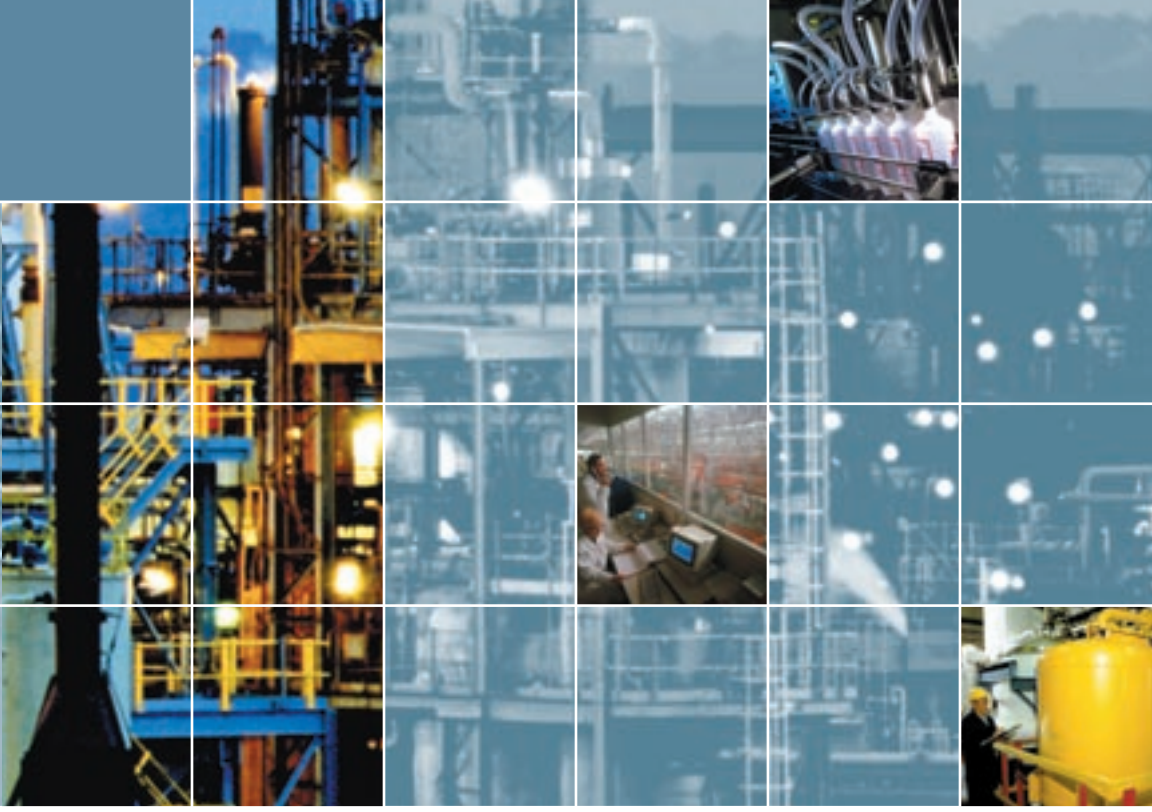

Control Systems Technician Training

PRIMEDIA
WORKPLACE LEARNING

Control Systems Technician Training

- Plant floor systems and equipment are increasing in complexity
- Highly experienced workers are retiring
- Enrollment at vocational institutions is declining
- High school students are chasing lucrative IT jobs in college
- Industries are shifting to a multi-craft work approach
- Workers are doing more with less

Never before has the demand for talented workers been higher. Many companies looking to the labor market for help have come to the realization that training must come from within. With PRIMEDIA Workplace Learning's newest training series, Control Systems Technician Training, discrete and process manufacturers now have a practical answer to the shortage of talented labor.

Developed to educate electrical maintenance and instrumentation/control systems technicians on their progressively overlapping roles, the Control Systems Technician training series cross-trains workers on topics such as Programmable Logic Controllers (PLCs), PC-Based Control, Variable Speed Drives, Controller and Loop Tuning as well as traditional Instrument Calibration. Included in this series is an electrical training curriculum designed to improve the knowledge and skills of the new Electrician/Instrumentation (E/I) Technician in the area of basic electrical work.

INTRODUCTION

CONTROL SYSTEMS – THE STORY

STREAMLINE PLANT FLOOR PRODUCTION

Data communication networks are enabling many companies to distribute real-time product and equipment information enterprise-wide, all the way to the CEO. With the advent of Supervisory Control and Data Acquisition (SCADA) systems, companies now have the capability to monitor and control specific plant floor processes from remote locations to increase productivity. All of this data sharing, however, necessitates more workers needing greater knowledge of complementary job functions.

CROSS-TRAIN ELECTRICAL MAINTENANCE AND COMPUTER NETWORK TECHNICIANS

In today's plant environment integration is the norm not the exception. Computers are linking horizontally with one another within the plant site and between plant sites via networks. Vertical integration is occurring as more minute components of plant floor processes are being joined together—DCSs, PLCs, motor drives, maintenance technicians, computer network technicians, plant managers, etc. As a result, an increasing number of electrical maintenance technicians are finding themselves involved in the troubleshooting and repair of data communication networks. Similarly, computer network technicians are struggling to understand plant automation and control systems. To eliminate unfamiliarity and remain competitive, companies are developing more elaborate and comprehensive training programs for plant floor personnel.

CONTROL SYSTEMS – THE TRAINING

Instructional Features

This new interactive training series is available in videotape and interactive CD-ROM formats. All CD-ROM units include up-to-date MPEG full-motion video, crisp audio, stunning three-dimensional graphics, lifelike animation, embedded activities and practical simulation exercises—all to stimulate and involve the trainee in real-life experiences and procedures. The interactive CD-ROM series is a Windows® application with course management network capabilities.

Each CD-ROM unit can be customized with site-specific information. Generic pretests and posttests are included, with the added capability of creating custom tests. An online glossary and an online test feature are provided for ease of reference. The automated Course Management System (CMS) for Windows® keeps track of all trainee test scores, log times, and site-information access and provides custom reporting options.

Objective

This series is designed to enhance the troubleshooting skills of Control Technicians, Electrical Maintenance Technicians, Instrumentation and Control (I&C) Technicians and the recently formed job role of the Electrician and Instrumentation (E&I) Technician. The curriculum provides technicians with an understanding of process plant safety considerations and working conditions, an overview of the processes, a foundation of technical knowledge, and specific training on the complex equipment found in today's industrial environment.

Benefits

The benefits of the CD-ROM format include: reduction of learning time, consistency of delivery, increase in mastery scores, automated record keeping, increased motivation, greater retention, privacy, and remedial or refresher training. Additional benefits include increased trainee interest and flexible scheduling. Also, training units accommodate all learning styles through a variety of media presentation formats.

The videotape series complements classroom instruction and provides instructors with a cost-efficient method for delivering training.

Structure

The 78 units of this series are divided into 12 subject areas focusing on basic theory and systems, equipment operation, and system operation. Included in this series are 34 electrical units designed to meet the requirements of the new Electrician/Instrumentation (E/I) Technician. Each training unit in this guide is comprehensively described following a common format: Overview, Objectives and Subjects.

Materials

Each CD-ROM comes with one unit overview and five handbooks. Additional support material includes one Administrator Guide and one User Guide. The standalone Course Management System (CMS) software is provided "free of charge" with the purchase of the first training unit. The CMS software and guide are provided for record keeping and reporting. The CMS also allows for customized testing and the incorporation of site-specific information. A network version of the CMS is available.

Each videotape lesson comes complete with one instructor guide and five user guides.

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FOUNDATIONS OF THE ELECTRICIAN CRAFT – LEVEL II

Control Systems Curriculum

Controls – Foundation

INTRODUCTION
(ACCIN)

OVERVIEW

The Introduction training program, or unit, is designed to familiarize trainees with the basic elements, terminology, and functions of control systems. After completing this program, the trainees should be able to identify and describe various types of input and output devices that are commonly used with automated control systems. They should also be able to identify and describe common types of control devices and control loop arrangement

OBJECTIVES

Define terms commonly associated with the input side of a control system.
Identify and describe common types of temperature sensors that provide input information to a control system.
Identify and describe common types of position sensors.
Identify and describe common types of pressure sensors, flow sensors, and level sensors.
Identify and describe common types of electric instruments, timers, counters, recorders, and pneumatic sensors.
Identify and describe common actuating devices used in the output side of a control system.
Describe common decision-making devices that connect the input and output elements in a control system.
Describe common control loop arrangements used in automatic control systems.

SUBJECTS

Input Elements
- Terminology
- Temperature Sensors
- Position Sensors
- Pressure, Flow, and Level Sensors
- Other Input Devices

Output Elements
- Actuating Devices

Control Elements
- Decision-Making Devices
- Control Loops

PRINCIPLES OF CALIBRATION
(ACCCA)

OVERVIEW

The Principles of Calibration training program, or unit, is designed to familiarize trainees with the basic principles associated with the calibration of input field devices and control loops. After completing this program, the trainees should be able to explain how to test, adjust, and calibrate various types of gauges and transmitters. They should also be able to explain how to test, set up, and adjust input field devices and calibrate control loops.

OBJECTIVES

Explain how to decide the best time to test and calibrate.
Describe the proper steps involved in a lockout/tagout procedure.
Describe how to perform basic calibration procedures on a typical pressure gauge, pressure transmitter, and thermocouple.
Describe how to adjust a typical sensor that switches in response to discrete position.
Describe how to test and adjust a typical sensor that switches at a temperature, pressure, or control signal set point.
Describe how to test and calibrate a typical sensor that responds to concentrations.
Describe how to test, set up, and adjust a typical sensor that responds to flow.
Describe how to perform basic calibration procedures on a typical output field device.
Describe how to perform basic calibration procedures on a typical control loop.

SUBJECTS

Gauges and Transmitters
Preparation
Pressure Gauge
Pressure Transmitter
Temperature Devices

Field Devices and Control Loops
Input Field Devices
Output Device and Loop Calibration

PRINCIPLES OF CONTROL
(ACCC0)

OVERVIEW

The Principles of Control training program, or unit, is designed to familiarize trainees with the basic operating principles of controllers used with discrete input/output devices and analog input/output devices. After completing this program, the trainees should be able to explain the control logic used in systems with discrete (digital) I/O, describe how to troubleshoot systems that use individual relays and solid state controllers, and describe how to program a PLC and troubleshoot PLC system problems. They should also be able to explain how analog variables can be converted to digital data and vice-versa, describe PID control, describe common controller options and applications, and describe how to diagnose problems in single and multiple control loops.

OBJECTIVES

Explain the control logic used in systems with discrete (digital) I/O.
Describe how to troubleshoot systems that use individual relays and solid state controllers.
Describe how to program a PLC, test the program, run and adjust the program, and troubleshoot PLC system problems.
Explain how analog variables can be converted to digital data and vice-versa.
Describe proportional control, derivative control, and integral control.
Describe common controller options and applications.
Diagnose problems in single and multiple control loops.

SUBJECTS

Controllers Used with Discrete I/O
Digital Logic
Individual Relays
PLC Applications

Controllers Used with Analog I/O
Analog/Digital Conversion
PID Control
Special Controller Features
Troubleshooting Control Loops

INTRODUCTION TO CONTROL AND DATA SYSTEMS
(ACCIC)

OVERVIEW

The Introduction to Control and Data Systems training program, or unit, is designed to familiarize trainees with the role of information systems in plant operations and the elements of modern information systems. After completing this program, the trainees should be able to identify the information needs of typical plant functional elements and explain how information gets into an information system. They should also be able to describe system architecture and explain how to use environment software and application software.

OBJECTIVES

List the information needs of typical plant functional elements.
Explain how alarms work in modern plants.
List the routes by which information gets into the system.
Explain I/O bus, LAN, WAN, client-server, and the role of network standards.
Explain the function of an operating system.
Describe the characteristics of common operating systems.
Explain the role of operating system and network software.
Explain virtual instrumentation.
Explain programmable logic controller (PLC) program creation.
Describe how to use graphical objects to create the system data structure and HMI.
Describe password hierarchy and the need for security.
Describe the functions and architecture of a SCADA system.

SUBJECTS

Information and Plant Operations
Information Needs
Information Sources

Information Systems
System Architecture
Environment Software
Application Software

THE HUMAN-MACHINE INTERFACE
(ACCHM)

OVERVIEW

The The Human-Machine Interface training program, or unit, is designed to familiarize trainees with the different types of HMIs that are likely to be found in a modern plant. After completing this program, the trainees should be able to obtain process information using typical instruments, operate typical switch controls, use smart I/O devices and controller interfaces, and perform common computer operations.

