Introduction and Overview to Rail Vehicle Systems, Operation and Maintenance

Course 100






PARTICIPANT GUIDE

RAIL CAR TRAINING CONSORTIUM

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REVISION INDEX

Any additions, deletions, or revisions are to be listed below.

Revision No.	Date	Section	Description of Change	Revision Author
1	11-2019		Tech Edits	Youngbluth
2	6-2020		Review Team Edits	SMEs & K.Ribaudo

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HOW TO USE THE PARTICIPANT GUIDE

Purpose of the Course

Course 100: Introduction and Overview to Rail Vehicle Systems, Operation and Maintenance provides participants with an overview to the rail vehicle systems as well as preparing to work on those systems in a rail car maintenance facility.

Approach of the Book

Each 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.

TABLE OF CONTENTS

LIST OF FIGURES

MODULE 1

Introduction to the Rail Vehicle

Outline

Purpose and Objectives

The purpose of this Module is to provide participants with an overview of rail vehicles and their environment for the purpose of inspection, maintenance and repair.

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

- Identify classes of rail.
- Identify parts of the rail vehicle.
- Explain the rail vehicle dynamic envelope.
- Explain the rail vehicle environment.
- Identify the Direct Current (DC) disconnect.

Key Terms

- Automated guided transit
- Cable car
- Commuter rail
- Dynamic envelope
- Heavy rail
- Inclined plane
- Light rail
- Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD)
- Pocket tracks
- Running repair
- Test tracks
- Trolley bus

1-1 OVERVIEW

Rail vehicle maintenance is a complex job involving knowledge of interrelated parts and systems that make up the rail vehicle and its environment. Understanding these inter-related parts and systems along with their reflective hazards concerns is key to ensuring the most effective inspection, maintenance and repair work is completed in the safest manner possible. Each agency establishes its own safety procedures for working on rail vehicles. The participant in this course should recognize that their agency's procedures supersedes the guidelines in the course. In fact, these guidelines and procedures are developed to enhance the agency's guidelines and policies.

Several organizations exist and operate to ensure the safety of workers in the United States. Organizations and handbooks overseeing and defining safety as related to electricity along with other hazards are described below. These organizations and their acronyms are referenced throughout this series of courses.

APTA **American Public Transportation Association**
www.apta.com
An industry association that has developed the Passenger Rail Equipment Safety Standards (PRESS).

CFR **Code of Federal Regulations**
http://www.ecfr.gov/cgi-bin/ECFR?page=browse
Produced by the executive departments and agencies of the United States federal government and published by the Federal Registry, the Code of Federal Regulations, of CFR, is the set of general and permanent rules and regulations. Also offered on the Electronic CFR website, the code is updated daily.

EPA **Environmental Protection Agency**
https://www.epa.gov/
Headquartered in Washington, D.C., the EPA's purpose is to protect human health and the environment by writing and enforcing regulations based on laws passed by the U.S. Congress.

FRA **Federal Railroad Administration**
https://www.fra.dot.gov/Page/P0001
The FRA is an agency within the U.S. Department of Transportation providing oversight and regulation for intermodal rail transportation. The FRA's mission to ensure standards are established and followed for the safe, reliable, and efficient movement of people and goods.

MUTCD **Manual on Uniform Traffic Control Devices**
https://mutcd.fhwa.dot.gov/kno-overview.htm

A result of years of collective experiences and research, The Manual on Uniform Traffic Control Devices (MUTCD) provides minimum standards and guidance for traffic control devices across the United States. The standardization provides consistency in traffic control devices (TCDs) which in turn helps to improve transportation systems while reducing accidents. Uniformity also helps reduce the cost of TCDs through standardization.

NEC **The National Electrical Code**

www.necconnect.org

Adopted in all 50 states, the NEC is the benchmark for safe electrical design, installation, and inspection to protect people and property from electrical hazards. The NEC addresses the installation of electrical conductors, equipment, and raceways; signaling and communications conductors, equipment, and raceways; and optical fiber cables and raceways in commercial, residential, and industrial occupancies. While not a U.S. law, NEC use is commonly mandated by state or local law. The authority having jurisdiction inspects for compliance with these minimum standards.

NIST **National Institute of Standards and Technology**

https://www.nist.gov/

A non-regulatory agency of the United States Department of Commerce, the NIST is a measurement standards laboratory providing programs for the promotion of industrial standards, competitiveness, and innovation. The NIST provides over 1300 standard reference materials to a variety of users. These standards are important for benchmark quality control and the measurement of equipment and procedures.

NFPA **National Fire Protection Association**

www.nfpa.org

NFPA is an American organization charged with creating and maintaining minimum standards and requirements for fire prevention and suppression activities, training, and equipment, as well as other life-safety codes and standards. This includes the creation of NFPA 70, the National Electrical Code (NEC).

NTSB **National Transportation Safety Board**

https://www.ntsb.gov/Pages/default.aspx

An independent Federal agency, the NTSB is responsible for investigating every civil aviation accident the United States as well as other accidents in railroad, highway, marine and pipeline forms of transportation. As part of the investigation,

a probable cause(s) for the accidents is identified and subsequent safety recommendations are developed to help prevent the same accident from recurring.

OSHA **Occupational Safety and Health Administration**
www.osha.gov
OSHA is an agency of the United States Department of Labor whose mission is to assure safe and healthful working conditions for working men and women by setting and enforcing standards and by providing training, outreach, education and assistance.

OSHA regulations are often described as the "Shall" and NFPA (NEC) as the "How" for electrical safety in the workplace. APTA, of which the participant's agency is a member, suggests minimum standards by which its member organizations should meet. Most transit organizations exceeds these safety and operational standards which ensures worker and passenger safety on and around rail vehicles.

Rail vehicle technicians will often hear terms used in their agency as related to the use of the vehicle when in service. These terms often interrelate to inspection, maintenance and repair work being completed. Standard definitions offered by APTA for some of these terms are included below.

Average Speed of a vehicle is the miles it operated in revenue service divided by the hours it is operated in revenue service.

Miles of Track is a measure of the amount of track operated by rail systems where each track is counted separately regardless of the number of tracks on a right-of-way.

Revenue Service is the operation of a vehicle during the period which passengers can board and ride on the vehicle. Revenue service includes the carriage of passengers who do not pay a cash fare for a specific trip as well as those who do pay a cash fare; the meaning of the phrase does not relate specifically to the collection of revenue.

Revenue Vehicle is a vehicle in the fleet that is available to operate in revenue service carrying passengers, including spares and vehicles temporarily out of service for routine maintenance and minor repairs. Revenue vehicles do not include service vehicles such as tow trucks, repair vehicles, or automobiles used to transport employees.

Running Rails are the two rails of the track upon which the wheels of the train rest and which provide the guidance for the train.

Vehicles Available for Maximum Service are vehicles that an agency has available to operate revenue service regardless of the legal relationship thorough which they are owned, leased, or otherwise controlled by the agency. Also called **revenue vehicles owned or leased**.

Vehicles Operated Maximum Service is the largest number of vehicles operated at any one time during the day, normally during the morning or evening rush hour periods.

Vehicle Total Miles are all the miles a vehicle travels from the time it pulls out from its garage to go into revenue service to the time it pulls in from revenue service, including "deadhead" miles without passengers to the starting points of routes or returning to the garage. For conventional scheduled services, it includes both revenue miles and deadhead miles.

Vehicle Revenue Miles are the miles traveled when the vehicle is in revenue service (i.e., the time when a vehicle is available to the general public and there is an expectation of carrying passengers). Vehicles operated in fare-free service are considered in revenue service. Revenue service excludes school bus service and charter service.

Vehicle Total Hours are the hours a vehicle travels from the time it pulls out from its garage to go into revenue service to the time it pulls in from revenue service, including "deadhead" miles without passengers to the starting points of routes or returning to the garage. For conventional scheduled services, it includes both revenue time and deadhead time.

Vehicle Revenue Hours are the hours traveled when the vehicle is in revenue service (i.e., the time when a vehicle is available to the general public and there is an expectation of carrying passengers). Vehicles operated in fare-free service are considered in revenue service. Revenue service excludes school bus service and charter service.

For more terms or additional information provided by APTA, visit http://www.apta.com/resources/statistics/Pages/glossary.aspx.

Classroom Activity

With assistance from your instructor, list and describe other common acronyms and/or common terms used in your agency but not mentioned above.

1-2 THE RAIL VEHICLE

The rail vehicle is the portion of the train system which transports people or goods from one location to another. In transit, the rail vehicle typically transports people and not goods as freight. The photo shown in Figure illustrates a rail vehicle in Dallas Area Rapid Transit (DART). The larger photo shows the rail vehicle from the outside and smaller insert photo shows the inside area of rail vehicle where people stand or sit during transportation.

Figure 1.1 Rail Vehicle. Courtesy of DART

The diagram below illustrates the various areas and equipment contained in the rail vehicle as introduced later in this course and then fully explained in subsequent later courses to follow: car body parts, doors, lighting, electrical systems, mechanical systems, comfort systems, pneumatic systems, hydraulic and suspension systems, and communication-based train control (CBCT). Areas of the rail vehicle related to these course sections include the trucks, battery, propulsion, auxiliary equipment box, low voltage power supply, auxiliary power, truck brakes, friction brake

system, coupler, carbody and articulation, pantograph, cab equipment, auxiliary, DC power supply, Cab heat/defrost/demist, PA/IC, ATP, and VBS.

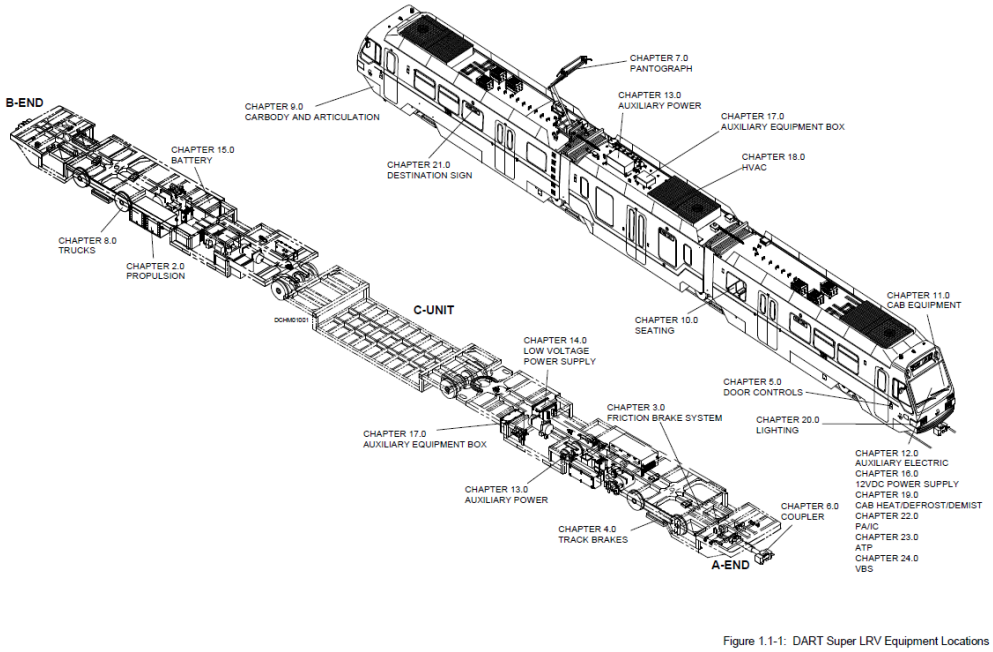

Figure 1.1-1: DART Super LRV Equipment Locations

Figure 1.2 Rail Vehicle Areas and Equipment . Courtesy of DART

The Rail Vehicle Dynamic Envelope

Prior to recent revitalization of urban and metropolitan railways, very little thought was given to the area around the moving rail vehicle. However, with advancements in sciences and increasingly busier roads and rails, this area of the rail vehicle has become an increasingly important element of the rail vehicle itself as well as for traffic control considerations.

The rail vehicle **dynamic envelope**, or kinematic envelope, is the clearance required for a train and its cargo to overhang due to any combination of loading, lateral motion, or suspension failure. The dynamic envelope speed and specs will vary between properties and rail vehicles themselves. Rolling stock engineers in train design are responsible for ensuring the train does not impose on the space the train may occupy.

Figure 10C-7. Light Rail Transit Vehicle Dynamic Envelope

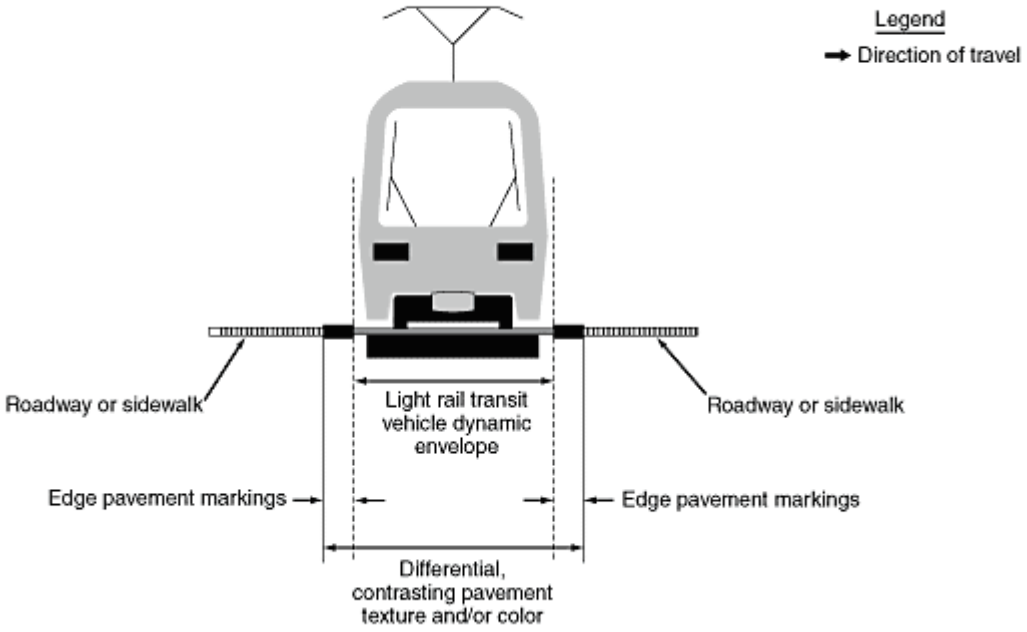

Figure 1.3 Train Dynamic Envelope. Source: Federal Highway Administration

This clearance is also most commonly known as represented on roadways at highway grade crossings by traffic markings near rail tracks indicating the maximum space required for any rail vehicle dynamic envelope as recommended by the **Manual on Uniform Traffic Control Devices for Streets and Highways** (MUTCD) published by the Federal Highway Administration. These markings offer guidance to drivers of roadway vehicles on stopping distance from the tracks to allow maximum room for train passage over the grade crossing. Markings on roads are studied and carefully considered regarding the dynamic envelope and reduction of instances of stopped vehicles in the envelope zone.

In the rail vehicle maintenance shop environment, as later described, the rail dynamic envelope is important for moving trains in and out of shop and ensuring proper clearances.

Figure 1.4 Rail Vehicle being Moved out of Shop. Courtesy of SFMTA

Civil engineers working to ensure the passage of trains is kept clear along the route of a railway will impose a "**structure gauge**" representing the dynamic envelope which helps to creates limits for building inside the area where trains pass. This building limit includes not only things like walls, bridge sand columns but also pipes, cables, brackets and signal posts. The structure gauge will vary according to maximum speeds allowed and the curvature of the rail line.

From time to time, and especially if new trains are being introduced, the structure gauge must be inspected to ensure the train passage path remains clear for the intended trains. Once done by hand, modern gauging is typically done by fitting trains with optical or laser equipment. Any breaks in the light beam will be recorded by mounted cameras.

1-2 RAIL CLASSES

Rail vehicles are organized by class, or type depending on their construction and use. Major types of rail passenger transportation for the purpose rail vehicle consortium courses include street car / light rail, subway, commuter rail, Amtrak / Intercity rail, and high-speed rail.

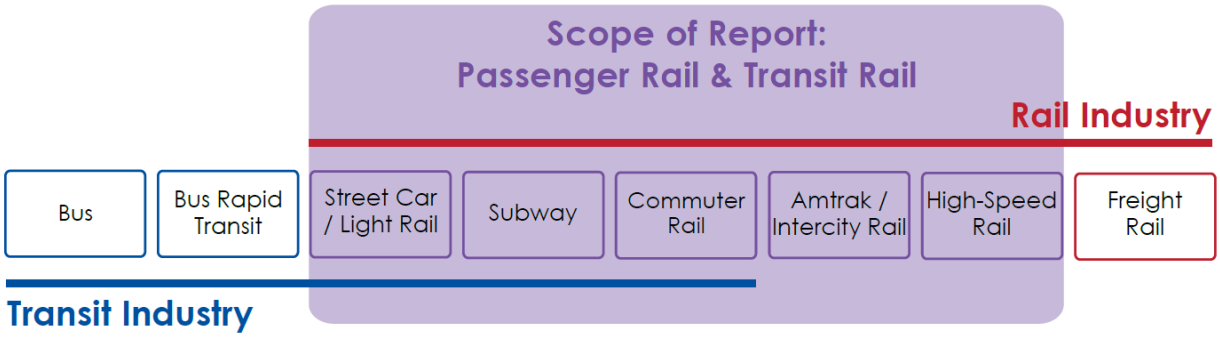

Figure 1.5 Scope of Rail Systems - ©Blue Green Alliance

Mode is a system for carrying passengers described by specific right-of-way, technology, and operational features.

Light Rail is a mode of rail service that operates using either single, two or three vehicle passenger trains. Rails in this system are fixed and found in right-of-way and separated from other traffic. Light rail vehicles are usually on-board operator-driven and electrically powered from an overhead electric line via a trolley or a pantograph. Entering or exiting the rail vehicle is usually from a high platform loading area or from a low-level boarding area using steps.

Figure 1.6 CATS Light Rail Vehicle. Courtesy of CATS

Heavy rail, also known as the metro, subway, rapid transit, or rapid rail operates on an electric railway. Characterized by high speed and rapid acceleration, this type of transit has capacity for a heavy volume of passenger traffic. Rail vehicles are either single or multi-car trains on fixed rails. Right-of-way is separated from all road vehicle and pedestrian traffic. This type of rail requires sophisticated signaling. Boarding generally occurs on a high platform loading area.

Figure 1.7 Heavy Rail. Courtesy of WMATA

Another mode of rail service is called **commuter rail**. Commuter rail is also sometimes known as metropolitan rail, regional rail, or suburban rail. This type of service used an electric or diesel electric railway for passenger trains. Operating on a regular basis, service consists of local short distance travel operating between a central city and adjacent suburbs with usually only one or two stations in the central business district. Intercity rail service is excluded, unless under contract with a public agency for predominantly commuter services. In many cases, this type of rail shares rail and routes with current or former freight railroads.

Figure 1.8 Commuter Rail. Courtesy of MBTA

Intercity rail services are express passenger train services that cover longer distances usually across several states is generally covers a larger geographic area than commuter or regional trains. Amtrak is an example of intercity rail service.

Figure 1.9 Intercity Rail. Source: Amtrak Northeast Corridor

Starting with Japan's bullet train in 1964 and operating faster than traditional rail traffic, **high-speed rail** uses an integrated system of specialized rolling stock and dedicated tracks. While there is no single standard that applies worldwide, new lines more than 160 miles per hour and existing lines more than 120 miles per hour are generally seen as high-speed. Some instances where lower speeds are still viewed as a significant upgrade may also be considered high speed rail. Rail vehicles in this system normally operate on standard gauge tracks of continuously welded rail located on grade-separated right-of-way.

Figure 1.10 Japanese High-Speed Rail. Source: Fernquest

Other Systems

Cable Car is a railway with individually controlled vehicles that are attached to a moving cable that is located below the street surface and powered by engines or motors at a central location not on board the vehicle.

Figure 1.11 Cable Car . Courtesy of SFMTA

Also known as a trolley coach, **the trolleybus** uses vehicles propelled by a motor drawing current from overhead wires via connecting poles. These poles are called a trolley poles and provide power from a central power source not on board the vehicle.

Figure 1.12 SFMTA Trolleybus, Courtesy of SFMTA

Automated guideway transit is sometimes also called personal rapid transit, group rapid transit, or people mover. This mode of transit is an electric railway using single or multi-car trains of guided transit vehicles. This system operates without an onboard crew and usually operates on a fixed schedule or by a passenger activated call button.

Figure 1.13 BART Automated Guideway Transit . Courtesy of BART

Inclined Plane is a railway operating over exclusive right-of-way on steep grades (slopes) with powerless vehicles propelled by moving cables attached to the vehicles and powered by engines or motors at a central location not on board the vehicle. The special tramway type of vehicles has passenger seats that remain horizontal while the undercarriage (truck) is angled parallel to the slope.

Figure 1.14 Inclined Plane in Johnstown, Pennsylvania. Source: Petrochko

For more information on other rail classes not addressed in Course 100
http://www.apta.com/resources/statistics/Pages/glossary.aspx.

Classroom Activity

With assistance from your instructor, list and describe the type of rail system or systems used in your agency.

_____

_____

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1-3 OVERVIEW OF RAIL CAR MAINTENANCE ENVIRONMENT

Most of the time, a rail vehicle is on tracks moving from place to place to transport people or goods. When taken out -of-service, a rail vehicle will require special facilities for storage and maintenance. A typical layout for storage and maintenance of rail vehicles consists of a storage train yard, an inspection and running repair area, a heavy maintenance shop, the car cleaning bay or platform, and a paint bay and/or area.

The Train Yard

The train yard is an area to store out-of-service trains waiting for maintenance and repair or to be placed into service. A train is moved into this area by its own power or will either be pushed or pulled by another rail car with multiple rail cars coupled together.

Figure 1.15 shows the Kimball Yard in CTA's rail system. Three tracks entering and exiting the train yard and maintenance areas are indicated by "Yard Lead Track", N.B (north bound) Main, S.B (south bound) Main. The two maintenance shops adjacent to the train yard are connected via rails. **Pocket tracks**, tracks that are physically separate from revenue or normal maintenance tracks and intended to be a holding/parking area for rail cars that aren't currently in revenue service or having maintenance performed on it, are adjacent to the maintenance shop. A **test track**, a track used for ensuring the train is ready for service after any work is completed, is between the maintenance shop and train yard.

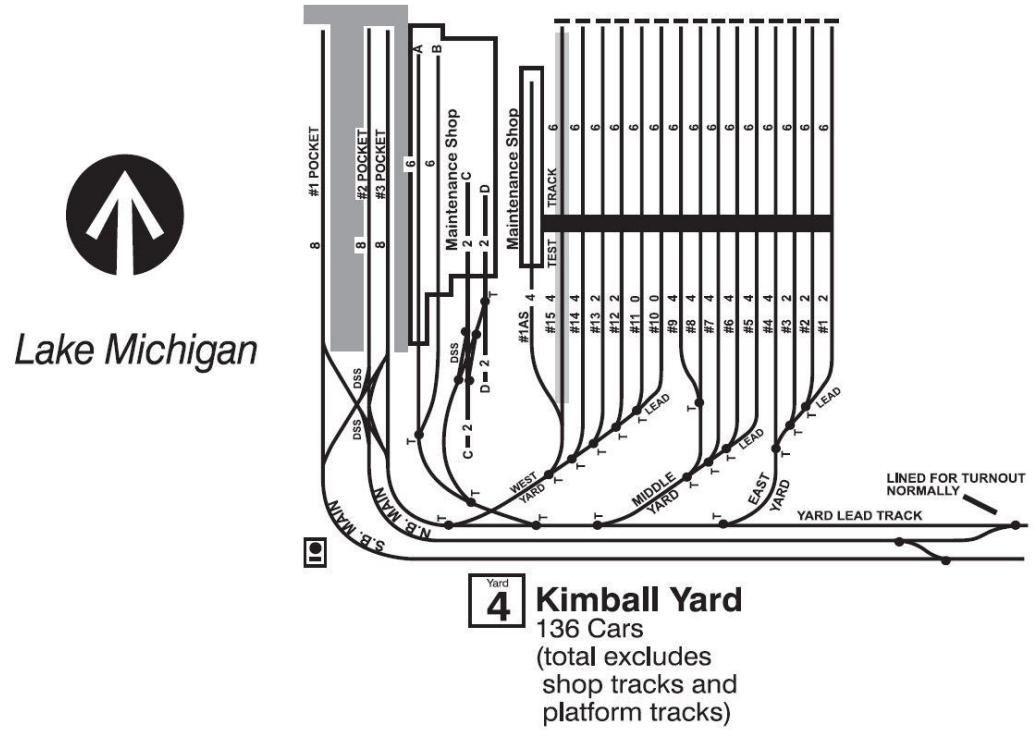

Figure 1.15 Diagram of a Train Yard. Courtesy CTA

Figure 1.16 Light Rail Trains Waiting for Maintenance, Courtesy of Denver RTD

Figure 1.17 Train Yard . Courtesy of Denver RTD

The Maintenance Shop

The shop is where rail vehicle maintenance takes place. Various types of and layouts of shops exist including a body shop, an inspection and light maintenance shop area where running repair takes place, a heavy repair maintenance shop area, a parts room, a paint bay, and a wash bay.

A **body shop** is where inspection, preventive maintenance, diagnostics, troubleshooting and repair take place. A **running repair** area is where a vehicle can be serviced with little interruption.

Figure 1.18 Signage Alerting of Running Repair Work being Completed. Courtesy of SFMTA

Figure 1.19 Running Repair Shop. Courtesy of Denver RTD

Heavy repair facilities typically look like body shops, only these facilities are dedicated to mid-life overhauls which may include, but are not limited to, replacing floors, replacing components, sanding down the vehicle for repainting, pressing wheels on axles, and repairing brake components and systems.

Figure 1.20 below shows an area of track where a rail vehicle would be rolled in from the outside for temporary service. A **truck turntable**, as indicated, allows for one truck to be turned at a time within the shop. A **truck** consists of one set of wheels and one or two motors. Depending on the location, two or three trucks may make up a rail vehicle. Some motors may be unpowered. Turntables may be found in heavy and running repair maintenance areas.

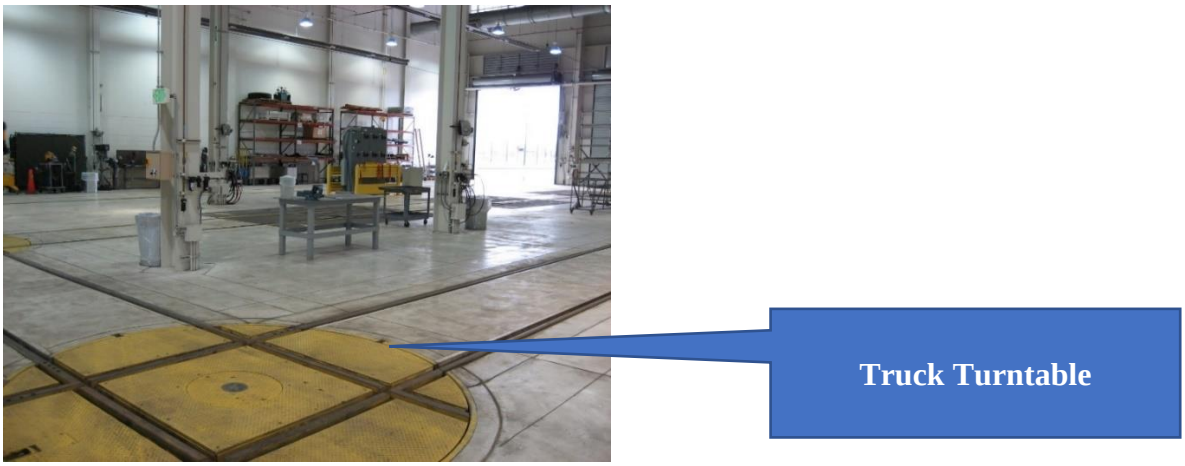

Figure 1.20 Truck Turntable. Courtesy of Denver RTD

Pit areas consist of open areas below grade and below the rail vehicle allowing maintenance technicians to access the areas underneath the rail vehicle for running repair, overhaul, etc. In the figure below, rail vehicles are parked above maintenance shop pits so that maintenance technicians have access to the underside of the vehicles. Signs are usually placed in these areas alerting of the work being completed and the need to wear appropriate Personal Protective Equipment (PPE) such as safety vests, safety glasses, etc.

Figure 1.21 Maintenance Shop Pits. Courtesy of Denver RTD

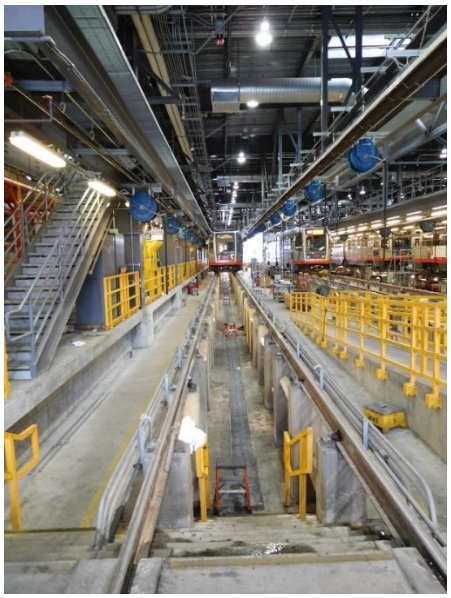

Figure 1.22 Maintenance Pit Area. Courtesy of SFMTA

A **wheel lathe**, as shown in the figure below, is an area where wheels are cut or measured and shaped to achieve optimum contact with the rail when put back into service.

Figure 1.23 Wheel Lathe. Courtesy of SFMTA

Figure 1.24 Wheel Lathe. Courtesy of SFMTA

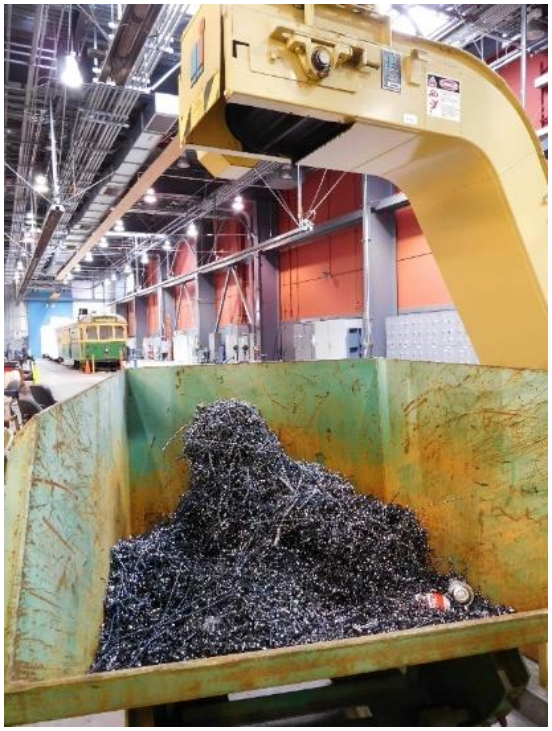

Figure 1.25 Wheel Lathe. Courtesy of SFMTA

Figure 1.26 Wheel Lathe. Courtesy of SFMTA

The **Direct Current (DC) disconnect** is the shop power supply for overhead and third rail power. Sometimes painted yellow, the DC disconnect is contained in a large box. A de-energize or energize switch to electronically open or close the switch for overhead power or third rail is contained within the box.

Figure 1.27 DC Disconnect. Courtesy of DART

Figure 1.28 DC Disconnect Side View. Courtesy of DART

A **parts room** is a room containing parts for rail vehicles. These rooms are typically located near the shops with controlled access measures in place to safeguard inventory of parts and equipment. Parts are organized for each agency and shop need.

Figure 1.29 Maintenance Parts Room. Courtesy of Denver RTD

Figure 1.30 Maintenance Parts Room. Courtesy of Denver RTD

A **paint bay** is an area where the rail vehicle may be painted. Most often, paint bays are used for touch-up paining, but sometimes they can be used to paint an entire rail car.

Paint bays have environmental controls for proper ventilation. Additionally, paint bays do not include additional rail vehicle power sources such as cantilevers or third rail power to keep the paint bays free from additional heat sources. Thus, rail vehicles entering or exiting the paint bay are typically pushed in or pulled out of the bay by a supporting rail vehicle.

Figure shows an area of a paint bay used for the painting of rail vehicle parts, such as bumpers and doors.

Figure 1.31 Paint Bay Area for Smaller Parts.
Courtesy of Denver RTD

A **cleaning bay**, or sometimes known as wash bay, is typically located on a separate track from maintenance pits and shops as well as away from paint bays. Cleaning bays provide an area where rail vehicles are cleaned on the outside before leaving the maintenance shop and being placed back in service.

Figure 1.32 Wash Bay. Courtesy of Denver RTD

Another area of the shop sometimes for cleaning is sometimes referred to as a **blow down pit**. This area serves two primary purposes: To allow access to the roof of the railcar for maintenance work as well as the cleaning of the interior areas of the vehicle and/or exterior if not scheduled for wash bay cleaning.

Figure 1.33 and 1.34 below show a blow down pit with Figure 1.33 showing the overhead walkways for top of vehicle access and Figure 1.34 showing the lower access and pit area with cleaning equipment available on either side of the tracks.

Figure 1.33 Blow Down with Pit Area. Courtesy of Denver RTD

Figure 1.34 Blow Down Area. Courtesy of SFMTA

Maintenance Shop Headquarters

The maintenance shop headquarters, or main office, is where administrative type activities are completed. These may include the tracking and/or management of rail vehicle movement in the shop and train yard areas; the location of time cards, OEM manuals, computerized shop-related resources, current OEM or agency bulletins for ongoing training purposes, Sometimes, manual

and other resources important for rail vehicle maintenance may also be kept in various locations around the shop. A yard master, someone who orchestrates and moves cars and trains in shop and yard, may also work in this office.

