Traction Power Maintenance Training Standards

Abstract: This Recommended Practice establishes standards for a program of traction power maintenance training.

Keywords: traction power, training,

Summary: The safe and efficient operation of transit rail systems is highly dependent on reliable traction power to allow train operations. Traction power maintenance has been identified by APTA and unions representing transit workers as a craft with a shortage of practitioners. In response to the need for traction power 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 practices for this craft.

Scope and purpose: The labor-management subject matter experts on the Traction Power 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. Completion of Level 100 to 300 learning objectives would typically require a three-year period, though these guidelines do not include instructional hour and on-the-job hours recommendations.
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The American Public Transportation Association greatly appreciates the contributions of the Traction Power Training Joint Steering Committee, who provided the primary effort in the drafting of this Recommended Practice:

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1. Objective of this standard

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

The safe and efficient operation of transit rail systems is highly dependent on reliable traction power to allow train operations. Traction power maintenance has been identified by APTA and unions representing transit workers as a craft with a shortage of practitioners. The inadequate numbers of traction power 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 traction power maintainers. The difficulty recruiting new entrants into the field is exacerbated by sometimes having to work in unfavorable weather, confined spaces and other less-desirable working conditions.

In response to the need for traction power 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 practices for this craft. 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. In addition, APTA is supporting programs to develop computer-based short courses of study using the training guidelines developed with the Center.

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 United States. Table 1 lists the participants.

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<th>State</th>
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<td><strong>Other participants:</strong></td>
<td>Beach Consulting, Charlotte Area Training Systems GE Transportation, Washington Group</td>
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Meeting over a period of two and one-half years, this committee of management and labor subject matter experts:

- Determined the job responsibilities and related tasks required of traction power maintainers.
- Determined the skills, knowledge and abilities required to successfully execute the job responsibilities and tasks of the traction power maintenance craft.
- Developed a program of training and order of instruction for classroom and on the job training for traction power maintainers.
- Determined the learning objectives associated with each phase of the training process to develop traction power maintainers.

1.1.1 Meeting dates
The Traction Power Training Joint Steering Committee met on the following dates:

- June 21, 2007
- September 27, 2007
- January 29, 2008
- September 4, 2008
- March 26, 2009

2. Traction power training guidelines
Traction power maintenance training guidelines are organized into 10 subject areas corresponding to the different job responsibilities of a traction power maintenance technician. These subject areas:

1. Comprehensive overview of train operations, safety and history of traction power systems
2. Traction power security related procedures and regulatory agency authority.
3. Specialized traction power tools and test equipment
4. Theory of power distribution (contact, catenary and third rail)
5. Theory, operation and maintenance of substations
6. Grounding
7. ANSI system, symbology
8. Battery backup power systems and emergency power
9. Incoming utility sources and management of utility power.
10. Electronics, relays and programmable logic circuits

The 10 areas of the curriculum include content and learning objectives at various levels of difficulty.

The committee identified several prerequisites candidates should have before starting the 100 level curriculum: basic print reading, basic electrical safety, AC and DC power, test meter reading, and computers. Level 100 training modules are introductory content and may overlap with other crafts that share a core of basic mechanical, electrical and electronic knowledge. Level 200 training areas are specific to traction power maintenance and build on the foundation technical knowledge, skills and abilities developed in the level 100 training areas. Level 300 training modules are the more advanced learning objectives imparting skills, knowledge and abilities required for traction power technicians and journeypersons to execute all of the job responsibilities required of a traction power maintainer. Identical course titles may appear in more than one level. This indicates that the class is on the same subject but presented at an increased level of complexity.

The labor-management subject matter experts on the Traction Power 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
Completion of Level 100 to 300 learning objectives would typically require a three-year period, though these guidelines do not include instructional hour and on-the-job hours recommendations.