OBJECTIVES

Read typical instruments.
Use typical switch controls.
Configure smart I/O devices.
Operate portable instruments.
Operate and program a variable frequency drive.
Take readings from and program a loop controller.
Use dedicated graphics terminals.
Describe the role of software in computer operation.
Describe the main functional components of a computer.
Use common DOS and character-based keyboard/screen functions.
Use common GUI keyboard/screen functions.
Turn a computer on and log on.
Find and run a program, enter data, save, print, exit, and shut down a computer.

SUBJECTS

Traditional Equipment Interfaces
Instruments
Controls

Microprocessor-Based HMIs
Smart I/O Interfaces
Controller Interfaces

The Computer Interface
Basic Computer Hardware and Operation
The Human-Computer Interface
Common Computer Operations

BASIC ELECTRICAL TEST EQUIPMENT
(ACCBE)

OVERVIEW

The Basic Electrical test Equipment training program, or unit, is designed to familiarize trainees with various types of electrical test instruments. After completing this program, the trainees should be able to follow safe work practices and procedures while properly using circuit testers, multimeters, ammeters, megohmmeters, and digital low resistance ohmmeters.

OBJECTIVES

Follow safe work practices and procedures while using electrical test equipment.
Use circuit testers to indicate the presence of energized electrical circuits.
Use an analog multimeter to measure voltage, resistance, and current in AC and DC circuits.
Use a digital multimeter to measure voltage, resistance, and current in AC and DC circuits.
Identify in-line and clamp-on ammeters.
Use an analog ammeter to measure current through a conductor.
Use a digital ammeter to measure current through a conductor.
Use a megohmmeter to test the insulation resistance of a conductor, transformer, and motor.
Explain how to measure the resistance of electrical circuits and equipment with a DLRO.

SUBJECTS

Test Equipment Safety
Safe Work Practices

Circuit Testers
Basic Operation

Multimeters
Basic Operation

Ammeters
Basic Operation

Megohmmeters
Basic Operation

DLRO
Basic Operation

DIGITAL AND ANALOG OSCILLOSCOPES
(ACCDA)

OVERVIEW

The Digital and Analog Oscilloscopes training program, or unit, is designed to familiarize trainees with the basic operation and use of digital and analog oscilloscopes. After completing this program, the trainees should be able to explain what an oscilloscope does, explain how to set up an oscilloscope for use, identify the controls used to adjust an oscilloscope display, and explain how to use an oscilloscope to make voltage measurements and time measurements.

OBJECTIVES

Briefly explain how an oscilloscope converts a voltage input to an on-screen trace.
Describe how an oscilloscope display is graduated.
Explain why proper grounding is important.
Explain how to set the controls to "standard position" for the initial setup of an oscilloscope.
Explain how to select, compensate, and use oscilloscope probes.
Identify the controls used to adjust an oscilloscope display and explain their functions.
Explain what an oscilloscope's vertical controls do and how to use them.
Explain what an oscilloscope's horizontal controls do and how to use them.
Determine an applied voltage by counting oscilloscope screen divisions.
Determine frequency by measuring the period on an oscilloscope screen.
Determine a pulse width and rise time.

SUBJECTS

Fundamentals
- Basic Operating Theory
- Display Fundamentals

Setting Up
- Grounding and Safety
- Controls
- Probes

Control Use
- Display
- Vertical
- Horizontal

Measurement Techniques
- Voltage
- Time

Controls – Continuous Process

PRINCIPLES
(ACPCR)

OVERVIEW

The Principles training program, or unit, is designed to familiarize trainees with some of the basic material, process, and system characteristics that can affect process control. After completing this program, the trainees should be able to identify and describe some basic factors that affect process control. They should also be able to describe common process control methods and the operation of loops that control critical process variables.

OBJECTIVES

Identify variables that are routinely monitored and controlled by process control systems.
Describe basic material properties and fluid flow characteristics.
Describe the relationship between temperature and pressure in fluids.
Describe the basic principles and methods of heat transfer.
Identify and describe some basic factors that affect process control.
Describe on/off, proportional, integral (reset), derivative (rate), and PID control algorithms.
Identify and describe pressure, temperature, level, flow, and pH control loops in a typical boiler system.

SUBJECTS

Process Characteristics
Example System Layout
Material Attributes

Control Systems
Basic Control Factors
Process Control Methods
Process Control Loops

PNEUMATIC CONTROLS
(ACPPC)

OVERVIEW

The Pneumatic Controls training program, or unit, is designed to familiarize trainees with the basic operation, maintenance, and calibration of components in a pneumatic control system. After completing this program, the trainees should be able describe to how to service the various devices that help dry and filter the air and how to check pressure control devices in the system for proper operation. They should also be able to describe the basic operation and maintenance of some typical control components in a pneumatic system.

OBJECTIVES

Describe the operation and maintenance of air supply components that dry and filter compressed air in a pneumatic control system.
Describe the operation and maintenance of pressure control components in a pneumatic control system.
Describe the operating principles of pneumatic control components.
Identify the basic types of pneumatic sensor-transmitters.
Describe the operation and maintenance of sensor-transmitters.
Identify and describe common types of pneumatic receiver-controllers.
Describe basic calibration procedures for a typical receiver-controller.
Identify and describe common types of pneumatic actuators.
Describe procedures involved in testing, calibrating, and maintaining pneumatic actuators.

SUBJECTS

Air Supply Maintenance
- Air Filtering
- Pressure Control

Control Components
- Basic Operation
- Sensor-Transmitters
- Receiver-Controllers
- Actuators

FIELD DEVICES: TEMPERATURE, PRESSURE AND WEIGHT
(ACPPT)

OVERVIEW

The Field Devices - Temperature, Pressure, and Weight training program, or unit, is designed to familiarize trainees with input field devices that sense and monitor temperature, pressure, or weight. After completing this program, the trainees should be able to describe the basic operation of various types of temperature, pressure, and weight transducers and transmitters.

OBJECTIVES

List typical temperature, pressure, and weight applications.
Explain how thermocouples, RTDs, and thermistors work.
Explain reference junction compensation.
Explain RTD lead length compensation.
Explain how load cells work.
Explain absolute, gauge, and differential pressure measurement.
Explain the function of set points.
Describe transmitter operating parameters, and define the following terms: range, LRL, URL, LRV, URV, span, turndown ratio, engineering units, PV, and SV.
Explain how transmitter accuracy can be specified.
Identify and describe common transmitter configuration options.
Describe the ways that transmitters communicate signal information.
Describe how to set up a traditional transmitter.
Explain how to communicate with, configure, and test a smart transmitter.

SUBJECTS

Temperature, Pressure, and Weight Inputs
- Applications
- Temperature Transducers
- Pressure and Weight Transducers
- Sensor Switches

Signal Equipment
- Transmitter Characteristics
- Transmitter Procedures

FIELD DEVICES: LEVEL AND FLOW
(ACPLF)

OVERVIEW

The Field Devices - Level and Flow training program, or unit, is designed to familiarize trainees with input field devices that sense and monitor level or flow. After completing this program, the trainees should be able to describe the basic operation of various types of level measurement and flow measurement devices.

OBJECTIVES

Define the following terms: level, point level measurement, continuous level measurement, direct level measurement, and indirect level measurement.
Identify common examples of point, continuous, direct, and indirect level measurement devices.
Identify factors that determine the type of level measurement device used for a particular application.
Define the following terms: density, specific gravity, and hydrostatic pressure.
Describe how pressure gauges, differential pressure transmitters, bubblers, and displacers provide level measurements.
Describe common applications and limitations associated with pressure gauges, differential pressure transmitters, bubblers, and displacers.
Describe factors that must be considered during the configuration of pressure gauges, differential pressure transmitters, bubblers, and displacers.
Describe how capacitance, or radio frequency (RF) devices, and conductance devices measure level.
Describe common applications and limitations associated with capacitance and conductance devices.
Describe factors that must be considered during the configuration of capacitance and conductance devices.
Describe how radar, ultrasonic, laser, and nuclear level measurement devices work.
Describe common applications and limitations associated with radar, ultrasonic, laser, and nuclear level measurement devices.
Describe how tuning fork sensors and weight devices provide level measurements.
Describe common applications and limitations associated with tuning fork sensors and weight devices.
Describe how differential pressure flowmeters provide flow measurements.
Identify common primary flow elements that are used in differential pressure measurement.
Describe common problems that can affect the operation of differential pressure flowmeters.
Describe how positive displacement flowmeters measure flow.
Describe how turbine flowmeters measure flow.
Describe applications and limitations associated with positive displacement flowmeters and turbine flowmeters.
Describe how magnetic, vortex, and ultrasonic flowmeters measure flow.
Describe applications and limitations associated with magnetic, vortex, and ultrasonic flowmeters.
Describe how Coriolis flowmeters and thermal flowmeters work.
Describe applications, limitations, and installation considerations for Coriolis flowmeters and thermal flowmeters.

continued

FIELD DEVICES: LEVEL AND FLOW (CONTINUED)

(ACPLF)

SUBJECTS

Level Measurement

- Types of Level Measurement
- Pressure- and Density-Based Devices
- Capacitance and Conductance Devices
- Non-Contact Devices
- Tuning Fork Sensors and Weight Devices

Flow Measurement

- Differential Pressure Flowmeters
- Mechanical Flowmeters
- Electronic Flowmeters
- Mass Flowmeters

FIELD DEVICES: ANALYTICAL
(ACPAF)

OVERVIEW

The Field Devices - Analytical training program, or unit, is designed to familiarize trainees with input field devices that perform online analyses. After completing this program, the trainees should be able to describe common applications and procedures that are associated with the use of online analyzers. They should also be able to describe some of the many different types of online analyzers that are used in continuous process systems.

OBJECTIVES

- Describe common applications of online analytical field devices in continuous process systems.
- Describe the essential components of most online process analyzers.
- Describe general concerns associated with the installation, operation, and maintenance of online analyzers.
- Describe common types of electrochemical analyzers that use property- or compound-specific sensors for online analyses in continuous process systems.
- Describe one type of flammable vapor analyzer that is commonly used in continuous process systems.
- Describe common maintenance concerns associated with electromagnetic analyzers.
- Describe optical analyzers that are commonly used for online analyses in continuous process systems.
- Describe mass spectrometers that are commonly used for online analyses in continuous process systems.
- Describe nuclear devices that are commonly used for online analysis of density.
- Describe common maintenance concerns associated with electromagnetic analyzers.
- Describe chromatographs that are commonly used for online analyses in continuous process systems.
- Describe common maintenance concerns associated with gas chromatographs.

SUBJECTS

Introduction
- Typical Applications
- Basic Concerns

Types of Online Analyzers
- Electrochemical Analyzers
- Electromagnetic Analyzers
- Chromatographs

FIELD DEVICES: ANALOG CONFIGURATION
(ACPCA)

OVERVIEW

The CONTINUOUS PROCESS: Field Devices - Analog Configuration training program, or unit, is designed to familiarize trainees with basic procedures for configuring traditional and "smart" analog field devices. After completing this program, the trainees should be able to explain how to set zero and span and perform a calibration procedure on a traditional analog transmitter. They should also be able to explain the basics of how to configure a smart analog field device using a portable communicator or a laptop PC.

OBJECTIVES

Define "analog" as it relates to process control signals.
Explain how analog field devices function in process control systems.
Explain how to set zero and span on a traditional electronic transmitter.
Explain how to perform a calibration procedure on a non-smart transmitter.
Explain the relationship between the value of a process variable and a transmitter's 4-20 milliamp output signal.
Identify the basic configuration parameters for smart transmitters.
Calculate a process measurement from a smart transmitter's analog signal output.
Explain how to configure a smart field devices with a portable communicator.
Explain how to configure a smart field device with a laptop PC.

SUBJECTS

Analog Field Devices
Analog Field Devices
Traditional Electronic Devices
Configuring Smart Devices

Configuration Methods
Portable Communicators
Laptop PCs

FIELD DEVICES: DIGITAL CONFIGURATION WITH A DCS

(ACPCD)

OVERVIEW

The CONTINUOUS PROCESS: Field Devices – Digital Configuration with DCSs training program, or unit, is designed to familiarize trainees with basic procedures for using a distributed control system (DCS) to configure digital field devices. After completing this program, the trainees should be able to explain how to use the Honeywell TDC 3000 and the Fisher-Rosemount DeltaV to configure a digital field device.

OBJECTIVES

Explain how digital field devices differ from analog field devices.
Describe how a DCS is used to monitor and control a process.
Identify and describe the information that is provided on the point detail screens of a typical DCS.
Describe a basic procedure for using a DCS to configure a digital field device.
Describe the basic operating principles and architecture of fieldbus technology.
Describe a basic procedure for using the DeltaV to configure a field device.

