

APTA RT-RMT-RP-003-10

Approved June, 2010

National Elevator/Escalator Maintenance Training Standards Development Committee

Elevator and Escalator Maintenance Training Guidelines Standards

Abstract: This document contains standards for a fully accredited Elevator/Escalator Apprenticeship Program.

Keywords: apprenticeship, elevator, escalator, training

Summary: As of 2007, 25 states have adopted formal elevator and escalator maintenance licensing requirements. The transit agency response correspondingly reflects this regulatory environment, as each agency attempts to develop training specific to their regulating authority. The result is largely an unfunded mandate with which no single transit company can afford to comply. This brief description of the dilemma faced by the industry illustrates the urgent need for national guidelines and related training programs.

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

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



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APTA greatly appreciates the contributions of the **National**

Elevator/Escalator Maintenance Training Standards Development

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1. Development of this standard

The National Elevator/Escalator Maintenance Training Standards Development Committee was formed in 2005 to create a dialog among transit agencies and unions engaged in in-house conveyance equipment maintenance. Several compelling factors brought this group together:

- **First**, the elevator and escalator industry is incorporating digital control technologies into their designs faster than the incumbent workforce can learn these new systems.
- **Second**, every agency has experienced difficulty recruiting qualified elevator/escalator mechanics. In fact, through 2016 the US Department of Labor projects nine percent growth in the number of escalator/elevator positions, leaving transit agencies to compete with private sector employers over an already scarce labor pool. Coincidentally, some 40 percent of the current transit workforce is eligible to retire.
- **Third,** regulatory and legislative changes have required transit agencies to meet state occupational certification requirements for recently hired elevator and escalator maintainers. This regulatory and occupational certification is expected to become more common.

The committee is comprised of labor union and management representatives from North American public transit providers who continue to perform in-house elevator and escalator maintenance. The American Public Transportation Association and the involved transit unions have sponsored this effort, and the Transportation Learning Center (the Center, formerly, the Community Transportation Center) has supported and facilitated this program with funding provided by the U.S. Department of Labor, the Federal Transit Administration and the Transportation Research Board.

1.1 Objective

This committee's ultimate objective is to develop a fully accredited Elevator/Escalator Apprenticeship Program certified through a national joint apprenticeship and training committee and continuing education training programs for incumbent technicians. The curriculum, courseware and training guidelines adopted by the group are designed to meet or exceed the licensing requirements of jurisdictions, which currently or in the future, may legislate professional licensure or certification for elevator and escalator technicians. The apprenticeship program will ultimately be registered by the U.S. Department of Labor's Office of Apprenticeship.

1.2 The committee

1.2.1

Participants

State	City	Agency	Union			
California	San Francisco	BART	SEIU Local 1132			
Illinois	Chicago	СТА	IBEW Local 137			
Georgia	Atlanta	MARTA	ATU Local 732			
New York	New York	MTA, NYCT	TWU Local 100			
Pennsylvania	Philadelphia	SEPTA	TWU Local 234			
DC	Washington	WMATA	ATU Local 68			
АРТА						
Transportation Learning Center						

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1.2.2 Meeting dates

The National Elevator/Escalator Maintenance Training Standards Development Committee met on the following dates:

- November 28, 2006
- April 3, 2007
- September 14, 2007
- November 7-8, 2007
- February 21, 2008
- June 14, 2008
- September 17, 2008
- November 5, 2008
- January 8-9, 2009

1.3 Current mix of licensing requirements

As of 2007, 25 states have adopted formal elevator and escalator maintenance licensing requirements. **Table 1** describes the current state of elevator and escalator regulation in the jurisdictions represented by the aforementioned transit agencies. This matrix of state and provincial regulations affects transit agencies' authority to service and maintain their equipment.

The agency response correspondingly reflects this regulatory environment as each agency attempts to develop training specific to their regulating authority. The result is largely an unfunded mandate with which no single transit company can afford to comply. This brief description of the dilemma faced by the industry illustrates the urgent need for national guidelines and related training programs.

TABLE 1Guidelines and Related Training Programs

State/Province	Certification Requirements for Elevator-Escalator Maintainers		
California	State-certified apprenticeship with annual renewal. BART is a certified ELES company.		
Georgia	Four-year training program and annual recertification.		
Illinois	State licensing performed by local constructor unions. Works with two years' experience grandfathered.		
Maryland/District of Co- lumbia	State-administered exam and apprenticeship graduate, with grandfathering for experience.		
Pennsylvania	State equipment inspections; no contractor licensing requirements.		
New York	No state requirement.		
Ontario	Provincial certification testing.		
Virginia	State-required exam for contractors.		

The partnership opportunity created by the transit industry makes developing an elevator/escalator apprenticeship and continuing education program, along with the corresponding courseware, far more manageable for the group than for any single agency.

