

Transit Bus Air Disc Brake Wheels-Off Inspection and Reline

Abstract: This *Recommended Practice* provides guidelines for performing complete brake maintenance on a bus with disc brakes. It includes disassembly, cleaning, inspection and assembly. This document is to be used in conjunction with the manufacturer's service manual. It is recommended that all components be replaced equally on both wheel ends of the axle. Failure to do so may affect braking performance.

Keywords: ABS tone ring, boot, bridge, bushing, caliper, carrier, disc, disc brake maintenance, hub, pads, pin, potentiometers, retaining strap, rotor, seal, slide pins, spring clips, torque plate, wear indicator, wear sensors, wheel seals

Summary: This document establishes a recommended practice for transit bus front/rear axle disc brake inspection and reline. Individual operating agencies should modify these guidelines to accommodate their specific equipment and mode of operation. The recommended practices and guidelines in this document assume that the end users have sufficient skills and knowledge to repair and maintain the related systems at a journeyman level. This must include a fluent understanding of safe shop working practices, not only for the agency but also OSHA/CCOHS/provincial/federal/state and local safety standards. A familiarity with applicable industries, component/system suppliers and vehicle manufacturers is also assumed.

Scope and purpose: This *Recommended Practice* provides guidelines for disassembly, preparation, inspection and reassembly of the typical heavy-duty transit bus disc brake. The components may be different than pictured, and some procedures will vary. Frequency of off-wheel inspections will vary depending on operating environment but should not be limited to pad change intervals. The purpose of this document is to provide a uniform standard for heavy-duty transit bus disc brake troubleshooting and reline.

This document represents a common viewpoint of those parties concerned with its provisions, namely operating/planning agencies, manufacturers, consultants, engineers and general interest groups. The application of any standards, recommended practices or guidelines contained herein is voluntary. In some cases, federal and/or state regulations govern portions of a transit system's operations. In those cases, the government regulations take precedence over this standard. The North American Transit Service Association and its parent organization APTA recognize that for certain applications, the standards or practices, as implemented by individual agencies, may be either more or less restrictive than those given in this document.

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Introduction

This introduction is not part of APTA BTS-BC-RP-007-17, “Transit Bus Air Disc Brake Wheels-Off Inspection and Reline.”

This *Recommended Practice* reflects the consensus of the APTA Bus Standards Program members on the items, methods and procedures that have provided the best performance record based on the experiences of those present and participating in meetings of the program task forces and working groups. *Recommended Practices* are voluntary, industry-developed and consensus-based practices that assist equipment suppliers, vehicle and component manufacturers, and maintenance personnel in the construction, assembly, operation and maintenance of transit bus vehicles. *Recommended Practices* may include test methodologies and informational documents. They are nonexclusive and voluntary and are intended to neither endorse nor discourage the use of any product or procedure. All areas and items included therein are subject to OEMs’ and manufacturers’ supplemental or superseding recommendations.

APTA recommends the use of this document by:

- individuals or organizations that operate rail transit systems;
- individuals or organizations that contract with others for the operation of rail transit systems; and
- individuals or organizations that influence how rail transit systems are operated (including but not limited to consultants, designers and contractors).

Transit Bus Air Disc Brake Wheels-Off Inspection and Reline

1. Hazardous material warning

Most brake pads no longer contain asbestos fibers. However, if working with any component that does contain asbestos, take all the necessary precautions prescribed by OSHA, and follow all federal, provincial/state and local safety requirements. The health impact of non-asbestos fibers (brake pads with glass, mineral wool, ceramic, aramid, carbon, etc.) is not specifically covered under current OSHA regulations. Although medical experts do not agree about the possible long-term risks of working with and breathing non-asbestos fibers, some experts believe that long-term exposure could cause pneumoconiosis, fibrosis and cancer. Therefore, it is recommended that workers avoid dust when working on brakes that contain non-asbestos materials.

Brake pads may also contain crystalline silica, lead, antimony, phenol and other possibly hazardous materials. Refer to the material's material safety data sheet (MSDS) for all necessary precautions. Follow the general safety procedures listed below when working with braking components:

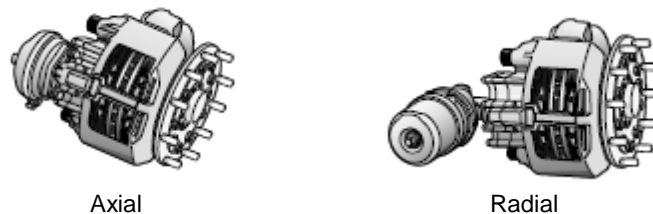
- Whenever possible, work on brakes in a separate area away from other operations.
- Always wear a respirator approved by NIOSH or MSHA during all brake service procedures.
- *Never* use compressed air or dry brushing to clean brake parts, assemblies or the working area. OSHA recommends using cylinders that enclose the brake. The cylinders have vacuums with HEPA filters and arm sleeves. If such equipment is not available, then carefully clean parts and assemblies in the open air. Used rags should be disposed of with care to avoid getting dust into the air. Use an approved respirator when emptying vacuum cleaners and handling used rags.
- During disassembly, carefully place all parts on the floor or in a suitable cleaning station to avoid getting dust into the air. After vacuum cleaning, any remaining dust should be removed using a rag soaked in water-based cleaner and then wrung until nearly dry.
- Workers should wash their hands before eating, drinking or smoking. Work clothes should not be worn home, but should be vacuumed after use and then laundered separately, without shaking, to prevent dust from getting into the air.

2. Operation

The air disc brake consists of an air-operated chamber, two plunger floating calipers, disc brake pads and a vented rotor. There are two air chamber mounting designs (axial and radial; see [Figure 1](#)), which are mounted directly to the caliper assembly. The disc brake can be installed onto any axle and can be used as a vehicle parking brake when equipped with a spring brake chamber.

FIGURE 1

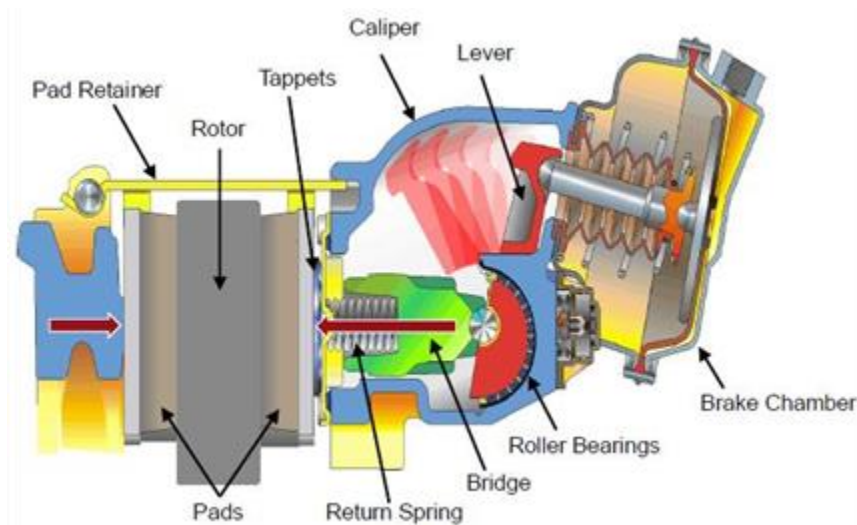
Axial and Radial Mounting Designs



Air disk foundation brakes operate as all foundation brakes. It takes a force, multiplying and applying it to a rotating member (disc or rotor) attached to the wheels such that a friction is created that converts energy of motion into heat and slows the vehicle. In the case of air disc brakes, air pressure is applied to a diaphragm, and the pressure on the diaphragm creates a large linear force, which is applied to a lever (internal to the brake caliper), which further increases the actuating force. See **Figure 2**.

FIGURE 2

Cross-Section of Knorr-Bremse Caliper Assembly



When the brake chamber is pressurized, the chamber push rod moves forward and acts against a cup in the internal lever. The lever, which has an abutment in the caliper housing, then acts against a pair of tappets, which apply the force onto the inner brake pad. The distances from cup to abutment to tappets are designed to provide a high leverage ratio to apply the required actuation force to the inner brake pad. The inner brake pad moves into contact with the brake rotor. The brake caliper, which is free to slide laterally relative to the brake rotor, then slides on two guide pins, and the reaction force applies an equal and opposite force to the outer brake pad and against the rotor. The rotor now is clamped between the inner and outer pad, and friction is created as the rotor moves across the clamped pads. This results in the creation of a brake torque acting through the wheel and tire, and this torque creates a stopping force acting on the vehicle through the tire contact patch. The higher the clamping force (which is proportional to the brake chamber air pressure), the higher the resulting brake torque.

The brake is released by reducing the chamber pressure, which in turn reduces the force on the internal lever, and thus the clamping force on the rotor. Integrated return springs return the tappets and operating lever back to the starting position, leaving the pads with a defined running clearance to the rotor.

2.1 Automatic adjustment

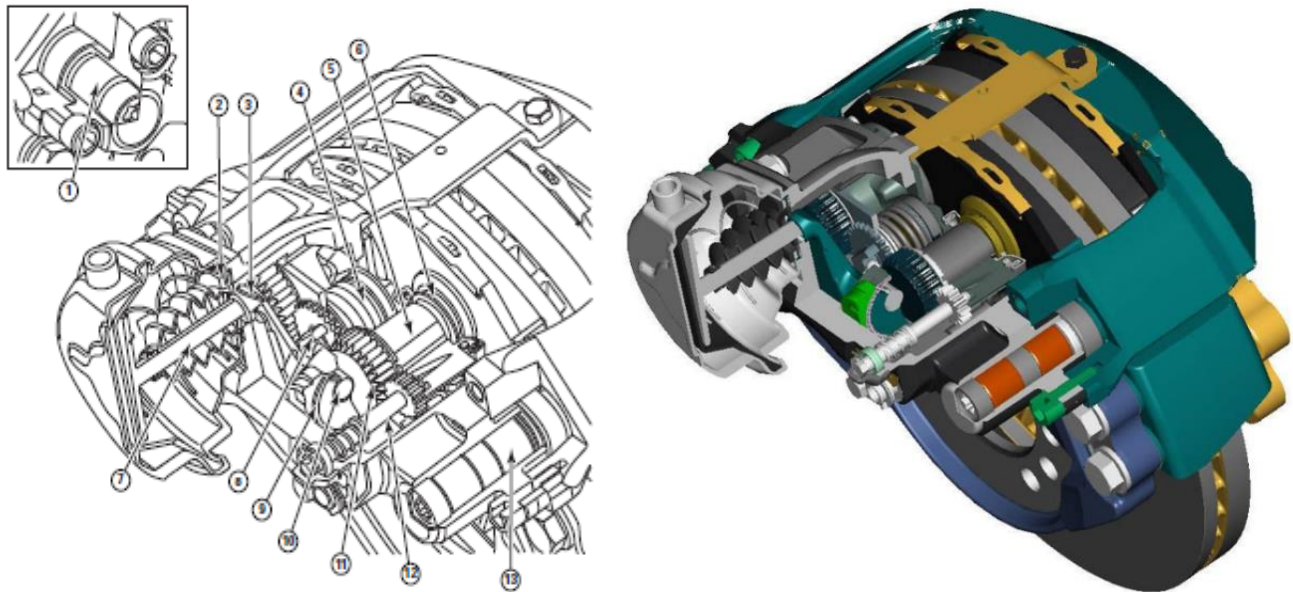
To ensure a consistent running clearance between pads and rotor, the brake is equipped with an automatic adjuster mechanism. The automatic adjuster inside the caliper adjusts the brake pad clearance to compensate for pad and rotor wear. Every time the brake is applied, the system senses whether the running clearance of the brake pads to the brake rotor is still within the specified range and does not need to be adjusted, or whether it is beyond the specified range and adjustment is required. For Knorr-Bremse brakes, the total running clearance (sum of clearance on both sides of the disc) should be between 0.024 in (0.60 mm) and 0.043 in. (1.1 mm); smaller clearances may lead to overheating problems. For Meritor EX225 brakes, no minimum is specified, but clearance must not exceed 0.030 in. (0.75 mm).

