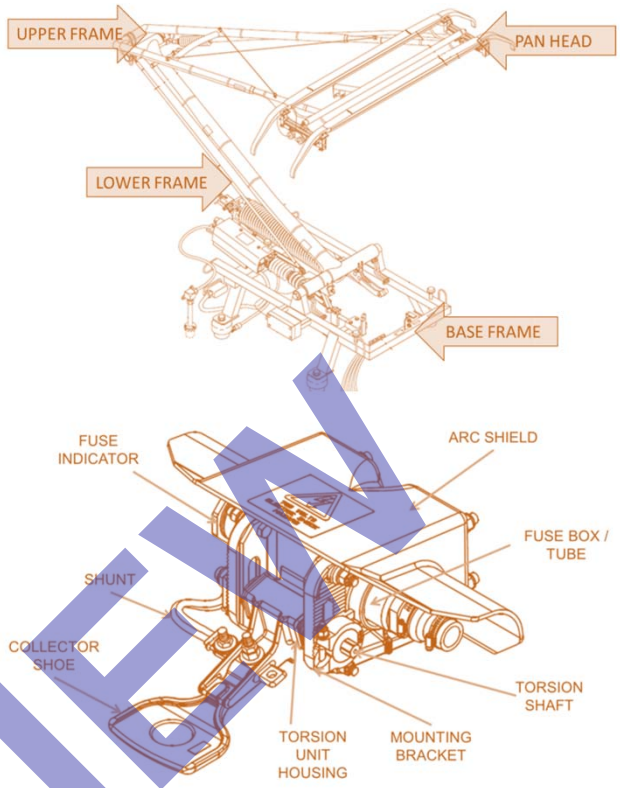
Introduction and Overview to Current Collection Systems



Course 107






PARTICIPANT GUIDE

RAIL CAR TRAINING CONSORTIUM

Current Collection

Introduction and Overview

Course 107

Participant Guide

Participant Guide

June 2018

Rail Car Training Consortium

HOW TO USE THE PARTICIPANT GUIDE

Purpose of the Course

Course 104: Introduction and Overview to Auxiliary Power Supply and Battery Systems provides participants with an overview to the principles of APS and battery systems as well as preparing to work on those systems in a transit rail car maintenance facility.

Approach of the Book

Each course module begins with an outline, a statement of purpose and objectives, and a list of key terms. The outline will discuss the main topics to be addressed in the module. A list of *key terms* identifies important terminology that will be introduced in this module. *Learning objectives* define the basic skills, knowledge, and abilities course participants should be able to demonstrate to show that they have learned the material presented in the module. *Exercises* are built in throughout the course materials to assist the participants in learning and reviewing key information.

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MODULE 1

General Safety Procedures

Outline

Outcome and Objectives

This module provides participants with a review of safety procedures when working on and around rail vehicles. Following the completion of this module, the participant should be able to complete the objectives with an accuracy of 75% or greater:

- Describe the dangers of working around high voltage.
- Recognize safety hazards when working with heavy and moving machinery.
- Explain lockout/tagout.
- Describe required PPE practices.

Explain the principles of rail current collectors – specifically overhead catenary, third rail, and trolley poles – and identify their major components. Areas to be discussed in this course will extend from collectors to the rail vehicle's knife switch.

Key Terms

- Fall Protection
- Hotstick
- Insulating Protective Equipment (IPE)

Abbreviations

- LOTO: Lockout/Tagout
- OEM: Original Equipment Manufacturer
- OSHA Occupational Safety and Health Administration
- PPE: Personal Protective Equipment

1-1 OVERVIEW

Safety is at the core of the career of a rail vehicle technician and it should always be a priority on every project or work order. The rail car technician can expect to work in confined spaces, around high voltage equipment, in noisy environments, and around heavy and moving machinery.

Each transit agency establishes its own safety procedures for working on rail vehicles. The participant in this course should recognize that their transportation agency's procedures supersede the guidelines in the course.

1-2 SAFETY REVIEW

The technician can expect that working on the rail vehicle's current collection systems will involve electrical, mechanical, and other hazards.

Learning Application 1A

Read the OSHA citation on a rail maintenance facility in Wood River, Illinois. Fortunately the carman suffered minor injuries after falling from an aerial lift. Which safety procedures were violated and what would you recommend to protect against these kinds of accidents?

Electrical

Data collected by the Bureau of Labor Statistics show that on an average 157 workers die each year from direct exposure to electricity while on the job. In the field of installation, maintenance and repair, each year an average of 425 workers were seriously injured by direct exposure to electricity while on the job. Direct exposure to electricity includes arc flashes and direct contact with power lines.

Electric current flowing inside the human body can cause deep burns and cardiac arrest. In many instances, the individual is unable to let go of the power source because of involuntary muscle contraction. The most sensitive organs to electrical shock are the brain and the heart. The effects of electrical current on the body are shown in Figure 1.1.

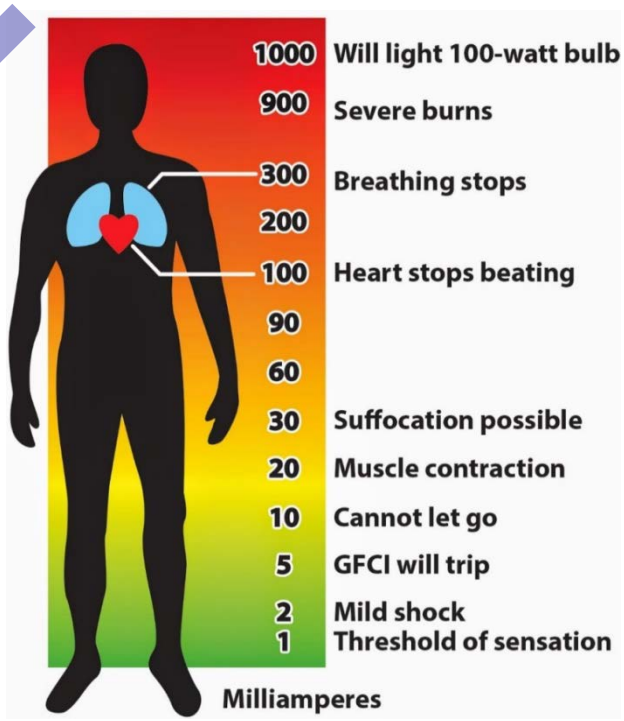


Figure 1.1 Effects of Electricity on the Human Body. Note that 1,000 mA = 1 amp.