1.4 Process and tasks

The maintenance training guidelines working group is nearing completion of an interagency apprenticeship and incumbent training curriculum. The next critical steps include a formal courseware sharing agreement between participating agencies and the collection and development of specialized courseware. The immediate critical needs of the agencies involved demands that the process be abbreviated for short-term gains, while continuing with the long term solution of developing a national joint apprenticeship and training program.

Table 2 describes the group's process to date. The adopted apprenticeship curriculum is presented in Section 2.

TABLE 2
Process to Date

Task	Status
Job task and maintenance program comparison among participant agencies.	Complete
2. Workforce skills assessment and training evaluation of each agency.	Complete
3. Interagency curriculum and training program comparison.	Complete
4. Comparison of state and provincial training, licensing and certification requirements.	Complete
5. Curriculum development and adoption.	Complete

2. Adopted Elevator/Escalator Apprenticeship Program

The following pages contain the adopted training content for transit elevator and escalator technicians

2.1 100-level courses

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

Traine the four classes of the and now to extinguish

Describe the technique used to lift a heavy load

Explain the importance of personal protective equipment (PPE) and name several types

Explain what MSDS stands for and how it applies to them (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 elevators and escalators

102. Electrical and Job Safety

• 102-1. Developing a Safe Attitude

Safety overview, personal responsibility

• 102-2. Using personal protective equipment

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 machinist's 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 a gantry crane

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

Indentify 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 reeving system

104. Basic Mathematics

NOTE: Committee discussed integrating content of this module throughout other 100-level modules. Content was agreed to in committee, but method for presenting alone or integrating with other modules was not resolved.

104-1. Whole Numbers and Arithmetic Operations

Demonstrate the ability to add, subtract, multiply and divide whole 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 and scientific 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

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 & 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 & 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

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 an 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

2.2 200-level courses

200. Overview of vertical transportation

- 200-1. Elevator/Escalator Types and Styles
- 200-2. Elevator/Escalator Components and Controls
- 200-3. Simulator Orientation
- 200-4. Hydraulic and Pneumatic Diagrams
- 200-5. Elevator and Escalator as-built drawing review

201. AC Motors, DC Motors and Generators

201-1. 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

201-2. Fundamentals of Rotating Machines

201-3. DC Motors and Generators

Explain the operating principles of a DC motor

Explain counter-electromotive 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

201-4. 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

- 201-5. Motor Controls
- 201-6. AC Induction Motors

Describe the operation of an induction motor

• 201-7. Synchronous Motors

Describe the operation of a synchronous motor

• 201-8. Three Phase Synchronous Operation

202. Troubleshooting Electrical/Electronic Systems

- 202-1. Symbols and Circuits Review
- 202-2. Meters and Terminology Review
- 202-3. Introduction to troubleshooting DC and AC systems
- 202-4. Introduction to troubleshooting digital systems
- 202-5. Circuits Measurement

203. Introduction to Electrical Ladder Drawings

- 203-1. Ladder Logic vs. Ladder Diagrams
- 203-2. Reading and interpreting schematics and circuits
- 203-3. Understanding International diagrams and symbols
- 203-4. Interpreting blueprints and flow charts
- 203-5. Concepts of relay logic
- 203-6. Understanding terminology
- 203-7. Interpreting logic gates and diagrams

204. AC Circuit Analysis

204-1. 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

204-2. Capacitance and RC Circuits

Define the terms "capacitor" and "capacitance"

Explain how capacitance affects current

Calculate the transient response time for an RC circuit

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

Determine capacitive reactance by using measurements of circuit currents and voltages

Calculate the equivalent capacitance in both series and parallel circuit arrangements

204-3. 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

205. Semiconductor Fundamentals

• 205-1. 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

205-2. Semiconductors, diodes

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

205-3. 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

• 205-4. 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

205-5. 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 (SCRs)

- Identify and label the schematic diagram of an SCR
- Explain the operation of an 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

206. Digital Fundamentals

206-1. 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

• 206-2. 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

206-3. 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

206-4. NAND, NOR, XOR Elements

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

206-5. Binary Number Shortcuts

Count using the binary numbering system

Compare place values for the digits of binary numbers

Convert binary numbers to decimal and decimal numbers to binary

Add unsigned binary numbers

Determine the twos complement of binary numbers and use the twos complement method to do binary subtraction

Add signed binary numbers

Determine if overflows have occurred when binary numbers have been added

206-6. 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"

207. Hydraulic and Pneumatic Applications

- 207-1. Practical Hydraulics
- 207-2. Practical Pneumatics
- 207-3. Hydraulic and Pneumatic drawings (review, troubleshooting applications)
- 207-4. Applications of Hydraulics and Pneumatics for ELES
- 207-5. Hydraulic and Pneumatic logical troubleshooting