Disc brakes by design do not allow for measurement of brake chamber pushrod travel, and therefore brake chamber pushrod travel is not referenced in North American Commercial Vehicle Safety Alliance (NACVSA) inspection or out-of-service criteria. Although brake chamber pushrod travel can be calculated by measuring both rotor-to-brake-pad clearances and multiplying this dimension by the lever ratio, it is not necessary.

The adjuster mechanism is not serviceable on either design and should not be disassembled. **Figure 3** and **Figure 4** show the difference between the Meritor EX225 (gear-driven) and the Knorr-Bremse (timing chain) caliper adjusting mechanism.

FIGURE 3

Meritor EX225 Caliper Gear-Driven Adjustment Mechanism (Not Serviceable)



Legend:

- | | |
|--------------------------------|--------------------------|
| 1 Short slide pin oval bushing | 8 Adjuster shaft |
| 2 Housing seal | 9 Half bearing |
| 3 Operating shaft | 10 Roller |
| 4 Return spring | 11 Tappet |
| 5 Piston | 12 Adjuster stem |
| 6 Piston head | 13 Long side pin bushing |
| 7 Chamber piston | |

FIGURE 3

Meritor EX225 Caliper Gear-Driven Adjustment Mechanism (Not Serviceable)

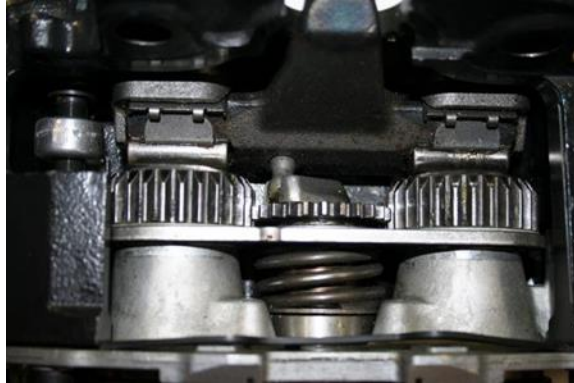
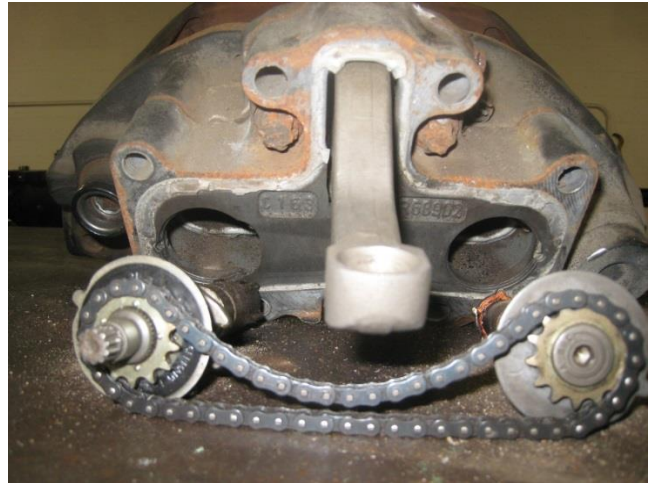
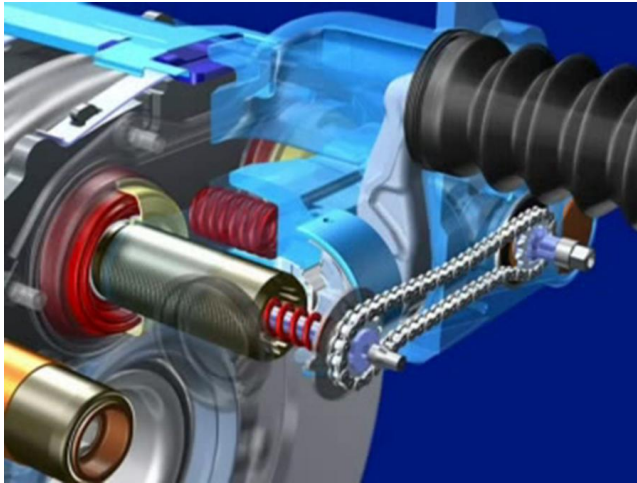


FIGURE 4

Knorr-Bremse Timing Chain Mechanism (Not Serviceable)



3. Inspection with wheels removed

Periodic inspection of the caliper, rotor, brake pads and visual wear indicator is recommended. Frequency of the inspection will depend upon the operating environment. Knorr-Bremse recommends a wheels-off pad wear inspection at a minimum of three-month intervals, with increased frequency for buses operated in harsh conditions. Meritor recommends a periodic inspection when tires are replaced, or at least four times during the lining life, or at the scheduled preventive maintenance inspection. Removal of wheels will provide complete visual access to the foundation brake system, which includes caliper, rotor, hub, wheel bearings, seals, brake chambers, mounting fasteners and other system parts.

Safely raise and support the bus by the axles at an appropriate working height and remove the wheels (see [Figure 5](#)).

FIGURE 5

Wheels-Off Inspection



3.1 Brake chamber identification

Brake chambers can be mounted in two positions, either axial, which is horizontal, or radial, which is vertical. See **Figure 6**.

FIGURE 6

Axial and Radial Positions



Axial



Radial

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Brake chambers will be either a service brake chamber used on the front axle or a spring brake chamber, comprised of a non-serviceable parking brake housing and a non-pressure housing found on the middle and rear axles. See **Figure 7**.

FIGURE 7
Brake Chamber Types



Service brake chamber



Spring brake chamber

3.2 Brake chamber initial inspection

Inspect brake chambers to ensure that the same size is on both ends of the same axle; mounting fasteners and clamps are properly installed; and there is no evidence of damage caused by impact or contact with wheels, frame, body or suspension. Also check for proper installation of vent plugs. With brake system pressures at governor cut-out, fully apply service brakes and listen for air leaks. Any leaks at the brake chamber mean the vehicle should be taken out of service, requiring further investigation and correction.

3.3 Caliper inspection

Before beginning the caliper inspection, remove dirt from the brake assembly with a vacuum and brush or a damp cloth. The nomenclature varies among manufacturers. **Figure 8** contains examples for reference comparison.

FIGURE 8
Caliper Types

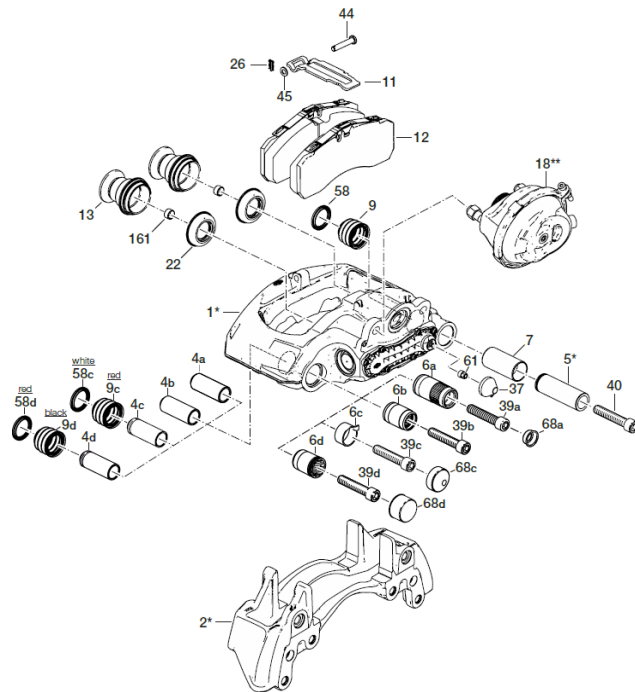


Meritor EX225 caliper

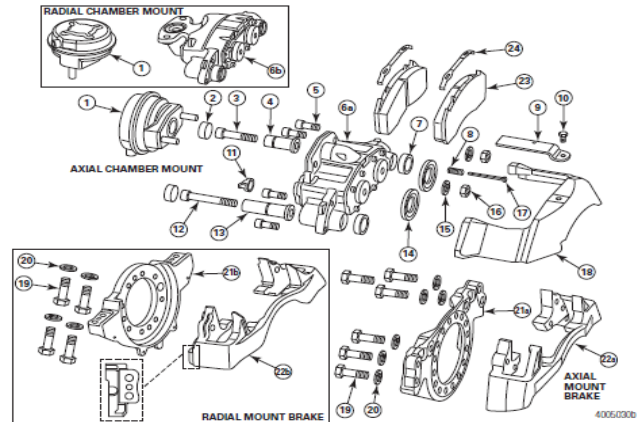


Knorr-Bremse SN7 caliper

FIGURE 8
Caliper Types



Knorr-Bremse SN7 caliper exploded view



Meritor EX225 caliper exploded view

Legend

1 Caliper*	26 Spring clip
2 Carrier*	37 Adjuster cap
4 Guide pin*	39 Caliper bolt*
5 Guide pin*	40 Caliper bolt*
6 Rubber bush or guide sleeve*	44 Pad retainer pin
7 Brass bush*	45 Washer
9 Inner boot*	58 Ring*
10 Cover*	61 Shear adapter
11 Pad retainer*	68 Cover*
12 Pad (complete)*	161 Tappet bush
13 Tappet and boot assembly	
18 Brake actuator**	
22 Inner seal*	

* Variants possible

** Brake chamber or spring brake

Legend

1 Air chamber	14 Piston boot (2)
2 Slide pin cap (2)	15 Air chamber washer (2)
3 Short slide pin bolt	16 Air chamber nut (2)
4 Short slide pin	17 Visual wear indicator
5 Bridge bolt (4)	18 Bridge
6a Caliper housing assembly—axial chamber mount	19 Carrier bolt—EX225L (4), EX225H (5-6)
6b Caliper housing assembly—radial chamber mount	20 Washer—EX225L (4), EX225H (5-6)
7 Slide pin boot (2)	21a Torque plate—radial mount
8 Visual wear indicator spring	21b Torque plate—axial mount
9 Pad retainer	22a Carrier—axial mount
10 Pad retainer bolt	22b Carrier—radial mount
11 Adjuster cover	23 Brake pad (2)
12 Long slide pin boot	24 Pad spring (2)
13 Long slide pin	

3.4 Torque plate inspection

- Inspect torque plate for cracks at fastener mounting holes and surfaces.
- Inspect mounting plate fastener holes for oversize, out of round and wear.

3.5 Fasteners and mounting hardware

- Fasteners should be replaced every time they are removed.
- Torque per the manufacturer's procedures and specifications upon installation.

3.6 Visual inspection

Perform a visual inspection of the brake assembly for possible indications of malfunctioning brakes.

