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PACCAR Inc

Law Department

November 13, 2002

RECEIVED NVS-215 2002 NOV 14 A 11:58 OFFICE OF DEFECTS INVESTIGATION

SENT VIA AIRBORNE EXPRESS

Richard Boyd, Chief
Medium and Heavy Vehicle Division
Office of Defects Investigation
National Highway Traffic Safety Administration
400 Seventh Street, S.W.
Washington, D.C. 20590

Re: NVS-214gtb
PE02-060 & 061

Dear Mr. Boyd:

PACCAR Inc (PACCAR) submits the following responses to the Information Request identified above. Responses to each specific request contain information from Peterbilt Motors Company and Kenworth Truck Company. Peterbilt and Kenworth are unincorporated divisions of PACCAR. The stated intent of the requests is to provide information about PACCAR's experience regarding ABS tone ring corrosion.

1. Provide the number of "individually-installed" ABS tone rings by supplier that PACCAR Inc has installed in original equipment subject vehicles by vehicle model and year of vehicle production since 1996.

Response:

There are none. PACCAR does not install "individually-installed" ABS tone rings in any of the subject vehicles it manufactures.

2. Provide the number of complaints, claims, reports or incidents occurring in a vehicle equipped with "individually-installed" ABS tone rings reported to PACCAR Inc from all sources of which PACCAR Inc is aware and which relate, or could relate, to the alleged defect in the subject vehicles including, but not limited to:

   a. owner/fleet complaints (fleet complaints should indicate qty of vehicles affected at the complaining fleet, not the number of fleets reporting an issue);
   b. warranty claims;
   c. field reports;
   d. crash/incident claims;
   e. subrogation claims;
   f. lawsuits; and

7356
P.O. Box 1518 Bellevue, Washington 98009 Telephone 425-468-
PACCAR Building 777-106th Avenue N.E. Bellevue, Washington 98004 Facsimile 425-468-8228

g. third-party arbitration proceedings (where PACCAR Inc is a party to the arbitration).

For each such complaint, claim, report, or incident identified above, please provide the following information:

a. VIN
b. For the "Individually-Installed" tone ring, identify
   1. The part number and description on the "individually-installed" tone ring component and
   2. The company name, address, and contact name of the supplier of the vehicle's tone ring component.
c. For the Anti-Lock Brake System (ABS), identify
   1. The part number, name, or description of the anti-lock brake system (ABS) installed and
   2. The company name, address, and contact name of the supplier of the vehicle's anti-lock brake system (ABS).

Response:
Not applicable, see response to 1.

3. Provide a summary of the number of "Integrated Tone Ring Components" by supplier that PACCAR Inc has installed in original equipment subject vehicles by year of vehicle production since 1996.

Response:
All of the subject vehicles manufactured by Peterbilt and Kenworth have Gunite Hub assemblies with integral tone rings.

	Peterbilt	Kenworth
'96-'99	0	0
2000	33	0
2001	52	44
2002	125	132

4. Provide the number of complaints, claims, reports or incidents occurring in a vehicle equipped with "Integrated Tone Ring Components" ABS tone rings reported to PACCAR Inc from all sources of which PACCAR Inc is aware and which relate, or could relate, to the alleged defect in the subject vehicles including, but not limited to:

a. owner/fleet complaints (fleet complaints should indicate qty of vehicles affected at the complaining fleet, not the number of fleets reporting an issue);
b. warranty claims;

c. field reports;
d. crash/incident claims;
e. subrogation claims;
f. lawsuits; and
g. third-party arbitration proceedings (where PACCAR Inc is a party to the arbitration).

For each incident of the alleged defect occurring in a vehicle equipped with an "Integrated Tone Ring Component" reported to PACCAR Inc, please provide the following information:

a. VIN
b. For the "Integrated Tone Ring Component," identify
    1. The part number and description on the "Integrated Tone Ring Component" and
    2. The company name, address, and contact name of the supplier of the "Integrated Tone Ring Component."
c. For the Anti-Lock Brake System (ABS), identify
    1. The part number, name, or description of the anti-lock brake system (ABS) installed and
    2. The company name, address, and contact name of the supplier of the vehicle's anti-lock brake system (ABS).

Response:

Kenworth and Peterbilt have not received any warranty claims, owner/fleet complaints, field reports, claims, or notifications from any source with regard to tone ring corrosion.

5. Provide a copy of any service or technical bulletins, advisories, or other communications to dealers, zone offices, or field offices that PACCAR Inc has issued pertaining to the alleged defect.

Response:

Nothing of this nature has been issued by Kenworth or Peterbilt because there are no instances of the alleged defect occurring in either product.

6. Provide a copy of all inspection, maintenance, and/or replacement recommendations regarding ABS tone/exciter rings installed in the subject vehicles.

Response:

1. Meritor Wabco Hydraulic ABS for Medium-Duty Trucks, Buses and Motor Home Chassis Maintenance Manual No. 39 Revised 09-00, for D Version Hydraulic ABS. (Enclosed, applicable for both Kenworth and Peterbilt)

2. GUNITE Disc Brake Rotors Maintenance Manual. (Enclosed, applicable for only Peterbilt)

The above information was compiled on November 8th, 2002. PACCAR is available to answer any further questions the Office of Defects Investigation may have regarding the information contained in this response.

Very truly yours,

Kenneth R. Brownstein
Senior Counsel

KRB:ptg
Enclosures

e-mail: ken.brownstein@paccar.com

$2.50

MERITOR WABCO

Hydraulic ABS for Medium-Duty Trucks, Buses and Motor Home Chassis

Maintenance Manual No. 39
Revised 09-00

For D Version Hydraulic ABS

Service Notes

Before You Begin

This manual provides maintenance and service instructions for Meritor WABCO's hydraulic ABS for medium-duty trucks, buses and motor home chassis. Before you begin procedures:

1. Read and understand all instructions and procedures before you begin to service components.
2. Read and observe all Caution and Warning safety alerts that precede instructions or procedures you will perform. These alerts help to avoid damage to components, serious personal injury, or both.
3. Follow your company's maintenance and service, installation, and diagnostics guidelines.
4. Use special tools when required to help avoid serious personal injury and damage to components.

Safety Alerts, Torque Symbol and Notes

⚠ *WARNING*	A Warning alerts you to an instruction or procedure that you must follow exactly to avoid serious personal injury and damage to components.
⚠ *CAUTION*	A Caution alerts you to an instruction or procedure that you must follow exactly to avoid damage to components and possible serious injury.
T	A torque symbol alerts you to tighten fasteners to a specified torque value.
NOTE	A Note provides information or suggestions that help you correctly service a component.

Access Information on ArvinMeritor's Web Site

Additional maintenance and service information for ArvinMeritor's commercial vehicle systems component lineup is also available at www.arvinmeritor.com.

To access information, click on Products & Services/Tech Library Icon/HVS Publications. The screen will display an index of publications by type.

MERITOR WABCO

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Asbestos and Non-Asbestos Fibers

MERITOR WABCO

ASBESTOS FIBERS WARNING

The following procedures for servicing brakes are recommended to reduce exposure to asbestos fiber dust, a cancer and lung disease hazard. Material Safety Data Sheets are available from Arvinmeritor.

Hazard Summary

Because some brake linings contain asbestos, workers who service brakes must understand the potential hazards of asbestos and precautions for reducing risks. Exposure to airborne asbestos dust can cause serious and possibly fatal diseases, including asbestosis (a chronic lung disease) and cancer, principally lung cancer and mesothelioma (a cancer of the lining of the chest or abdominal cavities). Some studies show that the risk of lung cancer among persons who smoke and who are exposed to asbestos is much greater than the risk for non-smokers. Symptoms of these diseases may not become apparent for 15, 20 or more years after the first exposure to asbestos.

Accordingly, workers must use caution to avoid creating and breathing dust when servicing brakes. Specific recommended work practices for reducing exposure to asbestos dust follow. Consult your employer for more details.

Recommended Work Practices

1. Separate Work Areas. Whenever feasible, service brakes in a separate area away from other operations to reduce risks to unprotected persons. OSHA has set a maximum allowable level of exposure for asbestos of 0.1 fiber as an 8-hour time-weighted average and 1.0 fiber averaged over a 30-minute period. Scientists disagree, however, to what extent adherence to the maximum allowable exposure levels will eliminate the risk of disease that can result from inhaling asbestos dust. OSHA requires that the following sign be posted at the entrance to areas where exposures exceed either of the maximum allowable levels:

AA

NIOSH ASBESTOS
CANCER AND LUNG DISEASE HAZARD
AUTHORIZED PERSONNEL ONLY
RESPIRATORS AND PROTECTIVE CLOTHING
ARE REQUIRED IN THIS AREA.

2. Respiratory Protection. Wear a respirator equipped with a high-efficiency (HEPA) filter approved by NIOSH or MSHA for use with asbestos at all times when servicing brakes, beginning with the removal of the wheels.

3. Procedures for Servicing Brakes.

a. Enclose the brake assembly within a negative pressure enclosure. The enclosure should be equipped with a HEPA vacuum and worker arm sleeves. With the enclosure in place, use the HEPA vacuum to loosen and vacuum residue from the brake parts.

b. As an alternative procedure, use a catch basin with water and a biodegradable, non-phosphate, water-based detergent to wash the brake drum or rotor and other brake parts. The solution should be applied with low pressure to prevent dust from becoming airborne. Allow the solution to flow between the brake drum and the brake support or the brake rotor and caliper. The wheel hub and brake assembly components should be thoroughly wetted to suppress dust before the brake shoes or brake pads are removed. Wipe the brake parts clean with a cloth.

c. If an enclosed vacuum system or brake washing equipment is not available, employers may adopt their own written procedures for servicing brakes, provided that the exposure levels associated with the employer's procedures do not exceed the levels associated with the enclosed vacuum system or brake washing equipment. Consult OSHA regulations for more details.

d. Wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA for use with asbestos when grinding or machining brake linings. In addition, do such work in an area with a local exhaust ventilation system equipped with a HEPA filter.

e. **NEVER** use compressed air by itself, dry brushing, or a vacuum not equipped with a HEPA filter when cleaning brake parts or assemblies. **NEVER** use carcinogenic solvents, flammable solvents, or solvents that can damage brake components or sealing agents.

4. Cleaning Work Areas. Clean work areas with a vacuum equipped with a HEPA filter or by wet wiping. **NEVER** use compressed air or dry sweeping to clean work areas. When you empty vacuum cleaners and handle used rags, wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA for use with asbestos. When you replace a HEPA filter, wet the filter with a fine mist of water and dispose of the used filter with care.

5. Worker Clean-Up. After servicing brakes, wash your hands before you eat, drink or smoke. Shower after work. Do not wear work clothes home. Use a vacuum equipped with a HEPA filter to vacuum work clothes after they are worn. Launder them separately. Do not shake or use compressed air to remove dust from work clothes.

6. Waste Disposal. Dispose of discarded linings, used rags, cloths and HEPA filters with care, such as in sealed plastic bags. Consult applicable EPA, state and local regulations on waste disposal.

Regulatory Guidance

References to OSHA, NIOSH, MSHA, and EPA, which are regulatory agencies in the United States, are made to provide further guidance to employers and workers employed within the United States. Employers and workers employed outside of the United States should consult the regulations that apply to them for further guidance.

NON-ASBESTOS FIBERS WARNING

The following procedures for servicing brakes are recommended to reduce exposure to non-asbestos fiber dust, a cancer and lung disease hazard. Material Safety Data Sheets are available from Arvinmeritor.

Hazard Summary

Most recently manufactured brake linings do not contain asbestos fibers. These brake linings may contain one or more of a variety of ingredients, including glass fibers, mineral wool, aramid fibers, ceramic fibers and silica that can present health risks if inhaled. Scientists disagree on the extent of the risks from exposure to these substances. Nonetheless, exposure to silica dust can cause silicosis, a non-cancerous lung disease. Silicosis gradually reduces lung capacity and efficiency and can result in serious breathing difficulty. Some scientists believe other types of non-asbestos fibers, when inhaled, can cause similar diseases of the lung. In addition, silica dust and ceramic fiber dust are known to the State of California to cause lung cancer. U.S. and international agencies have also determined that dust from mineral wool, ceramic fibers and silica are potential causes of cancer.

Accordingly, workers must use caution to avoid creating and breathing dust when servicing brakes. Specific recommended work practices for reducing exposure to non-asbestos dust follow. Consult your employer for more details.

Recommended Work Practices

1. Separate Work Areas. Whenever feasible, service brakes in a separate area away from other operations to reduce risks to unprotected persons.

2. Respiratory Protection. OSHA has set a maximum allowable level of exposure for silica of 0.1 mg/m³ as an 8-hour time-weighted average. Some manufacturers of non-asbestos brake linings recommend that exposures to other ingredients found in non-asbestos brake linings be kept below 1.0 fiber as an 8-hour time-weighted average. Scientists disagree, however, to what extent adherence to the maximum allowable exposure levels will eliminate the risk of diseases that can result from inhaling non-asbestos dust.

Therefore, wear respiratory protection at all times during brake servicing, beginning with the removal of the wheels. Wear a respirator equipped with a high-efficiency (HEPA) filter approved by NIOSH or MSHA, if the exposure levels may exceed OSHA or manufacturers' recommended maximum levels. Even when exposures are expected to be within the maximum allowable levels, wearing such a respirator at all times during brake servicing will help minimize exposure.

3. Procedures for Servicing Brakes.

a. Enclose the brake assembly within a negative pressure enclosure. The enclosure should be equipped with a HEPA vacuum and worker arm sleeves. With the enclosure in place, use the HEPA vacuum to loosen and vacuum residue from the brake parts.

b. As an alternative procedure, use a catch basin with water and a biodegradable, non-phosphate, water-based detergent to wash the brake drum or rotor and other brake parts. The solution should be applied with low pressure to prevent dust from becoming airborne. Allow the solution to flow between the brake drum and the brake support or the brake rotor and caliper. The wheel hub and brake assembly components should be thoroughly wetted to suppress dust before the brake shoes or brake pads are removed. Wipe the brake parts clean with a cloth.

c. If an enclosed vacuum system or brake washing equipment is not available, carefully clean the brake parts in the open air. Wet the parts with a solution applied with a pump-spray bottle that creates a fine mist. Use a solution containing water, and, if available, a biodegradable, non-phosphate, water-based detergent. The wheel hub and brake assembly components should be thoroughly wetted to suppress dust before the brake shoes or brake pads are removed. Wipe the brake parts clean with a cloth.

d. Wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA when grinding or machining brake linings. In addition, do such work in an area with a local exhaust ventilation system equipped with a HEPA filter.

e. **NEVER** use compressed air by itself, dry brushing, or a vacuum not equipped with a HEPA filter when cleaning brake parts or assemblies. **NEVER** use carcinogenic solvents, flammable solvents, or solvents that can damage brake components or sealing agents.