Fall arrest equipment is required when working atop rail vehicles to protect workers from falls. Rail car technicians commonly use a body harness with a shock-absorbing lanyard connected to a proper anchor point. Fitting a body harness can be done in five simple steps:

1. Inspect		2. Position back D-ring between shoulder blades.	
3. Buckle up legs.		4. Buckle up front.	
	5. Adjust so the harness fits snugly and D-ring remains in the correct position.		

Figure 1.5 Simple Steps to fitting a full body harness –courtesy OSHA

Generally the rail car technician is responsible for the following:

- Properly wear PPE when required.
- Attend training sessions on PPE.
- Properly care for, clean and maintain PPE.
- Inform a supervisor of the need to repair or replace PPE.

1-4 SUMMARY

Each transit agency establishes its own safety procedures for working on rail vehicles. The participant in this course should recognize that their transportation agency's procedures supersede the guidelines in the course.

MODULE 2

Overhead Catenary

Outline

Outcome and Objectives

This module provides participants an overview of current collection from the overhead catenary and its distribution to the pantograph and associated equipment. Following the completion of this module, the participant should be able to complete the objectives with an accuracy of 75% or greater:

- Describe the principle of operation of the overhead catenary with respect to the pantograph.
- Identify major components of the pantograph and associated equipment.

Explain the principles of rail current collectors – specifically overhead catenary, third rail, and trolley poles – and identify their major components. Areas to be discussed in this course will extend from collectors to the rail vehicle's knife switch.

Key Terms

- Base Frame Assembly
- Carbon Strips
- Catenary
- End horn
- Lightning Arrester
- Metal Oxide Varistor (MOV) Disk
- Pan Head / Collector Head Assembly
- Pantograph
- Raising Mechanism Springs
- Shunt

Abbreviations Used in this Module

- APS Auxiliary Power Supply
- APTA American Public Transportation Association
- HVAC Heating, Ventilation, and Air Conditioning
- OCS Overhead Catenary System
- OEM Original Equipment Manufacturer

2-2 PRINCIPLE OF OPERATION

The **catenary** is an overhead bare copper wire suspended from above and parallel to the running rail. Current flows from the catenary wire and is collected by a **pantograph** assembly. The collected power is then conditioned for distribution to the various electrical demands of the rail vehicle. The major sub-systems in an overhead catenary system which we will explore in this course are highlighted below in Figure 2.1.

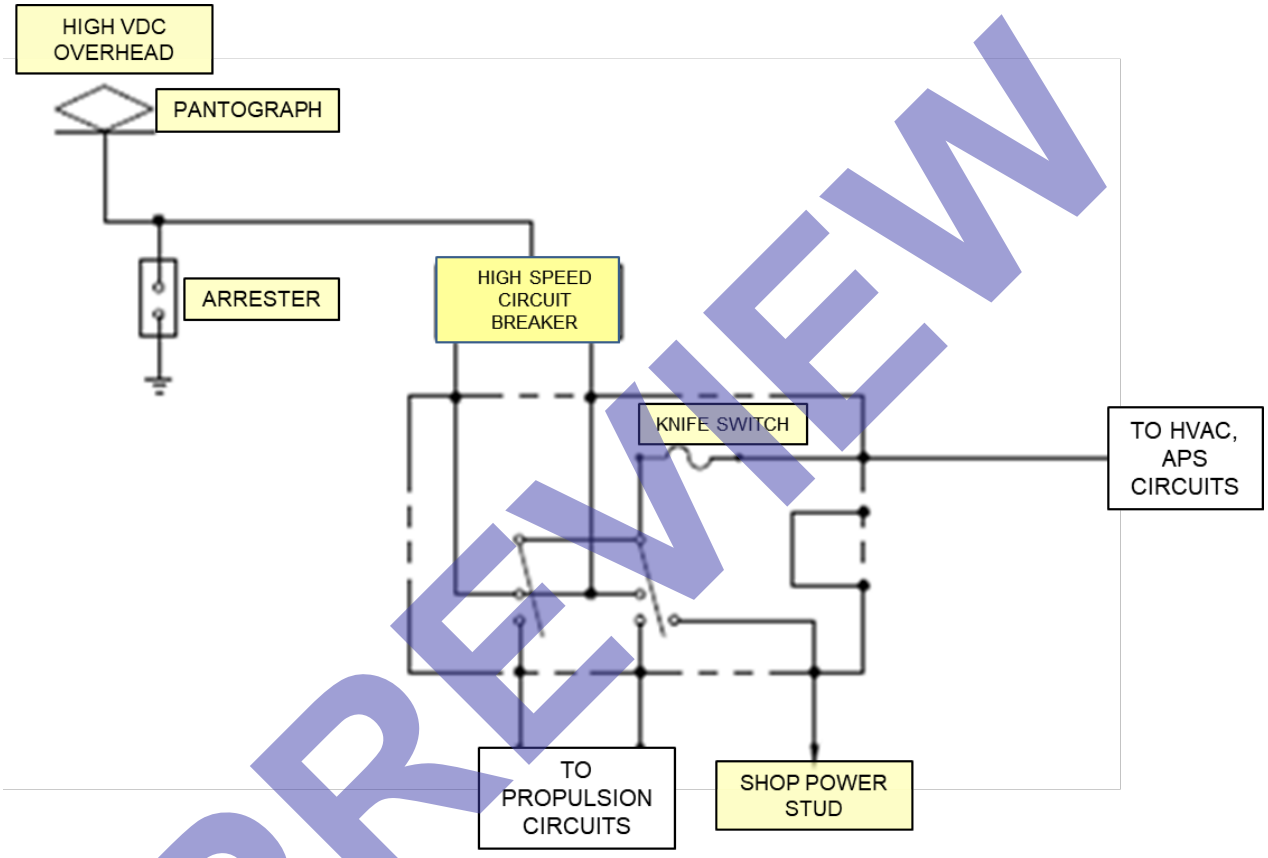


Figure 2.1 Catenary System for Current Collection –Courtesy DART (redrawn)

