APTA

AMERICAN PUBLIC TRANSPORTATION ASSOCIATION

APTA Standards Quarterly Webinar Series

Disc Brake Wheels Off Inspection and Reline

Presented by

APTA Brake and Chassis Working Group

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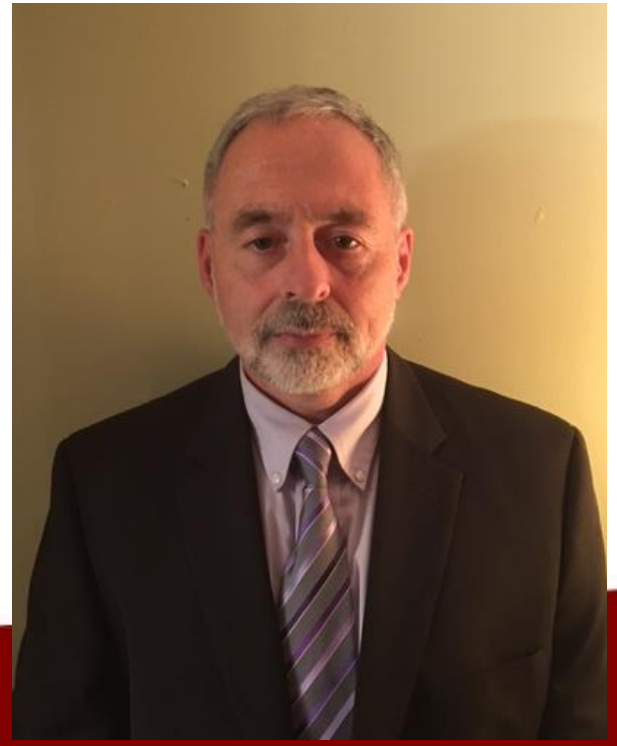

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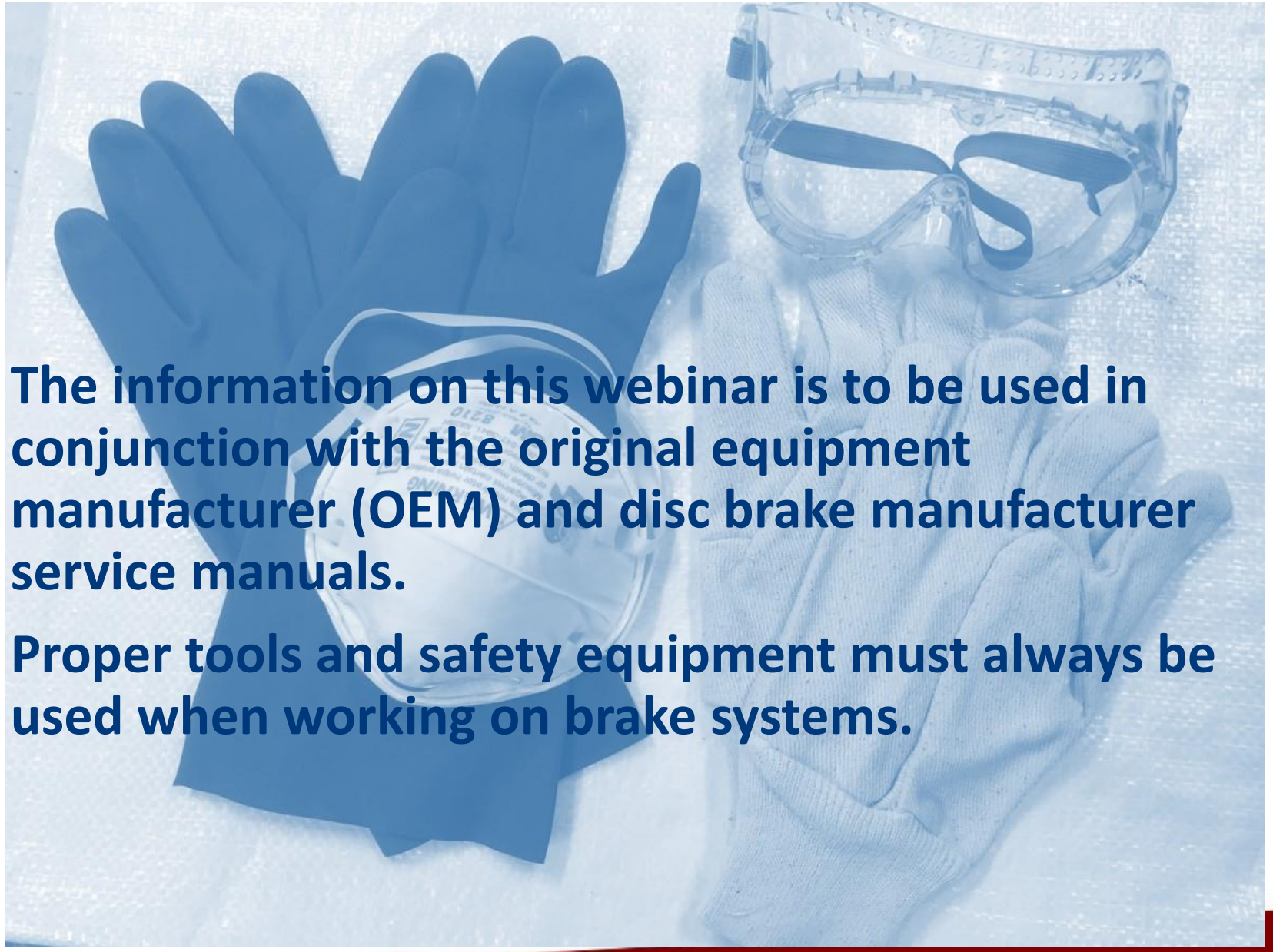
Objective

Welcome to today's webinar in which you will learn how to perform a *Wheels Off Disc Brake Inspection*. We will cover disc brake operation, inspection points, visual and functional checks.



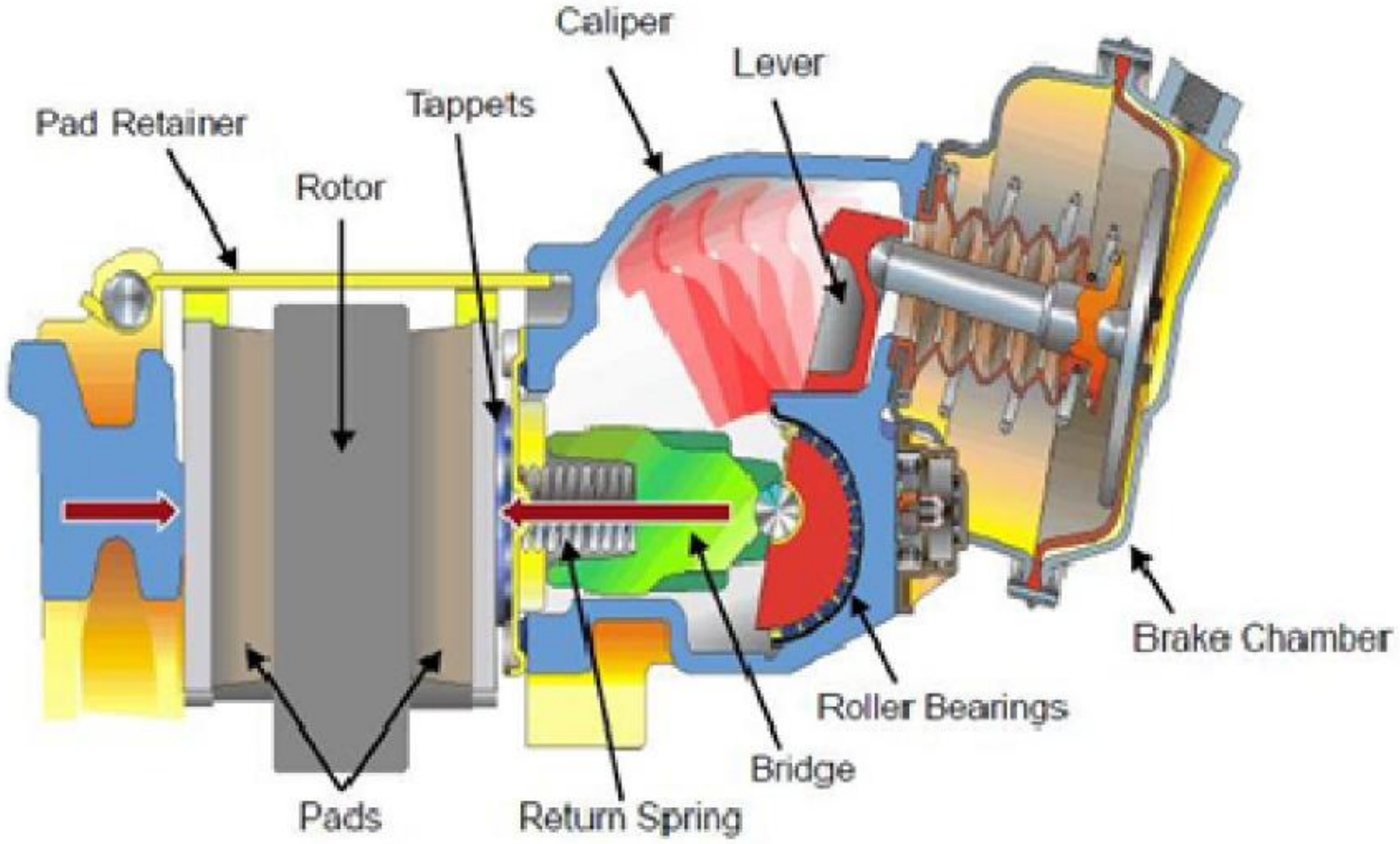
- The information on this webinar is to be used in conjunction with the original equipment manufacturer (OEM) and disc brake manufacturer service manuals.
- Proper tools and safety equipment must always be used when working on brake systems.

Overview

- *Nomenclature*
- *Caliper Identification*
- *Pre-Inspection*
- *Caliper Inspection and Tests*
- *Brake Pad Inspection*
- *Wear Indicators*
- *Rotor Inspection*
- *Brake Chamber Inspection*
- *Brake Pad Installation*
- *Testing and Validation*

Nomenclature

Cross-Section of Knorr-Bremse Caliper Assembly



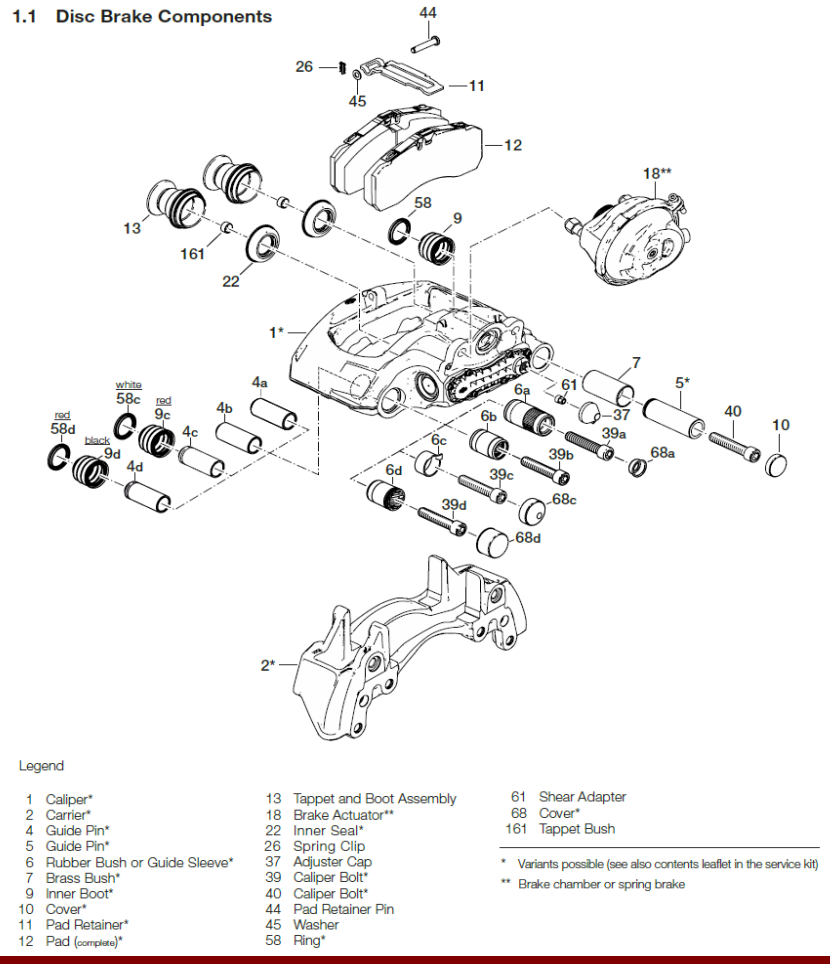
Caliper Identification

Knorr-Bremse SN7 Caliper

Meritor EX225 Caliper

Nomenclature and Identification

Knorr SN7 exploded view



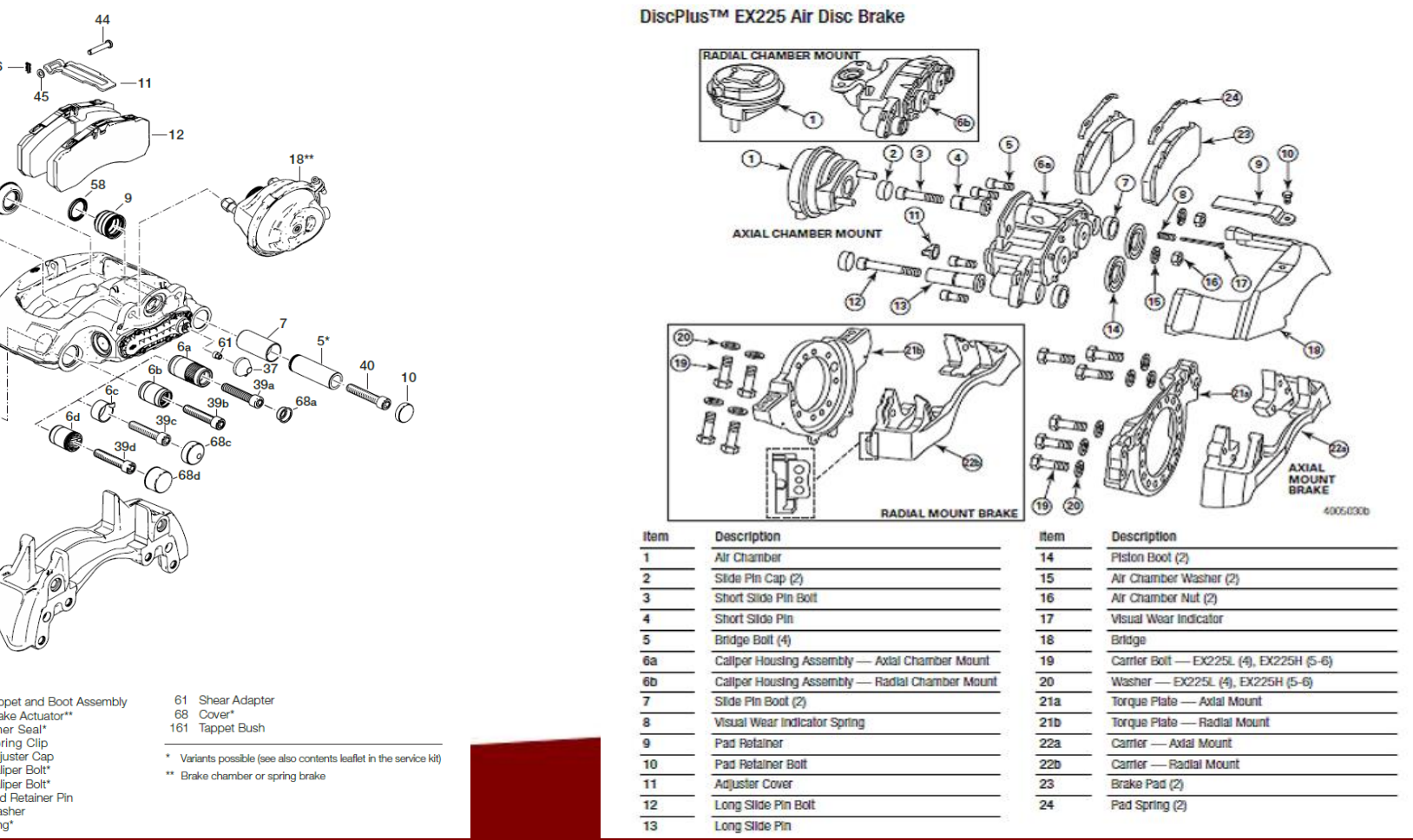
Legend

1 Caliper*
2 Carrier*
4 Guide Pin*
5 Guide Pin*
6 Rubber Bush or Guide Sleeve*
7 Brass Bush*
9 Inner Boot*
10 Cover*
11 Pad Retainer*
12 Pad (complete)*
13 Tappet and Boot Assembly
18 Brake Actuator**
22 Inner Seal*
26 Spring Clip
37 Adjuster Cap
39 Caliper Bolt*
40 Caliper Bolt*
44 Pad Retainer Pin
45 Washer
58 Ring*
61 Shear Adapter
68 Cover*
161 Tappet Bush

* Variants possible (see also contents leaflet in the service kit)

