APTA BTS-SS-RP-003-07
Approved 5/5/07

Recommended Practice for Transit Bus Brake Shoe Rebuild

Approved April 30, 2007
APTA Bus Brake Working Group

Approved May 5, 2007
APTA Bus Standards Committee

Abstract: This recommended practice provides guidelines for rebuilding brake shoes. The practice includes the disassembly, preparation, inspection, and assembly of brake shoes.

Keywords: brake, brake block, brake shoe, brake shoe roller, brake reline, brake rebuild, rebuild, riveted brake, riveted block, bolted block, bonded brake, bonded block

Introduction

(This introduction is not a part of APTA BTS-SS-RP-003-07, Recommended Practice for Transit Bus Brake Shoe Rebuild)

This Recommended Practice for Transit Bus Brake Shoe Rebuild reflects the consensus of the APTA Bus Standards Program members on the items, methods, and procedures that have provided the best practice 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. Recommended practices are non-exclusive and voluntary; they are intended to neither endorse nor discourage the use of any product or procedure. All areas and items included herein are subject to manufacturers' supplemental or superceding recommendations. APTA recognizes that for certain applications, the practices, as implemented by operating agencies, may be either more or less restrictive than those given in this document.

This recommended practice provides guidelines for transit bus brake shoe rebuild. APTA recommends the use of this recommended practice by:

Individuals or organizations that inspect and maintain transit buses

Individuals or organizations that contract with others for the inspection and maintenance of transit buses

Individuals or organizations that influence how transit buses are inspected and maintained

Test results must meet or exceed federal, state, or other local regulatory agency requirements if different from the recommendations outlined in this document.

Participants

The American Public Transportation Association (APTA) greatly appreciates the contributions of the Bus Transit Standards Brake System Working Group, who provided the primary effort in drafting the Recommended Practice for Transit Bus Brake Shoe Rebuild.

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Recommended Practice for Transit Bus Brake Shoe Rebuild

1 Overview

This document establishes a recommended practice for brake shoe rebuild. Individual operating agencies may modify these guidelines to accommodate their specific equipment and mode of operation.

This recommended practice is to be used in conjunction with the original vehicle equipment manufacturer and brake manufacturer service manuals.

1.1 Scope

This recommended practice provides guidelines for air drum brake shoe disassembly, preparation, inspection, and assembly for heavy duty transit bus vehicles. This document addresses both steel and cast iron shoes. This document does not cover system maintenance or repairs. The removal and installation of brake shoes from the vehicle are covered in documents referenced with the key word "brake". The tables and examples in this document are for commonly used transit applications. Not all brakes are included.

1.2 Purpose

The purpose of this recommended practice is to provide a uniform method for brake shoe rebuild. Proper brake shoe rebuild can restore brake performance.

2 References

This standard shall be used in conjunction with the most recent edition of the following publications.

ANSI specification 18.6.1 2, 3 and 4

ASTM B-117

ASTM D 3359

Original equipment vehicle manufacturer (OEM) manuals

OSHA regulations

Brake manufacturer service manuals (example: ArvinMeritor Maintenance Manual 23B Bus and Coach Cam Brakes)

SAE specification J478

Technology and Maintenance Council of the American Trucking Association *Recommended Practices*

3 Definitions, abbreviations, and acronyms

For the purposes of this recommended practice, the following terms, definitions, abbreviations, and acronyms apply.

3.1 Definitions

3.1.1 Original equipment manufacturer (OEM): The vehicle manufacturer.

3.1.2 Brake block: For the purposes of this document all friction material and/or brake lining will be referred to as brake block.

3.1.3 Combination brake blocks: Brake blocks with more than one formulation identification for each wheel.

3.2 Abbreviations and acronyms

ASTM American Society of Testing Materials
DOT Department of Transportation
FMCSA Federal Motor Carrier Safety Administration
FMVSS Federal Motor Vehicle Safety Standard
GAWR Gross Axle Weight Rating
GVWR Gross Vehicle Weight Rating
HEPA High Efficiency Particulate Air
MSDS Material Safety Data Sheets
MSHA Mine Safety and Health Administration
NIOSH National Institute for Occupational Safety and Health
OEM Original Equipment Manufacturer
OSHA Occupational Health and Safety Administration

4 Safety provisions

Failure to comply with the safety provisions can result in personal injury or death.

