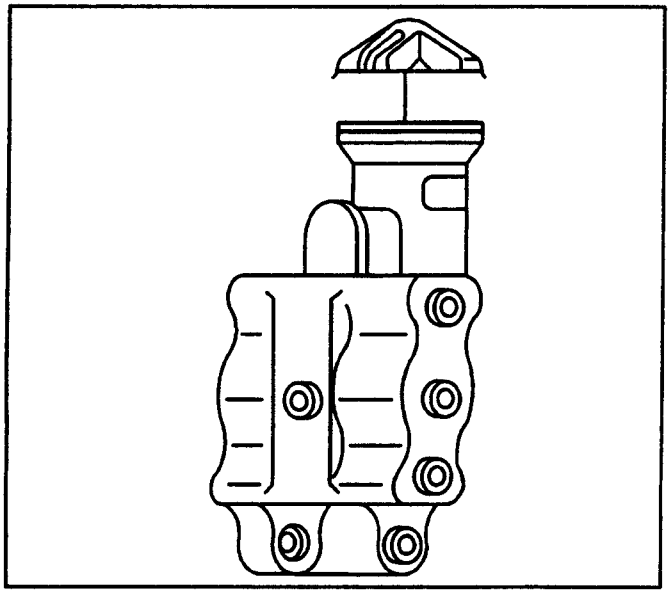
   Tighten

   Tighten the nuts to 33 N·m (16 lb ft).



230283

5. Install the air lines.
6. Start the engine.
7. Adjust the chain cut-in and the cut-out pressures. Refer to *Air Compressor Governor Valve Adjustment.*
8. Check the system for leaks.
9. Ensure that the brakes operate properly.
10. Remove the wheel blocks.



200542

Air Compressor Governor Valve Adjustment

You may need to adjust the governor under the following conditions:

- The range falls below 100 kPa (15 psi) of the recommended pressures
- The pressure settings are incorrect

Before you make any adjustments, check the engine air filter element and the governor air inlet hose for restrictions using the following procedure:

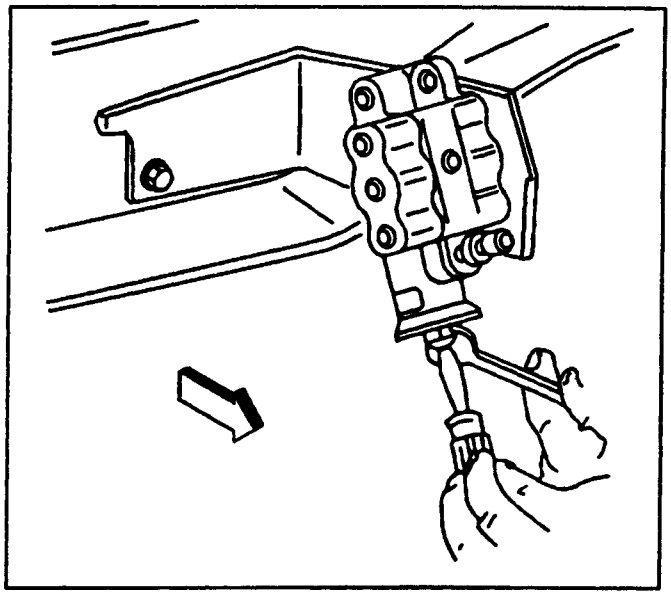
1. Remove the top cover from the governor.

2. Loosen the adjusting screw locknut.

   Important: Do not over adjust the adjusting screw. Each 1/4 turn of the adjusting screw locknut raises or lowers the pressure settings approximately 28 kPa (4 psi).

   - The pressure range between the cut-in and the cut-out setting is not adjustable.
   - In order to raise the pressure setting, turn the adjusting screw counter-clockwise. In order to lower the pressure setting, turn the adjusting screw clockwise.
   - After you make the adjustment, tighten the adjusting screw locknut.
   - Recheck the cut-in and the cut-out pressures.
   - Install the cover on the governor.

Refer to *Air Compressor Gov Valve Adjustment Specifications* for the correct governor settings.



230291

Description and Operation

Air Compressor Description

The air compressor is a one-cylinder, single-stage, reciprocating air compressor. The air compressor consists of three major subassemblies:

- The cylinder head
- The cylinder body
- The crankcase

The cylinder head houses the inlet and the discharge valving. The cylinder body contains the cylinder bore and the piston. The crankcase is a one-piece casting. The crankcase houses the crankshaft and the bearings.

Air Compressor Operation

The air compressor is flange mounted to the flywheel housing and is gear driven. The air compressor is lubricated from the engine oil lubrication system and is cooled through the engine cooling system. The model identification number is located on a plate that is attached to the air compressor crankcase.

A coolant inlet pipe provides coolant from the engine head to the air compressor. The coolant outlet pipe carries hot coolant back to the engine block.

An oil supply tube provides lubrication from the engine block to the air compressor. The oil is returned to the engine through the air compressor crankcase.

As the air compressor piston moves downward, air is drawn into the cylinder through the inlet valve of the cylinder head. This action is referred to as the intake stroke. As the piston begins to move upward, the inlet valve closes and the air above the piston is compressed. This action is referred to as the compression stroke. When the air pressure in the cylinder is greater than the air pressure in the air reservoir, the discharge valve raises off of the discharge valve seat. Air is then allowed to pass through the exhaust port and out of the discharge tube. As the intake stroke begins, the discharge valve seats again.

Air Compressor Governor Valve Description

The Bendix® D-2 governor operates in conjunction with the air compressor unloader mechanism. The governor automatically controls the air pressure in the air brake supply system between a maximum cut-out pressure and a minimum cut-in pressure. The air compressor runs continually while the engine runs. The governor actuates the air compressor unloader mechanism, controlling the actual compression of air. The mechanism stops or starts the compression of air when the maximum or the minimum air reservoir pressures are reached.

Air Compressor Governor Valve Operation

The air compressor runs continually while the engine is running. The actual compression of air is controlled by the governor actuating the air compressor unloader mechanism. The air compressor unloader mechanism stops or starts the compression of air under the following conditions:

- When the maximum reservoir pressure is reached
- When the minimum reservoir pressure is reached

The governor directs compressed air to the unloader assembly when the air pressure in the system reaches the governor cut-out pressure. The unloader pistons move and hold the inlet valves open. With the inlet valves open, the compression stroke can not occur. The governor exhausts air from the unloader assembly when the air pressure in the system drops to the governor cut-in pressure. The unloader springs move the pistons back to the normal positions and allow the inlet valves to function normally.

Antilock Brake System

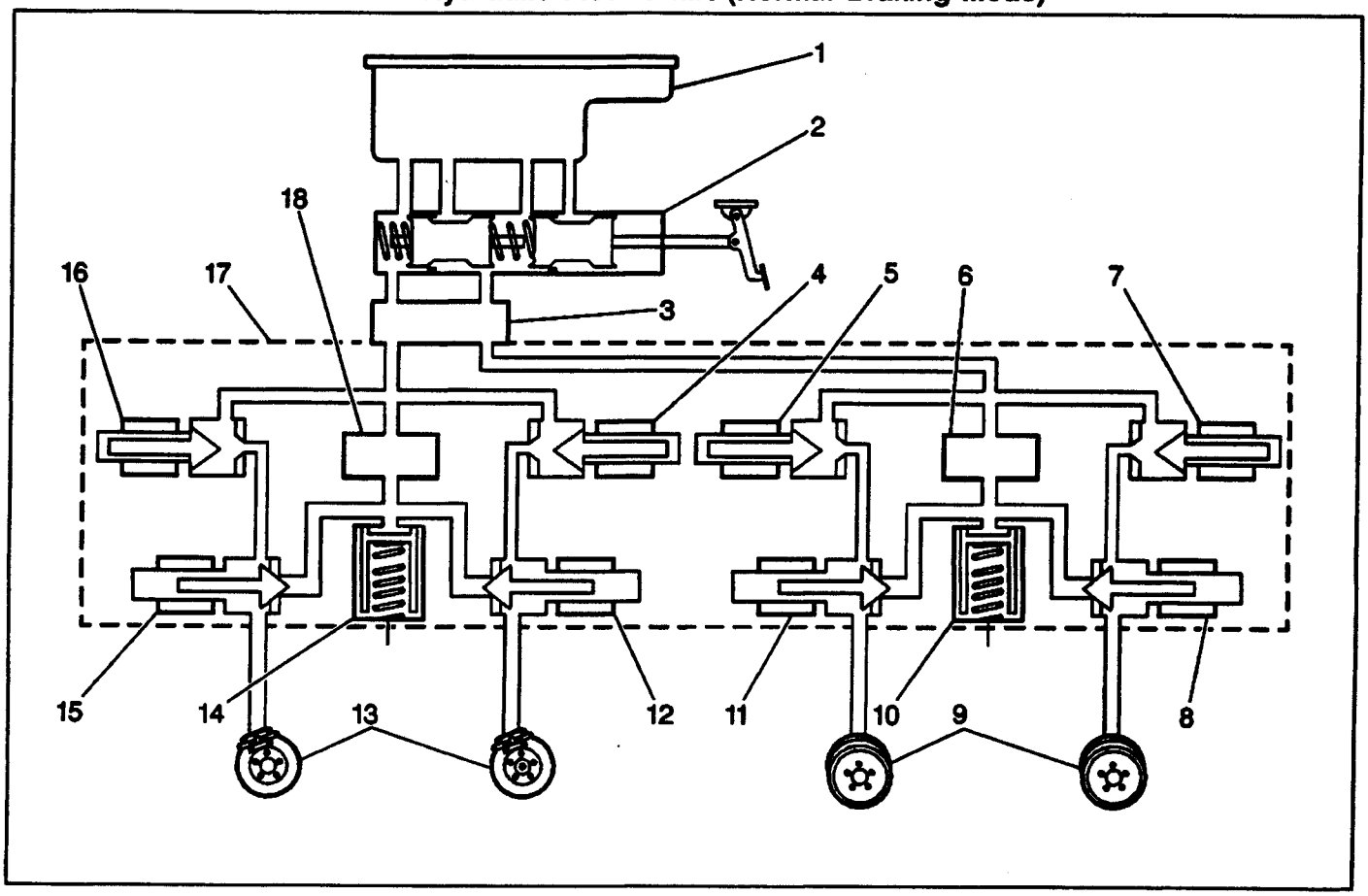
Specifications

Fastener Tightening Specifications

Application	N.m	Lb Ft	Lb In
EHCU Bracket Mounting Bolts	36	28	—
Combination Valve to BPMV	16	12	—
EBCM to BPMV	5	—	39
EHCU to Bracket	9	7	—
Front Brake Line to Combination Valve	24	18	—
Front Wheel Speed Sensor Mounting Bolts	26	19	—
Rear Brake Line to Combination Valve	24	18	—
Splash Shield Mounting Bolts	11	9	—
Tube Adapters to BPMV	31	23	—
Front Wheel Speed Sensor Harness Clip	11	9	—
EHCU Crossmember Nuts	36	28	—

Schematic and Routing Diagrams

BPMV Hydraulic Flow Chart (Normal Braking Mode)

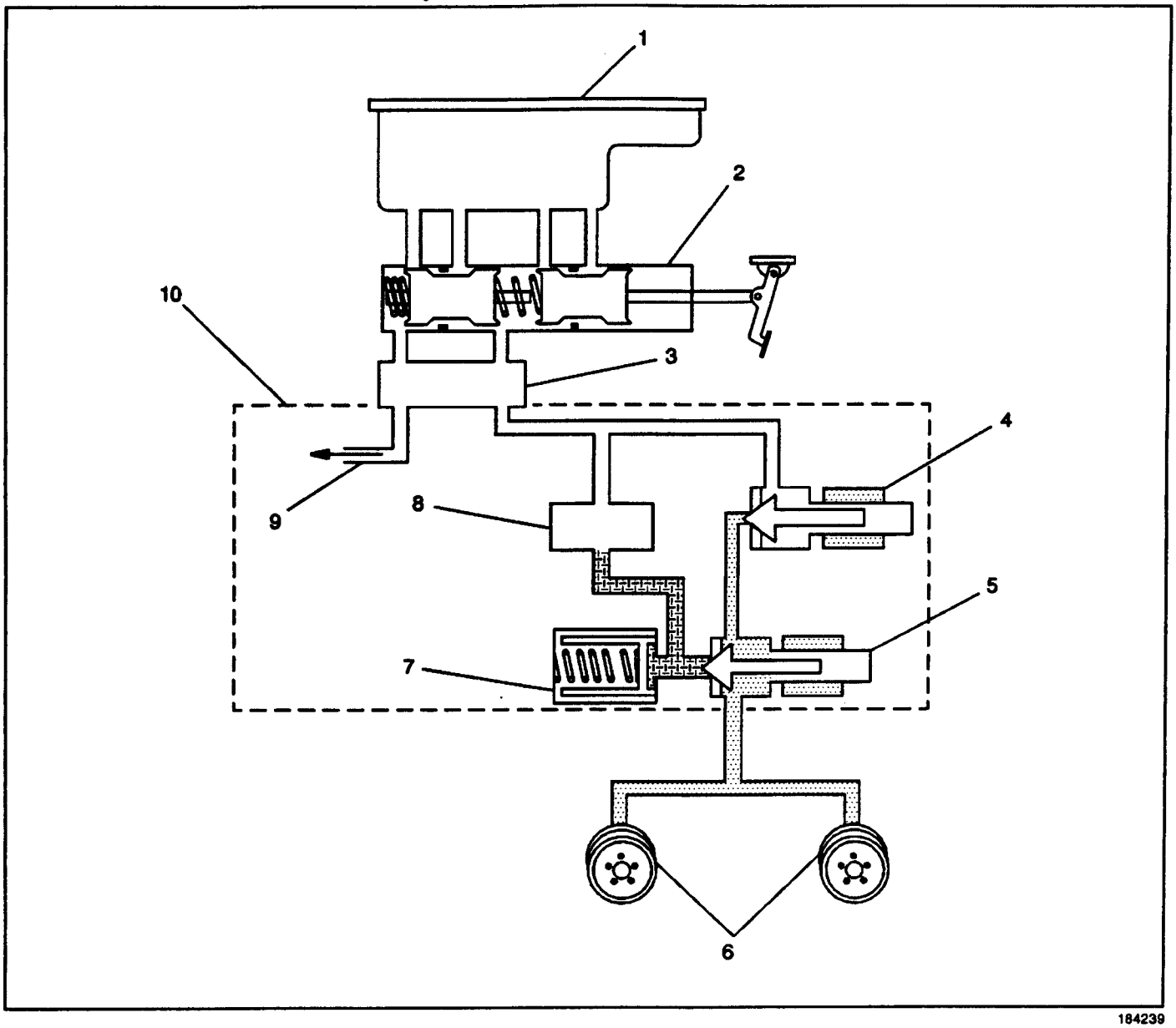


333254

Legend

(1) Master Cylinder Reservoir
(2) Master Cylinder
(3) Combination Valve
(4) Right Front Isolation Valve
(5) Left Rear Isolation Valve
(6) Rear Pump
(7) Right Rear Isolation Valve
(8) Right Rear Dump Valve
(9) Rear Drum Brakes
(10) Rear Accumulator
(11) Left Rear Dump Valve
(12) Right front Dump Valve
(13) Front Disc Brakes
(14) Front Accumulator
(15) Left Front Dump Valve
(16) Left Front Isolation Valve
(17) Brake Pressure Modulator Valve (BPMV)
(18) Front Pump

BPMV Hydraulic Flow Chart (Isolation Mode)

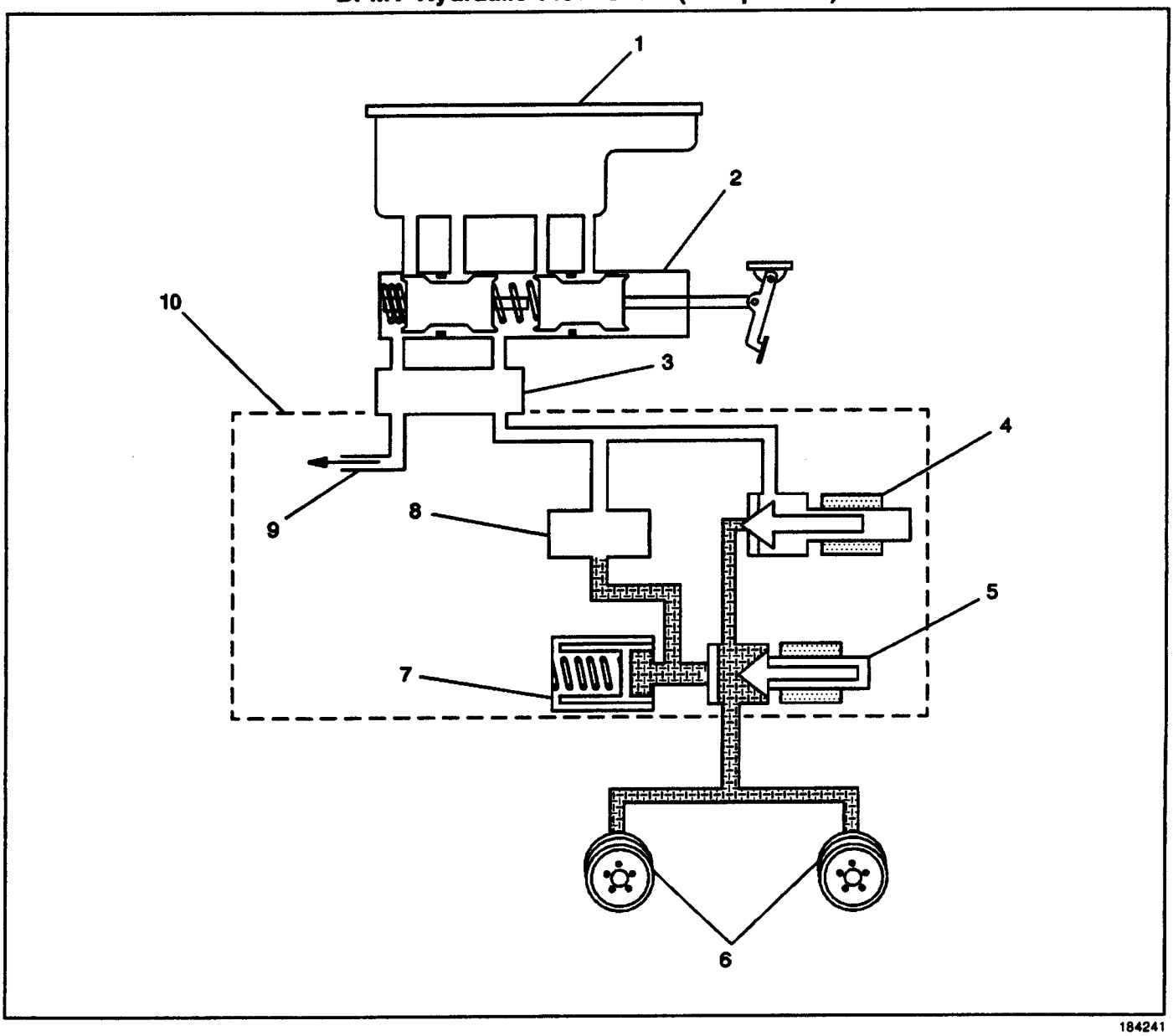


184239

Legend

(1) Master Cylinder Reservoir
(2) Master Cylinder
(3) Combination valve
(4) Rear Isolation Valve
(5) Rear Dump Valve
(6) Rear Wheels
(7) Rear Accumulator
(8) Rear Pump
(9) To Front Channels
(10) Brake Pressure Modulator Valve (BPMV)

BPMV Hydraulic Flow Chart (Dump Mode)

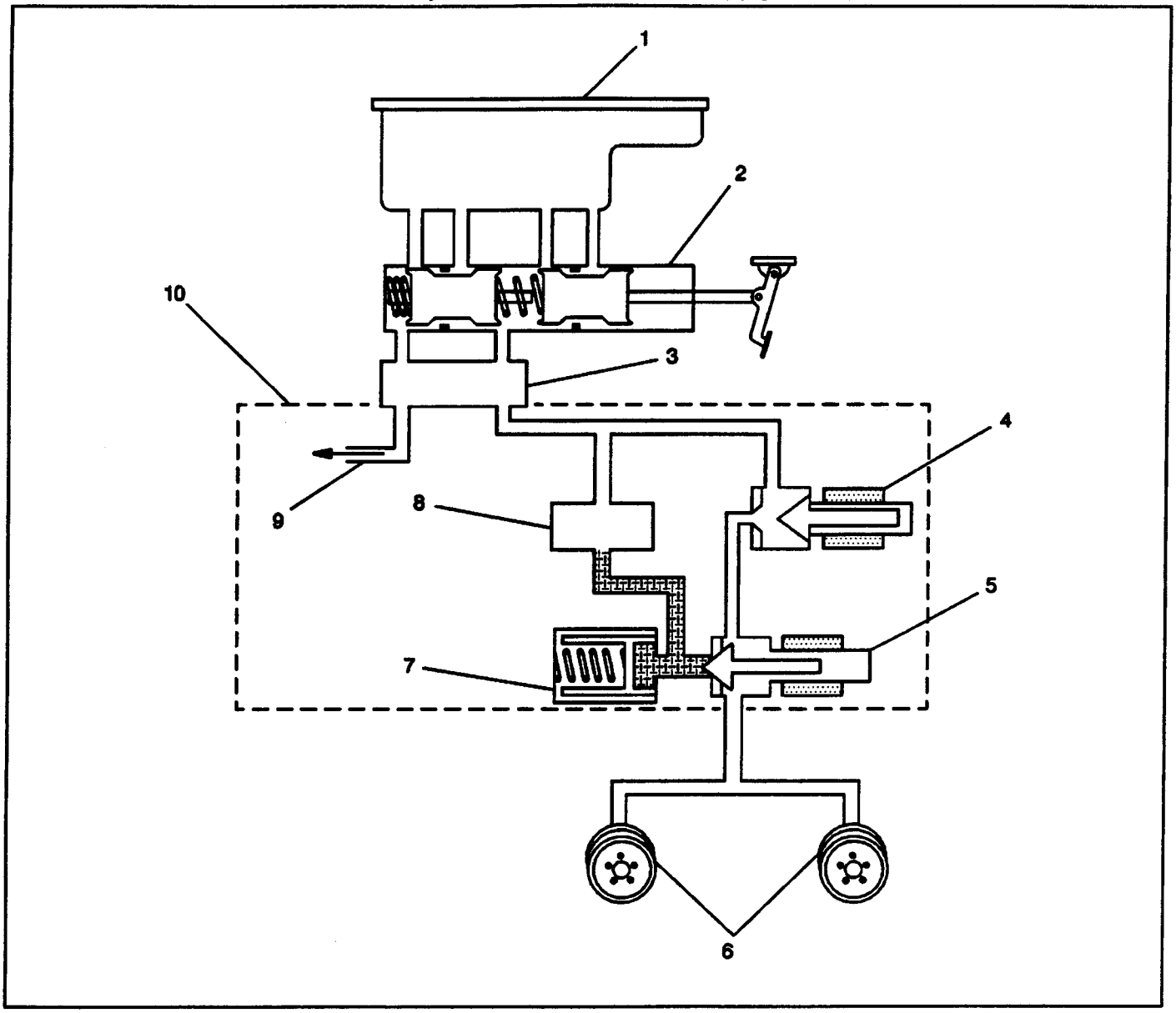


184241

Legend

(1) Master Cylinder Reservoir
(2) Master Cylinder
(3) Combination valve
(4) Rear Isolation Valve
(5) Rear Dump Valve
(6) Rear Wheels
(7) Rear Accumulator
(8) Rear Pump
(9) To Front Channels
(10) Brake Pressure Modulator Valve (BPMV)

BPMV Hydraulic Flow Chart (Reapply Mode)

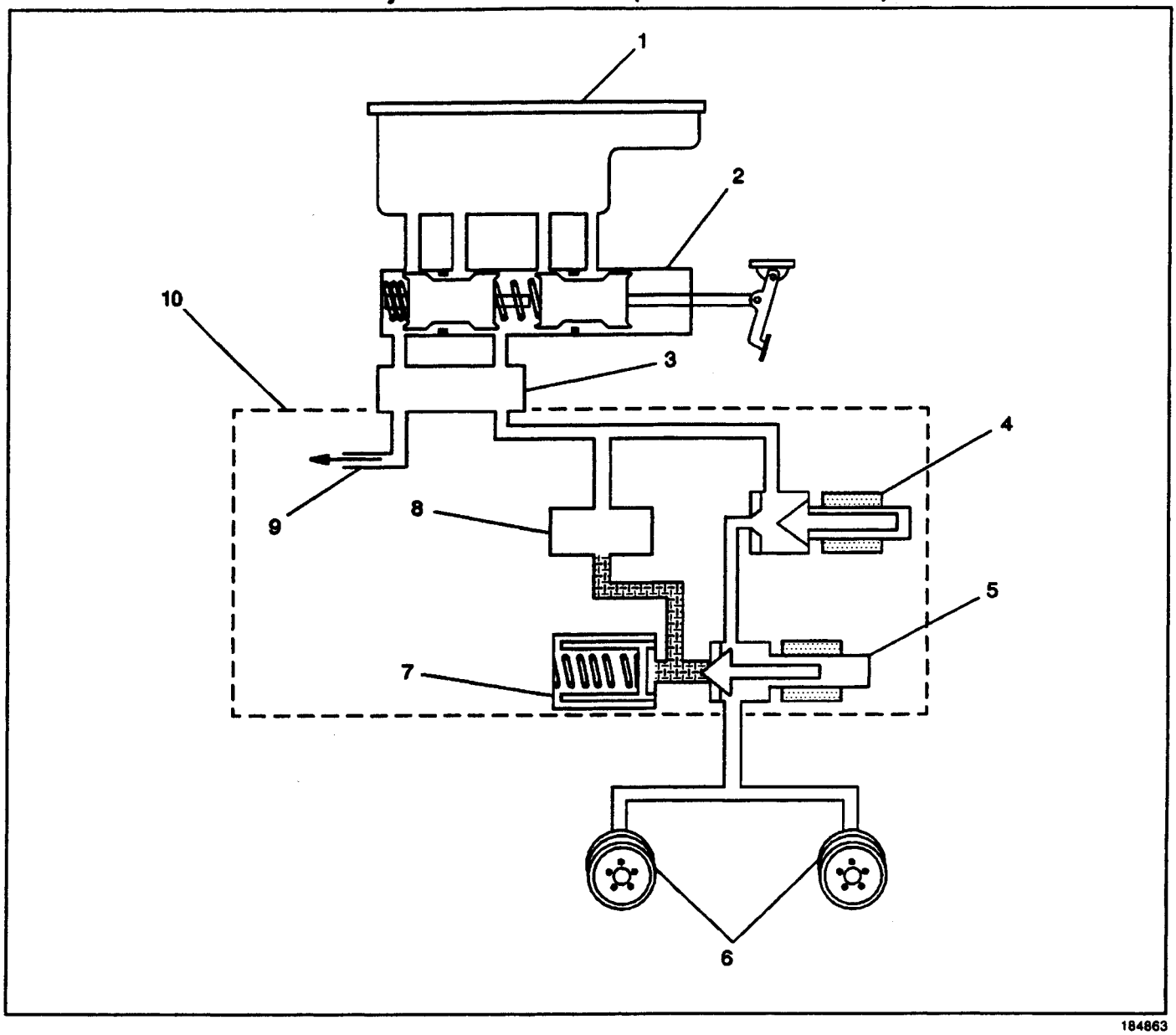


184243

Legend

(1) Master Cylinder Reservoir
(2) Master Cylinder
(3) Combination valve
(4) Rear Isolation Valve
(5) Rear Dump Valve
(6) Rear Wheels
(7) Rear Accumulator
(8) Rear Pump
(9) To Front Channels
(10) Brake Pressure Modulator Valve (BPMV)

BPMV Hydraulic Flow Chart (Brake Release Mode)



184863

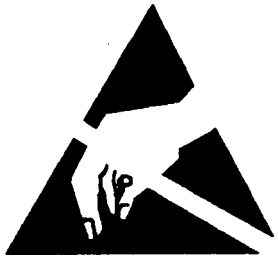
Legend

(1) Master Cylinder Reservoir
(2) Master Cylinder
(3) Combination valve
(4) Rear Isolation Valve
(5) Rear Dump Valve
(6) Rear Wheels
(7) Rear Accumulator
(8) Rear Pump
(9) To Front Channels
(10) Brake Pressure Modulator Valve (BPMV)

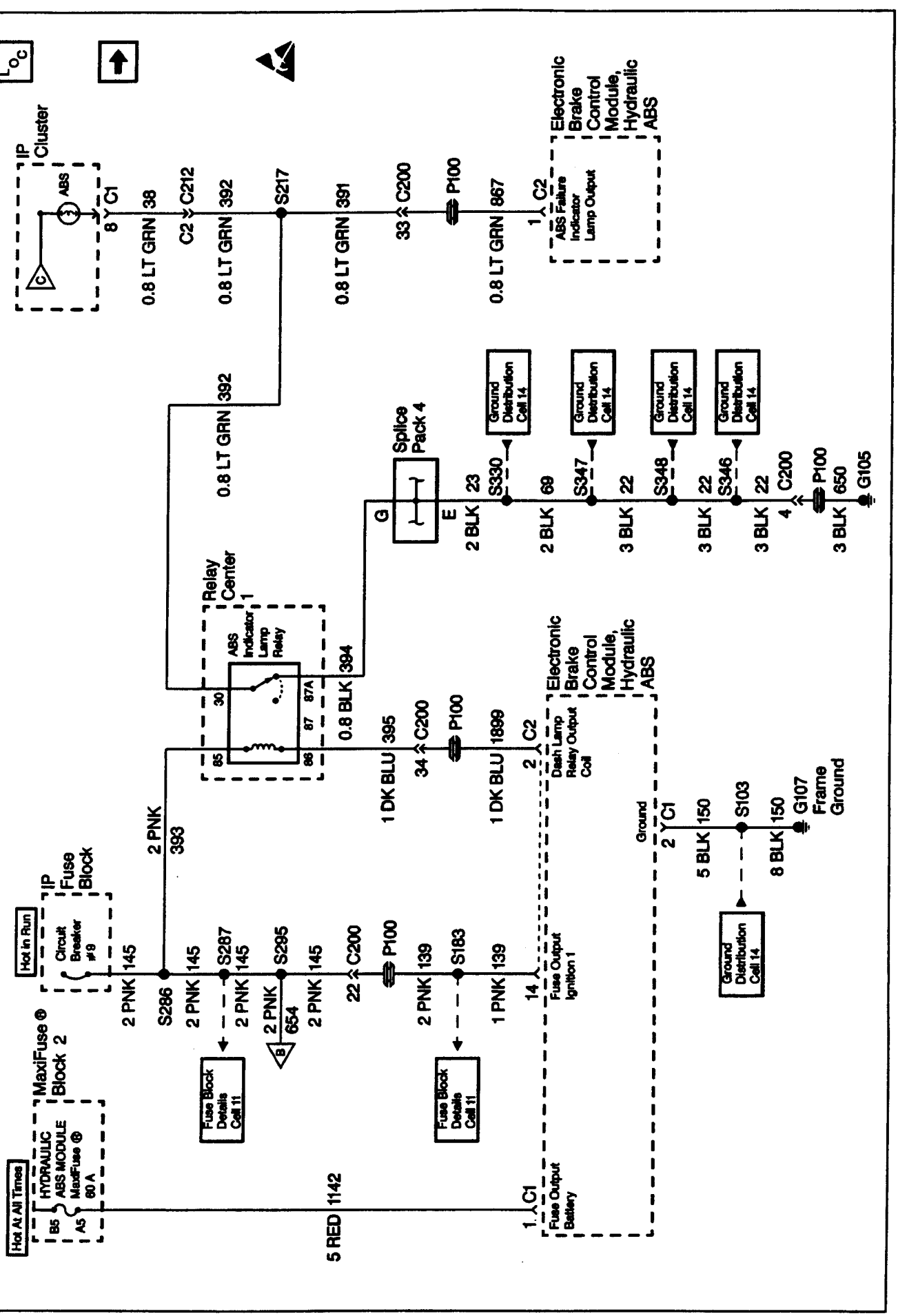
Antilock Brakes System Schematic References

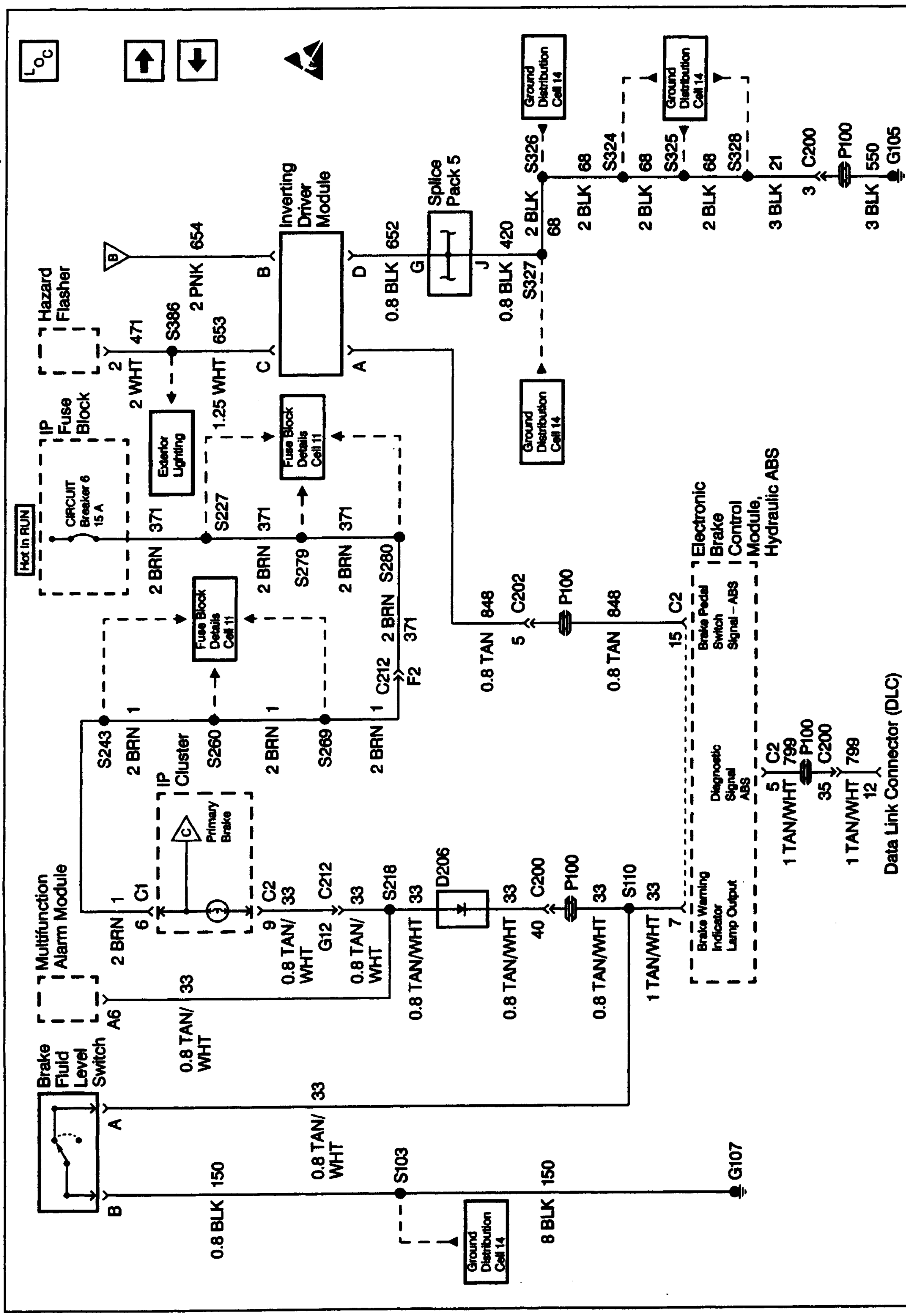
Reference on Schematic	Section Number - Subsection Name
Fuse Block Details Cell 11	8—Wiring Systems
Ground Distribution Cell 14	8—Wiring Systems

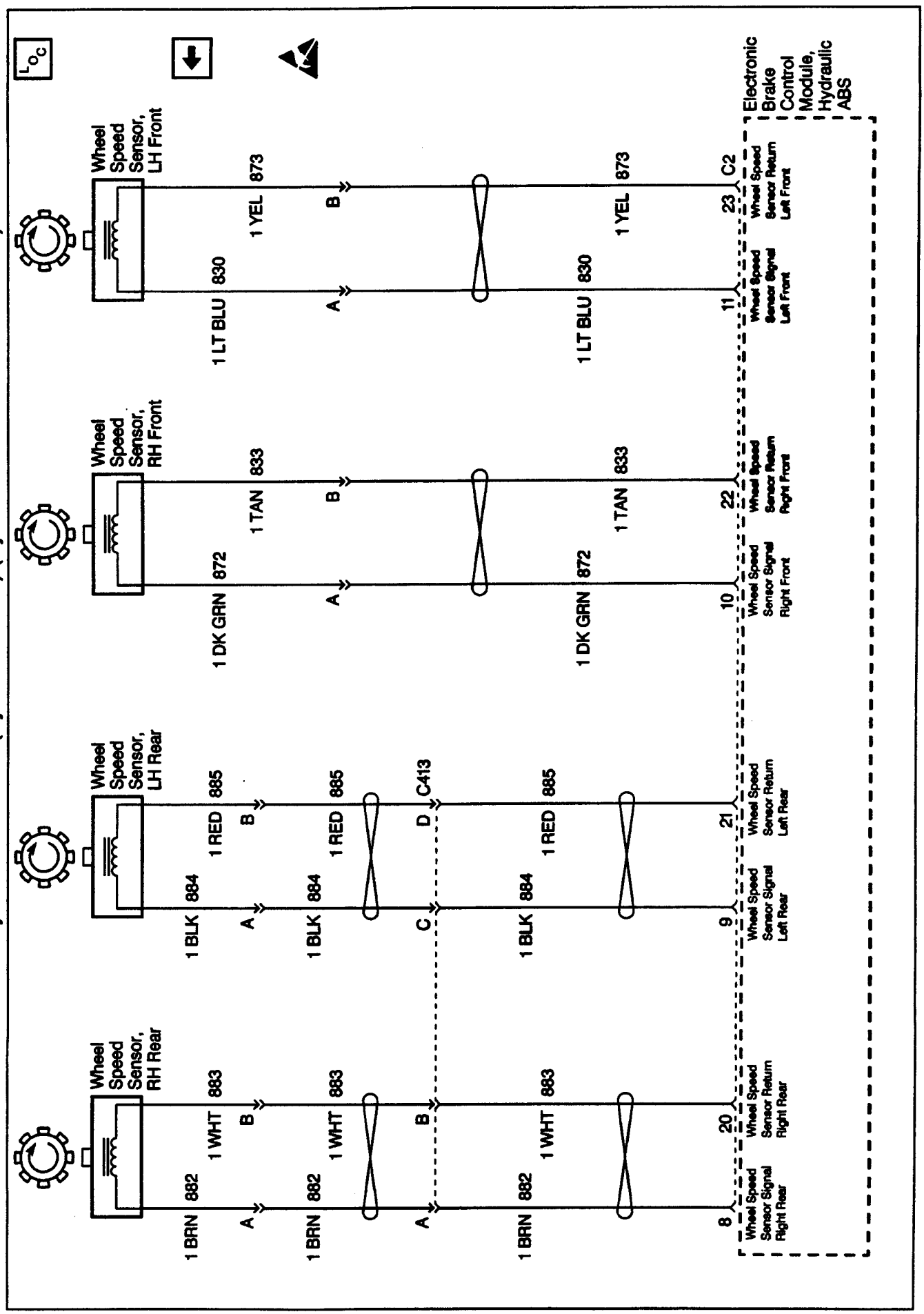
Antilock Brakes System Schematic Icons

Icon	Icon Definition
 19384	Refer to *ESD Notice.*

Antilock Brake System Schematics (Hydraulic Brake) (Hydraulic Antilock Brake Schematics 1 of 3)




Antilock Brake System Schematics (Hydraulic Antilock Brake) (Cell 44: Hydraulic Antilock Brake System 2 of 3)
302592
Hot In RUN
IP Fuse Block
CIRCUIT Breaker 6 15 A
Hazard Flasher
Exterior Lighting
Fuse Block Details Cell 11
Inverting Driver Module
Splice Pack 5
Ground Distribution Cell 14
Multifunction Alarm Module
Brake Fluid Level Switch
IP Cluster
Primary Brake
Electronic Brake Control Module, Hydraulic ABS
Brake Pedal Switch Signal - ABS
Diagnostic Signal ABS
Brake Warning Indicator Lamp Output
Data Link Connector (DLC)
2 BRN 371
2 WHT 471
1.25 WHT 653
2 PNK 654
0.8 BLK 652
0.8 BLK 420
2 BLK 68
3 BLK 21
3 BLK 550
0.8 TAN 848
2 BRN 1
0.8 TAN/WHT 33
1 TAN/WHT 33
1 TAN/WHT 799
0.8 BLK 150
8 BLK 150
S386 S227 S279 S280 S243 S260 S269 S218 S110 S103 S326 S324 S325 S328 S327
C200 C202 C212 C1 C2 F2 G12 D206 P100 G105 G107 A6


Antilock Brake System Schematics (Hydraulic Brake) (Hydraulic ABS Schematics 3 of 3)
292722
Wheel Speed Sensor, RH Rear
Wheel Speed Sensor, LH Rear
Wheel Speed Sensor, RH Front
Wheel Speed Sensor, LH Front
Electronic Brake Control Module, Hydraulic ABS
1 BRN 882 A
1 WHT 883 B
1 BLK 884 A
1 RED 885 B
1 DK GRN 872 A
1 TAN 833 B
1 LT BLU 830 A
1 YEL 873 B
C413 D
C2
8 Wheel Speed Sensor Signal Right Rear
20 Wheel Speed Sensor Return Right Rear
9 Wheel Speed Sensor Signal Left Rear
21 Wheel Speed Sensor Return Left Rear
10 Wheel Speed Sensor Signal Right Front
22 Wheel Speed Sensor Return Right Front
11 Wheel Speed Sensor Signal Left Front
23 Wheel Speed Sensor Return Left Front

Component Locator

Antilock Brakes System Components

Name	Location	Locator View	Connector End View
ABS Indicator Relay	On the right top of the IP, under the access panel, in relay center 1	Refer to *Antilock Brakes System Component Views*	Refer to *Antilock Brakes System Connector End Views*
Data Link Connector (DLC)	On the left side of the lower IP	Refer to *Data Link Connector Component Views*	Refer to *Data Link Connector End Views*
Electronic Brake Control Module (EBCM) (ABS-Hydraulic)	On the rear of the #1 crossmember	Refer to *Antilock Brakes System Component Views*	—
Electronic Brake Control Module (EBCM) (ABS-Hydraulic) C1 (2 cavities)	In the front chassis harness to the EBCM	Refer to *Antilock Brakes System Component Views*	Refer to *Antilock Brakes System Connector End Views*
Electronic Brake Control Module (EBCM) (ABS-Hydraulic) C2 (24 cavities)	In the front chassis harness to the EBCM	Refer to *Antilock Brakes System Component Views*	Refer to *Antilock Brakes System Connector End Views*
Instrument Panel Cluster (IPC)	On the left side of the IP	Refer to *Instrument Cluster Component Views*	—
Instrument Panel Cluster (IPC) C1 (15 cavities)	In the upper IP harness to the IPC	Refer to *Instrument Cluster Component Views*	Refer to *Instrument Cluster Connector End Views*
Instrument Panel Cluster (IPC) C2 (9 cavities)	In the upper IP harness to the IPC	Refer to *Instrument Cluster Component Views*	Refer to *Instrument Cluster Connector End Views*
IP Fuse Block	In the right top of the IP, under the access panel	Refer to *Power and Grounding Component Views*	—
MaxiFuse® Block 2	On the left rear of the cab, below the cab bridge	Refer to *Power and Grounding Component Views*	—
Multifunction Alarm Module (MFAM) (Hydraulic Brakes)	Under the right seat	Refer to *Audible Warnings Component Views*	—
Multifunction Alarm Module (MFAM) (Hydraulic Brakes) C1 (16 cavities)	In the lower IP harness to the MFAM	Refer to *Audible Warnings Component Views*	Refer to *Audible Warnings Connector End Views*
Multifunction Alarm Module (MFAM) (w/ Automatic Engine Shutdown) C2 (2 cavities)	In the lower IP harness to the MFAM	Refer to *Audible Warnings Component Views*	Refer to *Audible Warnings Connector End Views*
Splice Pack 5	Under the crash pad, in the top of the IP, joint connector 1, row 3, terminals A, B, C, D, E, F, G, H, J and L	—	—
Wheel Speed Sensor (WSS), Left Front (ABS-Hydraulic)	Mounted in the left front brake backing plate	Refer to *Antilock Brakes System Component Views*	Refer to *Antilock Brakes System Connector End Views*

Antilock Brakes System Components (cont'd)

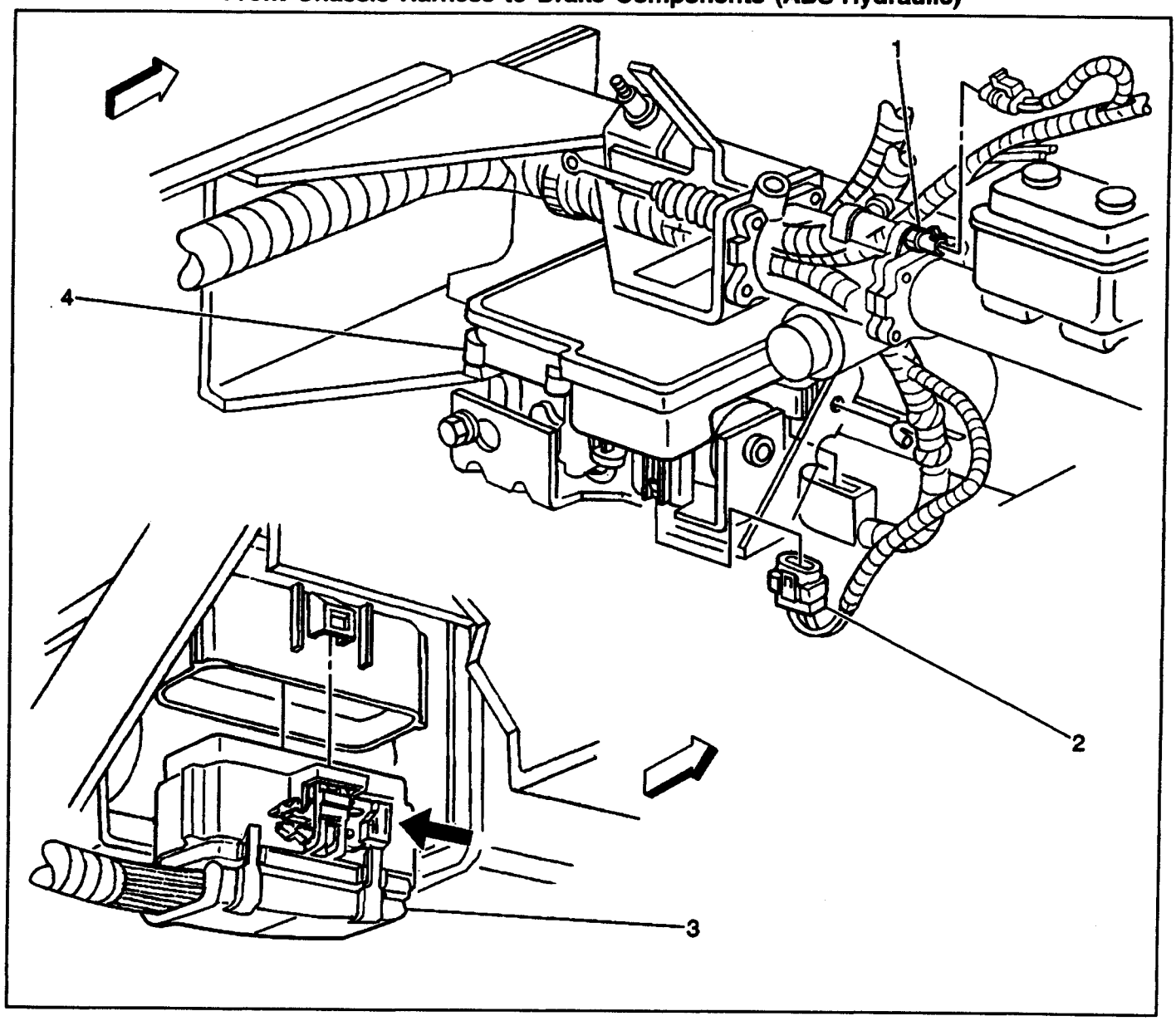
Name	Location	Locator View	Connector End View
Wheel Speed Sensor (WSS), Left Rear (ABS-Hydraulic)	Mounted in the left rear brake backing plate	Refer to *Antilock Brakes System Component Views*	Refer to *Antilock Brakes System Connector End Views*
Wheel Speed Sensor (WSS), Right Front (ABS-Hydraulic)	Mounted in the right front brake backing plate	Refer to *Antilock Brakes System Component Views*	Refer to *Antilock Brakes System Connector End Views*
Wheel Speed Sensor (WSS), Right Rear (ABS-Hydraulic)	Mounted in the right rear brake backing plate	Refer to *Antilock Brakes System Component Views*	Refer to *Antilock Brakes System Connector End Views*
C200 (56 cavities)	In the lower IP harness, to the front chassis harness, in the left center of the cab, in the cab interface connector housing	Refer to *Harness Routing Views*	Refer to *Inline Harness Connector End Views*
C202 (56 cavities)	In the lower IP harness, to the front chassis harness, in the left center of the cab, in the cab interface connector housing	Refer to *Harness Routing Views*	Refer to *Inline Harness Connector End Views*
C212 (84 cavities)	In the lower IP harness, to the upper IP harness, in the left center of the IP at the floor		
C413 (4 cavities)	In the front chassis harness, to the transmission harness, on inboard side of the left frame rail, to the left of the transmission		
D206	In the lower IP harness, plugged into the diode connector breakout	—	—
G105	On the left front of the #1 crossmember	Refer to *Power and Grounding Component Views*	—
G107	From the front chassis harness, on the left frame rail, approximately 25 cm (9.8 in) to the rear of the front shock absorber	Refer to *Power and Grounding Component Views*	—
P100	On the front chassis harness, under the hood, in the center of the bulkhead, in the cab interface connector housing	Refer to *Harness Routing Views*	—
S103	In the front chassis harness, approximately 7 cm (2.8 in) to the rear of the main harness breakout	—	—
S110	In the front chassis harness, approximately 7 cm (2.8 in) from the brake harness breakout toward the front turn signal harness	—	—
S183	In the front chassis harness, approximately 3 cm (1.2 in) forward of the engine oil pressure switch breakout	—	—
S217	In the lower IP harness, in the main branch, to the right of relay center 1	—	—
S218	In the upper IP harness	—	—
S227	In the upper IP harness, under the IP, approximately 6 cm (2.4 in) to the left of the fuse block breakout	—	—
S243	In the upper IP harness, approximately 13 cm (5.1 in) from the IP connector toward the main harness	—	—

Antilock Brakes System Components (cont'd)

Name	Location	Locator View	Connector End View
S260	In the upper IP harness, in the main harness at the speedometer breakout	—	—
S269	In the upper IP harness, in the main harness, approximately 21 cm (8.3 in) from the upper IP connector C212 (84 cavities)	—	—
S279	In the lower IP harness, below the IP, approximately 5 cm (2.0 in) to the right of the relay center 1 harness breakout	—	—
S280	In the lower IP harness, in the main harness, at the frame harness breakout	—	—
S286	In the lower IP harness, in the main harness, at the fuse block harness breakout	—	—
S287	In the lower IP harness, in the main harness, approximately 22 cm (8.7 in) to the right of the fuse block harness breakout	—	—
S295	In the lower IP harness, in the main branch, at the C200 (56 cavities) and C202 (56 cavities) breakout	—	—
S324	In the lower IP harness	—	—
S325	In the lower IP harness	—	—
S326	In the lower IP harness	—	—
S327	In the lower IP harness	—	—
S328	In the lower IP harness	—	—
S330	In the lower IP harness	—	—
S346	In the lower IP harness	—	—
S347	In the lower IP harness	—	—
S348	In the lower IP harness	—	—
S386	In the lower IP harness	—	—

Antilock Brakes System Component Views

Front Chassis Harness to Brake Components (ABS-Hydraulic)

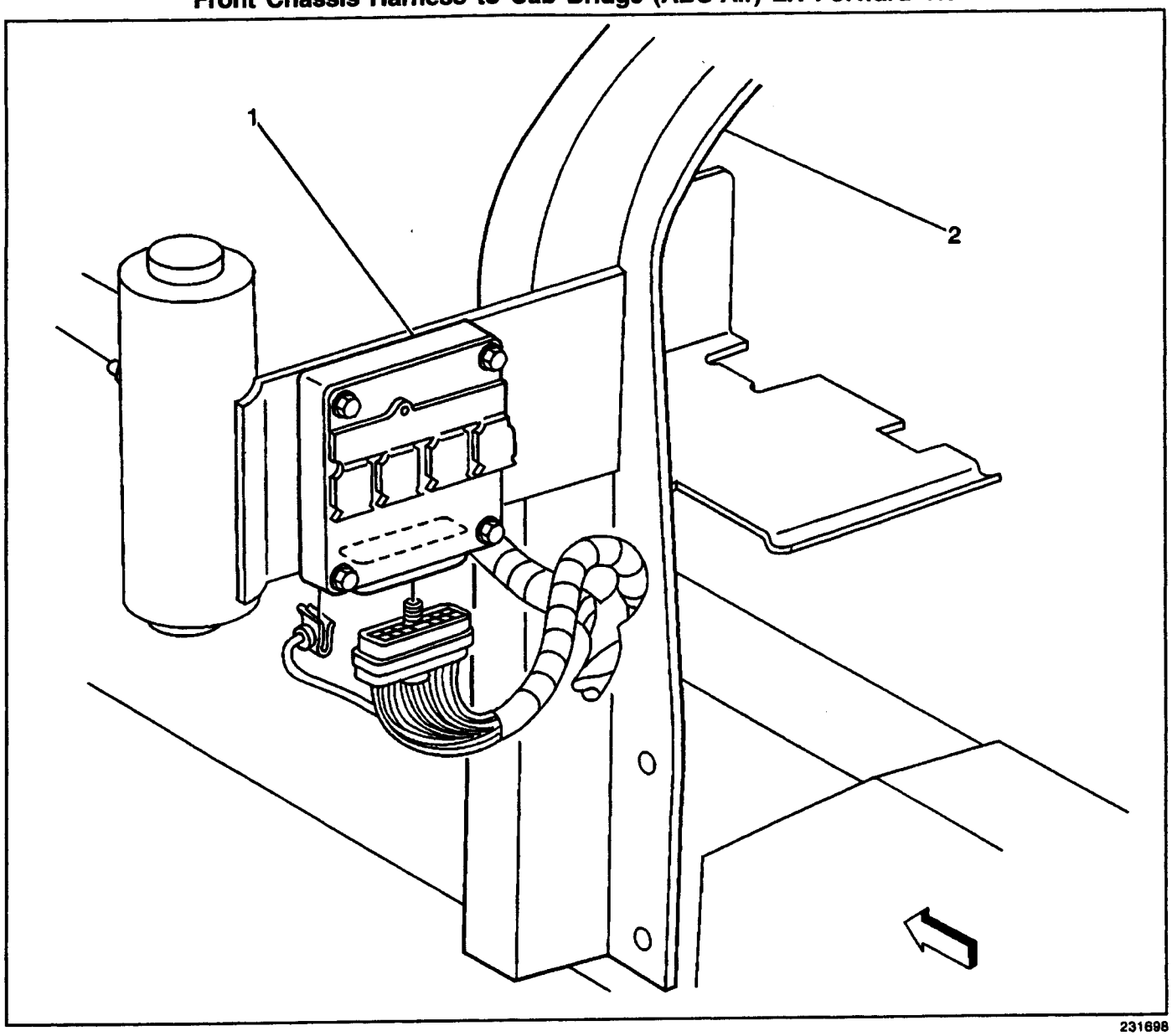


231487

Legend

(1) Brake Fluid Flow Switch
(2) Electronic Brake Control Module (EBCM) (ABS-Hydraulic) Connecor C2 (2 cavities)
(3) Electronic Brake Control Module (EBCM) (ABS-Hydraulic) Connector C1 (24 cavities)
(4) Electronic Brake Control Module (EBCM) (ABS-Hydraulic) Connector C2 (2 cavities)

Front Chassis Harness to Cab Bridge (ABS-Air) LH Forward View

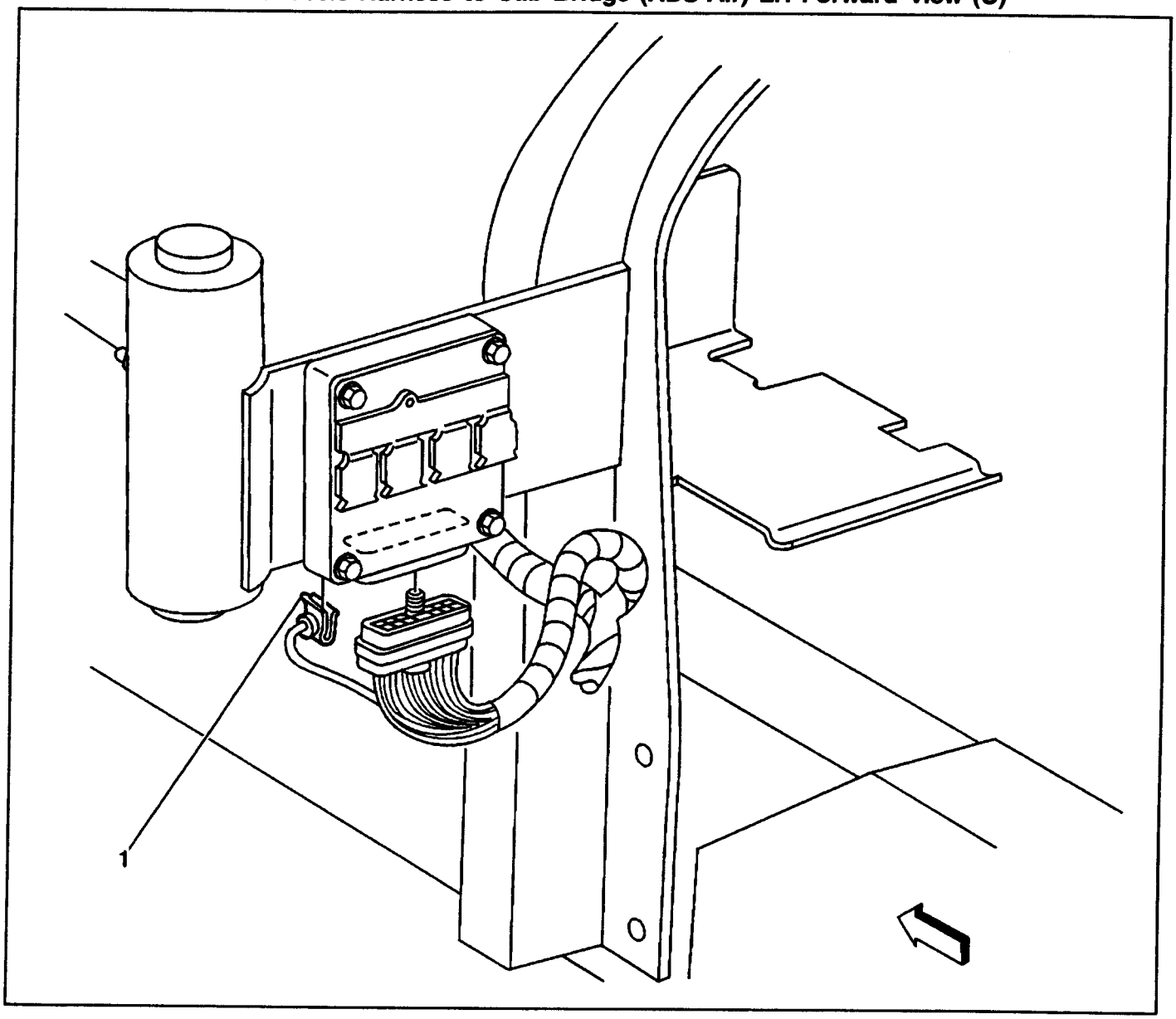


Legend

(1) Electronic Brake Control Module (EBCM) (ABS-Air)

(2) Cab Bridge

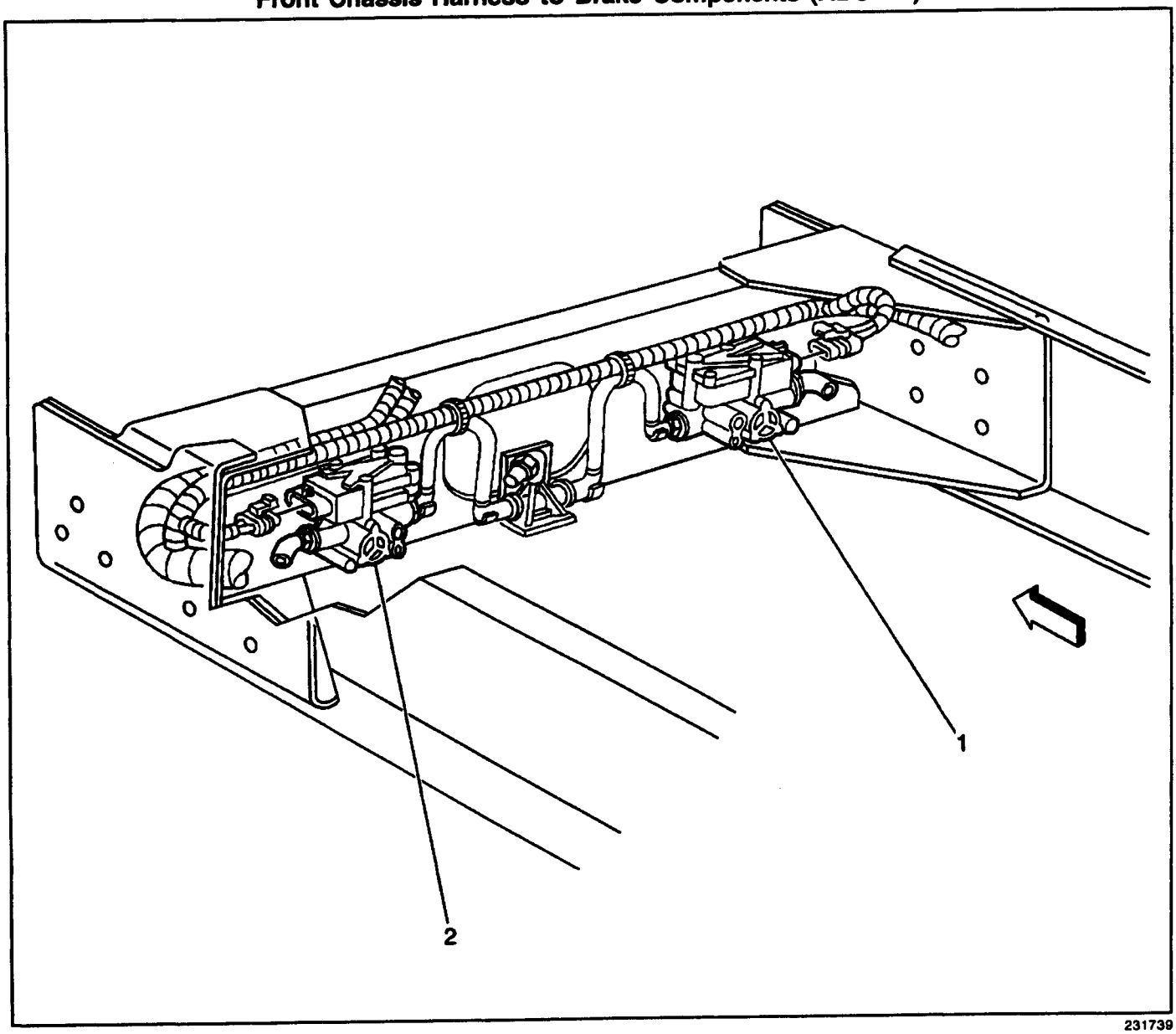
Front Chassis Harness to Cab Bridge (ABS-Air) LH Forward View (C)



Legend

(1) G104 (ABS-Air)

Front Chassis Harness to Brake Components (ABS-Air)



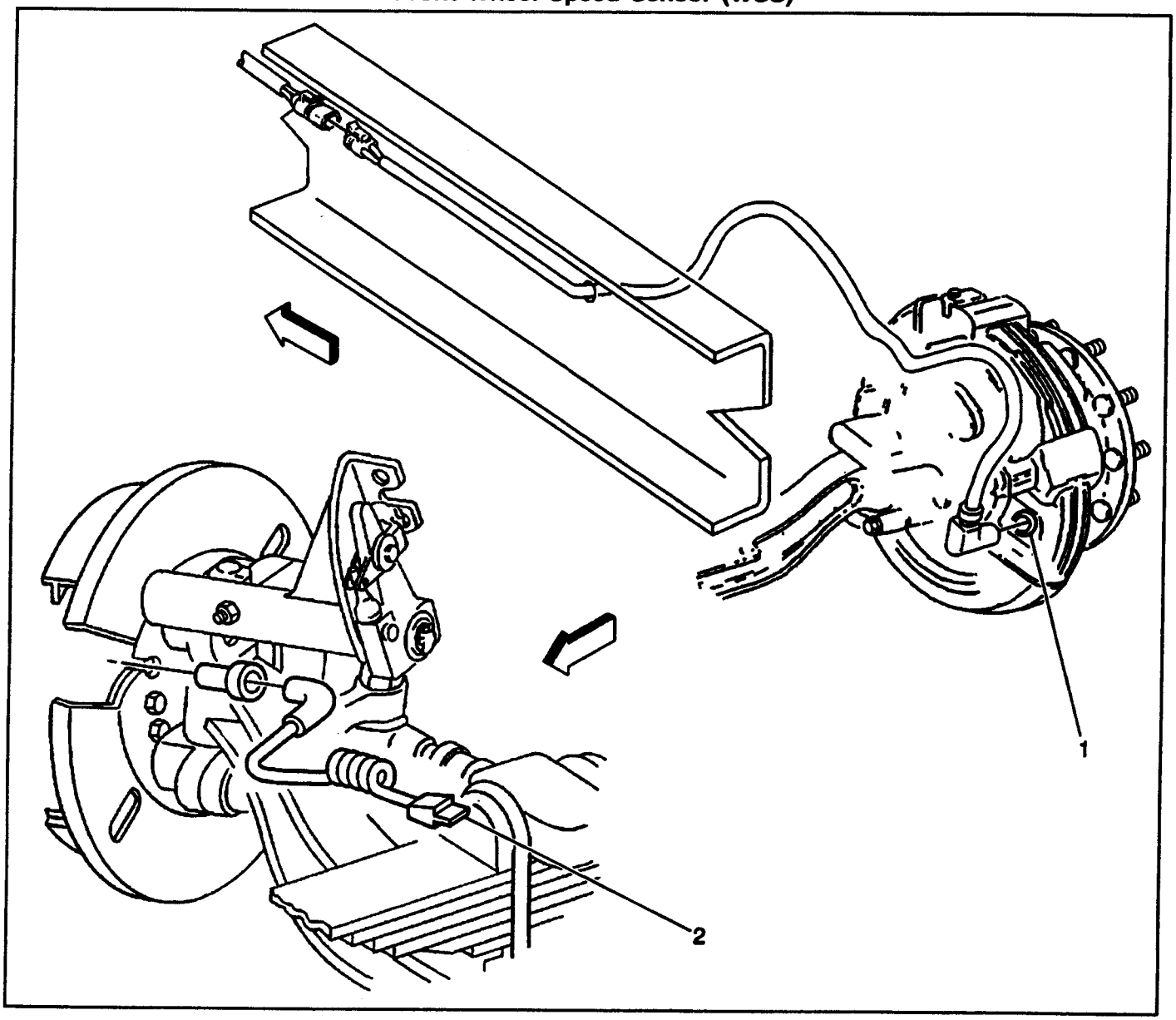
231739

Legend

(1) Brake Pressure Modulator Valve (BPMV), RH Front (ABS-Air)

(2) BPMV, LH Front (ABS-Air)

Front Wheel Speed Sensor (WSS)



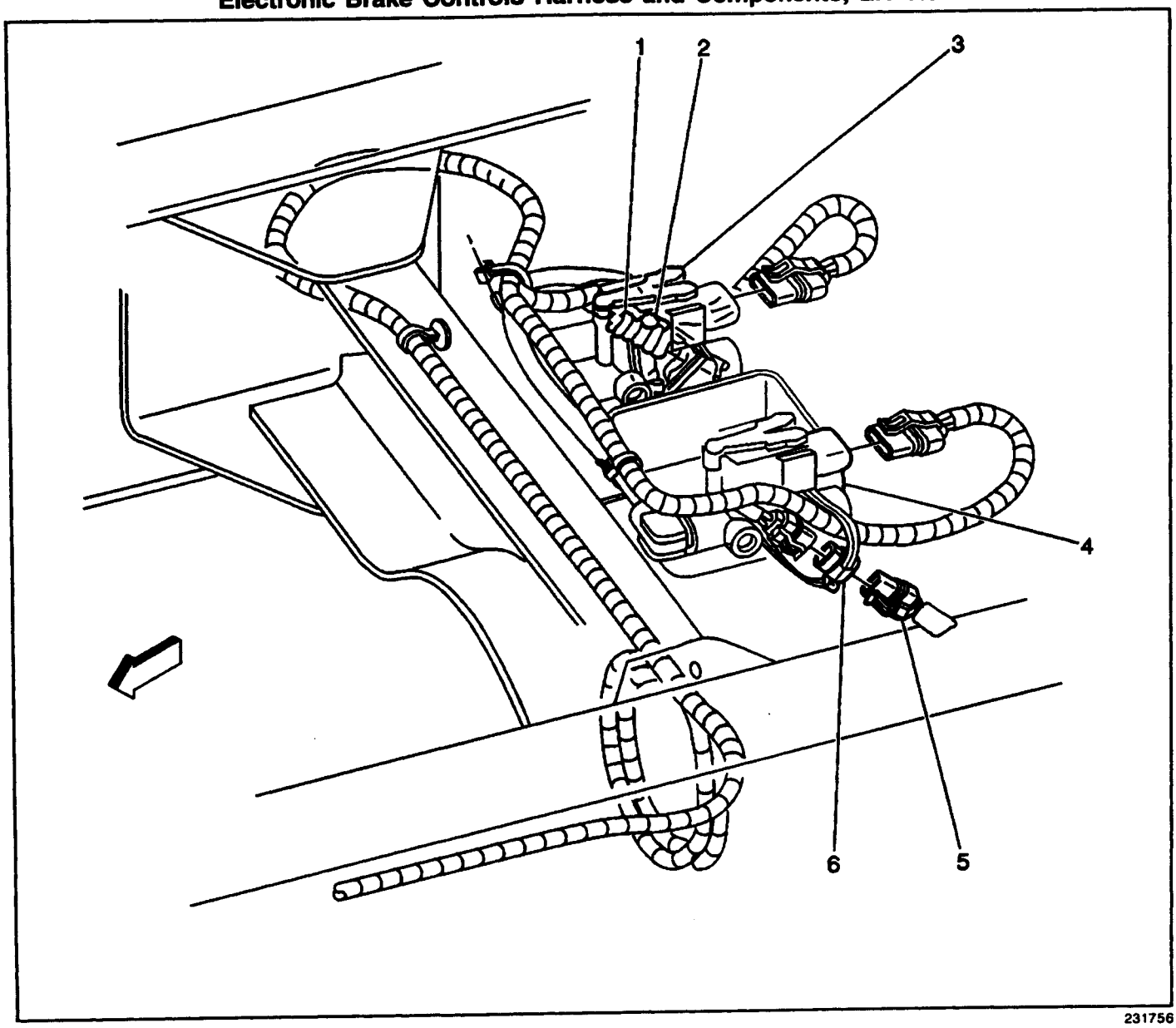
231740

Legend

(1) RH Front Wheel Speed Sensor (WSS) (ABS-Hydraulic)