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For example, a thermal overload (**Figure 9**) is an indication of excessive heat frequently caused by dragging brakes. The cause of the thermal overload must be identified and repaired.

FIGURE 9
Brake Assemblies With and Without Thermal Overload



Examples of brake assemblies exhibiting thermal overload



Examples of brake assemblies exhibiting normal operating conditions

A missing pad retainer strap can allow pads to climb out of the caliper and wear on the rim, resulting in rim and brake failure (see **Figure 10**).

FIGURE 10

Other Types of Brake Assembly Damage



Damage caused by a missing pad retainer strap



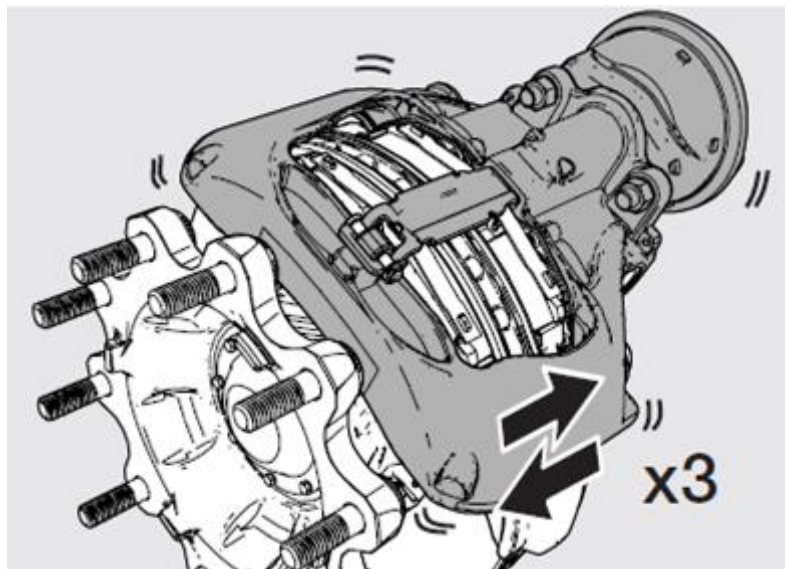
Damaged rim and brake chamber caused by missing pad retainer strap

3.7 Knorr-Bremse caliper movement test

The caliper movement test is conducted to make sure that the caliper slides on its pins and that there is sufficient clearance between the rotor and brake pads. With the spring brakes released or caged, push the caliper inboard on its guide pins. Connect an air line to the bus to maintain air system pressure of at least 95 psi (6.5 bar) to prevent a pressure drop. Move the caliper in and out three times by hand, and then use a suitable tool to press the inboard pad away from the tappets. See [Figure 11](#).

FIGURE 11

Knorr-Bremse Caliper Movement Test

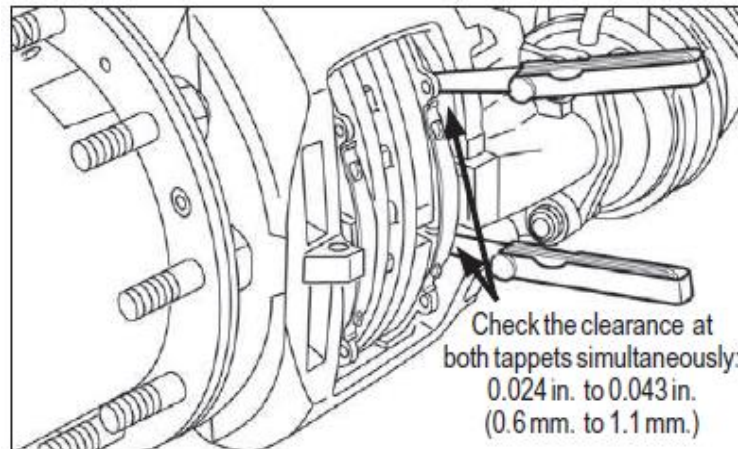


Push and pull caliper by hand three times in an axial direction.

Check that there is no dirt in the gap, and clean if necessary. Use two long feeler gauges to measure over the whole tappet surface, and check the gap between the tappet and the inboard pad backplate. Knorr-Bremse requires the gap to be between 0.024 in. (0.6 mm) and 0.043 in. (1.1 mm). If the gap is within this range, then

the test is complete. If the clearance is too wide, then there is a danger of brake failure. If the distance is too small, or if there is no gap at all, then there is a danger of the brake overheating. These conditions must be corrected before returning the vehicle to service. Knorr-Bremse does allow a difference of 0.010 in. (0.25 mm) between the upper and lower tappet and pad measurements (**Figure 12**). If the tappets-to-pad clearance exceeds 0.010 in. (0.25 mm), then the caliper bearing must be checked.

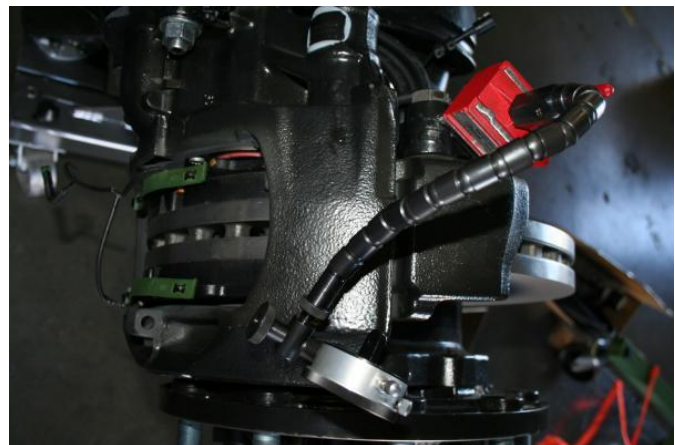
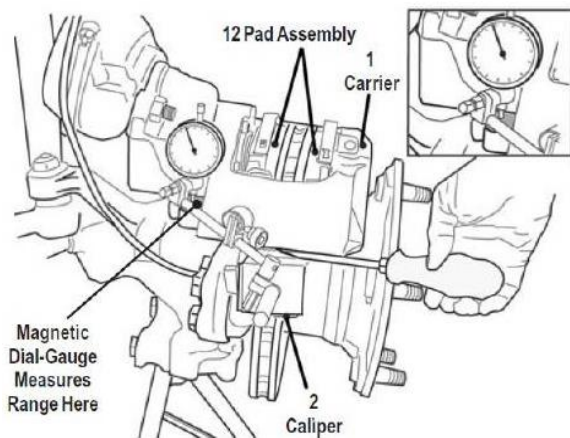
FIGURE 12
Knorr-Bremse Tappets-to-Pad Clearance



3.8 Knorr-Bremse guide pin inspection with pads installed

Guide pins and bushings keep the brake caliper perpendicular to the brake rotor and therefore must be maintained to ensure proper brake performance. The guide pin inspection will be conducted in two parts (**Figure 13**). The first part will be done before the brake pads are removed. The second part will be done after the other caliper tests are done and the pads are removed. The first test will need to be done with a new set of brake pads installed to ensure an accurate measurement. If the original pads are to be reused, then the current position of the assembled pads must be noted, so that they can be reassembled in the same position.

FIGURE 13
Measuring Knorr-Bremse Caliper Guide Pin Wear

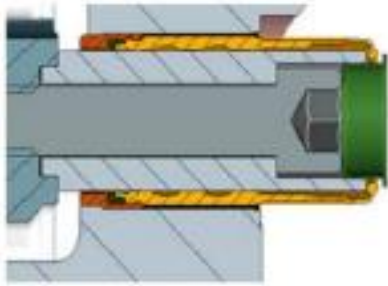


Place a flat-blade screwdriver between carrier and caliper, forcing them in opposite directions; then read the maximum value on the dial-gauge.

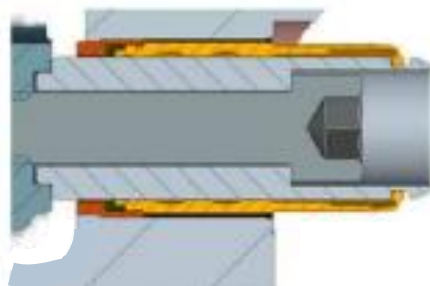
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The specification for allowable measured movement varies due to the differences in the slide pin bushing design (**Figure 14**). Always confirm which slide pin bushing is installed in the caliper, and refer to the Knorr-Bremse manual for the appropriate specification.

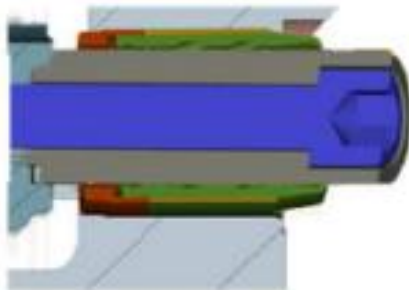
FIGURE 14
Slide Pin Bushing Designs



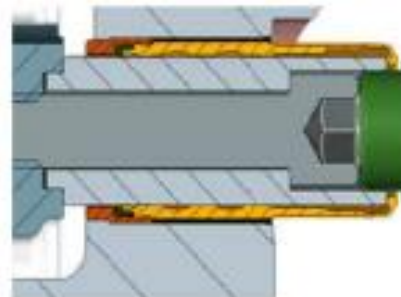
Closed rubber bush bearing with metal hood



Closed rubber bush bearing without metal hood



Open rubber bush bearing



Closed rubber bush bearing with metal hut

3.9 Knorr-Bremse caliper adjuster test

Check that the adjusting screw cap is properly installed and is not torn or loose. Remove the cap and visually inspect the adjusting screw seal for damage (see **Figure 15**).

FIGURE 15

Adjuster Components



Adjuster screw cap



Shear adapter



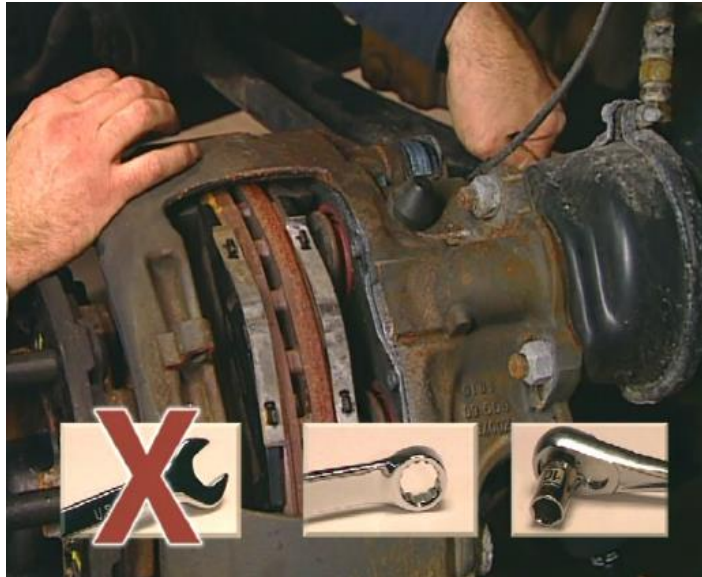
Adjuster with seal visible

Make sure the bus has at least 95 psi air pressure and, if applicable, make sure the spring brake is released. Using the shear adapter, turn the adjuster three clicks counterclockwise, increasing the running clearance. Make sure the shear adapter is used with a box wrench or socket (**Figure 16**). Using the wrong wrench or continuing to torque after the tappets are fully retracted will cause the shear adapter to fail.