4.1 Dust control

Although the health impact of non-asbestos fibers (such as brake blocks with glass, mineral wool, ceramic, carbon fibers) is not specifically covered under current Occupational Safety and Health Administration (OSHA) regulations, take all the necessary precautions prescribed by OSHA for dust control, and follow all federal, provincial/state, and local laws.

HAZARDOUS MATERIAL WARNING: If there is any uncertainty regarding brake blocks composition, follow OSHA regulations for handling asbestos.

Material safety data sheets (MSDS) on brake blocks, as required by OSHA, are available from the manufacturer.

4.2 Personal protective equipment

Personal protective equipment should be worn at all times during the rebuild process as required by the operating agency.

Wear a respirator approved by NIOSH or MSHA during all brake service procedures.

4.3 Training

The operating agency and/or their maintenance contractors should develop and execute training programs that provide employees with the knowledge and skills necessary to perform the tasks outlined in this recommended practice safely and effectively.

4.4 Tools

The following tools are recommended for the procedures in this document:

Stretch gauge

Web gauge

Rivet-bolt hole gauge

Shoe table thickness gauge

Anchor pin hole gauge

Table arc gauge

Additional tools as recommended by the OEM or as used by the transit industry

5 Shoe preparation for inspection

5.1 Block removal

Remove excessive grease and contaminants using OSHA approved procedures from the brake shoe prior to removal of block. Remove the block from the brake shoe while taking care not to damage the shoe.

5.1.1 Bolted block

There are various methods for removing bolted block from the shoe. The order of preference for maintaining shoe integrity is as follows:

a) Unbolting.

b) Over-torque (solid brass bolts only – not for brass-coated steel bolts). This procedure breaks the fasteners by over tightening them. Over torqueing steel bolts may damage shoe.

c) Shearing (individually or machine).

Caution: Improper shearing of block may result in excess pressure being placed against the bolt holes thus causing oversized or egg-shaped bolt holes and raising of the metal around the hole. The raised metal around the bolt hole(s) can damage the brake block(s) when it is bolted to the shoe or during brake application. Improper machine shearing may damage the shoe table or webs. To avoid damaging the shoe table or web, make certain the chisel or brake block removal machine blades are kept sharp.

5.1.2 Riveted block

There are various methods for removing riveted block from the shoe. The order of preference for maintaining shoe integrity is as follows:

a) Punching.

b) Drilling.

c) Shearing (individually or machine).

Caution: Improper shearing of block may result in excess pressure being placed against the rivet holes thus causing oversized or egg-shaped rivet holes and raising of the metal around the hole. The raised metal around the rivet hole(s) can damage the brake block(s) when it is riveted to the shoe or during brake application. Improper machine shearing may damage the shoe table or webs. To avoid damaging the shoe table or web, make certain the chisel or brake block removal machine blades are kept sharp.

5.1.3 Bonded block

Removing bonded block is a specialized process that should be performed by a qualified vendor only.

5.2 Cleaning

a) Remove the brake shoe rollers from the brake shoe.

b) Remove all rust from brake shoe surface. Abrasive blasting is preferable; however if using a wire brush, be certain to remove all rust and scale from the brake shoe surface.

NOTE 1–Use glass bead no larger than S-280 or shot size 0.15 to 0.35 inches to remove all residue. When using a tumbler type blaster, make sure that the tumbler is filled with shoes to minimize damage to the shoes.

6 Inspection

Inspect the brake shoe assembly for wear and distortion after cleaning. In order to obtain maximum brake performance, the geometry of the brake shoe must fit the brake drum and the brake spider.

If the shoe does not meet the tolerances criteria discard the shoe.

Brake shoe rejection should be documented on a form similar to the example in Annex A. This can assist in identifying maintenance and quality problems.

Figure 1 – Typical Brake Shoe Gauge Kit

The tools that are used in the inspection of the brake shoe are available from various manufacturers. Contact your brake component supplier for a list of companies that can supply the tools shown in this procedure.

6.1 Checking for stretch

Check both sides of the shoe for stretch. A stretched brake shoe will not allow the brake block to properly mate with the shoe table. A stretched shoe may result in reduced braking performance and cracked brake block. Excessive bushing wear can affect this inspection procedure. This step does not apply to wedge brakes.