(2) RH Front WSS (ABS-Air)

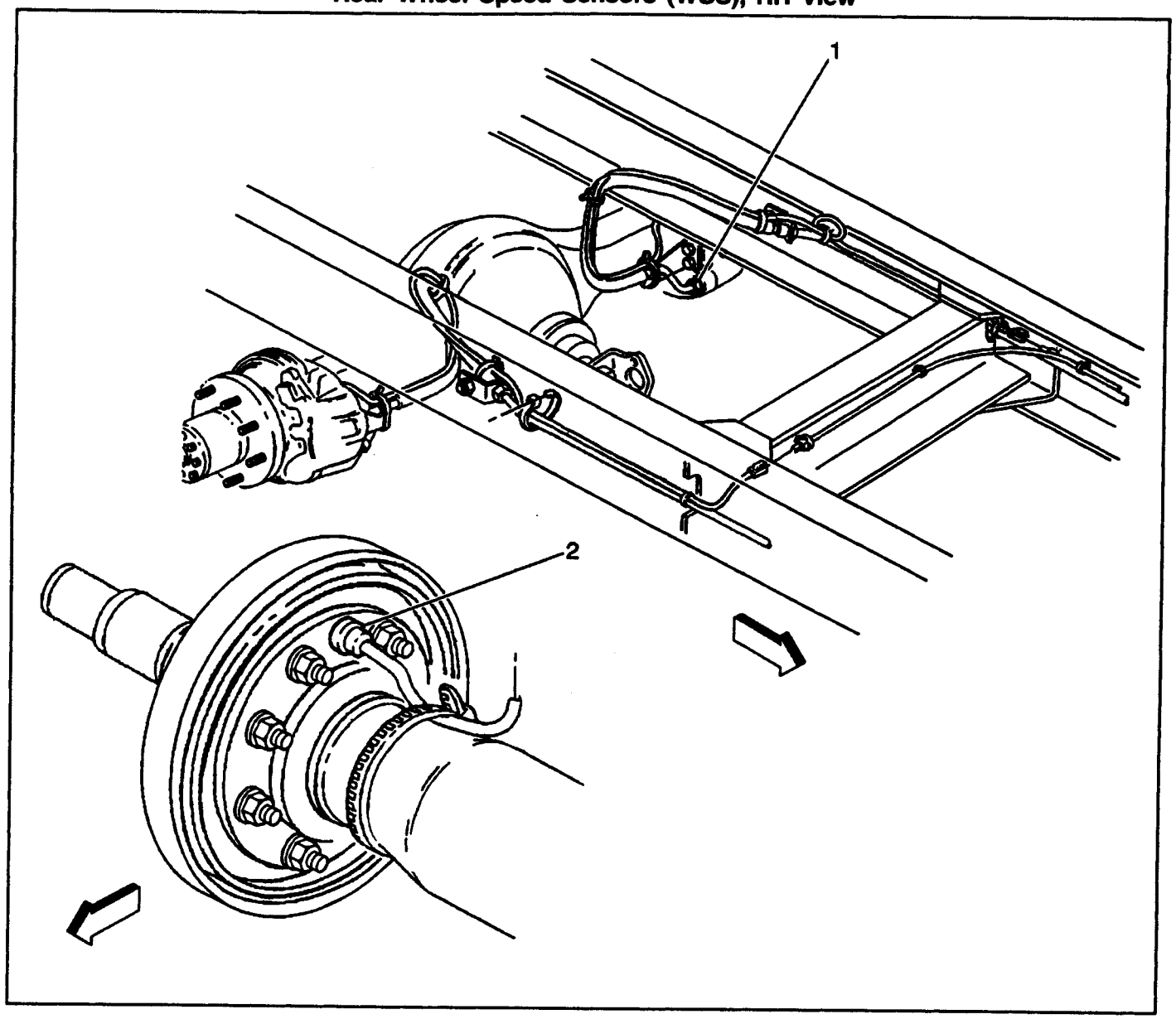
Electronic Brake Controls Harness and Components, LH View



Legend

(1) RH Rear Wheel Speed Sensor (WSS) (ABS-Air)
(2) RH R3ear Gender Adapter Connector (4 male-to-male cavities) (ABS-Air)
(3) RH Rear Brake Pressure Modulator Valve (BPMV) (ABS-Air)
(4) LH Rear BPMV (ABS-Air)
(5) LH Rear WSS (ABS-Air)
(6) LH Rear Gender Adapter Connector (4 male-to-male cavities) (ABS-Air)

Rear Wheel Speed Sensors (WSS), RH View



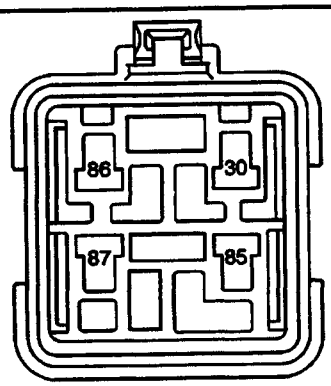
Legend

(1) LH Rear Wheel Speed Sensor (WSS) (ABS-Hydraulic)

(2) RH Rear WSS (ABS-Air)

Antilock Brakes System Connector End Views

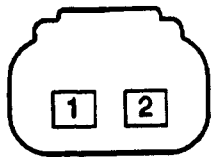
ABS Relay



39670

Connector Part Information	• 12129716 • 4 Way F Metri-Pack 280 Series, Flexlock, Sealed (GRY)		
Pin	**Wire Color**	**Circuit No.**	**Function**
30	RED	1442	Fuse Output-Battery
85	PNK	139	Fuse Output-Ignition
86	BLK	150	Ground
87	PNK	839	Fuse Output-Ignition

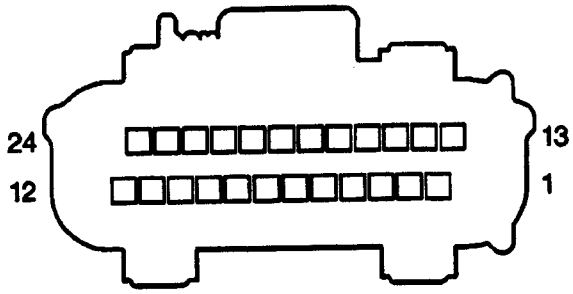
Electronic Brake Control Module C1 (Hydraulic)



239998

Connector Part Information	• 12162896 • 2 Way F Sealed (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
1	RED	1142	Fuse Output-Battery
2	BLK	150	Ground

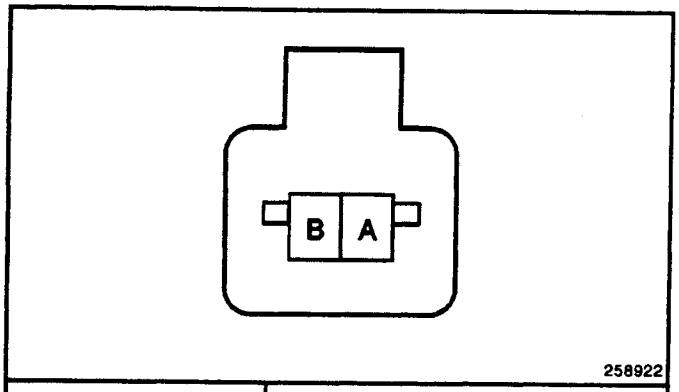
Electronic Brake Control Module C2 (Hydraulic)



309424

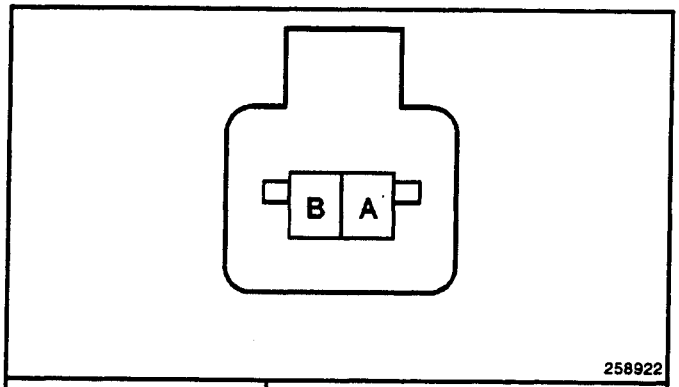
Connector Part Information	• 15324027 • 24 Way F (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
1	LT GRN	867	ABS Failure Indicator Lamp Output
2	DK BLU	1899	Dash Lamp Relay Output-Coil
3–4	—	—	Not Used
5	TAN/WHT	799	Diagnostic Signal-ABS
6	—	—	Not Used
7	TAN/WHT	33	Brake Warning Indicator Lamp Output
8	BRN	882	Wheel Speed Sensor Signal-Right Rear
9	BLK	884	Wheel Speed Sensor Signal-Left Rear
10	DK GRN	872	Wheel Speed Sensor Signal-Right Front
11	LT BLU	830	Wheel Speed Sensor Signal-Left Front
12–13	—	—	Not Used
14	PNK	139	Fuse Output-Ignition
15	TAN	848	Brake Pedal Switch Signal-ABS
16-19	—	—	Not Used
20	WHT	883	Wheel Speed Sensor Return-Right Rear
21	RED	885	Wheel Speed Sensor Return-Left Rear
22	TAN	833	Wheel Speed Sensor Return-Right Front
23	YEL	873	Wheel Speed Sensor Return-Left Front
24	—	—	Not Used

Wheel Speed Sensor, LH Front



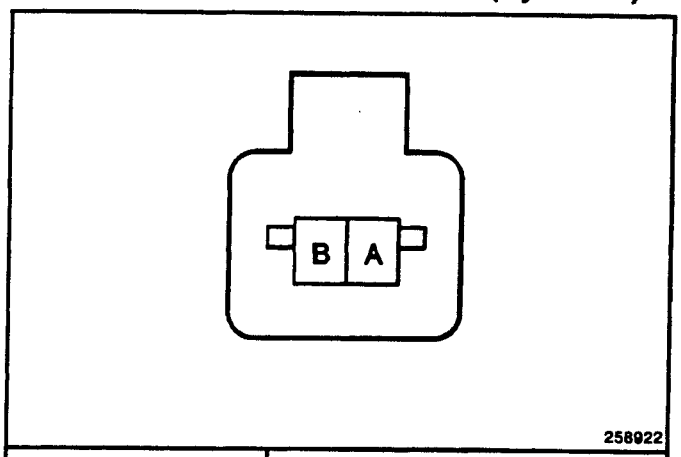
Connector Part Information	• 12162852 • 2Way F Metri-Pack 150.2 Series Pull To Seat (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	LT BLU	830	Wheel Speed Sensor Signal-Left Front
A	LT GRN	1903	AAS Wheel Speed Sensor Signal-Left Front
B	YEL	873	Wheel Speed Sensor Return-Left Front
B	ORN	1904	AAS Wheel Speed Sensor Return-Left Front

Wheel Speed Sensor, RH Front



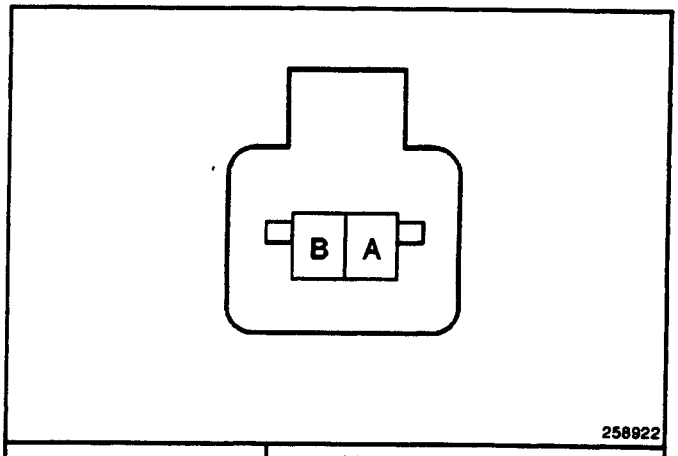
Connector Part Information	• 12162852 • 2Way F Metri-Pack 150.2 Series Pull To Seat (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	DK GRN	872	Wheel Speed Sensor Signal-Right Front
A	WHT	1909	AAS Wheel Speed Sensor Signal-Right Front
B	TAN	833	Wheel Speed Sensor Return-Right Front
B	BRN/WHT	1910	AAS Wheel Speed Sensor Return-Right Front

Wheel Speed Sensor, LH Rear (Hydraulic)



Connector Part Information	• 12162852 • 2Way F Metri-Pack 150.2 Series Pull To Seat (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BLK	884	Wheel Speed Sensor Signal-Left Rear
B	RED	885	Wheel Speed Sensor Return-Left Rear

Wheel Speed Sensor, RH Rear (Hydraulic)



Connector Part Information	• 12162852 • 2Way F Metri-Pack 150.2 Series Pull To Seat (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BRN	882	Wheel Speed Sensor Signal-Right Rear
B	WHT	883	Wheel Speed Sensor Return-Right Rear

Diagnostic Information and Procedures

Self-Diagnostics

The EBCM performs self-diagnostics of the ABS. The EBCM detects and isolates system failures. When a malfunction is detected, the EBCM sets a corresponding diagnostic trouble code (DTC).

Displaying DTCs

Read DTCs using a *Scan Tool*. No provisions are made for Flash Code DTCs.

Clearing DTCs

Use a *Scan Tool* in order to erase the DTCs in the EBCM memory. Verify proper system operation and absence of DTCs when the clearing procedure completes. The EBCM will not permit DTC clearing until all DTCs have been displayed. Also, DTCs cannot be cleared by unplugging the EBCM, by disconnecting the battery cables, or by turning the ignition OFF.

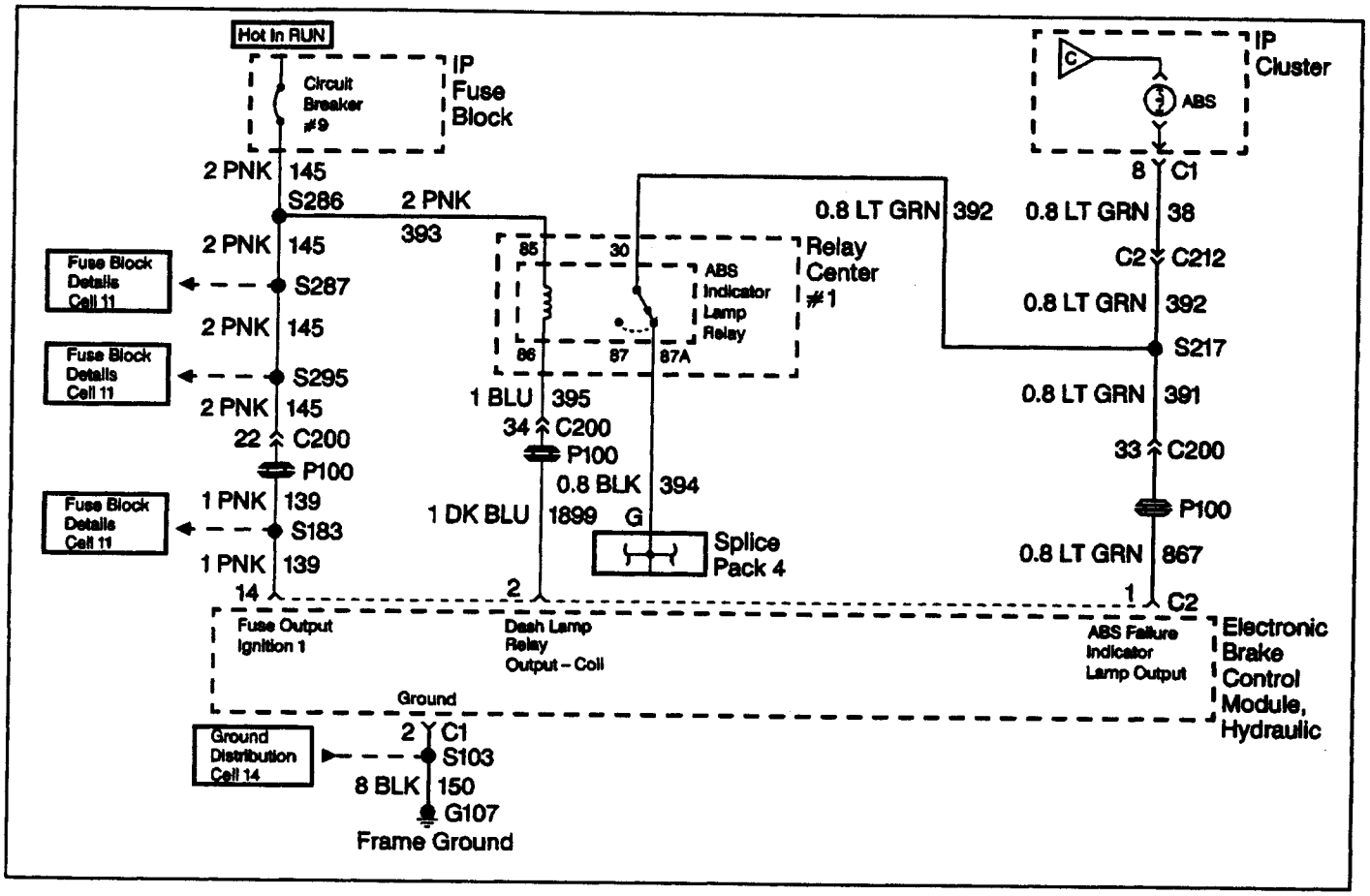
Intermittents and Poor Connections

Most intermittent faults are caused by a faulty electrical connection or faulty wiring. Occasionally a damaged EBCM can be the cause of an intermittent fault. Refer to Intermittents and Poor Connections in Electrical Diagnosis for a detailed explanation of how to locate and repair intermittent conditions.

Scan Tool Diagnosis

Refer to the Scan Tool Owner's Manual for information about the Scan Tool and the various modes.

Diagnostic System Check



324876

System Description

The diagnostic system check is an organized approach to identifying an Antilock Brake System (ABS) malfunction. The diagnostic system check must be the starting point for any ABS complaint diagnosis. The diagnostic system check directs the service technician to the next logical step in diagnosing the complaint. Refer to the appropriate table (below) for Gas, or Diesel engines.

Diagnostic serial data is transmitted/received by the EBCM through connector C2, terminal 5. The EBCM is supplied switched ignition voltage through connector C2, terminal 14, and ground is provided through connector C1, terminal 2.

Diagnostic Aids

Excessive resistance in the ground or power supply circuits will not allow communication with the EBCM. If communication with the EBCM is not possible, ensure that the ABS ground connection is good and that there is no excessive resistance in any of the power supply circuits.

Test Description

The numbers below refer to the steps in the diagnostic table:

3. This step checks for normal ABS indicator lamp operation.
4. This step checks for ignition voltage at the EBCM.
5. This step checks for high resistance in the ground circuit.
9. This step checks for high resistance in the ignition voltage circuit.
10. This step checks for a short to ground in the ignition voltage circuit.
11. This step checks for a short to ground in the EBCM.

Diagnostic System Check

Step	Action	Value(s)	Yes	No
1	1. Verify that all of the EBCM connectors are connected properly. 2. Install the *Scan Tool*. 3. Turn the ignition to RUN. 4. Attempt to communicate with the EBCM using the *Scan Tool*. Is data being received from the EBCM?	—	Go to Step *2*	Go to Step *4*
2	Using the *Scan Tool*, check for any DTCs. Are any current or history DTCs displayed?	—	Refer to the Appropriate DTC Table	Go to Step *3*
3	1. Turn the ignition to OFF for 10 seconds. 2. Turn the ignition to RUN and observe the ABS indicator lamp. Did the ABS indicator lamp turn ON for three seconds and then turn OFF?	—	System is operating normally. Refer to Diagnostic Aids.	Go to Step *12*
4	1. Turn the ignition to OFF. 2. Disconnect the 24-way EBCM harness connector. 3. Turn the ignition to RUN. 4. Using the *J 39200*, measure the voltage between the 24-way EBCM harness connector terminal 14 and ground. Is the voltage measured within the specified range?	10–15V	*Go to Step 5*	*Go to Step 9*
5	1. Turn the ignition to OFF. 2. Disconnect the negative battery cable. Refer to *Battery Disconnect Caution* in Cautions and Notices. 3. Using the *J 39200*, measure the resistance between the 2-way EBCM harness connector terminal 2 and the negative battery terminal. Is the resistance measured within the specified range?	0–2Ω	Go to Step *6*	Go to Step *13*
6	1. Inspect the EBCM terminals and the EBCM harness connector terminals for poor terminal contact. 2. Inspect the battery terminals and the battery cable terminals for poor connection. Refer to Checking Terminal Contact in Electrical Diagnosis. Is the terminal contact or the connection poor?	—	Go to Step *7*	Go to Step *8*
7	Replace the terminals or repair the poor connection. Is the repair complete?	—	Go to Step *1*	—
8	Reconnect the EBCM connectors and the battery cables. Are the EBCM connectors and the battery cables reconnected?	—	Refer to Wiring Systems (Cell 50) for serial data circuit diagnosis	—

Diagnostic System Check (cont'd)

Step	Action	Value(s)	Yes	No
9	1. Disconnect the positive battery cable. 2. Turn the ignition to RUN. (This is to provide circuit continuity.) 3. Using the *J 39200*, measure the resistance between the 24-way EBCM connector terminal 14 and the positive battery cable. Is the resistance measured within the specified range?	0–2Ω	Go to Step *10*	Go to Step *14*
10	1. Turn the ignition to OFF. 2. Remove Circuit Breaker 9. 3. Using the *J 39200*, measure the resistance between the 24-way EBCM connector terminal 14 and ground. Is the resistance measurement equal to the specified value?	OL	Go to Step *11*	Go to Step *15*
11	1. Reconnect the EBCM. 2. Using the *J 39200*, measure the resistance between the ABS indicator relay terminal 85 and ground. Is the resistance measurement within the specified range?	OL	Problem is intermittent. Refer to Diagnostic Aids.	Go to Step *16*
12	Observe the ABS indicator lamp. Does the ABS indicator lamp stay on?	—	Go to *ABS Indicator On No DTC Set*	Go to *ABS Indicator Off No DTC Set*
13	Repair open or high resistance in CKT 150. Is the repair complete?	—	Go to Step *1*	—
14	1. Repair open or high resistance in CKT 139. 2. Check Circuit Breaker 9 for proper operation. Is the repair complete?	—	Go to Step *1*	—
15	1. Repair short to ground in CKT 139. 2. Check for an open in Circuit Breaker 9. Is the repair complete?	—	Go to Step *1*	—
16	Inspect CKT 139 and the 24-way EBCM harness connector for physical damage which may result in a short to ground with the 24-way EBCM harness connector connected to the EBCM. Is there evidence of damage?	—	Go to Step *16*	Go to Step *17*
17	Repair the terminals which are damaged. Is the repair complete?	—	Go to Step *1*	—
18	1. Replace the EBCM. 2. Check for an open in Circuit Breaker 9. Is the repair complete?	—	Go to Step *1*	—

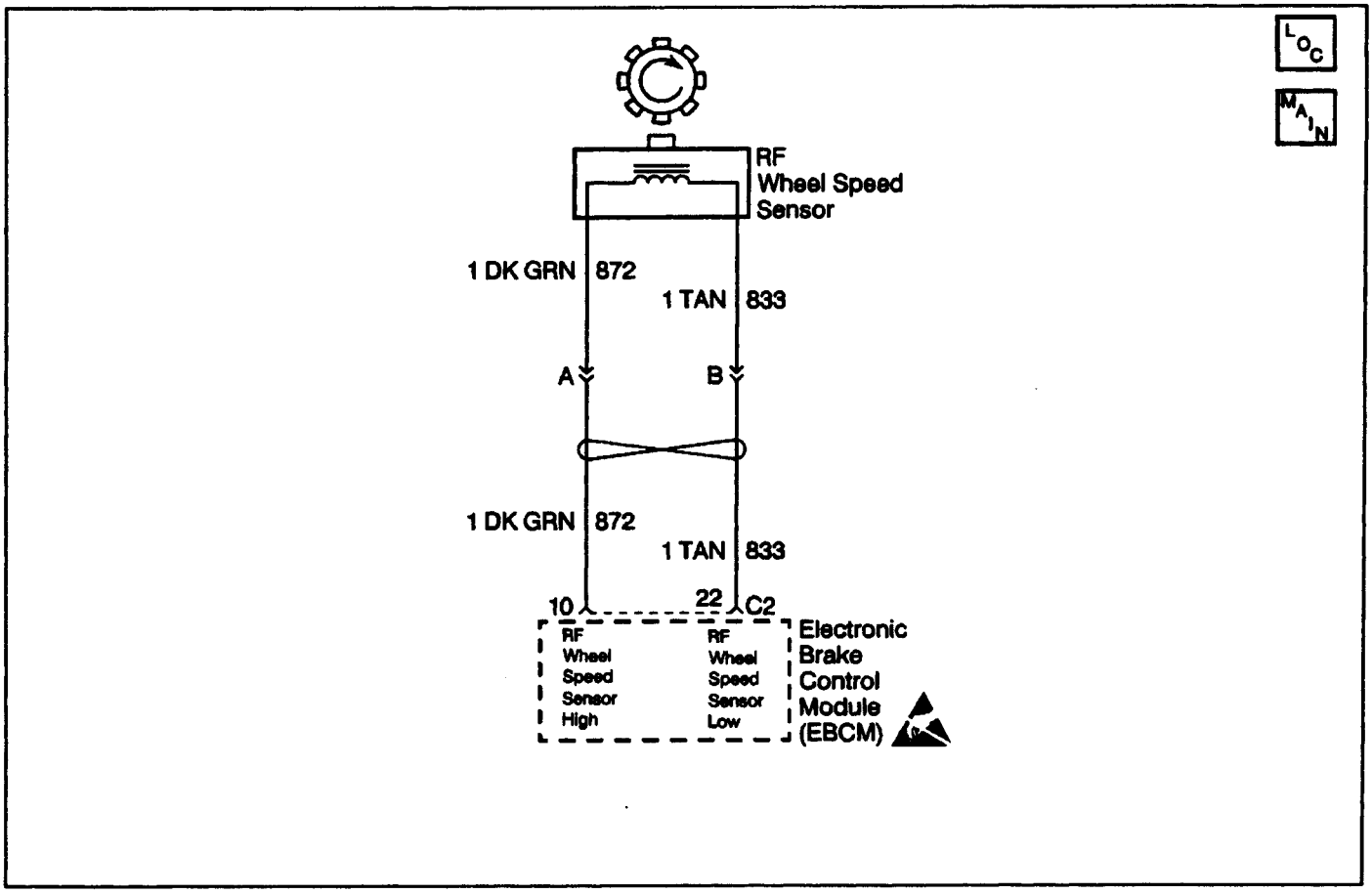
DTC List

DTC	Definition
DTC C0221	*DTC C0221 RF Wheel Speed Sensor Circuit Open*
DTC C0222	*DTC C0222 RF Wheel Speed Signal Missing*
DTC C0223	*DTC C0223 RF Wheel Speed Signal Erratic*
DTC C0225	*DTC C0225 LF Wheel Speed Sensor Circuit Open*
DTC C0226	*DTC C0226 LF Wheel Speed Signal Missing*
DTC C0227	*DTC C0227 LF Wheel Speed Signal Erratic*
DTC C0231	*DTC C0231 RR Wheel Speed Signal Circuit Open*
DTC C0232	*DTC C0232 RR Wheel Speed Signal Missing*
DTC C0233	*DTC C0233 RR Wheel Speed Signal Erratic*
DTC C0235	*DTC C0235 LR Wheel Speed Signal Circuit Open*
DTC C0236	*DTC C0236 LR Wheel Speed Signal Circuit Missing*
DTC C0237	*DTC C0237 LR Wheel Speed Signal Erratic*
DTC C0238	*DTC C0238 Wheel Speed Mismatch*
DTC C0241	*DTC C0241-C0258 EBCM Control Valve Circuit*
DTC C0242	*DTC C0241-C0258 EBCM Control Valve Circuit*
DTC C0243	*DTC C0241-C0258 EBCM Control Valve Circuit*
DTC C0244	*DTC C0241-C0258 EBCM Control Valve Circuit*
DTC C0245	*DTC C0241-C0258 EBCM Control Valve Circuit*
DTC C0246	*DTC C0241-C0258 EBCM Control Valve Circuit*
DTC C0247	*DTC C0241-C0258 EBCM Control Valve Circuit*
DTC C0248	*DTC C0241-C0258 EBCM Control Valve Circuit*

DTC List (cont'd)

DTC	Definition
DTC C0251	*DTC C0241-C0258 EBCM Control Valve Circuit*
DTC C0252	*DTC C0241-C0258 EBCM Control Valve Circuit*
DTC C0253	*DTC C0241-C0258 EBCM Control Valve Circuit*
DTC C0254	*DTC C0241-C0258 EBCM Control Valve Circuit*
DTC C0255	*DTC C0241-C0258 EBCM Control Valve Circuit*
DTC C0256	*DTC C0241-C0258 EBCM Control Valve Circuit*
DTC C0257	*DTC C0241-C0258 EBCM Control Valve Circuit*
DTC C0258	*DTC C0241-C0258 EBCM Control Valve Circuit*
DTC C0265	*DTC C0265 or C0266 EBCM Relay Circuit*
DTC C0266	*DTC C0265 or C0266 EBCM Relay Circuit*
DTC C0267	*DTC C0267 or C0268 Pump Motor Circuit Open/Shorted*
DTC C0268	*DTC C0267 or C0268 Pump Motor Circuit Open/Shorted*
DTC C0269	*DTC C0269 or C0274 Excessive Dump/ Isolation Time*
DTC C0271	*DTC C0271-C0273 EBCM Malfunction*
DTC C0272	*DTC C0271-C0273 EBCM Malfunction*
DTC C0273	*DTC C0271-C0273 EBCM Malfunction*
DTC C0274	*DTC C0269 or C0274 Excessive Dump/ Isolation Time*
DTC C0279	*DTC C0279 Trim Level Not Selected*
DTC C0281	*DTC C0281 Brake Switch Circuit*
DTC C0286	*DTC C0286 ABS Indicator Lamp Circuit Shorted to B+*

DTC C0221 RF Wheel Speed Sensor Circuit Open



324880

Circuit Description

The wheel speed sensor coil emits an electromagnetic field. A toothed ring on the wheel passes by the wheel speed sensor and disrupts this electromagnetic field. The disruption in the field causes the wheel speed sensor to produce a sinusoidal (AC) voltage signal. The frequency and amplitude of the sinusoidal (AC) voltage signal are proportional to the speed of the wheel. The amplitude of the wheel speed signal is also directly related to the distance between the wheel speed sensor coil and the toothed ring. This distance is referred to as the air gap.

Conditions for Setting the DTC

- No output from the right front wheel speed sensor for 1.0 second.
- Excessive right front wheel speed sensor resistance for 1.0 second.

Action Taken When the DTC Sets

- The ABS indicator lamp turns on
- The ABS disables

DTC C0221 is a Condition Latched DTC, which indicates that the above actions remain true only as long as the condition persists.

Conditions for Clearing the DTC

- Repair the conditions responsible for setting the DTC
- Use the *Scan Tool* Clear DTCs function

Diagnostic Aids

Any of the following conditions may cause an intermittent malfunction:

- A poor connection
- Wire insulation that is rubbed through
- A wire breaks inside the insulation

Thoroughly check any circuitry that is suspected of causing the intermittent complaint for the following conditions:

- Backed out terminals
- Improper mating
- Broken locks
- Improperly formed or damaged terminals
- Poor terminal to wiring connections
- Physical damage to the wiring harness

If the customer says that the ABS indicator lamp is on only during humid conditions such as rain, snow, or vehicle wash, then thoroughly inspect all wheel speed sensor circuits for signs of water intrusion.

Use the following procedure:

1. Spray the suspected area with a 5% salt water solution (two teaspoons of salt to 12 oz. of water)
2. Drive the vehicle above 24 km/h (15 mph) for at least 30 seconds

If the DTC returns, replace the suspected harness.

When inspecting a wheel speed sensor, inspect the sensor terminals and the harness connector for corrosion. If evidence of corrosion exists, replace the wheel speed sensor. Refer to *Wheel Speed Sensor Replacement - Front.*

Resistance of the wheel speed sensor will increase with an increase in sensor temperature. Refer to the following table for temperature/resistance values.

WSS Temperature vs. Sensor Resistance

°C	°F	Ohms
Temperature vs Resistance Values (Approximate)		
-40 to 4	-40 to 40	1500 to 2500
5 to 43	41 to 110	1500 to 2500
44 to 93	111 to 200	1500 to 2500
94 to 150	201 to 302	1500 to 2500

Test Description

The numbers below refer to the steps in the diagnostic table:

2. This step checks the resistance of the right front wheel speed sensor circuit.
3. This step checks the resistance of the right front wheel speed sensor wiring.
4. This step checks the resistance of the right front wheel speed sensor.

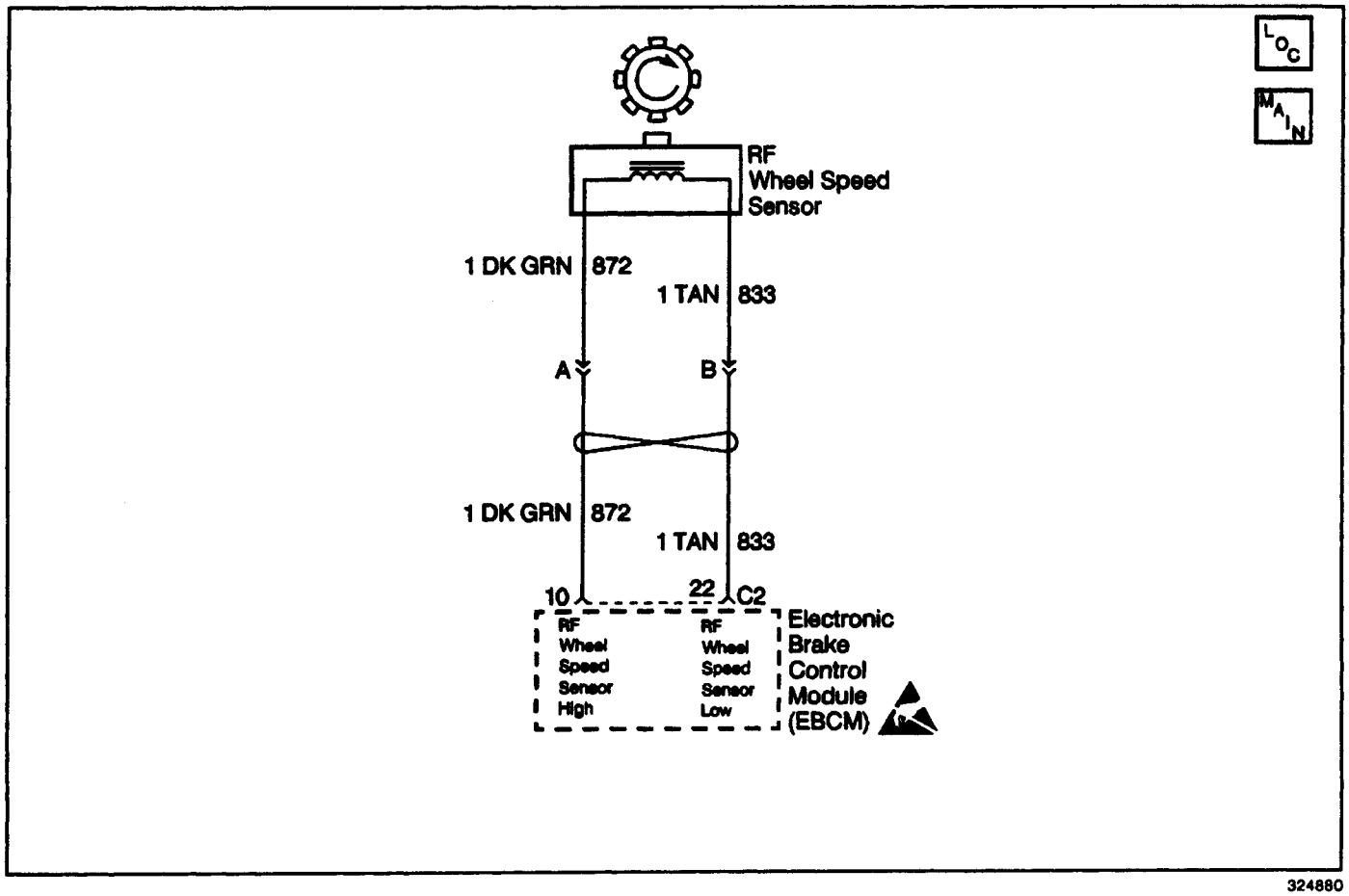
DTC C0221 RF Wheel Speed Sensor Circuit Open

Step	Action	Value(s)	Yes	No
1	Was the Diagnostic System Check performed?	—	Go to Step *2*	Go to *Diagnostic System Check*
2	1. Turn ignition to OFF. 2. Disconnect the 24-way EBCM harness connector. 3. Using a *J 39200*, Measure the resistance between terminals 10 and 22 of the 24-way EBCM harness connector. Is the resistance measurement within the specified range?	1500–2500 Ω	Go to Step *5*	Go to Step *3*
3	1. Disconnect the right front wheel speed sensor harness connector from the wheel speed sensor pigtail. 2. Using a *J 36169-A* connect terminal A and terminal B of the 2-way wheel speed sensor harness connector (chassis harness side). 3. Using a *J 39200* measure the resistance between terminals 10 and 22 of the 24-way EBCM harness connector. Is the resistance measurement within the specified range?	0–2 Ω	Go to Step *4*	Go to Step *7*
4	Using a *J 39200*, measure the resistance between terminal A and terminal B of the right front wheel speed sensor pigtail. Is the resistance measurement within the specified range?	1500–2500 Ω	Go to Step *5*	Go to Step*8*
5	1. Inspect the 24-way EBCM harness connector terminals 10 and 22 for poor terminal contact or corrosion. 2. Inspect CKT 833 and CKT 872 for damage that could result in an open circuit. Repair damage if evident. 3. Replace the terminals if poor contact or corrosion exists. 4. Reconnect all the connectors. 5. Using the *Scan Tool*, clear all DTCs. 6. Test drive the vehicle above 16 km/h (10 mph). Does DTC C0221 set as a current DTC?	—	Go to Step *6*	Malfunction is intermittent. Refer to Diagnostic Aids

DTC C0221 RF Wheel Speed Sensor Circuit Open (cont'd)

Step	Action	Value(s)	Yes	No
6	Replace the EBCM. Is the repair complete?	—	Go to *Diagnostic System Check*	—
7	Repair the open or high resistance in CKT 833 or CKT 872. Is the repair complete?	—	Go to *Diagnostic System Check*	—
8	Replace the wheel speed sensor. Is the repair complete?	—	Go to *Diagnostic System Check*	—

DTC C0222 RF Wheel Speed Signal Missing



324880

Circuit Description

The wheel speed sensor coil emits an electromagnetic field. A toothed ring on the wheel passes by the wheel speed sensor and disrupts this electromagnetic field. The disruption in the field causes the wheel speed sensor to produce a sinusoidal (AC) voltage signal. The frequency and amplitude of the sinusoidal (AC) voltage signal are proportional to the speed of the wheel. The amplitude of the wheel speed signal is also directly related to the distance between the wheel speed sensor coil and the toothed ring. This distance is referred to as the air gap.

Conditions for Setting the DTC

- The right front wheel speed is less than 6 km/h (4 mph)
- All other wheel speeds are greater than 13 km/h (8 mph)
- No unexpected wheel acceleration/deceleration. Anything that keeps the right front wheel speed sensor low while the vehicle is moving above 13 km/h (8 mph).

Action Taken When the DTC Sets

- The ABS indicator lamp turns on
- The ABS disables

DTC C0222 is an Ignition Latched DTC, which indicates that the above actions remain true until the ignition is turned to OFF (even if the cause of the DTC is intermittent).

Conditions for Clearing the DTC

- Repair the conditions responsible for setting the DTC
- Use the *Scan Tool* Clear DTCs function

Diagnostic Aids

Any of the following conditions may cause an intermittent malfunction:

- A poor connection
- Wire insulation that is rubbed through
- A wire breaks inside the insulation

Thoroughly check any circuitry that is suspected of causing the intermittent complaint for the following conditions:

- Backed out terminals
- Improper mating
- Broken locks
- Improperly formed or damaged terminals
- Poor terminal to wiring connections
- Physical damage to the wiring harness

If the customer says that the ABS indicator lamp is on only during humid conditions such as rain, snow, or vehicle wash, then thoroughly inspect all wheel speed sensor circuits for signs of water intrusion. Use the following procedure:

1. Spray the suspected area with a 5% salt water solution (two teaspoons of salt to 12 oz. of water)
2. Drive the vehicle above 24 km/h (15 mph) for at least 30 seconds

If the DTC returns, replace the suspected harness.

When inspecting a wheel speed sensor, inspect the sensor terminals and the harness connector for corrosion. If evidence of corrosion exists, then replace the wheel speed sensor. Refer to *Wheel Speed Sensor Replacement - Front.*

Resistance of the wheel speed sensor will increase with an increase in sensor temperature. Refer to the following table for temperature/resistance values.

WSS Temperature vs. Sensor Resistance

°C	°F	Ohms
Temperature vs Resistance Values (Approximate)		
-40 to 4	-40 to 40	1500 to 2500
5 to 43	41 to 110	1500 to 2500
44 to 93	111 to 200	1500 to 2500
94 to 150	201 to 302	1500 to 2500

Test Description

The numbers below refer to the steps in the diagnostic table:

3. This step checks the resistance of the right front wheel speed sensor.
4. This step checks the voltage output of the right front wheel speed sensor.
5. This step checks for a short in the wiring between the wheel speed sensor circuits.
6. This step checks for a short to ground in the right front wheel speed sensor circuits.

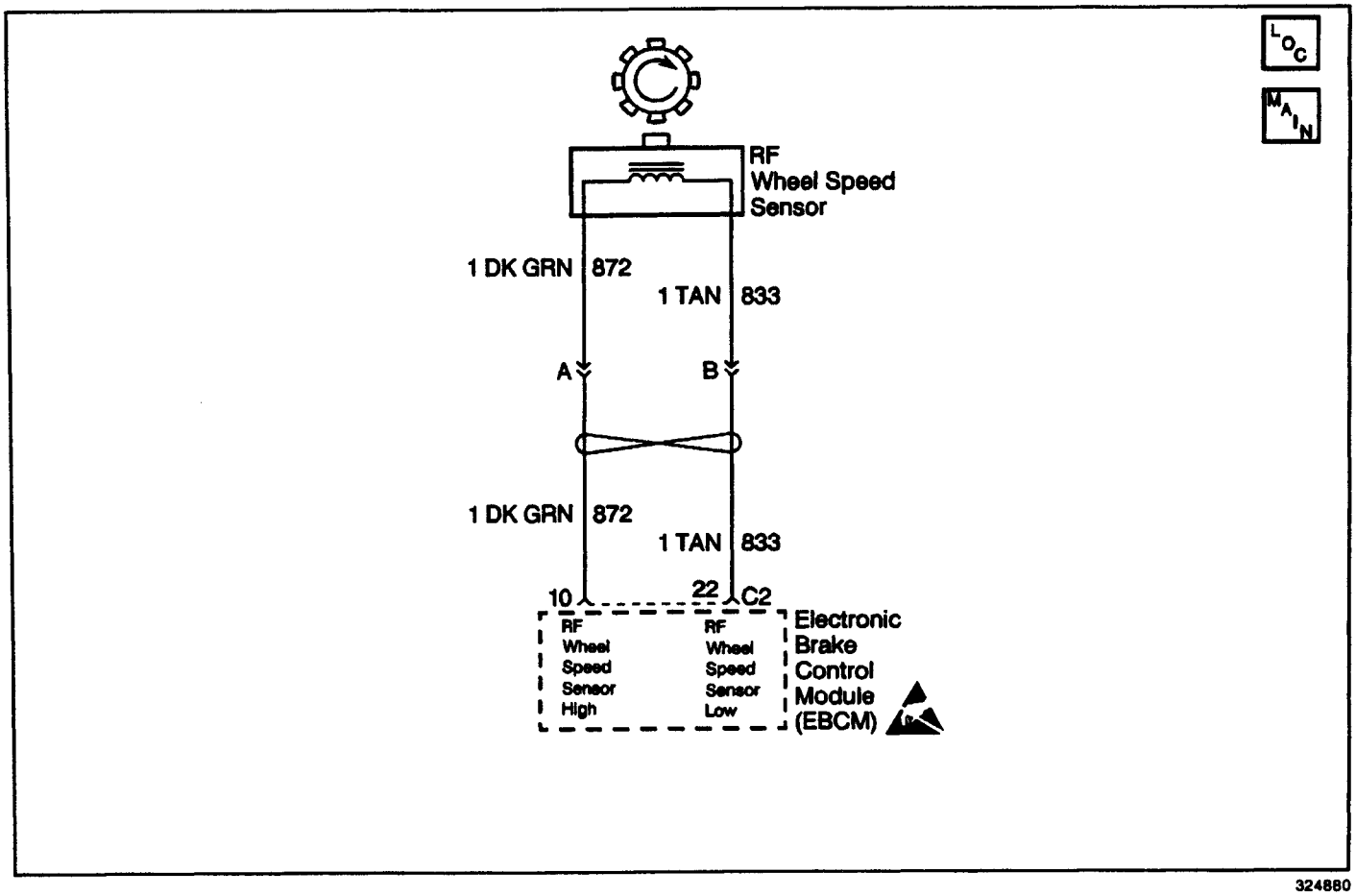
DTC C0222 RF Wheel Speed Signal Missing

Step	Action	Value(s)	Yes	No
1	Was the Diagnostic System Check performed?	—	Go to Step *2*	Go to *Diagnostic System Check*
2	1. Turn ignition to OFF. 2. Inspect the right front wheel speed sensor, sensor wire and the connectors for signs of damage or corrosion. 3. Inspect the wheel speed sensor and the toothed ring for looseness, paying particular attention to the toothed ring. Any deviation will affect the wheel speed sensor output signal. 4. Inspect the 24-way EBCM harness connector and harness for signs of damage or corrosion. Is there evidence of physical damage?	—	Go to Step *8*	Go to Step *3*
3	1. Disconnect the right front wheel speed sensor harness connector from the wheel speed sensor. 2. Using a *J 39200*, measure the resistance between terminal A and terminal B of the right front wheel speed sensor pigtail connector. Is the resistance measurement within the specified range?	1500–2500 Ω	Go to Step *4*	Go to Step *9*
4	1. With the *J 39200* still connected, select the A/C voltage scale. 2. Spin the wheel by hand while observing the voltage reading. Is the voltage measured equal to or greater than the specified value?	100 mV	Go to Step *5*	Go to Step *9*

DTC C0222 RF Wheel Speed Signal Missing (cont'd)

Step	Action	Value(s)	Yes	No
5	1. Disconnect the 24-way EBCM harness connector from the EBCM. 2. Using a *J 39200*, measure the resistance between terminals 10 and 22 of the 24-way EBCM harness connector. Is the resistance measurement equal to the specified value?	OL	Go to Step *6*	Go to Step *11*
6	1. Reconnect the right front wheel speed sensor. 2. Using a *J 39200*, measure the resistance between terminal 10 of the 24-way EBCM harness connector and ground. Is the resistance measurement equal to the specified value?	OL	Go to Step *7*	Go to Step *12*
7	1. Inspect the 24-way EBCM harness connector terminals 10 and 22 for poor terminal contact or corrosion. Inspect CKT 833 and CKT 872 for damage that could result in a shorted circuit. Repair any evident damage. Replace the terminals if poor contact or corrosion exists. 2. Reconnect all the connectors. 3. Using the *Scan Tool* clear all DTCs. 4. Test drive the vehicle above 16 km/h (10 mph). Does DTC C0222 set as a current DTC?	—	*Go to Step 10*	Malfunction is intermittent. Refer to Diagnostic Aids
8	Make the necessary repairs. Is the repair complete?	—	Go to *Diagnostic System Check*	—
9	Replace the right front wheel speed sensor. Is the repair complete?	—	Go to *Diagnostic System Check*	—
10	Replace the EBCM. Is the repair complete?	—	Go to *Diagnostic System Check*	—
11	Repair the short between CKT 833 or CKT 872. Is the repair complete?	—	Go to *Diagnostic System Check*	—
12	Repair the short to ground in CKT 833 or CKT 872. Is the repair complete?	—	Go to *Diagnostic System Check*	—

DTC C0223 RF Wheel Speed Signal Erratic



324880

Circuit Description

The wheel speed sensor coil emits an electromagnetic field. A toothed ring on the wheel passes by the wheel speed sensor and disrupts this electromagnetic field. The disruption in the field causes the wheel speed sensor to produce a sinusoidal (AC) voltage signal. The frequency and amplitude of the sinusoidal (AC) voltage signal are proportional to the speed of the wheel. The amplitude of the wheel speed signal is also directly related to the distance between the wheel speed sensor coil and the toothed ring. This distance is referred to as the air gap.

Conditions for Setting the DTC

- The average wheel speed for all wheel speed signals is greater than 40 km/h (25 mph).
- The average left front wheel speed is greater than 40 km/h (25 mph).
- No speed signal input to the EBCM from the right front wheel speed sensor for 15ms. Anything which suddenly prevents (intermittent) the right front wheel speed signal from toggling while the vehicle is moving greater than 40 km/h (25 mph).

Action Taken When the DTC Sets

- The ABS indicator lamp turns on
- The ABS disables

DTC C0223 is an Ignition Latched DTC, which indicates that the above actions remain true until the ignition is turned to OFF (even if the cause of the DTC is intermittent).

Conditions for Clearing the DTC

- Repair the conditions responsible for setting the DTC
- Use the *Scan Tool* Clear DTCs function

Diagnostic Aids

Any of the following conditions may cause an intermittent malfunction:

- A poor connection
- Wire insulation that is rubbed through
- A wire breaks inside the insulation

Thoroughly check any circuitry that is suspected of causing the intermittent complaint for the following conditions:

- Backed out terminals
- Improper mating
- Broken locks
- Improperly formed or damaged terminals
- Poor terminal to wiring connections
- Physical damage to the wiring harness

If the customer says that the ABS indicator lamp is on only during humid conditions such as rain, snow, or vehicle wash, then thoroughly inspect all wheel speed sensor circuits for signs of water intrusion. Use the following procedure:

1. Spray the suspected area with a 5% salt water solution (two teaspoons of salt to 12 oz. of water)
2. Drive the vehicle above 24 km/h (15 mph) for at least 30 seconds

If the DTC returns, replace the suspected harness.

When inspecting a wheel speed sensor, inspect the sensor terminals and the harness connector for corrosion. If evidence of corrosion exists, then replace the wheel speed sensor. Refer to *Wheel Speed Sensor Replacement - Front.*

Resistance of the wheel speed sensor will increase with an increase in sensor temperature. Refer to the following table for temperature/resistance values.

WSS Temperature vs. Sensor Resistance

°C	°F	Ohms
Temperature vs Resistance Values (Approximate)		
-40 to 4	-40 to 40	1500 to 2500
5 to 43	41 to 110	1500 to 2500
44 to 93	111 to 200	1500 to 2500
94 to 150	201 to 302	1500 to 2500

Test Description

The numbers below refer to the steps in the diagnostic table:

3. This step checks the resistance of the right front wheel speed sensor
4. This step checks the voltage output of the right front wheel speed sensor.
5. This step checks for a short in the wiring between the wheel speed sensor circuits.
6. This step checks for a short to ground in the wheel speed sensor circuits.

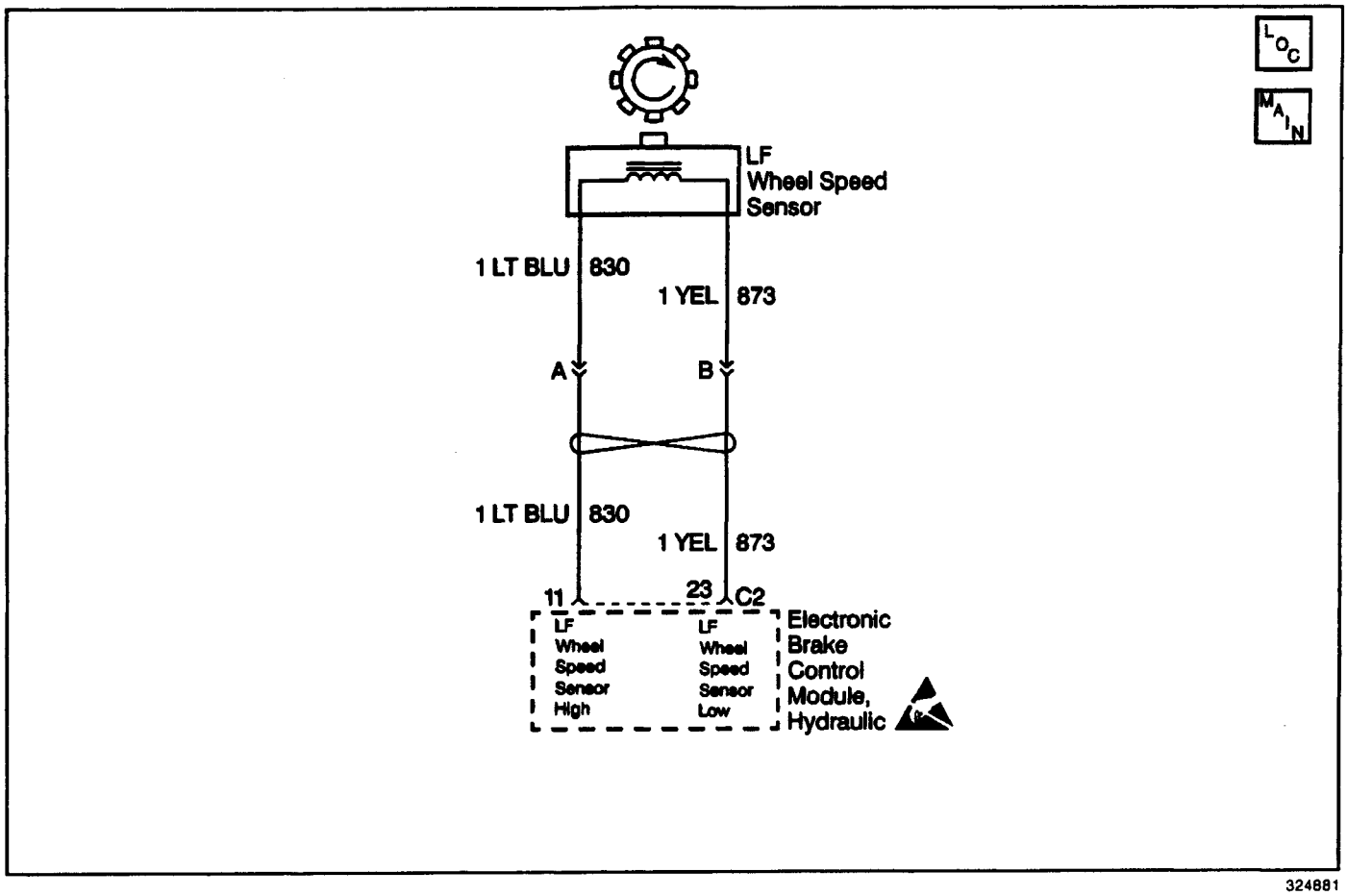
DTC C0223 RF Wheel Speed Signal Erratic

Step	Action	Value(s)	Yes	No
1	Was the Diagnostic System Check performed?	—	Go to Step *2*	Go to *Diagnostic System Check*
2	1. Turn the ignition to OFF. 2. Disconnect the 24-way EBCM harness connector from the EBCM. Inspect the EBCM harness connector for signs of damage or corrosion. 3. Inspect the wheel speed sensor harness and the sensor harness connector for signs of damage or corrosion. Are all the connections clean and tight?	—	Go to Step *3*	Go to Step *6*
3	Using a *J 39200*, measure the resistance between terminals 10 and 22 of the 24-way EBCM harness connector. Is the resistance measurement within the specified range?	1500–2500 Ω	Go to Step *5*	Go to Step *4*
4	1. Disconnect the wheel speed sensor from the wheel speed sensor harness pigtail connector. 2. Using a *J 39200*, measure the resistance between terminal A and terminal B of the right front wheel speed sensor pigtail connector. Is the resistance measurement within the specified range?	1500–2500 Ω	Go to Step *7*	Go to Step *8*
5	1. Reconnect all the connectors. 2. Verify that the right front wheel speed sensor is securely mounted and that the tone wheel is in good condition. Are the wheel speed sensor and the tone wheel in good condition?	—	Malfunction is intermittent. Refer to Diagnostic Aids	—

DTC C0223 RF Wheel Speed Signal Erratic (cont'd)

Step	Action	Value(s)	Yes	No
6	Make the necessary repairs to the 24-way EBCM harness connector. Is the repair complete?	—	Go to *Diagnostic System Check*	—
7	Repair the open or high resistance in CKT 833 or CKT 872. Is the repair complete?	—	Go to *Diagnostic System Check*	—
8	Replace the wheel speed sensor. Is the repair complete?	—	Go to *Diagnostic System Check*	—

DTC C0225 LF Wheel Speed Sensor Circuit Open



324881

Circuit Description

The wheel speed sensor coil emits an electromagnetic field. A toothed ring on the wheel passes by the wheel speed sensor and disrupts this electromagnetic field. The disruption in the field causes the wheel speed sensor to produce a sinusoidal (AC) voltage signal. The frequency and amplitude of the sinusoidal (AC) voltage signal are proportional to the speed of the wheel. The amplitude of the wheel speed signal is also directly related to the distance between the wheel speed sensor coil and the toothed ring. This distance is referred to as the air gap.

Conditions for Setting the DTC

- No output from the left front wheel speed sensor for 1.0 second.
- Excessive left front wheel speed sensor resistance for 1.0 second.

Action Taken When the DTC Sets

- The ABS indicator lamp turns on
- The ABS disables

DTC C0225 is a Condition Latched DTC, which indicates that the above actions remain true only as long as the condition persists.

Conditions for Clearing the DTC

- Repair the conditions responsible for setting the DTC
- Use the *Scan Tool* Clear DTCs function

Diagnostic Aids

Any of the following conditions may cause an intermittent malfunction:

- A poor connection
- Wire insulation that is rubbed through
- A wire breaks inside the insulation

Thoroughly check any circuitry that is suspected of causing the intermittent complaint for the following conditions:

- Backed out terminals
- Improper mating
- Broken locks
- Improperly formed or damaged terminals
- Poor terminal to wiring connections
- Physical damage to the wiring harness

If the customer says that the ABS indicator lamp is on only during humid conditions such as rain, snow, or vehicle wash, then thoroughly inspect all wheel speed sensor circuits for signs of water intrusion.

Use the following procedure:

1. Spray the suspected area with a 5% salt water solution (two teaspoons of salt to 12 oz. of water)
2. Drive the vehicle above 24 km/h (15 mph) for at least 30 seconds

If the DTC returns, replace the suspected harness.

When inspecting a wheel speed sensor, inspect the sensor terminals and the harness connector for corrosion. If evidence of corrosion exists, replace the wheel speed sensor. Refer to *Wheel Speed Sensor Replacement - Front.*

Resistance of the wheel speed sensor will increase with an increase in sensor temperature. Refer to the following table for temperature/resistance values.

WSS Temperature vs. Sensor Resistance

°C	°F	Ohms
Temperature vs Resistance Values (Approximate)		
-40 to 4	-40 to 40	1500 to 2500
5 to 43	41 to 110	1500 to 2500
44 to 93	111 to 200	1500 to 2500
94 to 150	201 to 302	1500 to 2500

Test Description

The numbers below refer to the steps in the diagnostic table:

2. This step checks the resistance of the left front wheel speed sensor circuit.
3. This step checks the resistance of the left front wheel speed sensor wiring.
4. This step checks the resistance of the left front wheel speed sensor.

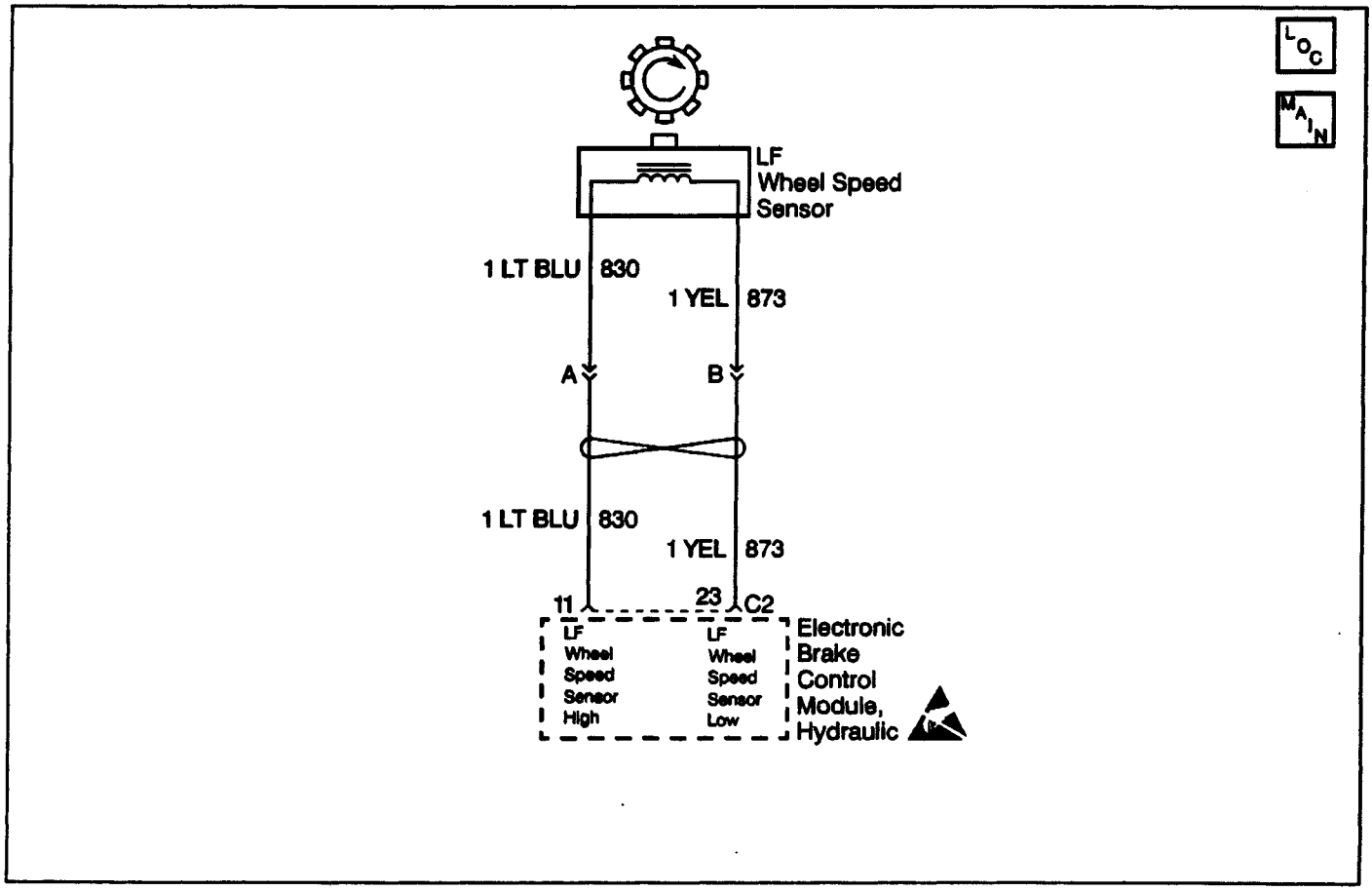
DTC C0225 LF Wheel Speed Sensor Circuit Open

Step	Action	Value(s)	Yes	No
1	Was the Diagnostic System Check performed?	—	Go to Step *2*	Go to *Diagnostic System Check*
2	1. Turn the ignition to OFF. 2. Disconnect the 24-way EBCM harness connector. 3. Use the *J 39200*, measure the resistance between terminal 11 and terminal 23 of the 24-way EBCM harness connector. Is the resistance measurement with the specified range?	1500–2500 Ω	Go to Step *5*	Go to Step *3*
3	1. Disconnect the left front wheel speed sensor harness connector from the wheel speed sensor pigtail. 2. Using a *J 36169-A* jumper terminal A and terminal B of the 2-way wheel speed sensor harness connector (chassis harness side). 3. Using a *J 39200*, measure the resistance between terminal 11 and terminal 23 of the 24-way EBCM harness connector. Is the resistance measurement within the specified range?	0–2 Ω	Go to Step *4*	Go to Step *7*
4	Using a *J 39200*, measure the resistance between terminal A and terminal B of the left front wheel speed sensor pigtail. Is the resistance measured within the specified range?	1500–2500 Ω	Go to Step *5*	Go to Step *8*
5	1. Inspect the 24-way EBCM harness connector terminals 11 23 for poor terminal contact or corrosion. Inspect CKT 830 and CKT 873 for damage that could result in an open circuit. Repair any evident damage. Replace the terminals if poor contact or corrosion exists. 2. Reconnect all the connectors. 3. Using the *Scan Tool* clear all DTCs. 4. Test drive the vehicle above 16 km/h (10 mph). Does DTC C0225 set as a current DTC?	—	Go to Step *6*	Malfunction is intermittent. Refer to Diagnostic Aids

DTC C0225 LF Wheel Speed Sensor Circuit Open (cont'd)

Step	Action	Value(s)	Yes	No
6	Replace the EBCM. Is the repair complete?	—	Go to *Diagnostic System Check*	—
7	Repair the open or the high resistance in CKT 830 or CKT 873. Is the repair complete?	—	Go to *Diagnostic System Check*	—
8	Replace the wheel speed sensor. Is the repair complete?	—	Go to *Diagnostic System Check*	—

DTC C0226 LF Wheel Speed Signal Missing



324881

Circuit Description

The wheel speed sensor coil emits an electromagnetic field. A toothed ring on the wheel passes by the wheel speed sensor and disrupts this electromagnetic field. The disruption in the field causes the wheel speed sensor to produce a sinusoidal (AC) voltage signal. The frequency and amplitude of the sinusoidal (AC) voltage signal are proportional to the speed of the wheel. The amplitude of the wheel speed signal is also directly related to the distance between the wheel speed sensor coil and the toothed ring. This distance is referred to as the air gap.

Conditions for Setting the DTC

- The left front wheel speed is less than 6 km/h (4 mph)
- All other wheel speeds are greater than 13 km/h (8 mph)
- No unexpected wheel acceleration/deceleration. Anything that keeps the left front wheel speed sensor low while the vehicle is moving above 13 km/h (8 mph).

Action Taken When the DTC Sets

- The ABS indicator lamp turns on
- The ABS disables

DTC C0226 is an Ignition Latched DTC, which indicates that the above actions remain true until the ignition is turned to OFF (even if the cause of the DTC is intermittent).

Conditions for Clearing the DTC

- Repair the conditions responsible for setting the DTC
- Use the *Scan Tool* Clear DTCs function

Diagnostic Aids

Any of the following conditions may cause an intermittent malfunction:

- A poor connection
- Wire insulation that is rubbed through
- A wire breaks inside the insulation

Thoroughly check any circuitry that is suspected of causing the intermittent complaint for the following conditions:

- Backed out terminals
- Improper mating
- Broken locks
- Improperly formed or damaged terminals
- Poor terminal to wiring connections
- Physical damage to the wiring harness

If the customer says that the ABS indicator lamp is on only during humid conditions such as rain, snow, or vehicle wash, then thoroughly inspect all wheel speed sensor circuits for signs of water intrusion. Use the following procedure:

1. Spray the suspected area with a 5% salt water solution (two teaspoons of salt to 12 oz. of water)
2. Drive the vehicle above 24 km/h (15 mph) for at least 30 seconds

If the DTC returns, replace the suspected harness.

When inspecting a wheel speed sensor, inspect the sensor terminals and the harness connector for corrosion. If evidence of corrosion exists, then replace the wheel speed sensor. Refer to *Wheel Speed Sensor Replacement - Front.*

Resistance of the wheel speed sensor will increase with an increase in sensor temperature. Refer to the following table for temperature/resistance values.

WSS Temperature vs. Sensor Resistance

°C	°F	Ohms
Temperature vs Resistance Values (Approximate)		
-40 to 4	-40 to 40	1500 to 2500
5 to 43	41 to 110	1500 to 2500
44 to 93	111 to 200	1500 to 2500
94 to 150	201 to 302	1500 to 2500

Test Description

The numbers below refer to the steps in the diagnostic table:

3. This step checks the resistance of the left front wheel speed sensor.
4. This step checks the voltage output of the left front wheel speed sensor.
5. This step checks for a short in the wiring between the left front wheel speed sensor circuits.
6. This step checks for a short to ground in the left front wheel speed sensor circuits.