4. Cleaning Work Areas. Clean work areas with a vacuum equipped with a HEPA filter or by wet wiping. **NEVER** use compressed air or dry sweeping to clean work areas. When you empty vacuum cleaners and handle used rags, wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA, to minimize exposure. When you replace a HEPA filter, wet the filter with a fine mist of water and dispose of the used filter with care.

5. Worker Clean-Up. After servicing brakes, wash your hands before you eat, drink or smoke. Shower after work. Do not wear work clothes home. Use a vacuum equipped with a HEPA filter to vacuum work clothes after they are worn. Launder them separately. Do not shake or use compressed air to remove dust from work clothes.

6. Waste Disposal. Dispose of discarded linings, used rags, cloths and HEPA filters with care, such as in sealed plastic bags. Consult applicable EPA, state and local regulations on waste disposal.

Regulatory Guidance

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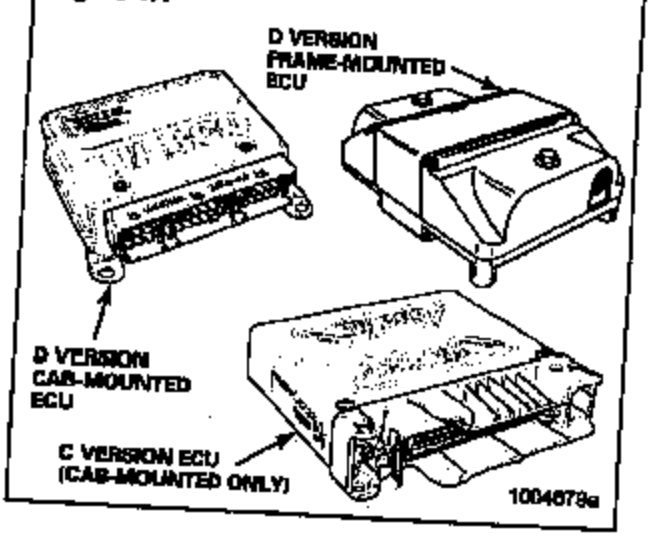
Overview

Meritor WABCO Hydraulic Anti-lock Braking System (ABS) is an electronic wheel speed monitoring and control system used on medium-duty trucks, buses and motor home chassis equipped with a hydraulic brake system.

There are two systems available, C and D version hydraulic ABS. D version ECUs are available in both cab- and frame-mounted versions. **Figure 1.1.**

Figure 1.1



Maintenance Manual Information

This manual contains service information for the Meritor WABCO **D version** cab- and frame-mounted hydraulic ABS. If you are servicing a **C version** hydraulic ABS, you will need Maintenance Manual 38.

To determine which version hydraulic ABS is installed on the vehicle you are servicing, please refer to the ECU Identification portion of this manual. If you are not able to identify the version, or to request service literature, please contact the Meritor Customer Service Support Center at 800-535-5560.

How Hydraulic ABS Works

ABS wheel sensors detect wheel speeds. The sensors generate signals that are transmitted to an Electronic Control Unit (ECU). If the wheels start to lock, the ECU signals the modulator assembly to regulate the brake pressure of each locking wheel.

During an ABS stop, a solenoid valve in the modulator assembly is rapidly pulsed; that is, it opens and closes several times per second to control the brake pressure. When this occurs, drivers may notice a pulsation of the brake pedal.

An ABS indicator lamp on the vehicle dash alerts the driver to a possible system fault and provides blink code information to diagnose the system.

If the ABS indicator lamp comes on during normal vehicle operation, drivers may complete their trip, but are instructed to have their vehicles serviced as soon as possible.

In the unlikely event of an ABS system malfunction, the ABS in the affected wheel will be disabled and will return to normal braking. The other sensed wheels will retain their ABS function.

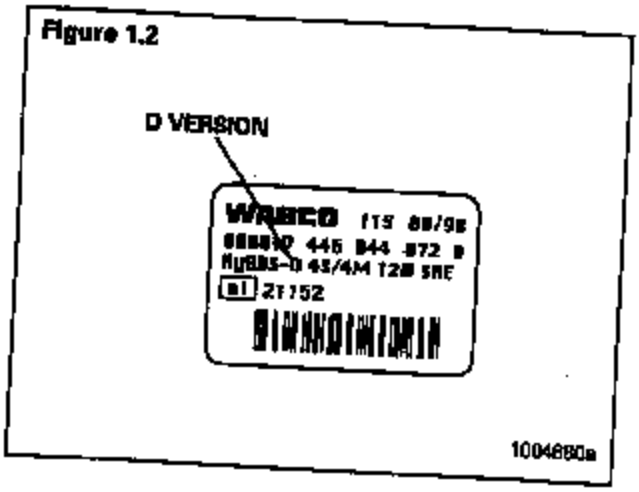
ECU Identification

NOTE: Do not open the ECU. Opening the ECU to gain access to the internal components will void the warranty.

It's easy to determine the hydraulic ABS version installed on the vehicle by looking at the ECU. C version system ECUs are larger than D version ECUs. (Refer to **Figure 1.1.**)

If the ECU is easily visible, look at the part number identification tag. D version ECUs will have a D designation printed on the tag. There is no letter designation on C version ECUs. **Figure 1.2.**

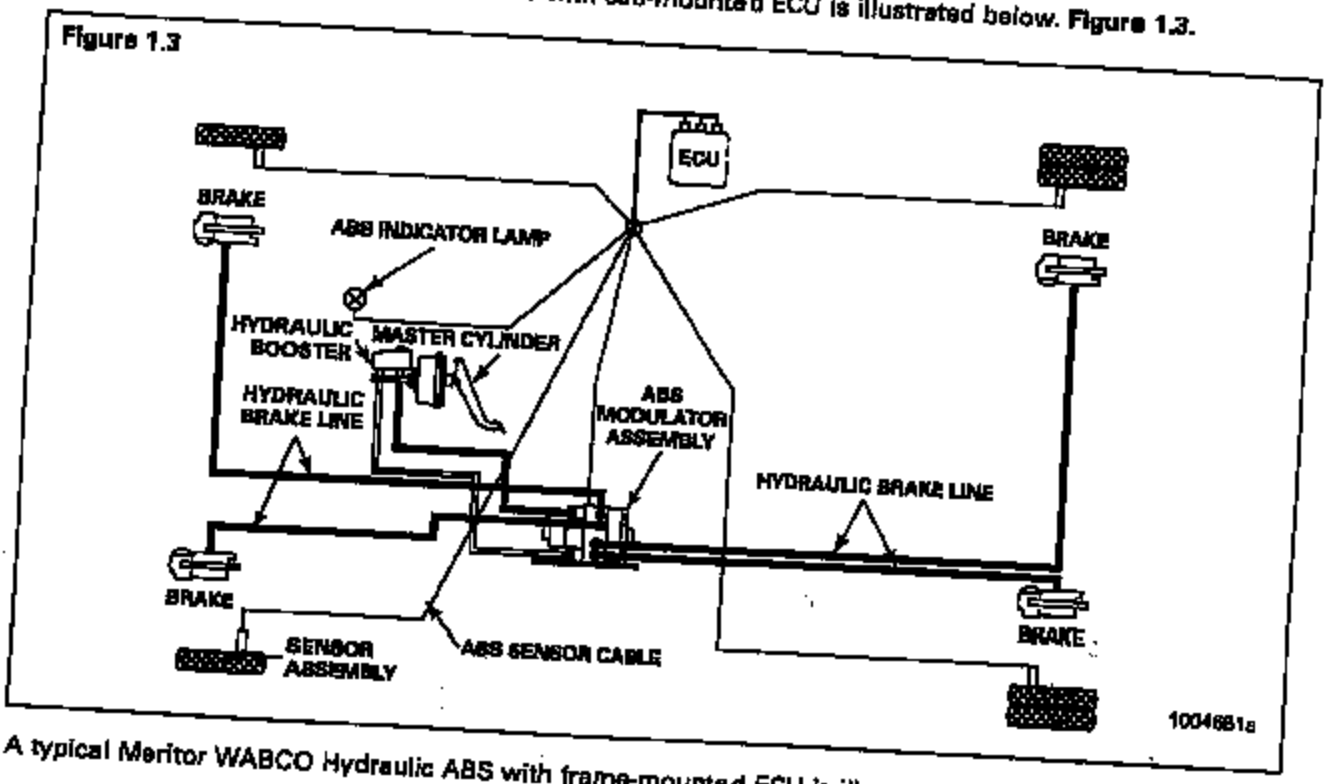
Figure 1.2



System Layout

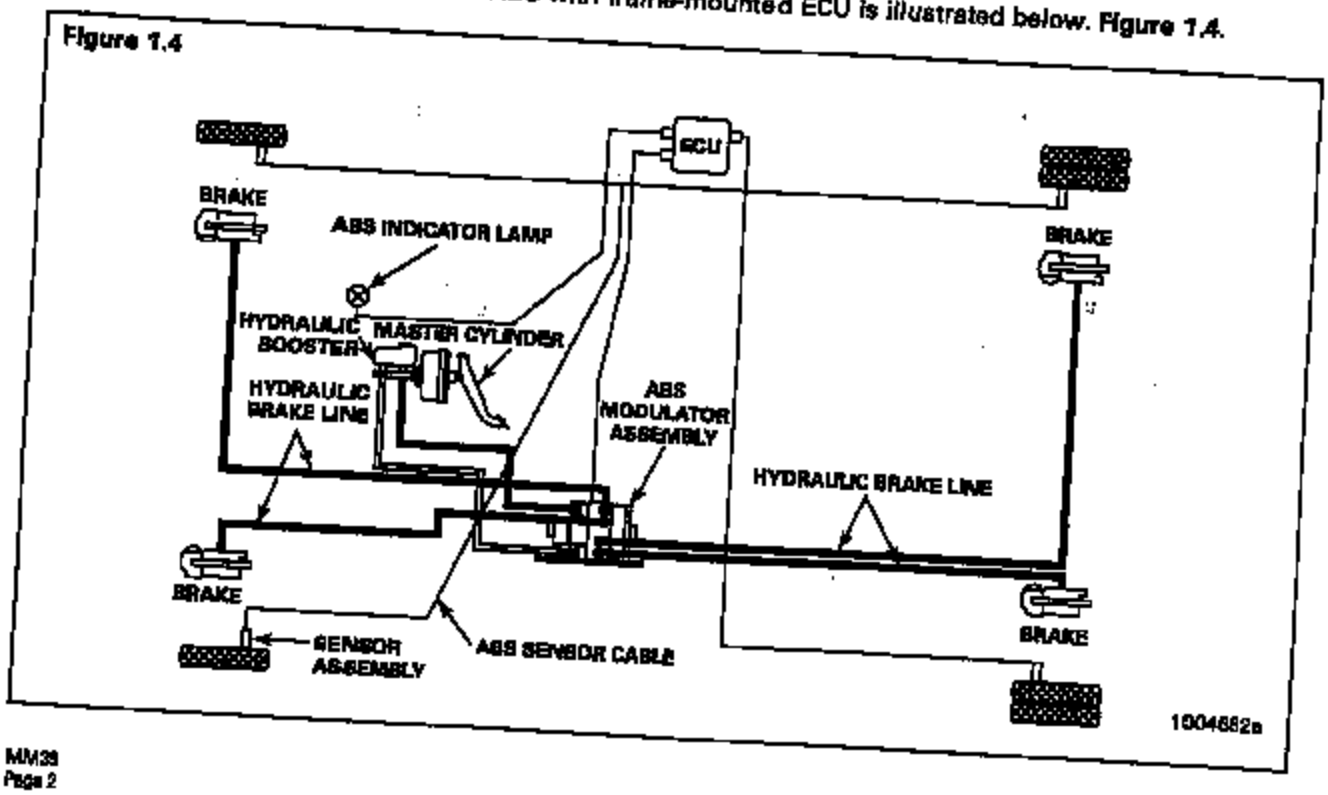
A typical Meritor WABCO Hydraulic ABS with cab-mounted ECU is illustrated below. Figure 1.3.

Figure 1.3



A typical Meritor WABCO Hydraulic ABS with frame-mounted ECU is illustrated below. Figure 1.4.

Figure 1.4

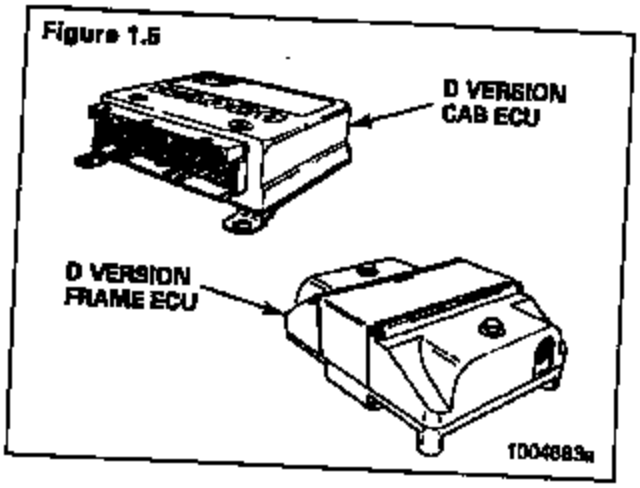


System Components

The following components make up the Meritor WABCO Hydraulic ABS.

Electronic Control Unit (ECU)

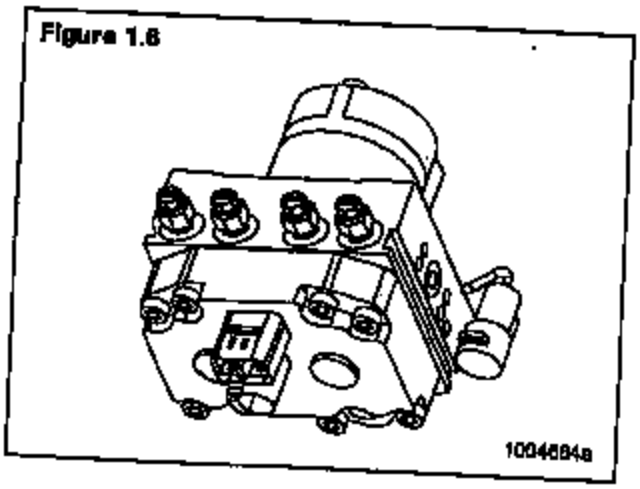
Figure 1.5



- Processes sensor signals and generates solenoid valve commands to reduce, maintain or reapply brake pressure.
- Mounting locations vary, depending upon the vehicle. Refer to the vehicle specifications for the exact location. Cab- and frame-mounted versions available.