A stretch gauge is the recommended method to measure the shoe.

a) Place the large end of the stretch gauge into the anchor end of the shoe. (see Figure 2).

b) Rotate the small end of the gauge into the roller cup.

c) If the small end of the gauge does not fit into the roller cup, the shoe must be replaced.

d) It is recommended to repeat the stretch test after replacing bushing.

Figure 2 – Stretch gauge

6.2 Check for table flatness

Check the shoe table for flatness. A shoe that is not flat will not allow the brake block to properly mate with the shoe. This can result in irregular wear and cracked or broken block.

a) Place a straight edge across the brake surface of the shoe table as shown in Figure 3.

b) Discard the brake shoe if a 0.010" feeler gauge can be inserted between the outer edges of the shoe and the straight edge.

c) Discard the brake shoe if a 0.025" feeler gauge can be inserted between the center of the shoe and the straight edge.

d) Check the shoe table at 3 locations (anchor end, center, and cam end).

Figure 3 – Measurement of shoe flatness

6.3 Check web for distortion

Check the web for distortion. Use of shoes with spread webs can result in irregular wear on both the shoe and foundation brake components. It can also reduce brake performance.

a) Use a go/no-go gauge as shown in Figure 4, or an accurate measuring device, such as vernier calipers, to measure the web for distortion.

b) Measure the full length of the web.

c) The distance between the webs of the shoe, and the distance between the ears at the anchor pin end, must not exceed the dimensions specified in Table 1.

Figure 4 - Using a go/no-go gauge

Table 1 – Shoe table web tolerances for stamped steel shoes

Brake size Inches	Maximum inner distance between webs on cam end	Maximum outer distance between webs on anchor end
14.5 x 6 W	0.855”	1.970”
14.5 x 10 W type 1 and 3	1.395”	2.167”
14.5 x 10 W type 2	1.520”	2.914”
15 and 16.5 Q-Plus	1.550”	1.550”

Reference OEM Maintenance Manuals for illustrations.

6.4 Check table arc

Check the shoe table for proper arc. A shoe that does not have a suitable arc will not allow the brake block to properly mate with the shoe. This can result in irregular wear and cracked or broken block.

a) Place a suitable arc gauge on center of the shoe table as shown in Figure 5.

b) Try to insert a 0.030 inch feeler gauge between the shoe table and the arc gauge. If there is an opening through which a 0.030 inch feeler gauge can be inserted, replace the shoe. Do not attempt to salvage.

c) Repeat steps a & b on both outer sides of the shoe.

Figure 5 – Table arc measurement

6.5 Check table thickness

Check the brake shoe table thickness. Each manufacture's shoe may have a different thickness, so care must be taken to select the proper gauge for determining this wear. A thin shoe table may cause uneven wear of the block and poor drum-to-shoe contact.

a) Attempt to insert a suitable gauge over the shoe table, as shown in Figure 6.

b) If the shoe table slides into the gauge, discard the shoe.

Figure 6 - Measuring stamped steel shoe table thickness

Minimum shoe table thickness	
Type	**Dimension (inches)**
S-Cam Q Plus	0.171
S-Cam W Brake	0.186
Wedge RDS	0.216

Table 2 - Recommended shoe dimensions for stamped steel shoes

6.6 Check bolt/rivet holes

Check the bolt/rivet holes. Shoes with bolt/rivet holes that are elongated or damaged should be discarded. Use of shoes with large or distorted bolt/rivet holes, burrs, or raised areas may result in cracked or broken block.

a) Insert a go/no-go gauge into each bolt/rivet hole as shown in Figure 7.

b) The gauge should fit snugly in the hole. Discard any shoe with enlarged or distorted holes.

Figure 7 – Bolt/rivet hole measurement

6.7 Check for cracked welds

Visually check the web-to-table welds for cracks as shown in Figure 8. A broken weld or crack can result in irregular wear, broken or cracked block and poor brake performance. Discard shoe if any cracks are found.

Caution: Do not attempt to repair the shoe.

