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SP-01100
Rev 07/08

Friction Material Basics and Brake Shoe Remanufacturing Procedures

Handbook for a
Better Understanding of
How Friction Materials are Specified

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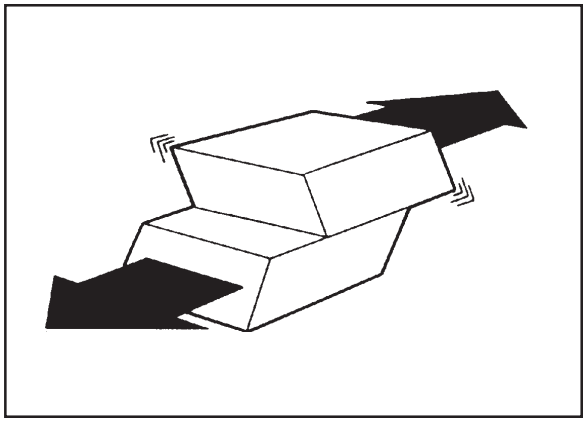
FUNDAMENTALS OF BRAKING

The discovery of the wheel was a tremendous technological “leap forward” in improving transportation. Sliding friction was replaced with rolling friction which presented much less resistance to forward motion. Once the wheel was in motion, however, a method had to be found to apply the sliding friction that had just been overcome, in order to stop the motion of the wheel. Basically, friction had to be applied on a demand basis. The component developed to do this became what we now call the ‘brake.”



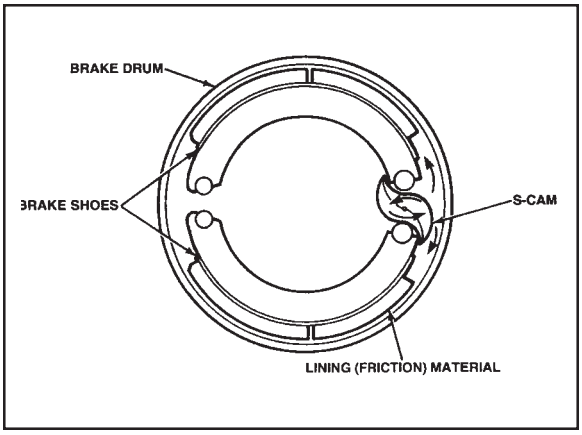
FRICTION: FORCE RESISTING MOVEMENT BETWEEN SURFACES IN CONTACT.

Since the first braking system was used, many new developments and innovations have taken place. However, the most important factor in braking remains that of friction.

Friction is the force that opposes or retards the motion of one surface against another. The friction developed by the vehicle’s braking system, between the **brake linings** and the brake drum, slows the vehicle down and eventually stops it. Through the friction between these two surfaces, the speed of the vehicle is converted into heat energy. A brake, therefore, can be thought of as a heat conversion machine.

Braking Action

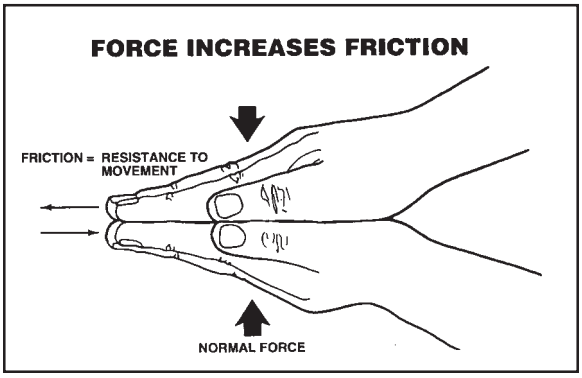
When friction is used to slow down or stop an object in motion, it is called braking action. There are two factors that determine the amount of friction that is developed during braking action: the amount of force or pressure applied and the coefficient of friction between the two friction surfaces.



FORCE INCREASES FRICTION

Key Points:
The amount of friction is dependent upon:

- **the force applied to the friction surfaces.**
- **the coefficient of friction between the surfaces.**



The first factor in determining the amount of friction developed in braking action is force. When a normal force is applied to two contacting surfaces, the force required to slide one of the surfaces across the other is increased. The greater the normal force applied, the greater the force required to move one surface over the other.

This can be demonstrated by placing the palms of your hands together. The harder you press your hands together, the more difficult it is to slide them apart. This is because the increased force increases the friction between the surfaces of your palms.

The frictional relationship between two bodies in contact is called their coefficient of friction. This value is expressed numerically as the ratio of normal force to sliding (or lateral) force.

Key Point:

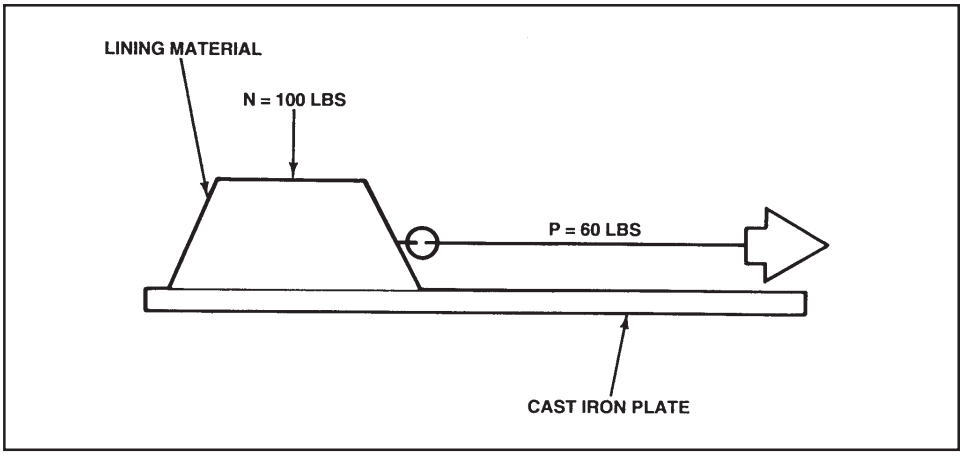
Coefficient of Friction

M ~L = P/N.

Where,

P = Force Required to Move an Object

N = Weight of Object



The illustration shows that it takes a 60 pound pull to slide a 100 pound block of lining material across a cast iron plate. Therefore, the coefficient of friction between the two surfaces is determined by dividing 60 by 100 which equals 0.6. If the block were made of a different material and it took only 35 pounds of pull, the coefficient of friction would be 0.35.

Coefficient of friction values between any two surfaces change with any variation in the condition of one or both surfaces. As an example, introducing a lubricant such as oil or grease between the two dry, flat surfaces greatly reduces the friction between them. The coefficient of friction will change when anything affects, either permanently or temporarily, the frictional interface between the two surfaces or the chemical make-up of these surfaces.

Friction Codes

Brake linings are generally manufactured in low, medium and high friction classes. Selection of the proper friction material is critical to the performance and safety of the brake system. The selection process, however, is complicated by the many different brake designs, vehicle weights, tire sizes, road surfaces and duty cycles. Brake linings are coded using a two-letter system that gives information on the coefficient of friction of the lining material. The first letter corresponds to the normal friction coefficient of a one square inch sample of the lining which is an average coefficient of friction from tests run at 200, 250, 300 and 400F. The second letter relates to the hot friction coefficient which is an average coefficient of friction from tests run between 300 and 600F.

Each block of lining used by ArvinMeritor has these two letters stenciled on its side. The following table shows the letter corresponding to the range for coefficient of friction values.

CODE LETTER	COEFFICIENT OF FRICTION
C	not over .15
D	over .15 but not over .25
E	over .25 but not over .35
F	over .35 but not over .45
G	over .45 but not over .55
H	over .55
Z	unclassified

For example, a lining block having an “EE” rating means that both the normal and hot friction coefficients can be over .25 but not over .35.

This coding system presents two major problems when trying to select a lining based on the friction coefficient alone.

1. Although two linings could have the same **friction codes** (e.g.EE) there could be as much as a 39% difference in their normal or hot friction coefficients.

	Normal	Hot
Lining A (EE)	.251	.251
Lining B (EE)	.35	.35

Difference in Friction Coefficient
= (.35 - .251/.251) x 100 = 39%

2. Two linings with very comparable friction coefficients could have different codes.

	Actual Friction	
	Normal/Hot	Code
Lining A	.35/.35	EE
Lining B	.36/.36	FF

In the aftermarket, friction codes are sometimes used to select a replacement lining material. However, this rating system is only one of many characteristics ArvinMeritor reviews before approving the use of a specific lining for a specific vehicle application. The system, by itself, tells little about how a lining will perform on a vehicle in various work conditions and should not be the deciding factor in the selection of replacement linings. ArvinMeritor uses other, more telling factors such as material properties, dynamometer performance, and field testing to determine if a lining can be used for a specific vehicle vocation.

Key Point:

Friction codes are an unreliable way to select a replacement lining material

If there is a concern about the performance capability of the linings and their respective friction ratings, replace them with ArvinMeritor original equipment linings that are the same as the linings that were included as original equipment on the vehicle.

BRAKE LININGS

Lining Composition

Nearly all drum brake friction material today is composed of non-asbestos, organic-based fibers. These fibers are generally made of a fiberglass, kevlar or ceramic compound. The fibers alone, however, do not have all the desired frictional properties needed to produce a brake lining that will perform adequately on today's vehicles. As a result, friction modifiers such as alumina or silica, are added to improve the lining's performance characteristics. A resin binder is also an important ingredient and holds the lining block together.

Only quality lining suppliers are able to determine the right mix of these ingredients such that the levels of lining wear, fade, recovery and effectiveness are maximized for a specific vehicle vocation.

Presently, the ideal friction material or brake lining does not exist. An ideal brake lining would have a coefficient of friction that remained constant for the life of the lining under all operating conditions of pressure, speed, temperature and humidity. This perfect lining would not score or wear the drum, and would operate quietly, wear slowly and not produce odors.

It is not difficult to develop a brake lining compound with an initial specific coefficient of friction. However, engineering a lining with the proper balance of speed spread, fade and wear throughout the life of the lining, and under different operating conditions, requires considerable knowledge and skill that only a handful of the top lining suppliers have mastered.

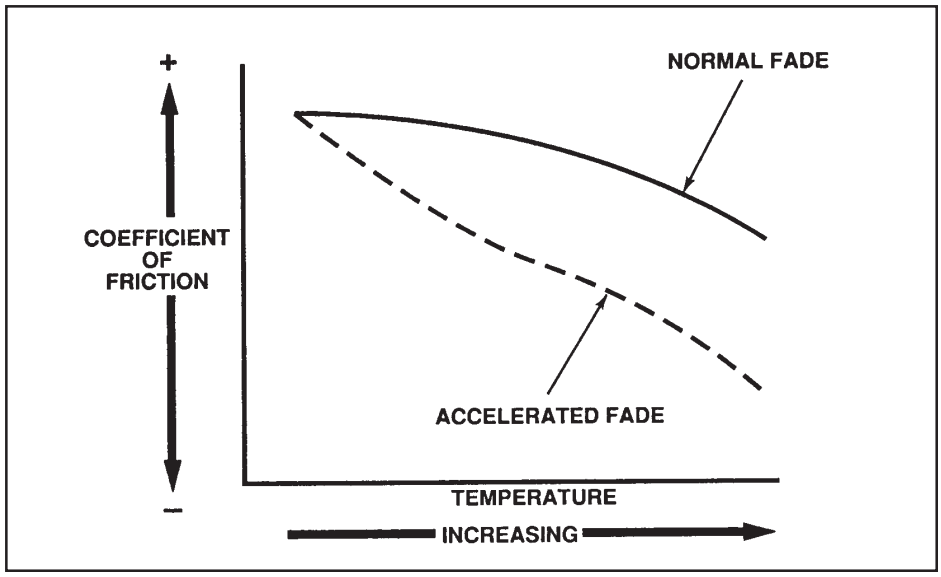
BRAKE LINING CHARACTERISTICS

Key Points:

The friction coefficient of a brake lining will change with:

- ***temperature***
- ***rubbing speed***
- ***contact force***

In general, friction varies with the temperatures of the surfaces in contact, the rubbing speed, and the pressure being applied on the friction material itself. The coefficient of friction of the lining directly affects the amount of torque generated by a brake.



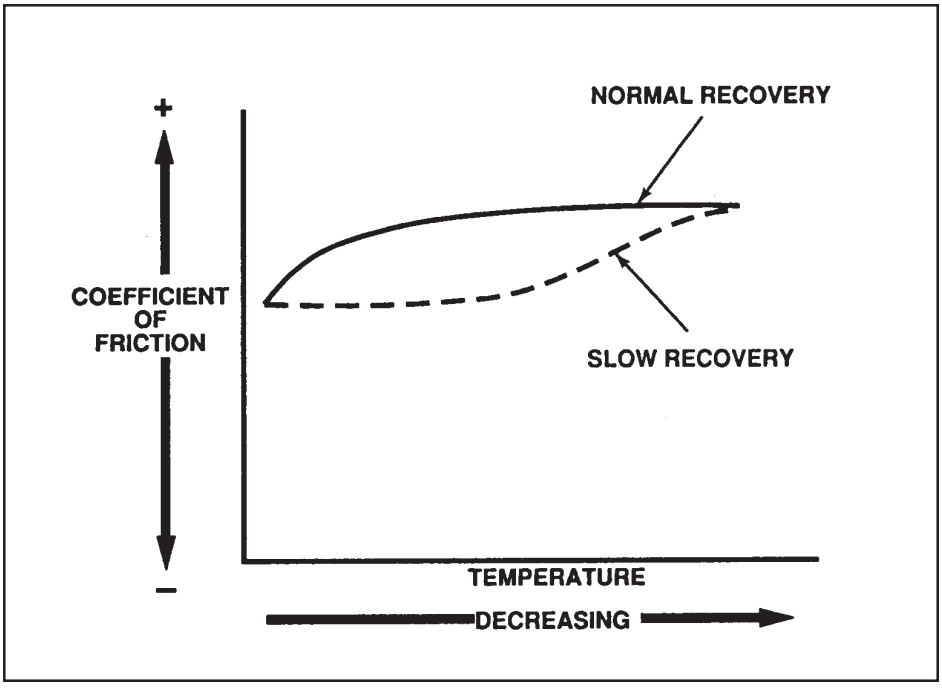
Fade may be described as the inability of the friction material to maintain its coefficient of friction at elevated temperatures. Fade is the reduction or loss in the coefficient of friction as the brake temperatures increase. Brake fade can take place within a single, high pressure stop or over a number of successive brake applications. In each case, the instantaneous torque output of the brake is reduced due to the higher than normal temperatures generated by heavy use of the brake.

Notice that in the graph, as the temperature increases, the brakes lose their ability to provide adequate stopping power.

Gradual and predictable fade is a desirable characteristic. Gradual fade is needed in situations where one or two brakes are doing most of the braking workload for a specific vehicle. If these brakes fade slightly, it allows the other brakes to “catch up” in the amount of the braking workload they are doing. In this sense, gradual fade ensures that the braking workload will be distributed throughout all of the brakes on a vehicle.

All linings undergo a transformation at the brake drum/lining contact zone due to the high temperatures generated when a brake is hard at work. These chemical and physical changes can cause either an increase or a decrease in friction. Quality linings will not exhibit drastic changes in friction levels over the temperature ranges anticipated in service. They may exhibit a slight decrease in friction coefficient due to repeated braking, but will quickly recover, regaining their friction level as they cool down. The coefficient of friction of a poor quality lining may change during its life. When the coefficient decreases, inadequate braking performance may result.

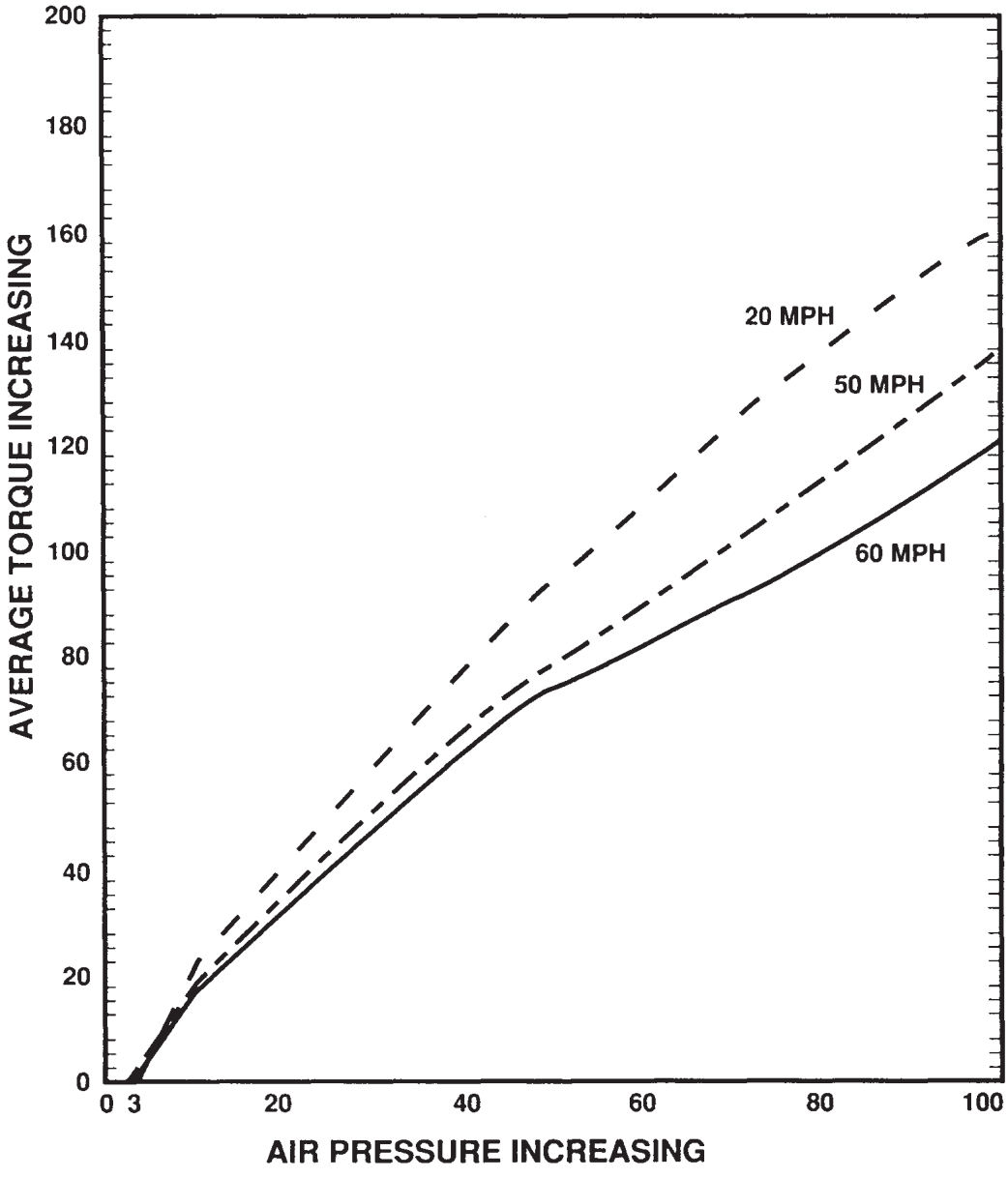
Some linings are sensitive to humidity and moisture. In humid situations, the vehicle may experience erratic, high friction



reactions during its first few stops. Due to the fact that this phenomena usually happens after the vehicle is parked overnight, it is known as morning sickness.