2.1 100-level courses

100. Introduction to Traction Power (Safety, Security, History)
   • 100-1. Understanding History of Traction Power Systems
   • 100-2. Understanding and following Traction Power Safety Practices
     100-2-1. Reference to FRA standards as appropriate
     100-2-2. Explain principles and demonstrate ability to refer to NEC and NFPA 70E
     100-2-3. Review Hazard Risk Assessment (part of NFPA 70E)
     100-2-4. Describe process of interfacing with public safety agencies
     100-2-5. Describe railway safety procedures
       100-2-5-1. Demonstrate process of referring to agency rail roadway worker protection procedures pertaining to track safety
     100-2-6. Explain the risk of working with an energized vs. de-energized system
     100-2-7. Describe principle of grounding of distribution system
     100-2-8. Describe grounding of OCS procedure
     100-2-9. Identify voltage classification of system related to federal, state and agency safety procedures
     100-2-10. Identify safety tools
     100-2-11. Describe purpose of lock-out/tagout and power securing procedures
       100-2-11-1. Describe consequences of an unexpected release of hazardous energy
     100-2-12. Describe automatic ground
     100-2-13. Describe state and federal requirements for lock-out/tag-out and power securing procedures
     100-2-14. Describe process of referring to agency regulations pertaining to lock-out/tag-out
     100-2-15. Describe process of referring to agency regulations pertaining to power securing procedures
     100-2-16. Demonstrate proper use of personal protective equipment
     100-2-17. Explain the remote control capabilities related to substation operation
     100-2-18. Explain and demonstrate safety procedures and safety equipment at your property
     100-2-19. Explain and demonstrate safety procedures for working at heights and fall protection (for OCS properties)
     100-2-20. Explain and demonstrate safety procedures for working in confined spaces
     100-2-21. Explain and demonstrate safety procedures for pole climbing
   • 100-3. Understanding Traction Power Security Related Procedures
     100-3-1. Explain limited access to substations
     100-3-2. Explain TSA recommended procedures for dealing with suspicious packages
     100-3-3. Explain processes for observing people
   • 100-4. Understanding Regulatory Agency Authority
     100-4-1. Describe state and federal regulation related to traction power systems
   • 100-5. Understanding ANSI System
     100-5-1. Explain design of traction power system includes ANSI and IEEE standards
   • 100-6. Using Specialized Traction Power Tools
     100-6-1. Demonstrate ability to use hot stick
     100-6-2. Demonstrate ability to use meters; multimeters, DVM
     100-6-3. Demonstrate ability to use various hand and power tools, and explain reasons for using double insulated tools and identify tool requirements at your location
     100-6-4. Describe specialized tools for maintaining substations and distributions (refer to substation and distribution for tool lists)
     100-6-5. Properly use tools for substation maintenance
102 Power Distribution (Intro and Overview of Theory and Operation)

- **102-1. Purpose and Methods of Power Distribution**
  - 102-1-1. Explain purpose and methods of power distribution
  - 102-1-2. Explain history of power distribution
  - 102-1-3. Describe the varying operating voltages
  - 102-1-4. Describe differences in systems between rail systems

- **102-2. How a Traction Power System Works**
  - 102-2-1. Follow and describe the local functional order of a traction power system, including:
    - Utility, through circuit breaker, to transformer
    - AC switchgear
    - Rectifier transformer
    - Rectifier
    - DC switchgear
    - Distribution to OCS/third rail
  - 102-2-2. Describe traction power control systems
  - 102-2-3. Describe how traction power system works
  - 102-2-4. Explain DC positive feed and its components
  - 102-2-5. Describe negative return and its components
  - 102-2-6. Describe concept of parallel negative return
  - 102-2-7. Describe traction power in context of track circuit
  - 102-2-8. Describe negative feeder cables
  - 102-2-9. Describe operation of battery backup power systems (UPS)
  - 102-2-10. Describe fault annunciation
  - 102-2-11. Describe transfer trip

- **102-3. Describe Function and Components of Substations**
  - 102-3-1. Explain history of substations
  - 102-3-2. Describe the varying operating voltages for substations
  - 102-3-3. Describe differences in systems between rail systems
  - 102-3-4. Describe purpose of automatic reclose of breakers

- **102-4. Describe Function and Components of Overhead Contact Systems**
  - 102-4-1. Describe difference between overhead contact system and overhead catenary system
  - 102-4-2. Explain how overhead contact systems works
  - 102-4-3. Identify components of overhead contact system and their purpose
  - 102-4-4. Describe process of determining whether energized vs. de-energized (sectioning wiring)

- **102-5. Describe Function and Components of Overhead Catenary System**
  - 102-5-1. Describe difference between overhead catenary system and overhead contact system
  - 102-5-2. Explain how overhead catenary systems works
  - 102-5-3. Identify components of overhead catenary system and their purpose
  - 102-5-4. Describe process of determining whether energized vs. de-energized (sectioning wiring)

- **102-6. Describe Function and Components of Third Rail Systems**
  - 102-6-1. Describe impedance bonds
  - 102-6-2. Describe sectionalization
  - 102-6-3. Explain energized vs. de-energized
  - 102-6-4. Describe differences between third rail power and overhead power systems
  - 102-6-5. Weld third rail feed cables

- **102-7. DC Theory and Power Components**
  - 102-7-1. Demonstrate process of isolating system by opening or closing DC switchgear
102-7-2. Demonstrate process of verifying load and no load situation with disconnect switches