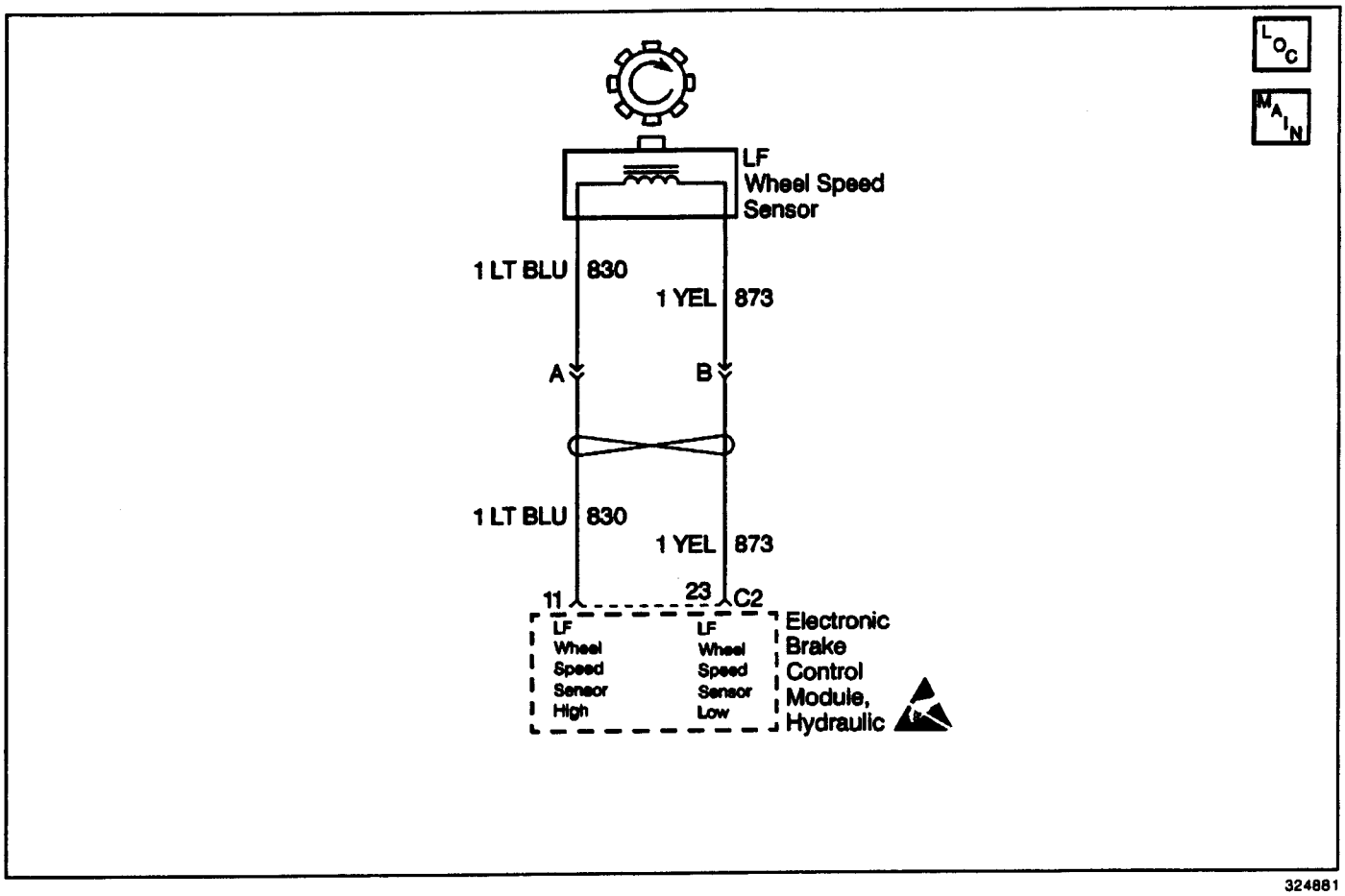
DTC C0226 LF Wheel Speed Signal Missing

Step	Action	Value(s)	Yes	No
1	Was the Diagnostic System Check performed?	—	Go to Step *2*	Go to *Diagnostic System Check*
2	1. Turn the ignition to OFF. 2. Inspect the left front wheel speed sensor, sensor wire and the connectors for signs of damage or corrosion. 3. Inspect the wheel speed sensor and the toothed ring for looseness paying particular attention to the toothed ring. Any deviation will affect the wheel speed sensor output signal. 4. Inspect the 24-way EBCM harness connector and harness for signs of damage or corrosion. Is there evidence of physical damage?	—	Go to Step *8*	Go to Step *3*
3	1. Disconnect the left front wheel speed sensor harness connector from the wheel speed sensor. 2. Using a *J 39200*, Measure the resistance between terminal A and terminal B of the left front wheel speed sensor pigtail connector. Is the resistance measurement within the specified range?	1500–2500 Ω	Go to Step *4*	Go to Step *9*
4	1. With the *J 39200* still connected, select the A/C voltage scale. 2. Spin the wheel by hand while observing the voltage reading. Is the voltage measured equal to or greater than the specified value?	100 mV	Go to Step *5*	Go to Step *9*
5	1. Disconnect the 24-way EBCM harness connector from the EBCM. 2. Using a *J 39200* Measure the resistance between terminal 11 and terminal 23 of the 24-way EBCM harness connector. Is the resistance measurement equal to the specified value?	OL	Go to Step *6*	Go to Step *11*

DTC C0226 LF Wheel Speed Signal Missing (cont'd)

Step	Action	Value(s)	Yes	No
6	1. Reconnect the left front wheel speed sensor. 2. Using a *J 39200*, measure the resistance between terminal 11 of the 24-way EBCM harness connector and ground. Is the resistance measurement equal to the specified value?	OL	Go to Step *7*	Go to Step *12*
7	1. Inspect the 24-way EBCM harness connector terminals 11 and 23 for poor terminal contact or corrosion. Inspect CKT 830 and CKT 873 for damage that could result in a shorted circuit. Repair any evident damage. Replace the terminals if poor contact or corrosion exists. 2. Reconnect all the connectors. 3. Using the *Scan Tool*, clear all DTCs. 4. Test drive the vehicle above 16 km/h (10 mph). Does DTC C0226 set as a current DTC?	—	Go to Step *10*	Malfunction is intermittent. Refer to Diagnostic Aids
8	Make necessary repairs. Is the repair complete?	—	Go to *Diagnostic System Check*	—
9	Replace the left front wheel speed sensor. Is the repair complete?	—	Go to *Diagnostic System Check*	—
10	Replace the EBCM. Is the repair complete?	—	Go to *Diagnostic System Check*	—
11	Repair the short between CKT 830 and CKT 873. Is the repair complete?	—	Go to *Diagnostic System Check*	—
12	Repair the short to ground in CKT 830 or CKT 873. Is the repair complete?	—	Go to *Diagnostic System Check*	—

DTC C0227 LF Wheel Speed Signal Erratic



324881

Circuit Description

The wheel speed sensor coil emits an electromagnetic field. A toothed ring on the wheel passes by the wheel speed sensor and disrupts this electromagnetic field. The disruption in the field causes the wheel speed sensor to produce a sinusoidal (AC) voltage signal. The frequency and amplitude of the sinusoidal (AC) voltage signal are proportional to the speed of the wheel. The amplitude of the wheel speed signal is also directly related to the distance between the wheel speed sensor coil and the toothed ring. This distance is referred to as the air gap.

Conditions for Setting the DTC

- The average wheel speed for all wheel speed signals is greater than 40 km/h (25 mph).
- The average left front wheel speed is greater than 40 km/h (25 mph).
- No speed signal input to the EBCM from the left front wheel speed sensor for 15ms. Anything which suddenly prevents (intermittent) the left front wheel speed signal from toggling while the vehicle is moving greater than 40 km/h (25 mph).

Action Taken When the DTC Sets

- The ABS indicator lamp turns on
- The ABS disables

DTC C0227 is an Ignition Latched DTC, which indicates that the above actions remain true until the ignition is turned to OFF (even if the cause of the DTC is intermittent).

Conditions for Clearing the DTC

- Repair the conditions responsible for setting the DTC
- Use the *Scan Tool* Clear DTCs function

Diagnostic Aids

Any of the following conditions may cause an intermittent malfunction:

- A poor connection
- Wire insulation that is rubbed through
- A wire breaks inside the insulation

Thoroughly check any circuitry that is suspected of causing the intermittent complaint for the following conditions:

- Backed out terminals
- Improper mating
- Broken locks
- Improperly formed or damaged terminals
- Poor terminal to wiring connections
- Physical damage to the wiring harness

If the customer says that the ABS indicator lamp is on only during humid conditions such as rain, snow, or vehicle wash, then thoroughly inspect all wheel speed sensor circuits for signs of water intrusion. Use the following procedure:

1. Spray the suspected area with a 5% salt water solution (two teaspoons of salt to 12 oz. of water)
2. Drive the vehicle above 24 km/h (15 mph) for at least 30 seconds

If the DTC returns, replace the suspected harness.

When inspecting a wheel speed sensor, inspect the sensor terminals and the harness connector for corrosion. If evidence of corrosion exists, then replace the wheel speed sensor. Refer to *Wheel Speed Sensor Replacement - Front.*

Resistance of the wheel speed sensor will increase with an increase in sensor temperature. Refer to the following table for temperature/resistance values.

WSS Temperature vs. Sensor Resistance

°C	°F	Ohms
Temperature vs Resistance Values (Approximate)		
-40 to 4	-40 to 40	1500 to 2500
5 to 43	41 to 110	1500 to 2500
44 to 93	111 to 200	1500 to 2500
94 to 150	201 to 302	1500 to 2500

Test Description

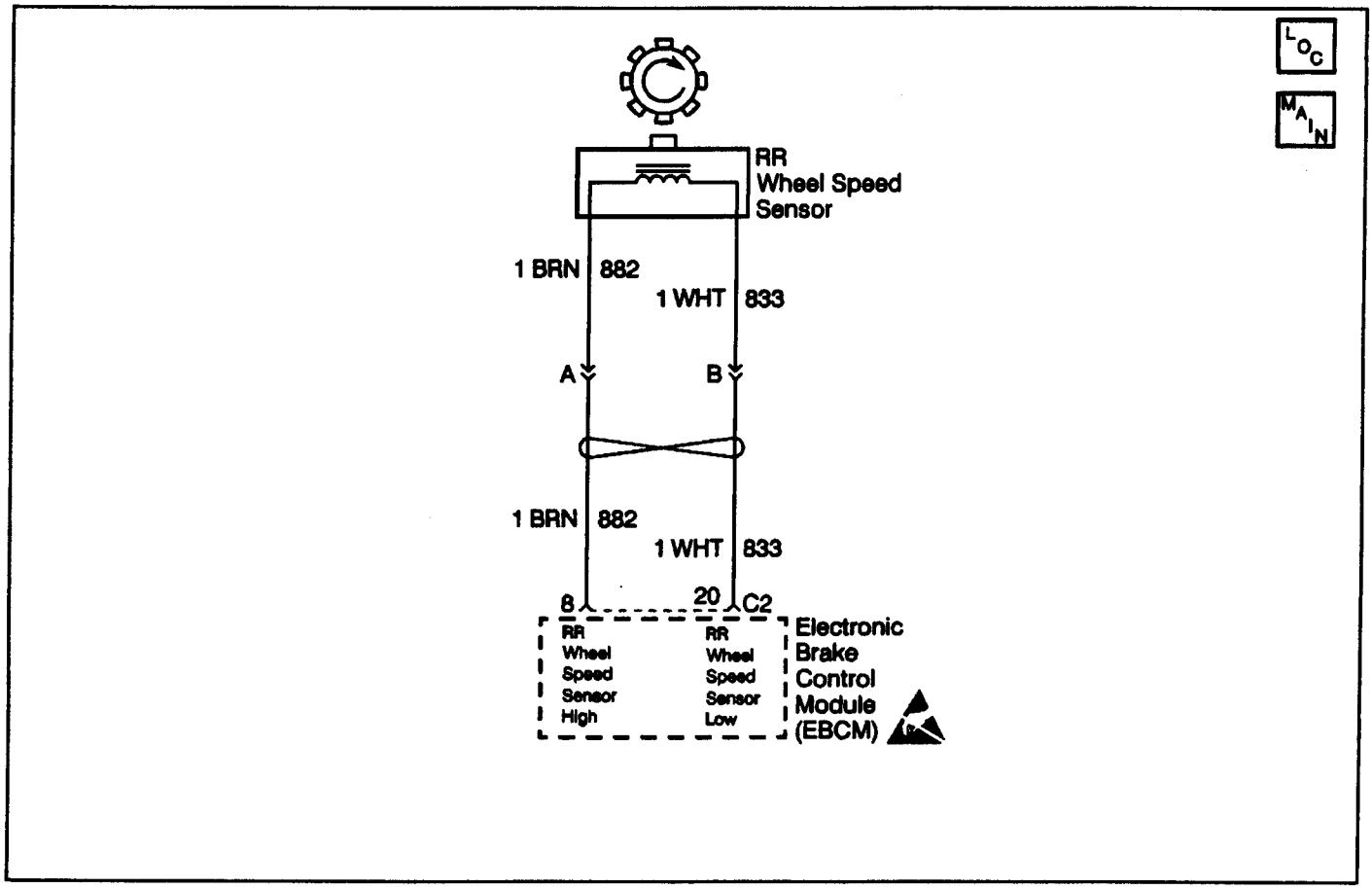
The numbers below refer to the steps in the diagnostic table:

2. This step checks the EBCM 24-way connector for looseness, corrosion, etc.
3. This step measures the resistance of the EBCM 24-way connector terminals 11 and 23.
4. This step measures the resistance at the left front wheel speed sensor connector.
6. This step inspects the left front WSS and the tone wheel for physical damage or excessive clearance.

DTC C0227 LF Wheel Speed Signal Erratic

Step	Action	Value(s)	Yes	No
1	Was the Diagnostic System Check performed?	—	Go to Step *2*	Go to *Diagnostic System Check*
2	1. Turn the ignition to OFF. 2. Disconnect the 24-way EBCM harness connector from the EBCM. 3. Inspect the harness connector for signs of damage or corrosion. 4. Inspect the wheel speed sensor harness and the sensor harness connector for signs of damage or corrosion. Are all the connections clean and tight?	—	Go to Step *3*	Go to Step *6*
3	Using a *J 39200*, measure the resistance between terminals 11 and 23 of the 24-way EBCM harness connector. Is the resistance measurement within the specified range?	1500–2500 Ω	Go to Step *5*	Go to Step *4*
4	1. Disconnect the wheel speed sensor from the wheel speed sensor harness connector. 2. Using a *J 39200*, measure the resistance between terminal A and terminal B of the left front wheel speed sensor pigtail connector. Is the resistance measurement within the specified range?	1500–2500 Ω	Go to Step *7*	Go to Step *8*
5	1. Reconnect all the connectors. 2. Verify that the left front wheel speed sensor is securely mounted and that the tone wheel is in good condition. Are the wheel speed sensor and the tone wheel in good condition?	—	Malfunction is intermittent. Refer to Diagnostic Aids	—
6	Repair the 24-way EBCM harness connector if necessary. Is the repair complete?	—	Go to *Diagnostic System Check*	—
7	Repair the open or the high resistance in CKTs 830 or 873. Is the repair complete?	—	Go to *Diagnostic System Check*	—
8	Replace the wheel speed sensor. Is the repair complete?	—	Go to *Diagnostic System Check*	—

DTC C0231 RR Wheel Speed Signal Circuit Open



324883

Circuit Description

The wheel speed sensor coil emits an electromagnetic field. A toothed ring on the wheel passes by the wheel speed sensor and disrupts this electromagnetic field. The disruption in the field causes the wheel speed sensor to produce a sinusoidal (AC) voltage signal. The frequency and amplitude of the sinusoidal (AC) voltage signal are proportional to the speed of the wheel. The amplitude of the wheel speed signal is also directly related to the distance between the wheel speed sensor coil and the toothed ring. This distance is referred to as the air gap.

Conditions for Setting the DTC

- No output from the right rear wheel speed sensor for 1.0 second.
- Excessive right rear wheel speed sensor resistance for 1.0 second.

Action Taken When the DTC Sets

- The ABS indicator lamp turns on
- The ABS disables

DTC C0231 is a Condition Latched DTC, which indicates that the above actions remain true only as long as the condition persists.

Conditions for Clearing the DTC

- Repair the conditions responsible for setting the DTC
- Use the *Scan Tool* Clear DTCs function

Diagnostic Aids

Any of the following conditions may cause an intermittent malfunction:

- A poor connection
- Wire insulation that is rubbed through
- A wire breaks inside the insulation

Thoroughly check any circuitry that is suspected of causing the intermittent complaint for the following conditions:

- Backed out terminals
- Improper mating
- Broken locks
- Improperly formed or damaged terminals
- Poor terminal to wiring connections
- Physical damage to the wiring harness

If the customer says that the ABS indicator lamp is on only during humid conditions such as rain, snow, or vehicle wash, then thoroughly inspect all wheel speed sensor circuits for signs of water intrusion.

Use the following procedure:

1. Spray the suspected area with a 5% salt water solution (two teaspoons of salt to 12 oz. of water)
2. Drive the vehicle above 24 km/h (15 mph) for at least 30 seconds

If the DTC returns, replace the suspected harness.

When inspecting a wheel speed sensor, inspect the sensor terminals and the harness connector for corrosion. If evidence of corrosion exists, replace the wheel speed sensor. Refer to *Wheel Speed Sensor Replacement - Rear.*

Resistance of the wheel speed sensor will increase with an increase in sensor temperature. Refer to the following table for temperature/resistance values.

WSS Temperature vs. Sensor Resistance

°C	°F	Ohms
Temperature vs Resistance Values (Approximate)		
-40 to 4	-40 to 40	1500 to 2500
5 to 43	41 to 110	1500 to 2500
44 to 93	111 to 200	1500 to 2500
94 to 150	201 to 302	1500 to 2500

Test Description

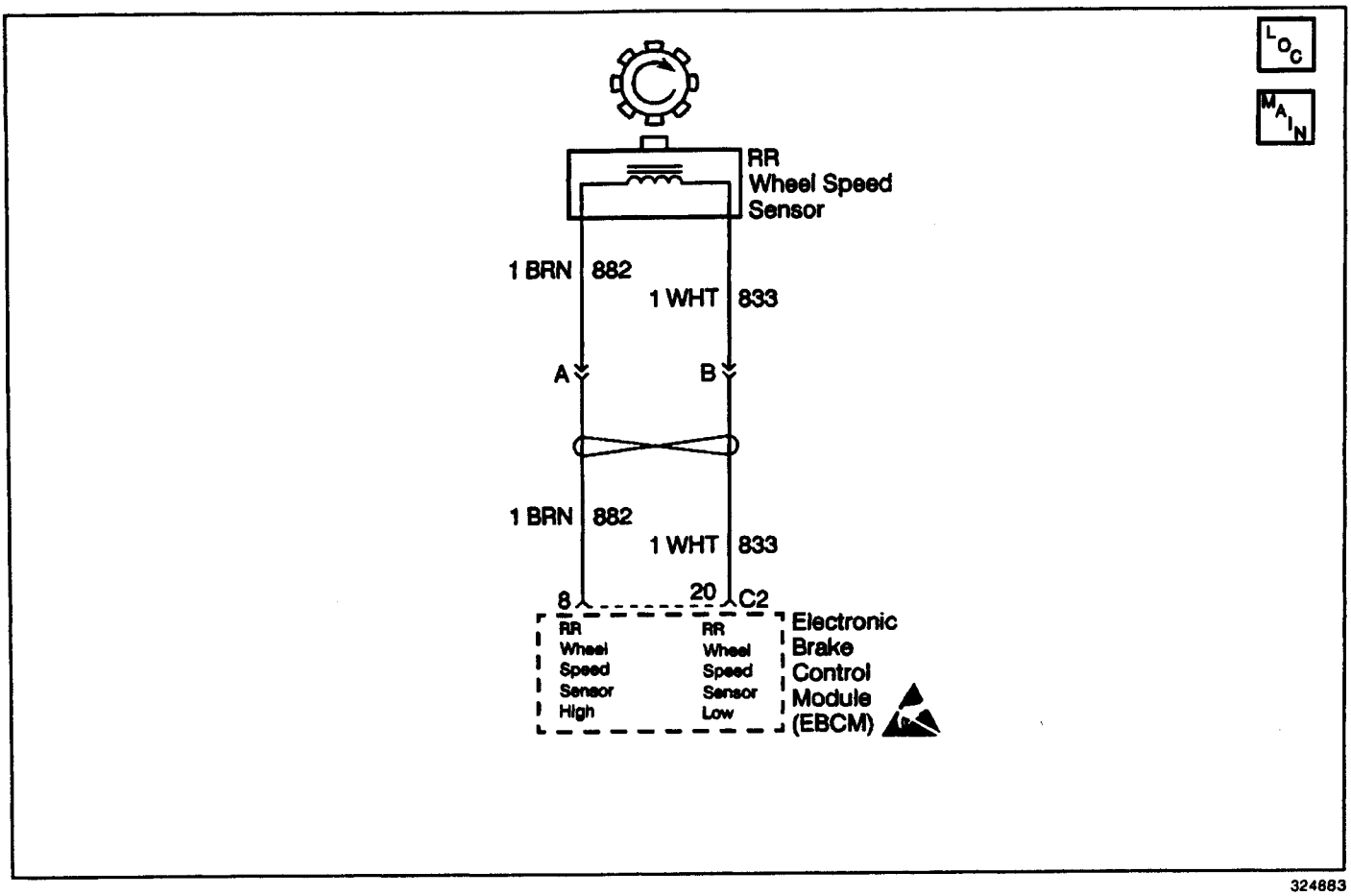
The numbers below refer to the steps in the diagnostic table:

2. This step checks the resistance of the right rear wheel speed sensor circuit.
3. This step checks the resistance of the right rear wheel speed sensor wiring.
4. This step checks resistance of the right rear wheel speed sensor.

DTC C0231 RR Wheel Speed Signal Circuit Open

Step	Action	Value(s)	Yes	No
1	Was the Diagnostic System Check performed?	—	Go to Step *2*	Go to *Diagnostic System Check*
2	1. Turn the ignition to OFF. 2. Disconnect the 24-way EBCM harness connector. 3. Using a *J 39200*, measure the resistance between terminals 8 and 20 of the 24-way EBCM harness connector. Is the resistance measurement within the specified range?	1500–2500 Ω	Go to Step *5*	Go to Step *3*
3	1. Disconnect the right rear wheel speed sensor harness connector from the wheel speed sensor pigtail. 2. Using a *J 36169-A* jumper terminal A and terminal B of the 2-way wheel speed sensor harness connector (chassis harness side). 3. Using a *J 39200*, measure the resistance between terminal 8 and terminal 20 of the 24-way EBCM harness connector. Is the resistance measurement within the specified range?	0–2 Ω	Go to Step *4*	Go to Step *7*
4	Using a *J 39200*, measure the resistance between terminal A and terminal B of the right rear wheel speed sensor pigtail. Is the resistance measurement within the specified range?	1500–2500 Ω	Go to Step *5*	Go to Step *8*
5	1. Inspect the 24-way EBCM harness connector terminal 8 and terminal 20 for poor terminal contact or corrosion. Inspect CKT 882 and CKT 883 for damage that could result in an open circuit. Repair any evident damage. Replace the terminals if poor contact or corrosion exists. 2. Reconnect all the connectors. 3. Using the *Scan Tool* clear all DTCs. 4. Test drive the vehicle above 16 km/h (10 mph). Does DTC C0231 set as a current DTC?	—	Go to Step *6*	Malfunction is intermittent. Refer to Diagnostic Aids
6	Replace the EBCM. Is the repair complete?	—	Go to *Diagnostic System Check*	—
7	Repair the open or the high resistance in CKT 882 or CKT 883. Is the repair complete?	—	Go to *Diagnostic System Check*	—
8	Replace the wheel speed sensor. Is the repair complete?	—	Go to *Diagnostic System Check*	—

DTC C0232 RR Wheel Speed Signal Missing



324883

Circuit Description

The wheel speed sensor coil emits an electromagnetic field. A toothed ring on the wheel passes by the wheel speed sensor and disrupts this electromagnetic field. The disruption in the field causes the wheel speed sensor to produce a sinusoidal (AC) voltage signal. The frequency and amplitude of the sinusoidal (AC) voltage signal are proportional to the speed of the wheel. The amplitude of the wheel speed signal is also directly related to the distance between the wheel speed sensor coil and the toothed ring. This distance is referred to as the air gap.

Conditions for Setting the DTC

- The right rear wheel speed is less than 6 km/h (4 mph)
- All other wheel speeds are greater than 13 km/h (8 mph)
- No unexpected wheel acceleration/deceleration. Anything that keeps the right rear wheel speed sensor low while the vehicle is moving above 13 km/h (8 mph).

Action Taken When the DTC Sets

- The ABS indicator lamp turns on
- The ABS disables

DTC C0232 is an Ignition Latched DTC, which indicates that the above actions remain true until the ignition is turned to OFF (even if the cause of the DTC is intermittent).

Conditions for Clearing the DTC

- Repair the conditions responsible for setting the DTC
- Use the *Scan Tool* Clear DTCs function

Diagnostic Aids

Any of the following conditions may cause an intermittent malfunction:

- A poor connection
- Wire insulation that is rubbed through
- A wire breaks inside the insulation

Thoroughly check any circuitry that is suspected of causing the intermittent complaint for the following conditions:

- Backed out terminals
- Improper mating
- Broken locks
- Improperly formed or damaged terminals
- Poor terminal to wiring connections
- Physical damage to the wiring harness

If the customer says that the ABS indicator lamp is on only during humid conditions such as rain, snow, or vehicle wash, then thoroughly inspect all wheel speed sensor circuits for signs of water intrusion. Use the following procedure:

1. Spray the suspected area with a 5% salt water solution (two teaspoons of salt to 12 oz. of water)
2. Drive the vehicle above 24 km/h (15 mph) for at least 30 seconds

If the DTC returns, replace the suspected harness.

When inspecting a wheel speed sensor, inspect the sensor terminals and the harness connector for corrosion. If evidence of corrosion exists, then replace the wheel speed sensor. Refer to *Wheel Speed Sensor Replacement - Rear.*

Resistance of the wheel speed sensor will increase with an increase in sensor temperature. Refer to the following table for temperature/resistance values.

WSS Temperature vs. Sensor Resistance

°C	°F	Ohms
Temperature vs Resistance Values (Approximate)		
-40 to 4	-40 to 40	1500 to 2500
5 to 43	41 to 110	1500 to 2500
44 to 93	111 to 200	1500 to 2500
94 to 150	201 to 302	1500 to 2500

Test Description

The numbers below refer to the steps in the diagnostic table:

3. This step checks for the resistance of the right rear wheel speed sensor.
4. This step checks the voltage output of the right rear wheel speed sensor.
5. This step checks for a short in the wiring between the wheel speed sensor circuits.
6. This step checks for a short to ground in the right rear wheel speed sensor circuits.

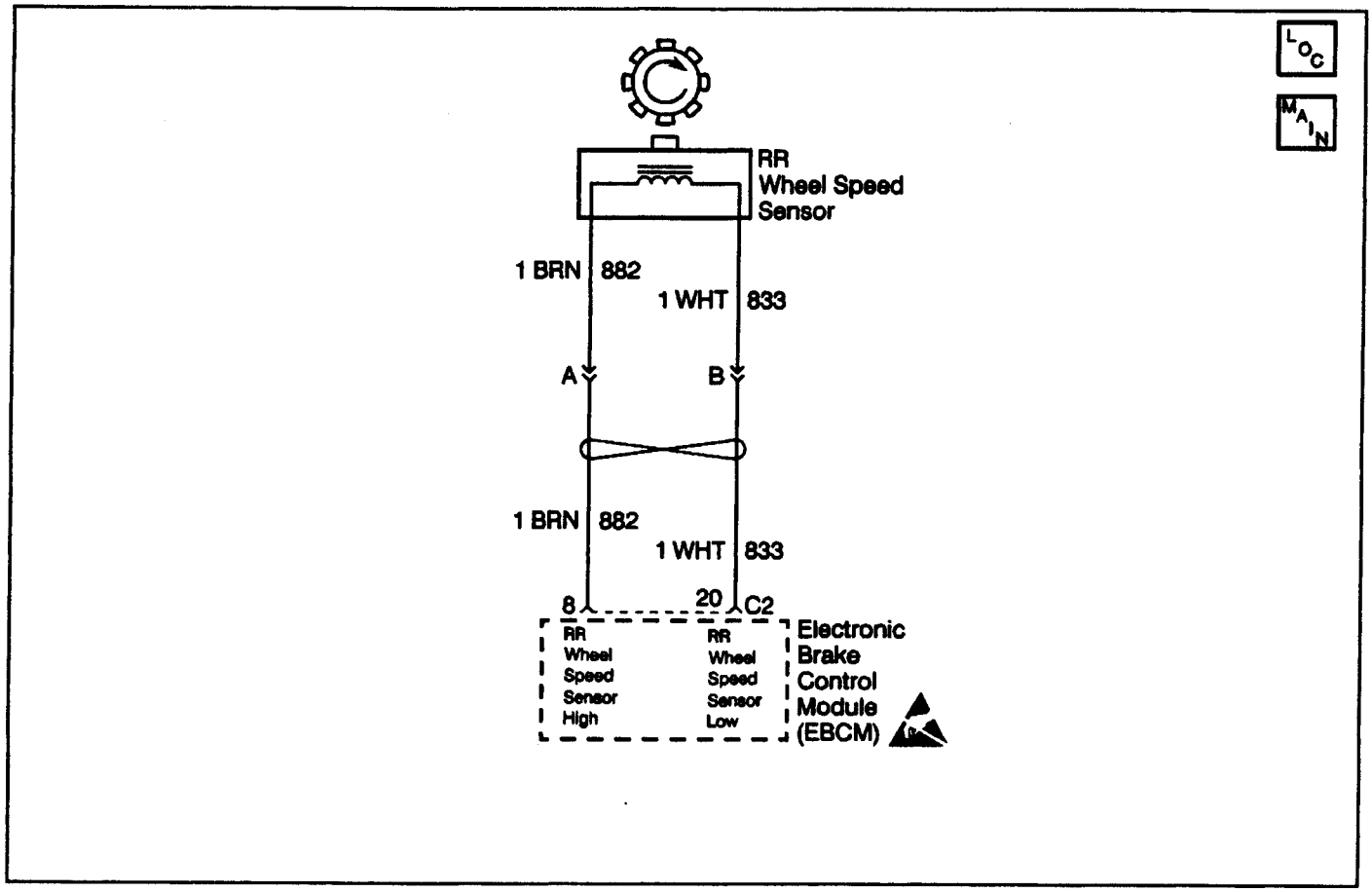
DTC C0232 RR Wheel Speed Signal Missing

Step	Action	Value(s)	Yes	No
1	Was the Diagnostic System Check performed?	—	Go to Step *2*	Go to *Diagnostic System Check*
2	1. Turn the ignition to OFF. 2. Inspect the right rear wheel speed sensor, sensor wire and the connectors for signs of damage or corrosion. 3. Inspect the wheel speed sensor and the toothed ring for looseness paying special attention to the toothed ring. Any deviation will affect the wheel speed sensor output signal. 4. Inspect the 24-way EBCM harness connector and harness for signs of damage or corrosion. Is there evidence of physical damage?	—	Go to Step *8*	Go to Step *3*
3	1. Disconnect the right rear wheel speed sensor harness connector from the wheel speed sensor. 2. Using a *J 39200*, measure the resistance between terminal A and terminal B of the right rear wheel speed sensor pigtail connector. Is the resistance measurement within the specified range?	1500–2500 Ω	Go to Step *4*	Go to Step *9*
4	1. With the *J 39200* still connected, select the A/C voltage scale. 2. Spin the wheel by hand while observing the voltage reading. Is the voltage measured equal to or greater than the specified value?	100 mV	Go to Step *5*	Go to Step *9*
5	1. Disconnect the 24-way EBCM harness connector from the EBCM. 2. Using a *J 39200*, measure the resistance between terminal 8 and terminal 20 of the 24-way EBCM harness connector. Is the resistance measurement equal to the specified value?	OL	Go to Step *6*	Go to Step *11*

DTC C0232 RR Wheel Speed Signal Missing (cont'd)

Step	Action	Value(s)	Yes	No
6	1. Reconnect the right rear wheel speed sensor. 2. Using a *J 39200*, measure the resistance between terminal 8 of the 24-way EBCM harness connector and ground. Is the resistance measurement equal to the specified value?	OL	Go to Step *7*	Go to Step *12*
7	1. Inspect the 24-way EBCM harness connector terminals 8 and 20 for poor terminal contact or corrosion. Inspect CKTs 882 and 883 for damage that could result in a shorted circuit. Repair any evident damage. Replace the terminals if poor contact or corrosion exists. 2. Reconnect all the connectors. 3. Clear all DTCs using the scan tool. 4. Test drive the vehicle above 16 km/h (10 mph). Does DTC C0232 set as a current DTC?	—	Go to Step *10*	Malfunction is intermittent. Refer to Diagnostic Aids
8	Repair as necessary. Is the repair complete?	—	Go to *Diagnostic System Check*	—
9	Replace the right rear wheel speed sensor. Is the repair complete?	—	Go to *Diagnostic System Check*	—
10	Replace the EBCM. Is the repair complete?	—	Go to *Diagnostic System Check*	—
11	Repair the short between CKT 882 and CKT 883. Is the repair complete?	—	Go to *Diagnostic System Check*	—
12	Repair the short to ground in CKT 882 or CKT 883. Is the repair complete?	—	Go to *Diagnostic System Check*	—

DTC C0233 RR Wheel Speed Signal Erratic



324883

Circuit Description

The wheel speed sensor coil emits an electromagnetic field. A toothed ring on the wheel passes by the wheel speed sensor and disrupts this electromagnetic field. The disruption in the field causes the wheel speed sensor to produce a sinusoidal (AC) voltage signal. The frequency and amplitude of the sinusoidal (AC) voltage signal are proportional to the speed of the wheel. The amplitude of the wheel speed signal is also directly related to the distance between the wheel speed sensor coil and the toothed ring. This distance is referred to as the air gap.

Conditions for Setting the DTC

- The average wheel speed for all wheel speed signals is greater than 40 km/h (25 mph).
- The average left rear wheel speed is greater than 40 km/h (25 mph).
- No speed signal input to the EBCM from the right rear wheel speed sensor for 15ms. Anything which suddenly prevents (intermittent) the right rear wheel speed signal from toggling while the vehicle is moving greater than 40 km/h (25 mph).

Action Taken When the DTC Sets

- The ABS indicator lamp turns on
- The ABS disables

DTC C0233 is an Ignition Latched DTC, which indicates that the above actions remain true until the ignition is turned to OFF (even if the cause of the DTC is intermittent).

Conditions for Clearing the DTC

- Repair the conditions responsible for setting the DTC
- Use the *Scan Tool* Clear DTCs function

Diagnostic Aids

Any of the following conditions may cause an intermittent malfunction:

- A poor connection
- Wire insulation that is rubbed through
- A wire breaks inside the insulation

Thoroughly check any circuitry that is suspected of causing the intermittent complaint for the following conditions:

- Backed out terminals
- Improper mating
- Broken locks
- Improperly formed or damaged terminals
- Poor terminal to wiring connections
- Physical damage to the wiring harness

If the customer says that the ABS indicator lamp is on only during humid conditions such as rain, snow, or vehicle wash, then thoroughly inspect all wheel speed sensor circuits for signs of water intrusion. Use the following procedure:

1. Spray the suspected area with a 5% salt water solution (two teaspoons of salt to 12 oz. of water)
2. Drive the vehicle above 24 km/h (15 mph) for at least 30 seconds

If the DTC returns, replace the suspected harness.

When inspecting a wheel speed sensor, inspect the sensor terminals and the harness connector for corrosion. If evidence of corrosion exists, then replace the wheel speed sensor. Refer to *Wheel Speed Sensor Replacement - Rear.*

Resistance of the wheel speed sensor will increase with an increase in sensor temperature. Refer to the following table for temperature/resistance values.

WSS Temperature vs. Sensor Resistance

°C	°F	Ohms
Temperature vs Resistance Values (Approximate)		
-40 to 4	-40 to 40	1500 to 2500
5 to 43	41 to 110	1500 to 2500
44 to 93	111 to 200	1500 to 2500
94 to 150	201 to 302	1500 to 2500

Test Description

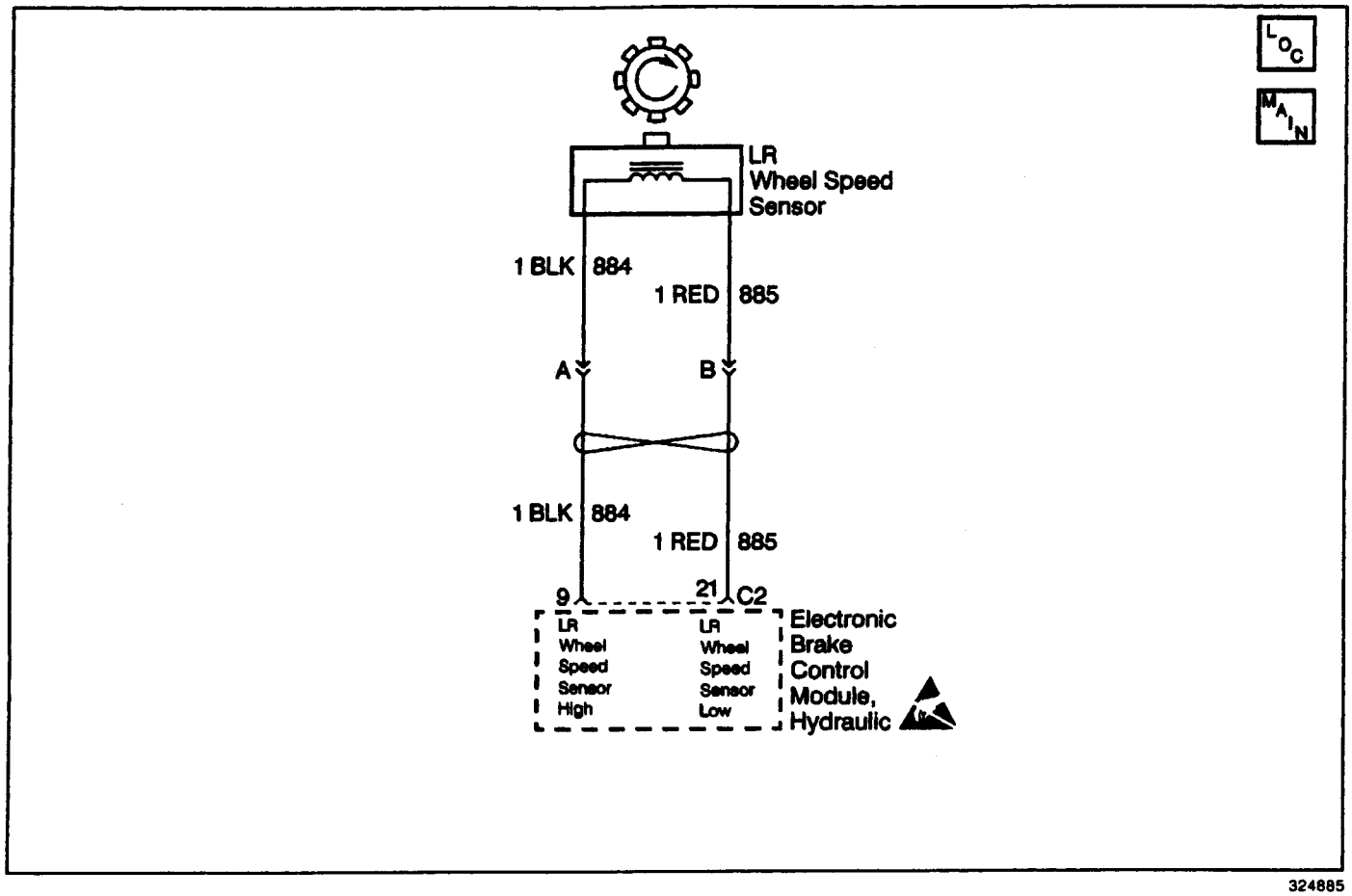
The numbers below refer to the steps in the diagnostic table:

2. This step checks the EBCM 24-way connector for looseness, corrosion, etc.
3. This step measures the resistance of the wheel speed sensor at the EBCM 24-way connector terminal 8 and terminal 20.
4. This step measures the resistance at the right rear wheel speed sensor connector.
6. This step inspects the right rear wheel speed sensor and the tone wheel for physical damage or excessive clearance.

DTC C0233 RR Wheel Speed Signal Erratic

Step	Action	Value(s)	Yes	No
1	Was the Diagnostic System Check performed?	—	Go to Step *2*	Go to *Diagnostic System Check*
2	1. Turn the ignition to OFF. 2. Disconnect the 24-way EBCM harness connector from the EBCM. 3. Inspect the EBCM harness connector for signs of damage or corrosion. 4. Inspect the wheel speed sensor harness and the sensor harness connector for signs of damage or corrosion. Are all connections clean and tight?	—	Go to Step *3*	Go to Step *6*
3	Using a *J 39200*, measure the resistance between terminal 8 and terminal 20 of the 24-way EBCM harness connector. Is the resistance measurement within the specified range?	1500–2500 Ω	Go to Step *5*	Go to Step *4*
4	1. Disconnect the wheel speed sensor from the wheel speed sensor harness connector. 2. Using a *J 39200*, measure the resistance between terminal A and terminal B of the right rear wheel speed sensor pigtail connector. Is the resistance measurement within the specified range?	1500–2500 Ω	Go to Step *7*	Go to Step *8*
5	1. Reconnect all the connectors. 2. Verify that the right rear wheel speed sensor is securely mounted and that the tone wheel is in good condition. Are the wheel speed sensor and the tone wheel in good condition?	—	Malfunction is intermittent. Refer to Diagnostic Aids	—
6	Repair the 24-way EBCM harness connector if necessary. Is the repair complete?	—	Go to *Diagnostic System Check*	—
7	Repair the open or the high resistance in CKTs 882 or 883. Is the repair complete?	—	Go to *Diagnostic System Check*	—
8	Replace the wheel speed sensor. Is the repair complete?	—	Go to *Diagnostic System Check*	—

DTC C0235 LR Wheel Speed Signal Circuit Open



324885

Circuit Description

The wheel speed sensor coil emits an electromagnetic field. A toothed ring on the wheel passes by the wheel speed sensor and disrupts this electromagnetic field. The disruption in the field causes the wheel speed sensor to produce a sinusoidal (AC) voltage signal. The frequency and amplitude of the sinusoidal (AC) voltage signal are proportional to the speed of the wheel. The amplitude of the wheel speed signal is also directly related to the distance between the wheel speed sensor coil and the toothed ring. This distance is referred to as the air gap.

Conditions for Setting the DTC

- No output from the left rear wheel speed sensor for 1.0 second.
- Excessive left rear wheel speed sensor resistance for 1.0 second.

Action Taken When the DTC Sets

- The ABS indicator lamp turns on
- The ABS disables

DTC C0235 is a Condition Latched DTC, which indicates that the above actions remain true only as long as the condition persists.

Conditions for Clearing the DTC

- Repair the conditions responsible for setting the DTC
- Use the *Scan Tool* Clear DTCs function

Diagnostic Aids

Any of the following conditions may cause an intermittent malfunction:

- A poor connection
- Wire insulation that is rubbed through
- A wire breaks inside the insulation

Thoroughly check any circuitry that is suspected of causing the intermittent complaint for the following conditions:

- Backed out terminals
- Improper mating
- Broken locks
- Improperly formed or damaged terminals
- Poor terminal to wiring connections
- Physical damage to the wiring harness

If the customer says that the ABS indicator lamp is on only during humid conditions such as rain, snow, or vehicle wash, then thoroughly inspect all wheel speed sensor circuits for signs of water intrusion.

Use the following procedure:

1. Spray the suspected area with a 5% salt water solution (two teaspoons of salt to 12 oz. of water)
2. Drive the vehicle above 24 km/h (15 mph) for at least 30 seconds

If the DTC returns, replace the suspected harness.

When inspecting a wheel speed sensor, inspect the sensor terminals and the harness connector for corrosion. If evidence of corrosion exists, replace the wheel speed sensor. Refer to *Wheel Speed Sensor Replacement - Rear.*

Resistance of the wheel speed sensor will increase with an increase in sensor temperature. Refer to the following table for temperature/resistance values.

WSS Temperature vs. Sensor Resistance

°C	°F	Ohms
Temperature vs Resistance Values (Approximate)		
-40 to 4	-40 to 40	1500 to 2500
5 to 43	41 to 110	1500 to 2500
44 to 93	111 to 200	1500 to 2500
94 to 150	201 to 302	1500 to 2500

Test Description

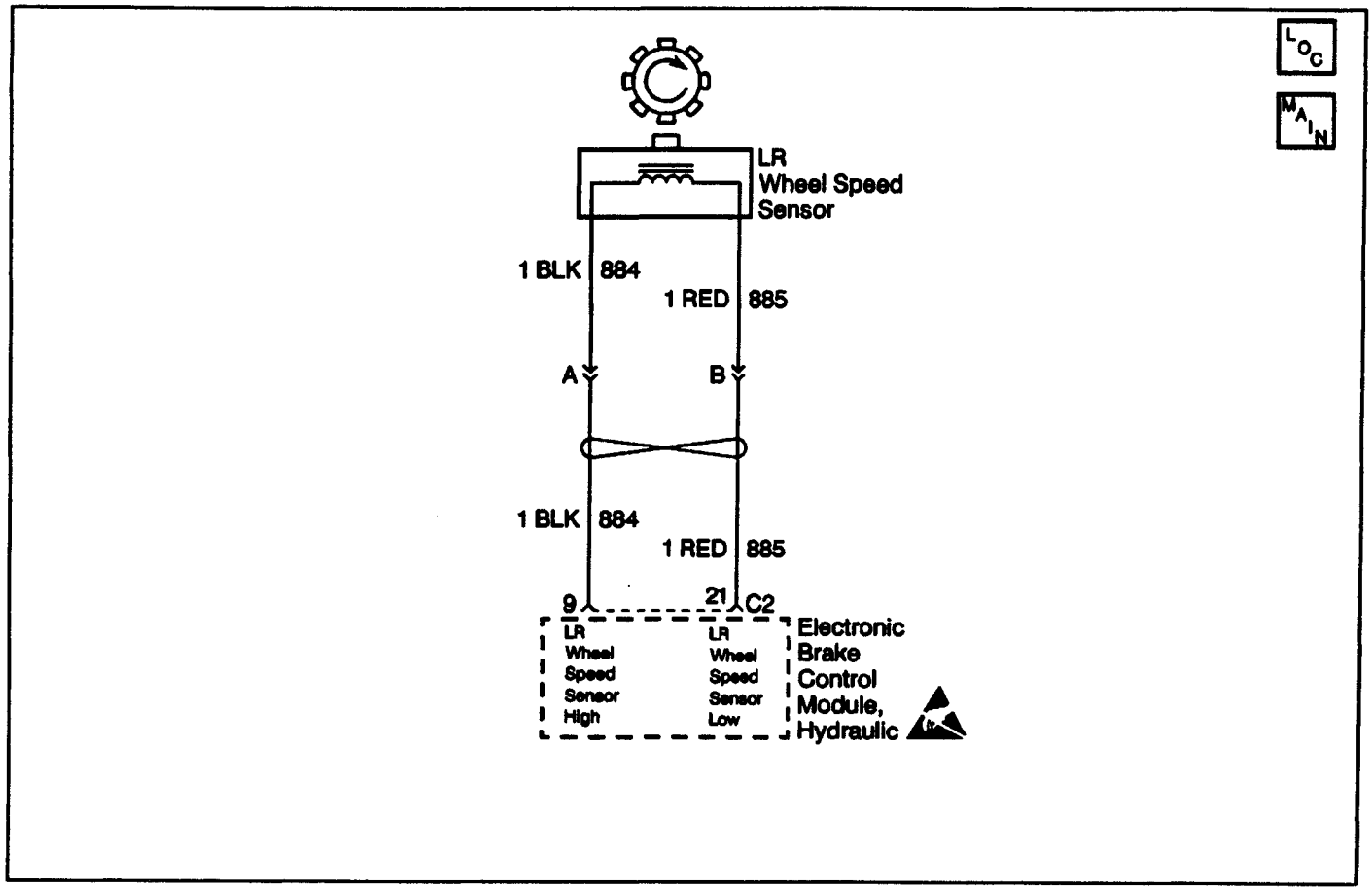
The numbers below refer to the steps in the diagnostic table:

2. This step checks the resistance of the left rear wheel speed sensor circuit.
3. This step checks the resistance of the left rear wheel speed sensor wiring.
4. This step checks the resistance of the left rear wheel speed sensor.

DTC C0235 LR Wheel Speed Signal Circuit Open

Step	Action	Value(s)	Yes	No
1	Was the Diagnostic System Check performed?	—	Go to Step *2*	Go to *Diagnostic System Check*
2	1. Turn the ignition to OFF. 2. Disconnect the 24-way EBCM harness connector. 3. Using a the *J 39200*, measure the resistance between terminal 9 and terminal 21 of the 24-way EBCM harness connector. Is the resistance within the specified range?	1500–2500 Ω	Go to Step *5*	Go to Step *3*
3	1. Disconnect the left rear wheel speed sensor harness connector from the wheel speed sensor pigtail. 2. Using a *J 36169-A*, jumper terminal A and terminal B of the 2-way wheel speed sensor harness connector (chassis harness side). 3. Using a *J 39200*, measure the resistance between terminal 9 and terminal 21 of the 24-way EBCM harness connector. Is the resistance measurement within the specified range?	0–2 Ω	Go to Step *4*	Go to Step *7*
4	Using a *J 39200*, measure the resistance between terminal A and terminal B of the left rear wheel speed sensor pigtail. Is the resistance measurement within the specified range?	1500–2500 Ω	Go to Step *5*	Go to Step *8*
5	1. Inspect the 24-way EBCM harness connector terminal 9 and terminal 21 for poor terminal contact or corrosion. Inspect CKT 884 and CKT 885 for damage that could result in an open circuit. Repair any evident damage. Replace the terminals if poor contact or corrosion exists. 2. Reconnect all connectors. 3. Using the *Scan Tool*, clear all DTCs. 4. Test drive the vehicle above 16 km/h (10 mph). Does DTC C0235 set as a current DTC?	—	Go to Step *6*	Malfunction is intermittent. Refer to Diagnostic Aids
6	Replace the EBCM. Is the repair complete?	—	Go to *Diagnostic System Check*	—
7	Repair the open or the high resistance in CKT 884 or CKT 885. Is the repair complete?	—	Go to *Diagnostic System Check*	—
8	Replace the wheel speed sensor. Is the repair complete?	—	Go to *Diagnostic System Check*	—

DTC C0236 LR Wheel Speed Signal Circuit Missing



324885

Circuit Description

The wheel speed sensor coil emits an electromagnetic field. A toothed ring on the wheel passes by the wheel speed sensor and disrupts this electromagnetic field. The disruption in the field causes the wheel speed sensor to produce a sinusoidal (AC) voltage signal. The frequency and amplitude of the sinusoidal (AC) voltage signal are proportional to the speed of the wheel. The amplitude of the wheel speed signal is also directly related to the distance between the wheel speed sensor coil and the toothed ring. This distance is referred to as the air gap.

Conditions for Setting the DTC

- The left rear wheel speed is less than 6 km/h (4 mph)
- All other wheel speeds are greater than 13 km/h (8 mph)
- No unexpected wheel acceleration/deceleration. Anything that keeps the left rear wheel speed sensor low while the vehicle is moving above 13 km/h (8 mph).

Action Taken When the DTC Sets

- The ABS indicator lamp turns on
- The ABS disables

DTC C0236 is an Ignition Latched DTC, which indicates that the above actions remain true until the ignition is turned to OFF (even if the cause of the DTC is intermittent).

Conditions for Clearing the DTC

- Repair the conditions responsible for setting the DTC
- Use the *Scan Tool* Clear DTCs function

Diagnostic Aids

Any of the following conditions may cause an intermittent malfunction:

- A poor connection
- Wire insulation that is rubbed through
- A wire breaks inside the insulation

Thoroughly check any circuitry that is suspected of causing the intermittent complaint for the following conditions:

- Backed out terminals
- Improper mating
- Broken locks
- Improperly formed or damaged terminals
- Poor terminal to wiring connections
- Physical damage to the wiring harness

If the customer says that the ABS indicator lamp is on only during humid conditions such as rain, snow, or vehicle wash, then thoroughly inspect all wheel speed sensor circuits for signs of water intrusion. Use the following procedure:

1. Spray the suspected area with a 5% salt water solution (two teaspoons of salt to 12 oz. of water)
2. Drive the vehicle above 24 km/h (15 mph) for at least 30 seconds

If the DTC returns, replace the suspected harness.

When inspecting a wheel speed sensor, inspect the sensor terminals and the harness connector for corrosion. If evidence of corrosion exists, then replace the wheel speed sensor. Refer to *Wheel Speed Sensor Replacement - Rear.*

Resistance of the wheel speed sensor will increase with an increase in sensor temperature. Refer to the following table for temperature/resistance values.

WSS Temperature vs. Sensor Resistance

°C	°F	Ohms
Temperature vs Resistance Values (Approximate)		
-40 to 4	-40 to 40	1500 to 2500
5 to 43	41 to 110	1500 to 2500
44 to 93	111 to 200	1500 to 2500
94 to 150	201 to 302	1500 to 2500

Test Description

The numbers below refer to the steps in the diagnostic table:

3. This step checks for the resistance of the left rear wheel speed sensor.
4. This step checks the voltage output of the left rear wheel speed sensor.
5. This step checks for a short in the wiring between the wheel speed sensor circuits.
6. This step checks for a short to ground in the left rear wheel speed sensor circuits.

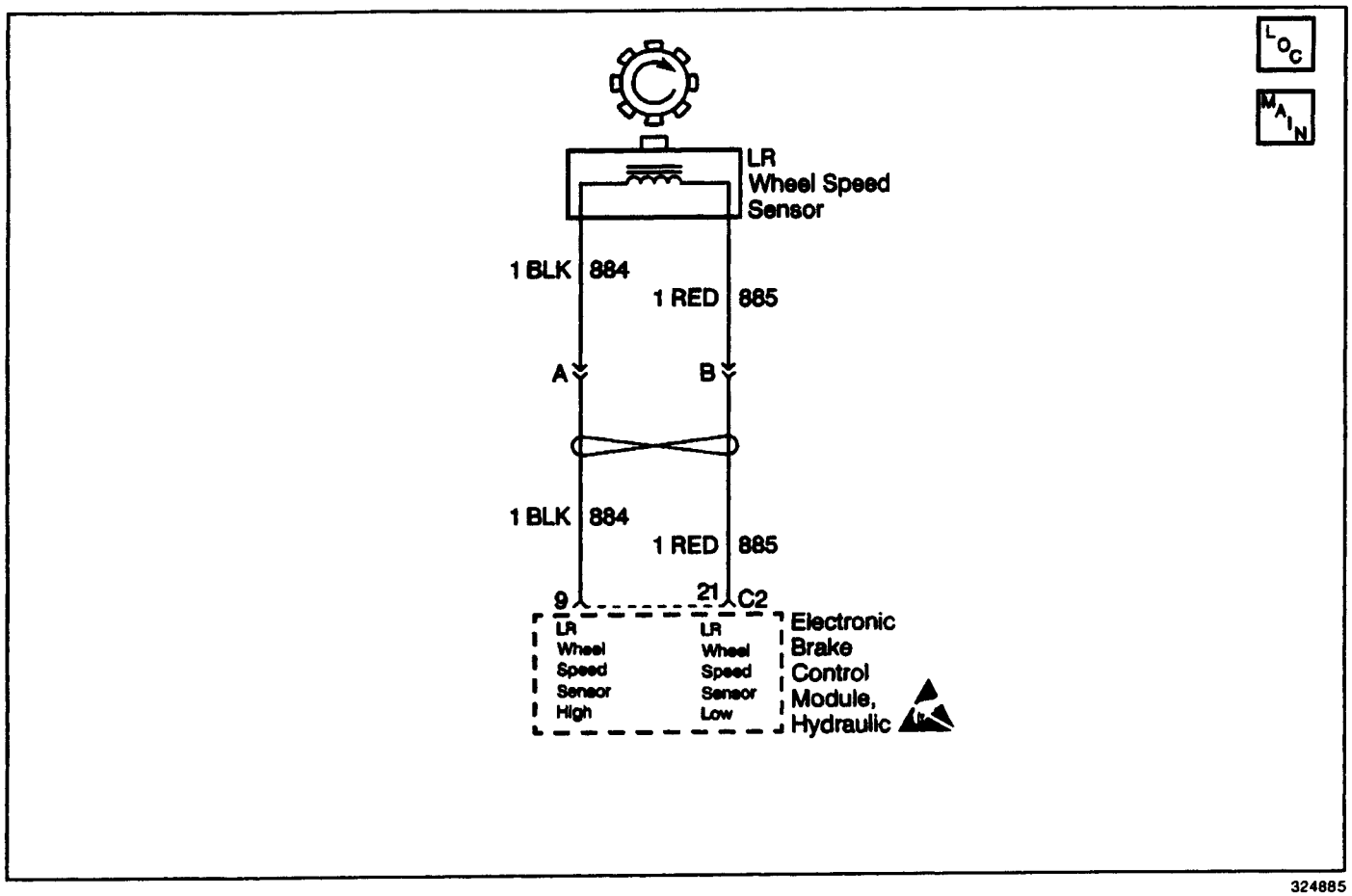
DTC C0236 LR Wheel Speed Signal Circuit Missing

Step	Action	Value(s)	Yes	No
1	Was the Diagnostic System Check performed?	—	Go to Step *2*	Go to *Diagnostic System Check*
2	1. Turn the ignition to OFF. 2. Inspect the left rear wheel speed sensor, sensor wire and connectors for signs of damage. 3. Inspect the wheel speed sensor and the toothed ring for looseness paying particular attention to the toothed ring. Any deviation will affect the wheel speed sensor output signal. 4. Inspect the 24-way EBCM harness connector and harness for signs of damage or corrosion. Is there evidence of physical damage?	—	Go to Step *8*	Go to Step *3*
3	1. Disconnect the left rear wheel speed sensor harness connector from the wheel speed sensor. 2. Using a *J 39200*, measure the resistance between terminal A and terminal B of the left rear wheel speed sensor pigtail connector. Is the resistance measurement within the specified range?	1500–2500 Ω	Go to Step *4*	Go to Step *9*
4	1. With the *J 39200* still connected, select the A/C voltage scale. 2. Spin the wheel by hand while observing the voltage reading. Is the voltage measured equal to or greater than the specified value?	100 mV	Go to Step *5*	Go to Step *9*
5	1. Disconnect the 24-way EBCM harness connector from the EBCM. 2. Using a *J 39200* measure the resistance between terminal 9 and terminal 21 of the 24-way EBCM harness connector. Is the resistance measurement equal to the specified value?	OL	Go to Step *6*	Go to Step *11*

DTC C0236 LR Wheel Speed Signal Circuit Missing (cont'd)

Step	Action	Value(s)	Yes	No
6	1. Reconnect the left rear wheel speed sensor. 2. Using a *J 39200*, measure the resistance between terminal 9 of the 24-way EBCM harness connector and ground. Is the resistance measurement equal to the specified value?	OL	Go to Step *7*	Go to Step *12*
7	1. Inspect the 24-way EBCM harness connector terminal 9 and terminal 21 for poor terminal contact or corrosion. Inspect CKT 884 and CKT 885 for damage that could result in a shorted circuit. Repair any evident damage. Replace the terminals if poor contact or corrosion exists. 2. Reconnect all the connectors. 3. Using the *Scan Tool*, clear all DTCs. 4. Test drive the vehicle above 16 km/h (10 mph). Does DTC C0236 set as a current DTC?	—	Go to Step *10*	Malfunction is intermittent. Refer to Diagnostic Aids
8	Make the necessary repairs. Is the repair complete?	—	Go to *Diagnostic System Check*	—
9	Replace the left rear wheel speed sensor. Is the repair complete?	—	Go to *Diagnostic System Check*	—
10	Replace the EBCM. Is the repair complete?	—	Go to *Diagnostic System Check*	—
11	Repair the short between CKTs 884 and 885. Is the repair complete?	—	Go to *Diagnostic System Check*	—
12	Repair short to ground in CKTs 884 or 885. Is the repair complete?	—	Go to *Diagnostic System Check*	—

DTC C0237 LR Wheel Speed Signal Erratic



324885

Circuit Description

The wheel speed sensor coil emits an electromagnetic field. A toothed ring on the wheel passes by the wheel speed sensor and disrupts this electromagnetic field. The disruption in the field causes the wheel speed sensor to produce a sinusoidal (AC) voltage signal. The frequency and amplitude of the sinusoidal (AC) voltage signal are proportional to the speed of the wheel. The amplitude of the wheel speed signal is also directly related to the distance between the wheel speed sensor coil and the toothed ring. This distance is referred to as the air gap.

Conditions for Setting the DTC

- The average wheel speed for all wheel speed signals is greater than 40 km/h (25 mph).
- The average left rear wheel speed is greater than 40 km/h (25 mph).
- No speed signal input to the EBCM from the left rear wheel speed sensor for 15ms. Anything which suddenly prevents (intermittent) the left rear wheel speed signal from toggling while the vehicle is moving greater than 40 km/h (25 mph).

Action Taken When the DTC Sets

- The ABS indicator lamp turns on
- The ABS disables

DTC C0237 is an Ignition Latched DTC, which indicates that the above actions remain true until the ignition is turned to OFF (even if the cause of the DTC is intermittent).

Conditions for Clearing the DTC

- Repair the conditions responsible for setting the DTC
- Use the *Scan Tool* Clear DTCs function

Diagnostic Aids

Any of the following conditions may cause an intermittent malfunction:

- A poor connection
- Wire insulation that is rubbed through
- A wire breaks inside the insulation

Thoroughly check any circuitry that is suspected of causing the intermittent complaint for the following conditions:

- Backed out terminals
- Improper mating
- Broken locks
- Improperly formed or damaged terminals
- Poor terminal to wiring connections
- Physical damage to the wiring harness

If the customer says that the ABS indicator lamp is on only during humid conditions such as rain, snow, or vehicle wash, then thoroughly inspect all wheel speed sensor circuits for signs of water intrusion. Use the following procedure:

1. Spray the suspected area with a 5% salt water solution (two teaspoons of salt to 12 oz. of water)
2. Drive the vehicle above 24 km/h (15 mph) for at least 30 seconds

If the DTC returns, replace the suspected harness.

When inspecting a wheel speed sensor, inspect the sensor terminals and the harness connector for corrosion. If evidence of corrosion exists, then replace the wheel speed sensor. Refer to *Wheel Speed Sensor Replacement - Rear.*

Resistance of the wheel speed sensor will increase with an increase in sensor temperature. Refer to the following table for temperature/resistance values.

WSS Temperature vs. Sensor Resistance

°C	°F	Ohms
Temperature vs Resistance Values (Approximate)		
-40 to 4	-40 to 40	1500 to 2500
5 to 43	41 to 110	1500 to 2500
44 to 93	111 to 200	1500 to 2500
94 to 150	201 to 302	1500 to 2500

Test Description

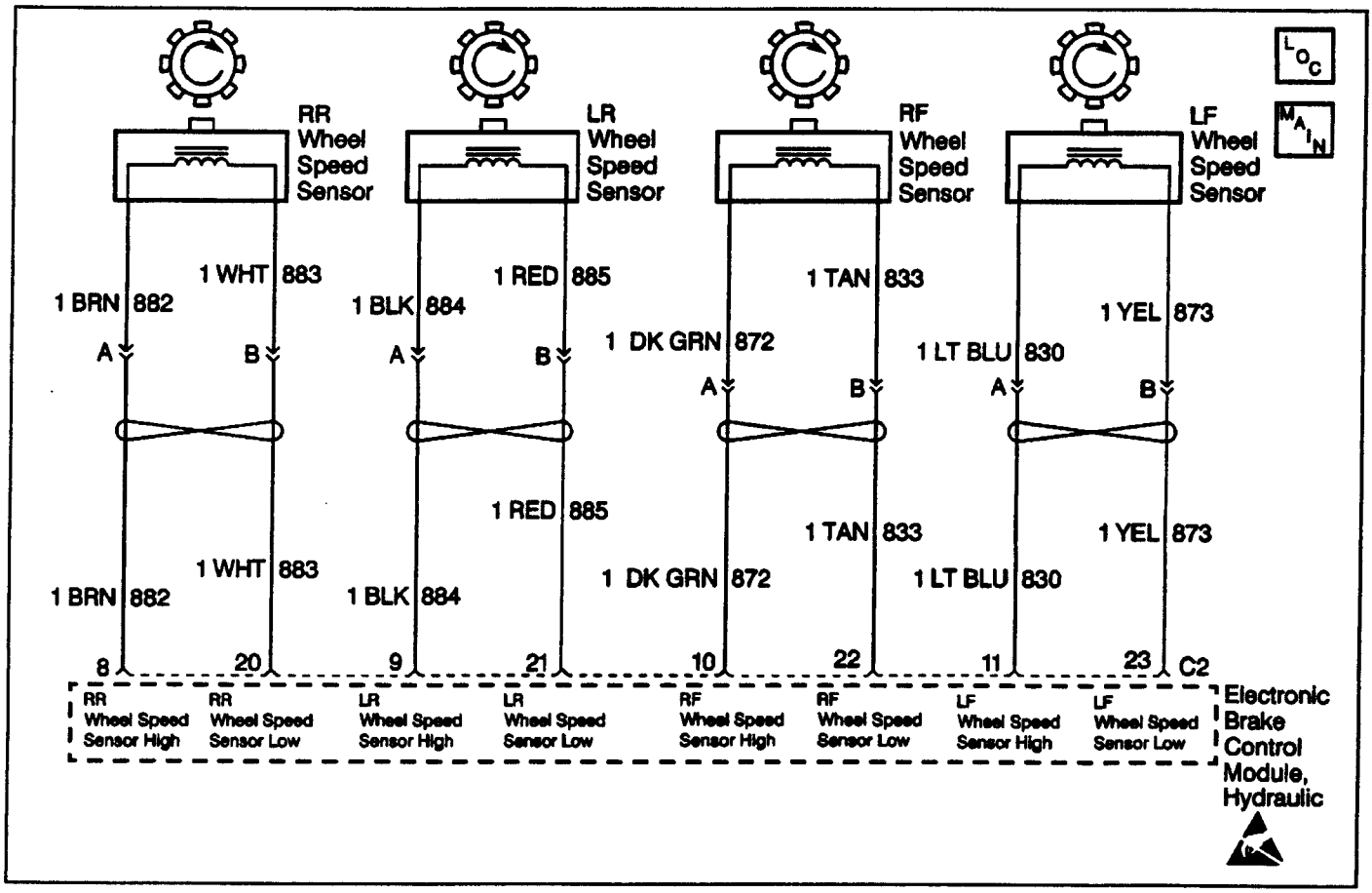
The numbers below refer to the steps in the diagnostic table:

2. This step checks the EBCM 24-way connector for looseness, corrosion, etc.
3. This step measures the resistance of the wheel speed sensor at the EBCM 24-way connector terminals 9 and 21.
4. This step measures the resistance at the left rear wheel speed sensor connector.
6. This step inspects the left rear wheel speed sensor and the tone wheel for physical damage or excessive clearance.

DTC C0237 LR Wheel Speed Signal Erratic

Step	Action	Value(s)	Yes	No
1	Was the Diagnostic System Check performed?	—	Go to Step *2*	Go to *Diagnostic System Check*
2	1. Turn the ignition to OFF. 2. Disconnect the 24-way EBCM harness connector from the EBCM. 3. Inspect the EBCM harness connector for signs of damage or corrosion. 4. Inspect the wheel speed sensor harness and the sensor harness connector for signs of damage or corrosion. Are all the connections clean and tight?	—	Go to Step *3*	Go to Step *6*
3	Using a *J 39200*, measure the resistance between terminals 9 and 21 of the 24-way EBCM harness connector. Is the resistance measurement within the specified range?	1500–2500 Ω	Go to Step *5*	Go to Step *4*
4	1. Disconnect the wheel speed sensor from the wheel speed sensor harness connector. 2. Using a *J 39200*, measure the resistance between terminal A and terminal B of the left rear wheel speed sensor pigtail connector. Is the resistance measurement within the specified range?	1500–2500 Ω	Go to Step *7*	Go to Step *8*
5	1. Reconnect all the connectors. 2. Verify that the left rear wheel speed sensor is securely mounted and that the tone wheel is in good condition. Are the wheel speed sensor and the tone wheel in good condition?	—	Malfunction is intermittent. Refer to Diagnostic Aids	—
6	Repair the 24-way EBCM harness connector if necessary. Is the repair complete?	—	Go to *Diagnostic System Check*	—
7	Repair the open or the high resistance in CKT 884 or CKT 885. Is the repair complete?	—	Go to *Diagnostic System Check*	—
8	Replace the wheel speed sensor. Is the repair complete?	—	Go to *Diagnostic System Check*	—

DTC C0238 Wheel Speed Mismatch



324888

Circuit Description

As a toothed ring passes by the wheel speed sensor, changes in the electromagnetic field cause the wheel speed sensor to produce a sinusoidal (AC) voltage signal. The frequency and amplitude of the sinusoidal (AC) voltage signal are proportional to the wheel speed. The amplitude of the wheel speed signal is directly related to the distance between the wheel speed sensor coil and the toothed ring. This distance is referred to as the air gap. The EBCM can detect wheel speed signal malfunctions as they happen. An error in reported wheel speed can be compensated for by the EBCM up to a point. The error compensation will allow the EBCM to continue to function normally instead of setting a DTC. If the wheel speed mismatch increases beyond that point, the EBCM will set DTC C0238.

Conditions for Setting the DTC

- One mismatched wheel speed is more than double or less than half the other three.
- The vehicle speed is greater than 19 km/h (12 mph)
- No unexpected wheel acceleration: anything that generates consistent differences between the wheel speed signals

Action Taken When the DTC Sets

- The ABS indicator lamp turns on
- The ABS disables

DTC C0238 is an Ignition Latched DTC, which indicates that the above actions remain true until the ignition is turned to OFF (even if the cause of the DTC is intermittent).