Modulator Assembly

Figure 1.6

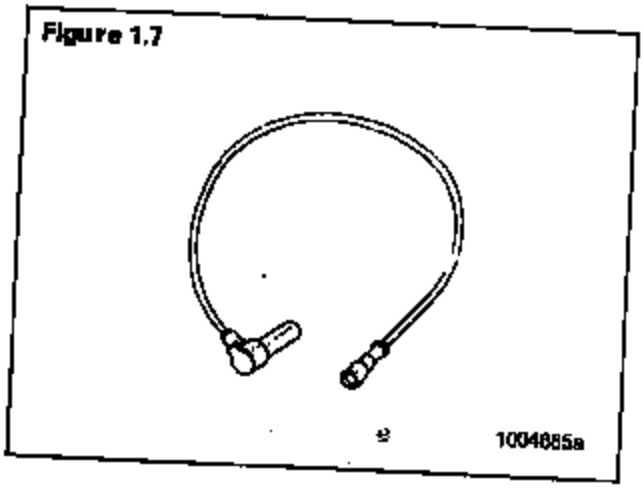


- Houses the ABS solenoid control valves (one inlet valve and one outlet valve per wheel), a pump motor and two accumulators.
- Contains brake fluid and must be handled with appropriate care. It should not be exposed to impact loads, excessive vibrations or compressed air blown into the hydraulic ports.

Sensors

Sensor with Molded Socket

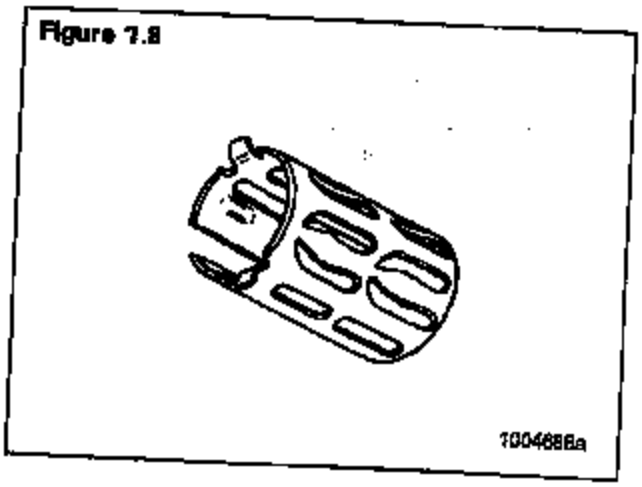
Figure 1.7



- Measures the speed of a tooth wheel rotating with the vehicle wheel.
- Produces an output voltage proportional to wheel speed.

Sensor Spring Clip

Figure 1.8



- Holds the wheel speed sensor in close proximity to the tooth wheel.

Tooth Wheel

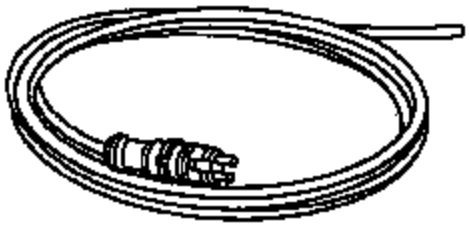
Figure 1.9

1004687a

- A machined or stamped ring mounted to a machined surface on the hub of each ABS-monitored wheel.

Sensor Extension Cables

Figure 1.10



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- Two-wire cable with molded-on connector.
- Connects the wheel speed sensor to the ECU.

ABS Indicator Lamp

Figure 1.11

1004689a

- Located on vehicle dash.
- Alerts drivers to a possible system fault.
- Used by service personnel to display blink codes.
- ABS indicator lamp is not provided by Meritor WABCO.

Figure 1.12

1004690a

- A PC-based diagnostics program.
- Displays system faults and wheel speed data, tests individual components, verifies installation wiring and more.
- Runs in Windows® 95, 98 or NT.
- To order, call 800-535-5560.

NOTE: An RS232 to J1708 converter box is required.

General Maintenance Information

There is no regularly scheduled maintenance required for Meritor WABCO D Version Hydraulic ABS. However, ABS does not change current vehicle maintenance requirements. For example, it is important that the vehicle brake fluid level be properly maintained.

System Wiring Information

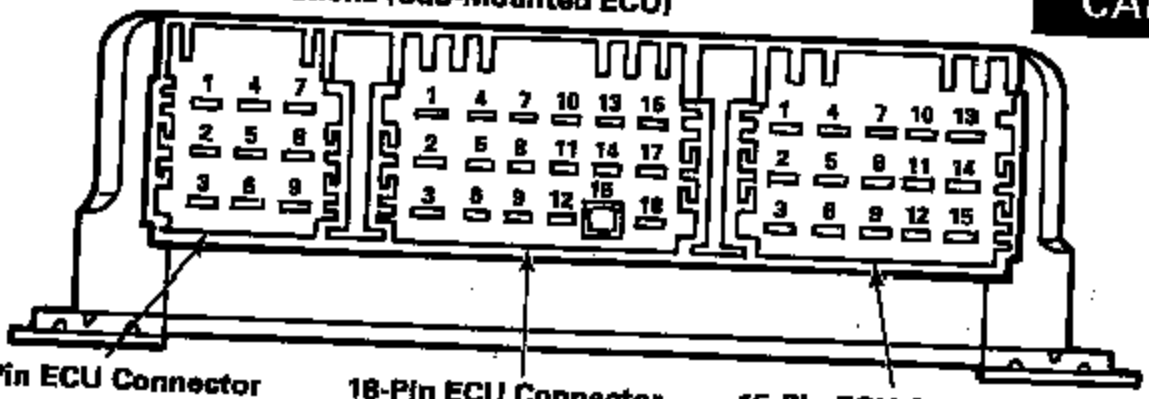
NOTE: Refer to **Table A** for ECU pin identification.

Wiring may vary, according to the vehicle. Refer to the vehicle specifications for specific wiring diagrams. A typical Meritor WABCO 4S/4M Hydraulic ABS wiring diagram appears in **Figure 2.1.**

Table A: Wiring **Refer to Appendix A for Modulator Assembly Connector Pin Assignments**

Pin Numbers and Locations (Cab-Mounted ECU)

CAB



9-Pin ECU Connector

Pin Number	Circuit Description
1	Left Front Sensor
2	Left Front Sensor
3	Right Rear Sensor
4	Right Front Sensor
5	Right Front Sensor
6	Right Rear Sensor
7	Left Rear Sensor
8	Left Rear Sensor
9	Not Used

18-Pin ECU Connector

Pin Number	Circuit Description
1	+12 Battery
2	+12 Ignition
3	Not Used
4	Not Used
5	SAE J1587 (–)
6	SAE J1587 (+)
7	Not Used
8	Motor Monitor
9	Not Used
10	Not Used
11	Not Used
12	Ground
13	Not Used
14	Not Used
15	Jumper
16	Not Used
17	Not Used
18	ABS Indicator Lamp and Blink Code Switch

15-Pin ECU Connector

Pin Number	Circuit Description
1	Left Front Outlet Valve
2	Left Front Inlet Valve
3	Ground
4	Right Front Outlet Valve
5	Right Front Inlet Valve
6	Not Used
7	Left Rear Outlet Valve
8	Left Rear Inlet Valve
9	Not Used
10	Right Rear Outlet Valve
11	Right Rear Inlet Valve
12	Retarder Relay
13	Not Used
14	Not Used
15	Pump Relay

1004691a

Figure 2.1

4S/4M D Version Hydraulic ABS Wiring Diagram (Cab-Mounted ECU)

CAB

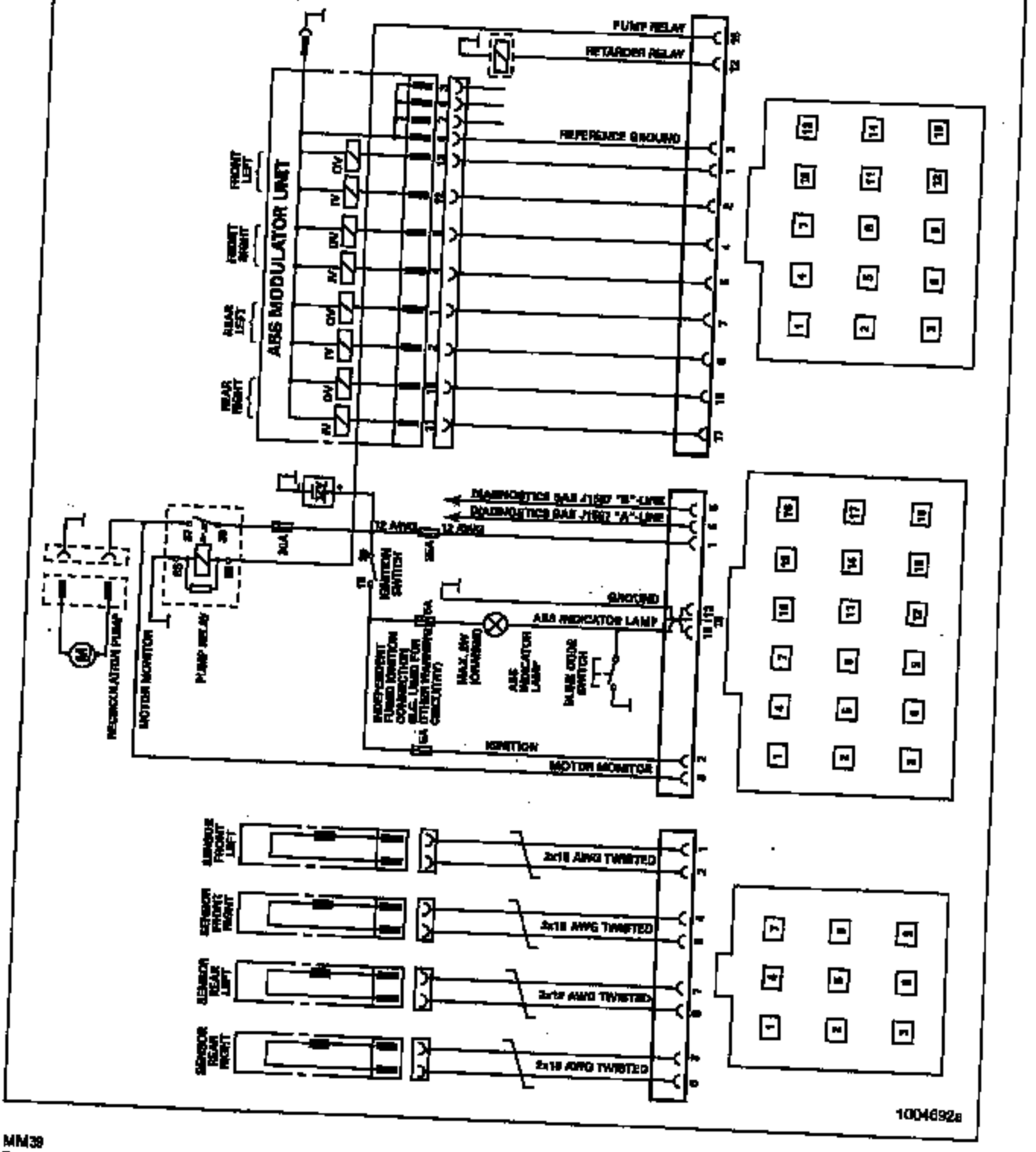
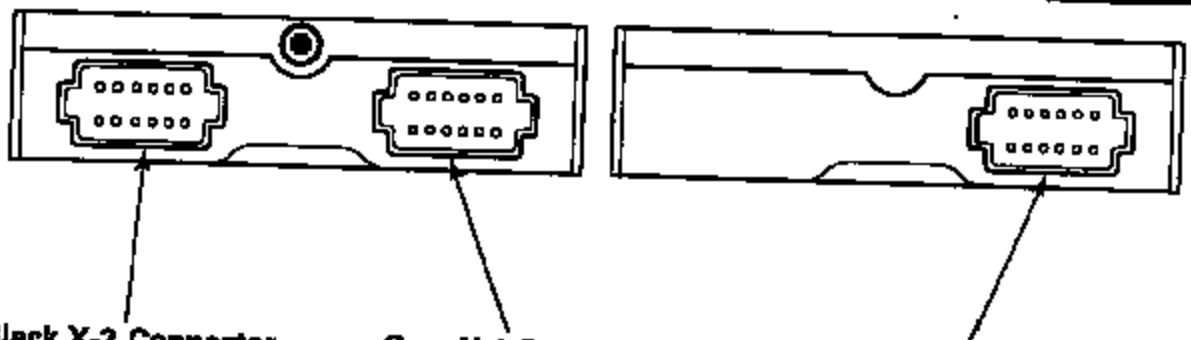


Table B: Wiring **Refer to Appendix A for Modulator Assembly Connector Pin Assignments**

Pin Numbers and Locations (Frame-Mounted ECU)

FRAME



Black X-2 Connector

Pin Number	Circuit Description
1	SAE J1587 (–)
2	+12 Ignition
3	+12 Battery
4	Warning Lamp Relay
5	X
6	Pump Relay
7	Retarder Relay
8	ABS Indicator Lamp and Blink Code Switch
9	Ground
10	Motor Monitor
11	+12 Battery
12	SAE J1587 (+)

Gray X-1 Connector

Pin Number	Circuit Description
1	X
2	Ground
3	Left Front Inlet Valve
4	Right Front Inlet Valve
5	Left Rear Inlet Valve
6	Right Rear Inlet Valve
7	Right Rear Outlet Valve
8	Left Rear Outlet Valve
9	Right Front Outlet Valve
10	Left Front Outlet Valve
11	X
12	X

Green X-3 Connector

Pin Number	Circuit Description
1	X
2	X
3	Left Rear Sensor
4	Right Front Sensor
5	Left Front Sensor
6	Right Rear Sensor
7	Right Rear Sensor
8	Left Front Sensor
9	Right Front Sensor
10	Left Rear Sensor
11	X
12	X