SUBJECTS

The DCS
Digital Field Devices
Distributed Control Systems

Honeywell TDC 3000
Point Details
Configuration of Digital Field Devices

Fisher Rosemount DeltaV
Fieldbus Technology
DeltaV Digital Configuration

FIELD DEVICES: USING FIELD COMMUNICATORS
(ACPFC)

OVERVIEW

The CONTINUOUS PROCESS: Field Devices - Using Field Commun-icators training program, or unit, is designed to familiarize trainees with basic procedures for using field communicators to configure "smart" analog field devices. After completing this program, the trainees should be able to explain how to configure smart analog transmitters using a HART communicator, a Honeywell communicator, a Yokogawa communicator, and the Foxboro Local Display Module.

OBJECTIVES

Explain how to use the HART communicator to perform the basic configuration of a magflow transmitter.
Explain how to use a Honeywell SFC to perform the basic configuration of a differential pressure transmitter.
Explain how to use the Yokogawa BT200 to perform the basic configuration of a pressure transmitter.
Explain how to use the Foxboro Local Display Module to perform the basic configuration of a transmitter.

SUBJECTS

HART Protocol — Magnetic Flow Transmitter
Using the HART Communicator

Honeywell Protocol — Pressure (DP) Transmitter
Using the Honeywell Communicator

Yokogawa Protocol — Pressure Transmitter
Using the Yokogawa Communicator

Foxboro — Local Display Module
Using the Foxboro Local Display Module

FIELD DEVICES: CONFIGURING WITH A LAPTOP PC
(ACPCL)

OVERVIEW

The Field Devices - Configuring with a Laptop PC training program, or unit, is designed to familiarize trainees with basic procedures for using a laptop PC to configure analog field devices. After completing this program, the trainees should be able to explain how to configure an input device such as a transmitter and an output device such as a control valve.

OBJECTIVES

Use Foxboro's PC-10 program to configure a transmitter.
Use Foxboro's PC-20 program to configure a control valve.

SUBJECTS

Configuring Input Field Devices
Configuring a Transmitter

Configuring Output Field Devices
Configuring a Control Valve

INTRODUCTION TO DISTRIBUTED CONTROL SYSTEMS
(ACPID)

OVERVIEW

The Introduction to Distributed Control Systems training program, or unit, is designed to familiarize trainees with DCS architecture and basic tasks that DCS technicians may be asked to perform. After completing this program, the trainees should be able to describe the architectural organization of DCS field components, central components, and control loops. They should also be able to describe ways that a DCS technician typically works with a DCS.

OBJECTIVES

Explain the functions of input and output devices.
Describe the difference between digital and analog I/O devices.
List examples of I/O field devices.
Describe how I/O devices communicate.
Identify I/O devices from a piping and instrument diagram.
Describe typical I/O field termination equipment.
Describe typical I/O and control processor cards and functions.
Explain the data functions of the system server.
Explain how to use a DCS user interface for basic information retrieval.
Describe DCS networks.
Explain why and how PLCs are sometimes part of a DCS.
Describe typical control loops.
Describe the information that can be obtained from loop sheets.
Describe preparations for working on a field device.
Describe basic service operations that may have to be performed on a field device.
Identify troubleshooting tasks that can be performed in a rack room.
Identify tasks that can be performed at a DCS user interface.

SUBJECTS

DCS Architecture
Field Components
Central Components
Control Loops

Working with a DCS
Field Device Tasks
Rack Room Tasks
At the User Interface

SMART CONTROLLERS
(ACPSC)

OVERVIEW

The Smart Controllers training program, or unit, is designed to familiarize trainees with the operation and use of smart controllers. After completing this program, the trainees should be able to describe basic procedures for installing, configuring, operating, and tuning smart controllers.

OBJECTIVES

Describe the purpose of a smart controller.
Describe a smart controller's common control options.
Explain how to install and wire a new or replacement smart controller.
Explain how to configure a smart controller.
Explain how to operate a smart controller.
Explain how to tune a smart controller for optimum performance.
Describe the procedures for troubleshooting a single loop process controlled by a smart controller.
Describe the procedures for tuning a single loop process controlled by a smart controller.

SUBJECTS

Setting Up Smart Controllers
Characteristics
Installation and Configuration

Using Smart Controllers
Operation and Tuning
Demonstration

SINGLE LOOP CONTROL
(ACPSL)

OVERVIEW

The Single Loop Control training program, or unit, is designed to familiarize trainees with the basic operation and use of single control loops. After completing this program, the trainees should be able to explain the basic operation of a feedback control loop, describe how the proportional-integral-derivative (PID) control algorithm works, and identify and describe features that may be used to enhance the performance of a PID controller.

OBJECTIVES

Describe a typical feedback control loop.
Describe how the proportional-integral-derivative (PID) control algorithm works.
Identify and describe features that are commonly used to enhance the performance of a PID controller.
Describe a typical single-loop pressure control system.
Describe a typical single-loop temperature control system.
Describe a typical single-loop level control system.
Describe a typical single-loop flow control system.
Describe a typical single-loop pH control system.

SUBJECTS

Control Basics
Feedback Control Loop
PID Control
Controller Enhancements

MULTIPLE LOOP CONTROL
(ACPML)

OVERVIEW

The Multiple Loop Control training program, or unit, is designed to familiarize trainees with the basic operation and use of multiple loop control. After completing this program, the trainees should be able to explain the basic operation of multiple single loops, cascade control, ratio control, feedforward control, and special connections that are used with multiple loop control. They should also be able to use a P & ID to trace boiler control functionality.

OBJECTIVES

Explain typical interactions between single control loops.
Explain several types and applications of cascade control.
Explain several types and applications of ratio control.
Describe computational components that are typically used in multiple loop control.
Explain how limiters, interlocks, override controls and selective controls are used.
Explain the difference between feedback control and feedforward control.
Describe the advantages, problems, and applications of feedforward control.
Identify the main boiler control components and connections on a P & ID.
Trace boiler control functionality.

SUBJECTS

Multiple Loop Applications

Multiple Single Loops
Cascade Control
Ratio Control
Special Multiple Loop Connections
Feedforward Control

Boiler Master Controls

P & ID Conventions and Symbology
Boiler Control Operation

TUNING LOOPS
(ACPTL)

OVERVIEW

The Tuning Loops training program, or unit, is designed to familiarize trainees with the basic principles of tuning control loops. After completing this program, the trainees should be able to describe how to prepare for tuning a loop and how to tune a loop manually using a systematic trial and error method, the Ziegler-Nichols open loop method, and the Ziegler-Nichols closed loop method. They should also be able describe how tuning can be accomplished by the auto-tune function, by artificial intelligence features, and by tuning software.

OBJECTIVES

Describe tuning in relation to loop response.
Describe the types of process upsets.
Explain process delays.
Describe the effects of gain, reset, and rate on response curves.
Explain how to identify and assess asymmetry, non-linearity, and noise.
Explain how to correct or reduce hysteresis, stiction, and noise.
Distinguish between random tuning and systematic trial and error tuning.
Describe the precautions necessary when tuning by trial and error.
Explain the procedure for tuning using the Z-N open loop method.
Explain the procedure for tuning using the Z-N closed loop, or ultimate gain, method.
Describe how the auto-tune function tunes.
Describe artificial intelligence (fuzzy logic) tuning features.
Explain how to connect and run tuning programs.
Describe the options tuning programs may provide.

SUBJECTS

Closed Loop Operation
Control Loop Response
Before Tuning

Manual Tuning
Trial and Error Tuning
Ziegler-Nichols Tuning Methods

Automated Tuning
Self-Tuning
Software Tuning

TROUBLESHOOTING LOOPS
(ACPTS)

OVERVIEW

The Troubleshooting Loops training program, or unit, is designed to familiarize trainees with basic procedures for troubleshooting control loop problems. After completing this program, the trainees should be able to explain how to use a systematic troubleshooting procedure to troubleshoot problems in control loops.

OBJECTIVES

Explain how to gather information about a control loop problem.
Explain how to eliminate components or functional elements as possible causes of a control loop problem.
Explain how to prioritize possible causes of a control loop problem.
Explain how to test possible causes of a control loop problem in a logical order.
Describe the steps that should be taken to complete the troubleshooting of a control loop problem.
Describe a basic procedure for troubleshooting a discrete control loop.
Describe a basic procedure for troubleshooting a single analog control loop.
Describe considerations in troubleshooting a multiloop control system.

SUBJECTS

The Troubleshooting Procedure
Investigating Symptoms
Identifying Possible Causes
Testing Possible Causes
Finishing Up

Loop Troubleshooting Examples
Discrete Loop
Single Control Loop
Multiloop Control

TROUBLESHOOTING DCS I/Os: PROCEDURES
(ACPTD)

OVERVIEW

The Troubleshooting DCS I/Os: Procedures training program, or unit, is designed to familiarize trainees with basic procedures for troubleshooting the inputs and outputs of a distributed control system. After completing this program, the trainees should be able to explain how to gather information about a DCS I/O problem, identify possible causes of the problem, test the possible causes, and finish up the troubleshooting procedure.

OBJECTIVES

Explain how to gather information about a DCS I/O problem.
Explain how to eliminate possible causes of a DCS I/O problem.
Explain how to prioritize possible causes of a DCS I/O problem.
Explain how to test possible causes of a DCS I/O problem in a logical order.
Explain how to complete the procedures for troubleshooting a DCS I/O problem.

SUBJECTS

Troubleshooting Procedures
Investigating Symptoms
Identifying Possible Causes
Testing Possible Causes
Finishing Up

TROUBLESHOOTING DCS I/OS: PRACTICES
(ACPTP)

OVERVIEW

The Troubleshooting DCS I/Os: Practices training program, or unit, is designed to familiarize trainees with some practical applications of basic procedures for troubleshooting the inputs and outputs of a distributed control system. After completing this program, the trainees should be able to explain how to troubleshoot problems in digital I/O devices that are part of a DCS, analog I/O devices that are part of a DCS, and miscellaneous I/O components of a DCS.

OBJECTIVES

Describe basic steps for troubleshooting a problem in a digital I/O device that is part of a DCS.
Describe basic steps for troubleshooting a problem in an analog I/O device that is part of a DCS.
Describe basic steps for troubleshooting a problem in a miscellaneous I/O component of a DCS.

SUBJECTS

Troubleshooting Practices
Troubleshooting Digital I/O Devices
Troubleshooting Analog I/O Devices
Troubleshooting Miscellaneous I/O Components

Controls - Networks

INTRODUCTION
(ACNIN)

OVERVIEW

The NETWORKS: Introduction training program, or unit, is designed to familiarize trainees with some different types of control systems and some basic concepts that apply to control system networks. After completing this program, the trainees should be able to describe the layout and operation of traditional non-networked control systems and the layout and operation of some common networked control systems. They should also be able to describe factors that can affect the speed at which signals can be sent across a network, describe the various levels of network protocol, and describe common physical network layouts, or topologies.

OBJECTIVES

Describe the layout and operation of traditional non-networked control systems.
Describe the layout and operation of some common networked control systems.
Describe how information is coded as digital data for network transmission.
Identify and describe factors that can affect the speed at which signals can be sent across a network.
Identify and describe the various levels, or layers, of network protocol (the rules that govern how a network functions).
Identify and describe common physical network layouts, or topologies
Identify common protocols used in network control systems.

SUBJECTS

Control Systems Overview
Non-Networked Systems
Networked Systems

Basic Network Concepts
Digital Data
Network Speed and Traffic
Network Protocol and Topology
Common Protocol Types

SETTING UP AND TROUBLESHOOTING
(ACNST)

OVERVIEW

The NETWORKS: Setting Up and Troubleshooting training program, or unit, is designed to familiarize trainees with basic concepts that apply to setting up and troubleshooting control networks. After completing this program, the trainees should be able to describe different types of cables and connectors that are used to link together devices in control networks. They should also be able to describe basic procedures for installing, testing, and troubleshooting control networks.

OBJECTIVES

Describe coaxial cable and explain how to install a connector onto the cable.
Describe common types of twisted pair cable and explain how to install connectors onto the cables.
Identify and describe factors that must be considered when cable is routed.
Describe how to connect and use a cable tester to perform various tests on network cabling.
Describe common hardware configuration procedures that need to be performed during network installation.
Describe common troubleshooting techniques that are helpful for identifying problems with network cabling and devices.

SUBJECTS

Cables and Connectors
Coaxial Cable
Twisted Pair Cable

Network Installation
Cable Routing
Circuit Testing
Hardware Configuration
Troubleshooting

FIBER OPTIC SYSTEMS
(ACNFO)

OVERVIEW

The NETWORKS: Fiber Optic Systems training program, or unit, is designed to familiarize trainees with the basic operating principles of fiber optic systems and some of the basic installation and testing methods. After completing this program, the trainees should be able to describe characteristics of glass fibers and describe the function and types of fiber optic connectors. They should also be able to describe basic procedures for installing and testing fiber optics.

