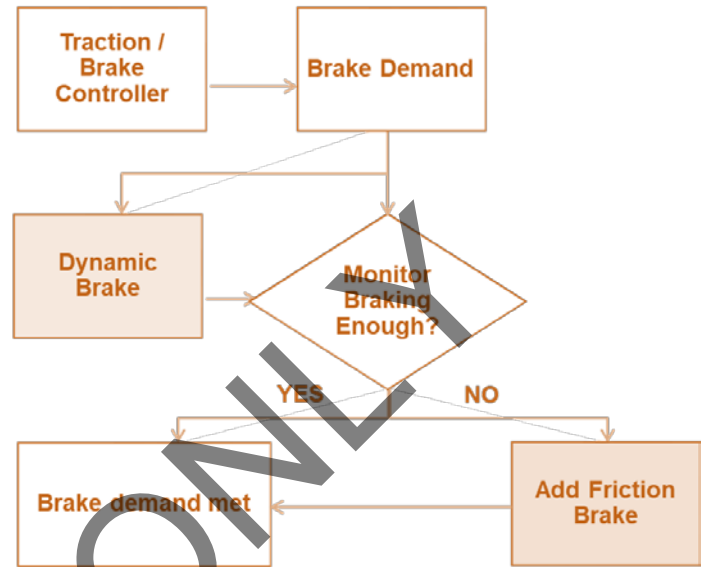


Introduction and Overview to Friction Brakes

Course 105



PARTICIPANT GUIDE

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MODULE 1

GENERAL PRINCIPLES AND TERMINOLOGY

Outline

- 1-1 Safety Review
- 1-2 Overview to Friction Brakes
- 1-3 Train Brakes Classification
- 1-4 Summary

Outcome and Objectives

Participants will be able to explain the principles of a rail vehicle's friction brakes. Following the completion of this module, the participant should be able to complete the objectives with an accuracy of 75% or greater:

- List safety considerations specific to working with friction brakes.
- Describe a rail vehicle's braking control system
- Explain the purpose of friction braking
- Categorize common classifications of friction braking systems

Key Terms

- Blended Service Braking
- Brake Control System
- Dynamic Braking
- Friction Braking
- Standard Operating Procedure (SOP)

Abbreviations

- ANSI: American National Standards Institute
- BCU: Brake Control Unit
- ECU: Electronic Control Unit
- HCU: Hydraulic Control Unit (sometimes HPCU for Hydraulic Pressure Control Unit)
- LOTO: Lockout/Tagout
- OEM: Original Equipment Manufacturer
- OSHA: Occupational Safety and Health Administration
- PPE: Personal Protective Equipment
- PSI: Pounds per Square Inch

demand for braking occurs than can be supplied by dynamic braking then then friction braking is applied. Figure 1.4 presents an overview to the sequencing of dynamic and friction braking.