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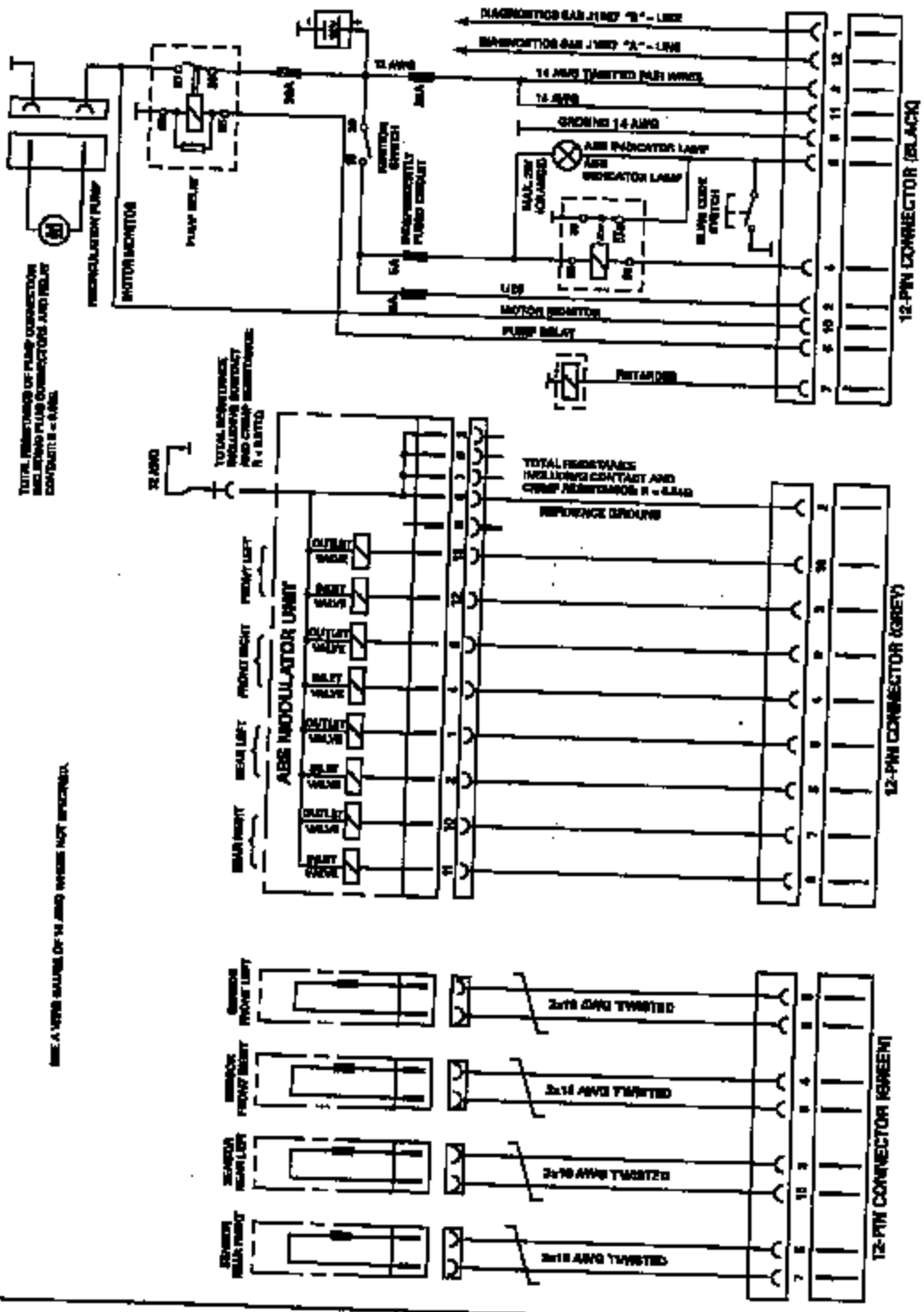
Figure 2.2

FRAME

4S/4M D Version Hydraulic ABS Wiring Diagram (Frame-Mounted ECU)



System Diagnostics

Use Meritor WABCO's PC-based diagnostic program, TOOLBOX Software, or standard blink codes to diagnose hydraulic ABS faults. Information for using standard blink codes appears on page 11 of this manual.

Meritor WABCO TOOLBOX Software

NOTE: For complete instructions for using this program, refer to the User's Manual, TP-99102. Contact Meritor WABCO at 800-535-5560 for information about TOOLBOX Software.

If you have TOOLBOX Software installed on your computer, use it to identify system faults. Then, follow the on-screen repair information to make the necessary repairs or replacements.

To display D version Hydraulic ABS faults, use the pull-down menu or the HABS icon **Figure 2.3** to select HABS (Hydraulic ABS) from the **Main Menu**. The **Hydraulic ABS Main Menu** will appear. **Figure 2.4.**

Select the View ECU Faults icon or select Display Faults to use the pull-down menu. **Figure 2.5.** This will display the **Fault Information** screen. **Figure 2.6.**

Figure 2.3

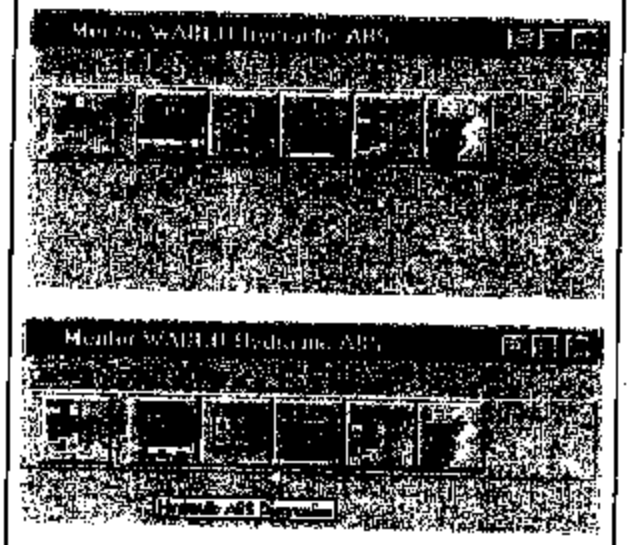


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Figure 2.4

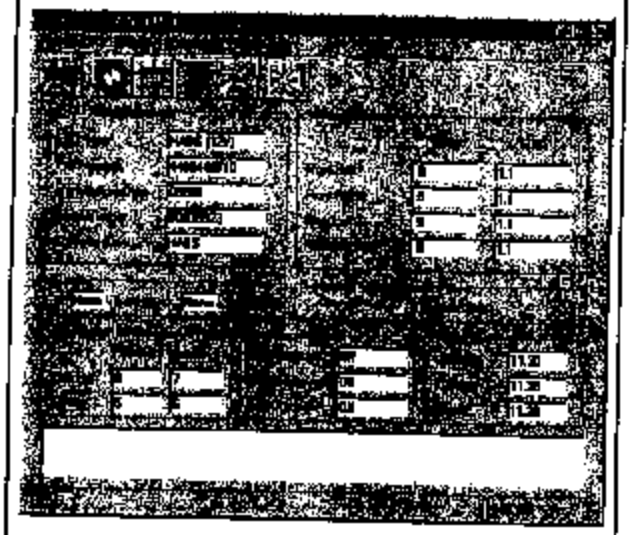

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Figure 2.5

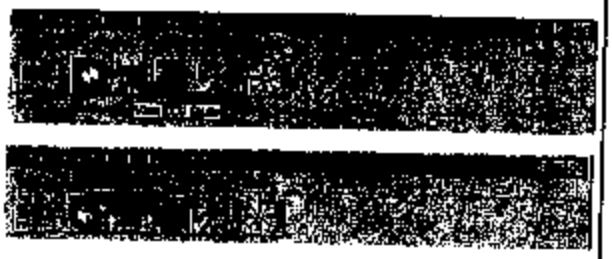

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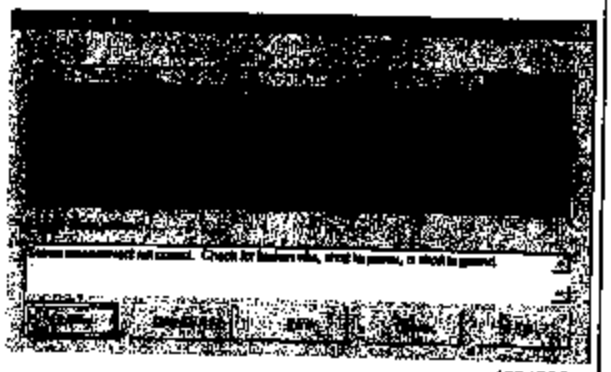
Figure 2.6



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The **Fault Information Screen** contains a description of the fault. Repair instructions for each fault appear at the bottom of the screen.

Faults that occur after the screen is displayed will not appear until a screen update is requested. Use the UPDATE button to refresh the fault information table.

After making the necessary repairs, use the CLEAR FAULTS button to clear the fault. Use the update button to refresh the fault information table and display the new list of faults.

Blink Code Diagnostics

Definitions

ABS Indicator Lamp: This lamp, located on the vehicle dash, serves two purposes:

1. Alerts drivers or service personnel to a possible fault in the hydraulic ABS, as follows:

   IF . . . the ABS indicator lamp comes on briefly then goes OFF when the ignition is turned ON . . . . . there are no active or stored faults in the hydraulic ABS

   IF . . . the ABS indicator lamp comes on and **stays on** AFTER the ignition is turned ON

   and

   The vehicle is driven in excess of 4 mph (6 km/h) . . . ➤ **There may be an active fault in the hydraulic ABS**

   IF . . . ABS indicator lamp comes on and stays on

   and

   Goes OFF after the vehicle is driven in excess of 4 mph (6 km/h) . . . ➤ **There may be a stored fault in the hydraulic ABS**

2. Displays diagnostic blink codes for easy servicing.

Blink Code: A series of blinks or flashes that describe a particular ABS system condition. (Refer to **Table D** [cab-mounted] or **Table E** [frame-mounted] for blink code identification.)

Blink Code Diagnostics: The ability of the Meritor WABCO ECU to sense faults in the ABS system and to define these faults via blink codes.

Blink Code Switch: A momentary switch that activates blink code diagnostic capabilities. Usually, it is mounted under the dash or on the steering column. Refer to the vehicle specifications for type and location.

Clearing Fault Codes: The process of erasing faults from the ECU memory bank. (Refer to **Table C.**)

Fault Code: An ABS condition (fault) detected and stored in memory by the Meritor WABCO ECU and displayed by blink code. System faults may be **Active** or **Stored.**

Active Fault: A condition that currently exists in the ABS system; for example, a sensor circuit malfunction on the left front steering axle. An active fault **must be repaired before you can display additional faults.** Once an active fault has been repaired, it becomes a stored fault.

Stored Fault: A condition that caused the system to register a fault, but **is not currently active.** For example, a loose wire that corrected itself. A stored fault can also be an active fault that has been corrected (refer to Active Fault).

Table C describes the method of distinguishing between active and stored faults and explains how to clear them.

Using Blink Code Diagnostics

Follow the steps listed in **Table C** to use blink code diagnostics. Refer to **Figure 2.7** for blink code illustrations.

Table C: Identifying D-Version Hydraulic ABS Blink Codes

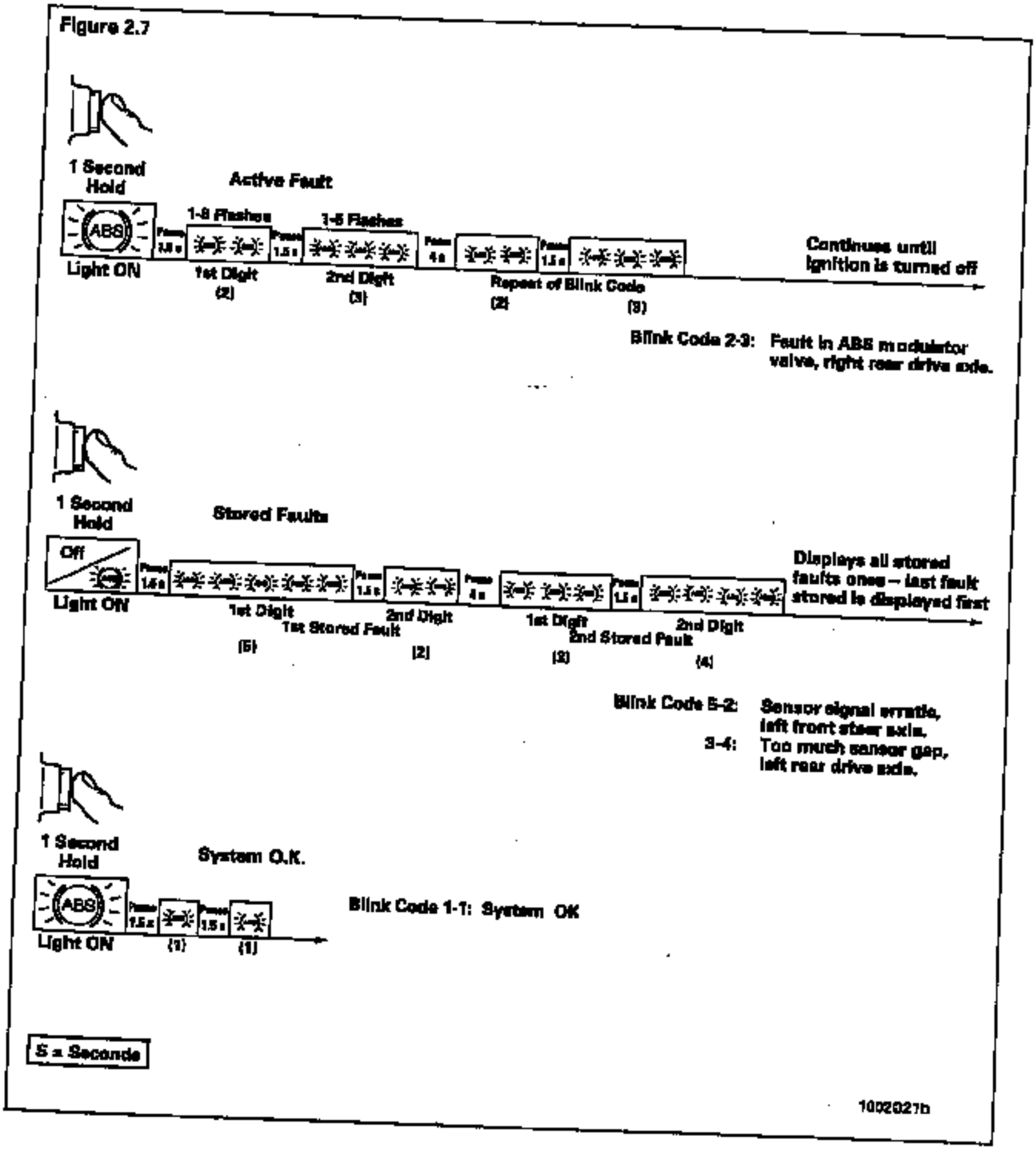
Troubleshooting with Blink Code Diagnostics			
Mode	**Procedure**	**System Response**	**Action**
DIAGNOSTIC	**Step I.** Turn Ignition ON.	Possible responses: 1. ABS indicator lamp comes on momentarily then goes out, indicating System O.K. 2. ABS indicator lamp does not light, indicating possible wiring fault or burned-out bulb. 3. ABS indicator lamp stays on, indicating: • Fault, or faults, in the system. • Sensor fault during last operation. • Faults cleared from ECU, but vehicle not driven. • ECU disconnected.	No recognizable active faults in the ABS. No action required. Inspect wiring. Inspect bulb. Make necessary repairs. Continue with blink code diagnostics. (Go to Step II.) Continue with blink code diagnostics. (Go to Step II.) Drive vehicle — lamp will go out when vehicle reaches 4 mph (6 km/h). Connect ECU.
	Step II. Press and hold Blink Code Switch for one second, then release.	ABS indicator lamp begins flashing two-digit blink code(s).	Determine if fault is active or stored: **Active Fault:** Lamp will repeatedly display one code. **Stored Fault:** Lamp will display code for each stored fault then stop blinking. Faults will be displayed **one time only.**
	Step III. Count the flashes to determine the blink code.	First Digit: 1 - 8 flashes, Pause (1-1/2 seconds). Second Digit: 1 - 8 flashes, Pause (4 seconds).	Find definition for blink code on blink code chart.
	Step IV. Turn Ignition OFF. Repair and Record faults.	Active Fault. Stored Faults.	Make the necessary repairs. Record for future reference.
CLEAR	**Step V.** Turn Ignition ON. Clear Faults from memory: **Press and hold** blink code switch for at least three seconds, then release.	ABS indicator Lamp flashes eight times. Eight flashes not received.	All stored faults successfully cleared. Turn ignition OFF. Turn ignition ON. The indicator lamp will stay on. This is because the ECU is looking for wheel speed. Drive the vehicle at a speed of 4 mph (6 km/h). Once the ECU senses wheel speed, the lamp will go off. Active faults still exist, repeat Steps I through V.