OBJECTIVES

Describe the composition of a common glass fiber.
Describe characteristics of multi-mode fiber.
Describe characteristics of single-mode fiber.
Describe characteristics of optic fibers and cables.
Describe the function and types of fiber optic connectors.
Describe hazards and work precautions associated with fiber optics.
List the main steps associated with running a new fiber optic drop.
Describe steps that are commonly used to terminate fiber.
Describe steps that are commonly used to make fiber splices.
Describe steps that can be used to check newly installed fibers.

SUBJECTS

Operating Principles
- Glass Fibers
- Basic System Hardware

Installation Tasks
- Safety
- Installing Cable
- Terminations and Splices

ARCHITECTURE, TYPES AND NETWORKS
(ACLAT)

OVERVIEW

The PLCs: Architecture, Types and Networks training program, or unit, is designed to familiarize trainees with the basic operation and components of programmable logic controllers (PLCs). After completing this program, the trainees should be able to explain what a PLC does, identify and describe PLC components, and explain how PLCs communicate.

OBJECTIVES

Explain how PLCs can be used to replace conventional, hard-wired ladder diagrams.
Explain how PLC programs can be used to control machines and processes.
Identify the three main parts of a PLC system.
Recognize a processor for a PLC and describe its functions.
Recognize different types of input modules.
Explain how to wire input devices into input modules.
Recognize different types of output modules.
Explain how to wire output devices into output modules.
Recognize power supplies.
Recognize different types of programming terminals.
Identify the three main time periods of the PLC scan cycle.
Identify factors that can affect the scan cycle time of a PLC.
Recognize different types of PLC networks.
List devices that typically communicate across different types of PLC networks.
Recognize that automated networks may include methods of machine control other than PLCs.

SUBJECTS

PLC Operations
Basic PLC Concepts
System Components
The Processor
The Input System
The Output System
Other Components

The PLC Scan
The PLC Scan Cycle
Scan Time

How PLCs Communicate
Networking PLCs
Other Methods of Machine Control

NUMERICS
(ACLNU)

OVERVIEW

The PLCs: Numerics training program, or unit, is designed to familiarize trainees with numbering systems and codes commonly used by programmable logic controllers (PLCs). After completing this program, the trainees should be able to interpret place values for decimal, binary, octal, and hexadecimal numbers and convert numbers from one numbering system to another. They should also be able to explain what BCD and ASCII codes are and how they are used.

OBJECTIVES

Identify commonly used numbering systems.
Explain the organization of a positional numbering system.
Interpret place values for binary numbers.
Describe ways that signed binary numbers may be represented in a PLC.
Convert between binary and decimal numbers.
Interpret place values for octal numbers.
Convert between octal, binary, and decimal numbers.
Interpret place values for hexadecimal numbers.
Convert between hexadecimal, octal, binary, and decimal numbers.
Explain what BCD code is.
Express and interpret information in BCD code.
Explain what ASCII code is.

SUBJECTS

Numbering Systems
- Numbering System Basics
- Positional Systems

Binary Numbering
- Place Values
- Signed Binary Numbers
- Conversions

Octal Numbering
- Place Values
- Conversions

Hexadecimal Numbering
- Place Values
- Conversions

Codes
- BCD Code
- BCD Conversions
- ASCII Code

LADDER LOGIC AND SYMBOLOGY
(ACLLL)

OVERVIEW

The PLCs: Ladder Logic and Symbology training program, or unit, is designed to familiarize trainees with how PLCs use ladder diagrams and what the symbols used on ladder diagrams mean. After completing this program, the trainees should be able to identify common ladder diagram symbols, explain how a ladder diagram rung performs the logic functions necessary to determine whether the rung is true or false, and interpret the meaning of some common PLC instructions.

OBJECTIVES

- Identify the major parts of a ladder diagram.
- Describe how a ladder diagram forms a parallel circuit.
- Identify the NEMA symbols for common input devices.
- Identify the NEMA symbols for common output devices.
- Differentiate between the Boolean AND, OR and NOT functions for multiple devices on a rung.
- Identify how each rung performs the logic functions necessary to determine whether the rung is true or false.
- Recognize rung numbers on a ladder diagram.
- Interpret cross references on a ladder diagram.
- Explain the PLC mode of operation with the Run-Rem-Prog key switch in each of its positions.
- Identify the typical symbols used in a PLC ladder program and explain the function of mnemonics.
- Identify each of the three parts of the PLC scan cycle.
- Interpret the meaning of some common complex instructions.
- Identify several things that may interrupt the normal scan cycle.

SUBJECTS

The Ladder Diagram Rung
- The Ladder Diagram as a Parallel Circuit
- Ladder Diagram Symbols
- Multiple Devices on a Rung

Complete Ladder Diagrams
- The Multiple Rung Control Program
- Rung Numbers and Cross References

Ladder Logic Execution
- PLC vs. Hardwired Program Execution
- Complex Instructions
- Interruptions to the Scan Cycle

I/O COMMUNICATION
(ACLIO)

OVERVIEW

The PLCs: I/O Communication training program, or unit, is designed to familiarize trainees with the various ways in which real-world devices can be connected to the input and output systems of a programmable logic controller. After completing this program, the trainees should be able to identify various types of I/O modules and field devices, and explain how direct I/O connections are made. They should also be able to identify some common device networks and identify some devices, other than PLC devices, that you might find on a typical device network.

OBJECTIVES

Identify the pieces of hardware that make up a PLC rack.
Differentiate between serial and parallel communication between racks.
Identify the three types of I/O modules.
Describe a typical I/O addressing scheme.
Describe the differences between discrete, or bit, devices; word devices; and analog field devices.
Describe the difference between sinking and sourcing I/O modules.
Explain why proper fusing, shielding and grounding are important when field devices are wired.
Relate I/O modules to the input and output image tables, and to the scan cycle.
Identify some common proprietary and non-proprietary device networks.
Identify some devices, other than PLC devices, that you might find on a typical device network.

SUBJECTS

Direct I/O Connections
How I/O Modules Are Mounted
I/O Module Types
I/O Module Addressing
Field Devices
Field Wiring
I/O Data Processing

Networked I/O Modules
Types of Device Networks
Devices

INTRODUCTION TO PROGRAMMING
(ACLIP)

OVERVIEW

The PLCs: Introduction to Programming training program, or unit, is designed to familiarize trainees with the basics of programming a programmable logic controller. After completing this program, the trainees should be able to enter a simple ladder diagram program into the memory of a PLC.

OBJECTIVES

Explain how to start programming software and verify proper drivers, connections, and node addresses.
Name the two main file types in PLC memory.
Explain how to clear PLC memory.
Identify PLC bit and word I/O addresses.
Explain how to use RSLogix‘ to insert a rung into a PLC.
Identify input and output instructions and explain how to add them to a rung.
Explain how to use RSLogix™ to add instructions and branches to a rung in a PLC.
Differentiate between the instructions for a discrete input device and the instructions for input-type contacts on an output device.
Differentiate between the instructions for real I/O devices and the instructions for virtual I/O devices.
Explain how to connect real, discrete I/O devices to a PLC.
Explain how to determine input and output addresses for PLC screw terminals.
Explain how to use RSLogix™ to program a PLC to emulate a hard-wired program.

SUBJECTS

Establishing Communications
Programming with a PC
The PLC Memory Model
Preparing to Program the PLC

Programming a Rung
Basic Rung Using Discrete I/O
Complex Rungs
Complex Discrete I/O Instructions

A Real System Example
The Hardware
The PLC Program

INSTALLING AND MAINTAINING
(ACLIM)

OVERVIEW

The PLCs: Installing and Maintaining training program, or unit, is designed to familiarize trainees with the basic procedures involved in installing and setting up PLC equipment. After completing this program, the trainees should be able to explain how to mount and wire up PLC hardware. They should also be able to describe how to establish communications between a PC and a PLC, clear the processor memory, and initially configure the processor.

OBJECTIVES

Describe what must be taken into consideration when mounting PLC hardware.
Describe how to connect various types of PLC power supplies.
Explain why emergency stop circuits must be hardwired.
Explain what to be aware of when populating PLC chassis.
Describe what to be aware of when wiring I/O field devices.
Describe what to be aware of when making network connections.
Explain how to establish communication between a PLC and a PC.
Explain the steps necessary to clear the memory of a PLC.
Explain the steps necessary to perform the initial configuration of a PLC.

SUBJECTS

Installing the PLC
- Mounting PLC Chassis
- Power Supplies and Connections
- E-Stop Circuits
- Configuring and Populating the Chassis
- I/O Wiring
- Network Connections

Initial Configuration
- Establishing Communications
- Clearing Memory
- Performing Initial Configuration

PROGRAM ENTRY, TESTING AND MODIFICATION
(ACLPE)

OVERVIEW

The PLCs: Program Entry, Testing, and Modification training program, or unit, is designed to familiarize trainees with the techniques used to install, test, and modify a PLC program, or project. After completing this program, the trainees should be able to explain how to prepare a system for program entry and how to download or enter the program. They should also be able to explain how to test and debug the program and make changes to the program in various processor modes.

OBJECTIVES

Explain how to establish communication between a PLC and a PC.
Explain the steps necessary to clear the memory of a PLC.
Explain how to install a project in a PLC.
Explain some common techniques used in test and debug operations.
Explain what must be done when a PLC's hardware or software configuration is changed.
Explain how to use the PLC EEPROM for program backup.
Explain how to use a PC hard drive for program backup.
Explain the differences between online and offline programming.
Describe the process for changing the PLC program while the system is in the program mode.
Describe the process for changing the PLC program while the system is in the run mode.

SUBJECTS

Entering and Testing the Program
Preparing for Program Entry
Downloading or Entering a Project
Testing and Debugging

Configuration and Program Changes
Configuration Changes
Uploading and Downloading Projects
Changes While in Program Mode
Changes While in Run Mode

PROGRAMMING COMMON FUNCTIONS
(ACLCF)

OVERVIEW

The PLCs: Programming Common Functions training program, or unit, is designed to familiarize trainees with the basics of programming common functions for a programmable logic controller. After completing this program, the trainees should be able to identify common non-I/O PLC instructions and explain how they are used.

OBJECTIVES

- Differentiate between bit addresses and word addresses.
- Explain the function of each part of a timer.
- Explain the function of each part of a counter.
- Explain how to use word addresses to send data to and from analog I/O modules.
- Explain how program control instructions modify the normal program scan sequence.
- Explain how immediate instructions interrupt the normal program scan cycle.
- Explain how data comparison instructions are used to make program decisions.
- Explain how math instructions are used to perform calculations and modify data.
- Explain how registers and sequencers are used to emulate motor-driven cam switches.
- Explain how file instructions are used to move and manipulate data.
- Explain the operating concept of a PID feedback loop.
- Explain how to connect real, word I/O devices to a PLC.
- Explain how to use RSLogix to program a PLC with some common functions.

SUBJECTS

Simple Word Instructions
- Word Addresses
- Timers
- Counters
- Analog I/O

Program Control Instructions
- Modifying the Scan Sequence
- Modifying the Scan Cycle

Comparison and Math Instructions
- Data Comparison Instructions
- Math Instructions

continued

PLCS: PROGRAMMING COMMON FUNCTIONS (CONTINUED)

(ACLCF)

Data Manipulation Instructions
- Registers and Sequencers
- File Instructions
- PID Loop Instruction

A Real System Example
- The Hardware
- The PLC Program

HMIs AND TROUBLESHOOTING
(ACLMT)

OVERVIEW

The PLCs: HMIs and Troubleshooting training program, or unit, is designed to familiarize trainees with human-machine interfaces and how they can be used in the troubleshooting of programmable logic controller system problems. After completing this program, the trainees should be able to identify various types of HMIs and explain how they are connected and used. They should also be able to describe the five steps of troubleshooting and explain how to use those steps and an HMI to troubleshoot a problem in a PLC system.

OBJECTIVES

- Identify common types of HMIs.
- List different ways to connect an HMI to a PLC.
- Describe some basic factors involved in using a PC-based HMI.
- Explain why it is important to know the equipment before you start to troubleshoot.
- List the aids available to you in investigating the symptoms.
- Explain how to use the half-splitting method of identifying symptoms.
- Explain how to prioritize and eliminate possible causes.
- Explain the importance of determining root causes of malfunctions.
- Explain how to use an HMI and the five-step troubleshooting process to troubleshoot a PLC-controlled system.

