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.
Participants

APTA appreciates the Vehicles Training Joint Steering Committee, which provided the primary effort in the drafting of this Recommended Practice:

Co-Chairs
John Costa (ATU Local 819)
Jay Shah (NYC Transit)

Atlanta (MARTA/ATU Local 689)
Frank Harris

Boston (MBTA/IBEW Local 103)
Robert Perry, John Burr

Chicago (CTA)
James Plomin

Denver (RTD Denver)
Phil Eberl

Los Angeles (LACMTA/ATU Local 1277)
Gary Dewater, James Avila, Jim Lindsay

Minneapolis (Metro Transit/ATU Local 1005)
Paul Swanson, Jack Shaw

New Jersey
Ken Boucher

New York City (TWU Local 100)
Rodney Glenn, Hector Ramirez

Philadelphia (SEPTA/Local 234)
Brian Miley, Phillip Lowe

Pittsburgh (ATU Local 85)
Adam Williams

Portland (ATU Local 757)
Joseph Ruffin

Sacramento (Sacramento Regional Transit District/IBEW Local 1245)
Kerry Kopp, Michael Ornelas, Bertrand Alexander

Salt Lake City (Utah Transit Authority/ATU Local 382)
Randy Welsh, Todd Simons

San Jose (ATU Local 265)
Ed Dolores

Washington, D.C. (ATU Local 689)
Bryan Matthew

ATU International/APTA
Bob Hykaway, John Remark
Pam Boswell

Contents

1. Objective of this standard ..................................................... 1
   1.1 The Steering Committee .......................................................... 1

2. Rail vehicles maintenance training guidelines ................... 2
   2.1 100-level courses: Fundamental Skills for Transit Maintenance. 2
   2.2 200-level courses: Vehicle Operations Overview and Maintenance of Rail Vehicles .......................................................... 15
   2.2.1 250-level courses: Overhaul and Rebuild of Rail Vehicles Components ..................................................................................... 60
   2.3 300-level courses: Advanced Theory of Operation and Troubleshooting of Systems ............................................................ 63

References .................................................................................. 73

Abbreviations and acronyms.................................................... 73
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>
<thead>
<tr>
<th>State</th>
<th>City</th>
<th>Agency</th>
<th>Union</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>Los Angeles</td>
<td>LACMTA</td>
<td>ATU 1277</td>
</tr>
<tr>
<td>California</td>
<td>Sacramento</td>
<td>Sacramento Regional Transit District</td>
<td>IBEW Local 245</td>
</tr>
<tr>
<td>Colorado</td>
<td>Denver</td>
<td>RTD Denver</td>
<td></td>
</tr>
<tr>
<td>District of Columbia</td>
<td>Washington</td>
<td></td>
<td>ATU Local 689</td>
</tr>
<tr>
<td>Florida</td>
<td>Miami</td>
<td>Miami Dade Transit</td>
<td></td>
</tr>
<tr>
<td>Georgia</td>
<td>Atlanta</td>
<td>MARTA</td>
<td>ATU Local 732</td>
</tr>
<tr>
<td>Illinois</td>
<td>Chicago</td>
<td>CTA</td>
<td></td>
</tr>
<tr>
<td>Massachusetts</td>
<td>Boston</td>
<td>MTA</td>
<td>ATU Local 589</td>
</tr>
<tr>
<td>Minnesota</td>
<td>Minneapolis</td>
<td>Metro Transit</td>
<td>ATU Local 1005</td>
</tr>
<tr>
<td>New Mexico</td>
<td>San Jose</td>
<td></td>
<td>ATU Local 265</td>
</tr>
<tr>
<td>New York</td>
<td>New York City</td>
<td>NYCT</td>
<td>TWU Local 100</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>Philadelphia</td>
<td>SEPTA</td>
<td>TWU Local 234</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>Pittsburgh</td>
<td></td>
<td>ATU Local 85</td>
</tr>
<tr>
<td>New Jersey</td>
<td>Newark</td>
<td>New Jersey Transit</td>
<td>ATU 819</td>
</tr>
<tr>
<td>Oregon</td>
<td>Portland</td>
<td></td>
<td>ATU 757</td>
</tr>
<tr>
<td>Utah</td>
<td>Salt Lake City</td>
<td>Utah Transit Authority</td>
<td>ATU Local 382</td>
</tr>
</tbody>
</table>

Other participants: 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 (Vinst) and voltage peak to peak (vpp)
  - 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 a 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 two's complement of binary numbers and use the two's 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 an 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 an inductive tester
Demonstrate ability to use a torque wrench
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 HydraulicBraking

   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 Schrader 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 wheelchair lifts
- Inspect wheelchair lifts
- Repair wheelchair lifts
- Replace wheelchair 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

• 307.1 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


- **310.1 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

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