102-8-1. Describe operations and components of an overhead contact system
102-8-2. Describe operations and components of an overhead catenary system
102-8-3. Describe operations and components of a third rail powered system

**102-9. Bond Types and Methods**
102-9-1. Describe types of bonds (impedance bonds and power bonds)
102-9-2. Describe methods of bond attachment (cadweld, spot weld, arc weld, mechanical, structure)
102-9-3. Describe effect of improper bonding on rail metallurgy and broken rail
102-9-4. Weld extensions to the structure; create structure bonds

**102-10. Impedance Bonds**
102-10-1. Describe traction power in context of the track circuit
102-10-2. Describe purpose of impedance bonds

**102-11. Circuit Breakers and Protective Devices**
102-11-1. Explain use and purpose of circuit breakers and protective devices
102-11-2. Demonstrate process of verifying circuit breaker is disconnected before performing maintenance on breakers that can be isolated
102-11-3. Demonstrate how to use personal protective equipment when working on circuit breakers that cannot be disconnected from traction power before performing maintenance

**102-12. Understand Source of Power for Switch Heaters/Snow Melters**

**102-13. Understanding Cathodic Protection**
102-13-1. Define cathodic protection principles
102-13-2. Describe principle of stray current

108. Linear induction

2.2 200-level courses

**200. Understanding and Following PM Programs**
- 200-1. Add content from agency specific PM programs
- 200-2. Teach general best practices and concepts of preventive maintenance

**202 Power Distribution and Control Systems (Inspection and Maintenance)**
- **202-1. AC Power Systems (Inspection and Maintenance)**
  - 202-1-1. Review of AC theory
  - 202-1-2. Describe and maintain instrument transformers
  - 202-1-3. Maintain circuit breakers and protective devices
  - 202-1-4. Maintain AC switchgear
  - 202-1-5. Maintain disconnect switches (load and non-load)
  - 202-1-6. Explain circuit breakers and protective devices
  - 202-1-7. Explain traction rectifier transformer (6 pulse vs. 12 pulse)
  - 202-1-8. Explain and maintain rectifier
  - 202-1-9. Maintain auxiliary transformers

- **202-2. DC Power Systems (Inspection and Maintenance)**
  - 202-2-1. Review of DC theory
  - 202-2-2. Describe and maintain instrument transformers
  - 202-2-4. Maintain DC switchgear
  - 202-2-5. Maintain disconnect switches (load and non-load)
  - 202-2-6. Explain and maintain rectifier
  - 202-2-7. Maintain auxiliary transformers
• **202-3 Bond types and methods**
  202-3-1. Perform cadweld bonding
  202-3-2. Perform spot weld bonding
  202-3-3. Perform arc weld bonding
  202-3-4. Perform mechanical bonding
  202-3-5. Perform impedance bonds

203 Substations (Inspection and Maintenance)
• **203-1. Read and Interpret Circuit Prints**
  203-1-1. Explain ANSI/IEEE nomenclature
  203-1-2. Explain and interpret local prints
• **203-2. Inspect and Maintain Substation Components**
  203-2-1. Inspect and maintain transformers
  203-2-2. Inspect and maintain rectifiers
  203-2-3. Inspect and maintain AC breakers
  203-2-4. Inspect and maintain DC breakers
  203-2-5. Inspect and maintain protective relays
  203-2-6. Inspect and maintain UPS and station battery banks
  203-2-7. Inspect auxiliary relay contacts
• **203-3. Describe and Follow Prescribed Substation PM Procedures**

204 Overhead Contact System (Inspection and Maintenance)
• **204-1. Preparing to Work on Overhead Contact System**
  204-1-1. Describe and explain safety procedures for working at heights and fall protection
  204-1-2. Describe sectionalization
  204-1-3. Explain energized vs. de-energized
• **204-2. Demonstrate Process of Determining Whether Energized vs. De-energized (Sectioning Wiring)**
  204-2-1. Verify whether OCS is de-energized
  204-2-2. Demonstrate proper application of a ground strap
• **204-3. Inspecting and Maintaining Overhead Contact System Components**
  204-3-1. Inspect and maintain contact cable(applying local parameters)
  204-3-2. Inspect and maintain supporting structure
  204-3-3. Maintain/repair supporting structure
  204-3-4. Inspect all insulators
  204-3-5. Inspect insulation and wash as applicable
  204-3-6. Inspect, maintain and replace contact cable
  204-3-7. Inspect and maintain overhead line feeder cable
  204-3-8. Inspect and maintain hangers
  204-3-9. Inspect and replace equalizing jumper cable
  204-3-10. Inspect and maintain poles
  204-9. Inspect and maintain back guy (expand on various types)
• **204-4. Check Section Insulation (Various Types)**
  204-1-1. Check arc horns
  204-1-2. Check rumes
  204-1-3. Check support structure
• **204-5. Inspect and Maintain Overhead System**
  204-5-1. Tighten and adjust cable
  204-5-2. Grease wheels on auto tension system where applicable
• **204-6. Describe and follow prescribed overhead contact system PM procedures**
205 Overhead Catenary System (Inspection and Maintenance)

