



APTA STANDARDS DEVELOPMENT PROGRAM  
**RECOMMENDED PRACTICE**

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

APTA RT-RMT-RP-001-10

Approved June, 2010

Vehicles Training Joint Steering  
Committee

# Rail Vehicles Maintenance Training Standards

**Abstract:** This *Recommended Practice* establishes standards for a program of rail vehicles maintenance training.

**Keywords:** training, rail vehicles

**Summary:** In response to the transit industry's need for rail vehicles maintenance training, the Transportation Learning Center has partnered with APTA, transit agencies and unions representing transit workers to develop these joint labor-management training guidelines and recommended training practices.

**Scope and purpose:** The curriculum, courseware and training guidelines adopted by the group and contained in this *Recommended Practice* are designed to meet or exceed the licensing requirements of jurisdictions, which currently or in the future, may legislate professional licensure or certification for rail vehicle technicians. The apprenticeship program will ultimately be registered by the U.S. Department of Labor's Office of Apprenticeship.

This Recommended Practice represents a common viewpoint of those parties concerned with its provisions, namely, transit operating/planning agencies, manufacturers, consultants, engineers and general interest groups. The application of any standards, practices or guidelines contained herein is voluntary. In some cases, federal and/or state regulations govern portions of a rail transit system's operations. In those cases, the government regulations take precedence over this standard. APTA recognizes that for certain applications, the standards or practices, as implemented by individual rail transit agencies, may be either more or less restrictive than those given in this document.



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## 1. Objective of this standard

Public transportation faces a technical skills shortage driven by changing technologies, shifting workforce demographics, record-breaking growth in ridership and the continuing expansion of transit systems and users. Industry leaders acknowledge that the pace of technological change has surpassed the capacity of most agencies to train skilled technicians and new entrants/employees in the effective diagnosis, repair and maintenance of advanced capital equipment. To address many of these issues, labor-management partnerships have been advocated in a number of blue-ribbon reports (see References) from the Transportation Research Board and its Transit Cooperative Research Program (TCRP) as well as from the American Public Transportation Association (APTA).

### 1.1 The Steering Committee

The development of recommended training guidelines was coordinated through a joint labor-management Steering Committee of subject matter experts drawn from rail transit agencies across the country. **Table 1** lists the participants.

**TABLE 1**  
Traction Power Training Joint Steering Committee Members

State	City	Agency	Union
California	Los Angeles	LACMTA	ATU 1277
California	Sacramento	Sacramento Regional Transit District	IBEW Local 245
Colorado	Denver	RTD Denver	
District of Columbia	Washington		ATU Local 689
Florida	Miami	Miami Dade Transit	
Georgia	Atlanta	MARTA	ATU Local 732
Illinois	Chicago	CTA	
Massachusetts	Boston	MTA	ATU Local 589
Minnesota	Minneapolis	Metro Transit	ATU Local 1005
New Mexico	San Jose		ATU Local 265
New York	New York City	NYCT	TWU Local 100
Pennsylvania	Philadelphia	SEPTA	TWU Local 234
Pennsylvania	Pittsburgh		ATU Local 85
New Jersey	Newark	New Jersey Transit	ATU 819
Oregon	Portland		ATU 757
Utah	Salt Lake City	Utah Transit Authority	ATU Local 382
<b>Other participants:</b> APTA, ATU International			

Meeting over a period of two years, this committee of management and labor subject matter experts:

- Determined the job responsibilities and related tasks required of rail vehicles mechanics.
- Determined the skills, knowledge and abilities required to successfully execute the job responsibilities and tasks of the craft.
- Developed a program of training and order of instruction for classroom and on the job training.

- Determined the learning objectives associated with each phase of the training process to develop rail vehicle mechanics.

## 2. Rail vehicles maintenance training guidelines

The safe and efficient operation of transit rail systems is highly dependent on having fully operational rail vehicles to satisfy schedule needs. As with most transit and rail occupations, a shortage of skilled vehicle mechanics exists. The inadequate numbers of rail vehicle maintainers is attributed to several factors, including the pending retirement of incumbent workers, the continued expansion of rail transit systems nationwide and inadequate recruitment and training of mechanics. The difficulty recruiting new entrants into the field is exacerbated by the need to require shift work of newer employees.

In response to the need which the transit industry expressed for rail vehicles maintenance training, the Transportation Learning Center has partnered with APTA, transit agencies and unions representing transit workers to develop joint labor-management training guidelines and recommended training practices. The development of these training guidelines was supported through grants from the U.S. Department of Labor, the Federal Transit Administration and the Transit Cooperative Research Program. Specifically, TCRP project E-7 deals with the researching and development of a national certification program for rail vehicle mechanics.

Rail vehicles maintenance training guidelines are organized into 12 subject areas corresponding to the different job responsibilities of a rail signal maintenance technician. These subject areas:

1. Couplers
2. Truck and axle
3. Propulsion and dynamic braking
4. Auxiliary inverters and batteries
5. Friction brakes
6. HVAC
7. Current collection and distribution
8. Monitoring and diagnosing
9. Car body
10. Doors
11. Communications systems
12. ATP-ATO

The labor-management subject matter experts on the Vehicles Training Joint Steering Committee developed the training curriculum and guidelines with the expectation that training would be instructor-led and include on-the-job training under the supervision of an experienced and qualified journeyman or technician.

### 2.1 100-level courses: Fundamental Skills for Transit Maintenance

#### **100. Property-specific orientation (including track safety, flagging, emergency evacuation)**

#### **101. Orientation and background**

- **101-1. General Safety Overview**
  - Name the agencies and organizations that make and enforce safety regulations
  - Name several electrical shock hazards and the techniques used to prevent those hazards
  - Name the four classes of fire and how to extinguish them
  - Describe the technique used to lift a heavy load
  - Explain the importance of PPE and name several types
  - Explain what MSDS stands for and how it applies, RtK
  - Confined space training

- **101-2. Customer Service**  
Crowd control  
Operational signage
- **101-3. System Security**  
Presentation by jurisdiction security force
- **101-4. Station Orientation**  
Explain how to use the transit system and locate all stations
- **101-5. Safety and Emergency Procedures**  
Explain how to reach both internal and external emergency service personnel
- **101-6. Public Safety**  
Demonstrate the proper barricade setup for both elevator and escalators

## 102. Electrical and Job Safety

- **102-1. Developing a Safe Attitude**  
Safety overview; personal responsibility
- **102-2. Using Personal Protective Equipment (PPE)**  
Discuss safety rules concerning PPE  
Determine when and what PPE is required for a job  
Demonstrate the proper use of various PPE  
Explain the proper care and storage of PPE
- **102-3. Understanding Electrical Safety**  
State (by jurisdiction) electrical safety rules  
Explain basic electrical concepts of current, voltage, resistance and insulation  
Discuss the hazards of electricity  
Discuss methods used to prevent electrical accidents  
Use scientific notation and metric measurements
- **102-4. Lockout/Tagout**  
Discuss the importance of using correct lockout/tagout procedures  
Identify various types of lockout and tagout devices  
Explain how to use lockout/tagout devices
- **102-5. MSDS (right to know)**  
Recognize the importance of safety and its priority  
Discuss OSHA laws and their relation to authority  
Explain how chemicals in the workplace can be a hazard  
Obtain and use material safety data sheets  
Properly label, store and dispose of hazardous chemicals  
Discuss methods used to determine exposure to hazardous substances, and how to minimize harmful effects

## 103. Tools and Material Handling

- **103-1. Basic Hand Tools**  
Measuring tools:
  - Explain how to hold a rigid rule correctly when measuring an object and show from which point the measurement begins
  - Describe how to set lock joint transfer-type calipers
  - Identify vernier calipers
  - Explain how to take a measurement with a micrometer caliper
  - Name the parts of a combination square
 Wrenches and screwdrivers:
  - Identify types of materials used for making wrenches

- Identify open-end, box-end, socket, socket-head, adjustable, torque and striking-face wrenches
- Describe two sizes that are important in identifying a socket wrench
- Identify standard, Phillips, offset and spiral-ratchet screwdrivers
- List the steps to follow when driving a screw

Pipefitting tools:

- Identify a straight pipe wrench, a Stillson wrench, a chain pipe wrench, a strap wrench and a compound-leverage wrench
- Explain how to use a pipe wrench
- Explain why a machinists' vise should not be used for holding pipe
- Explain how to thread pipe
- Explain how to clean a pipe tool
- Explain how to cut and flare tubing
- Explain procedures for brazing
- Demonstrate the ability to braze a section of pipe

Plumbing tools:

- Explain how to use a mechanical tubing bender
- List the steps in joining hubless pipe
- Explain why the drain pipe should be completely covered by the force cup
- Name the criteria used in selecting line clearing tools
- List the steps in measuring pipe when using the center-to-center measuring systems

Electrician's tools:

- Explain how to use an EMT bender
- Explain and demonstrate the use of an analog and digital meter
- Name the uses of the all-purpose tool
- Demonstrate the use of the all purpose tool
- Explain the use of a knockout punch

Sheet metalworking tools:

- Identify the different types of snips and punches
- List six safety practices to follow when working with sheet metal
- Describe different types of sheet metal
- Demonstrate the ability to measure the thicknesses of sheet metal

Metalworking tools:

- Demonstrate the ability to select the proper hacksaw blades for cutting various materials
- Explain the difference between single-cut and double-cut files
- List the types of taps usually found in a tap set
- Explain how to cut an external thread on a bolt, screw or stud
- Explain how to remove a reamer from a hole

Hoisting and pulling tools:

- Explain how to prevent synthetic and fiber rope from unraveling
- Explain how individual wires and strands of wire are formed into wire rope
- Identify the most appropriate sling for use near corrosive chemicals
- Identify a slide-hammer puller
- Describe the different kinds of slings and loads

• **103-2. Basic Power Tools**

Electric drills

- Name four parts that are common to both the light-duty drill and the heavy-duty drill
- Name the parts of a drill bit
- Explain how to drill a blind hole
- List the safety rules to follow when using electric power tools

Electric hammers:

- Explain the difference in hammering action between a percussion hammer and a rotary hammer
- Select the proper chisel to use for each of the following jobs: brick cleaning; general demolition work; edging, chipping and channeling; and removing floor tile
- List the precautions that should be taken to ensure electrical safety when using an electric hammer
- Name two safety items to use when operating an electric hammer in damp or wet areas

Pneumatic drills and hammers:

- Explain how drill size is determined
- Describe the chiseling action of a bull point chisel when it is used to clean masonry seams
- Describe how to use a rivet buster
- Explain drill speed requirements
- Identify various types of drill bits used in pneumatic hammers

Screwdrivers, nutrunners and wrenches:

- Identify the operating advantages of pneumatic tools
- Define stalling torque
- Describe the clutch action of direct drive, positive drive and adjustable torque drive
- Explain how to install a bit in an electric screwdriver
- Describe how to install multiple fasteners correctly in a circular pattern
- List safety rules to follow when using power screwdrivers and wrenches
- Describe the difference between pneumatic and electric nutrunners

Linear-motion saws:

- List other names for both the saber saw and the reciprocating saw
- Describe the cutting action of a saber saw
- Explain how to draw a saw blade with regular set teeth and one with wavy set teeth
- Explain how to plunge cut a rectangular opening
- List the types of band saw blades described in this lesson and a few characteristics of each

Circular saws:

- Name the major parts of a circular saw
- Describe the cutting action of a circular saw
- List the factors that determine feed speed
- State the definition of an arbor
- Identify different types of blades

Electric sanders:

- Explain how to install a sanding belt
- Identify different types of sanding belts
- Explain how to flush the gear chamber of a belt sander
- Discuss the assembly of a sanding disk
- List the safety rules to follow when using a disk sander

Grinders and shears:

- State the meaning of each symbol in the six-symbol standard marking system for grinding wheels
- Explain the correct procedure for mounting a grinding wheel
- List safety rules to follow when using a grinder
- Discuss how to maintain grinders

Tool sharpening:

- State the reasons for sharpening tools
- Explain the use of whetstones
- Identify a bench stone

- Explain how to sharpen taps, dies, screwdrivers and chisels
- **103-3. Moving Machinery Using a Dolly**  
Identify the different types of dollies and their use  
Describe the safe procedure of using dollies
- **103-4. Moving Machinery Using Roller Pipes**  
Explain the difference between wood and steel pipes  
Determine the proper number of rollers required  
Explain roller friction  
Describe the use of shoes and skids with rollers
- **103-5. Assembly of Gantry Crane**  
Describe the proper use of and limits of a gantry crane  
Identify the parts of and inspection procedures for each  
Properly assemble using correct steps and procedures  
Understand the proper use, inspection and assembly of
- **103-6. Rigging and Hoisting**  
Describe the theoretical principles of the seven basics of mechanisms  
Solve basic mechanism problems using concepts of mechanical advantage and friction loss  
Identify the types of rigging jobs in which load equalization or load distribution are necessary  
Identify the basic rigging safety guidelines  
Perform necessary calculations for load equalization and distribution  
Describe and classify the various type of wire rope, fiber rope and chains  
Properly inspect wire rope and chain  
Identify various types of slings and their proper use  
Describe the common types of sling hardware and their proper use  
Demonstrate how to calculate the efficiency of a reeving system

## 104. Mathematics

- **104-1. Whole Numbers and Arithmetic Operations**  
Demonstrate the ability to add, subtract, multiply and divide whole numbers with numbers with an accuracy of 75 percent or greater  
Identify the place value of digits in a whole number  
Identify and list the prime numbers between 0 and 100  
Demonstrate the ability to round whole numbers and approximate whole numbers  
Demonstrate the ability to solve application (word) problems
- **104-2. Integers and Order of Operations**  
Demonstrate the ability to add, subtract, multiply and divide signed numbers and integers with an accuracy of 75 percent or greater  
Identify exponential notation  
Identify a radical  
Demonstrate the ability to work with positive and negative numbers on a calculator  
Demonstrate the ability to solve problems observing the order of operations
- **104-3. Decimals and Percents**  
Demonstrate the ability to add, subtract, multiply and divide decimals and percentages with an accuracy of 75 percent or greater  
Demonstrate the ability to read, order and round decimals  
Demonstrate the ability to multiply and divide by the powers of 10  
Demonstrate the ability to convert from percent to decimal and decimal to percent  
Demonstrate the ability to calculate percentages



- **104-4. Fractions**
  - Demonstrate the ability to add, subtract, multiply and divide fractions with an accuracy of 75 percent or greater
  - Demonstrate the ability to change improper fractions into mixed numbers and mixed numbers into fractions
  - Demonstrate the ability to reduce a fraction to its lowest terms
  - Demonstrate the ability to convert fractions to decimals and decimals to fractions
  - Demonstrate the ability to determine equivalent fractions
- **104-5. Measurements and Applications**
  - Demonstrate the ability to work with operations of powers of 10
  - Demonstrate the ability to work with zeros as an exponent, negative exponents, scientific notation and engineering notation
  - Demonstrate the ability to work with applications of length, weight, area and volume
  - Demonstrate the ability to convert between the customary and metric systems
- **104-6. Algebra: Basic Operations**
  - Demonstrate how to calculate the value of an expression by performing mixed operations in the correct order
  - Demonstrate how to write an algebraic equation, based on a relationship stated in words
  - Demonstrate how to solve an algebraic equation for a specific variable

## 105. Introduction to Electricity

- **105-1. Review Electrical Safety**
- **105-2. Fundamentals of Electricity**
  - Power supply, distribution and usage
- **105-3. Introduction to Electrical Symbols, Schematics and Print Reading**
- **105-4. Motors Transformers and Switches**

## 106. Electrical Meters

- **106-1. Multimeter Basics**
  - Explain how meters are used to measure current, voltage, and resistance
- **106-2. Use of Meter to Measure**
- **106-3. Meter Safety**
- **106-4. Understanding Meter Types**

## 107. Wiring Technologies and Equipment

- **107-1. Safety Rules in Power Electronics**
  - Discuss and list the safety rules for avoiding electrical shock
  - Describe several causes of electrical burns
  - Know the reason for grounding of electrical equipment
  - Determine dangerous levels of electrical current as it relates to the human body
  - Physiological effects of electric current on the human body
  - Rules for safe practice and avoiding electric shock
  - Avoiding burns and avoiding equipment related injuries
- **107-2. Wiring Tools and Insulation Removal**
  - Discuss and identify by name the different types of hand tools associated with wire
  - Demonstrate the ability to strip various types of insulation materials from different gauges of wire
  - Hand tools
  - Stripping techniques
  - Demonstration and practice

- **107-3. Hand Splicing Techniques**

Demonstrate the ability to make each of the splice types discussed and demonstrated:

- Western Union
- Twisted pair
- Fixture joint
- Knotted tap

- **107-4. Mechanical Terminals**

Know the maximum allowable temperature for heat shrink tubing

Demonstrate the ability to make several wire splice connections utilizing wirenuts