** Brake chamber or spring brake

Meritor EX225 exploded view

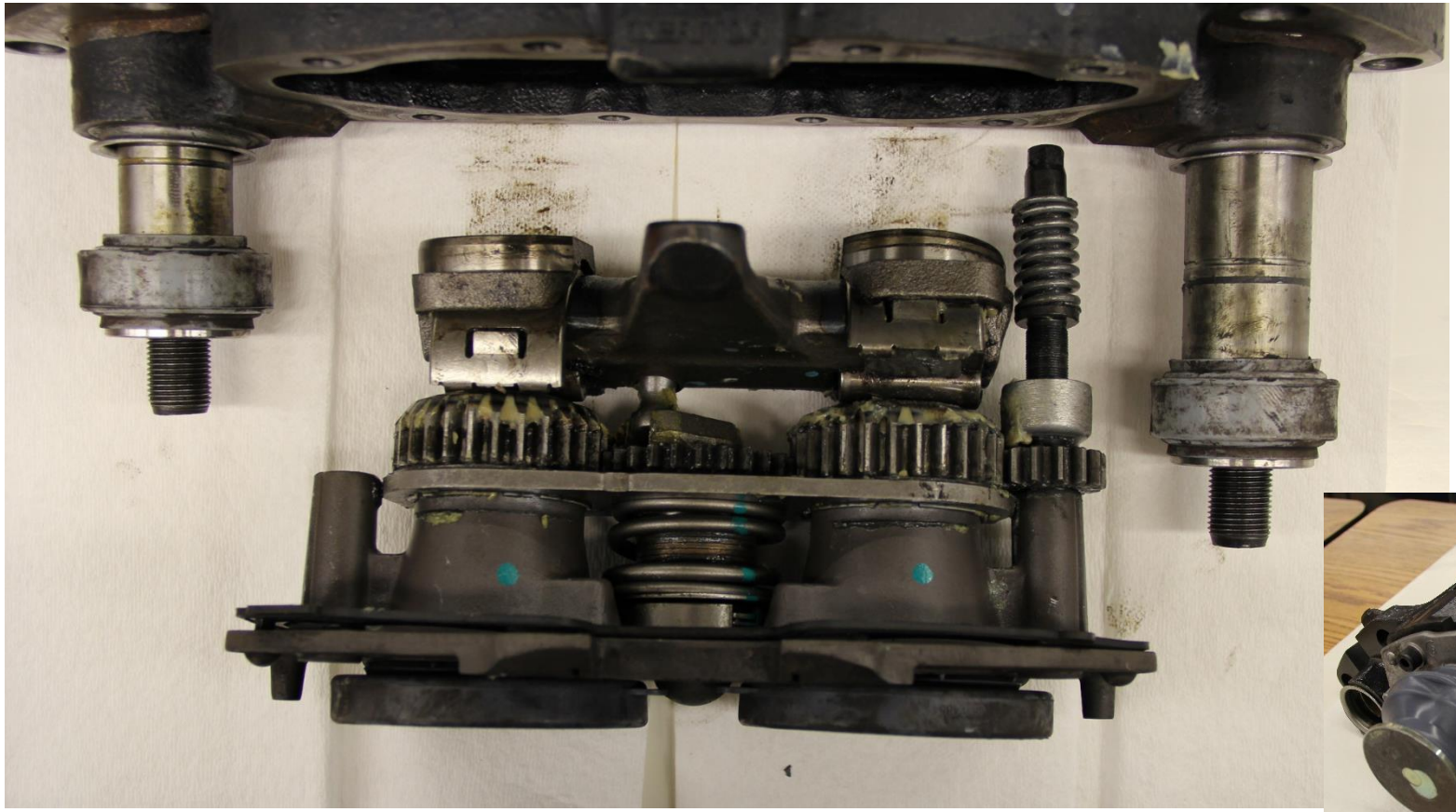


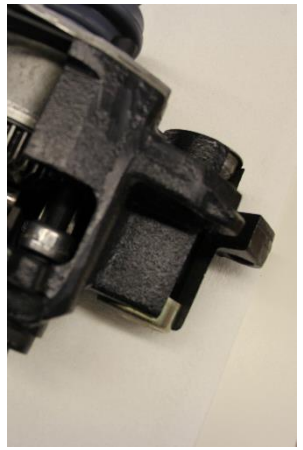
Item	Description
1	Air Chamber
2	Slide Pin Cap (2)
3	Short Slide Pin Bolt
4	Short Slide Pin
5	Bridge Bolt (4)
6a	Caliper Housing Assembly — Axial Chamber Mount
6b	Caliper Housing Assembly — Radial Chamber Mount
7	Slide Pin Boot (2)
8	Visual Wear Indicator Spring
9	Pad Retainer
10	Pad Retainer Bolt
11	Adjuster Cover
12	Long Slide Pin Bolt
13	Long Slide Pin

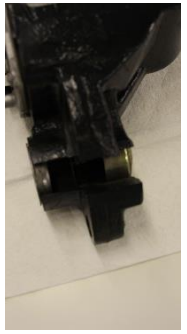
Item	Description
14	Piston Boot (2)
15	Air Chamber Washer (2)
16	Air Chamber Nut (2)
17	Visual Wear Indicator
18	Bridge
19	Carrier Bolt — EX225L (4), EX225H (5-6)
20	Washer — EX225L (4), EX225H (5-6)
21a	Torque Plate — Axial Mount
21b	Torque Plate — Radial Mount
22a	Carrier — Axial Mount
22b	Carrier — Radial Mount
23	Brake Pad (2)
24	Pad Spring (2)

Nomenclature and Identification

Meritor EX225 Caliper





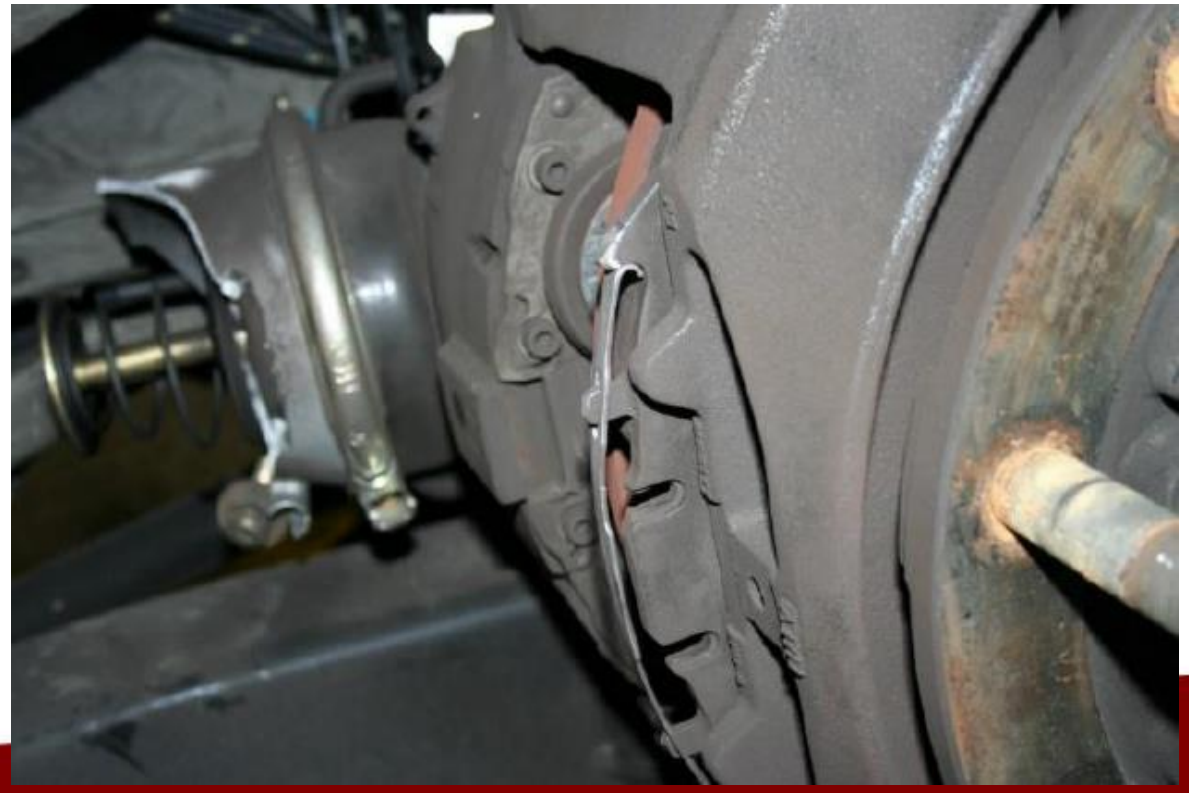


Nomenclature and Identification

Knorr-Bremse Caliper

Pre-Inspection – Other Types of Brake Assembly Damage

Damage caused by a missing pad retainer strap



Damage from a thermal event

Brake Pad Retaining Strap

Inspect caliper brake pad retaining strap and fastener.

Meritor brake pad retaining strap correctly installed with pad anti-rattle springs in place.

Brake Pad Retaining Strap

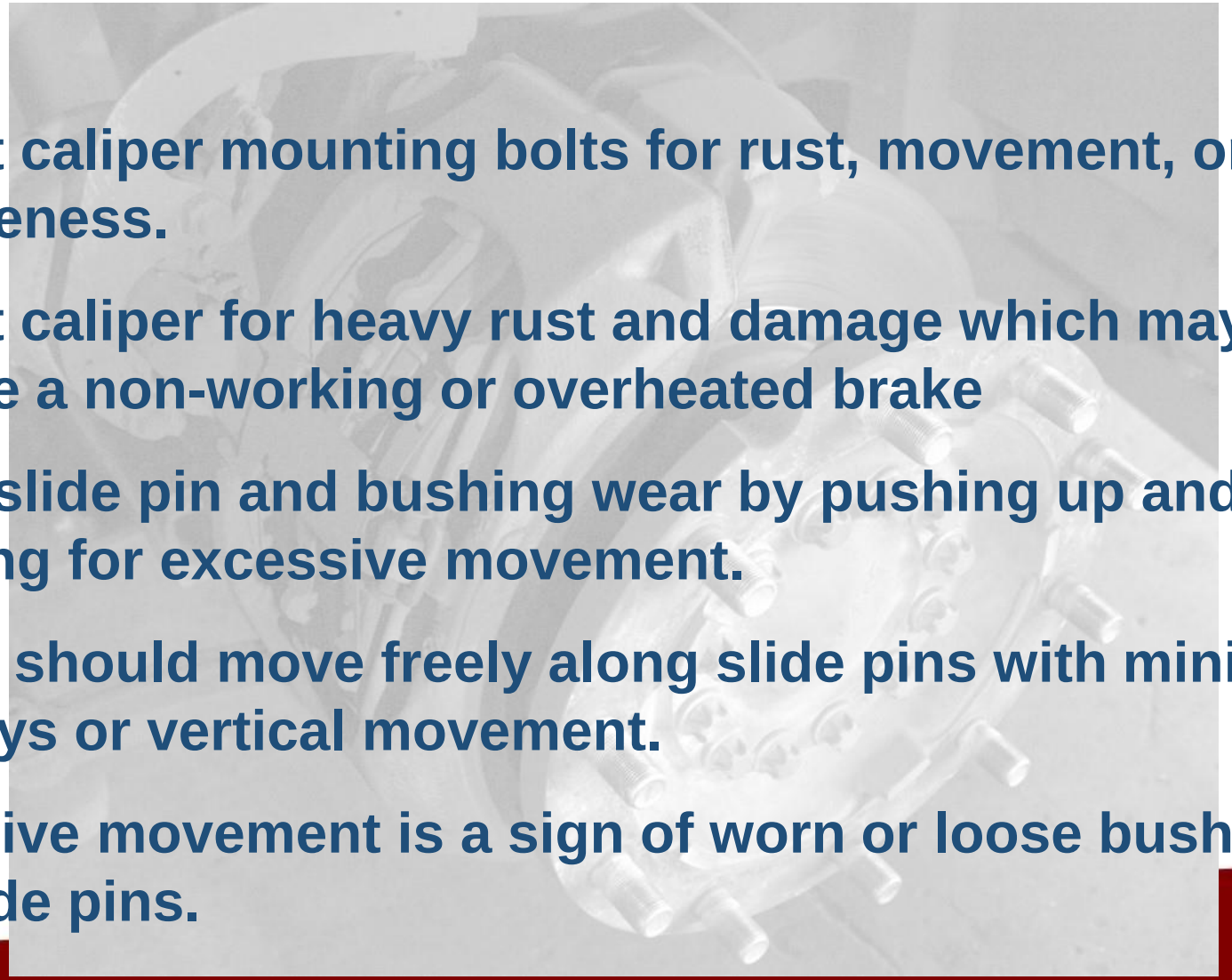
Inspect caliper brake pad retaining strap and fastener

Knorr-Bremse brake pad retaining strap correctly installed with pad anti-rattle springs in place.

Brake Pad Retaining Strap

A missing brake pad retaining strap can allow brake pads to climb out of caliper and wear on the rim resulting in rim and brake failure.

Caliper Inspection

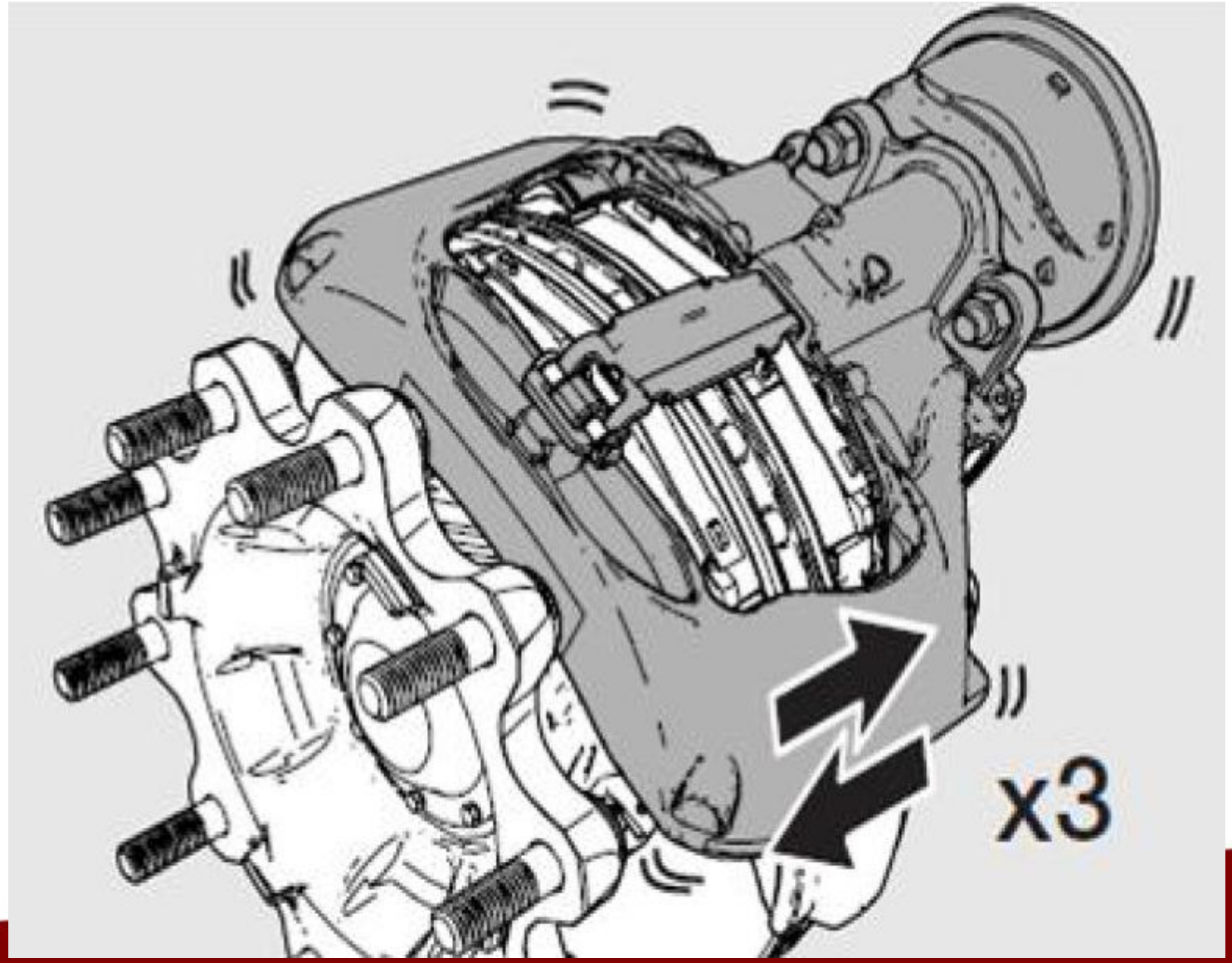


- Inspect caliper mounting bolts for rust, movement, or signs of looseness.
- Inspect caliper for heavy rust and damage which may indicate a non-working or overheated brake
- Check slide pin and bushing wear by pushing up and down checking for excessive movement.
- Caliper should move freely along slide pins with minimum sideways or vertical movement.
- Excessive movement is a sign of worn or loose bushings and slide pins.