* If you receive a blink code that is not identified in **Table D** or **Table E**, contact the Customer Support Center at 800-535-5560.

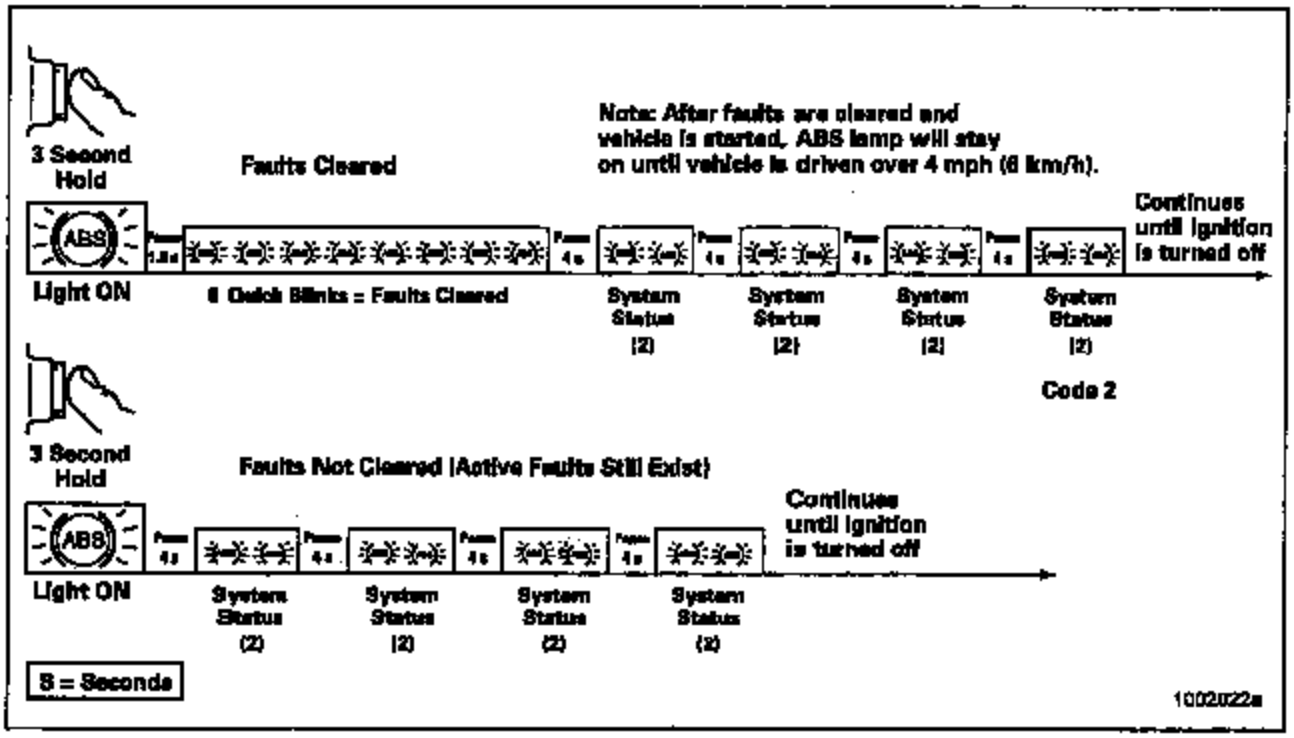
Using Blink Code Diagnostics, Continued

Blink Codes Illustrated

Figure 2.7



Using Blink Code Diagnostics, Continued



Using Blink Code Diagnostics, Continued

Use the information in **Table D, D Version Hydraulic ABS Blink Codes (Cab-Mounted ECU)** or **Table E, D Version Hydraulic ABS Blink Codes (Frame-Mounted ECU)**, to identify a fault, check for proper volt or ohm measurements and repair the fault.

1. Identify and record the blink code. Blink codes are identified in Columns **1** and **2**.
2. Test the pins indicated. Pin locations to be tested are listed in Column **3**.
3. Compare the measurement received against the correct volt or ohm measurement listed in Column **4**.
4. Follow the instructions listed in Column **5**.

Table D: D Version Hydraulic ABS Blink Codes (Cab-Mounted ECU)

Ignition Key ON to determine ABS blink code fault		Ignition Key OFF to test system (except where noted) — CAB			
1	2	3		4	5
Fault Code	**Problem Area**	**Connector**	**Pins to be Tested**	**Correct Volt Ohm Meter Readings**	**Action**
1-1	System OK				None required
2-1	**Right Front** Solenoid valve (inlet or outlet valve) failure in modulator, wiring harness or inside ECU	15-pin	IV 5 and 3 OV 4 and 3	Inlet valve: 6.5 ± 0.5 ohms Outlet valve: 3.5 ± 0.5 ohms	Check electrical resistance of affected valve wiring to ground at ECU vehicle connector and at modulator plug. Check voltages at wiring harness and connectors. Voltage of ground connector should be approximately 0 volts. Make necessary repairs.
2-2	**Left Front** Solenoid valve (inlet or outlet valve) failure in modulator, wiring harness or inside ECU	15-pin	IV 2 and 3 OV 1 and 3		
2-3	**Right Rear** Solenoid valve (inlet or outlet valve) failure in modulator, wiring harness or inside ECU	15-pin	IV 11 and 3 OV 10 and 3		
2-4	**Left Rear** Solenoid valve (inlet or outlet valve) failure in modulator, wiring harness or inside ECU	15-pin	IV 6 and 3 OV 7 and 3		
2-7	Reference to ground interrupted	15-pin	3 to chassis ground	0 ohms	Check ABS ground connections. Make necessary repairs.

IV = Inlet Valve
OV = Outlet Valve

Using Blink Code Diagnostics, Continued

Table D: D Version Hydraulic ABS Blink Codes (Cab-Mounted ECU), Continued

Ignition Key ON to determine ABS blink code fault		Ignition Key OFF to test system (except where noted)			CAB
1	2	3		4	5
Fault Code	**Problem Area**	**Connector**	**Pins to be Tested**	**Correct Volt Ohm Meter Readings**	**Action**
3-1	**Right Front** sensor — Air gap	9-pin	4 and 5	Greater than .2 volts AC at 30 RPM *(Rotate wheel 1/2 revolution per second)*	Check for sensor adjustment. Check for excessive wheel bearing endplay. Repair or replace as needed.
3-2	**Left Front** sensor — Air gap	9-pin	1 and 2		
3-3	**Right Rear** sensor — Air gap	9-pin	3 and 6		
3-4	**Left Rear** sensor — Air gap	9-pin	7 and 8		
4-1	**Right Front** sensor — Electrical fault	9-pin	4 and 5	900-2000 ohms	Check electrical resistance of affected sensor and wiring at ECU connector and at harness plugs. Repair or replace as needed.
4-2	**Left Front** sensor — Electrical fault	9-pin	1 and 2		
4-3	**Right Rear** sensor — Electrical fault	9-pin	3 and 6		
4-4	**Left Rear** sensor — Electrical fault	9-pin	7 and 8		
5-1	**Right Front** wheel — Erratic wheel speed				Check for tire size mismatch or tooth wheel difference. Check sensor, sensor cable and connector for intermittent contact. Repair or replace as needed.
5-2	**Left Front** wheel — Erratic wheel speed				
5-3	**Right Rear** wheel — Erratic wheel speed				
5-4	**Left Rear** wheel — Erratic wheel speed				
7-3	Retarder Relay	15-pin	12 to chassis ground	50-200 ohms	Verify proper connections to relay. (Refer to wiring diagram.)
7-4	ABS warning lamp	18-pin	18 and 2	10-200 ohms	Check bulb. Repair or replace as needed.

Using Blink Code Diagnostics, Continued

Table D: D Version Hydraulic ABS Blink Codes (Cab-Mounted ECU), Continued

CAB

Ignition Key ON to determine ABS blink code fault		Ignition Key OFF to test system (except where noted)			
1	2	3		4	5
Fault Code	Problem Area	Connector	Pins to be Tested	Correct Volt Ohm Meter Readings	Action
7-7	Recirculation pump does not switch off. OR Recirculation pump does not switch on (low level with act). OR Recirculation pump motor locked.	15- and 18-pin	Link pin 15 on 15-pin connector and pin 1 on the 18-pin connector. Measure between pin 8 on the 18-pin connector and chassis ground. Do not hold for more than one minute.	12 volts if linked 0 volts if not linked	Check the recirculation pump wiring, the pump relay and fuse and pump connections. Repair or replace as needed. If pump does not run when pins are linked, replace modulator assembly.
7-8	Recirculation pump relay sticks.				
8-1	No voltage to ABS solenoid valves.	18-pin	1 and 12	12 volts DC	Check the valve relay, fuse and wiring. Repair or replace as needed.
8-2	Continuous supply to ECU with ignition off.				Check for proper wiring connections. Make necessary repairs. If problem persists, replace ECU.
8-3	Internal ECU Fault				Replace ECU.

Using Blink Code Diagnostics, Continued

Table E: D Version Hydraulic ABS Blink Codes (Frame-Mounted ECU)

Ignition Key ON to determine ABS blink code fault		Ignition Key OFF to test system (except where noted) FRAME			
1	2	3		4	5
Fault Code	Problem Area	Connector	Pins to be Tested	Correct Volt Ohm Meter Readings	Action
1-1	System OK				None required
2-1	**Right Front** Solenoid valve (inlet or outlet valve) failure in modulator, wiring harness or inside ECU	Gray X-1	IV 4 and 2 OV 9 and 2	Inlet valve: 6.5 ± 0.5 ohms Outlet valve: 3.5 ± 0.5 ohms	Check electrical resistance of affected valve wiring to ground at ECU vehicle connector and at modulator plug. Check voltages at wiring harness and connectors. Voltage of ground connector should be approximately 0 volts. Make necessary repairs.
2-2	**Left Front** Solenoid valve (inlet or outlet valve) failure in modulator, wiring harness or inside ECU	Gray X-1	IV 3 and 2 OV 10 and 2		
2-3	**Right Rear** Solenoid valve (inlet or outlet valve) failure in modulator, wiring harness or inside ECU	Gray X-1	IV 6 and 2 OV 7 and 2		
2-4	**Left Rear** Solenoid valve (inlet or outlet valve) failure in modulator, wiring harness or inside ECU	Gray X-1	IV 5 and 2 OV 8 and 2		
2-7	Reference to ground interrupted	Gray X-1	2 to chassis ground	0 ohms	Check ABS ground connections. Make necessary repairs.

IV = Inlet Valve
OV = Outlet Valve

Using Blink Code Diagnostics, Continued

Table E: D Version Hydraulic ABS Blink Codes (Frame-Mounted ECU), Continued

FRAME

Ignition Key ON to determine ABS blink code fault		Ignition Key OFF to test system (except where noted)			
1	2	3		4	5
Fault Code	**Problem Area**	**Connector**	**Pins to be Tested**	**Correct Volt Ohm Meter Readings**	**Action**
3-1	**Right Front** sensor — Air gap	Green X-3	4 and 9	Greater than .2 volts AC at 30 RPM *(Rotate wheel 1/2 revolution per second)*	Check for sensor adjustment. Check for excessive wheel bearing endplay. Repair or replace as needed.
3-2	**Left Front** sensor — Air gap	Green X-3	5 and 8		
3-3	**Right Rear** sensor — Air gap	Green X-3	7 and 6		
3-4	**Left Rear** sensor — Air gap	Green X-3	3 and 10		
4-1	**Right Front** sensor — Electrical fault	Green X-3	4 and 9	900-2000 ohms	Check electrical resistance of affected sensor and wiring at ECU connector and at harness plugs. Repair or replace as needed.
4-2	**Left Front** sensor — Electrical fault	Green X-3	5 and 8		
4-3	**Right Rear** sensor — Electrical fault	Green X-3	7 and 6		
4-4	**Left Rear** sensor — Electrical fault	Green X-3	3 and 10		
5-1	**Right Front** wheel — Erratic wheel speed				Check for tire size mismatch or tooth wheel difference. Check sensor, sensor cable and connector for intermittent contact. Repair or replace as needed.
5-2	**Left Front** wheel — Erratic wheel speed				
5-3	**Right Rear** wheel — Erratic wheel speed				
5-4	**Left Rear** wheel — Erratic wheel speed				
7-3	Retarder Relay	Black X-2	7 to chassis ground	50-200 ohms	Verify proper connections to relay. (Refer to wiring diagram.)
7-4	ABS warning lamp	Black X-2	8 and 2	10-200 ohms	Check bulb. Repair or replace as needed.

Using Blink Code Diagnostics, Continued

Table E: D Version Hydraulic ABS Blink Codes (Frame-Mounted ECU), Continued

Ignition Key ON to determine ABS blink code fault		Ignition Key OFF to test system (except where noted) FRAME			
1	2	3		4	5
Fault Code	Problem Area	Connector	Pins to be Tested	Correct Volt Ohm Meter Readings	Action
7-7	Recirculation pump does not switch off. OR Recirculation pump does not switch on (low level with act). OR Recirculation pump motor locked.	Black X-2	Link pins 6 and 3. Measure between pin 10 and chassis ground. Do not hold for more than one minute.	12 volts if linked 0 volts if not linked 12 volts DC Turn ignition ON	Check the recirculation pump wiring, the pump relay and fuse and pump connections. Repair or replace as needed. If pump does not run when pins are linked, replace modulator assembly.
7-8	Recirculation pump relay sticks.				
8-1	No voltage to ABS solenoid valves.	Black X-2	3 and 9	12 volts DC	Check the valve relay, fuse and wiring. Repair or replace as needed.
8-2	Continuous supply to ECU with ignition off.				Check for proper wiring connections. Make necessary repairs. If problem persists, replace ECU.
8-3	Internal ECU Fault				Replace ECU.