Speed Spread

Another important lining characteristic involves the speed sensitivity (speed spread) of the lining. This is a measure of the ability of the lining to maintain its coefficient of friction at varying vehicle speeds.

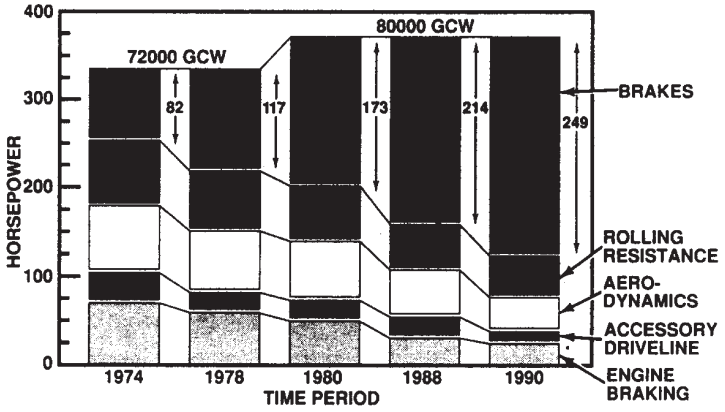


The ideal material would show the same effectiveness at virtually all speeds. However, effectiveness typically diminishes as speeds increase. Usually, speed sensitivity becomes an issue when a vehicle's brake system is unable to stop the vehicle at high speeds in the required distance. Some linings, however, may exhibit low speed sensitivity under certain conditions. Too much speed sensitivity at low speeds may cause problems such as brake grab, wheel lock-up and chatter.

Key Points:
Too much speed spread in a lining can result in the following problems:

- ***Inability to stop effectively at high speeds***
- ***Wheel lock, brake grab and sudden stops at low speeds***

TYPICAL 5 AXLE TRACTOR/TRAILER COMBINATION RETARDING CAPABILITY
AT 50 MPH ON 3.5% DOWNHILL GRADE



BRAKES HAVE COME FROM DOING 24% TO DOING 66% OF THE RETARDATION WORK.

Wear

The primary cause of poor brake lining and brake drum life is the high temperatures generated while applying the brakes. Minimizing the temperature in the system will improve the life expectancy and reliability of these two components.

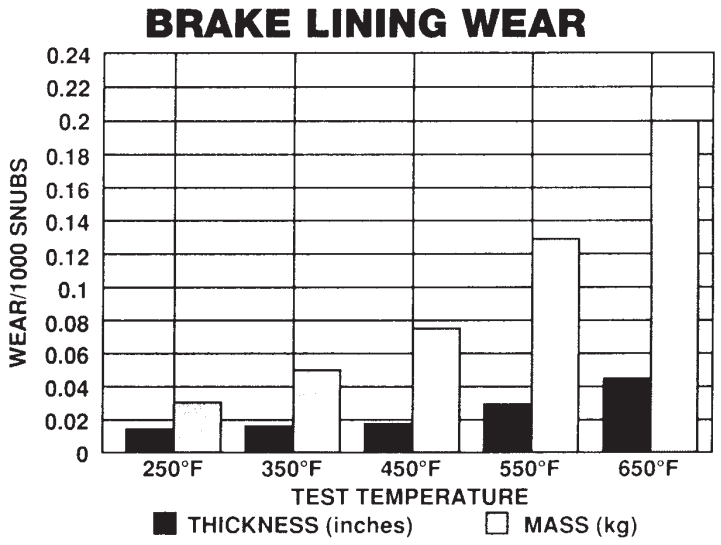
However, as the figure shows for a typical tractor trailer combination, the amount of vehicle retardation that the brakes are required to provide has increased approximately 200% in the last 20 years. This means that, overall, today's brakes are running hotter and working harder than ever before.

The factors causing brakes to work harder today include:

- Aerodynamically designed trucks with low-profile radial tires produce less drag.
- Today's low RPM engines do not offer as much retarding potential when coasting as older engines
- The use of synthetic lubricants or different axle ratios may mean greater life for mechanical components. Their use, however, results in reduced friction and easier vehicle/ drivetrain roll.
- Increased use of larger trailers carrying heavier loads.
- A reduction in empty backhauls.

The end result is seen in the fact that brake system maintenance has risen to second place among all vehicle sub-systems in cost per mile of operation, trailing only cab and sheet metal.

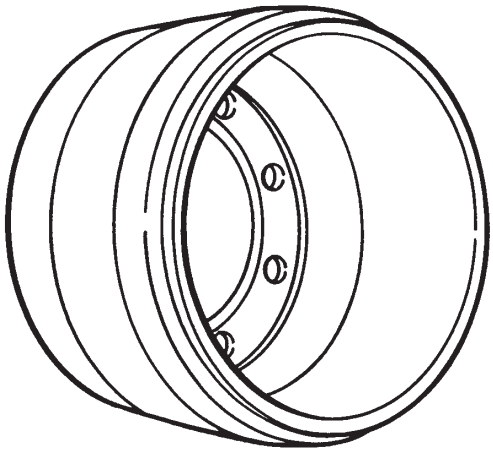
In fact, wear rates for brake linings are directly related to the temperatures at which they are used. As brake operating temperatures double, brake lining wear rates can increase significantly.



OTHER BRAKE RELATED ISSUES AND CONCERNS

Brake Drums

Brake drums provide a heat sink for the thermal energy generated during braking. The more efficiently the drum can absorb and dissipate heat, the greater the fade and wear resistance of the brake system.



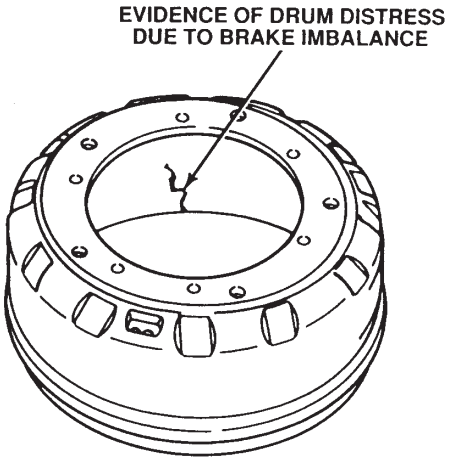
Temperature has less of an effect on brake drum wear than it does on lining wear. However, the repetitive heating and cooling cycles could eventually lead to thermal fatigue and drum cracking. Extreme temperatures, occurring just at the lining/drum contact zone, can actually cause changes to the composition of the brake drum material. Over time these changes to the brake drum material can lead to brake drum distress or cracking.

Driver Habits

Driving habits can affect the life of the brake system. For example, trailer brake life can be reduced dramatically by regular use of the driver's hand valve. In many cases, the driver will use the hand valve to stop the vehicle solely with the trailer brakes. In this situation the trailer brakes absorb more than double the energy each brake is designed for. The additional heat energy applied to the trailer brake results in overheating and reduces lining and drum life.

Another situation in which a driver can reduce the life of the brake system is in his brake application technique down steep mountain grades. If the driver applies the brakes such that they drag as the vehicle travels down the grade, brake temperatures can be greater than if he snubbed the brakes. Again, this increased temperature will result in reduced lining and drum life.

Brake System Balance



Brake lining life is also greatly influenced by brake imbalance. **Brake imbalance** occurs when a brake or a set of brakes are working harder to stop a vehicle than another brake or set of brakes. Imbalance often occurs when the trailer brakes are doing more work than the tractor brakes or vice versa. This, in turn, means trailer brakes will work harder and have shorter lining life. Brake imbalance may be caused by:

- Air chamber pressure differentials between the front, drive and trailer axles exceed the ± 2 psi recommended.
- Improper brake adjustment.
- Improper lining materials.
- Different chamber sizes on tractor and trailer axles.
- Use of hand valves to apply trailer brakes only.

Application Errors

Key Points:
The following information is needed to properly select a replacement lining.

- ***Lining***
  - ***Wear Performance***
  - ***Torque Capabilities***
  - ***Fade Characteristics***

- ***Vehicle***
  - ***Vocation***
  - ***Axle Weight***
  - ***Chamber Size***
  - ***Slack Length***
  - ***SLR***

ArvinMeritor feels that it is important to match the replacement brake linings to the specific vehicle's brake parameters. To do this correctly, information other than just the lining friction code is needed. It is necessary to understand the performance characteristics of the lining with respect to wear, torque output, and fade to make sure the lining fits a specific vehicle's braking needs. Vehicle information such as vocation, loads, air chamber size, slack adjuster length, and the static loaded radius of the tires is also required to make the correct lining selection.

The misapplication of a lining can result in wear and/or torque related problems for the vehicle. For instance, a high friction lining formulated for heavy axle loads may be too aggressive on a lightly loaded vehicle. Additionally, a lining mix created for light axle loads will not be able to generate sufficient torque to stop a heavy vehicle within the proper distance.

When considering what lining material to use, one should remember that ArvinMeritor approved linings are required to meet federal requirements with respect to torque and fade performance as well as the stringent performance standards (swell and growth, balance and wear) set forth by ArvinMeritor. Aftermarket linings are not subject to any minimum government performance requirements. As a result, lining quality and performance consistency is left to the aftermarket lining supplier.

Brake Maintenance

One very important aspect of brake performance and lining and drum wear involves brake maintenance. Proper brake maintenance includes regular brake adjustments and using the correct brake relining procedures. ArvinMeritor strongly recommends the replacement of rollers and all hardware (springs, clips, anchor pins, seals, etc.) components with each relining operation. In addition, cam bushings should be replaced if they show excessive wear.

During the brake maintenance activity, the following components should be inspected and their proper operation and condition verified.

- Slack adjuster and chamber
- Foundation brake components
- Drum and lining surfaces
- Lubrication of anchor pin, brake shoe rollers, camshafts, and slack adjusters
- Air system components

SAFETY AND QUALITY

The Safety Issue

Heavy truck brake safety is an important issue to fleet managers, operators and the general public. An important question to ask is: How do I maintain the same high level of performance I had with my original brakes when I reline them?

NTSB STUDY

A study done in 1992 by the National Transportation Safety Board (NTSB) found that replacement brake linings that do not meet OEM specifications can "greatly upset a heavy vehicle's brake system balance." This can result in unpredictable braking behavior, especially in emergency situations.

The study concluded with some of the following observations:
"… the Safety Board is concerned that the potential is great for aftermarket installation of linings with frictional characteristics less than the (vehicle) manufacturer's recommendations, which would result in reduced brake torque output."
"… proper maintenance is paramount to safe performance ... or the use of proper lining is negated."

The report stated further that truck operators can legally install replacement brake friction materials that have not passed any reasonable performance tests or validation procedures. This practice represents one of the lapses in heavy truck maintenance today.

As you can see, it is vitally important NOT to switch friction material from what came originally on the vehicle unless recommended and approved by the vehicle and/or brake manufacturer.

RATING REPLACEMENT LININGS

With no government mandated grading system established for aftermarket linings, it has been left up to the many aftermarket lining suppliers to put forth a grading system of their own. This, however, has led to the current confusing situation in which each aftermarket lining supplier uses a different system to determine how their linings should be used. For instance, some aftermarket lining manufacturers may categorize their linings as Good, Better and Best.

Confusion results when other lining suppliers use the same designations (Good, Better and Best) but define these designations differently. In this situation, a “Good” lining from the first supplier will probably have different performance characteristics than a “Good” lining from the second lining supplier.

This situation is further complicated by the fact that all aftermarket lining quality is not the same. In fact, the products in the lining aftermarket can be segmented into the following three categories:

- OE approved linings
- Non-OE approved linings made by OE suppliers
- Non-OE approved linings made by non-OE suppliers

Although some of the aftermarket lining suppliers offer proven products, others offer linings that have undergone little testing and offer few performance advantages. All in all, only a few of the top lining suppliers have lining performance standards that approach those of ArvinMeritor**.**

As a result of the current aftermarket situation, buyers and operators do not have a reliable method of guaranteeing that the replacement brake linings will perform as well as the originals.

The Quality Issue

Today, buyers and operators of heavy trucks must evaluate the overall cost of replacement brake linings, available from a number of manufacturers, against their perceived performance and quality.

Initial cost should not be the primary factor in selecting replacement brake linings or components. Before making a lining replacement decision, a buyer or operator should consider the savings that will result in longer intervals between relines and fewer brake system problems associated with using ArvinMeritor approved brake linings.

Customer Feedback

ArvinMeritor is concerned about the quality of replacement brake linings in today's marketplace. Typical questions asked by fleet customers include:

- "Why didn't my replacement brakes last as long as the ones that came with the new truck?"
- "Why doesn't my vehicle stop as quickly as it did originally?"
- "Why isn't there a convenient way to identify equivalent brake lining materials from the many brands available in the aftermarket?"
- "How do I know when I've purchased the right brake material for my particular application?"

When brakes must be replaced on a vehicle, the primary goal is to maintain the vehicle's brakes at their original equipment performance level. By insisting on ArvinMeritor replacement parts, the fleet will benefit from:

- Original equipment performance
- Consistent performance
- OEM approved lining materials
- ArvinMeritor approved tolerances and shoe specifications resulting in better lining-to-drum contact

The problems with non-OEM brake replacement materials in terms of safety and quality, can be summarized as follows:

- The wear life from the replacement linings may be less than with the original set of linings.
- Replacement linings may not provide stopping performance comparable to the original brake linings.
- The correct brake replacement parts are more difficult to identify.
- The quality of lining material may be inconsistent.
- It can be difficult to get answers to questions or problems due to the limited field support of the product.

There are various state mandated highway checks to ensure brake systems are functioning properly. A brake system that is not operating within these limits carries with it the risk of costly down-time or other penalties for non-compliance.

SUMMARY

In this training module, we have discussed the relationship between friction and temperature in medium and heavy vehicle braking systems. Within this discussion, the effects of temperature on the performance and longevity of the lining material and brake drum have confirmed that it is extremely important to replace linings with OEM grade materials designed for a specific application.

Using linings other than those recommended by the vehicle manufacturer may cause unpredictable braking behavior. When this condition exists, safety and performance may be compromised.

Brake system safety, quality and performance equivalent to the original vehicle brakes can be more readily achieved with OEM replacement linings and parts. As we have discussed, many of the aftermarket lining suppliers do not use the same rigorous engineering, manufacturing and testing standards as ArvinMeritor. Because of this, they may not provide the required level of brake performance.

ArvinMeritor aftermarket brake products meet the same rigid standards as original parts because they are the same parts. It is your assurance that these products will provide the same performance as the original vehicle brakes.

REVIEW QUESTIONS

The following questions are based on the information contained in this module. Choose the ONE correct answer:

1. Which of the following is not one of the four points of

a. To improve overall truck safety
b. To supply genuine brake replacement components
c. To evaluate fleet concerns regarding heavy truck brakes
d. To certify the performance of “will-fit” brake components

2. Friction:

a. Is the force that opposes or retards the motion of one surface against another.
b. Is developed by the vehicle’s braking system.
c. Slows the vehicle down and eventually stops it.
d. All of the above.

3. In a two-letter rating system for linings, what does the first letter represent?

a. A higher friction lining
b. The normal friction coefficient of the lining
c. The hot friction rating
d. The actual friction level of the lining

4. Fade may be described in all the following ways except:

a. The inability of the friction material to maintain its coefficient of friction at elevated temperatures.
b. May result from a single, high pressure stop or over a number of successive brake applications.
c. A reduction in instantaneous brake torque output caused by heavy use of the brake.
d. A measure of the lining’s ability to maintain its coefficient of friction at varying vehicle speeds.

5. The National Transportation Safety Board (NTSB) study concluded that:

a. Replacement brake linings that do not meet OEM specifications can interfere with a heavy vehicle’s brake system balance.
b. Installing aftermarket linings with different frictional characteristics than those originally on the vehicle can result in reduced brake torque output.
c. Proper brake maintenance is required for safe vehicle operation.
d. All of the above.

6. In what way(s) can the coefficient of friction between two surfaces change?

a. By introducing a lubricant between the surfaces
b. By increasing or decreasing the temperature of one or both surfaces
c. By changing the chemical make-up of one surface.
d. All of the above.

REVIEW QUESTIONS (Continued)

7. What is a common concern with aftermarket brake replacement products?

a. The replacement brake lining may have a shorter wear life than the original set.
b. The stopping performance may be lower than it was with original brake linings.
c. Correct brake replacement parts are difficult to identify.
d. All of the above.