If the shear adapter fails, check for free movement of the pads and caliper slide pins before attempting a second time. Replace the shear adapter and make a second attempt. If the adapter fails on the second attempt, and the caliper slide pins or brake pads are not stuck, then the shear adjuster mechanism is seized and the caliper must be replaced. The shear adapter is designed to shear if excessive torque is required to turn the adjuster. See **Figure 17**.

FIGURE 16

Knorr-Bremse Caliper Adjuster Test



Use only a box wrench or a socket.

FIGURE 17

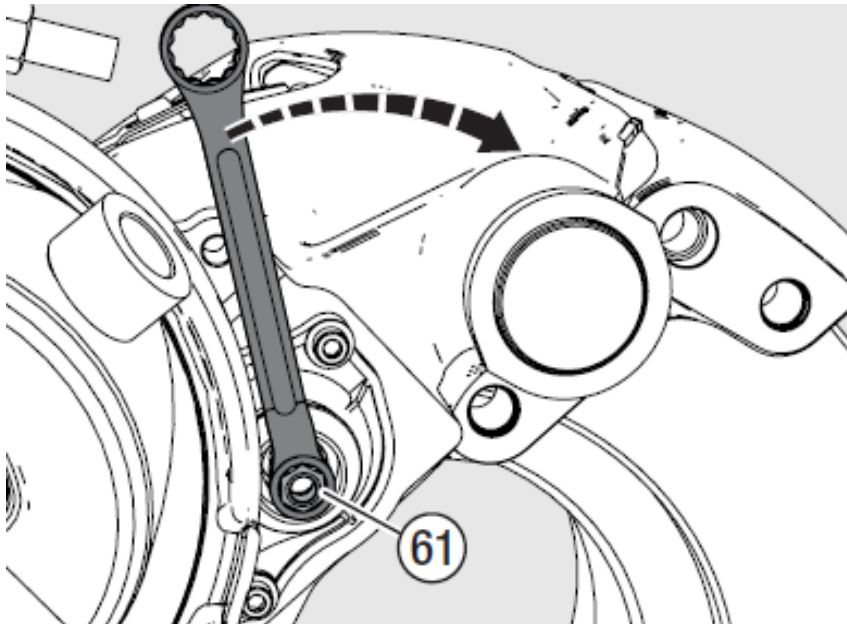
Broken Shear Adapter



Leave the box wrench on the shear adapter and make sure it can move in the clockwise direction without obstruction. Apply the brakes with about 30 psi (2 bar) pressure five to 10 times. The wrench should turn clockwise as seen from the actuator side. If the wrench does not turn, turns only on the first application or turns forward and backward with every application, then the automatic adjuster has failed and the caliper must be replaced.

FIGURE 18

Knorr-Bremse Caliper Adjuster Test



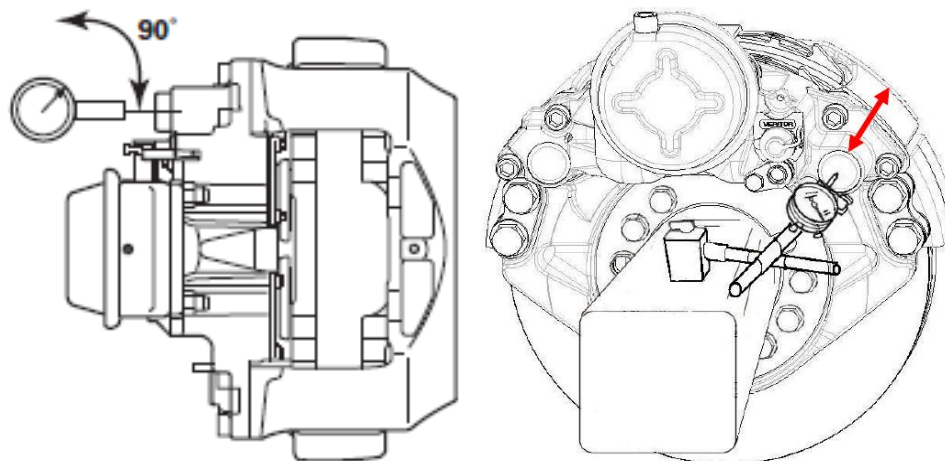
Number 61 is the shear adapter.

3.10 Meritor EX225 caliper movement test

For Meritor EX225 calipers, attach a magnetic dial indicator as shown in **Figure 19** to the torque plate or axle, with the indicator parallel to the slide pin as close as possible to the center of the caliper. Slide the caliper fully inboard and zero the gauge. Move the caliper fully outboard by hand and note the reading. The nominal running clearance should be 0.030 in. If the reading is less than 0.030 in. or exceeds 0.080 in., then the brake is out of adjustment and requires further attention. If the gap is within this range, then the test is complete. If the clearance is too wide, then there is a danger of brake failure. If the distance is too small, or if there is no gap at all, then there is a danger of the brake overheating. These conditions must be corrected before returning the vehicle to service. A second caliper test will be done when the pads are removed to check for free movement of the caliper on the guide pins.

FIGURE 19

Meritor EX225 Caliper Movement Test



3.11 Meritor EX225 caliper adjuster test

Check that the adjusting screw cap is properly installed and is not torn or loose. Remove the cap and visually inspect the adjusting screw seal for damage (**Figure 20**).

FIGURE 20

Meritor EX225 Dust Cap with Adjuster and Seal Visible



Make sure the bus has at least 95 psi air pressure and, if applicable, make sure the spring brake is released. Using a 10 mm box wrench, de-adjust the brakes one quarter turn. Do not exceed 30 ft-lbs (40 Nm) of torque. Leave the box wrench on the adjuster, and make sure it can move in the clockwise direction without obstruction. Apply the brakes with about 30 psi (2 bar) pressure. The wrench should turn clockwise as seen from the actuator side (**Figure 21**). If the wrench does not turn or turns forward and backward with each application, then the automatic adjuster has failed, and the caliper must be replaced.

FIGURE 21

Meritor EX225 Caliper

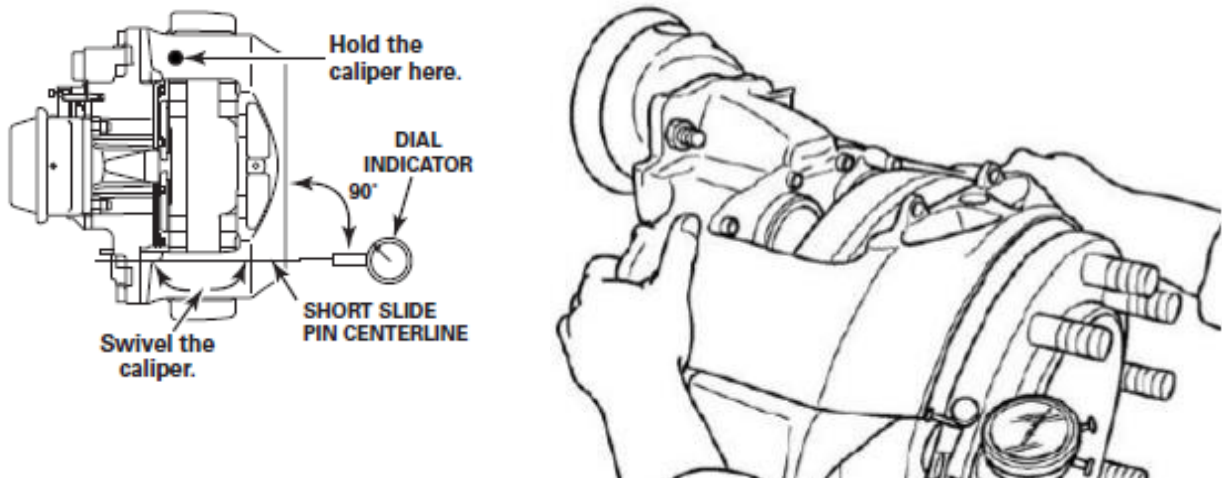


3.12 Meritor EX225 slide pin bushing tangential test

With the pads removed, pull the caliper housing assembly *outward* toward the wheel flange to the center position, as it would be when brake pads are installed. Attach a dial indicator so that it is in line with the centerline of the short slide pin. Attach the indicator to the hub. Hold the caliper so that it cannot move. Swivel the caliper until it stops in one direction. Set the gauge to zero. Move the housing in the opposite direction until it stops. The maximum acceptable reading is 0.118 in. (3 mm). If the reading is more than 0.118 in. (3 mm), then replace the bushings, slide pins or caliper assembly. See [Figure 22](#).

FIGURE 22

Checking Meritor EX225 Slide Pin Bushing Clearance

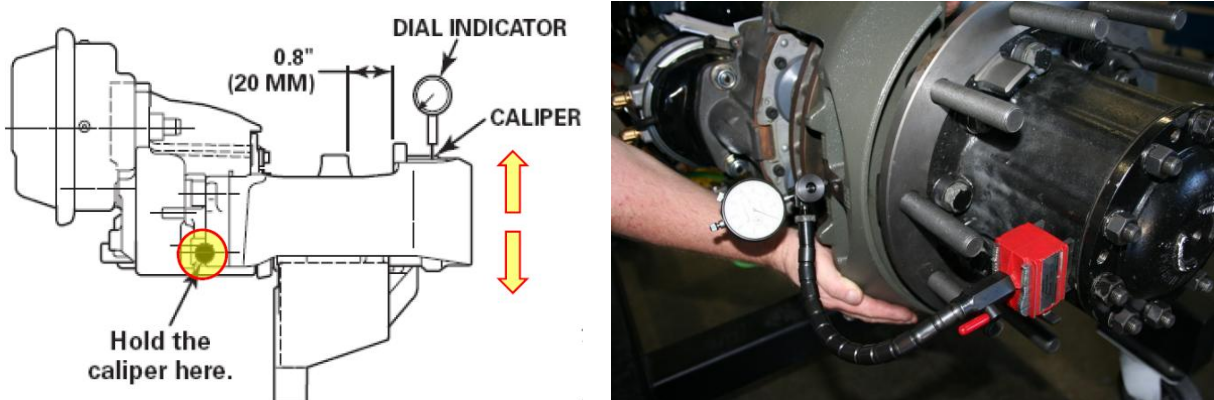


3.13 Meritor EX225 slide pin bushing radial test

Attach a dial indicator onto the vehicle hub and set it against the caliper. Position the brake caliper in the center position as it would be when the brake pads are installed. This is set when a gap of approximately 0.8 in. (20 mm) exists between the rotor and the bridge ([Figure 23](#)). Hold the caliper at the outboard pad edge and by the air chamber. Push the brake caliper down by hand as far as possible and set the gauge to zero. Pull the caliper up as far as possible without allowing the caliper to slide. The maximum acceptable reading is 0.078 in. (2 mm). If the reading is more than 0.078 in. (2 mm), then replace the bushings, slide pins or caliper assembly.