Demonstrate the ability to install heat shrink tubing on various wire connections

- Wire nuts and bolt splices
- Snap-lock splices
- Splice insulation

- **107-5. Electrical Wiring, Connector and Terminal Repair**

Discuss the advantage of crimped terminal repairs vs. soldering

Demonstrate the ability to install various sizes of crimp-on wiring terminals both insulated and non-insulated

Explain the difference in terminals and splices used on aluminum wiring as compared to other wiring materials

Discuss why pre-insulated terminals and lugs are color-coded

- Non-insulated terminals and splices
- Specialized terminals for aluminum wire
- Preinsulated terminals lugs and splices
- Specialized crimping techniques

- **107-6. Solder and Soldering Process**

Discuss the advantages of using soldering to join two pieces of metal together as an electrical path

Discuss the nature of solder and the wetting action

Explain the proper technique for applying solder and handling the soldering iron during the solder process

Demonstrate the ability to correctly tin various sizes of stranded wire

Identify the correct tolerances allowed for insulation clearance when soldering to different types of terminals

Explain the various wrapping techniques

Review and discuss the steps of the soldering process

Explain why flux is used in the soldering process

Demonstrate the ability to properly wrap and solder various types of electrical terminations

Identify the characteristics of both acceptable and unacceptable solder connections in accordance with acceptable standards

Demonstrate the ability to perform leaded and lead-free soldering

- **107-7. Printed Circuit Board Fundamentals**

Discuss the various manufacturing methods for hole-through, surface-mount and mixed technology types of circuit boards

Explain proper handling, shipping and storage of circuit boards

Demonstrate knowledge of electrostatic discharge using grounding straps and other dissipative devices

Identify all types of active and passive components and their orientation on the circuit board

Discuss various methods of inspection and inspection devices

Demonstrate the ability to find visual defects of circuit board components and solder joints in accordance with acceptable standards

Demonstrate the ability to replace hole-through and surface-mount devices

## 108. DC Fundamentals

- **108-1. Safety Rules in Power Electronics**
  - Discuss and list the safety rules for avoiding electrical shock
  - Describe several causes of electrical burns
  - Know the reason for grounding of electrical equipment
  - Determine dangerous levels of electrical current as it relates to the human body
  - Physiological effects of electric current on the human body
  - Rules for safe practice and avoiding electric shock
  - Avoiding burns and avoiding equipment related injuries
- **108-2. Science of Electricity and Electronics**
  - Identify the relationship between elements and compounds
  - Diagram a model of an atom
  - Discuss the concepts of atomic weight and atomic number
  - State the law of charges and explain it using examples
  - Explain what is meant by electric current, voltage and resistance
  - Describe the two theories of current direction
  - Distinguish between conductors, insulators and semiconductors
  - State and explain Ohm's law
- **108-3. Basic Instruments and Measurements**
  - Explain and demonstrate the correct procedure for using an ammeter, a voltmeter and an ohmmeter
  - Discuss the difference between a DMM and a VOM
  - Interpret a linear scale
  - Interpret a nonlinear scale
  - Calculate the values of shunt resistors and multiplier
  - Discuss the concept of meter sensitivity
  - Understand basic electrical diagrams
- **108-4. Circuit Materials, Energy and Source of Electricity**
  - Identify different conductor and insulator materials
  - Discuss the factors that affect resistance in a conductor
  - Identify different types of switching devices
  - Identify different types of resistors
  - Determine the value of color coded resistors
  - Calculate electrical power in watts
  - Convert horsepower to watts
  - Define polarization as it relates to an electrical circuit
  - Determine efficiency of an electrical circuit
  - Combine Ohm's law and Watt's law to find unknown values in a given circuit
  - Discuss different sources of electrical energy
  - Explain the difference between primary and secondary
  - Calculate the outputs of batteries connected in series and parallel
- **108-5. Series Circuits**
  - Determine the total resistance of a series circuit
  - Determine the voltage drops in a series circuit
  - Determine the current values of a series circuit
  - Determine the wattage values of a series circuit
  - Apply Ohm's law to solve for unknown voltage, current and resistance in a series circuit
  - Apply series circuit theory to assist in troubleshooting a series circuit
- **108-6. Parallel Circuits**
  - Determine the total resistance of a parallel circuit
  - Determine the voltage drops in a parallel circuit

Determine the current values of a parallel circuit  
 Determine the wattage values of a parallel circuit  
 Apply Ohm's law to solve for unknown voltage, current, and resistance in a parallel circuit  
 Apply parallel circuit theory to assist in troubleshooting a series circuit

- **108-7. Combination (Series-Parallel) Circuits**

Determine the equivalent circuit resistance for a given combination circuit  
 Determine the voltage drops in a combination circuit  
 Determine the current values of a combination circuit  
 Determine the wattage values of a combination circuit  
 Apply combination circuit theory to troubleshoot a combination circuit

## 109. AC Fundamentals

- **109-1. Alternating Current Principles**

Explain how a generator is used to produce alternating current using a graph to show a typical AC wave  
 Define and calculate average (avg), effective (rms), instantaneous voltage ( $V_{inst}$ ) and voltage peak to peak ( $v_{pp}$ )  
 Demonstrate the ability to operate an oscilloscope while performing typical circuit measurements (amplitude, frequency, time, phase, etc.)  
 Determine voltage both AC and DC using an oscilloscope  
 Determine the frequency of a waveform using an oscilloscope

- **109-2. Transformers**

Explain and demonstrate important operating characteristics of single-phase transformers  
 Connect transformer windings in series-aiding or series-opposing configurations  
 Calculate the current and voltage ratios for a given transformer  
 Determine the phase relationship of a transformer primary to secondary  
 Determine the frequency of a waveform using an oscilloscope

- **109-3. Series Circuits**

- **109-4. Parallel Circuits**

- **109-5. Combination (Series-Parallel) Circuits**

- **109-6. Basic Troubleshooting Theory (AC-DC)**

## 110. Basic Hydraulic and Pneumatic Theory and Applications

- **110-1. Safety Rules in Power Hydraulics and Pneumatics**

- **110-2. Basic Hydraulic Principles**

Hydraulic pumps, valves, actuators

- **110-3. Basic Pneumatic Principles**

Pneumatic pumps, valves, actuators

- **110-4. Basic Hydraulic and Pneumatic Symbols, Schematics and Print Reading**

## 111. Basic Mechanical Theory and Application

- **111-1. Mechanical Power Transmission**

Discuss the different styles of belts that are used in industry  
 Discuss the benefits of a positive-drive belt  
 Discuss the benefits of a chain drive system  
 Discuss the use of gears and gearboxes  
 Define pitch diameter, circular pitch, pitch line and gear ratio  
 Perform speed calculations for belt drives, gear drives and chain drives  
 Assemble and perform alignments on belt drives, gear drives and chain drives  
 Properly tension belts and chains

- **111-2. Pumps and Compressors**
  - List types of pumps in use today
  - Explain and calculate volumetric efficiency
  - Explain and calculate the delivery of a pump
  - Discuss some of the common problems that may be encountered while troubleshooting a pump
  - Discuss some of the common problems that may be encountered while troubleshooting a pump
- **111-3. Fluid Power**
  - Discuss some fluid power fundamentals
  - Explain psi, psig, psia, and inches of mercury ("Hg)
  - Understand how force is transmitted through a hydraulic system
  - Understand the effects of compressing air for a fluid power system
  - Learn how to recognize the different valves that may be used in a fluid power system
  - List and explain at least eight methods of valve actuation
  - Discuss the operation of different actuators
  - Use a hydraulics/pneumatics trainer to construct fluid systems for various operations
- **111-4. Lubrication**
  - Explain some basic terms that are used when referring to lubrication
  - Discuss the necessity for lubrication
  - Discuss the different forms of lubrication
  - List the types of lubricants used in industry
  - Discuss application of lubrication
  - Discuss the importance of a lubrication schedule
  - Demonstrate the proper use of a viscometer
  - Lubricate equipment using a grease gun and chain oiler
- **111-5. Bearings**
  - Define radial, axial and radial-axial loads
  - List the different parts of a bearing
  - List the different types of antifriction bearings and the different types of plain bearings
  - Correctly install and remove a bearing
  - List several reasons for bearing failure
- **111-6. Coupled Shaft Alignment**
  - Discuss the fundamentals of shaft coupling alignment
  - Demonstrate how to correctly use the dial indicator to align coupling shafts
  - Demonstrate the use of the reverse dial indicator method to correct coupling shaft misalignments
  - Demonstrate how to use the feeler gauge, taper gauge and dial caliper to detect and correct coupling shaft
  - Explain the advantages and disadvantages of using a laser alignment kit to detect and correct coupling shaft misalignments
- **111-7. Seals and Packing**
  - Discuss the different styles of belts that are used in industry
  - Discuss the benefits of a positive-drive belt
  - Discuss the benefits of a chain drive system
  - Discuss the use of gears and gearboxes
  - Define pitch diameter, circular pitch, pitch line and gear ratio
  - List different types of gears
  - Perform speed calculations for belt drives, gear drives and chain drives
  - Assemble and perform alignments on belt drives, gear drives and chain drives
  - Properly tension belts and chains
- **111-8. Hydraulic and Pneumatic Applications**
  - Practical hydraulics

Practical pneumatics  
 Hydraulic and pneumatic drawings (review, troubleshooting applications)  
 Applications of hydraulics and pneumatics for ELES  
 Hydraulic and pneumatic logical troubleshooting

## 112. AC Motors, DC Motors and Generators

- **112-1. Magnetism**  
 Explain the basic magnetic principles  
 State the three laws of magnetism  
 Describe the link between electric current and magnetism  
 Explain Roland's law  
 Discuss various types of relays and the manner in which they work  
 Describe the use of magnetic shields
- **112-2. Fundamentals of Rotating Machines**
- **112-3. DC Motors and Generators**  
 Explain the operating principles of a DC motor  
 Explain counterelectromotive force  
 Identify various DC motors  
 Discuss the purpose for, and operation of, motor starting circuits  
 Identify and explain the operation of various DC motors  
 State the function of the field windings in a DC generator or motor  
 State the function of the armature in a DC generator or motor
- **112-4. AC Motors**  
 Discuss the operation of an induction motor  
 Identify and explain the operation of various three-phase motors  
 Explain how a split-phase condition is created  
 Discuss the purpose of ac motor protection circuits  
 List the common causes of motor failure  
 Explain basic trouble shooting techniques for AC motors
- **112-5. Motor Controls**
- **112-6. AC Induction Motors**  
 Describe the operation of an induction motor
- **112-7. Synchronous Motors**  
 Describe the operation of a synchronous motor
- **112-8. Three Phase Synchronous Operation**

## 113. Introduction to Electrical Ladder Drawings

- **113-1. Ladder Logic vs. Ladder Diagrams**
- **113-2. Reading and Interpreting Schematics and Circuits**
- **113-3. Understanding International Diagrams and Symbols**
- **113-4. Interpreting Blueprints and Flow Charts**
- **113-5. Concepts of Relay Logic**
- **113-6. Understanding Terminology**
- **113-7. Interpreting Logic Gates and Diagrams**

## 114. AC Circuit Analysis

- **114-1. Inductance and RL Circuits**  
 Define the terms inductor and inductance  
 Explain how inductance affects current  
 Calculate the transient response time for an RL circuit

Define mutual inductance

Use various measuring and computing methods to determine the values of currents and voltages in an inductive circuit

Determine inductive reactance by using measurements of circuit currents and voltages

Calculate the equivalent inductance in both series and parallel circuit arrangements

- **114-2. Capacitance and RC Circuits**

Define the terms capacitor and capacitance

Explain how capacitance affects current

Calculate the transient response time for an RC circuit

Use various measuring and computing methods to determine the values of currents and voltages in an capacitive circuit

Determine capacitive reactance by using measurements of circuit currents and voltages

Calculate the equivalent capacitance in both series and parallel circuit arrangements

- **114-3. Tuned Circuits and RLC Networks**

Explain resonant frequency and how it affects various RCL circuits

Calculate a resonant frequency

Discuss the characteristics of a series RCL circuit at its resonant frequency

Discuss the characteristics of a parallel RCL circuit at its resonant frequency

List four types of filters and explain their action

## 115. Semiconductor Fundamentals

- **115-1. Safety Review**

Discuss and list the safety rules for avoiding electrical shock

Describe several causes of electrical burns

Know the reason for grounding of electrical equipment

Determine dangerous levels of electrical current as it relates to the human body

Physiological effects of electric current on the human body

Rules for safe practice and avoiding electric shock

Avoiding burns and avoiding equipment related injuries

- **115-2. Semiconductors, Diodes**

Describe the function, installation and use of various semiconductor diodes and other solid-state devices and systems

- **115-3. DC Power Supplies, Single Phase**

Draw and describe the basic operation of a half-wave rectifier circuit

Draw and describe the basic operation of a full-wave rectifier circuit

Draw and describe the basic operation of a full-wave bridge rectifier circuit

Describe the basic action of a filter using a simple schematic diagram

Explain the methods used for improving filtering action

Construct and test a simple dc power supply circuit

- **115-4. Solid-State Transducers**

Describe the purpose of a transducer

List various types of transducers

Describe the operation of a PTC and NTC thermistor

Identify typical applications of common transducers

Describe the operation of a Hall effect transducer

- **115-5. Transistor Theory**

Identify PNP and NPN transistor symbols and their respective component leads

Explain the operation of a bipolar transistor

Identify key factors on a transistor operation curve

Identify common base, common collector and common emitter circuit configurations



Explain the methods used for testing a bipolar transistor  
 Demonstrate the ability to properly test a bipolar transistor  
 Silicon controlled rectifiers (SCR)  
 Identify and label the schematic diagram of an SCR  
 Explain the operation of and SCR  
 Describe how an SCR operates using a simple circuit  
 Describe how an SCR can be used as a switch to control a simple lamp circuit  
 Describe how an SCR can be used to vary the current in a simple lamp circuit  
 Demonstrate the ability to properly test and SCR  
 Triacs, diacs and unijunction transistors  
 Draw the schematic symbol and describe the basic operation of a triac  
 Draw the schematic symbol and describe the basic operation of a diac  
 Draw the schematic symbol and describe the basic operation of a UJT  
 Describe the typical applications of a triac  
 Describe the typical applications of a diac  
 Describe the typical applications of a UJT  
 The transistor as an amplifier  
 Describe amplifier concepts using a typical circuit for illustration  
 Describe the three main classes of amplification using typical circuits  
 FETs, GTOs and IGBTs  
 - Describe the typical applications of an FET  
 - Describe the typical applications of a GTO  
 - Describe the typical applications of an IGBT  
 Identify and understand the proper operating parameters of FETs, GTOs and IGBTs utilizing manufacturer's data sheets

## 116. Digital Fundamentals

- **116-1. Digital Technology**  
 Describe the characteristics of industrial and electronic revolutions  
 List the members of the technical team in electronics and describe their typical educational backgrounds  
 Define such terms as analog, signal, digital signal, bus, MSB, LSB, DIP, IC, TTL and CMOS  
 Count to at least 20 in the binary system and convert binary numbers to decimal  
 List names given to the two logic levels
- **116-2. Logic Elements**  
 Recognize switch-based AND, OR and NOT circuits and explain their actions in terms of truth tables and Boolean algebra expressions  
 Recognize symbols for integrated circuit AND, OR and NOT logic elements and explain their actions in terms of truth tables, Boolean expressions and timing diagrams  
 Describe the actions of multi-input logic elements  
 Predict logic levels at all points in circuits containing AND, OR and NOT elements
- **116-3. Combination Logic**  
 Construct truth tables for combinational logic circuits containing AND, OR and NOT elements based on their logic diagrams  
 Construct truth tables for such circuits based on their Boolean expressions  
 Write Boolean expressions for combinational logic circuits composed of AND, OR and NOT elements based on their logic diagrams  
 Draw logic diagrams for such circuits based on their Boolean expressions  
 Write Boolean expressions for combinational logic circuits composed of AND, OR and NOT elements based on their truth tables using sum-of-products and product-of-sums methods



- **116-4. NAND, NOR and XOR Elements**
  - Construct truth tables for combinational logic circuits containing NAND, NOR and XOR elements based on their logic diagrams
  - Construct truth tables for such circuits based on their Boolean expressions
  - Write Boolean expressions for combinational logic circuits composed of NAND, NOR and XOR elements based on their logic diagrams
  - Draw logic diagrams for such circuits based on their Boolean expressions
  - Write Boolean expressions for combinational logic circuits composed of NAND, NOR, and XOR elements based on their truth tables using sum-of-products and product-of-sums methods
- **116-5. Binary Number Shortcuts**
  - Count using the binary numbering system
  - Compare place values for the digits of binary numbers
  - Convert binary numbers to decimal and decimal numbers to binary
  - Add unsigned binary numbers
  - Determine the twos complement of binary numbers and use the twos complement method to do binary subtraction
  - Add signed binary numbers
  - Determine if overflows have occurred when binary numbers have been added
- **116-6. Numbering Systems and Codes**
  - Count using the octal and hexadecimal numbering systems
  - Convert between binary and octal numbers and between binary and hexadecimal numbers
  - Convert between decimal and octal numbers and between decimal and hexadecimal numbers
  - Convert between decimal and binary-coded decimal numbers
  - Describe the nature of the gray code and its most important application
  - State the meaning of the term ASCII
- **116-7. Data Communications**
  - Explain the history of data communications in computing
  - Describe interface protocols and adjustments needed for computer software
  - Demonstrate the ability to connect intelligent systems to portable test equipment using RS-232 and USB interfaces
  - Understand fiber-optic data communications
  - Understand wireless data communications
  - Describe various types of data communications software (i.e. hyerterminal, procomm plus)

## 2.2 200-level courses: Vehicle Operations Overview and Maintenance of Rail Vehicles

### 200. Vehicle Theory of Operation and Overview of Major Systems

**NOTE:** This section contains different versions of class for the main types of rail systems: LRV, HR, commuter rail and for various power distribution systems used for propulsion (third rail, catenary, AC, DC).