SUBJECTS

The Human-Machine Interface
- Types of HMIs
- Connection to the PLC
- Using an HMI

The Five Steps of Troubleshooting
- Know the Equipment
- Investigate Symptoms
- List Probable Causes
- Test Probable Causes
- Discover Root Causes
- A Troubleshooting Case Study

TROUBLESHOOTING HARDWARE
(ACLTH)

OVERVIEW

The PLCs: Troubleshooting Hardware training program, or unit, is designed to familiarize trainees with tools and procedures for troubleshooting hardware-related PLC problems. After completing this program, the trainees should be able to explain how to isolate a PLC problem to either hardware or software and network and how to use PLC hardware indicators, programming software, and appropriate test equipment to troubleshoot processor faults and I/O problems.

OBJECTIVES

Explain how to isolate a problem to hardware vs. software and network.
Explain how to identify a software and network problem.
Explain the meanings of common processor indicators.
Describe common I/O problems.
Identify the troubleshooting aids commonly found on a PLC power supply.
Identify the indicators commonly found on a PLC processor module.
Identify the indicators commonly found on a PLC I/O module.
Explain how to go on-line using RSLogix.
Explain how to use common search functions.
Explain how to force an input or output instruction.
Describe how cross references and I/O monitors can be used in troubleshooting.
Identify the three main parts of a typical I/O system.
Differentiate between test equipment that is and is not appropriate for troubleshooting PLC systems.
Use the appropriate programming software and test equipment to troubleshoot a typical input system.
Use the appropriate programming software and test equipment to troubleshoot a typical output system.

SUBJECTS

Isolating PLC Problems
Isolating the Problem
Software and Network Problems
Hardware Problems

Hardware Indicators
Power Supply
Processor
I/O Modules

continued

TROUBLESHOOTING HARDWARE (CONTINUED)
(ACLTH)

Troubleshooting with Programming Software
- Starting the Software
- Using the Search Functions
- Using the Force Functions
- Using Cross References and I/O Monitors

Troubleshooting I/O Systems
- I/O System Organization
- Using Test Equipment on I/O Systems
- Troubleshooting an Input System
- Troubleshooting an Output System

TROUBLESHOOTING SOFTWARE AND NETWORKS
(ACLSN)

OVERVIEW

The PLCs: Troubleshooting Software and Networks training program, or unit, is designed to familiarize trainees with how to use PLC programming software to isolate software and network problems. After completing this program, the trainees should be able to go on-line to connect to a PLC network and be able to identify and describe the major parts of the PLC memory and some memory protection options. They should be able to explain how to diagnose timer, counter, and sequencer problems and how to use PLC indicators, processor status information, TND and SUS instructions, Custom Data Monitors, and histograms to troubleshoot software problems. They should also be able to explain how to use processor indicators and communications software to isolate network problems, how to isolate network media problems, how to find and fix a network configuration problem, and how to connect to a PLC across a network and then troubleshoot a problem.

OBJECTIVES

Explain how to start software and select drivers.
Explain how to use a browser to connect to a stand-alone or networked PLC.
Describe the major parts of the PLC memory.
Describe some major memory protection options.
Explain how to use the five-step troubleshooting process to troubleshoot a PLC-controlled system.
Explain how to isolate a problem to software and network vs. hardware.
Explain how to isolate a problem to software vs. network.
Explain how the fault indication in the processor status box can be used for troubleshooting.
Explain how to use processor status table information to isolate problems.
Explain how to check I/O configuration.
Explain how to use the TND and SUS instructions to monitor program control instructions.
Explain how to diagnose timer, counter, and sequencer problems.
Explain how to use the Custom Data Monitor.
Explain how to use histograms.
Explain how to isolate a problem to a specific network node on DH+.
Explain how to isolate a problem to a specific network node on Rem I/O.
Explain how to isolate an HMI communication problem.
Explain how to isolate network media problems.
Explain how to find and fix network configuration problems.
Explain how to connect to a PLC across a network.
Explain how the key switch affects programming across a network.

continued

TROUBLESHOOTING SOFTWARE AND NETWORKS (CONTINUED)

(ACLSN)

SUBJECTS

Connecting to the PLC Network
- Starting the Software
- Examining the PLC Memory

Troubleshooting Software Problems
- Isolating Problems
- Using PLC Status and Configuration Files
- Program Control Problems
- Timer, Counter, and Sequencer Problems
- Using Data Monitors

Troubleshooting Network Problems
- Isolating the Problem
- Problems with Network Media
- Problems with Network Configuration
- Troubleshooting PLCs Across a Network

INTRODUCTION TO VSDs
(ACVSD)

OVERVIEW

The Introduction to Variable Speed Drives training program, or unit, is designed to familiarize trainees with the operation and use of variable speed drives. After completing this program, the trainees should be able to identify different types of DC and AC drives and explain how they control motor operation.

OBJECTIVES

Identify different types of variable speed DC drives.
Explain the operation of a DC motor controlled by a variable speed controller.
Identify the major components of a variable speed controller operating a DC motor.
Explain the operation of a variable speed controller operating a DC motor.
Identify different types of inverter drives.
Explain the operation of a AC motor controlled by an inverter.
Identify the major components of a PWM inverter operating an AC motor.
Explain the operation of a PWM inverter operating an AC motor.
Identify the major components of a flux vector drive.
Explain the operation of an AC motor controlled by a flux vector drive.
Identify different types of flux vector drives.
Explain the operation of a flux vector drive.

SUBJECTS

DC Drives
Control of DC Motors
DC Controller Components
DC Controller Operation

Inverter Drives
Inverter Control of AC Motors
AC Inverter Components
PWM Controller Operation

Flux Vector Drives
Flux Vector Control of AC Motors
Flux Vector Controller Operation

APPLICATIONS
(ACVDA)

OVERVIEW

The VARIABLE SPEED DRIVES – Applications training program, or unit, is designed to familiarize trainees with common applications of variable speed drives and basic procedures for variable speed drive installation. After completing this program, the trainees should be able to describe ways in which variable speed drives are used and ways in which they are set up and tested.

OBJECTIVES

Identify common applications for variable speed drives.
Describe typical network configurations for drives
Identify common problems associated with the installation of variable speed drives.
Set up a variable speed drive for operation.
Test the operation of a variable speed drive.
Create checkpointing documentation for a variable speed drive installation.

SUBJECTS

Common Applications
- Selecting Drives
- Networking Drives
- Identifying Problems

VSD Installation
- Setting Up
- Testing the Setup
- Creating Checkpointing

SYSTEM INTEGRATION
(ACVSI)

OVERVIEW

The VARIABLE SPEED DRIVES: System Integration training program, or unit, is designed to familiarize trainees with several common ways in which variable speed drives and automated systems are linked together. After completing this program, the trainees should be able to describe how variable speed drives are integrated into distributed control systems and programmable control systems. They should also be able to describe the operation of tachometers, encoders, and resolvers, and explain how to install field devices for variable speed drives.

OBJECTIVES

Describe how variable speed drives are integrated into distributed control systems.
Identify the network connections between a variable speed drive and a distributed control system.
Explain how to install a variable speed drive in a distributed control system.
Describe how variable speed drives are integrated into programmable control systems.
Identify the network connections between a variable speed drive and a programmable control system.
Explain how to install a variable speed drive in a programmable control system.
Describe the operation of a tachometer used to control a variable speed drive.
Explain how to install and set up tachometers for variable speed drives.
Describe the operation of an encoder used to control a variable speed drive.
Explain how to install and set up encoders for variable speed drives.
Describe the operation of a resolver used to control a variable speed drive.
Explain how to install and set up resolvers for variable speed drives.
Explain how to install field devices for variable speed drives.

SUBJECTS

Control System Integration
DCS Integration
PLC Integration

Feedback and Field Device Integration
Tachometers
Encoders and Resolvers
Field Devices

PROGRAMMING CONTROLLERS
(ACVPC)

OVERVIEW

The VARIABLE SPEED DRIVES: Programming Controllers training program, or unit, is designed to familiarize trainees with the basic principles of programming controllers for variable speed DC and AC motors. After completing this program, the trainees should be able to identify and describe common parameters that may have to be programmed for a DC variable speed controller and for an AC variable speed controller. They should also be able to describe additional programming that may be required when an AC variable speed controller is set up for flux vector operation.

OBJECTIVES

Identify and describe common parameters that may have to be programmed during the setup of a DC variable speed drive controller.
Identify and describe common parameters that may have to be programmed when configuring the I/O for a DC variable speed drive controller.
Identify and describe common parameters that may have to be programmed in order to monitor the operation of a DC variable speed drive controller.
Identify and describe common parameters that may have to be programmed during the setup of an AC variable speed drive controller.
Identify and describe common parameters that may have to be programmed when configuring the I/O for an AC variable speed drive controller.
Identify and describe common parameters that may have to be programmed in order to monitor the operation of an AC variable speed drive controller.
Describe additional programming that may be required when an AC variable speed controller is set up for flux vector operation.

SUBJECTS

Programming DC Controllers
- Setup
- I/O Configuration
- Monitoring

Programming AC Controllers
- Setup
- I/O Configuration
- Monitoring
- Flux Vector Programming

CONTROLLERS AND TROUBLESHOOTING
(ACVCT)

OVERVIEW

The VARIABLE SPEED DRIVES: Controllers and Troubleshooting training program, or unit, is designed to familiarize trainees with general procedures for using a variable speed drive controller to troubleshoot system problems and for troubleshooting problems in the controller itself. After completing this program, the trainees should be able to describe how to safely use a variable speed drive controller to locate basic system problems. They should also be able to explain how to use a test point checklist to troubleshoot a variable speed drive controller and how to test the major components of the controller.

OBJECTIVES

Describe safe work practices for troubleshooting a variable speed drive.
Identify and describe the four basic categories of electrical test equipment.
Explain how to use a controller display to locate operating problems in a variable speed drive.
Explain how to set up, interpret, and use a key test point checklist to troubleshoot a variable speed drive controller.
Explain how to check the major components of a variable speed drive controller.

SUBJECTS

Troubleshooting with the Controller
Safety Basics
Common Drive Problems

Troubleshooting the Controller
Test Point Checking
Component Checking

SYSTEM TROUBLESHOOTING
(ACVST)

OVERVIEW

The VARIABLE SPEED DRIVES: System Troubleshooting training program, or unit, is designed to familiarize trainees with the use of a basic five-step troubleshooting method to troubleshoot a variable speed drive system. After completing this program, the trainees should be able to describe problems associated with a variable speed drive system's motor, wiring, and electrical supply. They should also be able to describe each step of the five-step troubleshooting process and explain how to use those steps to troubleshoot a problem in a variable speed drive system.

OBJECTIVES

Explain how to locate and correct loose motor connections.
Explain how to detect conditions that could lead to motor winding failure, and suggest remedies for those conditions.
Explain how to detect conditions that could lead to motor bearing failure, and suggest remedies for those conditions.
Explain how to detect motor leakage currents, and suggest remedies for the problem.
Explain how to locate and correct loose wiring connections.
Identify and suggest modifications to variable speed drives affected by improper shielding and grounding.
Explain how to check and monitor control system feedback.
Identify and suggest modifications to variable speed drives affected by overvoltage reflections.
Explain how to locate and correct loose wiring connections.
Identify and suggest methods for correcting voltage imbalance in variable speed drive systems.
Explain how to detect single phasing in variable speed drive applications.
Explain how to detect harmonic anomalies, and suggest remedies for those conditions.
Explain why it is important to know the equipment before you start to troubleshoot.
List the aids available to you in investigating the symptoms.
Explain how to identify probable causes.
Explain how to prioritize probable causes.
Explain why it is important to determine the root causes of malfunctions.
Explain how to use the five-step troubleshooting method to troubleshoot a variable speed drive.

SUBJECTS

Troubleshooting a VSD System
Troubleshooting the Motor
Troubleshooting the Wiring
Troubleshooting the Electrical Supply

continued

SYSTEM TROUBLESHOOTING (CONTINUED)
(ACVST)

Five-Step Troubleshooting Method

Know the Equipment
Investigate Symptoms
List Probable Causes
Test Probable Causes
Discover Root Causes
Troubleshooting Case Study

Electrical Curriculum

Circuit Breakers

BREAKERS & SWITCHGEAR I

(AECLV)

OVERVIEW

This interactive training unit is designed to familiarize trainees with the basic operation and maintenance of low voltage circuit breakers and switchgear. After completing this unit, trainees should be able to describe the basic operation of a circuit breaker and the basic functions of switchgear. They should be able to explain how an arc forms and how arcs can be extinguished, and also describe basic procedures for racking out a circuit breaker and performing maintenance and testing on it.

OBJECTIVES

Basic Operation

Describe how an electromagnetic trip device operates in a typical circuit breaker.
Describe how a thermal element trip device operates in a typical circuit breaker.
Describe how a dashpot can be used to delay the movement of a trip device.
Describe ways in which circuit breaker contacts can be closed.
Describe the functions of three sections of a typical switchgear assembly.
Describe how a typical circuit breaker is connected to primary power and control power.