Figure 1.35 SFMTA Employee Managing the Movement of Rail Vehicles in and Around the Shop Areas. Courtesy of SFMTA

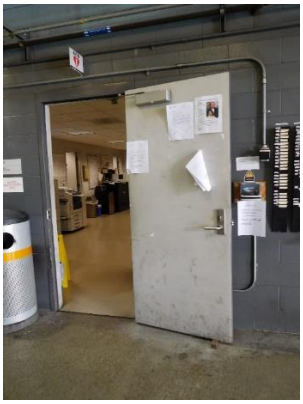

Figure 1.36 Maintenance Shop Headquarters in SFMTA. Courtesy of SFMTA

Central Support

Central support is the central location and office where all stations, vehicles, and maintenance shops communicate through. The location of all rail vehicles, power supply and other information are displayed on connected computer screens across the office wall(s) in a map-style presentation. Yard masters communicate with central support regarding the movement of all vehicles.

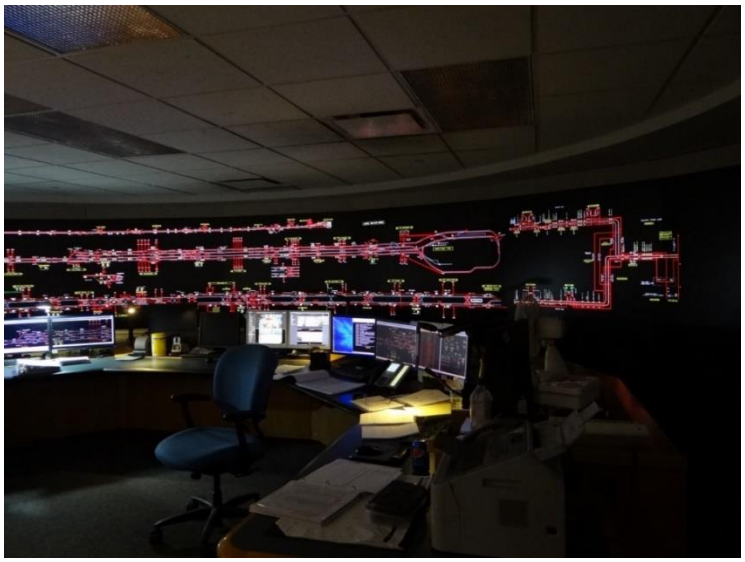

Figure 1.37 Central Support. Courtesy of SEPTA

Classroom Activity

With assistance from your instructor, list and describe the areas in and around the rail vehicle maintenance shop in your agency.

1-5 SUMMARY

Rail vehicle maintenance is a complex job involving knowledge of interrelated parts and systems that make up the rail vehicle and its environment. Understanding these inter-related parts and systems along with their respective hazards and concerns is key to ensuring the most effective inspection, maintenance and repair work is completed in the safest manner possible. Module 1 explored basic terminology, a general introductory overview of the rail vehicle, oversight agencies, and the maintenance shop environment for the new rail vehicle mechanic. While this course provides general guidelines, every agency also establishes its own safety procedures for working on rail vehicles. It is critical for every rail vehicle mechanic and anyone else working in or around a rail vehicle maintenance shop know their agency's procedures and guidelines.

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MODULE 2

VEHICLE WORKER PROTECTION AND SHOP SAFETY

Outline

Purpose and Objectives

The purpose of this Module is to provide participants with an overview of the principles of rail vehicle worker protection and shop safety.

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

- Identify general rail car PPE.
- Identify shop and yard hazards and related safety.
- Identify emergency response resources.
- Explain the importance of a job safety briefing.
- Identify methods for and explain importance of housekeeping.

Key Terms

- Approach boundary
- Arc blast
- Arc flash
- Automatic external defibrillator (AED)
- Bump cap
- Catwalk
- Defective equipment
- Emergency cutout switch
- Emergency evacuation plan
- Exposed
- Eye wash station
- Fire alarm system
- Flash protection boundary
- General first aid kit
- Grounding
- Hard hat
- HazMat spill kit
- High visibility vest
- Housekeeping
- Insulation
- Job hazard analysis
- Job safety briefing
- Mushrooms
- Personal protective equipment
- Pinch point
- Potential electrical hazard
- Zero energy state

2-1 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. This Module explores safety in a general as well as safety specific for rail maintenance and repair work in terms of personal protective equipment, shop hazards, emergency response resources, job safety briefings, and housekeeping methods and guidelines.

Warning: Safety Precautions!

Follow all agency-specific policies, bulletins, rules and procedures.

2-2 RAIL VEHICLE PERSONAL PROTECTIVE EQUIPMENT (PPE)

Hazards exist in every workplace in many different forms: sharp edges, falling objects, flying sparks, chemicals, noise and a myriad of other potentially dangerous situations. The Occupational Safety and Health Administration (OSHA) requires employers to protect their employees from workplace hazards that can cause injury.

Controlling a hazard at its source is the best way to protect employees. Depending on the hazard or workplace conditions, OSHA recommends the use of engineering or work practice controls to manage or eliminate hazards to the greatest extent possible. For example, building a barrier between the hazard and the employees is an engineering control; changing the way in which employees perform their work duties is a work practice control.

When engineering, work practice and administrative controls are not feasible or do not provide sufficient protection, employers must provide personal protective equipment (PPE) to their employees and ensure its use. Personal protective equipment, commonly referred to as "PPE", is equipment worn to minimize exposure to a variety of hazards. Examples of PPE include such items as gloves, foot and eye protection, protective hearing devices (earplugs, muffs), hard hats, respirators and full body suits.

OSHA Standard **1910.132(a)** states that protective equipment, including protective equipment for eyes, face, head, and extremities, protective clothing, respiratory devices, and protective shields and barriers, shall be provided, used, and maintained in a sanitary and reliable condition whenever it is

necessary by reason of hazards or processes or environment, chemical hazards, radiological hazards, or mechanical irritants encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation or physical contact.

The following chart shows a general list and common symbols for PPE.

Personal Protective Equipment

Protective equipment, including personal protective equipment for eyes, face, head, and extremities, protective clothing, respiratory devices, and protective shields and barriers, shall be provided, used, and maintained in a sanitary and reliable condition wherever it is necessary by reason of hazards of processes or environment, chemical hazards, radiological hazards, or mechanical irritants encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation or physical contact.

 SAFETY GLOVES	General requirements. Employers shall select and require employees to use appropriate hand protection when employees' hands are exposed to hazards such as those from skin absorption of harmful substances; severe cuts or lacerations; severe abrasions; punctures; chemical burns; thermal burns; and harmful temperature extremes.
 HARD HAT	Employees should wear a protective helmet when working in areas where there is a potential for injury to the head from falling objects. A protective helmet designed to reduce electrical shock hazard is worn by each such affected employee when near exposed electrical conductors which could contact the head.
 FACE PROTECTION	Uses appropriate eye or face protection when exposed to eye or face hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation.
 SAFETY SHOES	General requirements. The employer shall ensure that each affected employee uses protective footwear when working in areas where there is a danger of foot injuries due to falling or rolling objects, or objects piercing the sole, and where such employee's feet are exposed to electrical hazards.
 EYE PROTECTION	Uses appropriate eye when exposed to eye hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation. The employer shall ensure that each affected employee who wears prescription lenses while engaged in operations that involve eye hazards wears eye protection that incorporates the prescription in its design, or wears eye protection that can be worn over the prescription lenses without disturbing the proper position of the prescription lenses or the protective lenses.
 HEARING PROTECTION	Always wear proper hearing protection when working around machinery, drilling and grinding.
 DUST PROTECTION	Proper respiratory protection must be used at all times. The employer shall select and provide an appropriate respirator based on the respiratory hazard(s) to which the worker is exposed and workplace and user factors that affect respirator performance and reliability in order help prevent those occupational diseases caused by breathing air contaminated with harmful dusts, fogs, fumes, mists, gases, smokes, sprays, or vapors, the primary objective shall be to prevent atmospheric contamination
 OVERALLS	General requirements. Employees exposed to the hazards created by welding, cutting, or brazing operations shall be protected by personal protective equipment Appropriate protective clothing required for any welding operation will vary with the size, nature and location of the work to be performed.
 SAFETY HARNESS	Personal fall arrests are one way to protect workers from falls. In general workers must use fall protection when they could fall 6 feet or more while they are working. The three main parts of the fall arrest are the anchor, the connecting lanyard or line and the full body harness. Ensure your safety harness lanyard does not cause a catching or tripping hazard.
 LOCKOUT/ TAGOUT PROCEDURES	"Lockout/Tagout (LOTO)" refers to specific practices and procedures to safeguard employees from the unexpected energization or startup of machinery and equipment, or the release of hazardous energy during service or maintenance activities.

To ensure the greatest possible protection for employees in the workplace, the cooperative efforts of both employers and employees will help in establishing and maintaining a safe and healthful work environment.

Employer Responsibility

The employer is responsible to assess the workplace to determine if hazards are present, or are likely to be present, which necessitate the use of PPE. If such hazards are present, or likely to be present, the employer shall:

- Select, and have each affected employee use the type of PPE that will protect the affected employee from the hazards identified in the hazard assessment.
- Communicate selection decisions to each affected employee.
- Select PPE that properly fits each affected employee.
- Verify that the required workplace hazard assessment has been performed through a written certification that identifies the workplace evaluated; the person certifying that the evaluation has been performed; the date(s) of the hazard assessment; and, which identifies the document as a certification of hazard assessment.

Employee Responsibility

The employee 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.

PPE Training

The employer shall provide training to each employee who is required to use PPE. Each employee shall be trained to know at least the following:

- When PPE is necessary.
- How to properly don, doff, adjust, and wear PPE.
- The limitations of the PPE.
- The proper care, maintenance, useful life and disposal of the PPE.
- Defective or damaged PPE shall not be used.

Each affected employee shall demonstrate an understanding of the training received, and the ability to use PPE properly, before being allowed to perform work requiring the use of PPE.

When the employer has reason to believe that any affected employee who has already been trained does not have the understanding and skill required to properly and effectively utilize the PPE, the employer shall retrain each such employee. Circumstances where retraining is required include, but are not limited to, situations where:

- Changes in the workplace which renders previous training obsolete.
- Changes in the types of PPE to be used which renders previous training obsolete.
- Inadequacies in an affected employee's knowledge or use of assigned PPE indicate that the employee has not retained the requisite understanding or skill.

Rail Vehicle PPE

While PPE used in rail vehicle maintenance may vary depending on each type of maintenance or repair work completed, general PPE used in most rail vehicle PPE will be described in this section. PPE required for each specialized area of rail vehicle maintenance tasks will be described later in individual courses where applicable.

General rail vehicle maintenance PPE may include, but not limited to, protection for the following areas of the body:

- General head protection;
- Face, eye, ear and respiratory protection;
- Limb protection;
- General body protection; and
- Other.

All rail vehicle maintenance personnel should ensure that their PPE, protective clothing, respiratory devices, and protective shields are used and maintained in a sanitary and reliable condition. Always carry your personal protective equipment with you. If you don’t have the proper PPE or the PPE is not in reasonable form or shape for use and protection, contact your supervisor before commencing work.

General Head Protection

General head protection includes protection for the top and sides of the head including the ears. For rail vehicle maintenance, general head protection may include but is not limited to hardhats and bump caps.

A **hardhat**, or sometimes known as a safety helmet, protects the head from possible falling objects or to reduce the risk of electrical shock hazards. Hardhats should be worn when working or walking beneath an overhead structure, when working on all right-of-way’s, while working near or around

electrical conductors that could encounter the head, while in areas where hardhat protection is require and posted, or when instructed by supervisors or management.

Hardhats for the protection of falling objects shall be Type 1, Class E per ANSI Z89.1-1997 (or latest) and shall be in compliance with OSHA 1926.100 and 1910.135 for electrical shock protection purposes.

Another type of head protection used in rail vehicle maintenance is a **bump cap**. A bump cap is a plastic protective cap that protects the head when there is a possibility of striking the head against a hard, stationary object or to reduce the risk of exposure to abrasions or lacerations. Bump caps are typically used for the repair and maintenance work under rail vehicles, while in areas where bump cap protection is required as posted, and when instructed by supervisors or management.

Wearing hardhats and bump caps properly is important as improper use may offer little, if any, protection. Any protective helmet should be inspected prior to use to ensure the suspension system supporting the shell of the helmet is undamaged. Protective helmets with cracks or severe dents should be replaced. Rail vehicle maintenance technicians should also be avoid wearing anything under the protective helmet that may impair vision or a proper fit. Often, protective helmets are color coded according to purpose. For example, a yellow protective helmet may be worn by shop trades without right-of-way functions and a white protective helmet may be worn by managers or supervisors.

Figure 2.1 Hardhat for a Supervisor in CTA as Indicated by Yellow. Courtesy of CTA

Figure 2.2 Hardhat for a Shop Maintenance Employee in CTA as Indicated by White. Courtesy of CTA

Face, Eye, Ear and Respiratory Protection

A variety of hazards to the eyes, ears and face exist in the rail vehicle shop environment. Proper PPE for each of these areas must be used when these hazards exist.

Eye Protection: Eye protection should be worn almost all the time, but especially when working overhead, when grinding, or when using chemicals or cleaners. Other work processes and environmental hazards can also cause injury, including drilling, chiseling, babbiting, welding, a dusty and windy atmosphere, etc. and eye protection should also be used in these instances as well.

To determine the correct eye and face protection, a hazard assessment should be conducted to ascertain which of several eye hazards exists for each job.

Prior to any work completed, a rail vehicle technician should find the suitable eye protection for potential hazards and confirm with their supervisor before proceeding. Maintenance and repair work requiring specific eye protection will be covered later in the course in the respective modules.

Figure 2.3 Safety Glasses or Goggles

Figure 2.4 Full Face Shield

Contact lenses should not be used when working around face or eye hazards, and instead, prescription safety glasses should be used. Observe warning labels referring to specific manufacturers' safety procedures and precautions.

Hearing Protection: Some rail vehicle work can create situations where hearing may be impacted. Thus, PPE for hearing protection should be considered in these instances. Hearing protection may include devices such as earplugs or muffs depending on your transit agency and tasks to be performed. Hearing protection is required in wheel dismount areas, wash rooms, and pressure washers, air test room, or in any situation that may exceed certain decibel limits as determined by each agency as well as OSHA oversight.

Figure 2.5 General Hear Protection

Figure 2.6 Disposable Ear Plugs for Hearing Protection. Courtesy of SFMTA

Respiratory Protection: Respiratory protection devices should be worn when working in an environment where you will be exposed to hazardous concentrations of dust, fumes, mists, gases, smoke, sprays, or vapors. Different levels of respiratory protection exist for different types of work Possible types of respiratory protection for rail vehicle work may include regular cloth masks, fitted masks, and portable breathing machines. Any respiratory protection device should be approved by the National Institute for Occupational Safety and Health (NIOSH). Always read the instructions on how to properly use your respirator or, if possible, attend a training session on their proper use. When in doubt whether to wear a respirator, contact you supervisor for clarification.

Limb Protection

Limb protection is the protection of the body's extremities including hands, arms, feet and legs.

Hand Protection: Wearing gloves should be worn to protect your hands from being burned or cut. Gloves give an added layer of protection that is needed when a rope slips through your hands, when something hot needs to be moved, or when something with sharp edges needs to be held. Proper hand protection is also needed when handling chemicals that can be absorbed through the skin, when working with some batteries, or during work that involves potential exposure to electrical hazards.

Gloves should NOT be worn when working near moving machinery.

Figure 2.7 Hand Protection. Courtesy of ELES Consortium

Figure 2.8 Safety Gloves for Electrical or Battery Work. Courtesy of ELES Consortium

Foot protection: The protection of feet is accomplished by selecting the appropriate footwear, or shoes or boots, for working on the shop floor or other field locations such as the train yard. Footwear must protect from sharp objects. Generally, footwear should be non-slip and use shoe laces. Heals should be not reach higher than 1 inch, and soles should not be over 3/8 inch thick. For rail operations, heels must be a distinct 90°.

Steel-toed shoes should be used if there is a possibility that something might accidentally fall on the toes causing them to be injured or even severed. Although these boots are heavy and sometimes uncomfortable, they are worth wearing if they can save you from severe foot injuries. If there is a possibility of an electrical hazard, it is recommended to wear ANSI-approved I75/C75 steel-toed shoes or boots.

If out-of-doors work is required during winter months, then appropriate shoes or boots must be selected in accordance with the transit agency policy or recommendations.

Shoes that should not be worn under any circumstances include gym shoes, high heel shoes, slip on shoes, sandals, or shoes that do not contain a continuous sole.

NOTE: Always follow your agency policy regarding approved footwear.

Figure 2.9 Electrical Hazard Safety Shoes

Figure 2.10 Hard Toe Safety Shoes. Courtesy of ELES Consortium

Figure 2.11 Insulated Safety Boots. Courtesy of ELES Consortium

Other: Metal jewelry can conduct electricity and possibly get caught on moving parts. Therefore, rings and other jewelry should not be worn when working on rail vehicles.

Figure 2.12 Metal and Other Jewelry Should NOT be Worn

General Body Protection

General body protection includes protection of the body itself or protection of person to alert others of their presence. For rail vehicle maintenance and repair, general body protection incudes the use of high visibility safety vests or jackets and thermal protection against arc flash.

High Visibility Safety Vests: High visibility safety vests are typically required to be worn on the shop floor of any rail vehicle maintenance facility. These vests are critical in alerting of the presence of individuals in any area of the shop are or train yard.

If the possibility of exposure to momentary electrical arcing or flames could be present, then these vests should be standard flame resistance meeting the NFPA 701-99 standard or should be high flame resistance meeting the ASTM F1506-2000 standard. Both standard flame resistance and high flame resistance vests should meet applicable ANSI/ISEA 107-1999 standards for Class 2 high visibility vests including a minimum square inch of reflective stripping and background fabric material, reflective and washing performance, and should be tested in accordance with the ASTM D6413-99 method.

Figure 2.13 Standard Safety Vest Front View. Courtesy of CTA

Figure 2.14 Standard Vest Back View. Courtesy of CTA

Figure 2.15 High Flame Resistance Safety Vest Front View. Courtesy of CTA

Figure 2.16 High Flame Resistance Safety Vest Back View. Courtesy of CTA

Figure 2.17 Long-sleeved Safety Jacket used in Cooler Weather Conditions. Courtesy of SFMTA

Figure 2.18 Shop Sign for Safety Vest Requirements. Courtesy of SFMTA

Vests should be worn in compliance with all agency rules, SOP's and safety bulletins. Vests should not be altered in any way, and nothing should be worn over the vest. For cleaning vests, follow all washing instructions on the label in the vest or as indicated by the agency.

Thermal and Fire Protection: Arc or hazard rated clothing is required for anyone working with high voltage. Voltage levels requiring such clothing will vary among agencies. For instance, one agency may require arc or hazard rated clothing for any work completed above 50 volts while other agencies may require the clothing for work completed above 600 volts.

Most rail vehicle maintenance technicians and mechanics have arc rated clothing unless they are vehicle body technicians such as sanders, painters, etc.

Lifting Protection: Rail vehicle maintenance and repair can sometimes require the manual lifting of components or equipment that may be light, heavy, or awkward. While lifting may not require specific PPE, proper lifting methods will protect the worker and those around them from potential injury. Proper lifting methods will also make the work easier to perform.

Planning is the first step associated with safe material and equipment handling. Always think through any task prior to and decide steps to take to prevent potential injuries related to lifting.

Some simple rules apply to safe lifting:

- Slippery or dirty objects must be wiped off before lifting.
- Always plan your lift deciding the path ahead of time, ensuring the path is clear of any obstacles or hazards, inspecting your load for any potential hazards, and checking the weight of your load before lifting. If a load is potentially too large to lift, break the object down into smaller parts, get a co-worker, or utilize approparite equipment such as a lift or dolly to assist in the lift.
    - A two person lift works best when both people are similar in height, one person is in charge providing commandes, both people lift and rise at the same time, the load is kept level at all times, and both people unload at the same time.
- Before lifting, stretch to warm up your muscles, position the body close to and directly facing the load. Place feet flat on the floor in a staggered position and shoulder width apart. Your body will now be in a stable position to lift. Bend at the knees and hips, rather than the back, and utilize all joints to perform a lifting task. Don't stoop at the waist. Avoid lifting from the floor and instead lift from wasit level whenever possible.
- While lifting, keep the back straight at all times by remembering the basics: Head up, shoulders back, chest out, stomach and rear end in. Do not twist, especially while bending. Consider using a one knee kneeling lift (left knee down, right knee up).
- Relax your shoulders. Grip the load firmly. Tuck in your chin again to make certain that your back is straight before starting to lift.

- Use your body weight to start the load moving. Lift by pushing up with your legs. This makes full use of the strongest set of muscles.
- Keep your arms and elbows close to your body while lifting. Keep your elbows bent and your wrists straight. Balance the load between your arms and hands, then lift smoothly and gradually, bending your elbows at 90 degrees. This will allow the strongest arm muscles to work during the lift. Remember that strength decreases when the arms are fully extended.
- Carry the load close to your body. Don't twist your body while carrying the load. To change direction, shift your foot position and turn your entire body. Make sure that you can see over the load and move carefully to your destination.
- To lower the object, bend at the knees. Don't stoop at the waist. To deposit the load on a shelf or table, place it on the edge and push it into position with your arms and body. Make sure that your hands and feet are clear when placing the load.
- If pain or discomfort is felt at any time, always stop.
- Escalators should never be used to move equipment.

Figure 2.19 Proper Lifting Technique. Courtesy of ELES Consortium

For more information on proper lifting and recommended practices, see OSHA's web page, "Materials Handling: Heavy Lifting", at https://www.osha.gov/SLTC/etools/electricalcontractors/materials/heavy.html

Usage and Handling of Rail Vehicle PPE

PPE should always be verified as proper type intended work and inspected for quality and effective protection. If a rail vehicle technician through assessment determines PPE defective in any way, a supervisor should be consulted prior to PPE use.

PPE is to be changed in a designated area. The designated area will be equipped to handle any contaminated PPE.

Contaminated or used PPE should be removed and handled in the following order:

1) Vacuum your entire person with a HEPA vacuum using the brush attachment.

2) Move to an area designated as a PPE change area.

- Remove the outer disposable coverall.
- Remove the disposable booties.
- Remove gloves.

Do not shake clothes.

If the garment will be reused during that shift, hang it in the immediate area. If the garment will not be re-used during the shift, then dispose in the waste PPE trashcan. Roll coveralls as to ensure they fit into the trashcan without having to compact them. Disposable coveralls and gloves may be reused up to **one full week** if they are intact and cleaned after each use. Disposable booties may be reused up to **one shift** if they are intact and cleaned after each use.

Immediately proceed to a hand wash station and wash your hands and face.

No contaminated PPE shall be worn or carried into other areas of the facility, especially areas where hand-mouth activities occur such as lunch or break areas.

Personal PPE (such as safety glasses, boots, respirators, etc.) should be vacuumed or wet wiped daily after cleaning activities are performed.

Work uniforms should be collected and managed as per standard practice.

Workers are encouraged to shower daily as soon as arriving home. In some cases, rail vehicle technicians may be required to mandate daily showers prior to workers leaving the transit property.

In addition to following all federal and state guidelines regarding PPE, a rail vehicle maintenance technician should also always follow agency-specific guidelines and procedures for the use and care of PPE.

Classroom Activity

With the guidance of your instructor and as a class, list specific PPE used in your agency along with related agency-specific guidelines and procedures in the box below.

PPE Used in Your Agency	Agency-Specific Guidelines and Procedure

For more information on PPE, see OSHA's webpage at https://www.osha.gov/SLTC/index.html.

2-3 SHOP HAZARDS

Hazards exist in all types of work environments. A hazard is the potential for harm often related to a condition or activity that can result in injury or illness if not addressed. Recognizing the signs and understanding these hazards are very important in maintaining a safe environment for everyone. The figure below provides universal signs with corresponding explanations for general safety hazards that everyone should recognize and know for any work in any maintenance or industrial-type areas. These hazards are also found in most inspection, maintenance and repair environments, and particularly in the rail vehicle shop environment.

Warning Signs

	PINCH POINT HAZARD	Avoid pinch points when handling materials. Review dangers of pinch points and the procedures for working safely on a regular basis. Perform frequent, targeted inspections to ensure that guards are not missing and procedures are being followed.
	ELECTRICAL SHOCK	Follow all proper safety precautions when dealing with electrical systems, i.e., measuring, grounding, proper insulation, disconnects lockout/tagout, maintain safety circuits, dry environment around electrical equipment
	ROTATING EQUIPMENT HAZARD	Always make sure your clothing cannot become caught in rotating equipment. Keep shirt sleeves button and your shirt tucked into your trousers, remove loose rags from pockets, Ensure unit cannon start when access covers are removed. Always engage step band lock before entering the step band area.
	TRIPPING HAZARD	Keep from producing tripping hazards by adopting specific work methods toward that end. For example, you can make a habit of looing for tripping hazards every tie you set up your work zone. You can identify tripping hazards left by otheres and eliminate those hazards before an accident occurs. Look for the obvious, portable cords, lanyards, belts, harnesses, cover from equipment and electrical boxes. Prevent tripping hazards by thinking about the things which can create them.
	RISK OF FALLING	There are a number of ways to protect workers from falls including conventional systems such as guardrail systems, safety net systems and personal fall protection systems as well as through the use of safe work practices and training. The use of warning lines, designated areas, control zones and similar systems can provide protection by limiting the number of workers exposed and instituting safe work methods and procedures.
	LIFTING HAZARD	Lifting, loading, pushing and pulling may be part of your job. You may also perform tasks that require bending, twisting or stretching for long period of time. Injuries can be prevented by learning and the proper lifting and bending techniques. Before lifting anything ask yourself: Can the load be lifted by one person safely? Is it too awkward for one person to handle? Remember: tuck you pelvis, bend the knees, "hug" the load, avoid twisting, make sure your footing is firm and your path is clear. Use safe techniques when you set the load down.
	RISK OF FIRE	Clear work sites of any unnecessary materials or equipment to avoid fire hazards. Local safety codes and rules must be obeyed at all times. Watch for missing or broken fire safety equipment i.e. extinguishers, alarms, detectors, monitoring systems, etc. Be aware of volatile chemicals which should not be used in the workplace.
	DISPOSE OF OIL PROPERLY	Do not spill any oil on the ground. Put your used oil in a clean plastic or metal container with a tight lid. Never store used oil in a container that once held chemicals, food, or beverages. Do not mix the oil with anything else, such as antifreeze, solvent, or paint. Recycle used oil to your facility's location that collects used oil for recycling.

Job Hazard Analysis and Review

Identifying a potential workplace or job hazard(s) is critical in any job. It is important to identify and address existing or potential workplace or job hazards as early as possible, preferably before the start of any work to be completed, to prevent injury and/or illness.

A **job hazard analysis** is a method of analyzing a workplace or job task to identify the existing or potential hazard(s). This analysis considers the relationship between the worker, task(s), tool(s) and workplace. Upon completion of a job hazard analysis, existing or potential hazard(s) can be addressed to eliminate or reduce the hazard(s) to an acceptable risk level.

Prior to completing a job hazard analysis, careful thought should be given to workplace observations and job tasks or steps. This information will be critical in completing a thorough job hazard analysis.

A job hazard analysis involves constant attention to playing "detective" with the goals of determining:

1. What can go wrong?
2. What are the potential consequences?
3. How could the hazard arise?
4. What are other contributing factors to the hazard?
5. How likely is it that the hazard will occur?

A good hazard analysis will include the identification of:

- Where is it happening or what is the environment?
- Who or what it is happening to or exposure?
- What is the trigger for the hazard, or what causes the hazard to happen?
- What is the outcome should the hazard occur?
- Other contributing factors to consider?

After a job hazard is completed, the rail maintenance technician should take the necessary steps to address, control and minimize the hazard and any potential consequences. These steps may include using the proper PPE, placing appropriate signage and barriers, etc. A supervisor should be consulted if there is any concern that a hazard has not been effectively addressed.

Zero-Energy State

Securing something in a **zero-energy state** means ridding it of any sort of potential or stored energy. This is often completed during rail vehicle maintenance and repair in various ways depend on work being completed. Securing something in a zero-energy state may include but not limited to:

- Electrical energy
- Spring pressure
- Hydraulic (liquid) pressure
- Pneumatic (air) pressure
- Suspended weight
- Chemical energy (flammable or otherwise reactive substances)

Securing a zero state of energy will be discussed further where applicable in later rail vehicle modules and maintenance courses.

Common Hazards in Rail Vehicle Maintenance

In addition to the general hazards illustrated in earlier figure, rail maintenance shop-specific hazards can be considered within the context of the following main categories or shop areas:

- Noise Hazards
- Slip, Trip and Fall Hazards
- Respiratory and Eye Hazards
- Pinch Points and Mechanical Hazards
- Vehicle and Equipment Movement
- Electrical Hazards
- Cat Walks
- Compressed Air Hazards
- Pit Area Hazards
- Hazardous and Flammable Storage
- Refrigerant Hazards
- Chemical Hazards

Noise Hazards

A rail vehicle maintenance shop may also present noise hazards. Tools and equipment such as blowers, compressors, and power tools can present noise that may be harmful to those in the area and especially the technicians using them. Proper PPE to protect hearing should be used when noise is expected to be harmful.

Figure 2.20 Single Use and Reusable Earplugs. Source: Wikipedia

Slip-Trip-Fall Hazards

Rail vehicle maintenance technicians should exercise caution regarding all potential trip, slip or fall hazards. Areas and equipment in the rail vehicle maintenance shop that present these hazards include:

- Exposed pits without railing
- Pit areas containing oil and condensation from AC units
- Tracks
- Air hoses
- Chords
- Fluids on the ground
- Ladders
- Stairs

Rail vehicle technicians should be aware of these areas and take care for their own safety as well as others when possible. Be aware of signs alerting of these hazards, or place signs where needed according to agency policy and procedures. Fluids on the ground should be removed according to type and agency procedures. Likewise, chords should be properly contained.

Figure 2.21 Pit Area. Courtesy of SFMTA

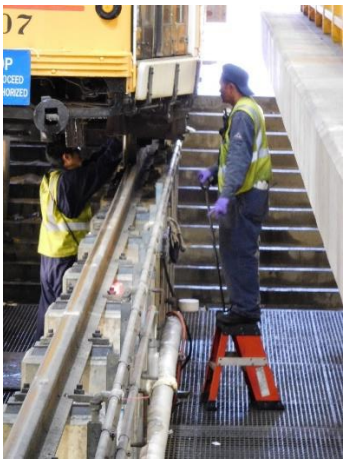


Figure 2.22 Pit Area with Stairs and Ladders. Courtesy of SFMTA

Respiratory and Eye Hazards

Rail vehicle maintenance technicians can sometimes be exposed to respiratory and eye hazards that can include dust, sprayed chemicals, solvent fumes, airborne metal fragments, and pressurized air from hydraulics.

Precautions to take include wearing the proper PPE for the type of work being performed as explained later in each specific course. Always take notice of signage and follow transit agency

policy for eye protection for various areas of the shop or specific work to complete. If an eye hazard is encountered and proper PPE was not effective, the nearest eye wash station should be located and utilized as per agency direction and policy.

Figure 2.23 Sign Alerting of Required Eye Protection. Courtesy of SFMTA

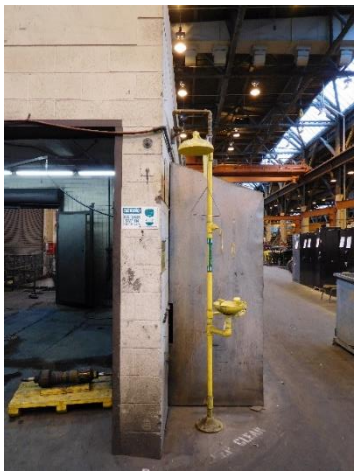


Figure 2.24 Eye-Wash Station. Courtesy of SFMTA

Proper area ventillation will also be important for any potential respiratory hazard. It is improtant the ensure rea ventilation remains operatable and clear of equipment or items stored.

Figure 2.25 Shop Ventilation Fan. Courtesy of SFMTA

Pinch Points and Mechanical Hazards

Inspection, maintenance and repair of mechanical systems typically present the possible exposure to pinch points. A **pinch point** is a place where it's possible for a body part to be caught between moving machine parts or between moving and stationary machine parts.

Figure 2.26 Pinch Point

In rail vehicle inspection, maintenance and repair pinch points can be found in many areas and types of work. Pinch points in rail vehicle maintenance work include but are not limited to:

Potential Pinch Point Hazard	Pinch Point Location
Areas of the Car	• where the wheels meet the rail • couplers (between rail vehicles) • doors/door mechanisms • rotating equipment such as motors and fan blades
Tools and Machinery	• press machines (hydraulic, mechanical, pneumatic) • vehicle lifts • fork lifts • bench grinders • metal working equipment (shears, brakes, punch machines)

The above chart illustrates some of the general pinch point hazards in rail vehicle inspection and maintenance. Additional pinch point hazards will be covered in later courses.

The technician is exposed to several mechanical hazards when working around moving machine parts such as those in a rail maintenance shop. OSHA's *Concepts and Techniques of Machine Safeguarding*, identifies three basic areas require safeguarding:

1. The point of operation: that point where work is performed on the material, such as cutting, shaping, boring, or forming of stock.
2. Power transmission apparatus: all components of the mechanical system which transmit energy to the part of the machine performing the work. These components include flywheels, pulleys, belts, connecting rods, couplings, cams, spindles, chains, cranks, and gears.