Testing the System

This section of the manual contains information for testing the hydraulic ABS with TOOLBOX Software, as well as procedures for conducting standard air and electrical tests.

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Exhaust gas contains poison. When testing a vehicle with the engine running, test in a well-ventilated area or route the exhaust hose outside.

To avoid serious personal injury, keep away, and keep test equipment away, from all moving or hot engine parts.

Refer to, and follow, the vehicle manufacturer's Warnings, Cautions and Service Procedures.

When testing, set the parking brake and place the gear selector in NEUTRAL (manual transmission) or PARK (automatic transmission) unless otherwise directed.

Meritor WABCO TOOLBOX Software

Use TOOLBOX Software to verify the activation of various system components:

Turn valves, pump and retarder relay on and off (Valve Activation Menu). Turn ABS indicator lamp on and off (Miscellaneous Output Activation Menu). Reset components in ECU memory.

NOTE: For complete instructions for using this program, refer to the User's Manual, TP-99102. Contact Meritor WABCO at 800-535-5560 for information about TOOLBOX Software.

Valve, Pump and Retarder Relay Activation

To activate the ABS valves, pump or retarder relay, select HABS (Hydraulic ABS) from the **Main Menu**. The **Hydraulic ABS Main Menu** will appear. **Figure 2.8.**

Select the Valve Activation Icon or select Component Tests, then Valves to use the pull-down menu. **Figure 2.9.** This displays the **Valve Activation** screen. **Figure 2.10.**

Figure 2.8

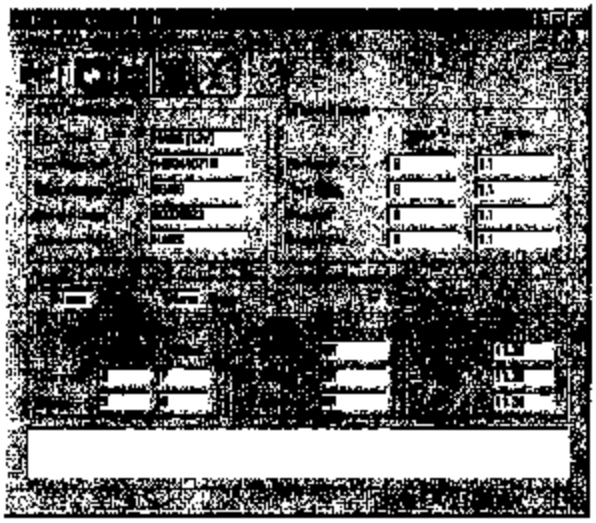


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Figure 2.9

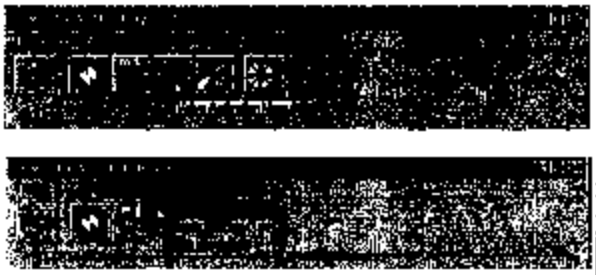

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Figure 2.10

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The **Valve Activation** screen lets you activate the four valves, the pump and the retarder relay. In addition to checking for proper activation, this screen provides an easy way to make sure the valves are wired properly — and that wiring is not reversed. Component activation status appears in the status box of this screen.

ABS Indicator Lamp Activation

To activate the ABS Indicator lamp, select HABS (Hydraulic ABS) from the **Main Menu**. The **Hydraulic ABS Main Menu** will appear. **Figure 2.8.**

Select the Miscellaneous Output Activation icon or select Component Tests to use the pull-down menu **Figure 2.11** to display the **Actuate Miscellaneous Output** screen. **Figure 2.12.**

Figure 2.11

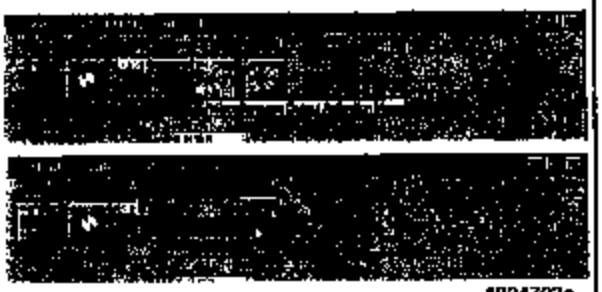

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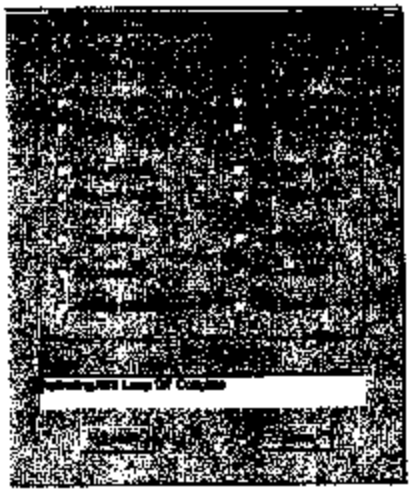
Figure 2.12



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This screen provides a check of the ABS indicator lamp. In addition, it provides a way to check either inlet or outlet activity of the valves, pump or retarder relay. Component activation status appears in the status box of this screen.

Reset Memorized

This is an automatic default and cannot be de-selected. It indicates the ECU has memorized the installed retarder relay. Once the ECU has seen a retarder, it expects to see it every time the vehicle is powered up. **Figure 2.13.**

Because there are times when an ECU is moved to another vehicle — or during diagnostic testing — you may want the ECU to disregard this learned component. Use the **Reset Memorized** command for this purpose.

Select **Component Tests** from the **Hydraulic ABS Main Menu**. Then, select **Reset Memorized** from the pull-down menu to reset the **Learned Component** screen. **Figure 2.14.**

Figure 2.13

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Figure 2.14

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Standard Testing

Test Equipment: Volt-Ohm Meter (VOM)

Use of a VOM with automatic polarity sensing is recommended. This eliminates the concern of the polarity of the meter leads during voltage measurements.

System Requirements and Component Tests

Tire Size Range

For proper hydraulic ABS operation, front and rear tire sizes must be within 16% of each other.

Contact the Meritor WABCO Customer Support Center at 800-535-5560 if you plan a tire size difference greater than ±8%.

Calculate the tire size with the following equation:

$$\% \text{ Difference} = \left\{\frac{\text{RPM Steer}}{\text{RPM Drive}}\right\} - 1 \times 100$$

RPM = tire revolutions per mile

CAUTION

When troubleshooting or testing the ABS system, do not damage the connector terminals.

Voltage Check

Voltage must be between 9.5 and 14 volts for the 12-volt hydraulic ABS to function properly.

Check voltage as follows:

1. Turn ignition ON.
2. Check for proper voltage:

   Cab-mounted ECU: Pins 12 and 1 and 12 and 2 on the 18-pin connector.

   Frame-mounted ECU: Pins 9 and 3 and 9 and 2 on the black connector.

   If voltage is not between 9.5 and 14 volts, verify proper wiring connections. Make corrections as required.

Standard Component Testing

ABS Indicator Lamp

If the ABS indicator lamp does not come on after the ignition is turned on, or it comes on but does not go out after three seconds, check all ABS fuses or circuit breakers and replace if necessary. Check the wiring to the ABS diagnostic switch and the indicator lamp and repair or replace the wiring as required. When checking the indicator lamp, follow these steps:

1. Check voltage potential at the lamp socket.
2. Check continuity of the wires to the socket.
3. Replace the bulb.

NOTE: A complete wiring diagram for 4S/4M D-version hydraulic ABS appears in **Figure 2.1**.

ABS Blink Code Switch

When testing the ABS Diagnostic switch:

1. Check the resistance between the terminals while cycling the switch. A lack of resistance is an indication of a faulty switch.
2. Check the continuity of the wires to the switch:

   Cab-mounted ECU: Pins 18 and 12 on the 18-pin connector.

   Frame-mounted ECU: Pins 8 and 9 on the black connector.

Sensor Adjustment

On steering axles, the sensor is typically accessible on the in-board side of the steering knuckle.

On drive axles, the sensor is typically accessible on the in-board side of the rear axle spindle.

To adjust the sensor, push the sensor in until it contacts the tooth wheel:

- Do not pry or push sensors with sharp objects
- Sensors will self-adjust during wheel rotation.

NOTE: No gap is allowable at installation. During normal operation a gap not to exceed 0.04-inch is allowable.

Sensor Output Voltage Test

Sensor output voltage must be at least 0.2 volts AC at 30 rpm. Test the sensor output voltage as follows:

1. Turn ignition OFF.
2. Disconnect the ECU. To measure voltage at the pins on the ECU connector, disconnect the sensor from the sensor extension cable.

WARNING

Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury can result.

3. Put blocks under the front and rear tires to stop the vehicle from moving.
4. Raise the vehicle off the ground. Put safety stands under the axle.
5. Rotate wheel by hand at 30 rpm (1/2 revolution per second).
6. Measure the voltage at the pins indicated in **Table F**.

Table F: Sensor Check Pins

Sensor	Cab-Mounted Pins (9-Pin Connector)	Frame-Mounted Green Connector
Left Front	1 and 2	5 and 8
Right Front	4 and 5	4 and 9
Left Rear	7 and 8	3 and 10
Right Rear	3 and 6	7 and 6

Sensor Resistance

The sensor circuit resistance must be between 900 and 2000 ohms. Measure resistance at the sensor connector, or at the pins on the ECU connector, as follows:

1. Turn ignition OFF.
2. To measure resistance at the pins on ECU connector, disconnect the ECU connector from the ECU.

   To measure resistance at the sensor connector, disconnect the sensor from the sensor extension cable.
3. Measure output at the pins indicated in **Table F**, Sensor Check Pins.

   If measurement is not between 900 and 2000 ohms, replace the sensor.

Component Removal and Installation

Sensors

Sensor Lube Specification

Meritor WABCO specifications call for a sensor lubricant with the following characteristics:

Lube must be mineral oil-based and contain molydisulfide. It should have excellent anti-corrosion and adhesion characteristics and be capable of continuous function in a temperature range of –40° to 300°F (–40° to 150°C).

Wheel Speed Sensor Replacement — Front Axle

Removal

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

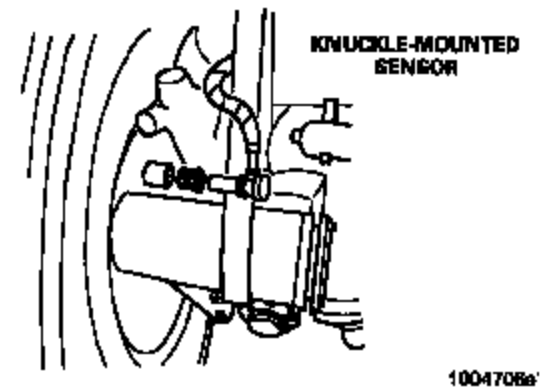
Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury can result.

To avoid damage to the electrical system or ABS components, when welding on an ABS-equipped vehicle disconnect the power connector from the ECU.

1. Apply the parking brakes. Chock the rear tires to prevent vehicle movement.

   If necessary, raise the front tires off the ground. Put safety stands under the axle.
2. Disconnect the fasteners that hold the sensor cable to other components.
3. Disconnect the sensor cable from the chassis harness.
4. Remove the sensor from the sensor holder. Twist and pull the sensor to remove it from the sensor bracket. **Do not pull on the cable. Figure 3.1.**

Figure 3.1



Installation

1. Connect the sensor cable to the chassis harness.
2. Install the fasteners used to hold the sensor cable in place.
3. Apply a Meritor WABCO-recommended lubricant to the sensor spring clip and sensor.
4. Install the sensor spring clip. Make sure the spring clip tabs are on the inboard side of the vehicle.
5. With the tabs on the inboard side, push the sensor spring clip into the bushing in the steering knuckle until the clip stops.
6. Push the sensor completely into the sensor spring clip until it contacts the tooth wheel.
7. Fasten the sensor cable with tie wraps every 12 inches. Properly bundle and store excess cable in the sub frame. **Figure 3.2.**
8. Remove the blocks and safety stands.
9. Perform a voltage output check to ensure proper installation. Refer to "Sensor Output Voltage Test" in Section 2.

Wheel Speed Sensor Replacement — Rear Axle

Removal

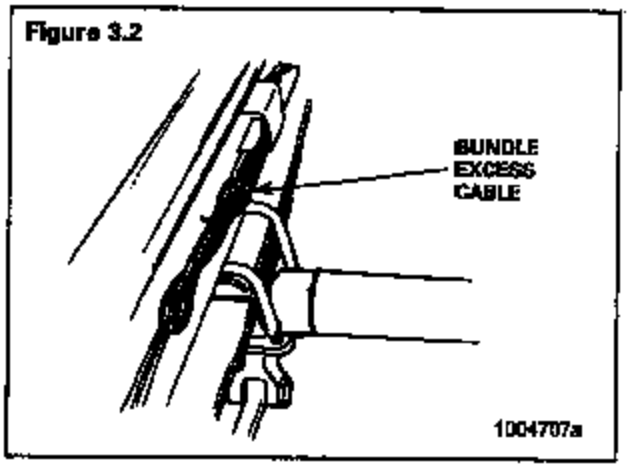
1. Apply the parking brake. Chock the front tires to prevent vehicle movement.
2. Raise the rear tires off of the ground. Put safety stands under the axle.
3. If the rear tire must be removed to gain access to the sensor, release the parking brake to release the brake shoe.

   Remove the wheel and tire assembly from the axle.
4. Remove the sensor from the mounting block in the axle housing. Use a twisting motion if necessary. **Do not pull on the cable.**
5. Disconnect the sensor cable from the chassis harness.
6. Remove the sensor cable from any cable clamps or clips.
7. Remove the sensor spring clip from the sensor bracket.

Installation

1. Connect the new sensor cable to the chassis harness.
2. Press the sensor spring clip into the sensor bracket, located on the rear axle, until it stops. Make sure the tabs are on the inboard side.
3. Apply a Meritor WABCO-recommended lubricant to the sensor.
4. Push the sensor completely into the spring clip until it contacts the tooth wheel.
5. Reattach the sensor cable to the cable clamps or clips.
6. Fasten the sensor cable with tie wraps every 12 inches. Properly bundle and store excess cable in the sub frame. **Figure 3.2.**

Figure 3.2



7. Replace the tire, remove the safety stands, lower the vehicle and remove the chocks from the front tires.
8. Perform a voltage output check to ensure proper installation. Refer to "Sensor Output Voltage Test" in Section 2.