Conditions for Clearing the DTC

- Repair the conditions responsible for setting the DTC
- Use the *Scan Tool* Clear DTCs function

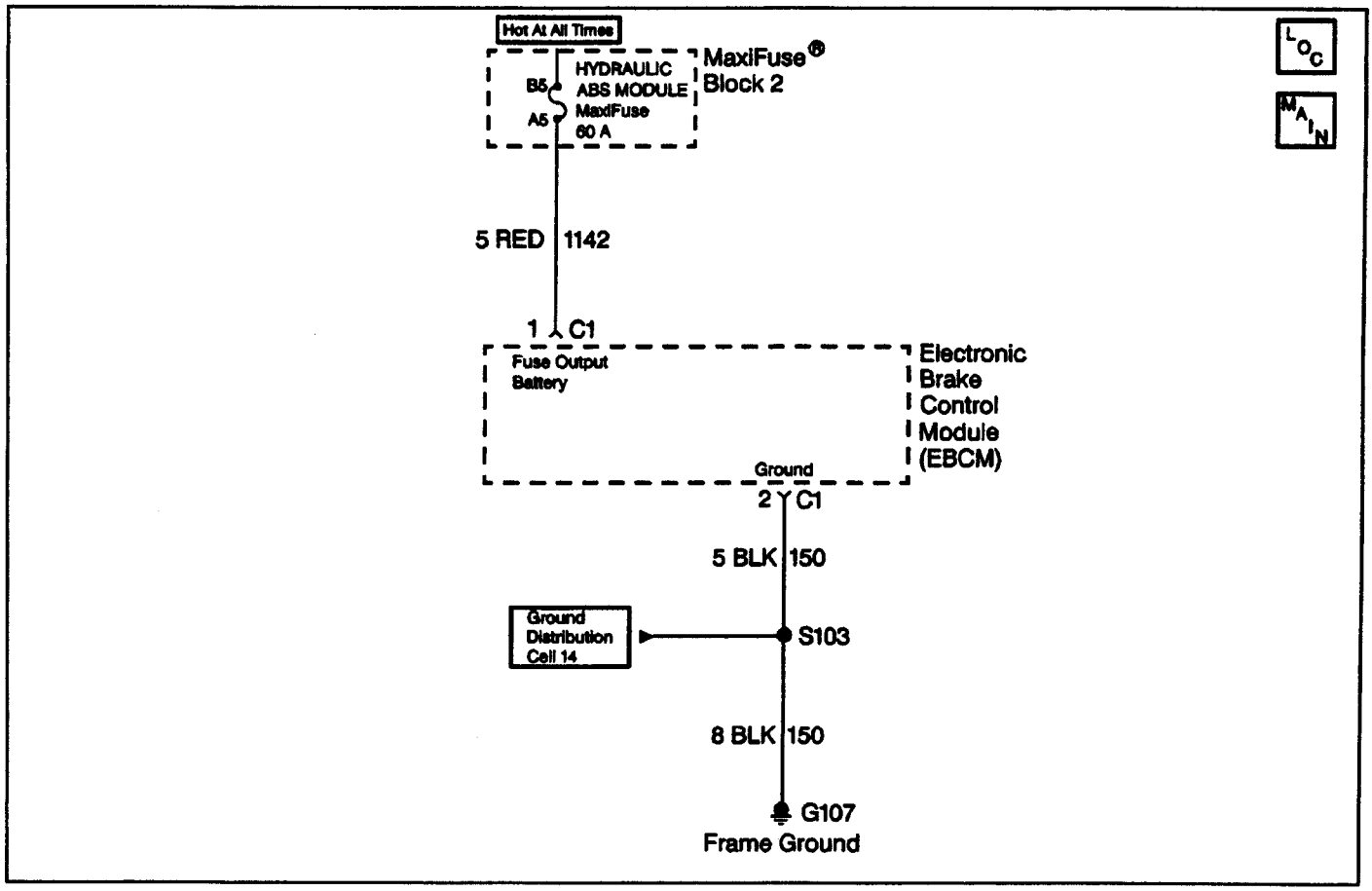
Diagnostic Aids

Installing significantly different tires on the vehicle usually sets a DTC C0238.

DTC C0238 Wheel Speed Mismatch

Step	Action	Value(s)	Yes	No
1	Was the Diagnostic System Check performed?	—	Go to Step *2*	Go to *Diagnostic System Check*
2	Inspect the vehicle tires for a variation in tire size. Are all four tire sizes the same?	—	Go to Step *3*	Refer to Diagnostic Aids
3	1. Using the *Scan Tool*, clear all DTCs. 2. While driving the vehicle, monitor and compare all the wheel speeds. Does the Scan Tool indicate a mismatch in wheel speeds?	—	Go to Step *4*	Malfunction is intermittent. Refer to Diagnostic Aids
4	Does the scan tool indicate a mismatch with the right front wheel speed?	—	Go to *DTC C0223 RF Wheel Speed Signal Erratic*	Go to Step *5*
5	Does the scan tool indicate a mismatch with the left front wheel speed?	—	Go to *DTC C0227 LF Wheel Speed Signal Erratic*	Go to Step *6*
6	Does the scan tool indicate a mismatch with the right rear wheel speed?	—	Go to *DTC C0233 RR Wheel Speed Signal Erratic*	Go to Step *7*
7	Does the scan tool indicate a mismatch with the left rear wheel speed?	—	Go to *DTC C0237 LR Wheel Speed Signal Erratic*	—

DTC C0241-C0258 EBCM Control Valve Circuit



324892

Circuit Description

The EBCM microprocessor will ground the indicated solenoid coil (RF dump/isolation, LF dump/isolation, RR dump/isolation, or LR dump/isolation) circuit to energize the solenoid coil whenever the solenoid valve is needed. Refer to ABS Braking Mode in *ABS System Operation*. The magnetic force created by the solenoid coil will close the isolation valve.

Conditions for Setting the DTC

Open Circuit

- The ABS bulb check is complete
- Low voltage exists on the EBCM solenoid driver circuit when high voltage is expected (the solenoid is not energized)

Shorted Circuit

- The ABS bulb check is complete
- High voltage is present on the EBCM solenoid driver circuit when the voltage is expected to be low (solenoid energized).

Action Taken When the DTC Sets

- The ABS indicator lamp turns on
- The ABS disables

DTCs C0241–C0258 are Ignition Latched DTCs, which indicates the above actions remain true until the ignition is turned to OFF (even if the cause of the DTC is intermittent).

Conditions for Clearing the DTC

- Repair the conditions responsible for setting the DTC
- Use the *Scan Tool* Clear DTCs function

Diagnostic Aids

This DTC usually sets because of an open/shorted solenoid coil within the EBCM. The solenoid coil is located within the BPMV and is not serviceable. If the test does not repair the DTC, then replace the EBCM.

If this DTC sets with other DTCs, check for the following conditions:

- A poor EBCM power or signal ground
- A poor EBCM power or ignition feed

Test Description

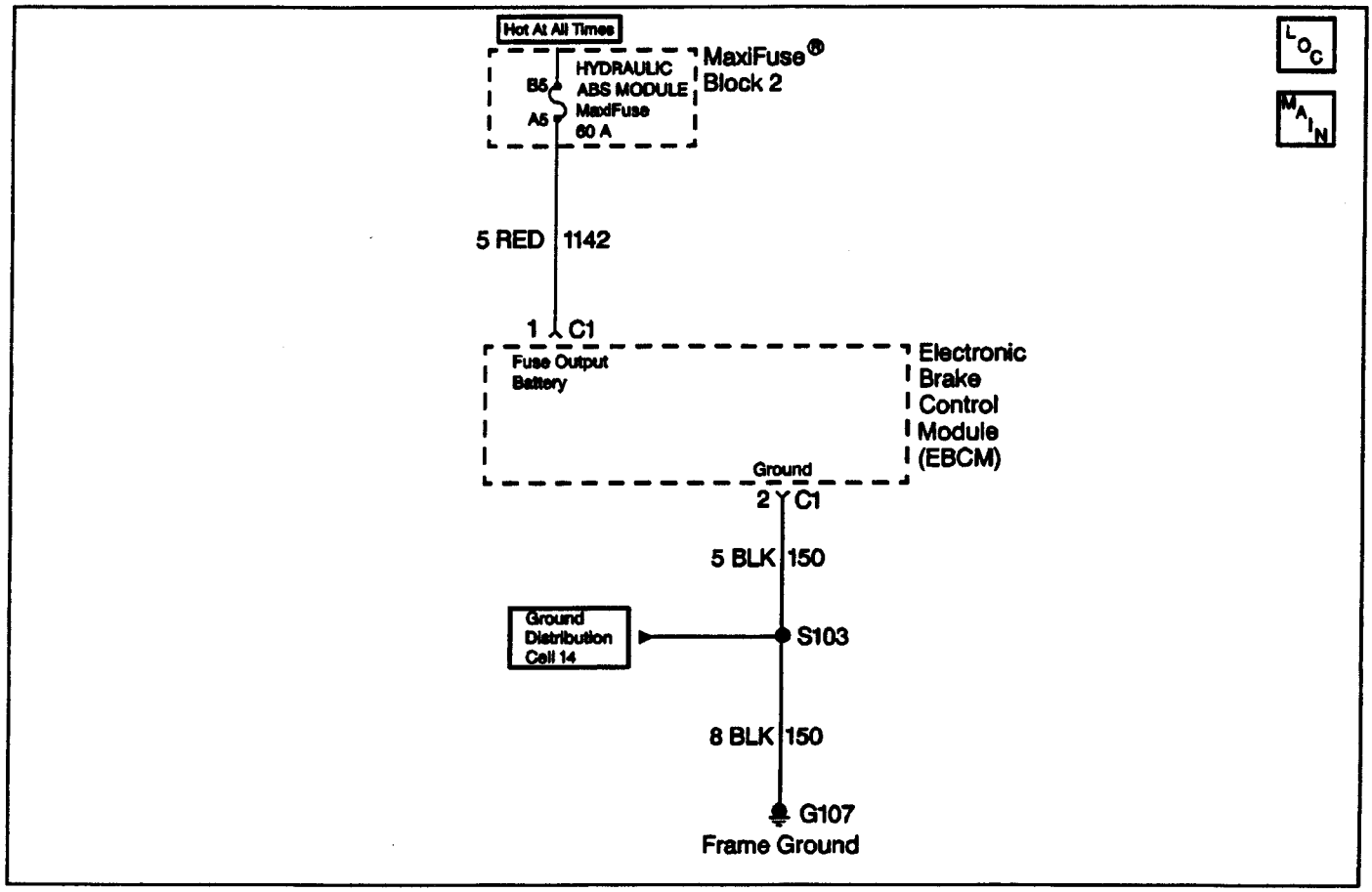
The numbers below refer to the steps in the diagnostic table:

3. This step checks the resistance of the ground circuit.
4. This step checks the ignition voltage available to the EBCM.

DTC C0241-C0258 EBCM Control Valve Circuit

Step	Action	Value(s)	Yes	No
1	Was the Diagnostic System Check performed?	—	Go to Step *2*	Go to *Diagnostic System Check*
2	1. Turn the ignition to OFF. 2. Disconnect the 2-way EBCM harness connector from the EBCM. 3. Inspect the connector for damage or corrosion that could cause a loss of power to the EBCM. Is the connector in good condition?	—	Go to Step *3*	Go to Step *7*
3	Using a *J 39200*, measure the resistance between terminal 2 of the 2-way EBCM harness connector and ground. Is the resistance measurement within the specified range?	0–2 Ω	Go to Step *4*	Go to Step *8*
4	1. Turn the ignition to RUN. 2. Using a *J 39200*, measure the resistance between terminal 1 of the 2-way EBCM harness connector and ground. Is the voltage measured equal to or greater than the specified value?	10 V	Go to Step *6*	Go to Step *5*
5	Inspect the 60 amp ABS maxi-fuse. Is the fuse open?	—	Go to Step *10*	Go to Step *11*
6	1. Inspect the 2-way EBCM harness connector for poor terminal contact or corrosion. Inspect CKT 1142 and CKT 150 for damage which may result in an open circuit. Repair damage if evdent. Replace the terminals if poor contact or corrosion exists. 2. Reconnect all the connectors. 3. Using the *Scan Tool* clear all DTCs. 4. Test drive the vehicle above 16 km/h (10 mph). Does the DTC set as a current DTC?	—	Go to Step *9*	Malfunction is intermittent. Refer to Diagnostic Aids
7	Repair the 2-way EBCM harness connector if necessary. Is the repair complete?	—	Go to *Diagnostic System Check*	—
8	Repair the open or the high resistance in CKT 150. Is the repair complete?	—	Go to *Diagnostic System Check*	—
9	Replace the EBCM. Is the repair complete?	—	Go to *Diagnostic System Check*	—
10	Repair the short to ground in CKT 1142. Is the repair complete?	—	Go to *Diagnostic System Check*	—
11	Repair the open or the high resistance in CKT 1142. Is the repair complete?	—	Go to *Diagnostic System Check*	—

DTC C0265 or C0266 EBCM Relay Circuit



324892

Circuit Description (DTC C0065/C0266)

The pump motor relay supplies power to all eight solenoid coils (four isolation solenoid coils and four dump solenoid coils) and the pump motor when the ABS is required. The relay and the eight solenoid coils are located within the EBCM.

Conditions for Setting the DTC (DTC C0265)

- The EBCM microprocessor commands the relay on
- Low voltage exists on all eight solenoid driver circuits when high voltage is expected (the solenoid is not energized)

Conditions for Setting the DTC (DTC C0266)

- The ABS bulb check is complete
- High voltage exists on the pump motor driver circuit when all are expected to be low (the relay is not commanded on)

Action Taken When the DTC Sets

- The ABS indicator lamp turns on
- The ABS disables

DTCs C0265–C0266 are Ignition Latched DTCs, which indicates that the above actions remain true until the ignition is turned to OFF (even if the cause of the DTC is intermittent).

Conditions for Clearing the DTC

- Repair the conditions responsible for setting the DTC
- Use the *Scan Tool* Clear DTCs function

Diagnostic Aids (DTC C0265)

DTC C0265 usually sets because of an open relay coil or non-closable relay contacts. The relay is located within the EBCM. The relay is not serviceable. If the test does not repair the DTC, then replace the EBCM.

If DTC C0265 appears with other DTCs repair the other DTCs first. Clear all DTCs. Then run three function tests with the *Scan Tool*. Refer to this diagnostic chart if DTC C0265 resets.

Diagnostic Aids (DTC C0266)

DTC C0266 usually sets when the relay contacts are stuck closed. The relay is located within the EBCM. The relay is not serviceable. If the test does not repair the DTC, then replace the EBCM.

Test Description

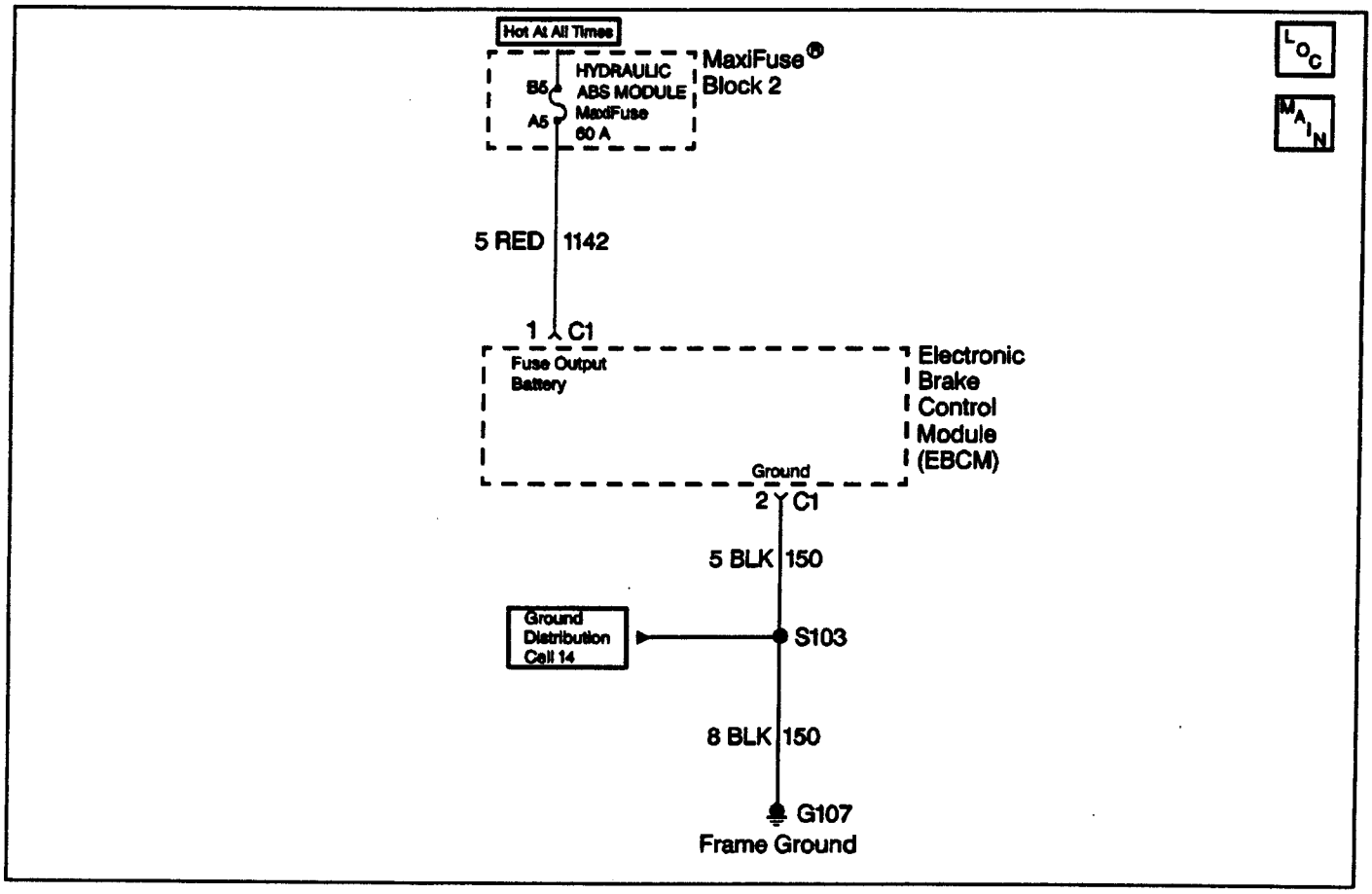
The numbers below refer to the steps in the diagnostic table:

3. This step checks the resistance of the ground circuit.
4. This step checks the ignition voltage available to the EBCM.

DTC C0265 or C0266 EBCM Relay Circuit

Step	Action	Value(s)	Yes	No
1	Was the Diagnostic System Check performed?	—	Go to Step *2*	Go to *Diagnostic System Check*
2	1. Turn the ignition to OFF. 2. Disconnect the 2-way EBCM harness connector from the EBCM. 3. Inspect the connector for damage or corrosion that could cause a loss of power to the EBCM. Is the connector in good condition?	—	Go to Step *3*	Go to Step *7*
3	Using the *J 39200*, measure the resistance between terminal 2 of the 2-way EBCM harness connector and ground. Is the resistance measurement within the specified range?	0-2 Ω	Go to Step *4*	Go to Step *8*
4	1. Turn the ignition switch to RUN. 2. Using a *J 39200*, measure the voltage between terminal 1 of the 2-way EBCM harness connector and ground. Is the voltage measured equal to or greater than the specified value?	10 V	Go to Step *6*	Go to Step *5*
5	Inspect the 60–amp ABS maxi-fuse. Is the fuse open?	—	Go to Step *10*	Go to Step *11*
6	1. Inspect the 2-way EBCM harness connector for poor terminal contact or corrosion. Inspect CKT 1142 and CKT 150 for damage that may result in an open circuit. Repair damage if evident. Replace the terminals if poor contact or corrosion exists. 2. Reconnect all the connectors. 3. Using the *Scan Tool* clear all DTCs. 4. Test drive the vehicle above 16 km/h (10 mph). Does the DTC set as a current DTC?	—	Go to Step *9*	Malfunction is intermittant. refer to Diagnostic Aids
7	Repair the 2-way EBCM harness connector if necessary. Is the repair complete?	—	Go to *Diagnostic System Check*	—
8	Repair the open or the high resistance in CKT 150. Is the repair complete?	—	Go to *Diagnostic System Check*	—
9	Replace the EBCM. Is the repair complete?	—	Go to *Diagnostic System Check*	—
10	Repair the short to ground in CKT 1142. Is the repair complete?	—	Go to *Diagnostic System Check*	—
11	Repair the open or high resistance in CKT 1142. Is the repair complete?	—	Go to *Diagnostic System Check*	—

DTC C0267 or C0268 Pump Motor Circuit Open/Shorted



324892

Circuit Description

The pump motor circuit is integral to the BPMV. The EBCM microprocessor energizes the relay within the EBCM in order to supply the battery voltage to the high side of the pump motor. The EBCM microprocessor grounds the low side of the pump motor when activation of the pump motor is required.

Conditions for Setting the DTC (C0267)

- The EBCM internal relay is on
- The pump motor is off
- Low voltage is present from the low side of the pump motor when high voltage is expected

Conditions for Setting the DTC (C0268)

- Vehicle speed is 13 km/h (8 mph)
- The EBCM internal relay is on
- The pump motor is commanded ON and then OFF
- High voltage exists from the low side of the pump motor for 100 ms when the voltage is expected to be low

Action Taken When the DTC Sets

- The ABS indicator lamp turns on
- The ABS disables

DTCs C0267/C0268 are ignition latched DTCs, which indicates that the above actions remain true until the ignition switch is turned to OFF (even if the cause of the DTC is intermittent).

Conditions for Clearing the DTC

- Repair the conditions responsible for setting the DTC
- Use the *Scan Tool* Clear DTCs function

Diagnostic Aids

The pump motor is integral with the BPMV. Do not service the pump motor separately. A poor power/ground connection at the 2-way EBCM connector or the 2-way pump motor harness from the EBCM to the pump motor can cause a DTC C0267. A seized pump motor, shorted pump motor windings or a poor power/ground at the 2-way EBCM connector can cause a DTC C0268. Replace the EBCM or the BPMV if the following tests show that the pump motor EBCM internal circuits have failed.

Important: Reset the J 39200 test leads to zero prior to making any resistance measurements. Refer to the J 39200 in the user's manual.

Test Description

The numbers below refer to the steps in the diagnostic table:

3. This step checks for an open pump motor circuit. The pump motor circuit resistance should not be above the 0.3 ohms. Reset the *J 39200* test leads to zero prior to making this low resistance measurement.
5. This step determines the resistance of the EBCM ground circuit.
7. This step determines the ignition voltage available to the EBCM.

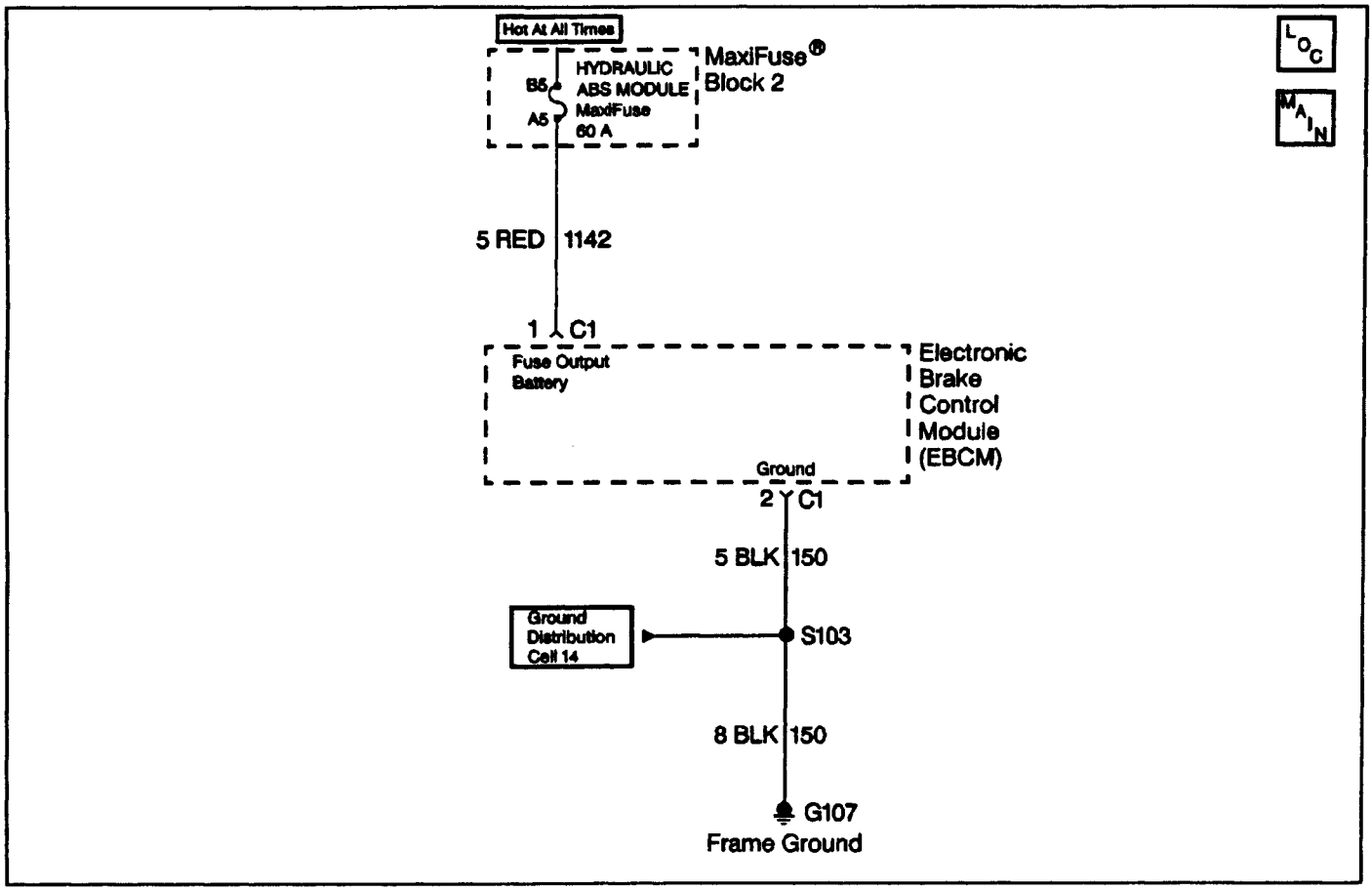
DTC C0267 or C0268 Pump Motor Circuit Open/Shorted

Step	Action	Value(s)	Yes	No
1	Was the Diagnostic System Check performed?	—	Go to Step *2*	Go to *Diagnostic System Check*
2	1. Turn the ignition to OFF. 2. Disconnect the 2-way pump motor pigtail connector from the EBCM. 3. Inspect the connector and the wiring for damage or corrosion that could result in an open circuit between the pump motor and the EBCM. Is the connector and the wiring in good condition?	—	Go to Step *3*	Go to Step *10*
3	Using a *J 39200*, measure the resistance between terminals 1 and 2 of the 2-way pump motor pigtail connector. Is the resistance within the specified range?	0.1–0.3 Ω	Go to Step *15*	Go to Step *4*
4	1. Turn the ignition to OFF. 2. Disconnect the 2-way EBCM harness connector from the EBCM. 3. Inspect the connector for damage or corrosion that could cause a loss of power to the EBCM. Is the connector in good condition?	—	Go to Step *5*	Go to Step *9*
5	Using a *J 39200*, measure the resistance between terminal 2 of the 2-way EBCM harness connector and the ground. Is the resistance within the specified range?	0–2 Ω	Go to Step *6*	Go to Step *11*
6	• Turn the ignition to RUN. • Using a *J 39200*, measure the voltage between terminal 1 of the 2-way EBCM harness connector and the ground. Is the voltage equal to or greater than the specified value?	10.0 V	Go to Step *8*	Go to Step *7*
7	Inspect the 60–amp ABS maxi-fuse. Is this fuse open?	—	Go to Step *13*	Go to Step *14*
8	• Inspect the 2-way EBCM harness connector for poor terminal contact or corrosion. Inspect CKT 1142 and CKT 150 for damage that could result in an open circuit. Repair any evident damage. Replace the terminals if poor contact or corrosion exists. • Reconnect all the connectors. • Using the *Scan Tool*, clear all the DTCs. • Test drive vehicle above 16 km/h (10 mph). Does the DTC set as a current DTC?	—	Go to Step *12*	Malfunction is intermittent. Refer to Diagnostic Aids
9	Repair the 2-way EBCM harness connector if necessary. Is the repair complete?	—	Go to *Diagnostic System Check*	—

DTC C0267 or C0268 Pump Motor Circuit Open/Shorted (cont'd)

Step	Action	Value(s)	Yes	No
10	Repair the 2-way pump motor pigtail connector or wiring if necessary. Is the repair complete?	—	Go to *Diagnostic System Check*	—
11	Repair the open or the high resistance in the CKT 150. Is the repair complete?	—	Go to *Diagnostic System Check*	—
12	Replace the EBCM. Is the repair complete?	—	Go to *Diagnostic System Check*	—
13	Repair short to ground in CKT 1142. Is the repair complete?	—	Go to *Diagnostic System Check*	—
14	Repair the open or the high resistance in CKT 1142. Is the repair complete?	—	Go to *Diagnostic System Check*	—
15	Replace the BPMV assembly. Is the repair complete?	—	Go to *Diagnostic System Check*	—

DTC C0269 or C0274 Excessive Dump/Isolation Time



324892

Circuit Description (DTC C0269)

The EBCM microprocessor grounds the dump valve coil(s) to energize and open the dump valve, allowing fluid to be dumped into the LPA. This is done with very short activation pulses opening and closing the dump valve passageway. Brake pressure is lowered at the wheel and allows the affected wheel to begin rolling again. Each dump valve is opened independently to control the deceleration of the wheel.

Circuit Description (DTC C0274)

The EBCM microprocessor grounds the isolation coil to energize and close the isolation valve. This will prevent any additional brake pressure applied by the driver from reaching the wheel. Further increases in brake pressure will be prohibited. Each isolation valve is closed independently to isolate each wheel. The EBCM microprocessor also uses a software subroutine to monitor for any ABS event which would initiate an isolation command. This subroutine is performed every 1.0 second.

Conditions for Setting the DTC (DTC C0269)

Dump time (pressure reduction) exceeds 9 seconds, which can be caused from:

- Locked rotors
- Excessively low road surface friction.

Conditions for Setting the DTC (DTC C0274)

Isolation time (pressure hold) exceeding 120 consecutive 1.0 second checks.

Action Taken When the DTC Sets

- The ABS indicator lamp turns on
- The ABS disables

DTCs C0269–C0274 are Ignition Latched DTCs, which indicates that the above actions remain true until the ignition is turned to OFF (even if the cause of the DTC is intermittent).

Conditions for Clearing the DTC

- Repair the conditions responsible for setting the DTC
- Use the *Scan Tool* Clear DTCs function

Diagnostic Aids (DTC C0269/C0274)

If any other DTCs are set, repair those DTCs first. If there are no DTCs set, ensure the ABS is operating properly by performing using the Scan Tool "Function Test."

Test Description

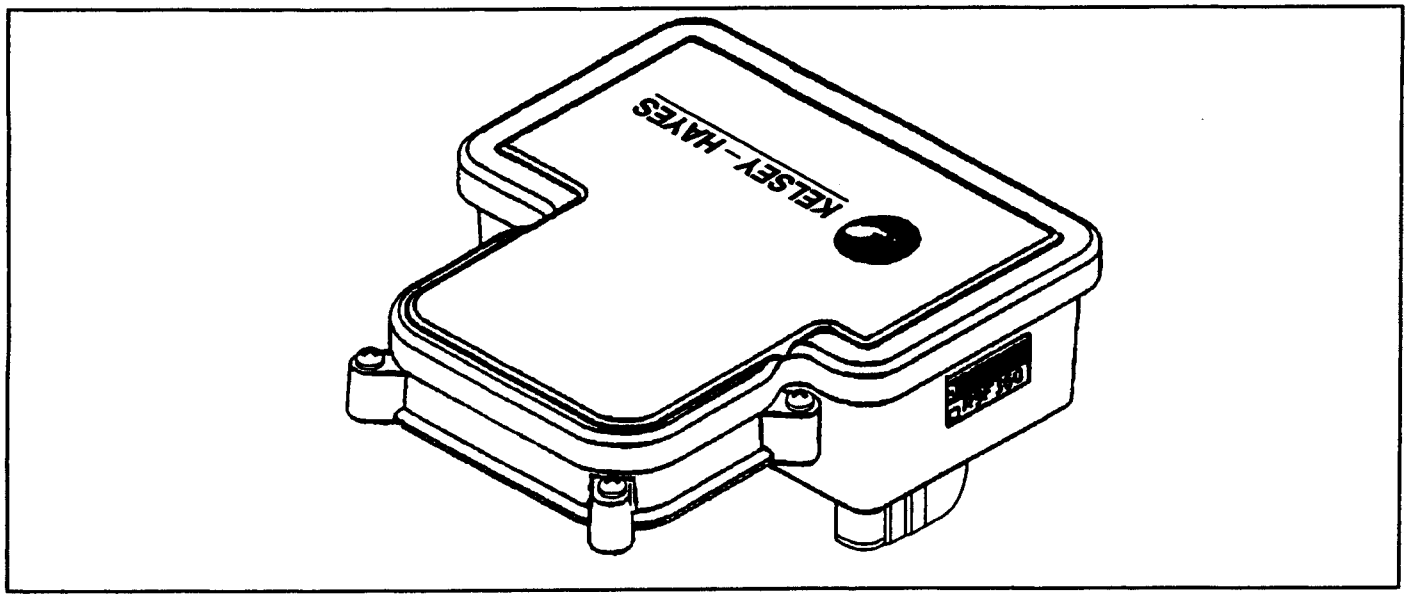
The numbers below refer to the steps in the diagnostic table:

3. This step determines the resistance of the ground circuit.
4. This step determines the ignition voltage available to the EBCM.

DTC C0269 or C0274 Excessive Dump/Isolation Time

Step	Action	Value(s)	Yes	No
1	Was the Diagnostic System Check performed?	—	Go to Step *2*	Go to *Diagnostic System Check*
2	1. Turn the ignition switch to OFF. 2. Disconnect the 2-way EBCM harness connector from the EBCM. 3. Inspect the connector for damage or corrosion that could cause a loss of power to the EBCM. Is the connector in good condition?	—	Go to Step *3*	Go to Step *7*
3	Using a *J 39200*, measure the resistance between terminal 2 of the 2-way EBCM harness connector and ground. Is the resistance measurement within the specified range?	0–2 Ω	Go to Step *4*	Go to Step *8*
4	1. Turn the ignition switch to RUN. 2. Using a *J 39200*, measure the voltage between terminal 1 of the 2-way EBCM harness connector and the ground. Is the voltage equal to or greater than the specified value?	10.0 V	Go to Step *6*	Go to Step *5*
5	Inspect the 60–amp ABS maxi-fuse. Is the fuse open?	—	Go to Step *10*	Go to Step *11*
6	1. Inspect the 2-way EBCM harness connector for poor terminal contact or corrosion. Inspect CKT 1142 and CKT 150 for damage that could result in an open circuit. Repair damage if evident. Replace the terminals if poor contact or corrosion exists. 2. Reconnect all the connectors. 3. Using the *Scan Tool* clear all DTCs. 4. Test drive vehicle above the 16 km/h (10 mph) Does the DTC set as a current DTC?	—	Go to Step *9*	Malfunction is intermittent. Refer to Diagnostic Aids
7	Repair the 2-way EBCM harness connector if necessary. Is the repair complete?	—	Go to *Diagnostic System Check*	—
8	Repair the open or the high resistance in the CKT 150. Is the repair complete?	—	Go to *Diagnostic System Check*	—
9	Replace the EBCM. Is the repair complete?	—	Go to *Diagnostic System Check*	—
10	Repair the short to ground in the CKT 1142. Is the repair complete?	—	Go to *Diagnostic System Check*	—
11	Repair the open or the high resistance in the CKT 1142. Is the repair complete?	—	Go to *Diagnostic System Check*	—

DTC C0271-C0273 EBCM Malfunction



175132

Circuit Description

The EBCM initializes a self-test when the ignition is turned to the RUN position. This internal self-test verifies that all ABS circuitry is operating correctly.

Conditions for Setting the DTC

Any condition within the EBCM which causes a memory error will set this DTC.

Action Taken When the DTC Sets

- The ABS indicator lamp is turned on
- The ABS is disabled

These DTCs are Permanent Latched DTCs, which indicates that the above actions remain true until the DTC is cleared using a *Scan Tool*.

Conditions for Clearing the DTC

- Repair the conditions responsible for setting the DTC
- Use the *Scan Tool* Clear DTCs function

Diagnostic Aids

DTCs C0271–C0273 are EBCM internal diagnosis trouble codes. Replace the EBCM if these tests show that the EBCM circuitry has failed.

Test Description

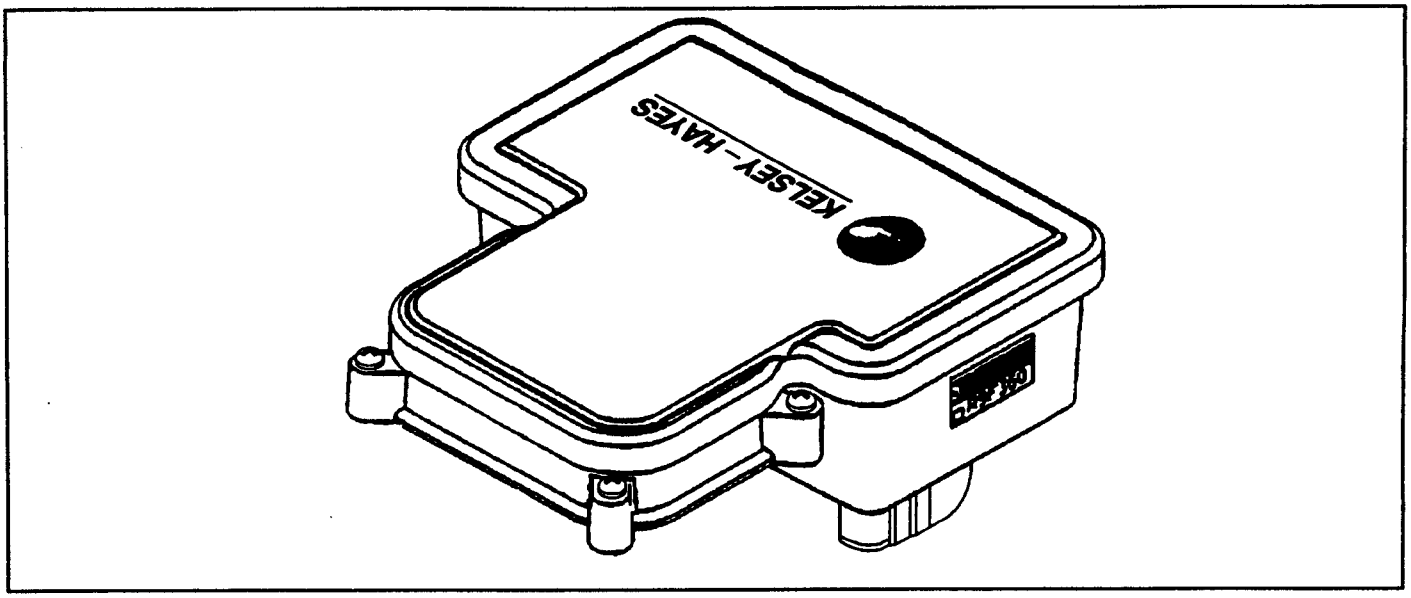
The numbers below refer to the steps in the diagnostic table:

2. This step checks if the EBCM will "Clear DTCs".
3. This step checks if the DTC has been set previously.

DTC C0271-C0273 EBCM Malfunction

Step	Action	Value(s)	Yes	No
1	Was the Diagnostic System Check performed?	—	Go to Step *2*	Go to *Diagnostic System Check*
2	Install the *Scan Tool* and attempt to clear the DTCs. Did the DTCs clear?	—	Go to Step *3*	Go to Step *4*
3	Check the history DTCs and the data. Was this the first time the DTC has set?	—	Go to *Diagnostic System Check*	Go to Step *4*
4	Replace the EBCM. Is the repair complete?	—	Go to *Diagnostic System Check*	—

DTC C0279 Trim Level Not Selected



175132

Circuit Description

The ABS is capable of operating with different brake types and different wheel bases from several different vehicle configurations. All vehicles are preprogrammed from the factory with the proper trim level calibration. The trim level calibration corresponds to the different wheel bases and brake types available on each vehicle. Whenever the EBCM is replaced and/or the wheel base is increased or decreased, it is necessary to set the trim level calibration in the EBCM. It will be necessary to obtain the wheel base and type of brakes (using RPO codes) to select the correct trim level on the Scan Tool. Once programmed, this calibration will remain even if the battery is disconnected or the EBCM is removed from the vehicle. Refer to "Trim Level Calibration", in *ABS System Description.*

Conditions for Setting the DTC

EBCM installed on vehicle without trim level calibration.

Action Taken When the DTC Sets

- The ABS indicator lamp is turned on
- The ABS is disabled

Conditions for Clearing the DTC

- Repair the conditions responsible for setting the DTC
- Use the *Scan Tool* Clear DTCs function

Diagnostic Aids

If any other DTCs are set, Repair those DTCs first. If no other DTCs are set, ensure that the correct trim level is set using the Scan Tool. Refer to "Trim Level Calibration", in *ABS System Description.*

Test Description

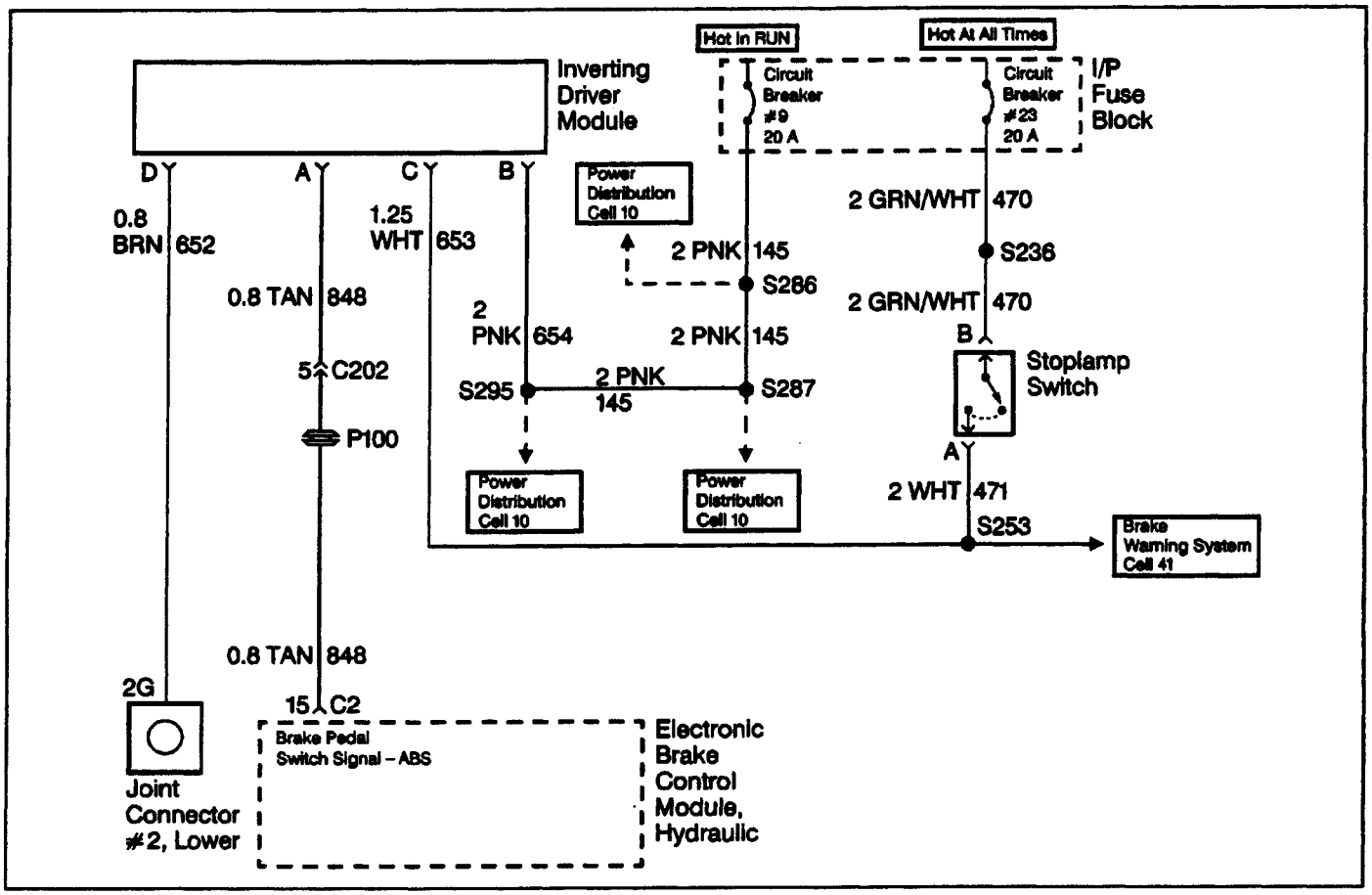
The numbers below refer to the steps in the diagnostic table:

2. This step checks for an EBCM trim level calibration.
3. This step checks for the correct EBCM trim level calibration.

DTC C0279 Trim Level Not Selected

Step	Action	Value(s)	Yes	No
1	Was the Diagnostic System Check performed?	—	Go to Step *2*	Go to *Diagnostic System Check*
2	Using the *Scan Tool*, read the current trim calibration level within the EBCM. Refer to Trim Level Calibration in *ABS System Description.* Is the trim level calibration correct for the vehicle?	—	Go to Step *3*	Go to Step *5*
3	1. Using the *Scan Tool*, clear all DTCs. 2. Test drive the vehicle above 16 km/h (10 mph). Does DTC C0279 set as a current DTC?	—	Go to Step *4*	Malfunction is intermittent. Refer to Diagnostic Aids on the facing page.
4	Replace the EBCM. Is the repair complete?	—	Go to *Diagnostic System Check*	—
5	Using the *Scan Tool*, calibrate the EBCM with the correct trim level. Refer to Trim level Calibration in *ABS System Description.* Is the repair complete?	—	Go to *Diagnostic System Check*	—

DTC C0281 Brake Switch Circuit



324893

Circuit Description

The Stop Lamp Switch is normally closed. With the ignition in the RUN position and the brake pedal not depressed, the EBCM will have ignition voltage present at terminal 15 of the 24–way connector. When the brakes are applied, the voltage present at terminal 15 of the EBCM will be zero.

Conditions for Setting the DTC

- Vehicle above 56 km/h (35 mph) for 10 seconds, followed by vehicle at rest for 1 second.
- Stop lamp never switching during the above condition

Action Taken When the DTC Sets

- The ABS indicator lamp will not be illuminated
- The ABS will not be disabled

DTC C0281 is advisory code only. The DTC is stored in memory, but the ABS indicator lamp will not light, and ABS will not be disabled.

Conditions for Clearing the DTC

- Repair the conditions responsible for setting the DTC
- Use the *Scan Tool* Clear DTCs function

Diagnostic Aids

DTC C0281 can be set by a faulty Stop Lamp Switch, misadjusted Stop Lamp Switch or damage in CKT 848 or CKT 451. Also, a driver who rides the brake at power-up through 24 km/h (15 mph can set this DTC.

Thoroughly check any circuitry that is suspected of causing the intermittent complaint for the following conditions:

- Backed out terminals
- Improper mating
- Broken locks
- Improperly formed or damaged terminals
- Poor terminal to wiring connections
- Physical damage to the wiring harness

Test Description

The numbers below refer to the steps in the diagnostic table:

2. This step checks the functionality of the Stop Lamp Switch circuit using the *Scan Tool.*
3. This step checks the functionality of the Stop Lamp Switch circuit (including the Inverter Driving Module) using a *J 39200.*
4. This step checks the functionality of the Stop Lamp Switch circuit up to the Inverting Driving Module.
8. This step checks for a short to ground in the Stop Lamp Switch circuit between the Inverting Driver Module and the EBCM.
9. This step checks the resistance in the ground circuit to the Inverting Driver Module.
10. This step checks the ignition voltage at the Inverting Driver Module.

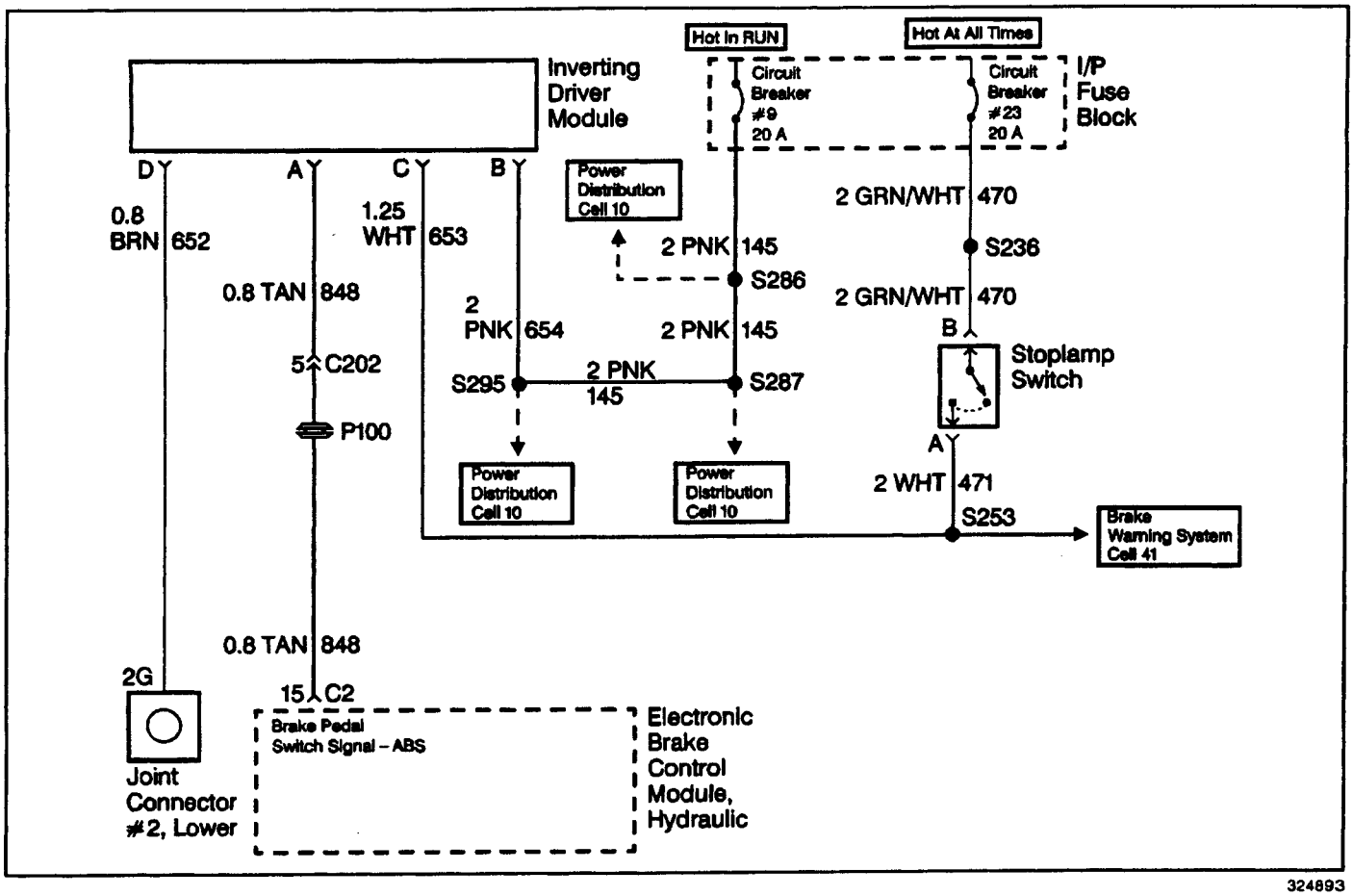
DTC C0281 Brake Switch Circuit

Step	Action	Value(s)	Yes	No
1	Was the Diagnostic System Check performed?	—	*Go to Step 2*	Go to *Diagnostic System Check*
2	1. Install the *Scan Tool.* 2. Turn the ignition to RUN. 3. Using the Data List function of the scan tool, check the operation of the Stop Lamp Switch while applying and releasing the brake pedal. Does the scan tool indicate that the Stop Lamp Switch is opening and closing?	—	*Go to Step 11*	*Go to Step 3*
3	1. Turn the ignition to OFF. 2. Disconnect the 24-way EBCM harness connector. 3. Using a *J 39200,* measure the voltage between terminal 15 of the 24-way connector and ground while applying and releasing the brake pedal. Is the voltage measured switching between the specified range?	0–12 V	*Go to Step 11*	*Go to Step 4*
4	1. Turn the ignition to OFF. Disconnect the Inverting Driver Module harness connector. 2. Using a *J 39200,* measure the voltage between terminal C of the Inverting Driver Module harness connector connector and ground while depressing the brake pedal. Is the voltage equal to or greater than the specified range?	10 V	*Go to Step 7*	*Go to Step 5*
5	1. Disconnect the brake switch harness connector from the brake switch. 2. Using a *J 39200,* measure the voltage between terminal B of the brake switch harness connector and ground. Is the voltage equal to or greater than the specified range?	10 V	*Go to Step 6*	*Go to Step 12*
6	Using a *J 39200,* measure the resistance between terminal A of the brake switch harness connector and terminal C of the Inverting Driver Module harness connector. Is the Stop Lamp Switch adjustment correct?	0–2 Ω	Malfunction is intermittent. Refer to Diagnostic Aids	*Go to Step 13*
7	Using a *J 39200,* measure the resistance between terminal A of the Inverting Driver Module harness connector and terminal 15 of the 24-way EBCM harness connector. Is the resistance measured within the specified range?	0–2 Ω	*Go to Step 8*	*Go to Step 15*

DTC C0281 Brake Switch Circuit (cont'd)

Step	Action	Value(s)	Yes	No
8	Using a *J 39200*, measure the resistance between terminal A of the Inverting Driver Module harness connector and ground. Is the resistance measured within the specified range?	OL	*Go to Step 13*	Malfunction is intermittent. Refer to Diagnostic Aids
9	Using a *J 39200*, measure the resistance between terminal D of the Inverting Driver Module harness connector and ground. Is the resistance measured within the specified range?	OL	*Go to Step 10*	*Go to Step 16*
10	Using a *J 39200*, measure the voltage between terminal B of the Inverting Driver Module harness connector and ground. Is the voltage equal to or greater than the specified range?	10 V	Malfunction is intermittent. Refer to Diagnostic Aids	*Go to Step 17*
11	1. Inspect the 24-way EBCM harness connector for poor terminal contact or corrosion. Inspect CKT 848 for damage which may result in an open or shorted circuit. Repair damage if evident. Replace terminals if poor contact or corrosion exists. 2. Reconnect all connectors. 3. Using the *Scan Tool*, clear all DTCs. 4. Test drive the vehicle above 16 km/h (10 mph). Does DTC C0281 set as a current code?	—	*Go to Step 19*	Malfunction is intermittent. Refer to Diagnostic Aids
12	Repair open in CKT 470. Is the repair complete?	—	Go to *Diagnostic System Check*	—
13	Repair open in CKT 653. Is the repair complete?	—	Go to *Diagnostic System Check*	—
14	Repair misadjusted or faulty brake switch. Is the repair complete?	—	Go to *Diagnostic System Check*	—
15	Repair open in CKT 848. Is the repair complete?	—	Go to *Diagnostic System Check*	—
16	Repair open in CKT 652. Is the repair complete?	—	Go to *Diagnostic System Check*	—
17	Repair open in CKT 654 or CKT 145. Is the repair complete?	—	Go to *Diagnostic System Check*	—
18	Repair short to ground in CKT 848. Is the repair complete?	—	Go to *Diagnostic System Check*	—
19	Replace the EBCM. Is the repair complete?	—	Go to *Diagnostic System Check*	—

DTC C0286 ABS Indicator Lamp Circuit Shorted to B+



324893

Circuit Description

The amber ABS indicator lamp operates in two modes; normal and backup. In the normal mode, ignition voltage is supplied to the ABS indicator light bulb in the instrument cluster through the IGN SW fuse. The indicator is normally on unless the EBCM switches the indicator off, by energizing the ABS indicator lamp relay and opening the circuit. If the EBCM senses that a fault has occurred, it will set a DTC and light the ABS indicator lamp by grounding the ABS indicator lamp circuit. In the backup mode, the ABS indicator lamp relay circuit (normally closed) will ensure that the ABS indicator lamp is illuminated if the 24-way connector is disconnected or poorly seated, or if the EBCM has failed during normal operation. If either of these fault conditions occur, the ABS indicator lamp will be illuminated.

Conditions for Setting the DTC

- High voltage is present on the ABS indicator lamp control circuit when low voltage is expected (lamp is turned on)
- Anything that keeps the ABS indicator lamp circuit high when the lamp is expected to be on

Action Taken When the DTC Sets

The ABS is not disabled.

Conditions for Clearing the DTC

- Repair the conditions responsible for setting the DTC
- Use the *Scan Tool* Clear DTCs function

Diagnostic Aids

DTC C0286 typically sets because of a shorted ABS indicator lamp. Yet DTC C0286 can also set because of a short to voltage in the wiring between the ABS indicator lamp and the EBCM.

Test Description

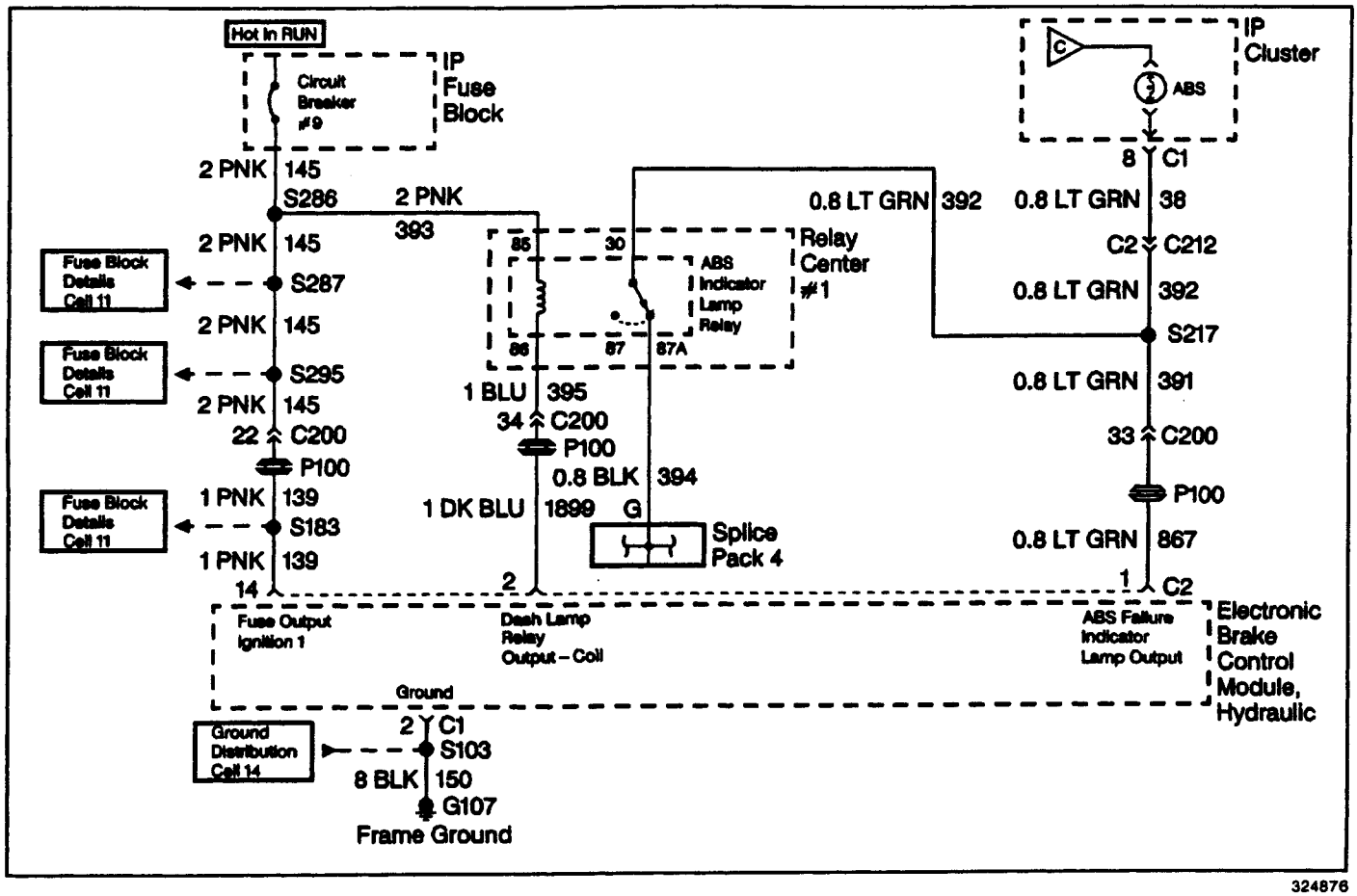
The numbers below refer to the steps in the diagnostic table:

2. This step checks for normal operation of the ABS indicator lamp.
3. This step turns off the ABS indicator lamp with a *J 36169-A*.

DTC C0286 ABS Indicator Lamp Circuit Shorted to B+

Step	Action	Value(s)	Yes	No
1	Was the Diagnostic System Check performed?	—	*Go to Step 2*	Go to *Diagnostic System Check*
2	1. Turn the ignition to RUN. 2. Observe the amber ABS indicator lamp operation. 3. Did the ABS indicator lamp turn on and then turn off after 3 seconds?	—	Malfunction is intermittent. Refer to Diagnostic Aids.	*Go to Step 3*
3	1. Turn the ignition to OFF. 2. Disconnect the 24–way EBCM harness connector from the EBCM. 3. Using a *J 36169-A* with a 10 amp fuse, connect terminal 2 of the 24–way EBCM harness connector to ground. 4. Turn ignition to RUN. Does the ABS indicator lamp turn off?	—	*Go to Step 5*	*Go to Step 4*
4	Inspect the jumper wire fuse. Is the fuse open?	10 V	*Go to Step 7*	*Go to Step 5*
5	1. Inspect the 24-way EBCM harness connector for poor terminal contact or corrosion. Inspect CKT 1899 or CKT 395 for damage which may result in a shorted circuit. Repair damage if evident. Replace the terminal if poor contact or corrosion exists. 2. Reconnect all connectors. 3. Using the *Scan Tool*, clear all DTCs. 4. Test drive the vehicle above 16 km/h (10 mph). Does DTC C0286 set as a current DTC?	—	*Go to Step 6*	Malfunction is intermittent. Refer to Diagnostic Aids
6	Replace the EBCM. Is repair complete?	—	Go to *Diagnostic System Check*	—
7	Repair a short to voltage in CKT 1899 or CKT 395. Is the repair complete?	—	Go to *Diagnostic System Check*	—

ABS Indicator Off No DTC Set



324876

Circuit Description

The amber ABS indicator lamp operates in two modes; normal and backup. In the normal mode, ignition voltage is supplied to the ABS indicator light bulb in the instrument cluster through the IGN SW fuse. The indicator is normally on unless the EBCM switches the indicator off, by energizing the ABS indicator lamp relay and opening the circuit. If the EBCM senses that a fault has occurred, it will set a DTC and light the ABS indicator lamp by grounding the ABS indicator lamp circuit. In the backup mode, the ABS indicator lamp relay circuit (normally closed) will ensure that the ABS indicator lamp is illuminated if the 24-way connector is disconnected or poorly seated, or if the EBCM has failed during normal operation. If either of these fault conditions occur, the ABS indicator lamp will be illuminated. if the following conditions exist:

- Open or high resistance in CKT 867
- The EBCM is faulty

Diagnostic Aids

If the ABS indicator lamp is off always with no DTCs set (never turns on at bulb check, with the vehicle started or with the ignition switch in the RUN position), an open or high resistance in the lamp circuit is present between the instrument panel and the EBCM. Also check for an open instrument panel fuse or an open bulb.

Test Description

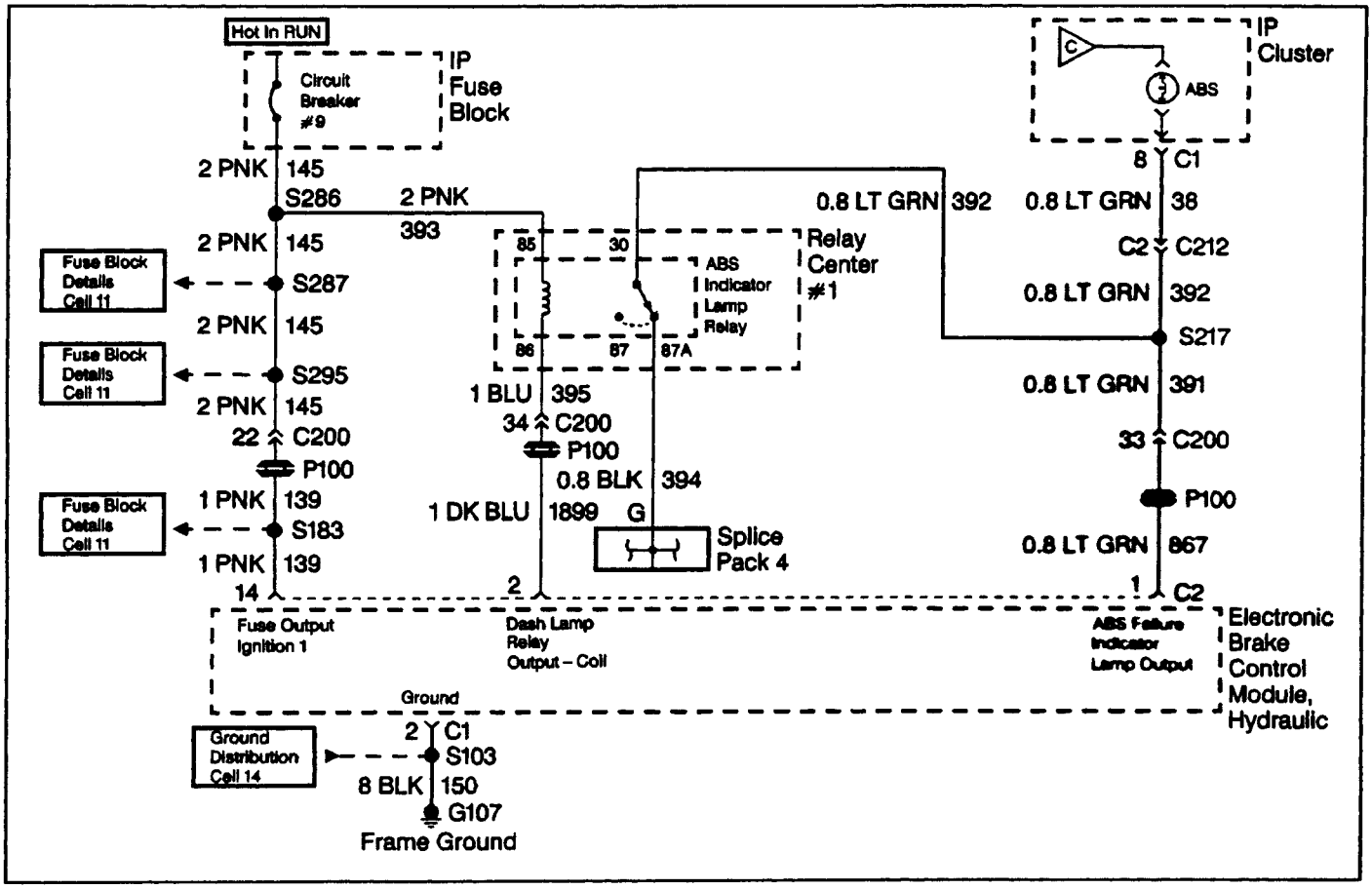
The numbers below refer to the steps in the diagnostic table:

2. This step checks for normal operation of the ABS indicator lamp.
3. This step manually (with fused jumper) turns on the ABS indicator lamp by bypassing the ABS indicator relay.
5. This step checks for a short to ground in CKT 1899.

ABS Indicator Off No DTC Set

Step	Action	Value(s)	Yes	No
1	Was the Diagnostic System Check performed?	—	*Go to Step 2*	Go to *Diagnostic System Check*
2	1. Disconnect the ABS indicator lamp relay. 2. Using a *J 36169-A*, connect terminal 30 of the ABS indicator lamp relay to ground. 3. Turn the ignition to RUN. Does the ABS indicator lamp turn on?	—	*Go to Step 3*	*Go to Step 4*
3	Using a *J 39200*, measure the resistance between the relay center harness connector terminal 87A and ground. Is the resistance within the specified range?	0–2 Ω	*Go to Step 9*	*Go to Step 7*
4	Inspect the jumper fuse wire. Is the fuse open?	—	*Go to Step 6*	*Go to Step 5*
5	1. Disconnect the 15-way instrument panel connector. 2. Using a *J 39200*, measure the resistance between the ABS indicator lamp relay harness connector terminal 30 and the 15-way instrument panel harness connector terminal 8. Is the resistance within the specified range?	0–2 Ω	Refer to Instrument Panel for ABS indicator light repair.	*Go to Step 8*
6	Repair a short to voltage in CKT 392, CKT 38, CKT 391 or CKT 867. Is the repair complete?	—	Go to *Diagnostic System Check*	—
7	Repair an open in CKT 394. Is the repair complete?	—	Go to *Diagnostic System Check*	—
8	Repair an open in CKT 392 or CKT 38. Is the repair complete?	—	Go to *Diagnostic System Check*	—
9	Repair the open or the high resistance in CKT 867. Is the repair complete?	—	Go to *Diagnostic System Check*	—

ABS Indicator On No DTC Set



324876

Circuit Description

The amber ABS indicator lamp operates in two modes; normal and backup. In the normal mode, ignition voltage is supplied to the ABS indicator light bulb in the instrument cluster through the IGN SW fuse. The indicator is normally on unless the EBCM switches the indicator off, by energizing the ABS indicator lamp relay and opening the circuit. If the EBCM senses that a fault has occurred, it will set a DTC and light the ABS indicator lamp by grounding the ABS indicator lamp circuit. In the backup mode, the ABS indicator lamp relay circuit (normally closed) will ensure that the ABS indicator lamp is illuminated if the 24-way connector is disconnected or poorly seated, or if the EBCM has failed during normal operation. If either of these fault conditions occur, the ABS indicator lamp will be illuminated. if the following conditions exist:

- Short to ground in CKT 867
- Open or high resistance in CKT 1899
- Open or high resistance in CKT 39
- The ABS indicator lamp relay is faulty
- The EBCM is faulty

Diagnostic Aids

If the ABS indicator lamp is on always with no DTCs set (never turns off with the vehicle started or with the ignition switch in the RUN position), there is a short to ground in CKT 867 between the instrument cluster and the EBCM, or there is a fault in the ABS indicator lamp relay circuit.