Thermal Overload

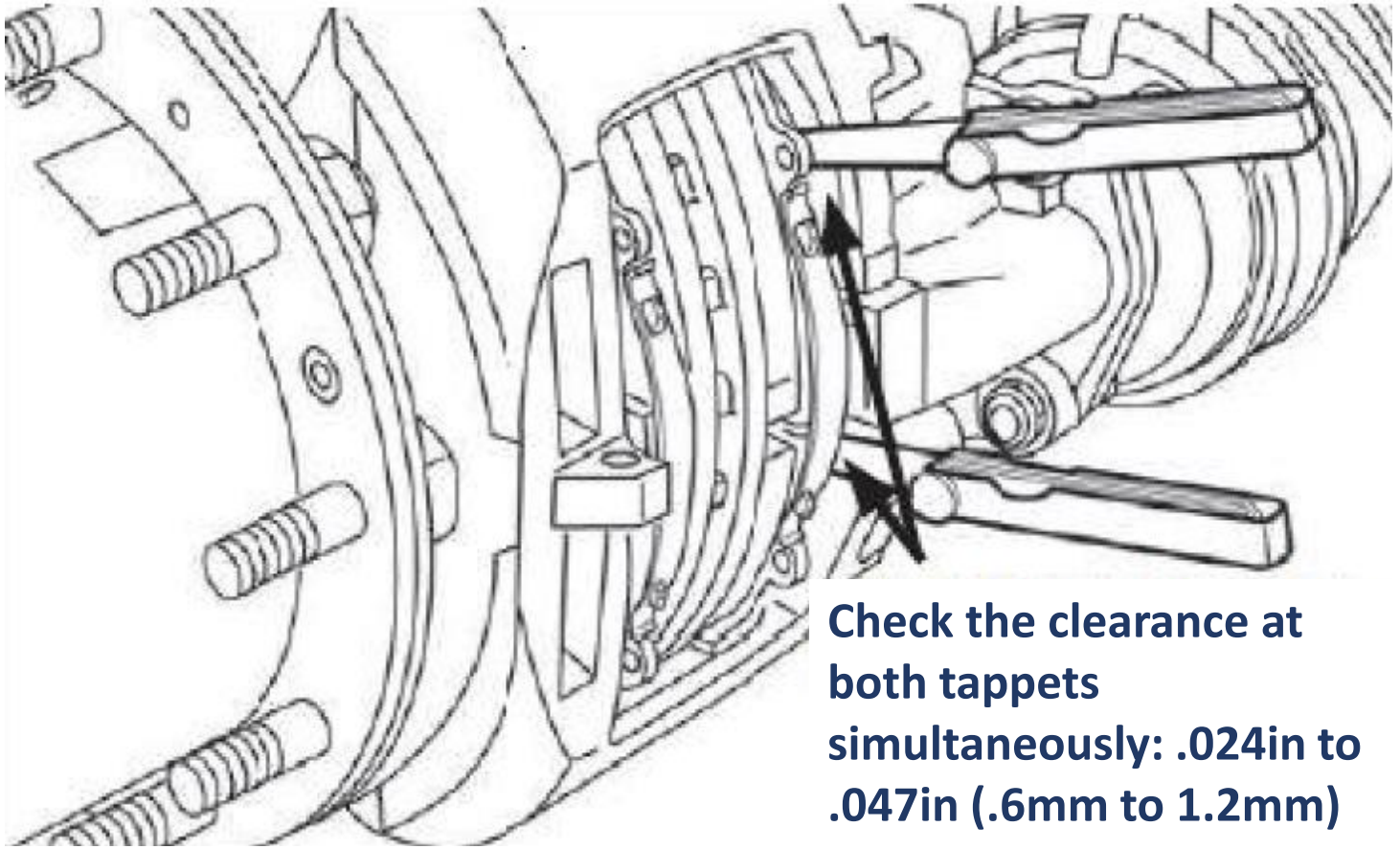
Below are examples of Thermal Overload which is an indication of excessive heat caused by dragging brakes. The cause must be identified and corrected

Knorr-Bremse Caliper Movement Test



The caliper movement test is done to make sure that the caliper slides on its pins and there is sufficient clearance between the rotor and brake pads

Knorr-Bremse Caliper Movement Test

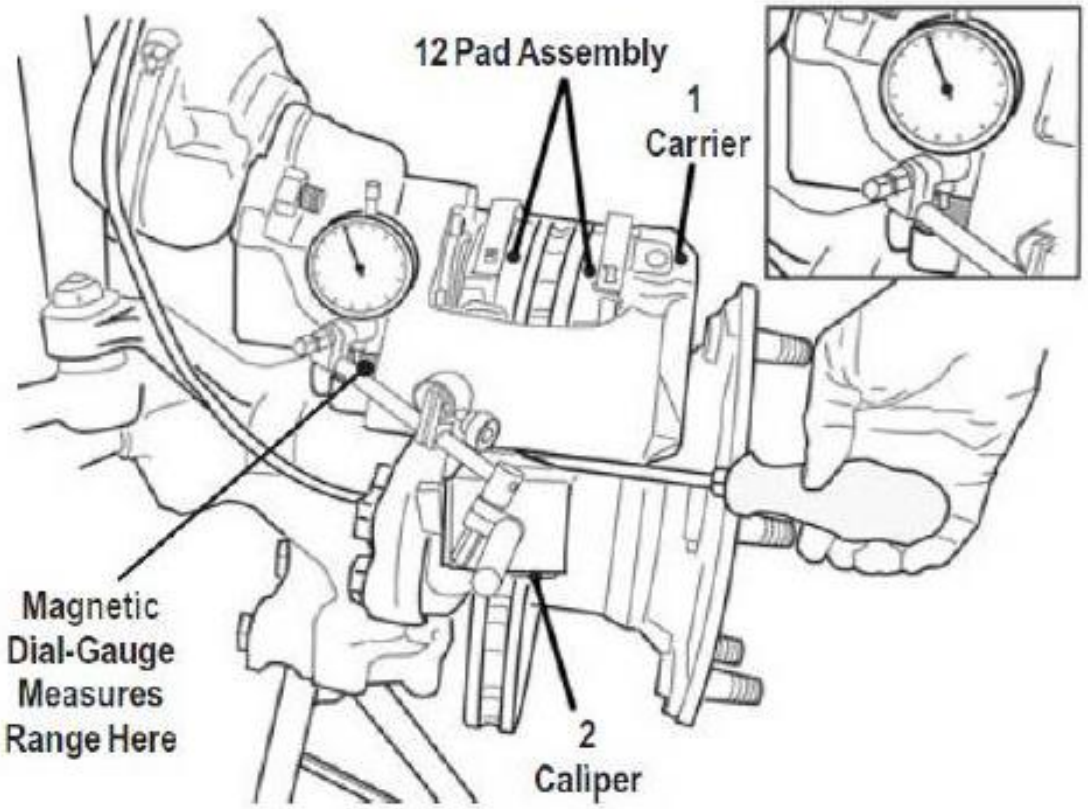


Check the clearance at both tappets simultaneously: .024in to .047in (.6mm to 1.2mm)

Knorr-Bremse does allow a difference of .010" between the upper and lower tappet and pad measurements

Knorr-Bremse Caliper Guide Pin Inspection

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



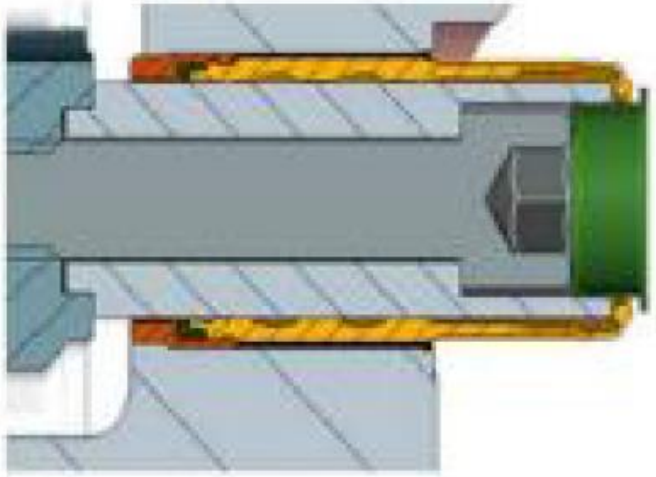
Knorr-Bremse guide pin inspection to be done with new brake pads. Mount a dial indicator as shown. If the caliper is removed, guide pins, bushings and seals should be replaced. The SB caliper version uses rubber bushings. Refer to the manual for specifications.

Knorr-Bremse Caliper Guide Pin Inspection

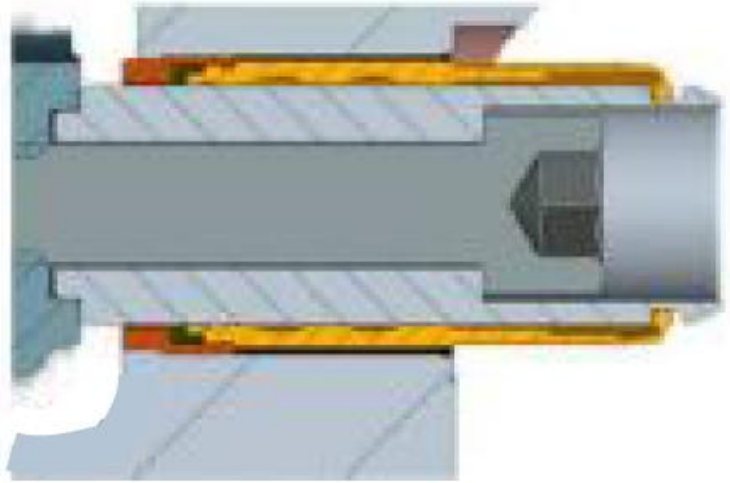
The specification for allowable movement varies due to differences in slide pin bushing design. Always confirm which slide pin bushing is installed in the caliper and refer to the Knorr-Bremse manual for the appropriate specification

Knorr-Bremse Caliper Guide Pin Inspection

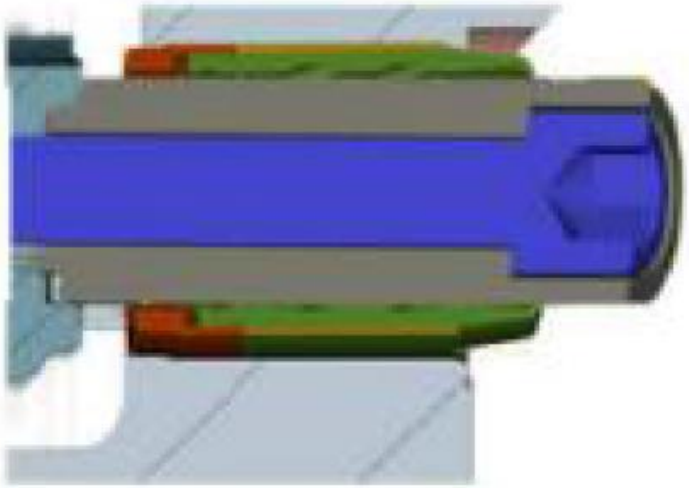
Different Knorr-Bremse guide (slide) pin bushing designs



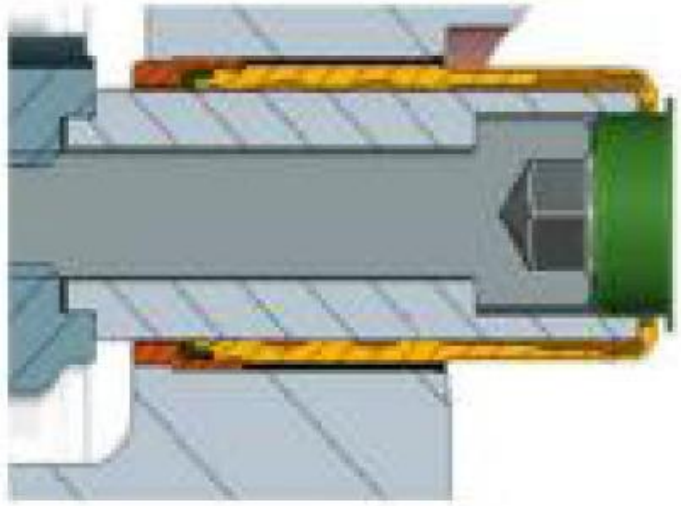
Closed rubber bush bearing with metal hood



Closed rubber bush bearing without metal hood



Open rubber bush bearing



Closed rubber bush bearing with metal hood

Adjusting Screw Seal and Cap

- Inspect adjusting screw cap for missing, damage, and a tight seal

Adjusting Screw Seal and Cap

Check the condition of the adjuster inner seal

Knorr-Bremse Shear Adapter

The Knorr-Bremse shear adapter is designed to shear if excessive torque is required to turn the adjuster

The shear adapter (above) fits over the splines on the Knorr-Bremse adjuster (right)

Knorr-Bremse Caliper Adjuster Test

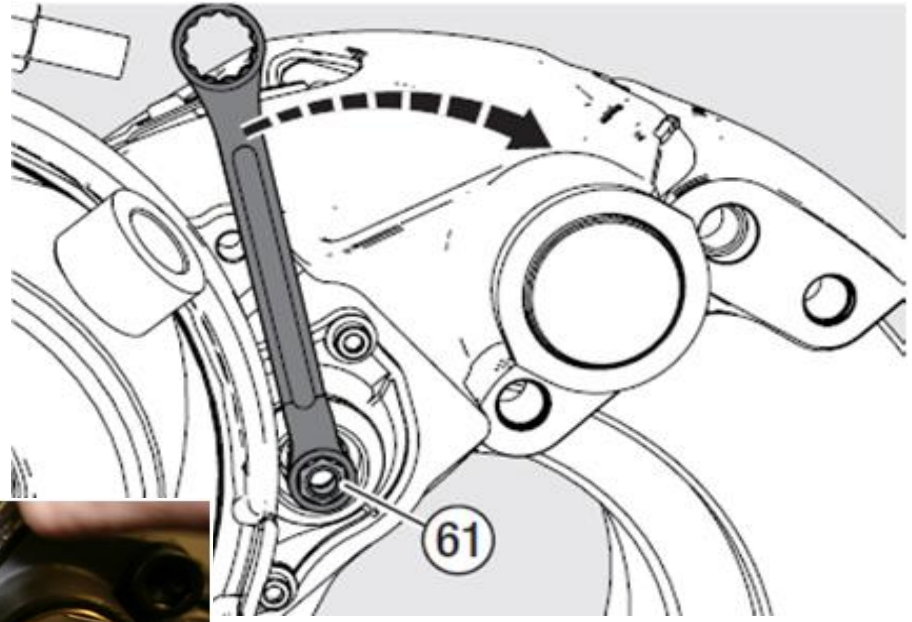
- Turn adjuster three clicks counter clockwise to back off using a 10mm box wrench or socket
- If the shear adapter fails, replace and attempt a second time
- If the shear adapter fails again, the adjuster is seized and the caliper needs to be replaced

Meritor Caliper Adjuster Test

- Turn adjuster counter clockwise to back off using a 10mm box wrench or socket
- Do not exceed 30 FT/LBS torque in either direction
- If higher torque is required. Caliper is seized and must be replaced

Caliper Adjuster Test

- Leave wrench on shear adapter (Knorr) or adjuster (Meritor)
- Make sure wrench is positioned so that it can move clockwise without obstruction
- Apply brakes with about 2 bar (30 psi) air pressure five to ten times
- The wrench should turn clockwise
- If the wrench does not turn, turns only on first application, or turns forward and backward with every application, the adjuster has failed and the caliper must be replaced



Meritor Caliper Adjustment Check

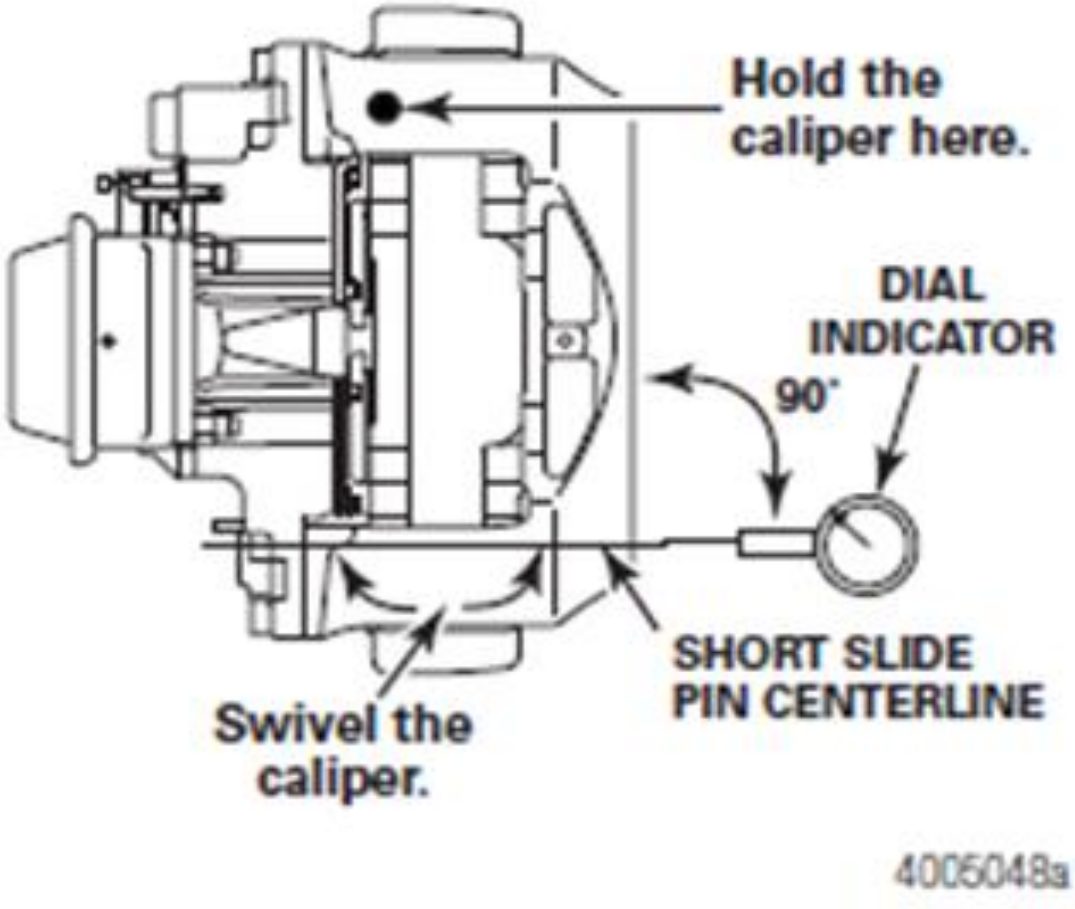
With the wheel off, attach the dial indicator to the axle placing the indicator pin parallel to the slide pin direction. Slide the caliper back and forth by hand. A reading in excess of 2mm (.080”) indicates a malfunctioning adjuster.