FIGURE 23

Checking Meritor EX225 Slide Pin Bushing Clearance

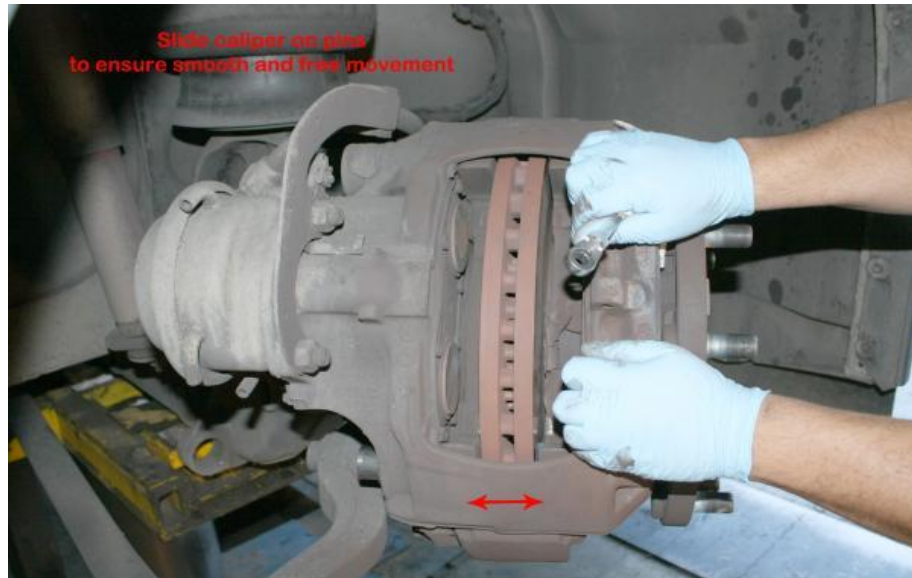


3.14 Caliper guide pin inspection with pads removed

This test is used for both the Meritor EX225 and Knorr-Bremse calipers. Using hand pressure only, with the brake pads removed, make sure the caliper slides freely along the whole length of the guide pins (**Figure 24**). Replace the guide pins and bushings if the caliper does not slide freely.

FIGURE 24

Checking for Smooth Caliper Movement on the Guide Pins



When the caliper is removed, visually inspect the caliper slide pin bushings for proper installation and positioning. Some bushings are round, and others are oval. Oval bushings should be installed with the oval shape in the horizontal position. Meritor EX225 has a combination of round and oval bushings, and Knorr-Bremse has round and elastic rubber bushings.

3.15 Brake pad removal

Ensure that the spring brake is caged. Follow the de-adjustment procedures identified previously for the appropriate caliper. Remove the bolt or clevis pin on the pad retaining strap and remove from the caliper.

Disconnect and remove wear sensors where applicable. Visually inspect the brake pad retainer for bending or wear. Replace if wear or damage is evident and when brake pads are replaced. Remove the brake pad springs. See **Figure 25**.

NOTE: Some pad springs are permanently affixed to the pads and cannot be removed. Slide the caliper outboard and remove the outer pad. Slide the caliper inboard and remove the inner pad.

FIGURE 25
Brake Pad Removal



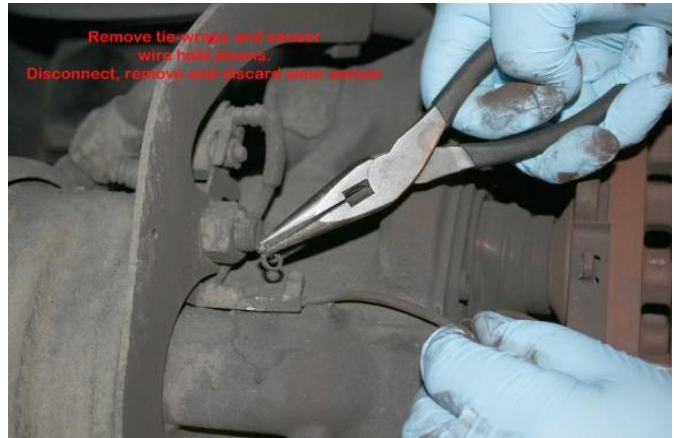
Knorr-Bremse pad retainer with clevis pin



Meritor EX225 caliper pad retainer secured with a bolt



Knorr-Bremse



Remove in-pad sensor components if so equipped.

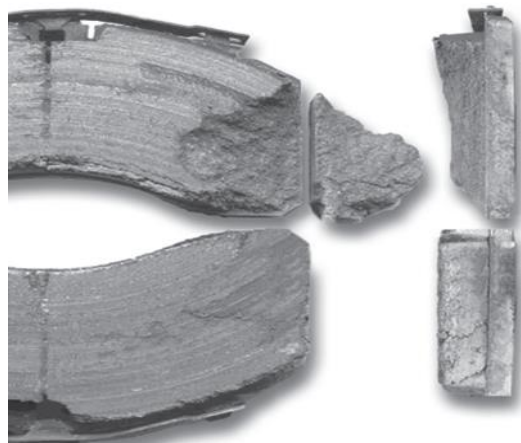
3.16 Brake pad inspection

Inspect the brake pads for uneven wear, thickness and damage. Measure the pad friction material thickness with a suitable measuring device. If pad thickness is within acceptable measurement, then inspect the pad surface. Minor damage at the edges is permitted. Replacement is required if major damage on the surface is found. Brake pad reuse is permitted if the pads pass inspection and are reinstalled in their original positions. When performing a replacement, you must replace all pads on the same axle (left and right side). See **Figure 26**.

FIGURE 26
Brake Pad Inspection



The cause of tapered brake pad wear must be identified and corrected. Possible causes include uneven tappet height and a loose caliper.



Reuse of brake pads with major damage is not permitted.

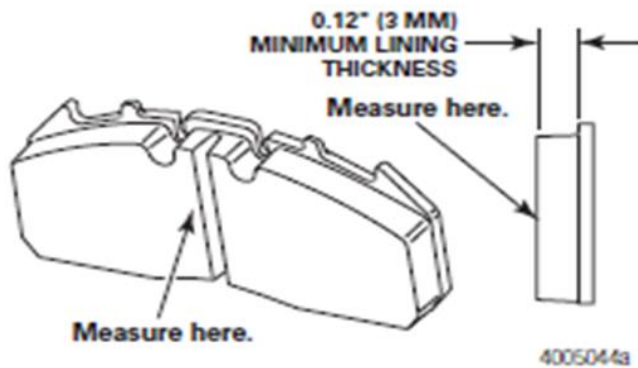


Minor wear patterns and edge wear are acceptable.

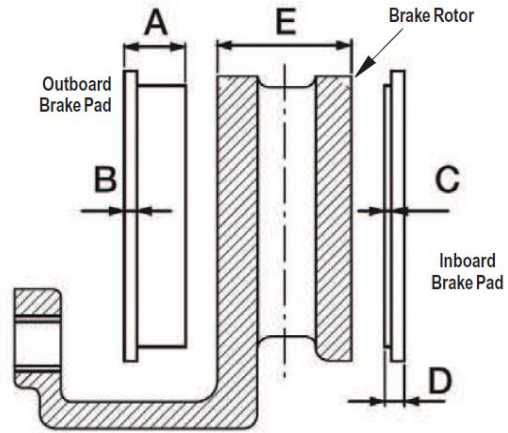


Thermal overload indicated by white discoloration. The cause of the thermal overload must be identified and corrected.

FIGURE 26
Brake Pad Inspection



Meritor EX225 brake pad dimension



Knorr-Bremse brake pad dimension

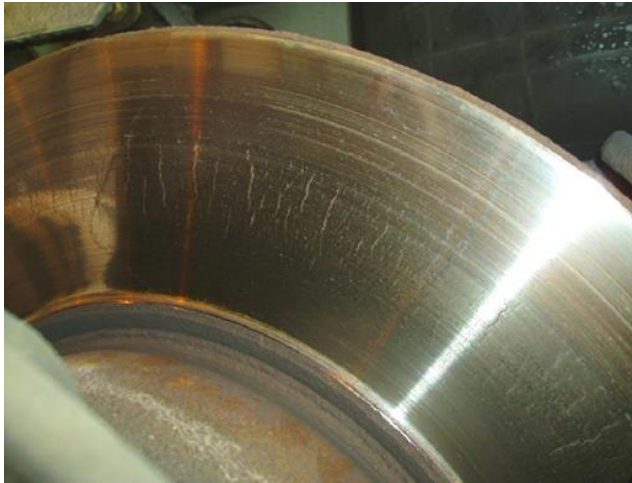
- A Thickness of a new pad (1.18 in. [30 mm])
- B Backing plate thickness (0.36 in. [9 mm])
- C Minimum thickness of friction material (0.08 in. [2 mm])
- D Minimum thickness of a worn pad (0.43 in. [11 mm]); replace pads
- E Thickness of a new rotor (1.77 in. [45 mm])
Minimum rotor thickness (1.46 in. [37 mm])

3.17 Rotor inspection

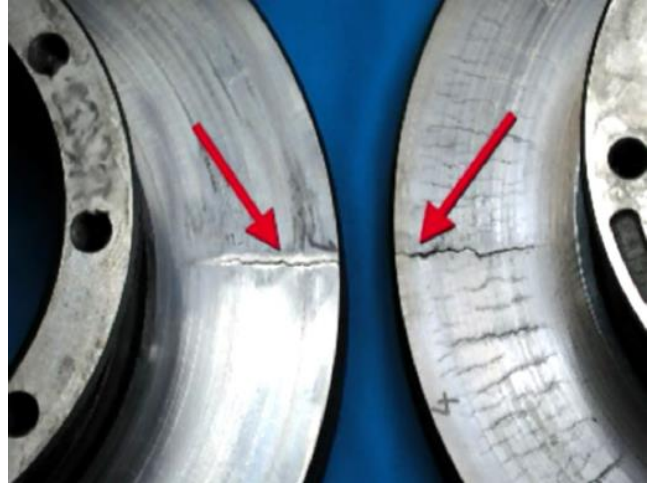
Visually inspect brake rotor for heat checks, grooving, scoring, surface degradation, cracking, bluing, wear, runout and damage.

Heat checks are short, thin, sometimes numerous radial interruptions of the rotor braking surfaces. They are the result of disc brake operation. They are caused by the heating and cooling that occurs as the brakes are applied time after time. Heat checks will frequently wear away and reform, or they may become braking surface cracks, depending on such factors as the lining and rotor wear rate, brake balance and how hard the brakes are used. There are two common types of heat checks: light heat checking and heavy heat checking. See [Figure 27](#).

FIGURE 27
Heat Checking



Small heat checks (as shown) are allowable. Cracks on the surface of the rotor that result from light heat checking are small and fine and do not require rotor replacement.

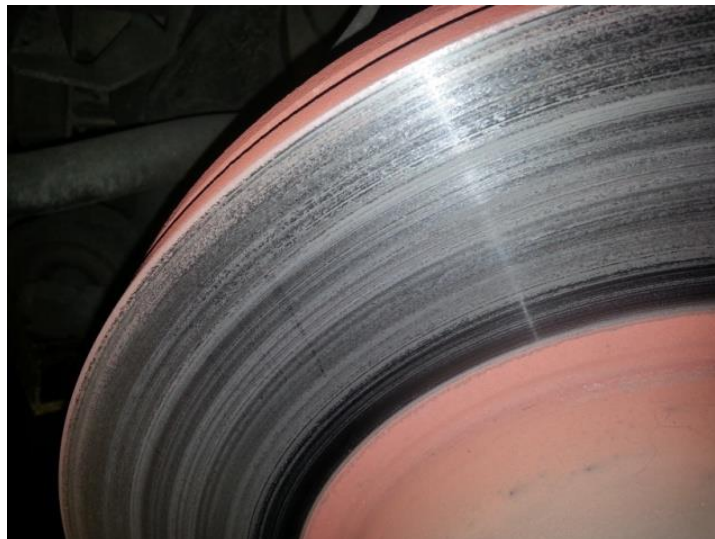


Large cracks creating a split in the rotor are not acceptable and require rotor replacement. Heavy heat checks have width and depth. Cracks going through to the cooling fins or into the inner or outer edge of the friction surface are not allowed, and the rotor must be replaced.