208. Escalator-Specific: Principles of Operation

- 208-1. Safety Procedures
- 208-2. Principles of Escalator Operation
- 208-3. Escalator Structural Overview
- 208-4. Main Drive Systems
- 208-5. Handrail Drive Systems
- 208-6. Braking Systems
- 208-7. Control Systems

209. Escalator-Specific: Electrical Systems

- 209-1. Safety Procedures
- 209-2. Electrical Systems Sequence of operation
- 209-3. Power Supplies
- 209-4. Wiring Supplies (NEC Code Compliance)
- 209-5. Safety Circuits
- 209-6. Control Circuits
- 209-7. Drive Motor Inspection and Maintenance
- 209-8. Troubleshooting escalator electrical

210. Escalator-Specific: Step Installation and Maintenance

- 210-1. Safety Procedures
- 210-2. Inspection and Troubleshooting
- 210-3. Step Removal and Replacement
- 210-4. Roller Removal and Replacement
- 210-5. Rack Maintenance
- 210-6. Alignment and Adjustment

211. Escalator-Specific: Handrail Installation & Maintenance

- 211-1. General Safety Procedures
- 211-2. Handrail Drive Systems
- 211-3. Inspection and Troubleshooting
- 211-4. Handrail Removal and Replacement

212. Escalator-Specific: Inspection and Basic Maintenance

- 212-1. Lighting
- 212-2. Steps
- 212-3. Handrails
- 212-4. Safety devices
- 212-5. Drive systems
- 212-6. Brakes
- 212-7. Controllers
- 212-8. General Housekeeping procedures
- 212-9. Operational Test
- 212-10. Code Compliance Overview / Jurisdictional testing
- 212-11. Internal communications (authority specific learning objectives)

Glossary of local terms and language

Reporting requirements and forms

Communication procedures

213. Elevator-Specific: Principles of Operation

213-1. Safety Procedures

Entrapment response, evacuation

- 213-2. Traction (Electrical) Elevators & MRL Elevators
- 213-3. Hydraulic Elevators
- 213-4. Rack & Pinion Elevators
- 213-5. ADA Accessibility (Wheelchair Lifts)
- 213-6. Door Systems
- 213-7. Control Systems

Understand relay logic

Understand programmable logic

- 213-8. Authority Specific Entrapment Guidelines
- 213-9. Introduction to Code Specifications (ASME 17.1A)

214. Elevator-Specific: Electrical Systems

- 214-1. Safety Procedures
- 214-2. Electrical Systems sequence of operations
- 214-3. Power Supplies
- 214-4. Wiring Systems (NEC Code Compliance)
- 214-5. Safety Circuits
- 214-6. Control Circuits

215. Elevator-Specific: Drive System Maintenance & Repair

- 215-1. General Safety Procedures
- 215-2. Troubleshooting
- 215-3. Gear Drive Systems
- 215-4. Gearless Drive Systems
- 215-5. Hydraulic Drive Systems
- 215-6. Component Removal and Replacement
- 215-7. Lubrication Requirements and Adjustments

216. Elevator-Specific: Principles of Door Operation & Maintenance

- 216-1. Safety Procedures
- 216-2. Principles of Elevator Door Operation

- 216-3. Troubleshooting
- 216-4. Lubrication and Adjustments
- 216-5. Component Removal and Replacement
- 216-6. Alignment and Testing
- 216-7. Code Compliance

217. Elevator-Specific: Traction (Electric) Elevators/MRL

- 217-1. Safety Procedures
- 217-2. Drive Systems
- 217-3. General traction and MRL systems
- 217-4. Control Systems

Selector

• 217-5. Roping

Maintaining Sheaves

- 217-6. Hoistway
- 217-7. Troubleshooting
- 217-8. Maintenance Requirements

Lubrication

• 217-9. Code Compliance

218. Elevator-Specific: Hydraulic Elevators

- 218-1. Safety Procedures
- 218-2. Drive Systems
- 218-3. Control Systems

Selector

- 218-4. Hoistway
- 218-5. Troubleshooting
- 218-6. Maintenance Requirements

Lubrication

218-7. Code Compliance

219. Elevator-Specific: Inspection and Basic Maintenance

- 219-1. Elevator Car
- 219-2. Lighting
- 219-3. Safety Devices
- 219-4. Machine room & Drive Systems

Valve system

Piston seals and jack

Oil

- 219-5. Brakes
- 219-6. Controllers
- 219-7. Hoistway
- 219-8. Hall / Landing devices
- 219-9. General Housekeeping procedures
- 219-10. Emergency Equipment
- 219-11. Code compliance review