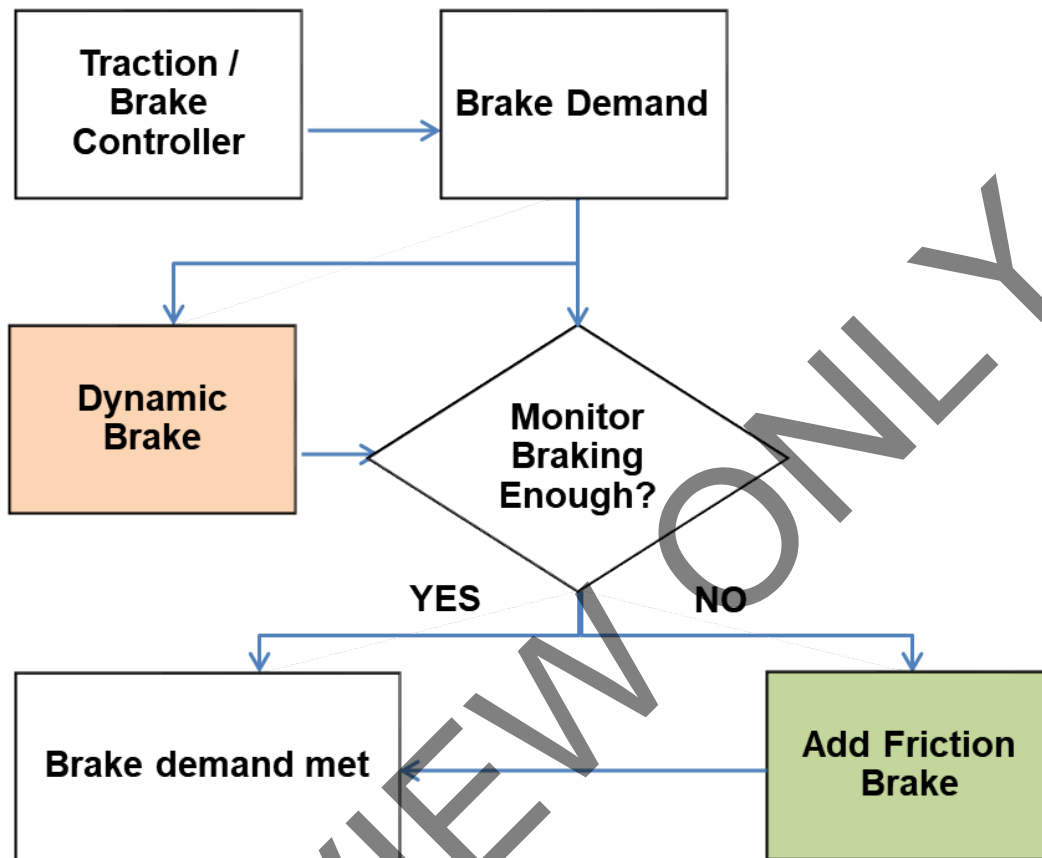


Figure 1.5 Train Braking Sequence Chart

The friction brake system on a rail vehicle is a complex system actuated by a pressure system (pneumatic or hydraulic) along with electromechanical and spring-applied systems. Many rail cars use three types of braking: dynamic, friction, and electromechanical. **Dynamic braking** is the use of the electric traction motors, which act as generators when decelerating or slowing down the train. The motion of the wheels causes the motors to rotate, which generates electrical energy. It is the traction motors that convert the energy into an electrical current. In the final phase of deceleration, dynamic braking fades out and **friction braking** begins to take over progressively and proportionally to decelerate the rail car. The combination of dynamic and friction braking is known as **blended service braking** and its purpose is to ensure a smooth and even deceleration rate.

Friction braking is a common braking system used by trains and it acts by dissipating the kinetic energy of the moving train and converting the energy to heat. The heat is generated from the friction between the brake pad and the brake disc or between block and wheel tire during braking. Friction braking is the most common type of brake used by trains, it acts by dissipating the kinetic energy of the moving train by converting the energy into heat. There is an entire course in this series devoted to friction brakes.

MODULE 2

Pneumatic Braking Systems

Outline

- 2-1 Overview and Principle of Operation
- 2-2 Electronic Control
- 2-3 Brake Control
- 2-4 Air Supply
- 2-5 Braking Devices
- 2-6 Summary

Outcome and Objectives

Participants will be able to explain the principles of pneumatic brakes and their components on rail cars used in major U.S. transportation agencies. Following the completion of this module, the participant should be able to complete the objectives with an accuracy of 75% or greater:

- Explain the principles of operation of a pneumatic brake system
- Identify the major components of the foundation subsystems of a pneumatic brake system: Electronic control, brake control, air supply, and braking devices.

Following the completion of this module, the participant should be able to complete the objectives with an accuracy of 75% or greater:

Key Terms

- Added weight (AW)
- Air supply unit
- Brake control unit
- Braking devices
- Check valves
- Control valves
- Control volume
- Dump valve
- Electronic control module
- Electronic control unit
- Emergency brake (EB) valve
- Emergency magnet valve
- Fail safe
- Flat spots (wheel flats)
- J-1 valve
- Load weigh valve
- P-signal
- Relay valve
- Slip/slide/creep control
- Test ports (test fittings)
- Variable load valve
- Wheel creep
- Wheel slide
- Wheel slip

2-1 OVERVIEW AND PRINCIPLE OF OPERATION

Pneumatic describes any equipment that is operated by or with air pressure. This is why pneumatic brakes are sometimes referred to as “air brakes.” A pneumatic brake system is a power braking system with compressed air as the operating medium. In the pneumatic friction braking system, high pressure air is used to create the friction forces necessary to slow or stop the rail vehicle.

In a broad sense, a rail vehicle’s pneumatic brake system operates in a similar fashion like the brakes on your car. When you press the brake foot pedal in your car, pressure is transferred through brake fluid to a set of pistons which, in turn, clamps a pair of brake pads over the brake discs in the car’s wheel. Instead of brake fluid, a rail vehicle uses pressurized air stored in a reservoir.