Modulator Assembly

Modulator Assembly Removal

CAUTION

The modulator assembly contains hydraulic brake fluid, a caustic substance. Remove the valve carefully so that fluid does not leak and cause skin irritation or damage to components.

1. Apply the parking brakes. Chock the front and rear tires to prevent vehicle movement.
2. Place a container under the modulator assembly to catch leaking brake fluid.
3. Disconnect the electrical harness connectors from the modulator assembly.
4. Mark the six brake lines for ease of installation. Disconnect the lines from the modulator assembly.
5. Remove the three mounting capscrews, washers and nuts that attach the modulator assembly and bracket assembly to vehicle.

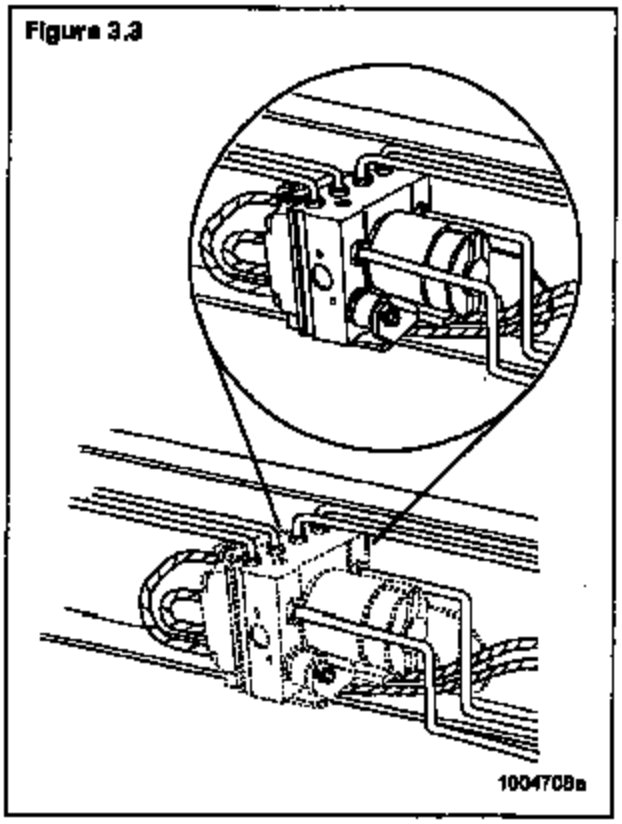
NOTE: Whenever any hydraulic system fitting is loosened or disconnected, the entire system must be bled to remove any air that may have entered.

6. Remove the modulator assembly and bracket.

Modulator Assembly Installation

1. Position the modulator assembly and bracket in place on the vehicle. **Figure 3.3.**

Figure 3.3



2. Tighten the three mounting nuts to 132 lb-in (15 N•m).
3. Connect and tighten brake line connections as follows:
   - Two small (M10X1) adapters: 108 lb-in (12 N•m).
   - Four large (M12X1) adapters: 132 lb-in (15 N•m).
4. Bleed the brake system, per the following instructions.
5. Connect the electrical harnesses to the modulator assembly.

Brake Bleeding Procedures

General

The following brake bleeding methods explain how to bleed the hydraulic ABS modulator assembly during installation, or in the event of air in the brake system. There are instructions for both pressure and manual bleeding procedures.

These instructions include the procedure for bleeding both the master cylinder and the brake system. In some cases, for example, if you are replacing only the modulator assembly, it may not be necessary to bleed the master cylinder. If you have any questions, please contact the Meritor Service Center at 800-535-5560.

NOTE: The modulator assembly must be handled with appropriate care and should not be exposed to excessive impact or compressed air at the hydraulic ports prior to assembly.

⚠ *WARNING*

Failure to bleed the system whenever any hydraulic system fitting is loosened or disconnected will allow air to remain in the system. This will prevent the hydraulic pressure in the brake system from rising enough to apply the brakes properly. This will cause the stopping distance to increase and can result in serious personal injury.

Properly discard hydraulic brake fluid that is removed from the brake system. Hydraulic brake fluid that is removed can be contaminated and can cause damage, loss of braking and serious personal injury.

Use only the type of hydraulic brake fluid specified by the equipment manufacturer. Do not use or mix different types of hydraulic brake fluid. The wrong hydraulic brake fluid will damage the rubber parts of the brake caliper and can cause damage, loss of braking and serious personal injury.

NOTE: Use DOT 3 or DOT 4 hydraulic brake fluid. Refer to the vehicle specifications to determine which fluid to use.

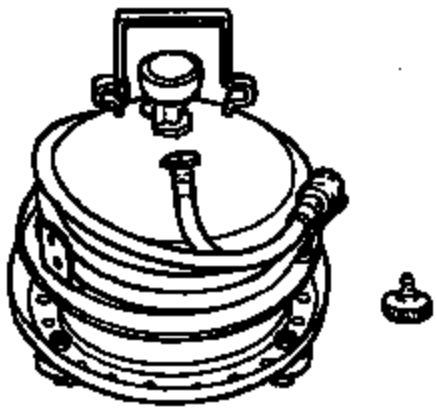
⚠ *CAUTION*

Hydraulic brake fluid is a caustic substance. Contact with hydraulic brake fluid can cause skin irritation. Do not let hydraulic brake fluid touch any painted surfaces, as it will remove the paint. Hydraulic brake fluid may also damage certain non-metal surfaces. Do not let fluid get on brake pads, shoes, rotors or disks.

Pressure Fill and Bleed

Pressure fill and bleed is the preferred method for bleeding the service brake system. It requires the use of a special pressure bleeder kit, consisting of a tank, pressure pump and valve, gauge, tubing and adapter. These kits are available from a number of manufacturers and include instructions for use. **Figure 3.4.**

Figure 3.4



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Pressure Fill and Bleed Procedure:

1. Apply the parking brake and chock the tires. Turn the ignition OFF and disconnect the battery terminals.

   NOTE: The ignition must remain off for the entire bleed procedure; energizing the unit during bleeding must be impossible.

2. Fill the pressure bleeder with new DOT 3 or DOT 4 hydraulic brake fluid. Refer to the vehicle specifications to determine which fluid to use.
3. Follow the manufacturer's instructions to connect the pressure bleeder to the brake master cylinder reservoir.
4. Set filling pressure to 20 to 30 psi (1.5 to 2.0 bar).
5. Turn on bleed equipment until fluid level in reservoir reaches approximately 0.875-inches (20 mm).
6. Release pressure for 3 to 5 seconds. Apply pressure for 5 to 10 seconds.
7. Repeat Steps 5 and 6 approximately 10 times. After releasing the pressure, air bubbles should rise up into the reservoir.

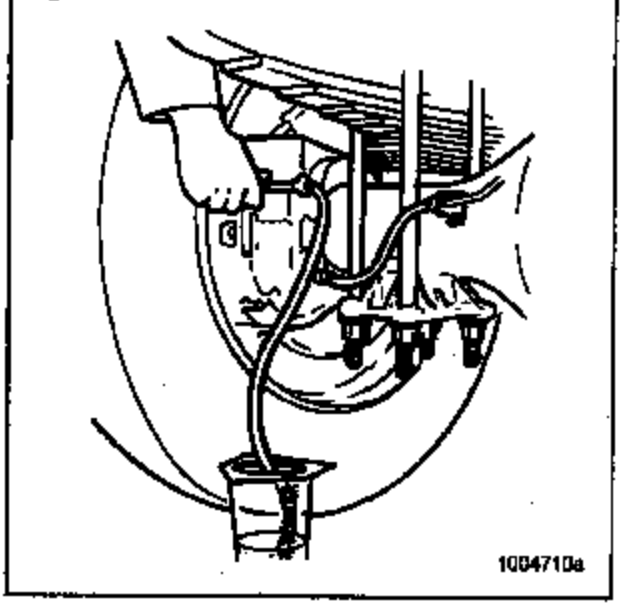
WARNING

Do not let the brake master cylinder fluid get below the minimum level during the bleeding operation. Keep the master cylinder reservoir filled with new DOT-approved brake fluid, as specified by the original equipment manufacturer. Failure to keep the brake reservoir level above minimum could result in more air entering system, making it impossible to effectively bleed the system.

8. Bleed the brake system:
   - Set filling pressure to 20 to 30 psi (1.5 to 2.0 bar).
   - Put a wrench on the brake actuator bleeder fitting. Start with the farthest from the modulator, (typically the right rear), then attach a length of clear plastic tubing to the bleeder fitting. Make sure the tube fits snugly.
9. Submerge the tubing in a container of clean hydraulic brake fluid. **Figure 3.5.**

   NOTE: Both the tubing and container must be able to withstand the effects of hydraulic brake fluid.

Figure 3.5



   Loosen the bleeder fitting until the fluid begins to flow (about 3/4 turn). Let the hydraulic fluid flow out of the fitting until it is free of air bubbles.

10. Tighten firmly to secure the fitting.
11. Repeat Steps 5 through 8 to bleed the remaining three brake actuators. Bleed in sequence of the longest to shortest circuit from the modulator assembly.
12. Turn off bleed equipment and remove pressure. Remove bleed device and check fluid level in reservoir. Fill if required. Replace reservoir cap and dispose of used brake fluid.
13. Remove wheel chocks.

Manual Bleed Procedure:

1. Apply the parking brake and chock the tires. Turn the ignition OFF and disconnect the battery terminals.

   NOTE: The ignition must remain off for the entire bleed procedure; energizing the unit during bleeding must be impossible.

2. Fill the reservoir with DOT 3 or DOT 4 hydraulic brake fluid. Refer to the vehicle specifications to determine which fluid to use.
3. Depress the brake pedal five times using the stroke between 1/3 travel and maximum travel in 6 seconds.
4. Release the pedal for 5 to 10 seconds. Air bubbles will rise into the reservoir while depressing and releasing pedal.
5. Repeat Steps 3 and 4 another three times, or until sufficient pedal resistance is felt.

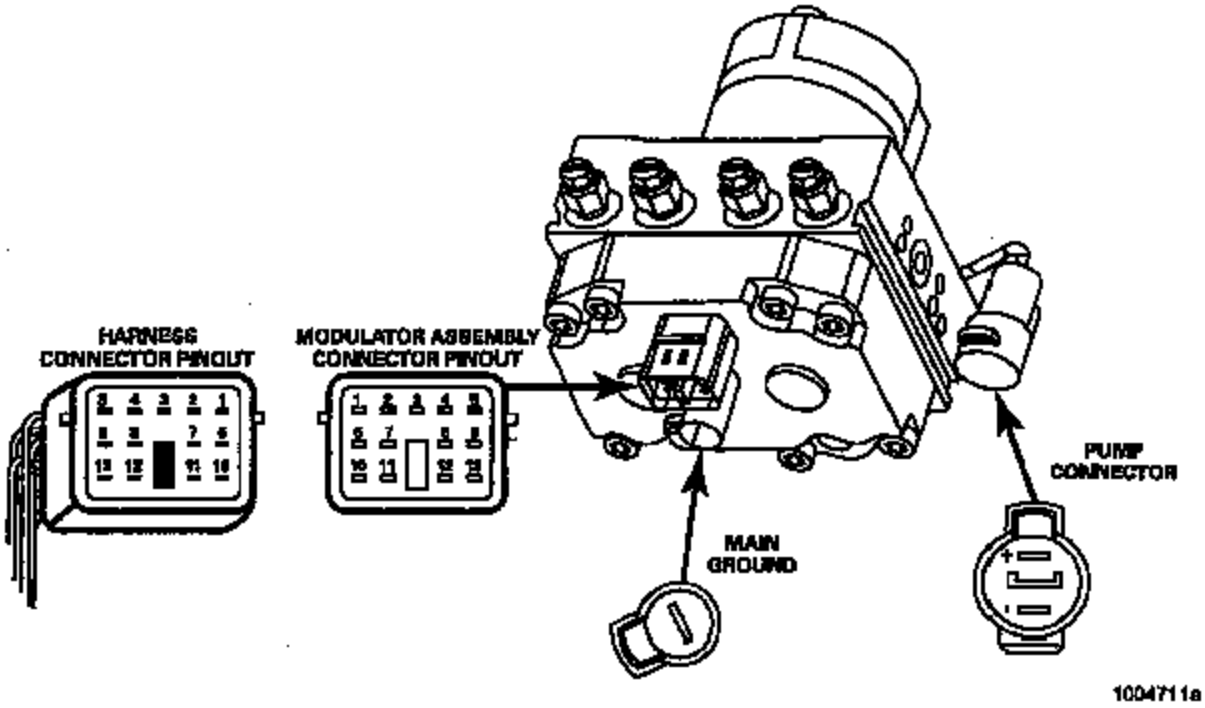
WARNING

Do not let the brake master cylinder fluid get below the minimum level during the bleeding operation. Keep the master cylinder reservoir filled with new DOT-approved brake fluid as specified by the original equipment manufacturer. Failure to keep the brake reservoir level above minimum could result in more air entering system, making it impossible to effectively bleed the system.

6. Bleed the brake system. Put a wrench on the brake actuator bleeder fitting. Start with the farthest from the modulator, (typically the right rear), then attach a length of clear plastic tubing to the bleeder fitting. Make sure the tube fits snugly.
7. Submerge the tubing in a container of clean brake fluid. **Figure 3.5.**

   NOTE: Both the tubing and container must be able to withstand the effects of brake fluid.
8. Depress the brake pedal 10 to 15 times, using the maximum available stroke.
9. Loosen the bleeder fitting until the fluid begins to flow, (about 3/4 turn), while depressing the brake pedal through its maximum available stroke.
10. Tighten the fitting firmly prior to releasing the brake pedal.
11. Repeat Steps 6 through 8 several times until the discharged fluid is free of air bubbles.
12. Repeat Steps 3 through 8 to bleed the remaining three brake actuators. Bleed in sequence of the longest to the shortest circuit from the modulator.
13. Check the travel of the brake pedal. If a firm resistance is felt the manual bleeding procedure is complete.
14. Check the fluid level in reservoir and fill if required. Replace reservoir cap and dispose of used brake fluid.
15. Remove wheel chocks.

Modulator Assembly Connector Pin Assignment



Pin Number	Circuit Description	Pin Number	Circuit Description
1	Outlet Valve RL	8	Reference Ground
2	Inlet Valve RL	9	------
3	-----	10	Outlet Valve RR
4	Inlet Valve FR	11	Inlet Valve RR
5	Outlet Valve FR	12	Inlet Valve FL
6	-----	13	Outlet Valve FL
7	-----		

Notes

Notes

MERITOR WABCO

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GUNITE DISC BRAKE ROTORS

Maintenance Manual

GUNITE®

Gunite is the industry leader in the development of brake system components for heavy-duty truck applications including air disc brake rotors. Gunite was the first to introduce ventilated disc brake rotors which significantly improved heat dissipation as required for applications on class 7 and 8 vehicles. Today, Gunite continues to lead the industry in the development of durable, light-weight disc brake rotor designs for current and future brake systems.