### 201. Couplers: Introduction and Preventive Maintenance

- **201.1 Electric Coupler Heads**
  - Inspecting and maintaining linear actuators/motors
    - Inspect linear actuators/motors
    - Service actuators/motors
    - Perform basic repairs on linear actuators/motors
    - Replace linear actuators/motors
    - Test linear actuators/motors
  - Inspecting and maintaining coupler suspension and linkage

- Check linkages for wear
  - Check suspension height
  - Lubricate coupler and/or linkage
  - Perform basic repairs on coupler suspension and linkage
  - Test coupler suspension and linkage
  - Replace coupler and/or linkage
- Inspecting and maintaining limit/proximity switches
- Adjust limit/proximity switches using appropriate gauge
  - Perform basic repairs on limit/proximity switches
  - Test limit/proximity switches
  - Replace limit/proximity switches
- Inspecting and maintaining release mechanism
- Adjust release mechanism, if applicable
  - Inspect release mechanism
  - Lubricate release mechanism, if applicable
  - Perform basic repairs on release mechanism
  - Replace release mechanism
  - Test release mechanism
- Inspecting and maintaining train line cables
- Inspect train line cables
  - Perform basic repairs on train line cables
  - Replace train line cables
  - Test train line cables
- Inspecting and maintaining drum/uncoupling switch
- Inspect drum/uncoupling switch
  - Perform basic repairs on drum/uncoupling switch
  - Replace drum/uncoupling switch
  - Test drum/uncoupling switch (electric test)
- Inspecting and maintaining heaters and temperature sensors
- Inspect heaters and temperature sensors
  - Perform basic repairs on heaters
  - Perform basic repairs on temperature sensors
  - Replace heaters
  - Replace temperature sensors
  - Test heaters and temperature sensors
- Inspecting and maintaining contact pin/tip assembly (insulated block)
- Check contact pin/tip assembly (insulated block) for physical damage
  - Clean contact pin/tip assembly (insulated block)
  - Identify proper parts
  - Identify proper solvents and lubricants
  - Inspect fixed and mobile contacts
  - Inspect gaskets
  - Replace fixed and mobile contacts and /or contact assembly
  - Test fixed and mobile contacts and/or contact assembly
- 201 Inspecting and maintaining coupling sensor
- Check adjustment of coupling sensor
  - Inspect coupling sensor
  - Perform basic repairs on coupling sensor
  - Replace coupling sensor
  - Test coupling sensor

- **201.2 Pneumatic Coupler**
  - Inspecting and maintaining tappet valves
    - Clean tappet valves
    - Replace tappet valves
    - Test tappet valves
  - Inspecting and maintaining heaters and temperature sensors
    - Inspect heaters and temperature sensors
    - Perform basic repairs on heaters
    - Perform basic repairs on temperature sensors
    - Replace heaters
    - Replace temperature sensors
    - Test heaters and temperature sensors
  - Inspecting and maintaining solenoid valves
    - Inspect solenoid valves
    - Replace solenoid valves
    - Test solenoid valves
  - Inspecting and maintaining valve filters
    - Clean valve filters
    - Replace valve filters
  - Inspecting and maintaining train line (brake pipe)
    - Inspect train line (brake pipe)
    - Replace train line (brake pipe)
    - Test train line (brake pipe)
  - Inspecting and maintaining drum switch/air actuator
    - Adjust drum switch/air actuator
    - Inspect drum switch/air actuator
    - Replace drum switch/air actuator
    - Test drum switch/air actuator
  - Inspecting and maintaining uncoupling air system
    - Inspect uncoupling air system
    - Lubricate uncoupling air system
    - Replace air cylinder
    - Replace uncoupling air system
    - Test air cylinder and uncoupling air system
- **201.3 Mechanical Coupler**
  - Inspecting and maintaining suspension and linkage components
    - Check linkages for wear
    - Check suspension height and level
    - Replace linkages
    - Replace suspension and linkage components
  - Inspecting and maintaining linear actuators
    - Inspect linear actuators
    - Lubricate linear actuators
    - Replace linear actuators
  - Inspecting and maintaining knuckle and slide lock
    - Inspect for wear, damage and proper locking
    - Gauge tightness
    - Lubricate mechanism
  - Inspecting and maintaining hook and plate
    - Inspect hook plate assembly

- Lubricate hook plate assembly
- Replace hook plate assembly
- Inspecting and maintaining limit switches
  - Adjust limit switches
  - Inspect limit switches
  - Replace limit switches
- Inspecting and maintaining alignment, anchor and suspension
  - Adjust coupler support
  - Check shear device hardware
  - Inspect anchor
  - Inspect buffer tubes, draft gear and absorption cartridge
  - Inspect centering device and springs
  - Inspect coupler support
  - Inspect shear device assembly
  - Replace buffer tubes, draft gear and absorption cartridge
  - Replace centering device and springs
  - Replace coupler support
  - Replace shear device
- Inspecting and maintaining heaters and temperature sensors
  - Inspect heaters and temperature sensors
  - Perform basic repairs on heaters
  - Perform basic repairs on temperature sensors
  - Replace heaters
  - Replace temperature sensors
  - Test heaters and temperature sensors
- Inspecting and maintaining release mechanism
  - Inspect release mechanism
  - Lubricate release mechanism
  - Replace release mechanism
- Inspecting and maintaining electrical pin door/shutter/gasket
  - Clean electrical pin door/shutter/gasket
  - Inspect electrical pin door/shutter/gasket
  - Lubricate electrical pin door/shutter/gasket
  - Replace electrical pin door/shutter/gasket
  - Test electrical pin door/shutter/gasket
- Inspecting and maintaining draw bar (married pairs)
  - Inspect draw bar (married pairs)
  - Lubricate draw bar (married pairs)
  - Replace draw bar (married pairs)
  - Check shear device hardware
  - Inspect buffer tubes and draft gear
- **201.4 Tools**
  - NOTE:** Can be integrated in other parts of module or taught separately.
  - Demonstrate proper use of wear gauges (go/no-go gauge)
  - Demonstrate proper use of head alignment tools
  - Demonstrate proper use of contact/pin replacement tools
  - Demonstrate proper use of vertical press
  - Demonstrate proper use of bushing driver
  - Demonstrate proper use of reamer

Demonstrate proper use of coupler repair stand  
 Demonstrate proper use of pneumatic/hydraulic jacks  
 Demonstrate proper use of overhead cranes  
 Demonstrate proper use of lift tables  
 Demonstrate proper use of forklift and adapter  
 Demonstrate proper use of continuity tester/breakout box  
 Demonstrate proper use of auxiliary power supply/connector tester  
 Demonstrate proper use of digital multimeter  
 Demonstrate proper use of torque wrench  
 Demonstrate proper use of dial indicator

## 202. Trucks and Axles: Introduction and Preventive Maintenance

### • 202.1 AC Traction Motor

Inspecting and maintaining speed/tach sensor

- Explain how speed sensors work
- Clean speed/tach sensor
- Inspect speed/tach sensor
- Inspect speed/tach sensor for debris
- Repair speed/tach sensor
- Replace speed/tach sensor

Inspecting and maintaining stator

- Check winding
- Inspect stator
- Repair stator
- Replace stator
- Test stator

Inspecting and maintaining internal fan

- Clean internal fan
- Inspect internal fan
- Replace internal fan

Inspecting and maintaining external fan

- Clean external fan
- Inspect external fan
- Repair external fan
- Replace external fan

Inspecting and maintaining bearings

- Identify different lubricants and their appropriate use
- Lubricate bearings
- Check for bearing noise
- Replace bearings

Inspecting and maintaining wiring and insulation

- Inspect wiring and insulation
- Repair wiring and insulation
- Replace wiring and insulation
- Test wiring and insulation

Inspecting and maintaining coupling

- Inspect coupling; check for coupling noise
- Lubricate coupling
- Remove coupling
- Replace coupling

Inspecting and maintaining traction motor

- Check and torque motor-to-gearbox bolts
- Check brush holder/spring tension and for free movement of brush in holder
- Check cable and insulation for cracks, arcing and odor
- Check cable routing
- Check ground shunts
- Clean brush area and brushes
- Clean traction motor
- Demonstrate knowledge of commutator motor parts and assembly
- Inspect air ducts
- Inspect brushes/brush holders
- Inspect traction motor
- Lubricate traction motor where applicable, use proper lubricant and fill to proper level
- Overhauling traction motor
- Replace brushes/brush holders

• **202.2 DC Traction Motor**

Inspecting and maintaining brushes

- Demonstrate ability to use basic hand tools
- Demonstrate knowledge of brush and brush holder function
- Identify brush location
- Inspect brushes
- Measure brush wear
- Remove excess grease
- Replace brushes

Inspecting and maintaining brush holders

- Adjust brush holders
- Check brush holders
- Check wear limits
- Clean off excess carbon
- Ensure brushes have travel
- Inspect brush holders
- Replace brush holders
- Test spring tension

Inspecting and maintaining commutator/armature

- Blow down commutator/armature
- Check commutator/armature runout
- Clean commutator/armature
- Inspect commutator/armature
- Replace commutator/armature

Inspecting and maintaining sun gear/coupling

- Drain sun gear/coupling
- Inspect sun gear/coupling
- Lubricate sun gear/coupling
- Replace sun gear/coupling

Inspecting and maintaining flash pins/arc horn/pin

- Adjust flash pins/arc horn/pin
- Inspect flash pins/arc horn/pin
- Replace flash pins/arc horn/pin

Inspecting and maintaining wiring and insulation

- Inspect wiring and insulation

- Repair wiring and insulation
- Replace wiring and insulation
- Test wiring and insulation
- Inspecting and maintaining field coils/interpoles
  - Clean field coils/interpoles
  - Inspect field coils/interpoles
  - Replace field coils/interpoles
  - Test field coils/interpoles
- Inspecting and maintaining bearings
  - Lubricate bearings
  - Check for bearing noise
  - Replace bearings
- Inspecting and maintaining ventilation (internal fan or forced)
  - Change breather
  - Check breather
  - Clean ventilation
  - Inspect ventilation
  - Repair ventilation
  - Replace bellows
  - Replace ventilation
- Inspecting and maintaining temperature sensors
  - Check connections
  - Replace temperature sensors
- Inspecting and maintaining speed sensor
  - Clean speed sensor
  - Inspect speed sensor for debris
  - Repair speed sensor
  - Replace speed sensor
- **202.3 Gearboxes**
  - Inspecting and maintaining high-speed coupling
    - Inspect high-speed coupling; check for noise
    - Lubricate high-speed coupling
    - Remove high-speed coupling
    - Replace high-speed coupling
  - Inspecting and maintaining worm gear
    - Adjust worm gear
    - Inspect worm gear
    - Repair worm gear
    - Replace worm gear
  - Inspecting and maintaining pinion gear
    - Adjust pinion gear; check backlatch
    - Inspect pinion gear
    - Repair pinion gear
    - Replace pinion gear
  - Inspecting and maintaining bearings/races
    - Adjust bearings/races
    - Inspect bearings/races
    - Repair bearings/races
    - Replace bearings/races

Inspecting and maintaining lubrication

- Change lubrication
- Check lubrication
- Replace lubrication
- Test lubrication

Inspecting and maintaining inspection plate and sight glass

- Inspect inspection plate and sight glass
- Inspect plate and sight glass
- Replace inspection plate and sight glass

Inspecting and maintaining housing

- Bead-blast/clean housing
- Clean housing
- Inspect housing
- Repair housing
- Replace housing

Inspecting and maintaining seals

- Inspect seals for leaks
- Replace seals

Inspecting and maintaining spider gears

- Inspect spider gears
- Repair spider gears
- Replace spider gears

Inspecting and maintaining coupler retainer

- Inspect coupler retainer
- Replace coupler retainer

Inspecting and maintaining breather

- Clean breather
- Inspect breather
- Replace breather

Inspecting and maintaining spider

- Inspect spider
- Replace spider

Inspecting and maintaining magnetic plugs

- Clean magnetic plugs
- Inspect magnetic plugs
- Replace magnetic plugs

Inspecting and maintaining loading/support rod

- Inspect loading/support rod
- Replace loading/support rod

Inspecting and maintaining ground bushing housing

- Clean ground bushing housing
- Inspect ground bushing housing
- Replace ground bushing housing
- Test ground bushing housing

• **202.4 Axles**

Inspecting and maintaining rotor (brake disc)

- Inspect rotor
- Machine rotor
- Replace rotor

Inspecting and maintaining wheel assembly



- Demonstrate ability to follow proper safety procedures
  - Inspect wheel assembly
  - Remove wheel assembly
  - True wheel assembly
- Inspecting and maintaining spider and vulcanized spacers/joint coupling assembly
- Inspect spider and vulcanized rubber spacers/joint coupling assembly
  - Replace spider and vulcanized rubber spacers/joint coupling assembly
- Inspecting and maintaining tooth gear (speed sensor)
- Clean tooth gear
  - Inspect tooth gear
  - Replace tooth gear
- Inspecting and maintaining ground brush and housing
- Clean ground brush and housing
  - Inspect ground brush and housing
  - Replace ground brush and housing
  - Test ground brush and housing
- Inspecting and maintaining hollow shaft
- Inspect and measure hollow shaft
  - Inspect hollow shaft
- Inspecting and maintaining journal bearings and housing
- Clean journal bearings and housing
  - Inspect journal bearings and housing
  - Repack journal bearings and housing
- **202.5 Wheel and Tires**
- Inspecting and maintaining shunts
- Clean connections
  - Inspect shunts
  - Replace shunts
  - Test shunts
- Inspecting and maintaining rubber
- Inspect rubber
  - Replace rubber
- Inspecting and maintaining bolts
- Inspect bolts
  - Replace bolts
- Inspecting and maintaining conical ring
- Inspect conical ring
  - Replace conical ring
- Inspecting and maintaining dampening ring
- Inspect dampening ring
  - Replace dampening ring
- Perform preventive maintenance on tires
- Inspect tires
  - Inspect tires and flange for cracks
  - Measure tires
  - Remove tires
  - Replace tires
  - True tires
- Inspecting and maintaining plugs
- Inspect plugs

- Replace plugs
- **202.6 Primary Suspension**
  - Inspecting and maintaining chevrons/rubber springs
    - Disassemble chevrons/rubber springs
    - Inspect chevrons/rubber springs
    - Measure chevrons/rubber springs
    - Reassemble chevrons/rubber springs
    - Replace chevrons/rubber springs
    - Shim chevrons/rubber springs
  - Inspecting and maintaining journal bearing housing
    - Clean bearings
    - Demonstrate knowledge of scratching and pitting bearings
    - Identify and use correct type of grease
    - Inspect journal bearing housing
    - Replace bearings
    - Replace journal bearing housing
  - Inspecting and maintaining speed sensors
    - Adjust speed sensors
    - Inspect speed sensors
    - Replace speed sensors
    - Test speed sensors
  - Inspecting and maintaining up stops and down stops/pedestal bar
    - Adjust up stops and down stops/pedestal bar
    - Inspect hardware
    - Repair up stops and down stops/pedestal bar
    - Replace up stops and down stops/pedestal bar
- **202.7 Frame**
  - Inspecting and maintaining traction/radius rod and bushings
    - Check for cracks in frame
    - Adjust traction/radius rod and bushings
    - Inspect traction/radius rod and bushings
    - Replace traction/radius rod and bushings
  - Inspecting and maintaining bovine board/cow catcher/safety board/life guard
    - Inspect bovine board/cow catcher/safety board/life guard
    - Replace bovine board/cow catcher/safety board/life guard
  - Inspecting and maintaining transom bearings/front and rear beam
    - Demonstrate ability to use truck lifts
    - Inspect transom bearings/front and rear beam
    - Inspect wiring
    - Replace bushings/bearings
    - Replace transom bearings/front and rear beam
  - Inspecting and maintaining antennas
    - Inspect antenna
    - Replace antenna
    - Test antenna
  - Inspecting and maintaining speed sensor device
    - Adjust speed sensor device
    - Inspect speed sensor device
    - Replace speed sensor device
    - Test speed sensor device