The pneumatic braking system begins with an air compressor which supplies the reservoir which holds the compressed air ready for use. The reservoir supplies the train operator’s controls and the train operator controls when to apply or release the brakes.

In this module the description of the operating principle of a rail pneumatic braking system is deliberately broad in its scope. The goal here is to introduce the participant to general principles which will open discussion during class and for the instructor and participants to compare and contrast these broad principles with the specific operation of the rail vehicles on which they will work. Additionally the illustrations of components are gathered from various types of rail vehicles courtesy of the Rail Car Training Consortium member agencies and so do not represent one specific vehicle.

Figure 2.1 represents the relationship among the four functional areas of the pneumatic brake which are:

- Electronic Control
- Brake Control
- Air Supply
- Braking Devices

The train operator uses the **master controller** to request braking effort. The request is processed by the **electronic control unit (ECU)** which interprets the requested braking effort and signals the **brake control unit (BCU)** to respond accordingly by activating various **braking devices**. Within the BCU are control valves that are supplied with compressed air stored by the **air supply unit** and provided by an **air compressor**.

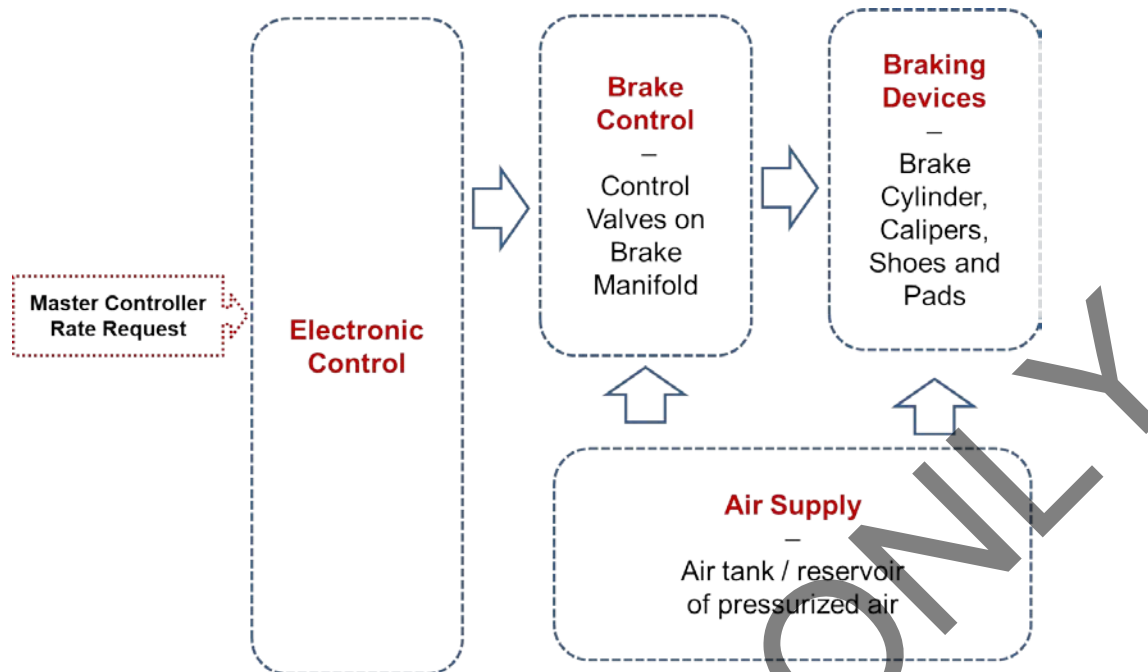


Figure 2.1 Pneumatic Braking System Functional Areas

For the rest of this module, we will build on these four foundation systems examining their components and the roles they play in the overall friction braking system.

2-2 ELECTRONIC CONTROL

The control center for the rail vehicle's braking system is governed by the **electronic control unit**¹ (ECU). This is a logic controller that monitors many functions of the rail vehicle including those which provide friction brake service and wheel-slide control. On newer rail cars, the ECU is a microprocessor-based device with extensive fault detection and annunciation capabilities to which portable test equipment (PTE) can be connected to report specific faults. For this course we will focus on the basic monitoring functions of the ECU some of which are represented in Figure 2.2. The location of the ECU varies by rail vehicle type and design.

The ECU takes in external signals from the vehicle, buffers these signals, and then uses them to provide a calculation of the required braking effort, which is output as a controlled volume pressure to control the brake cylinder pressure.

¹ On some rail car configurations the ECU is referred to as an **electronic control module** (ECM) and on others this is referred to as the **electronic controlled pneumatic** (ECP) equipment.