3. Other moving parts: all parts of the machine which move while the machine is working. These can include reciprocating, rotating, and transverse moving parts, as well as feed mechanisms and auxiliary parts of the machine.

There is a wide variety of mechanical motions and actions may present hazards to the worker. These can include the movement of rotating members, reciprocating arms, moving belts, meshing gears, cutting teeth, and any parts that impact or shear. These different types of hazardous mechanical motions and actions are basic in varying combinations to nearly all machines, and recognizing them is the first step toward protecting workers from the danger they present.

OSHA defines mechanical actions as machines that cut, punch, shear, and bend materials.

Requirements for Safeguards for Mechanical Hazards

What must a safeguard do to protect workers against mechanical hazards? According to OSHA, safeguards must meet these minimum general requirements:

- Prevent contact: The safeguard must prevent hands, arms, and any other part of a worker's body from making contact with dangerous moving parts. A good safeguarding system eliminates the possibility of the operator or another worker placing parts of their bodies near hazardous moving parts.
- Secure: Workers should not be able to easily remove or tamper with the safeguard, because a safeguard that can easily be made ineffective is no safeguard at all. Guards and safety devices should be made of durable material that will withstand the conditions of normal use. They must be firmly secured to the machine.
- Protect from falling objects: The safeguard should ensure that no objects can fall into moving parts. A small tool which is dropped into a cycling machine could easily become a projectile that could strike and injure someone.
- Create no new hazards: A safeguard defeats its own purpose if it creates a hazard of its own such as a shear point, a jagged edge, or an unfinished surface and can cause a laceration. The edges of guards, for instance, should be rolled or bolted in such a way that they eliminate sharp edges.
- Create no interference: Any safeguard which impedes a worker from performing the job quickly and comfortably might soon be overridden or disregarded. Proper safeguarding can actually enhance efficiency since it can relieve the worker's apprehensions about injury.
- Allow safe lubrication: If possible, one should be able to lubricate the machine without removing the safeguards. Locating oil reservoirs outside the guard, with a line leading to the lubrication point, will reduce the need for the operator or maintenance worker to enter the hazardous area.

Vehicle and Equipment Moving Hazards

The movement of heavy equipment and vehicles is a routine occurrence in a rail vehicle maintenance shop. Rail vehicles themselves are moved in and out of the shop on a daily routine basis. Vehicles are often lifted or may be mounted to overhead or pit areas for work required under the car. Heavy equipment related to the parts or work may also be moved throughout the shop.

Caution for the rail vehicle shop regarding the movement of vehicles and equipment is important. Overhead clearance, especially doorways and frames must be identified and accounted for in any rail vehicle movement. Signs indicating the possible movement of rail vehicles should be used and followed as recommended every rail agency. Extreme care and caution must also be exercised when moving equipment and cars overhead via hoist.

Figure 2.27 43 Signage Alerting to the Possibility of Moving Vehicles. Courtesy of SFMTA

Figure 2.28 Rail Vehicle Proceeding to Move from the Shop to the Train Yard. Courtesy of SFMTA

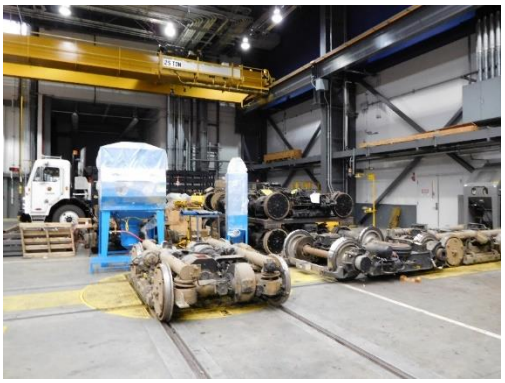


Figure 2.29 Rail Vehicle Equipment and Components. Courtesy of SFMTA

Rail vehicle lifts jack stands also pose a danger and hazard in the rail vehicle maintenance shop. Rail vehicle lifts include a variety of types from cranes to floor-based vehicle jacks. Each of these will be covered later in the course.

Figure 2.30 Jack Stand. Courtesy of SFMTA

The movement of vehicles and equipment will be covered in depth later in Module 4.

Electrical Hazards

Electrical hazards exist anytime work is being completed using or near an electrical supply. An estimated 30,000 non-fatal electrical shock accidents occur each year. Over 200 people die from electrocution each year on average in the United States. Electrocution remains the fourth highest cause of industrial fatalities and approximately 3000 flash burn incidents are reported annually along with approximately 200 deaths.

Electricity is an ever-present energy agent to that many workers in different occupations and industries are exposed to daily in the performance of their duties. Many workers know that the

principal danger from electricity is that of electrocution, but few really understand just how minute a quantity of electrical energy is required for electrocution. In reality, the current drawn by a tiny 7.5 watt, 120-volt lamp, passed from hand to hand or hand to foot across the chest is sufficient to cause electrocution. The number of people who incorrectly believe that normal household current is not lethal or that power lines are insulated and do not pose a hazard is alarming. Electrocutions may result from contact with an object as seemingly innocuous as a broken light bulb or as lethal as an overhead power line. Electrocutions have affected workers since the first electrical fatality was recorded in France in 1879 when a stage carpenter was killed by an alternating current of 250 volts.

Electrical injuries can occur in the form of electrocution, electric shock, burns, and falls because of contact with electrical energy. An electrically safe condition shall be achieved by completing all of the following:

1. Determine all sources of electrical supply (drawings, diagrams).
2. Open disconnecting device for each source.
3. Visually verify all blades of disconnecting devices are fully open or drawout-type breakers are withdrawn.
4. Apply lockout/tagout (LOTO) devices in accordance with policy. *
5. Test each phase conductor using an adequately rated voltage detector.
6. Ground phase conductors where the possibility exists for induced or stored energy.

*LOTO will be further explained later in this course and when applicable in other courses.

An electrically safe work condition does not exist until all the six steps have been completed. Until then, workers might contact an exposed live part. If an electrically safe work condition does exist, no electrical energy is in proximity of the work task(s). All danger of injury from an electrical hazard has been removed, and neither protective equipment nor special safety training is required. However, other hazards might remain.

The implementation of the following preventive measures can also help to reduce or eliminate electrical hazards within the workplace:

1. Extension cords should only be used for temporary power to equipment that is in use by someone “NOW”. They should never be used:
    a) To power equipment on a semi-annual basis, in lieu of plugging the equipment directly into a proper outlet
    b) Run through walls, above ceilings, in standing water, etc.
    c) Attached to building surfaces.
    d) In a place where they me be subject to crushing or pinching.
2. Extension cords should never be left coiled up while plugged into an outlet. This can cause inductive heating that will damage the insulation and can cause fires.

3. Multiple outlet strips should be used only where equipped with a surge suppressor and used to power only computer equipment. They must never be used to power appliances or other electrical equipment. Doing so can overload outlets and branch circuits.
4. Circuits must not over-loaded. Warm or hot circuit breakers indicate an overloaded circuit and a serious fire hazard.
5. Romex type wiring must be properly secured and supported. It should never be used as flexible temporary wiring. Damaged conduit, wires, junction boxes, outlets and switches must be de-energized and repaired by a qualified electrician immediately.
6. Air vents on electrical and electronic equipment must never be blocked or obstructed and should be kept clear of dust and lint.
7. Circuit breakers should be "exercised" every six months, by turning them off and on, to ensure proper function.
8. Grounding – Three prong plugs assure that the equipment is grounded. **Do not modify a plug by cutting off the grounding prong.** A two-prong adapter with grounding strap should be use instead.
9. Lock-outs – Distribution panels and/or fuse boxes can be fitted with key locks to add an additional safety measure. These panels/boxes should be locked to prevent unauthorized individuals from contacting the wiring inside. When working on an electrical circuit that is out of eye sight of the electrical panel/fuse box, the fuse box, panel, or controller should be locked to prevent accidental re-energizing of the circuit by another person. Refer to OSHA regulation governing Lockout/Tagout procedures.
10. Underground Utilities – Telephone, electrical, gas, satellite TV, and dog training wires may be buried on or near your planned worksite area. For public utilities, call before digging. Check with www.digsafe.com, a national directory and a free service, for the phone number in your state.

Even when all steps have been taken to ensure electrical safety is in place other **potential electrical hazards.** These hazards include but are not limited to:

- Defective equipment and insulation
- Inadequate or overload wire hazards
- Exposed electrical parts
- Improper grounding hazards
- Potential for inclement weather and wet condition hazards
- Proximity of power lines and other high voltage situations
- Shock boundaries
- The possibility of arc blasts

Warning: Safety Precautions!

In event of electrical storm, it is recommended to avoid work on or around power.

Defective Equipment and Insulation: All electrical protection covered in previous courses applies to inspection and maintenance of rail vehicles as well, and this includes the possibility of defective equipment and insulation.

In some instances, **defective equipment** may be present and unintentionally charged with hazardous voltage. Rail vehicle maintainers performing inspection and maintenance of rail vehicle systems must be aware of the potential for this problem to exist and work accordingly.

Defective or inadequate insulation can also be a potential electrical hazard a rail vehicle maintainer may encounter during routine inspection and maintenance. **Insulation**, the plastic or rubber covering of bare wire, prevents conductors from coming in contact with each other as well as coming in contact with people. Possible damaged insulation may occur in extension cords or inside a damaged electrical tool or component.

Damaged insulation may expose metal parts which could become energized by a live wire. If something with damaged insulation is touched, the person in contact with the damaged insulation will receive a shock. If damaged power tools or other damaged equipment are touched, the person in contact with the damaged tools or equipment may receive a shock. Grounded or double-insulated equipment will reduce the likelihood of exposure to defective insulation since double-insulated tools have two insulation barriers and no exposed metal parts.

Warning: Safety Precautions!

Treat every circuit as energized.

Inadequate Wiring and Overcurrent Protection Device Hazards: Wires must be of appropriate gauge and size for intended use as the wire must be able to handle the current safely. Likewise, the insulation must be appropriate for the intended voltage and environmental conditions with terminations reliable and protected. In the event wires are inappropriately sized or insulation is insufficient, an electrical hazard can occur.

Overcurrent protection devices in a circuit, such as a fuse or circuit breaker, must be sized appropriately. If the breakers or fuses are too big for the wires they are supposed to protect, an overload in the circuit will not be detected and the current will not be shut off. Overloading leads to overheating of circuit components (including wires) and may cause a fire.

	A guide to the National Electric Code (NEC) rules for circuit conductor identification and sizing.	http://ecmweb.com/qampa/code-qa-identification-circuit-conductors

Exposed and Energized Electrical Parts: When electrical parts or wires are **exposed** or easily accessible, an electrical hazard may exist. Electrical parts, as well as wires, may exist through a removed cover, by exposed terminals, or in older equipment or tools. Exposure and contact with live electrical parts will cause an electrical shock.

All wires must be considered energized (LIVE), except when it is known they have been de-energized and made safe by a **qualified employee**. Electrical conductors must be tested deenergized before any work commences. Only qualified employees may work on or near energized wires and/or equipment. It is recommended that employees notify the Power Dispatcher or similar department prior to beginning such work to obtain proper permits and apply required protection.

Supervisors must know that employees working under their supervision understand and comply with these instructions. When inexperienced or unqualified employees or contractors are required to work in electrified territory, they must do so under the supervision of a qualified person. The qualified person in charge must remind them of the danger and hazards involved in their work.

Employees must not touch dangling wires or foreign objects hanging from electric wires nor attempt to remove them by any means. An eight-foot clearance must always be maintained unless the voltage is known and proper distances are maintained accordingly. When possible, leave someone to warn others.

Insulation, weather proofing or covering on wire, electrical apparatus or equipment must not be depended upon for protection against shock.

Improper Grounding Hazards: The improper **grounding** of electrical systems can create a hazard and parts may become energized. When a circuit is not grounded properly, a hazard exists because unwanted voltage cannot be safely eliminated. When no safe path to ground for fault currents exists, exposed metal parts in damaged equipment can become energized. Contact with a defective electrical device that is not grounded (or grounded improperly) will cause an electrical shock.

The following guidelines should be considered for protective grounding procedures:

- Where the possibility of inducted voltages or stored electrical energy exists, grounding of the phase conductors or circuit parts before touching them shall be done.
- Temporary protective grounds shall be placed at such locations and arranged in such a manner as to prevent each employee from being exposed to hazardous differences in electrical potential.
- Temporary protective grounds shall be capable of conducting the maximum fault current that could flow at the point of grounding for the time necessary to clear the fault.
- Temporary protective grounds shall have an impedance low enough to cause immediate operation of protective devices in case of accidental energizing of the electrical conductors or circuit parts.
- Temporary protective grounds shall be inspected before and after each use.
- Temporary protective grounds shall be maintained in a safe working condition and shall meet the requirements for ASTM F 855.

Electrical systems are often grounded to metal pipes. All pipes must be made of conductive material (a type of metal).

Wet Condition Hazards: Wet conditions can provide an easy path for electrical current. Touching a live wire or other electrical component including live electrical parts causes by damaged insulation, while standing on a wet surface will cause a shock. Wet clothing, high humidity, and perspiration can also reduce resistance and increase the chances for electrocution.

High Voltages and the DC Disconnect: Catenary wires and third rails are sometimes present in some rail installations and shops. Careful consideration must be taken when performing inspection and maintenance around any high voltage power supply. Both catenary wires and third rails are high voltage and can produce fatal shocks.

In rail vehicle maintenance shops, high voltage power is managed by means of the earlier mentioned DC Disconnect. The DC disconnect and related safety steps will be thoroughly explained later in this course.

Arc Flash and Approach Boundaries: As part of electrical safety, signal maintainers should be aware of arc flashes and blasts along with approach boundaries. **Arc flashes** and **arc blasts** consist of a luminous electrical discharge across a gap between conductors of high voltages and high-amperage currents arc, or travel, through the air. The arc flash is the luminous electrical discharge while the arc blast consists of the wave of energy produced. Some arc flashes and blasts have produced temperatures as high as 35,000°F. Typically, arc flashes and blasts occur because of equipment failure resulting from abuse or fatigue.

Hazards associated with arc blasts include burns, wave blasts, and equipment meltdown. Burns that occur from arc blasts are due to thermal radiation and intense light. The use of proper clothing, work distances, and overcurrent protection can help reduce this risk. Wave blasts which can occur with a 25,000-amp arc can result in a force of approximately 480 pounds on the front of the body at 2 feet away. While these wave blasts can throw individuals away from the arc and resulting thermal radiation, serious ear damage and memory loss due to concussion can still occur. The pressure waves can also send equipment flying and can knock over walls. An arc flash can also melt equipment. As equipment melts down, droplets of molten equipment metal can be projected by the arc blast. These droplets can cause burns and/or fires even at distances of 10 feet or more away.

	Arc Flash Safety by Eaton Videos	https://www.youtube.com/watch?v=fZU06zNeICw

As determined by the NFPA 70E, **approach boundaries** consist of four boundary levels determined by distance to protect from exposed live parts and arc flashes or blasts.

The three boundaries used to protect individuals from exposure to live parts include the following:

- **Limited approach boundary** – The closest approach for unqualified person unless accompanied by a qualified person.
- **Restricted approach boundary** – The closest approach without proper PPE for a qualified person. Careful attention of tools and movements that could be exposed to live parts with unintentional movement.

- **Prohibited approach boundary** – The distance a person must keep from live parts to prevent flashover or arcing in the air. A person closer than the prohibited approach boundary would essentially be in contact with a live part.

Electric Shock Boundaries to Live Parts 300 – 600 Volts			
Limited Approach Boundary **3 feet 6 inches →**	Restricted Approach Boundary **1 foot →**	Prohibited Approach Boundary **1 inch →**	**Power Source**

The fourth boundary is intended to protect against arc flash and is known as the **flash protection boundary**. At this boundary, PPE is required to prevent incurable burns in the event of an arc flash. In many agencies, only qualified persons are allowed to enter areas identified as "Arc Flash and Shock Hazard" locations.

Flash Protection Boundary to Live Parts 300 – 600 Volts	
Flash Protection Boundary **4 feet →**	**Power Source**

Your Agency Policy and Procedures Regarding Approach Boundaries

Pit Hazards

Pit areas are the places in the shop that are below ground where rail vehicle mechanics can descend to complete work beneath the underside of the rail vehicle.

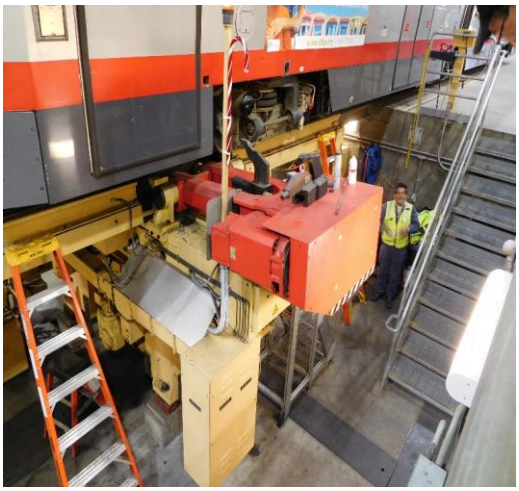


Figure 2.31 Wheel Lathe with Pit. Courtesy of SFMTA

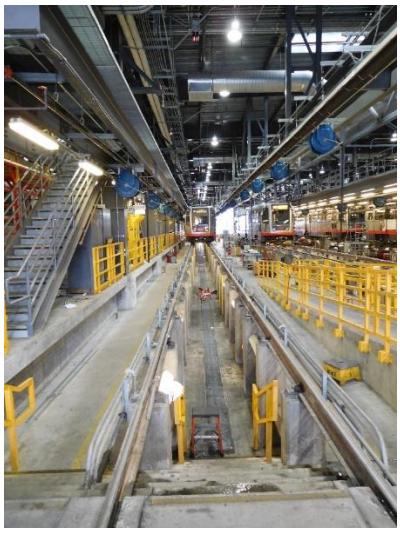


Figure 2.32 Pit for Running Repair Area. Courtesy of SFMTA

While most pit areas are protected by way of railings, some are open with no protection thus creating the possibility of a fall hazard. Stairs are also present in pit areas, some of which are open without railing. Care must always be taken to prevent falls into pit areas, especially those without railings. Other hazards may also exist in pit areas.

The possibility of being struck by a vehicle in movement could occur. Also, and as mentioned earlier, water and oil may sometimes be found on pit floors thus creating slip, trip and fall hazards. Following proper communication procedures as established by your agency and cleaning any spills will help to minimize the potential of these pit hazards.

Cat Walks

A **catwalk** is a narrow walkway or bridge-type structure either suspended from a structure or self-supporting and often used in industrial installations to access areas high from ground. In rail vehicle maintenance, catwalks are used to access the top of rail vehicles for inspection and maintenance purposes. Some catwalks are permanent structures in a shop and some may be moveable to various areas as needed.

Catwalks must be designed to meet OSHA standards. Catwalks are designed to help prevent slip, trip and fall accidents and typically contain railings to help in fall protect, toe boards to prevent tools and materials from falling to work areas below, and non-skid surfaces. In addition, catwalk areas are often locked to prevent unintended movement and access to these areas. This lock system will be explained later in the course.

Figure 2.33 Permanent Catwalk. Courtesy of SFMTA

Figure 2.34 Moveable Catwalk. Courtesy of SFMTA

Compressed Air

Compressed air is used in rail vehicle maintenance for a variety of reasons including cleaning areas of the rail vehicle and to power certain tools.

Compressed air hazards include the high pressurized air itself, the whipping of the hose, and blowing debris.

Precautions to take when using compressed air include:

- Always wear proper PPE when using compressed air which should include eye, face and respiratory protection meeting minimum ANSI or other applicable national industry standards. Work gloves should also be worn.
- Never use compressed air for dusting or cleaning clothes.
- Never dry off your body using compressed air as air may enter the blood stream through a scratch or wound and could result in death.
- Always turn off the air supply valve before changing or disconnecting pneumatic tools.
- Check the coupling and condition of the hose before opening the air valve into the hose. Always maintain a firm grasp of the discharge end of the hose to prevent the possibility of the whipping of the hose which could result in a possible injury.
- If using compressed air to clean machines, tool tables or other work surfaces, ensure pressure is reduced to less than 30 psi, effective chip guarding and proper PPE is used, and ensure others in the area are protected from blown debris.
- Use only those cleaning products and lubricants proven safe and authorized for use by the rail transit system. Consult OEM and MSDS references for suitability for each application to prevent personal injury and damage to the equipment

Overhead Door and Frame Familiarization

Employees involved in rail vehicle inspection, maintenance and repair must be familiar with overhead doors and their frames located at the shop entrances and exits.

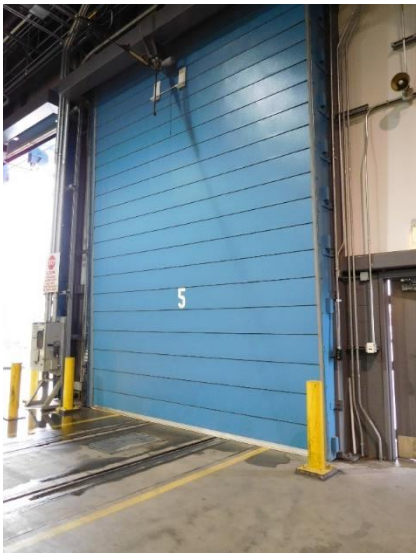


Figure 2.35 Framed Doorway for the Movement of Rail Vehicles in and Out of Shop. Courtesy of SFMTA

Figure 2.36 Door Movement Equipment with Signage. Courtesy of SFMTA

Hazardous/Flammable Materials

Proper hazardous and flammable material handling and storage is important for the safety of the shop environment.

Figure 2.37 Flammable Material in Shop. Courtesy of SFMTA

Hazardous and flammable liquids can be categorized into three classes according to their flash point, or the minimum temperature at which a liquid gives off a vapor in sufficient concentration to ignite. Three classes of hazardous and flammable liquids include:

- Class I – any material with a flash point below 100°F
- Class II – any material with a flash point between 100°F and 140°F
- Class III – any material with a flash point between 140°F and 200°F

Hazardous materials should be stored in containers appropriate for their class. Class I liquids should only be stored in one-gallon safety cans or sealed containers not larger than one gallon each and not exceeding a total of 10 gallons in the work area. Class II should be stored in sealed containers of not more than 5 gallons or in barrels, drums, or tanks not exceeding 60-gallon capacity. The maximum aggregate amount for any work area is 60-gallons. Class III liquids should be stored in sealed containers of not more than 5-gallon capacity or in barrels, drums, or tanks not exceeding one hundred twenty-gallon capacity. The maximum aggregate amount for any work area is 120 gallons.

Up to ten, 55-gallon drums of oils, paints, varnishes and similar fluids having a flash point above 200° F can be stored in a work area. Liquids having a flash point above 200° F can be stored in quantities less than 10 gallons in drums or ordinary tanks and if drawn on the premises, suitable drip pans shall be provided to catch the drips.

Hazardous materials should not be stored near floor drains or other connections to the city sewer system or the facilities oil/water separator. Flammable liquids shall not be stored in direct sunlight or near another heat source like electoral heaters (600-volt DC and various AC heaters). Flammable liquids shall not be stored next to an ignition source such as boilers, heaters with an open flame, combustion engines, cigarettes, and sparks from cutting and welding. Smoking, eating, drinking and food storage in a hazardous materials storage area or when working with hazardous materials is prohibited.

All storage containers shall be labeled with the product name, lot number, and both chemical and physical health hazards. If labels are needed, request a label for the container from your supervisor or the appropriate agency department who will contact the manufacturer or vendor for the product label. When transferring a material from one container to another, always label the new container with the lot number and product name.

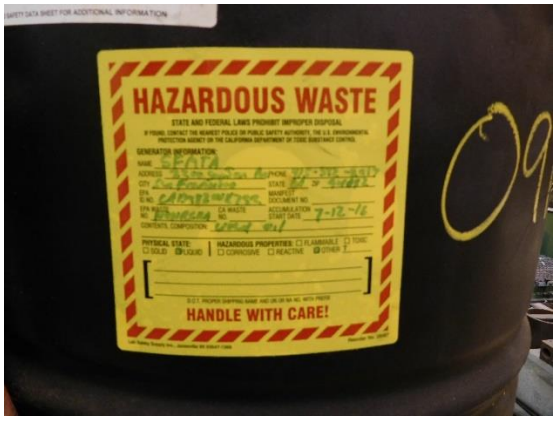


Figure 2.38 Hazardous Waste Label. Courtesy of SFMTA

All containers of hazardous materials shall be stored with lids, covers and/or bungs in place. When storing materials outside, plastic covers are available to protect drum tops from corrosion and accumulation of water in the drum.

Every building, room or area that is used to store flammable liquids shall have a sign that says "Flammable – Keep Fire Away" written with legible, bright, red letters on a white background.

Refrigerant Hazards

To avoid injuries and costly mistakes, technicians should consistently follow defined procedures, follow safety data sheet (SDS) guidelines, and use common sense when handling refrigeration equipment. Taking simple precautions can be a substantial leap toward industry-wide safety.

Refrigerant safety is straightforward: If the refrigerant stays contained in the cylinder or in the system then it presents little danger to people. The hazard occurs when the refrigerant comes out of the container or system, often quickly and unexpectedly. Regular checks on containers and systems

for holding pressure, and preparing safety equipment and procedures to minimize personal exposure after unexpected releases should help avoid any injuries when handling refrigerants.

Specific hazards from refrigerant fall into three categories:

1. Toxicity
2. Flammability/Combustion/Decomposition
3. Pressure/ Refrigerant Gas

Employees working with refrigerants must be certified. None-the-less, a rail vehicle mechanic who is not trained and working with refrigerants should still be aware of their use, potential hazards and precautions in the shop environment.

Refrigerant hazards and required training will be further explained in Rail Vehicle Course 106: Introduction and Overview of HVAC Systems.

Chemical Hazards

Nickel-cadmium (NiCad) batteries are widely used in today's passenger rail cars and the Rail car Training Consortium has decided to focus on NiCad batteries and no other battery types. Some agencies may have other types of batteries in use on their rail cars and this section on chemical hazards may not therefore apply to all agencies and all rail cars.

Working around batteries may expose the rail vehicle technician to various chemical hazards. Chemical hazards will be further covered in Course 104: Introduction and Overview of APS and Battery Systems.

Classroom Activity

With guidance from your instructor and as a class, fill in the table to identify the hazard sign, the location(s) of the hazard(s) in your agency, and appropriate PPE to use for each hazard.

Hazard Symbol	Hazard Name	Hazard Location(s) in Your Agency	Agency Recommended PPE
			
			
			
			
			
			
			
			

2-4 EMERGENCY RESPONSE RESOURCES

In the event of an emergency such as a rail vehicle crash or shop fire, every agency must have in place emergency response procedures. These procedures are to outline and explain various possible emergencies that may occur and approved procedures for response to those emergencies. Rail vehicle technicians should understand these procedures and related resources which include:

- Emergency evacuation plan
- Emergency response agencies and their contact information
- Fire prevention and safety
- Emergency Kits: First Aid, AED, Hazmat spill kits
- Emergency cut-out switch
- Emergency vehicles and re-railment trucks
- Agency-Specific Locations for all Emergency Resources

An **emergency evacuation plan** and related plans provide direction for how to safely exit a building in an emergency that requires building inhabitants to leave. While the main manager of the building or facility always maintains detailed evacuations plans, agency workers will typically be most familiar with the emergency evacuation directions indicated on signage displayed throughout a facility. These signs usually provide the name and physical address of the building itself, indications of the particular location the sign is displayed which may include a map of the building and/or floor and floor level indication if needed, emergency contact numbers, any specific directions for disabled persons, and a description of what alarms will indicate the need to evacuate. These signs will also be displayed in braille for people who are visually impaired.

Figure 2.39 Emergency Evacuation Plan. Courtesy of SFMTA

Emergency Action Response

If an emergency should occur, every employee in the rail maintenance shop and surrounding area should know who to contact and how to contact them. At a minimum, a supervisor should be contacted for any emergency. In some cases, other emergency response agencies should also be consulted. The agency to contact and when to contact depends on the type of emergency. For example, if a fire should occur, then the appropriate emergency response number to call would be 911 and that should be done immediately.

The phone numbers associated with each emergency response agency will vary according to location. The list of emergency response agencies should be kept in a centralized area, and it is the responsibility of each employee to know where to find this in their agency.

Class Activity

In the space below -

1. Describe organization or agencies in your local area that may be contacted during an emergency.
2. Explain where to locate the emergency response contact information in your rail vehicle maintenance shop.

Fire Prevention and Safety

Fire safety equipment in the transit workplace is available for response to emergencies involving fire. In the event of a fire, a variety of responses may be possible depending on the type and location of the fire. General fire safety equipment transit workers should be able to understand, identify and can properly use include:

- Fire alarm systems
- Fire and extinguishing basics
- Fire response equipment

Fire Alarm Systems

Fire alarm systems are found throughout the transit environment including transit work areas such as stations, central instrument areas, and maintenance shops. Fire alarm systems contain a various number of devices that work together to warn people both visually and audibly of the presence of smoke, fire or other possible emergencies. These devices are typically activated automatically through smoke or heat detectors, but sometimes they may be manually activated such as at a pull station.

Figure 2.40 Fire Alarm System with Loud Speaker and Pull Station. Courtesy of SFMTA

Anyone working in an agency should immediately locate the manual pull-station alarms for their given work areas. Once activated, fire systems provide an audible alert such as a bell, buzzer, or horn. Sometimes the audible warning may also contain a voice evacuation message warning of the emergency and reminding those in the area not to use elevators. Visual alerts may include a flashing or strobe-type lighting that is strategically placed throughout the work space areas. Typically, a fire alarm that has been activated is also connected to central operations and local emergency agencies.

All agencies maintain specific directions for response to fire alarms. Led by management, routine fire drills are at a minimum held quarterly for each shift to ensure everyone is safe and prepared.

Fire and Response Equipment

A variety of fire response equipment is kept and maintained throughout the transit workplace. But, before identifying and discussing this equipment, it is important to review some fire basics.

Fire burns when three basic elements are present: heat, fuel, and oxygen. If any one of these three elements are removed, then the fire is extinguished. For instance, heat can be removed through cooling, oxygen can be excluded, fuel can be removed, or the chemical reaction that is the origin of the fire itself is extinguished through by inhibiting the oxidation of the fuel.

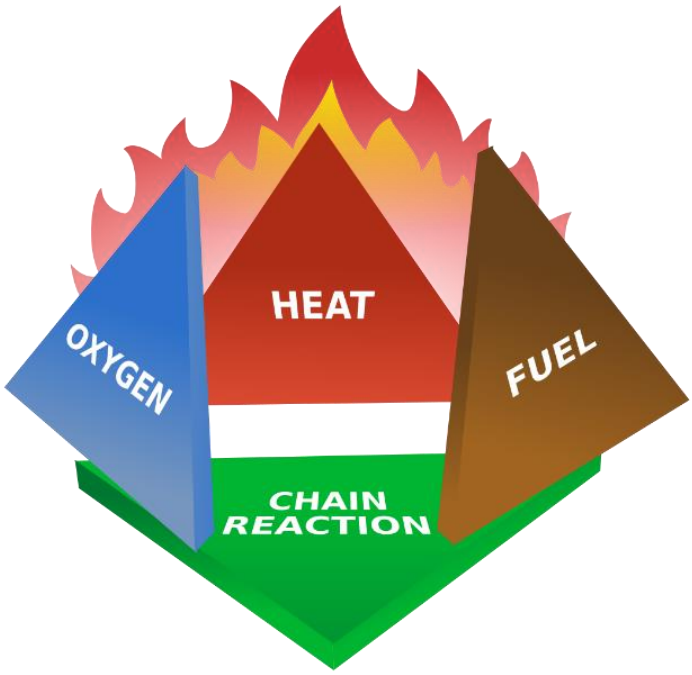


Figure 2.41 Basic Elements Required for Fire. Source: Wikipedia

To extinguish a fire through cooling, something must be applied to remove the heat. The most common method to cool a fire is through the application of water as the cooling agent. Water is typically applied in the form of a solid stream, finely divided spray, or incorporated as foam.

Oxygen can be removed from a fire by covering it with a wet blanket, dirt, or foam that is either chemical or mechanical. In addition, other heavier gases, such as carbon dioxide and vaporizing liquid, can be used to extinguish the fire when applied as a “blanket” and therefore preventing additional oxygen from reaching the fire.

Removing fuel from a fire is difficult, dangerous. Only in certain instances is this method used to extinguish a fire. When flammable liquid storage tanks are arranged, they are set up so their contents can be pumped into an isolated empty tank in the event of a fire. If flammable gases catch fire when flowing from a pipe, the fire will go out when the valve controlling the flow is turned off.

If dry chemicals or halogenated hydrocarbons are used as extinguishing agents, the flame reaction will be inactivated and combustion rate lowered thus extinguishing the fire.

Fires themselves are classified depending on the source or materials involved. Each classification, or type of fire, requires certain types of extinguishing methods. In the table below, the classification of fires and methods for extinguishing are explained.

Fire Extinguisher Types

Fire extinguishers are available throughout all facilities.

Fire extinguishers are divided into five categories, based on the type of fires they are designed to extinguish:

- Class A Fire Extinguishers
- Class B Fire Extinguishers
- Class C Fire Extinguishers
- Class D Fire Extinguishers

Each fire extinguisher also has a numerical rating that serves as a guide for the amount of fire the extinguisher can handle. The higher the number, the more fire-fighting power.

The following provides guidance for choosing the right type of extinguisher.