Because of its many components, we will describe the pantograph in its own section, Section 2-3. Other related subsystems of the catenary system are the arrester and the high speed circuit breaker. These are described in Section 2-4.

2-3 PANTOGRAPH

The **pantograph** is a device mounted on the roof of the rail vehicle that is raised to connect to the overhead catenary. Its function is to collect current from the catenary and provide an electrical path to vehicle for distribution to the propulsion, HVAC and APS circuits. A spring pushes the pantograph upward to maintain the proper force against the catenary. The surface of the pantograph that rides against the catenary is comprised of a replicable carbon element that collects power from the catenary for the operation of the rail vehicle.

Figure 2.2 Catenary and Pantograph –courtesy Denver RTD

Learning Application 2A

1. Watch the YouTube video uploaded by Alstom titled “Catenary and pantograph: how does it work?” https://youtu.be/kFPJ8eF9M2A
2. Participate in the discussion led by your instructor.

Length: 3 minutes

The major components of the pantograph may be categorized into four sections as Figure 2.7 shows. These sections are:

- Pan Head Assembly
- Upper Frame Assembly
- Lower Frame Assembly
- Base Frame Assembly

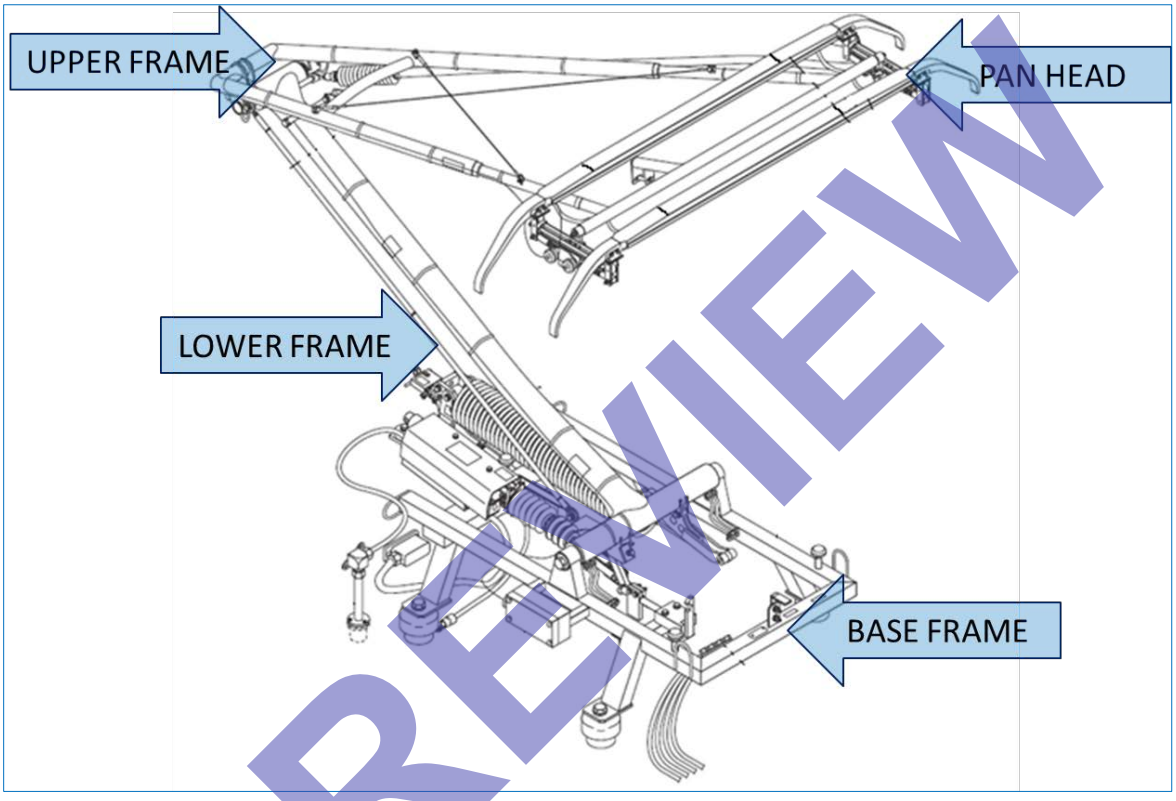


Figure 2.7 Main Sections of Pantograph

Current flows from the catenary wire into the carbon strips on the pan head assembly, through the upper frame assembly, the lower frame assembly, the base frame assembly, and to the vehicle's electrical system from the contact plate of the base frame assembly (Figure 2.8).