Learning Application 2.3 Variable Load Valve

Your instructor will hand you a two-page printout from PATCO's Running Maintenance and Service Manual describing a variable load valve and how it works in the brake control system on their rail cars.

1. Working with a partner, highlight the flow of air into port 8A and out to cavity 4A on the diagram on the handout.

2. Complete this sentence from the manual:

The VLV provides a proportional _____ in braking effort as _____ pressure increases. The amount of braking effort _____, relative to air spring pressure increase, is a function of the _____ of the lower _____ spring plus the ratio of the areas of the _____ and _____ step piston surfaces.

3. Through what does air under pressure flow into chamber A from chamber C?

4. Through what does supply pressure flow into chamber D?

5. What happens when the force of air in chamber A exceeds the force of the air spring pressure in chamber B?

6. Under what conditions does zero air spring pressure occur?

7. What is the only force operating against the force of the pressurized air in chamber A? What is the result of this situation?

8. Which component cuts off further flow of SR air into chambers A and 4A? What happens then?



Figure 2.11 Air Compressor Unit on HRV –courtesy Maryland MTA

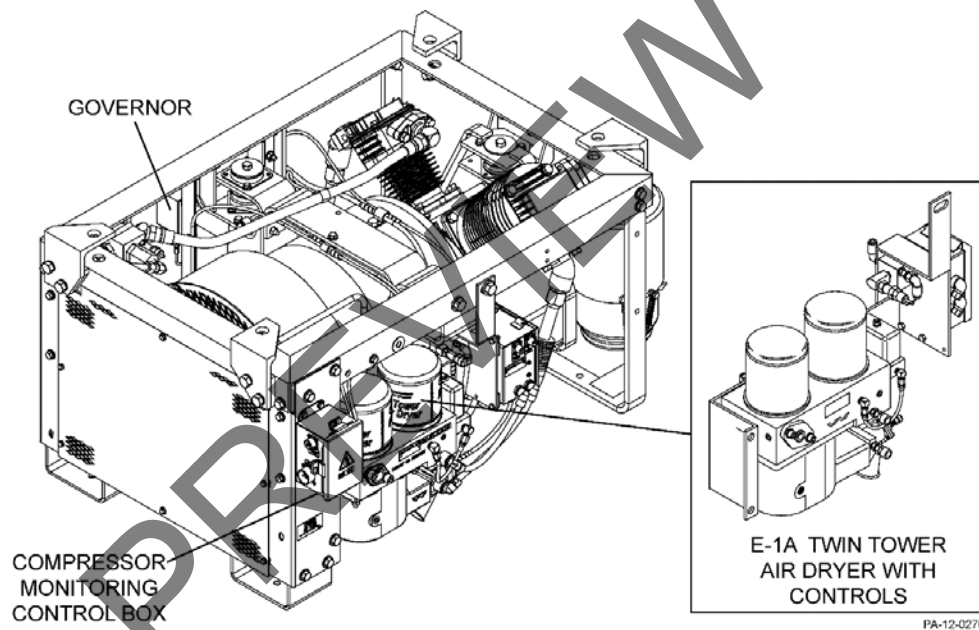


Figure 2.12 Air Compressor Unit with Air Dryer Unit–courtesy PATCO

Overpressure safety valves are used between certain stages and will vent the air to atmosphere if the system's normal operating parameters are exceeded. They are installed for safety purposes. A **pressure switch** which monitors the reservoir's air pressure is used to turn the compressor on when the air tank's lower pressure set point is reached, and off when the air tank's upper pressure set point is achieved. By doing this, adequate air pressure can be maintained for the braking system's use.

MODULE 3

Hydraulic Braking Systems

Outline

- 3-1 Overview and Principle of Operation**
- 3-2 Electronic Control**
- 3-3 Brake Control**
- 3-4 Braking Devices**
- 3-5 Summary**

Outcome and Objectives

Participants will be able to explain the principles of hydraulic braking and their components on rail cars used in major U.S. transportation agencies. Following the completion of this module, the participant should be able to complete the objectives with an accuracy of 75% or greater:

- Explain the principles of operation of a hydraulic brake system.
- Identify the major components of the foundation subsystems of a hydraulic brake system: Electronic control, brake control, and braking devices.