205-1. Preparing to Work on Overhead Catenary System
   - Understand and follow safety procedures for working at heights and fall protection
   - Describe sectionalization
   - Explain energized vs. de-energized

205-2. Inspecting and Maintaining Overhead Catenary System
   - Measure and install messenger wire, staggering contact wire to prevent wear on pantograph
   - Inspect and maintain hangers
   - Inspect and maintain overhead line feeder wire
   - Inspect and maintain poles
   - Check and adjust wire tension
   - Check and adjust fixed tension wires
   - Check and adjust auto (constant) tension
   - Inspect and maintain snow and ice removal equipment
   - Inspect all insulators
   - Inspect and maintain contact wire

205-3. Check Section Insulation (Various Types)
   - Check arc horns
   - Check rumes
   - Check support structure

205-4. Describe and Follow Prescribed Overhead Catenary System PM Procedures

206 Third Rail Systems (Inspection and Maintenance)

206-1. Inspecting and Maintaining Third Rail and Components
   - Inspect bonds
   - Perform cable bonding
   - Maintain third rail feed cables
   - Inspect and replace third rail insulators
   - Inspect third rail structure and conditions for wear or any abnormality
   - Inspection and condition of third rail gaps and inclines
   - Inspect and replace third rail joints
   - Inspect third rail feeder cable
   - Cable splicing and insulation

206-2. Inspecting and Maintaining Snow and Ice Removal Equipment

206-3. Inspecting and Maintaining Cables
   - Explain and demonstrate the routing of cables through ducts
   - Perform duct rodding
   - Perform work on manholes
   - Read duct and manhole prints
   - Explain and demonstrate processes and equipment used to pull cable
   - Explain and demonstrate processes for cable fault location

207. HVAC and Lighting

   NOTE: Include equipment that is relevant to traction power maintainers in a given property.

208. Understanding Low Resistance Groundings vs. High Resistance Groundings
2.3 300-level courses

300 Incoming Utility (Service Power) Sources and Basic Diagnosis

- 300-1. Explain Operation of Equipment
- 300-2. Describe Primary Power Distribution
- 300-3. Determine Voltage
- 300-4. Identify Whether AC or DC
- 300-5. Locate and Utilize Disconnect Switch
- 300-6. Describe Isolation of Circuits
- 300-7. Demonstrate Ability to Read Single-Line Blueprints
- 300-8. Describe How Metering System Works
- 300-9. Use and Maintain Portable Generators
  - 300-9-1. Safely set up portable generators
  - 300-9-2. Demonstrate various hookups
  - 300-9-3. Check phasing
  - 300-9-4. Select correct voltage

301 Traction Power Control Systems (Troubleshooting, Adjustment and Repair)

- 301-1. Describe Various Points of Control of Substations and Distribution Network
- 301-2. Define and Describe Supervisory Control and Data Acquisition System (SCADA)
  - 301-2-1. Fiber optics and communication systems
- 301-3. Use SCADA to Troubleshoot and Improve System Performance

302 Power Distribution Systems (Troubleshooting, Adjustment and Repair)

- 302-1. Power Isolation
  - 302-1-1. Identify section of rail where power needs to be turned off to perform maintenance
  - 302-1-2. Read and interpret rail feeder and return drawings
  - 302-1-3. Identify power sections on rail feeder and return drawings
  - 302-1-4. Communicate with power control center to isolate power in appropriate section
  - 302-1-5. Field confirm power isolation with a voltage tester
  - 302-1-6. Remove taps and open switches as applicable
  - 302-1-7. Communicate with power control center to restore power
  - 302-1-8. Follow agency safety precautions and procedures
- 302-2 AC Power Systems (Troubleshooting and Repair)
  - 302-2-1. Troubleshoot, repair and replace Instrument Transformers
  - 302-2-2. Troubleshoot, repair and replace Circuit breakers and protective devices
  - 302-2-3. Troubleshoot and repair Traction rectifier transformer (6 pulse vs. 12 pulse)
  - 302-2-4. Troubleshoot and repair rectifier
  - 302-2-5. Troubleshoot and repair no-load disconnect
  - 302-2-6. Troubleshoot and repair auxiliary transformers
- 302-3 DC Power Systems (Troubleshooting and Repair)
  - 302-3-1. Troubleshoot and repair instrument transformers
  - 302-3-2. Troubleshoot and repair circuit breakers and protective devices
  - 302-3-3. Troubleshoot and repair rectifier
  - 302-3-4. Demonstrate proper method to replace diodes
  - 302-3-5. Troubleshoot and repair no-load disconnect
  - 302-3-6. Troubleshoot and repair auxiliary transformers