8. What does ArvinMeritor guarantee for ArvinMeritor replacement parts?

a. Original equipment performance
b. Varying performance
c. Untested lining materials
d. Will-fit tolerances and shoe specifications

GLOSSARY

Brake imbalance	A condition in which one brake or set of brakes is working harder to stop a vehicle than another brake or set of brakes.
Brake lining	A friction material attached to a brake shoe that retards the motion of a vehicle when the material contacts the drum.
Fade	The reduction of brake output torque even though application pressure remains constant.
Friction	The force that opposes or retards the motion of one surface over another.
Friction code	The two-letter designation for brake linings that compares the normal coefficient of friction to the hot friction coefficient.
OEM	Original equipment manufacturer.
Speed spread	A measure of the ability of the lining to maintain its coefficient of friction at varying vehicle speeds and input pressures.

PURPOSE OF QUALIFICATION PROCESS

As the leading air foundation brake supplier, ArvinMeritor has taken responsibility for developing and closely monitoring brake linings used on its foundation brakes. The ArvinMeritor lining qualification process was established to ensure that brake linings used by ArvinMeritor meet the following criteria:

- Meet ArvinMeritor's stringent performance requirements
- Meet FMVSS-121 requirements
- Are consistent year-to-year
- Meet today's requirements for better brake performance

All Linings are Not the Same

As we have discussed before, all brake linings are not created equally. Although OE and aftermarket linings may look the same, they can be very different in quality and performance. Unlike linings used by ArvinMeritor, aftermarket linings are not required to meet or comply with any Federal regulations regarding performance or safety. With no government requirements, each aftermarket lining manufacturer can set their own quality and performance standards.

Key Point:

- **Lining quality and performance differs between aftermarket and OE materials.**

Every lining material that ArvinMeritor uses must first pass strict quality, laboratory, and vehicle testing. ArvinMeritor testing -goes above and beyond that required by the government. The customer can be assured that when a ArvinMeritor-qualified shoe is relined, the brakes will continue to perform as they did-before the reline.

FMVSS-121

FMVSS-121 REGULATIONS

APPLY TO OE LININGS ONLY

The National Highway Traffic Safety Administration (NHTSA) requires that all medium and heavy duty air braked vehicles meet minimum safety and performance requirements. This regulation, referred to as FMVSS-121, was originally enacted to address concerns with respect to air brake usage on medium and heavy duty trucks. The dynamometer test portion of FMVSS-121 requires that brakes meet minimum torque requirements in panic and non-panic situations.

Key Point:

- **Government regulations apply to OE approved linings only.**

Recently, NHTSA proposed maximum stopping distances for a straight line stop on dry, high coefficient of friction pavement. All medium and heavy air braked vehicles (trucks, tractors, tractor-trailers and buses) will have to comply with the new requirements which will probably go into effect some time in 1996. As currently proposed, the regulation would require that vehicles meet the following stopping distances from 60 mph:

- Loaded single unit trucks: 310 feet
- Unloaded single unit trucks and bobtail tractors (no semi-trailer): 335 feet
- Loaded and unloaded buses: 280 feet
- Loaded tractor trailer (without trailer brakes): 355 feet

To an OE brake manufacturer like ArvinMeritor, FMVSS-121 means **that** dynamometer **and vehicle testing are required for the brake** and lining combination it sells.

Asbestos vs. Non-Asbestos Linings

There are four major components which make up any brake lining composition. They are the:

- Fiber
- Filler
- Binder
- Friction Modifiers

Key Point:

The change from asbestos to non asbestos fiber material reduced the number of quality lining suppliers.

Due to the change in fiber material from asbestos to non-asbestos in the late 1980's, ArvinMeritor has continued to increase its role in the development and testing of new linings. This was due to the fact that, prior to the change, there were many OE lining suppliers that had mastered the art of producing quality linings. Back then, linings were made using asbestos as the fiber material and the best lining suppliers had lining formulations that were used for decades. Asbestos has many characteristics which makes it superior for use as a friction material fiber.

However, due to a change in the U.S. Government's OSHA (Occupational Safety and Health Administration) requirements in the early 1980's, the lining suppliers converted to non-asbestos lining materials that had very different performance properties than their asbestos predecessors. Only a few lining suppliers had the development and testing capabilities to survive the changeover from asbestos to non-asbestos linings. These are the suppliers that ArvinMeritor deals with exclusively.

Increased Customer Satisfaction

Performance demands placed on a vehicle's brakes have increased in the past due to the use of more aerodynamic vehicles, low RPM engines and low-profile tires. Coupling these factors with the increasing performance demands proposed by FMVSS-121, and the ever increasing industry need for long-lasting, durable linings, it has become imperative for ArvinMeritor to ensure that it uses only the best lining formulations available with its brakes. Long-term suitability of a brake lining for a particular vehicle can only be determined through extensive testing and evaluation.

Key Point:

Customers demand more from a brake lining today.

As the leading heavy-duty foundation brake supplier, ArvinMeritor has taken upon itself to guide its lining suppliers in the development of every lining it uses. Through this guidance, ArvinMeritor ensures that a lining will meet the specific needs of a particular vehicle vocation and its customers.

ARVINMERITOR GOES BEYOND FMVSS-1 21

ArvinMeritor Design and Engineering Standards

ArvinMeritor goes beyond the requirements of FMVSS-121 for two reasons:

- To elevate the industry braking standard beyond FMVSS-121
- To provide the marketplace with brake products that offer superior safety, performance and durability

Due to the fact that ArvinMeritor is the major OE supplier of heavy duty air brakes, the company takes the responsibility of making sure that all linings it uses comply with stringent testing standards.

FMVSS-121 testing is geared toward testing brakes and brake linings in emergency situations. In addition to this testing, ArvinMeritor tests linings to ensure superior performance in everyday braking. These tests evaluate the wear characteristics, torque output, and balance characteristics of a lining at various temperatures, vehicle speeds and input pressures. ArvinMeritor also ensures that after running these initial tests in the lining development phase, the formulation of the lining stays intact throughout the use of the lining. As a result, ArvinMeritor approved linings coupled with genuine ArvinMeritor brake shoes ensure consistent performance from reline to reline for the vehicle owner.

Testing and Evaluation

WHAT WE TEST	WHAT IT MEANS TO YOU
Lining meets all FMVSS-121 requirements for retardation, power and recovery	Your assurance that your Rockwell lining meets federal requirements for performance and safety.
Meets physical properties of swell and growth, specific gravity, and Gogan hardness	Reduces the possibility of dragging brakes, premature wear, and overheating.
Wear requirements including temperatures from 250° to 650°F, lining wear rate and drum wear	Helps ensure longer brake life.
Performance including normal and elevated temperatures, speed spread (20, 50, and 60 mph), emergency torque, and low pressure torque	Helps improve brake performance and compatibility.
Parking — draw bar and hill holding	Ensures linings meet FMVSS-121 requirements for hill holding.
Field evaluations including: real world driving, wear, compatibility, long-term structural integrity, and noise	Your assurance that Rockwell linings will work effectively under real world conditions.

The chart above highlights some testing criteria used to ensure that all linings meet ArvinMeritor's requirements.

ARVINMERITOR QUALIFICATION PROGRAM

Supplier Selection

Key Points:

ArvinMeritor insists that linings:

- ***Consistently be of high Quality***
- ***Comply with FMVSS-121***
- ***Comply with ArvinMeritor standards***

Because of its position in the industry, ArvinMeritor is responsible for establishing and maintaining high quality and performance standards for its brake products. ArvinMeritor requires its brake lining suppliers to make a similar commitment.

ArvinMeritor considers several factors when it selects, evaluates and approves OE linings. Linings supplied to ArvinMeritor must meet the following criteria to be approved:

- Consistently be of high quality.
- Comply with all FMVSS-121 dynamometer and vehicle performance requirements.
- Comply with the additional design and engineering standards developed by ArvinMeritor.

ArvinMeritor determines how well each lining complies with these requirements through regular testing and evaluation. For example, as one way to check product quality, ArvinMeritor receives the results of lining dynamometer tests from suppliers on a periodic basis. Dynamometer testing determines whether the lining is providing the kind of performance levels specified by ArvinMeritor.

Lining Evaluation

Key Points:
The ArvinMeritor lining evaluation program includes:
Laboratory testing
Dynamometer testing
Vehicle testing
Field evaluation

Four primary testing activities are incorporated within ArvinMeritor's overall brake lining evaluation program: laboratory testing, **dynamometer testing, vehicle testing and** field evaluation.

Laboratory Testing

Laboratory testing evaluates the physical properties of the brake lining material. This is done to ensure that the quality and consistency of the material meets ArvinMeritor specifications. Four parameters are tested:

- Strength
- Swell and growth
- Gogan hardness
- Specific gravity

STRENGTH

The strength of a lining material is checked to ensure that the lining does not crack during handling or when in service. Strength is needed in order for the lining to withstand the riveting procedure and the forces generated during braking.

SWELL AND GROWTH

This test determines how much thicker the lining material will become at high temperatures. Swell and growth affects the ability **of the** Automatic Slack Adjusters **(ASAs) to maintain good brake** drum-to-lining clearance. A lining material that swells and grows could promote dragging brakes, high brake temperatures, and premature lining wear.

GOGAN HARDNESS

The Gogan hardness test measures the hardness of the lining material. To perform this test, a weight is applied to the lining material and removed. The size of the dent left in the material is observed. Gogan hardness gives an indication of the lining's compressibility.

SPECIFIC GRAVITY

Specific gravity measures the density of the lining material. ArvinMeritor uses the specific gravity test to make sure that the formulation is produced consistently year after year.

Dynamometer Testing

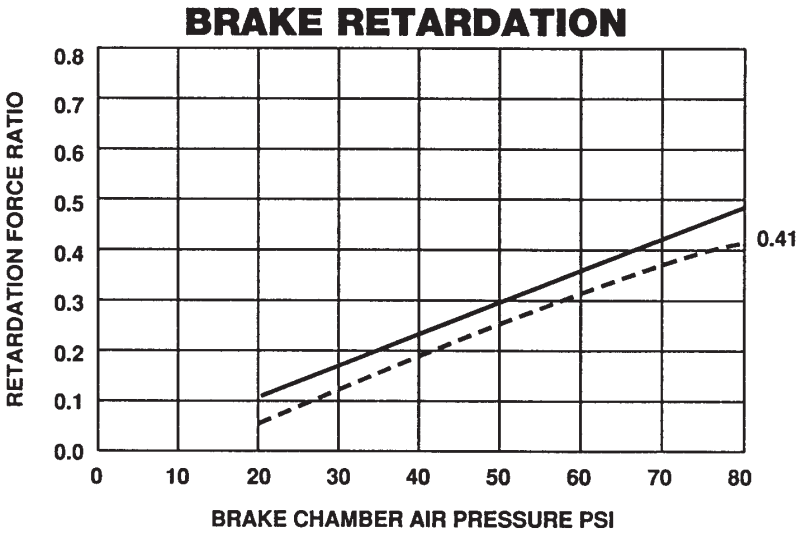
As part of its qualification procedure, ArvinMeritor performs the following tests on its computerized brake inertia dynamometers:

- Retardation (FMVSS-121)
- Power and recovery (FMVSS-121)
- Effectiveness
- Wear

These dynamometer tests are explained in the following pages.

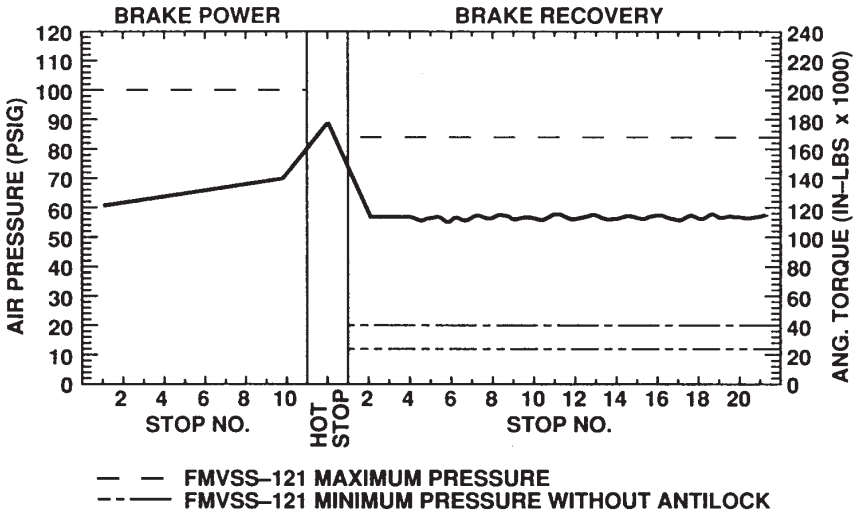
RETARDATION

Retardation is a portion of the FMVSS-121 dynamometer test.



Required for trailer brakes, this test determines if a brake and lining meet the required torque output for specific axle weight and wheel speed. The brake is heated to 2000F, and seven stops are made from 50 mph. The first stop is made with a chamber pressure of 20 psi. Each additional stop is made with a 10 psi increase in chamber pressure (30, 40, 50, 60, 70 psi). The last stop is made at 80 psi. The brake must produce a retardation force equal to 41 percent of the wheel load at 80 psi.

POWER AND RECOVERY

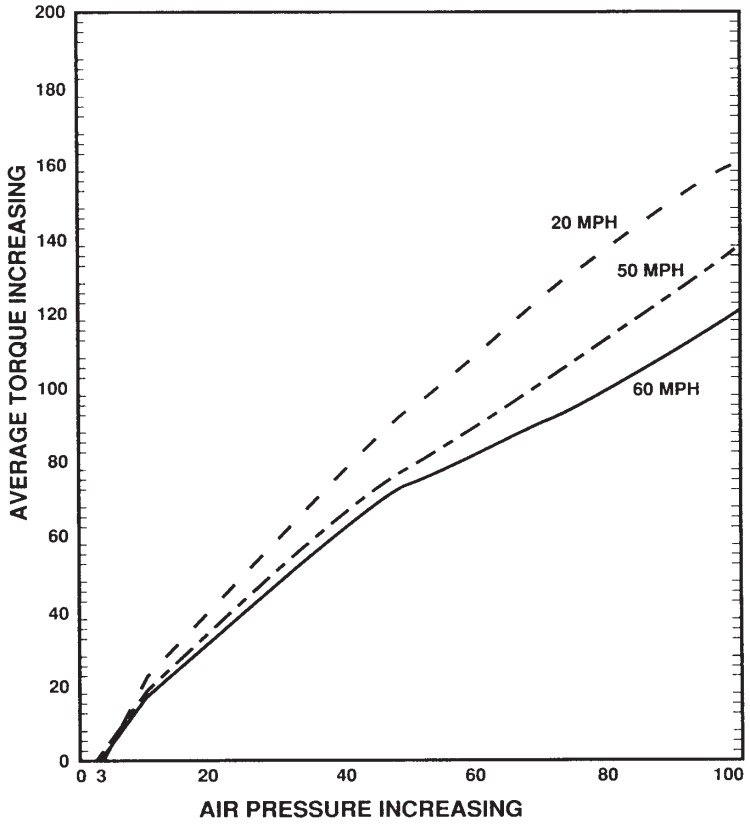


The power portion of the FMVSS-121 dynamometer test determines how the brake and lining react to repeated stops and increasing temperature. Braking power usually decreases as brake temperature increases. Therefore, ten snubs are performed from 50 to 15 mph at a deceleration rate of 9 feet/(sec)'. If no more than 100 psi maximum pressure is used during any snub, the brake and lining have passed the power portion of FMVSS-121.

ArvinMeritor brake linings fade much less than that allowed by FMVSS-121. Under the current FMVSS-121 test procedure, a lining could fade from 5 psi on the first snub to 99 psi on the tenth and still pass the test. In general, ArvinMeritor looks for linings that fade only slightly in ten snubs. This slight fade promotes better brake balance on a vehicle. If the brake doing most of the initial braking fades slightly, then the other brakes on a vehicle will work harder to stop the vehicle.

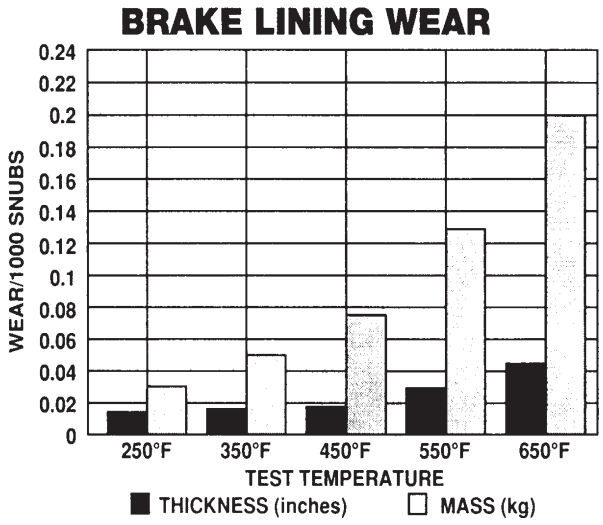
Brake recovery is tested to determine how the brake lining behaves as it starts to cool. The recovery test starts 3 minutes after the last power test. A series of 20 stops are made from 30 to 0 mph at a deceleration rate of 12 feet/(sec)'. Brake chamber air pressure must fall within the range of 85 psi maximum and 20 psi minimum. In the recovery portion of the test, a lining should show consistency in performance as the temperature decreases. Typically, ArvinMeritor likes to see pressures consistently at the mid-point of the maximum and minimum pressures allowed.

EFFECTIVENESS



The effectiveness test required by ArvinMeritor indicates how the lining performance changes with vehicle speed. The friction properties of the lining must stay relatively constant throughout the range of typical vehicle speeds in order to meet ArvinMeritor standards. In this test, ArvinMeritor makes brake stops from 10 to 100 psi in 10 psi increments at speeds of 20, 50 and 60 mph.