Class A Fire Extinguishers: For ordinary combustible materials such as paper, wood, cardboard, and most plastics.
Class B Fire Extinguishers: For fires involving flammable or combustible liquids such as gasoline, kerosene, grease, and oil. The numerical rating for class B extinguishers indicates the approximate number of square feet of fire it can extinguish.
Class C Fire Extinguishers: For fires involving electrical equipment, such as appliances, wiring, circuit breakers and outlets. The C classification means the extinguishing agent is non-conductive. Never use water to extinguish class C fires—the risk of electrical shock is far too great. Class C extinguishers do not have a numerical rating.
Class D Fire Extinguishers: For fires commonly found in a chemical laboratory. They are for fires that involve combustible metals, such as magnesium, titanium, potassium and sodium. These types of extinguishers also have no numerical rating, nor are they given a multi-purpose rating. They are designed for class D fires only.
Class W Fire Extinguishers: Used at or around pre-plumbed fire suppression systems such as restaurant hood (Ansul) systems.

Figure 2.42 Fire Extinguisher Labeled for Use as Indicated by A, B and C. Courtesy of GCRTA

The table below shows common symbols for each fire extinguisher type and summarizes their applications and use.

Table 1 Fire Class and Extinguisher Type

Class of Fire	Types of Fire	Extinguisher Symbols	
		Rating Symbol	Picture Symbol
A Ordinary Combustion	Wood Cloth Paper Rubber Plastic		
B Flammable Liquids	Liquids Greases Gasses Oil Tar Oil-based Paint Lacquer		
C Electrical Equipment	Energized Electrical Equipment		
D Combustible Metals	Magnesium Sodium Zinc Calcium Titanium Lithium Other Flammable Metals		
E Cooking Media	Vegetable Oils Animal Oils Fats/Lards		

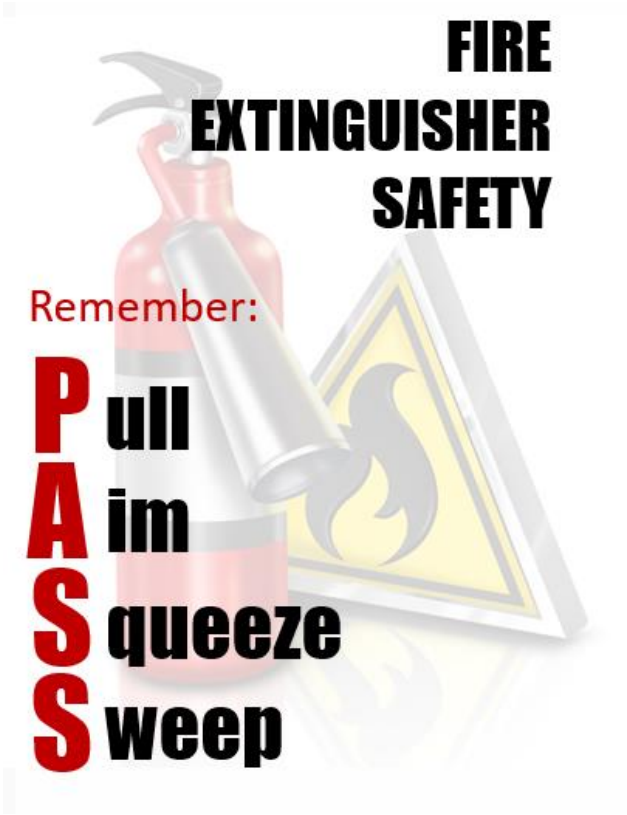
Fire Extinguisher Use

The first step in fire extinguisher use is to identify the type of fire and what fire extinguisher is required. Typically, agencies will have identified the potential types of fires that may exist in various site locations and will have placed the appropriate fire extinguishers in those areas. None-the-less,

have knowledge of the types of fires and what extinguisher is required is important in the event a variation from expectation should ever occur.

Different types of fire extinguishers may require different procedures for use. For example, a Class A fire extinguisher may require certain steps to initiate and use while a Class B fire extinguisher may require other steps to initiate and use. Depending on the job being performed, respective training for the types of fire extinguishers one may need to use in that job will be handled by each agency and their training procedures.

None-the-less, a general principle for the use of any fire extinguisher is the **PASS principle**. The PASS principle consists of four steps for the use of any fire extinguisher: Pull the pin, aim low at the base of the fire, squeeze the lever slow and even, and sweep the nozzle side to side.



Emergency Cut-Out Switch

Emergency cut-out switches, sometimes known as "**mushrooms**" are located throughout the rail vehicle maintenance shop. The purpose of these switches, or buttons, is to provide the means to stop power to the third rail or overhead catenary line. If a button is pushed, the power must be reset at the main disconnect.

Figure 2.43 Emergency Cut-Off Switch Exterior View. Courtesy of SEPTA

Figure 2.44 Emergency Cut-Off Switch Interior View. Courtesy of SEPTA

Figure 2.45 Emergency Cut-Off Button, or Mushroom. Courtesy of GCRTA

Figure 2.46 Main Electrical Cut-Off Switches. Courtesy of GCRTA

Emergency Kits: First Aid, AED, Hazardous Material (HazMat) Spill Kits

First aid equipment is located throughout transit agency operations such as in machine rooms, repair centers and shops, and signal central instrument locations. First aid equipment is strategically selected and placed in these areas depending on the types of risks and hazards existing there. General first aid equipment that may be present in transit could include general first aid kits, defibrillators, and eye wash stations.

General First Aid Kits

General first aid kits are permanently located in all indoor work areas. For outdoor areas, general first aid kits may be in work vehicles or in the nearest indoor location. Containing items such as band aids, antiseptic wash, and ace bandages, general first aid kits can be accessed and used for minor injuries requiring minimum first aid. Always follow agency procedures for any on-the-job injury and for the care of these kits as items may be accessed and used.

Figure 2.47 General First Aid Kit. Courtesy of SFMTA

Figure 2.48 First Aid Instructional Sign. Courtesy of SFMTA

Automated External Defibrillators

Defibrillation is a treatment for life-threatening cardiac dysrhythmias. A defibrillator delivers a dose of electric current (often called a countershock) to the heart. The electrical shock does not have to be timed with the heart's intrinsic cardiac cycle. This depolarizes a large amount of the heart muscle, ending the dysrhythmia. Subsequently, the body's natural pacemaker in the heart is able to reestablish a normal rhythm.

In situations where cardiac arrest may occur either naturally or due to an emergency such as electric shock, portable **automated external defibrillators** (**AED**s) are usually located in work areas and can be helpful in ensuring the affected individual receives the immediate help they may need until emergency officials arrive.

Figure 2.49 Sign Alerting of Portable AED Station. Courtesy of SFMTA

Figure 2.50 Portable AED. Courtesy of SFMTA

Eye Wash Stations

As earlier described, **eye wash stations** are typically located in maintenance and repair areas where there may be exposure to materials hazardous to the eyes and sight. Agency workplace sites with these stations will have procedures and train employees for when the use of the stations may be necessary as well as any steps to take.

Figure 2.51 Sign for Eye Wash Station. Courtesy of SFMTA

Hazardous Material Spill Kits

Hazardous material (HazMat) spill kits are typically found in rail vehicle maintenance work areas where hazardous materials are found. These kits are intended to centralize materials and PPE required for spill control.

Figure 2.52 HazMat Spill Kit. Source: Wikipedia

Emergency Vehicles and Re-Railment Trucks

In some agencies, emergency vehicles and re-railment trucks are part of rail vehicle shops. The emergency vehicles are vehicles instended to serve the sole purpose of providing support for emergency situations. Re-railment trucks serve to assist re-rail a train. In some agencies, all employees are trained in the use and application of these vehicles, while in other agencies only some employees are selected to operate the vehicles. In either case, additiona training beyond standard rail vehicle maintenance is required for any employee in their care and use.

Figure 2.53 Re-Railment Truck. Courtesy of GCRTA

Locations of Emergency Response Resources

Emergency resources as outlined in this Module section, such as fire extinguishers, are strategically placed throughout rail vehicle maintenance shops depending on the layout and needs of the shop. In addition, and once again depending on needs, other emergency resources may be maintained in various agencies.

Class Activity

In the space below, list the specific emergency response resources, their purpose, and where to locate them in your rail vehicle maintenance shop.

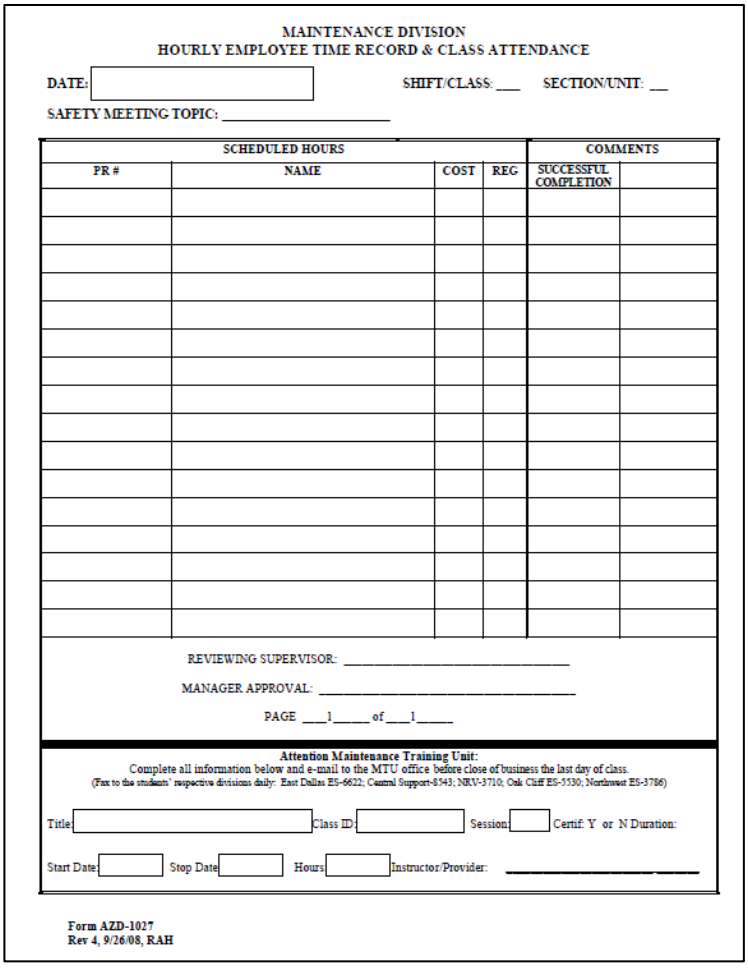
Emergency Resource	Purpose	Location

2-5 JOB SAFETY BRIEFINGS

A form of regular communication and important for shop safety in most rail vehicle shop is the **job safety briefing**, also sometimes known as tail gate meetings or toolbox talks.

These briefings are small meeting sessions with groups of employees led by supervisors. As determined by the shop and agency need, they generally occur weekly or monthly. Sometimes meetings may be scheduled for longer times or more often if the need arises depending on the topic to address. Often, these meetings are agency required and employees must sign a document indicating their attendance and participation in the meeting. These signed attendance and participation documents are stored as transit agency records and employee files.

An example of a job briefing attendance sheet is shown below.



MAINTENANCE DIVISION
HOURLY EMPLOYEE TIME RECORD & CLASS ATTENDANCE

DATE: SHIFT/CLASS: ___ SECTION/UNIT: __

SAFETY MEETING TOPIC: _____

SCHEDULED HOURS				COMMENTS	
PR #	NAME	COST	REG	SUCCESSFUL COMPLETION	

REVIEWING SUPERVISOR: _____

MANAGER APPROVAL: _____

PAGE ___1____ of ___1____

Attention Maintenance Training Unit:
Complete all information below and e-mail to the MTU office before close of business the last day of class.
(Fax to the students' respective divisions daily: East Dallas ES-6622; Central Support-8543; NRV-3710; Oak Cliff ES-5530; Northwest ES-3786)

Title: Class ID: Session: Certif: Y or N Duration:

Start Date: Stop Date: Hours: Instructor/Provider: _____

Form AZD-1027
Rev 4, 9/26/08, RAH

Figure 2.54 Job Safety Briefing. Courtesy of DART

The purpose of the job safety briefing is just as the name would imply, to address an element of job safety. The content of the meeting may be selected based on recent data collected by the agency, as

determined by supervisor observations for on-going job training purposes, updates for existing equipment, or a need to train on new equipment or methods. Depending on the need, supporting materials may be included as part of the meeting. These supporting materials may be in the form of a shop rule or routine, standard operating procedures (SOPs), original manufacturer bulletins and material, developed supporting material, or work orders.

Class Activity

With help from your instructor, review job safety briefing example material from your agency. In the space below, list and describe the frequency, purpose and other important information for job safety briefings in your agency.

2-6 HOUSEKEEPING

Housekeeping in the workplace generally means the maintenance and upkeep of the workplace itself. In the case of rail vehicle maintenance, housekeeping refers to the activities and tasks rail vehicle maintenance technicians must complete to ensure the shop is continuously cleaned and maintained.

Rail vehicle maintenance technicians are responsible for keeping their work areas, lockers and facilities clean and in operational conditions. To ensure this goal is met, rail vehicle maintenance technicians should:

- Store all tools, materials and equipment when not in use.
- Ensure all refuse and loose materials or tools are not creating hazards in walkways or on tracks.
- Ensure to immediately clean work areas to prevent the accumulation of sanding and grinding dust by vacuuming surfaces, the floor area beneath and surrounding, and the tool surfaces (including the vacuum) themselves. In some cases, sweeping and mopping may also be required.
- Immediately wipe spilled oil or grease with a rag or cover with absorbent material sweeping up as soon as possible, cleaning materials must be disposed of in accordance with EPA regulations.
- Promptly place refuse, trash, and salvage materials in appropriate receptacles
- Never toss any object from a vehicle
- Any slippery conditions should be cleaned or covered with salt or an abrasive such as sand.
- All walkways shall be kept clean and free of debris.
- DO NOT use dust generating methods for any cleaning activity
- Follow all transit agency policy and direction for daily and monthly housekeeping procedures

As indicated above, some elements of housekeeping require additional training, such as in the case of cleaning and/or disposing of spilled oil. Often such training is in accordance with safety oversight organizations such as the EPA or OSHA.

The proper PPE must always be selected and used for any housekeeping task when required. Likewise, all safety measures as earlier described and in addition to safety measures outline by your agency must always be followed.

In some agencies, employees may be designated or assigned to specific areas of the shop or housekeeping responsibilities. In these cases, those individuals will be trained specifically for

their role and responsibilities. For example, in some agencies, only a few employees may be trained and authorized to move and operate a forklift or for the cleaning of human fluids such as blood or vomit.

Class Activity – In the space below, list the housekeeping tasks in your rail vehicle maintenance shop, who is responsible for each task, and any PPE and/or additional training required.

Housekeeping Task	Who is Responsible	PPE or Training Required

2-7 SUMMARY

In summary, working in the rail vehicle shop maintenance includes many hazards. Rail vehicle maintenance workers should know all potential hazards in their shop as well as appropriate measures, including the selection, care and use of PPE.

The following list provides a summary of Module 2.

- Remember all electrical safety considerations including the possibility of high voltage, the location and operations procedures for circuit breakers and emergency cut-off switches.
- De-energization before working on electrical systems.
- Always follow and complete LOTO of any stored or potential energy sources (electrical, mechanical, hydraulic, pneumatic, gravity, to name a few).
- Securing a vehicle during maintenance (on a lift, or when brakes are cut out).
- Appropriate PPE.
- Being familiar with vehicle movements in rail shop, always know your surroundings.
- Complete a safety walk around or before moving a vehicle ensuring no one will get hurt or damage will occur.
- Blue Flag/Signal Protection.
- High pressure associated with hydraulic systems.
- Awareness of door systems and potential dangers.
- Concurrent maintenance actions – how one individual action can affect another.

Source

Wikipedia. (16 December 2019). Retrieved December 16, 2019 from Wikipedia: https://en.wikipedia.org/wiki/Fire_triangle

Wikipedia. (8 December 2019). Retrieved December 18, 2019 from Wikipedia: https://en.wikipedia.org/wiki/Earplug

MODULE 3

INTRODUCTION TO RESOURCES

Outline

Purpose and Objectives

The purpose of this Module is to provide participants with an overview of the resources available in the rail vehicle maintenance shop for rail vehicle maintenance and employee safety.

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

- Locate and describe the importance of technical manuals.
- Describe and explain the importance of bulletins, SOPs, and SDSs.
- Explain how to use manuals for parts, maintenance, etc.
- Locate and explain a work order as used in your agency.

Key Terms

- Bulletin
- Rail test bulletin
- Regulatory agency
- Safety data sheet (SDS)
- Safety oversight
- Service bulletin
- Shop status board
- Shop tag
- Standardized operating procedure (SOP)
- Standardized
- Technical manual
- Work order

3-1 OVERVIEW

Providing a wide variety of information, resources are very important in rail vehicle maintenance. Resources come in various forms and located in various areas throughout a maintenance and repair shop. Sometimes, resources are used for training and job safety briefings. Resources for rain vehicle inspection, maintenance and repair include technical manuals, bulletins, standard operating procedures, safety data sheets, and work orders. This Module explains each type of resource, where they are commonly found, and their typical uses.

3-2 SHOP STATUS BOARDS

Shop status boards are often used in rail vehicle maintenance shops to communicate daily or weekly messages and updates for employees. These boards are maintained in a central location and generally updated by supervisors or managers. Employees are encouraged to read the board prior to any shift, and the boards may be used in daily, weekly, or monthly meetings or as part of job safety briefings.

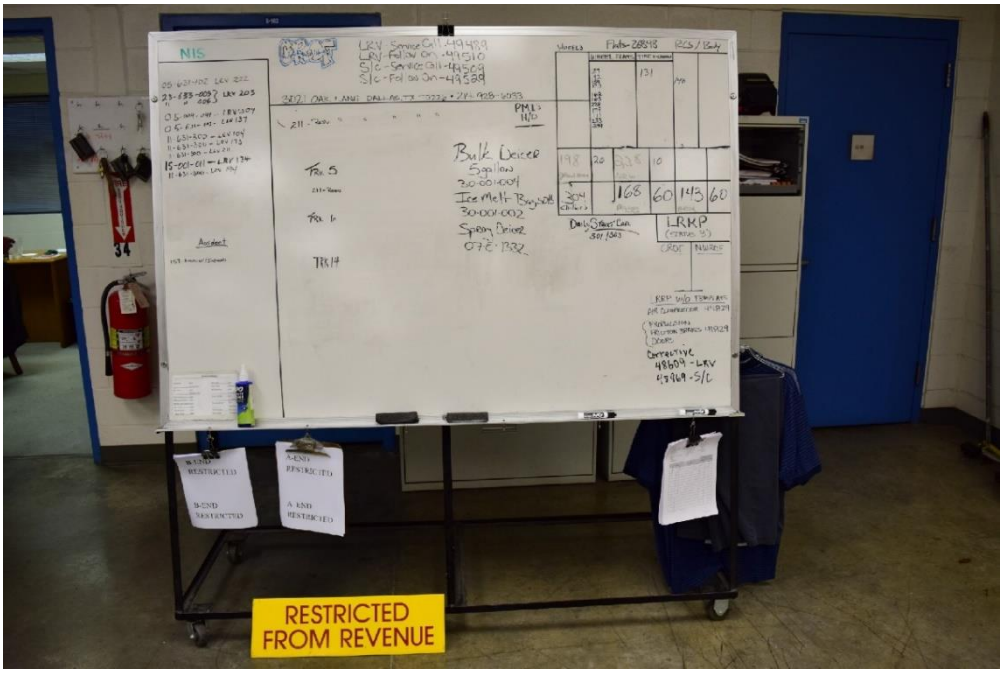


Figure 3.1 Shop Board. Courtesy of of DART

3-3 TECHNICAL MANUALS

Technical manuals are an important part of rail vehicle maintenance. Located in every shop, these manuals provide information for the maintenance and repair work for all rail vehicles and their related parts.

Technical manuals contain information about each rail car including the description, the make and model of the vehicle, rail vehicle procedures, related prints and schematics, part information, and other valuable information important for inspection, maintenance and repair work.

Typically, technical manuals can be found as hard copies and/or in digital format. Hard copies manuals, printed on paper and stored in binders on office shelving or similar, are typically found in the main office or a manager's office of the shot. Employees can access these manuals in this format as needed. Digital manuals, saved in digital file format in a computer system, can be found on computers at local work stations or on portable test units or laptops.

Figure 3.2 Maintenance Manuals. Courtesy of SFMTA

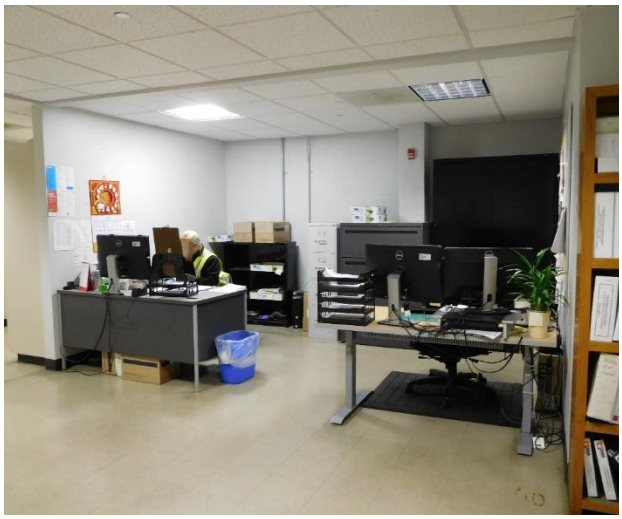


Figure 3.3 Computer Work Area. Courtesy of SFMTA

Sometimes, information commonly retrieved from technical manuals may be displayed on walls, as shown in the figure below.

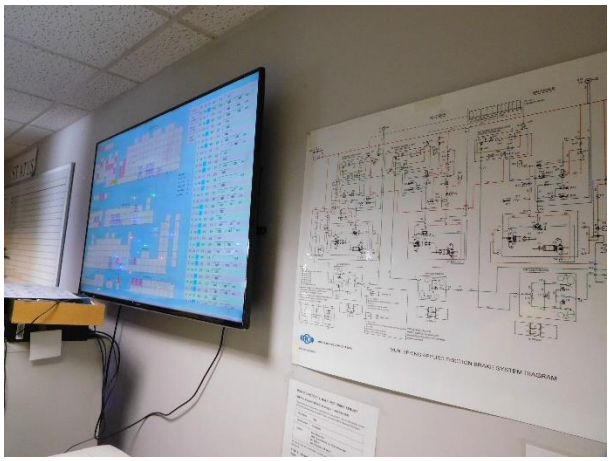


Figure 3.4 Schematic Displayed on Maintenance Shop Wall. Courtesy of SFMTA

3-4 BULLETINS

Another type of resource for rail vehicle work is a **bulletin**. Bulletins contain or feature information related to technical manuals, agency procedures, regulatory updates or guidelines, OEM updates, new parts or equipment, or testing information. Sometimes bulletins are intended for short-term purposes, and other times they contain information that may be "set in stone" and for long-term work. Each agency will determine what bulletins are shared and how that information is distributed to employees. In some instances, an original bulletin may be shared in an unaltered format. Other times, information may be simplified and re-created by the agency into their own format for timely understanding and training purposes.

Bulletins featuring information from technical manuals typically relate to long-term information. From data collected through supervisor observations or other means, a determination may have been made that revisiting a technical manual for some purpose of inspection, maintenance or repair is necessary. For example, it may have come to attention that a step for a part replacement is not being completed as intended. Therefore, a bulletin may be developed by the transit agency highlighting the area of the technical manual that explains how to complete this task. Sometimes, bulletins may be shared in a job safety briefing, a shift change meeting, delivered to individual employees, and/or posted on a shop wall(s) or computer station(s) where everyone can access and read on their own.

Bulletins may contain information related to shop, agency or standard operating procedures, or letter-type notices. These bulletins are also long-term in nature, although they may contain information that could be new for the agency such as a change in a policy or procedure, or related to a maintenance or part modification issue.

Regulatory agencies will also issue bulletins. Depending on the agency issuing, these bulletins may contain updated or a review of safety information, technical updates and reviews, or an update to a code or standard.

APTA STANDARDS DEVELOPMENT PROGRAM

RECOMMENDED PRACTICE

American Public Transportation Association
1666 K Street, NW, Washington, DC, 20006-1215

APTA RT-VIM-RP-008-03 Rev 1
First Published: Sept. 28, 2003
First Revision June 28, 2013

APTA Rail Transit Standards Vehicle Inspection and Maintenance Working Group

Rail Transit Vehicle Pre-Departure Inspection

Abstract: This *Recommended Practice* provides guidance for the pre-departure inspection of systems and components on rail transit vehicles. It covers exterior inspection, interior inspection and brake system tests.

Keywords: pre-departure inspection, rail transit system, rail transit vehicle, vehicle inspection and maintenance

Summary: This *Recommended Practice* provides guidance for the development of pre-departure inspections of rail transit vehicles. Individual rail transit systems should tailor these practices to accommodate their specific equipment and mode of operation.

Scope and purpose: This *Recommended Practice* applies to rail transit systems that operate light rail, heavy rail or rail subway systems. This document does not apply to rail transit systems regulated by the Federal Railroad Administration. This document should be used by rail transit systems that operate under Federal Transit Administration state safety oversight jurisdiction. This *Recommended Practice* provides recommendations for pre-departure inspections of rail transit vehicles to confirm the fitness for service of these vehicles. It includes a pre-departure operator's cab check, vehicle exterior inspection, vehicle interior inspection and brake system functional check. As resources and operating tempo permit, some rail transit systems may be able to perform an expanded pre-departure inspection that incorporates inspection of items and systems related to comfort, quality and reliability.

APTA Standards Development Program
Lead the Way

Participants

The American Public Transportation Association greatly appreciates the contributions of **Jayendra Shah** and **Steve Bethel** who provided the primary effort in revising this *Recommended Practice*.

At the time this document was revised, the working group included the following members:

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Contents

OEMs may sometimes send out updates regarding specific equipment or parts. Sometimes these bulletins are known as **service bulletins**.

Rail test bulletins are also used in rail vehicle maintenance and repair work. These bulletins may address the addition of parts which were not available for the original test of the product when it was new. So, one the parts are added and tested is completed with passing acceptance, the information becomes a rail modification/bulletin and is shared with the appropriate audience as determined by the agency.

3-5 STANDARD OPERATING PROCEDURES (SOP)

Standard operating procedures, or **SOP**s as they are commonly known, are written document developed by each agency to describe a process used by a department. SOPs may include procedures for a lockout/tagout process, or a hazardous material spill. Standard operating procedures should be part of employee training. After training, an employee should reference these documents when any question arises. If the questions still exist after a document has been consulted and reviewed, an employee should immediately contact their supervisor. Sometimes standard operating procedure may be reviewed with a supervisor individually or in a group setting such as a job safety briefing if the procedure has not been followed properly by one or more people or if the procedure has changed and employees must be updated. In either case, there may be some type of documentation by means of employee signature indicating their review and understanding of the procedure whether new or not.

Below is an example of an SOP used in DART.

DALLAS AREA RAPID TRANSIT
MAINTENANCE DOCUMENT CONTROL
STANDARD OPERATING PROCEDURES

"SUPER 13 SOP'S ONLY" INDEX

Date Modified: 11/11/2016

DOC #	SUBJECT	REV	DATE OF EFFECT	STATUS	ISO QP SECTION
NPG-0752	Power Industrial Truck	2	01/26/06	RLSE	
NPG-0753	Fall Protection Procedure	2	12/28/05	RLSE	
NPG-0758	Blood-Borne Pathogens and Bio-Hazard Clean Up Procedure	2	02/17/06	RLSE	
NPG-0759	Fire and Emergency Evacuation Safety Practices	0	03/12/01	RLSE	
NPG-0760	Welding, Cutting and Brazing Safety Procedures	1	07/13/06	RLSE	
NPG-0769	Hazardous Communication (HAZCOM) Safety Procedures	2	09/15/06	RLSE	
NPG-0770	Hearing Conservation	1	10/24/05	RLSE	
NPG-0771	Electrical Safe Work Practices	3	05/30/06	RLSE	
NPG-0773	Personal Protective Equipment Safety Procedures	0	07/11/02	RLSE	
NPS-0039	Respiratory Protection Safety Procedure	5	07/13/06	RLSE	
NPS-0041	Lockout / Tagout Safety Practices	1	05/16/06	RLSE	7.8
NPS-0045	Spill Response Safety Procedures	7	10/07/14	RLSE	7.8
NPS-0525	Confined Space Safety Practices	3	05/30/06	RLSE	7.8

NEWEST DOCUMENT (S) WILL BE BOLDED AND ITALICIZED

SOP NUMBER	REVISION	EFFECTIVE DATE	PAGE
NPS-0045	7	October 7, 2014	1 of 7

STANDARD OPERATING PROCEDURE

DALLAS AREA RAPID TRANSIT
MAINTENANCE DEPARTMENT

SPILL RESPONSE SAFETY PROCEDURES

7	10/07/14	COMPLY WITH DFW AIRPORT REQUIREMENTS	DCM-2520	JMH
6	02/04/09	CLARIFIED RESPONSIBILITIES, CLARIFIED INSTRUCTIONS AND REMOVED UNNECESSARY REFERENCES	DCM-1323	DJ
5	02/28/06	ADDED 7.3 TRAINING SECTION	DCM-0838	RH
4	02/10/04	UPDATE SPILL FORM	DCM-0429	JMH
3	12/19/02	UPDATE SPILL FORM	DCM-0320	TAS
REV	DATE	DESCRIPTION	RLSE NO.	INIT

ORIGINATED BY: _____ DATE: _____
Jeffrey M. Haynes, MGR Environmental Compliance Projects

APPROVED BY: MDC WORKFLOW DOCUMENT #1741587 DATE: _____
Mike Hubbell, V.P. of Maintenance

SUBJECT:	SPILL RESPONSE SAFETY PROCEDURES	SOP NUMBER	REV	PAGE
		NPS-0045	7	2 of 7

TABLE OF CONTENTS

SUBJECT:	SPILL RESPONSE SAFETY PROCEDURES	SOP NUMBER	REV	PAGE
		NPS-0045	7	3 of 7

1.0 SCOPE

This Standard Operating Procedure (SOP) is applicable to all DART Maintenance personnel.

2.0 PURPOSE

This SOP establishes guidance to ensure release of regulated or hazardous materials occurring on or near DART owned properties or during the operation of DART vehicles, are investigated, reported, and safely confined and cleaned. It also provides guidance to ensure precautions are taken to minimize impact to human health and the environment.

3.0 DEFINITIONS / ABBREVIATIONS

DART Spill Kit	Supplies and materials assembled and deployed specifically for spills common to DART operations.
Environmental Compliance Section	Contact number is 214-830-0840
Regulated or Hazardous Material	Any fluid used for the operation, maintenance or cleaning of DART Vehicles and property.
Spill	The leaking, pumping, emitting, emptying or dumping of regulated or hazardous materials that can have an adverse impact on human health or the environment.
Vehicle Fluids	Those fluids that are integral to the operation of a vehicle and are contained within the vehicles reservoirs and mechanical components. The following are examples of vehicle fluids: **A.** Diesel fuel **B.** Engine oil **C.** Gear oil **D.** Transmission fluid **E.** Steering fluid **F.** Hydraulic fluids **G.** Engine coolant The following are excluded as being vehicle fluids during spill incidents: **A.** Any material carried as cargo by a non-DART vehicle. **B.** Flammable fluids with the exception of diesel fuel.

SUBJECT:	SPILL RESPONSE SAFETY PROCEDURES	SOP NUMBER	REV	PAGE
		NPS-0045	7	4 of 7

4.0 REFERENCES

Referenced OSHA regulations are available at www.OSHA.gov.

MDC	MANUAL AND/OR DOCUMENT DESCRIPTION	SECTION	PAGE
N/A	OSHA 29 CFR 1910.120, Hazardous Waste Operation and Emergency Response	N/A	Complete Document
NPG-0769	Standard Operating Procedures, Hazardous Communication Safety Procedures	N/A	Complete Document
NPG-0758	Blood-Borne Pathogens and Bio-Hazard Clean Up Procedure	N/A	Complete Document
NPG-0773	Personal Protective Equipment Safety Procedure	N/A	Complete Document
NPG-0039	Respiratory Protection Safety Procedure	N/A	Complete Document
APL-0837	Standard Operating Procedures, Documenting Weekly Safety Meetings and Safety Training	N/A	Complete Document

5.0 FORMS

FORM DESCRIPTION	FORM LOCATION AND/OR MDC NUMBER
Spill Report Form	EUROPA\MDC\FORMS\AZD-1093

6.0 REQUIRED SAFETY EQUIPMENT / SPECIAL TOOLS

DART Spill Kit

7.0 PROCEDURE

7.1 Response for Spills of DART Cargo, DART Vehicle Fluids, or Any Spills On DART Property

A. Assess the spill from a safe up wind distance and determine if it can be safely approached.

B. If the employee is unfamiliar with the spilled material, the spill is too large to handle, or if the employee is uncertain about the spill, the employee should immediately contact their supervisor and DART's Environmental Compliance Section.

SUBJECT:	SPILL RESPONSE SAFETY PROCEDURES	SOP NUMBER	REV	PAGE
		NPS-0045	7	5 of 7

C. If the material is a flammable material other than diesel fuel, the employee should not start clean up until DART's Environmental Compliance Section has been notified. If the spill is more than 2 gallons, the local fire department may need to be notified.

D. If the material is recognizable and determined to be hazardous to people, warn others in the near area and secure the scene as best possible to prevent exposure to people and vehicles.