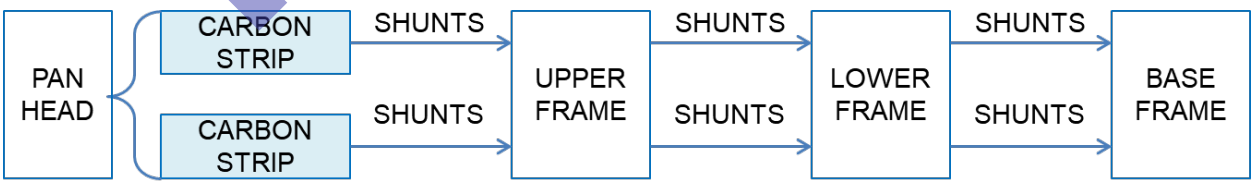


Figure 2.8 Flow of Current Through Sections of Catenary –courtesy CATS

2-4 OTHER MAJOR COMPONENTS

Lightning Arrester / Surge Arrester

This is a component with two correct spellings! One spelling is “arrester” and the other is “arrestor.” Sometimes referred to as a “surge arrester” the **lightning arrester** is an appliance designed to protect the pantograph and the rail vehicle from overvoltages that can occur from lighting or other voltage surges.

The arrester limits the voltage spikes by either blocking or by shorting to ground any unwanted voltages above a predetermined threshold. The arrester contains a **metal oxide varistor**, or MOV, disk which is a semiconductor that is sensitive to voltage. When there are voltage surges, the arrester activates and diverts the lighting to ground where it will disperse harmlessly.

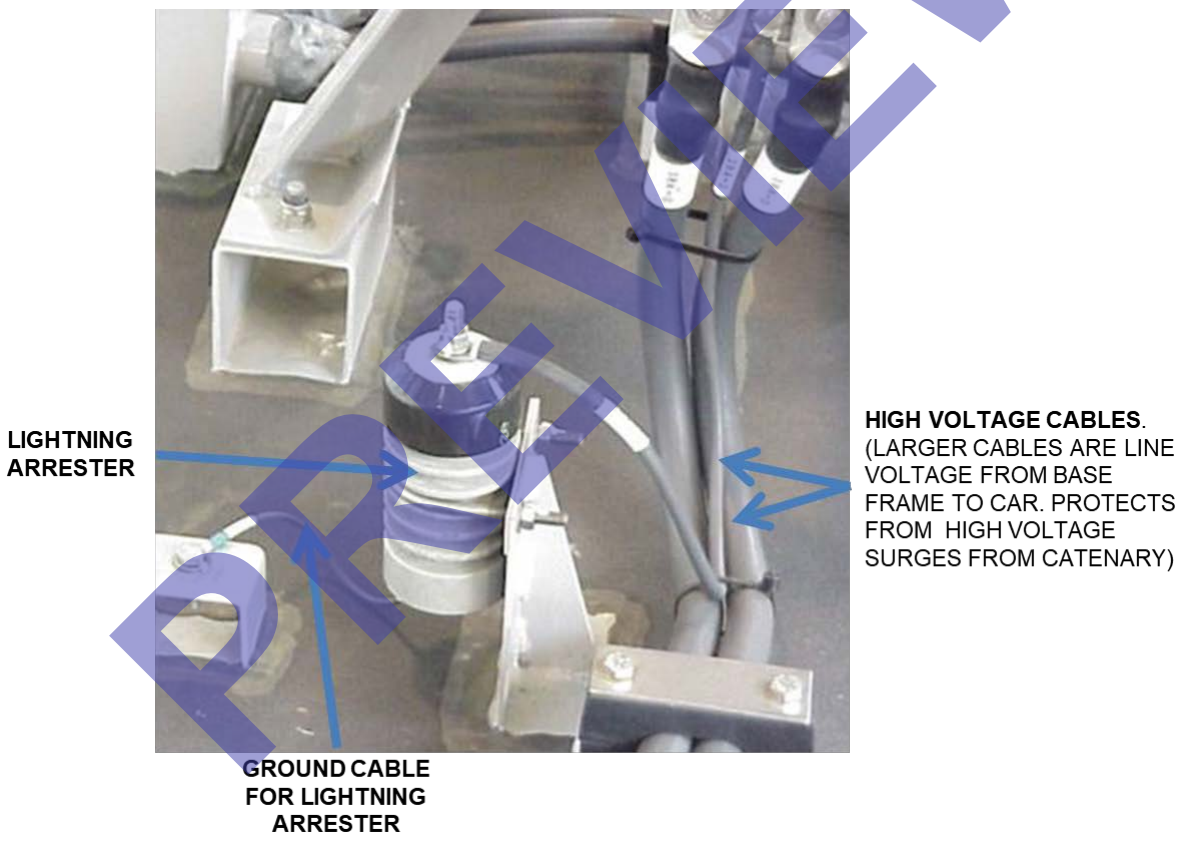


Figure 2.16 Lightning Arrester and Related Components –courtesy DART

power to propulsion and auxiliary power systems creating what some technicians call a “dead car.” When the rail vehicle is returned to service the knife switch is moved to the NORMAL position.