Test Description

The numbers below refer to the steps in the diagnostic table:

2. This step checks for normal operation of the ABS indicator lamp.
3. This step manually (with fused jumper) turns off the ABS indicator lamp.

ABS Indicator On No DTC Set

Step	Action	Value(s)	Yes	No
1	Was the Diagnostic System Check performed?	—	*Go to Step 2*	Go to *Diagnostic System Check*
2	1. Turn the ignition to OFF. 2. Disconnect the 24-way EBCM harness connector. 3. Using a *J 36169-A*, connect terminal 2 of the 24-way EBCM harness connector to ground. 4. Turn the ignition to RUN. Does the ABS indicator lamp turn off?	—	*Go to Step 5*	*Go to Step 3*
3	1. Turn the ignition to OFF. 2. Remove the ABS indicator relay. 3. Turn the ignition to RUN. Does the ABS indicator lamp turn off?	—	*Go to Step 4*	*Go to Step 6*
4	Using a *J 39200*, measure the voltage between the ABS indicator relay harness connector terminal 85 and ground. Is the voltage measured equal to or greater than the specified value?	10 V	*Go to Step 4*	*Go to Step 7*
5	Using a *J 39200*, measure the resistance between the relay center harness connector terminal 86 and the EBCM harness connector terminal 2. Is the resistance within the specified range?	0–2 Ω	*Go to Step 9*	*Go to Step 8*
6	1. Inspect the 24-way EBCM harness connector terminal 2 for poor terminal contact or corrosion. Inspect CKT 1899 or CKT 395 for damage that could result in an open circuit. Repair damage if evident. Replace the terminals if poor contact or corrosion exists. 2. Reconnect all the connectors. 3. Turn the ignition to RUN. Is the ABS indicator lamp on constantly?	—	*Go to Step 7*	Malfunction is intermittent. Refer to Diagnostic Aids
7	Repair the short to ground in CKT 392 or CKT 38. Is the repair complete?	—	Go to *Diagnostic System Check*	—
8	Repair the open or the high resistance in CKT 393, CKT 145 or a damaged circuit breaker #9. Is the repair complete?	—	Go to *Diagnostic System Check*	—
9	Repair an open in CKT 395 or CKT 1899. Is the repair complete?	—	Go to *Diagnostic System Check*	—
10	Replace the ABS indicator relay. Is the repair complete?	—	Go to *Diagnostic System Check*	—

Repair Instructions

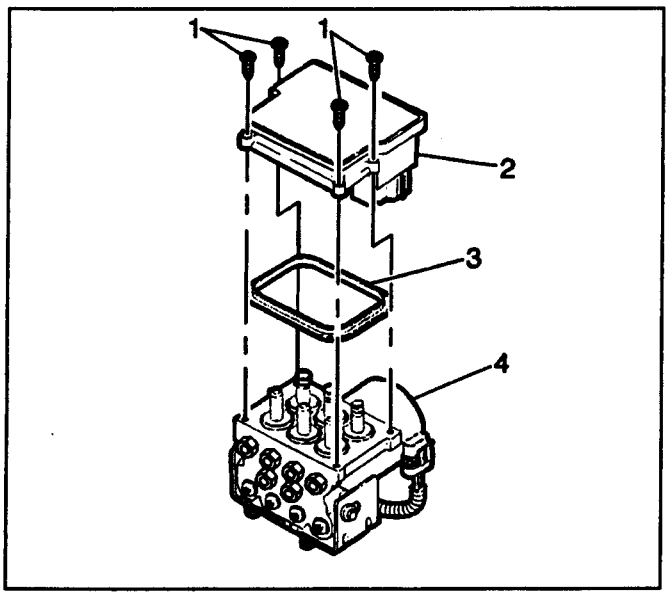
ABS Bleed Procedure

Important:

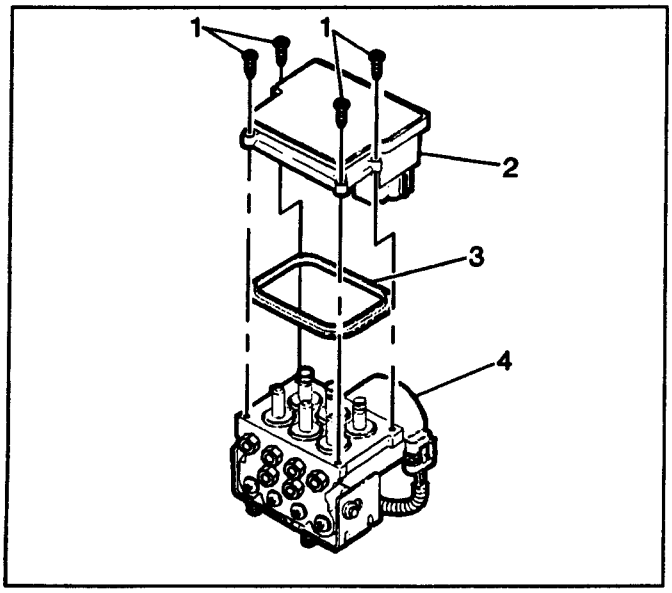
- Use the two-person bleed procedure under the following conditions:
  - Installing a new Electro-Hydraulic Control Unit (EHCU) or Brake Pressure Modulator Valve (BPMV)
  - Air is trapped in the valve body
- Do not drive the vehicle until the brake pedal feels firm.
- Do not reuse brake fluid that is used during bleeding.
- Use the vacuum, the pressure and the gravity bleeding procedures only for base brake bleeding.

Two Person Procedure

1. Raise the vehicle in order to access the system bleed screws.
2. Bleed the system at the right rear wheel first.
3. Install a clear hose on the bleed screw.
4. Immerse the opposite end of the hose into a container partially filled with clean DOT 3 brake fluid.
5. Open the bleed screw 1/2 to one full turn.
6. Slowly depress the brake pedal. While the pedal is depressed to its full extent, tighten the bleed screw.
7. Release the brake pedal and wait 10–15 seconds for the master cylinder pistons to return to the home position.
8. Repeat the previous steps for the remaining wheels. The brake fluid which is present at each bleed screw should be clean and free of air.
9. This procedure may use more than a pint of fluid per wheel. Check the master cylinder fluid level every four to six strokes of the brake pedal in order to avoid running the system dry.
10. Press the brake pedal firmly and run the *Scan Tool* Function Test four times. Release the brake pedal between each test.
11. Bleed all four wheels again using Steps 3–9. This will remove the remaining air from the brake system.
12. Evaluate the feel of the brake pedal before attempting to drive the vehicle.
13. Bleed the system as many times as necessary in order to obtain the appropriate feel of the pedal.



156566



156566

Electronic Brake Control Module Replacement

Removal Procedure

Important: After installation, calibrate the new EBCM to the tire size that is appropriate to the vehicle. Refer to Tire Size Calibration and to Trim Level Calibration in *ABS System Description*.

1. Remove the negative battery cable. Refer to *Battery Disconnect Caution* in Cautions and Notices.
2. Remove the three EBCM wiring harness connectors.
3. Remove the four T-25 Torx® bolts (1) that fasten the EBCM to the BPMV.
4. Remove the EBCM (2) from the BPMV (4) Removal may require a light amount of force.

   Important: Do not use a tool to pry the EBCM from the BPMV. Excessive force will damage the EBCM.
5. Clean the BPMV with a clean, dry cloth.

Installation Procedure

Important: If the EBCM mounting bolts are corroded or damaged, do not reuse the old mounting bolts. Install new EBCM mounting bolts with the new EBCM.

Important: Do not use RTV or any other type of sealant on the EBCM to BPMV mating surface.

1. Install EBCM (2) to BPMV (4).
2. Install the four EBCM bolts (1).

   Tighten

   Tighten the four bolts to 5 N·m (39 lb in) in an X-pattern.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
3. Connect the four electrical connectors to the EBCM.
4. Connect the negative battery cable. Refer to *Battery Disconnect Caution* in Cautions and Notices.
5. Revise the tire calibration using the *Scan Tool*.
6. Return to Diagnostic System Check. Refer to *Diagnostic System Check*.

Brake Pressure Modulator Valve Replacement

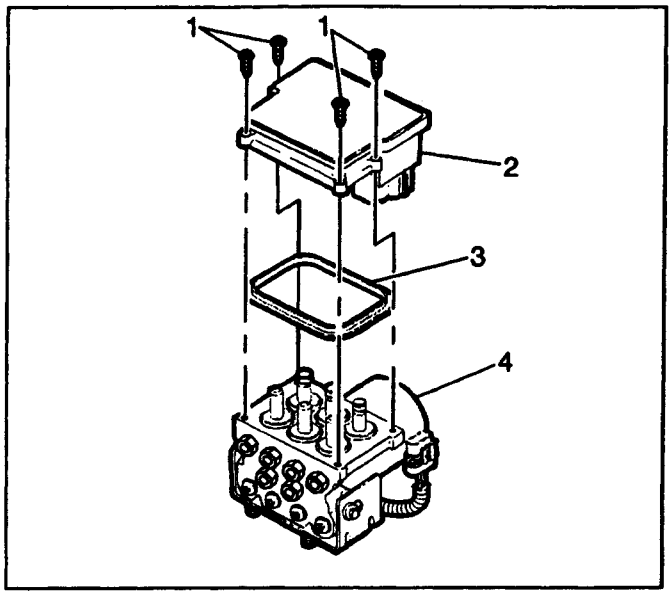
Removal Procedure

1. Disconnect the negative battery cable. Refer to *Battery Disconnect Caution* in Cautions and Notices.
2. Remove the three EBCM electrical connectors.
3. Remove the combination valve electrical connector.
4. Remove the six brake lines from the BPMV.
5. Remove the BPMV pump motor electrical connector from the EBCM.

6. Remove the four T-25 Torx® bolts (1) that fasten the EBCM to the BPMV.
7. Remove the EBCM (2) from the BPMV (4) Removal may require a light amount of force.

   Important: Do not use a tool to pry the EBCM from the BPMV. Excessive force will damage the EBCM.
8. Remove the three allen bolts (11) which fasten the combination valve to the BPMV.
9. Remove the combination valve from the BPMV.
10. Remove the two transfer tubes (13).

    Important: Do not reuse the transfer tubes. Always install new transfer tubes when replacing the BPMV.
11. Remove the three tube adapters (6).
12. Remove the three BPMV mounting bracket bolts (9).
13. Remove the BPMV (4) from the EHCU mounting bracket (7).
14. Clean the BPMV (4) with a clean, dry cloth.



156566

Installation Procedure

Important: Do not reuse the EBCM mounting bolts. Always install new EBCM mounting bolts with the new EBCM.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the BPMV (4) onto the EHCU (7) mounting bracket.

   Tighten

   Tighten the three BPMV mounting mounting bolts (9) to 9 N.m (7l lb ft).
2. Install the three tube adapters (6).

   Tighten

   Tighten the tube adapters to 31 N.m (23 lb ft).

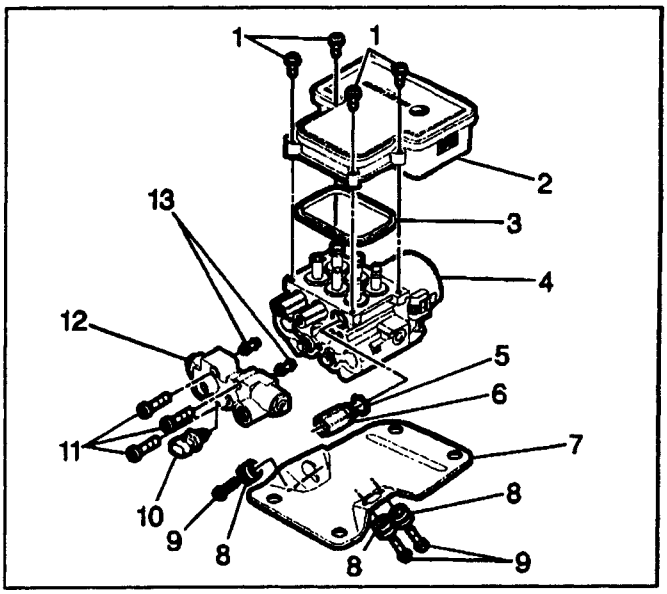
   Important: Do not reuse the transfer tubes (13). Always install new transfer tubes when removing the combination valve (12).
3. Install two new transfer tubes (13) into the combination valve (12).
4. Install the combination valve (12) onto the BPMV (4).
5. Install the three combination valve fastening bolts (11).

   Tighten

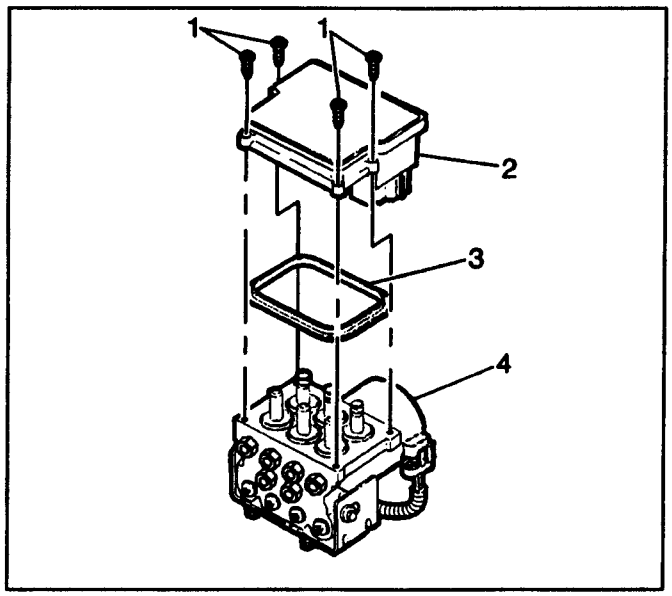
   Tighten the three allen bolts first to 8 N.m (6 lb ft) and then to 12 N.m (12 lb ft).
6. Install EBCM (2) to BPMV (4).
7. Install the four new EBCM bolts (1).

   Tighten

   Tighten the four bolts to 5 N.m (39 lb in) in an X-pattern.
8. Install the BPMV pump motor electrical connector to the EBCM.
9. Install the EHCU to vehicle.

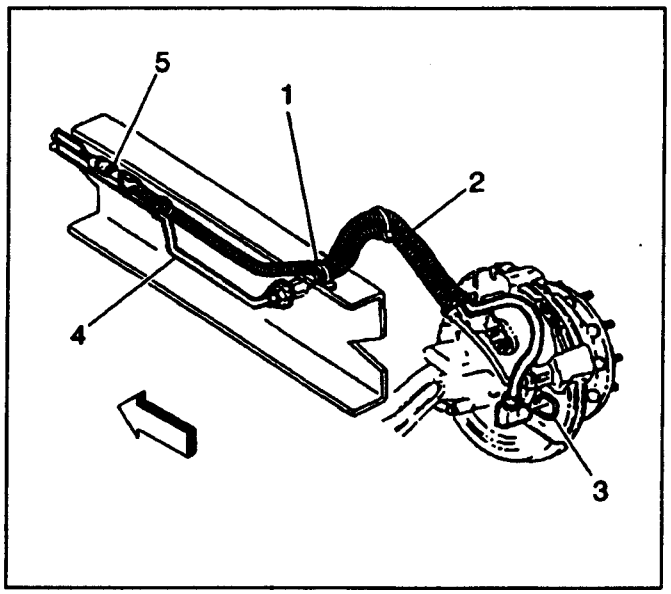


184208



156566

10. Connect the three electrical connectors to the EBCM.
11. Connect the five brake lines to the combination valve.
    Tighten
    Tighten the five brake lines to 30 N.m (22 lb ft).
12. Connect the negative battery cable.
13. Bleed the brake system. Refer to *ABS Bleed Procedure.*
14. Return to *Diagnostic System Check.*

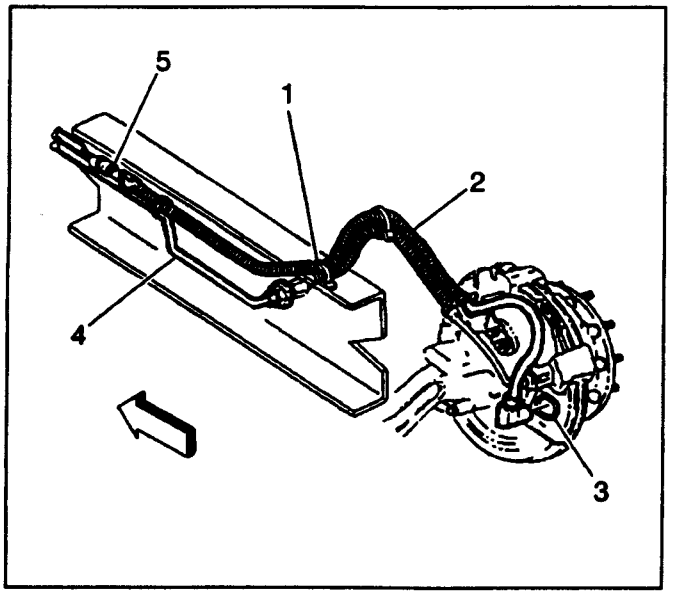


156568

Wheel Speed Sensor Replacement - Front

Removal Procedure

1. Disconnect the electrical connector (5).
2. Remove the nylon straps (1) retaining the sensor wire to the brake line. Note the location of the straps.
3. Remove the wheel speed sensor from the bore.
4. Remove the speed sensor retaining clip (3). The clip may come out with the wheel speed sensor or stay in the bore. If the sensor retaining clip (3) is still functioning correctly, save it for reinstallation. If the sensor retaining clip (3) is not functioning correctly, replace the sensor retaining clip (3).



156568

Installation Procedure

Important: You may have to use the wire retainers from the old wheel speed sensor wire on the new sensor. Do not damage the new wire when installing the retainers.

Important: When the wheel speed sensor is fully installed in the block bore, it contacts the tone ring which is attached to the wheel hub. Normal bearing play between the sensor tip and tone ring in the wheel hub will move the sensor tip away from the tone ring. This automatically establishes the proper air gap.

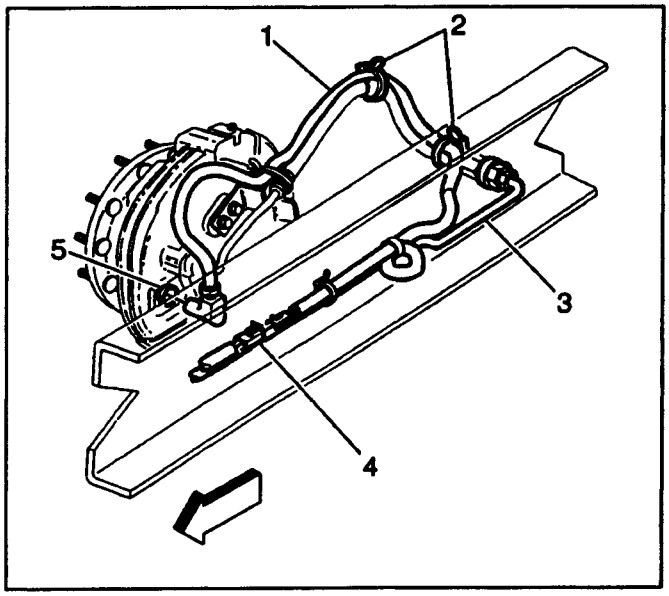
1. Install the wheel speed sensor retaining clip (3). completely into the bore. The clip should stop at the retaining tabs. Insert the wheel speed sensor into the clip. The wheel speed sensor should contact the tone ring.

2. Secure the sensor wire to the brake line with a wire tie(1) in the location noted during removal.
3. Connect the electrical connector (5).

Wheel Speed Sensor Replacement - Rear

Removal Procedure

1. Disconnect the electrical connector.
2. Remove the nylon straps retaining the sensor wire to the brake line. Note the location of the straps.
3. Remove the wheel speed sensor (1) from the bore.
4. Remove the speed sensor retaining clip (2). The clip may come out with the wheel speed sensor or stay in the bore. If the sensor retaining clip is still functioning correctly, save it for reinstallation. If the sensor retaining clip is not functioning correctly, replace the sensor retaining clip.



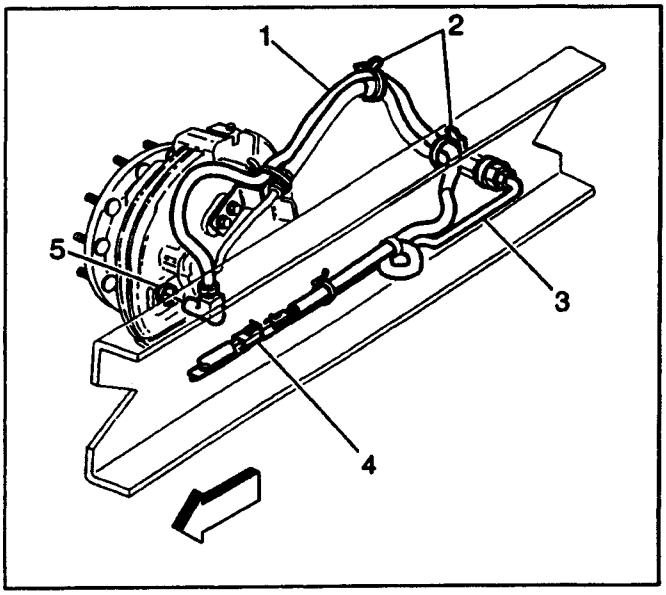
156570

Installation Procedure

Important: You may have to use the wire retainers from the old wheel speed sensor wire on the new sensor. Do not damage the new wire when installing the retainers.

Important: When the wheel speed sensor is fully installed in the block bore, it contacts the tone ring which is attached to the wheel hub. Normal bearing play between the sensor tip and tone ring in the wheel hub will move the sensor tip away from the tone ring. This automatically establishes the proper air gap.

1. Install the wheel speed sensor retaining clip (2) completely into the bore. The clip should stop at the retaining tabs. Insert the wheel speed sensor (1) into the clip. The wheel speed sensor should contact the tone ring.
2. Secure the sensor wire to the brake line with a wire tie in the location noted during removal.
3. Connect the electrical connector.



156570

Tube Adapter Replacement

Removal Procedure

Important: If you must remove more than one tube adapter at one time, stamp the BPMV with a number (1, 2 or 3) in order to indicate the number of grooves cut into the tube adapters. This procedure will aid proper reassembly.

1. Remove the appropriate brake line from the tube adapter.
2. Remove the tube adapter.

Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the new tube adapter.
   Tighten
   Tighten the tube adapter to 31 N.m (23 lb ft).
2. Install the brake line.
   Tighten
   Tighten the brake line to 30 N.m (22 lb ft).
3. Bleed the system. Refer to *ABS Bleed Procedure.*

Description and Operation

Service Precautions

When working on this system, observe the following precautions:

- Before welding on the vehicle with an electric welding unit, complete the following steps:
  - Turn the ignition switch OFF.
  - Disconnect the EBCM connectors.
- Do not use a fast charger for starting the engine.
- Disconnect the negative battery cable when fast charging. Refer to *Battery Disconnect Caution* in Cautions and Notices.
- Never disconnect the battery from the vehicle electrical system while the engine is running.
- Connect all wiring harness connectors securely.
- Proper speed sensor wiring, routing and retaining are necessary in order to prevent false signals due to electrical noise. You can achieve proper system operation only by restoring the system to its original condition.

  When servicing the ABS, note the routing, position, mounting and locations of the following items:
  - All components
  - The wiring
  - The connectors
  - The clips
  - The brackets
  - The brake pipes

Follow the above mentioned precautions when working on ABS. Familiarize yourself with ABS and it relationships with other components on the vehicle.

General System Description

This section covers diagnostic and service procedures for the four wheel antilock brake system (ABS). These models use the three sensor ABS. Speed information is obtained using a wheel speed sensor (WSS) at each front wheel and the vehicle speed sensor (VSS) for rear wheel speed information. ABS reduces the occurrence of wheel lockup during severe brake applications. The system regulates hydraulic pressure to all four wheels. The pressure is regulated by the brake pressure modulator valve (BPMV).

ABS is designed to provide the average driver with the following:

- Optimal steering control and stability when braking
- Optimal braking performance with available traction

Wheel Slip
The ability of a vehicle to stop is related to the friction of the road surface. At 0% slip, the tires rotate freely; at 100% slip, the tire and wheel are locked. Stopping distance increases and steering control is diminished.

With a 10%-20% slip, vehicle stopping distance will be as short as possible and steering control will be at its optimum. Some slip is necessary to stop the wheel and achieve maximum braking.

When ABS operation occurs, the driver of the vehicle should always continue to push hard on the brake pedal. Never pump the brakes. The ABS system will automatically modulate the brakes.

Steering Control
Steering control, like braking, also depends on tire traction. A locked tire in a 100% slip condition delivers less than optimum braking and directional control. Thus, some tire rotation is desirable for steering control. The tires must regain traction before steering control is restored to the vehicle.

Abbreviations and Definitions

BPMV: Brake Pressure Modulator Valve

CKT: Circuit

DLC: Data Link Connector

DMM: Digital Multimeter

DTC: Diagnostic Trouble Code

EBCM: Electronic Brake Control Module

EHCU: Electro-Hydraulic Control Unit

Infinite: Open Circuit/Unmeasurably High Resistance

LPA: Low Pressure Accumulator

OL: Open Circuit/Unmeasurably High Resistance

WSS: Wheel Speed Sensor

The EHCU is the entire ABS unit, including the BPMV and the EBCM. The BPMV is defined as the hydraulic control portion of the EHCU. The BPMV includes the internal control valves, the electric motor and the pumps. The BPMV does not include the EBCM. The EBCM is the electronic control portion of the EHCU. The EBCM mounts to the top of the BPMV. The EBCM is housed in aluminum with a black plastic top.

Basic Knowledge Required

You must have a basic knowledge of the following items before using this section. Without this basic knowledge, you will have difficulties using the diagnostic procedures contained in this section.

If you need a review of basic electrical troubleshooting, see the introduction to Electrical Diagnosis. Electrical Diagnosis also contains information on the basic use of circuit testing tools.

Basic Electrical Circuits

You should understand the basic electrical theory. You should also know the meaning of basic electrical concepts and measurement: voltage (volts), current (amperes) and resistance (ohms). You should understand what happens in a circuit with an open or shorted wire. You should be able to read and understand a wiring diagram.

Use of Circuit Testing Tools

You should be familiar with the high impedance Digital Multimeter (DMM) *J 39200*. You should be familiar with the meter controls and how to use them correctly. You should be able to measure voltage, resistance and current. You should also know how to use jumper wires to bypass components in order to test circuits.

ABS System Description

Electro-Hydraulic Control Unit

The Electro-Hydraulic Control Unit (EHCU) is located on the left frame rail behind the cab. The EHCU assembly includes the Electronic Brake Control module (EBCM) and the Brake Pressure Modulator Valve (BPMV). The EHCU regulates hydraulic pressure in the brake system during an antilock stop.

Electronic Brake Control Module

The Electronic Brake Control Module (EBCM) is part of the EHCU. The EBCM is the electronic portion of the EHCU. The major function of the EBCM is to control the BPMV. Inputs to the EBCM include the following items:

- Four wheel speed signals
- Stop Lamp Switch
- Differential pressure switch
- Ignition switch voltage
- Un-switched battery voltage

Outputs of the EBCM include the following items:

- Four isolation solenoids (internal to the EBCM)
- Four dump solenoids (internal to the EBCM)
- The amber ABS indicator lamp
- The red BRAKE warning lamp
- The pump motor

A diagnostic serial data link (UART, ABS only) is also used for diagnostic service tools and assembly plant testing. A serial data circuit (Class 2) is used for transmitting a "rough road" signal to the PCM.

The EBCM monitors the speed of each wheel. If any wheel approaches lockup, the EBCM controls the solenoids (isolation solenoid and dump solenoid) in order to reduce brake pressure to the wheel approaching lockup. Once the wheel regains traction, brake pressure is increased until the wheel again approaches lockup. This cycle repeats until either the vehicle comes to a stop, the brake is released, or the wheel is no longer approaching lockup. The EBCM also runs self diagnostics in order to check for any system malfunctions. Refer to *Self-Diagnostics*. If the EBCM detects a malfunction with the system, the ECBM will illuminate the amber ABS indicator in order to alert the driver of a malfunction.

Brake Pressure Modulator Valve

The Brake Pressure Modulator Valve (BPMV) is part of the EHCU. The BPMV is the hydraulic portion of the EHCU. The EBCM controls the BPMV. The BPMV is split into the following four hydraulic channels:

- Left front
- Right front
- Left rear
- Right rear

Each channel has an isolation valve and a dump valve.

Wheel Speed Sensors

The Wheel Speed Sensors (WSS) are a magnetic coil/pickup type. Each WSS produces an AC voltage signal which is transmitted to the EBCM in order to indicate how fast the wheel is turning. The speed of the wheel is directly proportional to the frequency and amplitude of the wheel speed signal.

Wheel Speed Sensor Tone Wheels

Each Wheel Speed Sensor (WSS) uses a tone wheel in order to produce an alternating current (AC) voltage signal. Tone wheels are metal rings with teeth on the outside diameter. The AC voltage is produced as the teeth pass through the magnetic field of the WSS pole piece. The tone wheels are attached to the rotor or the drum. Any imperfections in the tone rings, such as a broken tooth or a missing tooth, can cause an inaccurate wheel speed signal.

Tire Size Calibration

The EBCM accepts wheel speed signals from several different sizes of tire and wheel combinations. All vehicles are preprogrammed from the factory with the proper tire size calibration. Whenever you replace the EBCM or change the tire size, you must reset the tire size calibration in the EBCM using *Scan Tool.*

Trim Level Calibration

The ABS can operate with different brake types and different wheel bases from several different vehicle configurations. All vehicles are pre-programmed from the factory with the proper trim level calibration. This trim level calibration corresponds to the different wheel bases and axles/brake types available on each vehicle. Whenever you replace the EBCM or change the wheel base of the vehicle, you must recalibrate the trim level within the EBCM.

Use the *Scan Tool.* You must first obtain the wheel base and axle type using RPO codes (refer to General Information) in order to select the correct trim level on the *Scan Tool.* Once programmed, this calibration will remain, even if the battery is disconnected or if the EBCM is removed from the vehicle. Refer to the following table for trim level calibration selection.

ABS System Description

Wheel Base	Front Axle RPO Code	Software Version
Less than or equal to 423 cm (170 in)	FL1	A
Less than or equal to 432 cm (200 in)	FL2/F43/FM6/ FS7	B
Greater than 423 cm (170 in)	FL1	C
Greater than 432 cm (200 in)	FL2/F43/FM6/ FS7	D

ABS System Operation

ABS Indicator Lamp Operation

The system uses an amber ABS indicator lamp in the instrument cluster in order to show system operation and malfunctions.

Normal Lamp Operation

A bulb check occurs each time the ignition switch is turned to the RUN position. The ANTILOCK and BRAKE lamps should turn on, remain on for about two seconds, then turn off. The ABS indicator lamp also indicates system malfunctions. When the EBCM detects a malfunction in the system, the EBCM turns the ANTILOCK and sometimes the BRAKE lamp on. The lamp may remain on or turn off depending on the malfunction. In order to determine the specific cause of the malfunction, refer to the ABS Diagnostic System Check.

Tires and ABS

Correct tire size, proper inflation, accurate alignment and even wear are needed for good brake performance. These items are essential for proper ABS performance.

Spare Tire

Use of the spare tire supplied with the vehicle will not affect the performance of the system.

Replacement Tires

If the replacement tires are not the same size as the original tires, you must change the tire size calibration within the EBCM using a *Scan Tool.* Refer to Tire Size Calibration portion of ABS System Description. Failure to change the tire calibration when replacing the original tires with a different size tire can affect the performance of the ABS.

Self-Tests

The ABS performs the following two system self-tests:

- The first self-test is performed when the ignition is turned to RUN. Both the ABS indicator lamp and the BRAKE warning lamp will turn on for 3 seconds, then they will turn off. This test confirms correct operation of the EBCM and the lamps. If one of the lamps remains on, either the ABS or the base brake system will require service.
- The second self-test is performed when the vehicle reaches a speed of greater than 3 mph. At this time the internal EBCM relay, six solenoid coils and BPMV pump motor are cycled and checked for shorts/opens. The BPMV pump will make a slight sound when this function occurs.

Normal Braking Mode

Refer to Normal Braking Mode in *BPMV Hydraulic Flow Chart.*

During normal braking, pressure is applied through the brake pedal. Fluid travels from the master cylinder, through the combination valve and into the BPMV. Once in the BPMV, the fluid travels through the normally-open isolation valves, through the normally-closed dump valves and out into the brakes.

During normal braking, the pumps are not turned on. The low pressure accumulators and attenuators are empty. Only residual pressure is stored in these accumulators and attenuators.

The EBCM constantly monitors wheel speed sensor inputs for rapid deceleration. If the ABS becomes disabled for any reason, the driver will always have base brakes. The normally-open isolation valves and normally-closed dump valves will remain in these positions in order to allow normal fluid pressure to the wheels.

ABS will not operate without wheel slip. The vehicle must be going at least 13 km/h (8 mph) in order to begin ABS operation.

ABS Braking Mode

The ABS will monitor the three-wheel speed sensors and control the hydraulic pressure changes at each wheel until the vehicle has come to a complete stop or until the driver has released the brake pedal. The system operates through the following process:

1. Pressure isolation/maintain
2. Pressure decrease
3. Pressure increase
4. Brake release (fluid return)

Sequence Of Events

1. With the vehicle at 13 km/h (8 mph) or greater, the driver depresses the brake pedal.
2. The wheel speed begins to decrease as the master cylinder pressure and brake pressure increase.
3. As the wheel speed continues to decrease from vehicle speed, the normally-open isolation valve for the affected channel closes to stop additional pressure to the wheel. The master cylinder pressure continues to increase as the driver depresses the pedal, but the wheel brake pressure is now limited to the ABS system pressure.
4. When the EBCM determines that the wheel is about to lock-up, the normally-closed dump valve opens. This bleeds off some of the pressure at the wheel cylinder (or caliper) in order to allow the wheel to return to a speed closer to the speed of the vehicle.
5. The dump valve is again closed and the isolation valve remains closed in order to allow the wheel speed to completely recover from the lock-up.
6. Once the vehicle has recovered from the lock-up tendency, the isolation valve is momentarily pulsed open in order to allow the master cylinder pressure and pump pressure to reach the brakes. This controlled pressure rise continues until the wheel is at optimum brake output or until the brake pressure is brought up to master cylinder output pressure. The ABS allows the brake fluid to flow to the wheel, build pressure and try to force another departure, repeating Step 3 through Step 6. The following paragraphs describe the various modes in detail.

Isolation Mode (Pressure Maintain)

Refer to Isolation Mode in *BPMV Hydraulic Flow Chart.*

Isolation will occur when the driver applies excessive braking for the given road conditions, causing the wheels to decelerate at a rate which exceeds the vehicle's capability.

If the information from the wheel speed sensors indicate excessive wheel deceleration (imminent lock-up), the first step in the antilock sequence is to isolate the brake pressure being applied by the driver.

The EBCM applies a voltage to the isolation coil in order to close the rear isolation valve. This will prevent any additional brake pressure applied by the driver from reaching the wheel. With the isolation valve closed, further increases in brake pressure from the driver will be prohibited.

Dump Mode (Pressure Decrease)

Refer to Dump Mode in *BPMV Hydraulic Flow Chart.*

Once the pressure is isolated, it must be reduced in order to get the wheels rolling once again. Reducing pressure is accomplished by dumping a portion of the brake fluid pressure into the rear low pressure accumulator (LPA).

The EBCM energizes the dump valve coil(s) in order to open the rear dump valve, allowing fluid from the wheels to be dumped into the LPA. Very short activation pulses open and close the dump valve passageway in order to control this action. Brake pressure is lowered at the wheel and allows the affected wheel to begin rolling again.

The fluid taken from the wheels forces a spring back. The fluid is stored in the LPA at approximately 1034 kPa (150 psi). A portion of the fluid also primes the pump so it can begin building reapply pressure. The dump valves are opened independently in order to control the deceleration of the wheel.

Reapply Mode (Pressure Increase)

Refer to Reapply Mode in *BPMV Hydraulic Flow Chart.*

The reapply sequence is initiated in order to obtain optimum braking at each wheel. The rear isolation valve is momentarily pulsed open in order to allow the master cylinder and rear pump pressure to reach the brakes. This controlled pressure rise continues until the wheel is at optimum brake output or until the brake pressure is brought up to the master cylinder output pressure.

If more pressure is required, more fluid is drawn from the master cylinder and applied to the brakes. The driver will feel pedal pulsations or pedal drop. This is normal and expected when in the antilock mode.

As fluid is reapplied, the wheels begin to slow down at the optimum rate. If the wheels approach imminent lock-up again, the module will isolate, dump and reapply. These control cycles (isolation, dump and reapply) occur in millisecond intervals, allowing several cycles to occur each second.

Brake Release

At the end of the antilock stop, when the driver releases the brake pedal, the motor will remain on for a short time in order to help drain any fluid left in the LPA. As the fluid drains back into the system, the spring force in the LPA pushes the piston to the home position. The isolation valve is turned off and fluid returns through the isolation orifice.

Special Tools and Equipment

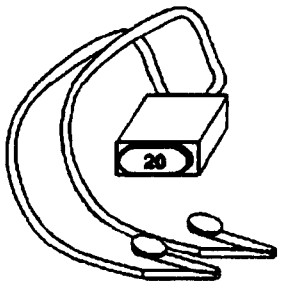
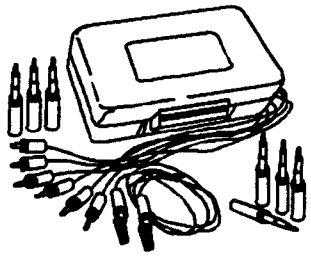
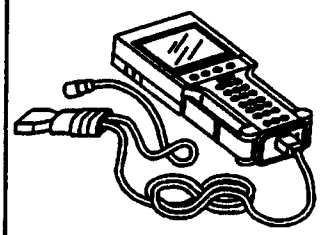
Illustration	Tool Number/ Description
 3430	J 39200 Digital Multi-Meter
 1025	J 36169 Fused Jumper Wire

Illustration	Tool Number/ Description
 11799	J 35616 Connector Adapter Test Kit
 39438	Tech 2 Scan Tool

Air Antilock Brake System

Specifications

Fastener Tightening Specifications

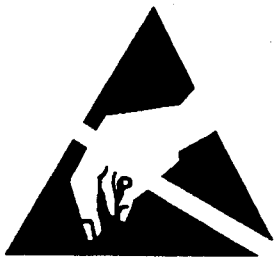
Application	N·m	Lb Ft	Lb In
Front Modulator Valve Fitting Supply Connector	22	16	—
Front Modulator Valve Fitting Supply Elbow	22	16	—
Front Modulator Valve Fitting Delivery Elbow	35	26	39
Rear Modulator Valve Fitting Supply Connector (single axle)	37	27	—
Rear Modulator Valve Fitting Delivery Connector (single axle)	37	27	—
Rear Modulator Valve Fitting Delivery Connector (tandem axle)	35	26	—
Rear Modulator Valve Fitting Supply Elbow (tandem axle)	35	26	—
Rear Modulator Valve Fitting Supply Tee (tandem axle)	35	26	—
Rear Modulator Valve Fitting Supply Nipple (tandem axle)	35	26	—
Front Modulator Valve to Crossmember	23	17	—
Rear Modulator Valve to Bracket (single axle)	30	22	—
Rear Modulator Valve Bracket to Frame (single axle)	70	52	—
Rear Modulator Valve to Bracket (tandem axle)	23	17	—
Rear Modulator Valve to Crossmember (tandem axle)	45	33	—
Front Wheel Speed Sensor Wire Retention Bracket	13	—	115
Rear Wheel Speed Sensor Wire Retention Bracket	33	24	—
EBCM to Bracket	8	—	71
EBCM Bracket to Cowl	29	21	—
EBCM Harness Connector	2	—	18

Schematic and Routing Diagrams

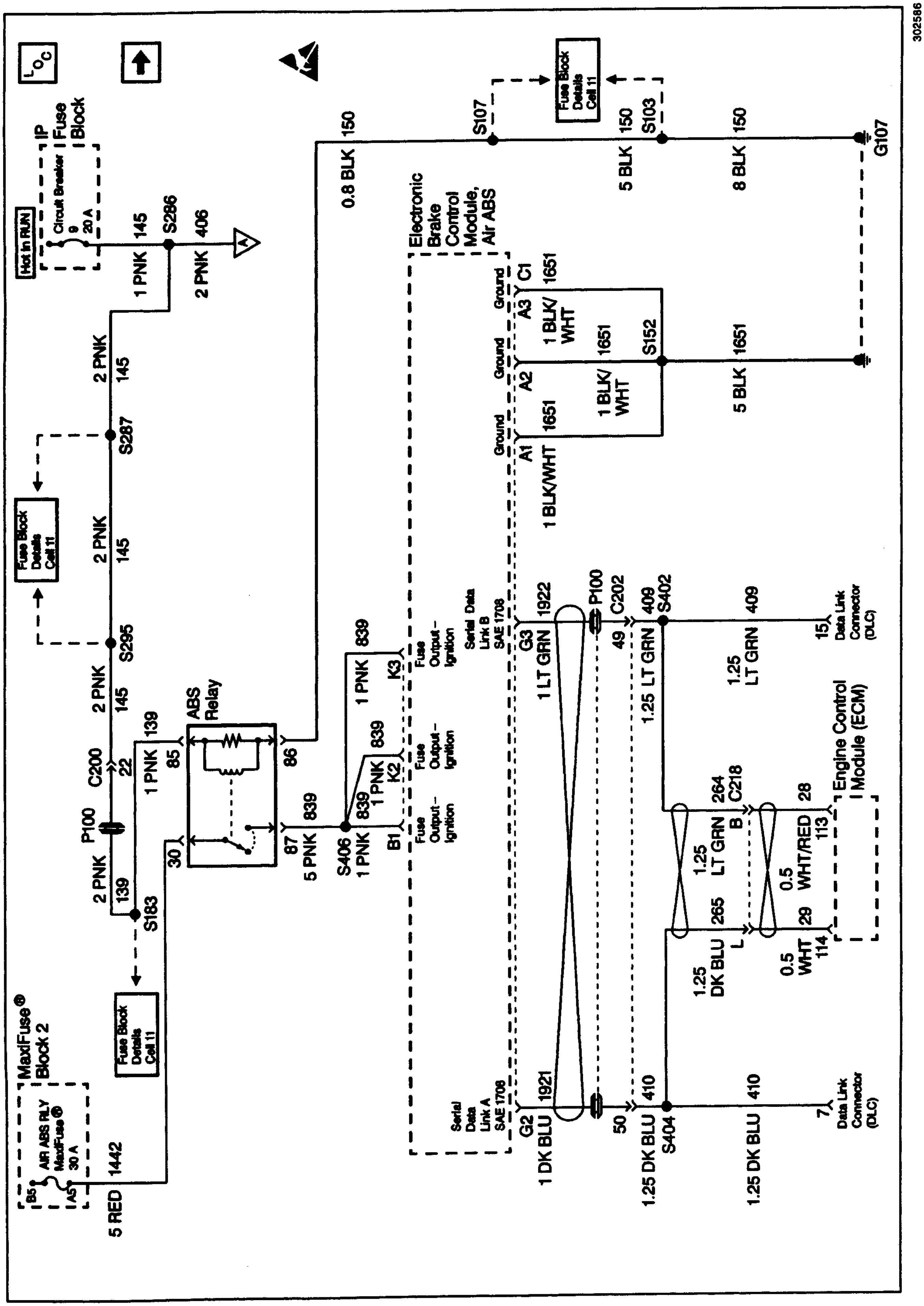
Air Antilock Brakes System Schematic References

Reference on Schematic	Section Number - Subsection Name
Fuse Block Details Cell 11	8—Wiring Systems
Ground Distribution Cell 14	8—Wiring Systems

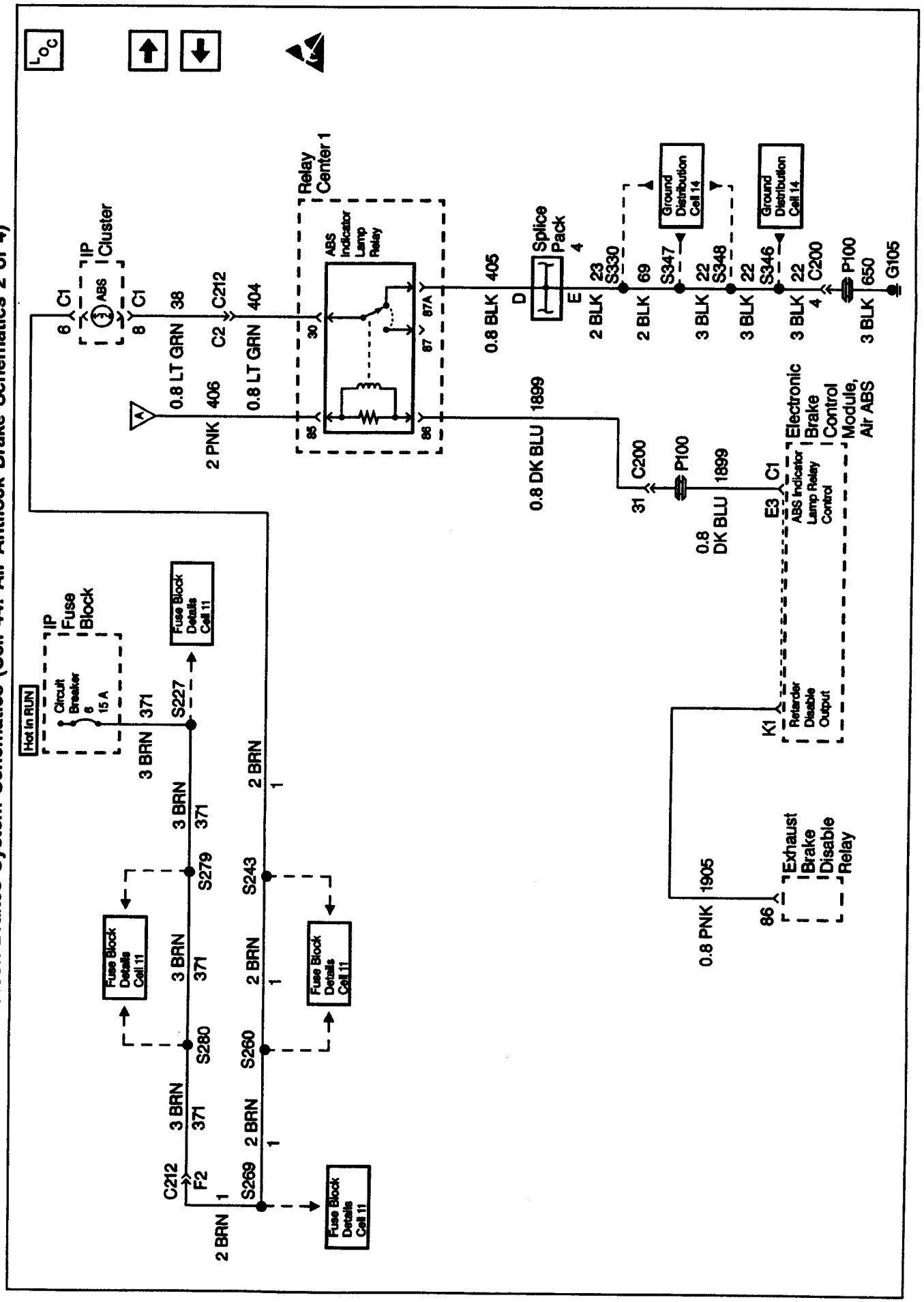
Air Antilock Brakes System Schematic Icons

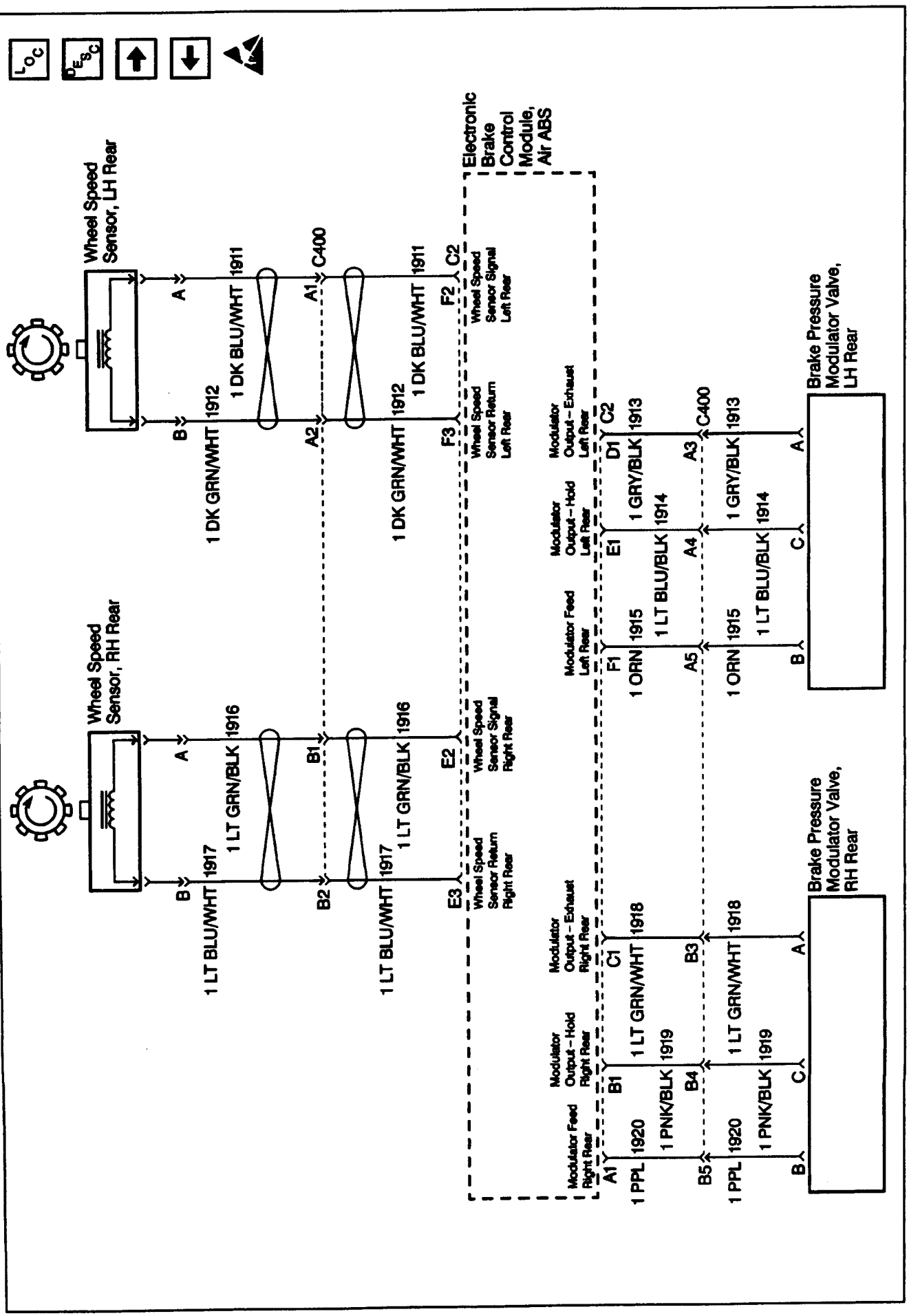
Icon	Icon Definition
 19384	Refer to *ESD Notice* in Cautions and Notices.

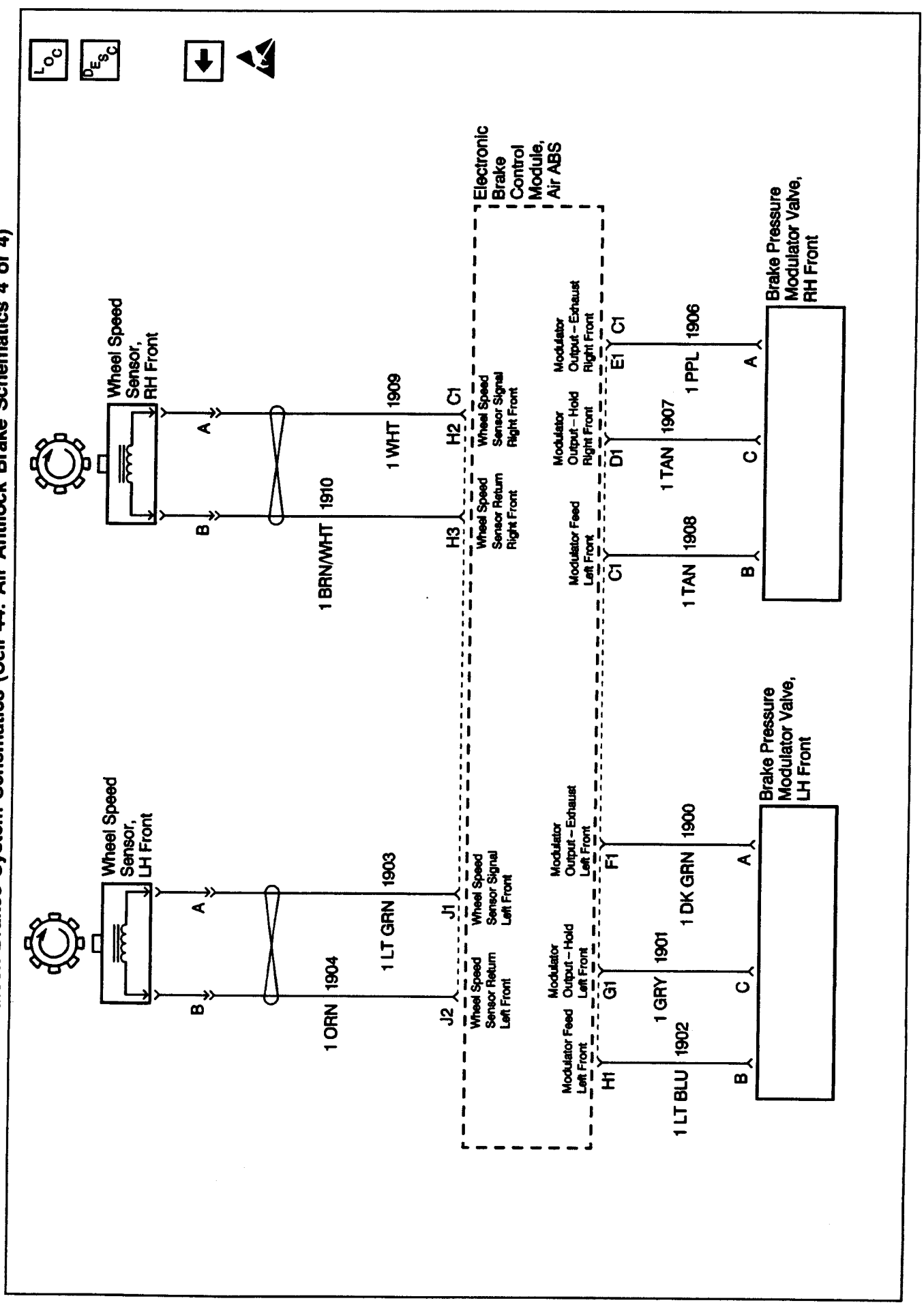
Air Antilock Brakes System Schematics (Cell 44: Air Antilock Brake Schematic 1 of 4)



Air Antilock Brakes System Schematics (Cell 44: Air Antilock Brake Schematics 2 of 4)




Air Antilock Brakes System Schematics (Cell 44 Air Antilock Brake Schematics 3 of 4)
292705
Wheel Speed Sensor, LH Rear
Wheel Speed Sensor, RH Rear
Electronic Brake Control Module, Air ABS
Brake Pressure Modulator Valve, LH Rear
Brake Pressure Modulator Valve, RH Rear
1 DK BLU/WHT 1911
1 DK GRN/WHT 1912
1 LT GRN/BLK 1916
1 LT BLU/WHT 1917
1 GRY/BLK 1913
1 GRY/BLK 1914
1 LT BLU/BLK 1914
1 ORN 1915
1 LT BLU/BLK 1915
1 LT GRN/WHT 1918
1 PNK/BLK 1919
1 PPL 1920
Wheel Speed Sensor Signal Left Rear
Wheel Speed Sensor Return Left Rear
Wheel Speed Sensor Signal Right Rear
Wheel Speed Sensor Return Right Rear
Modulator Output - Exhaust Left Rear
Modulator Output - Hold Left Rear
Modulator Feed Left Rear
Modulator Output - Exhaust Right Rear
Modulator Output - Hold Right Rear
Modulator Feed Right Rear
C400
C2
F2
F3
E1
D1
A3
A4
A5
C1
B1
B3
B4
B5
E2
E3
B2
A1
A2
B


Air Antilock Brakes System Schematics (Cell 44: Air Antilock Brake Schematics 4 of 4)
292709
Wheel Speed Sensor, RH Front
Wheel Speed Sensor, LH Front
Electronic Brake Control Module, Air ABS
Brake Pressure Modulator Valve, RH Front
Brake Pressure Modulator Valve, LH Front
A
B
C
1 BRN/WHT 1910
1 WHT 1909
1 ORN 1904
1 LT GRN 1903
1 TAN 1908
1 TAN 1907
1 PPL 1906
1 LT BLU 1902
1 GRY 1901
1 DK GRN 1900
H3
H2
C1
J2
J1
G1
F1
H1
D1
E1
Wheel Speed Sensor Return Right Front
Wheel Speed Sensor Signal Right Front
Wheel Speed Sensor Return Left Front
Wheel Speed Sensor Signal Left Front
Modulator Feed Left Front
Modulator Output – Hold Left Front
Modulator Output – Exhaust Left Front
Modulator Feed Left Front
Modulator Output – Hold Right Front
Modulator Output – Exhaust Right Front

Component Locator

Air Antilock Brakes System Components

Name	Location	Locator View	Connector End View
ABS Relay (ABS-Air)	On the left side of the cab bridge, on the relay bracket on the front of the electronic brake control module (EBCM)	*Air Antilock Brakes System Component Views* in Antilock Brake System	*Air Antilock Brakes System Connector End Views* Views in Antilock Brake System
Brake Pressure Modulator Valve (BPMV), LH Rear (ABS-Air)	On the left crossmember, forward of the rear axle	*Air Antilock Brakes System Component Views* in Air Brakes-ABS	*Air Antilock Brakes System Connector End Views* in Air Brakes-ABS
Brake Pressure Modulator Valve (BPMV), RH Rear (ABS-Air)	On the right crossmember, forward of the rear axle	*Air Antilock Brakes System Component Views* in Air Brakes-ABS	*Air Antilock Brakes System Connector End Views* in Air Brakes-ABS
Brake Pressure Modulator Valve (BPMV), LH Front (Cat® Diesel)	On the left rear of the front crossmember	*Air Antilock Brakes System Component Views* in Air Brakes-ABS	*Air Antilock Brakes System Connector End Views* in Air Brakes-ABS
Brake Pressure Modulator Valve (BPMV), RH Front (Cat® Diesel)	On the right rear of the front crossmember	*Air Antilock Brakes System Component Views* in Air Brakes-ABS	*Air Antilock Brakes System Connector End Views* in Air Brakes-ABS
Data Link Connector (DLC)	On the left side of the lower IP	*Data Link Connector Component Views* in Wiring Systems	*Data Link Connector End Views* in Wiring Systems
Electronic Brake Control Module-C1 (EBCM) (ABS-Air)	On the left side of the cab bridge, on the power steering reservoir mounting bracket	*Air Antilock Brakes System Component Views* in Antilock Brake System-Air	*Air Antilock Brakes System Connector End Views* in Antilock Brake System-Air
Electronic Brake Control Module-C2 (EBCM) (ABS-Air)	On the inboard side of the left frame rail, to the rear of #1 crossmember, on the bracket	*Air Antilock Brakes System Component Views* in Antilock Brake System-Air	*Air Antilock Brakes System Connector End Views* in Antilock Brake System-Air
Instrument Panel Cluster (IPC) *C1 (15 cavities)	In the upper IP harness to the IPC	—	*Instrument Cluster Connector End Views* in Instrument Panel, Gauges and Console
IP Fuse Block	On the right top side of the IP, under the access panel	*Power and Grounding Component Views* in Wiring Systems	—
MaxiFuse® Block 2	On the left rear of the cab, below cab bridge	*Power and Grounding Component Views* in Wiring Systems	—
Relay Center 1	In the right top of the IP, under the access cover	*Power and Grounding Component Views* in Wiring Systems	—
Wheel Speed Sensor (WSS) Left Front (ABS-Air)	Mounted in the left front brake backing plate	—	*Air Antilock Brakes System Connector End Views* in Antilock Brake System-Air
Wheel Speed Sensor (WSS) Right Front (ABS-Air)	Mounted in the right front brake backing plate	—	*Air Antilock Brakes System Connector End Views* in Antilock Brake System-Air
Wheel Speed Sensor (WSS) Left Rear (ABS-Air)	Mounted in the left rear brake backing plate	—	*Air Antilock Brakes System Connector End Views* in Antilock Brake System-Air

Air Antilock Brakes System Components (cont'd)

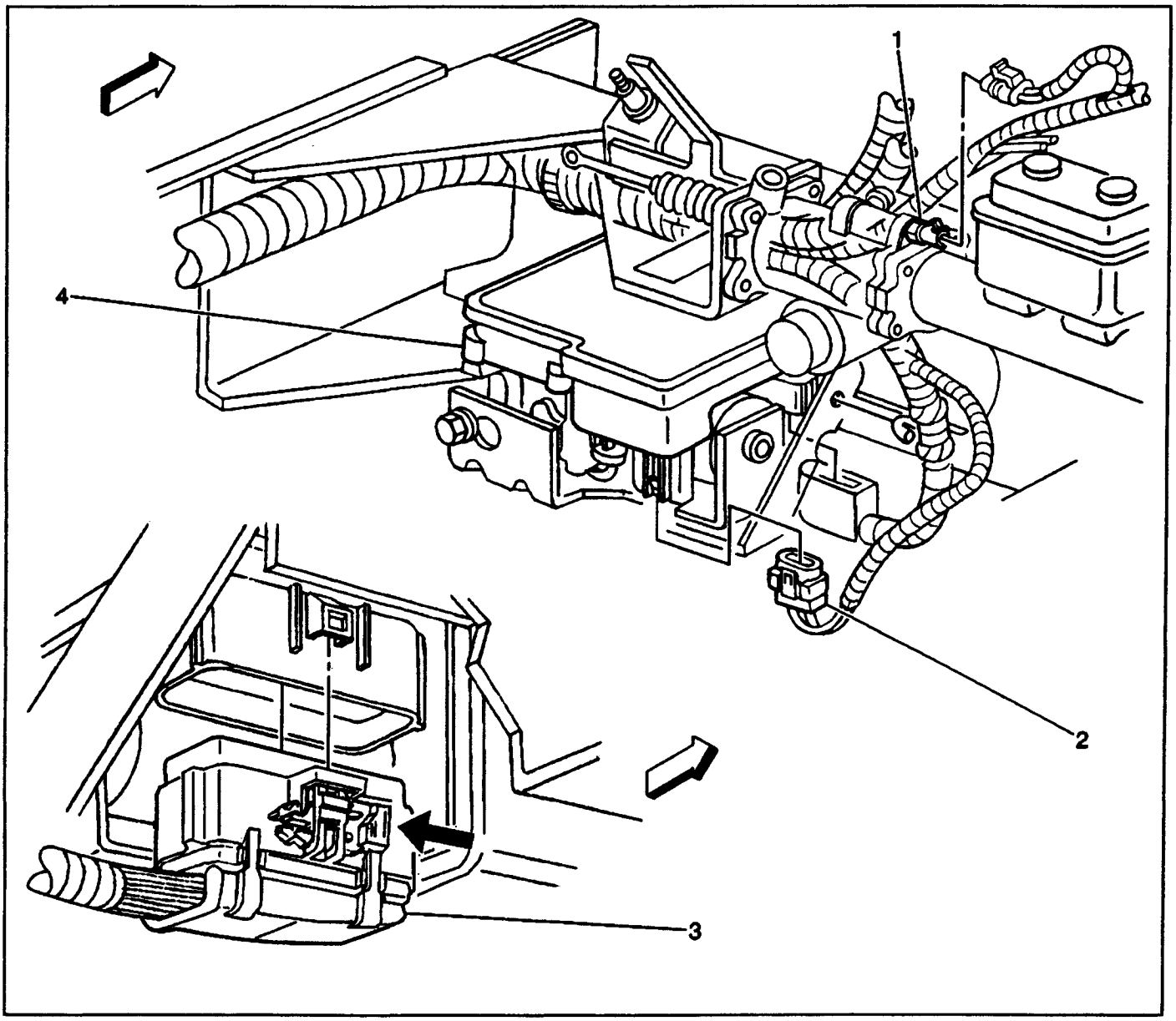
Name	Location	Locator View	Connector End View
Wheel Speed Sensor (WSS) Right Rear (ABS-Air)	Mounted in the right rear brake backing plate	—	*Air Antilock Brakes System Connector End Views* in Antilock Brake System-Air
C200 (56 cavities)	On the lower IP harness, to the front chassis harness, left center of the cab, in the cab interface connector.	—	*Inline Harness Connector End Views* in Wiring Systems
C202 (56 cavities)	On the lower IP harness, to the front chassis harness, left center of the cab, in the cab interface connector.	—	*Inline Harness Connector End Views* in Wiring Systems
C212 (84 cavities)	On the lower IP harness to the upper IP harness, left center of the IP at the floor	—	*Inline Harness Connector End Views* in Wiring Systems
C400 (15 cavities) (ABS-Air)	On the front chassis harness, to the ABS-air brake harness, inboard of the left frame rail left of the transmission	—	*Inline Harness Connector End Views* in Wiring Systems
C406 (7 cavities) (Cat® Diesel)	Inside the right frame rail inboard of the batteries	—	*Inline Harness Connector End Views* in Wiring Systems
G107	On the front chassis harness, on the left frame rail, approximately 25 cm (9.9 in) rear of the front shock absorber	—	—
G111		—	—
P100	In the front chassis harness, underhood, center of the bulkhead, in the cab interface connector housing	—	—
Splice Pack 4	In the upper IP harness, under the crash pad, on the top of the IP, joint connector 1, row 2, terminals 2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2J and 2L	—	—
S103	In the front chassis harness, approximately 7 cm (2.8 in) rear of the main harness breakout	—	—
S107 (Cat® Diesel)	In the front chassis harness, approximately 10 cm (3.9 in) forward of the MaxiFuse® block breakout	—	—
S109	In the front chassis harness, approximately 4 cm (1.6 in) rear of the engine harness breakout	—	—
S152	In the front chassis harness, approximately 9 cm (3.5 in) from the G107 ground breakout	—	—
S183 (Cat® Diesel)	In the front chassis harness, approximately 16 cm (6.3 in) from the G107 ground breakout	—	—
S227	In the upper IP harness, under the IP, approximately 6 cm (2.4 in) left of the fuse block breakout	—	—
S243	In the upper IP harness, approximately 13 cm (5.1 in) from the IP connector toward the main harness	—	—
S260	In the upper IP harness, the main harness at the speedometer breakout	—	—

Air Antilock Brakes System Components (cont'd)

Name	Location	Locator View	Connector End View
S269	In the upper IP harness, the main harness, approximately 21 cm (8.3 in) from the upper IP connector C212 (84 cavities)	—	—
S279	In the lower IP harnes, below the IP, approximately 5 cm (2.0 in) right of the relay center 1 harness breakout	—	—
S280	In the lower IP harness, in the main harness at the frame harness breakout	—	—
S286	In the lower IP harness, in the main harness at the fuse block harness breakout	—	—
S287	In the lower IP harness, in the main harness, approximately 22 cm (8.7 in) right of the fuse block harness breakout	—	—
S295	In the lower IP harness, in the main branch, at the C200 (56 cavities) and C202 (56 cavities) breakout	—	—
S402	In the front chassis harness, 10 cm (3.9 in) to the front of the ABS harness breakout in the main harness	—	—
S404	In the front chassis harness, 17 cm (6.7 in) to the front of the ABS harness breakout in the main harness	—	—
S406	In the front chassis harness, approximately 7 cm (2.8 in) to the ABS harness breakout	—	—

Air Antilock Brakes System Component Views

Front Chassis Harness to Brake Components (ABS-Hydraulic)

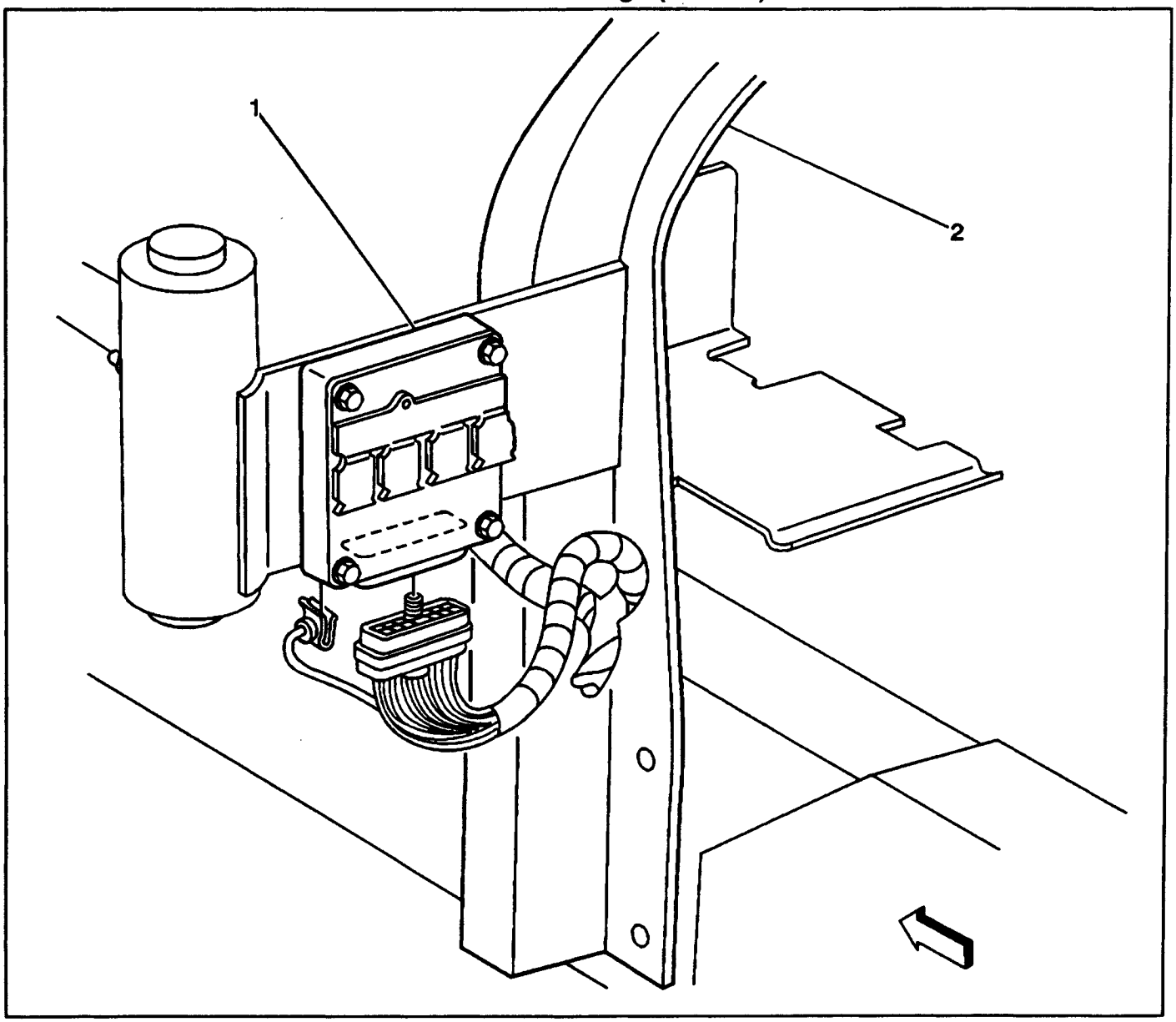


231487

Legend

(1) Brake Fluid Flow Switch
(2) Electronic Brake Control Module (EBCM) (ABS-Hydraulic) Connecor C2 (2 cavities)
(3) Electronic Brake Control Module (EBCM) (ABS-Hydraulic) Connector C1 (24 cavities)
(4) Electronic Brake Control Module (EBCM) (ABS-Hydraulic) Connector C2 (2 cavities)