Meritor requirements are to replace the rotor if the heat checks have a width greater than 0.02 in. (0.5 mm), a depth greater than 0.04 in. (1 mm) and extend across the surface more than 75 percent in the radial direction.

Knorr-Bremse allows radial cracks (**Figure 28**) less than 0.06 in. (1.5 mm) deep or wide if their length is less than 75 percent of the radial measurement of the friction surface and the cracks do not extend to either end of the friction surface.

FIGURE 28
Radial Grooves

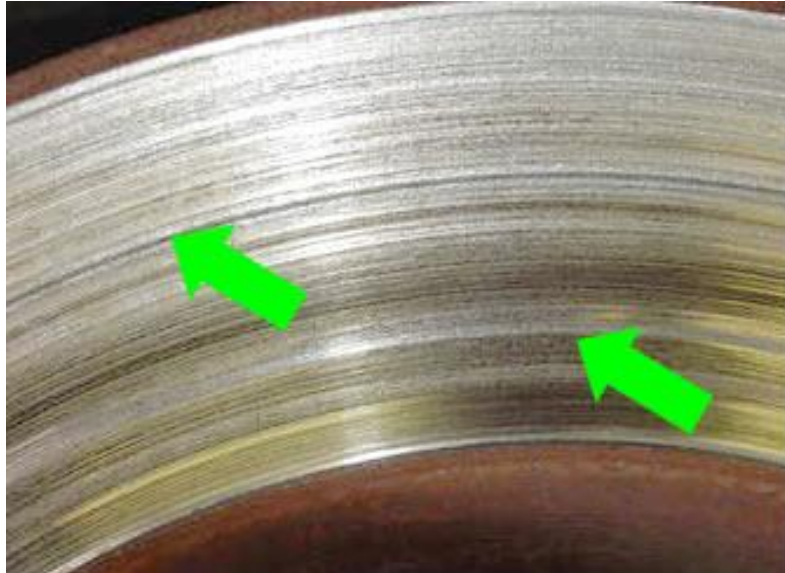


Blue bands and discoloration indicate that the rotor was very hot.

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The cause must be identified and corrected. Rotors and pads must be replaced after identifying and repairing the cause of the hot brakes.

FIGURE 29
Axial Grooves



Knorr-Bremse allows axial grooves (**Figure 29**) less than 0.06 in. (1.5 mm) deep or wide. Meritor permits axial grooves less than 0.02 in. (0.5 mm) deep or wide. Grooves that exceed manufacturer's specifications will require rotor resurfacing or replacement. See **Figure 30**.

FIGURE 30
Measuring Brake Rotor Thickness with a Brake Rotor Micrometer



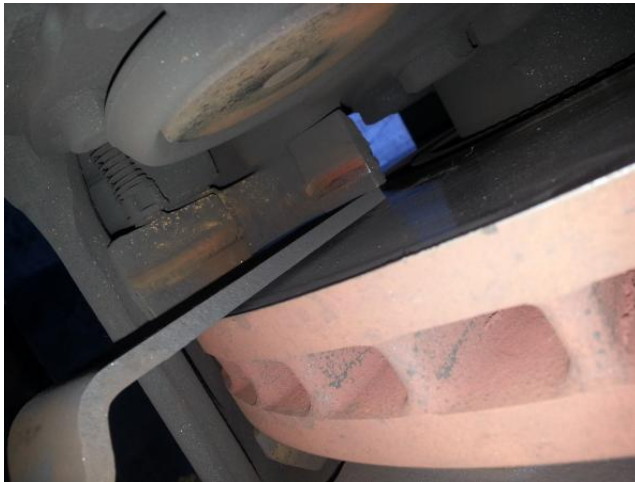
Use a brake rotor micrometer to measure thickness at 90-degree intervals at the thinnest portion of the rotor. Avoid measuring near the edge of the rotor, as minor burrs may result in inaccurate measurement. If unsure of

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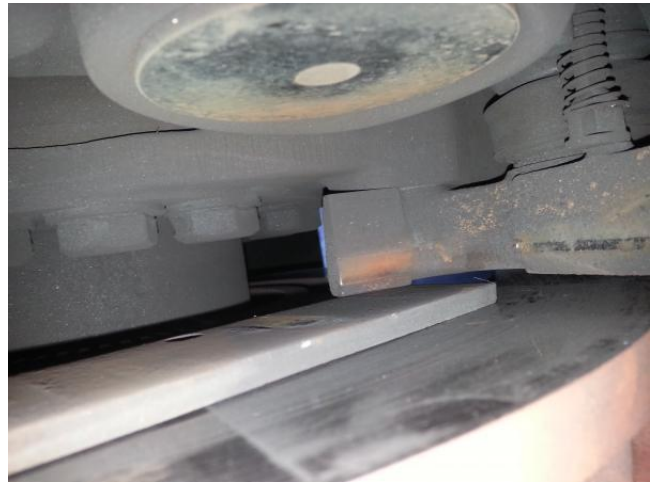
the thinnest point, measure at three points. Point one is about 10 mm below the outer friction diameter. Point two is at the friction surface center. Point three is about 10 mm above the inner friction diameter. The brake rotor micrometer must be square to the rotor friction surface for accurate measurement. Typical new rotor thickness is 45 mm. Rotors must be discarded when a minimum thickness of 37 mm or the minimum discard thickness found on the rotor casting is reached. The discard thickness is frequently cast into the rotor hat flange and is the minimum thickness the rotor can be worn to before the rotor is no longer considered safe for operation. Minimum thickness is not the minimum brake pad change thickness. New brake pads can be installed with a used rotor, providing that the rotor passes the visual inspection and no portion of the rotor friction surface measures less than 39 mm in thickness.

Meritor EX225 pad retainers can be used as a gauge to help identify uneven wear or worn rotors. To check wear, place the retainer between the rotor surface and the carrier pad abutment. Make sure that wear is checked on both the inboard and outboard sides of the rotor.

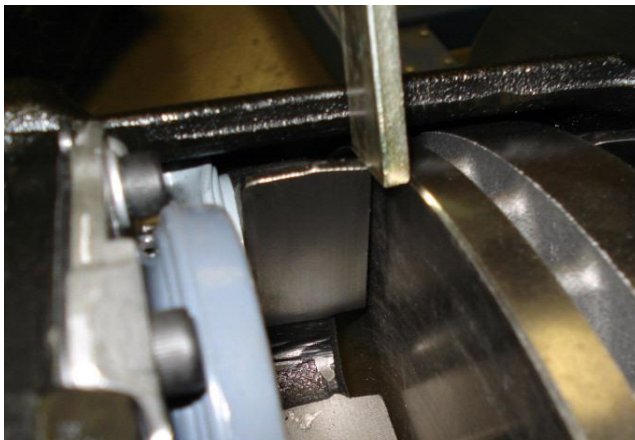
FIGURE 31
Rotor Wear



Uneven Meritor EX225 rotor wear indicated by angular gap between pad retainer and carrier. The rotor will need to be replaced.



Worn Meritor EX225 rotor indicated by gap between the pad retainer and the carrier. The rotor will need to be replaced.



Acceptable Meritor EX225 rotor thickness indicated, as the pad retainer will not fit between the rotor and the carrier.



Some Meritor rotors have different inboard and outboard swept area thickness. The flange and hub add to brake mass and increase heat transfer.

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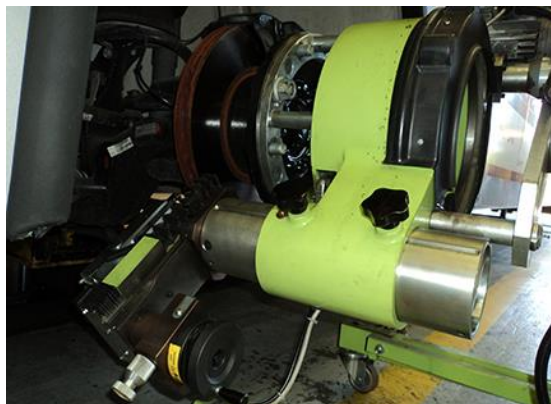
Check rotor run-out by using a dial indicator mounted on the carrier with the measurement taken at the center of the swept area of the rotor. Slowly rotate the rotor by hand one full revolution and note the measurement. The end play of the hub bearings should not be included in this measurement. The run-out should not exceed 0.009 in. (0.2 mm) for Meritor EX225 and 0.006 in. (0.15 mm) for Knorr-Bremse. If the run-out is greater, then check wheel bearings for the correct adjustment.

If need be, check rotor thickness in several areas, as rotors can experience different wear rates in different areas. Thickness can vary, creating the false illusion of run-out. These variances in thickness can cause wheel vibration during braking. If these differences in thickness occur at different locations, they can appear as minor run-out, but when compared with both sides, they can appear as exaggerated run-out. See [Figure 32](#).

FIGURE 32
Checking the Rotor



Measuring rotor run-out



Options exist to turn rotors both on and off the vehicle.

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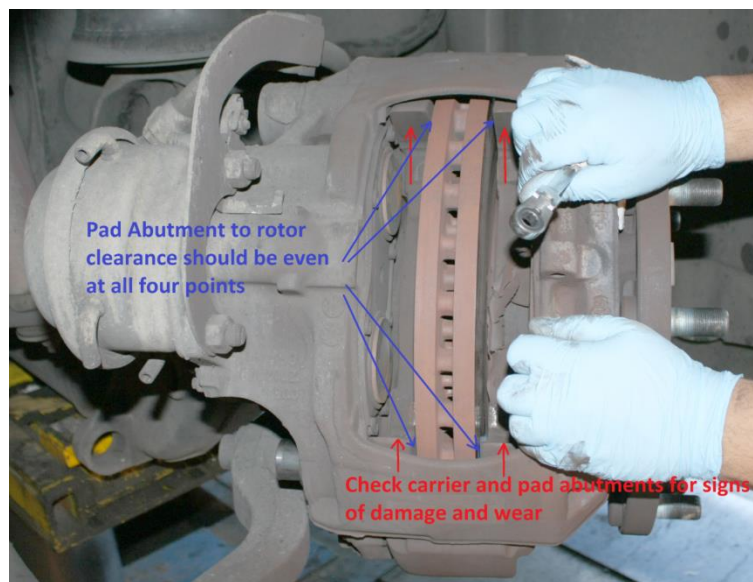
Rotor discard thickness is frequently cast into the rotor hat flange and is the minimum thickness the rotor can be worn to before the rotor is no longer considered safe for operation. Consideration should be taken as brake rotors wear over the course of brake pad life. Wear rates can be calculated by first installing and measuring new rotors and pads. Then measure both when the pads are worn to their minimum thickness. It is not recommended to install brake pads if rotor wear rates would cause rotor thickness to wear below discard limits during the expected life of the brake pads. Rotors can be resurfaced to acceptable conditions, providing that all other specifications are met.

