APTA Standards Quarterly Webinar Series

Disc Brake Wheels Off Inspection and Reline

Presented by
APTA Brake and Chassis Working Group
MODERATORS

Marie Benton
Interim Assistant Vice President of Rail Maintenance
Dallas Area Rapid Transit (DART)
Dallas, Texas

Jerry Guaracino
Assistant Chief Engineering Officer – Bus Engineering
Southeastern Pennsylvania Transportation Authority (SEPTA)
Philadelphia, PA
Brian D. Markey
President
Custom Training Aids Inc.
La Verne, CA

PRESENTER
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

Meritor EX225 exploded view
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
Inspect caliper brake pad retaining strap and fastener.

Meritor brake pad retaining strap correctly installed with pad anti-rattle springs in place.
Inspect caliper brake pad retaining strap and fastener

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

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

Check the clearance at both tappets simultaneously: .024in to .047in (.6mm to 1.2mm)
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.
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
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.
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.
Check carrier for signs of damage or excessive wear

- Pad Abutment to rotor clearance should be even at all four points
- Check carrier and pad abutments for signs of damage and wear
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.
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.
To optimize caliper life, consideration should be given for proactive preventative replacement of tappet seals and boots.
Replace inner tappet seals on Knorr-Bremse calipers whenever tappets and outer seal assemblies are replaced.
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
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.

Brake pad uneven wear (taper)

Brake pads showing unacceptable wear—note edges

The cause of improper pad wear must be identified and corrected.
Check for brake pad contamination and overheating

Brake pad contamination

Brake pad excessive heat

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

Make sure the brake chamber is properly installed
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.
Brake Chambers

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

The current approved lubricants are Textar CERA TEC, ATE Plastilube and Dow Corning P-40 Paste.
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.
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, Omnitran, MBTA, Custom Training Aids, Link Engineering, and other members of the APTA Brake and Chassis Work Group.