WEAR



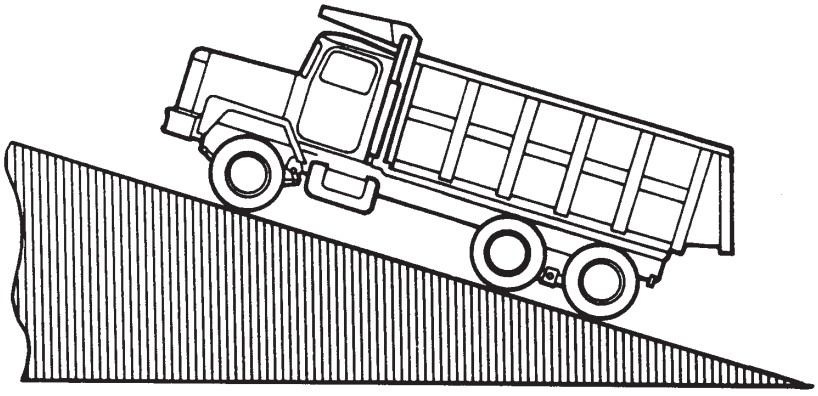
Like the effectiveness test, the wear test is not required in FMVSS-121. An independent dynamometer laboratory performs this test for ArvinMeritor. At 250, 350, 450, 550 and 650 degrees F, a lining is subjected to 1000 snubs. After each 1000 snubs, the lining thickness and mass are checked to determine the lining wear at each temperature. This test helps ArvinMeritor determine the wear versus temperature characteristics of a lining material. This test also monitors how the friction properties of the lining vary, during and after testing, at each temperature.

Vehicle Testing

If a lining performs well in the dynamometer testing portion of the qualification process, vehicle testing begins. In this phase, -Arvin-Meritor requires the lining to be tested on a vehicle in many different ways:

- Hill holding/drawbar
- Durability (test track evaluation)
- Brake balance

HILL HOLDING/DRAWBAR TESTS



These tests, required by FMVSS-121, are used to determine the parking capability of the brake and brake lining. Vehicles must pass either the hill holding or drawbar test.

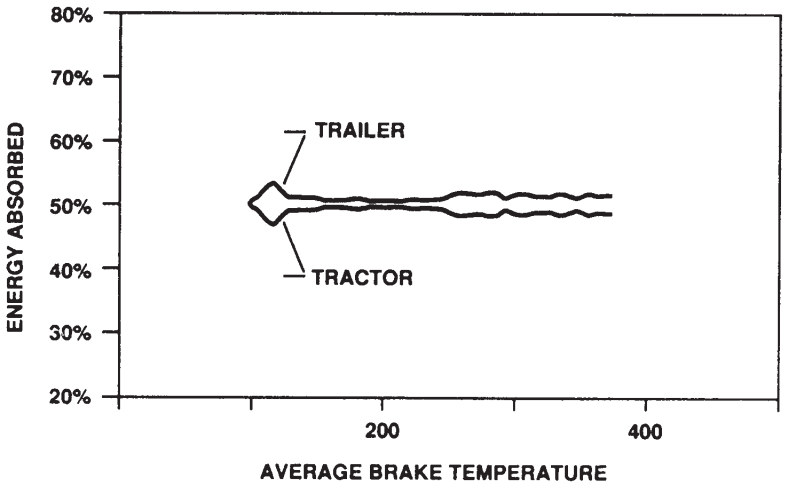
In the hill holding test, the vehicle is loaded to its **Gross Vehicle Weight Rating (GVWR).** Then the vehicle is parked (using its rear axle spring brakes) on a 20 percent grade facing uphill and then downhill with the vehicle loaded and empty. These positions are necessary to ensure that the vehicle can pass the test with a different axle load distribution. If the brakes hold in both directions, the test is passed.

The drawbar test is performed on a level surface with the vehicle loaded to its GVWR. A hydraulic winch or drawbar is attached to the vehicle, and the parking brakes are applied. The drawbar then pulls the vehicle until the static torque of the parking brakes is overcome, and the vehicle's wheels begin to roll. When the wheels turn, the pulling force is recorded. This force must be more than 14 percent of the GVWR for tractors and 28 percent of the GAWR for trucks.

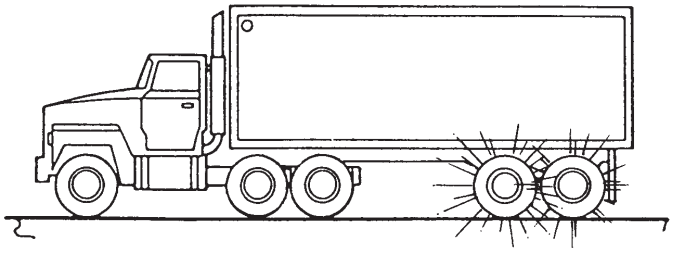
DURABILITY

This ArvinMeritor test exposes the vehicle to severe duty conditions, such as high brake pressures and operating temperatures. Vehicles are tested either on a test track or on routes in severe environments to determine the effectiveness and performance of the lining material. Vehicles are run for long periods of time to determine the structural integrity of the lining.

BRAKE BALANCE



Balance testing is used to check the compatibility of a lining with other lining materials on the vehicle. For example, the tractor and trailer brakes are monitored to make sure that differences in the linings do not cause poor braking performance.



IMPROPER TORQUE BALANCE CAN CAUSE SOME BRAKES TO WORK HARDER THAN OTHERS

Brake balance has three components:

- Torque balance refers to how each brake contributes to the actual slowing of the vehicle.
- Wear balance refers to the rate that the brake linings wear.
- Thermal balance is achieved when all brakes are operating in the same temperature range.

Achieving proper foundation brake balance in a tractor/trailer combination is a difficult task. This complex task has been a concern of the trucking industry for many years.

To further test the lining, ArvinMeritor may vary front brake sizes as well as drive and trailer brake power during its evaluation.

Field Evaluation

After the vehicle testing program is completed, the product is evaluated in a fleet environment for a period of 6 to 24 months. A number of drivers and maintenance personnel evaluate the brakes to see how well the product works in the “real world.” They determine whether the lining material causes any unusual performance or maintenance related problems.

Basically, the field evaluation phase monitors four elements. Some are similar to those we discussed in the Vehicle Testing section.

- Lining and drum wear and durability
- Brake noise
- Long term integrity
- Tractor/trailer balance

The lining material will be released if ArvinMeritor feels it performs well with respect to these criteria.

All tests are done under typical vehicle operating conditions. After the field evaluation period, ArvinMeritor reviews the results and determines the brake sizes, axle weights and vehicle applications for which the lining is best suited.

ArvinMeritor places much importance on the performance of its linings. As a result, it may take anywhere from 1-1/2 to 4 years before a new lining material is qualified by ArvinMeritor.

APPLICATION OF ARVINMERITOR LININGS

Key Points:

To help customers obtain the best lining for an application, ArvinMeritor has developed the following:

- ***Brake lining specification sheets***
- ***Brake application survey***

Let's turn our attention to the subject of brake lining application.

ArvinMeritor is not limited to making selections from only one lining manufacturer's inventory. We choose the "best-of-the-best" from three OEM-level suppliers.

Too often, in the aftermarket, one popular lining is used regardless of the vocation, vehicle weight, tire size or brake power. However, poor brake lining choices can result in brake imbalance, rapid wear and poor stopping ability. One of the keys to bringing worn brakes back to their original performance level is choosing the right lining for the particular brake and its application.

Of course, if the vehicle is still being used in the original application and the fleet is satisfied with its lining performance on the new vehicle, they should simply replace the lining with exactly the same lining. ArvinMeritor has made this much easier by implementing the ArvinMeritor Brake Shoe System and identifying every brake shoe placed in production.

The following will help reliners and customers to select the correct brake lining.

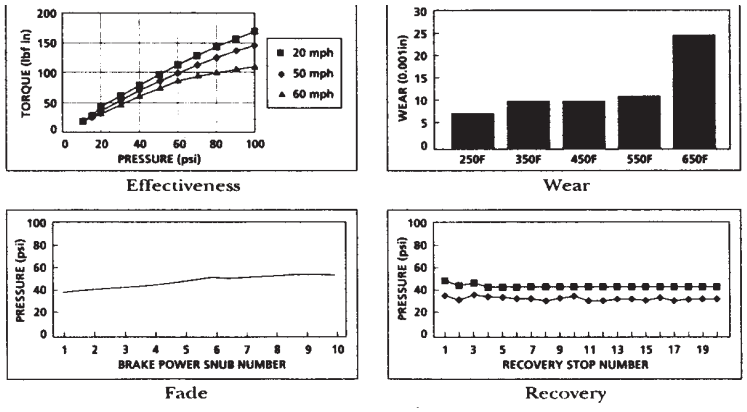
• Brake lining specification sheets

• Brake application survey

• Brake shoe label

• On-line help

Brake Lining Specification Sheet



ArvinMeritor provides brake lining specification sheets to share its knowledge about brake linings. Aftermarket customers can use this information to review the performance characteristics and determine the best ArvinMeritor lining for their application.

To specify a lining material that will match the work being done, it is necessary to review some of the information on the specification sheet.

- **Friction Code** - A two-letter code that indicates the normal and hot friction coefficients of a particular brake lining.

NOTE: As mentioned earlier, the friction rating is not the best way to select a lining. However, it is a government standard that appears on all linings. ArvinMeritor does not recommend the use of the rating alone to choose a lining.

- **Material** - Non-asbestos or metallic-based material.
  Specific Gravity - This number is a quality control check of the lining formulation.

- **Recommended Service** - identifies whether the lining should be used for normal, severe or light duty applications.
  GAWR - The **Gross Axle Weight Rating** identifies the axle weight range for which the lining should be used on ArvinMeritor's 16.5 x 7 inch cam brakes.

- **Effectiveness** - Shows the consistency of the torque output of the lining over a range of speeds and pressures.

- **Fade** - The decrease in brake torque output after repeated stops due to brake temperature increase.

- **Recovery** - Shows the performance fluctuation of the lining as the temperature decreases through 20 snubs.

- **Wear** - This graph shows the wear versus temperature characteristics of the lining material.

As you can see, ArvinMeritor uses an extensive testing and evaluation program to approve any new lining material.

VEHICLE TYPE

Vehicle type influences the type of brake used (cam, wedge or disc), the size of the front and rear brakes used in combination and the input power (AL factor = slack length x chamber size). For instance, trucks generally use larger front brakes than do tractors because of the larger weight transfer during stopping.

Vocation (fire service, school bus, linehaul, etc.) also informs ArvinMeritor Brake Engineering of the vehicle duty cycle and the relative amount of braking the vehicle has to do. This has a major impact on the selection of the brake lining material.

The vehicle configuration indicates the number of extra axles (tag or pusher) used on the vehicle. This allows ArvinMeritor to recommend a lining that effectively distributes the total brake workload throughout the vehicle.

AXLE TYPE and AXLE RATING

Axle type is essential in determining the size of the brake. Typically, front axle brakes are smaller in diameter and/or have less lining volume than drive or trailer axle brakes. Additionally, trailer axle brakes usually use a longer slack adjuster than used on the drive axle brakes thus increasing the input torque to the brake.

The axle rating is used to determine the retardation forces needed to meet FMVSS-121 dynamometer certification. Axle rating is the most important consideration in determining the brake size, AL factor (slack length x chamber size) and lining mix for a particular vehicle.

BRAKE SIZE and TYPE

ArvinMeritor needs to know the brake size and type to ensure the proper lining material and block size are supplied to the customer.

SLACK LENGTH and CHAMBER SIZE (AL FACTOR)

Slack length and chamber size are also required to determine the proper lining material needed for a specific vehicle. Typically, a drive or trailer axle brake uses a Type 24, 30 or 36 chamber while a front brake can use chamber sizes ranging from Type 12 to Type 30. Front brakes also typically use either 5 or 5.5 inch slack adjusters. Drive and trailer axle brakes use anything from a 5 inch to a 6.5 inch slack.

A specific lining mix and brake size and type, will meet FMVSS-121 requirements at a certain axle rating with limited sizes of chambers and slacks. For instance, a 16.5 x 7 inch cam brake with a “20K’ lining material will meet 121 requirements with a Type 30 chamber and a 5.5 inch slack adjuster (AL Factor = 30 x 5.5 = 165). This same brake and lining probably would not meet 121 if the AL Factor was increased or decreased considerably.

Brake Shoe Label

Key Points:

The brake shoe label includes the following information:

- The type of brake shoe ArvinMeritor lining material designation Replacement brake shoe and lining part number The **brake shoe label** is designed to provide you with the critical information needed to specify genuine ArvinMeritor brake replacement components. The procedure is outlined below.

1. Find the brake shoe label on the web of your new or relined ArvinMeritor brake shoe. This label shows all the necessary information to ensure accurate replacement for the specific application.

2. Locate the lining number on the brake shoe label. The lining number takes the guesswork out of lining replacement by accurately identifying the exact lining used on the original vehicle.

3. To determine the correct replacement shoe and lining assembly, locate the replacement part number on the tag. This number will make sure that the customer gets exactly the right replacement part.

SUMMARY

A major benefit of using ArvinMeritor linings on new or relined brake shoes is that the customer is guaranteed to receive OE quality lining performance for his application.

In this training module, we have discussed ArvinMeritor's lining qualification and application processes. These processes have been put into place to ensure that only the best linings are used with ArvinMeritor brakes.

The qualification process was established to help ArvinMeritor develop brake linings manufactured by ArvinMeritor's brake lining suppliers.

- ArvinMeritor uses this process to ensure that linings meet ArvinMeritor specifications, meet the FMVSS-121 requirements, are manufactured from the best materials, and meet today's requirements for greater brake performance.

- ArvinMeritor determines how well each supplier complies with these requirements through extensive testing and evaluation. Testing includes laboratory testing, dynamometer testing, vehicle testing and field evaluation. ArvinMeritor testing goes well beyond the government regulations specified in FIVIVSS-121.

As a part of ArvinMeritor's application process, the following has been developed:

Specification sheets contain information about the performance characteristics of brake linings used by ArvinMeritor. Reliners and their aftermarket customers can use this information to evaluate the best ArvinMeritor lining for their application.

The brake shoe data tag provides critical information to specify genuine ArvinMeritor brake replacement components.

REVIEW QUESTIONS

The following questions are based on the information contained in this module.
Choose the ONE best correct answer.

1. The purpose of the qualification process is to make sure that linings:
- a. Are within OE specifications for quality and performance.
- b. Meet the applicable FMVSS-121 requirements.
- c. Are manufactured from consistent, long-lasting and durable materials.
- d. All of the above.

2. The FMVSS-121 regulation:
- a. Requires that all medium and heavy duty air brake vehicles meet minimum safety and performance requirements.
- b. Applies to OE and aftermarket lining manufacturers.
- c. Requires that brakes meet minimum torque requirements in non-panic situations only.
- d. All of the above.

3. Specific gravity:
- a. Could be affected by the forces that are generated during riveting or during high pressure brake applications.
- b. Is an indication of the density of the lining material.
- c. Affects the ability of the Automatic Slack Adjusters (ASAs) to maintain good brake drum-to-lining clearance.
- d. Refers to the hardness of the lining material.

4. What dynamometer tests are performed by ArvinMeritor?
- a. Effectiveness
- b. Retardation
- c. Power and recovery
- d. All of the above.

5. The brake power test:
- a. Determines the torque variation of a brake and lining at different speeds and pressures.
- b. Determines how the brake lining behaves as it starts to cool.
- c. Determines the fade resistance of the lining material.
- d. All of the above.

6. The effectiveness test:
- a. Indicates how the lining performance changes with vehicle speed and input pressure.
- b. Is required in FMVSS-121.
- c. Helps ArvinMeritor determine the temperatures in which a lining performs best.
- d. All of the above.

REVIEW QUESTIONS (Continued)

7. What vehicle testing is performed by ArvinMeritor?

a. Durability
b. Hill holding
c. Brake balance
d. All of the above.

8. Torque balance:

a. Refers to how each brake contributes to the actual slowing of the vehicle.
b. Refers to the rate at which the brake linings wear.
c. Is achieved when all brakes are not operating at the same temperature.
d. All of the above.

9. A field evaluation:

a. Is performed before vehicle testing.
b. Is completed in less than 6 months.
c. Is conducted to determine whether the lining material causes any unusual performance or maintenance related problems.
d. None of the above.

10. The brake shoe label contains what information?

a. The brake shoe type
b. A lining material designation
c. A replacement part number for the brake shoe and lining assembly
d. All of the above.

GLOSSARY

AL Factor	A mathematical expression of the slack adjuster and brake chamber combination. “A” equals the effective area, in square inches, of the brake chamber. “U” equals the effective length, in inches, of the slack adjuster.
Automatic Slack Adjuster (ASA)	A lever connecting the brake chamber push rod with the foundation brake camshaft. It provides torque to rotate the brake camshaft when the brake pedal is depressed. It also provides a means of automatically adjusting clearance between brake shoes and the drum to compensate for lining wear.
Brake Balance	Brake balance is achieved when all brakes on all axles do their fair share of the work.
Brake Lining Formulation	The combination of elements (filler, binder, fiber and friction modifiers) used to produce the brake lining material.
Brake Lining	The heat-resistant friction material that is pressed against the drum or disc to achieve the braking action.
Broke Lining Specification Sheets	Lining information, provided by ArvinMeritor, to help aftermarket customers determine the best ArvinMeritor lining for their application.
Drawbar	A test which determines the static torque capability of the vehicle’s rear brakes. In this test, the vehicle’s parking brakes are applied and a winch pulls the vehicle until its brakes give way to the force of the winch.
Dynamometer	A device that can simulate the inertia of a vehicle. A dynamometer is used to test the performance characteristics of brakes and brake linings.
Fade	The reduction of brake output torque even though application pressure remains constant.
Field Evaluation	Testing program where the lining is evaluated by a fleet of drivers and maintenance personnel. The fleet determines whether the lining causes any unusual performance or maintenance related problems in the “real world.”

FMVSS-1 21	A government mandated test procedure for heavy trucks, buses, tractors and trailers. Includes vehicle testing and brake dynamometer testing.
Gogan Hardness	A test to determine the relative hardness of a lining material.
Gross Axle Weight Rating (GAWR)	The rated capacity for a particular axle.
Gross Vehicle Weight Rating (GVWR)	This term pertains to the total carrying capacity of any given vehicle.
Hill Holding	Test performed to determine whether the brakes will hold when a vehicle is parked on a 20% grade.
Power	Part of the FMVSS-121 dynamometer test procedure. This portion of the test determines the fade characteristics of the brake and lining as the temperature increases with repeated snubs.
Recovery	Part of the FMVSS-121 dynamometer test procedure. This portion of the test determines the behavior of a lining material as the brake cools through its typical working temperature.
Retardation	Part of the FMVSS-121 dynamometer test procedure. This portion of the test determines if the brake being tested generates enough retardation force to be used with a specific trailer axle load.
Specific Gravity	The relative density of a lining material.
Swell and Growth	The degree to which a lining material may increase in size due to increasing operating temperatures.