303 Substations (Troubleshooting, Adjustment and Repair)

- 303-1 Troubleshooting Methods and Best Practices
303-1-1. Using OEM manuals in troubleshooting
303-1-2. Read and interpret circuit prints to discover and repair problems
303-1-3. Describe and demonstrate linear troubleshooting method
303-1-4. Describe and demonstrate half split troubleshooting method
303-1-5. Explain when to use each method
• 303-2. Substation Components Troubleshooting and Repair
  303-2-1. Troubleshoot and replace transformers
  303-2-2. Troubleshoot and replace rectifiers
  303-2-3. Troubleshoot and replace breakers (AC and DC)
  303-2-4. Troubleshoot and replace protective relays
  303-2-5. Troubleshoot and replace UPS
  303-2-6. Troubleshoot and replace station battery banks

304 Overhead Contact Systems (Troubleshooting, Adjustment and Repair)
• 304-1. Troubleshooting and Repairing Overhead Contact System Components
  304-1-1. Repair contact cable (applying local parameters)
  304-1-2. Repair supporting structure
  304-1-3. Replace and splice contact cable
  304-1-4. Maintain/repair supporting structure
• 304-2. Troubleshoot and Repair Contact Cable Defects
• 304-3. Troubleshoot and Repair Hangers
• 304-4. Troubleshoot and Repair Poles
• 304-5. Check and Adjust Cable Tension
  304-5-1. Check and adjust fixed tension cables
  304-5-2. Check and adjust auto (constant) tension
• 304-6. Repair and Replace Section Insulation (Various Types)
  304-6-1. Repair and replace arc horns
  304-6-2. Repair and replace rumes
  304-6-3. Repair and replace support structure
• 304-7. Troubleshoot and Repair Back Guy

305 Overhead Catenary Systems (Troubleshooting, Adjustment and Repair)
• 305-1. Troubleshooting and Repairing Overhead Catenary System
  305-1-1. Troubleshoot and repair contact wire
  305-1-2. Troubleshoot, adjust and repair hangers
  305-1-3. Troubleshoot, adjust and repair poles
  305-1-4. Check and adjust wire tension
  305-1-5. Check and adjust fixed tension wires
  305-1-6. Check and adjust auto (constant) tension
  305-1-7. Troubleshoot and repair snow and ice removal equipment
  305-1-8. Repair and replace down guy
  305-1-9. Repair and replace span wire
• 305-2 Repair and Replace Section Insulation (Various Types)
  305-2-1. Repair and replace arc horns
  305-2-2. Repair and replace rumes
  305-2-3. Repair and replace support structure

306 Third Rail Systems (Troubleshooting, Adjustment and Repair)
• 306-1. Troubleshoot and Repair Third Rail and Components
• 306-2. Troubleshoot and Repair Third Rail Structure
• 306-3. Troubleshoot and Repair Snow and Ice Removal Equipment
• 306-4. Measure a Curved Radius for Rail Installation and Replacement
References

Abbreviations and acronyms

AC     alternating current
ANSI   American National Standards Institute
APTA   American Public Transportation Association
ATU    Amalgamated Transit Union
BART   Bay Area Rapid Transit
CTA    Chicago Transit Authority
DART   Dallas Area Rapid Transit
DC     direct current
DVM    digital volt meter
FRA    Federal Railroad Administration
HVAC   heating, ventilation, air conditioning
IBEW   International Brotherhood of Electrical Workers
IEEE   Institute of Electrical and Electronic Engineers
LACMTA Los Angeles County Metropolitan Transportation Authority
MBTA   Massachusetts Bay Transportation Authority
MTS    Metropolitan Transit System (San Diego)
NEC    National Electrical Code
NFPA   National Fire Prevention Association
OCS    overhead catenary system
OEM    original equipment manufacturer
PM     preventative maintenance
SCADA  supervisory control and data acquisition system
SEPTA  Southeastern Pennsylvania Transportation Authority
TSA    Transportation Security Administration
TWU    Transport Workers Union of America
UPS    uninterruptible power supply