Meritor Caliper Slide Pin Radial Test

Mount a dial indicator as shown with the caliper in the middle position on the slides with the brake pads removed.
Push the caliper and down and set the dial indicator to “0”
Next, pull up on the caliper as far as possible without allowing the caliper to slide and note the measurement
If the reading is more than .078” (2mm), replace the bushings and slide pins

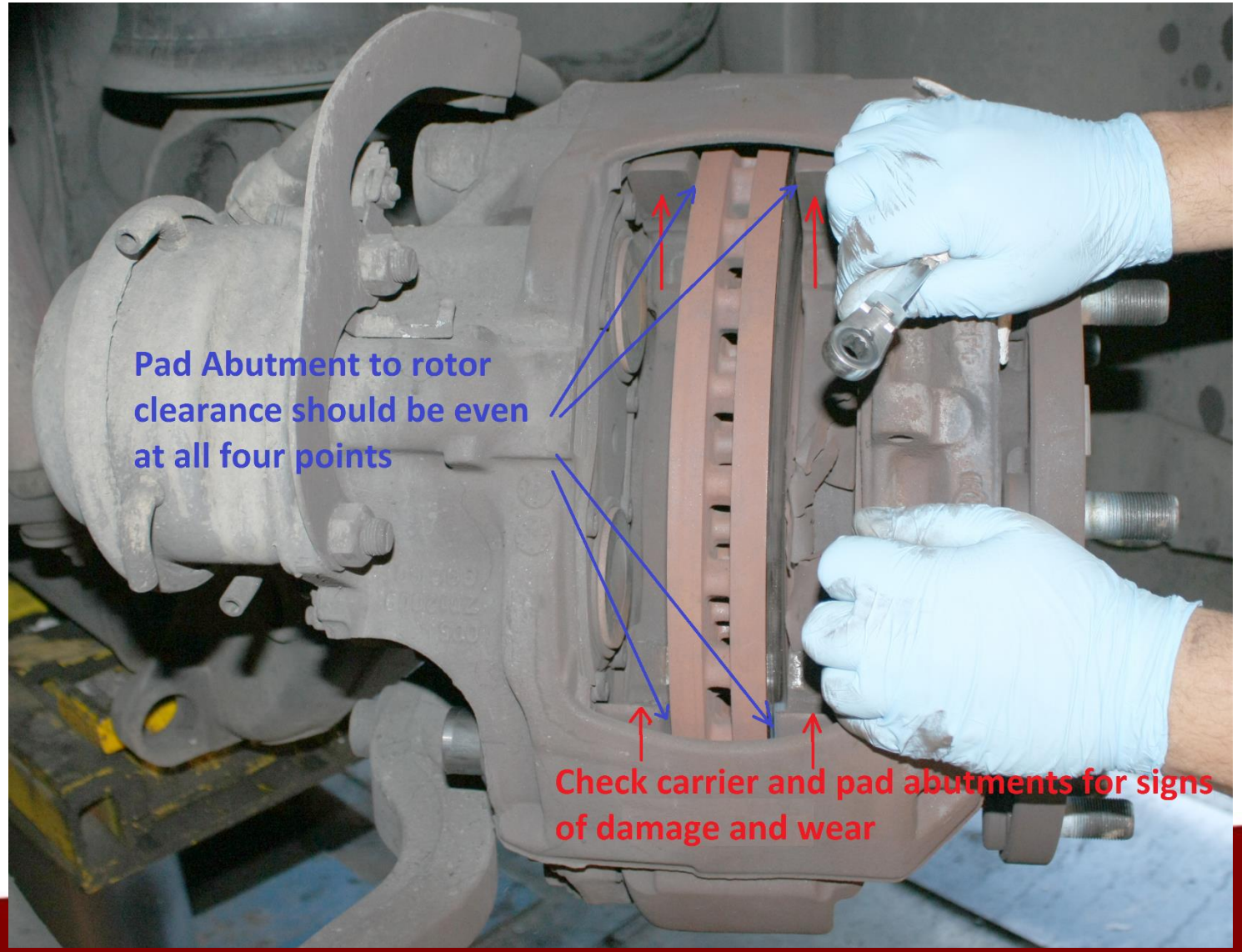
Meritor Caliper Slide Pin Tangential Test

- Mount a dial indicator to the hub so that it is in line with the centerline of the short slide pin as shown with the caliper in the middle position on the slides with the brake pads removed
- Hold the caliper so that it cannot move
- Swivel the caliper until it stops in one direction and set the gauge to “0”
- Move the housing in the opposite direction until it stops and note the reading
- If the reading is more than .118” (3mm) replace the bushings, slide pins, or caliper assembly



Carrier Inspection

Check carrier for signs of damage or excessive wear



Carrier Brake Pad Abutment

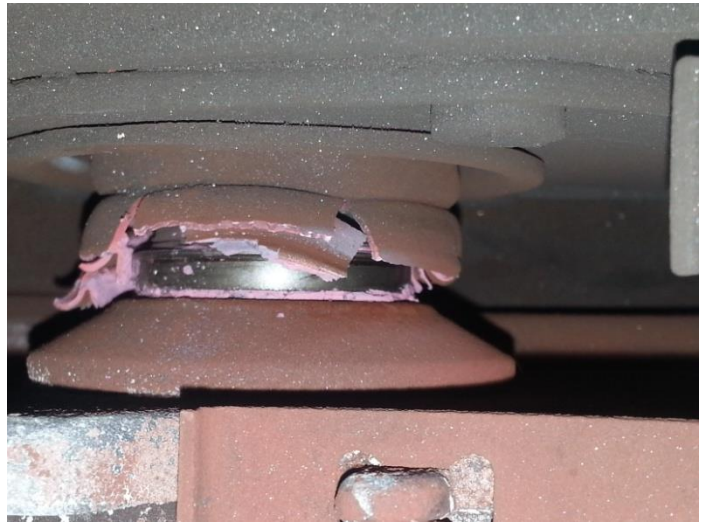
Dirty Abutment

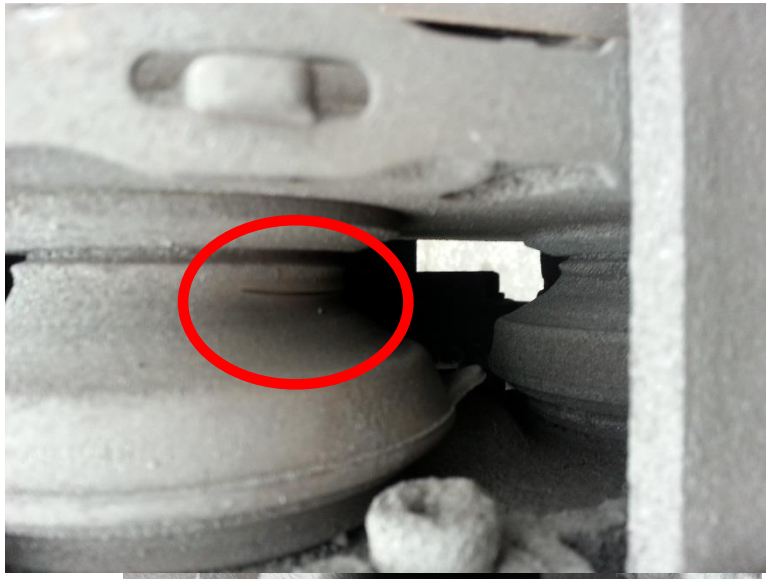
Clean the abutment areas. Depending on the amount of contamination observed, the tools required for cleaning will vary but may include a wire brush, file, sandpaper or blunt scraper.

Clean Abutment

Tappet Boots and Seals

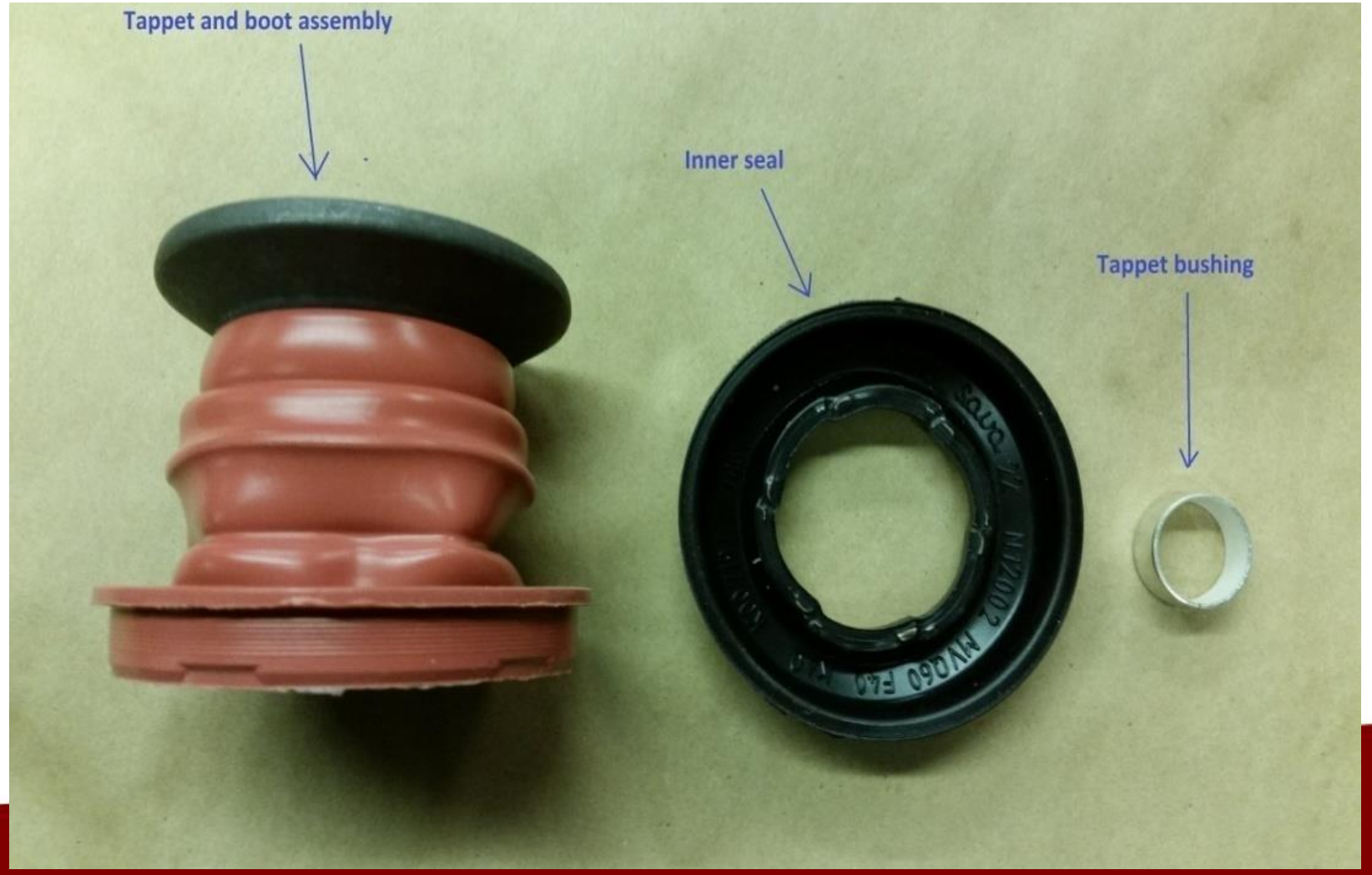
- Visually inspect tappet boots and seals for damage.
- Damaged boots and seals require further inspection and replacement
- Damaged, improperly seated, loose or worn boots and seals can allow moisture to enter the caliper.
- Rust and contamination of the internal caliper mechanism can cause the caliper to malfunction and not adjust or release, resulting in dragging or slack brakes.





Knorr-Bremse Tappet Boots and Seals

To optimize caliper life, consideration should be given for proactive preventative replacement of tappet seals and boots.



Tappet Boots and Seals

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

Tappet Boots and Seals

Using a straight edge, measure tappet height to ensure both tappets are at equal height. Uneven tappet height indicates incorrect tappet installation or that tappet synchronization has been lost. *Knorr does allow a maximum of .25mm (.0098”) difference of tappet height

Meritor Boots and Slide Pin Seals

To optimize caliper life, consideration should be given for proactive preventative replacement of piston boots and slide pin seals.

Caliper Guide/Slide Pin Inspection

Check guide/slide pin boots. Boots, slide pins and the cap should be replaced as a set.

All slide pin boots must be free from damage and be properly seated.

Brake Pad Inspection

- Inspect caliper and brake pads for:
  - Missing brake pads
  - Loose friction material on pad backing plate
  - Brake pad thickness
  - Overheated brake pads
  - Contamination
- Note: Brake pad thickness of .079 inch (2 mm) or worn to wear sensor requires immediate reline.
- Caliper mounted wear indicator or electronic wear indicator is acceptable for measuring pad thickness.

Brake Pad Inspection

Check for uneven pad wear, wear beyond tolerance, tapered and broken pads.

The cause of improper pad wear must be identified and corrected.

Brake pad uneven wear (taper)

Brake pads showing unacceptable wear—note edges

Brake Pad Inspection

Check for brake pad contamination and overheating

The cause of improper pad conditions must be identified and corrected.

Brake pad contamination

Brake pad excessive heat

Brake Pad Wear Indicators

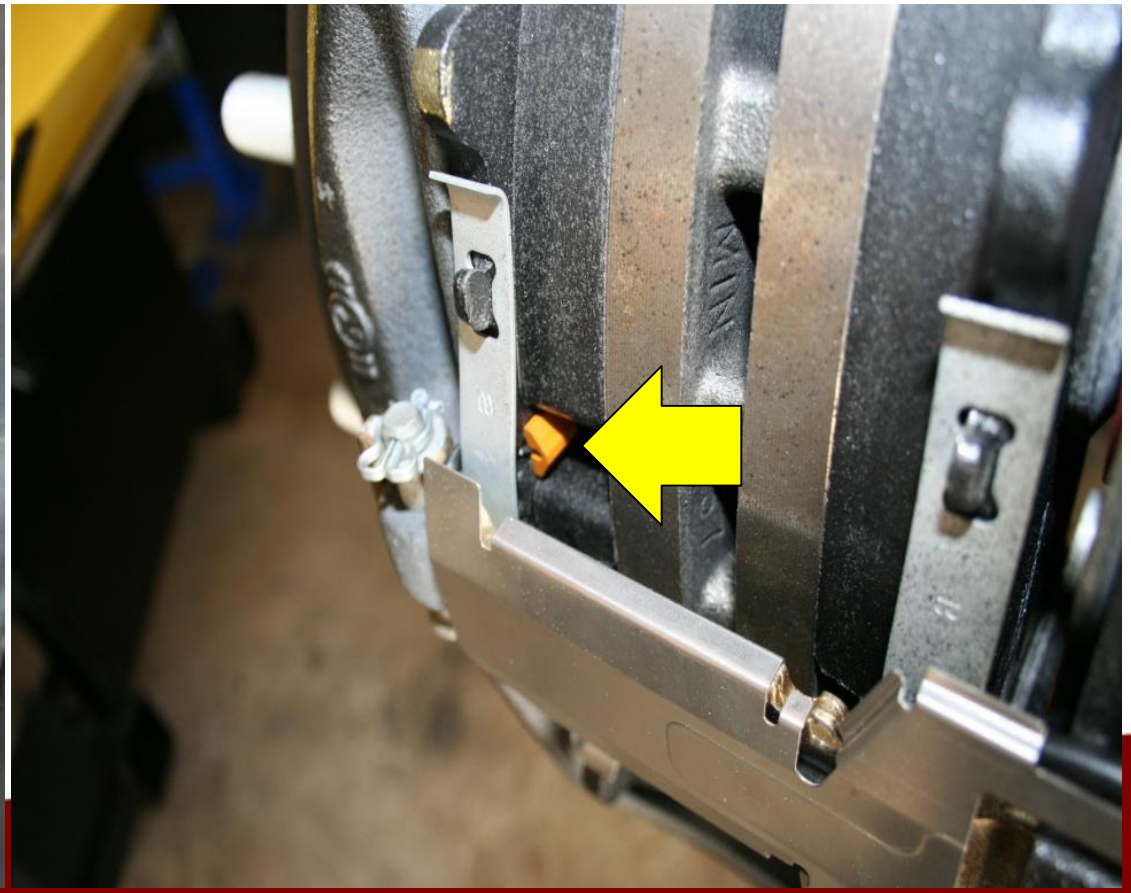
- Electronic brake pad wear indicators:
  - Warn operator prior to maximum wear limit and end of pad life
  - Account for rotor wear
- Mechanical brake pad wear indicators:
  - Measure pad thickness based on a pre-determined rotor thickness of 45 mm
  - Do not account for rotor wear