SECTION 3 - AIR CAM FOUNDATION BRAKE TROUBLESHOOTING

Module Goal

The goal of this training module is to provide the participant with the information needed for foundation brake troubleshooting.

Module Objectives

After successful completion of this training module, you will be able to:

- describe the factors that lead to a reduction in foundation brake performance.
- identify and describe the factors that affect brake lining life.
- describe the symptoms, causes and solutions for troubleshooting the foundation brakes.

The Importance of Troubleshooting

This program module features the foundation brake troubleshooting of brake shoe, lining and drum concerns which can affect the performance of heavy vehicle brake systems. The importance of troubleshooting foundation brakes is to discover any concerns before a problem arises. This module deals with and focuses on foundation brake problems such as lining wear and brake torque performance. There are other issues that may contribute to brake system problems, such as the air system. Information concerning other brake related problems is available through the vehicle manufacturers' service manuals, other brake system component manufacturers or the air system supplier.

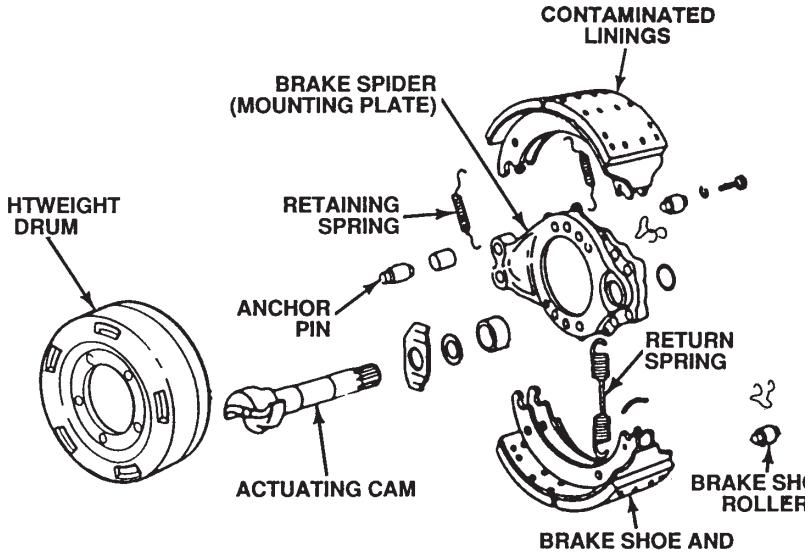
Study this module material to improve your understanding and troubleshooting capability.

Troubleshooting:

- a symptom, such as poor lining life on one axle, may be the result of another problem in the vehicle's brake system.
- ran lead to the actual cause of the problem such as the possibility of incorrect crack pressures or poorly adjusted slack adjusters**.**
- if performed improperly, may lead to the replacement of a brake component which will not eliminate a poor lining life problem.

LINING TROUBLESHOOTING GUIDE

Accelerated Lining Wear



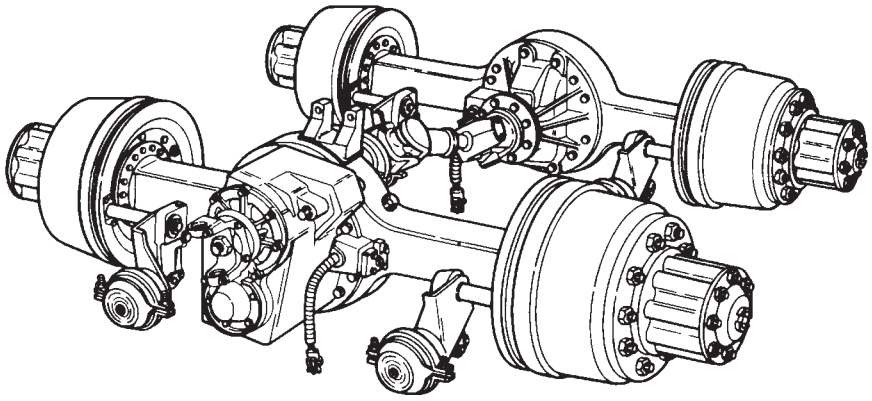
Key Points:

Accelerated lining wear can be caused by:

- ***Vehicle overloaded***
- ***Severe operation***
- ***Contamination***
- ***Incorrect drums***

Symptom	Cause	Solution
Accelerated Lining Wear Throughout Vehicle	1. Vehicle is loaded over gross vehicle weight rating (GVWR).	1. Reduce vehicle load to GVWR.
	2. High temperatures due to severe operation, such as frequent brake application.	2. Install quality lining. Avoid using low quality, non-OE material. Check with brake manufacturer for appropriate lining material.
	3. Contaminants are present between brake lining and drum.	3. Review possible use of dust shield.
	4. Lightweight or low quality drums. Cause poor heat dissipation during frequent brake applications.	4. Install drums with mass to withstand temperature output of the specific vehicle vocation.

LINING TROUBLESHOOTING GUIDE

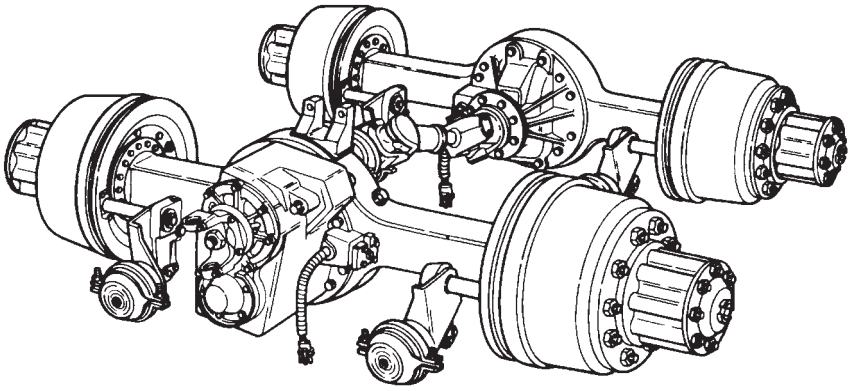


Key Points:

- ***Accelerated lining wear on rear axle brakes can be caused by:***
- ***Low rear brake crack pressures***
- ***Dragging brakes Incorrect linings***
- ***Cracked drums***
- ***Non-functioning slack adjusters***
- ***Mixed slack adjusters***

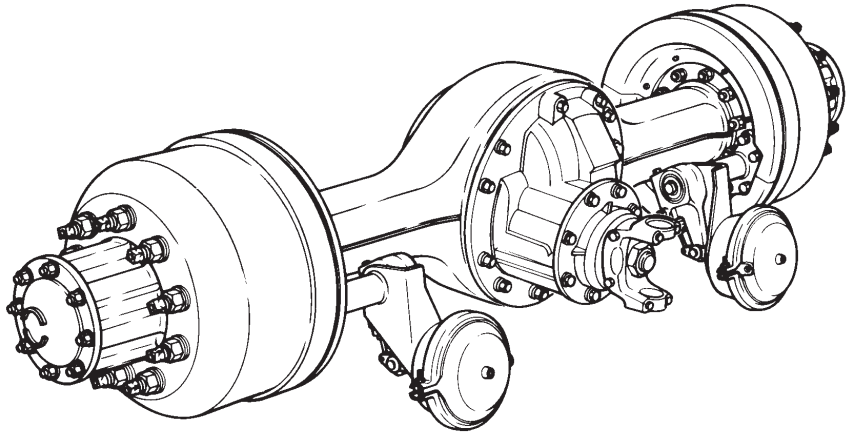
Symptom	Cause	Solution
Accelerated Lining Wear on Rear Axles	1. Pneumatic imbalances such as low rear brake crack pressure or the use of automatic limiting valves on the front axle can increase the rate of wear on rear brakes.	1 . Crack pressures between axles should not exceed 2 psi. Automatic limiting valves on front axles are not recommended by ArvinMeritor.
	2. Brake shoe drag due to lack of air pressure to cage park brake spring or broken spring.	2. Check the air pressure to the spring brake. If low, check for air line leaks. If normal, replace chamber.
	3. Incorrect linings for current application (light duty type used under severe duty conditions).	3. Avoid using low quality, non-OE material. Check brake manufacturer for appropriate lining material.
	4. Drum cracks at lining to drum contact surface are “machining” lining.	4. Replace drums.

LINING TROUBLESHOOTING GUIDE



Symptom	Cause	Solution
Accelerated Lining Wear on Rear Axles (Continued)	5. Brakes on front and/or trailer axle have improperly adjusted slacks.	5. Check adjuster stroke on each wheel to ensure proper adjustment.
	6. Automatic slacks are used on rear axle(s) and manual slack adjuster are used on front and/or trailer brakes.	6. Replace manual slacks with automatic slacks.

LINING TROUBLESHOOTING GUIDE



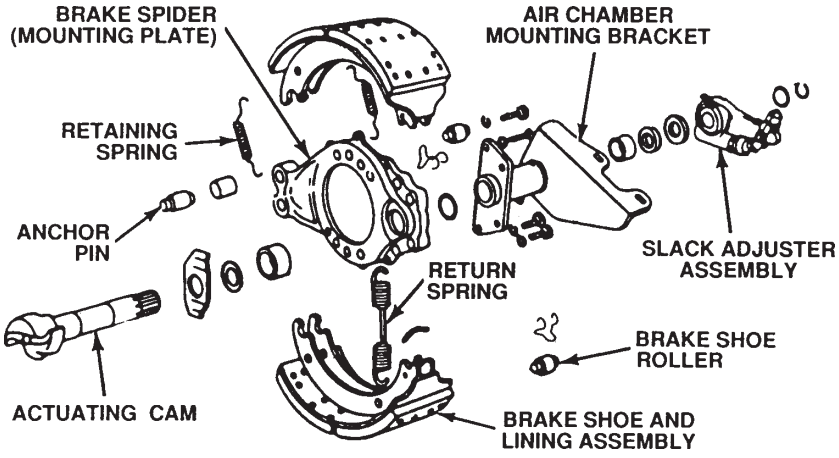
Key Points:

Accelerated lining wear on only one brake of an axle can be caused by:

- ***Seal leaks***
- ***Parking brake drag***
- ***Incorrect adjustment***
- ***Incorrect brake chamber size***
- ***Incorrect slack adjuster length***
- ***Restricted air flow to brake***

Symptom	Cause	Solution
Accelerated Lining Wear: Brake To Brake On One Axle	1. Wheel seal on one side is leaking, contaminating linings.	1. Replace wheel seal. Replace shoes on both sides of axle.
	2. Spring in one parking brake chamber not fully retracted, allowing shoes to contact drum.	2. Check the air pressure to the spring brake. If low, check for air line leaks. If normal, replace chamber.
	3. Uneven brake adjustment (one too loose, one too tight).	3. Check air chamber pushrod stroke. Adjust slack as necessary.
	4. Slack adjuster length or chamber size is different on the two brakes.	4. Inspect and replace if improper component sizes are used.
	5. One brake has less air circulation for cooling due to obstruction on vehicle.	5. Eliminate obstructions restricting air flow if possible.

LINING TROUBLESHOOTING GUIDE



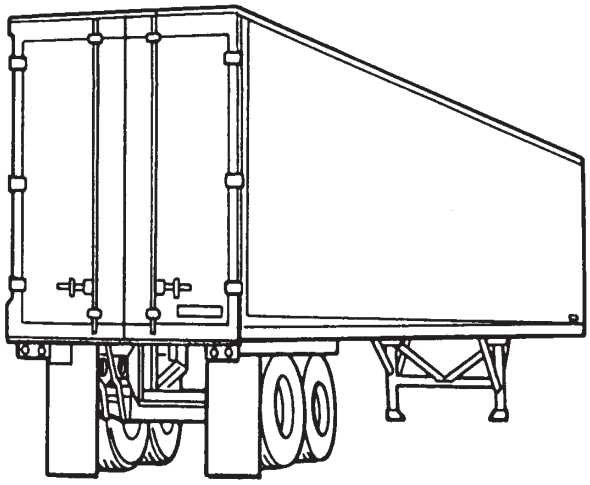
Key Points:

Accelerated lining wear between shoes within a brake can be caused by:

- ***Weak return springs***
- ***Worn cam bushing***

Symptom	Cause	Solution
Accelerated Lining Wear: Between Shoes Within a Brake	1. Brake shoe return spring is weak or broken allowing bottom shoe to drag.	1. Replace the return spring. Remember, blue for 0 Plus and orange for Q.
	2. Inside diameter of camshaft bushing worn beyond recommended tolerances. Allows cam to cock toward one shoe, causing uneven wear	2. Replace camshaft bushing and seal. Inspect camshaft and rollers for wear and replace If necessary.

LINING TROUBLESHOOTING GUIDE



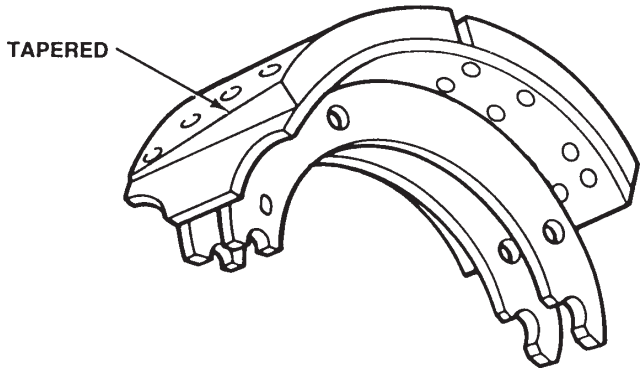
Key Points:

Accelerated lining wear on trailer axles can be caused by:

- ***Low crack pressure on trailer axle***
- ***Hand valve overuse***

Symptom	Cause	Solution
Accelerated Lining Wear On Trailer Axles	1. Trailer axle crack pressure is lower than that of drive and front axles.	1. Crack pressures between all axles should not exceed 2 psi.
	2. Excessive use of hand valve causing trailer lining wear.	2. ArvinMeritor does not recommend the use of hand valves.

LINING TROUBLESHOOTING GUIDE



Other Lining Related Problems

Key Points:

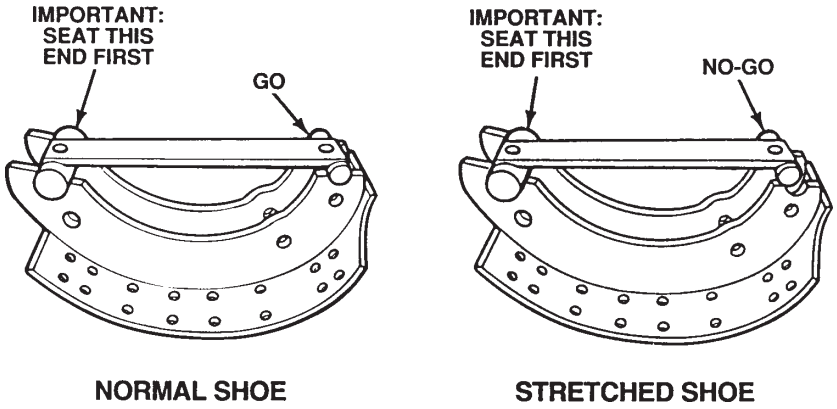
Tapered lining wear across brake shoes can be caused by:

- ***Loose wheel bearings***
- ***Contamination***
- ***Bent shoe webs***

Symptom	Cause	Solution
Tapered Lining Wear Across Brake Shoes	1. Loose wheel bearing allows hub and drum to cock.	1. Adjust wheel bearing to proper specification.
	2. Contaminants between lining and drum may cause bellmouthing of drum.	2. Review possible use of dust shields to reduce contaminants. Replace drum.
	3. Shoe webs not square to shoe table.	3. Replace with shoes to approved specifications.

LINING TROUBLESHOOTING GUIDE

SHOE CHECKING GAUGE



NORMAL SHOE STRETCHED SHOE

Key Points:

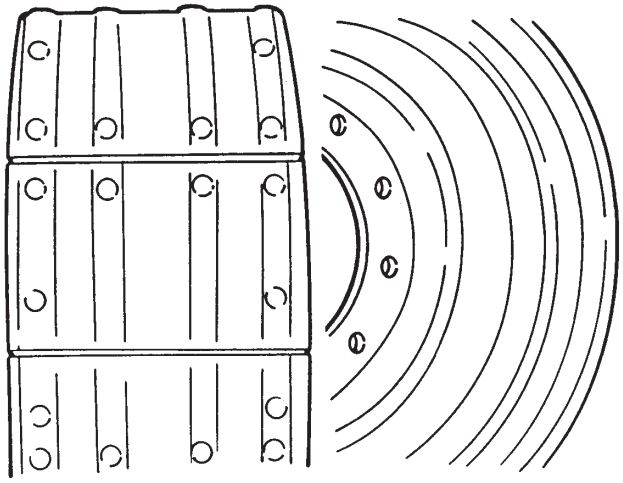
Poor lining-to-drum contact can be caused by:

- ***Shoe stretch***
- ***Wrong components***
- ***Shoe table flatness***

Symptom	Cause	Solution
Poor Lining-To-Drum Contact	1. Shoe "stretched" causing lining ends to contact drum. Promotes brake noise.	1. Replace shoes with shoes to approved (ArvinMeritor) specifications.
	2. Incorrect components installed.	2. Replace components with original ArvinMeritor parts.
	3. Shoe table not flat causing uneven pressure at lining to drum surface.	3. Check lining surface for cracks. Replace shoes and linings if necessary.
	4. Bands worn around inside diameter of drum surface due to contaminants between lining and drum.	4. Check drum inside surface flatness using straightedge and feeler gauges. Replace or turn drum as needed.
	5. Shoe stretched due to excessive rellnes on one shoe.	5. Replace lining and shoe assemblies on both sides of the axle with original ArvinMeritor parts.