Principles of Circuit Interruption

Describe what an arc is and how it forms.
Describe how speed, distance, and cooling affect extinguishing an arc.
Describe how a metal fin arc chute can be used to extinguish an arc in a typical circuit breaker.
Explain what *current zero* is.

Maintenance

Describe a procedure for racking a circuit breaker out for preventive maintenance.
Describe a procedure for cleaning and inspecting a typical circuit breaker as part of preventive maintenance.
Describe how arc chutes and contacts are inspected and cleaned on a typical circuit breaker.
Describe how to clean a typical circuit breaker during an overhaul.
Describe how primary and secondary disconnect fingers are inspected on a typical circuit breaker.
Describe how to lubricate the moving parts in the operating mechanism of a typical circuit breaker.
Describe three checks that can be performed on the movable and stationary contacts of a typical circuit breaker.
Describe how to perform an instantaneous trip test and a time delay trip test on a typical circuit breaker.

continued

BREAKERS & SWITCHGEAR I (CONTINUED)

(AECLV)

SUBJECTS

Basic Operation
- Circuit Breakers
- Switchgear

Principles of Circuit Interruption
- Arcs
- Extinguishing an Arc

Maintenance
- Preventive Maintenance
- Overhaul
- Testing

BREAKERS & SWITCHGEAR 2

(AECHV)

OVERVIEW

This interactive training unit is designed to familiarize trainees with the basic operation and maintenance of high voltage breakers and switchgear. After completing this unit, trainees should be able to describe the basic operation of an air-magnetic circuit breaker and an oil circuit breaker. They should also be able to explain how each type of circuit breaker extinguishes an arc, and describe basic procedures for racking out high voltage circuit breakers and performing maintenance and testing on them.

OBJECTIVES

Principles of Operation

Describe the main components of a typical air-magnetic circuit breaker.
Describe how an arc is extinguished in a typical air-magnetic circuit breaker.
Describe the main components of a typical oil circuit breaker.
Describe how an arc is extinguished in a typical oil circuit breaker.
Describe a typical undervoltage and overvoltage protection system used with high voltage circuit breakers.

Maintenance of Air-Magnetic Circuit Breakers

Describe one way to disconnect an air-magnetic circuit breaker from power.
Describe how to inspect the interior of an empty switchgear cell.
Describe how to inspect the arc chutes and arc runners on a typical air-magnetic circuit breaker.
Describe how to inspect and clean the stationary and movable contacts on a typical air-magnetic circuit breaker.
Describe how to inspect the operating mechanism and the primary and secondary disconnects on a typical air-magnetic circuit breaker.
Describe how to perform electrical tests on a typical air-magnetic circuit breaker.

Maintenance of Oil Circuit Breakers

Describe a procedure for electrically isolating a typical oil circuit breaker.
Explain why an oil sample is typically taken from an oil circuit breaker before maintenance is performed.
Describe a procedure for disassembling a typical oil circuit breaker.
Describe how the contacts and the operating mechanism are maintained on a typical disassembled oil circuit breaker.
Describe a procedure for reassembling a typical oil circuit breaker.

SUBJECTS

Principles of Operation

Air-Magnetic Circuit Breakers
Oil Circuit Breakers
Circuit Protection

Maintenance of Air-Magnetic Circuit Breakers

Preparations
Inspection and Cleaning
Electrical Tests

Maintenance of Oil Circuit Breakers

Preparations
Inspection, Cleaning, and Reassembly

Electric Motors

DC MOTORS
(AEEDM)

OVERVIEW

This interactive training unit is designed to familiarize trainees with the basic operation and maintenance of DC motors. After completing this unit, trainees should be able to describe the operation and basic parts of a DC motor. They should also be able to describe basic procedures for maintaining and overhauling a DC motor.

OBJECTIVES

Motor Principles

Explain what *motor action* is.
Describe armature reaction in DC motors.
Identify the basic parts of a DC motor.
Explain how DC motors can be classified.

Motor Maintenance

Describe problems that can occur with the brushes in a DC motor.
Describe the characteristics of a good brush.
Explain how to inspect and replace brushes in a DC motor.
Describe how a commutator can be cleaned.
Describe typical commutator problems.
Describe a basic procedure for troubleshooting a DC motor's armature and field windings and their connections.
Describe how to test for grounds, opens, and shorts in a DC motor.

Motor Overhaul

Describe how to disassemble a DC motor.
Describe how to inspect and clean a disassembled DC motor.
Describe how to reassemble a DC motor.

SUBJECTS

Motor Principles

Motor Action
DC Motors

Motor Maintenance

Brushes and Brush Rigging
Commutators
Troubleshooting

Motor Overhaul

Disassembly
Inspection and Cleaning
Reassembly

THREE-PHASE
(AEETP)

OVERVIEW

This interactive training unit is designed to familiarize trainees with three-phase AC motor operation, inspection, testing, and maintenance. After completing this unit, trainees should be able to explain the basic principles of three-phase AC motor operation, how to inspect one, and how to conduct electrical tests on one. They should also be able to explain how to disconnect, disassemble, clean, reassemble, and reconnect a three-phase AC motor.

OBJECTIVES

Motor Principles

Describe alternating current.
Explain the relationship between the three phases of three-phase alternating current.
Identify the basic parts of a three-phase AC motor.
Identify and describe common types of three-phase AC motors.
Describe the operation of a typical three-phase AC motor.
Explain what slip is, and describe the effects of increasing load on an AC motor.
Describe how speed control can be accomplished in a three-phase AC motor.

Inspection and Testing

Describe how an operating and non-operating three-phase AC motor can be inspected.
Explain the purpose of an insulation test and describe how it can be conducted on a three-phase AC motor.
Describe how to test for grounds in the stator of a three-phase AC motor.
Describe how to test for opens in a wye-connected stator of a three-phase AC motor.
Describe how to test for opens in a delta-connected stator of a three-phase AC motor.
Describe how to test for shorts in the stator of a three-phase AC motor.
Describe how to test for grounds, opens, and shorts in the rotor circuit of a wound three-phase AC motor.

Motor Maintenance

Describe how to disconnect and disassemble a three-phase AC motor.
Describe how to inspect and clean a disassembled three-phase AC motor.
Describe how to reassemble and reconnect a three-phase AC motor.

continued

THREE-PHASE (CONTINUED)

(AEETP)

SUBJECTS

Motor Principles
- AC Review
- Three-Phase AC Motors
- Speed Control

Inspection and Testing
- Motor Inspection
- Insulation Testing
- Stator Testing
- Rotor Testing

Motor Maintenance
- Disconnection and Disassembly
- Inspection and Cleaning
- Reassembly and Reconnection

AC MOTOR CONTROLLERS I

(AEEA1)

OVERVIEW

This interactive training unit is designed to familiarize trainees with the basic functions and operation of AC motor controllers. After completing this unit, trainees should be able to explain how an AC motor controller operates and describe the operation of master switches and pilot devices that can be used with AC motor controllers. They should also be able to explain how an AC motor can provide overload protection and low voltage protection, and to describe the operation of special types of AC motor controllers.

OBJECTIVES

Introduction

Describe how a manual controller can be used to control a motor.
Describe how a magnetic controller can be used to control a motor.
Describe the parts and operation of a typical magnetic contactor.
Describe the operation of a magnetic contactor in a typical AC motor controller.
Describe the operation of maintaining master switches and momentary master switches.
Describe the operation of float switches, pressure switches, limit switches, and flow switches.
Describe the operation of bellows thermostats and bimetallic strip thermostats.
Explain how a mercury switch can be used in a pilot device.

Protective Devices

State the purpose of overload devices.
Describe the parts and operation of two types of thermal overload devices.
Describe the parts and operation of a typical magnetic overload device.
State the purpose of low voltage protection in a magnetic motor controller.
Describe the operation of an LVP and an LVR motor controller.
Explain how a low voltage relay operates.

Special Motor Controllers

Explain how a reduced voltage start motor controller provides protection to motors when they are first started.
Describe the operation of a two-speed and a reversible motor controller.

SUBJECTS

Introduction

Basic Principles
Contactors
Master Switches and Pilot Devices

Protective Devices

Overload Protection
Low Voltage Protection

Special Motor Controllers

Reduced Voltage Start
Two-Speed
Reversible

AC MOTOR CONTROLLERS 2
(AEEA2)

OVERVIEW

This interactive training unit is designed to familiarize trainees with basic procedures for troubleshooting and maintaining AC motor controllers. After completing this unit, trainees should be able to use diagrams and charts to obtain information about an AC motor controller. They should also be able to explain how to troubleshoot a problem in an AC motor controller and how to inspect and clean a controller's parts.

OBJECTIVES

Introduction
- Explain how to use a schematic diagram to obtain information about the operation of an AC motor controller.
- Explain how to use a wiring diagram to locate the components in an AC motor controller.
- Describe a typical legend and a typical sequencing chart.
- Describe a basic procedure for troubleshooting an AC motor controller.
- Identify and describe typical sources of information about the normal operation of an AC motor controller.
- Identify and describe possible sources of information about an AC motor controller malfunction.
- Describe how to use a schematic diagram to diagnose an AC motor controller malfunction.

Troubleshooting
- Describe how a voltage tester can be used to locate a malfunction in an energized AC motor controller.
- Describe how to test an AC motor controller to determine if it is de-energized.
- Describe how a megohmmeter can be used to test a de-energized AC motor controller for grounds.
- Describe how a multimeter can be used to locate an open and a short in a de-energized AC motor controller.

Maintenance
- Explain why an AC motor controller should be kept clean.
- Describe how an AC motor controller can be cleaned.
- Describe a basic procedure for inspecting an AC motor controller's magnetic contactor.
- Describe how to inspect an AC motor controller's wiring and components.

SUBJECTS

Introduction
- Diagrams and Charts
- Procedures

Troubleshooting
- Energized Controllers
- De-Energized Controllers

Maintenance
- Cleaning
- Inspection

MOTOR BRANCH CIRCUIT PROTECTION

(AEEMB)

OVERVIEW

This interactive training unit is designed to familiarize trainees with the basic operation and maintenance of motor branch circuits. After completing this unit, trainees should be able to describe the components of a typical motor branch circuit, preventive maintenance procedures, and one way to troubleshoot a problem in a motor branch circuit.

OBJECTIVES

Motor Branch Circuits

Describe a typical motor branch circuit.
Identify and describe protection devices typically used in motor branch circuits.
Describe a procedure for overriding a safety switch enclosure interlock.
Describe general characteristics of fuses commonly used in motor branch circuits.
Describe how to determine what size fuse to use when the proper fuse rating for a motor branch circuit is unknown.
Describe a typical molded-case circuit breaker and explain how it can be reset.
Describe the operation of thermal, magnetic, and thermal-magnetic molded-case circuit breakers.

Maintenance

Describe a low-impedance grounding system typically used with motor branch circuits and explain how it can be maintained.
Describe a general preventive maintenance procedure for a motor branch circuit.
Describe one way to troubleshoot a motor branch circuit.

SUBJECTS

Motor Branch Circuits

Circuits
Safety Switches
Circuit Breakers

Maintenance

Preventive Maintenance
Troubleshooting

BATTERY SYSTEMS

(AEETM)

OVERVIEW

This interactive training unit is designed to introduce trainees to industrial battery systems, and battery cells, and how to inspect and test batteries. After completing this unit, trainees should know the characteristics and basic operation of a typical battery system and its components. They should also understand how to inspect and perform basic tests on industrial batteries.

OBJECTIVES

Introduction to Battery Systems

Describe a typical industrial battery system.
List the basic components of a lead-acid cell.
Describe the electrochemical action in a cell that is charging.
Describe the electrochemical action in a cell that is discharging.
State the voltage rating for a typical cell at full charge.
Explain a cell's capacity rating.
Briefly describe the relationship of cell capacity, voltage, and specific gravity during discharge and recharge.
Describe the functions of a typical battery system charger.
List the common components of most battery chargers and describe their functions.

Inspection and Testing

List the protective equipment and safety procedures associated with working on batteries.
Describe typical visual inspection checks.
State the purpose of and describe the basic steps for checking intercell and terminal connection resistances.
State the purpose of and describe the basic steps for checking specific gravity.
Explain the effect of temperature on specific gravity.

SUBJECTS

Introduction to Battery Systems

System Overview
Cell Components
Cell and Battery Ratings
Battery Chargers

Inspection and Testing

Battery System Safety
Battery Inspection
Voltage and Resistance Testing
Specific Gravity Testing

TROUBLESHOOTING ELECTRICAL CIRCUITS

(AEETA)

OVERVIEW

This interactive training unit is designed to familiarize trainees with the use of basic troubleshooting procedures to troubleshoot problems in electrical circuits. After completing this unit, trainees should be able to identify and describe the main steps of a basic troubleshooting procedure and use the procedure to troubleshoot problems in electrical equipment and electrical systems.