E. If an employee is familiar with the material and the size of the spill is manageable, he may work the spill accordingly.

1. The employee shall use proper personnel protective equipment (as outlined in SOP NPG-0773) during spill cleanup.
2. Confine a flowing spill
3. Use absorbent material to clean up a spill
4. Spill and absorbent materials from clean-up actions are to be placed in waste drums or other appropriate waste container at a DART facility.
5. Spilled material of petroleum-based materials should not be mixed with water-based materials.

F. If the size of spill is unmanageable, try to confine the spill to prevent spill from entering storm water drains, drainage ditch, creeks, or other waterways. Then notify Environmental Compliance Section.

G. For bio-hazard spill cleanup (e.g. blood, vomit, or other bodily fluids), refer to SOP Blood-Borne Pathogen and Bio-Hazard Cleanup Procedures (NPG-0758).

7.2 Response for Spills of Non-DART Cargo or Non-DART Vehicle Fluids Spilled on Non-DART Property

A. Notify the DART's Environmental Compliance Section for Spills involving non-DART Cargo, Non-DART Vehicle Fluids or any flammable fluids (with the exception of diesel fuel). These types of spills cannot be handled by DART Employees until the situation has been assessed. Immediately contact Environmental Compliance Section for Spills on Non-DART Property.

B. Spills into bodies of water, or complex incidents involving spills from non-DART Vehicles require notification to the DART Environmental Compliance Section. These types of incidents may require additional evaluation and/or action by a Contractor to confine and clean up the material

SUBJECT:	SPILL RESPONSE SAFETY PROCEDURES	SOP NUMBER	REV	PAGE
		NPS-0045	7	6 of 7

7.3 Reporting Spills

A. Reportable Spills:

1. On-DFW Airport property: Any spill amount shall be immediate reported to Environmental Compliance Section.
2. Off-DFW Airport property: Any spill more than two-gallons or a spill of any amount into a non-oil/water separator storm drain.
3. Reportable Spill (to State or Federal Agencies)
   a. Petroleum products greater than 25 gallons on land, or any quantity that creates sheen on water.
   b. Engine coolant (ethylene glycol) greater than twelve gallons directly into a storm drain or body of water.
   c. Only the DART Environmental Compliance Section staff will make reports to State and Federal Agencies.

B. Immediately contact DART's Environmental Compliance Section at the phone number listed on "DART Spill Report Form" (AZD-1093)

C. Spill Reports are to be completed in writing on the "DART Spill Report Form" (AZD-1093) and forwarded to the Environmental Compliance Office as soon as possible but no more than 8 **HOURS** after the spill event.

D. A copy of the Spill Report is to be maintained at the section or department that completed the report.

7.4 Spill Kit

The following are possible materials that can be use in spill cleanup.

A. White pads –Repels water-based fluids and absorbs oil-based fluids. This material is good to use when cleaning an oil or diesel spill, even during a rain event.

B. Grey pads – Used to absorb all liquids. Including water-based fluids (e.g. antifreeze).

C. Spill Booms – Used to contain spills.

D. Granule Absorbent – Used to absorb liquids. This material is especially good at getting residual liquid off paved surfaces.

SUBJECT:	SPILL RESPONSE SAFETY PROCEDURES	SOP NUMBER	REV	PAGE
		NPS-0045	7	7 of 7

7.5 Training

A. The minimal training required to confine and clean spills consists of:

1. HAZ-COM Training - Including SDS access and relevant material properties listed on an SDS, as outlined in SOP NPG-0769.
2. SDS are located on the web at http://dart.online-msds.com/.
3. Related Workplace Safety Meetings.

B. Employees shall review this SOP as necessary to ensure understanding and compliance and shall direct all questions regarding this SOP to their immediate supervisor for clarification.

3-6 SAFETY DATA SHEETS

Once known as Material Safety Data Sheets, or MSDS, now called **Safety Data Sheet**, or **SDS** is another type of resource common in any place where chemicals, cleaners, oils, and other potentially harmful or hazardous materials exist. SDS is widely used resource for rail vehicle maintenance and repair work.

An SDS is usually created by the manufacturer of the potentially hazardous product. SDS is usually **standardized** in presentation and contains 12 sections in each SDS. SDS can be found in books or online. SDS is governed by OSHA, and any product determined to be potentially hazardous or toxic by OSHA must contain an SDS. SDS should also indicate the proper PPE for each identified product as well as how to dispose and steps to take should the product come into contact with the employee or others in an unintended way.

Common products with SDS in rail vehicle maintenance and repair work include lubricants, cleaner products, solvent contact cleaners, acidic material such as batteries, and other chemicals such as “Spot Check” used to identify broken welds.

A rail vehicle mechanic should always consult SDS for spills or products never used before. As part of a worker’s “right-to-know”, if a rail vehicle mechanic has determined a product is identified as potentially hazardous, then the employee should request the SDS sheet if their employer has not already provided the information. The figure below shows a sample SDS sheet.

NATIONAL REFRIGERANTS, INC.

R-410A

Safety Data Sheet

R-410A

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: R-410A
OTHER NAME: Difluoromethane, Pentafluoroethane
USE: Refrigerant Gas

DISTRIBUTOR: National Refrigerants, Inc.
661 Kenyon Avenue
Bridgeton, New Jersey 08302

FOR MORE INFORMATION CALL:
(Monday-Friday, 8:00am-5:00pm)
1-800-262-0012

IN CASE OF EMERGENCY CALL:
CHEMTREC: 1-800-424-9300

2. HAZARDS IDENTIFICATION

CLASSIFICATION: Gases under pressure, Liquefied Gas
SIGNAL WORD: WARNING
HAZARD STATEMENT: Contains gas under pressure, may explode if heated
SYMBOL: Gas Cylinder
PRECAUTIONARY STATEMENT: STORAGE: Protect from sunlight, store in a well ventilated place

Figure 3.5 Sample Refrigerant Safety Data Sheet (SDS)

Some agencies will display posters or other information to help guide employees in their understanding and use of SDS sheets.

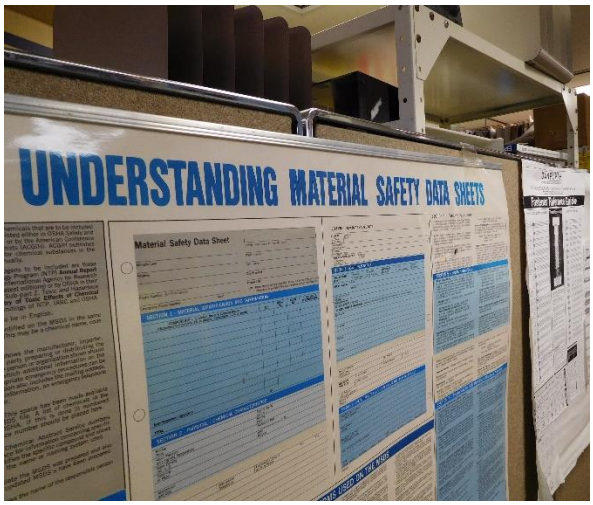


Figure 3.6 SDS Poster. Courtesy of SFMTA

Figure 3.7 SDS Station with Poster and Organized SDS. Courtesy of SFMTA

Classroom Activity – Reading and Understanding a Safety Data Sheet
In small groups or pairs, pick one of the Safety Data Sheets (SDS) provided by the instructor. Identify the 12 sections of the SDS. Using the space below, note the 12 sections and what is located in each for this particular SDS.

Section	SDS Section Name	SDS Section Description
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

3-7 WORK ORDERS

Daily, rail vehicle mechanics will consult computer stations for **work orders**. These digital documents housed in computers or laptops are part of a software system with information about the inspection, maintenance and repair work completed on each vehicle. Each mechanic must understand the work station software used by their agency to complete their work and properly document for future work and preventive maintenance purposes.

Parts of work order typically contain vehicle information and identification, the history of the vehicle including past work reports and vehicle current status, procedures for rail vehicle maintenance, part identification information and an area to input documentation of work completed.

The figure below illustrates one screen of a work order system used in Greater Cleveland Regional Transit Authority (GCRTA).

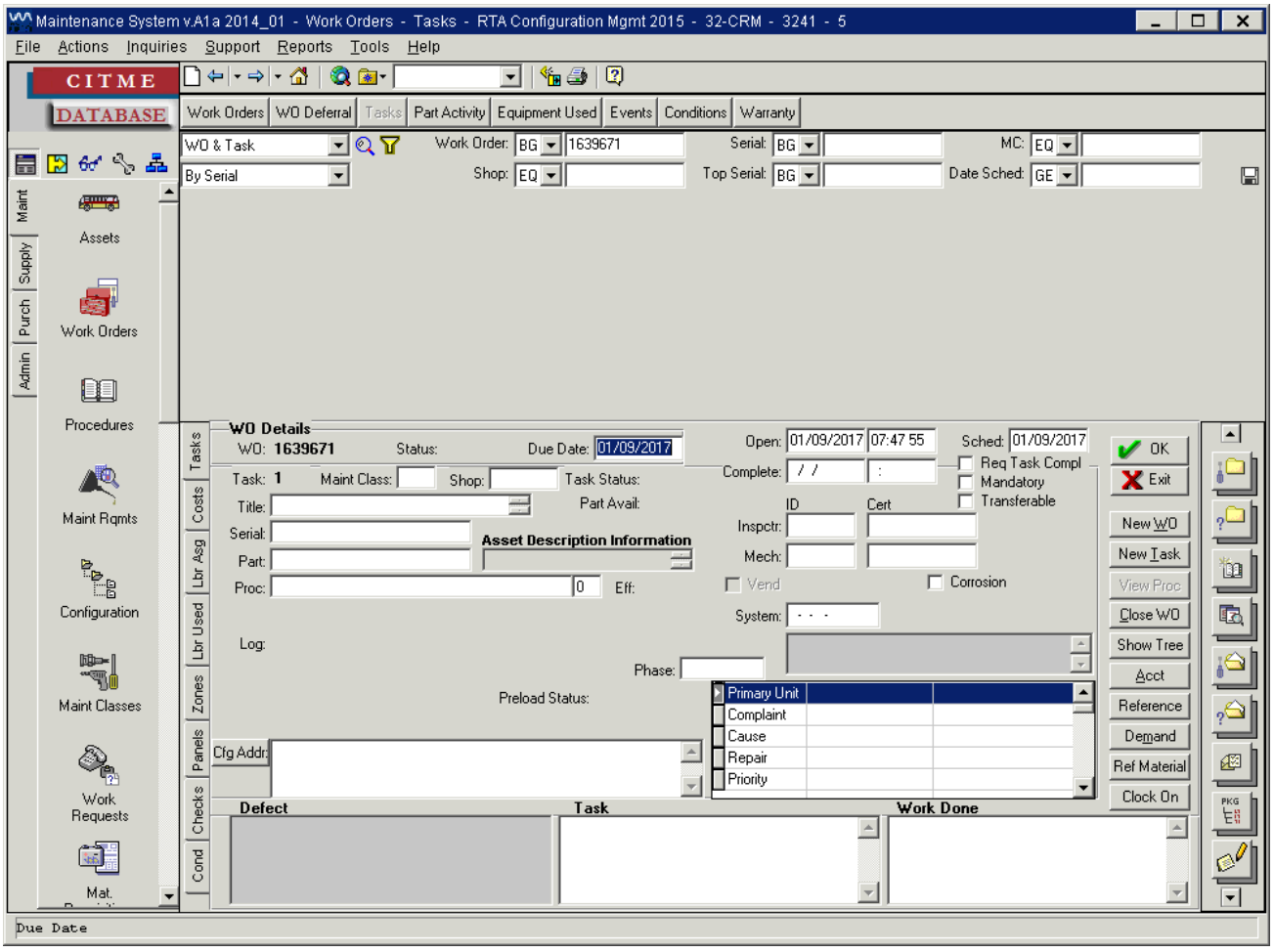


Figure 3.8 Ultramain Data Base. Courtesy of GCRTA

Rail vehicle mechanics should know how to access, navigate and document work completed in their own agency's work order system.

Classroom Activity – With the assistance of your instructor, explain how work orders are accessed and maintained in your rail agency.

3-8 OVERSIGHT RESOURCES

Safety oversight resources are also part of the rail vehicle maintenance shop environment. These resources provide guidelines, and sometimes laws, pertaining to the safety of the work environment. These oversight resources may be provided by local government oversight, state government oversight, federal government oversight, agency oversight, or union oversight.

Documents are stored and maintained by each agency as they see best. In some instances, certain oversight resources are required by law to be displayed in public areas for all to see. The figure below shows a collection of state and federal oversight resources displayed in a rail vehicle maintenance facility in SFMTA.

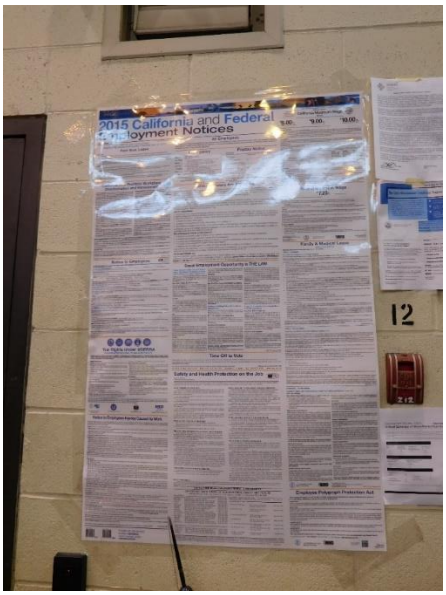


Figure 3.9 Oversight Resource. Courtesy of SFMTA

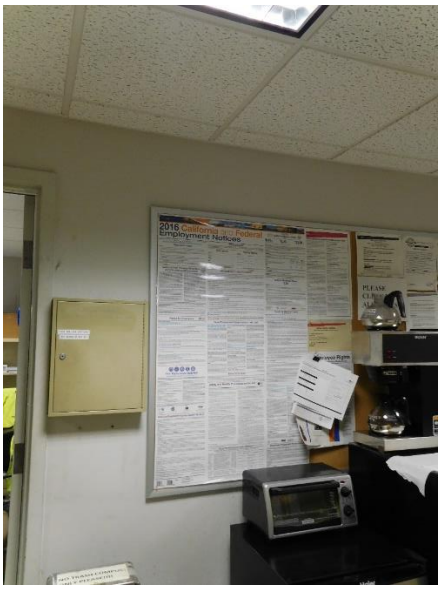


Figure 3.10 Oversight Resource. Courtesy of SFMTA

3-9 SHOP TAGS

Shop tags are important sources of information in the rail vehicle shop. These tags contain information about parts and equipment that are pulled for service. Each agency has its own system for shop tags. Below is an example of a shop tag in SFMTA.

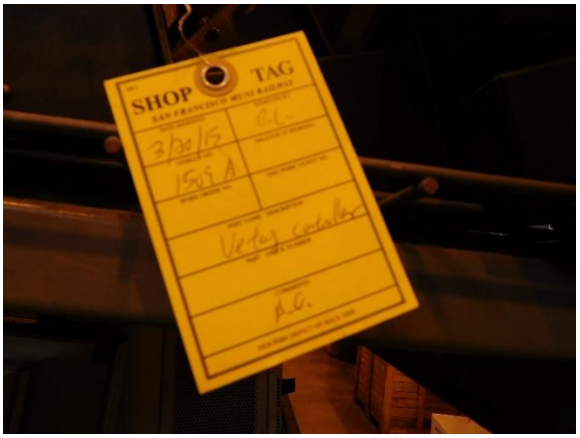


Figure 3.11 Shop Tag. Courtesy of SFMTA

Classroom Activity – With the assistance of your instructor, identify the types of resources found in your agency. List each resource below, describe

where each is located, and explain the importance of each for rail vehicle inspection and maintenance.

3-10 SUMMARY

Providing a wide variety of information, resources are very important in rail vehicle maintenance. Resources come in various forms and located in various areas throughout a maintenance and repair shop. Resources are used for a variety of purposes and come in a variety of forms in the rail vehicle maintenance shop including job safety briefings, technical maintenance and repair manuals, standard operating procedures, safety data sheets, safety oversight resources, and rail vehicle work orders. This Module explained each type of resource, where they are commonly found, and their typical uses. Every rail vehicle mechanic should know and understand their own agency's resources, where they are located, and how to navigate to use them throughout work performed during a shift.

MODULE 4

INTRODUCTION TO RAIL VEHICLE INSPECTION AND MAINTENANCE

Outline

Purpose and Objectives

The purpose of this Module is to provide participants with an introduction to the general principles and practices for rail vehicle-specific inspection and maintenance.

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

- Identify types of maintenance.
- Explain importance of inspection.
- Differentiate between types, strength, and identification of nuts, bolts, and screws.
- Identify DC disconnect and related shop power.
- Explain LOTO.
- Explain purpose, use and safety considerations of tools used in rail vehicle maintenance.
- Describe communication within the shop.
- Identify safety procedures specific to shop procedures and environment.

Key Terms

- Announcements
- Battery jack
- Blue flag
- Corrective maintenance
- DC disconnect
- Diameter
- Drive type
- Fastener type
- Fork lift
- Grade
- Head diameter
- Head style
- Heavy maintenance
- Hoist
- Hydraulic lift
- Jib crane
- Joyce Jack™
- Length of fastener
- Material
- Measuring tools
- Overhead bridge crane
- Pneumatic lift
- Pneumatic power tool
- Predictive maintenance
- Preventive maintenance
- Preventive maintenance plan
- Primary maintenance
- Reactive maintenance
- Running maintenance
- Scheduled maintenance
- Secondary maintenance
- Shift briefing
- Standard tool kit
- Testing
- Thread count
- Torque wrench

4-1 OVERVIEW

While all types of inspection, maintenance and repair work may share similar characteristics, rail vehicle work has some unique aspects which set it apart from other transportation fields. Module 4 will introduce the participant to some general principles as well as specific guidelines or aspects of rail vehicle inspection, maintenance and repair work.

4-2 TYPES OF MAINTENANCE

For almost all types of maintenance, general maintenance approaches can be categorized in three ways: Reactive maintenance, predictive maintenance, and preventive maintenance.

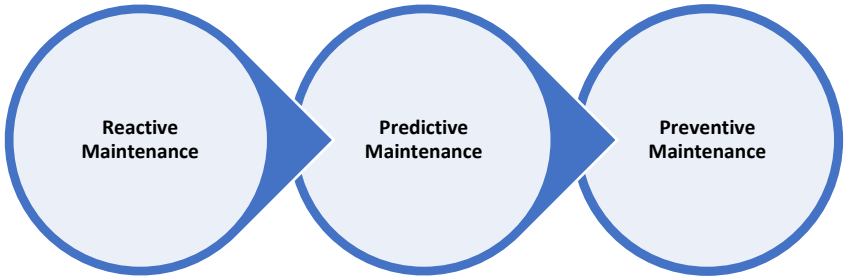


Figure 4.1 Three Types of Maintenance

The first type of maintenance is **reactive maintenance,** sometimes call breakdown maintenance. Reactive maintenance is “run it till it breaks." No action or effort is taken to maintain the equipment as the OEM intended. The advantages of reactive maintenance are minimal incidents of failure of new equipment, limited manpower as the manpower is not used until something breaks, and no one sees any associated maintenance cost. The disadvantages of reactive maintenance are decreased equipment life expectancy, increased labor costs for repairs because failures will most likely be more extensive, and increased capital cost for premature equipment replacement. Additionally, the lack of maintenance will increase the probability of accidents and lawsuits.

The second type is **predictive maintenance**. Predictive maintenance is maintenance based on the actual condition of the rail vehicle, rather than on a preset schedule. For example, consideration for mileage may be incorporated into predictive maintenance. The advantages of predictive maintenance are decreased costs for parts and labor, allows for preemptive corrective actions, and decreased downtime used for unneeded maintenance. The disadvantages of predictive maintenance are increased investment in diagnostic equipment, increased investment in staff training, and savings potential not easily seen by management.

The third type of maintenance is **preventive maintenance** (PM). Preventive maintenance is scheduled maintenance procedures at predetermined time intervals. These procedures are performed by cleaning, inspecting, adjusting, lubricating and replacing worn parts before they fail or may include time-based, seasonal type maintenance such as pre-summer HVAC checks or annual inner motor inspections prior to winter. The advantages of preventive maintenance are increased car and system life expectancy, improved reliability, and decreased operating costs over the life of the rail vehicle. The disadvantages of preventive maintenance are very labor intensive, includes performance of unneeded maintenance, and potential for incidental damage to components in conducting unneeded maintenance.

A good **preventive maintenance plan** is a structured approach to making sure that any equipment used in a system is functioning with the highest possible degree of efficiency. The goal is to minimize opportunities for the equipment to break down and adversely affect the riding public. While a plan of this type will vary based on the nature of the transit authority's approach, there are a few basics that are likely to be part of any ongoing preventive maintenance strategy. These include regular testing, periodic adjustments, lubrication of parts, replacement of worn parts before they fail, and routine cleaning. Properly performed preventive maintenance increases reliability and reduces breakdowns.

A preventive maintenance plan is NOT "IF IT'S NOT BROKEN OR NOISEY, LET IT ALONE". Preventive maintenance is NOT OPTIONAL. Preventive maintenance is required by code, industry standards, and equipment manufacturers'. The code book states it is mandatory.

Testing is a basic part of the preventive maintenance plan which involves examination of the equipment to ensure that each device is functioning properly as designed. It is not unusual for testing

of this type to be conducted at regular scheduled intervals such as monthly, quarterly or annually. Often, running these periodic tests helps to identify potential issues that could over time cause the equipment to become inoperable, and provide the chance to address those issues now rather than later.

Rail Vehicle-Specific Maintenance

Inspection and maintenance of rail vehicles depends on a variety of circumstances and conditions. Some types of maintenance occur independently of one another and sometimes they occur together.

The process of preventive maintenance for rail vehicles can be divided into two separate sub-categories: Planned maintenance and corrective maintenance. Scheduled maintenance includes scheduled overhauls as well as scheduled equipment replacement (individual component or block systems).

Corrective maintenance is more reactive and is unscheduled occurring in response to an unanticipated required repair encountered during the preventive maintenance process. Here, the maintenance personnel performing the PM perform routine service to the equipment, as well as using the opportunity to correct problems that they may encounter. The PM process helps to identify any differences between the actual and the expected behavior of the systems. Corrective maintenance includes any on-vehicle repair completed on the floor or in the pit.

Maintenance personnel should always be aware that the scheduled maintenance they are performing serves two purposes. One is to keep equipment working properly and/or to extend the life of the equipment and the other stage of preventive maintenance is the corrective action (repair), which maintenance personnel must take to restore the equipment to its proper working order when encountering a fault. Generally, regulatory and code requirements, technical safety requirements, in-service inspection and testing, as well as engineering decisions are all used in the pursuit of practical planned maintenance. The life expectancy of rail vehicle is always considered for inspection and maintenance purposes. For instance, there will be a certain number of **routine inspections** required depending on the vehicle and regulations. These inspections may be mileage or time based. The goal of the routine inspections and preventive maintenance is to ensure the vehicle meets its life expectancy, or is a viable vehicle until it is no longer deemed able to be used unless rehabbed. Vehicle rehabs, or complete overhauls, are also mileage or time based.

Within all types of rail vehicle maintenance, maintenance may either be **heavy maintenance** or **running maintenance**. Heavy maintenance/repair, sometimes also known as rebuilds or heavy overhaul, occurs when a vehicle is taken out-of-service for a large repair such as a motor rebuild. Running maintenance is the day-to-day maintenance or replacement for basic operation.

Primary maintenance and **secondary maintenance** are also two type of maintenance approaches occurring in the rail vehicle shop. Primary maintenance includes on-vehicle repair on the floor or in a pit area while secondary maintenance pertains to a component that is pulled for maintenance somewhere else besides the shop floor or pit areas.

Classroom Activity
With the assistance of your instructor, explain in the space below the inspection and maintenance procedures and schedules for your rail vehicle shop.

4-3 SHOP COMMUNICATION

While forms of communication in terms of resources was explained in Module 3, shop communication for this Module focuses on the immediate and daily verbal and non-verbal communication that takes place in rail vehicle maintenance shops for a variety of purposes. This daily communication occurs between team members, supervisors, and other affiliated employees. This immediate communication is used for movement of vehicles and/or equipment, energizing and de-energizing high voltage shop power, shop hazards or difficulties, emergencies, and for entering

and exiting vehicles. Shop communication is essential for the protection of employees and anyone else in the shop area. In addition to work boards and job briefings earlier described, communication may also occur in the form of announcements, shift briefings, and blue flag communication.

Announcements: Announcements occur in various forms in the rail vehicle shop. They may happen over a loud speaker or via radio. Announcements are usually given when there is a difficulty in the shop, for instance in moving a vehicle, or in the case of an emergency, such as a need for building evacuation.

Shift Briefings: Shift briefings are small meetings where shift team members and supervisors can discuss planned work for the day. Any other important information may be distributed at this time.

Blue Flag: Blue flags, sometimes in the form a blue cone or blue tag, are used throughout many shop environment alerting of the presence of different type of work being performed and associated dangers. Sometimes, a blue light will be used during nighttime hours. Blue flags are intended to protect those who are working so that no one else can access or power a vehicle. Blue flags are also used in the train yard to prevent movement of a car in that location as well.

Each agency has their own procedures governing the use of blue flags. In some cases, only a supervisor may place or remove a blue flag. In other cases, the blue flag may only be removed by the person who placed it there. The use of blue flags are typically documented and recorded in log books or systems.

Figure 4.2 Blue Flag. Courtesy of SFMTA

4-4 HARDWARE AND TOOLS FOR RAIL VEHICLE MAINTENANCE AND REPAIR

Hardware for rail vehicle maintenance and repair includes fasteners, fittings and tools required for the identified work to be completed. Selecting the correct hardware for each task is critical to ensure the task is completed properly and safely. Selecting the wrong hardware could result in an accident and subsequent injury(ies) either during the process of maintenance and repair or later when the rail vehicle is in service. Hardware is provided by approved sources from each agency, and rail vehicle mechanics must know the various configurations of hardware and any related safety measures.

Fasteners: Nuts, Bolts and Screws

Fasteners are often used for rail vehicle maintenance and repair work. When using fasteners, it is important to realize the different types, strength corrosion resistance, galvanic properties and any system of identification used by an agency.

Fasteners can be identified by five categories: type, material, diameter, length and thread pitch.

Fastener type can be considered by category of fastener, drive type, and head style. Categories of fasteners are based on their function or design and include the various types of screws and bolts.

Drive type refers to configuration of the top of the head of the screw and includes types such as Phillips, Allen, or Slotted.

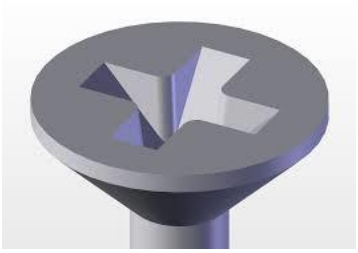


Figure 4.3 Phillips Head Screw. Source: Wikipedia

Head style of fastener types refers to the shape or style of the head of the fastener, such as flat, oval, round or hex.

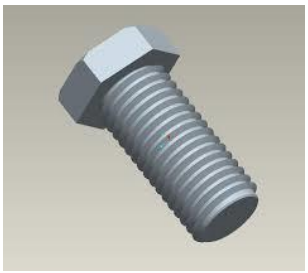


Figure 4.4 Hex Head Screw. Source: Wikipedia

Material is what the fastener is made from, such as steel, and may also include the **grade** of the material. Grade indicates the strength of the material. Coatings may also make up fastener material. Coatings may be used to increase corrosive resistance, for galvanizing purposes, or for appearances.

A fastener's **diameter** is either a size number or direct measurement and refers to the circumference measurement of the fastener. The most common diameter measurements include the thread diameter (T) – shank diameter.

The fastener diameter is usually the thread diameter. Nuts and washers will use the same numbered size as the bolt or screw diameter. For example, a ½ inch washer will fit with a ½ inch bolt. In addition to matching sizes, nuts must also match in thread density as explained later.

Another aspect of the fastener diameter is the **head diameter,** which refers to the size of the head measured across the flats. This measurement is also the wrench size the bolt will use.

Screw sizes below ¼ inch are usually identified by a number size which is usually preceded by a number sign.

The **length of the fastener** is usually measured from the surface of the material to end of the fastener. The exception to this is when the head of the fastener sits above the surface, for example a hex bolt, or when the faster is intended to be counter sunk as in the case of flat head screws. In the case of the fastener set above the surface, the measurement of the length will be from directly under the head to the end of the fastener. In the case of the counter sunk fastener, the measurement is taken from the surface of the material point on the head will be to the end of the fastener.

Thread count, or pitch count, only pertains to machine thread fasteners. This count indicates how fine the thread. American fasteners are usually identified by thread count or threads per square inch (TPI). Metric fasteners are usually identified by thread pitch expressed in millimeters. Thread count or pitch is usually measured using a thread gauge.

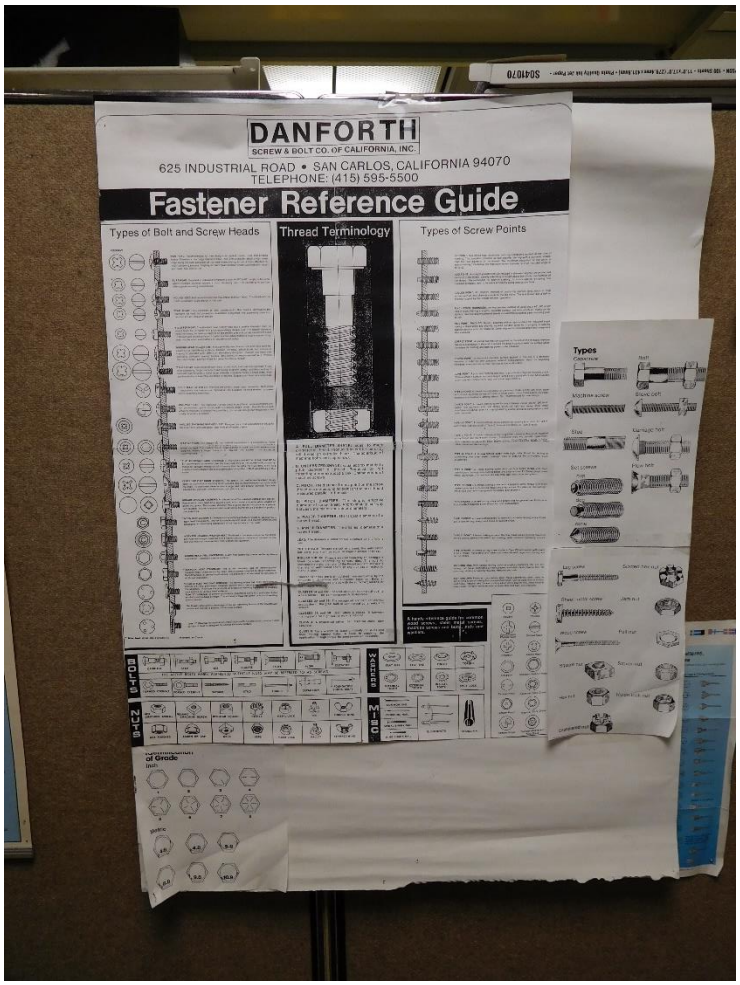


Figure 4.5 Fastener Reference Guide Resource Poster. Courtesy of SFMTA

For more information on types of fasteners, visit websites:
Electronix Express:
http://www.elexp.com/Images/AllAboutScrews.pdf
The Bolt Depot:
https://www.boltdepot.com/fastener-information/Printable-Tools/Type-Chart.pdf

Tools

Tools are used every day by rail vehicle mechanics. Tools used should be agency-approved. Tool safety guidelines, proper PPE usage, and effective tool care must be followed to ensure the safe use of tools.

Tools covered in this section include:

- Standard Tool Kit
- Measuring Tools
- Power Tools
- Lift and Moving Tools
- Tools for cleaning

Standard Toolkits

A **standard toolkit** comprised of hand tools and used by rail vehicle mechanics may include but are not limited to:

- Assorted wrenches
- Chisels, punches
- Crimpers
- Lineman's pliers
- Files, fine and rough
- Fuse pullers
- Gauges including switch, filing and obstruction
- Grease gun, oil can
- Grinders / bonding equipment
- Hammer and mallet
- LOTO materials
- Penetrating oil
- Pliers including needle nose, duckbill and slip joint
- Pocket knife
- Pry bars
- Ratchet and extension
- Ruler – tape measure (must be non-conductive material)
- Screwdrivers, assorted including Phillips, straight-end
- Wire strippers
- Vices and clamps

Figure 4.6 Needle Nose Pliers

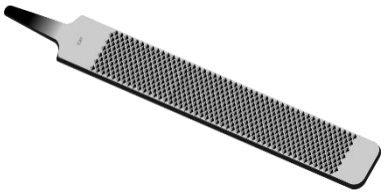


Figure 4.7 File

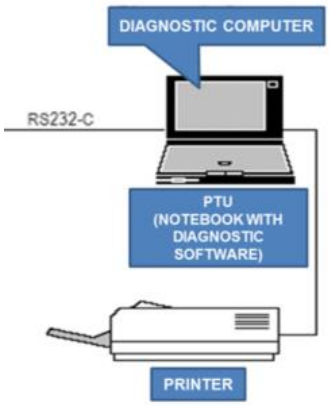
Figure 4.8 Wire Strippers

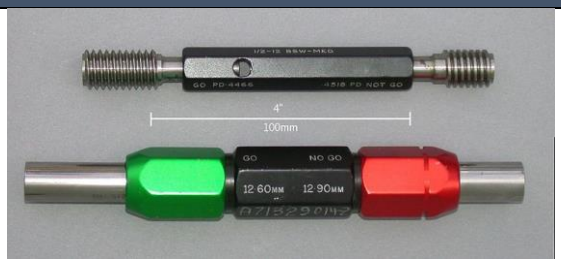
In addition to common and general hand tools, measuring tools, lift and jack tools, pneumatic tools and power cutting tools may also be used in transit maintenance.