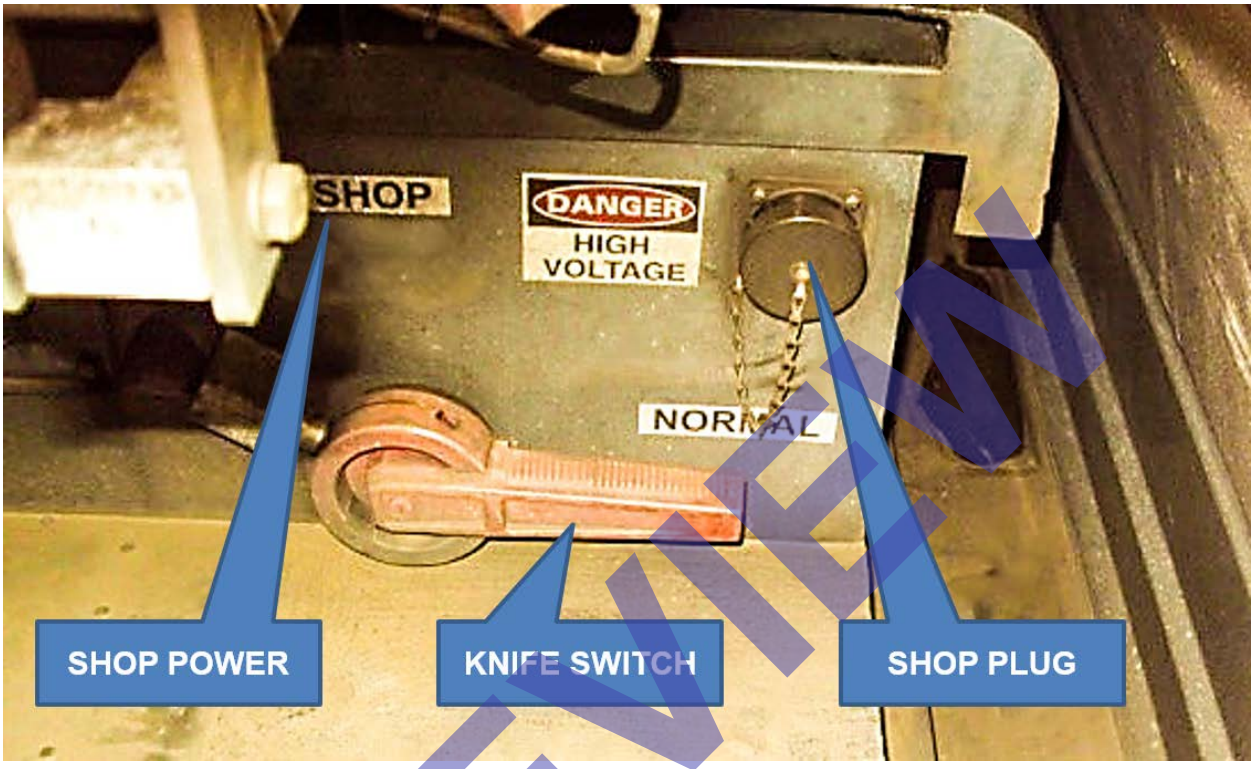


Figure 2.20 Knife Switch on Rail Vehicle –courtesy CATS

Learning Application 2F

With help from your instructor, list the positions of the knife switch on the types of rail vehicles you will likely work. List the functions of each position, i.e. which systems on the rail car will be affected with each position of the knife switch.

Ice Cutters

In cold, climates with potential for snow and ice can build up on the catenary wires thereby affecting power to the rail vehicle. Ice building up on the wire acts as an electrical insulator, preventing the carbon strips from making contact with the wire where the ice accumulates. This interruption in the flow of the current from the wire to the pantograph can cause visible arcing. To reduce this problem, rail cars are equipped with ice cutters. There are various configurations of ice cutters: some rail vehicles have heated ice cutters installed on the pantograph itself. Others use a system whereby rail cars are coupled where the carbon strips on the lead car pantograph are replaced with ice cutters while the coupled second car retains the carbon strips to collect current.

Learning Application 2G

Working with a partner or in small groups, read Metro Transit's blog *Light-rail vehicles ready for all seasons* and answer the following questions.

1. What are the two light rail vehicles (LRV) manufactures mentioned in this blog?
2. This blog entry was in November 2014. Prior to that time, what was rail vehicle maintenance staff tasked to do each time ice was in the weather forecast?
3. What are the two new all-weather features added to Metro Transit's LRVs that are mentioned in the blog?

2-5 SUMMARY

This module described the principle of operation of an overhead catenary system (OCS) used in by a public rail transportation agency in North America. The module further described the OCS current collector system which is the rail vehicle's pantograph and its associated assemblies and components including lightning arrester, high speed circuit breaker, and ice cutter.

Module 3

Third Rail

Outline

Outcome and Objectives

This module provides participants an overview of current collection from the third rail and its distribution to the collector assemblies and associated equipment. Following the completion of this module, the participant should be able to complete the objectives with an accuracy of 75% or greater:

- Describe the principle of operation of the third rail.
- Identify major components of the third rail system.

Key Terms

- Collector Paddle
- Current Limiting Fuse
- Gravity Type Collector Shoe
- Shoe Mount
- Torsion Lock
- Torsion Shaft
- Torsion Unit
- Stinger

Abbreviations Used in this Module

- APS Auxiliary Power Supply
- APTA American Public Transportation Association
- HVAC Heating, Ventilation, and Air Conditioning
- OEM Original Equipment Manufacturer

3-2 PRINCIPLE OF OPERATION

The **third rail** is just that, a rigid conductor that is placed parallel to the two running rails on which the train runs. Placed alongside or between the running rails, it provides electric power to a train. The power is collected by the train's **collector shoes** (or paddles) that are held down against the third rail by spring pressure.