LINING TROUBLESHOOTING GUIDE

SCORED LINING AND DRUM



Key Points:

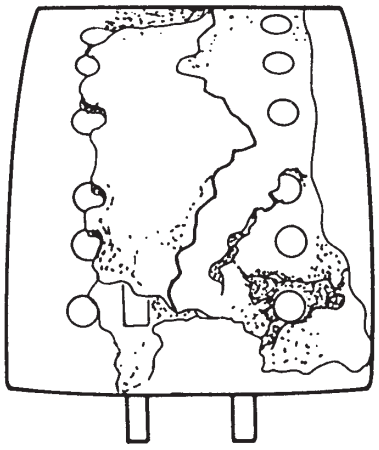
Scored linings can be caused by:

• Contaminants

Symptom	Cause	Solution
Scored Linings	1. Contaminants such as dirt or sand entrapped between lining and drum.	1a. Reduce contaminants by reviewing the use of dust shields.
		1b. Replace shoo and lining assembly on both sides of the vehicle.
		1c. Check for excessive drum wear due to contamination. Replace if necessary.

LINING TROUBLESHOOTING GUIDE

LINING PITTING, CRACKING, FLAKING



Key Points:

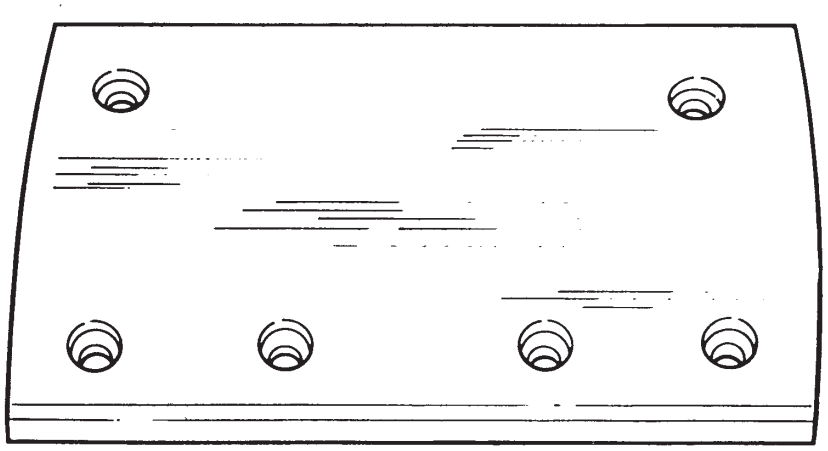
Lining pitting, cracking or flaking can be caused by:

- ***Contamination***
- ***Sustained overheating***
- ***Poor quality lining***
- ***Warped shoe table***

Symptom	Cause	Solution
Lining pitting, cracking, flaking	1 . Contaminants (sand, lining dust, dirt) between lining and drum can cause bonding agents in lining material to break down.	1. Review the use of dust shields to reduce contaminants.
	2. Exposure to sustained brake overheating.	2. Investigate and correct cause(s) of overheating. Replace components as required.
	3. Poor lining quality and/or inadequate vendor quality control.	3. Use replacement parts that meet original specifications.
	4. Poor table flatness causes linings to crack at installation or in service.	4. Check shoe flatness, replace shoe if not to the brake specifications.

LINING TROUBLESHOOTING GUIDE

GLAZED LINING



Key Points:

Glazed linings can be caused by :

Brake overuse and excessive temperature due to:

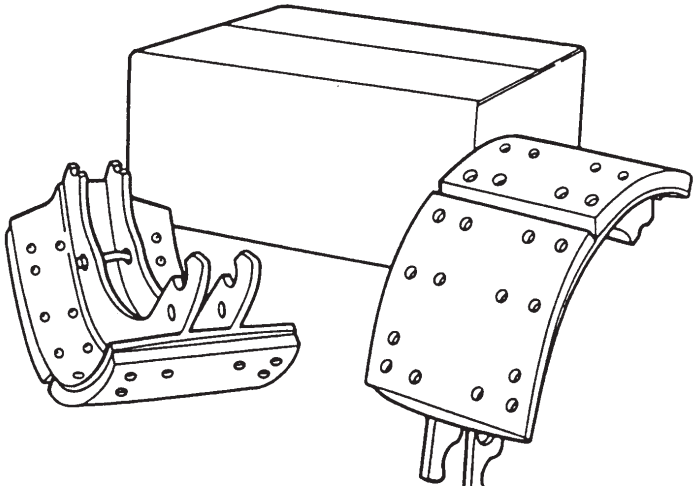
- **Vehicle overload**
- **Excessive use of hand valve (trailer axle)**
- **Misapplication of brakes**
- **Slack adjustment too tight**
- **Low relative crack pressure**

Brake underuse due to:

- **High crack pressures on axle with problem**
- **Use of automatic limiting valves (front axle)**
- **Small chamber size or slack length with large brakes**
- **Slack adjustment too loose**
- **High relative crack pressure**

Symptom	Cause	Solution
Glazed Linings	1. Brake overuse due to vehicle overloading, excessive use of hand valve (trailer axle), misapplication of brakes, slack adjusters too tight, low relative crack pressure.	1. Investigate and correct the causes of brake overuse. Reline shoes with OE quality linings.
	2. Brake underuse due to high crack pressures. Use of automatic limiting valves (front axles). Small chamber size or slack adjuster lengths with large brakes. Slack adjustment too loose. High relative crack pressure.	2. Investigate and correct the causes of brake underuse. Reline brakes.

BRAKE PERFORMANCE TROUBLESHOOTING GUIDE



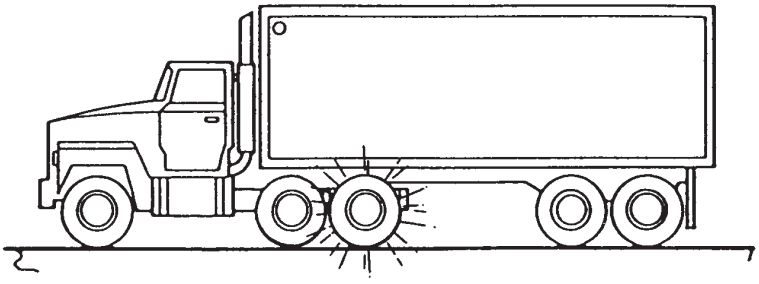
Key Points:

Poor stopping capability can be caused by:

- ***Misapplication of linings***
- ***Overloaded vehicle***
- ***Oil/grease on linings***
- ***Pneumatic problems***
- ***Insufficient torque output***

Symptom	Cause	Solution
Poor Stopping Capability and Insufficient Torque	1. Some non-OE linings may have unfavorable speed spread characteristics or excessive fade.	1. Replace shoes and linings with OE components.
	2. Vehicle overloaded.	2. Reduce vehicle load.
	3. Grease or oil on lining or drum surface.	3. Reline brakes, clean drum and check brake and wheel seals.
	4. Pneumatic problems such as kinked, clogged or leaking air lines or low compressor cutout pressure.	4. Check air system pressure at each wheel end and Inspect air lines and compressor for problems.
	5. Combined torque output of all brakes is not sufficient to effectively stop the vehicle.	5. Check with brake or vehicle manufacturer to determine if brakes are adequate for vehicle load.

BRAKE PERFORMANCE TROUBLESHOOTING GUIDE



EXCESSIVE TORQUE CAN CAUSE WHEEL LOCK-UP

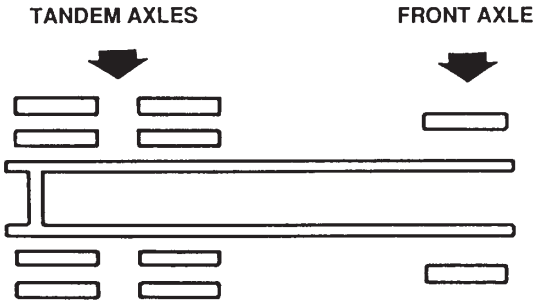
Key Points:

Excessive torque can be caused by:

- ***Brake's design for heavier loads***
- ***Misapplicated aftermarket linings***

Symptom	Cause	Solution
Excessive Torque	1. Vehicle's brakes are designed to be operated at loads higher than actual.	1. Check with the brake or vehicle manufacturer. A change In chamber size or slack length may be recommended.
	2. Brakes relined with linings designed for heavier loads or more severe duty cycles.	2. Consult with ArvinMeritor representative or authorized reliner to ensure proper lining selection.
	3. Vehicle is operated on slippery roads.	3. Driver needs to reduce application pressure.

BRAKE PERFORMANCE TROUBLESHOOTING GUIDE



BOTH WHEEL ENDS OF EACH AXLE MUST HAVE IDENTICAL DRUMS AND LINING

Key Points:

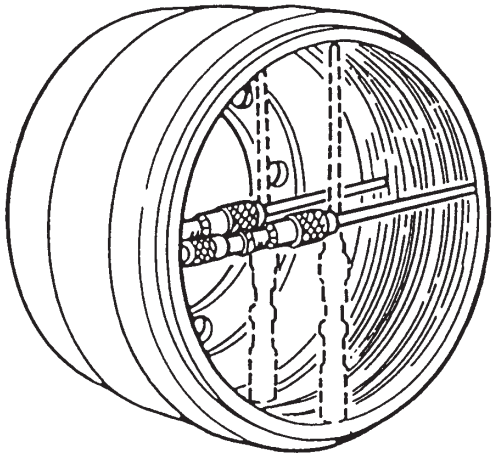
Vehicle pulling to one side during braking can be caused by:

- ***Differences in lining materials***
- ***Contaminated linings***
- ***Differing chamber or slack sizes***
- ***Slack adjuster adjustment***

Symptom	Cause	Solution
Vehicle pulls to one side during braking	1. Brake(s) on one side relined with different lining material.	1. Reline both sides of axle with same lining material at the same intervals.
	2. Linings on one front brake are contaminated with oil or grease.	2. Check for oil or grease leaks. Reline both front brakes.
	3. Front brakes have differing chamber or slack sizes from side to side.	3. Inspect and replace chamber or slack as necessary.
	4. One front brake adjusted tighter than opposing brake.	4. Check and correct brake adjustment. If auto slacks are used, check their operation.
	5. Kinked, clogged, leaking air line to brake(s) on one side of vehicle.	5. Check air lines and line pressures. Correct problems as needed.
	6. Manual/automatic slack adjusters mixed on vehicle,	6. Install automatic slacks at all locations.
	7. Drums of different weight are used from side-to-side on a vehicle.	7. One drum type should be used throughout a vehicle. All rear brakes should have drums of the same weight and both front drums should be the same weight.

BRAKE STABILITY TROUBLESHOOTING GUIDE

OUT OF ROUND DRUM



Brake Stability Problems

Key Points:

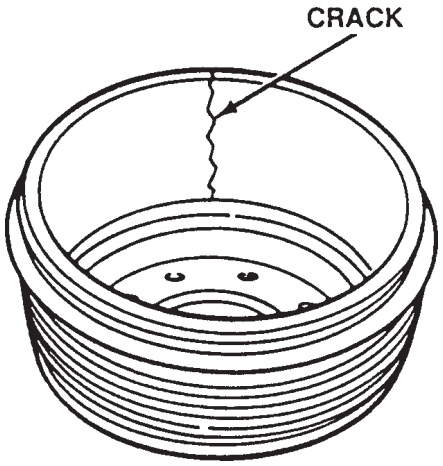
Chatter or noise can be caused by:

- **Glazed linings**
- **Brake over/underuse**
- **Drum out of round**
- **Shoe slap**
- **Incorrect drum surface finish**

Symptom	Cause	Solution
Chatter or noise	1. Glazed linings.	1. Determine If glazing is due to brake over/ underuse. Make changes to correct.
	2. Drum out of round.	2. Replace drum.
	3. “Shoo slap” caused by abnormal drum wear or incorrect surface finish after machining.	3. Replace drum. Use dust shields.
	4. Cam bushing is worn allowing cam to vibrate.	4. Check bushing wear and replace if worn.
	5. Brake cam rotation is opposite wheel rotation.	5. ArvinMeritor recommends cam rotation to follow wheel rotation on drive axles and requires the cam rotation to follow wheel rotation on front and trailer axles.

BRAKE DRUMS TROUBLESHOOTING GUIDE

Drum Problems



Key Points:

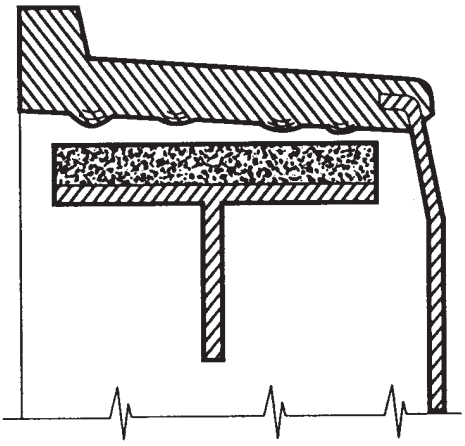
Drum cracking can be caused by:

- ***Brake ineffectiveness***
- ***Excessive heat***
- ***Inadequate weight***
- ***Driver abuse***

Symptom	Cause	Solution
Drum Cracking	1. High input pressures required due to brake ineffectiveness can overstress drum.	1. Replace drum and install OE linings appropriate for vehicle application.
	2. Excessive heat build-up due to inadequate weight, driver abuse, or resurfacing drum beyond manufacturer's limit.	2. Research cause of excessive heat and replace drum.
	3. Brake balance problems.	3. Research cause and correct.

BRAKE DRUMS TROUBLESHOOTING GUIDE

HOT SPOTS



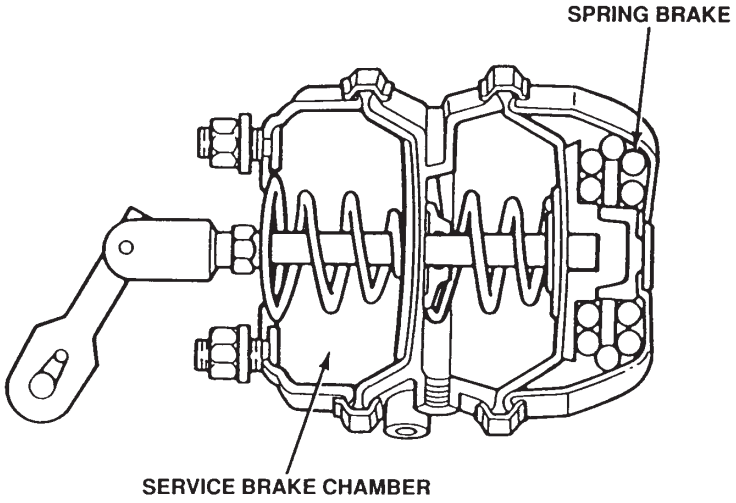
Key Points
Hot spots, heat checking or bluing can be caused by:

- ***Excessive drum runout***
- ***Dragging brakes***
- ***Lightweight, low quality drums***

Symptom	Cause	Solution
Hot Spots, Heat Checking, Bluing	1. Drum diameter with excessive runout.	1. Replace drum.
	2. Dragging brakes.	2. Find or correct reason for brake drag and replace drums.
	3. Lightweight or low quality drums which cause poor heat dissipation during frequent brake application.	3. Install drums with mass and quality to withstand high temperatures.
	4. Brake balance problems.	4. Research cause and correct.

PARKING BRAKES TROUBLESHOOTING GUIDE

Parking Brake Problems



Key Points:

Inadequate holding ability can be caused by:

- ***Drum expansion***
- ***Brakes misadjusted***
- ***Spring chambers not correct size***

Symptom	Cause	Solution
Inadequate Holding Ability	1. Drum diameter has temporarily expanded due to high temperatures.	1. Allow brakes to cool before applying parking brake.
	2. Brakes on which spring chambers are located are out of adjustment.	2. Check and reset slack adjusters following manufacturer's instructions.
	3. Inadequate spring chamber force to effectively hold the vehicle or vehicle overloaded.	3. Install correctly sized spring brakes or reduce vehicle load.
	4. Broken springs in spring chamber.	4. Replace spring chamber.
	5. Some non-OE linings have low parking friction.	5. Use of linings.

SUMMARY

In this training module, we have discussed various problems that can occur with foundation brakes.

Fundamental knowledge of foundation brakes, along with knowledge of lining materials and braking performance, are required to determine the actual cause of a problem. When the actual cause is discovered, a solution can be applied to provide a lasting, high quality repair.

REVIEW QUESTIONS

The following questions are based on the information contained in this module.
Choose the ONE best correct answer.

1. Accelerated brake lining wear can be caused by:
   a. An overloaded vehicle.
   b. Severe operation.
   c. Contamination between lining and drum.
   d. All of the above.

2. Tapered lining wear can be caused by:
   a. Loose or misadjusted slack adjusters.
   b. A bellmouth shaped drum.
   c. Shoe stretch.
   d. None of the above.

3. Glazed linings can be caused by:
   a. High crack pressures and brake underuse.
   b. The use of automatic limiting valves.
   c. Improperly adjusted brakes.
   d. All of the above.

4. A brake shoe that is stretched and has become too long will cause accelerated wear of its lining material:
   a. In the middle.
   b. On the ends.
   c. Towards the outer edge.
   d. Towards the inner edge.

5. Hot spots or heat checking of a drum can be caused by dragging brake shoes. True or False?
   a. True
   b. False

6. Drum cracking can be caused by:
   a. Poor lining to drum contact.
   b. High input pressures coupled with ineffective brake linings.
   c. High crack pressures.
   d. Vehicle load heavier than gross vehicle weight rating.

REVIEW QUESTIONS (Continued)

7. Poor vehicle stopping capability can be caused by:
- a. Air system design problems.
- b. Low cutout pressure.
- c. Brake system capacity too low for vehicle application and weight.
- d. All of the above.

8. A vehicle that pulls to one side while braking could be caused by:
- a. Incorrect brake adjustment.
- b. Different slack adjuster sizes on the front axle brakes.
- c. Different brake air chamber sizes on the front axle brakes.
- d. All of the above.