Front Chassis Harness to Cab Bridge (ABS-Air) LH Forward View



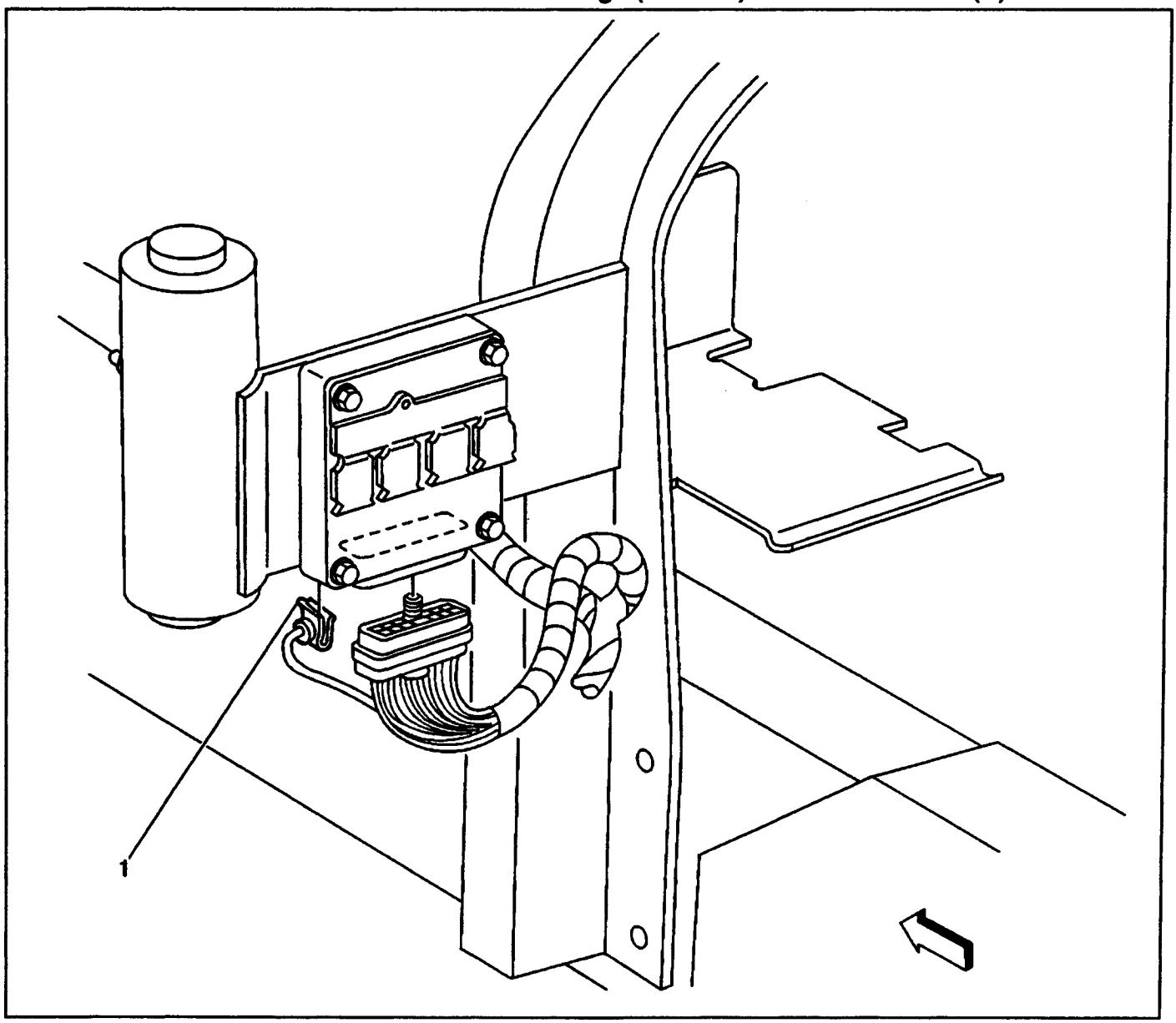
231698

Legend

(1) Electronic Brake Control Module (EBCM) (ABS-Air)

(2) Cab Bridge

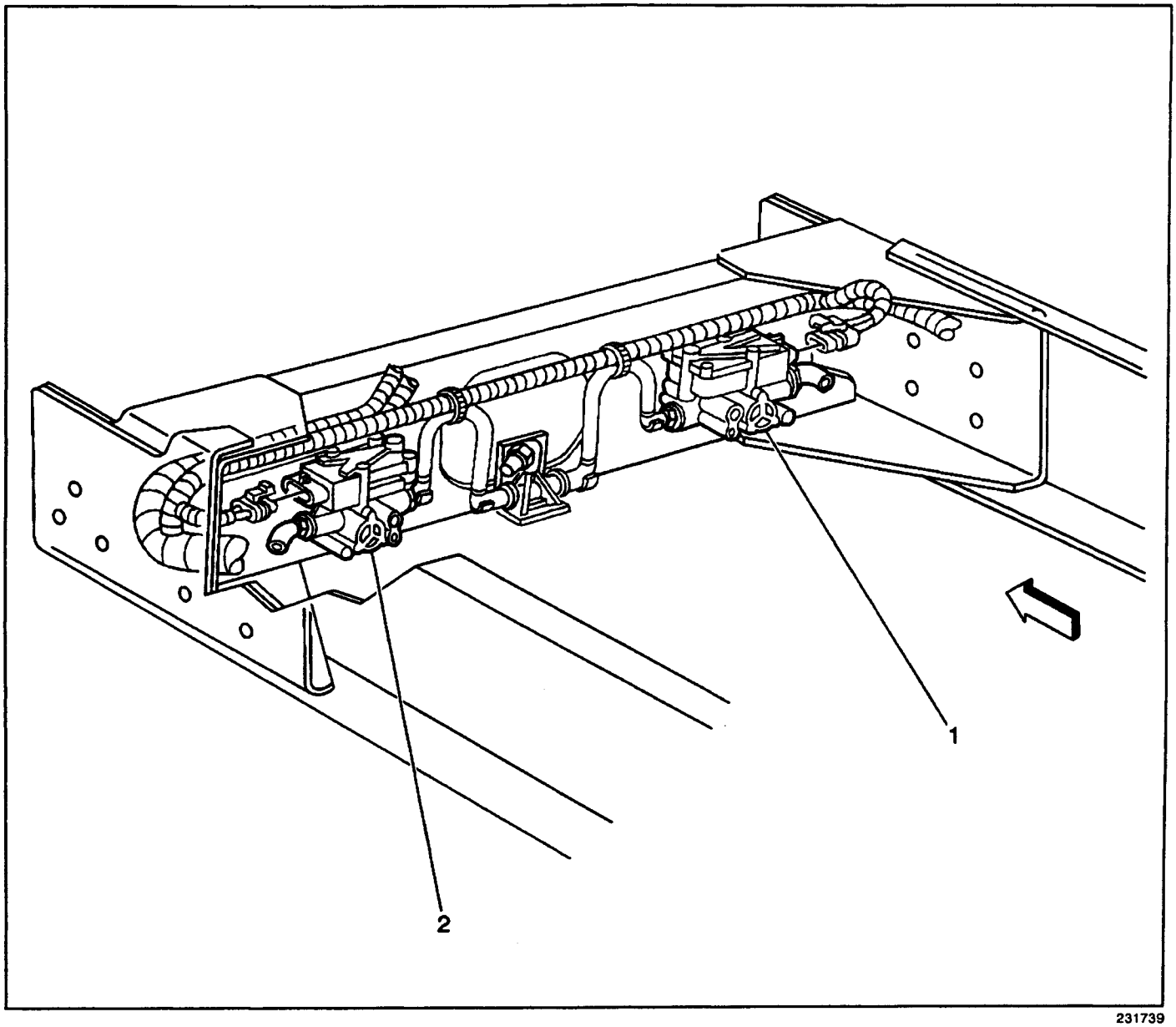
Front Chassis Harness to Cab Bridge (ABS-Air) LH Forward View (C)



Legend

(1) G104 (ABS-Air)

Front Chassis Harness to Brake Components (ABS-Air)



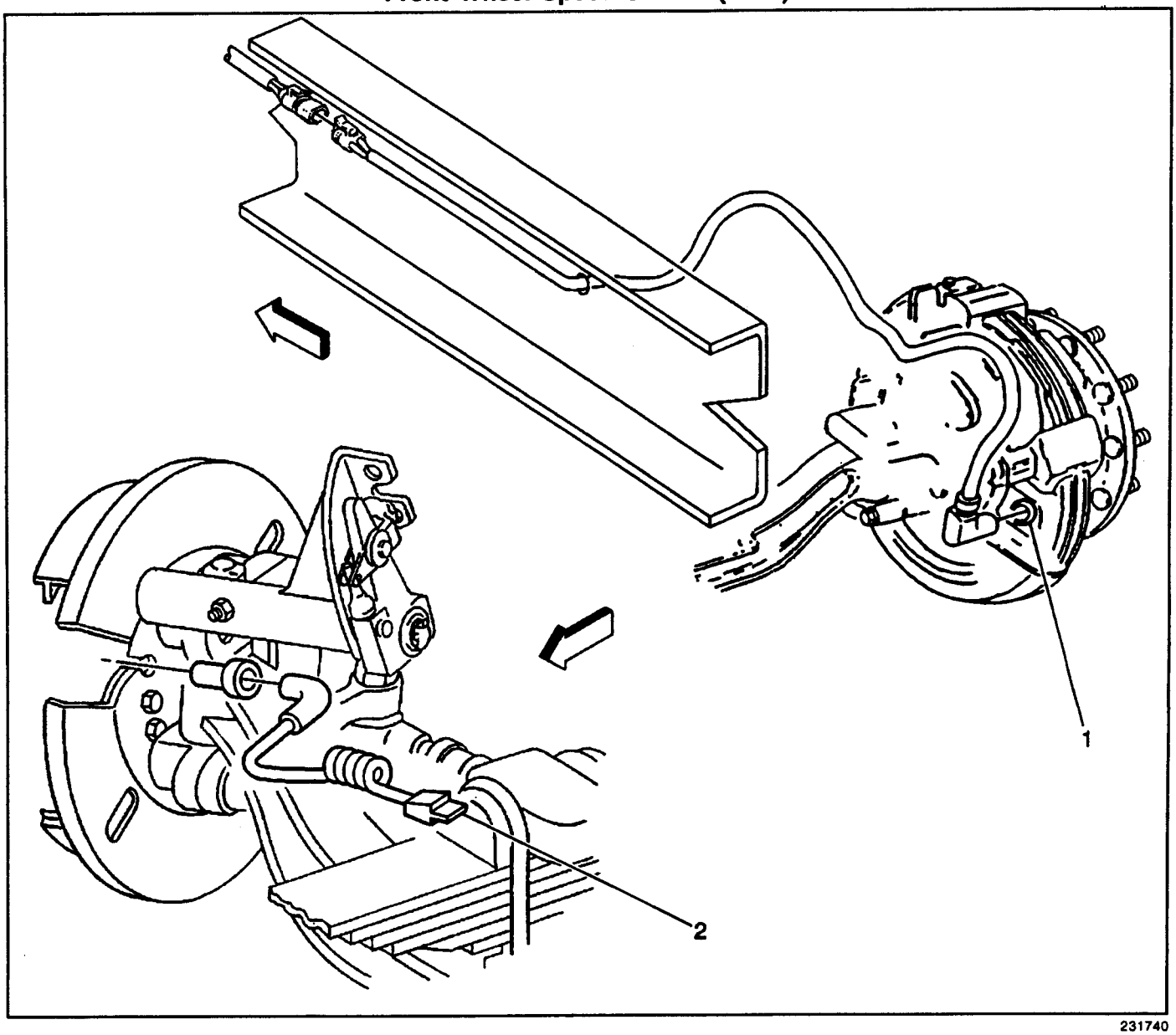
231739

Legend

(1) Brake Pressure Modulator Valve (BPMV), RH Front (ABS-Air)

(2) BPMV, LH Front (ABS-Air)

Front Wheel Speed Sensor (WSS)



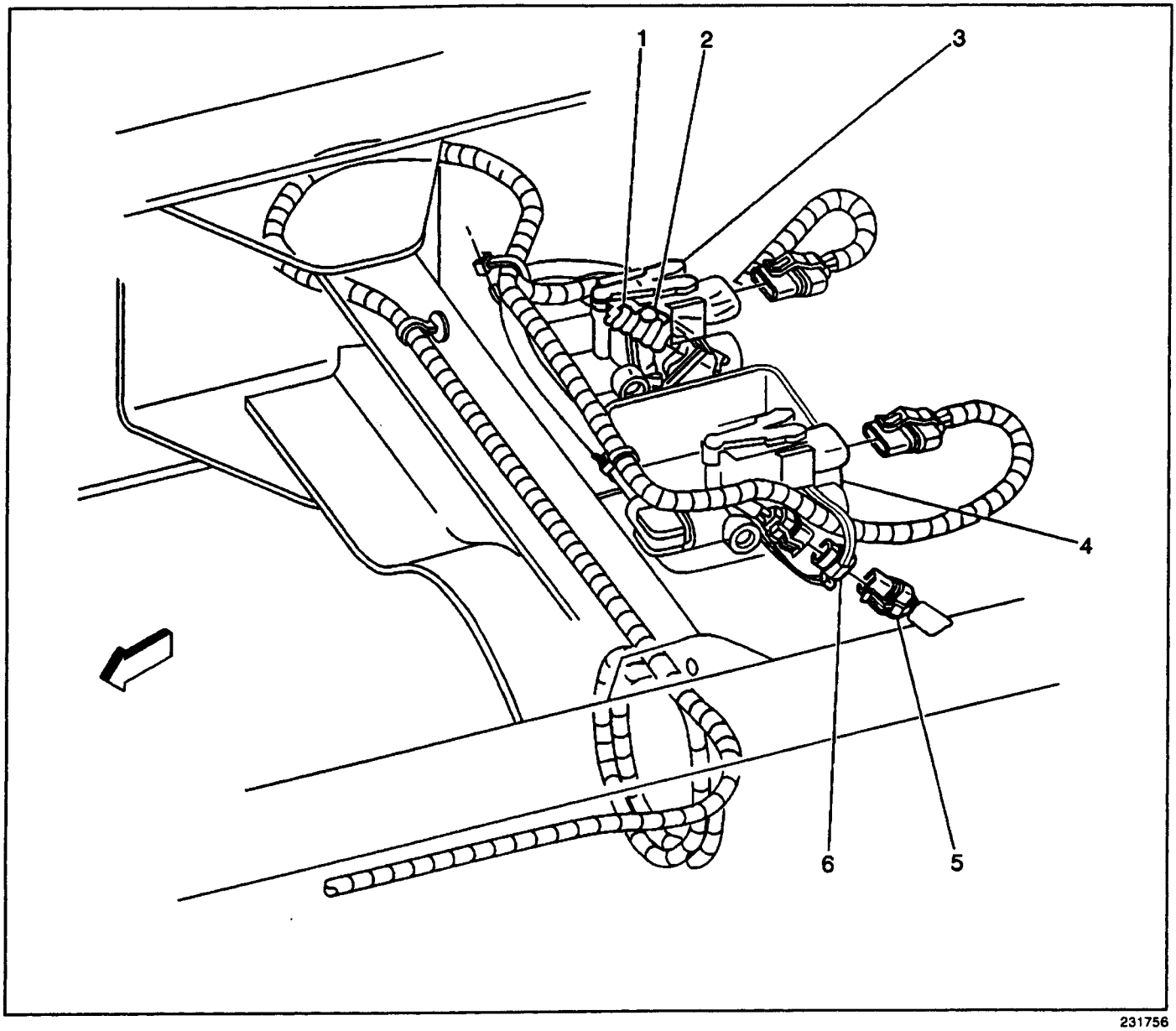
231740

Legend

(1) RH Front Wheel Speed Sensor (WSS) (ABS-Hydraulic)

(2) RH Front WSS (ABS-Air)

Electronic Brake Controls Harness and Components, LH View

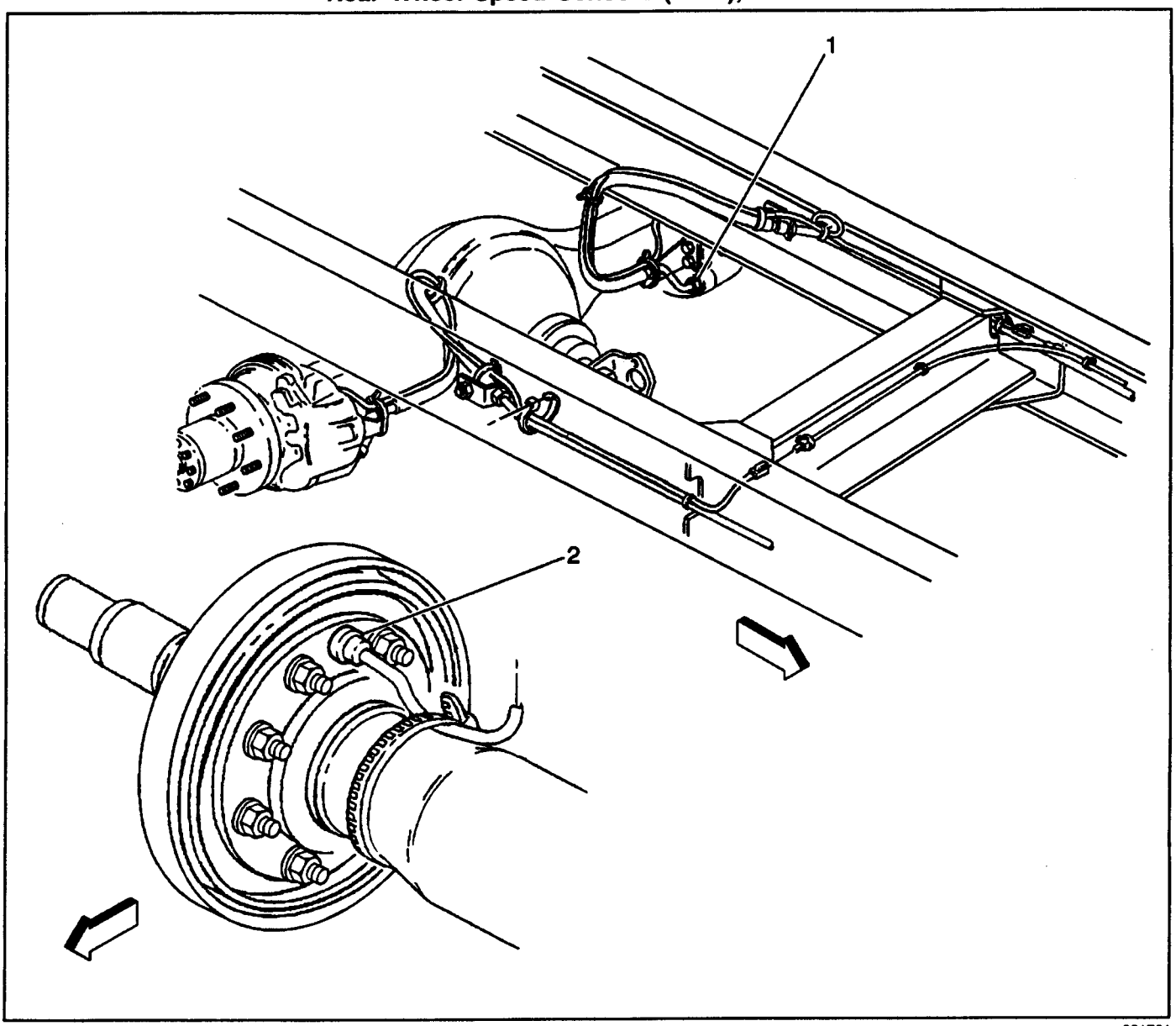


231756

Legend

(1) RH Rear Wheel Speed Sensor (WSS) (ABS-Air)
(2) RH R3ear Gender Adapter Connector (4 male-to-male cavities) (ABS-Air)
(3) RH Rear Brake Pressure Modulator Valve (BPMV) (ABS-Air)
(4) LH Rear BPMV (ABS-Air)
(5) LH Rear WSS (ABS-Air)
(6) LH Rear Gender Adapter Connector (4 male-to-male cavities) (ABS-Air)

Rear Wheel Speed Sensors (WSS), RH View



231761

Legend

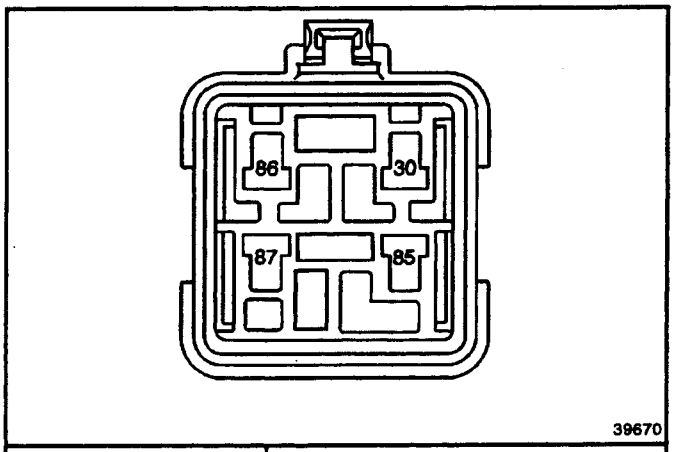
(1) LH Rear Wheel Speed Sensor (WSS) (ABS-Hydraulic)

(2) RH Rear WSS (ABS-Air)

Visual Identification

Air Antilock Brakes System Connector End Views

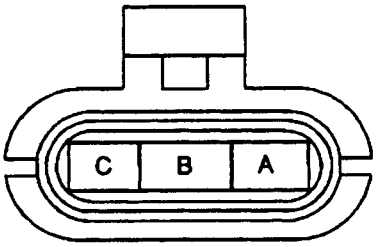
ABS Relay



39670

Connector Part Information	• 12129716 • 4 Way F Metri-Pack 280 Series, Flexlock, Sealed (GRY)		
Pin	**Wire Color**	**Circuit No.**	**Function**
30	RED	1442	Fuse Output-Battery
85	PNK	139	Fuse Output-Ignition
86	BLK	150	Ground
87	PNK	839	Fuse Output-Ignition

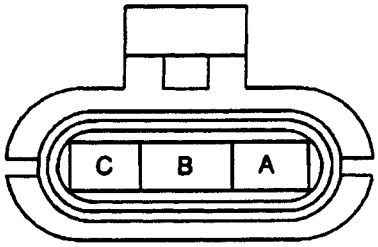
Brake Pressure Modulator Valve, LH Front



38598

Connector Part Information	• 12040977 • 3 Way F Metri-Pack 280 Series Sealed (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	DK GRN	1900	AAS Modulator Output-Exhaust-Left Front
B	LT BLU	1902	AAS Modulator Feed-Left Front

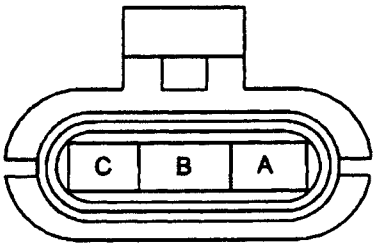
Brake Pressure Modulator Valve, LH Front (cont'd)



38598

Connector Part Information	• 12040977 • 3 Way F Metri-Pack 280 Series Sealed (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
C	GRA	1901	AAS Modulator Output-Hold- Left Front

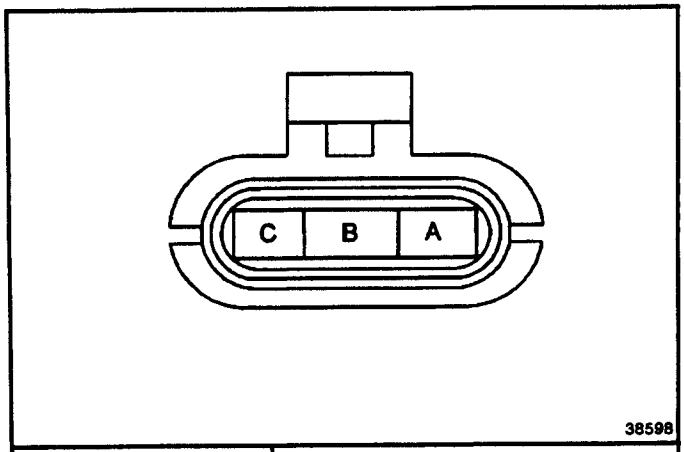
Brake Pressure Modulator Valve, RH Front



38598

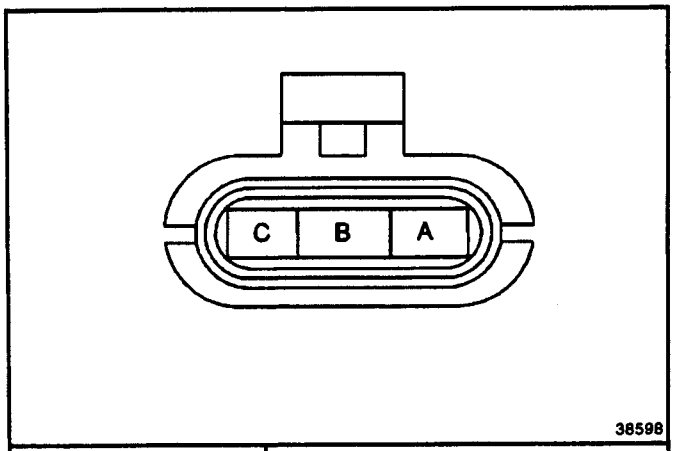
Connector Part Information	• 12040977 • 3 Way F Metri-Pack 280 Series Sealed (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	PPL	1906	AAS Modulator Output-Exhaust-Right Front
B	TAN	1908	AAS Modulator Feed-Right Front
C	YEL	1907	AAS Modulator Output-Hold-Right Front

Brake Pressure Modulator Valve, LH Rear (Air)



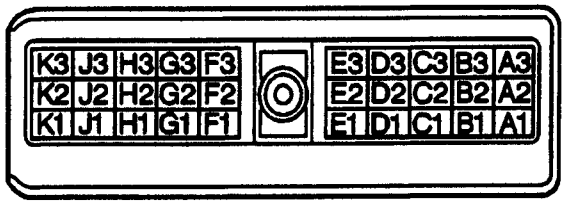
Connector Part Information	• 12040977 • 3 Way F Metri-Pack 280 Series Sealed (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	GRA/BLK	1913	AAS Modulator Output -Exhaust-Left Rear
B	ORN	1915	AAS Modulator Feed-Left Rear
C	LT BLU/BLK	1914	AAS Modulator Output-Hold-Left Rear

Brake Pressure Modulator Valve, RH Rear (Air)



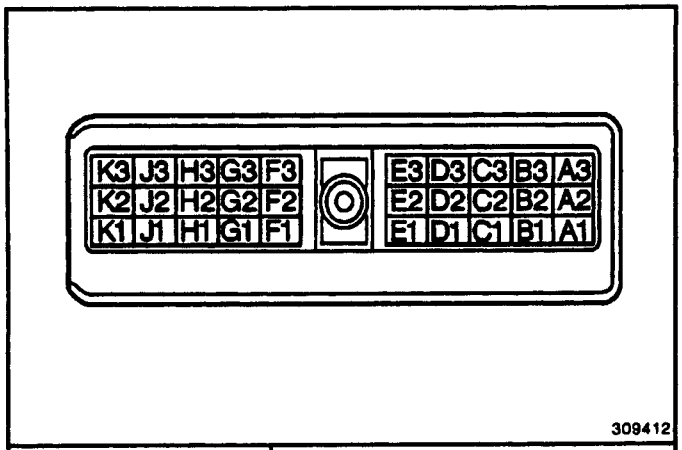
Connector Part Information	• 12040977 • 3 Way F Metri-Pack 280 Series Sealed (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	LT GRN/WHT	1918	AAS Modulator Output-Exhaust-Right Rear
B	PPL	1920	AAS Modulator Feed-Right Rear
C	PNK/BLK	1919	AAS Modulator Output-Hold- Right Rear

Electronic Brake Control Module C1 (Air)



Connector Part Information	• 12034398 • 30 Way F Metri-Pack 150 Series Pull To Seat, Sealed (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A1	BLK/WHT	1651	Air Anti Skid System Ground
A2	BLK/WHT	1651	Air Anti Skid System Ground
A3	BLK/WHT	1651	Air Anti Skid System Ground
B1	PNK	839	Fuse Output-Ignition
B2–B3	—	—	Not Used
C1	TAN	1908	AAS Modulator Feed-Right Front
C2–C3	—	—	Not Used
D1	YEL	1907	AAS Modulator Output-Hold-Right Front
D2–D3	—	—	Not Used
E1	PPL	1906	AAS Modulator Output-Exhaust-Right Front
E2	—	—	Not Used
E3	DK BLU	1899	Dash Lamp Relay Output-Coil
F1	DK GRN	1900	AAS Modulator Output-Exhaust-Left Front
F2–F3	—	—	Not Used
G1	GRA	1901	AAS Modulator Output-Hold-Left Front
G2	TAN/BLK	1921	Serial Data Link-A-SAE 1707

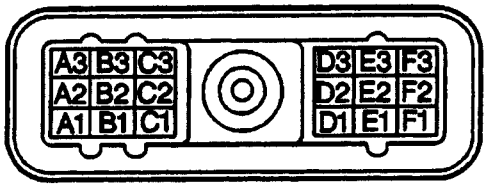
Electronic Brake Control Module C1 (Air) (cont'd)



309412

Connector Part Information		• 12034398 • 30 Way F Metri-Pack 150 Series Pull To Seat, Sealed (BLK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
G3	WHT/BLK	1922	Serial Data Link-B-SAE 1707
H1	LT BLU	1902	AAS Modulator Feed-Left Front
H2	WHT	1909	AAS Wheel Speed Sensor Signal-Right Front
H3	BRN/WHT	1910	AAS Wheel Speed Sensor Return-Right Front
J1	LT GRN	1903	AAS Wheel Speed Sensor Signal-Left Front
J2	ORN	1904	AAS Wheel Speed Sensor Return-Left Front
J3	—	—	Not Used
K1	PNK	1905	Retarder Disable Output
K2	PNK	839	Fuse Output-Ignition
K3	PNK	839	Fuse Output-Ignition

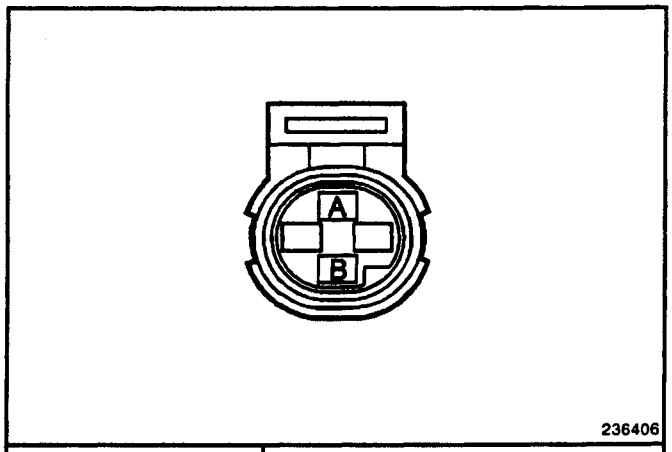
Electronic Brake Control Module C2 (Air)



230155

Connector Part Information		• 12040921 • 18 Way F Metri-Pack 150 Series Pull To Seat, Sealed (BLK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A1	PPL	1920	AAS Modulator Feed-Right Rear
A2–A3	—	—	Not Used
B1	PNK/BLK	1919	AAS Modulator Output-Hold-Right Rear
B2–B3	—	—	Not Used
C1	LT GRN/WHT	1918	AAS Modulator Output-Exhaust-Right Rear
C2–C3	—	—	Not Used
D1	GRA/BLK	1913	AAS Modulator Output-Exhaust-Left Rear
D2–D3	—	—	Not Used
E1	LT BLU/BLK	1914	AAS Modulator Output-Hold-Left Rear
E2	LT GRN/BLK	1916	AAS Wheel Speed Sensor Signal-Right Rear
E3	LT BLU/WHT	1917	AAS Wheel Speed Sensor Return-Right Rear
F1	ORN	1915	AAS Modulator Feed-Left Rear
F2	DK BLU/WHT	1911	AAS Wheel Speed Sensor Signal-Left Rear
F3	DK GRN/WHT	1912	AAS Wheel Speed Sensor Return-Left Rear

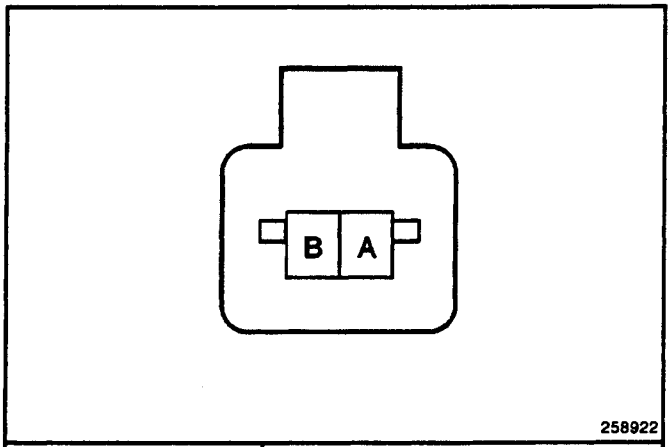
Low Air Pressure Switch



236406

Connector Part Information	• 12065400 • 2 Way F Metri-Pack 150 Series, Sealed (GRN)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	TAN/WHT	33	Brake Warning Indicator Lamp Output
B	BLK	150	Ground

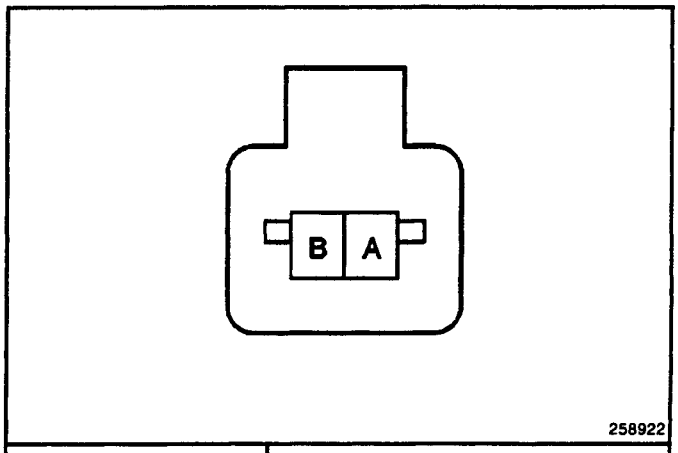
Wheel Speed Sensor, LH Front



258922

Connector Part Information	• 12162852 • 2Way F Metri-Pack 150.2 Pull To Seat (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	LT BLU	830	Wheel Speed Sensor Signal-Left Front
A	LT GRN	1903	AAS Wheel Speed Sensor Signal-Left Front
B	YEL	873	Wheel Speed Sensor Return-Left Front
B	ORN	1904	AAS Wheel Speed Sensor Return-Left Front

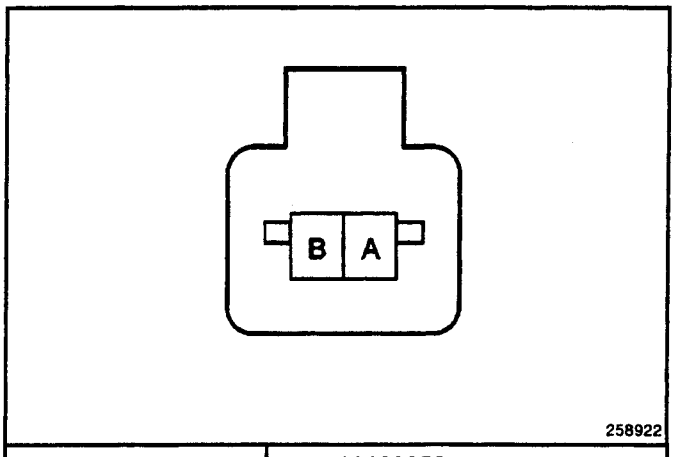
Wheel Speed Sensor, RH Front



258922

Connector Part Information	• 12162852 • 2Way F Metri-Pack 150.2 Pull To Seat (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	DK GRN	872	Wheel Speed Sensor Signal-Right Front
A	WHT	1909	AAS Wheel Speed Sensor Signal-Right Front
B	TAN	833	Wheel Speed Sensor Return-Right Front
B	BRN/WHT	1910	AAS Wheel Speed Sensor Return-Right Front

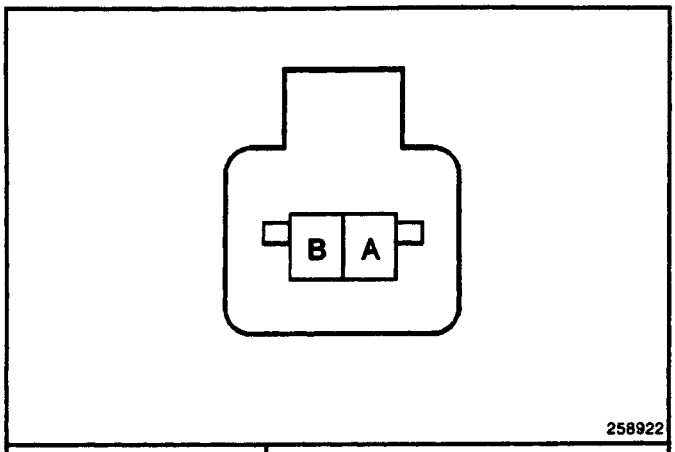
Wheel Speed Sensor, LH Rear (Air)



258922

Connector Part Information	• 12162852 • 2Way F Metri-Pack 150.2 Pull To Seat (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	DK BLU/WHT	1911	AAS Wheel Speed Sensor Signal-Left Rear
B	DK GRN/WHT	1912	AAS Wheel Speed Sensor Return-Left Rear

Wheel Speed Sensor, RH Rear (Air)



258922

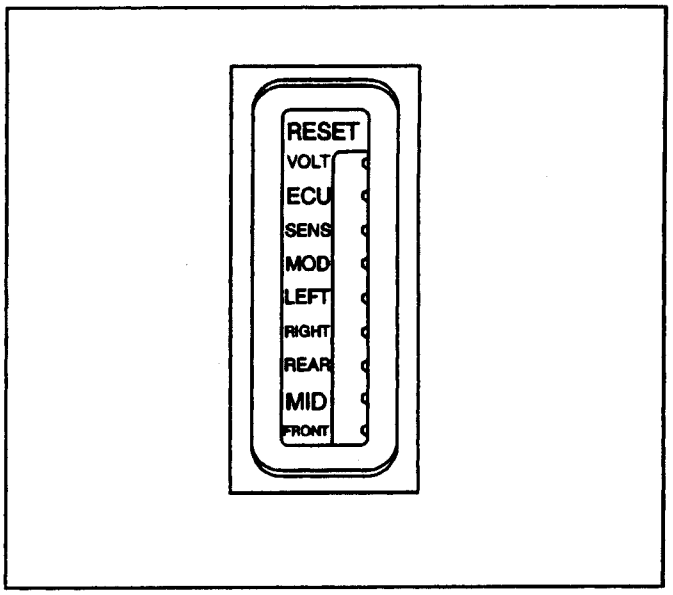
Connector Part Information		• 12162852 • 2Way F Metri-Pack 150.2 Pull To Seat (BLK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	LT GRN/BLK	1916	AAS Wheel Speed Sensor Signal-Right Rear
B	LT BLU/WHT	1917	AAS Wheel Speed Sensor Return-Right Rear

Diagnostic Information and Procedures

Self-Diagnostics

EBCM Self Test

The EBCM performs a self test which continuously checks for proper operation of the entire ABS. The ABS indicator lamp (controlled by the (EBCM) located in the instrument panel) alerts the driver of a malfunction with the ABS. The diagnostic status lamps (located on the side of the EBCM housing) assist the technician to locate a malfunction with a specific ABS component. Special tools or equipment are not needed in order to read the EBCM diagnostic status lamps.



156583

- When the EBCM detects a malfunction with the ABS, the following actions occur:
  - The ABS indicator lamp is illuminated
  - The associated diagnostic status lamps are illuminated
  - All or a portion of the ABS is disabled (standard braking is available)
  - The portion of the ABS disabled is dependent upon the type of malfunction present
- If the air modulator at the right front wheel has an open circuit, the EBCM disables the ABS for BOTH the right front and left rear wheels (the EBCM divides and separates the brakes diagonally).

  The ABS will continue to function for the left front wheel and right rear wheel. A low voltage problem or EBCM malfunction will result in complete disabling of the ABS.

  Two or more failures will also result in the disabling of the entire system. With the failed component approach described above, the vehicle will retain improved braking stability after a single failure.
- The failed condition is stored and not cleared by the loss of power to the EBCM. The diagnostic status lamps will illuminate when the power is restored and remain illuminated until the failure is corrected.

  After the problem is corrected, the technician can clear or reset the EBCM diagnostics by passing a small magnet over the RESET point in the diagnostics window.

EBCM DIAGNOSTIC STATUS LAMPS
There are nine diagnostic status lamps located on the side of the EBCM. There is also a mechanically actuated reset switch. The first five diagnostic status lamps locate a problem to a specific component on the vehicle. The remaining four diagnostic status lamps indicate the location of the component. For normal operation, the only diagnostic status lamp illuminated will be the green VOLT diagnostic status lamp. If a malfunction exists with a component or component wiring, three diagnostic status lamps will be illuminated. For example, a malfunction with a right front wheel speed circuit would illuminate the RIGHT, FRONT and SENS diagnostic status lamps. The diagnostic status lamps are controlled by the EBCM and are either on or off depending upon their monitor function.

RESET
The EBCM contains a magnetically sensitive switch that is used to reset the EBCM. The reset switch is located directly beneath the RESET label on the EBCM. The device will respond to a magnet which has strength sufficient to lift a three (3) ounce weight. Holding a magnet against the RESET will cause all diagnostic status lamps to initially illuminate and erase all malfunctions (turning off any illuminated diagnostic status lamps).

VOLT Diagnostic Status Lamp
The VOLT diagnostic status lamp is green and will be illuminated during vehicle operation in order to indicate that vehicle voltage is present at the EBCM. If vehicle voltage is below 11.0 V or above 17.0 V, the VOLT status lamp will flash.

ECU Diagnostic Status Lamp
The ECU diagnostic status lamp is red and will illuminate in order to indicate an EBCM malfunction. The ECU diagnostic status lamp is illuminated for all EBCM failures except low voltage. For voltages less than 9.0 V, the ECU diagnostic status lamp illuminates to indicate an inoperative controller. When the voltage exceeds 9.0 V, the ECU status lamp will no longer be illuminated.

SENS Diagnostic Status Lamp
The SENS diagnostic status lamp is red and will illuminate in order to indicate a malfunction with one of the four wheel speed sensor circuits. The SENS diagnostic status lamp will illuminate with the RIGHT or LEFT diagnostic status lamp and the FRONT or REAR diagnostic status lamp.

MOD Diagnostic Status Lamp
The MOD diagnostic status lamp is red and will illuminate in order to indicate a malfunction with one of the four modulator solenoid circuits. The MOD diagnostic status lamp will illuminate with the RIGHT or LEFT diagnostic status lamp and the FRONT or REAR diagnostic status lamp.

LEFT Diagnostic Status Lamp
The LEFT diagnostic status lamp is red and will illuminate in order to indicate the location of a malfunction. The LEFT diagnostic status lamp will illuminate with the FRONT or REAR diagnostic status lamp and the MOD or SENS diagnostic status lamp.

RIGHT Diagnostic Status Lamp
The RIGHT diagnostic status lamp is red and will illuminate in order to indicate the location of a malfunction. The RIGHT diagnostic status lamp will illuminate with the FRONT or RIGHT lamps and the MOD or SENS diagnostic status lamp.

REAR Diagnostic Status Lamp
The REAR diagnostic status lamp is red and will illuminate in order to indicate the location of a malfunction. The REAR diagnostic status lamp will illuminate with the RIGHT or LEFT diagnostic status lamp and the MOD or SENS diagnostic status lamp.

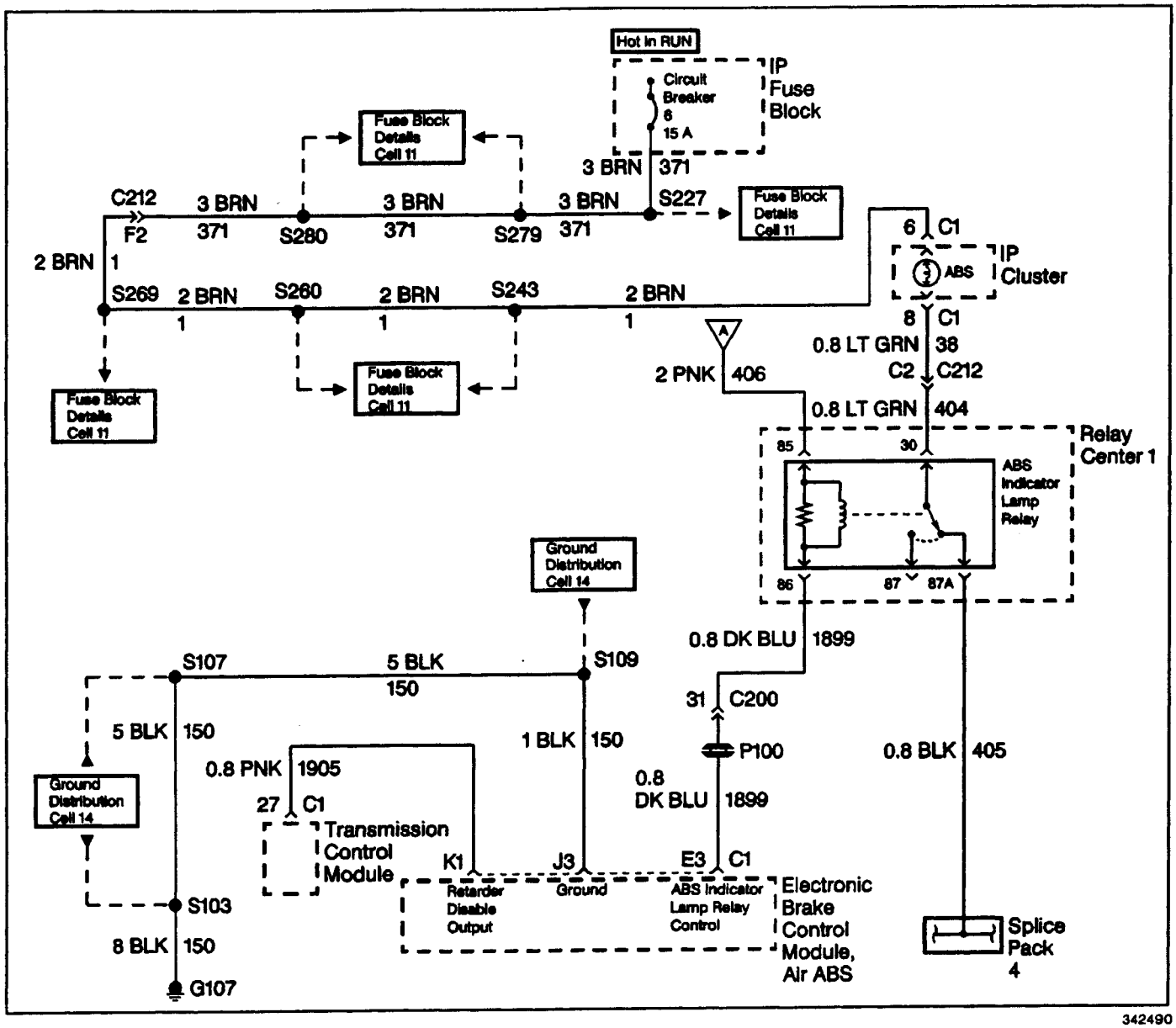
MID Diagnostic Status Lamp
The MID diagnostic status lamp is not used in troubleshooting the ABS and should illuminate only when a magnet is held on the RESET switch.

FRONT Diagnostic Status Lamp
The FRONT diagnostic status lamp is red and will illuminate in order to indicate the location of a malfunction. The FRONT diagnostic status lamp will illuminate with the RIGHT or LEFT diagnostic status lamp and the MOD or SENS diagnostic status lamp.

Intermittents and Poor Connections

Most intermittent faults are caused by a faulty electrical connection or faulty wiring. Occasionally a damaged EBCM can be the cause of an intermittent fault. Refer to Intermittents and Poor Connections in Electrical Diagnosis for a detailed explanation of how to locate and repair intermittent conditions.

Air ABS Diagnostic System Check



342490

System Description

The diagnostic system check is an organized approach to identifying an Antilock Brake System (ABS) malfunction. The diagnostic system check must be the starting point for any ABS complaint diagnosis because it directs the service technician to the next logical step in diagnosing the complaint. Failure to perform the Diagnostic System Check will result in extended diagnostic time, incorrect diagnosis and parts replacement.

The EBCM is supplied battery voltage (through the ABS relay) to terminals K1 and K2. Ground is provided through terminals A1, A2 and the ground clip on the EBCM chassis.

Diagnostic Aids

Excessive resistance in the signal ground or ignition power circuit will not allow communication with the EBCM. If communication with the EBCM is not possible, ensure that the ABS signal ground connection is good and that there is no excessive resistance in the ignition power circuit.

Test Description

An example test description follows:

5. This test will by-pass the ABS indicator relay in order to help isolate the malfunction.
15. This test checks the ABS indicator lamp and the wiring in order to help isolate the malfunction.

18. This test isolates the malfunction to either a shorted ABS indicator lamp relay coil or a wire shorted to voltage.
20. This test measures the voltage present at the EBCM.
23. This test measures the voltage present at the ABS relay contacts.
28. This test checks for a malfunctioning EBCM. If the red diagnostic status lamp is on, the voltage available to the EBCM is either below 9 V or above 9 V.
41. If the 30 amp ABS fuse is open, a short to ground in CKT 142, CKT 1941 or an internal short in the ABS relay is indicated.

Air ABS Diagnostic System Check

Step	Action	Value(s)	Yes	No
1	Turn the ignition to RUN and observe the ABS indicator lamp. Does the ABS indicator lamp turn on, flash twice, then remain on?	—	*Go to Step 3*	*Go to Step 2*
2	Does the ABS indicator lamp turn on, and remain on without flashing.	—	*Go to Step 11*	*Go to Step 4*
3	Drive the vehicle at speeds above 16 km/H (10 mph) while observing the ABS indicator lamp. Does the ABS indicator lamp remain on?	—	*Go to Step 11*	System OK. Refer to Diagnostic Aids on the facing page.
4	1. Turn the ignition to OFF. 2. Remove the ABS indicator lamp relay from the relay center #1. 3. Using a fused jumper wire such as *J 36169-A*, jumper terminal 30 of relay center #1 to ground. 4. Turn the ignition to RUN. Observe the ABS indicator lamp, is the ABS lamp on?	—	*Go to Step 6*	*Go to Step 5*
5	1. Turn the ignition to OFF. 2. Remove and inspect the ABS indicator lamp (refer to Instrument Panel and Gauges). Is the ABS indicator lamp open?	—	*Go to Step 30*	*Go to Step 31*
6	1. Remove the jumper wire. 2. Using a *J 39200*, measure the voltage between terminal 85 of the relay center #1 and ground. Is the voltage measured within the specified range?	11-16 V	*Go to Step 7*	*Go to Step 8*
7	1. Turn the ignition to OFF. 2. Using a *J 39200*, measure the resistance between terminal 87A of the relay center #1 and ground. Is the resistance measured within the specified range?	0-2 Ω	*Go to Step 9*	*Go to Step 35*
8	Inspect the circuit breaker #9. Is the circuit breaker closed?	—	*Go to Step 32*	*Go to Step 33*
9	1. Install the ABS indicator lamp relay. 2. Disconnect the EBCM harness connector from the EBCM. 3. Turn the ignition to RUN. Is the ABS indicator lamp on?	—	*Go to Step 34*	*Go to Step 10*
10	1. Turn the ignition to OFF. 2. Using a *J 39200*, measure the resistance between terminal 86 of the relay center #1 and ground. Is the resistance measured equal to the specified value?	OL	*Go to Step 36*	*Go to Step 37*
11	Observe the diagnostic status lamp window on the side of the EBCM. Is the green VOLT status lamp on?	—	*Go to Step 12*	*Go to Step 13*

Air ABS Diagnostic System Check (cont'd)

Step	Action	Value(s)	Yes	No
12	Is the green VOLT status lamp flashing?	—	*Go to Step 20*	*Go to Step 14*
13	1. Turn the ignition to RUN. 2. Observe the diagnostic status lamp window on the side of the EBCM. Are any red diagnostic status lamps on?	—	*Go to Step 34*	*Go to Step 20*
14	Observe the diagnostic status lamp window on the side of the EBCM. Are any red diagnostic status lamps on?	—	*Go to Step 28*	*Go to Step 15*
15	1. Turn the ignition to OFF. 2. Disconnect the EBCM harness connector from the EBCM. 3. Using a fused jumper wire such as *J 36169-A*, jumper terminal E3 of the EBCM harness connector to ground. 4. Turn the ignition to RUN. Is the ABS indicator lamp off?	—	*Go to Step 34*	*Go to Step 16*
16	Remove and inspect the jumper wire fuse. Is the fuse open?	—	*Go to Step 18*	*Go to Step 17*
17	Remove the ABS indicator lamp relay from the relay center. Is the ABS indicator lamp on?	—	*Go to Step 39*	*Go to Step 19*
18	1. Remove the ABS indicator lamp relay from the relay center #1. 2. Using a *J 39200*, measure the resistance between terminal E3 of the EBCM harness connector and ground. Is the resistance measured equal to the specified value?	OL	*Go to Step 38*	*Go to Step 36*
19	Using a *J 39200*, measure the voltage between terminal 85 of the relay center #1 and ground. Is the voltage measured within the specified range?	11–14 V	*Go to Step 36*	*Go to Step 32*
20	1. Turn the ignition to OFF. 2. Disconnect the EBCM harness connector from the EBCM. 3. Turn the ignition to RUN. 4. Using a *J 39200*, measure the voltage between terminal K2 and terminal A1 of the EBCM harness connector. Is the voltage measured within the specified range?	11–14 V	*Go to Step 34*	*Go to Step 21*
21	1. Turn the ignition to OFF. 2. Using a *J 39200*, measure the resistance between terminal A1 of the EBCM harness connector and ground. 3. Using a *J 39200*, measure the resistance between terminal A2 of the EBCM harness connector and ground. 4. Make sure that the ground clip on the EBCM chassis is clean and tight. Are both resistance measurements within the specified range?	0–2 Ω	*Go to Step 22*	*Go to Step 40*
22	Using a *J 39200*, measure the voltage of the vehicle battery. Refer to the Battery section. Is the voltage measured within the specified range?	11.5–14 V	*Go to Step 23*	Refer to Battery section

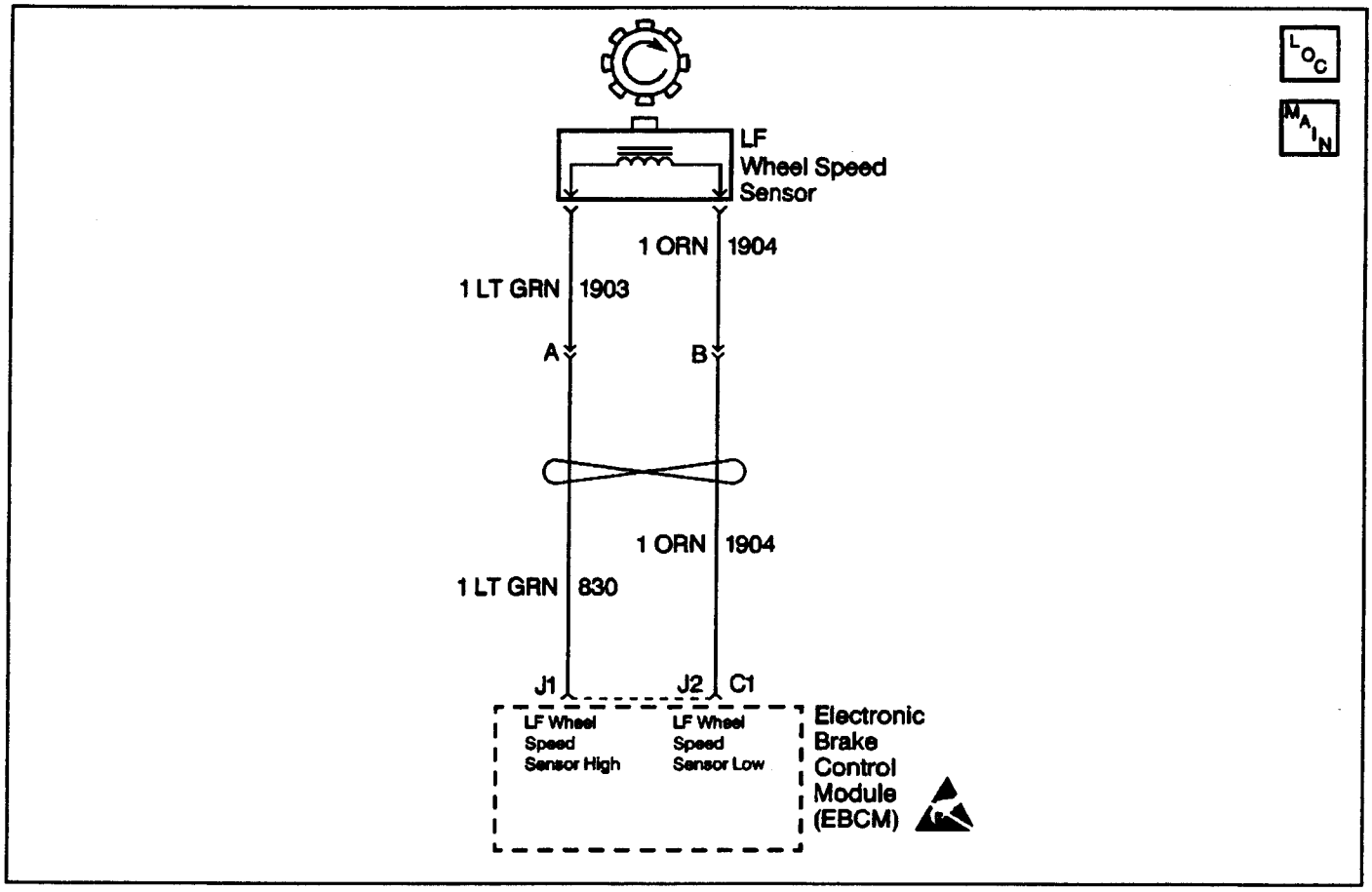
Air ABS Diagnostic System Check (cont'd)

Step	Action	Value(s)	Yes	No
23	1. Remove the ABS relay. 2. Turn the ignition to RUN. 3. Using a *J 39200*, measure the voltage between terminal 30 of the ABS relay harness connector and ground. Is the voltage measured within the specified range?	11–14 V	*Go to Step 25*	*Go to Step 24*
24	1. Turn the ignition to OFF. 2. Remove and inspect the 30 amp ABS fuse. Is the fuse open?	—	*Go to Step 41*	*Go to Step 42*
25	1. Turn the ignition to OFF. 2. Using a *J 39200*, measure the resistance between terminal 87 of ABS relay harness connector and terminals B1, K2 and K3 of the EBCM harness connector. Is the resistance measured within the specified range?	0–2 Ω	*Go to Step 26*	*Go to Step 43*
26	1. Turn the ignition to RUN. 2. Using the *J 39200*, measure the voltage between terminal 85 of the ABS relay harness connector and ground. Is the voltage measured within the specified range?	11–14 V	*Go to Step 27*	*Go to Step 44*
27	1. Turn the ignition to OFF. 2. Using a *J 39200*, measure the resistance between terminal 86 of the ABS relay harness connector and ground. Is the resistance measured within the specified range?	0–2 Ω	*Go to Step 45*	*Go to Step 35*
28	Observe the diagnostic status lamps on the side of the EBCM. Is the red ECU lamp on?	—	*Go to Step 20*	*Go to Step 29*
29	Observe the diagnostic status lamps on the side of the EBCM. There should be a minimum of three diagnostic status lamps on: • One LEFT or RIGHT • One FRONT or REAR • One MOD or SENS Are there three diagnostic status lamps on?	—	Go to the EBCM Diagnostic Status Lamps Table	*Go to Step 34*
30	Replace the ABS indicator lamp. Refer to Body and Chassis in Instrument Panel and Gauges.	—	*Go to Step 1*	—
31	Repair the open or high resistance in CKT 38 or CKT 404. Is the the broken wire or high resistance condition repaired?	—	*Go to Step 1*	—
32	Repair the open or high resistance in CKT 145 or CKT 406. Is the the broken wire or high resistance condition repaired?	—	*Go to Step 1*	—
33	1. Check for a short to ground in CKT 145 or CKT 406. 2. Replace the circuit breaker. Is the short corrected or the circuit breaker replaced?	—	*Go to Step 1*	—

Air ABS Diagnostic System Check (cont'd)

Step	Action	Value(s)	Yes	No
34	1. Inspect the EBCM harness connector for physical damage that may cause a malfunction with the EBCM connector connected to the EBCM. 2. Reconnect all of the connectors. 3. Drive the vehicle above 24 km/h (15 mph) for at least 30 seconds. Is the malfunction still present?	—	*Go to Step 46*	The malfunction is intermittant. Go to Diagnostic Aids
35	Repair the open or high resistance in CKT 150. Is the broken wire or high resistance repaired?	—	*Go to Step 1*	—
36	Replace the ABS indicator lamp relay. Is the malfunction corrected?	—	*Go to Step 1*	—
37	Repair the short to ground in CKT 1899. Is the short corrected?	—	*Go to Step 1*	—
38	Repair the short to voltage in CKT 1899. Is the short corrected?	—	*Go to Step 1*	—
39	Repair the short to ground in CKT 38 or CKT 404. Is the short corrected?	—	*Go to Step 1*	—
40	Repair the open or high resistance in CKT 1651. Is the broken wire or high resistance repaired?	—	*Go to Step 1*	—
41	Check for a short to ground in CKT 1442 or a shorted ABS relay. Is the shorted wire or shorted ABS relay repaired?	—	*Go to Step 1*	—
42	Repair the open or high resistance in CKT 1442. Is the broken wire or high resistance repaired?	—	*Go to Step 1*	—
43	Repair the open or high resistance in CKT 839. Is the broken wire or high resistance repaired?	—	*Go to Step 1*	—
44	Repair the open or high resistance in CKT 139 or CKT 145. Is the broken wire or high resistance repaired?	—	*Go to Step 1*	—
45	Replace the ABS relay. Is the malfunction corrected?	—	*Go to Step 1*	—
46	Replace the EBCM. Is the malfunction corrected?	—	System OK	—

Status Lamps Illuminated - Left, Front, and Sens



325396

Circuit Description

As the toothed ring passes by the wheel speed sensor, changes in the electromagnetic field cause the wheel speed sensor to produce a sinusoidal (AC) voltage signal whose frequency and amplitude is proportional to wheel speed. The magnitude of this signal is directly related to wheel speed and the proximity of the wheel speed sensor to the toothed ring, often referred to as the air gap.

Conditions for Illuminating Diagnostic Status Lamps

- Open wheel speed sensor or wheel speed sensor wiring
- Shorted wheel speed sensor or wheel speed sensor wiring
- Wheel speed signal not present or does not conform to design criteria

Action Taken When Diagnostic Status Lamps Illuminate

- The ABS indicator lamp is illuminated
- The ABS is disabled

Conditions for Clearing Diagnostic Status Lamps

- Repair the condition responsible for illuminating status lamps
- Reset the EBCM (see Diagnostic Status Lamps)

Diagnostic Aids

An intermittent malfunction may be caused by a poor connection, rubbed through wire insulation, or a wire that is broken inside the insulation. If the LEFT, FRONT and SENS diagnostic status lamps are on only during moist environmental changes (rain, snow, vehicle wash), all wheel speed sensor circuitry should be thoroughly inspected for signs of water intrusion. Use the following procedure. Spray the suspected are with a 5% salt water solution (two teaspoons of salt to 12 oz. of water). Test drive the vehicle over various road surfaces (bumps, turns, etc.) above 24 km/H (15 mph) for at least 30 seconds. If condition returns, replace suspected harness.

Any circuitry that is suspected of causing the intermittent complaint should be thoroughly checked for backed out terminals, improper mating, broken locks, improperly formed or damaged terminals, poor terminal to wiring connections or physical damage to the wiring harness.

When inspecting a wheel speed sensor, inspect the sensor terminals and harness connector for corrosion and/or water intrusion. If evidence of corrosion or water intrusion exists, replace the wheel speed sensor. Refer to *Wheel Speed Sensor Replacement - Front* in this section.

Resistance of the wheel speed sensor will increase with an increase in sensor temperature. Refer to the following table for temperature/resistance values.

WSS Temperature vs. Sensor Resistance

°C	°F	Ohms
Temperature vs Resistance Values (Approximate)		
-40 to 4	-40 to 40	1500 to 2500
5 to 43	41 to 110	1500 to 2500
44 to 93	111 to 200	1500 to 2500
94 to 150	201 to 302	1500 to 2500

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

3. This test checks for the correct resistance of the wheel speed sensor circuit (including wiring).
4. This test checks for the correct resistance of the wheel speed sensor.
5. This step checks for a short to ground in the wheel speed sensor circuit.

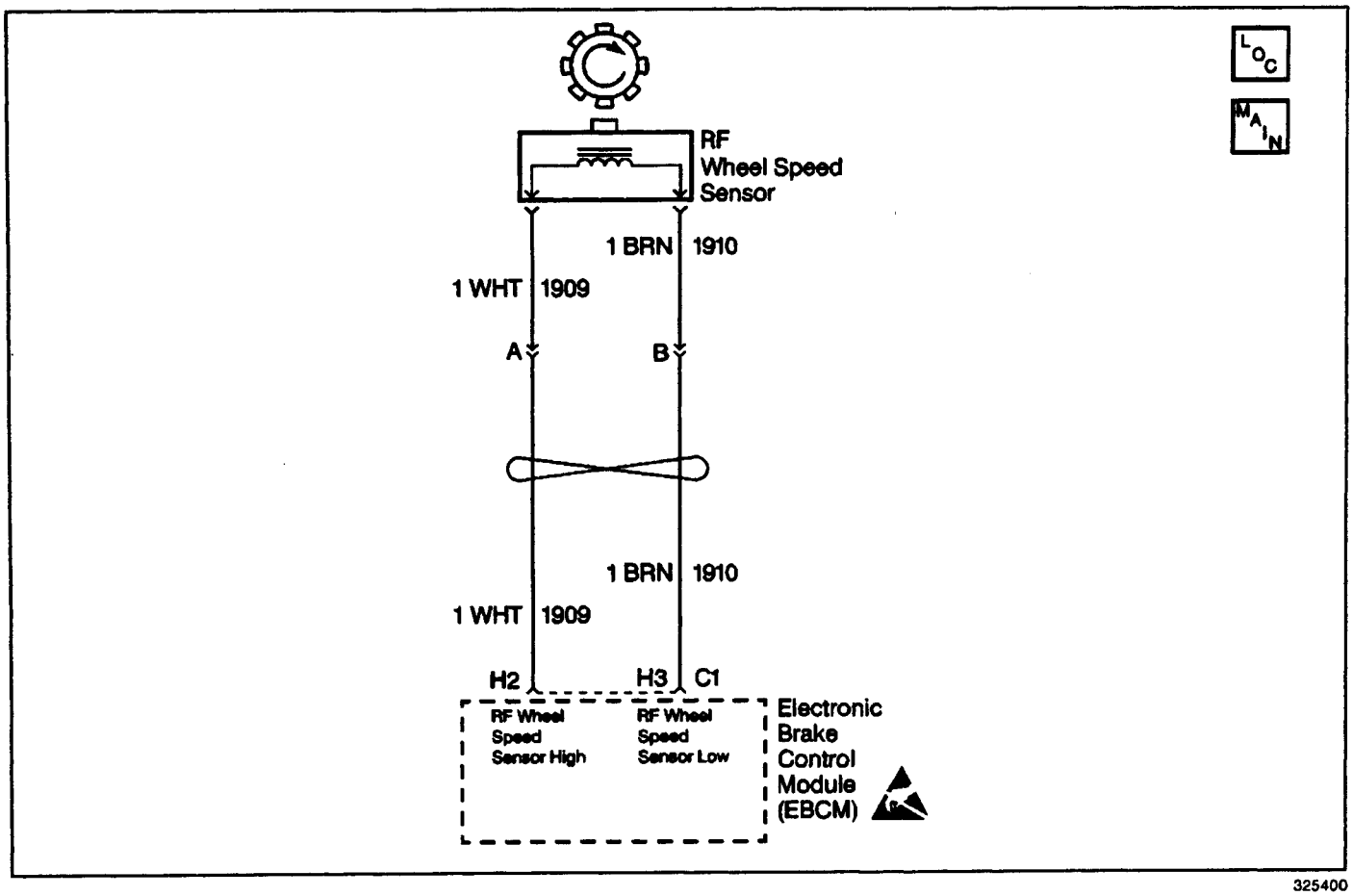
Status Lamps Illuminated - Left, Front, and Sens

Step	Action	Value(s)	Yes	No
1	Were you sent here from the Diagnostic System Check?	—	*Go to Step 2*	Go to *Air ABS Diagnostic System Check*
2	1. Turn the ignition to OFF. 2. Disconnect EBCM connector C1. 3. Inspect the connector for signs of damage or corrosion. Is the connector OK?	—	*Go to Step 3*	*Go to Step 9*
3	Using a *J 39200*, measure the resistance between terminals J1 and J2 of the EBCM connector. Is the resistance measured within the specified range?	1500–2500Ω	*Go to Step 5*	*Go to Step 4*
4	Using a *J 39200*, measure the resistance between terminals A and B of the LF wheel speed sensor connector. Is the resistance measured within the specified range?	1500–2500Ω	*Go to Step 13*	*Go to Step 12*
5	Using a *J 39200*, measure the resistance between terminal J1 of the EBCM connector and ground. Is the resistance measured equal to the specified value?	OL	*Go to Step 6*	*Go to Step 15*
6	Inspect the wheel bearings for looseness or excessive wear and verify that the bearing free play is within specific Refer to "Front Suspension" for bearing information. Are the wheel bearings OK?	—	*Go to Step 7*	*Go to Step 10*
7	Inspect the wheel speed sensor for proper installation. Is the wheel speed sensor properly installed?	—	*Go to Step 8*	*Go to Step 11*
8	1. Reconnect all connectors. 2. Perform magnetic reset. 3. Test drive the vehicle above 16 km/H (10 mph). Did the ABS indicator lamp turn on and stay on?	—	*Go to Step 14*	Malfunction is intermittent. Refer to Diagnostic Aids
9	Repair the EBCM connector. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
10	Repair excessive bearing play. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
11	Repair the wheel speed sensor. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—

Status Lamps Illuminated - Left, Front, and Sens (cont'd)

Step	Action	Value(s)	Yes	No
12	Replace the wheel speed sensor. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
13	Repair open or high resistance in CKT 1903 or 1904. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
14	Replace the EBCM. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
15	Repair short to ground in CKT 1903 or 1904. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—

Status Lamps Illuminated - Right, Front and Sens



325400

Circuit Description

As the toothed ring passes by the wheel speed sensor, changes in the electromagnetic field cause the wheel speed sensor to produce a sinusoidal (AC) voltage signal whose frequency and amplitude is proportional to wheel speed. The magnitude of this signal is directly related to wheel speed and the proximity of the wheel speed sensor to the toothed ring, often referred to as the air gap

Conditions for Illuminating Diagnostic Status Lamps

- Open wheel speed sensor or wheel speed sensor wiring
- Shorted wheel speed sensor or wheel speed sensor wiring
- Wheel speed signal not present or does not conform to design criteria

Action Taken When Diagnostic Status Lamps Illuminate

- The ABS indicator lamp is illuminated
- The ABS is disabled

Conditions for Clearing Diagnostic Status Lamps

- Repair the condition responsible for illuminating status lamps
- Reset the EBCM (see Diagnostic Status Lamps)

Diagnostic Aids

An intermittent malfunction may be caused by a poor connection, rubbed through wire insulation, or a wire that is broken inside the insulation. If the RIGHT, FRONT and SENS diagnostic status lamps are on only during moist environmental changes (rain, snow, vehicle wash), all wheel speed sensor circuitry should be thoroughly inspected for signs of water intrusion. Use the following procedure. Spray the suspected are with a 5% salt water solution (two teaspoons of salt to 12 oz. of water). Test drive the vehicle over various road surfaces (bumps, turns, etc.) above 24 km/H (15 mph) for at least 30 seconds. If condition returns, replace suspected harness.