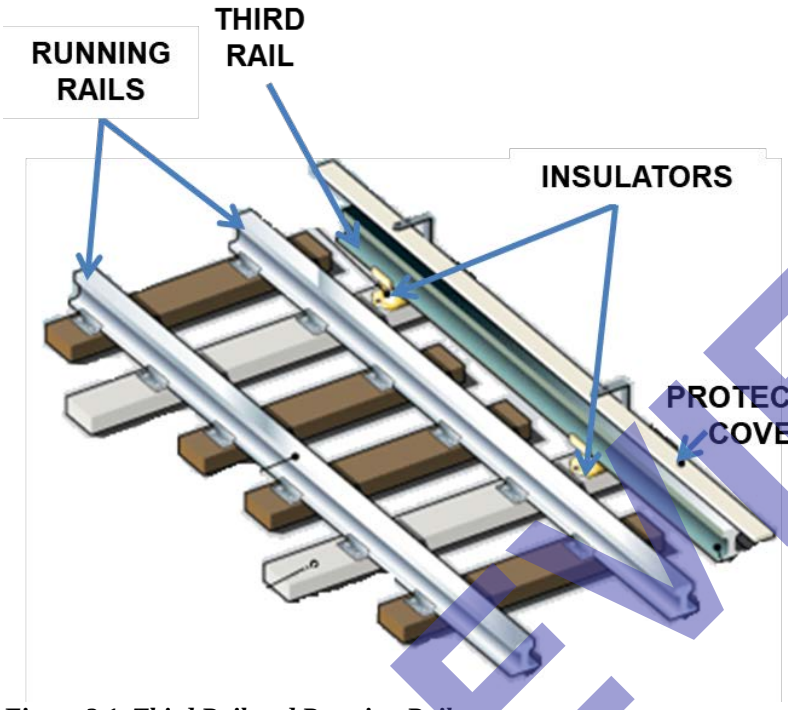


Figure 3.1 Third Rail and Running Rails

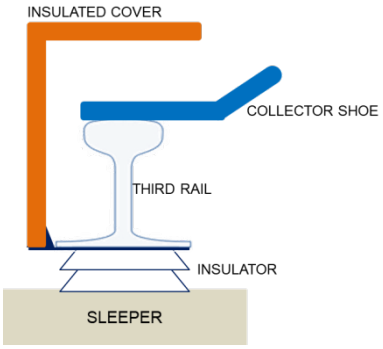
Learning Application 3A

1. Watch the YouTube video uploaded by Schunk Group titled "Third-rail current collectors."
2. Participate in the discussion led by your instructor then fill out the required information in the space below.

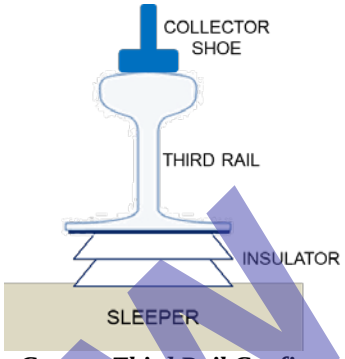
https://youtu.be/Uwni2exCC0U

Length: 1.5 minutes

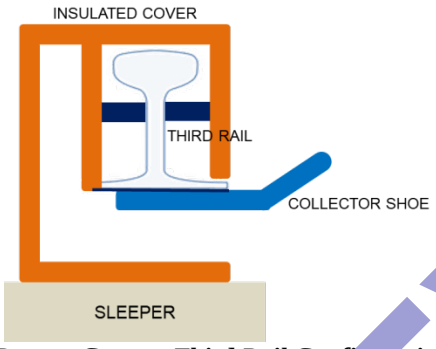
There are different configurations of third rail current collectors used by rail transportation agencies. BART, for example, uses the *Top Contact with Cover* configuration shown in one of the four configurations below.



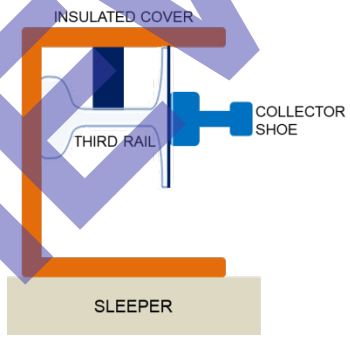
Top Contact with Cover Third Rail Configuration



Top Contact Third Rail Configuration



Bottom Contact Third Rail Configuration



Side Contact Third Rail Configuration

Figure 3.2 Third Rail Configurations and Current Collection

Third rail power is collected and conditioned for distribution to the various electrical demands of the rail vehicle. The major sub-systems in a third rail system which we will explore in this course are highlighted below in Figure 3.3.

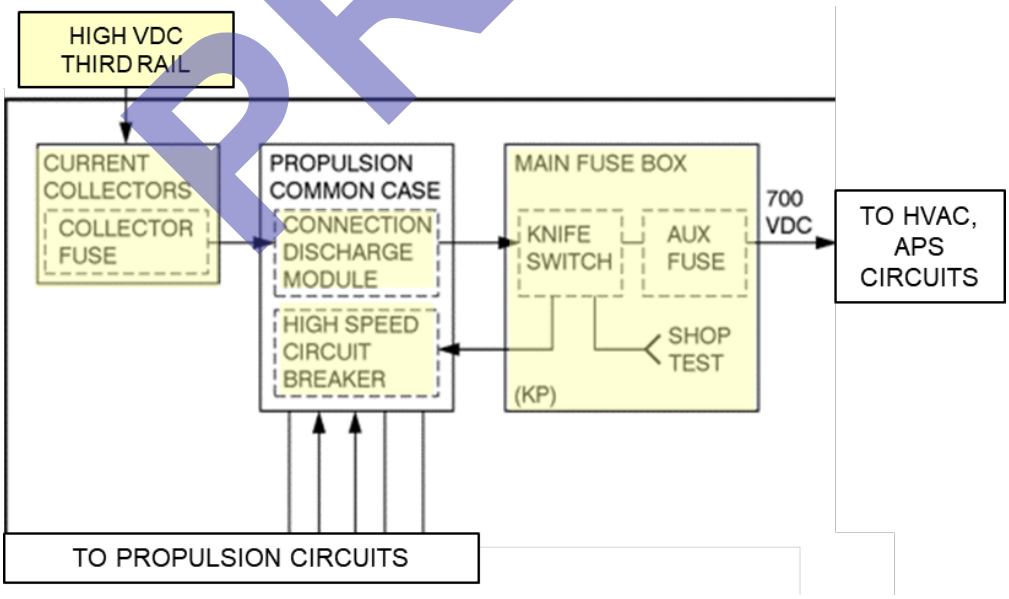


Figure 3.3 Third Rail System for Current Collection –Courtesy WMATA (redrawn)

3-3 Current Collector Assembly

The collector assembly is a mechanical assembly mounted to the rail vehicle's truck frame (Figure 3.4).Typically there are usually four assemblies per car (wired in parallel) which are electrically linked together. The collector assembly torsion unit and paddle provides the desired paddle contact pressure to the third rail at high speeds. The sliding contact of the collector shoe (paddle) on the third rail is responsible for the transfer of power (500 to 900 volts dc) from the third rail to the rail transit vehicle.