Measuring Tools

Measuring tools are used to measure areas of the rail vehicle including wheels, brake actuators, and busing pins. Measuring tools for rail vehicles include calibrated tools such as torque wrenches, crimpers, electrical meters, and precision measuring devices; Go/No-go gauges; micrometers; Pi tape; and push-pull gauges. These are all further explained in the table below.

Measuring Tool	Illustration	Description/Use
Torque wrenches	 ***Figure 4.9 Torque Wrench. Courtesy of GCRTA***	Used for precision tightening of fasteners.

Measuring Tool	Illustration	Description/Use
Electrical Meters	 ***Figure 4.10 Digital Multimeter ©Fluke***  ***Figure 4.11 Oscilliscope . Source: Wikipedia***	Measures electrical conditions in equipment, batteries and wiring. Includes multimeters, meggers, oscilloscopes
Portable Test Units (PTUs)		Rail car technicians rely on portable computerized equipment that diagnose, test, and report faults on the operation of auxiliary power supply units.

Measuring Tool	Illustration	Description/Use
Go/No-go gauge	 ***Figure 4.12 Go / No-Go Gauge Source: Wikipedia***	Double-sided tool to indicate if something fits Measures brake actuators and bushing pins

Other Measuring Tools

Measuring Tool	Description
Micrometers	Gauge that measures small distances or thicknesses between its two faces, one of which can be moved away from or toward the other by turning a screw with a fine thread
Pi Tape	A steel ribbon, measure the diameter of wheels
Push-pull gauge	Measures the tension of paddles on rails or sliding doors for opening/closing purposes
Profilometer	A profilometer is a device used to measure the finish or roughness of a surface.
Chart Recorder	Calibrate chart recorder to specified directions according to manufacturer and graph the results. Recently, chart recorders have been replaced with laptops running diagnostic software in real time
Other –	
Other –	

Torque Wrenches

Torque wrenches are commonly used in rail vehicle maintenance. Invented in 1918 by Conrad Bahr while working for the New York City Water Department, torque wrenches are used for specific torque application when fastening nuts or bolts for preventing over or under-tightening. Knowledge of use, application, and care of these tools is particularly important for their effectiveness and longevity in the rail vehicle maintenance shop environment.

All torque wrenches are not alike. Types of torque wrenches include:

- **Beam Type-Torque Wrench:** Low-cost torque wrench with longer lever, which bends when the wrench is tightened.
- **The Dial Version-Torque Wrench:** Like a beam wrench, but pressure is translated to a dial displaying the pressure relative to the dial chart.
- **Electronic Dial-Torque Wrench:** Like a dial wrench but displays the torque setting digitally.
- **The Clicker Type-Torque Wrench:** Is a click-type wrench with a mechanism that pops in the wrench when the correct tightness is applied alerting the user to stop tightening. Preset measurements are displayed on the side of the handle to adjust the wrench for tightness.

Before using a torque wrench, always read the manufacturer literature to understand the features of the tool and any recommendations for care and use. Be sure to test the wrench to ensure it functions as intended and has been certified as calibrated. Always ensure the socket or bit properly fits on the drive and the adjustment mechanism works correctly.

Adjustable scales are found on most torque wrenches. Torque wrenches with external adjustable scales usually contain a master scale as well as sometimes a micrometer scale. Increments or graduations indicate how fine a tool can be set, and those with micrometer scales are more complex and can be set to finer increments since the two scales can be adjusted simultaneously. Torque wrenches with internal adjustable scales are typically used for only one torque setting or in production-type environments.

The accuracy of a torque wrench will be displayed as Full Scale (FS) or Indicated Value (IV). FS accuracy indicates the allowable error over the full-scale range of the tool, while IV accuracy indicates allowable error at the set point on the wrench. IV stated wrenches are more accurate, especially on the lower end of the range. A torque wrench must be selected based on the accuracy needed for its use.

It is important to ensure torque wrenches are calibrated and maintained. Torque wrenches should be inspected regularly and serviced as needed. Regular inspection and maintenance of torque wrenches may include but are not limited to:

- Monitor the number of times the tool is used, inspect for excessive wear, loose or unstable components
- Ratchet screws are tight and ratchet spins freely
- Ratchet is cleaned and lubricated
- Wrench handle is not loose and free of corrosion and lubrication
- Proper calibration
- Clean outside of wrench with dry cloth

If the torque wrench requires additional maintenance or calibration, then the wrench should be serviced as per OEM recommendations or by a as per agency procedures. Torque wrenches should be stored properly in a clean, dry place to protect from dust, chemicals and other possible hazards.

Classroom Activity – With assistance from your instructor, examine a torque wrench used in your agency. In the space below and as directed by your instructor, list directions for use and care for the torque wrench in the space below.

Power Tools

Power cutting tools are used to remove material by means of rotating or linear action. Drills and saws are common cutting tools. Some power tools are electrically driven and others pneumatically driven. Always use the correct PPE as determined by agency policy for each type of power tool when used.

The illustration below shows a hand drill and common components including the drill bit, chuck, torque selection ring, on/off trigger, and forward/reverse switch.

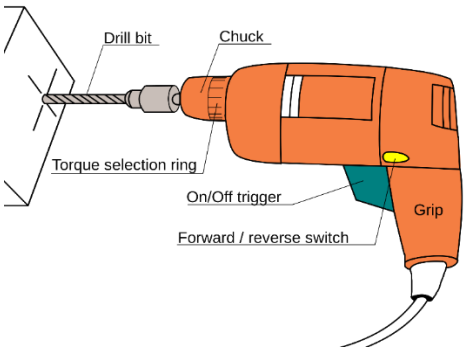


Figure 4.13 Common Hand Drill. Source: Wikipedia

Figure 4.14 Power Tool. Courtesy of SFMTA

Pneumatic power tools can be driven by compressed air either supplied by an air compressor or driven by portable smaller cylinders containing compressed carbon dioxide (CO2) for portability. Pneumatics tool include an assortment of different types of power tools including drills and saws. Because these types of tools involve compressed air, special consideration and care must be taken for the safety of working around and use of pneumatic tools as described in Module 2.

Lift and Move Tools

Lift and move tools are used to raise or mount the vehicle for work to be performed on the underside of the car or used to move heavy parts and equipment. Lift and move tools covered in this section include fork lifts, cranes, and lift and jack tools.

Fork Lifts

Different types of **fork lifts** exist in the rail vehicle maintenance and repair shop for a variety of purposes including a drivable forklift and hand forklifts. Drivable forklifts are used for the movement of heavier items and components, while hand forklifts are used for light maintenance. Training is required to operate drivable forklifts with re-certification every three years as required by OSHA.

Cranes

A crane may also be used for moving heavy equipment. There are two types of cranes: Overhead and jib. **Overhead bridge cranes** provide heavier capacity for cars. **Jib cranes** are used to move components from the floor to a work table, such as for moving a compressor.

Training is generally required for anyone assigned to using a crane to move vehicles and equipment. Training is generally a two-day course involving general operation, safety, capacity, and how to select correct straps. Sometimes these courses are also known as a "Rigging Class."

Figure 4.15 Overhead Bridge Crane. Courtesy of Denver RTD

Figure 4.16 Jib Crane

Lift and Jack Tools

Lift and jack tools are used for mounting the car. Four types of lifts and jacks may be used in a rail shop: A battery jack, pneumatic/hydraulic lift, a "Joyce Jack", and special jacks such as caliper jacks.

A **battery jack** is used for lifting heavy sets of batteries. These jacks may also be used for lifting components as well. A foot pump is usually part of battery jack. A **pneumatic/hydraulic lift** is usually used for lifting the rail vehicle. A **Joyce Jack™** is OEM brand of electric jacks that work in a way so that all for lifts act in tandem to lift entire car. Special jacks, such as caliper jacks, are used to lift specific parts such as calipers. Generally, these jacks are smaller.

Figure 4.17 Jack used in SFMTA. Courtesy of SFMTA

Another type of lift tool used in rail vehicle maintenance are **hoists**. This type of lift tool includes both the outer and inner hoists referred to as the car hoist. The thin outer lifts are called the body stands. The inner larger ones are called the truck hoists. Hoists are weight rated. When used, the whole car is lifted by the truck hoists. After the car is raised, then the body stands hold the car are raised as we lower the truck hoist which has been disconnected from the car body. This allows us to move the truck itself to a different area so one can access the trucks to repair any issues.

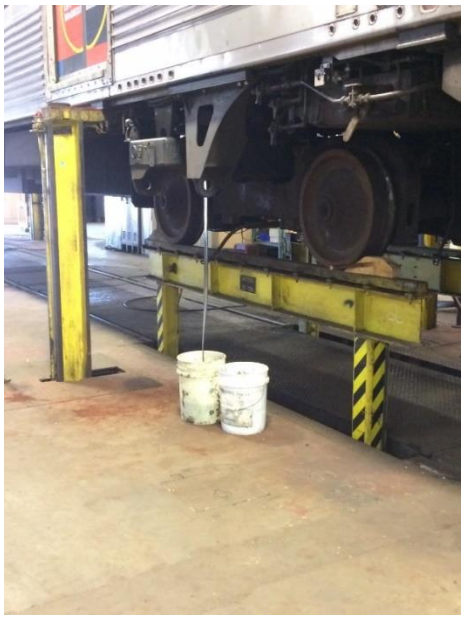


Figure 4.18 Hoist. Courtesy of SEPTA

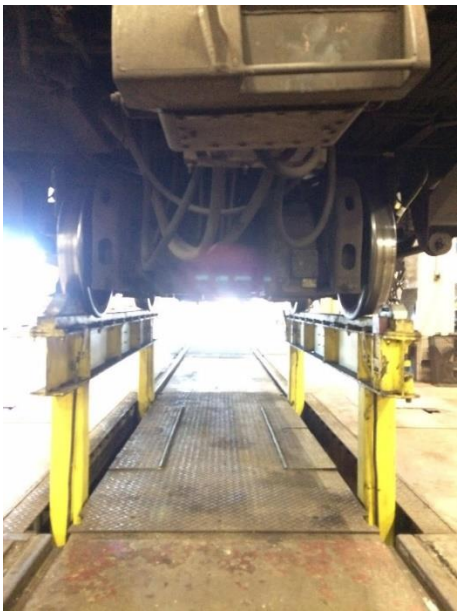


Figure 4.19 Hoist. Courtesy of SEPTA

Lift Tools: Communication and Agency Policy

As explained elsewhere in the course, signs will be posted and agency communications in place in the shop area alerting of the use and necessary precautions to take when rail vehicles and equipment are being moved. A rail vehicle mechanic working in a shop area must know their agency's types of lifts and related policy and procedures for working around and using them.

Figure 4.20 Communication at SFMTA. Courtesy of SFMTA

Classroom Activity – With assistance from your instructor, identify the types of moving and lift tools used in your agency rail vehicle maintenance shop. List each type below and explain what each is used for as well as any additional training and or procedures that must be followed to work around or operate.

	Type of Lift or Moving Tool	Uses	Training and/or Agency Policy
Fork Lifts			
Cranes			
Lift and Jack Tools			

Tools for Cleaning

Most equipment and components need regular cleaning. While cleaning, the maintainer should inspect the external condition of the equipment as well as connections. Cleaning tools include cloths, solvents, brushes, brooms, hot gloves, to name a few. When cleaning equipment, follow any OEM-specific guidelines.

General Tool Safety

The use of any tool in transit can present a safety hazard for both the user and those in the general area where work is being completed. General tool safety guidelines for transit maintenance include:

- Always use caution with metal tools around electricity and batteries
- Always use the correct tool for each job
- Ensure to monitor and maintain the tools to keep them serviceable
- Understand the differences and safety concerns for hand tools, pneumatic tools, cutting tools,
- Always use the proper PPE for each type of tool

Tools	Hazards	PPE
Hand tools	Shock hazards near electrical, tool breakage and striking hazard, ensure tools are not defective, improper use	Gloves, eye protection
Electric power tools	Shock hazard, cutting limbs, catching sleeves, hair, etc. in machine	Gloves, eye protection, removing jewelry, ear protection
Pneumatic power tools	Shock hazard, cutting limbs, catching sleeves, hair, etc. in machine, compressed air hazards	Gloves, eye protection, removing jewelry, hearing protection, ear protection

Care and Maintenance of Tools

Tools should be cleaned after each use before returning them to storage. In general , transit technicians should:

- Check handles for splinters, breaks, and cracks.
- Check for rust or signs of corrosion
- Inspect for signs of wear and proper working
- Ensure electrical cords are intact
- Ensure proper tool lubrication
- Follow OEM and agency recommendations

Warning: Safety Precautions!

- Broken tools can cause injury! Don't use tools that need repair or replacement.
- Use appropriate tools for maintenance tasks.
- Use tools appropriately.
  Use approved cleaning materials on tools.

4-5 SHOP POWER

As explained in Module 1, rail vehicles are dependent on **high voltage feed** from an external source, typically 600 to 1000 Vdc. Due to the use of high voltage power for rail vehicle operation in many instances, special care and accommodations must be made to safely move and complete work on the vehicle when removed from regular service and placed into the yard or shop environment. In some cases, work required needs the car to be deenergized, as in the case of internal repairs for propulsion. However, some work will require the vehicle to be powered, or energized, such as during periodic inspections or to test doors, lights, propulsion, and HVAC systems. It is critical for a rail vehicle mechanic to know what type of power is used in their shop and how to safely energize or deenergize depending on the work or task required.

The table below illustrates types of power found in several Consortium agencies.

Transit Agency City	Collected Power Voltage	Shop Power Route
CATS Charlotte	Overhead Catenary 750 Vdc	750 Vdc routed through main fuse (250 A) to a knife switch then distributed to auxiliary power supply. Shop plug on roof of train.
GCRTA Cleveland	Overhead Catenary 600 Vdc	600 Vdc shop plug on side of train.
RTD Denver	Catenary 750 Vdc	750 Vdc Does not use shop power. Catenary throughout shop.
BART San Francisco	Third Rail 1000 Vdc	Two kinds of shop power: • 208 Vdc 3-phase shop power for LVPS systems on rail vehicle. • 1000 Vdc checking full operation of APSE and HVAC. Shop plug under car.
MBTA Boston	Overhead Catenary 620 Vdc	620 Vdc Shop plug on side of train.
San Diego	Overhead Catenary 740 Vdc	740 Vdc Shop plug on roof of train.
Dallas	Overhead 845 Vdc	845 Vdc routed to a main fuse to a knife switch then distributed to auxiliary power supply. Shop plug on side of car with knife switch.
NFTA	Overhead 650	650 shop plug side of train.
SFMTA	Overhead 600	600 volt plug on side of car activated by stinger, near the knife switch.
Chicago	600 Vdc – third rail	600 volt test box to the test plug. Stinger to the shoe. Utilize a jumper if in the rail gap.

LA Metro	Overhead and third rail 750 for both	Deliver power to vehicle overhead system 750 volts. Light rail – remote stinger power 750 volts to power up auxiliary. Heavy rail – two types of stingers – bug power on, stinger to move the vehicle.
SEPTA	600 volts third rail	Auxiliary power – plug on side of car with knife switch. Propulsion – pole to shoe.

Rail vehicle maintenance shops are also supplied with **AC power** for lighting, tools use, and other equipment purposes. This AC power is initially distributed to the shop, or an area of the shop, through a main disconnect before delivery to a distribution panel or supplied directly to a need. While this voltage is not as high as what is used for rail vehicle movement, there is still the potential for electrical safety hazards and arc flash. All rail vehicle mechanics should know and follow their agency's policies for when working with AC power and its distribution system.

Figure 4.21 Main Disconnect Switch for AC Power Supply. Courtesy of SFMTA

Lockout/Tagout (LOTO)

Lockout/tagout or **LOTO** is required procedure by all agencies whenever the technician is working in the rail vehicle shop. For example, when it is necessary to isolate the vehicle from its high voltage source, LOTO must be applied.

A LOTO procedure works like this: all individuals working on a secured circuit have their own personal padlock or combination lock that they set on the control lever of a disconnect device prior to working on the system. Additionally, they must fill out and sign a tag that they hang from their lock describing the nature and duration of the work they intend to perform on the system. If there are multiple sources of energy to be "locked out" (multiple disconnects, both electrical and mechanical energy sources to be secured, etc.), the technician must use as many of their locks as necessary to secure power from the system before work begins. This way, the system is maintained in a zero energy state until every last lock is removed from all the disconnect and shutoff devices, and that means every last worker gives consent by removing their own personal locks. If the decision is made to re-energize the system and one person's lock(s) still remain in place after everyone present removes theirs, the tag(s) will show whom that person is and what it is they are doing.

Even with a good LOTO safety program in place, there is still need for diligence and common-sense precaution. This is especially true in industrial settings where a multitude of people may be working on a device or system at once. Some of those people might not know about proper LOTO procedure, or might know about it but are too complacent to follow it. Do not assume that everyone has followed the safety rules! Follow your transit agency’s procedures regarding LOTO procedures.

After an electrical system has been locked out and tagged with your own personal lock, you must then double-check to see if the voltage really has been secured in a zero state. One way to check is to see if the machine (or whatever it is that is being worked on) will start up if the start switch or button is actuated. If it starts, then you know you haven't successfully secured the electrical power from it.

Figure 4.22 Lockout/Tagout Applied to High Voltage Power Line. Courtesy of GCRTA

Classroom Activity – With assistance from your instructor, describe your agency's LOTO procedures in the space below.

The DC Disconnect

The **DC disconnect** switch provides shop power to overhead catenary line and third rail. There may be several DC disconnects in a single rail vehicle maintenance shops, one for each section of the shop. As shown earlier in the course, the DC disconnect is enclosed in a large box sometimes with a glass face. The box typically contains a sign explaining what track is being powered. The switch itself electronically energizes or de-energizes the catenary line or third rail, and a red light on the outside of the box is usually lit to indicate or alert of high voltage in use anywhere in the shop.

Figure 4.23 The DC Disconnect. Courtesy of SFMTA

Figure 4.24 Catenary Power Detector. Courtesy of SFMTA

Communication with the shop is essential for energizing and de-energizing high voltage power via the DC disconnect. Each agency should have its own procedures and policies that each employee must know and understand. These procedures are typically explained in SOPs. Below is an example communication strategy used for energizing and de-energizing high voltage shop power.

- Energizing High Voltage Power - Ensure people are warned /notify verbally twice before any adjustment to electric line “Track 9 going hot”.
- De-energizing High Voltage Power– Employees must ensure the vehicle / train is also de-energized, lower catenary to ensure know current draw/arch across the DC disconnect box.
- De-energize the DC disconnect.

Critical safety measures are in place for working around or with the DC disconnect in all agencies. In some agencies, a course such as NFPA 70E is required before any work is completed involving the DC disconnect. Also in some agencies, a key or lock system is in place for access to the catwalk and subsequent proximity to the overhead power. This is known as a **kirk key system**. In some

cases, the gate will remain locked until the DC disconnect is de-energized. The DC disconnect cannot be re-energized until the key is replaced. In other agencies, a type of laser beam is used to detect any movement past a certain point in the shop. If movement is detected, then high voltage power is de-energized until other steps to ensure a safe situation are taken.

Figure 4.25 Kirk Key System in DART. Courtesy of DART

Figure 4.26 Kirk Key on DC Disconnect. Courtesy of SFMTA

Figure 4.27 Kirk Key on Open Gate. Courtesy of SFMTA

Figure 4.28 Kirk Key System. Courtesy of SFMTA

Shop Power

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 APS system and power for the propulsion system is not available.

Figure 4.29 Auxiliary Power Source. Courtesy of SFMTA

When the rail vehicle is in the shop for maintenance, the normal source of collected power is not always available. Power is then provided by an auxiliary source referred to as **shop power**. The shop power is connected to the vehicle by a cable called the **stinger**. The shop stinger is generally made from heavily insulated copper cable with a metal contact tip at one end and a heavy-duty connection to high voltage direct current at the other end. The shop stinger provides a path for the transfer of high voltage power from a fixed location in a shop to the third rail shoe of a rail car when relocating cars in the shop, moving them out of the shop and, at some locations, moving them into the shop. Always wear appropriate eye protection when using a stinger as per your agency's guidelines and policies.

Figure 4.30 Stinger Spool. Courtesy of CATS

Figure 4.31 Stinger Connected to Rail Vehicle. Courtesy of GCRTA

Warning: Safety Precautions!

- Do not allow the stinger's metal contact tip to touch any object other than a third rail shoe.
- Use of the shop stinger requires two employees: one to operate the vehicle and one to apply the stinger to a third rail shoe.

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.

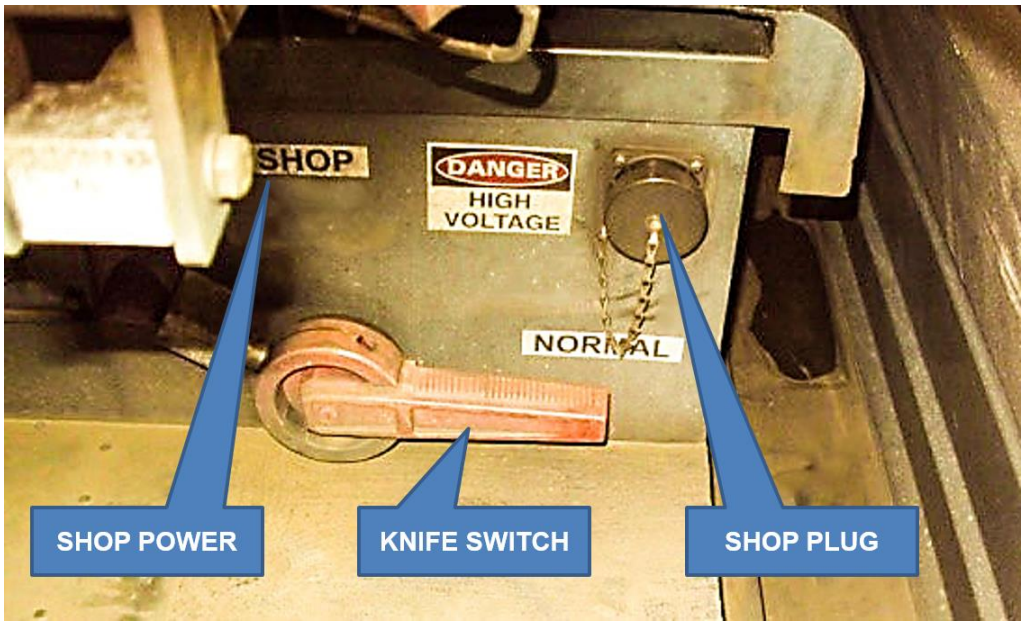


Figure 4.32 Knife Switch on Rail Vehicle. Courtesy of CATS

Some shops have source power available to the rail vehicles while they are being maintained or repaired. In the two case studies below, both agencies have overhead catenary systems in their repair shops as well as shop power from stinger cables.

Classroom Activity

With assistance from your instructor, describe your agency's high voltage power as well as energizing and de-energizing procedures in the space below.

4-6 SUMMARY

While all types of inspection, maintenance and repair work may share similar characteristics, Module 4 covered rail vehicle-specific inspection and maintenance general practices important for all aspects of rail vehicle work. Types of maintenance and the importance of schedules for longevity of rail vehicles was discussed. Shop communication along with the wide array of basic tools and fasteners used in the rail shop environment was explored. Finally, rail vehicle and shop power was introduced. As with every topic covered in rail vehicle courses, it is important to know your agency's equipment and all related procedures for the safety of all involved and for the most effective rail maintenance work.

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MODULE 5

INTRODUCTION TO RAIL VEHICLE SYSTEMS

Outline

Purpose and Objectives

The purpose of this Module is to provide participants with an overview of rail vehicle areas and systems.

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

- Identify car body areas and parts of the rail vehicle.
- Identify rail vehicle electrical systems.
- Identify rail vehicle mechanical systems.
- Identify rail vehicle braking.
- Identify rail vehicle comfort systems.
- Suspension systems.
- Identify rail vehicle communication.

Key Terms

- A car
- Actuated
- Air supply unit
- Articulation section
- Automatic Train Control (ATC)
- Automatic Train Operation (ATO)
- Automatic Train Protection (ATP)
- Automatic Train Supervision (ATS)
- Axles
- B car
- Background communication
- Bearings
- Bellows
- Blinker door
- Block style
- Brake caliper
- Braking control unit
- Braking devices
- C car
- Cab area
- Catenary
- Center truck
- Collector shoes
- Compressor
- Condenser
- Coupler
- Derailing
- Dynamic braking
- Dedicated heating units
- Electronic control unit
- Electric coupler
- Evaporator
- Flange
- Frame assembly
- Friction braking
- Gearbox
- Glazing
- Ground
- Ground brushes
- Ground brush devices
- Hydraulic braking Individual cells
- Lead Acid
- Main breaker
- Mechanical coupler
- Metering device
- Motor truck
- Nickel Cadmium (NiCad)
- Onboard communication
- Over-the-air communication
- Pantograph
- Plug door
- Pneumatic braking
- Pneumatic coupler
- Propulsion
- Regenerative braking
- Running rails
- Running stability
- Secondary suspension assembly
- Supply air heater
- Surge arrestor
- Third rail
- Tires
- Track brakes
- Trucks
- Unsuspended axle
- Wheels

5-1 OVERVIEW

The rail vehicle is comprised of mechanical and electrical equipment and systems. Module 5, Introduction to Rail Vehicle Systems, provides an overview to the areas and systems of the rail vehicle that will be further explores in later rail vehicle courses.

5-2 CAR BODY

While there are many different types of systems and subsystems that make up a rail vehicle, the general rail vehicle can be thought of in four basic parts: The car body interior parts, car body exterior parts, the lighting, and the cab.

The Rail Vehicle Car Body

Rail vehicles all differ between agencies and even within agencies. However, and while differences do exist, a rail vehicle typically consist of two cars, the **A car** and the **B car**. These car bodies tend to be similar, and in some cases, can operate from either end. In a light rail vehicle with two cars, there is also a **C car** which joins the A car and the B car serving as a small linking car body also known as the **articulation section**. The C car not usually powered by propulsion.

Figure C

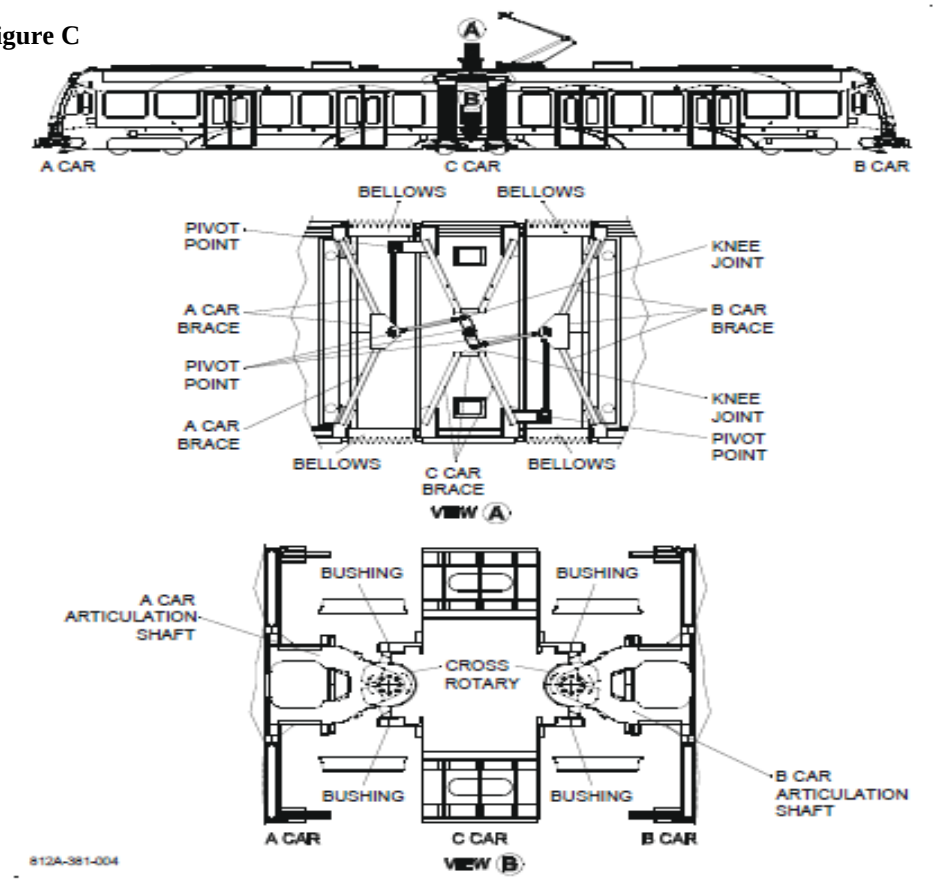


Figure 5.1 A Car, B Car, and C Car or Articulation Section Example

There are two **bellows** on the vehicle, one between the end of the C car and the non-cab end of the A car and a second bellows between the other end of the C car and the non-cab end of the B car. A protective outer bellows partially surrounds the inner bellows. See the figure below showing the interior bellows, exterior side bellows, and exterior angled bellows.

Figure D

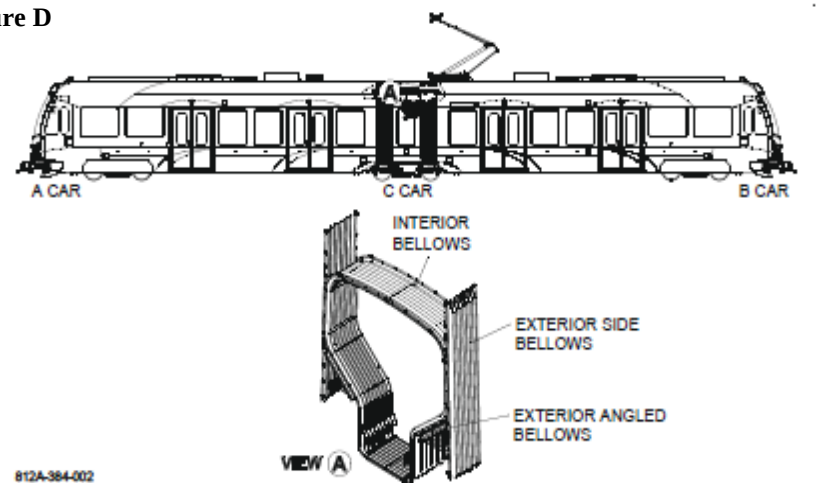


Figure 5.2 Bellows Example

Each car body consists of a welded steel frame with attached exterior and interior equipment and panels. The frame is an assembly of the side frames, roof frame, end frames, and floor frame, all welded to the under-floor chassis. **Glazing**, or windows, and seats are included in car body structures.

The Rail Vehicle Interior and Cab Equipment

Generic interior components include flooring, stairs, windows, seats, signage, exit path marking, fire extinguishers, doors, interior panels, threshold heaters, passenger hand rails, luggage racks and wheelchair restraints. The materials used for these components can vary widely. Lighting is another component of the rail vehicle interior area that will be explained later in this Module.

Figure 5.3 Rail Vehicle Interior Example

Technicians will need to be familiar with repair and fabrication of the many materials used as well as the electrical and mechanical skills necessary to maintain the various components.

Figure B

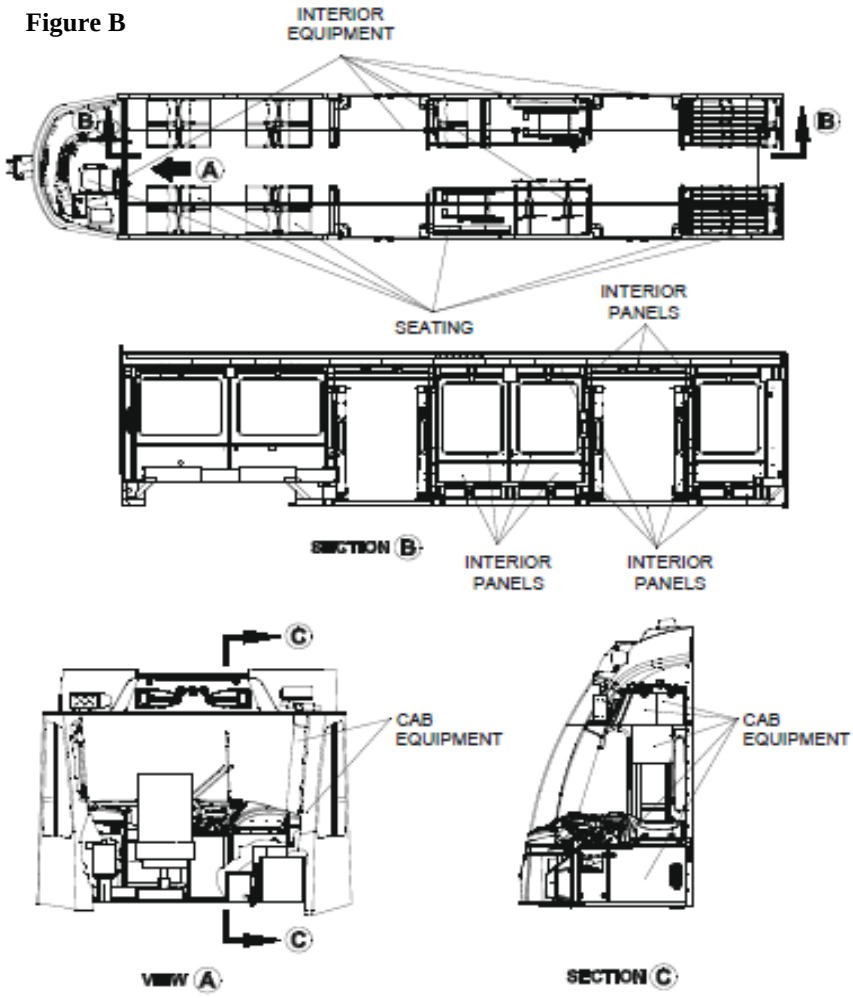


Figure 5.4 Car Interior Example

The rail vehicle also includes a **cab area** where the train operator is stationed. Cab equipment typically includes the following:

- Cab Door
- Roller Blinds
- Cab Wall Lining
- Cab Console Lining
- Upper Cab Panels.