9. Accelerated lining wear on trailer axles can be caused by a lower crack pressure to the trailer axles than to the tractor axles. True or False?
- a. True
- b. False

10. Contamination in the brake can cause:
- a. Accelerated lining wear.
- b. Brake drum scoring.
- c. Poor brake performance.
- d. All of the above.

GLOSSARY

Automatic Limiting Valve (ALV)	A valve which limits the amount of pressure during normal stops to brakes on a specific axle but allows full pressure in a panic stop situation. In the past ALVs were frequently used to reduce the pressure to front axle brakes.
Blueing (of a drum)	Brake drum with friction surface blued from high temperatures.
Contaminants	Dirt, rocks, sand, etc.
Glazed Linings	Surface of the lining builds up with resin causing a reduction in friction coefficient of the lining. Lining surface appears shiny. Can be caused by over-use or under-use.
Hand Valve (Trailer control valve)	Hand-operated valve, located on the steering column, which permits independent control of the trailer brakes.
Heat Checks	Can form on drum hot spots. These are small cracks in the drum surface.
Hot Spots	Hard, slightly raised dark spots of martinsite that have formed on the drum surface. These are caused by overheating and sudden cooling.
Manual Slack Adjusters	Slack adjuster that has no self-adjusting mechanism.
Parking Brake (Spring Brake)	Generally refers to a tandem-chamber brake actuator that incorporates an air-applied service brake chamber and an air release/spring-applied parking or emergency brake chamber.
Pneumatic Imbalance	When individual air chambers do not receive air in a sequential time frame. In a combination vehicle, imbalance is likely to occur because tractor brakes receive air faster than trailer brakes causing the trailer to “push” the tractor.
Scored Linings & Drums	Linings and drums with grooved friction surfaces resulting from contaminants entering the friction interface.
Shoe Slap	A result of an incorrectly machined drum. In this instance the drum machining leaves threads (grooves) in the drum which guide the brake lining to contact the outboard face of the drum thus producing noise.

ASBESTOS WARNING

Recommended Procedures for Reducing Asbestos Dust, a Cancer and Lung Disease Hazard. For All ArvinMeritor Brake Linings with Asbestos.

1. Because some brake linings contain asbestos, it is important that people who handle brake linings know the potential hazards of asbestos and the precautions to be taken. Exposure to airborne asbestos dust can cause serious and possibly fatal diseases; namely, asbestosis (a chronic lung disease) and cancer, principally lung cancer and mesothelioma (a cancer of the lining of the chest or abdominal cavities). The risk of lung cancer among asbestos workers who smoke is much greater than that among nonsmokers. Symptoms of these diseases are not usually seen until 15 or 20, or more, years after the first exposure to asbestos.
2. OSHA has set the maximum allowable level for asbestos at 0.2 fibers of asbestos per cubic centimeter of air (0.2 f/cc) as an eight hour time weighted average and at 1.0 fiber per cubic centimeter (1.0 f/cc) averaged over a 30-minute sampling period. There is scientific debate whether even these levels will eliminate all risk of asbestos-related disease. Therefore, workers doing brake work should take steps to minimize exposure to asbestos to the extent possible.
3. Areas where brake work is done should be separate from other operations if possible. OSHA requires that the following sign be posted at the entrance to areas where exposures exceed either 0.2 f/cc (as an eight hour time weighted average) or 1.0 f/cc (averaged over a 30-minute sampling period).

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

4. During brake servicing, the mechanic should wear an air purifying respirator with high-efficiency filters approved by NIOSH or MSHA for asbestos dust. (Disposable dust masks are no longer allowed by OSHA.) The respirator should be worn during all procedures, starting with the removal of wheels and including reassembly.
5. OSHA recommends that enclosed cylinders equipped with vacuums with high-efficiency (HEPA) filters be used in brake repairs. Under this system, the entire brake assembly is placed within the cylinder and the mechanic works on the brake through sleeves attached to the cylinder. Compressed air is blown into the cylinder to clean the assembly, and the dirty air is removed from the cylinder by the vacuum.
6. If such an enclosed system is not available, the mechanic must carefully clean the brake assembly in the open air. During disassembly, all parts should be carefully placed on the floor to minimize creation of airborne dust. Dust should first be cleaned from the brake drums, brake backing plates and brake assemblies using an industrial vacuum cleaner equipped with a HEPA filter system. After vacuum cleaning, any remaining dust should be removed using a rag soaked in water and wrung until nearly dry.
7. Compressed air or dry brushing should never be used for cleaning brake assemblies.
8. If grinding or other machining of brake linings is necessary, other precautions must be taken because exposure to asbestos dust is the highest during such operations. In addition to use of an approved respirator, there must be local exhaust ventilation such that worker exposures are kept as low as possible.
9. Work areas should be cleaned by industrial vacuums with HEPA filters or by wet wiping. Compressed air or dry sweeping should **never** be used for cleaning. Asbestos-containing waste, such as dirty rags, should **be sealed, labeled** and disposed of as required by EPA and OSHA regulations. Respirators should be used when emptying vacuum cleaners and handling asbestos waste products. Workers should wash before eating, drinking, or smoking, should shower after work, and should not wear work clothes home. Work clothes should be vacuumed after use and then laundered, without shaking,
to prevent the release of asbestos fibers into the air.

NON-ASBESTOS FIBER WARNING

Most recently manufactured brake linings no longer contain asbestos fibers. In place of asbestos, these linings contain a variety of ingredients, including glass fibers, mineral wool, aramid fibers, ceramic fibers and carbon fibers. At present, OHSA does not specifically regulate these non-asbestos fibers, except as nuisance dust. Medical experts do not agree about the possible long-term risks from working with and inhaling non-asbestos fibers. Some experts nonetheless think that long-term exposure to some non-asbestos fibers could cause diseases of the lung, including pneumoconiosis , fibrosis and cancer. Therefore, ArvinMeritor recommends that workers use caution to avoid creating and breathing dust when working on brakes that contain non-asbestos fibers.
1. Whenever possible, work on brakes in a separate area away from other operations.
2. Always wear a respirator approved by NIOSH or MSHA during all brake service procedures. Wear the respirator from removal of the wheels through assembly.
3. **Never** use compressed air or dry brushing to clean brake parts or assemblies. OSHA recommends that you use cylinders that enclose the brake. These cylinders have vacuums with high efficiency (HEPA) filters and worker's arm sleeves. But, if such equipment is not available, carefully clean parts and assemblies in the open air.
4. Clean brake parts and assemblies in the open air. During disassembly, carefully place all parts on the floor to avoid getting dust into the air. Use an industrial vacuum cleaner with a HEPA filter system to clean dust from the brake drums, backing plates and other brake parts. After using the vacuum, remove any remaining dust with a rag soaked in water and wrung until nearly dry.
5. Grinding or machining brake linings. If you must grind or machine brake linings, take additional precautions because contact with fiber dust is higher during these operations. In addition to wearing an approved respirator, do such work in an area with exhaust ventilation.
6. Cleaning the work area. **Never** use compressed air or dry sweeping to clean the work area. Use an industrial vacuum with a HEPA filter and rags soaked in water and wrung until nearly dry. Dispose of used rags with care to avoid getting dust into the air. Use an approved respirator when emptying vacuum cleaners and handling used rags.
7. Worker cleanup. Workers should wash their hands before eating, drinking or smoking. Do not wear your work clothes home. Vacuum your work clothes after use and then launder them separately, without shaking, to prevent fiber dust from getting into the air.
8. Material safety data sheets on this product, as required by OSHA, are available from ArvinMeritor.

WARNING

To prevent serious eye injury, always wear safe eye protection when doing maintenance or service.

MODULE OVERVIEW

This module introduces ArvinMeritor authorized brake relining procedures.
After a discussion of the program's policies and obligations, we will describe the authorized reline process and procedures.
The module will cover inspection procedures, brake shoe checks, lining selection and installation, and final inspection. We have also included a group activity that will allow you to practice some of the procedures described in this manual.

Module Goal

The goal of this Brake Relining Procedures module is to provide participants with a set of standards for relining brake shoes. This provides a basis for improved brake balance and more consistent braking performance in the vehicle.

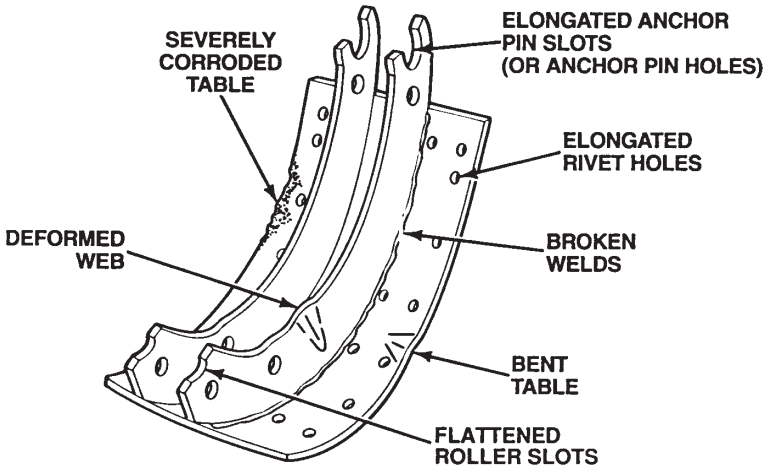
Module Objectives

At the completion of this module, participants will be able to:

- Inspect the core condition of the brake shoe and qualify it for relining.
- Perform various brake shoe checking procedures.
- Prepare the brake shoe for relining.
- Select the appropriate lining material.
- Install the lining material.
- Perform a quality check of the installation process.
- Conduct a final inspection of the lined shoe.

Visual Inspection

VISUAL INSPECTION PROCEDURE



Key Points: Check:

- ***Shoe table***
- ***Web***
- ***Roller slots***
- ***Anchor pin slots or holes***
- ***Welds***
- ***Rivet holes***

Perform a visual inspection to check for surface damage, such as:

- Badly corroded shoe table (especially between the webs)
- Deformed web
- Web or table cracks
- Flattened roller slots
- Elongated anchor pin slots or holes
- Elongated rivet holes
- Broken welds
- Bent shoe table

Other damage may be hard to see during a visual inspection, but may have a serious effect on brake performance. There are several quick checks that can tell you if a brake shoe qualifies for relining.

⚠ WARNING
Refer to the ASBESTOS/ NON-ASBESTOS OS Warning Statement found at the beginning of this module.

BRAKE SHOE INSPECTION

The shape of the brake shoe changes during its normal life cycle. Changes in the shape (or geometry) of the shoe have a direct effect on brake performance. Every shoe must be checked for arc, length (stretch) and squareness (twist) with the specially designedgauges.

If the core is in good condition and the shoe passes these simple GO/NO-GO checks, then the shoe qualifies for relining.

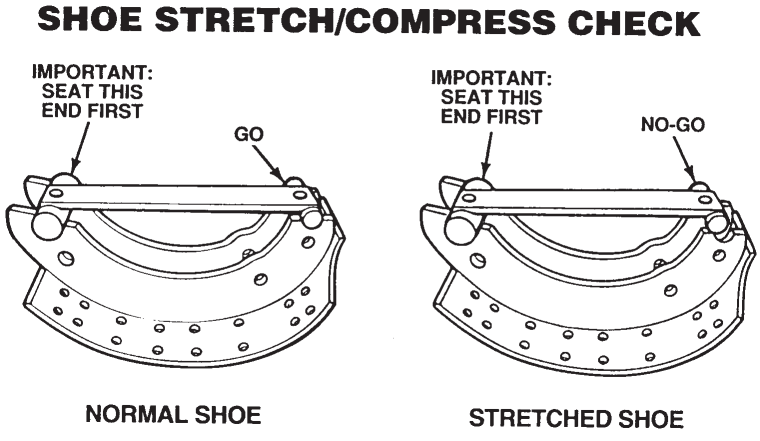
Most of these brake shoe checks must be performed after the worn lining material is removed from the shoe.

Removing the Lining

Remove the old brake lining material from the shoe. Take care during this process. The shoe table can be damaged by improper removal of the old lining.

Be careful not to damage the holes in the shoe. Drilling or shearing may cause oversize or elongated rivet holes which will make the shoes unsuitable for use. The process may also push up the metal surrounding the rivet hole.

Shoe Stretch/Compress Check



Use a shoe check floater gauge to determine if the shoe has been stretched. Use your reference card to select the correct gauge for the brake shoe you are checking. This check must be performed after the old lining material is removed.

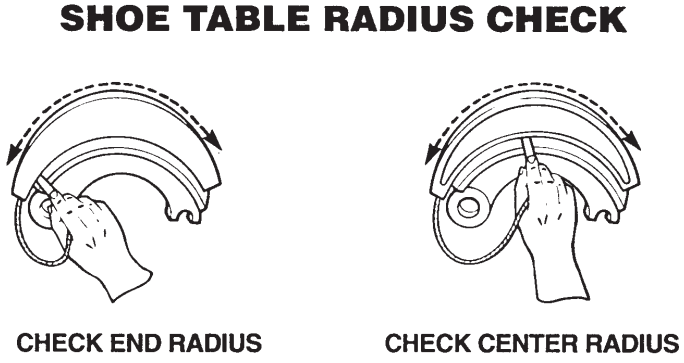
- Place the shoe with the webs up.
- On “0” shoes with anchor pin slots: From the top, place the large end of the gauge into the anchor pin slots, and drop the gauge across the shoe into the open ends.

- On “P” shoes with anchor pin holes: From the side, slide the large end of the gauge into one anchor pin hole, then slide the smaller end of the gauge into the open end of the shoe. Repeat this procedure on the other side of the shoe.

- If the small end of the gauge seats properly into the open end, the shoe is not stretched. You may proceed to the next check.

- If the gauge does not seat properly, the shoe has stretched. It must be rejected.

Shoe Table Radius Check



Use a shoe table **radius validator gauge** to confirm the condition of the shoe table. Use your reference card to select the correct gauge for the brake shoe you are checking. This check must be performed after the old lining material is removed.

- Place the shoe on the bench with the shoe table up.

- Place the validator on both ends and the center of the shoe table.

- Try to insert a feeler gauge between the validator and the shoe table, at the ends and across the center.

- If the feeler gauge does not fit, the shoe passes the table radius check. You may proceed to the next inspection.

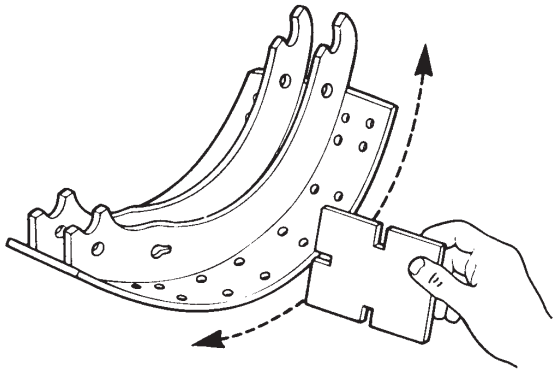
- If the feeler gauge does fit, the shoe has failed this check. It must be rejected.

NOTE: It is extremely important that the condition of the table surface allows the new lining block to make full contact with the table. The entire table surface must be free of rust build-up and pitting.

NOTE: Do not use putty or other fillers between the table and the shoe to correct surface contact problems between the table and the lining block.

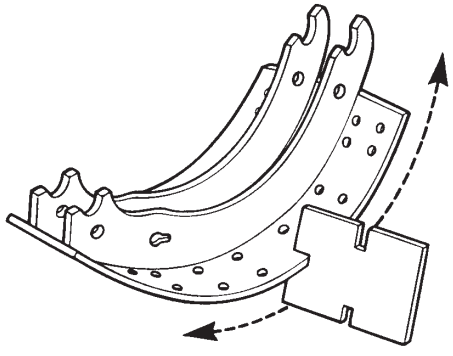
Shoe Table Thickness Check

SHOE TABLE THICKNESS CHECK



GOOD SHOE

SHOE TABLE THICKNESS CHECK



BAD SHOE

The next check measures the thickness of the shoe table. It requires one shoe table **thickness gauge** that fits all brake shoes. This check must be performed after the old lining material is removed.

- Select the correct gauge opening for the brake shoe you are checking. This information is stamped on the surface of the gauge, or you may use your reference card to find the correct size opening.

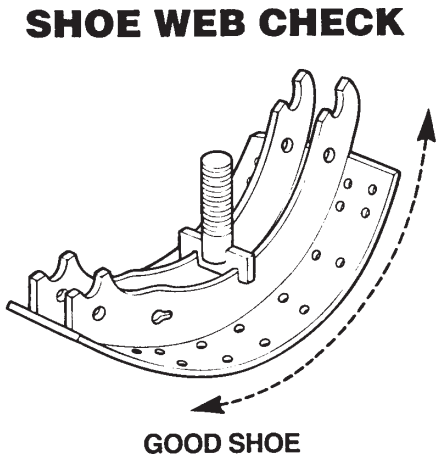
- Try to insert the gauge over the edge of the shoe table as in the illustration. Repeat this procedure at several points along the edge.

- If the gauge does not fit anywhere along the edge, the table thickness is acceptable. You may proceed to the next inspection.

- If the gauge fits in any position along the edge, the table is not thick enough. The shoe must be rejected.

NOTE: Moisture tends to collect near the center of the shoe table where it is attached to the web. Rust and corrosion will therefore be more concentrated here. As a result, the center of the table may not be as thick as the edges. Consequently, this check alone may not be completely reliable to qualify the shoe for relining. That is why you must complete all checks described in this section.