3.18 Carrier and pad abutment inspection

Carrier and pad abutments should be inspected for signs of wear and damage. See **Figure 33**.

FIGURE 33

Pad Abutment Inspection

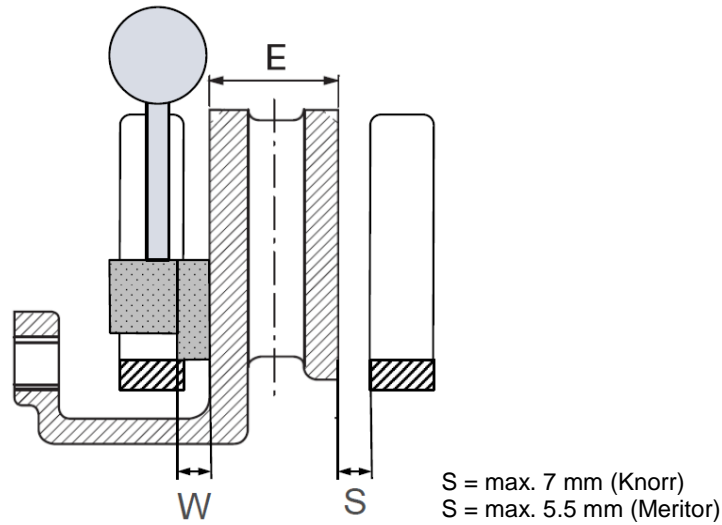


Checking pad abutment to rotor clearance and pad abutment wear

Pad abutment to rotor clearance should be approximately equal at all four points. Large variances from side to side can indicate hub and rotor position off center caused by uneven rotor wear, incorrectly installed spindle wear ring, or incorrect or out-of-adjustment wheel bearings. Minor abutment wear is normal. Wear that will cause the pads to hang up will require carrier replacement.

FIGURE 34

Maximum Permissible Gap Between the Rotor and Pad Abutment



3.19 Guide and slide pin boot inspection

All slide/guide pin boots should be free from damage and should be correctly seated. When a damaged or leaking slide pin seal is identified, the caliper should be removed for replacement of the bushings and seals. See **Figure 35**.

FIGURE 35

Guide/Slide Pin Boot Inspection



Knorr-Bremse guide pin boot

FIGURE 35

Guide/Slide Pin Boot Inspection



Meritor EX225 slide pin boot and tappet boot



Improperly installed slide pin boot

3.20 Tappet boot and seal inspection

With the pads removed, rotate the adjuster clockwise until the boots are clearly visible.

CAUTION: *Do not* extend the Knorr-Bremse tappets more than 1.18 in. (30 mm). Meritor EX225 pistons can be extended to a maximum of approximately 2 in. (50 mm). Extending tappets beyond the maximum will cause a synchronization failure and will require caliper replacement.

All tappet boots and seals should be free from damage and should be correctly seated. Damaged tappet boots and seals should be replaced prior to installing brake pads. Damaged, improperly seated, loose or worn boots and seals (**Figure 36**) can allow moisture to enter the caliper. The caliper-to-boot sealing surface must not be damaged. A damaged sealing surface can allow contamination of the internal mechanism. Rust and contamination of the internal mechanism can cause the caliper to malfunction and not adjust or release, resulting in dragging or slack brakes. Calipers suspected as contaminated, or damaged sealing surfaces, must be replaced (**Figure 37**). Knorr-Bremse has a replaceable inner tappet seal that is accessible when the tappet and boot are removed.

FIGURE 36

Examples of Damaged or Improperly Installed Tappet Boots

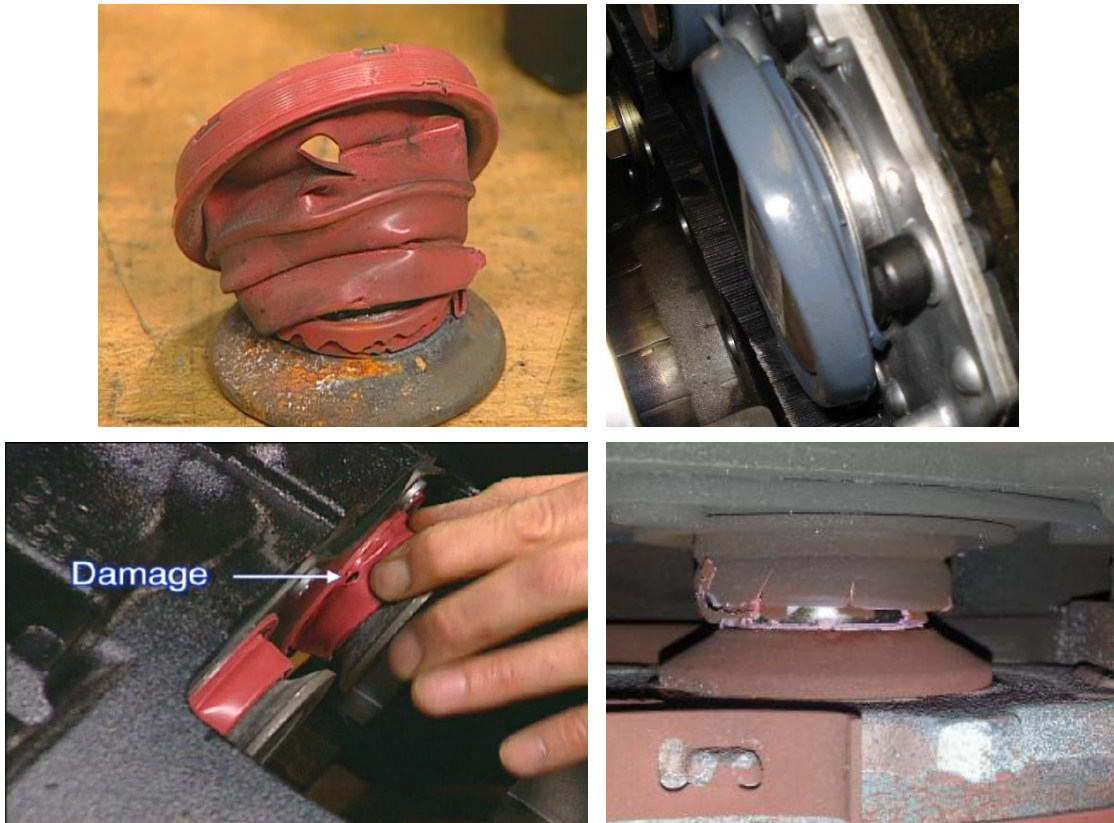


FIGURE 37

Knorr-Bremse Inner Tappet Seal Replacement



3.21 Tappet seal and guide/slide pin seal replacement

It is recommended that caliper slide/glide pin boots and tappet seals be replaced each time the caliper is removed from the vehicle to improve caliper life and performance. Tappet and seal assemblies should always

be replaced as a set. Replace inner tappet seals on Knorr-Bremse calipers whenever tappets and outer seal assemblies are replaced.

To optimize caliper life, consider proactive preventive replacement of tappet seals and boots.

3.22 Tappet inspection

Clean the tappet pad contact surfaces. Using a straight edge, measure tappet height to ensure that both tappets are at equal height (**Figure 38**). Uneven tappet height indicates that tappet synchronization is lost and the caliper must be replaced.

FIGURE 38
Straight Edge Showing Uneven Tappet Height



3.23 Brake chamber inspection

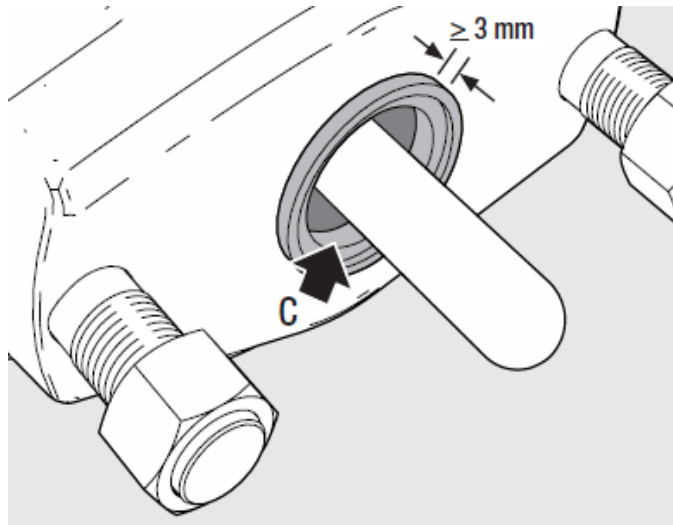
When removing service brake chambers, if there is no spring brake chamber to cage, then carefully remove the service brake chamber from the caliper and proceed to the inspection procedure. If the caliper has a spring chamber, then carefully cage and lock the spring prior to removing it from the caliper and performing the inspection procedure. Follow the chamber manufacturer's instructions to completely cage and release the brake.

With the air chamber removed, visually inspect the chamber mounting studs for damage, bending and missing threads. If there are signs of uneven wear or broken, loose or missing studs, then replace the chamber.

Visually inspect the chamber push rod and chamber seal. If there is damage, then replace the chamber. For chambers used on the Knorr-Bremse caliper, minimum tolerance is 3 mm of seal protrusion (**Figure 39**). If the seal protrudes less than 3 mm, then the chamber must be replaced. Knorr-Bremse calipers do not have a seal on the caliper between the chamber and the caliper. Knorr-Bremse relies exclusively on the brake chamber seal to prevent water and contaminant intrusion.

FIGURE 39

Brake Chamber Seal Protrusion



MGM E-Stroke brake chambers (**Figure 40**) use a seal on the sensor pack with the same 3 mm minimum protrusion. If equipped, this seal must be inspected and replaced if worn or damaged.

FIGURE 40

MGM E-Stroke Brake Chamber Inspection



MGM E-Stroke sensor pack



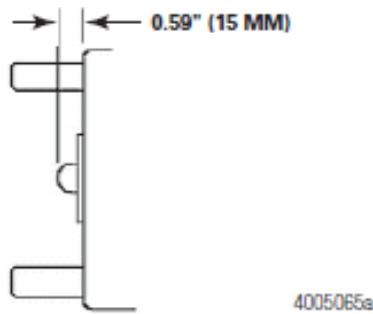
MGM E-Stroke sensor fitted to a brake chamber

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Visually inspect the chamber piston, chamber seal and chamber-mounting aperture on the caliper housing assembly. If signs of water entry and corrosion are present, then replace the chamber and caliper assembly.

Measure brake chamber push rod protrusion from non-pressure housing to ensure that it is set to 0.590 in. or 15 mm (**Figure 41**) prior to installing the brake chamber onto the caliper (same for Meritor EX225 and Knorr-Bremse).

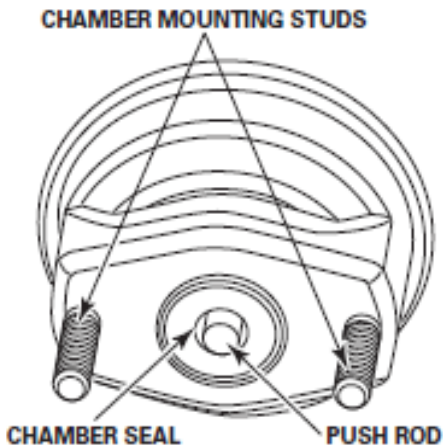
FIGURE 41
Brake Chamber Push Rod Protrusion



Check for lubrication on the brake chamber push rod ball end stud prior to assembly onto the caliper. Refer to Knorr-Bremse or Meritor EX225 maintenance manual for lubricant specification.