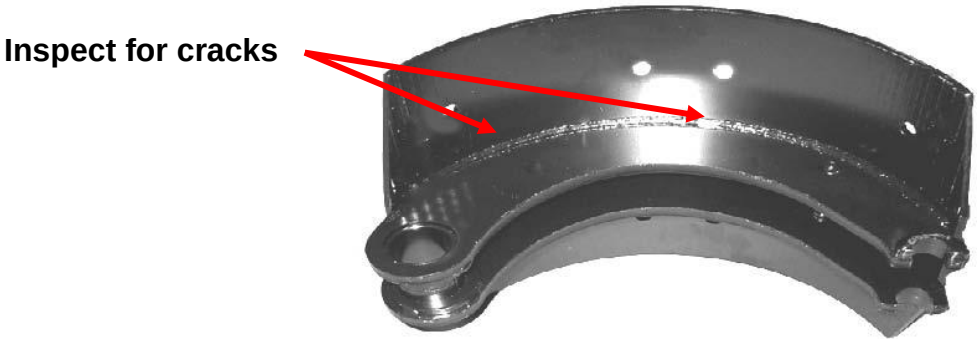

Figure 8 – Shoe weld Inspection

6.8 Check roller seat

Check roller seat (see Figure 9) for:

a) wear

b) out of roundness

c) flared condition

Worn roller seats can cause uneven braking and damage to s-cams.

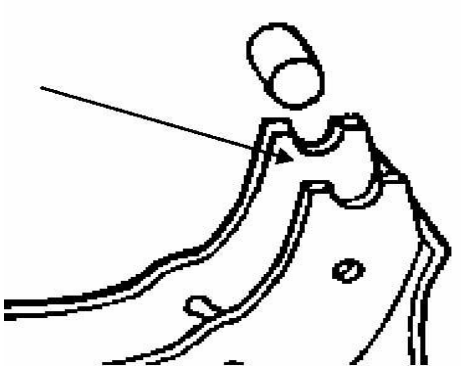

Figure 9 - Roller seat inspection

6.9 Check return spring pin

Inspect the brake shoe for return spring pin wear, damage, or looseness. If the pin is missing or loose, check holes with a new pin. Discard the shoe if the new pin is loose. If serviceable, follow the replacement procedure in Section 9.

Important: Wedge-style and Q Plus brake shoe pins are designed to be loose.

7 Anchor pin bushing replacement

Replace the anchor pin bushings at each rebuild. Bushing wear increases the spacing between the shoe and the anchor pin. This may affect cam rotation and brake chamber push rod stroke. Worn bushings can cause uneven braking and prevent automatic brake adjusters from maintaining proper push rod travel.

Figure 10- Bushing removal/installation tool

Insert a new bushing on the removal/installation tool as shown in Figure 10. Using a hammer, drive the old bushing out while at the same time inserting the new bushing. It is important to support the web of the brake shoe when installing bushing. Failure to support the web may result in bent, damaged or broken webs. Verify sliding fit of the anchor pin and ream if necessary.

8 Corrosion inhibitor treatment of brake shoes

After cleaning and inspecting the brake shoe, apply the corrosion inhibitor prior to installation of the brake block.

Minimum specifications for corrosion inhibitor include:

• ASTM B-117 salt spray test for 96 hours. (It is recommended that properties with operating conditions that are conducive to severe corrosion should consider using a product that passes a 168-hour salt spray test.)

• ASTM D 3359 crosshatch adhesion test

CAUTION: To avoid getting corrosion inhibitor on the working surface of the bushings, mask the bushing with tape or a thin layer of grease or install the bushing after the corrosion inhibitor process.

9 Install return spring pin

Use a brass hammer to install the brake return spring pin. DO NOT damage the pin or shoe. See Figure 11.

Figure 11 – Installation of brake shoe return spring pin

10 Brake block installation

Inspect the brake block by visually checking it for cracks, chipped edges and corners as shown in Figure 12. The surface that mounts on the brake shoe table should be clean and free of loose material. Brake blocks that show any sign of damage or imperfections should not be used.

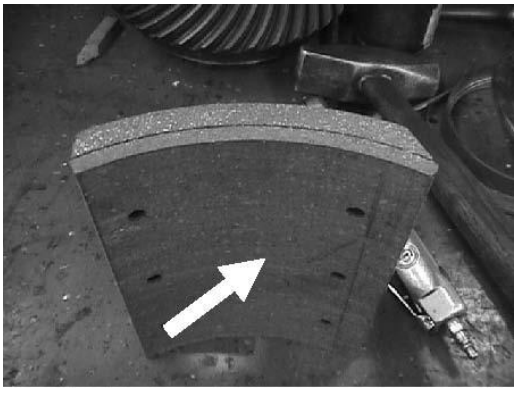

Figure 12 – Brake block inspection

10.1 Combination brake block installation

There are multiple methods of installing combination blocks. Refer to the manufacture's instructions for your application.