Electronic Brake Pad Wear Indicators

- Electronic brake pad wear indicators
  - Have a sensing wire embedded in the friction material at the minimum service thickness
  - When friction material wear approaches minimum thickness, sensor wire contacts rotor creating a electrical path to ground and illuminates a service warning requiring further inspection
  - As the friction material wears further the sensor wire breaks creating an open circuit illuminating an end of life warning

Electronic Brake Pad Wear Indicators

In-pad electronic wear sensor and wiring harness



Electronic Brake Pad Wear Indicators

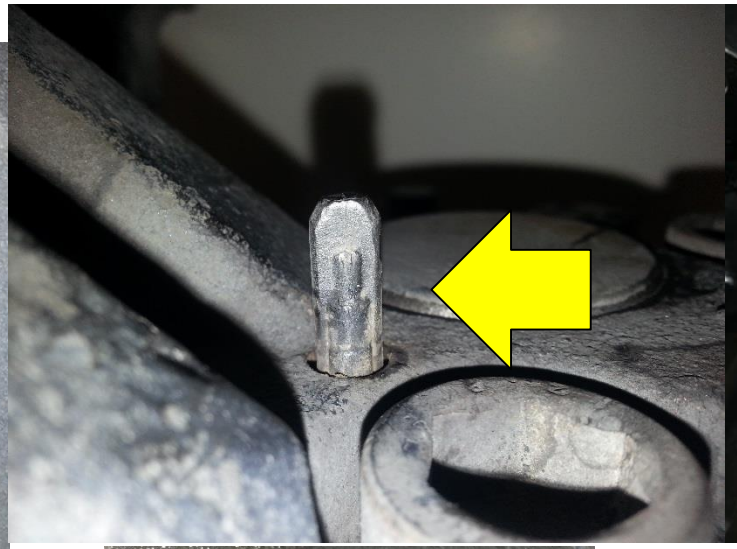
Brake pad approaching minimum wear tolerance—note sensor wear

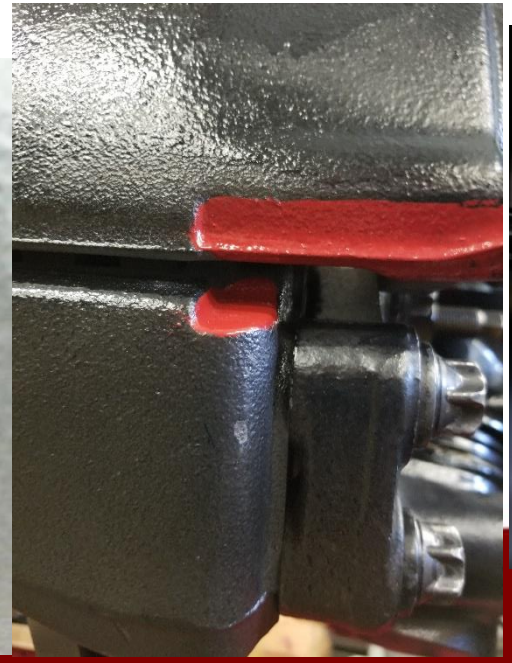
Mechanical Brake Pad Wear Indicators

- Mechanical brake pad wear indicators
  - Measure brake pad thickness based on caliper position and new rotor thickness of 45mm
  - As friction material and rotor wear, indicator moves providing a general reference of remaining friction material
  - Don’t compensate for rotor wear
  - Are less accurate when new pads are installed on used rotors
  - Require visual inspection of pads and rotor more frequently

Mechanical Brake Pad Wear Indicators

Some examples of different types of mechanical brake pad wear indicators





Electronic Brake Wear Indicators

Knorr-Bremse caliper mounted wear sensor (potentiometer) indicates combined pad and rotor wear

Electronic Brake Monitoring

An EBM system can be an effective maintenance tool to aid in the inspection or troubleshooting of the air brake system

Brake Rotor Inspection

- 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
- Rotors must be replaced or resurfaced as an axle set

Brake Rotor Inspection

Visually inspect rotor for:

- Wear
- Overheating
- Heat checks
- Cracks
- Grooves
- Discoloring
- Damage
- Contamination

Brake Rotor Inspection

Check rotor for damage and excessive wear

Brake Rotor Inspection

Blue bands or marks indicate the rotor was very hot

Brake Rotor Inspection

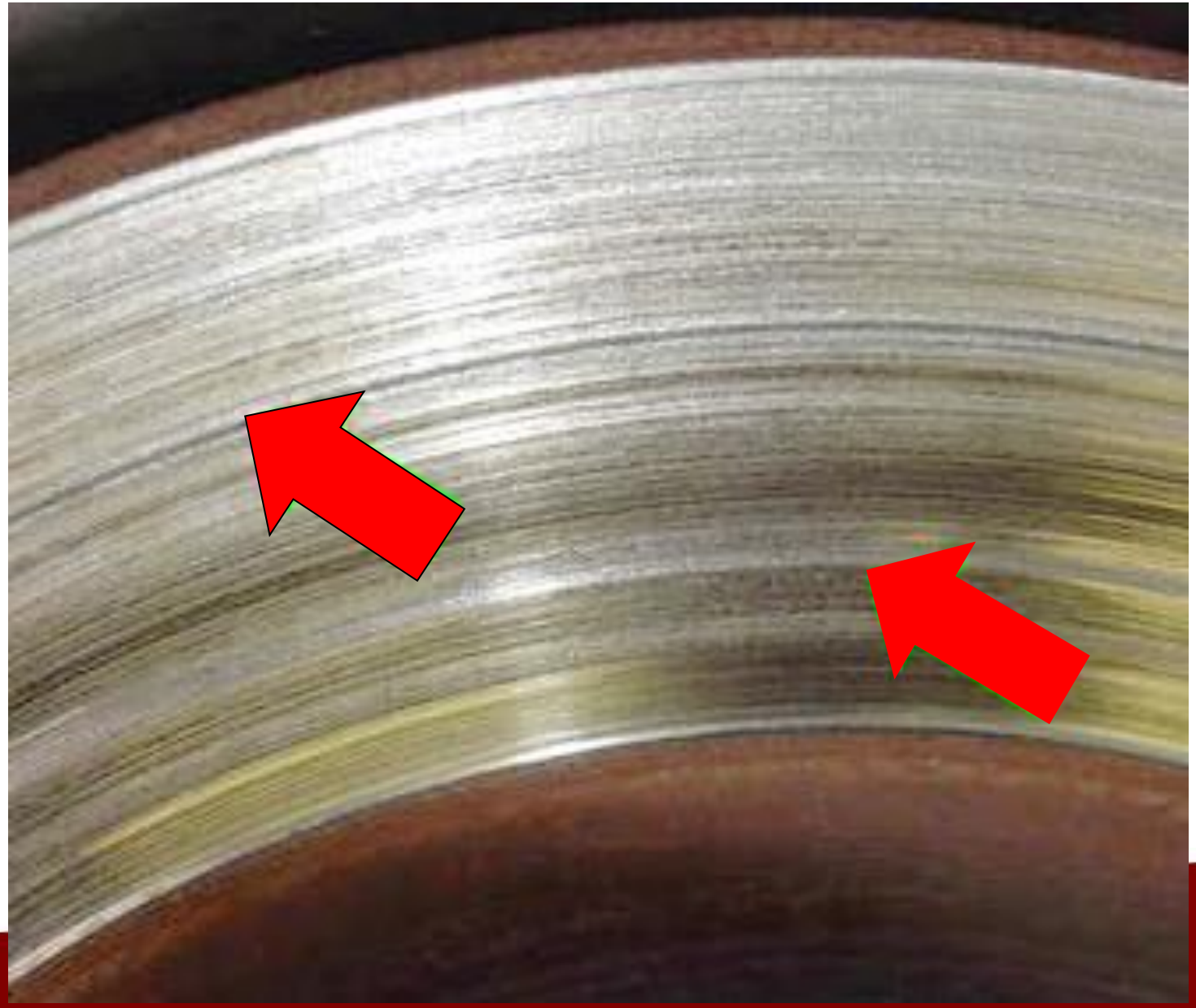
Rusting on rotor surface indicating possible inoperative brakes

Brake Rotor Inspection

Rotor damage caused by tappet to rotor contact due to missing brake pad

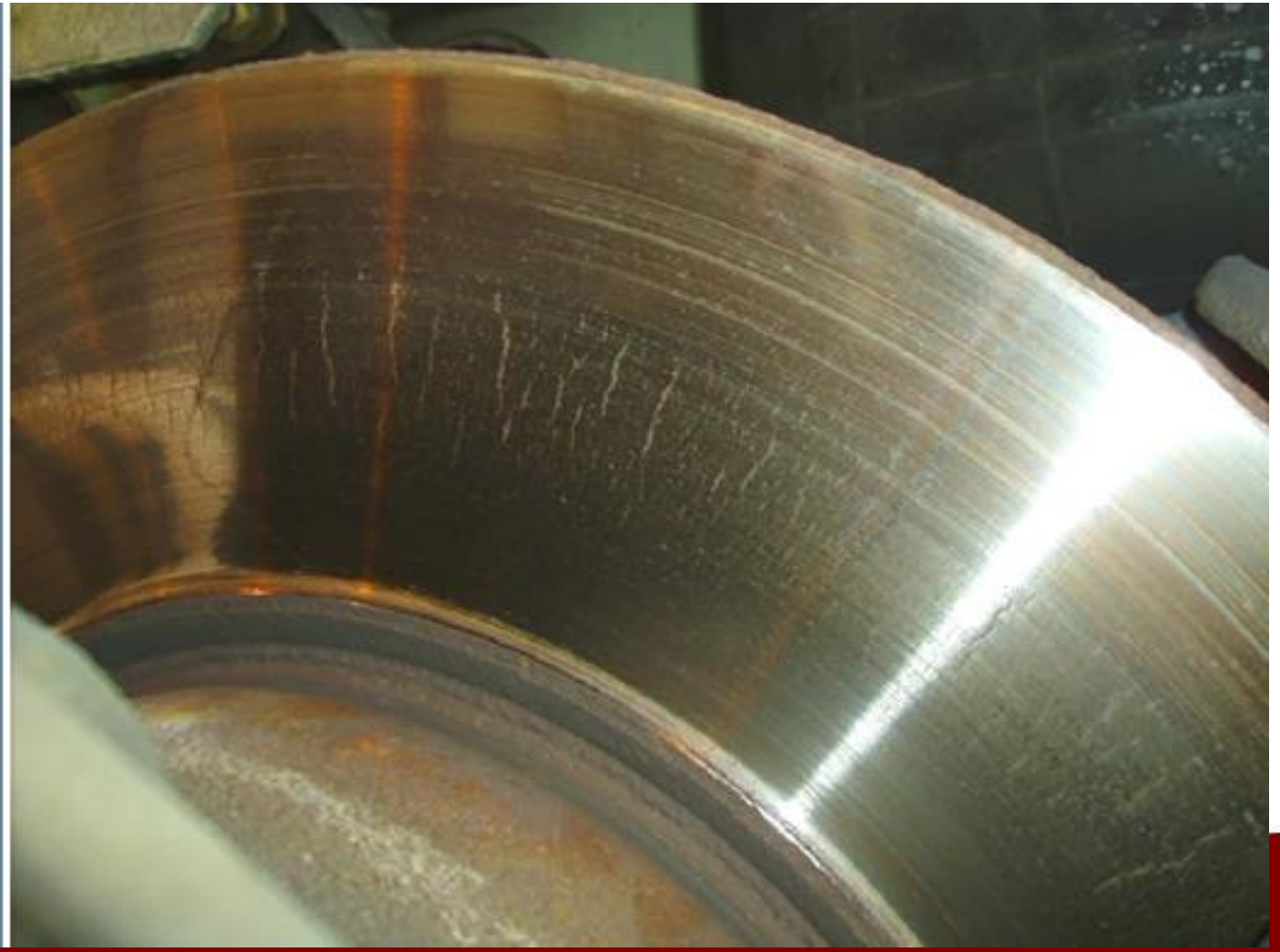
Brake Rotor Inspection

Grooves deep enough that the rotor thickness, when measured in the grooves, is thinner than the minimum allowable rotor thickness will require a rotor replacement. The cause must be identified and corrected.



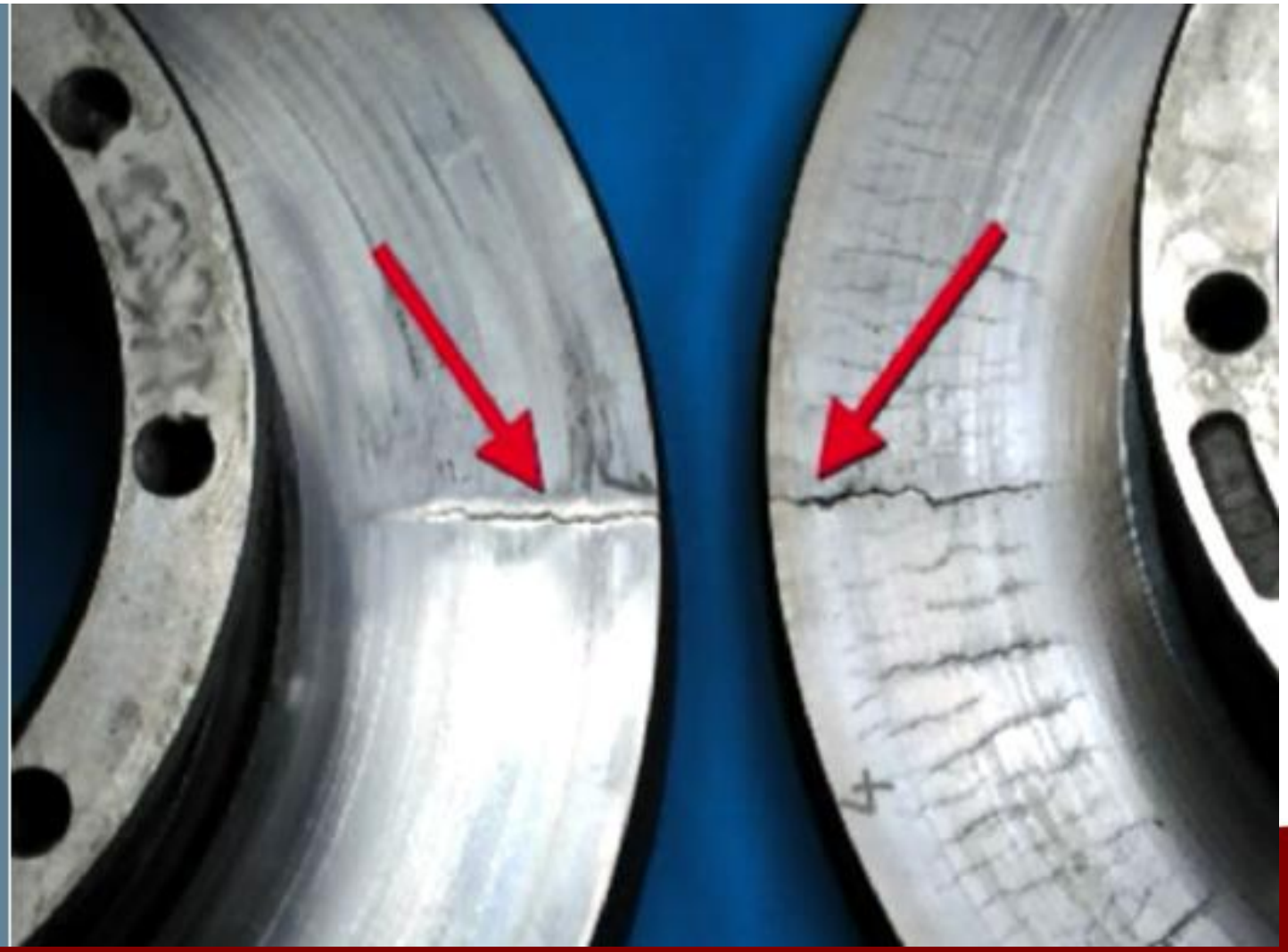
Brake Rotor Inspection

Small heat check are allowable (as shown)



Brake Rotor Inspection

Large cracks creating a split in the rotor is not acceptable and requires rotor replacement