Meritor EX225 disc brake calipers frequently have a double seal between the chamber and caliper (**Figure 42**). The seal pressed into the caliper is serviced as a replaceable seal. The chamber seal is an integral part of the brake chamber and can be serviced only by replacing the brake chamber. Check chamber-to-caliper seals for damage and replace seals as necessary. If the seal on the mating surface of the brake chamber is damaged, then replace the brake chamber.

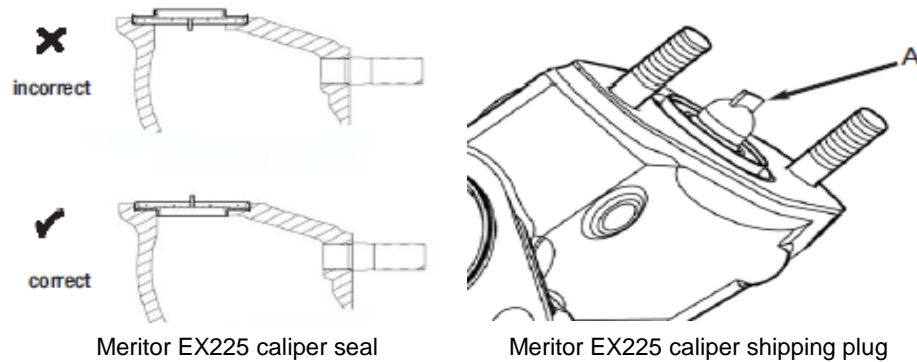
FIGURE 42
Meritor EX225 Brake Chamber



NOTE: The Meritor EX225 caliper has a seal on the caliper that rests against the brake chamber seal (see **Figure 43**). New calipers are shipped with a transit plug and should not be confused with the caliper seal. The transit plug must be removed before the chamber is installed.

FIGURE 43

Meritor EX225 Caliper Seal and Shipping Plug

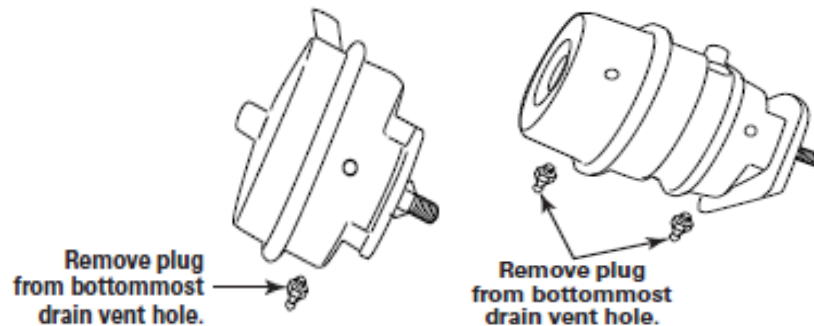


3.24 Brake chamber non-pressure housing plugs

Prior to installing a new brake chamber, ensure that at least one, but always the bottom, brake chamber non-pressure housing plug is removed. Failure to do so will result in a slow-releasing, dragging brake. Contaminants can also be forced into the caliper, resulting in corrosion and malfunction. See [Figure 44](#).

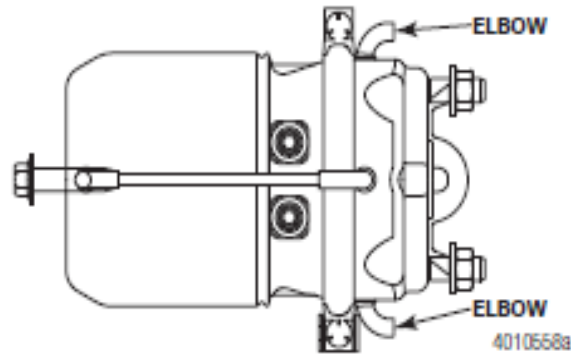
FIGURE 44

Brake Chamber Non-Pressure Housing Plugs



For brake chambers equipped with elbows, the brake chamber must be oriented in such a way that the two elbows will easily allow water and contaminants to drain from the brake chamber. Ensure that the vent tubes have no internal restrictions, which could cause poor venting and dragging brakes. See [Figure 45](#).

FIGURE 45
Brake Chamber Elbow Orientation



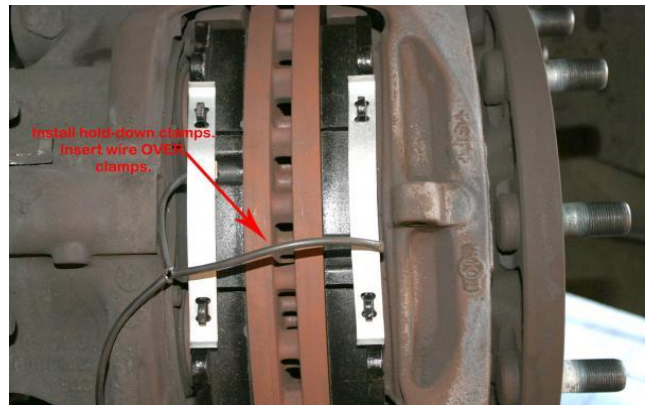
3.25 Brake pad installation and adjustment

Brake pads must be changed as an axle set and *not* individually. Before installing the pads, make sure that the tappets are fully retracted and that all surfaces are clean. Install the new pads with new pad retainers, springs and hardware. Knorr-Bremse permits the use of a light lubricant film on the brake pad metal surface with no excess evident. Anti-seize must not be used. If required, connect and fit cable/sensor guides. Make sure harnesses are secured per the manufacturer's recommendations to prevent chafing against the rotor or rim. See **Figure 46**.

FIGURE 46
Brake Pad Installation and Adjustment



Install sensors as required



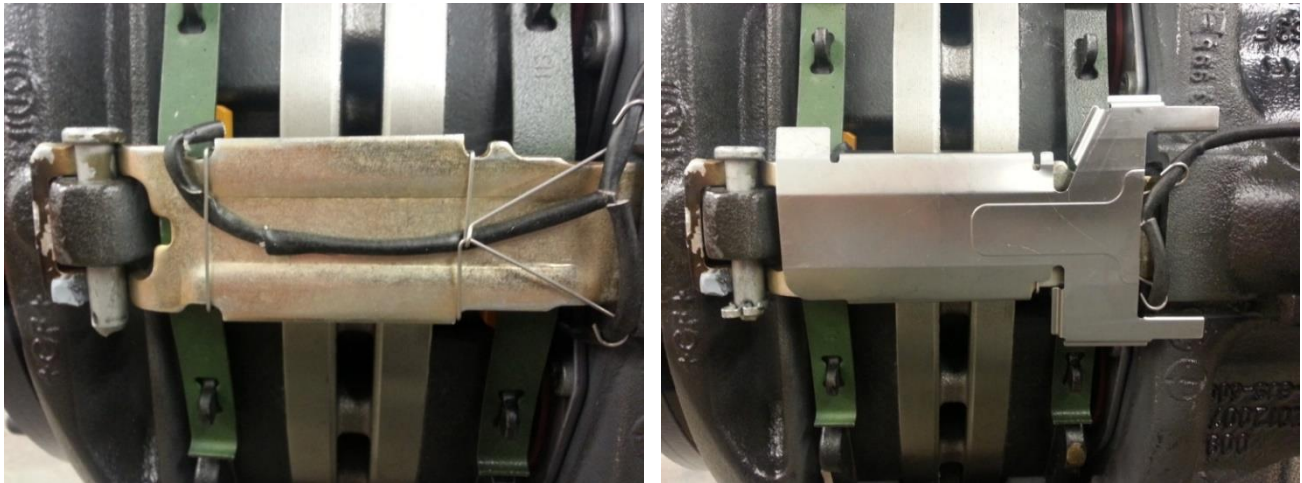
Knorr-Bremse wear sensor harness routing

FIGURE 46

Brake Pad Installation and Adjustment



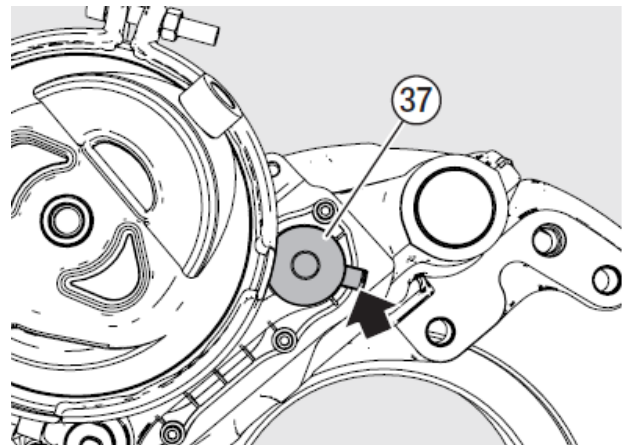
Knorr-Bremse pad retainer installation



If equipped, properly secure Knorr-Bremse wear sensor harness.



Adjusting the brakes to set the initial clearance



Adjuster stem cap position

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For Knorr-Bremse calipers, turn the shear adapter clockwise until the pads come in contact with the rotor. Then back off the adjuster three clicks and check the running clearance. Clearance should be between 0.024 and 0.043 in. (0.6 and 1.2 mm). Apply and release the brake, making sure the hub turns easily by hand. Put a small amount of grease in the adjuster stem sealing cap and install, noting the orientation of the tab.

To set the initial running clearance on Meritor EX225 calipers, use a 10 mm socket and turn the adjuster clockwise until both pads contact the rotor. Turn the adjuster back one half-turn to create a running clearance. Apply the brakes five times to set the correct running clearance. Check that the rotor is free to turn and confirm that the brake-pad-to-rotor clearance is within specification. Nominal total pad-to-rotor clearance should be 0.030 in. (0.75 mm). Install the adjuster stem cap.

Complete a final visual inspection. Install tires, follow brake pad manufacturer's brake pad break-in recommendations, and perform a brake performance test to verify satisfactory operation of the brakes.

Related APTA standards

APTA BTS-BC-RP-006-17, Transit Bus Air Disc Brake Operation and Wheels-On Inspection

References

This *Recommended Practice* is to be used in conjunction with the OEM and disc brake manufacturer service manuals.

Definitions

disc brake assembly: Consists of the brake pads, rotor and caliper assembly.

These terms are interchangeable:

- **brake pad:** friction material, brake lining
- **bearing cups:** bearing races
- **brake chamber:** air chamber
- **machining:** turning, reboring, grinding, sanding and cutting of components

Abbreviations and acronyms

CCOHS	Canadian Centre for Occupational Health and Safety
EBM	electronic brake monitoring
ECU	electronic control unit
ft-lbs	foot-pounds
HEPA	high-efficiency particulate air
MSDS	material safety data sheet
MSHA	Mine Safety and Health Administration
NACVSA	North American Commercial Vehicle Safety Alliance
NATSA	North American Transportation Services Association
Nm	Newton-meters
NIOSH	National Institute for Occupational Safety and Health
OEM	original equipment manufacturer
OSHA	Occupational Safety and Health Administration
psi	pounds per square inch

Summary of document changes

This is a new document hence no changes at this time.

Document history

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First revision	—	—	—	—	—
Second revision	—	—	—	—	—