10.2 Brake block fastening procedure

Block and fastening hardware must be compatible.

10.2.1 Installing riveted brake block

10.2.1.1 Cracks in the rivet curl can be avoided by:

a) Inspecting and maintaining the rivet setting equipment and tools
b) Utilizing brass-plated steel rivets with a wax coating
c) Inspecting the concentricity of rivet hole to shank
d) Utilizing riveting equipment that compensates for variations in rivets, counter-bores, and table thickness.

10.2.1.2 Rivet lengths

Rivet lengths are measured from the underside of the head to the end of the shank. See Figure 13 and Table 3 for an example of a rivet length calculation.

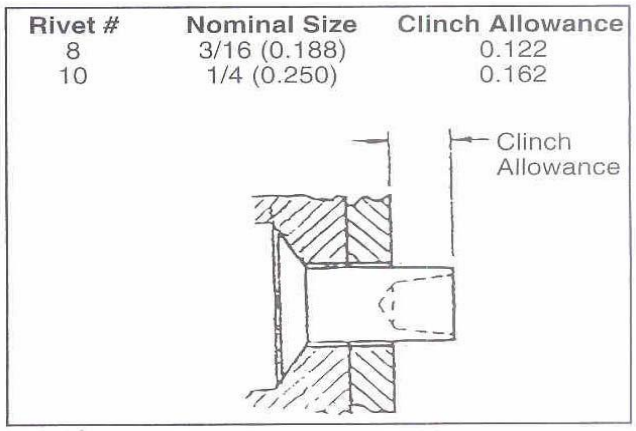

Figure 13– Rivet Length Calculation

Table 3 – Rivet Length Calculation (example)

Combined material thickness	.500
Clinch allowance (1/4 inch)	+.162
Rivet length	.662 = 11/16 inch long

If the manufacturer does not provide the exact rivet length, use the next larger size.

10.2.1.3 Fastening sequence

Follow block manufacturers' recommended fastening sequence to minimize the flex on the brake block and thus reduce block breakage. See Figure 14 for an example of a typical fastening sequence.

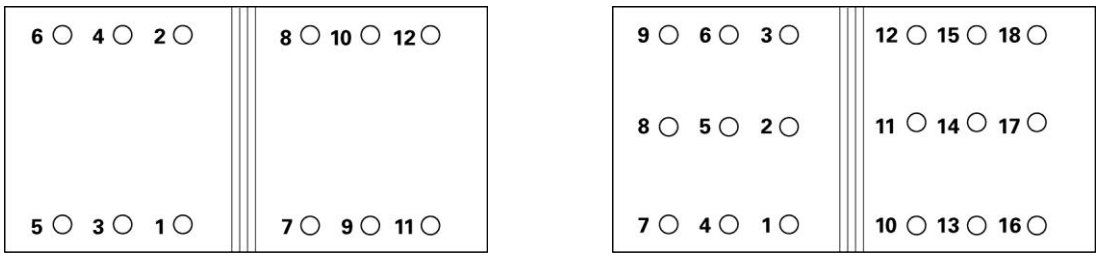

Figure 14 –Typical fastener attachment sequence

10.2.1.4 Rivet installation quality standard and inspection criteria

It is recommended that the quality of the riveting be checked at regular intervals. One quality control method is to inspect every 20th shoe.

To test rivet tightness, attempt to manually turn the rivet. One method is to use a screw driver bit or bolt extraction tool and a small torque wrench to try and turn rivets (from the underside of the shoe). If any of the rivets turn at less than 20 lb-ft., then that shoe and the 19 previous need to be fully inspected and possibly re-worked. Riveting equipment must be inspected and corrected before proceeding.

Figure 15 – Ideal rivet installation condition

A single hairline radial crack, provided it does not extend into solid or "hole" portion of rivet shank, is acceptable.

Any of the following are unacceptable:

- Non-radial cracks
- "Slice of pie" cracks
- Cracks that extends into the solid or "hole" portion of the rivet shank

Figure 15a - "Slice of pie" cracks or cracks that extends into solid or "hole" portion of rivet shank

Figure 15b - Multiple hairline Cracks

Most North American brake blocks designed for riveted installation have 150 degree counter-bore. European blocks may have 180 degree counter-bore. Most North American brake blocks designed for bolted installation have either an 82 degree counter-bore and 3/8 inch bolt or 150 degree counter-bore and a 1/4 inch bolt. When using a different fastener be sure to use the appropriate counter-bore angle.