Following the completion of this module, the participant should be able to complete the objectives with an accuracy of 75% or greater:

Key Terms

- Accumulator
- Actuator
- Brake control unit
- Braking devices
- Electro Hydraulic Unit (EHU)
- Electronic control unit
- Fail safe
- Flat spots (wheel flats)
- Load weigh valve
- P-signal
- Slip/slide/creep control
- Suspension legs (struts)
- Variable load valve
- Wheel creep
- Wheel slide
- Wheel slip

3-2 ELECTRONIC CONTROL

The control center for the rail vehicle's braking system is governed by the **electronic control unit**² (ECU). This is a logic controller that monitors many functions of the rail vehicle including those which provide friction brake service and wheel-slide control. On newer rail cars, the ECU is a microprocessor-based device with extensive fault detection and annunciation capabilities to which portable test equipment (PTE) can be connected to report specific faults. For this course we will focus on the basic monitoring functions of the ECU some of which are represented in Figure 3.2. The location of the ECU varies by rail vehicle type and design.

The ECU takes in external signals from the vehicle, buffers these signals, and then uses them to provide a calculation of the required braking effort, which is output as a controlled volume pressure to control the brake cylinder pressure.

It is easy to see why the ECU is typically described as the “brains” of the hydraulic braking system. Along with the request from the Master Controller, the ECU processes other inputs including load weigh pressure, emergency brake request, dynamic brake feedback, automatic train protection, and other inputs.

While in-depth examination of the ECU is outside the scope of this course, the participant should be able to describe those functions of the ECU which directly relate to friction brakes. These are also shown in Figure 3.2.

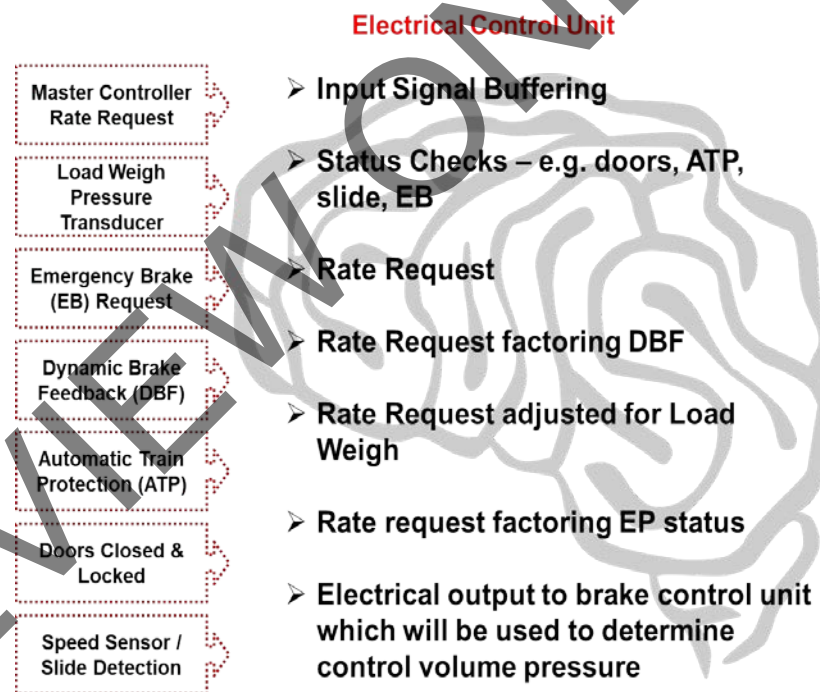


Figure 3.2 ECU Functionality

² On some rail car configurations the ECU is referred to as an **electronic control module** (ECM).

Accumulator

Pressurized hydraulic fluid is stored in accumulators. Liquids for the purpose of hydraulic actuation are incompressible and they need to be pressurized through some external source. This external source can be a spring, a raised weight, or more commonly, compressed gas. Gasses are highly compressible. In many rail vehicle hydraulic braking systems, the accumulators use a flexible diaphragm with fluid on one side and pressurized gas on the other side. Nitrogen is commonly used as the pressurized gas.

The function of the accumulator is to provide high capacity flow rate as for braking. It also provides reserve pressure source in the event of a hydraulic pump failure.