Inspecting and maintaining fenders

- Clean fenders
- Inspect fenders
- Repair fenders

Inspecting and maintaining sanding tubes

- Adjust sanding nozzle to proper height
- Adjust sanding tubes
- Align sanding tubes
- Disassemble sanding tubes
- Reassemble sanding tubes
- Inspect heater nozzles
- Inspect sanding tubes
- Repair sanding tubes
- Replace heater nozzles
- Test heater nozzles

Inspecting and maintaining lubricators

- Adjust lubricators
- Align lubricators
- Inspect lubricators
- Repair lubricators

Inspecting and maintaining wiring

- Inspect wiring
- Repair wiring
- Replace wiring

Inspecting and maintaining tripping device

- Adjust tripping device
- Inspect tripping device
- Remove as needed

Inspecting and maintaining piping

- Flush piping
- Inspect piping
- Inspect piping for leaks
- Repair piping
- Replace piping

Inspecting and maintaining track brake

- Adjust hangers/support/suspension
- Adjust pole/segment pieces/brake pads/brake shoes
- Align hangers/support/suspension
- Inspect bushings
- Inspect cabling
- Inspect guide pads
- Inspect hangers/support/suspension
- Inspect pole/segment pieces/brake pads/brake shoes
- Inspect wiring
- Repair hangers/support/suspension
- Repair wiring
- Replace bushings
- Replace cabling
- Replace guide pads
- Replace pole/segment pieces/brake pads/brake shoes

- Replace wiring
- Test cabling
- Test wiring
- Inspecting and maintaining debris sweeper
  - Adjust debris sweeper
  - Inspect debris sweeper
  - Replace debris sweeper
- Inspecting and maintaining down hanger (caliper hanger)
  - Inspect down hanger
  - Lubricate down hanger
  - Replace down hanger
- Inspecting and maintaining brake shoe support/brake hanger
  - Inspect brake shoe support/brake hanger
  - Lubricate brake shoe support/brake hanger
  - Repair brake shoe support/brake hanger
  - Replace brake shoe support/brake hanger
- Inspecting and maintaining lateral bumper/stop
  - Inspect lateral bumper/stop
  - Replace lateral bumper/stop
- **202.8 Bolster/Secondary Suspension**
  - Inspecting and maintaining coil spring
    - Inspect coil spring
    - Replace coil spring
  - Inspecting and maintaining airbags
    - Drain air tanks/reservoir
    - Inspect air tanks/reservoir
    - Inspect airbags
    - Remove airbags
    - Replace bias/check valves
    - Replace bypass/cutoff valves
    - Test bias/check valves
    - Test bypass/cutoff valves
  - Inspecting and maintaining leveling device
    - Adjust leveling device
    - Inspect leveling device
    - Replace leveling device
  - Inspecting and maintaining load weight sensor
    - Adjust load weight sensor
    - Inspect load weight sensor
    - Inspect wiring
    - Repair wiring
    - Replace load weight sensor
    - Replace wiring
    - Test load weight sensor
    - Test wiring
  - Inspecting and maintaining hydraulic suspension leg
    - Inspect accumulator (hydraulic)
    - Inspect hydraulic suspension leg
    - Replace accumulator (hydraulic)
    - Replace hydraulic suspension leg

- Test accumulator (hydraulic)
- Inspecting and maintaining vertical stop/lifting rods
  - Adjust vertical stop/lifting rods
  - Inspect vertical stop/lifting rods
  - Replace vertical stop/lifting rods
- Inspecting and maintaining shocks/dampers
  - Adjust shocks/dampers
  - Inspect shocks/dampers
  - Refill oil
  - Replace shocks/dampers
  - Test shocks/dampers
- Inspecting and maintaining piping
  - Flush piping
  - Inspect piping
  - Inspect piping for leaks
  - Repair piping
  - Replace piping
- Inspecting and maintaining friction disc/side bearing
  - Adjust friction disc/side bearings
  - Inspect friction disc/side bearings
  - Replace friction disc/side bearings
- Inspecting and maintaining shims (floor height adjustment/static inspection)
  - Add shims as needed
  - Check shims (floor height adjustment/static inspection)
- Inspecting and maintaining spherical ring/slewing ring
  - Inspect spherical bearing/slewing ring
  - Lubricate spherical bearing/slewing ring
  - Replace spherical bearing/slewing ring
- Inspecting and maintaining articulation support
  - Inspect articulation support
  - Repair articulation support
- Inspecting and maintaining ball and socket
  - Inspect ball and socket
  - Replace Teflon liner
- **202.9 Tools**

**NOTE:** Can be integrated in other parts of module or taught separately.

- Demonstrate ability to use an axle press
- Demonstrate ability to use a wheel press
- Demonstrate ability to use a wheel bore
- Demonstrate ability to use a wheel profile gauge
- Demonstrate ability to use a back-to-back gauge
- Demonstrate ability to use a depth gauge
- Demonstrate ability to use a wheel tape/pie tape gauge
- Demonstrate ability to use a steel wheel gauge
- Demonstrate ability to use a dial indicator
- Demonstrate ability to use a car body height gauge
- Demonstrate ability to use a coupler height gauge
- Demonstrate ability to use a tape measure/ruler
- Demonstrate ability to use an armature run-out gauge

Demonstrate ability to use a coupler level gauge  
 Demonstrate ability to use a grease level gauge  
 Demonstrate ability to use a feeler gauge  
 Demonstrate ability to use a go no-go gauge  
 Demonstrate ability to use a current collector gauge  
 Demonstrate ability to use a trip device gauge  
 Demonstrate ability to use a ultrasonic wheel measuring tool/profile meter  
 Demonstrate ability to use a wheel truing machine  
 Demonstrate ability to use a truck/tramming press  
 Demonstrate ability to use a tire press  
 Demonstrate ability to use a journal bearing press  
 Demonstrate ability to use an industrial sized bandsaw  
 Demonstrate ability to use a lathe  
 Demonstrate ability to use undercutters  
 Demonstrate ability to use mills  
 Demonstrate ability to use a spin/load tester  
 Demonstrate ability to use a hydraulic press  
 Demonstrate ability to use a hydraulic fluid cleaning machine  
 Demonstrate ability to use an inductive bearing heater  
 Demonstrate ability to use a truck frame tester  
 Demonstrate ability to use a hydraulic test bench/hydraulic caliper test bench/brake force tester  
 Demonstrate ability to use portable test equipment  
 Demonstrate ability to use a breakout box  
 Demonstrate ability to use gearbox specialty tools  
 Demonstrate ability to use brake adjustor tools  
 Demonstrate ability to use a hydraulic pullers  
 Demonstrate ability to use a torque wrench  
 Demonstrate ability to use a megger  
 Demonstrate ability to use a digital multi-meter  
 Demonstrate ability to use a hydraulic vulcanized rubber spacers  
 Demonstrate ability to use a parts-per-million brake fluid tester  
 Demonstrate ability to use an oven  
 Demonstrate ability to use an impregnator  
 Demonstrate ability to use a plasma cutter  
 Demonstrate ability to use a hoist  
 Demonstrate ability to use basic hand tools  
 Demonstrate ability to use a laptop and diagnostic software  
 Demonstrate ability to use a bearing puller  
 Demonstrate ability to use a test stand

## **203. Propulsion and Dynamic Braking -- Intro and Preventive Maintenance**

### **• 203.1 AC Propulsion**

Inspecting and maintaining propulsion inverter

- Clean and blow out inverter enclosure
- Check for leaking capacitors and oil
- Demonstrate ability to follow safety procedures
- Demonstrate ability to read electrical schematics
- Demonstrate knowledge of three phase motors
- Torque screws to specifications
- Use high-pressure on appropriate areas

Inspecting and maintaining master controller (for AC propulsion system)

- Check lever for free movement
- Demonstrate knowledge of pulse width modulation
- Inspect master controller for debris
- Lubricate using proper lubricant
- Overhauling master controller
- Repair master controller
- Replace master controller
- Test master controller

Inspecting and maintaining train line control

- Demonstrate knowledge of active high and low
- Demonstrate knowledge of difference between a short and an open circuit
- Demonstrate knowledge of grounding
- Identify correct coupler pins
- Read and interpret schematics

Inspecting and maintaining the IGBT/GTO

- Clean IGBT/GTO
- Demonstrate knowledge of capacitor charge
- Demonstrate knowledge of electrostatic discharge
- Demonstrate knowledge of lock out/tag out
- Demonstrate proper use of thermal compound
- Follow procedures for making unit safe to work on
- Inspect IGBT/GTO for damage and odor
- Overhaul IGBT/GTO
- Perform reduced power test
- Repair module
- Replace module
- Test IGBT/GTO using laptop

Inspecting and maintaining electronic control system

- Access faults
- Access history
- Clean electronic control system
- Demonstrate ability to read hexadecimal code
- Demonstrate ability to read the LEDs
- Demonstrate knowledge of MVFB (multifunction vehicle bus)
- Inspect electronic control system
- Overhauling electronic control system
- Read LEDs on propulsion container
- Replace cards
- Replace electronic control system
- Test electronic control system
- Test individual modules
- Test input and output

Inspecting and maintaining software

- Demonstrate ability to use testing functions
- Locate connectors
- Upgrade software
- Ping connectors to read values
- Take measurements using connectors
- Verify correct version of software

Inspecting and maintaining ventilation system

- Blow out sensors and blower fans
- Check airflow direction
- Check all fasteners
- Check fans using reduced power test
- Check pipe routing
- Check TCU for blower faults
- Check ventilation system for debris
- Clean ventilation system
- Identify intake and exhaust ends
- Lubricate ventilation system
- Overhaul ventilation system
- Perform air flow test on ventilation system using proper safety procedures
- Repair fan and motor assembly
- Repair sensors
- Replace fan and motor assembly
- Replace filter following proper safety procedures
- Replace sensors
- Unclog heat sink
- Use proper nozzle for blowout

Inspecting and maintaining capacitor filtering coils

- Identify leaks and bulges
- Inspect capacitor filtering coils for arcing, debris and damage
- Overhaul capacitor filtering coils
- Replace capacitor filtering coils
- Test capacitor filtering coils

Inspecting and maintaining chokes/transformer

- Inspect chokes/transformer
- Overhaul chokes/transformer
- Replace chokes/transformer

Inspecting and maintaining high-speed circuit breaker

- Adjust high-speed circuit breaker
- Check fuse
- Check operation of main solenoid
- Clean high-speed circuit breaker
- Disassemble high-speed circuit breaker
- Inspect high-speed circuit breaker
- Overhaul high-speed circuit breaker
- Test high-speed circuit breaker

Inspecting and maintaining ground fault system

- Change blown fuses
- Check fuses
- Demonstrate ability to read VOD (vehicle operator display)
- Inspect brushes, springs, wires and connectors
- Inspect ground fault system
- Isolate system
- Overhaul ground fault system
- Reset GFS relay
- Test fuses
- Test ground fault system



Inspecting and maintaining contactor/arc chutes

- Adjust contactor/arc chutes
- Clean contactor/arc chutes with compressed air
- Identify different types of connectors
- Identify excessive arcing
- Inspect contactor/arc chutes
- Overhauling contactor/arc chutes
- Replace contactor/arc chutes
- Test contactor/arc chutes

Inspecting and maintaining resistance units

- Check insulators and cage
- Check resistance
- Clean resistance units
- Inspect resistance units for cracks and damage
- Overhaul resistance units
- Replace resistance units

Inspecting and maintaining knife switch (DC link)

- Adjust knife switch
- Clean knife switch
- Inspect knife switch
- Lubricate knife switch
- Overhauling knife switch
- Replace knife switch
- Test knife switch

Inspecting and maintaining traction motor

- Blow out traction motor
- Check cable routing
- Check fasteners
- Clean drain hole
- Clean traction motor
- Demonstrate knowledge of motor parts
- Inspect traction motor
- Lubricate traction motor in proper place using correct lubricant and correct amount
- Overhaul traction motor

Inspecting and maintaining speed sensors/tach sensors

- Adjust speed sensors/tach sensors
- Clean speed sensors/tach sensors
- Inspect speed sensors/tach sensors, wiring and connectors
- Overhaul speed sensors/tach sensors (if done locally)
- Remove speed sensors/tach sensors
- Replace speed sensors/tach sensors

Inspecting and maintaining speed sensor cable

- Test speed sensor cable
- Replace speed sensor cable

Inspecting and maintaining load weight sensors

- Adjust load weight sensors
- Inspect load weight sensors
- Inspect wearable items
- Measure wheel, floor level and load
- Overhaul load weight sensors (if done locally)

- Replace load weight sensors
  - Replace wearable items
  - Test load weight sensors
- Inspecting and maintaining load cell
- Adjust link bar
  - Adjust value
  - Test value
- Inspecting and maintaining overcurrent protection
- Check operation of overcurrent protection
  - Clean overcurrent protection
  - Overhauling overcurrent protection
  - Replace overcurrent protection
- Inspecting and maintaining pulse conditioning unit
- Test pulse conditioning unit
  - Replace pulse conditioning unit
- **203.2 DC Propulsion**
- Inspecting and maintaining chopper
- Check capacitor bank for leaks
  - Clean above, around and interior of enclosure
  - Clean capacitor bank
  - Clean chokes/transformers
  - Clean heat sink
  - Clean thyristors
  - Demonstrate knowledge of location and function of chopper
  - Disassemble thyristors
  - Identify capacitor bank
  - Inspect capacitor bank
  - Inspect chokes/transformers
  - Inspect thyristors
  - Overhaul chopper
  - Reassemble thyristors
  - Replace capacitor bank
  - Replace chokes/transformers
  - Replace thyristors
- Inspecting and maintaining cam control
- Adjust cams and switches
  - Adjust contactors
  - Clean cams and switches
  - Clean pilot motor
  - Explain difference between acknowledgement and actuator contacts
  - Inspect cams and switches
  - Inspect pilot motor
  - Overhaul cam control
  - Repair pilot motor
  - Replace cams and switches
  - Replace pilot motor
  - Test pilot motor
- Inspecting and maintaining master controller (for DC propulsion system)
- Check lever for free movement
  - Demonstrate knowledge of pulse width modulation

- Inspect master controller for debris
- Locate and use repair manual
- Lubricate using proper lubricant
- Overhaul master controller
- Repair master controller
- Replace master controller
- Test master controller

Inspecting and maintaining electronic control unit

- Access faults
- Access history
- Calibrate after battery removal
- Change batteries
- Clean electronic control system
- Demonstrate knowledge of MVFB (multifunction vehicle bus)
- Identify cards by box number
- Inspect electronic control system
- Overhaul electronic control unit
- Interpret LEDs on propulsion container
- Replace cards
- Replace electronic control system
- Set time/date on TCU
- Test electronic control system
- Test individual modules
- Test input and output

Inspecting and maintaining ventilation system

- Adjust air flow sensor and timers
- Blow out sensors and blower fans
- Check airflow direction, unclog heat sink if needed
- Check all fasteners
- Check fans using reduced power test
- Check pipe routing
- Check TCU for blower faults
- Check ventilation system for debris
- Clean ventilation system
- Demonstrate knowledge of blower monitor circuit
- Identify intake and exhaust ends
- Lubricate ventilation system
- Overhaul ventilation system
- Perform air flow test on ventilation system using proper safety procedures
- Repair fan and motor assembly
- Repair sensors
- Replace fan and motor assembly
- Replace filter following proper safety procedures
- Replace sensors
- Use proper nozzle for blow out

Inspecting and maintaining high-speed circuit breaker

- Adjust high-speed circuit breaker
- Check fuse
- Check operation of main solenoid
- Clean high-speed circuit breaker

- Disassemble high-speed circuit breaker
- Inspect high-speed circuit breaker
- Overhauling high-speed circuit Breaker
- Test high-speed circuit breaker

Inspecting and maintaining contactor/arc chutes

- Adjust contactor/arc chutes
- Clean contactor/arc chutes with compressed air
- Identify different types of connectors
- Identify excessive arcing
- Inspect contactor/arc chutes
- Overhaul contactor/arc chutes
- Replace contactor/arc chutes
- Test contactor/arc chutes