Brake Rotor Inspection

Excessive cracking will require rotor replacement

Brake Rotor Inspection

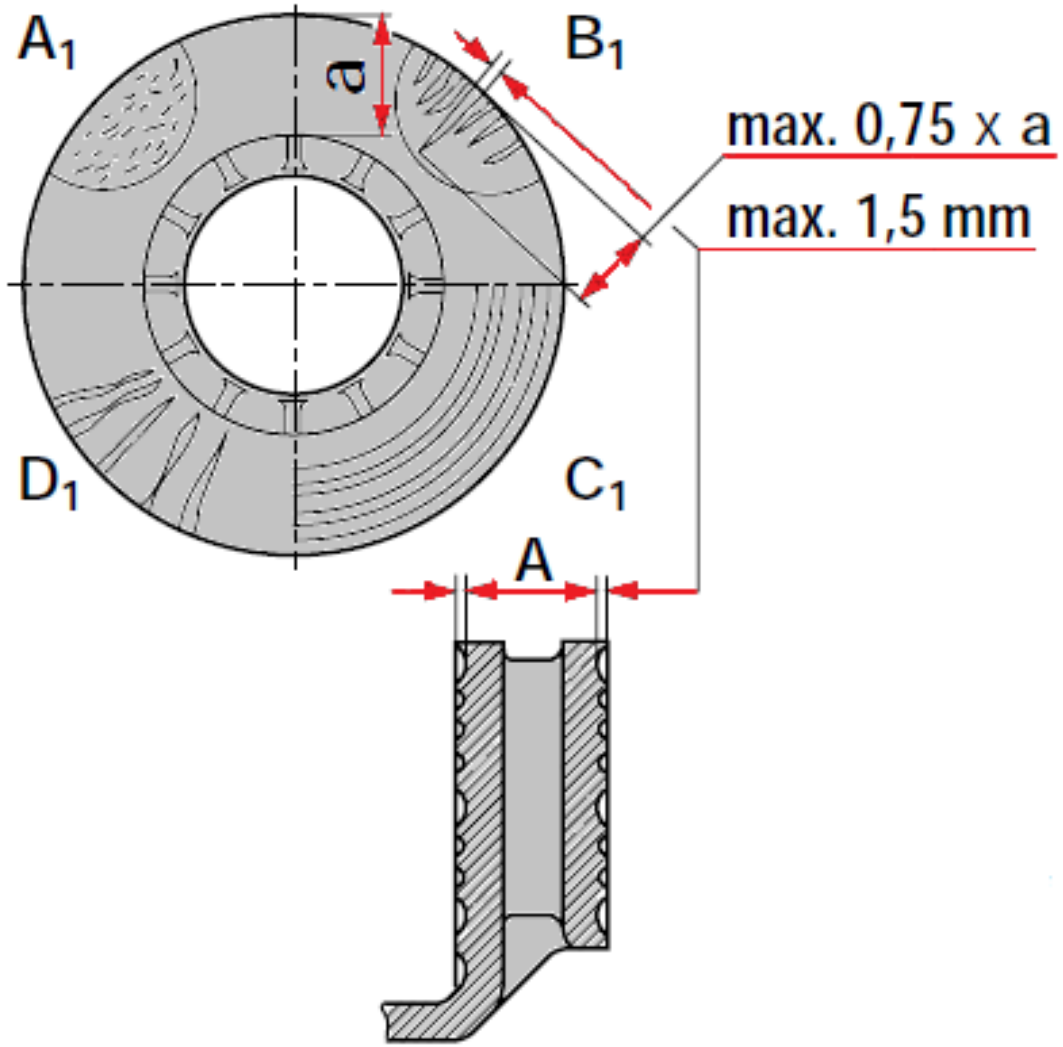
Excessive heat and cracking

Knorr-Bremse Rotor Wear Recommendations

Check Disc at each change of Pads for grooves and cracks.

This diagram shows possible surface conditions.

A1= Small cracks spread over the surface are allowed
B1= Cracks less than 1.5mm deep or wide, running in a Radial direction are allowed
C1= Grooves (circumferential) less than 1.5mm deep are allowed
D1= Cracks in the vanes are not allowed and the Disc MUST BE REPLACED
a = Pad contact area



Note: In case of surface conditions A1, B1 and C1, the Disc can continue to be used until the minimum thickness A of 37mm is reached.

Brake Rotor Inspection

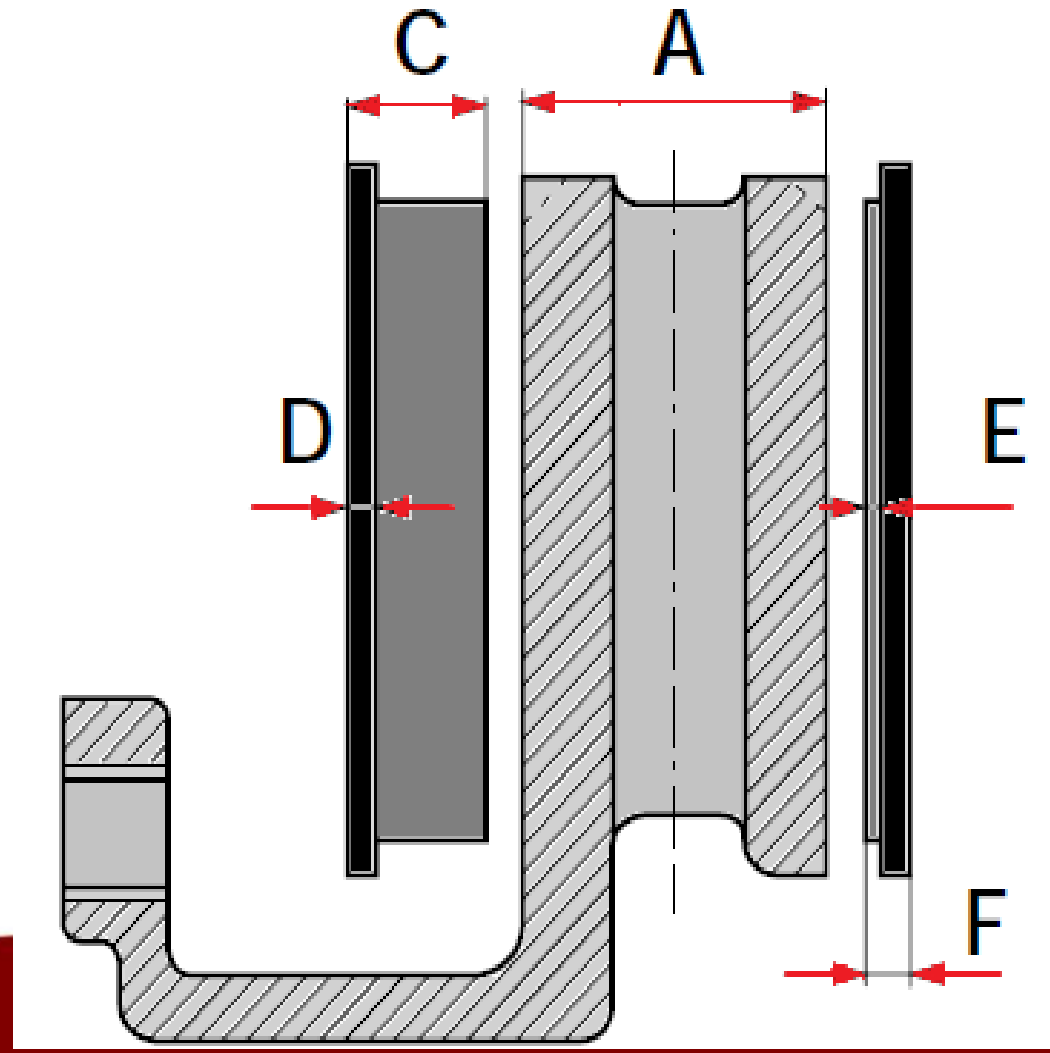
- Brake rotors should be checked for contamination from:
  - Leaking axle grease or oil seals
  - Road debris and contaminants
- Note: Oil and grease contaminated rotors should be replaced as the oil and grease can never be fully removed from the metal and will cause unbalanced brakes

Brake Rotor Inspection

Rotor contamination from grease or oil will require rotor replacement

Knorr-Bremse Measurements and points of Measurement

A= Disc Thickness
new Disc = 45mm
worn Disc= 37mm (must be replaced)
C= Overall thickness of Pad
new Pad = 30mm
D= Backplate of Pad -9mm
E= Minimum thickness of friction material is 2mm
F= Minimum allowed thickness in worn condition for backplate and friction material is 11mm (replacement of Pads is required)

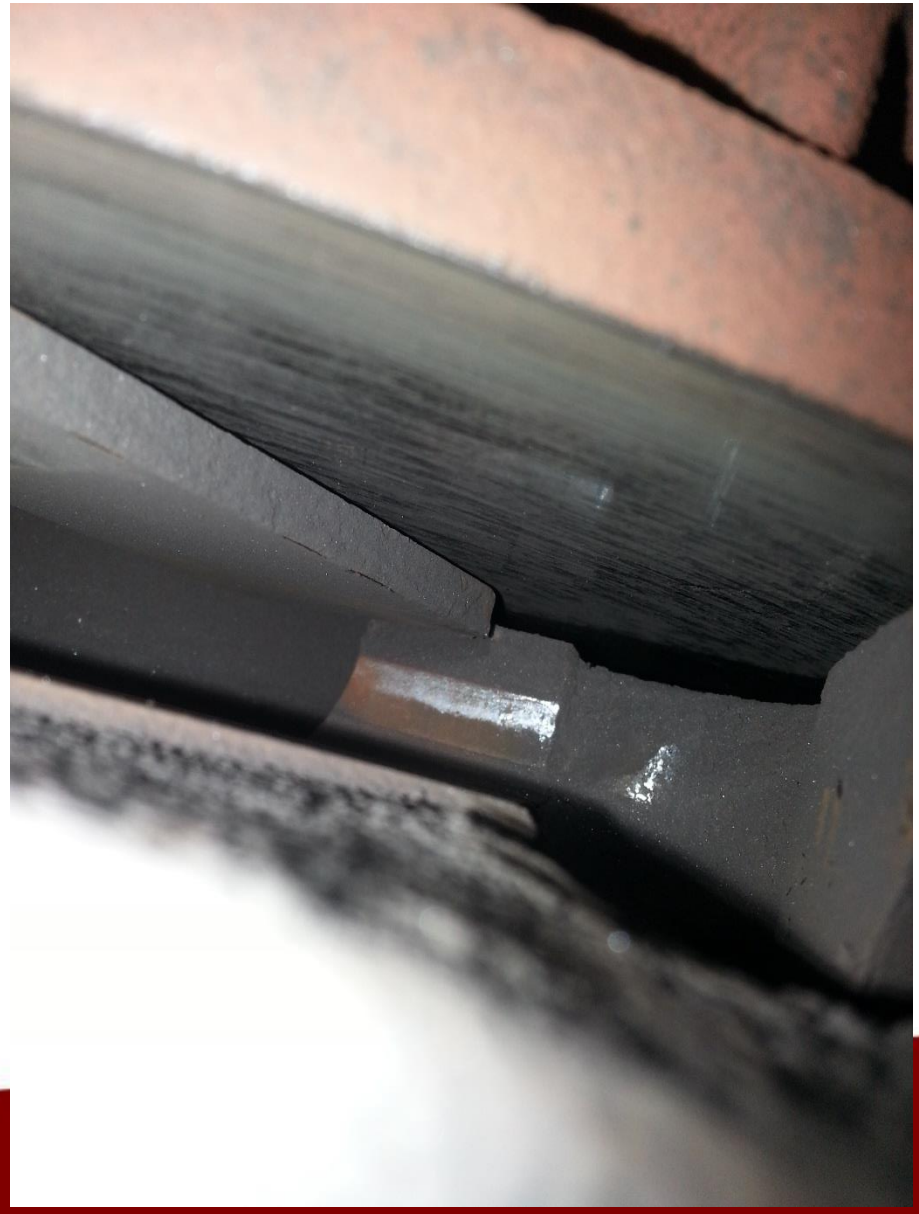


Brake Rotor Inspection

Meritor brake pad retainer straps being used to check rotor taper and wear

Brake Rotor Inspection

Meritor brake pad retainer straps being used to check rotor taper and wear. If the strap fits between the rotor and the carrier, the rotor is worn and needs to be replaced



Brake Rotor Inspection

Some Meritor rotors have different swept area thickness with the inboard swept area thinner than the outboard and should not be confused for wear. (picture for reference only)

Brake Rotor Inspection

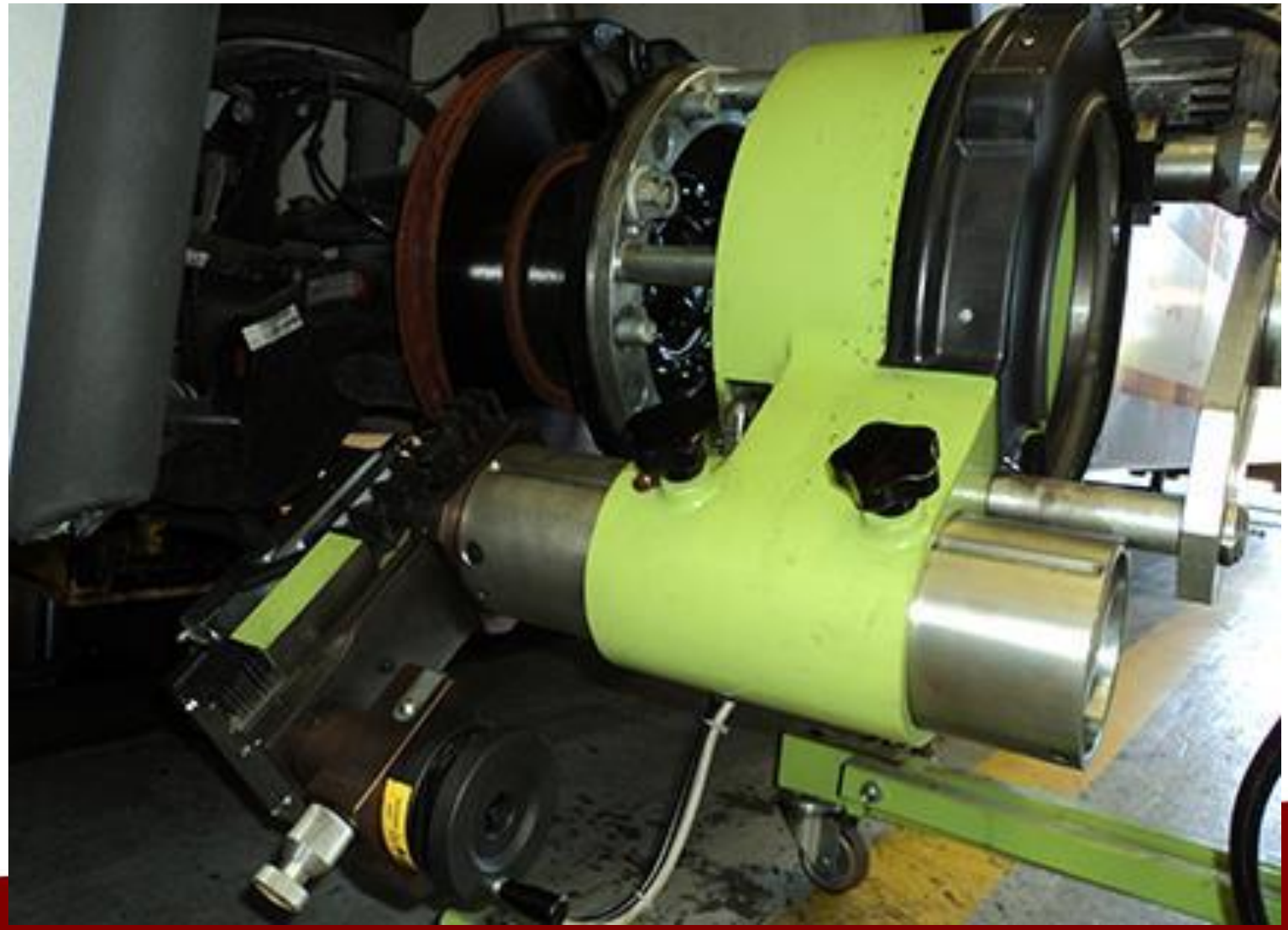
Check rotor runout with the dial indicator mounted on the carrier and the measurement taken at the middle of the swept area. Meritor should not exceed .009” (.2mm) and Knorr-Bremse .006 (.15mm). Note: If readings are beyond specifications, check wheel bearings for play and correct as required, then recheck rotor runout.

Brake Rotor Inspection

Use a brake micrometer to measure rotor thickness at 90 degree intervals at the thinnest portion of the rotor. The micrometer must be held perpendicular to the rotor surface for an accurate measurement. Rotors must be discarded when a minimum thickness of 37mm or the minimum discard thickness found on the rotor casting is reached.