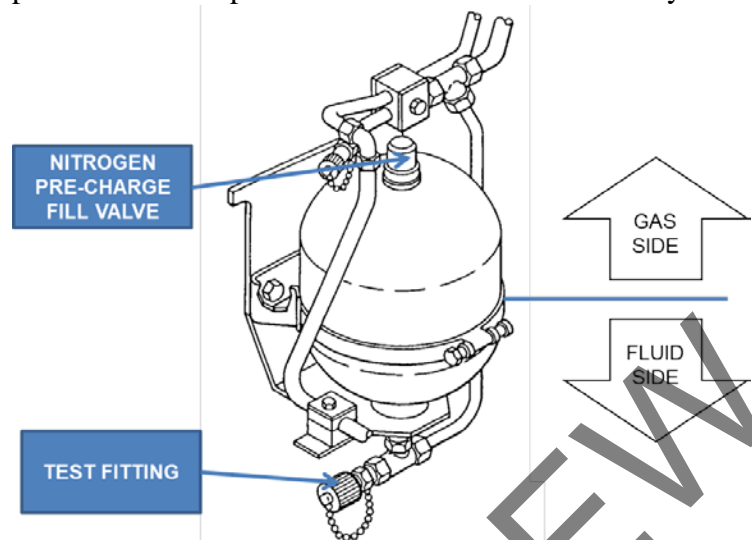


Figure 3.8 Brake Accumulator –courtesy CATS

MODULE 4

Electromechanical Brakes

Outline

- 4-1 Overview and Principle of Operation**
- 4-2 Types of Electromechanical Brakes**
- 4-3 Summary**

Outcome and Objectives

Participants will be able to explain of the principles of electromechanical brakes and their major components on rail cars used in major U.S. transportation agencies. Following the completion of this module, the participant should be able to complete the objectives with an accuracy of 75% or greater:

- Explain the principles of operation of an electromechanical brake system
- Identify the types of electromechanical brakes and their major components.

Following the completion of this module, the participant should be able to complete the objectives with an accuracy of 75% or greater:

Key Terms

- Eddy Currents
- Electromagnetic Brakes (EM)
- Electromechanical

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MODULE 3: ELECTROMECHANICAL BRAKES

The EM brake on the rail vehicle is connected to batteries that create alternating north and south poles which form magnetic fields between the poles. The magnetic fields generate eddy currents in the top surface of the rails, creating a force acting in an opposite direction to the movement of the train, in other words, a braking force. This principle of operation of electromagnetic brakes on a rail car is illustrated in Figure 4.1.

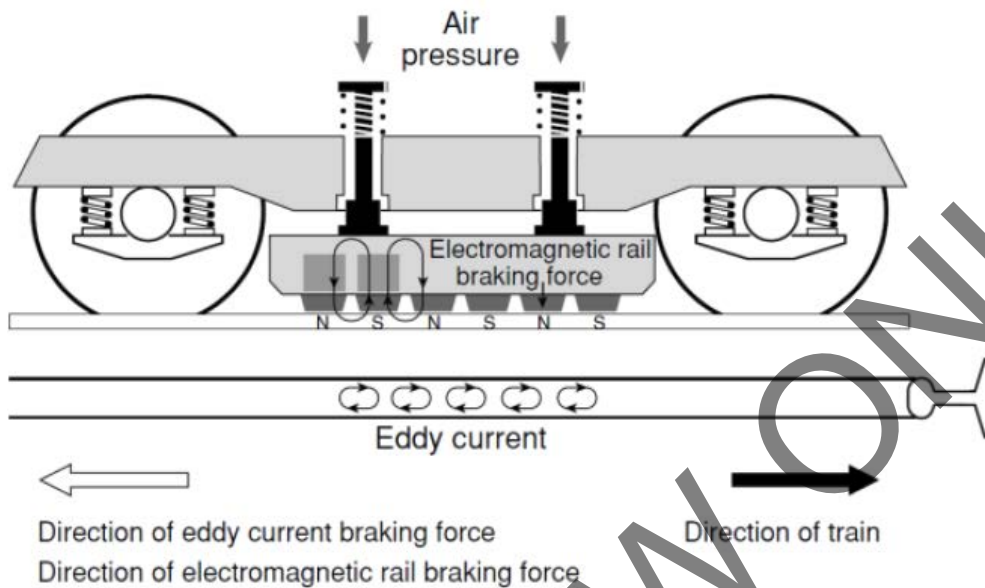


Figure 4.1 Electromagnetic Rail Braking Force and Eddy Currents [Source](#)

One type of electromagnetic brake which is common on light rail vehicles is the **track brake** (see Figure 4.2).