The equipment listed above is described in the subsections that follow. An illustration of the cab is shown in Figure below

Figure K

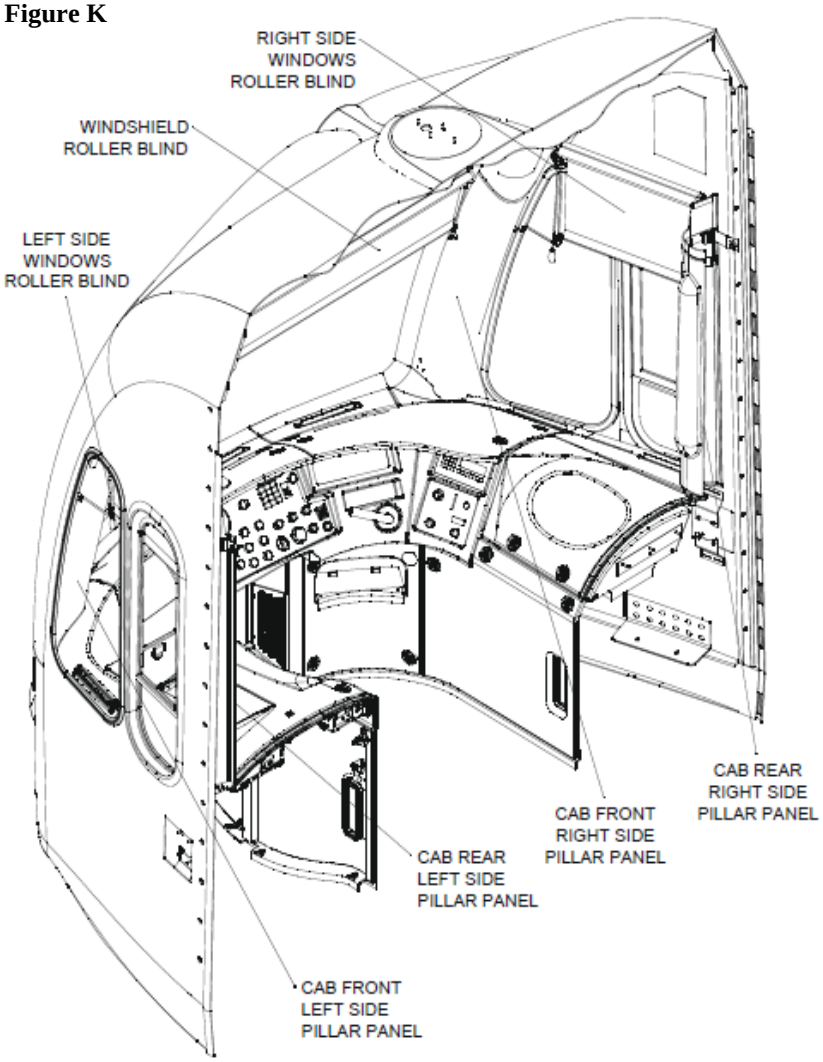


Figure 5.5 Car Cab Example

Figure 5.6 Rail Vehicle Cab Example

The Rail Vehicle Exterior

Rail vehicle exteriors also vary widely, but all have similar components that can generally be addressed. Almost all rail vehicles include body panels, glazing, signage, skirts and struts, mirrors, grab rails, wipers, horns, various equipment boxes, under-frame brackets, ADA ramps and wheelchair lifts, ducts, grills, barriers between cars (rods, chains etc.), sanders and sometimes even snow plows. Some of these features can be seen in the figure below.

Figure A

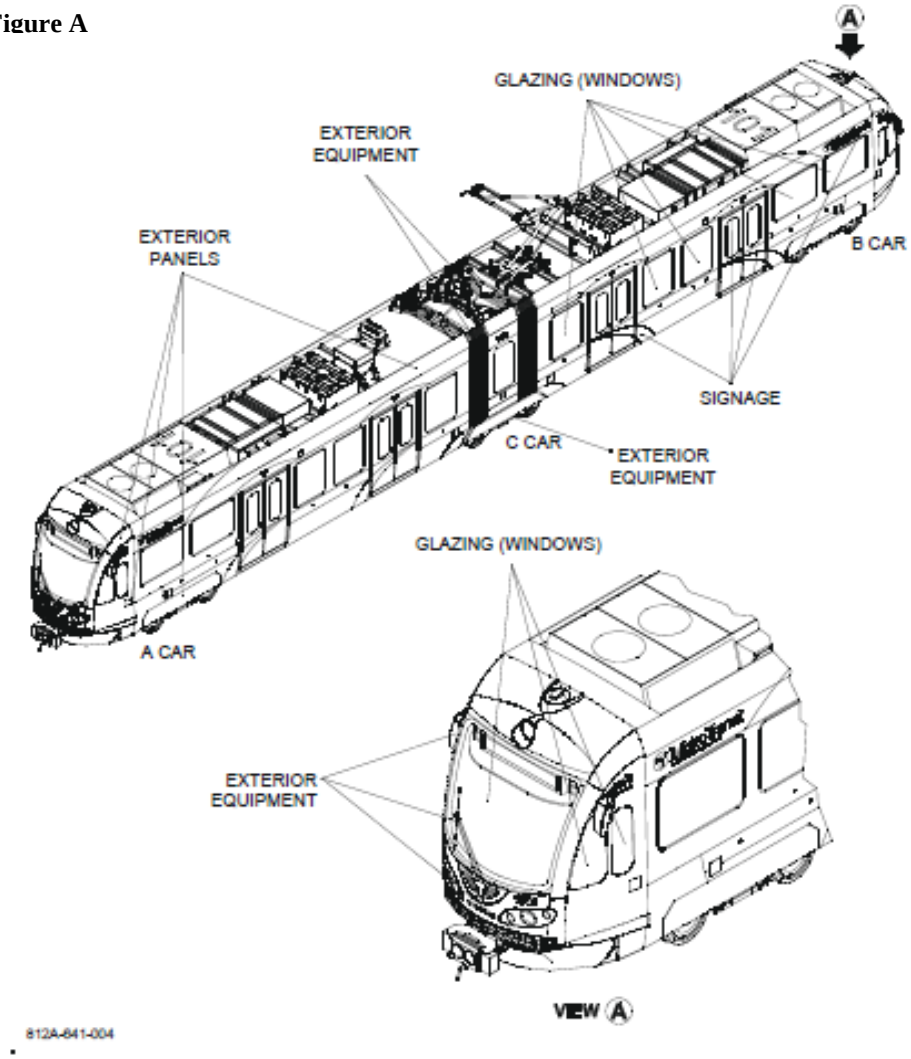


Figure 5.7 Car Exterior Example

Rail Vehicle Lighting

There are numerous lights on the car body for interior lighting, exterior lighting and warning lights. Some lights are **actuated** by an event such as a door opening or brakes being applied. Other lights actuate when an event does not take place as intended such as a “door open” indicator. Other lighting applications are headlights, interior passenger convenience lighting, emergency flashers, exterior marker lights (can be found on the roof, and sides of the car), emergency lights, destination signs and in some cases, stop request lights.

Typical lighting types for rail vehicles may include AC or DC ballast, LED or fluorescent lighting.

The Washington Metro photos below show destination signs, door indicator lights, headlights and marker lights; the DART schematic further below shows example lighting locations.

Figure 5.8 Rail Vehicle Lighting at WMATA. Courtesy of WMATA

Figure 5.9 Rail Vehicle Lighting at WMATA. Courtesy of WMATA

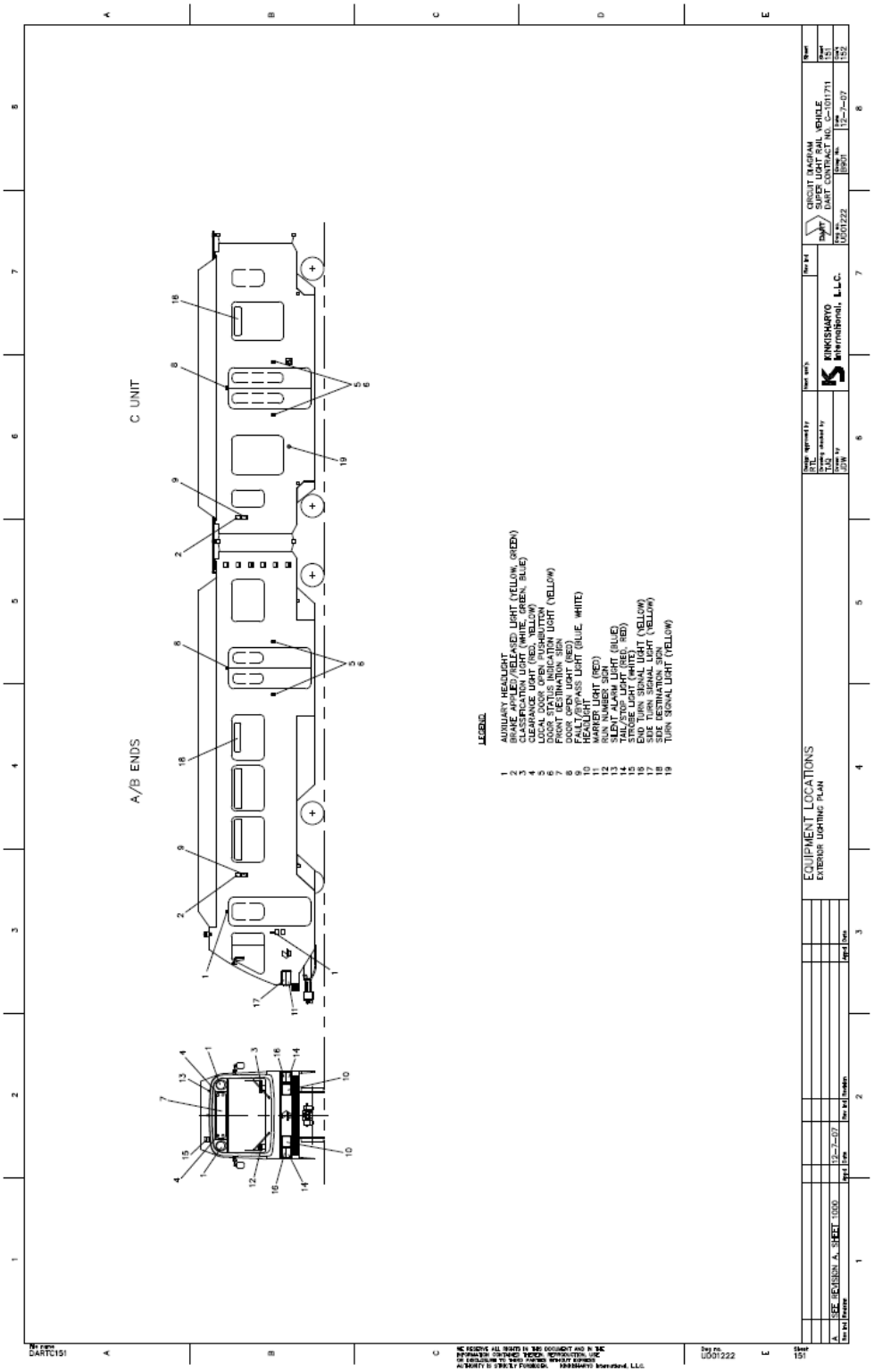


Figure 5.10 Lighting Location Schematic. Courtesy of DART

5-3 RAIL VEHICLE DOORS

Rail vehicle doors are the entrance and exit points for the rail vehicle. There are multiple types of door system configurations for rail vehicles and each differs by which the doors move to open and close and what powers their operation: Either air or electricity.

To open, a door can slide, fold or swing. Sliding doors come as either pocket types or exterior exposed types. Folding doors normally have a bi-fold and either fold inward or outward. Swinging doors also either swing inward, **blinker doors**, or outward, or **plug doors**.

All doors have an emergency release. Emergency release-internal external or both.

Doors are part of a larger system which consists of the following parts:

Operator and Non-operator cars (A car and B car)

- Door monitoring and control unit
- Interior guard light
- Crew switch – Exterior and interior
- Guard light – Exterior and interior
- Fault light assembly
- Door closing warning light
- Door panels
- Door Control Relay panel
- Door Operators (including limit switches) – type varies with system
    - Overhead
    - Side panel
    - Or under seat

Operator Car only (A car)

- Master Door Controller
- Buzzer

Various types of doors and door configurations exist in rail vehicles. While door locations will vary from car to car, the main types of doors locations in rail vehicles include side doors, end doors, cab doors, and storm doors.

Figure 5.11 Side Door

Figure 5.12 End Door

Figure 5.13 Cab Door

Figure 5.14 Storm Door

The locations of these doors vary from car to car. None-the-less, the figure below gives you an example of where these doors may be located.

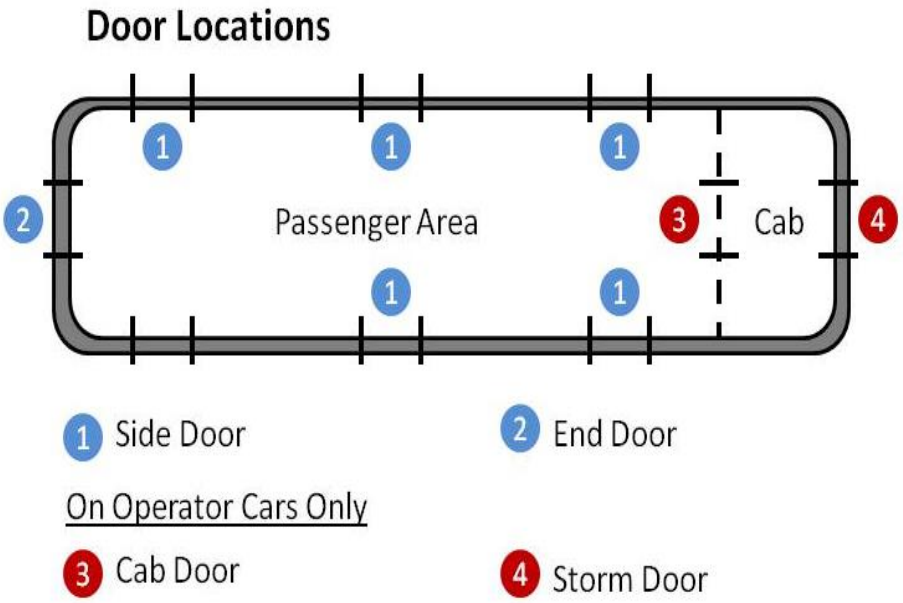


Figure 5.15 Example of rail vehicle with doors marked. Note – these locations will vary from car to car.

Door controls are also part of the door system. There are basically 3 types of door controls including:

- Door monitoring and control unit (DMCU)
- Door Control Relay panel (DCRP)
- Master Door Controller (MDC)

Of these three, the DMCU and DCRP are in the car itself. The MDC is in the operator's cab of the car.

The location of door locks may vary. There are three common approaches to door locking include mechanical, electrical and hybrid locks.

5-4 CURRENT COLLECTION AND DISTRIBUTION

The current collection and distribution systems for rail vehicles will vary between rail systems.

Current Collection

Light and heavy rail transit vehicles are dependent on high voltage feed from an external source (typically 600 to 1000 Vdc). Because the vehicles are in motion, a sliding contact is necessary to collect this high voltage power. This is typically accomplished with one or a combination of the following methods:

1. Overhead catenary with pantograph.
2. Third rail and collector shoes (paddles).
3. Diesel generation.

Whichever method is used, the **running rails** serve as the ground return. The participant should recall that within an electrical circuit, ground or earth refers to a common return path for electrical current. In an electrical circuit, **ground** is the reference point that voltages are measured. Ground also refers to the common return path for electric current and may have a direct physical connection to the Earth.

The **catenary** is an overhead bare copper wire suspended from above and parallel to the running rail. A **pantograph** mounted on the roof of the vehicles is hinged to provide an electrical path to vehicle while providing and up and down motion. 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 5.16 New Cars in a Train Yard Waiting to be Placed in Service. Coutesy of Denver RTD

A **third rail** is a method of providing electric power to a railway train, through a semi-continuous rigid conductor placed alongside or between the rails of a railway track. It is used typically in a mass transit or rapid transit system, which has alignments in its own corridors, fully or almost fully segregated from the outside environment. Third rail systems are always supplied from direct current electricity. The power is collected by the train's **collector shoes** (or paddles) that is held down against the third rail by spring pressure. Multiple shoes connected parallel ensure uninterrupted power when transiting from one section of third rail to another.

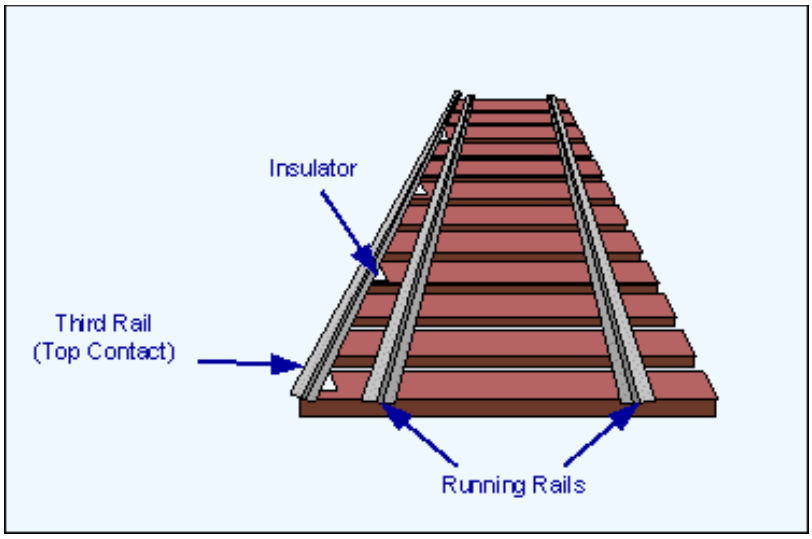


Figure 5.17 Third Rail and Running Rails. Courtesy www.railway-technical.com

Some passenger trains are powered by a diesel locomotive, which is electrically driven by a diesel engine. Unlike collected power from catenaries and third rails, diesel-driven trains are self-contained with their own power source on board. A fuel tank is essential. **Error! Reference source not found.** s hows the fuel tank as well as all major components of a modern U.S. diesel electric locomotive.

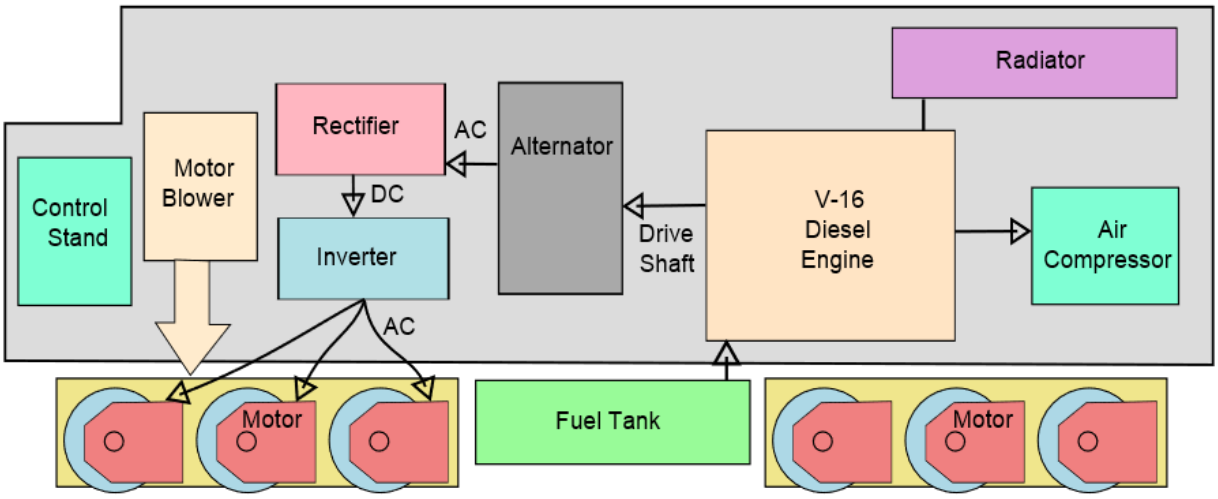


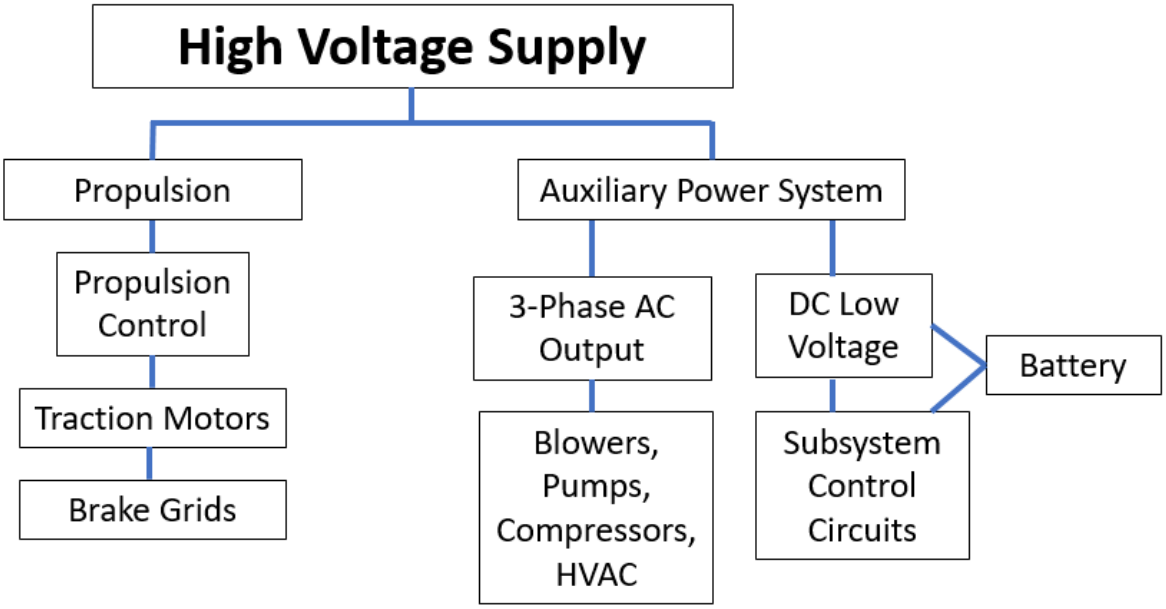
Figure 5.18 Schematic Diagram of Modern U.S. Diesel Electric Locomotive

Classroom Activity

With assistance from your instructor, explain in the space below how power is collected by rail vehicles in your transit agency.

Rail Vehicle Electrical Distribution

Once the car is energized, the electricity is distributed to different areas of the rail vehicle for different purposes which include propulsion, auxiliary power systems and HVAC.



Propulsion

Propulsion refers to the electrical system that powers transportation rail vehicles, while dynamic braking is the use of the same electric traction motors that propels the vehicle as generators when slowing the rail vehicle. The propulsion system has been described by some as the "heart, muscles, and brain" of the rail vehicle. Each rail car on the train is independently controlled and powered by the propulsion system which receives power from a high voltage feed collected from an external source that typically supplies 600 to 1000 Vdc to the rail car. With a diesel locomotive the prime mover is, of course, the diesel engine.

HVAC and Auxiliary Power

With the use of appropriate transformers, switching and control circuits, high voltage is converted to usable control voltages including 3-phase AC and low-voltage DC applications. AC voltages may be used for blowers, pumps, compressors, HVAC systems, etc. Low voltage DC provides power for subsystem control circuits and battery charging.

Batteries are a source of DC power and will provide power to the rail vehicle auxiliary power systems in the event high voltage power is lost. Batteries store energy through the interaction of positively and negatively charged poles. The area between these poles can either be made of liquid or gel – resulting in wet or dry cell batteries, respectively. This material is ca ustic and should be handled with care. Sufficient PPE should be worn while dealing with batteries and batteries should always be well ventilated as they do give off a dangerous gas.

For transit rail vehicle systems, the two most commonly used batteries are **Nickle Cadmium (NiCad)** and **Lead Acid** Batteries as further explained below. While connected to a running rail vehicle, these batteries are generally charged at 1.5 to 2 volts above operating voltage. For example, if 10 volts are needed to run a system, the charge being transmitted will be 11.5 to12 volts.

Batteries in transit systems come in two different types: **block style** with 5 individual cells put together in a casing (ex: car battery) or as **individual cells** which would be like 1/5 of a block style battery. Individual cells have the same lay out but is a different size.

Figure 5.19 Batteries in Block Style

Other Critical Electrical Distribution Components

The **main breaker**, also known a high-speed circuit breaker, is a single contact breaker, thermally rated for the design current. It is designed to protect the equipment and prevents damage from over current. When the systems experiences over current caused by short circuit, inverter failure, etc., the high-speed circuit breaker (HSCB) disconnects the main DC line circuit.

The **surge arrestor** is an appliance designed to protect electrical devices from voltage spikes. A surge protector attempts to limit the voltage supplied to an electric device by either blocking or by shorting to ground any unwanted voltages above a safe threshold.

5-5 Trucks and Axles

This section of the module will focus on the frame assembly along with the two different truck types, the motor and center.

Frame Assembly

The frame can be considered the backbone of rail vehicle trucks. The **frame assembly** is a casted or welded steel construction, composed of two same parts welded in the center. The frame is made up of at least two longitudinal beams across the length of the truck on one transverse beam across the of the car. The frame primarily houses all suspension components, the axle assemblies, and motors.

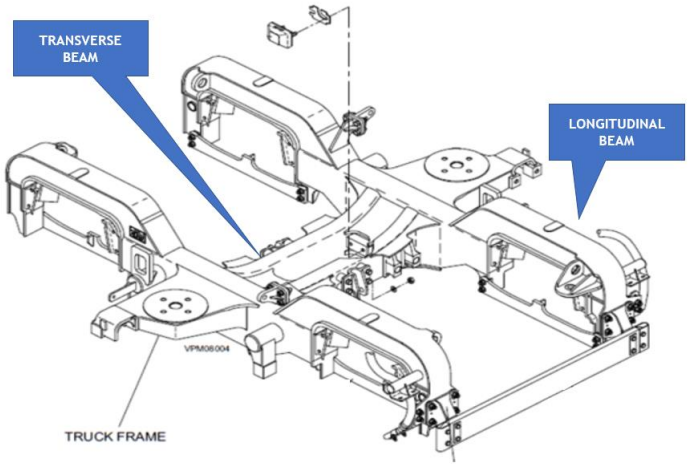


Figure 5.20 Transverse Beam and Longitudinal Beam on Frame Assembly Example

The truck frame is plays a major role in the primary suspension assembly of both types of trucks. As stated previously, the primary suspension is a flexible connection between the axle (resilient wheel) and the frame. And on motor trucks, the secondary suspension unit is installed between the frame and the bolster.

Trucks and Axles

This section of the module will focus on the two different truck types (motor and center) and describe the function of their main components as well as how these components work together.

Trucks are the heart and soul of the railcar. They include the means by which the car rolls down the track (wheels and axles), is propelled (propulsion motors) and is stopped (brakes). On third-rail

systems the power pick-up is located on the truck. The trucks also link the car body to the suspension, isolating passengers from the bumps and noise of steel wheels riding on steel rails, thus providing for a more enjoyable customer experience.

There are two types of trucks, the **motor truck** (also known as a power truck) and **center truck** (also known as a trailer truck). The major difference between the two types of trucks is that the center has no motor, while the motor truck is more complex with a motor and two propulsion axle assembly. A center truck could have a stub axle or a full axle. Rail vehicles motor trucks are bidirectional and are located at each the end of the vehicle.

Both motor and center trucks have similar components. The motor trucks' AC and DC traction motors are two components.

Figure 5.21 Motor Truck Assembly. Courtesy of PA Transit

The motor truck consists primarily of the following components:

- Frames, either welded or casted.
- Primary suspension
- Secondary suspension assembly.
- Truck to body connection
- Wheels
- Bi-motor and mono-motor trucks

In addition, other major truck components include the braking, electrical and auxiliary equipment, and the hydraulic piping assembly.

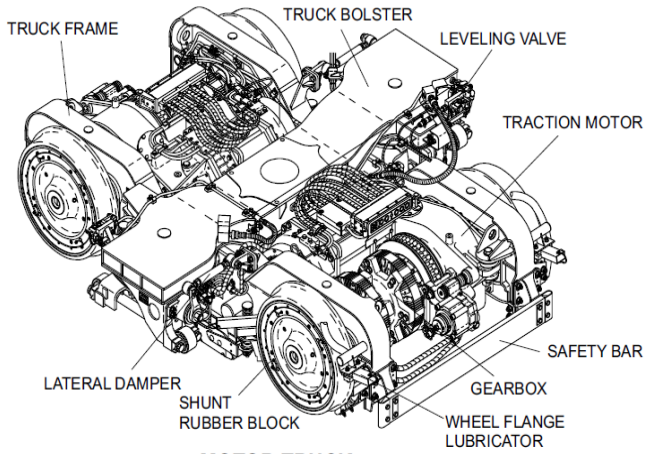


Figure 5.22 Motor Truck Assembly. Courtesy of Santa Clara VTA LRV

A center truck, also known as non-moto truck, the center/trailer truck consists primarily of the following components:

- Frame assembly
- Carbody / truck interface
- Primary suspension
- Secondary suspension
- Axle wheels or four independent wheels mounted on a Wheel Brake Unit (WBU)
- Other components include: the braking, electrical, auxiliary and suspension equipment.

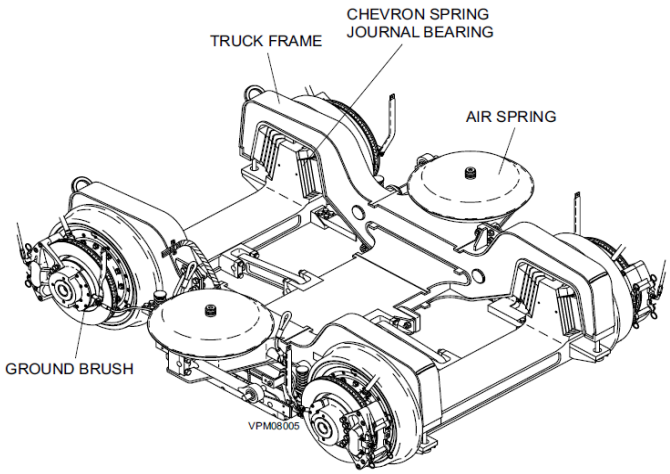


Figure 5.23 Center Truck Assembly. Courtesy of Santa Clara VTA LRV

The **gearbox** serves a primary purpose as it transmits the torque of the motor through to the hollow shaft coupling into the axle. The motor is attached to the gearbox and the gearbox spins the axle. The gearbox found only on motor trucks, is one component of the propulsion axle assembly. More specifically, the gearbox along with the motor and coupling comprise the traction unit components.

The primary return circuits for high voltages are grounded to the axles per the **ground brushes** and carry ground fault return currents to the rail. Their function is to provide a protection for the axle box bearings for all types of current. Each motor truck is equipped with three identical ground brush devices.

Warning: Safety Precautions!

Do not perform maintenance on ground brushes unless the vehicle is isolated from high voltage energy.

Ground brush devices are active for current returns, at least one per axle. One ground brush is active for the safety grounding and is placed on axle.

Axles

Axles are what rotate allowing the wheels to roll on the rail. Axles include two axle assemblies and are key motor truck components. Each axle assembly has at a minimum brakes, bearings, two wheels, and a gear box if applicable.

Two different axle boxes are on one side of the truck. The difference consists of the bore of the axle bearing. The functions of the axle boxes are centering the axle through the bearing, and the interface to the primary suspension.

The axle box is equipped with a journal bearing unit. **Bearings** are high precision parts and need to be treated accordingly. The function of the bearing is to allow the wheels to spin with low friction and carry the entire weight of the vehicle. This in effect will prevent the axle seizing up. The functions of the journal bearings are centering the axle through the bearing, and the interface to the primary suspension. All loads coming from or to the axle will pass through the axle box into the bearing.

The **wheels** are the connection between the car and the track with many important functions. They are made of metal and mounted to the axle. The **flange** keeps the wheel on the track. **Tires** are metal. The tire or wheels are located at the inside or outside of the truck frame.