Brake Rotor Inspection

Options are available to cut the rotors both on and off the vehicle



Brake Chambers

Two mounting positions for brake chambers

Axial

Radial

Brake Chambers

- With the brake system at governor full cut-out, release parking brake (when applicable) then apply service brakes and listen for an air leak
- Any air leaks will deem the vehicle out of service until repairs are made
- Chambers must:
  - Be same size
  - Contain cage tool and sealing plug
  - Display no evidence of contact with wheel, body, suspension, or frame
  - Mounting nuts are tight and chamber is secure

Front Service Brake Chamber

Rear Spring Brake Chamber

Brake Chambers

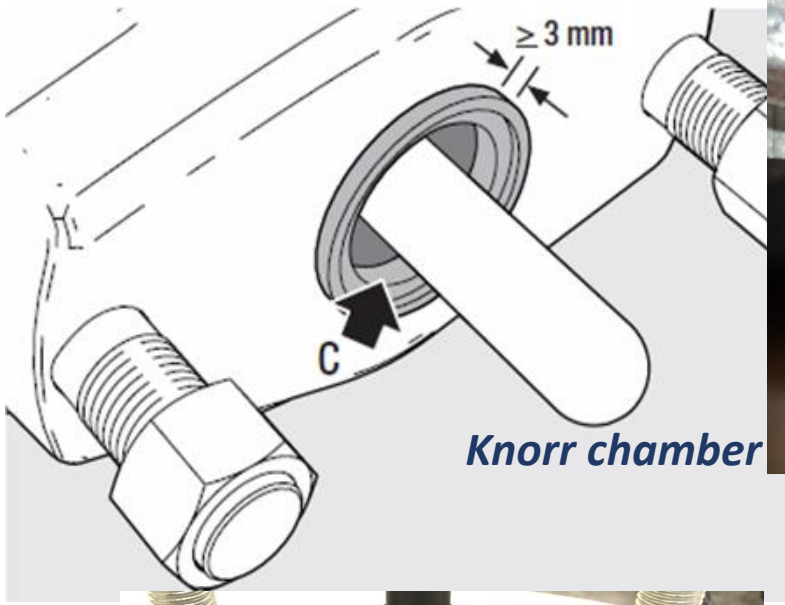
Make sure the brake chamber is properly installed

Brake Chambers

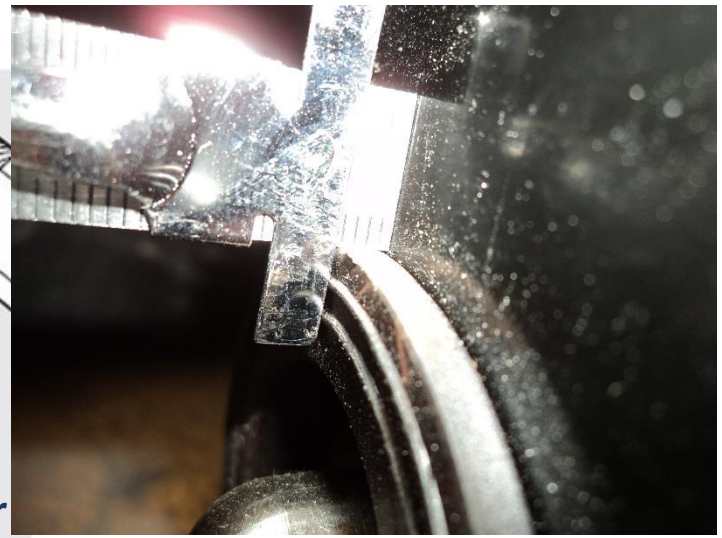
A failure indicated by a chamber pushrod that is not perpendicular to the housing will require a chamber replacement.

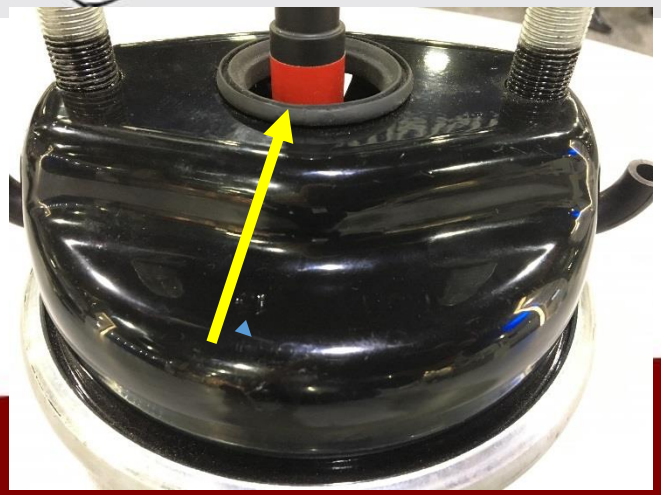
Brake Chambers

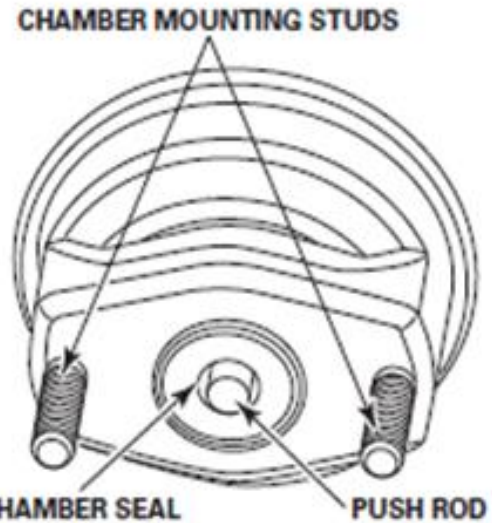
- When removing spring brake chambers, follow the manufacturer's instructions to completely cage and release the brake
- When the chamber is removed for inspection or replacement, check for mounting stud damage, push rod protrusion, and signs of water intrusion into the caliper
- Knorr / Bendix calipers rely solely on the brake chamber seal to prevent water and contaminant intrusion
- Meritor calipers use a seal in the caliper and another seal on the brake chamber
- If the brake chamber seals have failed, the chambers must be replaced
- If water or contamination is found in the caliper, the caliper will need to be replaced. Caliper seals should be inspected and replaced as needed



Knorr chamber



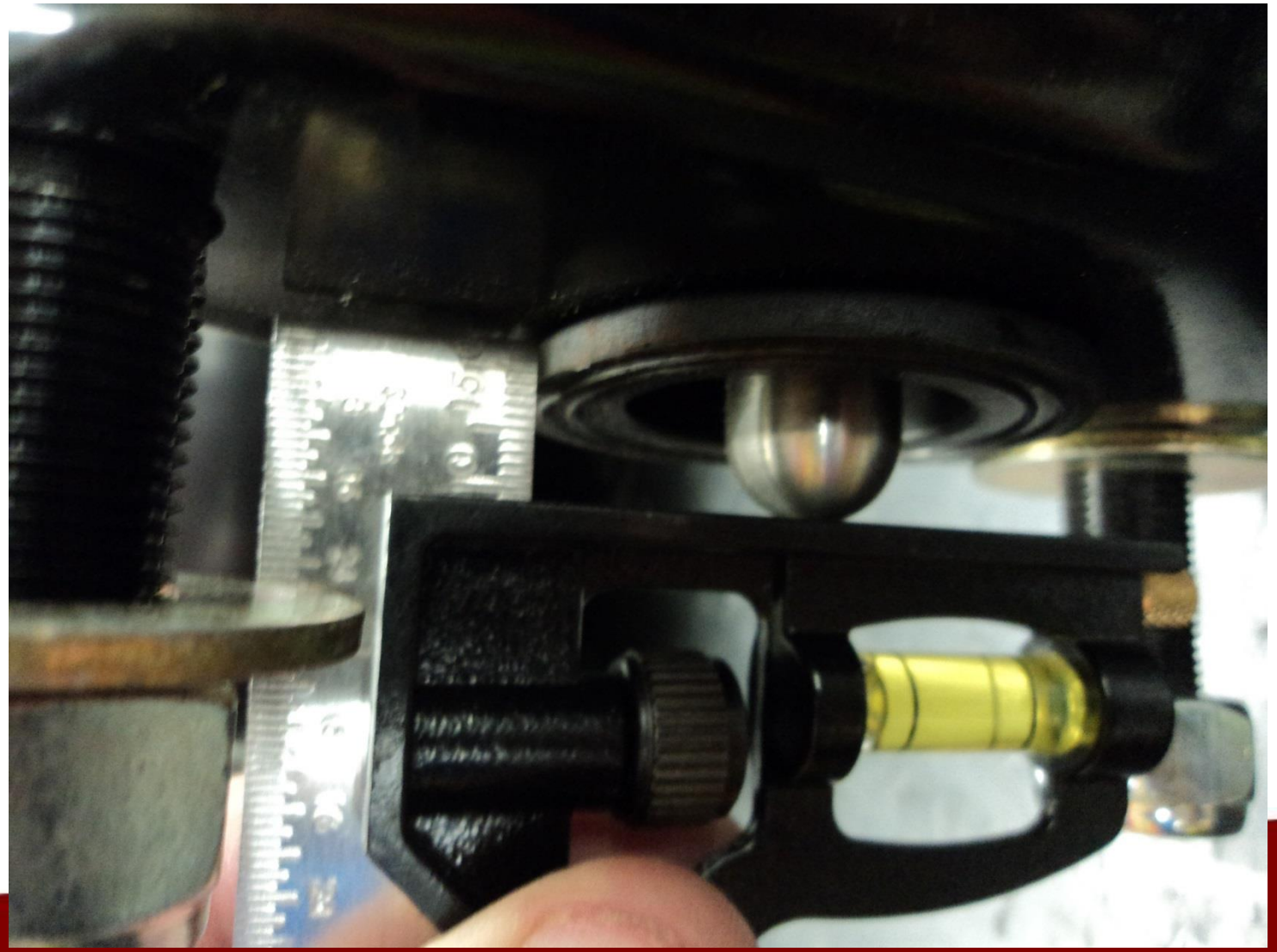




Meritor chamber

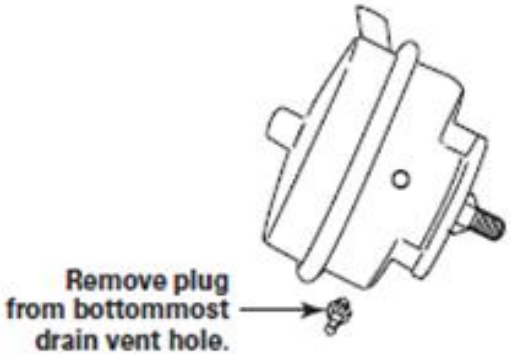
Brake Chambers

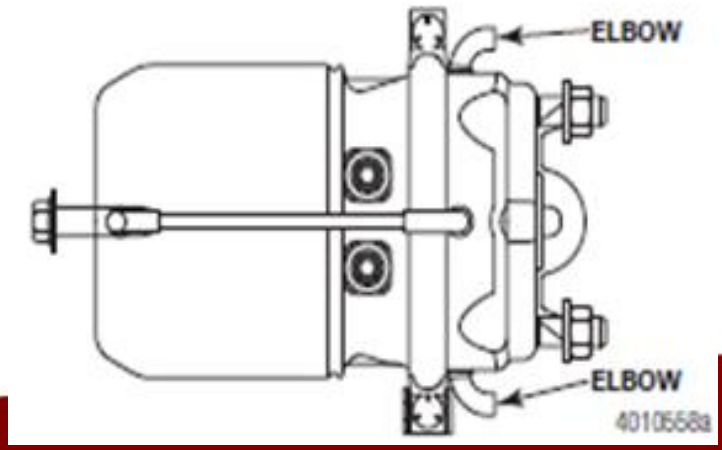
Measure brake chamber pushrod protrusion to ensure that it is .590” (15mm)



Brake Chambers

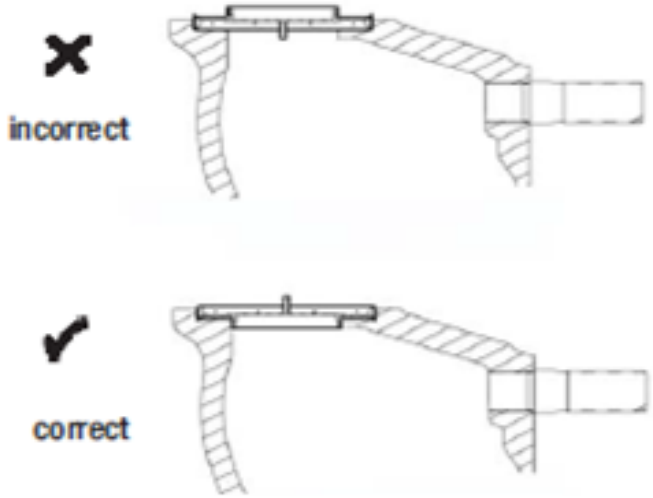
- Ensure the bottommost housing plug is removed
- Failure to remove a plug from the non-pressure housing will cause a slow releasing, dragging brake
- For brake chambers equipped with elbows, the chamber must be oriented in such a way that the two elbows will easily allow water and contaminants to drain from the chamber



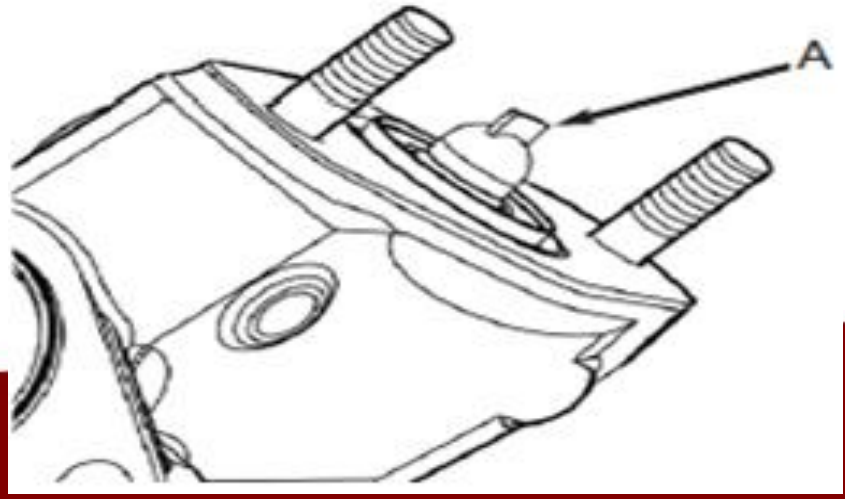


Brake Chambers

- Meritor caliper seals need to be inspected and replaced as necessary
- Water intrusion into the caliper will require caliper replacement
- New Meritor chambers are shipped with a transit plug and should not be confused with the caliper seal
- The transit (shipping) plug must be removed before the chamber is installed