Inspecting and maintaining resistance banks

- Check insulators and cage
- Check resistance
- Clean resistance banks
- Demonstrate knowledge of conditions that can make resistance banks implode
- Inspect resistance banks for cracks and damage
- Overhaul resistance banks
- Repair sections of resistance banks
- Replace resistance banks

Maintaining knife switch (DC link)

- Adjust knife switch
- Clean knife switch
- Inspect knife switch
- Lubricate knife switch
- Overhaul knife switch
- Replace knife switch
- Test knife switch

Inspecting and maintaining overcurrent protection

- Check operation of overcurrent protection
- Clean overcurrent protection
- Overhaul overcurrent protection
- Replace overcurrent protection

• **203.3 Tools**

**NOTE:** Can be integrated in other parts of module or taught separately.

Demonstrate ability to use bench test equipment (electric and hydraulic)

Demonstrate ability to use laptop and software

Demonstrate ability to use fluid cleaner/pump/oil analyzer

Demonstrate ability to use caliper/brake release tools

Demonstrate ability to use suspension spacer

Demonstrate ability to use caliper stands

Demonstrate ability to use brake force tester

Demonstrate ability to use quick disconnect adapters/fittings

Demonstrate ability to use signal generator to test sensors

Demonstrate ability to use digital multi meter

Demonstrate ability to use repin connectors

Demonstrate ability to use insulation blankets (cutting rotor)

Demonstrate ability to use acetylene torch  
 Demonstrate ability to use welding equipment (arc, MIG, TIG, plasma cutter)  
 Demonstrate ability to operate equipment mover  
 Demonstrate ability to use filter carts  
 Demonstrate ability to use breakout boxes  
 Demonstrate ability to use portable test equipment  
 Demonstrate ability to use oscilloscopes  
 Demonstrate ability to use voltage/current regulators  
 Demonstrate ability to use anti-static bags  
 Demonstrate ability to use torque wrenches  
 Demonstrate ability to use hand tools  
 Demonstrate ability to use crimping tools and use  
 Demonstrate ability to use soldering tools  
 Demonstrate ability to use heat shrink guns  
 Demonstrate ability to use wire labeler  
 Demonstrate ability to use vibration meter

## 204. Auxiliary Inverters and Batteries: Introduction and Preventive Maintenance

### • 204.1 Batteries

Inspecting and Maintaining NiCd Batteries

- Check and verify battery specifications
- Clean NiCd batteries and connections
- Check NiCd battery specific gravities
- Check NiCd battery voltages
- Check liquid level of cells
- Calibrate and verify calibration
- Charge and load test battery condition

Inspecting and maintaining lead acid batteries

- Check and verify battery specifications
- Clean lead acid batteries
- Check lead acid battery specific gravities
- Check lead acid battery voltages
- Check liquid level of cells
- Calibrate and verify calibration
- Charge and load test battery condition

Maintaining low voltage sensor

- Inspect and test thermal switches
- Inspect and test low voltage sensor
- Clean low voltage sensor
- Replace thermal switch
- Replace low voltage sensor

Maintaining battery breaker disconnect

- Inspect battery breaker disconnect
- Clean battery breaker disconnect
- Test battery breaker disconnect
- Replace battery breaker disconnect

### • 204.2 Motor Alternator

Maintaining DC motors

- Clean DC motors
- Inspect DC motors

- Check and replace DC motor brushes
- Test DC motors
- Repair DC motors
- Replace DC motors
- Maintaining AC motors
  - Clean AC motors
  - Inspect AC motors
  - Test AC motors
  - Repair AC motors
  - Replace AC motors
- Maintaining voltage regulators
  - Adjust voltage regulators
  - Test voltage regulators
  - Repair voltage regulators
  - Replace voltage regulators
- Maintaining frequency/speed control components
  - Test speed/frequency control
  - Adjust speed/frequency control
  - Repair speed/frequency control
  - Replace speed/frequency control
- **204.3 Solid State Inverter**
  - Maintaining GTOs
    - Inspect GTOs
    - Clean GTOs
    - Test GTOs
    - Replace GTOs
  - Maintaining IGBTs
    - Inspect IGBTs
    - Clean IGBTs
    - Test IGBTs
    - Replace IGBTs
  - Maintaining thyristors
    - Inspect thyristors
    - Clean thyristors
    - Test thyristors
    - Replace thyristors
  - Maintaining other inverter components
    - Maintain capacitor filters
    - Maintain electronic controls
    - Maintain output transformers
    - Maintain ventilation
- **204.4 Battery Charger/LVPS**
  - Maintaining battery charger and LVPS
    - Maintain rectifier and filters
    - Maintain input capacitor
    - Maintain temperature sensor
    - Maintain heater
    - Maintain electronic controls
  - Maintaining AUX inverter ventilation system
    - Replace filters

- Test sensors
- Replace sensors
- Test blower fan
- Replace blower fan

- **204.5 Tools**

**NOTE:** Can be integrated in other parts of module or taught separately.

Demonstrate ability to use laptop to test and diagnose system  
 Demonstrate ability to use bench test equipment to diagnose system  
 Demonstrate ability to use digital multimeter  
 Demonstrate ability to use oscilloscopes  
 Demonstrate ability to use chart recorder  
 Demonstrate ability to use ohm wheel/speed sensor

## **205. Friction Brakes: Introduction and Preventive Maintenance**

- **205.1 Hydraulic Braking**

Inspecting and maintaining hydraulic braking

- Analyze fluid
- Bleed system
- Check fluids
- Check system pressure
- Depressurize system
- Explain cause of low and high fluid readings
- Explain causes of fluid breakdown
- Explain fluid flash point and related safety precautions
- Fill fluids
- Flush fluids
- Identify braking system check points/sight glass location
- Identify contaminants and their effect on fluid appearance
- Identify different fluids and their uses
- Measure vehicle weight to set brake effort
- Recycle fluids
- Set up flush cart with proper piping

Inspecting and maintaining flush cart

- Change filters
- Reset pump pressure
- Clean flush cart
- Explain meaning of different fault codes
- Describe load cells

- **205.2 Electrical Hydraulic Unit**

Inspecting and maintaining electrical unit

- Blow out and clean commutators
- Check electrical unit for chafing and vibration
- Check for leaks and damage
- Check LORD mounts
- Check tightness of ground shunts
- Clean valves
- Disassemble electrical unit
- Identify correct hose size and type
- Inspect electrical carbon brushes

- Reassemble electrical unit
- Replace breathers
- Replace cannon plugs
- Replace damaged fittings
- Replace damaged hoses
- Replace electrical carbon brushes
- Replace filters
- Replace fluid
- Replace transducers and seals
- Replace valves
- Replace wiring
- Test electrical unit

Inspecting and maintaining varistors/pressure transducers

- Check transducer output
- Choose proper filter
- Compare demand and actual readings
- Demonstrate ability read hydraulic schematics
- Demonstrate ability to diagnose transducer problems
- Replace varistors/transducer
- Test varistors/transducer

Inspecting and maintaining motor assembly

- Cycle motor
- Inspect electrical carbon brushes
- Measure startup timing
- Repair bearings
- Repair electrical carbon brushes
- Replace bearings
- Replace electrical carbon brushes
- Replace motor assembly
- Test motor assembly

Inspecting and maintaining control valves

- Verify valve position
- Describe control valve operation
- Test control valves
- Repair control valves
- Replace control valves

Inspecting and maintaining pump-off circuit

- Test release cable
- Check for leaks
- Inspect emergency brake hand pump
- Fill emergency brake hand pump
- Test emergency brake hand pump
- Describe purpose of a witness tag
- Test pump-off circuit
- Repair leaks in hoses or hard lines
- Test emergency brake hand pump
- Repair emergency brake hand pump
- Replace emergency brake hand pump
- Lock out emergency brake hand pump system
- Bleed pressure



Maintaining cut-off switch

- Replace cut-off switch

Inspecting and maintaining accumulators

- Check nitrogen levels
- Fill accumulators
- Follow high-pressure safety procedures
- Identify Schrader valve
- Check accumulator and mounting for damage and missing components
- Fill accumulators
- Replace accumulators
- Repair accumulators
- Change mounts
- Change rock shields
- Change hardlines
- Change Schraeder valves

- **205.3 Actuator Brake**

Maintaining spring

- Check spring
- Adjust spring
- Replace spring

Maintaining electric motor

- Replace electric motor
- Test electric motor

- **205.4 Pneumatic Braking System**

Inspecting and maintaining check valves

- Inspect check valves
- Test check valves
- Replace check valves

Inspecting and maintaining air reservoir

- Inspect air reservoir
- Drain air reservoir

Inspecting and maintaining pneumatic control unit

- Inspect pneumatic control unit
- Test pneumatic control unit
- Repair pneumatic control unit
- Replace pneumatic control unit

Performing preventive maintenance on brake valves

- Inspect brake valves
- Test brake valves
- Repair brake valves
- Replace brake valves

Inspecting and maintaining air gauges

- Test air gauges
- Replace air gauges

Inspecting and maintaining air cocks

- Test air cocks
- Replace air cocks

Inspecting and maintaining hydraulic/pneumatic unit

- Test hydraulic/pneumatic unit
- Check oil level

- Fill hydraulic/pneumatic unit
- Replace hydraulic/pneumatic unit
- Inspecting and maintaining air compressor
  - Test air compressor
  - Check oil level
  - Fill air compressor
  - Inspect filter-drier
  - Replace filter-drier
  - Adjust pressure switches
  - Replace air compressor
  - Test filter-dryer
  - Test pressure switches
  - Replace pressure switches
  - Replace air compressor
  - Adjust pressure switches
  - Replace pressure switches
- **205.5 Common Brake Components**
  - Inspecting and maintaining parking brake
    - Test parking brake
    - Test failsafe operation
    - Replace parking brake
    - Repair parking brake
  - Inspecting and maintaining electronic control unit
    - Clean electronic control unit
    - Vacuum electronic control unit
    - Check connectors
    - Clear fault codes
    - Explain function of reset button
    - Replace electronic control unit
    - Test cards
    - Repair cards
    - Replace cards
  - Inspecting and maintaining brake calipers
    - Check pivots
    - Lubricate pivots
    - Check brake calipers for leaks
    - Check mountings and seals
    - Identify uneven wear patterns and explain causes
    - Align caliper to rotor of train
    - Replace brake calipers
    - Repair brake calipers
    - Test brake calipers
  - Inspecting and maintaining rotors
    - Inspect rotors for cracks, FOD damage, wear lines, concaveness/convexness and rust
    - Torque bolts to proper specifications
    - Replace rotors
    - Torque bolts to proper specifications
    - Turn rotors
  - Inspecting and maintaining brake pads/shoes
    - Inspect brake pads/shoes

- Replace brake pads/shoes
  - Inspect clips
  - Explain wear indicator
  - Explain wear patterns and causes
  - Remove clips/pins
  - Replace clips/pins in correct orientation
- Inspecting and maintaining brake transducers
- Inspect brake transducers
  - Clean brake transducers
  - Repair brake transducers
  - Replace brake transducers
  - Test brake transducers
- Inspecting and maintaining manual brake release
- Inspect manual brake release
  - Replace manual brake release
  - Test manual brake release
- Inspecting and maintaining brake bypass switch (electric cutout)
- Test brake bypass switch
  - Repair brake bypass switch
  - Replace brake bypass switch
- Inspecting and maintaining track brake
- Measure track brake
  - Test track brake
  - Replace track brake
  - Check suspension clearance and height
  - Check for corrosion on wear plate
  - Explain isolation
  - Clean debris
  - Replace rusty components
- Inspecting and maintaining sanding system
- Test sanding system
  - Fill sanding system
  - Clean sanding system
  - Check sand level
  - Inspect tubes for obstructions
  - Inspect nozzle
  - Inspect heaters
  - Inspect compressor
  - Inspect level filters
  - Clean seal
  - Repair sanding system
  - Replace sanding system
  - Replace valve
  - Replace drop tube
- Inspecting and maintaining electrical cabling
- Inspect cabling
  - Check for corrosion on hangers
  - Verify cables slide smoothly
  - Inspect wiring harnesses for damage
  - Identify when rerouting is necessary

- Repair electrical cabling
  - Replace electrical cabling
  - Repair connectors
- Inspecting and maintaining piping and hoses
- Inspect piping and hoses
  - Verify piping and hoses slide smoothly
  - Inspect wiring harnesses for damage
  - Identify when rerouting is necessary
  - Repair piping and hoses
  - Replace piping and hoses
  - Identify correct hose size and type
- Inspecting and maintaining caliper support rod
- Lubricate caliper support rod
  - Replace caliper support rod
  - Adjust caliper support rod
- Inspecting and maintaining caliper support
- Lubricate caliper support
  - Replace caliper support
- Inspecting and maintaining filters
- Clean filters
  - Replace filters
  - Inspect intake filter for motors and electrical boxes
  - Locate correct filter type and part number
  - Replace filters
- Inspecting and maintaining anti-spinslide circuits
- Test anti-spinslide circuits
  - Clean speed sensors
  - Locate sensors on axles, motor and gearbox
  - Test anti-spinslide circuit
  - Repair anti-spinslide circuit
  - Replace anti-spinslide circuits
- **205.6 Tools**
- NOTE:** Can be integrated in other parts of module or taught separately.
- Demonstrate ability to use bench test equipment (electric and hydraulic)
- Demonstrate ability to use laptop and software
- Demonstrate ability to use fluid cleaner/pump/oil analyzer and filter cart
- Demonstrate ability to use caliper/brake release tools
- Demonstrate ability to use caliper stands
- Demonstrate ability to use brake force tester
- Demonstrate ability to use signal generator to test sensors
- Demonstrate ability to use digital multi meter
- Demonstrate ability to use oscilloscope
- Demonstrate ability to use breakout boxes
- Demonstrate ability to use voltage/current regulators
- Demonstrate ability to use portable test unit
- Demonstrate ability to use megger/HiPot
- Demonstrate ability to use a wheel lathe

## 206. HVAC: Introduction and Preventive Maintenance

- **206.1 Background Knowledge**

Demonstrate ability to read schematics

Demonstrate knowledge of what three phase is and how it works

Explain the concept of a thermal fuse

Identify different refrigerants and types of oil

Identify correct seals for different refrigerants and types of oil

Attain 608 Certification if required, or understand the requirements

- **206.2 Compressor/Motor**

Inspecting and maintaining compressor assembly

- Adjust unloader valve
- Change oil and sight glass
- Check for air bubbles
- Check for moisture in sight glass
- Check oil level and sight glass
- Demonstrate knowledge of difference between scroll compressor and piston compressor
- Describe failure symptoms
- Identify smell of burning oil
- Inspect compressor seals
- Perform oil analysis
- Repair crank case heater
- Replace compressor assembly
- Replace compressor seals
- Replace crank case heater
- Replace unloader valve
- Test crank case heater
- Test unloader valve operation

Inspecting and maintaining motor coupling

- Inspect motor coupling
- Replace motor coupling

Inspecting and maintaining AC motor

- Inspect AC motor
- Check for frozen bearings
- Replace AC motor or worn bearings

Inspecting and maintaining DC motor

- Inspect DC motor
- Check commutator for wear or damage
- Clean brushes
- Change brushes
- Repair brush assembly
- Replace and adjust brush assembly
- Replace DC motor

Inspecting and maintaining compressor mountings

- Inspect compressor mountings
- Change cushions on mountings
- Replace compressor mountings

Inspecting and maintaining piping and fittings

- Check piping and fittings for leaks
- Check braided line for fraying or damage
- Repair piping and fittings

Inspecting and maintaining compressor service valves

- Inspect compressor service valves
- Replace compressor service valves

Inspecting and maintaining protection devices

- Test pressure limit switches
- Inspect motor overload device
- Replace pressure limit switches

- **206.3 Evaporators and Condensers**

Inspecting and maintaining condenser assembly

- Inspect condenser assembly
- Clean coils with compressed air or water
- Replace condenser assembly

Inspecting and maintaining fan assembly

- Inspect AC motor
- Inspect DC motor
- Clean brushes
- Change brushes
- Inspect grill
- Replace grill
- Repair grill
- Replace AC motor
- Replace DC motor

Inspecting and maintaining condenser fins

- Inspect fins for bends and other damage
- Clean fins
- Straighten fins
- Check for leaks

Inspecting and maintaining evaporator fins

- Inspect fins for bends and other damage
- Clean fins
- Straighten fins
- Check for leaks

- **206.4 Refrigeration Components**

Inspecting and maintaining liquid receiver tank

- Inspect liquid receiver tank
- Replace liquid receiver tank

Maintaining filter dryer

- Inspect filter dryer
- Replace filter dryer

Inspecting and maintaining heater core elements

- Inspect thermal switches
- Test heater core elements for opens
- Inspect heater core elements
- Replace heater core elements

Inspecting and maintaining piping

- Inspect piping for leaks and chafing
- Inspect relief plugs
- Inspect piping
- Repair piping