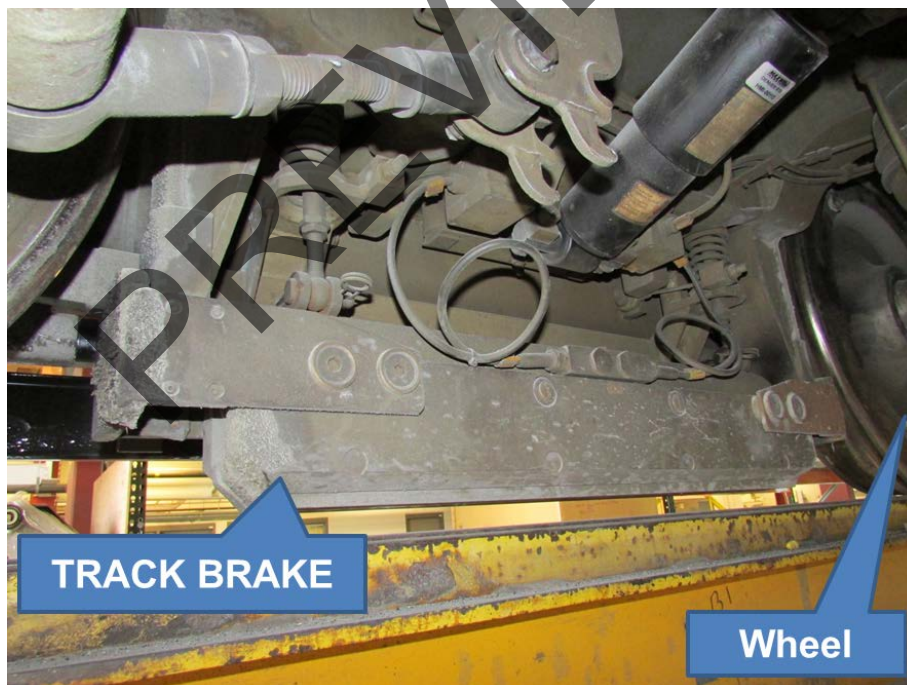


Figure 4.2 Track Brake on LRV –courtesy DenverRTD

MODULE 5

Foundation Brake Equipment

Outline

- 5-1 Overview
- 5-2 Major Components
- 5-3 Summary

Outcome and Objectives

Participants will be able to explain the foundation brake equipment common to various types of braking systems on passenger rail vehicles in the U.S.

Following the completion of this module, the participant should be able to complete the objectives with an accuracy of 75% or greater:

- Identify major components that comprise the foundation brake equipment of friction braking systems.
- Describe the functions of the foundation brake equipment

Key Terms

- Brake Calipers
- Brake Head
- Disc Brake
- Rotor (Friction Ring, Brake Disc)
- Shoes
- Tread Brake Unit

5-2 MAJOR COMPONENTS

The major foundation braking equipment located around the train wheel includes the calipers, brake pads or shoes, the brake disc or rotor, and shunt.