10.2.2 Installing bolted blocks

Refer to manufacturers' instructions for alternate installation, such as Integrablok ®

10.2.2.1 Specifications for brake bolts SAE J663

The standard bolt for bolted blocks is brass or brass-plated, slotted, flat-head screw. The dimension, thread size and angle of the countersink are dependent on the style of brake. Refer to Annex B, Table 2 for the bolt dimensions.

Refer to SAE Specification J478 or ANSI Specification 18.6.1 2, 3 and 4 for additional details of dimensional specifications.

10.2.2.2 Specifications for lock washers

Use a hardened carbon steel helical spring lock washer. Refer to Annex B, Table 3.

Refer to SAE Specification J489b for additional details of dimensional specifications.

10.2.2.3 Specifications for nuts

Use zinc coated or brass nuts with the appropriate dimensions and thread size as noted in Annex B, Table 4.

10.2.2.4 Fastening sequence

Install all of the bolts through the block and the shoe table. Install the lock washers and nuts. Tighten all fasteners finger tight.

Follow block manufacturer's recommended torque pattern sequence to minimize the flex of the brake block and to reduce block breakage. Using a torque wrench, tighten 1/4" fasteners to 80-100 lb-in, 3/8" fasteners to 18-23 lb-ft, and 10mm to 22 lb-ft.

Note: Refer to Figure 14 on page 17 for an example of proper torque sequence.

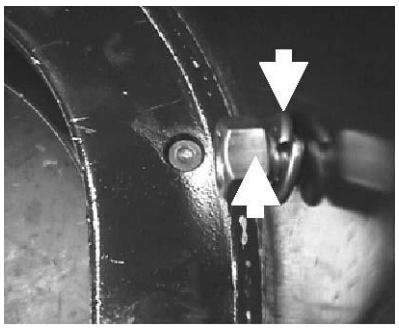

Figure 16 – Block fastener installation

10.2.3 Bonded blocks

Attaching bonded block is a specialized process that should only be performed by a qualified vendor.

11 Final Assembly

Lubricate and install roller at time of brake shoe installation to prevent contamination.

Caution: Take care not to get any grease on the surface of the roller that contacts the s-cam.

If continuing with installation, refer to APTA BT-RP-009-06, Recommended Practice for Transit Bus Front and Rear Axle S-cam Brake Reline.

If equipped, install wear sensor per manufacturer's instructions.

12 Final Inspection

a) Use a feeler gauge to measure at the outer edges between the shoe table and the brake block.

b) A gap of 0.010” maximum is acceptable between the shoe and linings along the sides and the ends of the assembly, except between the webs, where a 0.025-inch gap is acceptable at the web of a stamped steel shoe. (This inspection is not applicable to bonded shoes.)

c) Visually inspect and replace any cracked blocks.

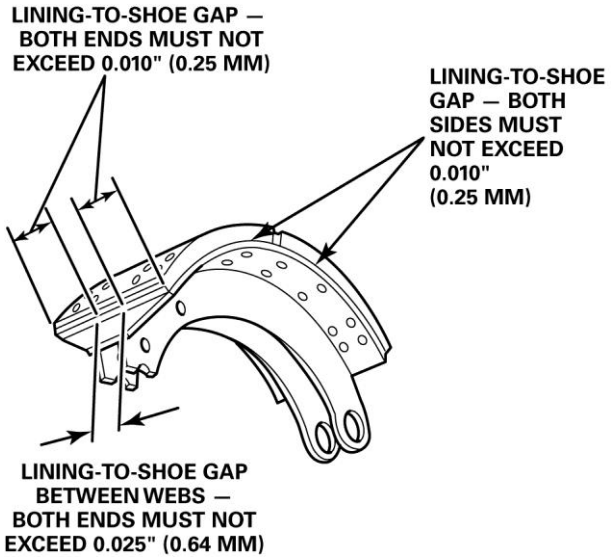

Figure 18 – Measuring for gap

13 Documentation

Brake shoe rebuild and inspection should be documented on a standard form (electronic or paper) and be reviewed and filed in accordance with operating agency procedures. See Annex A for an example.