Inspecting and maintaining air filters

- Replace air filter

Inspecting and maintaining condensation pan/drain

- Inspect condensation pan/drain
- Clean condensation pan/drain
- Blow out drain lines with compressed air

Inspecting and maintaining sight glass

- Inspect sight glass for moisture
- Replace sight glass

Inspecting and maintaining expansion valve

- Inspect expansion valve
- Test expansion valve using super heat check
- Replace or adjust expansion valve

Inspecting and maintaining solenoid valve

- Check solenoid valve operation
- Inspect solenoid valve
- Replace solenoid valve

- **206.5 Heaters**

Inspecting and maintaining cab heaters/defrosters

- Inspect cab heaters/defrosters
- Test cab heaters/defrosters
- Clean cab heaters/defrosters
- Replace cab heaters/defrosters (teach in level 250 if this is backshop work)
- Repair cab heaters/defrosters (teach in level 250 if this is backshop work)
- Rebuild cab heaters/defrosters (teach in level 250 if this is backshop work)

Inspecting and maintaining sidewall/floor heaters

- Test sidewall/floor heaters
- Clean sidewall/floor heaters
- Repair sidewall/floor heaters
- Replace sidewall/floor heaters

Inspecting and maintaining overhead heat

- Inspect overhead heat
- Test overhead heat
- Repair overhead heat
- Replace overhead heat

- **206.6 HVAC Controls**

Inspecting and maintaining thermostats

- Adjust thermostats
- Replace thermostats

Inspecting and maintaining low-pressure switch

Inspecting and maintaining high-pressure switch

Inspecting and maintaining flow switch

- Test flow switch
- Replace flow switch

Inspecting and maintaining temperature controls/sensors

- Test temperature controls/sensors
- Replace temperature controls/sensors

- **206.7 Electrical Circuits and Electronic Controls**

Inspecting and maintaining relays and connectors

- Test if relays and connectors can hold load

- Inspect relays and connectors
- Replace relays and connectors
- Inspecting and maintaining control boards
  - Test control boards
  - Perform function tests with portable test equipment
  - Replace control boards
- Inspecting and maintaining overcurrent protection
  - Test overcurrent protection
  - Replace overcurrent protection
- Inspecting and maintaining GFI protection
  - Test GFI protection
  - Replace GFI protection
- **206.8 Tools**
  - Demonstrate ability to use oil test kit
  - Demonstrate ability to use refrigerant recovery/recycle machine
  - Demonstrate ability to use two-stage vacuum pumps
  - Demonstrate ability to use pressure and vacuum micron gauge
  - Demonstrate ability to use refrigerant leak detectors
  - Demonstrate ability to use laptop, software and portable test unit
  - Demonstrate ability to use breakout box
  - Demonstrate ability to use thermometers
  - Demonstrate ability to use manifold gauge set
  - Demonstrate ability to use temp bulb/ribbon
  - Demonstrate ability to use laser sensor
  - Demonstrate ability to use vibration meter

## **207. Current Collection and Distribution: Introduction and Preventive Maintenance**

- **207.1 Background Knowledge**
  - Demonstrate understanding of basic AC/DC electricity
- **207.2 Safety**
  - Follow safety procedures
- **207.3 Pantograph**
  - Inspecting and maintaining pantograph collector
    - Inspect carbon strips condition and thickness
    - Adjust carbon strips
    - Inspect head bushings
    - Replace head bushings
    - Inspect horns
    - Paint horns
    - Inspect carbon strip heater
    - Test carbon strip heater
    - Measure head for proper leveling and carbon strips parallelism
    - Replace carbon strips
    - Replace horns
    - Replace carbon strip heater
  - Inspecting and maintaining pantograph collector head
    - Test electrical lowering device
    - Adjust electrical lowering device
    - Repair electrical lowering device
    - Replace electrical lowering device



Inspecting and maintaining manual lowering device

- Test manual lowering device
- Repair or replace manual lowering device

Inspecting and maintaining insulator

- Clean all insulators
- Inspect frame and insulated mounts
- Replace insulators

Inspecting and maintaining raising mechanism (springs)

- Inspect shear pin
- Adjust raising mechanism
- Check spring tension
- Replace raising mechanism

Inspecting and maintaining control box

- Test control box
- Adjust control box
- Adjust pole controls
- Replace control box

Inspecting and maintaining coupling rod

- Inspect coupling rod
- Lubricate coupling rod
- Replace and adjust coupling rod

Inspecting and maintaining auto drop

- Inspect auto drop
- Replace auto drop

- **207.4 Third Rail**

Describe safety considerations for working with high voltage third rail

Inspecting and maintaining collector paddle assembly

- Inspect collector paddle assembly
- Adjust paddle assembly
- Clean paddle assembly
- Replace paddle assembly
- Inspect arc shield
- Clean arc shield
- Inspect height adjustor
- Adjust height adjustor
- Inspect paddle
- Adjust paddle angle
- Replace paddle
- Replace arc shield
- Replace height adjustor
- Replace arc shield

Inspecting and maintaining bus bar

- Inspect bus bar
- Clean bus bar
- Replace bus bar

Inspecting and maintaining shoe beams/gibs

- Inspect shoe beams/gibs
- Adjust shoe beams/gibs
- Clean shoe beams/gibs
- Replace shoe beams/gibs

- **207.5 Trolley Pole**
  - Inspecting and maintaining pole base
    - Test pole base
    - Inspect pole base
    - Replace pole base
  - Inspecting and maintaining pole
    - Test pole
    - Replace pole
  - Inspecting and maintaining harp
    - Test harp
    - Replace harp
  - Inspecting and maintaining slider
    - Replace slider
  - Inspecting and maintaining rope and retriever
    - Inspect rope and retriever
    - Replace rope and retriever
- **207.6 Common Components**
  - Inspecting and maintaining surge arrestor (lightning arrestor)
    - Inspect surge arrestor
    - Clean surge arrestor
    - Replace surge arrestor
  - Inspecting and maintaining main breaker (high-speed circuit breaker, line contactor)
    - Inspect main breaker
    - Test main breaker
    - Lubricate main breaker
    - Shim main breaker
    - Replace contacts on main breaker
  - Inspecting and maintaining fuse
    - Inspect fuse
    - Test fuse
    - Replace fuse
  - Inspecting and maintaining cables
    - Inspect cables
    - Replace cables
  - Inspecting and maintaining shunts
    - Inspect shunts for looseness and fraying
    - Replace shunts
  - Inspecting and maintaining tension spring
    - Inspect tension spring
    - Adjust tension spring
- **207.7 Tools**
  - Demonstrate ability to use a spring tension gauge
  - Demonstrate ability to use gauges/collector stick
  - Demonstrate ability to use a level or square
  - Demonstrate ability to use a test stand
  - Demonstrate ability to use a torque wrench
  - Demonstrate ability to use a spanner wrench
  - Demonstrate ability to use a chart recorder
  - Demonstrate ability to use calipers
  - Demonstrate ability to use contact balance

Demonstrate ability to use a volt/Ohm meter

Demonstrate ability to use a megger

## 208. Car Body: Introduction and Preventive Maintenance

- **208.1 Articulation**

Inspecting and maintaining Link

- Inspect link
- Lubricate link
- Adjust link
- Replace link

Inspecting and maintaining bearings, rollers and slides

- Inspect bearings, rollers and slides
- Lubricate bearings, rollers and slides
- Replace bearings, rollers and slides

Inspecting and maintaining dampener

- Inspect dampener
- Lubricate dampener
- Replace dampener

Inspecting and maintaining bellows

- Inspect bellows
- Replace bellows

Inspecting and maintaining removable panels

- Inspect removable panels
- Replace removable panels

Inspecting and maintaining articulation joint

- Inspect articulation joint
- Lubricate articulation joint
- Repair articulation joint
- Replace articulation joint

- **208.2 Interior**

Inspecting and maintaining flooring

- Inspect flooring
- Clean flooring
- Test threshold heaters
- Repair flooring
- Repair threshold heaters
- Replace threshold heaters

Inspecting and maintaining stairs

- Inspect stairs
- Clean stairs
- Test step heaters
- Repair stairs
- Repair step heaters
- Replace step heaters

Inspecting and maintaining windows

- Inspect windows
- Clean windows
- Inspect vandal guard
- Clean vandal guard
- Repair windows

- Replace windows
- Replace vandal guard
- Inspecting and maintaining seats
  - Inspect seats
  - Clean seats
  - Repair seats
  - Replace seats
- Inspecting and maintaining sanding system
  - Test sanding system
  - Clean sanding system
  - Fill sanding system
  - Repair sanding system
- Inspecting and maintaining stanchions/modesty panel
  - Inspect stanchions/modesty panel
  - Clean stanchions/modesty panel
  - Repair stanchions/modesty panel
  - Replace stanchions/modesty panel
- Inspecting and maintaining interior panels
  - Inspect interior panels
  - Clean interior panels
  - Repair interior panels
  - Replace interior panels
- Inspecting and maintaining signage
  - Inspect signage
  - Replace signage
- Inspecting and maintaining low-level exit path marking
  - Inspect low-level path exit marking
  - Replace low-level path exit marking
- Inspecting and maintaining fire extinguisher
  - Inspect fire extinguisher
  - Replace fire extinguisher
- Inspecting and maintaining first aid kit
  - Inspect first aid kit
  - Replace first aid kit
- Inspecting and maintaining end doors
  - Inspect end doors
  - Adjust end doors
  - Repair end doors
  - Replace end doors
- **208.3 Exterior**
  - Inspecting and maintaining body panels
    - Inspect body panels
    - Repair body panels
    - Replace body panels
  - Inspecting and maintaining skirts/struts
    - Inspect skirts/struts
    - Repair skirts/struts
    - Replace skirts/struts
  - Inspecting and maintaining mirrors
    - Inspect mirrors

- Clean mirrors
  - Test mirror heaters
  - Repair mirrors
  - Replace mirrors
  - Repair mirror heaters
  - Replace mirror heaters
- Inspecting and maintaining grab rails
- Inspect grab rails
  - Replace grab rails
- Inspecting and maintaining wipers
- Test wipers
  - Inspect wipers
  - Replace wipers
  - Inspect or replace wiper linkage
- Inspecting and maintaining horn/gong/whistle
- Test horn/gong/whistle and horn mount
  - Inspect horn/gong/whistle and horn mount
  - Replace horn/gong/whistle
- Inspecting and maintaining windows/frames
- Inspect windows/frames
  - Replace windows/frames
- Inspecting and maintaining under-frame and brackets
- Measure under-frame and brackets
  - Inspect under-frame and brackets
  - Repair under-frame and brackets
  - Replace under-frame and brackets
- Inspecting and maintaining equipment boxes (mounts and covers)
- Inspect equipment boxes
  - Repair equipment boxes
  - Replace equipment boxes
- Inspecting and maintaining snow plow/pilot
- Measure snow plow/pilot
  - Inspect snow plow/pilot
  - Repair snow plow/pilot
  - Replace snow plow/pilot
- Inspecting and maintaining ADA ramps/tread plate
- Inspect ADA ramps/tread plate
  - Repair ADA ramps/tread plate
  - Replace ADA ramps/tread plate
- Inspecting and maintaining wheelchair lifts
- Test wheel chair lifts
  - Inspect wheel chair lifts
  - Repair wheel chair lifts
  - Replace wheel chair lifts
- Inspecting and maintaining ducts and grills
- Inspect ducts and grills
  - Clean ducts and grills
  - Repair ducts and grills
  - Replace ducts and grills
- Inspecting and maintaining safety boards

- Measure safety boards
  - Inspect safety boards
  - Repair safety boards
  - Replace safety boards
- Inspecting and maintaining between car barriers/chains
- Inspect between car barriers/chains
  - Replace between car barriers/chains
- **208.4 Lighting Systems**
- Inspecting and maintaining door buttons
- Test door buttons
  - Inspect door buttons
  - Replace door buttons
- Inspecting and maintaining emergency flashers
- Test emergency flashers
  - Inspect emergency flashers
  - Replace emergency flashers
- Inspecting and maintaining door indicator lights
- Test door indicator lights
  - Inspect door indicator lights
  - Replace door indicator lights
- Inspecting and maintaining headlights
- Test headlights
  - Inspect headlights
  - Replace headlights
  - Align headlights
  - Clean headlights
- Inspecting and maintaining stop/tail lights
- Test stop/tail lights
  - Inspect stop/tail lights
  - Replace stop/tail lights
- Inspecting and maintaining brake indicator lights
- Test brake indicator lights
  - Inspect brake indicator lights
  - Replace brake indicator lights
- Inspecting and maintaining roof/rail lights
- Test roof/rail lights
  - Inspect roof/rail lights
  - Replace roof/rail lights
  - Align roof/rail lights
  - Clean roof/rail lights
- Inspecting and maintaining marker lights
- Test marker lights
  - Inspect marker lights
  - Replace marker lights
- Inspecting and maintaining interior lights
- Test interior lights
  - Inspect interior lights
  - Replace interior lights
- Inspecting and maintaining car fault indicator
- Test car fault indicator

- Inspect car fault indicator
- Replace car fault indicator
- Inspecting and maintaining passenger emergency lights
  - Test passenger emergency lights
  - Inspect passenger emergency lights
  - Replace passenger emergency lights
- Performing preventive stop request lights
  - Test stop request lights
  - Inspect stop request lights
  - Replace stop request lights
- **208.5 Cab**
  - Inspecting and maintaining cab door
    - Inspect cab door
    - Repair cab door
    - Replace cab door
  - Inspecting and maintaining windshield/frame
    - Inspect windshield/frame
    - Repair windshield/frame
    - Replace windshield/frame
  - Performing preventative maintenance on operator seat
    - Test operator seat
    - Inspect operator seat
    - Repair operator seat
    - Replace operator seat
  - Inspecting and maintaining operator controls/indicators
    - Test operator controls/indicators
    - Inspect controls/indicators
    - Clean controls/indicators
    - Replace controls/indicators
    - Repair controls/indicators
  - Inspecting and maintaining breakers/cut-out switches
    - Inspect breakers/cut-out switches
    - Repair breakers/cut-out switches
    - Replace breakers/cut-out switches
  - Inspecting and maintaining wiper motors/regulator
    - Test wiper motors/regulator
    - Inspect wiper motors/regulator
    - Repair wiper motors/regulator
    - Replace wiper motors/regulator
  - Inspecting and maintaining cab ceiling lighting
    - Test cab ceiling lighting
    - Inspect cab ceiling lighting
    - Replace cab ceiling lighting
    - Repair cab ceiling lighting
  - Inspecting and maintaining dash lights
    - Test dash lights
    - Inspect dash lights
    - Repair dash lights
    - Replace dash lights

Inspecting and maintaining first aid kit

- Inspect first aid kit
- Replace first aid kit

Inspecting and maintaining fire extinguisher

- Inspect fire extinguisher
- Replace fire extinguisher

Inspecting and maintaining sun visors

- Test sun visors
- Inspect sun visors
- Repair sun visors
- Replace sun visors

## **209. Doors: Introduction and Preventive Maintenance**

### **• 209.1 Door Controls**

Explaining safety concerns of door operation and maintenance (pinching, motors, voltage)

Inspecting and maintaining control unit

- Inspect control unit
- Test control unit with portable test equipment
- Download software, reprogram door controller and check for faults
- Replace control unit

Inspecting and maintaining door cut-out

- Test door cut-out
- Test individual doors and door interlocks
- Adjust and/or repair door cut-out
- Replace door cut-out

Inspecting and maintaining out-of-service and door open indicator lights

- Test out-of-service light
- Replace out-of-service light
- Test door open indicator light
- Replace door open indicator light

Inspecting and maintaining relays/solenoids

- Test relays/solenoids
- Replace relays/solenoids

Inspecting and maintaining motors/drive mechanisms

- Test motors/engines
- Repair motors/engines
- Replace motors/engines
- Adjust motors/engines

Inspecting and maintaining limit, proximity and micro switches

- Test switches
- Adjust switches
- Replace switches

Inspecting and maintaining sensors

- Test sensors
- Adjust sensors
- Replace sensors

Inspecting and maintaining sensitive edges

- Test sensitive edges
- Adjust sensitive edges
- Replace sensitive edges



Inspecting and maintaining ADA warnings

- Test ADA warnings
- Replace ADA warnings

Inspecting and maintaining crew switch

- Test crew switch
- Repair crew switch
- Replace crew switch

Inspecting and maintaining emergency release mechanism

- Test emergency release mechanism
- Lubricate emergency release mechanism
- Adjust emergency release mechanism
- Repair emergency release mechanism
- Replace emergency release mechanism