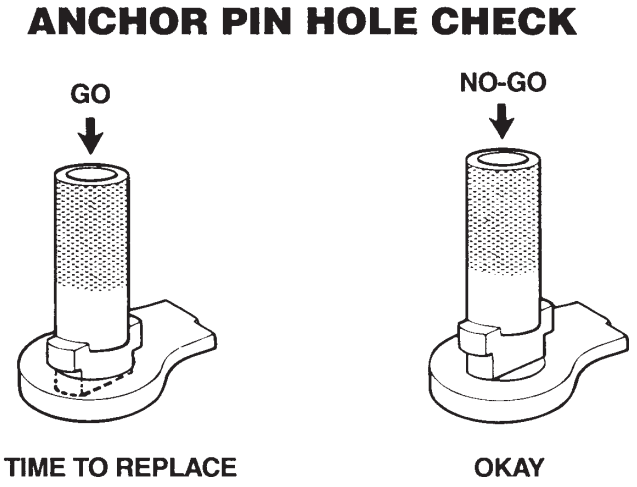
Shoe Web Check



The shoe has already been checked for web-to-table cracks during the visual inspection. The shoe web inspection checks for distortion of the web from such conditions as stretching.
The web gauge can measure the web dimensions for all shoes This check can be performed before or after the old lining material is removed.

- Attempt to insert both slots of the gauge over the edges of the web. Repeat this procedure at various points along the web.
- If the gauge fits properly at all points, the web passes. You may proceed to the next inspection.
- If the gauge does not fit, the shoe is distorted. It must be rejected.

Anchor Pin Hole Check



An enlarged anchor pin hole can cause noise and premature lining wear. If the brake you are checking has anchor pin holes, use the **anchor pin hole gauge** to check the diameter of the anchor pin hole. One combination gauge can check both 1 inch and 1-1/4 inch anchor pin holes. Use your reference card to determine the correct hole diameter for the brake shoe you are checking.

- For the 1 inch diameter hole: The gauge should not fit into the hole at all. If the gauge fits, the shoe must be rejected.

- For the 1-1/4 inch diameter hole: The gauge may fit up to the 1-1/4 inch stop. If the gauge passes beyond the stop, the hole is too large, and the shoe must be rejected.

Anchor or roller slots may also show signs of wear. Check the slot clearance for out of roundness, flare and looseness.

If all these checks qualify the brake shoe core for relining, the relining process can begin. If the core fails to qualify in any of these areas, it cannot be used for relining purposes. It must be rejected.

PREPARATION

Brake Shoe
Preparation

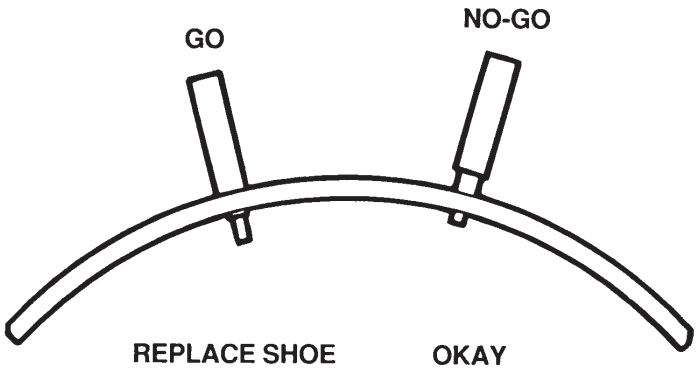
PREPARATION PROCESS

- CHECK RIVET HOLES
- CLEAN SHOE
- SCRAPE RUST AND SCALE
- FILE BURRS AND NICKS
- CHECK FOR FLAT SPOTS
- APPLY RUST PREVENTIVE PAINT

Check the rivet holes to make sure they were not damaged when the old linings were removed for the shoe checks. Use the rivet hole gauge to verify proper rivet hole diameter.

Key Points:

- ***Check rivet holes***
- ***Clean shoe tables***
- ***Scrape rust***
- ***Check for flat spots***
- ***Apply paint***



If the rivet hole size exceeds the nominal 0.25 inch diameter plus an allowable tolerance of 0.020 inches, the tip of the gauge will go through the hole to the handle. This indicates a Go condition and the shoe must be replaced.

If the hole has not been extended or enlarged, the tool will stop at the 0.25 inch midpoint. This indicates a No-Go condition and the shoe is acceptable.

If a hole is enlarged, it must not be reworked for a larger rivet and the shoe must be rejected. An elongated hole will result in a loose lining installation. If holes are burred, they should be filed down flush with the shoe table.

Remember that rust often develops on the surface of the shoe table under the brake lining or blocks. In addition, scale may form from salt, or tar and oil may find its way into the brake assembly. Clean the shoe table thoroughly.

It is also necessary to check for flat spots on the shoe that were caused by removing the rust that was under the block. This will ensure that the lining material conforms to the true shoe table radius and does not stress the lining material when it is secured by the rivets.

After the shoe is cleaned and inspected, apply a ArvinMeritor approved rust preventive coating of paint.

LINING SELECTION

Proper lining selection for a given application is crucial to improving proper brake shoe performance. The type of lining required is based on several technical considerations. Always use the lining material specified by

Both wheels of a single axle and all four wheels of a tandem axle must be relined at the same time. Always install the same linings and drums on both wheels of a single axle and all four wheels of a tandem axle.

Combination Linings

Combination lining sets with different lining materials on the anchor and cam ends of the shoe are sometimes used. If combination lining sets are used, the lining blocks must be installed in the same linings and drums on both wheels of a single axle and all four wheels of a tandem axle and all four wheels of a tandem axle.

Combination lining set with different lining materials on the anchor and cam ends of the shoe are sometimes used. If combination lining sets are used, the lining blocks must be installed in the correct locations on the brake shoes. ArvinMeritor can provide Technical Service Aids which indicate the correct installation procedure for these lining sets.

NOTE: Always follow the instructions supplied with the replacement combination linings for correct installation.

LINING INSTALLATION

Rivet Selection

Rivets are often regarded as commodity items. Yet they are critical to the integrity of the shoe and lining assembly. Rivets of poor design or quality can cause premature failure of the assembly and permanent shoe and drum damage. Use only rivets which meet the specifications of SAE J663.

Assembly Process

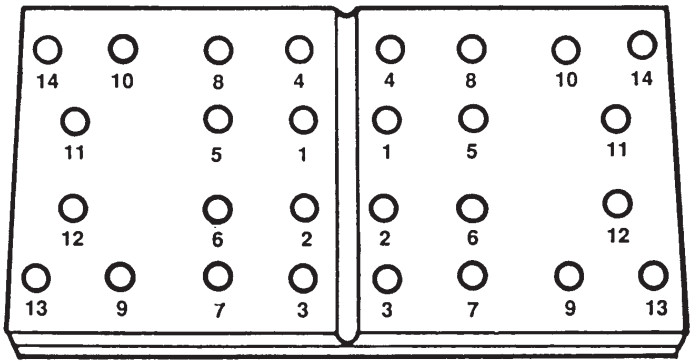
The program requires reliners to install OE linings on ArvinMeritor OE
brake shoes. This assembly process involves four steps:

- Riveting Pattern
- Rivet Inspection
- Clearance Check
- Identification Tag Application

Key Points:

- ***Use only SAE J663 approved rivets.***

RIVETING PATTERN



After the lining and rivet selections are made based on the particular application, the lining can be attached to the shoe. Use the following procedure to do this.

1. Check to make sure that the lining and shoe contact faces are clean.

2. Adjust the riveting machine so that the roll of the rivet can be completed without a split.

WARNING

Follow the safety precautions in the rivet machine manufacturer's instructions before you disassemble, adjust, assemble, or use the rivet machine. Failure to follow the safety precautions can cause serious personal injury.

Always use a roll set, never a star set, when riveting brake linings. A star set does not compress the rivet and expand it to fill the hole. Consequently, the lining may work loose in service.

3. Select and install the proper rivets into the rivet holes following the recommended sequence shown in the illustration.

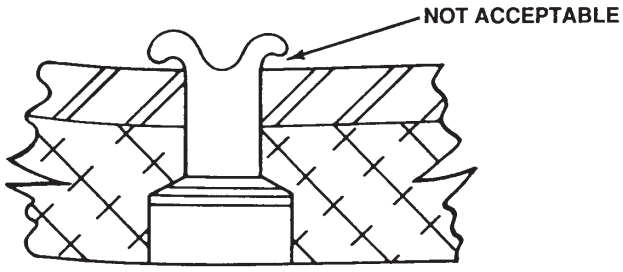
   Notice that you begin at the center of the block and work toward the ends. This ensures that the lining will conform to the table surface.

   NOTE: DO NOT use shims or fillers between the block and the shoe table to adjust for clearance. Brake noise may result because of cracked or loose linings. The inside surface of the lining is the correct arc to match the shoe table. The rivet (or bolt) holes in the linings will only line up with holes in the shoes when they are in direct contact.

RIVET INSPECTION

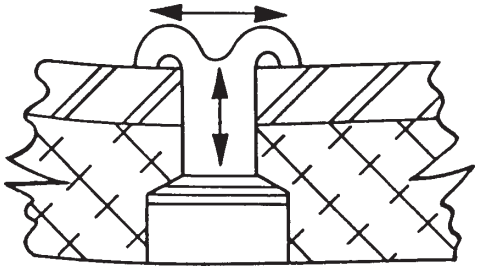
All rivets should be tight. The next three illustrations show improper rivet installation. If any of these conditions are found during the inspection process, the rivet(s) must be removed and replaced with rivets having the proper fit and tightness.

Poor RivetCurl



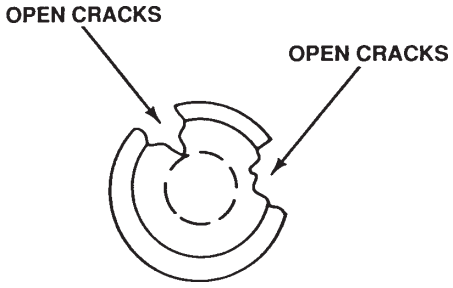
A rivet curl that does not completely contact the shoe table (a gap between the curl and the shoe) is not acceptable.

Loose Rivets



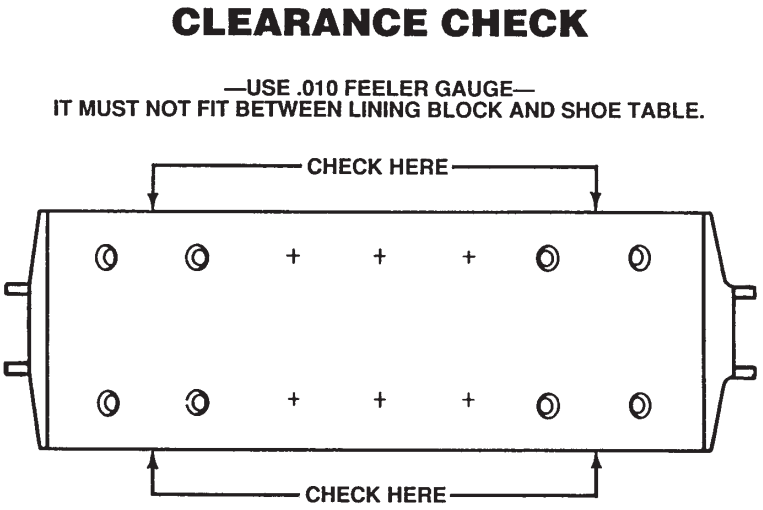
Loose rivets that can be detected by hand movement or rivet movement that occurs when hit with a small hammer indicates a poor installation and is not acceptable.

Open Cracks



More than one open crack in the rivet curl is not acceptable.

CLEARANCE CHECK



After all rivets are installed in the lining block, use a .010 inch feeler gauge to check the clearance between the brake shoe table and the lining block. The gauge must not fit between the lining block and the table.

IDENTIFICATION TAG APPLICATION

A maroon mylar tag with a corrosion resistant adhesive, identifies the shoe as an ArvinMeritor authorized product. It is your assurance that the shoe meets ArvinMeritor specifications. The tag has the authorized reliner name and address printed on it. Only ArvinMeritor shoes can be relined in this program.

A silver/gray mylar tag is used for non-ArvinMeritor brake applications (Eaton, Fruehauf, Spicer, etc.)

CALIBRATION TESTS

Measurement Tools

TOOL	TEST FREQUENCY
OUTSIDE MICROMETER (0-1")	30 DAYS
INSIDE/OUTSIDE DIAL CALIPER (0-6")	30 DAYS
RIVET HOLE GAUGES	30 DAYS
FEELER GAUGE (.010)	30 DAYS

The chart lists the basic measuring tools and shows how often they should be calibrated. You should keep records for each tool, showing the dates the tool was calibrated and the test results.

NOTE: The chart shows only the minimum recommendations. High-use tools and tools that might have been used improperly must be checked more often.

Maintaining Records

Record keeping can give you a good way to check the relining process. Records will alert you to variations in the process. Variations from authorized procedures can result in parts that do not meet ArvinMeritor's high quality standards. You can use the information in your records to improve the process so that consistent product quality is maintained.

Key Points: Good record keeping improves:

- ***Product quality***
- ***Consistency***
- ***Customer satisfaction***

The ArvinMeritor Authorized Reliner Program requires accurate record keeping to ensure consistent, high quality products and services.

You must:

- Retain all records for NOT LESS than five (5) years.
- Keep all production records in order by part number and date manufactured.
- Identify every inspection tool by make, model and part number (or tool number).

You must keep these records orderly and up to date for quick access.

PROGRAM SUPPORT

ArvinMeritor supports its authorized reliners with service assistance and market promotions designed to help market these OEM aftermarket products.

National Trade Advertising

Nationally distributed trade advertising explains the benefits of ArvinMeritor authorized relined brake shoes versus other relined brake shoes. Interested readers have a toll-free number to call for the name of their nearest reliner. You will find ArvinMeritor authorized reliner ads in many national trade publications. These magazines include reader service cards that invite potential customers to request more information.

Customer Sales Brochure

A brochure is designed to inform key customers about the ArvinMeritor authorized reliner program. It includes the following:

- an explanation of how the program works
- a feature and benefit story about the advantages of the program
- an overview of the cost effectiveness of using the program

The brochure can be used by the reliner as a hand-out mailer. This advertising piece can also be used as a follow-up to requests for additional product literature.

SUMMARY

One of the most important steps in the relining process is the shoe qualification procedure. The only shoes that qualify for relining are ArvinMeritor shoes that pass visual inspection and a series of brake shoe checks. We have demonstrated how to perform these checks. These checks will help ensure that relined ArvinMeritor shoes continue to perform to ArvinMeritor standards.

Shoe preparation and lining installation must also be performed to meet ArvinMeritor standards. This module presented guidelines to prepare the shoe for relining and to select the appropriate lining material. Installation guidelines covered rivet selection, riveting procedures and rivet checks. We also presented final inspection procedures to help ensure that the relined shoe will perform to ArvinMeritor's high standard of quality.

REVIEW QUESTIONS

The following questions are based on the information contained in this module. Choose the ONE best correct answer.

1. Brake shoes can only qualify for relining if they:
- a. Pass a visual inspection.
- b. Pass all brake shoe checks.
- c. Are ArvinMeritor OE shoes.
- d. All of the above.

2. Visual inspection of brake shoes cannot reveal:
- a. Severe corrosion.
- b. A stretched web.
- c. An elongated anchor pin slot.
- d. A broken weld.

3. A shoe check floater gauge is used to check:
- a. Stretching of the shoe.
- b. Shoe table thickness.
- c. Shoe web distortion.
- d. Shoe table radius.

4. Preparing the brake shoe includes:
- a. Removing the old lining material.
- b. Visual inspection for surface damage.
- c. Cleaning rust from the table surface.
- d. Checking anchor pin holes for elongation.

5.To install a new lining block, you must always:
- a. Clamp the block to the shoe.
- b. Use shims to adjust for clearance between the block and the shoe table.
- c. Begin riveting at the center and work toward the ends.
- d. Use a star set to rivet the lining block to the shoe.

REVIEW QUESTIONS (Continued)

7. The following rivet installation condition(s) that would be considered unacceptable include:

a. Use of rivets that do not meet SAE J663 specifications.
b. Loose rivets.
c. Rivets that are installed using a star set.
d. All of the above.

8. To determine if the lining has been properly attached to the brake shoe, you should:

a. Use a .008 inch feeler gauge to check lining to shoe table clearance.
b. Use a .010 inch feeler gauge to check lining to shoe table clearance.
c. Use a .004 inch feeler gauge to check lining to shoe table clearance.
d. None of the above.

9. All of the following are benefits of good record keeping except:

a. Maintaining consistent product quality.
b. Ensuring that tools and gauges are properly calibrated.
c. Ensuring that proper lining to shoe table clearance is maintained.

10. ArvinMeritor supports the authorized reliner program by:

a. Providing marketing assistance.
b. Providing service assistance.
c. Providing engineering and technical support
d. all of the above.

GLOSSARY

Anchor pin hole gauge	A test instrument that checks the inside diameter of the anchor pin hole of a brake shoe.
Friction codes	A two-letter system which indicates the normal and hot friction coefficients of a particular brake lining.
OEM	Original equipment manufacturer.
Rivet hole gauge	An instrument that determines if a rivet hole has the proper diameter.
Floater gauge	A test instrument that determines if a brake shoe is stretched from wear.
Radius validator gauge	An instrument that tests the arc of a brake shoe table.
Thickness gauge	A test instrument that determines if a brake shoe table is thick enough to reline.

NOTES

NOTES

ARVINMERITOR AFTERMARKET PARTS WARRANTY

We warrant all new parts for one year from date of shipment to the buyer against defective material or workmanship (but not against damage caused by accident, abuse or improper installation, maintenance or repair) when such parts are used on vehicles the specifications of which have been approved by our Engineering Department.

As the exclusive remedy under this warranty, we will, at our option, repair or replace such parts free of charge, or take back the nonconforming parts and refund the monies paid by buyer for such parts, if found on examination by us to be nonconforming and if any necessary return charges are prepaid.

If it is necessary to return any parts under this warranty, buyer agrees not to make any deduction on account thereof from remittances on current accounts while claims are in the process of disposition. Any expense incurred without our consent for repairs or replacement will not be allowed.

THIS WARRANTY IS EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES OR CONDITIONS, EXPRESS, IMPLIED OR STATUTORY, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR PARTICULAR PURPOSE. IN NO EVENT SHALL SELLER BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES OF ANY NATURE.

Only genuine ArvinMeritor replacement parts are covered by this aftermarket parts warranty.

ArvinMeritor™
Commercial Vehicle Aftermarket

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888-725-9355
www.arvinmeritor.com

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SP-01100