Any circuitry that is suspected of causing the intermittent complaint should be thorough checked for backed out terminals, improper mating, broken locks, improperly formed or damaged terminals, poor terminal to wiring connections or physical damage to the wiring harness.

When inspecting a wheel speed sensor, inspect the sensor terminals and harness connector for corrosion and/or water intrusion. If evidence of corrosion or water intrusion exists, replace the wheel speed sensor. Refer to *Wheel Speed Sensor Replacement - Front* in this section.

Resistance of the wheel speed sensor will increase with an increase in sensor temperature. Refer to the following table for temperature/resistance values.

WSS Temperature vs. Sensor Resistance

°C	°F	Ohms
Temperature vs Resistance Values (Approximate)		
-40 to 4	-40 to 40	1500 to 2500
5 to 43	41 to 110	1500 to 2500
44 to 93	111 to 200	1500 to 2500
94 to 150	201 to 302	1500 to 2500

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

3. This test checks for the correct resistance of the wheel speed sensor circuit (including wiring).
4. This test checks for the correct resistance of the wheel speed sensor.
5. This step checks for a short to ground in the wheel speed sensor circuit.

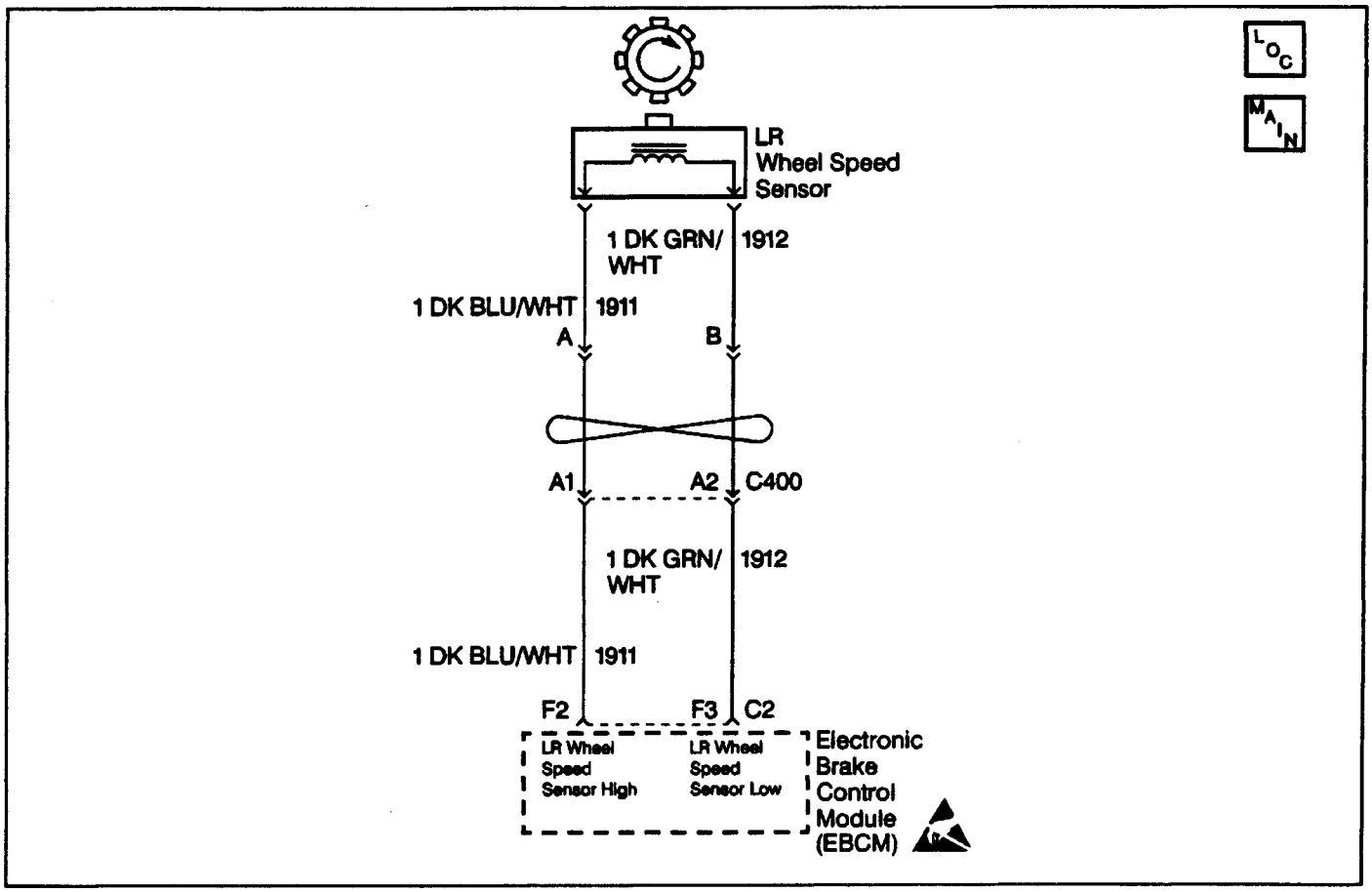
Status Lamps Illuminated - Right, Front and Sens

Step	Action	Value(s)	Yes	No
1	Were you sent here from the Diagnostic System Check?	—	*Go to Step 2*	Go to *Air ABS Diagnostic System Check*
2	1. Turn the ignition to OFF. 2. Disconnect EBCM connector C1. 3. Inspect the connector for signs of damage or corrosion. Is the connector OK?	—	*Go to Step 3*	*Go to Step 9*
3	Using a *J 39200*, measure the resistance between terminals H3 and H2 of the EBCM harness connector. Is the resistance measured within the specified range?	1500–2500Ω	*Go to Step 5*	*Go to Step 4*
4	Disconnect the wheel speed sensor wiring harness from the wheel speed sensor pigtail connector. Using a *J 39200*, measure the resistance between terminals A and B of the RF wheel speed sensor connector. Is the resistance measured within the specified range?	1500–2500Ω	*Go to Step 13*	*Go to Step 12*
5	Using a *J 39200*, measure the resistance between terminal H3 of the EBCM connector and ground. Is the resistance measured equal to the specified value?	OL	*Go to Step 6*	*Go to Step 15*
6	Inspect the wheel bearings for looseness or excessive wear and verify that the bearing free play is within specification. Refer to "Front Suspension" for bearing information. Are the wheel bearings OK?	—	*Go to Step 7*	*Go to Step 10*
7	Inspect the wheel speed sensor for proper installation. Is the wheel speed sensor properly installed?	—	*Go to Step 8*	*Go to Step 11*
8	1. Reconnect all connectors. 2. Perform magnetic reset. 3. Test drive the vehicle above 16 km/H (10 mph). Did the ABS indicator lamp turn on and stay on?	—	*Go to Step 14*	Malfunction is intermittent. Refer to Diagnostic Aids
9	Repair the EBCM connector. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—

Status Lamps Illuminated - Right, Front and Sens (cont'd)

Step	Action	Value(s)	Yes	No
10	Repair excessive bearing play. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
11	Repair the wheel speed sensor. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
12	Replace the wheel speed sensor. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
13	Repair open or high resistance in CKT 1909 or 1910. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
14	Replace the EBCM. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
15	Repair short to ground in CKT 1909 or 1910. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—

Status Lamps Illuminated - Left, Rear, and Sens



341059

Circuit Description

As the toothed ring passes by the wheel speed sensor, changes in the electromagnetic field cause the wheel speed sensor to produce a sinusoidal (AC) voltage signal whose frequency and amplitude is proportional to wheel speed. The magnitude of this signal is directly related to wheel speed and the proximity of the wheel speed sensor to the toothed ring, often referred to as the air gap.

Conditions for Illuminating Diagnostic Status Lamps

- Open wheel speed sensor or wheel speed sensor wiring
- Shorted wheel speed sensor or wheel speed sensor wiring
- Wheel speed signal not present or does not conform to design criteria

Action Taken When Diagnostic Status Lamps Illuminate

- The ABS indicator lamp is illuminated
- The ABS is disabled

Conditions for Clearing Diagnostic Status Lamps

- Repair the condition responsible for illuminating status lamps
- Reset the EBCM (see Diagnostic Status Lamps)

Diagnostic Aids

An intermittent malfunction may be caused by a poor connection, rubbed through wire insulation, or a wire that is broken inside the insulation. If the LEFT, REAR and SENS diagnostic status lamps are on only during moist environmental changes (rain, snow, vehicle wash), all wheel speed sensor circuitry should be thoroughly inspected for signs of water intrusion. Use the following procedure. Spray the suspected are with a 5% salt water solution (two teaspoons of salt to 12 oz. of water). Test drive the vehicle over various road surfaces (bumps, turns, etc.) above 24 km/H (15 mph) for at least 30 seconds. If condition returns, replace suspected harness.

Any circuitry that is suspected of causing the intermittent complaint should be thoroughly checked for backed out terminals, improper mating, broken locks, improperly formed or damaged terminals, poor terminal to wiring connections or physical damage to the wiring harness.

When inspecting a wheel speed sensor, inspect the sensor terminals and harness connector for corrosion and/or water intrusion. If evidence of corrosion or water intrusion exists, replace the wheel speed sensor. Refer to *Wheel Speed Sensor Replacement - Rear* in this section.

Resistance of the wheel speed sensor will increase with an increase in sensor temperature. Refer to the following table for temperature/resistance values.

WSS Temperature vs. Sensor Resistance

°C	°F	Ohms
Temperature vs Resistance Values (Approximate)		
-40 to 4	-40 to 40	1500 to 2500
5 to 43	41 to 110	1500 to 2500
44 to 93	111 to 200	1500 to 2500
94 to 150	201 to 302	1500 to 2500

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

3. This test checks for the correct resistance of the wheel speed sensor circuit (including wiring).
4. This test checks for the correct resistance of the wheel speed sensor.
5. This step checks for a short to ground in the wheel speed sensor circuit.

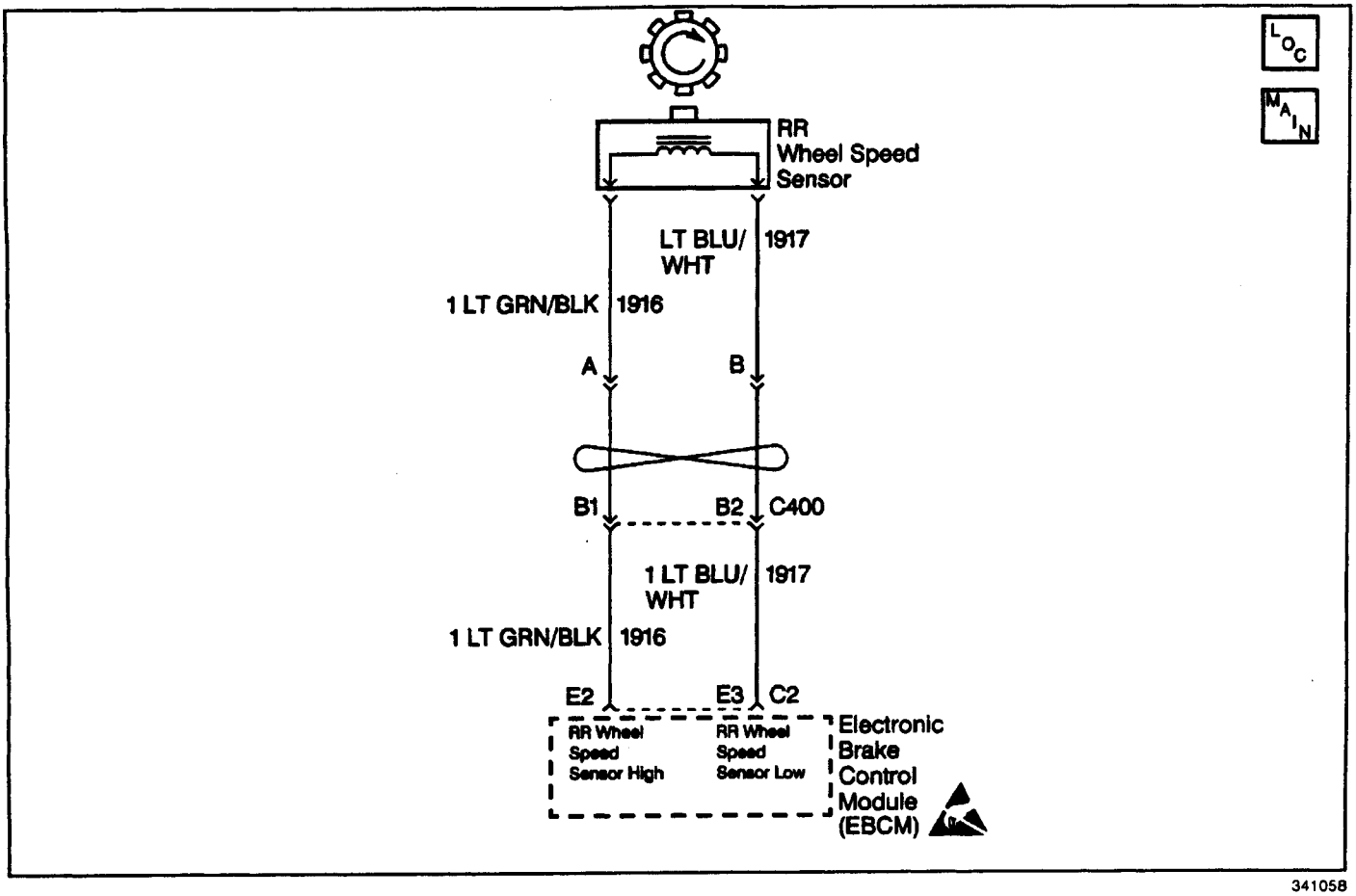
Status Lamps Illuminated - Left, Rear, and Sens

Step	Action	Value(s)	Yes	No
1	Were you sent here from the Diagnostic System Check?	—	*Go to Step 2*	Go to *Air ABS Diagnostic System Check*
2	1. Turn the ignition to OFF. 2. Disconnect EBCM connector C2. 3. Inspect the connector for signs of damage or corrosion. Is the connector OK?	—	*Go to Step 3*	*Go to Step 9*
3	Using a *J 39200*, measure the resistance between terminals F2 and F3 of the EBCM harness connector. Is the resistance measured within the specified range?	1500–2500Ω	*Go to Step 5*	*Go to Step 4*
4	Disconnect the wheel speed sensor wiring harness from the wheel speed sensor pigtail connector. Using a *J 39200*, measure the resistance between terminals A and B of the LR wheel speed sensor connector. Is the resistance measured within the specified range?	1500–2500Ω	*Go to Step 13*	*Go to Step 12*
5	Using a *J 39200*, measure the resistance between terminal F2 of the EBCM connector and ground. Is the resistance measured equal to the specified value?	OL	*Go to Step 6*	*Go to Step 12*
6	Inspect the wheel bearings for looseness or excessive wear and verify that the bearing free play is within specification. Refer to "Rear Axle" for bearing information. Are the wheel bearings OK?	—	*Go to Step 7*	*Go to Step 10*
7	Inspect the wheel speed sensor for proper installation. Is the wheel speed sensor properly installed?	—	*Go to Step 8*	*Go to Step 11*
8	1. Reconnect all connectors. 2. Perform magnetic reset. 3. Test drive the vehicle above 16 km/H (10 mph). Did the ABS indicator lamp turn on and stay on?	—	*Go to Step 14*	Malfunction is intermittent. Refer to Diagnostic Aids
9	Repair the EBCM connector. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
10	Repair excessive bearing play. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
11	Repair the wheel speed sensor. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—

Status Lamps Illuminated - Left, Rear, and Sens (cont'd)

Step	Action	Value(s)	Yes	No
12	Replace the wheel speed sensor. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
13	Repair open or high resistance in CKT 1911 or 1912. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
14	Replace the EBCM. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
15	Repair short to ground in CKT 1911 or 1912. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—

Status Lamps Illuminated - Right, Rear and Sens



341058

Circuit Description

As the toothed ring passes by the wheel speed sensor, changes in the electromagnetic field cause the wheel speed sensor to produce a sinusoidal (AC) voltage signal whose frequency and amplitude is proportional to wheel speed. The magnitude of this signal is directly related to wheel speed and the proximity of the wheel speed sensor to the toothed ring, often referred to as the air gap.

Conditions for Illuminating Diagnostic Status Lamps

- Open wheel speed sensor or wheel speed sensor wiring
- Shorted wheel speed sensor or wheel speed sensor wiring
- Wheel speed signal not present or does not conform to design criteria

Action Taken When Diagnostic Status Lamps Illuminate

- The ABS indicator lamp is illuminated
- The ABS is disabled

Conditions for Clearing Diagnostic Status Lamps

- Repair the condition responsible for illuminating status lamps
- Reset the EBCM (see Diagnostic Status Lamps)

Diagnostic Aids

An intermittent malfunction may be caused by a poor connection, rubbed through wire insulation, or a wire that is broken inside the insulation. If the RIGHT, REAR and SENS diagnostic status lamps are on only during moist environmental changes (rain, snow, vehicle wash), all wheel speed sensor circuitry should be thoroughly inspected for signs of water intrusion. Use the following procedure. Spray the suspected are with a 5% salt water solution (two teaspoons of salt to 12 oz. of water). Test drive the vehicle over various road surfaces (bumps, turns, etc.) above 24 km/H (15 mph) for at least 30 seconds. If condition returns, replace suspected harness.

Any circuitry that is suspected of causing the intermittent complaint should be thoroughly checked for backed out terminals, improper mating, broken locks, improperly formed or damaged terminals, poor terminal to wiring connections or physical damage to the wiring harness.

When inspecting a wheel speed sensor, inspect the sensor terminals and harness connector for corrosion and/or water intrusion. If evidence of corrosion or water intrusion exists, replace the wheel speed sensor. Refer to *Wheel Speed Sensor Replacement - Rear* in this section.

Resistance of the wheel speed sensor will increase with an increase in sensor temperature. Refer to the following table for temperature/resistance values.

WSS Temperature vs. Sensor Resistance

°C	°F	Ohms
Temperature vs Resistance Values (Approximate)		
-40 to 4	-40 to 40	1500 to 2500
5 to 43	41 to 110	1500 to 2500
44 to 93	111 to 200	1500 to 2500
94 to 150	201 to 302	1500 to 2500

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

3. This test checks for the correct resistance of the wheel speed sensor circuit (including wiring).
4. This test checks for the correct resistance of the wheel speed sensor.
5. This step checks for a short to ground in the wheel speed sensor circuit.

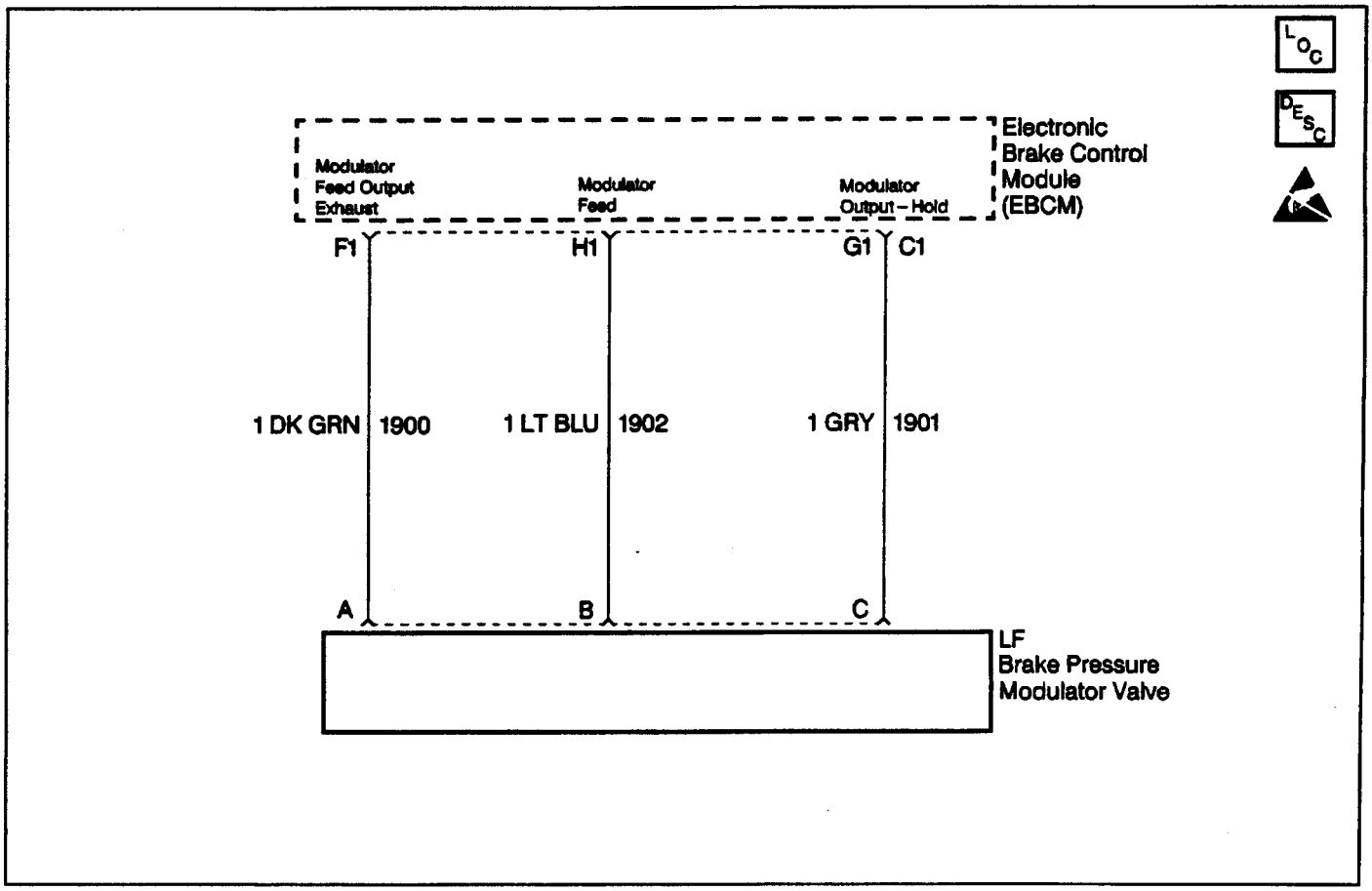
Status Lamps Illuminated - Right, Rear and Sens

Step	Action	Value(s)	Yes	No
1	Were you sent here from the Diagnostic System Check?	—	*Go to Step 2*	Go to *Air ABS Diagnostic System Check*
2	1. Turn the ignition to OFF. 2. Disconnect EBCM connector C2. 3. Inspect the connector for signs of damage or corrosion. Is the connector OK?	—	*Go to Step 3*	*Go to Step 9*
3	Using a *J 39200*, measure the resistance between terminals E2 and E3 of the EBCM harness connector. Is the resistance measured within the specified range?	1500–2500Ω	*Go to Step 5*	*Go to Step 4*
4	Disconnect the wheel speed sensor wiring harness from the wheel speed sensor pigtail connector. Using a *J 39200*, measure the resistance between terminals A and B of the RR wheel speed sensor connector. Is the resistance measured within the specified range?	1500–2500Ω	*Go to Step 13*	*Go to Step 12*
5	Using a *J 39200*, measure the resistance between terminal E2 of the EBCM connector and ground. Is the resistance measured equal to the specified value?	OL	*Go to Step 6*	*Go to Step 15*
6	Inspect the wheel bearings for looseness or excessive wear and verify that the bearing free play is within specification. Refer to "Rear Axle" for bearing information. Are the wheel bearings OK?	—	*Go to Step 7*	*Go to Step 10*
7	Inspect the wheel speed sensor for proper installation. Is the wheel speed sensor properly installed?	—	*Go to Step 8*	*Go to Step 11*
8	1. Reconnect all connectors. 2. Perform magnetic reset. 3. Test drive the vehicle above 16 km/H (10 mph). Did the ABS indicator lamp turn on and stay on?	—	*Go to Step 14*	Malfunction is intermittent. Refer to Diagnostic Aids
9	Repair the EBCM connector. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—

Status Lamps Illuminated - Right, Rear and Sens (cont'd)

Step	Action	Value(s)	Yes	No
10	Repair excessive bearing play. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
11	Repair the wheel speed sensor. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
12	Replace the wheel speed sensor. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
13	Repair open or high resistance in CKT 1916 or 1917. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
14	Replace the EBCM. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
15	Repair short to ground in CKT 1916 or 1917. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—

Status Lamps Illuminated - Left, Front, and Mod



325410

Circuit Description

The red diagnostic status lamps latches on to indicate a permanent or intermittent open or short circuit in the solenoids of one of the four modulators or the wiring connecting it to the system.

Conditions for Illuminating Diagnostic Status Lamps

- Open in modulator valve solenoid or modulator valve wiring
- Short in modulator valve solenoid or modulator valve wiring

Action Taken When Diagnostic Status Lamps Illuminate

- The ABS indicator lamp is illuminated
- The ABS is disabled

Conditions for Clearing Diagnostic Status Lamps

- Repair the condition responsible for illuminating status lamps
- Reset the EBCM (see Diagnostic Status Lamps)

Diagnostic Aids

An intermittent malfunction may be caused by a poor connection, rubbed through wire insulation, or a wire that is broken inside the insulation. If the LEFT, FRONT and MOD diagnostic status lamps are on only during moist environmental changes (rain, snow, vehicle wash), all modulator valve circuitry should be thoroughly inspected for signs of water intrusion. Use the following procedure. Spray the suspected are with a 5% salt water solution (two teaspoons of salt to 12 oz. of water). Test drive the vehicle over various road surfaces (bumps, turns, etc.) above 24 km/H (15 mph) for at least 30 seconds. If condition returns, replace suspected harness.

Any circuitry that is suspected of causing the intermittent complaint should be thoroughly checked for backed out terminals, improper mating, broken locks, improperly formed or damaged terminals, poor terminal to wiring connections or physical damage to the wiring harness.

When inspecting a modulator valve, inspect the sensor terminals and harness connector for corrosion and/or water intrusion. If evidence of corrosion or water intrusion exists, replace the modulator valve. Refer to *Modulator Valve Replacement - Front* in this section.

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

3. This test checks for the correct resistance of the modulator valve exhaust solenoid circuit (including wiring). This test also checks for a short to ground in the modulator valve circuitry.
4. This test checks for the correct resistance of the modulator valve hold solenoid circuit (including wiring).

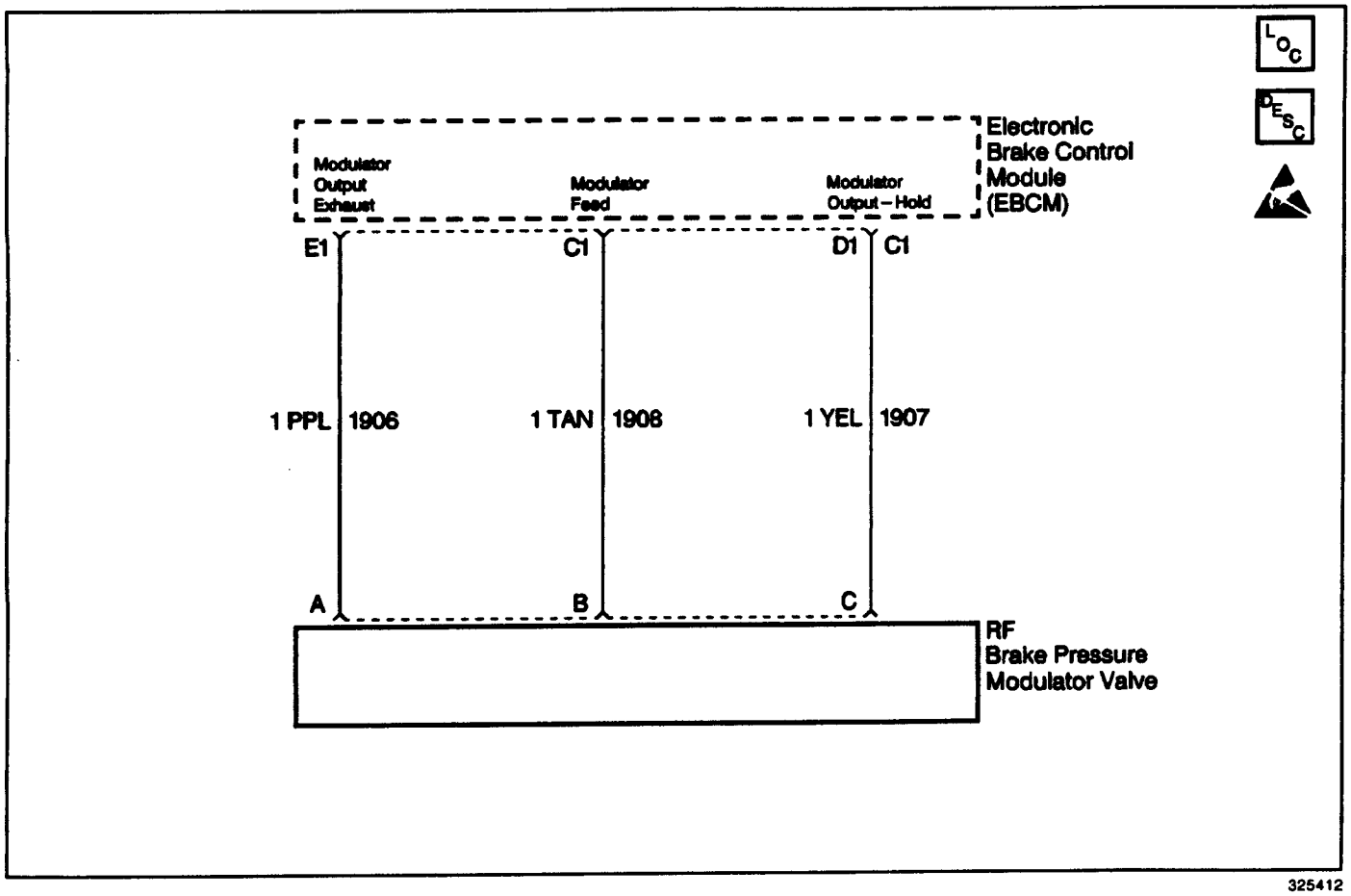
Status Lamps Illuminated - Left, Front, and Mod

Step	Action	Value(s)	Yes	No
1	Were you sent here from the Diagnostic System Check?	—	*Go to Step 2*	Go to *Air ABS Diagnostic System Check*
2	1. Turn the ignition to OFF. 2. Disconnect EBCM connector C1. 3. Inspect the connector for signs of damage or corrosion. Is the connector OK?	—	*Go to Step 3*	*Go to Step 9*
3	Using a *J 39200*, measure the resistance between terminals H1 and F1 of the EBCM connector. Is the resistance measured within the specified range?	3.5–5Ω	*Go to Step 4*	*Go to Step 6*
4	Using a *J 39200*, measure the resistance between terminals H1 and G1 of the EBCM connector. Is the resistance measured within the specified range?	3.5–5Ω	*Go to Step 5*	*Go to Step 7*
5	Using a *J 39200*, measure the resistance between terminal H1 of the EBCM connector and ground. Is the resistance measured equal to the specified value?	OL	*Go to Step 8*	*Go to Step 13*
6	1. Disconnect the left front modulator harness connector. 2. Using a *J 39200*, measure the resistance between terminals A and B of the LF modulator valve. Is the resistance measured within the specified range?	3.5–5Ω	*Go to Step 11*	*Go to Step 10*
7	1. Disconnect the left front modulator harness connector. 2. Using a *J 39200*, measure the resistance between terminals B and C of the LF modulator valve. Is the resistance measured within the specified range?	3.5–5Ω	*Go to Step 12*	*Go to Step 10*
8	1. Reconnect all connectors. 2. Perform magnetic reset. 3. Test drive the vehicle above 16 km/H (10 mph). Did the ABS indicator lamp turn on and stay on?	—	*Go to Step 14*	Malfunction is intermittent. Refer to Diagnostic Aids
9	Repair the EBCM connector. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
10	Replace the left front modulator valve. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
11	Repair open or high resistance in CKT 1900 or 1902. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—

Status Lamps Illuminated - Left, Front, and Mod (cont'd)

Step	Action	Value(s)	Yes	No
12	Repair open or high resistance in CKT 1902 or 1901. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
13	Repair short to ground in CKT 1900, 1901 or 1902. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
14	Replace the EBCM. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—

Status Lamps Illuminated - Right, Front and Mod



Circuit Description

The red diagnostic status lamps latches on to indicate a permanent or intermittent open or short circuit in the solenoids of one of the four modulators or the wiring connecting it to the system.

Conditions for Illuminating Diagnostic Status Lamps

- Open in modulator valve solenoid or modulator valve wiring
- Short in modulator valve solenoid or modulator valve wiring

Action Taken When Diagnostic Status Lamps Illuminate

- The ABS indicator lamp is illuminated
- The ABS is disabled

Conditions for Clearing Diagnostic Status Lamps

- Repair the condition responsible for illuminating status lamps
- Reset the EBCM (see Diagnostic Status Lamps)

Diagnostic Aids

An intermittent malfunction may be caused by a poor connection, rubbed through wire insulation, or a wire that is broken inside the insulation. If the RIGHT, FRONT and MOD diagnostic status lamps are on only during moist environmental changes (rain, snow, vehicle wash), all modulator valve circuitry should be thoroughly inspected for signs of water intrusion. Use the following procedure. Spray the suspected are with a 5% salt water solution (two teaspoons of salt to 12 oz. of water). Test drive the vehicle over various road surfaces (bumps, turns, etc.) above 24 km/H (15 mph) for at least 30 seconds. If condition returns, replace suspected harness.

Any circuitry that is suspected of causing the intermittent complaint should be thoroughly checked for backed out terminals, improper mating, broken locks, improperly formed or damaged terminals, poor terminal to wiring connections or physical damage to the wiring harness.

When inspecting a modulator valve, inspect the sensor terminals and harness connector for corrosion and/or water intrusion. If evidence of corrosion or water intrusion exists, replace the modulator valve. Refer to *Modulator Valve Replacement - Front* in this section.

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

3. This test checks for the correct resistance of the modulator valve exhaust solenoid circuit (including wiring). This test also checks for a short to ground in the modulator valve circuitry.
4. This test checks for the correct resistance of the modulator valve hold solenoid circuit (including wiring).

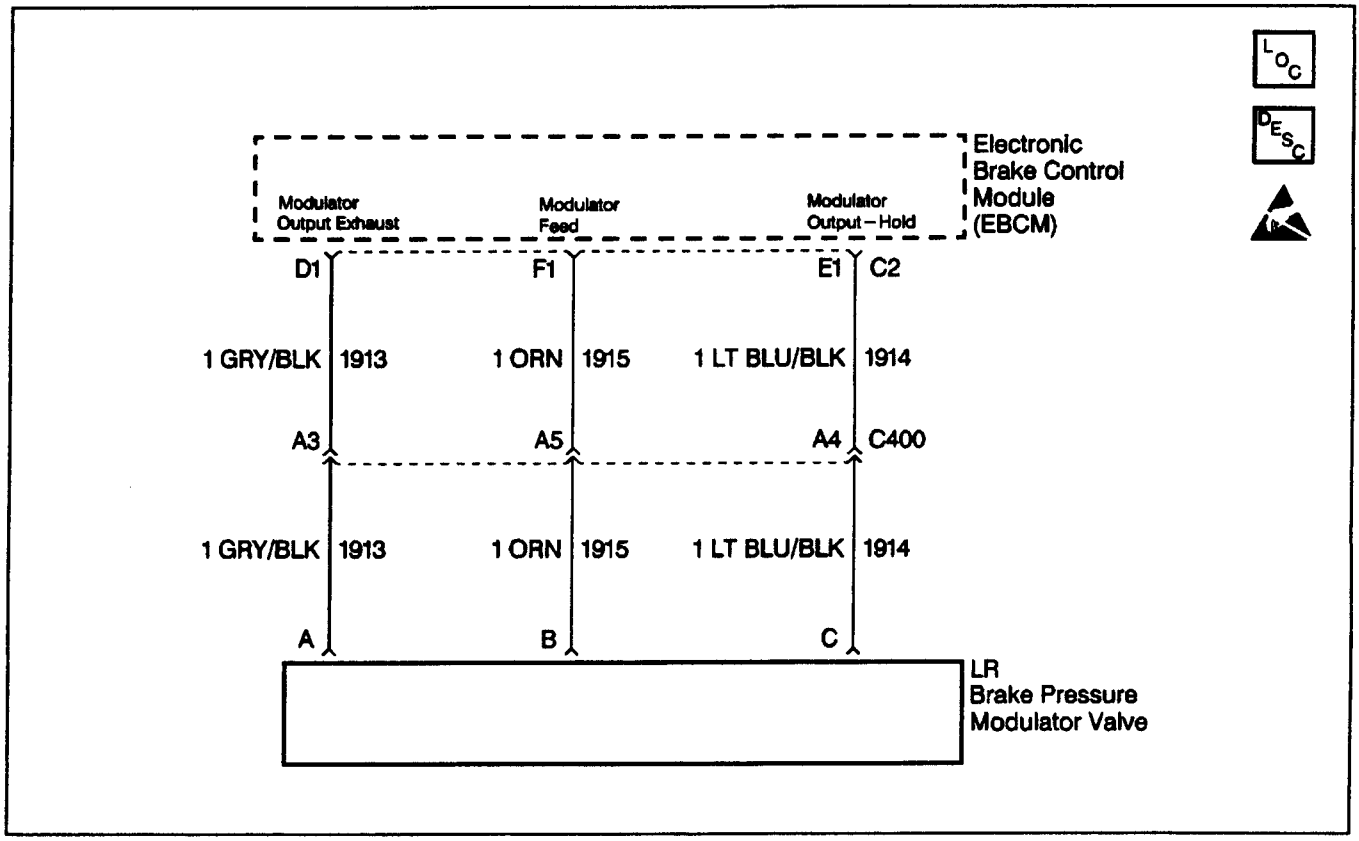
Status Lamps Illuminated - Right, Front and Mod

Step	Action	Value(s)	Yes	No
1	Were you sent here from the Diagnostic System Check?	—	*Go to Step 2*	Go to *Air ABS Diagnostic System Check*
2	1. Turn the ignition to OFF. 2. Disconnect EBCM connector C1. 3. Inspect the connector for signs of damage or corrosion. Is the connector OK?	—	*Go to Step 3*	*Go to Step 9*
3	Using a *J 39200*, measure the resistance between terminals C1 and E1 of the EBCM connector. Is the resistance measured within the specified range?	3.5–5Ω	*Go to Step 4*	*Go to Step 6*
4	Using a *J 39200*, measure the resistance between terminals C1 and D1 of the EBCM connector. Is the resistance measured within the specified range?	3.5–5	*Go to Step 5*	*Go to Step 7*
5	Using a *J 39200*, measure the resistance between terminal C1 of the EBCM connector and ground. Is the resistance measured equal to the specified value?	OL	*Go to Step 8*	*Go to Step 13*
6	1. Disconnect the right front modulator harness connector. 2. Using a *J 39200*, measure the resistance between terminals A and B of the RF modulator valve. Is the resistance measured within the specified range?	3.5–5Ω	*Go to Step 11*	*Go to Step 10*
7	1. Disconnect the right front modulator harness connector. 2. Using a *J 39200*, measure the resistance between terminals B and C of the RF modulator valve. Is the resistance measured within the specified range?	3.5–5Ω	*Go to Step 12*	*Go to Step 10*
8	1. Reconnect all connectors. 2. Perform magnetic reset. 3. Test drive the vehicle above 16 km/H (10 mph). Did the ABS indicator lamp turn on and stay on?	—	*Go to Step 14*	Malfunction is intermittent. Refer to Diagnostic Aids
9	Repair the EBCM connector. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
10	Replace the right front modulator valve. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
11	Repair open or high resistance in CKT 1906 or 1908. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—

Status Lamps Illuminated - Right, Front and Mod (cont'd)

Step	Action	Value(s)	Yes	No
12	Repair open or high resistance in CKT 1907 or 1908. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
13	Repair short to ground in CKT 1906, 1907 or 1908. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
14	Replace the EBCM. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—

Status Lamps Illuminated - Left, Rear, and Mod



341608

Circuit Description

The red diagnostic status lamps latches on to indicate a permanent or intermittent open or short circuit in the solenoids of one of the four modulators or the wiring connecting it to the system.

Conditions for Illuminating Diagnostic Status Lamps

- Open in modulator valve solenoid or modulator valve wiring
- Short in modulator valve solenoid or modulator valve wiring

Action Taken When Diagnostic Status Lamps Illuminate

- The ABS indicator lamp is illuminated
- The ABS is disabled

Conditions for Clearing Diagnostic Status Lamps

- Repair the condition responsible for illuminating status lamps
- Reset the EBCM (see Diagnostic Status Lamps)

Diagnostic Aids

An intermittent malfunction may be caused by a poor connection, rubbed through wire insulation, or a wire that is broken inside the insulation. If the LEFT, REAR and MOD diagnostic status lamps are on only during moist environmental changes (rain, snow, vehicle wash), all modulator valve circuitry should be thoroughly inspected for signs of water intrusion. Use the following procedure. Spray the suspected are with a 5% salt water solution (two teaspoons of salt to 12 oz. of water). Test drive the vehicle over various road surfaces (bumps, turns, etc.) above 24 km/H (15 mph) for at least 30 seconds. If condition returns, replace suspected harness.

Any circuitry that is suspected of causing the intermittent complaint should be thoroughly checked for backed out terminals, improper mating, broken locks, improperly formed or damaged terminals, poor terminal to wiring connections or physical damage to the wiring harness.

When inspecting a modulator valve, inspect the sensor terminals and harness connector for corrosion and/or water intrusion. If evidence of corrosion or water intrusion exists, replace the modulator valve. Refer to *Modulator Valve Replacement - Rear* in this section.

Test Description

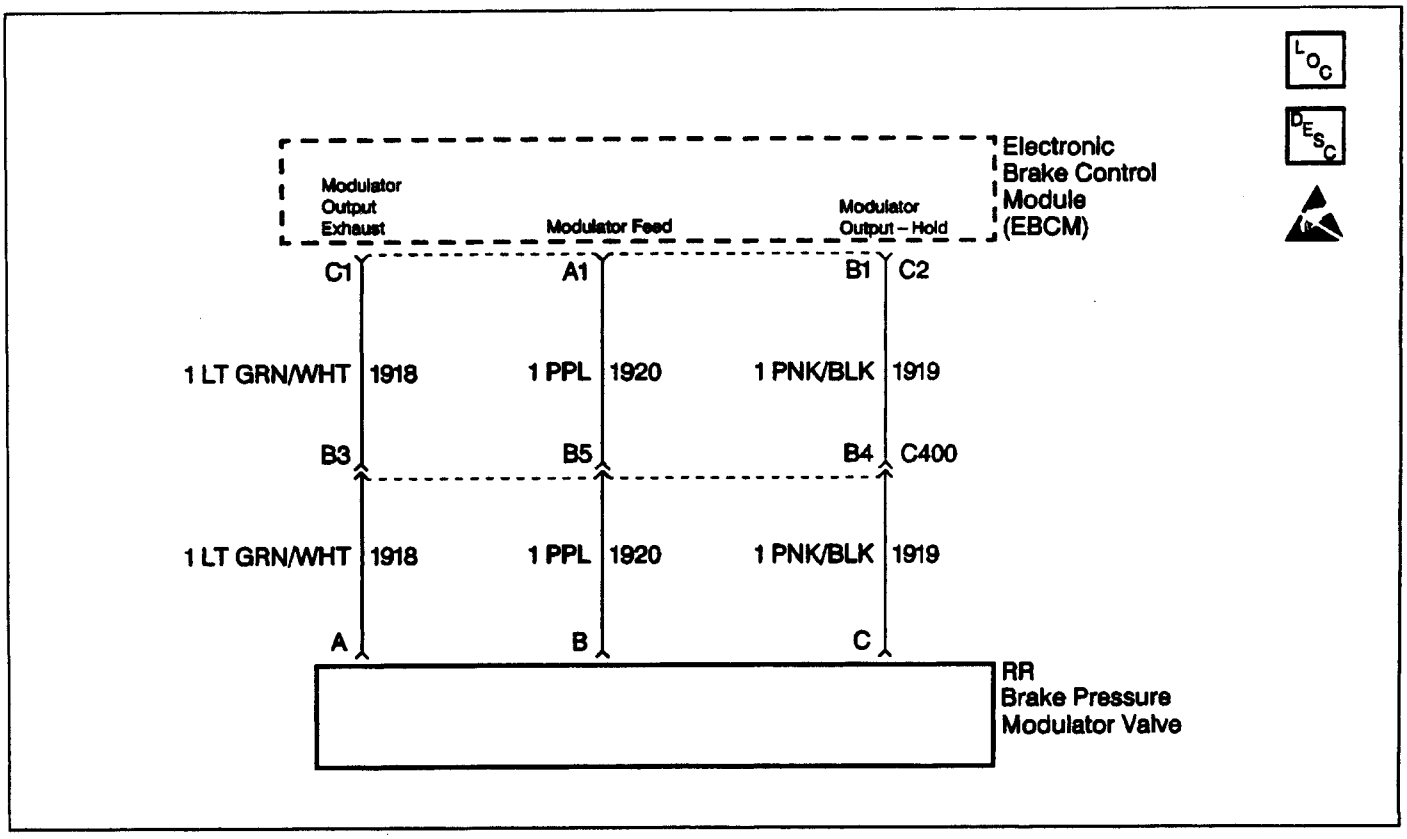
The number(s) below refer to the step number(s) on the diagnostic table.

3. This test checks for the correct resistance of the modulator valve exhaust solenoid circuit (including wiring). This test also checks for a short to ground in the modulator valve circuitry.
4. This test checks for the correct resistance of the modulator valve hold solenoid circuit (including wiring).

Status Lamps Illuminated - Left, Rear, and Mod

Step	Action	Value(s)	Yes	No
1	Were you sent here from the Diagnostic System Check?	—	*Go to Step 2*	Go to *Air ABS Diagnostic System Check*
2	1. Turn the ignition to OFF. 2. Disconnect EBCM connector C2. 3. Inspect the connector for signs of damage or corrosion. Is the connector OK?	—	*Go to Step 3*	*Go to Step 9*
3	Using a *J 39200*, measure the resistance between terminals F1 and D1 of the EBCM connector. Is the resistance measured within the specified range?	3.5–5Ω	*Go to Step 4*	*Go to Step 6*
4	Using a *J 39200*, measure the resistance between terminals F1 and E1 of the EBCM connector. Is the resistance measured within the specified range?	3.5–5Ω	*Go to Step 5*	*Go to Step 7*
5	Using a *J 39200*, measure the resistance between terminal F1 of the EBCM connector and ground. Is the resistance measured equal to the specified value?	OL	*Go to Step 8*	*Go to Step 13*
6	1. Disconnect the left rear modulator harness connector. 2. Using a *J 39200*, measure the resistance between terminals A and B of the LR modulator valve. Is the resistance measured within the specified range?	3.5–5Ω	*Go to Step 11*	*Go to Step 10*
7	1. Disconnect the left rear modulator harness connector. 2. Using a *J 39200*, measure the resistance between terminals B and C of the LR modulator valve. Is the resistance measured within the specified range?	3.5–5Ω	*Go to Step 12*	*Go to Step 10*
8	1. Reconnect all connectors. 2. Perform magnetic reset. 3. Test drive the vehicle above 16 km/H (10 mph). Did the ABS indicator lamp turn on and stay on?	—	*Go to Step 14*	Malfunction is intermittent. Refer to Diagnostic Aids
9	Repair the EBCM connector. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
10	Replace the left rear modulator valve. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
11	Repair open or high resistance in CKT 1913 or 1915. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
12	Repair open or high resistance in CKT 1915 or 1914. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
13	Repair short to ground in CKT 1913, 1914 or 1915. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
14	Replace the EBCM. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—

Status Lamps Illuminated - Right, Rear and Mod



341609

Circuit Description

The red diagnostic status lamps latches on to indicate a permanent or intermittent open or short circuit in the solenoids of one of the four modulators or the wiring connecting it to the system.

Conditions for Illuminating Diagnostic Status Lamps

- Open in modulator valve solenoid or modulator valve wiring
- Short in modulator valve solenoid or modulator valve wiring

Action Taken When Diagnostic Status Lamps Illuminate

- The ABS indicator lamp is illuminated
- The ABS is disabled

Conditions for Clearing Diagnostic Status Lamps

- Repair the condition responsible for illuminating status lamps
- Reset the EBCM (see Diagnostic Status Lamps)

Diagnostic Aids

An intermittent malfunction may be caused by a poor connection, rubbed through wire insulation, or a wire that is broken inside the insulation. If the RIGHT, REAR and MOD diagnostic status lamps are on only during moist environmental changes (rain, snow, vehicle wash), all circuitry should be thoroughly inspected for signs of water intrusion. Use the following procedure. Spray the suspected are with a 5% salt water solution (two teaspoons of salt to 12 oz. of water). Test drive the vehicle over various road surfaces (bumps, turns, etc.) above 24 km/H (15 mph) for at least 30 seconds. If condition returns, replace suspected harness.

Any circuitry that is suspected of causing the intermittent complaint should be thoroughly checked for backed out terminals, improper mating, broken locks, improperly formed or damaged terminals, poor terminal to wiring connections or physical damage to the wiring harness.

When inspecting the modulator valve, inspect the sensor terminals and harness connector for corrosion and/or water intrusion. If evidence of corrosion or water intrusion exists, replace the modulator valve. Refer to *Modulator Valve Replacement - Rear* in this section.

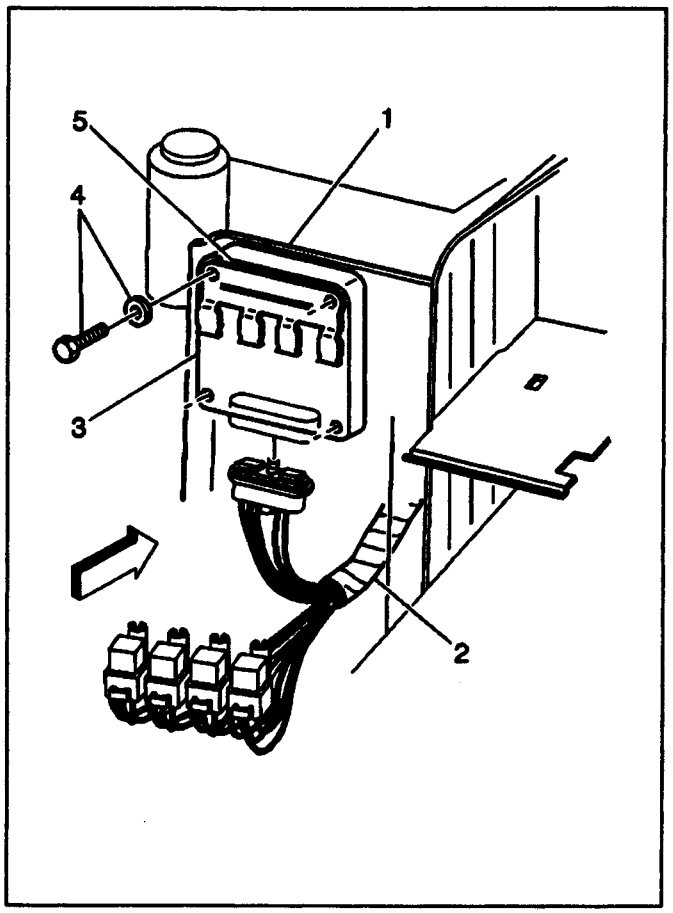
Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

3. This test checks for the correct resistance of the modulator valve exhaust solenoid circuit (including wiring). This test also checks for a short to ground in the modulator valve circuitry.
4. This test checks for the correct resistance of the modulator valve hold solenoid circuit (including wiring).

Status Lamps Illuminated - Right, Rear and Mod

Step	Action	Value(s)	Yes	No
1	Were you sent here from the Diagnostic System Check?	—	*Go to Step 2*	Go to *Air ABS Diagnostic System Check*
2	1. Turn the ignition to OFF. 2. Disconnect EBCM connector C2. 3. Inspect the connector for signs of damage or corrosion. Is the connector OK?	—	*Go to Step 3*	*Go to Step 9*
3	Using a *J 39200*, measure the resistance between terminals A1 and C1 of the EBCM connector. Is the resistance measured within the specified range?	3.5–5Ω	*Go to Step 4*	*Go to Step 6*
4	Using a *J 39200*, measure the resistance between terminals A1 and B1 of the EBCM connector. Is the resistance measured within the specified range?	3.5–5Ω	*Go to Step 5*	*Go to Step 7*
5	Using a *J 39200*, measure the resistance between terminal A1 of the EBCM connector and ground. Is the resistance measured equal to the specified value?	OL	*Go to Step 8*	*Go to Step 13*
6	1. Disconnect the right rear modulator harness connector. 2. Using a *J 39200*, measure the resistance between terminals A and B of the RR modulator valve. Is the resistance measured within the specified range?	3.5–5Ω	*Go to Step 11*	*Go to Step 10*
7	1. Disconnect the right rear modulator harness connector. 2. Using a *J 39200*, measure the resistance between terminals B and C of the RR modulator valve. Is the resistance measured within the specified range?	3.5–5Ω	*Go to Step 12*	*Go to Step 10*
8	1. Reconnect all connectors. 2. Perform magnetic reset. 3. Test drive the vehicle above 16 km/H (10 mph). Did the ABS indicator lamp turn on and stay on?	—	*Go to Step 14*	Malfunction is intermittent. Refer to Diagnostic Aids
9	Repair the EBCM connector. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
10	Replace the right rear modulator valve. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
11	Repair open or high resistance in CKT 1918 or 1920. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
12	Repair open or high resistance in CKT 1920 or 1919. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
13	Repair short to ground in CKT 1918, 1919 or 1920. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—
14	Replace the EBCM. Is the repair complete?	—	Go to *Air ABS Diagnostic System Check*	—



341642

Repair Instructions

Electronic Brake Control Module Replacement

Removal Procedure

1. Negative Battery Cable. Refer to *Battery Disconnect Caution.*
2. Remove the electrical connector bolt from EBCM.
3. Remove the electrical connector from EBCM.

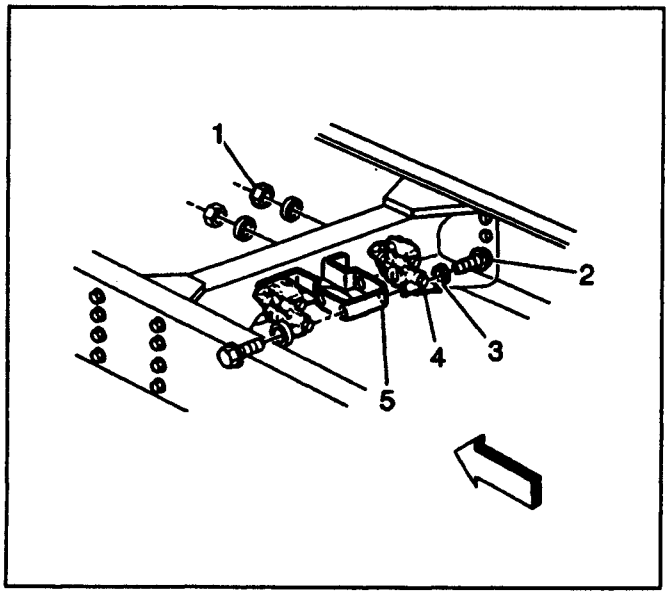
Installation Procedure

1. Install EBCM to bracket.
2. Install the EBCM electrical connector.
3. Install the EBCM electrical connector bolt.

   Tighten

   Tighten the EBCM electrical connector bolt to 2 N.m (18 lb in)

   Notice: Refer to *Fastener Notice* in General Information.
4. Connect the negative battery cable. Refer to *Battery Disconnect Caution.*
5. Return to *Air ABS Diagnostic System Check.*



156601

Modulator Valve Replacement - Rear

Removal Procedure

1. Disconnect the negative battery cable.

   Caution: Refer to Battery Disconnect Caution in Cautions and Notices.
2. Remove tie straps.
3. Disconnect electrical connector.
4. Remove the air lines.

   Refer to *Hose and Line Replacement* in Air Brakes.
5. Remove the two mounting bolts (2), four washers (3) and two nuts (5).
6. Remove the modulator (4).

Installation Procedure

Important: It may be necessary to transfer the fittings from the old modulator to the replacement part.

1. Install the modulator to vehicle using two mounting bolts (2), four washers (3) and two nuts (5).

   Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. **Tighten**

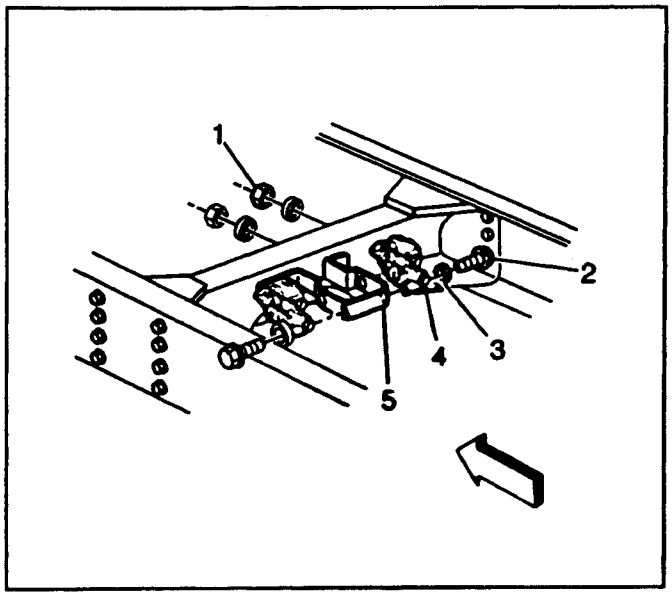
   Tighten the modulator nuts (5) to 70 N.m (52 lb ft).

3. Connect air lines to modulator valve.

   Refer to *Hose and Line Replacement* in Air Brakes.

4. Install the modulator electrical connector.
5. Install new tie straps.
6. Reconnect the negative battery cable.

   Caution: Refer to Battery Disconnect Caution in Cautions and Notices.



156601

Modulator Valve Replacement - Front

Removal Procedure

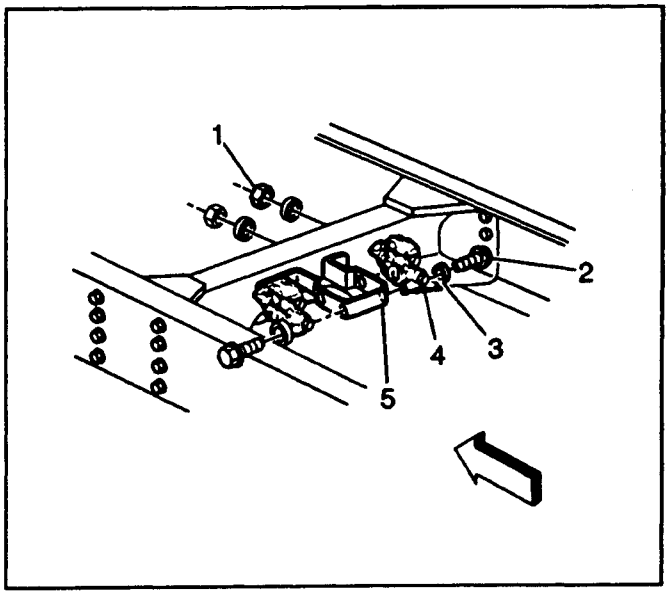
1. Disconnect the negative battery cable.

   Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

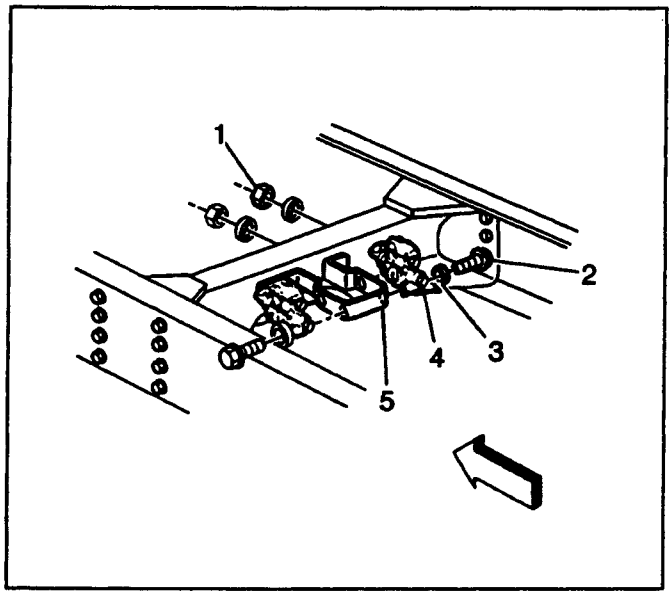
2. Remove tie straps.
3. Disconnect electrical connector.
4. Remove the air lines.

   Refer to *Hose and Line Replacement* in Air Brakes.

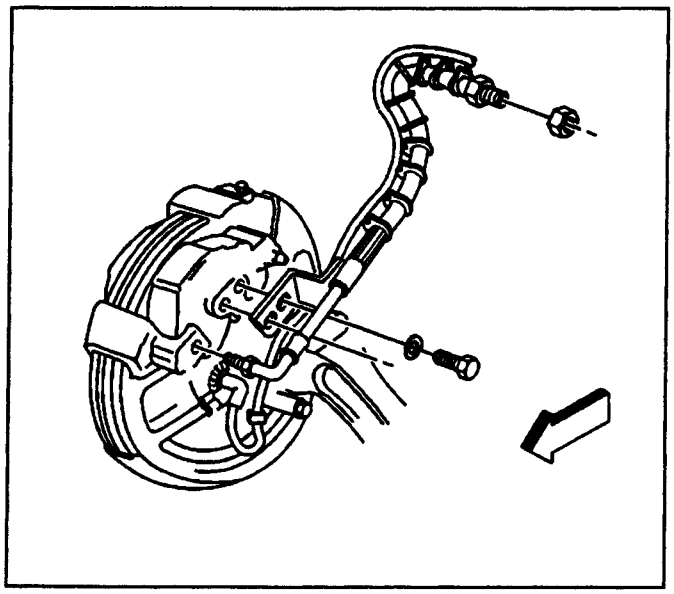
5. Remove the two mounting bolts (2), four washers (3) and two nuts (5).
6. Remove the modulator (4).



156601



156601



305635

Installation Procedure

Important: It may be necessary to transfer the fittings from the old modulator to the replacement part.

1. Install the modulator to vehicle using two mounting bolts (2), four washers (3) and two nuts (5).

   Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. **Tighten**

   Tighten the modulator nuts (5) to 70 N·m (52 lb ft).

3. Connect air lines to modulator valve.

   Refer to *Hose and Line Replacement* in Air Brakes.

4. Install the modulator electrical connector.
5. Install new tie straps.
6. Reconnect the negative battery cable.

   Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

Wheel Speed Sensor Replacement - Front

Removal Procedure

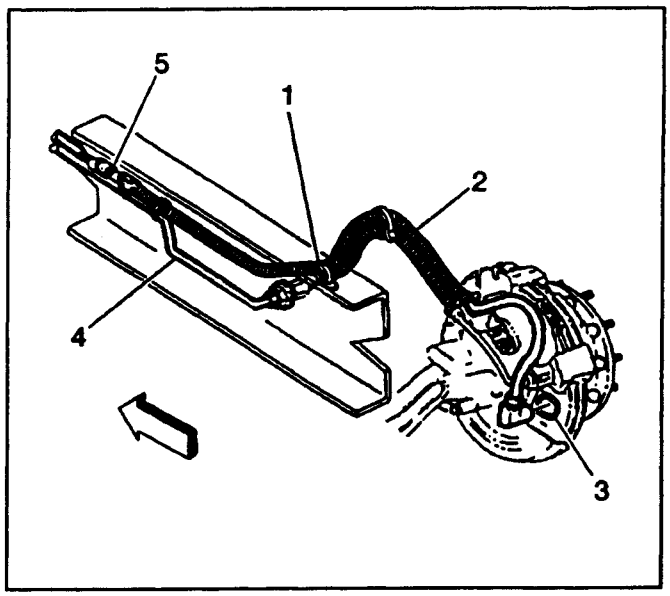
1. Disconnect the electrical connector.
2. Remove the nylon straps retaining the sensor wire to the brake line. Note the location of the straps.
3. Remove the wheel speed sensor from the bore.
4. Remove the speed sensor retaining clip. The clip may come out with the wheel speed sensor or stay in the bore. If the sensor retaining clip is still functioning correctly, save it for reinstallation. If the sensor retaining clip is not functioning correctly, replace the sensor retaining clip.

Installation Procedure

Important: You may have to use the wire retainers from the old wheel speed sensor wire on the new sensor. Do not damage the new wire when installing the retainers.

Important: When the wheel speed sensor is fully installed in the block bore, it contacts the tone ring which is attached to the wheel hub. Normal bearing play between the sensor tip and tone ring in the wheel hub will move the sensor tip away from the tone ring. This automatically establishes the proper air gap.

1. Install the wheel speed sensor retaining clip (3) completely into the bore. The clip should stop at the retaining tabs. Insert the wheel speed sensor into the clip. The wheel speed sensor should contact the tone ring.
2. Secure the sensor wire (2) to the brake line (4) with a wire tie (1) in the location noted during removal.
3. Connect the electrical connector (5).

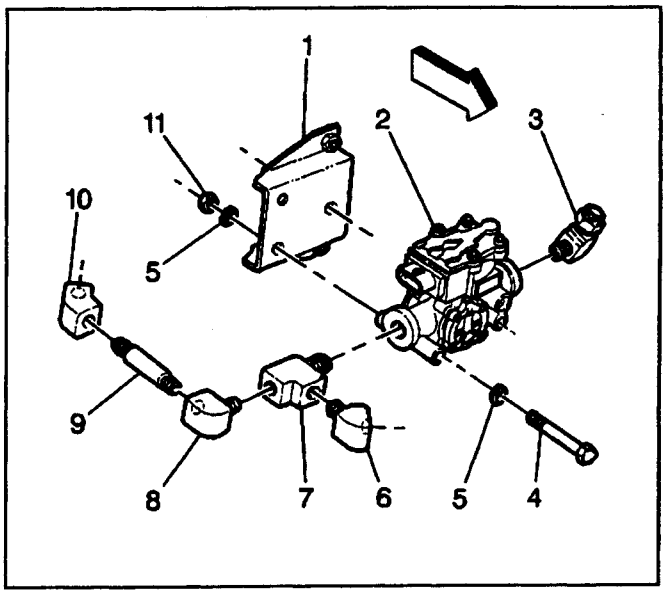


156568

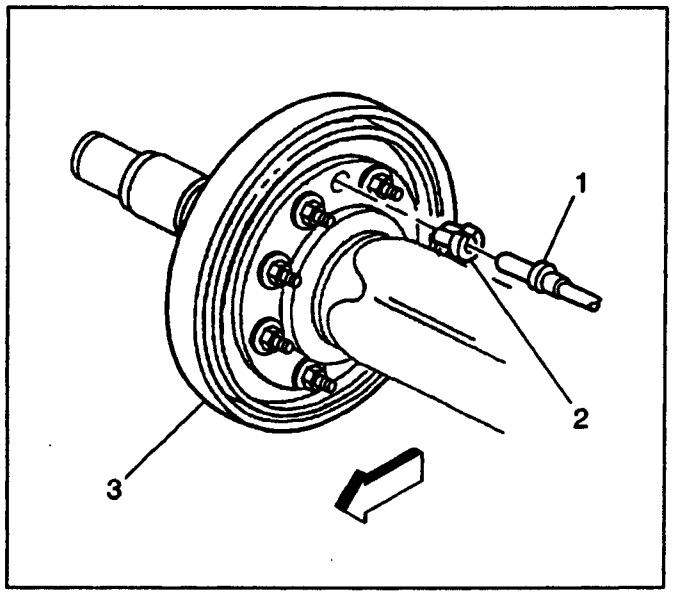
Wheel Speed Sensor Replacement - Rear

Removal Procedure

1. Disconnect the electrical connector.
2. Remove the nylon straps retaining the sensor wire to the brake line. Note the location of the straps.
3. Remove the wheel speed sensor (1) from the bore.
4. Remove the speed sensor retaining clip (2). The clip may come out with the wheel speed sensor or stay in the bore. If the sensor retaining clip is still functioning correctly, save it for reinstallation. If the sensor retaining clip is not functioning correctly, replace the sensor retaining clip.