- **209.2 Door Panel and Track**

Inspecting and maintaining roller/hangers and linkage

- Inspect roller/hangers
- Lubricate roller/hangers
- Adjust roller/hangers
- Repair roller/hangers
- Replace roller/hangers
- Inspect door guide
- Adjust door guide
- Replace door guide

Inspecting and maintaining door glass

- Clean door glass
- Inspect door glass
- Replace door glass

Inspecting and maintaining gaskets/seals

- Inspect gaskets/seals
- Lubricate gaskets/seals
- Adjust gaskets/seals
- Replace gaskets/seals

Inspecting and maintaining cab door locks

- Test door locks
- Replace door locks

Inspecting and maintaining cab doors

- Test cab doors
- Lubricate cab doors
- Adjust cab doors
- Replace cab doors

Inspecting and maintaining heated thresholds (Northern climates only)

- Inspect heated thresholds
- Test heated thresholds
- Repair heated thresholds

- **209.3 Tools**

Demonstrate ability to use a laptop/portable test unit

Demonstrate ability to use gauges

Demonstrate ability to use a sensitive edge tester

Demonstrate ability to use a window installation tool

## Communication Systems: Introduction and Preventive Maintenance

- **210.1 Communication Control Unit**

Inspecting and maintaining radio (two-way)

- Test radio (two-way)
- Replace radio (two-way)
- Repair radio (two-way)

Maintaining dedicated power supply (radio)

- Replace dedicated power supply (radio)

Inspecting and maintaining handset/mic

- Test handset/mic
- Replace handset/mic
- Repair handset/mic

Inspecting and maintaining public address system

- Test control unit public address system
- Repair public address system

Inspecting and maintaining amplifier(s)

- Test amplifier(s)
- Adjust amplifier(s)
- Replace amplifier(s)
- Rebuild amplifier(s)

Inspecting and maintaining automatic announcement circuit

- Test automatic announcement circuit
- Replace automatic announcement circuit
- Rebuild automatic announcement circuit

Inspecting and maintaining interior communications

- Test interior communications
- Replace interior communications

Inspecting and maintaining passenger emergency intercom

- Test passenger emergency intercom
- Repair passenger emergency intercom
- Replace passenger emergency intercom

Inspecting and maintaining passenger emergency switch

- Test passenger emergency switch
- Repair passenger emergency switch
- Replace passenger emergency switch

Inspecting and maintaining switch

- Test speakers
- Measure speakers
- Repair speakers
- Replace speakers

Inspecting and maintaining antenna

- Test antenna
- Measure antenna
- Replace antenna

- **210.2 Signs**

Inspecting and maintaining destination signs

- Inspect destination signs
- Test destination signs
- Repair destination signs
- Replace destination signs

Inspecting and maintaining next stop signs

- Inspect next stop signs
- Test next stop signs
- Repair next stop signs
- Replace next stop signs

Inspecting and maintaining route sign

- Inspect route sign
- Test route sign
- Repair route sign
- Replace route sign

- **210.3 Closed-Circuit TV**

Inspecting and maintaining digital video recorder

- Inspect digital video recorder
- Replace digital video recorder
- Reformat digital video recorder
- Download digital video
- Test digital video recorder
- Program digital video recorder
- Repair digital video recorder

Inspecting and maintaining removable hard drives

- Inspect removable hard drives
- Replace removable hard drives
- Reformat removable hard drives

Inspecting and maintaining cameras

- Inspect cameras
- Replace cameras

Inspecting and maintaining amplifier(s)

- Test amplifier(s)
- Replace amplifier(s)
- Program amplifier(s)

Inspecting and maintaining monitors

- Test monitors
- Replace monitors

*Inspecting and maintaining wiring*

- Inspect wiring
- Replace wiring
- Repair wiring

Inspecting and maintaining mounts/hardware

- Inspect mounts/hardware
- Replace mounts/hardware
- Repair mounts/hardware

## **CBTC (ATP-ATO): Introduction and Preventive Maintenance**

- **211.1 Automatic Train Protection**

Inspecting and maintaining coils

- Test coils
- Inspect coils

Inspecting and maintaining modules/CPU

- Test modules/CPU
- Replace modules/CPU

Inspecting and maintaining circuit boards

- Test circuit boards
- Replace circuit boards

Inspecting and maintaining vital relay

- Test vital relay
- Replace vital relay

Inspecting and maintaining power supply

- Test power supply
- Replace power supply

Inspecting and maintaining radio/antenna

- Test radio/antenna
- Replace radio/antenna

Inspecting and maintaining operator acknowledgement button

- Test operator acknowledgement button
- Replace operator acknowledgement button

Inspecting and maintaining operator bypass switch

- Test operator bypass switch
- Replace operator bypass switch

Inspecting and maintaining visual and audible alarms

- Test visual and audible alarms
- Replace visual and audible alarms

Inspecting and maintaining train operator display

- Test train operator display
- Replace train operator display

Inspecting and maintaining operator interface panel

- Test operator interface panel
- Replace operator interface panel

Inspecting and maintaining speed measuring device

- Test speed measuring device
- Replace speed measuring device

• **211.2 Automatic Train Operation**

Inspecting and maintaining train operator display

- Test train operator display
- Replace train operator display

Inspecting and maintaining train operator panel

- Test train operator panel
- Replace train operator panel

Inspecting and maintaining ATO modules/CPU

- Test ATO modules/CPU
- Replace ATO modules/CPU

Inspecting and maintaining power supply

- Test power supply
- Replace power supply

Inspecting and maintaining radio antenna

- Test radio/antenna
- Replace radio/antenna

Inspecting and maintaining train-to-wayside communication

- Test train-to-wayside communication
- Replace train-to-wayside communication

Inspecting and maintaining operator acknowledgement button

- Test operator acknowledgement button
- Repair operator acknowledgement button
- Replace operator acknowledgement button
- Inspecting and maintaining operator bypass switch
  - Test operator bypass switch
  - Replace operator bypass switch
- Inspecting and maintaining visual and audible alarms
  - Test visual and audible alarms
  - Replace visual and audible alarms
- Inspecting and maintaining operator interface panel
  - Test operator interface panel
  - Replace operator interface panel
- **211.3 Automatic Train Supervision**
  - Inspecting and maintaining monitor
    - Test monitor
    - Replace monitor
  - Inspecting and maintaining module/CPU
    - Test module/CPU
    - Replace module/CPU
- **211.4 Speed Regulator**
  - Inspecting and maintaining power supply
    - Test power supply
    - Replace power supply
  - Inspecting and maintaining module/CPU
    - Test module/CPU
    - Replace module/CPU

## 212. Monitoring, Diagnosing and Troubleshooting Overview

- **212.1 Troubleshooting Electrical/Electronic Systems**
  - Symbols and circuits review
  - Meters and terminology review
  - Introduction to troubleshooting DC and AC systems
  - Introduction to troubleshooting digital systems
  - Circuits measurement
- **212.2 Monitoring and Diagnostic System (M&D)**
  - Inspecting and maintaining operator display
    - Access codes
    - Boot up system
    - Demonstrate knowledge of difference between active and passive car
    - Demonstrate knowledge of how the operator display connects to monitoring and diagnostic system
    - Demonstrate knowledge of system addressing functions
    - Demonstrate knowledge of train control unit function
    - Ensure correct terminator is installed on correct side of train
    - Program unit from floppy disk
    - Remove display from power supply
    - Replace display
    - Test functions
  - Inspecting and maintaining local panel indicator
    - Change light bulbs

- Check for burnt bulbs
  - Demonstrate knowledge of indicator lights
  - Demonstrate knowledge of proper method for opening control panel
  - Orient decals
- Inspecting and maintaining trainline monitoring and diagnosing station/equipment
- Demonstrate knowledge of digital-to-analog module function
  - Demonstrate knowledge of monitoring and diagnosing station function
  - Identify function of each module
  - Identify functions of input module lights
  - Identify location of monitoring and diagnosing components
  - Program system software and subsystem communication protocol for multifunction vehicle bus operation
  - Set and verify address of system components
  - Test light on power supply
  - Test lights on input module
- Inspecting and maintaining software
- Check annunciation systems in communication software
  - Check automatic passenger counter software
  - Check brake control unit software codes and faults
  - Check chip programmer software
  - Check multimeter software
  - Check inverter software phases, voltages, currents and faults
  - Check traction control unit software codes, switches, relays and line power
  - Demonstrate knowledge of hyperterminal
  - Run HVAC software test program
  - Run traction control unit software tests
  - Set HVAC software parameters
  - Set traction control unit software parameters and times
  - Set timing in door software

## 2.2.1 Level 250: Overhaul and Rebuild of Rail Vehicles Components

**NOTE:** Learning objectives for all components that can be substantially overhauled or re-built/reinstalled are listed here. Inclusion of some or all of these items in a training program depends on local labor agreements and job structure.

- **250.1 Electric Coupler Heads**  
Overhauling and rebuilding coupler components
  - Rebuild linear actuators/motors
  - Rebuild coupler and/or linkage
  - Rebuild train line cables
  - Rebuild drum/uncoupling switch
  - Rebuild contact pin/tip assembly (insulated block)
- **250.2 Pneumatic Coupler**  
Overhauling and rebuilding coupler components
  - Rebuild drum switch/air actuator
  - Rebuild air cylinder
  - Rebuild uncoupling air system
- **250.3 Mechanical Coupler**  
Overhauling and rebuilding coupler components
  - Rebuild suspension and linkage components
  - Rebuild linear actuators

- Rebuild hook and plate
- Rebuild knuckle and slide lock
- Rebuild anchor
- Rebuild shear bolt assembly
- Rebuild buffer tubes, draft gear and absorption cartridge
- Rebuild centering device and springs
- Rebuild coupler support
- Rebuild release mechanism
- Rebuild electrical pin door/shutter/gasket
- Rebuild draw bar (married pairs)
- **250.4 AC Traction Motor**  
Rebuilding and repairing rotors
  - Inspect rotor
  - Repair rotor
  - Replace rotor
  - Test rotor
- **250.5 Gearboxes**  
Overhauling shims
  - Inspect shims
  - Replace shims
  - Adjust shims
  - Rebuild speed sensor
- **250.6 Primary Suspension**
  - Rebuild speed sensors
  - Rebuild up stops and down stops/pedestal bar
- **250.7 Frame**
  - Rebuild traction/radius rod and bushings
  - Rebuild speed sensor device
- **250.8 Bolster/Secondary Suspension**
  - Rebuild hydraulic suspension leg
- **250.9 AC Propulsion**
  - Rebuild electronic control system
  - Rebuild chokes/transformer
  - Rebuild high-speed circuit breaker
  - Rebuild ground fault system
  - Rebuild contactor/arc chutes
  - Rebuild resistance units
  - Rebuild knife switch
  - Rebuild traction motor
  - Rebuild speed sensors/tach sensors
  - Rebuild load weight sensors
- **250.10 DC Propulsion**
  - Rebuild chokes/transformers
  - Rebuild thyristors
  - Rebuild master controller
  - Rebuild electronic control system
  - Rebuild high-speed circuit breaker
  - Rebuild contactor/arc chutes
  - Rebuild resistance banks
  - Rebuild knife switch

- Rebuild traction motor
- Overhauling speed sensors/tach sensors
  - Rebuild speed sensors/tach sensors
  - Replace speed sensors/tach sensors
- Overhauling load weight sensors
  - Test load weight sensors
  - Rebuild load weight sensors
  - Replace load weight sensors
- **250.11 Motor Alternator**
  - Rebuild AC motors
  - Rebuild voltage regulators
  - Rebuild speed/frequency control
- **250.12 Solid State Inverter**
  - Rebuild GTOs
  - Rebuild IGBTs
  - Rebuild thyristors
- **250.13 Electrical Hydraulic Unit**
  - Rebuild motor assembly
  - Rebuild control valves
  - Rebuild emergency brake hand pump
- **250.14 Actuator Brake**
  - Rebuild spring
  - Rebuild electric motor
- **250.15 Pneumatic Braking System**
  - Rebuild check valves
  - Rebuild pneumatic control unit
  - Rebuild brake valves
  - Rebuild hydraulic/pneumatic unit
  - Rebuild air compressor
- **250.16 Common Brake Components**
  - Rebuild parking brake
  - Rebuild brake calipers
  - Resurface rotors
  - Rebuild manual brake release
  - Rebuild track brake
  - Rewire electrical cabling
  - Rebuild caliper support rod
  - Rebuild caliper support
- **250.17 Compressor/Motor**
  - Rebuild AC motor
  - Rebuild DC motor
- **250.18 Evaporators and Condensers**
  - Rebuild AC motor
  - Rebuild DC motor
- **250.19 Heaters**
  - Inspect sidewall/floor heaters
  - Rebuild sidewall/floor heaters
  - Rebuild overhead heat
- **250.20 Pantograph**
  - Rebuild lowering device



- Rebuild insulator
- Rebuild collector head assembly
- Rebuild pantograph
- Rebuild control box
- **250.21 Third Rail**
  - Rebuild paddle assembly
  - Rebuild shoe beams/gibs
  - Rebuild pole base
- **250.22 Common Components**
  - Rebuild main breaker
- **250.23 Door Controls**
  - Rebuild door motors/drive mechanisms
- **250.24 Automatic Train Protection**
  - Rebuild coils
  - Rebuild modules/CPU
  - Rebuild circuit boards
  - Rebuild vital relay
  - Rebuild power supply
  - Rebuild operator acknowledgement button
  - Rebuild ATO modules/CPU
  - Rebuild power supply
  - Rebuild radio/antenna
  - Rebuild train to wayside communication
- **250.25 Speed Regulator**
  - Rebuild power supply

## 2.3 300-level courses: Advanced Theory of Operation and Troubleshooting of Systems

### 300. Advanced methods of Monitoring, Diagnosing and Troubleshooting

- **300.1 Advanced Troubleshooting Techniques for Electrical - Electronic Systems**
  - Electric motor drives
  - Mechanical and solid state switches
  - Testing diodes, transistors and thyristors
  - Troubleshooting electronic systems
- **300.2 Advanced Electrical Ladder Drawings**
  - Multiple-page prints
  - Electronic sensors
  - International drawings
  - PLC prints
  - Troubleshooting exercises
- **300.3 Event Recorder**
  - Maintaining sensors/inputs
    - Replace sensors/inputs
    - Overhaul sensors/inputs
  - Maintaining hard drives
    - Replace hard drive
    - Overhaul hard drives
  - Maintaining circuit boards
    - Replace circuit boards
    - Overhaul circuit boards

Maintaining power supplies

- Replace power supplies
- Overhaul power supplies

Maintaining batteries

- Replace batteries
- Overhaul batteries

Maintaining software

- Upload software
- Download software
- Overhaul software

- **300.4 Tools**

Demonstrate ability to access system with laptop

Demonstrate ability to analyze system with laptop

Demonstrate ability to use correct cables for hooking up laptop

### **301. Couplers: Advanced Theory of Operation and Troubleshooting**

- **301.1 Electric Coupler Heads**

Troubleshooting linear actuators/motors

Troubleshooting linear coupler suspension and linkage

Troubleshooting limit/proximity switches

Troubleshooting manual release mechanism

Troubleshooting train line cables

Troubleshooting drum/uncoupling switch

Troubleshooting heaters and temperature sensors

Troubleshooting fixed and mobile contacts and contact assembly

Read schematic for the head (check with meter)

Troubleshooting coupling sensor

- **301.2 Pneumatic Coupler**

Troubleshooting tappet valves

Troubleshooting heaters and temperature sensors

Troubleshooting solenoid valves

Troubleshooting valve filters

Troubleshooting train line (brake pipe)

Troubleshooting drum switch/air actuator

Troubleshooting uncoupling air system

- **301.3 Mechanical Coupler**

Troubleshooting suspension and linkage components

Troubleshooting linear actuators

Troubleshooting hook plate assembly

Troubleshooting knuckle and slidelock mechanism

Troubleshooting limit switches

Troubleshooting alignment, anchor and suspension

Troubleshooting heaters and temperature sensors

Troubleshooting release mechanism

Troubleshooting electrical pin door/shutter/gasket

Troubleshooting draw bar (married pairs)