220: Elevator-Specific: Other Systems

220-1. Rack & Pinion Elevators

Safety Procedures

Drive Systems

Control Systems

Hoistway

Troubleshooting

Maintenance Requirements

Code Compliance

220-2. Dumbwaiters

Safety Procedures

Drive Systems

Control Systems

Hoistway

Troubleshooting

Maintenance Requirements

Code Compliance

220-3. Wheelchair lifts

Safety Procedures

Drive Systems

Control Systems

Hoistway

Troubleshooting

Maintenance Requirements

Code Compliance

2.3 300-level courses

300. Electrical/Electronic Systems

- 300-1. Electric Motor Drives
- 300-2. Mechanical and Solid State Switches
- 300-3. Testing Diodes, Transistors and Thyristors
- 300-4. Troubleshooting electronic systems

301. Advanced Electrical Ladder Drawings

- 301-1. Multiple Page Prints
- 301-2. Electronic Sensors
- 301-3. International Drawings
- 301-4. PLC Prints
- 301-5. Troubleshooting Exercises

302. Automated Equipment

- 302-1. Understanding Control Devices
- 302-2. Sensors Primary Purposes
- 302-3. Digital control Devices
- 302-4. Variable Control Devices
- 302-5. Applications
- 302-6. Troubleshooting Exercises

303. Elevator-Specific Courses by Manufacturer and/or Model

- 303-1. Elevator-Specific: Principles of Operation
- 303-2. Elevator-Specific: Electrical/Control Systems
- 303-3. Elevator-Specific: Troubleshooting
- 303-4. Elevator-Specific: Drive System Maintenance & Repair

- 303-5. Elevator-Specific: Principles of Door Operation & Maintenance
- 303-6. Elevator-Specific: Inspection and Maintenance
- 303-7. Elevator-Specific: Safety Devices

304. Escalator Specific Courses by Manufacturer and/or Model (e.g., Kone, Fujitec, Schindler, Otis)

- 304-1. Escalator Specific Principles of Operation
- 304-2. Escalator Specific Electrical / Control Systems
- 304-3. Escalator Specific Troubleshooting
- 304-4. Escalator Specific Drive System Maintenance & Repair
- 304-5. Escalator Specific Step Installation & Maintenance
- 304-6. Escalator Specific Handrail Installation & Maintenance
- 304-7. Escalator Specific Inspection and Maintenance
- 304-8. Escalator Specific Safety Devices

2.4 400-level courses

400. Advanced Controllers

- 400-1. Controller functions and Components
- 400-2. Relay Logic

Interpretation of Relay-type Instructions

- 400-3. Solid state controllers
- 400-4. Programmable Controller Systems
- 400-5. Troubleshooting I/O Devices and Processors

Controller Diagnostics

Diagnostic use of laptop or handheld device

 400-6. Controller Programming / Reprogramming / Upgrading Programming Terminology

401. Manufacturer-Specific Controllers

- 401-1. SLC500 Processor Operation
- 401-2. Introduction to RSLogic Software

402. Advanced Equipment Inspections

402-1. Use of human senses to identify problems

403. Root Cause Failure Analysis

- 403-1. Review of OEM Service Bulletins (Find Connections to Local Failures)
- 403-2. Information gathering
- 403-2. Component analysis
- 403-3. Interpretation of statistics (e.g. MTBF, etc.)

404. Predictive Maintenance

- 404-1. Introduction to vibration analysis
- 404-2. Lubrication sampling
- 404-3. Thermal imaging scans
- 404-4. Engineering or vendor discussion / consultation

Abbreviations and acronyms

AC alternating current

APTA American Public Transportation Association

ASCII American Standard Code for Information Interchange

ATU **Amalgamated Transit Union**

avg average

BART Bay Area Rapid Transit

complementary metal-oxide-semiconductor CMOS

CTA Chicago Transit Authority

DC direct current DIP dual inline package DMM digital multimeter **ELES** elevator/escalator **EMT** electrical metallic tubing

Hg mercury

IBEW International Brotherhood of Electrical Workers

IC integrated circuit LSB least significant bit

MARTA Metropolitan Area Rapid Transit Authority (Atlanta)

MRL machine room-less (elevators)

MSB most significant bit

MSDS material safety data sheets MTBF mean time between failures NEC National Electrical Code

NTC negative temperature coefficient

NYCT New York City Transit

PLC programmable logic controller PPE personal protective equipment psi pounds per square inch

psi absolute psia psig psi gauge

PTC positive temperature coefficient

RC resistor-capacitor

RCL resistor-capacitor-inductor

RL resistor-inductor rms root mean square RtK right to know

SCR silicon-controlled rectifiers

SEIU Service Employees International Union SEPTA Southeastern Pennsylvania Transit Authority

TTL transistor-transistor logic TWU Transport Workers Union UJT unijunction transistor VOM volt/ohm meter vinst instantaneous voltage

voltage peak to peak qqv

WMATA Washington Metropolitan Area Transit Authority