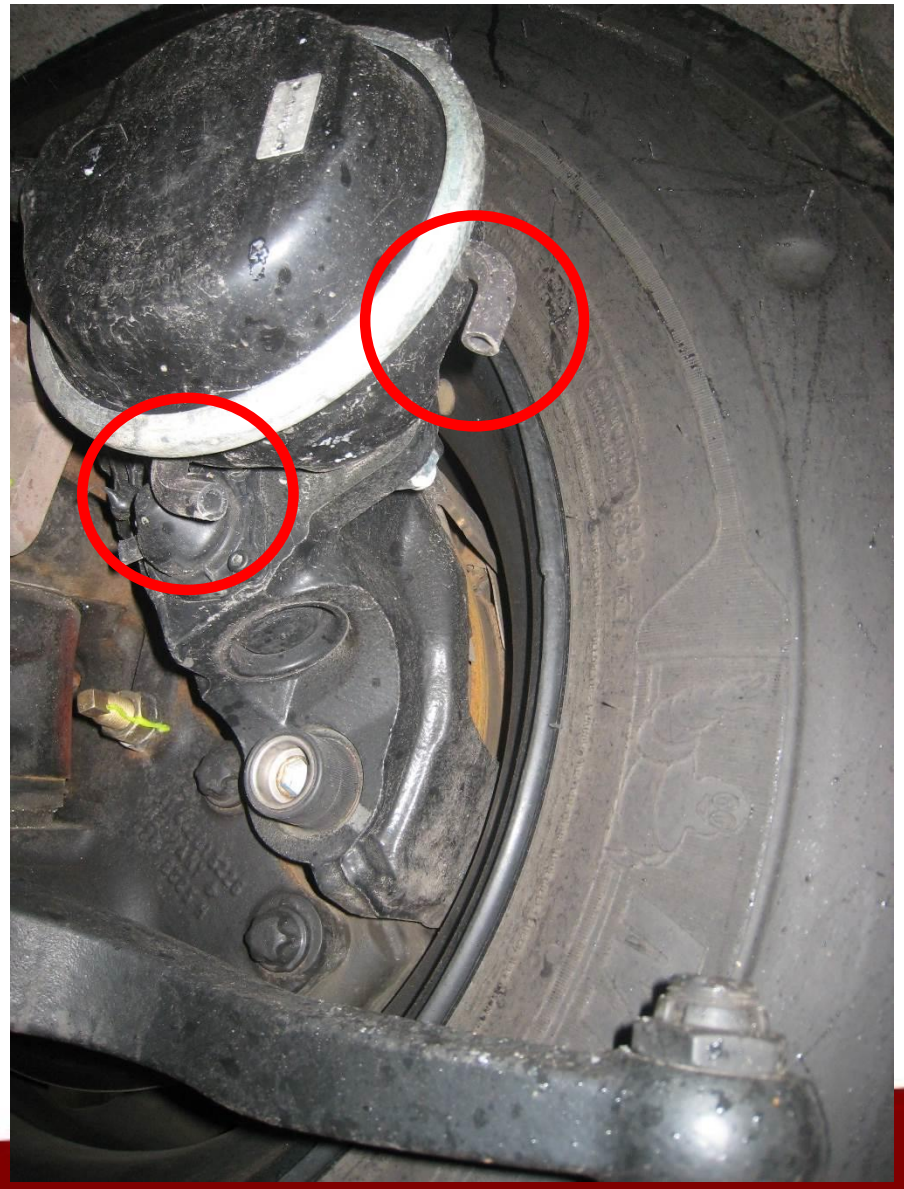


Meritor caliper seal



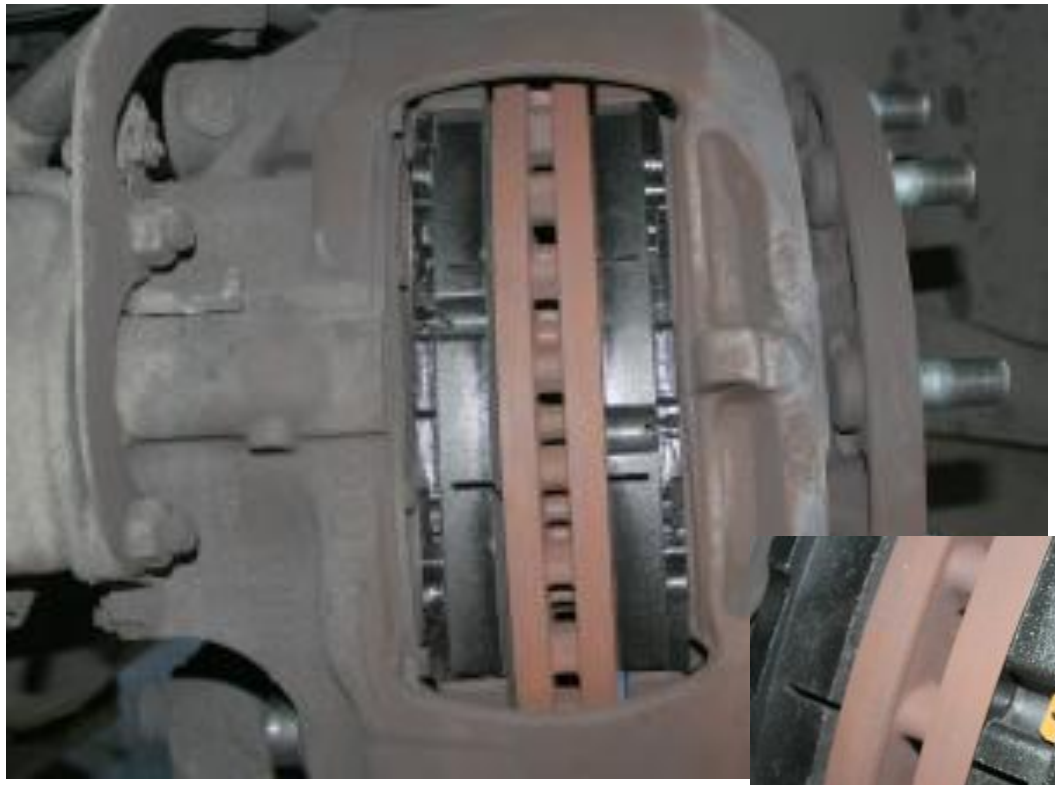
Meritor shipping plug

Brake Chamber Vent



Brake Pad Installation and Adjustment

- Make sure the tappets are fully retracted and all surfaces are clean
- Brake pads must be changed as an axle set and NOT individually
- Install new pads with new retainers and hardware
- If equipped, fit and connect wear sensors
- Knorr notes that a good high temperature grease (but never copper paste or anti-seize) can be applied to the carrier wear pads and the metallic brake pad surface
- The grease must not land on the brake pad friction area, brake rotor, or boot assemblies



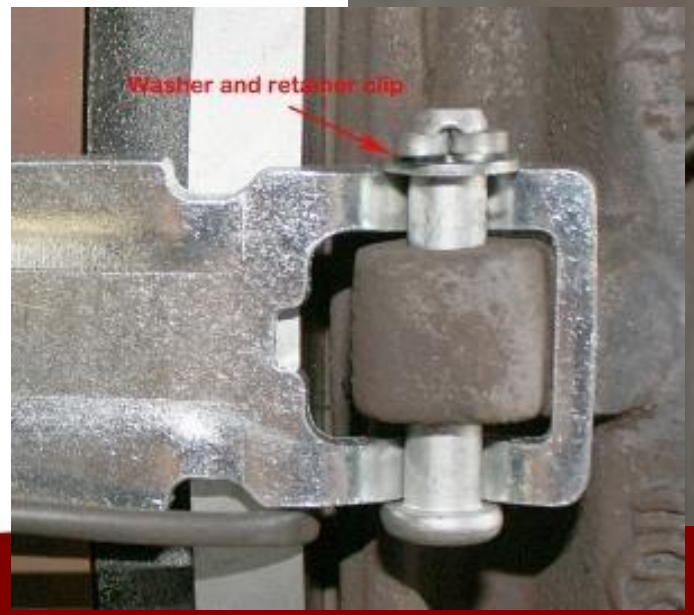
Knorr-Bremse Brake Pad and Abutment Lubrication

The current approved lubricants are Textar CERA TEC, ATE Plastilube and Dow Corning P-40 Paste.

Knorr-Bremse allows the use of certain lubricants on the abutment surfaces and corresponding edges on the brake pads. Do not lubricate tappets or any other parts of the caliper with this lubricant.

Brake Pad Installation and Adjustment

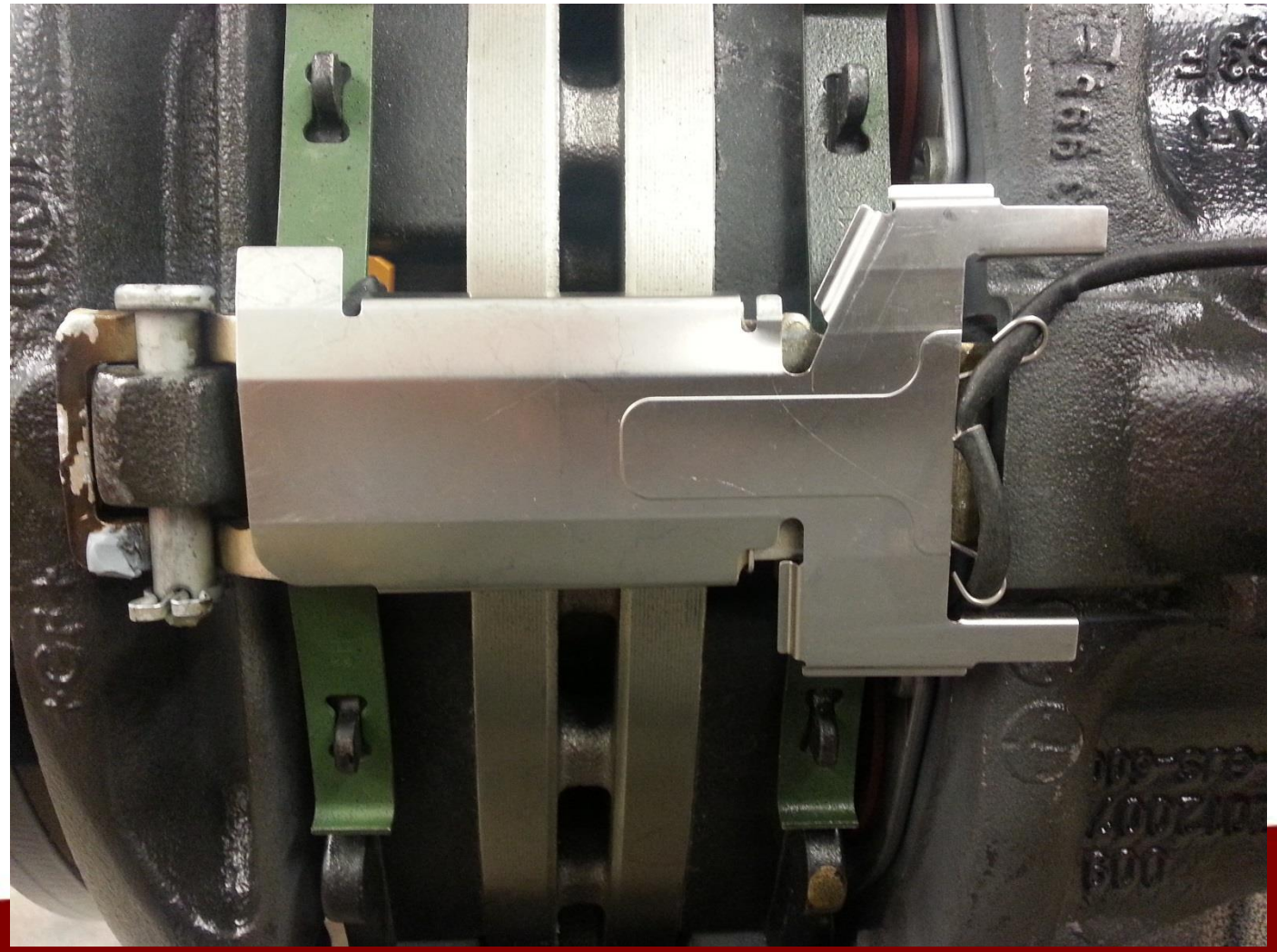
- Install new pad retainers and hardware
- Make sure sensor harnesses are secure per the manufacturer's recommendations to prevent chafing



Brake Pad Retaining Strap

Inspect caliper brake pad retaining strap and fastener

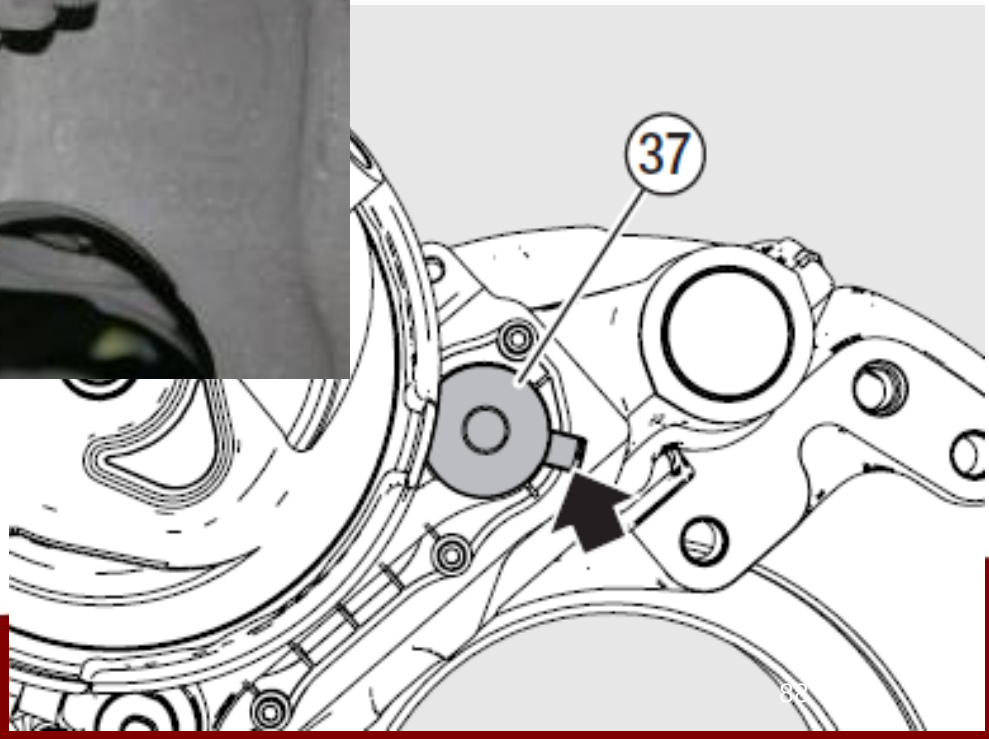
Knorr-Bremse brake sensor harness retainer and pad retainer properly installed



Adjuster Location

Brake Pad Installation and Adjustment

- For Knorr/Bendix 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 .024” and .047” (.6mm and 1.2mm)
- Apply and release the brake making sure the hub turns easily by hand
- Install the adjuster stem cap noting the orientation of the tab

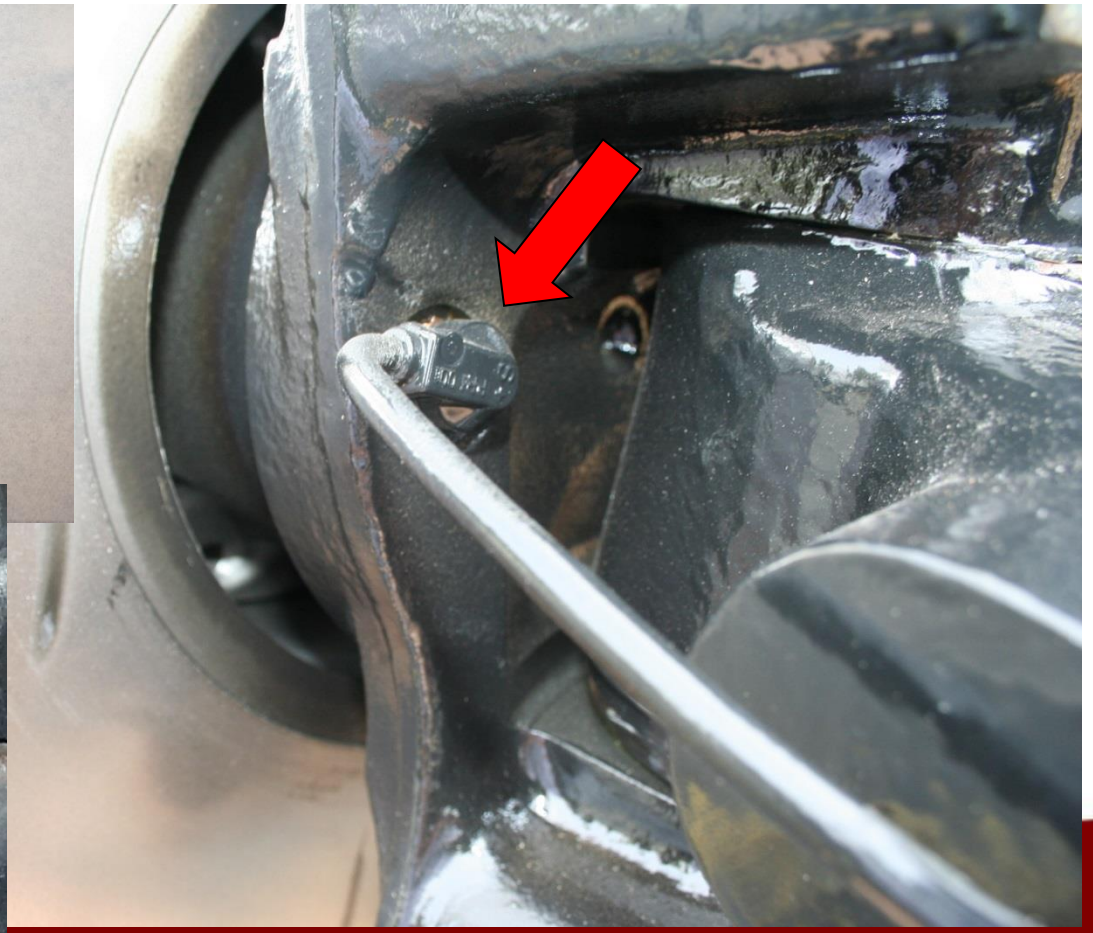


Brake Pad Installation and Adjustment

- To set the initial running clearance on Meritor calipers, use a 10mm socket and turn the adjuster clockwise until both pads contact the rotor
- Turn the adjuster back ½ 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 the brake pad to rotor clearance is within specification
- Nominal pad-to-rotor clearance should be .030” (.75mm)
- Install the adjuster stem cap

ABS Sensor

Inspect ABS sensor mounting, wiring, and adjustment. Replace as necessary.



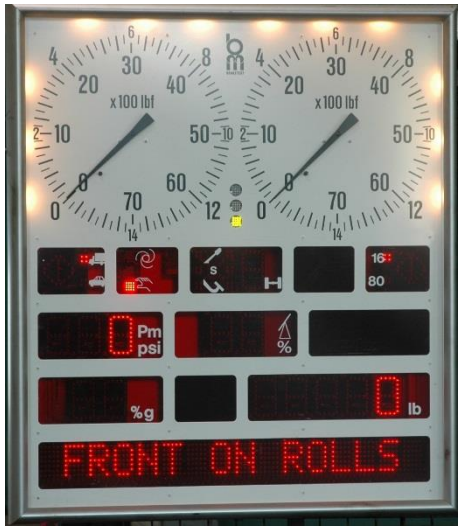
Final Inspection and Test

- Complete a final visual inspection
- Install tires
- Burnish brakes
- Perform a brake performance test to verify satisfactory brake operation

Frequency of wheel off inspections will vary depending on the operating environment but should not be limited to pad change intervals.

Validation

Perform a brake performance test to verify satisfactory brake operation



Any Questions?

Please e-mail the questions to standards@apta.com

The APTA Brake and Chassis Work Group and the APTA Bus Standards Committee would like to thank you for joining our Webinar.

Pictures, drawings and technical information courtesy of MAN, ZF, Meritor, Knorr-Bremse, Bendix, MGM Brakes, LA Metro, Omnitrans, MBTA, Custom Training Aids, Link Engineering, and other members of the APTA Brake and Chassis Work Group