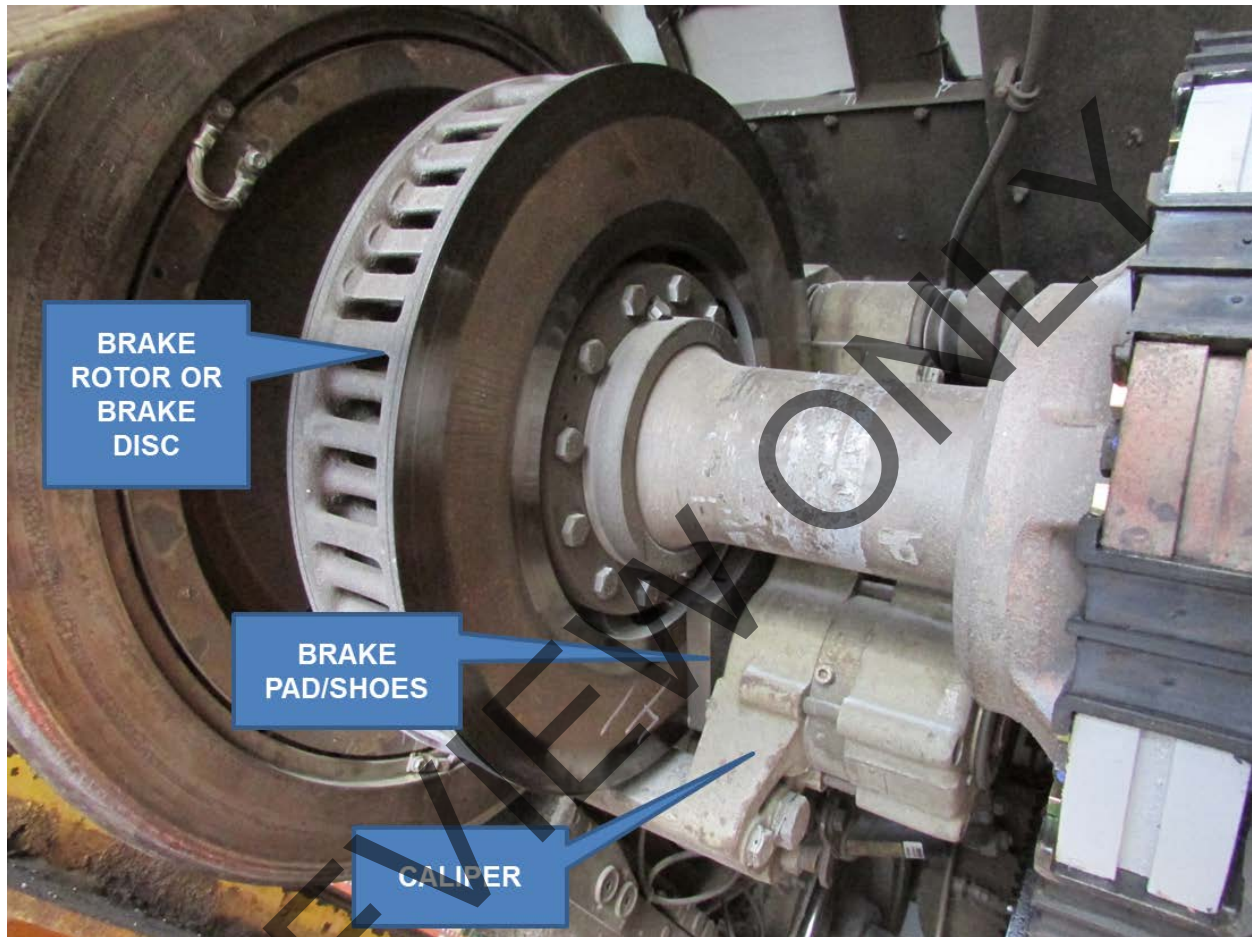


Figure 5.1 Brake Components Located Near the Wheel

Brake Pads / Shoes

The **brake pad** or shoe is a replaceable friction element that is secured to a brake head for the purpose of producing a retarding friction force on to the face of a brake disc.

MODULE 6

Tools and Materials

Outline

- 6-1 Overview**
- 6-2 General Tools**
- 6-3 Specialized Tools**
- 6-4 Summary**

Outcome and Objectives

Participants will be able to explain the tools and materials the technician may use while working on the rail vehicle's friction brake systems.

Following the completion of this module, the participant should be able to complete the objectives with an accuracy of 75% or greater:

- Identify tools and supplies specific to working on a rail vehicle's friction brake system.

PREVIEW ONLY

6-1 OVERVIEW

It is almost impossible to list all the tools a rail car technician must use while performing work on the friction brakes system on the rail car! This module presents some of the common tools, equipment, and materials used across the Consortium's rail transit agencies. Of course these tools and equipment vary by agency with respect to their configuration, layout, availability, and design. Generally the OEM manuals list required tools and materials need for inspection, maintenance, and repair of friction brakes systems. A good example is shown in Figure 6.1.

20.1 Required tools and consumable

1. Open end wrenches	8, 10 and 13 mm
2. Adjustable torque wrench with open end wrenches	0 to 35 Nm; 10 and 13 mm
3. Ratchet wrenches for adjustable torque wrench	8 and 10 mm
4. Allen wrenches (preferably ratchet wrenches)	3, 4 and 5 mm
5. Flat head screwdrivers	N° 3 and 5
6. Pozidriv screwdriver	N° 2
7. Pin remover	3 mm
8. Plastic hammer	200 gr.
9. Electric test multi-meter	
10. Sécheron depth gauge W-6	HSBA431494P0001
11. Sécheron arc chute gauge (80 x 200 mm)	SG100029P1
12. Knife or scraper	
13. Multi-purpose abrasive rubber fine	grade 0
14. Dry cloth	

Grease for general purpose
Shell Rhodina LT2; Sécheron's number SG104245P00001 (except for the swivel area of the mobile contact where the Shell Alvania RL3 Secheron's number SG104245P00002 grease must be used; see 20.1.6.6 for details; the not anymore produced Aseol Litea 806-12 grease can also be used).

Important!
The use the Shell Alvania RL3 grease on the swivel area of the mobile contact is mandatory!

Figure 6.1 Required tools and materials from heavy repair manual –courtesy of NFTA

Where applicable, illustrations in this module are specific to the equipment used by the rail transportation agency cited below each illustration.