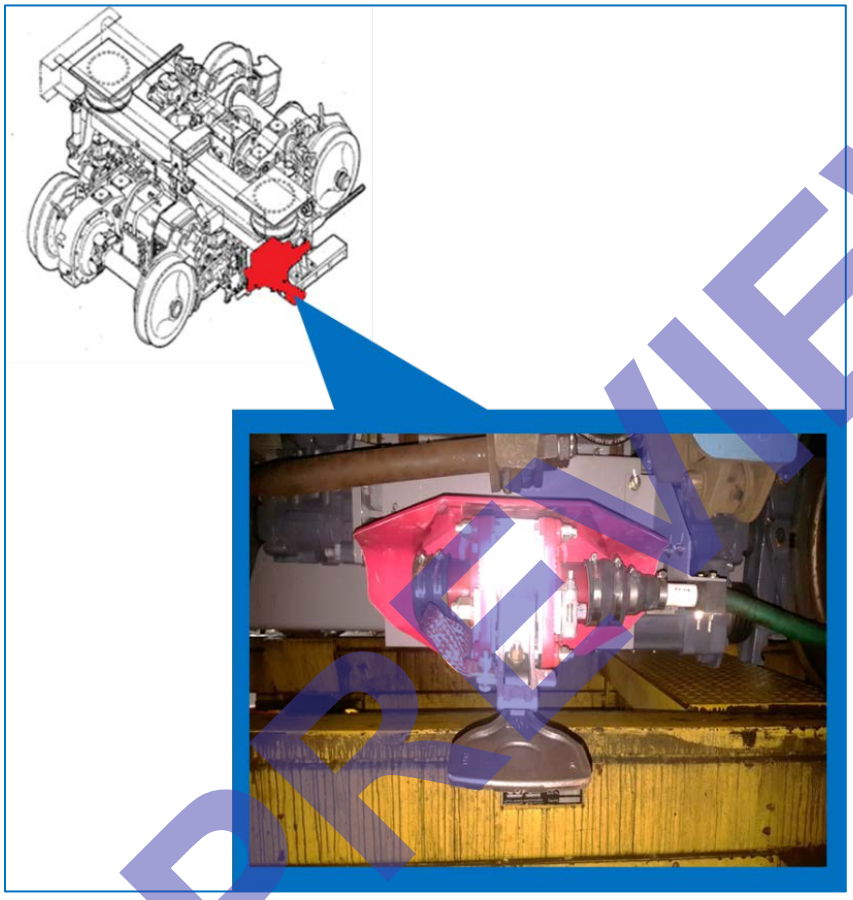


Figure 3.4 Collector Assembly Location on Rail Car Axle –courtesy MTA

The collector assembly is comprised of several components including:

- Collector shoe
- Collector fuse
- Collector shunt
- Fuse indicator
- Collector shoe mount
- Collector arc shield
- Torsion shaft

The **shoe mount** retains the shoe on the collector assembly holding it in the correct position under the cover board to pick up the third rail approach ramps. The rubber torsion units housed within the shoe mount apply torsional spring force to maintain shoe contact on the third rail.

The **torsion shaft** attaches the current collector shoe, shoe mount, and torsion units to the current collector mounting channel and brackets. Rotation of the torsion shaft applies torque to the torsion unit which, in turn, applies pressure to the shoe. Counter-rotation of the torsion shaft is prevented by the torsion lock. The **torsion lock** functions to maintain the desired shoe pressure by locking the torsion shaft.

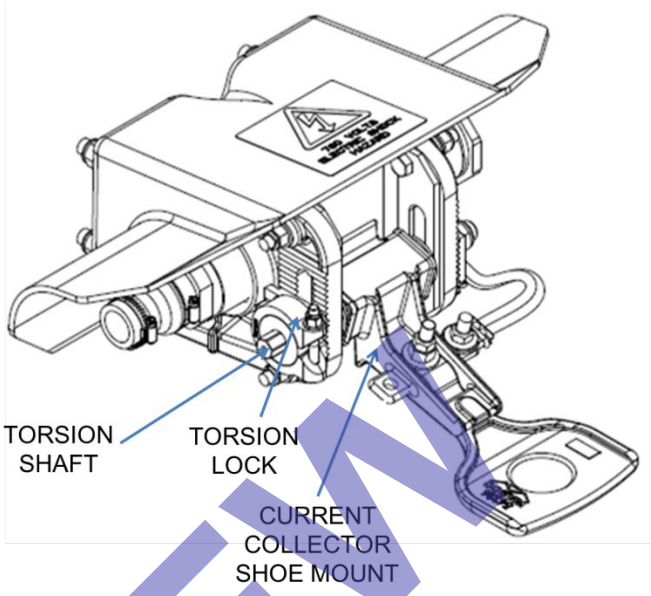


Figure 3.10 Current Collector Shoe Mount –courtesy WMATA

Learning Application 3C

- Working with a partner or in a small group, examine the features of the third rail current collector designed by Hall Industries, Your instructor will give you a copy of a flyer to do this exercise.
- Compare these features and design with the current collector assemblies used on rail vehicles at your location.

Located on the vehicle itself is a **knife switch** which allows the technician to switch the vehicle's source power from the high voltage collected power to the shop power source. In some rail car maintenance facilities, shop power extends to all the rail car's power systems while in others, shop power extends only to auxiliary power supply system and power for the propulsion system is not available

There are two main types of knife switch designs used on rail vehicles and these are shown in Figure 3.14 and Figure 3.15 below.