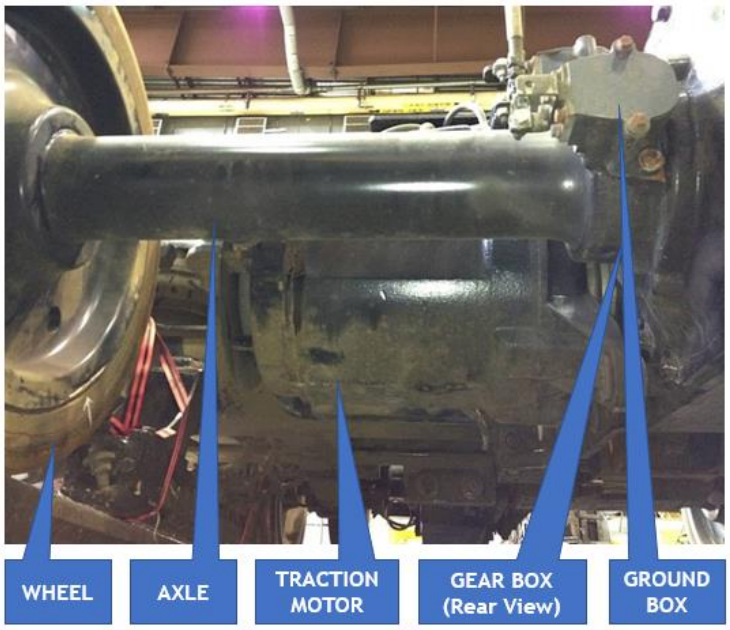


Figure 5.24 Axle Assembly Example

5-6 COUPLERS

The purpose of the **coupler** is to lock two rail vehicles together. Couplers provide a mechanical, electrical, and pneumatic connections.

Coupler Function:

- Provides a mechanical connection between two rail cars
- Provides electrical connection between two rail cars
- Allows for travel on vertical and horizontal curves
- Allows rotational movement

Electrical couplers are designed with an electrical device mounted to a mechanical coupler assembly that makes the electrical circuit connections between rail transit vehicles through a series of mating contacts. Electrical head covers protect the electrical heads when not connected to another

rail vehicle. Leading cab ends and trailing cab ends not coupled will have covers protecting the electrical heads. Electrical head covers swing open to expose the electric contacts.

A **pneumatic coupler** provides a self-sealing valve assembly mounted to a coupler assembly that allows for air pressure equalization between coupled rail vehicles.

A **mechanical coupler** is a device, which as part of a coupler assembly makes the physical connection between rail transit vehicles. It consists of a face plate with alignment pins holes to mate to a like device on another transit vehicle. It is also known as the mechanical coupler head.

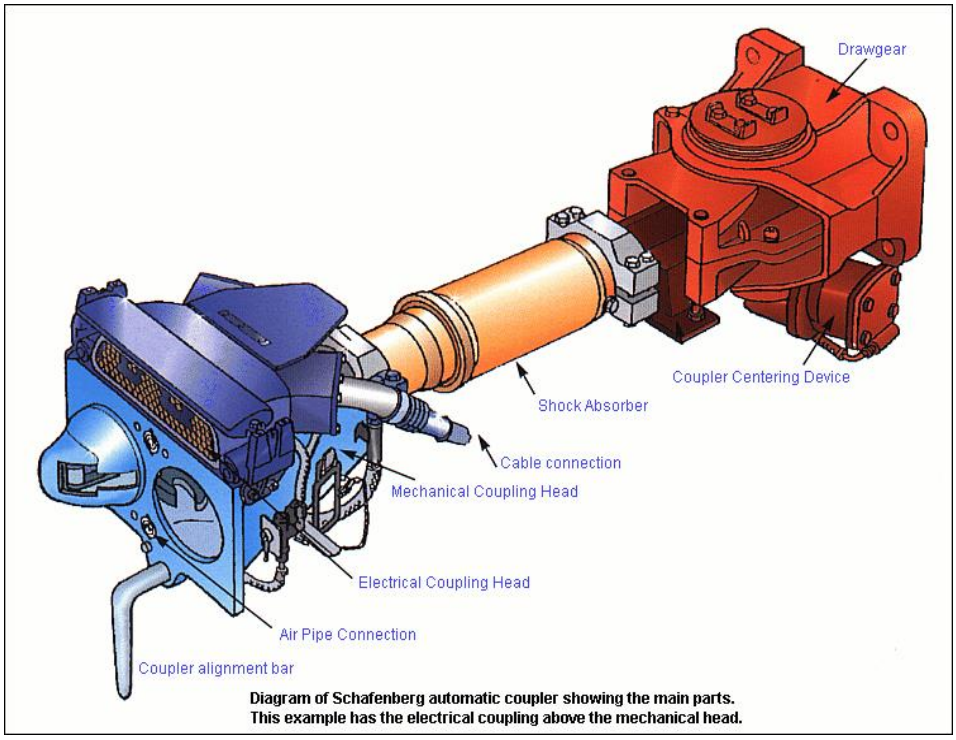


Figure 5.25 Mechanical Coupler Example

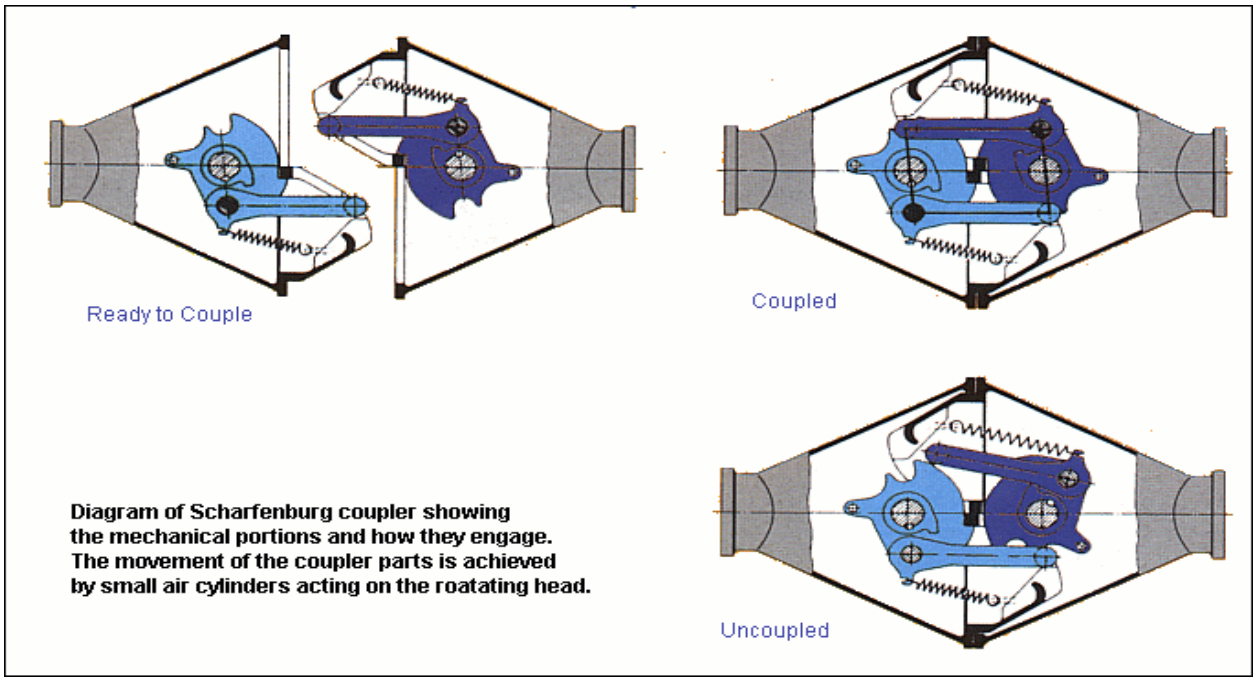


Figure 5.26 Mechanical Coupler Example

5-7 SUSPENSION SYSTEM

Rail vehicles are equipped with primary and secondary suspension systems.

Primary Suspension

Motor Truck

The primary suspension on motor trucks is a flexible connection between the nearly **unsuspended axle** (resilient wheel) and the truck frame. Functions include influencing the **running stability** (lateral stiffness) of the vehicle and the comfort and the safety against **derailing** (vertical stiffness). The primary suspension itself consists of two conical rubber springs per axle box. They provide proper wheel equalization, and because of the rubber, a self-dampered connection between the axle assemblies and the truck frame. The inner metal part of the spring, a steel center pin is connected to the frame. The steel ring (outer ring) ensures the right interface to the axle box. In between these two parts is the vulcanized rubber compound including a metal interleave, providing the required stiffness, both in vertical and lateral direction.

Note that limit stops in upper and lower direction limit the maximum possible deflection of the truck frame in vertical direction. The upper limit stop is located at the bottom of the primary suspension between a machined area on the axle box and the adapted busher screwed on the spring. The lower stop is integrated into the truck frame to permit a mechanical stop between machined areas on the axle box and limits the downward deflection of the truck frame.

Primary Suspension Assembly Components

Center trucks, if so equipped, may include one or more of the following as part of their primary suspension assembly components:

- Chevrons
- Coil springs
- Air bags
- Resilient wheels
- Conical springs
- Hub Assembly
- Wheel
- Bearing
- Ground Brush Assembly

Bolster and Secondary Suspension

The **secondary suspension assembly** of the motor truck has the following main components: (Note: There are two of every component accept that there is only one bolster.)

- Bolster (1)
- Traction rods (2)
- Lateral stops (buffers) and lateral stop brackets (2)
- Connecting rod axle fixation (2)
- Secondary suspension units (2)
- Level senor assemblies (2)
- Hydraulic horizontal dampers (lateral shock absorbers) (2)

5-8 BRAKING SYSTEMS

Brakes may be considered one of the most vital systems of the rail vehicle. The failure of this system would be catastrophic. As such, the inspection and maintenance of rail vehicle friction brakes is critical.

Rail vehicle braking is a blend of two different types of braking: dynamic braking and friction braking.

Dynamic and Propulsion Braking

As mentioned above, dynamic braking uses the electric traction motors of a rail vehicle as generators to slow down the vehicle with two types of systems used: regenerative braking and rheostatic braking.

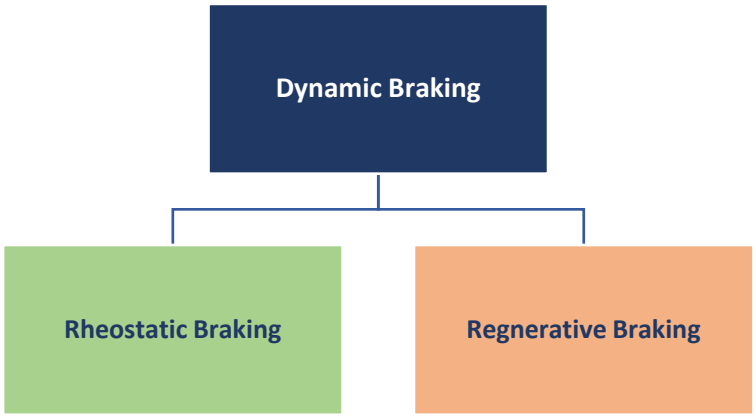


Figure 5.27 Dynamic Braking Types

Before the advent of power electronics, there were some attempts to combine the two forms of what we now call "**dynamic braking**" so that the generated current would go to the power supply overhead line or third rail if it could be absorbed by other trains but diverted to on-board resistors if not. In the case of diesel-electric locomotives, dynamic braking is restricted to the rheostatic type. Racks of resistors can often be seen on the roofs of heavy-haul locomotives for which dynamic braking is a big advantage on long downhill grades where speed must be maintained at a restricted level for long periods, such as descending a mountain.

Regenerative Braking
Since the DC motor and a DC generator are virtually the same machine mechanically, it was immediately realized that a train could use its motors to act as generators and that this would provide some braking effect if a suitable way could be found to dispose of the energy. The idea formed that if the power could be returned to the source, other trains could use it. Trains were designed therefore, which could return current, generated during braking, to the supply system for use by other trains. Various schemes were tried over many years with success but it was not until the adoption of modern electronics that reliable schemes have been available.

Rheostatic Braking
The major drawback with the regenerative braking system is that the line is not always able to accept the regenerated current. Some railways had substations fitted with giant resistors to absorb regenerated current not used by trains but this was a complex and not always reliable solution. As

each train already had resistors, it was a logical step to use these to dispose of the generated current. The result was **rheostatic braking**. When the driver calls for brake, the power circuit connections to the motors are changed from their power configuration to a brake configuration and the resistors inserted into the motor circuit. As the motor generated energy is dispersed in the resistors and the train speed slows, the resistors are switched out in steps, just as they are during acceleration. Rheostatic braking on a DC motored train can be continued down to less than 20 mph when the friction brakes are used to bring the train to a stop.

Friction Braking

Typically, the braking system is responsive to the train operator's master controller request for braking effort.

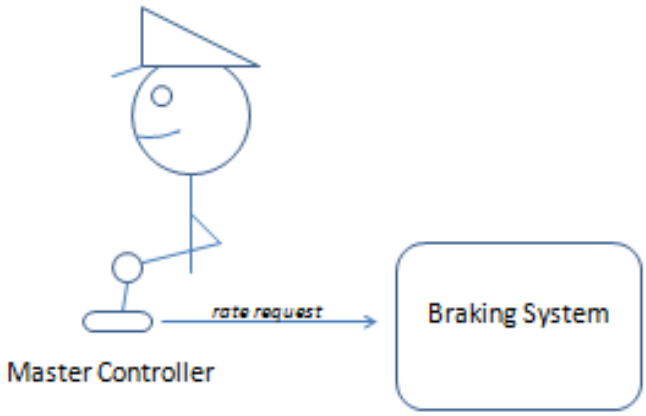


Figure 5.28 Friction Braking System

Track brakes are a form of brakes unique to rail borne vehicles. The braking force derives from the friction resulting from the application of wood or metal braking shoes directly to the tracks (as the name suggests). Early systems used manual force to apply the braking shoes; more recently system have used arrays of electromagnets to hold the shoes against the rail.

The **brake caliper** is the assembly which houses the brake pads and pistons. The pistons are usually made of plastic, aluminum or chrome-plated steel.

Calipers are of two types, floating or fixed. A fixed caliper does not move relative to the disc and is thus less tolerant of disc imperfections. It uses one or more pairs of opposing pistons to clamp from each side of the disc, and is more complex and expensive than a floating caliper. A floating caliper (also called a "sliding caliper") moves with respect to the disc, along a line parallel to the axis of

rotation of the disc; a piston on one side of the disc pushes the inner brake pad until it makes contact with the braking surface, then pulls the caliper body with the outer brake pad so pressure is applied to both sides of the disc.

The major types of **friction braking** for rail vehicles include pneumatic braking systems and hydraulic braking systems. Common brake components will also be explained in this section. Because brake component names vary system to system, one particular set of names have been chosen and are defined below.

Note that since pneumatic braking systems are the most common across transit systems and both the pneumatic and hydraulic braking systems have several similar components this section will detail pneumatic braking first, followed by hydraulic braking

Pneumatic Braking System

As the name would imply, air is the "heart" of the pneumatic friction braking system. High pressure air is used to create the friction forces necessary to slow or stop the rail vehicle. The pneumatic braking components are typically associated with one of the four functional groups depicted later.

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

An overview of a typical electronic **pneumatic braking system** is detailed in Figure 1 below.

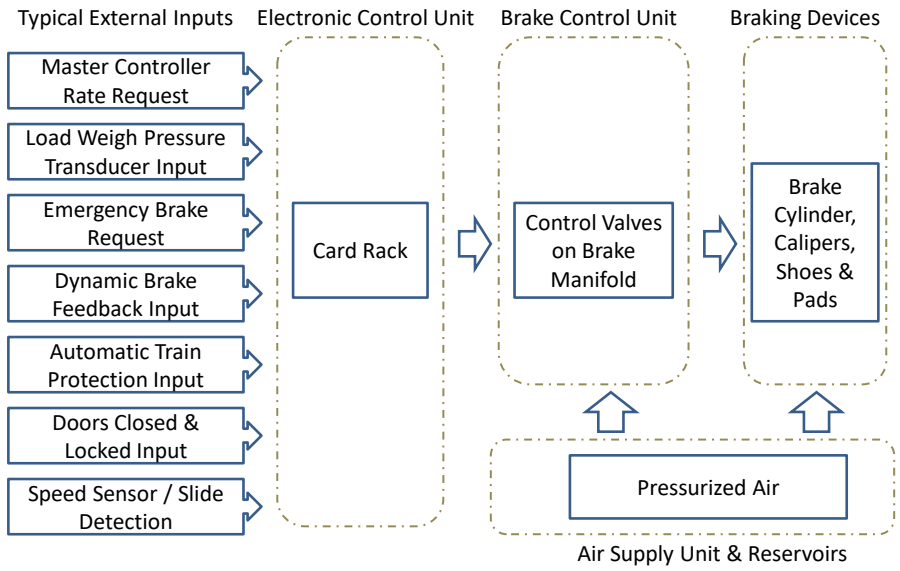


Figure 5.29 Pneumatic Brake System Overview

Air supply unit – The air supply unit is the "power" of the pneumatic braking system. It provides pressurized air to the brake system by compressing atmospheric air using a series of cylinders, and then routing this compressed air, which is at a higher pressure, into an air tank such that this compressed air can be used to do work at a later time.

Electronic control unit – The electronic control unit is the "brains" of the pneumatic braking system. 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.

Brake control unit (also called **truck control unit**) – The brake control unit (BCU) is the "controlling" portion of the pneumatic braking system. The BCU is typically made up of groups of controlling valves whose purpose is to respond to the electrical inputs for the ECU and pneumatic inputs from the vehicle's air springs (secondary load weigh input). The output of the BCU is a dynamic brake cylinder pressure, responsive to the ECU input.

Brake cylinder, calipers, shoes and pads – The brake cylinder, calipers, shoes and pads are the "muscle" of the pneumatic brake system. They take the output of the BCU's relay valve, which controls the brake cylinder's pressure, and create proportional mechanical friction forces designed to resist the rotation of the vehicle's axle, thereby slowing or stopping the vehicle.

Hydraulic Braking

Hydraulic braking in vehicles is a braking mechanism which uses hydraulic fluid to transfer pressure from the controlling mechanism to the braking mechanism. Generally, hydraulic braking systems are reliable and quite powerful. These systems involve an electro-hydraulic unit (EHU), hydraulic fluid, hydraulic lines, brake calipers, accumulators. The basic principles of hydraulics include: 1) Fluids cannot be compressed; 2) Fluids can transmit movement--they act like a steel rod in a closed container and EHU transmits fluid to wheel cylinder or caliper piston; and 3) Fluids can transmit and increase force.

A simplified configuration of this process is depicted in the figure below.

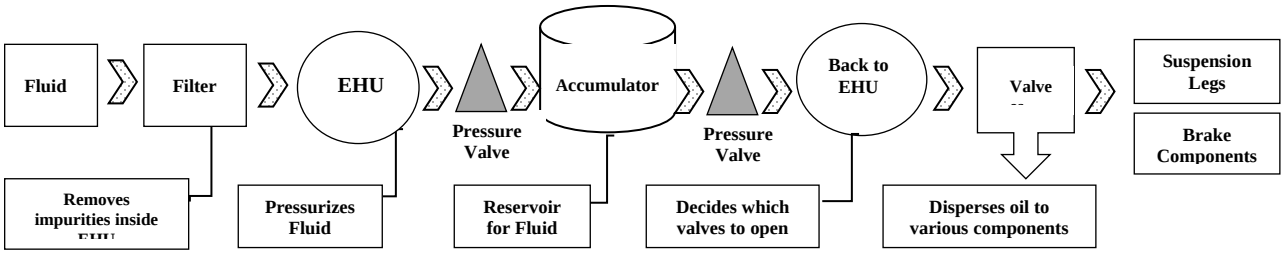


Figure 5.30 Hydraulic System Fluid Flow Simplified

The hydraulic braking system is designed as a closed system: Unless there is a leak in the system, none of the brake fluid enters or leaves it, nor does the fluid get consumed through use.

The hydraulic braking system operates much the same of the pneumatic braking system, which was explained in detail in the text above. Instead of a compressor, there is an electric hydraulic unit (EHU) that pressurizes fluid instead of air. Secondly, the accumulator functions as an air tank would in the pneumatic braking system.

A hydraulic brake system for vehicles, particularly light rail vehicles, includes at least one brake actuator for engaging the brake by means of a group of springs and disengaging the brake by hydraulic pressure.

The system is comprised of an electric drive motor and pump for supplying pressurized hydraulic fluid to the actuator, and a safety valve and solenoid valves for controlling the pressure of the hydraulic fluid in the actuator. An accumulator is connected to the electric drive motor and pump for delivering the pressurized hydraulic fluid via valves and restriction for adjusting the pressure in the accumulator to a value substantially inversely proportional to the load of the vehicle. It is connected to the actuator by shuttle valves controlled by the pressure of the accumulator when the control safety valve and solenoid valves are actuated to relieve hydraulic fluid from the actuator.

5-9 RAIL VEHICLE COMFORT SYSTEMS

The proper functioning of Heating, Ventilation and Air Conditioning (HVAC) Systems ensures rail passengers' comfort, and for some passengers it may be needed for health reasons. The periodic inspection and maintenance of rail vehicles HVAC systems is determined by the individual rail transit systems. Minimally, inspection and maintenance tasks should comply with government regulations (Federal, state and local) and OEM recommended intervals. For ideal operation, it is suggested that other items be considered when developing a preventative maintenance schedule such as industry experience, operating environment, historical data and failure analysis.

Refrigeration and Air Conditioning

Air conditioning (AC) on a rail vehicle works the same way it does in an office, a car or a house. Some components of AC systems vary in the way they do their work, but the basic systems are all the same as is the theory. Air conditioners use refrigeration to remove heat from indoor air, thereby cooling it. Refrigeration is the process of cooling or lowering the temperature of a space or a substance to a level below that of the surrounding area. You might also think of refrigeration as the process of removing heat.

Refrigeration Components

All air conditioner units must have four basic components to work:

1. **Evaporator:** An evaporator is used in an air-conditioning system to allow a compressed refrigerant, such as R-22 or R-410A, to evaporate from liquid to gas while absorbing heat in the process.
2. **Compressor:** The compressor is commonly called the heart of the HVAC system. It is the pump of a refrigeration system which draws a low pressure on the cooling side of a refrigerant cycle and squeezes or compresses the gas into the high pressure or condensing side of the cycle.
3. **Condenser:** A condenser usually uses water or air to remove heat from the refrigerant.
4. **Metering Device** (also called the Expansion Valve): A metering device or expansion valve is responsible for metering the correct amount of refrigerant to the evaporator.

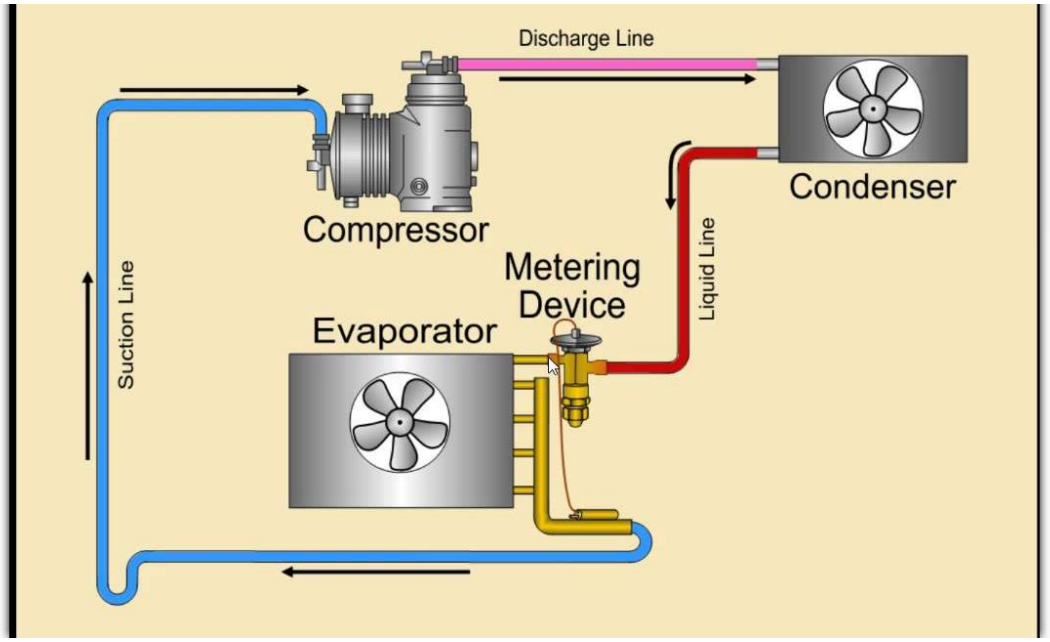


Figure 5.31 Generic Air Conditioning System. Source:

Rail Car Passenger Compartment Heating

Rail vehicles typically have two methods that heat is introduced into the passenger compartment. Some train HVAC units have coils near the evaporator (**Error! Reference source not found.** and REF _Ref451254357 \h * MERGEFORMAT **Error! Reference source not found.**) that generate heat. This type of heater is sometimes referred to as integrated or **supply air heater**. The heater coils are located downstream of the cooling coils and has sufficient capacity to heat the total volume of outside air from minimum ambient temperature to the required interior temperature during the winter

operation. Open wire type or low thermal inertia tubular type heater elements are generally used to minimize high temperature overshoots when power is interrupted suddenly.

In this type of design, outside air (supply air) is heated and inside air is reheated, and the warm air is then distributed throughout the car body by way of the plenum or duct work that otherwise carries cooled air from the HVAC unit. Because heated, overhead distributed supply air for passenger compartment heating requires highly elevated air temperature and can cause passenger discomfort, heated air is normally distributed from the window sill or floor level. Supply air heat is generally used in mild climate applications where heating requirements are relatively small and/or infrequent.

Some rail vehicles have **dedicated heating units** under the seats or along the baseboards. These too create heat by passing electricity through a series of wires or wire coils. Forced-air heating is used in many rail car floor and wall heating systems (**Error! Reference source not found.** and **Error! Re ference source not found.**).

Figure 5.32 Forced Air Floor Heater. Courtesy of Denver RTD

Figure 5.33 Forced Air Floor Heater without Cover. Courtesy of Denver RTD

Most under-the-seat units are self-contained and have a squirrel cage blower fan within the casing as well as heater coils . See **Error! Reference source not found.** below.

Figure 5.34 Under-the-seat Forced-air Heater

5-10 ONBOARD COMMUNICATIONS

Rail Communications Systems are perhaps the most easily understood but most often misunderstood in the spectrum of onboard systems, which a train crew must monitor and use in its daily work. There are many types of hardware in current use, and "New Technology" or computer based trains only add to the misunderstandings of how they operate. Essentially, most on-board communication systems are similar in nature to any conventional public-address system, with a radio transmitter and some automatic switching thrown into the mix. If you've ever seen a public speaker pick up a microphone to address an audience and suddenly find himself surrounded by loud squeals and ear-piercing howls, you've just discovered how a seemingly simple system can go wrong. But, perhaps, it wasn't the system gone wrong, but rather the operator. This material covers the basic equipment and proper operation of so-called "New Technology" (computer based) Train Communication Systems in simple language, bearing in mind that because of the equipment used on individual systems, only general architecture can be given. It will be up to trainers at each location to detail the specific design of the *equipment actually in use*, which may vary substantially from the examples presented here.

In considering all basic communications on railway systems, there are basically three types:

- On Board Communication
- Over the Air Communication
- "Background" or "Housekeeping" Communications

On Board

Systems typically used for onboard communication on a train include signage, audio and video. Trains have used signage of some sort since the earliest days of railroading. Whether a hand-painted destination sign, or a printed scroll listing various destinations that could be set to

correspond with the train's route, the net purpose was to inform passengers of the train line and route they were riding and where the train was going – its final destination.

Today's newest trains meet all the requirements stated above, but with electronic technology come an added advantage – flexibility! Utilizing electroluminescent displays (liquid crystals – LCDs), Light Emitting Diodes (LEDs), and video displays consisting of LCD's or plasma (gas charged), the train operator and/or the conductor may easily and efficiently create signage and change it nearly instantly.

Audio for rail vehicle on board communications typically includes Public Address (P.A.), Automatic Announcement (AAS) Systems, Intercoms between crew members (ICM/ICS) and Passenger Emergency Intercoms (PEI).

On board communication in the way of video includes recorded visual images of activity onboard the train that may be monitored in real time (CCTV) or recorded for later review. Sometimes, previously recorded messages, such as safety videos which might be played on screens inside the train for passengers.

Over the Air

Over the air communications consist of **r**adio (voice) and Digital Data such as maintenance information sent wirelessly to a central computer. Some systems may also include Video Data, which may also be wirelessly transmitted to a remote receiver or remote recorder.

"Background" or "Housekeeping" Communications

Background communications consist of data information networks and systems that are not usually apparent to train occupants, but run silently in the background between units. Their task is to keep the train running smoothly and to record operating conditions, faults and failures for later downloads or analysis. Included are the:

- Event Recorder Unit (ERU),
- Monitoring and Diagnostic System/Logic (MDSS or MDL),
- Door Monitoring and Control Logic Unit (DMCU),
- Inter Car Unit Networks (ICU),
- Propulsion and Braking Networks,
- Train Line and Train Network Controllers, and the
- Multiplexer (TMX, TMS, multiplexer/demultiplexer or "Mux/Demux"), a digital time-sharing system responsible for passing trainline status communications between two or more consists or sections of a train unit.

There are multiple digital background networks on today's New Technology (computer based) trains. They are also sometimes referred to as “housekeeping” signals.

5-11 AUTOMATIC TRAIN CONTROL (ATC)

Automatic Train Control (ATC) is the process by which the movement of rail rapid vehicles is regulated for the purposes of safety and efficiency. This process is accomplished by a combination of elements (some human, some machines) located on the train (referred to as carborne equipment), along the track and in stations (referred to as wayside equipment), and at remote central facilities (referred to as central control). The carborne, wayside and central control elements interact to form a command and control system with three major subsystems:

- Automatic Train Protection (ATP) which prevents collisions and derailments.
- Automatic Train Operation (ATO) which controls train movement and stopping at stations.
- Automatic Train Supervision (ATS) which directs train movement in relation to the schedule.

A variety of safety features have been designed into the ATC system to assure that any component failure does not result in a dangerous situation. In case of a failure or malfunction the systems are designed to slow and stop the train, rather than accelerate. Figure 1 shows an ATC block diagram of how the various systems interact with one another.

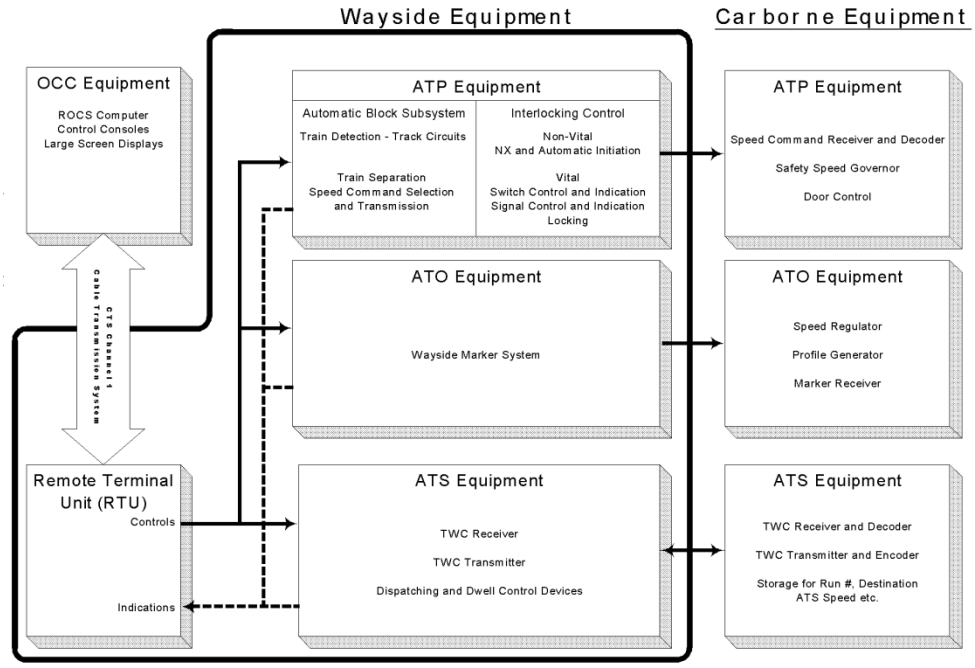


Figure 5.35 ATC System Block Diagram

The **Automatic Train Protection** (ATP) assists in enforcement of safe operation of the system. It imposes speed limits both to maintain safe train separation and to operate trains in accordance with civil speed restrictions. At interlockings, (locations containing track crossings), ATP ensures that train movement is permitted only when a clear, uncontested route is available through the interlocking, and the track switches are locked in position. In all cases where two or more trains are competing for the use of a common segment of track, the system allocates the track to one train at a time in an orderly fashion and locks out all others.

The **Automatic Train Operation (ATO)** subsystem performs the functions normally performed by the motorman or operator. Those functions include the smooth acceleration of the train to running speed, regulation of the train's speed to the command speed, and stopping the train smoothly at the proper position in the station. The command speed (reference speed) for the ATO's speed regulation function may be the ATP speed limit, the ATS speed limit, or the ATO station stopping profile speed command. The ATO subsystem selects the lowest of the three as the command or reference speed.

The **Automatic Train Supervision** (ATS) system controls the arrival and departure of trains from all stations, first by automatic equipment at the wayside and secondly by central control computer programs automatically called into operation to accomplish minor schedule adjustments. The central control operator's console displays are updated from data supplied by the ATS subsystem; data are also provided to other central control computer programs that compile operating statistics on each transit car. An important element in the Automatic Train Control installation is the TWC (Train/Wayside Communication) system which provides for two-way train/wayside communication. Although nominally a part of the ATS subsystem, the TWC system has important functions in ATP and ATO.

5-12 Summary

In this Module, we have begun the discussion on the areas and systems of the rail car which include: Car body areas, doors, current collection and distribution, trucks and axles, couplers, suspension systems, braking systems, HVAC systems, onboard communications, and communication-based train control. These rail vehicles parts and systems together make up and the rail vehicle and will each be further discussed and covered in later rail vehicle course