Annex A (Informative)

Quality control sample form

Brake shoe inspection repair and block replacement

Batch No: _____ Part No. _____

Description: _____

Inspection	Rejected Qty
Stretch	
Table flatness	
Web distortion	
Table arch	
Bolt holes	
Table thickness	
Welds	
Roller seats	
Anchor pin holes	
Broken casting	

Quantity of shoes inspected _____ Quantity of shoes rejected _____

Inspected by: _____

Maintenance _____

Material control _____

Annex B (Informative)

RIVETS AND BOLTS FOR BRAKE BLOCKS – SAE J663b

Brass Tubular Rivets for Brake Blocks – Table 1 gives dimensions for brass tubular rivets used for brake blocks.

Note: For drill and countersink dimensions for rivet and bolt holes, see SAE J 660.

Table 1 – Typical Dimensions for Common Brake Block Semi-Tubular SAE Rivets

Rivet Number	#10	#20	3/8
Rivet Shank Diameter, nominal	0.250”	0.200”	0.375”
Clinch allowance	0.162”	0.162”	0.218”
Diameter of hole in shoe	17/64”	14/64”	25/64”
Rivet Length in increments of	1/16”	1/16”	1/16”

Bolts for Brake Blocks – The standard bolt for bolted blocks is brass or brass-plated, slotted, flat-head screw. The dimension, thread size and angle of the countersink are dependent on the style of brake. Refer to Annex B, Table 2 and figures 1 and2 for the bolt dimensions.

Table 2 -Brake bolt specifications SAE J663 Jul2001

Bolts										
Brake Type	**Size**	**Threads per Inch**	**Body Diameter**	**Depth of Head**	**Width of Slot**		**Depth of Slot**		**Material**	**Torque**
				Max	Max	Min	Max	Min		
W-series	3/8”	3/8-16 UNC-2A	0.375	0.219	0.094	0.081	0.106	0.070	EJ461 (brass)	18-23 lb-ft
Cast plus	1/4"	1/4-28 UNF-2A	0.25	0.108	0.061	0.031	0.0385	0.0235	UNS C27000 (brass)	7-8 lb-ft

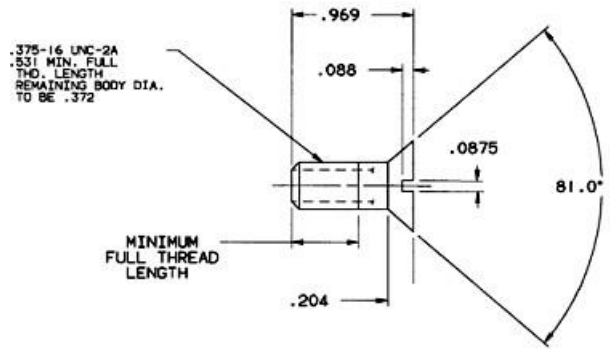

Figure 1 - W type brake bolt

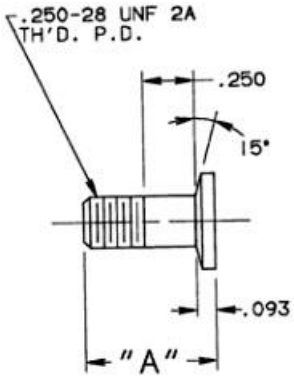

Figure 2 - Cast Plus brake bolt

Table 3 – Lock washer specifications

Lock Washer								
Brake Type	**Nominal Size**		**Inside Diameter**		**Outside Diameter**	**Section Width**	**Material**	**Process**
			Max	Min		Min		
W-series	3/8”	0.375	0.375	0.219	0.68	0.141	SAE 1055-1056	38-46 HRC
Cast plus	1/4"	0.250	0.25	0.108	0.487	0.109	SAE 1055-1056	38-46 HRC

Table 4 – Zinc coated and brass nut specifications

Nut										
Brake Type	**Nominal Size**		**Thread**	**Thickness**		**Flat Width**		**Corner Width**		**Material**
				Max	Min	Max	Min	Max	Min	
W-series	3/8”	0.375	3/8-16 UNC-2B	0.337	0.320	0.562	0.551	0.650	0.628	38-46 HRC
Cast plus	1/4"	0.250	14-28 UCF-2B	0.226	0.212	0.438	0.428	0.505	0.488	38-46 HRC