OBJECTIVES

Troubleshooting Fundamentals

Explain what troubleshooting is.
Identify and describe the main steps of a basic troubleshooting procedure.
Describe how electrical tests can be used in the process of elimination.
Describe two basic ways that the process of elimination can be used in troubleshooting.

Troubleshooting Examples

Describe how to troubleshoot a problem in a piece of electrical equipment.
Describe how to troubleshoot a problem in an electrical system.

SUBJECTS

Troubleshooting Fundamentals

What is Troubleshooting?
The Process of Elimination

Troubleshooting Examples

Electrical Equipment
Electrical Systems

AC CIRCUITS
(AEEAC)

OVERVIEW

This interactive training unit is designed to familiarize trainees with basic concepts associated with the operation of AC circuits. After completing this unit, trainees should be able to explain how current flows through AC circuits and how AC current and voltage are affected by inductance and capacitance. They should also be able to define true power, reactive power, apparent power, and power factor, and to identify various types of single-phase and three-phase systems.

OBJECTIVES

Alternating Current

Explain the difference between direct current and alternating current.
Explain how current flow and polarity change in AC circuits.
Describe a sine wave that represents AC voltage.
Explain what frequency is, and how it is measured.
Define *peak value, peak-to-peak value*, and *effective value* with respect to AC voltage and current.

Inductance

Define *inductance* and *inductive reactance*.
Explain how inductive reactance limits current flow.
Explain how the inductive reactance in a circuit can be increased.
Describe the effects of inductance on current and voltage.

Capacitance

Define *capacitance* and *capacitive reactance*.
Explain how a capacitor is charged.
Describe the effects of capacitance on current and voltage.

AC Power

Differentiate between true power, reactive power, and apparent power.
Explain how power factor is used in calculating true power in AC circuits.
Explain how a three-wire single-phase AC system supplies two different voltages.
Differentiate between delta-connected and wye-connected three-phase AC systems.

SUBJECTS

Alternating Current

Current Flow
Sine Waves
Peak Values and Effective Values

Inductance

Inductance and Inductive Reactance
Factors That Affect Inductive Reactance
Inductance, Current, and Voltage

Capacitance

Capacitance and Capacitive Reactance
Capacitance, Current and Voltage

AC Power

True Power, Reactive Power, and Apparent Power
Single Phase and Three-Phase Systems

BASIC ELECTRICITY REVIEW
(AEBER)

OVERVIEW

This interactive training unit is designed to familiarize trainees with some of the basic principles associated with electricity and electrical circuits. After completing this unit, trainees should be able to explain where electricity comes from; what voltage, current, and resistance are; and how their values can be calculated for various types of circuits. They should also be able to explain how electrical circuits are affected by induction, inductance, and capacitance.

OBJECTIVES

Basic Concepts

Explain what atoms are, and how they are constructed.
Explain what voltage is, and how it can be produced.
Explain what current is, and state the basic difference between direct current and alternating current.
Explain what resistance is, and state the basic difference between a conductor and an insulator.
Explain how voltage, current, and resistance can be measured.
Explain what power and electrical energy are and how they can be measured.
Explain how Ohm's Law relates to current, voltage, and resistance.
Explain how to use Ohm's Law to calculate current, voltage, or resistance when the other two values are known.

Circuit Types

Describe the basic operating principles of a series circuit.
Explain how to calculate values for current, voltage, and resistance in a series circuit.
Describe the basic operating principles of a parallel circuit.
Explain how to calculate values for current, voltage, and resistance in a parallel circuit.
Describe the basic operating principles of a series-parallel circuit.
Explain how to calculate values for current, voltage, and resistance in a series-parallel circuit.

Circuit Characteristics

Explain what induction is and how voltage can be induced in a conductor.
Describe the basic operation of a transformer.
Explain what inductance is and how it affects electrical circuits.
Explain how the inductance of an inductor can be increased.
Explain what capacitance is and how it affects electrical circuits.
Describe the basic operation of a capacitor.

continued

BASIC ELECTRICITY REVIEW (CONTINUED)

(AEBER)

SUBJECTS

Basic Concepts
- Where Does Electricity Come From?
- Basic Electrical Quantities
- Ohm's Law

Circuit Types
- Series
- Parallel
- Series-Parallel

Circuit Characteristics
- Induction
- Inductance
- Capacitance

Electrical Wiring

CABLES AND CONDUCTORS
(AEECC)

OVERVIEW

This interactive training unit is designed to familiarize trainees with the basic construction and installation of electrical cables and conductors. After completing this unit, trainees should be able to describe the basic construction of cables and conductors, and how conductors are classified and rated. They should also be able to describe factors that affect the installation of a conductor for a specific application, and how to make splices and terminations.

OBJECTIVES

Basic Concepts
- Describe the basic construction of conductors.
- Describe how the physical characteristics of a conductor's wires affect how the conductor is classified and rated.
- Describe how the physical characteristics of a conductor's insulation affect how the conductor is classified and rated.

Installation Requirements
- Describe factors that determine the current requirements of a circuit.
- Describe factors that determine the voltage requirements of a circuit.
- Describe characteristics in an environment that affect the type of conductor that should be installed.
- Explain how environmental temperatures affect the type of conductor that should be installed.

Electrical Connections
- Describe factors that should be considered when a mechanical connector is selected.
- Describe factors that should be considered when replacement insulation is selected.
- Describe how to make a splice.
- Describe how to make a termination.

SUBJECTS

Basic Concepts
- Construction
- Classifications and Ratings

Installation Requirements
- The Circuit
- The Environment

Electrical Connections
- Connectors and Replacement Insulation
- Splices and Terminations

CONDUIT INSTALLATION

(AEECI)

OVERVIEW

This interactive training unit is designed to familiarize trainees with the basic concepts of conduit and conduit fittings, and typical methods of cutting, bending, and installing conduit. After completing this unit, trainees should be able to describe the basic types of metallic and nonmetallic conduit, common types of conduit fittings, and procedures for cutting, bending, and installing metallic and nonmetallic conduit.

OBJECTIVES

Materials

Define terms that are commonly used to describe conduit and conduit installations.
Describe common types of metallic conduit.
Describe common types of nonmetallic conduit.

Fittings

Describe types of couplings that are used to connect conduit in a straight line.
Describe types of fittings that are used to change the direction of a conduit run.
Describe types of fittings that are used to secure conduit when it is installed.

Cutting

Describe a method for cutting rigid types of metal conduit.
Describe a method for cutting flexible types of metal conduit.
Describe methods for cutting nonmetallic conduit.

Bending

Describe different types of conduit bends and explain where they might be used in an installation.
Explain how bends affect conduit measurements.
Describe how rigid-type metal conduit can be bent.
Describe how rigid PVC can be bent.

Installing

Describe tasks associated with terminating conduit to an electrical control box.
Describe how conductors can be installed in conduit.

SUBJECTS

Materials

Overview
Metallic Conduit
Nonmetallic Conduit

Fittings

Making Straight Connections
Changing Run Direction
Securing Conduit

Bending

Bend Types
Measurements
Demonstrations

Installing

Termination to a Box
Pulling Conductors

Foundations of the Electrician Craft – Level I

COMMERCIAL AND INDUSTRIAL WIRING

(AEECW)

OVERVIEW

This interactive training unit is designed to familiarize trainees with wiring devices and wiring techniques used at commercial and industrial sites. After completing this unit, the trainees should be able to identify various types of switches, enclosures, control devices, and receptacles. They should also be able to describe basic techniques for planning and installing branch circuits, mounting boxes, and working with conductors.

OBJECTIVES

Switches and Control Devices

Identify and state the functions of basic types of switches.
Describe NEMA classifications for switches and enclosures.
Describe the basic operation of a relay.
Describe the basic operation of a limit switch.
Describe basic types of switchgear.

Receptacles and Installation Methods

Describe common types of receptacles.
Identify and describe the operation of a ground-fault circuit interrupter receptacle.
Describe general steps involved in planning and installing a branch circuit.
Describe NEC requirements relating to box mounting procedures.
Describe a procedure for stripping, bending, and splicing conductors during the installation of a single-pole switch.

SUBJECTS

Switches and Control Devices

Switches
Switch and Enclosure Classifications
Control Devices

Receptacles and Installation Methods

Receptacles
Box Mounting and Wiring Techniques.

CONDUCTORS
(AEECO)

OVERVIEW

This interactive training unit is designed to familiarize trainees with the construction and use of various types of conductors and cables. After completing this unit, the trainees should be able to describe the physical construction of conductors, explain how to determine the electrical capacity of a conductor, identify various types of conductor assemblies, and describe procedures for pulling conductors through conduit.

OBJECTIVES

Physical Construction

Describe how conductors and cables can be constructed.
Describe two systems used to designate wire size.
Describe the construction and explain the purpose of stranding and compressing conductors.
Describe the functions that insulation serves on conductors.
Describe the letter coding and color coding systems used on conductor insulation.

Conductor Types

Describe factors that determine the electrical capacity of a conductor.
Describe various types of conductors and cables that are commonly used in residential and commercial construction.

Installation in Conduit

Describe tools and processes that can be used to pull lightweight conductors through conduit.
Describe tools and processes that can be used to pull heavyweight conductors through conduit.

SUBJECTS

Physical Construction

Conductors
Wires
Insulation

Conductor Types

Electrical Capacity
Conductor Assemblies

Installation in Conduit

Lightweight Pulls
Heavyweight Pulls

ELECTRICAL DIAGRAMS
(AEEED)

OVERVIEW

This interactive training unit is designed to familiarize trainees with various types of electrical diagrams. After completing this unit, trainees should be able to explain why symbols are used on electrical diagrams, and how to obtain information from a title block and an equipment location index. They should also be able to explain how to use each of the following types of diagrams: block, single line, schematic, wiring, connection, interconnection, and raceway.

OBJECTIVES

Diagram Basics

Explain why symbols are used on electrical diagrams.
State the purpose of the American Standard Device Function Numbers Table and the Standard Diagram Abbreviations Table.
State the purpose of legends on electrical diagrams.
Describe information commonly found in title blocks on electrical diagrams.
State the purpose of notes on electrical diagrams.
Define *equipment location index*.
Describe how to use an equipment location index.

Types of Diagrams

State the purpose of a block diagram.
State the purpose of a single line diagram.
Identify symbols commonly used on single line diagrams.
Describe information that can be found on single line diagrams.
State the purpose of a schematic diagram.
Describe how to read a schematic diagram.
State the purpose of a wiring diagram.
Describe how to use a wiring diagram to locate components.
State the purpose of a connection diagram.
Describe how to read a connection diagram.
State the purpose of an interconnection diagram.
Describe how to read an interconnection diagram.
State the purpose of a raceway diagram.
Describe how to read a raceway diagram.
Explain how to use *Raceway Notes, Symbols, and Detail Reference,* and a *Raceway Schedule*.

SUBJECTS

Diagram Basics

Symbols
Title Blocks
Equipment Location Index

Types of Diagrams

Block Diagrams
Single Line Diagrams
Schematic Diagrams
Wiring Diagrams
Connection Diagrams
Raceway Diagrams

ELECTRICAL SAFETY
(AEEES)

OVERVIEW

The purpose of this unit is to give trainees a general understanding of basic principles of electricity and electrical safety.

At the conclusion of this unit, trainees will have a basic understanding of various aspects of working safely around electrical equipment.

OBJECTIVES

Electrical Concepts
Describe the basic electrical quantities of current, voltage, and resistance.

Shock
State what an electrical shock is.
Describe factors that affect the severity of an electrical shock.
Describe the physical effects of current passing through the human body.

Hazards
Describe hazards associated with working near electrical equipment.

Protection
Describe ways of providing protection to personnel from hazards associated with electricity.

Emergencies
Describe how to safely give aid to an electrical shock victim.
Describe how to safely respond to an electrical fire.

SUBJECTS

Electrical Concepts
Friend or Foe?
Current
Voltage
Resistance

Shock
What Is Shock?
Amount of Current
Length of Time
Path Through the Body
Effects

Hazards
High Voltage Area
Overloaded Circuits
Damaged Cords
Bare Connectors
Long and Tall Objects
Mobile Equipment
Standing Water

ELECTRICAL TEST EQUIPMENT
(AEEET)

OVERVIEW

This interactive training unit is designed to familiarize trainees with the basic operation and use of common types of electrical test equipment. After completing this unit, trainees should be able to explain how to set electrical test equipment to measure current, voltage, and resistance; how to take readings; and how to interpret the readings.

OBJECTIVES

Fundamentals

Describe two basic types of displays commonly found on test equipment.
Describe controls commonly found on test equipment.
Describe how to read a meter that has a digital display.
Describe how to read a meter that has an analog display.