### **302. Trucks and Axles: Advanced Theory of Operation and Troubleshooting**

- **302.1 AC Traction Motor**

Troubleshooting speed/tach sensor

- Troubleshooting stator
- Troubleshooting internal fan
- Troubleshooting external fan
- Troubleshooting bearings
- Troubleshooting wiring and insulation
- Troubleshooting coupling
- **302.2 DC Traction Motor**
  - Troubleshooting brushes
  - Troubleshooting brush holders
  - Troubleshooting commutator/armature
  - Troubleshooting sun gear/coupling
  - Troubleshooting flash pins/arc horn/pin
  - Troubleshooting wiring and insulation
  - Troubleshooting field coils/interpoles
  - Troubleshooting bearings
  - Troubleshooting ventilation (internal fan or forced)
  - Troubleshooting temperature sensors
  - Troubleshooting speed sensor
- **302.3 Gearboxes**
  - Troubleshooting high-speed coupling
  - Troubleshooting worm gear
  - Troubleshooting pinion gear
  - Troubleshooting bearings and races
  - Troubleshooting housing
  - Troubleshooting seals
  - Troubleshooting spider gears
  - Troubleshooting coupler retainer
  - Troubleshooting breather
  - Troubleshooting spider
  - Troubleshooting speed sensor
  - Troubleshooting magnetic plugs
  - Troubleshooting loading/support rod
- **302.4 Axles**
  - Troubleshooting rotor (brake disc)
  - Troubleshooting wheel assembly
  - Troubleshooting spider and vulcanized spacers/joint coupling assembly
  - Troubleshooting tooth gear (speed sensor)
  - Troubleshooting ground brush and housing
  - Troubleshooting hollow shaft
  - Troubleshooting journal bearings and housing
  - Troubleshooting ground bushing housing
- **302.5 Wheel and Tires**
  - Troubleshooting shunts
  - Troubleshooting rubber
  - Troubleshooting bolts
  - Troubleshooting conical ring
  - Troubleshooting dampening ring
  - Troubleshooting plugs
- **302.6 Primary Suspension**
  - Troubleshooting chevrons/rubber springs

- Troubleshooting journal bearing housing
- Troubleshooting speed sensors
- Troubleshooting up stops and down stops/pedestal bar
- **302.7 Frame**
  - Troubleshooting traction/radius rod and bushings
  - Troubleshooting bovine board/cow catcher/safety board/life guard
  - Troubleshooting transom bearings/front and rear beam
  - Troubleshooting antennas
  - Troubleshooting speed sensor device
  - Troubleshooting fenders
  - Troubleshooting sanding tubes
  - Troubleshooting lubricators
  - Troubleshooting wiring
  - Troubleshooting tripping device
  - Troubleshooting piping
  - Troubleshooting track brake
  - Troubleshooting debris sweeper
  - Troubleshooting down hanger (caliper hanger)
  - Troubleshooting brake shoe support/brake hanger
  - Troubleshooting lateral bumper/stop
- **302.8 Bolster/Secondary Suspension**
  - Troubleshooting coil spring
  - Troubleshooting airbags
  - Troubleshooting leveling device
  - Troubleshooting load weight sensor
  - Troubleshooting hydraulic suspension leg
  - Troubleshooting vertical stop/lifting rods
  - Troubleshooting shocks/dampers
  - Troubleshooting piping
  - Troubleshooting friction disc/side bearing
  - Troubleshooting shims (floor height adjustment/static inspection)
  - Troubleshooting spherical ring/slewing ring
  - Troubleshooting articulation support
  - Troubleshooting ball and socket

### **303. Propulsion and Dynamic Braking: Advanced Theory of Operation and Troubleshooting**

- **303.1 AC Propulsion**
  - Troubleshooting propulsion inverter
    - Demonstrate ability to locate and use troubleshooting procedures and tech manuals
    - Demonstrate knowledge of sensor feedback and how it affects components
  - Troubleshooting master controller
  - Troubleshooting train line control
    - Demonstrate knowledge of relays and how they work
  - Troubleshooting IGBT/GTO
  - Troubleshooting electronic control system
    - Demonstrate knowledge of fault codes as they relate to different boards
    - Demonstrate knowledge of individual circuit board function
    - Download and analyze electronic control system
    - Isolate TCU for troubleshooting

- Program cards
- Troubleshooting software
- Troubleshooting ventilation system
- Troubleshooting capacitor filtering coils
- Troubleshooting chokes/transformer
- Troubleshooting high-speed circuit breaker
- Troubleshooting ground fault system
- Troubleshooting contactor/arc chutes
- Troubleshooting resistance units
- Troubleshooting knife switch (DC link)
- Troubleshooting traction motor
- Troubleshooting speed sensors/tach sensors
- Troubleshooting speed sensor cable
- Troubleshooting load weight sensors
- Troubleshooting load cell
- Troubleshooting overcurrent protection
- Troubleshooting pulse conditioning unit
- **303.2 DC Propulsion**
  - Troubleshooting chopper
  - Troubleshooting cam control
    - Demonstrate ability to recognize variance in replacement parts
  - Troubleshooting master controller
  - Troubleshooting electronic control unit
    - Demonstrate knowledge of difference between AC and DC electronic control systems
    - Demonstrate knowledge of fault codes as they relate to different boards
    - Demonstrate knowledge of individual circuit board function
    - Download and analyze electronic control system
    - Isolate TCU for troubleshooting
    - Program cards
  - Troubleshooting ventilation system
  - Troubleshooting high-speed circuit breaker
  - Troubleshooting contactor/arc chutes
  - Troubleshooting resistance banks
  - Troubleshooting knife switch (DC link)
  - Troubleshooting traction motor
    - Demonstrate knowledge of brush wear patterns
    - Demonstrate knowledge of commutator patterns
  - Troubleshooting overcurrent protection

## **304. Auxiliary Inverters and Batteries: Advanced Theory of Operation and Troubleshooting**

- **304.1 Batteries**
  - Diagnosing and Repairing NiCd Batteries
    - Replace NiCd batteries
    - Charge NiCd batteries
    - Perform battery drain
    - Diagnose and repair/replace shorted cells
    - Diagnose charging rates and non-charging rates
    - Diagnosing and repairing lead acid batteries
    - Replace lead acid batteries

- Charge lead acid batteries
  - Perform battery load test
  - Diagnose and repair/replace shorted cells
  - Diagnose charging rates and non-charging rates
- Troubleshooting low-voltage sensor  
 Troubleshooting battery breaker disconnect
- **304.2 Motor Alternator**  
 Troubleshooting DC motors  
 Troubleshooting AC motors  
 Troubleshooting voltage regulators  
 Troubleshooting frequency/speed control components
  - **304.3 Solid State Inverter**  
 Troubleshooting GTOs  
 Troubleshooting IGBTs  
 Troubleshooting thyristors  
 Troubleshooting other inverter components  
 Using diagnostic software
  - **304.4 Battery Charger/LVPS**  
 Troubleshooting battery charger and LVPS  
 Using diagnostic software  
 Troubleshooting AUX Inverter ventilation system

### 305. Friction Brakes: Advanced Theory of Operation and Troubleshooting

- **305.1 Hydraulic Braking**  
 Troubleshooting hydraulic braking  
 Troubleshooting flush cart
  - Identify correct software applications for troubleshooting
- **305.2 Electrical Hydraulic Unit**  
 Troubleshooting electrical unit  
 Troubleshooting varistors/pressure transducers
  - Calibrate switches
  - Demonstrate ability to read mechanical schematics and cross sectionals
  - Demonstrate ability to use engineering drawings
  - Explain causes of variances
  - Explain the function of valves
  - Repair varistors/transducer
 Troubleshooting motor assembly
  - Demonstrate ability to diagnose motor assembly problems based on noise and current draw
  - Explain causes of noise from bearings and pumps
 Troubleshooting control valves  
 Troubleshooting pump-off circuit  
 Troubleshooting cut-off switch  
 Troubleshooting accumulators
- **305.3 Actuator Brake**  
 Troubleshooting spring  
 Troubleshooting electric motor
- **305.4 Pneumatic Braking System**  
 Troubleshooting check valves  
 Troubleshooting air reservoir  
 Troubleshooting pneumatic control unit

- Troubleshooting air gauges
- Troubleshooting air cocks
- Troubleshooting hydraulic/pneumatic unit
- Troubleshooting air compressor
- **305.5 Common Brake Components**
  - Troubleshooting parking brake
  - Troubleshooting electronic control unit
    - Test electronic control unit
    - Download electronic control unit readings
    - Access settings and stored data
    - Identify correct software for testing
  - Troubleshooting brake calipers
  - Troubleshooting rotors
  - Troubleshooting brake pads/shoes
  - Troubleshooting brake transducers
  - Troubleshooting manual brake release
  - Troubleshooting brake bypass switch (electrical cutout)
  - Troubleshooting track brake
  - Troubleshooting sanding system
    - Identify correct software for testing
  - Troubleshooting electrical cabling
  - Troubleshooting piping and hoses
  - Troubleshooting caliper support rod
  - Troubleshooting caliper support
  - Troubleshooting anti-spinslide circuits

### 306. HVAC: Advanced Theory of Operation and Troubleshooting

- **306.1 Compressor/Motor**
  - Troubleshooting compressor assembly
  - Troubleshooting motor coupling
  - Troubleshooting AC motor
  - Troubleshooting DC motor
  - Troubleshooting compressor mountings
  - Troubleshooting piping and fittings
  - Troubleshooting compressor service valve
  - Troubleshooting protection devices
- **306.2 Evaporators and Condensers**
  - Troubleshooting condenser/evaporator assembly
  - Troubleshooting fan assembly
- **306.3 Refrigeration Components**
  - Troubleshooting liquid receiver tank
  - Troubleshooting filter dryer
    - Demonstrate knowledge of symptoms related to faulty filter dryer (no cooling, refrigerant not moving)
  - Troubleshooting heater core elements
  - Troubleshooting piping
  - Troubleshooting condensation pan/drain
  - Troubleshooting expansion valve
  - Troubleshooting solenoid valve

- **306.4 Heaters**
  - Troubleshooting cab heaters/defrosters
  - Troubleshooting sidewall/floor heaters
  - Troubleshooting overhead heat
- **306.5 HVAC Controls**
  - Troubleshooting thermostats
  - Troubleshooting low pressure switch
  - Troubleshooting high pressure switch
  - Troubleshooting flow switch
  - Troubleshooting temperature controls/sensors
- **306.6 Electrical Circuits and Electronic Controls**
  - Troubleshooting relays and connectors
  - Troubleshooting control boards
  - Troubleshooting overcurrent protection
  - Troubleshooting GFI protection

### **307. Current Collection and Distribution: Advanced Theory of Operation and Troubleshooting**

- **307.1 Pantograph**
  - Troubleshooting pantograph collector head
  - Troubleshooting electrical lowering device
  - Troubleshooting manual lowering device
  - Troubleshooting frame and insulated mounts and bearings
  - Troubleshooting raising mechanism (springs)
  - Troubleshooting control box
  - Troubleshooting coupling rod
  - Troubleshooting auto drop
- **307.2 Third Rail**
  - Troubleshooting collector paddle assembly
  - Troubleshooting bus bar
  - Troubleshooting shoe beams/gibs
- **307.3 Trolley Pole**
  - Troubleshooting pole base
  - Troubleshooting pole
  - Troubleshooting harp
  - Troubleshooting slider
  - Troubleshooting rope and retriever
- **307.4 Common Components**
  - Troubleshooting surge arrestor (lightning arrestor)
  - Troubleshooting main breaker (high-speed circuit breaker, line contactor)

### **308. Car Body: Advanced Theory of Operation and Troubleshooting**

- **308.1 Lighting Systems**
  - Troubleshooting interior lights
  - Troubleshooting car fault indicator
  - Troubleshooting passenger emergency lights
- **308.2 Cab**
  - Troubleshooting cab door
  - Troubleshooting operator controls/indicators
  - Troubleshooting breakers/cut-out switches



Troubleshooting wiper motors/regulator  
 Troubleshooting cab ceiling/lighting

### **309. Doors: Advanced Theory of System Operation and Troubleshooting**

- **309.1 Door Controls**
  - Troubleshooting electrical and electronics of door operation
  - Troubleshooting passenger indication system
  - Troubleshooting manual mechanical operation of door
  - Troubleshooting relays/solenoids
  - Troubleshooting door motors and drive mechanisms
  - Troubleshooting switches
  - Troubleshooting sensors
  - Troubleshooting sensitive edges
  - Troubleshooting crew switch
  - Troubleshooting ADA warnings
  - Troubleshooting emergency release
- **309.2 Door Panel, Track and Installation**
  - Troubleshooting rollers/hangers and linkage
  - Troubleshooting window/frame
  - Troubleshooting gasket seals
  - Troubleshooting door guide
  - Troubleshooting door locks
  - Troubleshooting cab door hinge and mounting

### **310. Communication Systems: Advanced Theory of Operation and Troubleshooting**

- **310.1 Communication Control Unit**
  - Demonstrate ability to use a “service monitor” for communication system diagnosis
  - Troubleshooting radio (two-way)
  - Troubleshooting dedicated power supply (radio)
  - Troubleshooting handset/mic
  - Troubleshooting public address system
  - Troubleshooting amplifier(s)
  - Troubleshooting automatic announcement circuit
  - Inspecting and maintaining software
    - Upload software
  - Troubleshooting interior communications
  - Troubleshooting radio passenger emergency intercom
  - Troubleshooting radio passenger emergency switch
  - Troubleshooting antenna
- **310.2 Signs**
  - Troubleshooting destination signs
  - Troubleshooting next stop signs
  - Troubleshooting route sign
- **310.3 Closed-Circuit TV**
  - Troubleshooting digital video recorder
  - Troubleshooting removable hard drive
  - Inspecting and maintaining software
    - Download software
  - Troubleshooting cameras
  - Troubleshooting amplifier(s)

Troubleshooting monitors  
Troubleshooting wiring  
Troubleshooting mounts/hardware

### **311. ATP-ATO: Advanced Theory of Operation and Troubleshooting**

- **311.1 Automatic Train Protection**
  - Troubleshooting coils
  - Troubleshooting module/CPU
  - Troubleshooting circuit boards
  - Troubleshooting vital relay
  - Troubleshooting power supply
  - Troubleshooting radio/antenna
  - Troubleshooting operator acknowledgement button
  - Troubleshooting operator bypass switch
  - Troubleshooting visual and audible alarms
  - Troubleshooting train operator display
  - Troubleshooting operator interface panel
  - Troubleshooting speed measuring device
- **311.2 Automatic Train Operation**
  - Troubleshooting train operator display
  - Troubleshooting train operator panel
  - Troubleshooting ATO modules/CPU
  - Troubleshooting power supply
  - Troubleshooting radio antenna
  - Troubleshooting train to wayside communication
  - Troubleshooting operator acknowledgement button
  - Troubleshooting bypass switch
  - Troubleshooting visual and audible alarms
  - Troubleshooting operator interface panel
- **311.3 Automatic Train Supervision**
  - Troubleshooting monitor
  - Troubleshooting module/CPU
- **311.4 Speed Regulator**
  - Troubleshooting power supply
  - Troubleshooting module/CPU

## References

Transportation Learning Center, “People Make the Hardware Work: Transit Experts Call for Labor-Management Training Partnerships,” 2007.

## Abbreviations and acronyms

<b>AC</b>	alternating current
<b>ADA</b>	Americans with Disabilities Act
<b>ASCII</b>	American Standard Code for Information Interchange
<b>ATO</b>	automatic train operation
<b>ATP</b>	automatic train protection
<b>BCU</b>	brake control unit
<b>CBTC</b>	communication-based train control
<b>CMOS</b>	complementary metal-oxide semiconductor
<b>CPU</b>	central processing unit
<b>DC</b>	direct current
<b>DIP</b>	dual in-line package (switch)
<b>ELES</b>	elevator-escalator
<b>FOD</b>	foreign object debris
<b>GFS</b>	ground fault system
<b>GFI</b>	ground fault interrupt
<b>GTO</b>	gate turnoff thyristor
<b>HVAC</b>	heating, ventilation and air conditioning
<b>IC</b>	integrated circuit
<b>IGBT</b>	integrated gate bipolar thyristor
<b>LED</b>	light-emitting diode
<b>LRV</b>	light-rail vehicle
<b>LSB</b>	local sensor bus
<b>LVPS</b>	low-voltage power supply
<b>MIG</b>	metal inert gas (welding)
<b>MSB</b>	most significant bit
<b>MSDS</b>	material safety data sheet
<b>MVFB</b>	multifunction vehicle bus
<b>NiCd</b>	nickel cadmium (battery)
<b>NOR</b>	A digital logic command/function/operation (not an acronym)
<b>NPN</b>	a type of transistor semi-conductor device
<b>NTC</b>	negative temperature coefficient
<b>OSHA</b>	Occupational Safety and Health Administration
<b>PNP</b>	a type of transistor semiconductor device
<b>PPE</b>	personal protective equipment
<b>PTC</b>	positive train control
<b>RC</b>	an electrical circuit composed of resistors and capacitors
<b>RCL</b>	an electrical circuit composed of resistors, capacitors and inductors
<b>RL</b>	an electrical circuit composed of resistors and inductors
<b>RtK</b>	right to know
<b>SCR</b>	silicon-controlled rectifier
<b>TCU</b>	telecommunications control unit
<b>TIG</b>	tungsten inert gas
<b>TTL</b>	transistor-to-transistor logic
<b>UJT</b>	unijunction transistor
<b>VOD</b>	vehicle operator display