325431



156576

Installation Procedure

Important: You may have to use the wire retainers from the old wheel speed sensor wire on the new sensor. Do not damage the new wire when installing the retainers.

Important: When the wheel speed sensor is fully installed in the block bore, it contacts the tone ring which is attached to the wheel hub. Normal bearing play between the sensor tip and tone ring in the wheel hub will move the sensor tip away from the tone ring. This automatically establishes the proper air gap.

1. Install the wheel speed sensor retaining clip (2) completely into the bore. The clip should stop at the retaining tabs. Insert the wheel speed sensor (1) into the clip. The wheel speed sensor should contact the tone ring.
2. Secure the sensor wire to the brake line with a wire tie in the location noted during removal.
3. Connect the electrical connector.

Description and Operation

Service Precautions

When working on this system, observe the following precautions:

- Before welding on the vehicle with an electric welding unit, complete the following steps:
  - Turn the ignition switch OFF.
  - Disconnect the EBCM connectors.
- Do not use a fast charger for starting the engine.
- Disconnect the negative battery cable when fast charging. Refer to *Battery Disconnect Caution* in Cautions and Notices.
- Never disconnect the battery from the vehicle electrical system while the engine is running.
- Connect all wiring harness connectors securely.
- Proper speed sensor wiring, routing and retaining are necessary in order to prevent false signals due to electrical noise. You can achieve proper system operation only by restoring the system to its original condition.

  When servicing the ABS, note the routing, position, mounting and locations of the following items:
  - All components
  - The wiring
  - The connectors
  - The clips
  - The brackets
  - The brake pipes

Follow the above mentioned precautions when working on ABS. Familiarize yourself with ABS and it relationships with other components on the vehicle.

General System Description

ABS Indicator Lamp Relay

The ABS indicator Lamp Relay is a normally closed relay. The ABS indicator is always on unless the EBCM energizes the relay coil and the relay contacts are opened.This logic ensures that the ABS indicator lamp will always be illuminated if there is a malfunction with the EBCM.

The Air ABS provides individual wheel braking control by using an Electronic Brake Control Module (EBCM), four wheel speed sensors and four air brake modulators. The EBCM monitors the rate of deceleration during braking and subsequently adjusts the brake application pressure at each wheel. The ABS will provide improved steerability and vehicle stability.

The rear axle brakes are controlled completely independent of each other. The brake application pressure at each individual wheel is adjusted solely on the basis of its behavior on the road surface on which it is traveling.

While each steering axle brake is under the control of an individual modulator, the EBCM does not treat these brakes totally independent of each other. The EBCM will control the braking force differences between the two brakes in order to minimize steering wheel pull, in the event each wheel is traveling on a different road surface.

In the case of vehicles equipped with tandem rear axles (6x2 or 6x4), the wheel speed sensors are installed at the wheels on the axle that is most likely to lose traction first. A single modulator controls both curb side brakes on the tandem, and another modulator controls both brakes on the drivers side of the tandem.

Since the brakes will likely be on the same road surface, both brakes on one side of the tandem are treated as one with this arrangement.

Base Braking Application

During normal braking, air pressure from the brake valve enters the control port of the service relay valve (either an antilock or standard service relay valve). The service relay valve delivers air through the ABS modulator located near the brake wheel and into the brake actuator.

ANTILOCK Braking Mode

If a service brake application is made and the wheel speed sensors detect an impending lockup, the EBCM will immediately begin modification of the brake application using the antilock modulator(s) at the affected wheel(s).

Solenoid valves contained in the modulator are energized and de-energized by the EBCM in order to modify the brake application. When a solenoid coil is energized, the solenoid valve will either open or close, causing exhaust or re-application of air pressure to the brake actuator. The solenoids in each modulator are controlled independently by the EBCM.

System Self Test

The EBCM will perform a self test which continuously checks for proper operation of the entire ABS. In order to alert the driver of a malfunction with the ABS, the EBCM will illuminate the ABS indicator lamp (located in the instrument panel).

In order to assist the technician locate a malfunction with a specific ABS component, the EBCM will illuminate any diagnostic status lamps associated with the malfunction (located on the side of the EBCM housing).

Wheel Speed Sensors

The front Wheel Speed Sensors (WSS) are a magnetic coil/pickup type. Each WSS produces an AC voltage signal which is transmitted to the EBCM in order to indicate how fast the wheel is turning. The speed of the wheel is directly proportional to the frequency and amplitude of the wheel speed signal.

Wheel Speed Sensor Tone Wheels

Each Wheel Speed Sensor uses a tone wheel in order to produce an AC voltage signal. Tone wheels are metal rings with teeth on the outside diameter. The AC voltage is produced as the teeth pass through the magnetic field of the WSS pole piece. The tone wheels are attached to the rotor or the drum. Any imperfections in the tone rings, such as a broken tooth or a missing tooth, can cause an inaccurate wheel speed signal.

Abbreviations and Definitions

MOD: Modulator Valve

CKT: Circuit

DLC: Data Link Connector

DMM: Digital Multimeter

DTC: Diagnostic Trouble Code

EBCM: Electronic Brake Control Module

EHCU: Electro-Hydraulic Control Unit

Infinite: Open Circuit/Unmeasurably High Resistance

LPA: Low Pressure Accumulator

OL: Open Circuit/Unmeasurably High Resistance

WSS: Wheel Speed Sensor

The EHCU is the entire ABS unit, including the BPMV and the EBCM. The BPMV is defined as the hydraulic control portion of the EHCU. The BPMV includes the internal control valves, the electric motor and the pumps. The BPMV does not include the EBCM. The EBCM is the electronic control portion of the EHCU. The EBCM mounts to the top of the BPMV. The EBCM is housed in aluminum with a black plastic top.

Basic Knowledge Required

You must have a basic knowledge of the following items before using this section. Without this basic knowledge, you will have difficulties using the diagnostic procedures contained in this section.

If you need a review of basic electrical troubleshooting, see the introduction to Electrical Diagnosis. Electrical Diagnosis also contains information on the basic use of circuit testing tools.

Additionally, General Motors Service Training offers courses in electrical and electronic service.

Basic Electrical Circuits
You should understand the basic electrical theory. You should also know the meaning of basic electrical concepts and measurement: voltage (volts), current (amperes) and resistance (ohms). You should understand what happens in a circuit with an open or shorted wire. You should be able to read and understand a wiring diagram.

Use of Circuit Testing Tools
You should be familiar with the high impedance Digital Multimeter (DMM) *J 39200*. You should be familiar with the meter controls and how to use them correctly. You should be able to measure voltage, resistance and current. You should also know how to use jumper wires to bypass components in order to test circuits.

Air ABS System Description

Electronic Brake Control Module
The controlling element of ABS is the Electronic Brake Control Module. Inputs to the system include four wheel speed sensors, brake switch, ignition switch, and unswitched battery power. Outputs include four air modulators and the ABS indicator lamp. The EBCM monitors the speed of each wheel. If any wheel begins to approach lock-up, the EBCM controls the air modulators to reduce brake pressure to the wheel approaching lock-up. Once the wheel regains traction, brake pressure is increased until the wheel again begins to approach lock-up. This cycle repeats until either the vehicle comes to a stop, the brake is released, or no wheels approach lock-up. Additionally, the EBCM monitors itself, each input and output for proper operation. If any system malfunction is detected, the EBCM will illuminate a light emitting diode (s) located in a window on the side of the EBCM housing. These diagnostic LED's are referred to as the diagnostic status lamps.

Wheel Speed Sensors
Wheel speed information is provided to the EBCM via a wiring harness from individual wheel speed sensors located at the wheels. Working in conjunction with a tone ring, wheel speed sensors provide information to the EBCM in the form of an AC voltage signal which varies in voltage and frequency as the speed of the wheel increases or decreases.The wheel speed sensor is installed in a mounting block on the axle housing. A spring loaded retaining clip is used to secure the wheel speed sensor into the mounting bore. This spring retainer is designed in a way that allows the wheel speed sensor to slide back and forth under force, but will retain it's position when force is removed. This allows the wheel speed sensor to self adjust after it is installed in the mounting bore and allows for an air gap between the wheel speed sensor and tone ring.

Wheel Speed Sensor Tone Wheels
Each Wheel Speed Sensor uses a tone wheel in order to produce an AC voltage signal. Tone wheels are metal rings with teeth on the outside diameter. The AC voltage is produced as the teeth pass through the magnetic field of the WSS pole piece. The tone wheels are attached to the rotor or the drum. Any imperfections in the tone rings, such as a broken tooth or a missing tooth, can cause an inaccurate wheel speed signal.

Tire Size Calibration
The EBCM accepts wheel speed signals from several different sizes of tire and wheel combinations. All vehicles are preprogrammed from the factory with the proper tire size calibration. Whenever tires of a different size are installed on the vehicle, the EBCM will automatically recalibrate itself to compensate.

Air ABS System Operation

ABS Indicator Lamp Operation
The system uses an amber ABS indicator lamp in the instrument cluster in order to show system operation and malfunctions.

Normal ABS Indicator Lamp Operation
The amber ABS indicator lamp is located in the instrument panel and alerts the driver of a malfunction in the ABS system. At vehicle start up, the EBCM illuminates the the amber ABS indicator light in the instrument cluster. The indicator will flash two times on start up and remain on until the vehicle reaches 11 to 16 km/H (7 to 10 mph), and then turn off. If a malfunction is present, the ABS indicator will remain on after the vehicle reaches 11 to 16 km/H (7 to 10 mph).

Tires and ABS
Correct tire size, proper inflation, accurate alignment and even wear are needed for good brake performance. These items are essential for proper ABS performance.

Spare Tire
Use of the spare tire supplied with the vehicle will not affect the performance of the system.

Replacement Tires
If the replacement tires are not the same size as the original tires, the EBCM will automatically recalibrate itself to compensate for the mismatch in wheel speeds.

Self-Tests
The EBCM performs a self test which continously checks for proper operation of the ABS system. The ABS indicator lamp alerts the driver of a malfunction in the ABS system. In the event that the EBCM detects a malfunction in the ABS system it will illuminate the amber ABS lamp located in the instrument panel. The associated diagnostic status lamps will also be illuminated.

Special Tools and Equipment

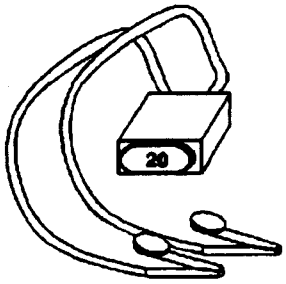
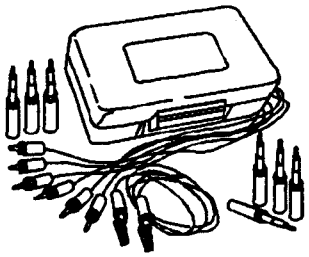
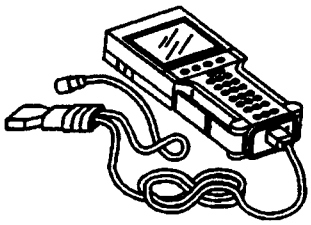
Illustration	Tool Number/ Description
 3430	J 39200 Digital Multi-Meter
 1025	J 36169 Fused Jumper Wire

Illustration	Tool Number/ Description
 11799	J 35616 Connector Adapter Test Kit
 39438	Tech 2 Scan Tool

BLANK

A

Abbreviations and Their Meanings 0-23
ABS Handling 3
A/C
  System Air Filter Replacement
    HVAC with A/C - Manual 1-145
Accumulator
  Description
    HVAC with A/C - Manual 1-171
Acid Rain 8-461
Air ABS
  Component Locations 5-405
  Component Views 5-408
  Connector End Views 5-415
  Description
    Abbreviations and Definitions 5-453
    Basic Knowledge Required 5-453
    General System Description 5-453
    Service Precautions 5-452
    System Description 5-454
    System Operation 5-454
  Diagnosis
    Diagnostic System Check 5-421
    Intermittents and Poor Connections 5-420
    Self-Diagnostics 5-419
    Status Lamps Illuminated
      Left, Front and Mod 5-438
      Left, Front and Sens 5-426
      Left, Rear and Mod 5-444
      Left, Rear and Sens 5-432
      Right, Front and Mod 5-441
      Right, Front and Sens 5-429
      Right, Rear and Mode 5-446
      Right, Rear and Sens 5-435
  Schematic
    Schematic Icons 5-400
    Schematic References 5-400
    System Schematics 5-401
  Special Tools 5-455
  Specifications
    Fastener Tightening 5-399
  Wheel Speed Sensor Replacement
    Front 5-450
    Rear 5-451
Air Brakes
  Air Dryer Replacement 5-190
  Applying Pipe Sealant 5-170
  Component Views 5-140
  Connector End Views 5-142
  Description
    Air Dryer/Moisture Ejector
      Circuit Description 5-225
    Air Dryer System 5-212
    Air Dryer System Operation 5-212
    Component Description 5-209
    Component Operation 5-210
    System Description 5-208
    System Operation 5-209
    Valves Description 5-212
    Valves Operation 5-218
  Diagnosis
    Air Dryer and Moisture Ejector
      Do Not Work 5-168
Air Brakes (cont.)
    Air Dryer/Moisture Ejector
      System Check 5-167
    Air Dryer or Moisture Ejector
      Does Not Work 5-168
    Air Dryer Testing 5-150
    Application Slow 5-143
    Brakes Drag 5-145
    Brakes Inoperative 5-143
    Brakes Not Operating Properly 5-143
    Braking Uneven
      Front to Rear 5-144
      Side to Side 5-145
    Desiccant Being Expelled From
      Purge Valve Exhaust 5-147
    Double Check Valve Test 5-156, 5-157
    Dryer Constantly Cycling or Purging 5-145
    Dryer Does Not Purge or Exhaust Air 5-147
    Dryer Purge Valve Exhausting Air 5-146
    Dryer Safety Valve Exhausting Air 5-146
    Dual Application Valve Test 5-158
    Front Axle Limiting (Ratio)
      Valve Test 5-158, 5-159
    Grinding Sound When Applied 5-145
    Inflation Valve Test 5-159
    Low Air Pressure Switch 5-149
    Moisture Ejector Valve Test 5-160
    Park Control Valve Test 5-151, 5-152
    Parking Control Valve Test 5-152, 5-153
    Pressure Loss w/Eng. Off -
      Brakes Applied 5-144
    Pressure Loss w/Eng. Off -
      Brakes Released 5-144
    Pressure Protection Valve Test 5-160, 5-161
    Primary Air Brake Supply Rsvr
      Safety Valve Test 5-164, 5-165
    Primary Brake Indicator or Alarm
      Always On 5-149
    Primary Brake Indicator or Alarm
      Inoperative 5-148
    Quick Release Valve Test 5-161
    Quick Release Valve w/Double
      Check Test 5-162
    Relay Valve Test 5-163
    Relay Valve w/ Double Check Test 5-163
    Reservoir Drain Valve Test 5-161
    Reservoirs Contain Water 5-146
    Safety Valve Blows Off 5-144
    Single Check Valve Test 5-155
    Spring Brake Control Valve Test 5-165
    Stoplamp Switch 5-149
    System Leak Test 5-150
    System Testing 5-148
    Towing Vehicle Protection
      Valve Test 5-165, 5-166
    Trailer Air Brake Control
      Valve Test 5-166, 5-167
    Trailer Stoplamp Switch 5-150
    Trailer Supply Valve Test 5-153, 5-154
  Double Check Valve Replacement 5-195
  Draining Reservoirs 5-169
  Dual Application Valve Replacement 5-196
  Filling Air Reservoirs 5-170

Air Brakes (cont.)
Front Axle Limiting (Ratio) Valve Replacement 5-198
Hose and Line Replacement 5-174, 5-176, 5-177, 5-179, 5-180
Inflation Valve Replacement....5-198
Park Control Valve Replacement....5-192, 5-205
Pedal Replacement 5-171
Pressure Protection Valve Replacement 5-200
Quick Release Valve Replacement 5-200
Quick Release Valve w/Double Check Replacement 5-202
Rear Air Brake Relay Dbl Check Valve Replacement 5-204
Relay Valve Replacement 5-203
Reservoir Drain Valve Replacement 5-187, 5-188, 5-199
Reservoir Replacement 5-181, 5-182, 5-184
Reservoir Support Replacement....5-185, 5-186
Safety Valve Replacement 5-205
Schematic
Air Brake Dryer Schematic 5-132
Icons 5-135
Park Brake Control Schematic 5-133
Park Brake Schematic 5-134
Single Check Valve Replacement....5-194
Specifications
Fastener Tightening....5-113
System Components 5-137
Towing Vehicle Protection Valve Replacement 5-206
Trailer Air Brake Control Valve Replacement 5-207
Trailer Supply Valve Replacement....5-193
Air Compressor
Description
General 5-301
Governor Valve....5-302
Governor Valve Operation 5-302
Operation 5-301
Diagnosis 5-288
Air Compressor and Governor Valve 5-289
Governor Valve Adjustment....5-300
Governor Valve Replacement 5-299
Overhaul....5-294, 5-298
Replacement....5-290
Specifications
Fastener Tightening....5-287
Governor Valve Adjustment 5-287
Mechanical....5-287
Air Distribution
Description
System Description
HVAC with A/C - Manual....1-165
Air Distribution System
Description (Non-A/C)....1-53
Air Distributor
Duct Replacement
HVAC with A/C - Manual....1-162, 1-163
Air Distributor Duct Replacement (Non-A/C)1-27, 1-28
Air Drums
Air Brake Chamber Clevis Replacement 5-258, 5-262
Air Brake Chamber Overhaul....5-267, 5-274
Air Drums (cont.)
Air Brake Chamber Replacement....5-264, 5-265
Front 5-265, 5-266
Air Drum Brake Adjustment 5-284, 5-285
Automatic Slack Adjuster Replacement 5-247, 5-253
Brake System Inspection 5-229
Caging the Spring Brake Chamber....5-282
Cam Brake Assembly Replacement....5-233, 5-234
Camshaft Replacement....5-243
Description....5-286
Diagnosis
Brake System....5-229
Drum Inspection 5-231
Drum Refinishing 5-232
Drum Replacement....5-230
Shoe Inspection....5-235
Shoe Replacement....5-236
Specifications
Components 5-227, 5-228
Fastener Tightening 5-227
Air Inlet Valve
Electric Actuator Replacement
HVAC with A/C - Manual....1-153
Air Spring
Replacement
Air Suspension 3-130
Air Suspension
Component Locations....3-109
Component Views....3-109
Connector End Views....3-110
Diagnosis
Dump Indicator Inoperative 3-111
Rear Air Springs Do Not Deflate 3-110
Preventive Maintance 3-112
Schematic
Schematic References 3-107
Specifications
Fastener Tightening 3-107
Suspension Alignment....3-111
Air Suspension Relief Valve Replacement 3-128
Aluminum Wheel
Clearcoat Damage....3-89
Refinishing 3-89
Antenna
Fixed Antenna Mast Replacement 8-139
Antilock Brake System
Bleed Procedure....5-389
BPMV Hydraulic Flow Chart 5-304
Brake Pressure Modulator Valve Replacement 5-390
Component Locations....5-313
Component Views....5-316
Connector End Views....5-323
Description
Abbreviations and Definitions 5-394
ABS System 5-395
ABS System Operation....5-396
Basic Knowledge Required....5-395
General 5-394
Service Precautions 5-394

Antilock Brake System (cont.)
Diagnosis
ABS Indicator Off No DTC Set 5-385
ABS Indicator On No DTC Set 5-387
Clearing Diagnostic Trouble Codes....5-325
Diagnostic System Check....5-326
Displaying Diagnostic Trouble Codes....5-325
DTC List....5-329
Intermittents and Poor Connections....5-325
Scan Tool Diagnostics....5-325
Self-Diagnostics....5-325
Electronic Brake Control Module Replacement....5-390
Schematic
ABS Schematic Icons....5-309
ABS Schematic References....5-308
Schematics....5-309
Special Tools....5-398
Specifications
Fastener Tightening....5-303
Tube Adapter Replacement....5-394
Wheel Speed Sensor Replacement
Front....5-392
Rear....5-393
Audible Warnings
Diagnosis
Chime Always ON....8-334
Chime Inoperative....8-334
Fasten Safety Belt Chime Always ON....8-336
Automatic Transmission - AT542 Allison
Cleaning Tips....7-23
Description and Operation....7-42
Diagnosis
Dirty Fluid....7-19
Excessive Creep in First and Reverse Gears....7-17
Excessive Slip and Clutch Chatter Only One Range....7-19
Fluid Leaking into Converter Housing....7-17
Fluid Out of Fill Tube or Breather....7-20
High Stall Speed....7-18
Intermittent Buzzing Noise....7-17
Low Lubrication Pressure....7-17
Low Main Pressure in All Ranges....7-16
Low Main Pressure in First Gear....7-16
Low Stall Speed....7-18
Output Shaft Seal Fluid Leak....7-19
Rough Shifting....7-18
Shift Speed Too Low....7-16
Slips in All Forward Ranges....7-19
Slips in Fourth and Reverse Gear Only....7-20
Slips in Reverse and First Gear Only....7-20
Transmission Overheats in All Ranges....7-17
Vehicle Moves Backward in Neutral....7-20
Vehicle Moves Forward in Neutral....7-20
Specifications
Fastener Tightening....7-15
Fluid Capacity....7-15
Automatic Transmission - AT543 Allison
Diagnosis
Shift Speed Too High....7-16
Axle Replacement, Front....3-59
Axle Shaft
Replacement
Rear Drive Axle....4-72

B

Battery
Cable Replacement (Engine Electrical)....6-86
Charging (Engine Electrical)....6-83
Charging Low or Completely Discharged (Engine Electrical)....6-83
Jump Starting in Case of Emergency (Engine Electrical)....6-85
Replacement (Engine Electrical)....6-80
Battery Box Replacement....8-383
Battery Disconnect....3
Blower Motor
Description
Control Description
HVAC with A/C - Manual....1-173
Diagnosis
Blower Motor Does Not Operate at Any Speed (Non-A/C)....1-14
Blower Motor Does Not Operate at High Speed (Non-A/C)....1-14
Blower Motor Does Not Operate at Low Speed Only (Non-A/C)....1-16
Blower Motor Does Not Operate at Medium Speed (Non-A/C)....1-15
High Speed Inoperative (A/C - Manual)....1-85
Inoperative at Any Speed (A/C - Manual)....1-82
Low and Medium Speeds Inoperative (A/C - Manual)....1-84
Low Speed Inoperative (A/C - Manual)....1-83
Medium Speed Inoperative (A/C - Manual)....1-84
Motor and Fan Assembly Replacement
HVAC with A/C - Manual....1-131
Motor and Fan Replacment (Non-A/C)....1-24
Resistor Replacement
HVAC with A/C - Manual....1-128
Resistor Replacement (Non-A/C)....1-21
Blower Switch Replacement (Non-A/C)....1-20
Body Front End
Air Scoop Replacement....8-395
Cab Lock Replacement....8-388
Cab Replacement....8-385
Cab Tilt Support Replacement....8-391
Component Box Replacement....8-384
Condenser Splash Shield Replacement....8-396
Front Fender Extension Bracket Replacement....8-394
Front Fender Replacement....8-381
Front Side Panel Replacement....8-396
Specifications
Fastener Tightening....8-377
Upper Step and Support Replacement....8-392
Wheelhouse Panel Replacement....8-397, 8-398
Body Mount Replacement....8-473, 8-477, 8-479
Brake Caliper
Mounting Plate Replacement....5-81, 5-82, 5-83, 5-84
Overhaul....5-70, 5-73, 5-75, 5-78
Replacement....5-51, 5-54, 5-58
Brake Caliper and Anchor Plate Wear Adjustment....5-62, 5-64, 5-66, 5-68

Brake Dust Caution 3
Brake Fluid 4
Brake Pad Inspection 5-43
Brake Pads Replacement 5-44, 5-45, 5-47, 5-49
Brake Pedal Replacement 5-25
Brake Warning System
Component Locations 5-11
Component Views 5-12
Connector End Views 5-15
Schematic
Icons 5-7
References 5-7
Schematics 5-8
Bumpers
Specifications
Fastener Tightening 8-373
Bushing Replacement, Rear Spring 3-71

C

Cab Tilting 0-27
Camber Adjustment, Front 3-20
Caster Adjustment, Front 3-17
Center Bearing Replacement
Propeller Shaft 4-54
Cleaning Tape Head and Capstan, Cassette Cleaning 8-138
Clearance Lamps 8-94
Clearcoat Repair w/o Repainting 8-460
Clearcoat Thickness 8-462
Clutch
Clutch Pressure Plate and Clutch Driven Plate Replacement 7-45
Description
Clutch Driven Members 7-48
Clutch Driving Members 7-48
Clutch Operating Members 7-48
Hydraulic Clutch 7-48
Diagnosis
Grabbing (Chattering) 7-44
Noisy 7-44
Noisy During Engagement 7-44
Rattle (Trans Click) 7-44
Slipping 7-44
Release Bearing Replacement 7-46
Specifications
Fastener Tightening 7-43
Sealers and Lubricants 7-43
Clutch Dust 4
Coding Keys and Lock Cylinders 0-26
Collision Repair 8-485
Compressor
Compressor and Assembly Hose Assembly
HVAC with A/C - Manual 1-108
Description
HVAC with A/C - Manual 1-171
Magnetic Clutch
HVAC with A/C - Manual 1-101, 1-102, 1-103, 1-104, 1-105
Overhaul Assembly
HVAC with A/C - Manual 1-108
Replacement
HVAC with A/C - Manual 1-96
Condenser
Description
HVAC with A/C - Manual 1-171
Condenser Fan Inoperative (A/C - Manual) 1-85
Condenser Fan On at All Times (A/C - Manual) 1-87
Condensor
Replacement
HVAC with A/C - Manual 1-124
Control Assemble
Description
HVAC with A/C - Manual 1-171
Control Assembly
Replacement
HVAC with A/C - Manual 1-146
Replacement (Non-A/C) 1-19
Conversion Table
English/Metric 0-3
Coolant
Description 6-41
Engine Coolant Temperature Sensor Replacement (Engine Cooling) 6-32
Level Sensor Replacement (Engine Cooling) 6-31
Recovery Pipe Replacement (Engine Cooling) 6-14
Recovery Reservoir Replacement (Engine Cooling) 6-13
Corrosion Repair 8-461
Cross Channel Replacement
Air Suspension 3-116
Crossmember
Replacement 8-473

D

Daytime Running Lamps
Relay Replacement 8-95
Decimal and Metric Equivalents 0-3
Defective Scan Tool 5
Definition of Caution, Notice, and Important 3
Diagnosis
Strategy Based Diagnosis 0-32
Differential
Replacement
Rear Drive Axle 4-70
Disc Brakes
Burnishing Pads and Rotors 5-51
Description 5-86, 5-87
Diagnosis
Brake Rotor Lateral Runout Check 5-42
Brake Rotor Thickness Variation Check 5-42
Brake Rotor Tolerance 5-43
Specifications
Brake Lathe 5-41
Component 5-41
Fastener Tightening 5-41
Dome Lamp Replacement 8-96
Doors
Description
Mirrors
Heated Mirror Circuit 8-429
Power Windows
Circuit Description 8-429

Doors (cont.)
Diagnosis
Any Window Inoperative From LH Window Switch 8-409
Heated Mirror System Check 8-407
Mirrors
Heated Side Mirrors Always On 8-412
Heated Side Mirrors Inoperative 8-410, 8-411
Power Windows System Check 8-407
RH Window Inoperative from Both Switches 8-407
Door Replacement 8-414
Door Trim Panel Replacement 8-413
Door Window Replacement 8-423
Inner Lower Window Replacement 8-425
Inside Door Handle Replacement 8-417
Mirrors Replacement 8-427
Outer Lower Window Replacement 8-426
Outside Door Handle Replacement 8-415
Power Door Systems Components 8-402
Power Door Systems Component Views 8-403
Power Door Systems Connector End Views 8-406
Schematic
Outside Mirrors 8-399
Power Door Systems Schematic References 8-399
Power Windows 8-399
Special Tools 8-430
Specifications
Fastener Tightening 8-399
Window Handle Replacement 8-422
Window Regulator Assembly 8-421, 8-422
Window Run Channel Replacement 8-424
Draining and Filling Cooling System (Engine Cooling) 6-10
Driveline
Angle Adjustment Propeller Shaft 4-8
DTC C0221 5-330
DTC C0222 5-333
DTC C0223 5-336
DTC C0225 5-339
DTC C0226 5-342
DTC C0227 5-345
DTC C0231 5-348
DTC C0232 5-351
DTC C0233 5-354
DTC C0235 5-357
DTC C0236 5-360
DTC C0237 5-363
DTC C0238 5-366
DTC C0241-C0258 5-368
DTC C0265/C0266 5-370
DTC C0267/C0268 5-372
DTC C0269/C0274 5-375
DTC C0271-C0273 5-377
DTC C0279 5-378
DTC C0281 5-380
DTC C0286 5-383

E

Electronic Brake Control Module Replacement (Air ABS) 5-448
Engine Cooling
Description
Air Baffles and Seals 6-41
Coolant 6-41
Cooling System 6-39
Engine Oil Cooler 6-40
Radiator Assembly 6-39, 6-40
Transmission/Transaxle Oil Cooler 6-40
Diagnosis
Coolant Concentration Testing 6-7
Cooling System Leak Testing 6-8
Fan Clutch 6-6
Loss of Coolant 6-4
Overheating 6-4
Thermostat 6-6
Special Tools 6-42
Specifications
Fastener Tightening 6-3
Specifications Engine Cooling System 6-3
Engine Electircal
Starting and Charging Connector End Views 6-53
Engine Electric
Specifications
Fastener Tightening 6-43
Engine Electrical
Schematic
Starting and Charging Icons 6-45
Starting and Charging Component Views 6-48
Description
Battery 6-105
Charging System 6-108
Charging System Circuit 6-109
Starting System 6-106
Starting System Circuit 6-108
Starting System Operation 6-106, 6-107
Diagnosis
Battery Electrical Drain/Parasitic Load 6-65
Battery Is Undercharged or Overcharged 6-67
Charge Indicator Always On 6-68
Charge Indicator Inoperative 6-68
Charging System Check 6-56, 6-57
Common Causes of Battery Failure 6-63, 6-64, 6-65
Generator Electrical Test 6-70
Noisy Generator 6-70
Starter Motor Noise 6-62
Starter Motor Relay Test 6-63
Starter No Load Test 6-62
Starter Solenoid Clicks, Engine Does Not Crank 6-61
Starter Solenoid Does Not Click 6-58
Starting System Check 6-55
Schematic
Starting and Charging 6-45
Starting and Charging References 6-45
Special Tools 6-110
Specifications
Battery Usage Table 6-44
General 6-43
Generator Usage Table 6-44

Engine Exhaust
Accelerator Pedal Switch Replacement.....6-141
Clutch Pedal Switch Replacement.....6-142
Description
Exhaust Brake Operation.....6-150
Exhaust System.....6-150
Diagnosis
Exhaust Noise.....6-137
Restricted Exhaust.....6-137
Vibration or Rattling.....6-137
Exhaust Clamps Replacement.....6-140, 6-141
Muffler Replacement.....6-147
Pipe Replacement.....6-145, 6-146
Specifications
Fastener Tightening.....6-137
System Replacement.....6-140
Tail Pipe Replacement.....6-149
Engine Exhaust Brake
Diagnosis.....6-138, 6-139
Engine Exhaust Brake Actuator
Control Valve Replacement.....6-142, 6-144
Engine Exhaust Brake Actuator Stop
Peg Replacement.....6-144
Engine Exhaust Brake Ball Joint
Replacement.....6-144
Engine Identification.....0-8
English/Metric Conversion Table.....0-3
Entertainment
Component Locations.....8-125
Component Views.....8-126
Connector End Views.....8-128
Description
Radio/Audio System.....8-141
Radio/Audio System Circuit.....8-142
Radio/Audio System Operation.....8-141
Diagnosis
Antenna System Test.....8-131
General Radio Noise.....8-130
No Display, No Sound from Speakers.....8-129
One or More Speakers
Inoperative.....8-134, 8-135
Radio Always On.....8-129
Radio Memory Inoperative.....8-129
Tape Player Inoperative.....8-130
Schematic
Icons.....8-123
Radio/Audio System.....8-123
References.....8-123
Evaporator
Core Replacement
HVAC with A/C - Manual.....1-135
Description
HVAC with A/C - Manual.....1-170
Heater/Evaporator Module Assembly
Replacement (A/C - Manual).....1-134
Hose Assembly Replacement
HVAC with A/C - Manual.....1-111
Exterior Trim
Cleaning Bright Metal Parts.....8-362
Emblem/Nameplate Replacement.....8-361
Foreign Material Deposit Removal.....8-362
Washing and Waxing.....8-362

F

Fan
Replacement (Engine Cooling).....6-19, 6-20
Shroud Replacement (Engine Cooling).....6-32
Fastener Notice.....5
Flexible Plastic Part
Refinishing.....8-453
Flushing (Engine Cooling).....6-10
Frame
Repair.....8-468
Straightening.....8-467
Frame and Underbody
Description
Minimizing Frame Service.....8-484
Welding.....8-483
Descrption
General.....8-483
Diagnosis
Checking Frame Alignment.....8-464
Frame.....8-465
Frame Conditions.....8-466
Specifications
Electrode Chart.....8-463
Fastener Tightening.....8-463
Plug Weld Chart.....8-463
Welding Chart.....8-463
Yeild Strength of Different Metals.....8-463
Front Bumper
Replacement.....8-373
Front Suspension
Description
General.....3-61
Diagnosis
Wheel Bearing Test.....3-25
Special Tools.....3-62
Specifications
Fastener Tightening.....3-25
Fuel and EVAP Pipe.....4
Fuel Pipe Fitting.....4
Fuel Pressure.....5
Fuel Storage.....4

G

Garnish Molding Replacement
Side Door Upper.....8-447
Gasoline/Gasoline Vapors.....4
Generator
Bracket Replacement
(Engine Electrical).....6-91, 6-92
Overhaul (Engine Electrical).....6-95
Replacement (Engine Electrical).....6-92
Grille Replacement.....8-361
Ground Strap
Replacement (Engine Electrical).....6-90

H

Handling Electrostatic Discharge (ESD)
Sensitive Parts.....5
Headlamp
Aiming Procedure.....8-93
Headlamp Replacement.....8-91

Heater
Core Replacement (Non-A/C) 1-45, 1-47
Description
Controls (Non-A/C) 1-53
Diagnosis
Heat Excessive (A/C - Manual) 1-93
Heating Insufficient (A/C - Manual) 1-92
Heater/Evaporator Module Assembly
Replacement (A/C - Manual) 1-134
System Description (Non-A/C) 1-52
Heater and Ventilation (Non-A/C)
Description
Air Distribution System 1-53
Heater and Ventiliation (Non-A/C)
Description
Heater System 1-52
Heater Blower Controls
Component Locations 1-6
Component Views (Non-A/C) 1-7
Connector End Views (Non-A/C) 1-12
Schematic
Schematic Reference (Non-A/C) 1-3
Schematics (Non-A/C) 1-3
Heater Pipes Replacement
(A/C - Manual) 1-143, 1-144
Heater System Description
HVAC with A/C - Manual 1-168
Heater/Vent
Module Replacement (Non-A/C) 1-50
Heating and Ventilation (Non-A/C)
Description
Controls 1-53
Operating Modes 1-54
Diagnosis
Excessive Heat 1-18
Insufficient Heating or Defrosting 1-17
Height Leveling Valve Replacement
Air Suspension 3-126, 3-127
Hood Latch Replacement 8-378
Hood Replacement 8-378
Horn
Replacement 8-359, 8-360
Horns
Component Locations 8-353
Component Views 8-353
Connector End Views 8-357
Description
Circuit 8-360
Diagnosis
Horns Inoperative 8-357, 8-358
Horns on at All Times 8-358
Schematic
References 8-351
Schematics 8-351
Specifications
Fastener Tightening 8-351
How to Obtain Replacement Labels 0-17
How to Use Diagnostic Tables 8-150
How to Use the Paper Version of the
Service Manual 0-4
Hub Cap, Adding Lubricant 3-45
Hub Cap Replacement, Front 3-44
HVAC
Component Locations
HVAC with A/C - Manual 1-65
HVAC (cont.)
Component Views
HVAC with A/C - Manual 1-66
Connector End Views
HVAC with A/C - Manual 1-75
Schematic Icons
HVAC with A/C - Manual 1-58
HVAC Blower
Control Schematic
HVAC with A/C - Manual 1-58
HVAC Compressor
Control Schematic
HVAC with A/C - Manual 1-58
HVAC with A/C - Manual
Description
Maintaining Chemical Stability 1-170
Diagnosis
A/C Compressor Clutch Does Not
Disengage 1-81
Improper Air Delivery 1-94
HVAC with A/C - Manual
Compressor Replacement 1-96
Compressor Sealing Washers
Replacement 1-99
Description
ACR4 Procedures 1-173
Compressor/Condenser Fan Ciruit 1-175
Manual A/C Circuit 1-174
Operating Modes 1-164
Relays and Switches 1-172
System Controls 1-174
Ventilation 1-172
Diagnosis
A/C Compressor Clutch Does
Not Engage 1-79
Blower Control System Check
(Manual A/C) 1-78
Condenser Fan Inoperative 1-85
Functional Check 1-78
Heat Excessive 1-93
Heating Insufficient 1-92
Insufficient Cooling 1-93
Leak Testing 1-90
Refrigerant System Checks 1-89
Odor Correction 1-94
O-Ring Replacement 1-101
Refrigerant Recovery 1-95
Special Tools 1-176
Specifications
Compressor 1-57
Fastener Tightening 1-57
Refrigerant Oil Distribution 1-57
Systems Capacities 1-57
HVAC with A/C -Manual
Diagnosis
System Performance Test 1-88
HVAC with A/C Manual
Diagnosis
Condenser Fan On at All Times 1-87
Hydraulic Brake Booster Replacement 5-35
Hydraulic Brakes
Description
Brake Warning System Circuit 5-39
Hydraulic Brake Booster Description 5-38

Hydraulic Brakes (cont.)
Diagnosis
AUX BRAKE Indicator and Alarm On w/Engine Running....5-17
AUX BRAKE Indicator Inoperative....5-18
Brake Fluid Leaks....5-20
Brake Pedal Excessive Effort to Stop....5-20
Brake Pedal Excessive Effort with Engine Off....5-19, 5-20
Brake System....5-19
Brake Warning Indicator Inoperative....5-16
EH Pump and Booster Mating Surface Fluid Leak....5-21
EH Pump End Plate Oil Leak....5-21
EH Pump Motor Oil Leak....5-21
EH Pump Noise....5-21
External Conditions that Affect Brake Performance....5-19
Hydraulic Booster Noise....5-22
Hydraulic System Fluid Loss....5-21
Master Cylinder Diagnosis....5-21
Electrohydraulic Pump Replacement....5-37
Front Brake Hose Replacement....5-29
ISO Flares Replacement....5-28
Master Cylinder Hose Replacement....5-26, 5-27
Pipe Replacement....5-25
Rear Brake Hose Replacement....5-30
Special Tools....5-40
Specifications
Fastener Tightening....5-7
System Bleeding....5-32, 5-33
System Flushing....5-34

I

Identification
Engine....0-8
Rear Axle....0-9
Transmission....0-8
Vehicle....0-5
Ignition OFF When Disconnecting Battery....5
Ignition Switch Replacement (Tilt)....2-65
Instrument Cluster
Description
Circuit....8-346
Instrument Panel
Carrier....8-340
Cluster Replacement....8-337, 8-338
Lamp Replacement....8-96
Instrument Panel, Gauges and Console
Audible Warnings Component Locations....8-330
Audible Warnings Component Views....8-331
Audible Warnings Connector End Views....8-333
Component Locations....8-291
Description
Audible Warnings Circuit....8-350
Audible Warnings Operation....8-347
Diagnosis
All Gauges Inoperative....8-321
Audible Warnings Diagnostic System Check....8-334
Check Gauge Indicator Always On....8-322
Check Gauge Indicator Inoperative....8-323
Instrument Panel, Gauges and Console (cont.)
Engine Coolant Temperature Gauge Always Indicates Cold....8-309
Engine Coolant Temperature Gauge Inaccurate/Inoperative....8-310
Engine Oil Pressure Gauge Always Indicates High Press....8-311
Engine Oil Pressure Gauge Always Indicates Low Press....8-312
Engine Oil Pressure Gauge Innacurate/Inoperative....8-312
Fasten Safety Belt Indicator Always On....8-324
Fasten Safety Belt Indicator Inoperative....8-324
Fuel Gauge Always Indicates Empty....8-313, 8-314
Fuel Gauge Always Indicates Full....8-315, 8-316
Fuel Gauge Innacurate or Inoperative....8-317, 8-318, 8-319
Low Engine Coolant Indicator Always ON....8-324
Low Engine Coolant Indicator Inoperative....8-325, 8-326
Speedometer and/or Odometer Inoperative....8-327
Tachometer Inoperative....8-328
Voltmeter Inaccurate or Inoperative....8-322
Instrument Cluster Component Views....8-292
Instrument Cluster Connector End Views....8-303
Schematic
Audible Warnings Schematic References....8-328
Audible Warnings Schematics....8-328
Instrument Cluster Analog....8-283
Instrument Cluster Schematic Icons....8-283
Instrument Cluster Schematic References....8-283
Specifications
Fastener Tightening....8-283
Interior Trim
Basic Steps Before Cleaning....8-451
Cargo Area Trim
Rear Panel Replacement....8-442
Cleaning Agents....8-450
Cleaning Glass Surfaces....8-451
Cleaning Vinyl Trim....8-450
Door Sill Plate
Replacement....8-442
Front Floor Mat/Carpet Replacement....8-441
Headliner Replacement....8-443
Interior Cleaning....8-451
Overhead Console Replacement....8-444
Quarter Trim Panel Replacement....8-449
Rear Window
Upper Molding Replacement....8-448
Removal Of Specific Stains....8-451
Seat Belt Care....8-452
Spot Cleaning Fabric Trim....8-450
Sunshade
Replacement....8-446
Windshield Pillar Garnish Molding
Replacement....8-446

J

Jacking and Lifting 0-26

K

Key Coding and Lock Cylinders 0-26
King Pin and Steering Knuckle Replacement 3-27
King Pin Bearing Preload 3-57
King Pin Bushing and Bearing Cup Replacement 3-49
King Pin Upper Bearing Repack 3-52

L

Label
Service Parts ID 0-11
Labels, Replacement
How to Obtain 0-17
Leaf Spring Replacement, Rear 3-74
Leaf Springs Replacement, Front 3-33
Lifting and Jacking 0-26
Lighter
Cigar Lighter Replacement 8-339
Lighting Systems
Component Locations 8-19
Component Views 8-22
Connector End Views 8-43
Description 8-100
Backup Lights Circuit 8-101
DaytimeRunning Lamps Circuit 8-100
Exterior Lights Circuit 8-100
Interior Lights 8-101
Interior Lights Dimming Circuit 8-101
Diagnosis
All IP Lamps Inoperative 8-64, 8-66
All Park, Side, and Front Marker Lamps Inoperative 8-70
All Side Marker Lamps Inoperative 8-74
All Stoplamps Inoperative 8-78, 8-79
Backup Lamps Inoperative 8-51
Backup Lights System Check 8-50
Both High Beam Headlamps Inoperative 8-62
Both Low Beam Headlamps Inoperative 8-56, 8-57
Clearance Lamps Inoperative 8-52
Courtesy Lamp or Dome Lamp Inoperative 8-52
Daytime Running Lamps Always On 8-53
Daytime Running Lamps Indicator Inoperative 8-53
Daytime Running Lamps On With Engine Not Running 8-63
Daytime Running Lamps System Check 8-50
Dome Lamp Inoperative When LH Door is Open 8-54
Exterior Lights System Check 8-50
Flash to Pass Inoperative 8-63
Front Parking Lamps Inoperative 8-68
Front Turn Signal Lamps Inoperative 8-81
Front Turn Signals and IP Indicators Inoperative 8-84
Hazard Lamps Inoperative 8-55
High Beam Indicator Inoperative 8-64
Interior Lights Dimming System Check 8-50
Lighting Systems (cont.)
Interior Lights System Check 8-50
IP Turn Signal Indicators Inoperative 8-87
Left High Beam Headlamp Inoperative 8-61
Left Low Beam Headlamp Inoperative 8-55
LF Park Lamp Inoperative 8-69
LF Turn Signal Inoperative 8-81
LH IP Turn Signal Indicator Inoperative 8-87
License and Tail Lamps Inoperative 8-66, 8-67
Lighted Outside Rearview Mirror Lamps Inoperative 8-71, 8-72, 8-73
Low Beam Headlamps On with Headlamp Switch Off 8-59, 8-60
LR Turn Signal Lamp Inoperative 8-85
No LH Turn Signal Output at Trailer Connector 8-88
No RH Turn Signal Output at Trailer Connector 8-89
One Headlamp Inoperative 8-63
One Side Marker Lamp Inoperative 8-73, 8-74
Park, Side Marker, and Clearance Lamps Always On 8-70
Park, Side Marker, and Clearance-Lamps Inoperative 8-70
Rear Turn Signal Lamps Inoperative 8-85
RF Park Lamp Inoperative 8-69
RF Turn Signal Lamp Inoperative 8-83
Right High Beam Headlamp Inoperative 8-61
Right Low Beam Headlamp Inoperative 8-55
RR Turn Signal Lamp Inoperative 8-86
Stoplamps Always On 8-76, 8-77
Stoplamps Inoperative 8-80
RH IP Turn Signal Indicator Inoperative 8-88
Special Tools 8-102
Specifications
Fastener Tightening 8-7
Lock Cylinder Replacement 8-420
Lock Cylinders and Key Coding 0-26
Lock Replacement
Door 8-418
Lock System
Diagnosis
System Sticks in Start
Tilt Wheel/Column 2-63
Lubricant Change
Rear Drive Axle 4-68

M

Main Support
Beam Repair
Air Suspension 3-113
Maintenance and Lubrication
Explanation of Scheduled Services 0-47
Inspections and Other Services 0-50
Long Trip/Highway Maintenance Schedule 0-43
Manitenance Schedule 0-35
Owner Checks and Services 0-43, 0-46
Short Trip/City Maintenance Schedule 0-43
Specifications
Approximate Fluid Capacities 0-33
Maintenance Items 0-34
Recommended Fluids and Lubricants 0-34

Manual Transmission
Description and Operation 7-14
Diagnosis
Jumps Out of Gear 7-3
Manual Transmission 7-3
Noisy Bearings 7-4
Noisy in All Gears 7-5
Noisy in Neutral with Engine Running 7-5
Noisy in the Gears 7-4
Oil Leak 7-4
Sticking in Gear 7-4
Oil Change Procedure 7-9
Replacement 7-12
Specifications
Fastener Tightening 7-3
Lubrication 7-3
Marker Lamp Replacement, Side 8-93
Master Cylinder
Bench Bleeding 5-24
Fluid Level Sensor Replacement 5-24
Replacement 5-23
Reservoir Filling 5-22
Meanings of Abbreviations 0-23
Mode Actuator
Replacement (A/C - Manual) 1-149
Mode Valve
Actuator Replacement (Non-A/C) 1-37
Modulator Valve Replacement (Air ABS)
Front 5-449
Rear 5-448
Moving Parts and Hot Surfaces 4
Multifunction Alarm Module Replacement 8-345

N

Nylon Fuel Lines 5

O

Ordering Information
Special Tools 0-5
Outside Mirror Clearance Lamp Replacement 8-99

P

Paint/Coatings
Anti-Corrosion Treatment 8-457
Paint Identification 8-459
Sheet Metal Refinishing
Basecoat/Clearcoat 8-457
Specifications
Clearcoat Repair - 3M Products 8-455
Clearcoat Repair - Meguiar Products 8-456
Paint Gauges 8-462
Park Brake
Bellcrank and Cam Lever Replacement 5-107
Brake Drum Inspection 5-105
Brake Drum Replacement 5-101, 5-103
Cable Inspection 5-101
Cable Replacement 5-99
Description
System Operation 5-112
Lever Adjustment 5-98
Lever Replacement 5-97
Lubrication Procedure 5-96
Park Brake (cont.)
Shoe Adjustment 5-94
Shoe Inspection 5-93
Shoe Replacement 5-89, 5-90
Specifications
Fastener Tightening 5-89
Support Replacement 5-106
Warning Lamp Switch Replacement 5-98
Parking/Turn Signal
Lamps Replacement 8-94
Pinion
Drive Pinion Yoke Replacement
Rear Drive Axle 4-74
Pitman Arm Replacement 2-59
Power Steering
Bleeding the System 2-27
Description
Power Steering System 2-51
Diagnosis
Excessive Wheel Kickback or
Loose Steering 2-5
Foaming, Milky-Appearing PS Fluid,
Low in Level 2-7
Increase in Effort While Turning
Steering Wheel 2-6
Low Oil Pressure Due to Restriction
in the Hose 2-7
Low Oil Pressure Due to Steering Gear 2-7
Low Oil Pressure Due to Steering Pump 2-6
Noise
Groan in Steering Pump 2-8
Growl in Steering Pump 2-8, 2-9
Objectionable Hiss 2-5
Rattle or Chuckle in Steering Gear 2-5
Rattle or Knock in Steering Pump 2-9
Swish in Steering Pump 2-9
Whine in Steering Pump 2-9
Poor Return of Steering Wheel 2-6
Steering Effort Hard in Both Directions 2-6
System Test Procedure 2-3
Vehicle Leads to One Side or the Other 2-7
Wheel Surges or Jerks While Turning 2-6
End Limiters Replacement 2-42
Flushing
Hoses 2-29
Power Steering System 2-28
Gear Replacement 2-34
Hoses Replacement 2-31
Input Dust Cap Replacement 2-37
Input Shaft Bearing Cap Replacement 2-40
Pressure Relief Valve Replacement 2-44
Pump Replacement 2-10
Reservior Replacement 2-47
Resuction Valve Replacement 2-46
Sector Shaft Dust Cap Replacement 2-36, 2-37
Special Tools 2-51
Specifications
Fastener Tightening 2-3
Power Steering Pump
Overhaul
Pump Assemble 2-12, 2-18
Propeller Shaft
Assembly Component Lubrication 4-51
Description 4-60
Center Bearing 4-62

Propeller Shaft (cont.)
Phasing 4-61
Universal Joint 4-61
Diagnosis
Ping, Snap, or Click Noise 4-7
Roughness or Vibration 4-3, 4-6
Driveline Angle Adjustment 4-8
One-Piece Propeller Shaft Replacement 4-10, 4-12, 4-14, 4-16, 4-18, 4-20, 4-22, 4-24, 4-26
Special Tools 4-62
Specifications
Fastener Tightening 4-3
Three-Piece Propeller Shaft Replacement 4-40, 4-43, 4-45, 4-48
Two-Piece Propeller Shaft Replacement 4-28, 4-30, 4-33, 4-35, 4-38
Proper Use of Torque Wrenches 0-21

R

Radiator
Assembly Description 6-39, 6-40
Cleaning (Engine Cooling) 6-11
Hose Replacement (Engine Cooling) 6-17, 6-18
Lower Mounting Panel Replacement (Engine Cooling) 6-36
Replacement (Engine Cooling) 6-33
Radio Replacement 8-137
Rail Dust Damage Repair 8-462
Rear Axle Controls
Components 4-92
Connector End Views 4-93
Description
Two Speed Rear Axle Circuit 4-102
Two Speed Rear Axle Shift System 4-101
Diagnosis
Two Speed Rear Axle Shift Motor 4-94, 4-95
Two Speed Rear Axle System Check 4-94
Schematic
Icons 4-89
References 4-89
Specifications
Fastener Tightening 4-89
Two Speed Rear Axle Schematics 4-90
Two Speed Rear Axle Shift Motor Relay Replacement 4-97
Two Speed Rear Axle Shift Motor Replacement 4-99
Rear Axle Identification 0-9
Rear Drive Axle
Description
Rear Axle 4-86, 4-87
Diagnosis
Determining Type of Noise 4-63
General Information 4-67
Noise Diagnosis 4-66
Housing Replacement 4-82
Special Tools 4-87
Specifications
Fastener Tightening 4-63
Rear Hub and Bearing Replacement
Rear Drive Axle 4-77, 4-80, 4-81
Rear Suspension
Diagnosis
Spring Maintenance 3-63
Rear Suspension (cont.)
Special Tools 3-86
Specifications
Fastener Tightening 3-63
Rear Window
Replacement 8-369
Receiver Dehydrator and Evaporator Hose Assembly
HVAC with A/C - Manual 1-115
Receiver Dehydrator Replacement
HVAC with A/C - Manual 1-117
Refrigerant
Description
Handling of Refrigerant Lines and Fittings (HVAC with A/C - Manual) 1-169
R-134a
HVAC with A/C - Manual 1-168
Handling R-134a
HVAC with A/C - Manual 1-169
Refrigeration System Description
HVAC with A/C - Manual 1-165, 1-167
Relay
Steering Linkage (Non-Rack Pinion)
Relay Rod Replacement 2-58
Relay Rod Replacement 2-58
Relief Valve Replacement, Air Suspension 3-128
Road Test 4

S

Safety Glasses and Compressed Air 4
Safety Goggles and Fuel 4
Seat Belts
Center Seat Belt Replacement 9-11
Description
System Operation 9-12
Diagnosis
Operational and Functional Checks 9-3
Driver or Passenger Seat Belt Replacement 9-4
Seat Belt Service Precautions 9-3
Specifications
Fastener Tightening 9-3
Seat Replacement
Center 8-433
Seats
Diagnosis
Manual Seat
Adjuster Between Lock Positions 8-431
Adjuster Does Not Lock 8-431
Adjuster Does Not Unlock 8-431
Seat Replacement 8-432
Seat Riser Replacement 8-434, 8-438
Specifications
Fastener Tightening 8-431
Service Manual
Description of Arrows and Symbols 0-5
General Information
Fasteners 0-17, 0-19, 0-20
Thread Inserts 0-20
How to Use the Paper Version 0-4
RPO Code List 0-11
Service Parts ID Label 0-11
Shift Cable
Adjustment (Automatic AT542 Allison) 7-26
Adjustment (Manual Transmission) 7-8
Replacement (Automatic AT542 Allison) 7-24

Shift Cable (cont.)
Replacement (Manual Transmission) 7-6
Shock Absorber
Replacement
Air Suspension 3-129
Shock Absorber Replacement, Front 3-47
Shock Absorber Replacement, Rear 3-70
ShopTowel Fuel Link 4
Single Cylinder Flooding 5
Slip Joint Replacement
Propeller Shaft 4-52
Speaker Replacement 8-140
Special Tools
Antilock Brake System 5-398
Doors 8-430
Engine Cooling 6-42
Engine Electrical 6-110
Front Suspension 3-62
HVAC with A/C - Manual 1-176
Hydraulic Brakes 5-40
Lighting Systems 8-102
Power Steering 2-51
Propeller Shaft 4-62
Rear Drive Axle 4-87
Rear Suspension 3-86
Stationary Windows 8-372
Steering Linkage (Non-Rack Pinion) 2-62
Steering Wheel/Column - Tilt 2-78
Special Tools Ordering Information 0-5
Specifications
Battery Usage Table
Engine Electrical 6-44
Brake Lathe
Disc Brakes 5-41
Components
Air Drums 5-227, 5-228
Disc Brakes 5-41
Compressor
HVAC with A/C - Manual 1-57
Engine Cooling System
Engine Cooling 6-3
Fastener Tightening
Air Brakes 5-113
Air Compressor 5-287
Air Drums 5-227
Air Suspension 3-107
Antilock Brake System 5-303
Clutch 7-43
Disc Brakes 5-41
Doors 8-399
Engine Cooling 6-3
Engine Electrical 6-43
Engine Exhaust 6-137
Front Suspension 3-25
Heater and Ventilation, Non-A/C 1-3
HVAC with A/C - Manual 1-57
Hydraulic Brakes 5-7
Lighting Systems 8-7
Manual Transmission 7-3
Park Brake 5-89
Power Steering 2-3
Propeller Shaft 4-3
Rear Axle Controls 4-89
Rear Drive Axle 4-63
Rear Suspension 3-63
Specifications (cont.)
Seat Belts 9-3
Seats 8-431
Steering Linkage (Non-Rack Pinion) 2-53
Tilt Wheel/Column 2-63
Tires and Wheels 3-87
Wheel Alignment 3-17
General
Engine Electrical 6-43
Generator Usage Table
Engine Electrical 6-44
Governor Valve Adjustment
Air Compressor 5-287
Lubrication
Manual Transmission 7-3
Mechanical
Air Compressor 5-287
Refrigerant Oil Distribution
HVAC with A/C - Manual 1-57
Sealers and Lubricants
Clutch 7-43
System Capacities
HVAC with A/C - Manual 1-57
Wheel Alignment 3-17
Speedometer Driven Gear
Backlash Adjustment
(Manual Transmission) 7-10
Replacement (Manual Transmission) 7-10
Splicing Inline Harness Diodes 8-172
Spring
Air Spring Frame Hanger Replacement
Air Suspension 3-117
Bumper Replacement, Rear 3-84
Bushing Replacement, Rear 3-71
Hanger Bracket Insulator Replacement
Air Suspension 3-119
Hanger Replacement, Rear 3-80
Leaf Replacement, Rear 3-78
Rear Leaf Spring Replacement 3-74
Spring Bumper Replacement 3-33
Spring Replacement, Front Leaf 3-33
Stabilizer Shaft Replacement 3-26
Stabilizer Shaft Replacement, Rear 3-64
Starter
Motor Inspection (Engine Electrical) 6-76
Motor Overhaul (Engine Electrical) 6-73
Motor Relay Replacement
(Engine Electrical) 6-71
Motor Replacement (Engine Electrical) 6-71
Stationary Windows
Quarter Window Replacement 8-368
Special Tools 8-372
Window Polishing 8-371
Steering Arm Replacement 2-56
Steering Knuckle and King Pin Replacement 3-27
Steering Linkage
Description
Non-Rack Pinion 2-62
Steering Linkage (Non-Rack Pinion)
Inspection 2-53
Pitman Arm Replacement 2-59
Special Tools 2-62
Specifications
Fastener Tightening 2-53
Steering Arm Replacement 2-56

Steering Linkage (Non-Rack Pinion) (cont.)
Tie Rod Arm Replacement....2-57
Tie Rod Replacement....2-54
Steering Shaft
Lower Shaft Assembly Replacement (Tilt)....2-74
Upper Shaft Assembly Replacement (Tilt)....2-71
Steering Wheel/Column - Tilt
Description
Steering Wheel and Column....2-77
Diagnosis
High Steering Shaft Effort....2-63
Key Cannot Be Removed in the Off Lock Position....2-63
Loose Steering Wheel (Every Other Tilt Position)....2-64
Noise in Steering Column....2-63
Noise When Tilting Steering Column....2-64
Steering Wheel Does Not Lock in Any Tilt Position....2-64
Steering Wheel Not Returning to Top Tilt Position....2-64
Turn Signal Does Not Cancel....2-64
Lock System Sticks in Start....2-63
Multifunction Signal Lever Replacement (Tilt)....2-66
Special Tools....2-78
Tilt Lever Replacement....2-67
Steering Wheel Replacement (Tilt)....2-68
Strategy Based Diagnostic Flow....8-160
Striker Replacement
Door....8-420
Struts or Shock Absorber
Diagnosis
Binding....3-7
Struts or Shock Absorbers
Diagnosis
Bench Test....3-8
Struts or Shock Absorbers
Diagnosis
On-Vehicle Testing....3-8
Surge Tank
(Diesel) Replacement (Engine Cooling)....6-11
Inlet Pipe Replacement (Engine Cooling)....6-15
Outlet Pipe Replacement (Engine Cooling)....6-16
Suspension
Air
Air Spring Frame Hanger Replacement....3-117
Air Spring Replacement....3-130
Cross Channel Replacement....3-116
Description
Air Control System....3-132
Air Suspension Relief Valve....3-132
Height Leveling Valve....3-132
Rear Air Suspension....3-132
Hanger Bracket Insulator Replacement....3-119
Height Leveling Valve Replacement....3-126, 3-127
Relief Valve Replacement....3-128
Shock Absorber Replacement....3-129
Suspension Controls Circuit Description....3-132
Torque Rod Bushing Replacement....3-121
Torque Rod Replacement....3-120
Air Transverse Rod Replacement....3-122, 3-124
Suspension (cont.)
Descriptioin
General....3-15
Diagnosis
Abnormal or Excessive Tire Wear....3-3
Excessive Road Shock....3-7
Front Wheel Shimmy....3-9
Hard Steering....3-9
Low or Uneven Trim Height....3-14
Noisy Front Suspension....3-6
Poor Directional Stability....3-7
Spring Breakage....3-9
Spring Noise....3-8
Spring Sags or Bottoms....3-8
Struts or Shock Absorber Bench Test....3-8
Struts or Shock Absorbers Binding....3-8
Struts or Shock Absorbers On-Vehicle Testing....3-8
Suspension Bottoms....3-3
Tire Hop or Poor Handling....3-7
Vehicle Leads/Pulls....3-3
Wander or Poor Steering Stability....3-6
Wheel Bearings....3-10
Front
Description
General....3-61
Rear
Description
General....3-86
Diagnosis
Spring Maintenance....3-63
Switch
Blower Switch
Replacement....1-147
Engine Oil Pressure Switch Replacement....8-339
Fluid Flow Switch Replacement....5-38
Ignition Switch Replacement (Tilt)....2-65
Low Air Pressure Warning Switch Replacement....5-189
Pneumatic Stoplamp Switch Replacement....5-173
Stoplamp Switch Replacement....5-38
Trailer Stoplamp Switch Replacement....5-174
Two Speed Rear Axle Shift Control Switch Replacement....4-97
Wipers/Washer Switch Replacement....8-120
Switch (Blower)
Replacement (Non-A/C)....1-20

T

Tail Lamp Replacement....8-97, 8-98
Temperature Valve
Actuator Replacement
HVAC with A/C - Manual....1-158
Temp Valve Actuator
Replacement (Non-A/C)....1-33
Thermal Expansion Valve Replacement
HVAC with A/C - Manual....1-119
Thermostat
Housing Replacement (Engine Cooling)....6-20
Replacement (Engine Cooling)....6-22
Tie Rod Arm Replacement....2-57
Tie Rod Replacement....2-54

Tilting
Cab....0-27
Tilt Lever Replacement....2-67
Tilt Wheel/Column
Specifications
Fastener Tightening....2-63
Tire
Description....3-102
Inflation Description....3-103
Matching....3-98
Measuring....3-101
Mounting and Dismounting....3-94
Repair Description....3-103
Rotation....3-98
Valve Core and Cap Replacement....3-102
Tires and Wheels
Description....3-102
Inflation....3-103
Load Range/Ply Rating....3-105
Repair....3-103
Vehicle Certification Label....3-105
Wheels....3-105
Diagnosis
Hub Bolt and Nut....3-87, 3-88
Rim/Hub Bolt Check....3-88
Wheel Mounting Surface Check....3-87
Specifications
Fastener Tightening....3-87
Wheel Installation....3-91, 3-92
Wheel Removal....3-90
Toe Adjustment, Front....3-21
Torque Rod
Bushing Replacement
Air Suspension....3-121
Replacement
Air Suspension....3-120
Torque Wrenches
Proper Use....0-21
Tow Hook Replacement....8-480
Towing
Disabled Vehicle....0-30
Transmission
Replacement (Automatic AT542 Allison)....7-30
Transmission Identification....0-8
Transverse Rod
Replacement
Air Suspension....3-122, 3-124

U

Universal Joints Replacement
Propeller Shaft....4-58

V

Valve Core and Cap Replacement....3-102
Vehicle Certification Label....0-7
Vehicle Identification....0-5
Vehicle Lifting....4
Vent Hose
Replacement
Rear Drive Axle....4-76
Vibration
Balancing Tires and Wheels....0-71
Vibration (cont.)
Correcting Driveline Vibration - RWD and 4WD....0-76
Correcting Non-Uniform Tires....0-75
Correcting Tire and Wheel Vibration....0-71
Description
General Description....0-94
Diagnosis....0-52
Classifying the Vibration....0-56
Driveline Vibration Analysis w/ EVA....0-63
Engine Related Vibration....0-67
Road Test....0-52
Systematic Approach....0-52
Tire and Wheel Vibration....0-59
Wheel Runout Measurement....0-59
General Service Precautions....0-71
Special Tools....0-105
Specifications
Vibration Diagnosis....0-51
Wheel Weight Usage....0-75
VIN
VIN Derivative....0-6

W

Washer Pump/Reservoir Replacement....8-114
Waterleaks
Diagnosis
Air Hose Test....8-364
Test Preparation....8-363
Water Hose Test....8-364
Generalized Testing....8-363
Stationary Window Waterleak Repair....8-364
Water Pump
Overhaul (Engine Cooling)....6-26
Replacement (Engine Cooling)....6-23
Wheel
Installation
Tires and Wheels....3-91, 3-92
Removal
Tires and Wheels....3-90
Wheel Alignment
Description
Camber....3-23
Caster....3-23
Frame Misalignment....3-24
General....3-23
Steering Axis Inclination....3-24
Toe....3-23
Front Camber Adjustment....3-20
Front Caster Adjustment....3-17
Front Toe Adjustment....3-21
Specifications....3-17
Fastener Tightening....3-17
Stop Screw Adjustment....3-21, 3-22
Wheel Bearing Adjustment
Rear Drive Axle....4-84
Wheel Bearing Adjustment, Front....3-45
Wheel Hub, Bearing, Knuckle, and Seal Replacement, Front....3-36, 3-40
Wheel Hub Bolt Replacement
Rear Drive Axle....4-86
Wheels
Description....3-105
Window Removal....4

Windshield
Replacement 8-366
Upper Reveal Molding Replacement 8-365
Wiper Arm Blade Replacement 8-116
Wiper Arm Replacement 8-116
Wiper Center Pivot Replacement 8-117
Wiper Chatter Repair 8-120
Wiper Motor Replacement 8-118
Wipers/Washer Systems
Component Locations 8-105
Component Views 8-106
Connector End Views 8-108
Description
Circuit 8-121
System Operation 8-121
Windshield Wipers/Washer System 8-121
Diagnosis
System Check 8-109
Washer Does Not Shut Off 8-113
Washer Pump Inoperative 8-112
Windshield Wiper Motor Inoperative (All Modes) 8-110
Windshield Wiper Operates Only in High Speed, Low Speed Inoperative 8-111
Wiper Arm Tip Pressure Check, Blade Element Check 8-114
Wiper Does Not Shut Off 8-111
Wiper Operates Only in Low Speed, High 8-110
Wipers and Washer Inoperative 8-109
Schematic References 8-103
Schematics (Pulse) 8-103
Wiper Transmission Replacement 8-119
Wiper/Washer Switch Replacement 8-120
Wiring Systems
Data Link Connector (DLC) Components 8-226
Data Link Connector (DLC) Component Views 8-226
Data Link Connector (DLC) End Views 8-227
Description
Data Link Connector (DLC) 8-229
Data Link Connector (DLC) Circuit 8-229
Data Link Connector (DLC) Operation 8-229
Harness Routing Views 8-258
Inline Harness Connector End Views 8-230
Diagnosis 8-150, 8-160, 8-172
Checking Aftermarket Accessories 8-162
Cigar Lighter Inoperative 8-222
Connector Position Assurance Locks 8-174
Connector Repairs 8-173
Data Link Connector (DLC) System Check 8-227
Electrical Symbols 8-151
General Electrical Diagnosis Procedures 8-156
HO2S Wiring Repairs 8-173
Wiring Systems (cont.)
How to Use Circuit Descriptions 8-151
How to Use Component Location Tables 8-147
How to Use Component Location Views 8-148
How to Use Connector End Views 8-149
How to Use Diagnostic System Checks 8-149
How to Use Electrical Diagnosis 8-146
How to Use Electrical Schematics 8-146
How to Use Schematic Icon Table 8-147
How to Use Schematic Reference Tables 8-147
Scan Tool Does Not Communicate w/Components 8-227, 8-228
Symptom Diagnostic Example 8-161
Terminal Position Assurance Locks 8-174
Testing for Continuity 8-164
Testing for Electrical Intermittents 8-166
Testing for Poor Connections 8-166
Testing for Short to Ground 8-165
Testing for Voltage 8-164
Troubleshooting with a Digital Multimeter 8-163
Troubleshooting with a Short Finder 8-163
Troubleshooting with a Test Light 8-162
Upfitter Provision Relay Inoperative 8-223
Using Connector Test Adapters 8-163
Using Fused Jumper Wires 8-163
Where to Find Electrical Schematics 8-143
Wiring Repairs 8-167
Power and Grounding Components 8-204
Power and Grounding Component Views 8-218
Power and Grounding Connector End Views 8-221
Schematics
Data Link Connector (DLC) Schematic Icons 8-224
Data Link Connector (DLC) Schematic References 8-224
Data Link Connector (DLC) Schematics 8-224
Fuse Block Details 8-175
Ground Distribution 8-175
Power and Grounding Schematic Icons 8-175
Power and Grounding Schematic References 8-175
Power Distribution 8-175
Upfitter Provision 8-175
Specifications
Fastener Tightening 8-143
Work Stall Test 5

Y

Yoke Replacement
Propeller Shaft 4-56

BLANK



FSI98-WSM-C01

FS198-WSM-C01_2
Printed in U.S.A.
855-WSM2-803KA01-C.86