This manual provides you with a comprehensive program for the inspection and maintenance of disc brake rotors. By following the proper procedures, you can effectively spot problems, take preventive or corrective action, and ensure many miles of profitable, trouble-free service from your Gunite disc brake rotors.

When and how to inspect Disc Brake Rotors

A regular and thorough inspection is very important to the proper operation of your braking system and should be included in your regularly scheduled preventative maintenance program. By inspecting your brake components on a regular basis, you can greatly reduce your per-mile brake maintenance cost as compared to simply reacting to brake problems as they occur.

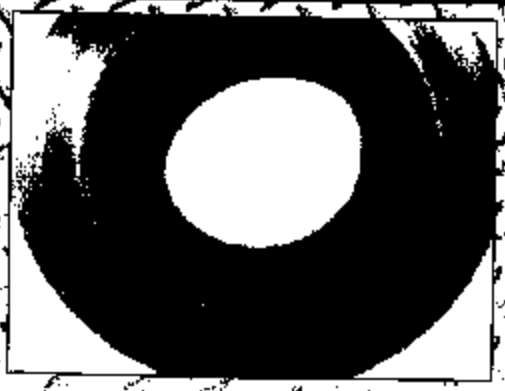
When following the inspection procedures outlined in this manual, it is not necessary to remove the rotor. The common problems shown here can easily be seen by simply removing the tire and rim and inspecting the rotor surface. The following problems are the most common problems experienced with rotors in the normal operation of the braking system. If one or more of these problems exist, the proper corrective action indicated should be taken immediately to insure safe braking on demand.

CRACKED ROTORS

Braking surface cracks are seen as radial cracks appearing in the braking surface and rounding the edge of the rotor at the inside or outside diameter of the braking surface.

These cracks are usually caused by torque imbalance which shifts a greater share of the braking function to only a few of the vehicles brakes. The brakes, which are providing a greater share of the braking action, will always be the ones to show the greater rotor wear and will sometimes crack.

Cracked rotors observed during regular inspection must be replaced. If the rotor is not replaced, the cracks will accelerate lining wear and can eventually progress into the barrel section of the rotor and cause separation of the braking section from the mounting flange. Rotors found to have cracks while enroute should be replaced at the next available service facility. After installing a new disc brake rotor, the braking system should be checked for proper brake balance to allow for maximum brake efficiency and prevent subsequent cracking.



HEAT-CHECKING

Heat-checking is the appearance of numerous short, thin, radial interruptions of the braking surfaces of the rotor. Heat-checking is a normal phenomena of the disc brake function just as they are on brake drums.

Heat-checking is the result of the heating and cooling of the braking surface which occurs as the brakes are applied during normal operation of the vehicle. Heat-checks are not detrimental to the function or the performance of the braking system and no corrective action is required for this condition. Heat-checks will frequently wear away and reform as a result of the normal braking process however, heat-checks can progress over time into cracks in the braking surface depending on such factors as lining/rotor wear rate, brake system balance, and how hard the brakes are used.

Proper Selection of New Rotors

Brake performance is directly affected by compatibility of each component in the brake system. Disc brake rotors are carefully engineered to meet the specific requirements of each brake system. All replacement rotors must meet the quality and performance standards set by the brake system manufacturer. By replacing worn or damaged rotors with rotors of equal quality, each brake will perform equally to provide a balanced system and maximum braking efficiency. In addition, care must be taken to properly match the correct brake lining with the replacement rotor specifications. Proper matching of brake components allows the braking system to operate efficiently which will result in maximum stopping performance, longer service life between relining and overall lower brake maintenance costs.

When replacing worn or damaged rotors, there is certain information which will be required to identify the correct replacement rotor. When specifying the replacement rotor you will need to know the manufacturer's part number and provide any other information appearing on the rotor.

Sizing of Disc Brake Rotors

If the manufacturer's part number is not available, your parts supplier can still determine the correct rotor for your application if you provide the following information. The first step is to identify the basic rotor design. It is either "U - Section" figure A or "Hat Section" figure B. Once this is determined, follow each of the eight steps pictured below making careful note of the measurements and information.

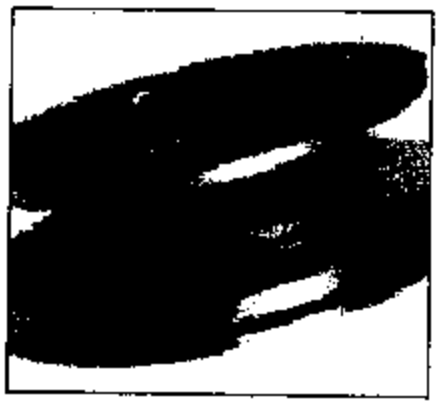


Figure A

Figure B

1. Outside diameter of rotor, measured across the braking surface.

2. Width of braking surface.

3. Rotor width, braking surface to braking surface.

4. Identification stamped on outer diameter.

5. Bolt circle diameter.

6. Size and number of bolts.

7. Are there any exciter teeth cast into this rotor?

8. Overall depth of the "U - Section" or "Hat Section" of the rotor.

LATERAL RUN-OUT (WOBBLE)

Using a dial indicator, as shown in the photo, measure the lateral runout or wobble of the rotor. The lateral run-out should not exceed a total indicator reading of .020" during one full revolution on properly adjusted wheel bearings. If the lateral run-out exceeds .020" total indicator reading, check the mounting surfaces between the rotor and the wheel or hub, fastener torques, as well as the condition of and adjustment of the wheel bearing.

RADIAL RUN-OUT

Using a dial indicator, check the radial run-out as measured at the outside diameter of the braking surface. The radial run-out should not exceed .035" total indicator reading. If the radial run-out of the rotor exceeds .035", replace the rotor.

ROTOR THICKNESS

Rotor thickness should be checked to make sure that the rotor thickness meets the dimensional tolerance stamped into the rotor casting. When measuring the thickness of the rotor, the thickness should not vary more than .005" when measured at several points around the rotor. If the measurement exceeds .005" and the rotor is within allowable tolerances to be resurfaced, the rotor should be resurfaced. If the rotor is not within the allowable tolerance for resurfacing, it should be replaced.

GREASE-STAINED ROTORS

If this condition exists, the brake rotors will show discolored spots on the braking surface, with oil and/or grease spattered on the brake assembly. This condition is most likely caused by a faulty lubrication system or improper greasing of the brake mechanism.

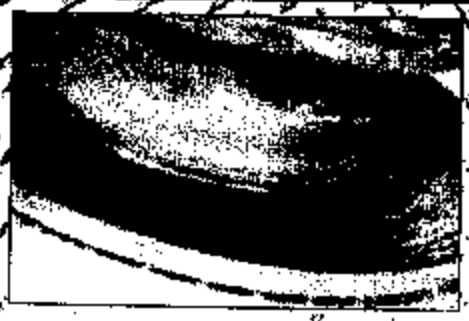
To correct the problem, the source of the grease and/or oil must be located and necessary repairs made to eliminate the leak. Remove the entire brake assembly and clean each component thoroughly. If the linings are soaked with oil or grease, they must be replaced.

MARTENSITE SPOTTED ROTORS

This condition indicates that the rotor has been subjected to extremely high temperatures caused by an improperly balanced braking system, a dragging brake or continued severe brake applications. These extremely high temperatures have caused structural changes to occur in the rotor material which makes the rotor more susceptible to cracking.

To correct this problem, the rotor should be resurfaced to restore concentricity by removing the hard raised areas. If resurfacing will not remove the heat spots, or if the resurfacing reduces the rotor thickness below the minimum recommended thickness, stamped on the outside diameter of the rotor, the rotor must be replaced. Brake linings should be checked for uneven wear and be replaced if necessary.

After reinstalling or replacing the rotor, the braking system should be checked for proper balance to restore maximum braking efficiency.



SCORED ROTORS

A scored rotor is indicated by a defined grooved appearance on the braking surface.

If the depth of the scoring exceeds .015" and the thickness of the braking surface can be resurfaced and still remain within allowable tolerances, then the rotor should be resurfaced to restore a smooth braking surface. The linings should also be replaced to provide maximum braking efficiency.

NOTE: WHEN RESURFACING THE ROTOR, THE FINISH OF THE BRAKING SURFACE MUST BE HELD TO A 5 MICROMETER (200 MICRO-INCH) MAXIMUM.

BLUING ROTORS

A rotor which shows the signs of bluing has been subjected to extremely high temperatures. This condition may be caused by continued hard stops or by brake system imbalance. It is not necessary to resurface or replace the rotor as long as the rotor remains within the allowable tolerance for operation.

To correct this problem the brake system should be checked for proper balance. The rotor should be checked to make sure that the rotor thickness is correct and the brake caliper should be checked for proper adjustment and clearance.

If this condition is left unresolved, it can result in the development of a martensite condition or cause the rotor to crack.

POLISHED ROTORS

A polished rotor can be identified by the mirror-like finish on the braking surface. This problem can easily be solved by sanding the braking surface with 80 grit emery cloth. It is also necessary to remove the glaze from the linings at the same time, using the 80 grit emery cloth.

If the problem recurs, the linings should be checked to make sure that they have the correct friction rating.

NOTE: IT IS A RECOMMENDED PROCEDURE TO SAND THE BRAKING SURFACE OF THE ROTOR AT THE TIME OF RELINING.

WORN ROTORS

The minimum worn rotor thickness is shown on the outside diameter of the rotor braking section or cast into the body of the rotor. The minimum dimension applies to the cross-sectional measurement between the two braking surfaces of the rotor. This measurement should be made at several points around the entire circumference of the rotor. If the thickness of the rotor is below the minimum dimension* shown on the rotor, the rotor must be replaced. If there is sufficient thickness remaining on the rotor, it may be resurfaced as long as the resulting thickness does not fall below the minimum thickness required.

The rotor should also be checked to make sure that the wear is approximately equal on both braking surfaces. If one surface is worn more than the other, the brake system is not functioning properly and should be inspected and repaired.

** See chart for minimum dimensions located on the back page.*

LINING TRANSFER

Lining transfer is indicated by a thin layer of lining material which has become welded to the rotor braking surface. Initially the lining deposits will be spotty; however, as the problem progresses the lining deposits will be covering more of the braking surface. Lining transfer will accelerate lining wear.

This problem is the result of extremely high operating temperatures which are usually caused by dragging brakes, continued hard stops, brake system imbalance or brake system malfunction. The rotor can be resurfaced to remove the lining deposits and restore a proper braking surface. The rotor thickness, after resurfacing, must not be below the minimum thickness stamped on the rotor.

CLOGGED OR RESTRICTED VENT HOLES

Vehicles operating in severe-duty environments may experience clogged or restricted vent holes due to the accumulation of mud, gravel or other debris. Such restrictions must be removed in order to provide even cooling of the rotor during normal operation.

Recommended Refinishing Dimensions

Applications	Outside Diameter	Width (New)	Minimum Dimension After Refinishing	Discard Dimension
Kelsey-Hayes Air Disc Brake–Model I	15.38	1.535	1.455	1.415
Kelsey-Hayes Air Disc Brake–Model II & IIF	15.38 17.19	1.750 1.750	1.670 1.670	1.630 1.630
Rockwell Air Disc Brake–Solid Rotor	14.82	.905	.825	.785
Rockwell Air Disc Brake–Ventilated Rotor	15.25 16.00	1.750 1.750	1.670 1.670	1.630 1.630
Kelsey-Hayes TH 24–Air Over Hydraulic Brakes	15.62	1.750	1.670	1.630
Bendix Hydraulic Brakes	15.00 15.39	1.435 1.535	1.355 1.455	1.315 1.415
Dayton Hydraulic Brakes	14.76 15.38 15.39	1.345 1.535 1.535	1.265 1.455 1.455	1.225 1.415 1.415

Trouble-Shooting Common Driver Complaints

In some cases, drivers may complain of braking irregularities between routine brake inspections. It is always recommended that the brake system and all components be inspected at the earliest possible time when complaints are received.

The following list contains some of the more common driver complaints, their causes and solutions. ***Note:*** *These conditions could result from a number of brake component malfunctions. This checklist can be used to isolate any specific problem with the rotor section of the brake assembly.*

Driver Complaint

Driver complains that the system squeals when the brakes are applied.

Common Causes:

Squealing brakes may be the result of one or more of the following problems: rotor distortion, polished rotors or improper lining friction ratings. However, other causes include vibration in the suspension or other brake components.

Solution:

Check the rotor for distortion (lateral run-out or wobble) using a dial indicator as shown on page 3. If the rotor shows excessive lateral run-out, the rotor must be replaced. If the rotor thickness allows, the problem may be eliminated by resurfacing the rotor.

Check the braking surfaces for "polishing" as described on page 4. If the condition exists, remove the glaze on the braking surface using 80 grit emery cloth.

Check the linings for glazing. If they are glazed, remove the glaze using 80 grit emery cloth. Check the friction rating of the linings to make sure that they meet the specifications of the braking system and rotor manufacturer.

Check to make sure that the linings are properly installed and adjusted to meet brake system specifications.

Driver Complaint

Driver complains of roughness or chatter during brake application.

Common Causes:

Roughness or chatter during braking applications may be caused by excessive variation in the rotor thickness, excessive lateral run-out (wobble) or a cracked rotor.

Solution:

Check the rotor for uneven surface areas. The thickness or width of the rotor should be checked for uniformity in several areas around the circumference of the rotor. If the thickness varies but the condition is not too serious, resurfacing the rotor commonly solves the problem. If the surface variance is excessive or if the problem persists, replace the rotor.

Check the rotor for distortion (lateral run-out or wobble) using a dial indicator as shown on page 3. If the rotor shows excessive lateral run-out, the rotor must be replaced. If the rotor thickness allows, the problem may be eliminated by resurfacing the rotor.

Check the rotor for cracks as described on page 2. If any cracks are found replace the rotor immediately.

WARRANTY

Gunite Corporation warrants to the original purchaser that its spoke wheels, rims, brake drums and brake rotors are free from defects in material and workmanship. Gunite Corporation agrees to repair or replace, without charge, any such all of its products which fail in normal use and service because of defects in material and/or workmanship.

Gunite Corporation shall not be liable for any incidental or consequential damages for any breach of warranty, its liability and the purchaser's exclusive remedy being expressly limited to repair or replacement of the product as herein provided. There are no other warranties, expressed or implied except such as is set forth herein.

This manual was developed to guide you in the inspection and maintenance of disc brake rotors. In addition, the instructions and procedures have been reviewed and approved by Eaton Axle-Brake Division, Rockwell International Brake Division and Bendix. If you have problems not covered in this publication, we suggest you contact the vehicle manufacturer for additional maintenance information.

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