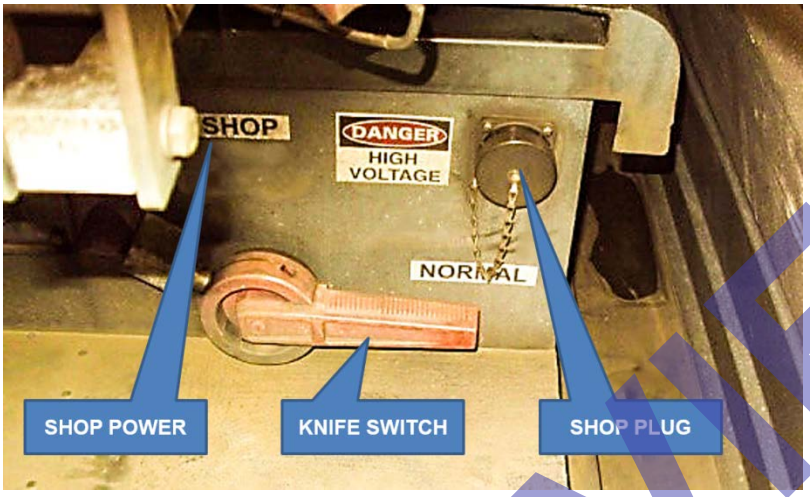


Figure 3.14 Knife Switch on Rail Vehicle –courtesy CATS

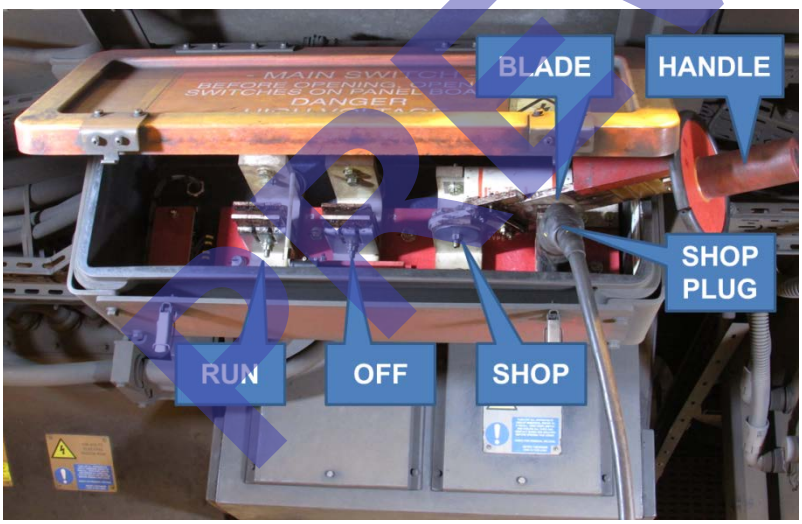


Figure 3.15 Knife Switch on Rail Vehicle –courtesy WMATA

3-4 SUMMARY

This module described the principle of operation of third rail power collection system used in by a public rail transportation agency in North America. The module further described the current collector shoe assembly components and other associated assemblies and components including high speed circuit breaker and the knife switch.

Module 4

Tools

Outline

Outcome and Objectives

Participants will be able to provide participants with an overview to some of the common hand and diagnostic tools while working on current collection systems on rail vehicle.

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

- Identify the following:
  - Hotstick
  - On/Off Rail Height Gauge
  - Spring Tension Gauge (Fish Scale)
  - Torque Wrench
  - Volt Meter (Megger)

Key Terms

- Torque Wrench
- Multimeters
- Hot Stick

Megohmmeters (Megger)

The megohmmeter, commonly called by its OEM name "Megger", is a portable instrument used to measure insulation resistance. See Figure 4.3. These are like multimeters except that they measure higher voltage and resistance.

Figure 4.3 Megger MT410®

Electrical current is sent along conductive wires in the auxiliary power supply unit. To contain the wires' conductivity, they are insulated with some kind of resistant material. Some of the current still manages to escape and, like a leak in a water pipe, an imperfection in wire insulation will cause electricity to escape which can be detrimental to the current collection system. Testing insulation resistance therefore helps identify problems before they result in injury or equipment failure.

Spring Scale

This tool has many names including "force gauge", "fish scale", and "Newton meter." The spring scale measures the force or tension during a pull test. It is used to set the current collector to the OEM-recommended range for force to keep the optimum tension of the current collector to the source of power i.e. the overhead catenary system or third rail. Spring scales can be mechanical or digital.

4-3 CATENARY-SPECIFIC TOOLS AND MATERIALS

In addition to the standard tools carried by maintenance personnel, the following tools and materials are normally required for pantograph current collection equipment inspection and maintenance:

- Rope or Chain
- Levels
- Tape Measure
- Masking Tape
- Approved non-conducting cleaning solvents
- Approved lubricants as required by the OEM and the railroad standard maintenance procedure (SMP)
- Additional materials as required by the OEM and the railroad standard maintenance procedure (SMP)

Learning Application 4A

1. With a partner or in a small group discuss where you think some of these tools and materials may be used when inspecting, maintaining, or troubleshooting the pantograph.

2. What other tools or materials will you likely use while performing work on the pantograph?

4-4 THIRD RAIL SPECIFIC TOOLS AND MATERIALS

For third rail applications, APTA recommends the following materials and tools:

- Shoe Height Adjustment Bar
- Shoe Height Adjustment Blocks
- Mallet
- Third rail shoe thickness gauge
- Third rail shoe height gauge

Materials

- Approved non-conducting cleaning solvents
- Approved lubricants as required by the OEM and the railroad standard maintenance procedure (SMP)
- Additional materials as required by the OEM and the railroad standard maintenance procedure (SMP)

Learning Application 4B

1. With a partner or in a small group discuss where you think some of these tools and materials may be used when inspecting, maintaining, or troubleshooting the third rail current collector assembly.
2. What other tools or materials will you likely use while performing work on the collector assembly?

4-5 SUMMARY

This module highlighted some of the tools that the rail car technician encounters when working on current collection systems on the rail vehicle.