Using Test Equipment

Describe two basic types of measurements.
Describe factors that should be considered when a piece of test equipment is selected for a job.
Describe general safety precautions associated with using test equipment.
Describe the basic steps involved in taking a measurement.
Describe the basic operation of an ammeter.
Describe the basic operation of a voltmeter.
Describe how to properly use a voltmeter.
Describe the basic operation of a test instrument that measures resistance.
Describe how to properly use test equipment that measures resistance.

SUBJECTS

Fundamentals

Types of Displays
Controls
Reading Displays

Using Test Equipment

Basic Guidelines
Measuring Current
Measuring Voltage
Measuring Resistance

FASTENERS
(AEEFA)

OVERVIEW

This interactive training unit is designed to familiarize trainees with various types of fasteners used in electrical work. After completing this unit, the trainees should be able to describe common types of threaded and non-threaded fasteners and identify applications for which each type might be used. They should also be able to describe basic procedures for installing fasteners.

OBJECTIVES

Types of Fasteners

Describe some common types of threaded fasteners and identify applications for which these fasteners may be used.
Describe some common types of non-threaded fasteners and identify applications for which these fasteners may be used.

Installing Fasteners

Describe general steps for installing threaded fasteners.
Describe a typical procedure for installing a toggle bolt.
Describe a typical procedure for installing an anchor bolt in wet concrete.
Describe a typical procedure for installing an expansion anchor bolt in hardened concrete.
Describe a typical procedure for installing blind rivets.

SUBJECTS

Types of Fasteners

Threaded Fasteners
Non-Threaded Fasteners

Installing Fasteners

Basic Steps
Installing Toggle Bolts
Installing Anchor Bolts
Installing Blind Rivets

HAND BENDING
(AEEHB)

OVERVIEW

This interactive training unit is designed to familiarize trainees with the basic concepts associated with cutting, measuring, and bending conduit. After completing this unit, the trainees should be able to describe how to make accurate stub bends, offset bends, three-bend saddles, and four-bend saddles. They should also be able to describe basic procedures for measuring conduit for specific types of bends and for cutting conduit.

OBJECTIVES

Bends & Equipment
- Describe types of bends that are commonly used in that are commonly used in conduit installations.
- Describe types of equipment that are commonly used to bend conduit.

Measurement
- Use terms from basic geometry to describe circles and triangles.
- Explain terms used to describe conduit bend measurements.

Bending Conduit
- Describe how to make accurate 90-degree stub bends.
- Describe how to make accurate offset and parallel offset bends.
- Describe how to make accurate three-bend saddles.
- Describe how to make accurate four-bend saddles.

Cutting Conduit
- Describe two methods for cutting metal conduit
- Describe how to ream and rethread metal conduit.
- Describe two methods for cutting PVC conduit.
- Describe a method for joining PVC conduit to a PVC junction box.

SUBJECTS

Bends & Equipment
- Bend Types
- Bending Equipment
- Measurement

Basic Geometry
- Bend Measurements
- Bending Conduit
- Stub Bends

Offset Bends
- Three-Bend Saddles
- Four-Bend Saddles

Cutting Conduit
- Cutting Metal Conduit
- Reaming & Threading Metal Conduit
- Cutting and Joining PVC Conduit

INTRODUCTION TO THE NEC
(AEEIN)

OVERVIEW

This interactive training unit is designed to familiarize trainees with the organization and layout of the National Electrical Code. After completing this unit, the trainees should be able to use the NEC to locate specific types of information.

OBJECTIVES

Overview

Explain the purpose and describe the history of the NEC.
Describe how the NEC was developed and revised.
Describe the role of testing laboratories in developing the NEC.
Describe the purpose of the NFPA and the NEMA.
Explain the difference between mandatory rules and advisory rules.
Describe the kinds of information found in Articles 90, 100, and 110 of the NEC.
Define the terms labeled and listed.
Describe how the chapters of the NEC are organized.
Describe the different types of text used in the NEC.

Using the NEC

Explain how to locate information for a particular procedure in the NEC.
Identify and describe key sections of the NEC that are often used as references for servicing electrical systems.
Describe how the NEC can be used as a reference for installing electrical systems.

SUBJECTS

Overview

Purpose and History
Layout

Using the NEC

Navigating
Examples

RACEWAYS
(AEERA)

OVERVIEW

This interactive training unit is designed to familiarize trainees with various types of raceways used to house electrical wiring. After completing this unit, the trainees should be able to describe various types of raceways, including conduit, wireways, and cable trays. They should also be able to describe procedures for installing raceways in various types of environments.

OBJECTIVES

Conduit and Boxes

Identify and describe types of conduit commonly used as raceways.
Identify and describe fittings used with conduit.
Identify and describe common types of supports used with conduit.
Describe typical boxes used with raceways.
Describe common fittings used to join conduit to boxes.
Describe how to make a conduit-to-box connection.

Wireways and Cable Trays

Define the term wireway and describe common types of wireways.
Identify and describe fittings used with wireways.
Identify and describe typical wireway supports.
Describe surface metal raceways.
Describe plugmold multi-outlet raceways.
Describe underfloor raceways.
Describe cellular metal floor raceways and cellular concrete floor raceways.
State the function of cable trays and identify two basic forms of cable trays.
Describe typical cable tray fittings and cable tray supports.

Procedures

Describe proper and safe methods for storing raceways.
Describe proper and safe methods for handling raceways.
Define the term duct.
Identify and describe typical methods that can be used to install underground cable.
Describe procedures for installing raceways and boxes in a metal stud environment.
Describe procedures for installing raceways and boxes in a wood frame environment.
Describe procedures for installing raceways in a steel environment.
Describe procedures for installing raceways and boxes in a drywall surface-mount environment.

continued

RACEWAYS (CONTINUED)
(AEERA)

SUBJECTS

Conduit and Boxes
- Conduit
- Fittings
- Supports
- Boxes

Wireways and Cable Trays
- Wireways
- Other Raceways
- Cable Trays

Procedures
- Storing & Handling Raceways
- Underground Systems
- Construction Procedures

Foundations of the Electrician Craft - Level II

ALTERNATING CURRENT
(AEEAL)

OVERVIEW

Alternating Current is an interactive training module designed to familiarize trainees how AC circuits work, and how voltage and current can change depending on the load, the source, and how the load and source are connected together. After completing this module, the trainees should be able to determine current and voltage values for an AC sine wave; explain how resistance, inductance, and capacitance affect AC circuits; explain how to calculate power in AC circuits and how to adjust power by correctly selecting and sizing circuit components; and describe the construction, operation, and use of various types of transformers.

OBJECTIVES

Explain why voltage rises and falls in an AC circuit.
Determine the voltage values for any theta of an AC sine wave.
Calculate the peak, effective, and rms voltage values for a given AC sine wave.
Identify the phase relationships between two AC waveforms.
Identify leading and lagging waveforms.
Create a vector diagram describing the phase relationships between two AC waveforms.
Describe the phase relationship between voltage and current in a resistive AC circuit.
Calculate the voltage, current, resistance, and power in an AC resistive circuit.
Describe the voltage and current transients that occur in an inductive AC circuit.
Identify factors that can affect the inductive reactance in an AC circuit.
Recognize a vector diagram for an AC inductive circuit.
Calculate the inductive reactance in an AC circuit.
Describe the voltage and current transients that occur in a capacitive AC circuit.
Identify factors that can affect the capacitance of an AC circuit.
Recognize a vector diagram for an AC capacitive circuit.
Calculate the capacitive reactance in an AC circuit.
Describe the voltage and current relationships in circuits that contain resistance, inductance, and capacitance.
Create vector diagrams that describe the impedance of AC circuits that contain resistance, inductance, and capacitance.
Calculate the impedance, voltage, and current through AC circuits that contain resistance, inductance, and capacitance.
Describe the effect of resonant frequencies in series and parallel circuits.
Describe how bandwidth is affected by resistance in series and parallel circuits.
Describe the relationship between true power, apparent power, and reactive power in an AC circuit.
Calculate the true power, apparent power, reactive power, and power factor of an AC circuit.
Determine whether the power factor of a circuit is leading or lagging.

continued

ALTERNATING CURRENT (CONTINUED)

(AEEAL)

Explain basic transformer action.
Identify the phase relationships between the windings in a transformer.
Use the turns ratio to determine transformer input and output voltages.
Calculate transformer input and output voltages.
Identify several types of transformers.
Describe the operation of several types of transformers.
Describe the applications of several types of transformers.

SUBJECTS

AC Voltage and Current
Sine Wave Concepts
Sine Wave Phase Relationships
AC Resistance, Inductance, and Capacitance
Resistance in AC Circuits
Inductance in AC Circuits
Capacitance in AC Circuits
Combination AC Circuits
Resonance in AC Circuits
Power in AC Circuits
True, Apparent, and Reactive Power
Transformers
Transformer Operating Characteristics
Common Transformer Types

MOTORS
(AEEMT)

OVERVIEW

Motors is an interactive training module designed to familiarize trainees with the operation and use of various types of electric motors. After completing this module, the trainees should be able to describe the basic construction and operation of DC motors, AC induction motors, and AC synchronous motors. They should also be able to explain how motor speed can be controlled and how motors and motor circuits can be protected from damage, and they should be able to interpret the information on a motor nameplate.

OBJECTIVES

Describe how DC motors operate.
Identify the component parts of series, shunt, and compound DC motors.
Identify typical applications of DC series, shunt, and compound motors.
Describe the basic construction and components of a three-phase squirrel cage induction motor.
Explain the relationship between speed and frequency in an induction motor.
Describe how torque is developed in an induction motor.
Explain how and why torque varies with rotor reactance and slip.
Define percent slip and speed regulation.
Explain how the direction of a three-phase induction motor is reversed.
Describe the component parts and operating characteristics of a three-phase, wound rotor induction motor.
Describe the component parts and operating characteristics of a three-phase synchronous motor.
Describe the operation of a variety of single-phase AC motors.
Identify the component parts of single-phase AC motors.
Recognize and interpret wiring diagrams for single-phase AC motors.
Identify specific applications where single-phase motors may be used.
Explain the relationship between speed and the number of poles in an induction motor.
Describe the operation of multiple-winding AC motors.
Describe the operation of consequent-pole AC motors.
Describe the operation of a variable speed AC drive.
Identify common types of open motors.
Identify common types of totally enclosed motors.
Describe types of motor enclosures using a NEMA table.
Identify the frame designation number on a machine nameplate.
Interpret the "D" and "2F" dimensions on the nameplate of a medium machine.
Read dimension sheets for foot-mounted machines.
Interpret the information on a motor nameplate.
Consult a nameplate when replacing or installing a motor.
Match a motor to an application by reading the nameplate.
Select fuses for motor control applications.
Determine how many overloads should be used in a motor control circuit.

continued

MOTORS (CONTINUED)
(AEEMT)

Determine the maximum allowable settings for overloads.
Determine the required ampacity of a motor control circuit.
Use a schematic and test equipment to identify the windings in a motor.
Use a schematic and test equipment to identify the arrangements of circuits in a motor.
Use a schematic and test equipment to identify the polarity of windings in a motor.
Recognize basic NEC requirements for motors.
Recognize basic NEC requirements for conductors.
Recognize basic NEC requirements for motor protectors.
Recognize basic NEC requirements for controllers.
Recognize basic NEC requirements for circuit protectors.
Recognize basic NEC requirements for disconnects.
Receive a motor for installation.
Check the basic condition of a motor prior to installation.
Begin the motor installation process.
Suggest maintenance procedures that may prolong the life of a motor.
Examine an induction motor stator for signs of obvious damage.
Examine an induction motor rotor for signs of obvious damage.
Suggest procedures to check for motor overloading and single-phasing.

SUBJECTS

Motor Theory
DC Motors
AC Motors
Synchronous Motors
Small AC Motors
Types of Single-Phase Motors
Motor Speed Control
Motor Terminology
Motor Enclosures
Motor Frames
Motor Nameplates
Motor Installation
Motor and Circuit Protection
Motor Connections
NEC Requirements
Working with Motors
Setting Up and Testing Motors
Troubleshooting Motors

GROUNDING
(AEEGD)

OVERVIEW

Grounding is an interactive training module designed to familiarize trainees with both system grounding and equipment grounding. After completing this module, the trainees should be able to describe different types of grounding, describe NEC requirements associated with system grounding, and describe how to size and install grounding electrode conductors. They should also be able to describe NEC requirements associated with equipment grounding, describe how to size equipment grounding conductors and bonding jumpers, and explain how to make sure that a grounding system is effective.

OBJECTIVES

Explain what grounding is.
Describe the different types of grounding.
Describe the problems of short circuits and ground faults, which are commonly associated with grounding.
Describe the parts of and the NEC grounding requirements for various types of electrical systems.
Describe NEC requirements for grounding electrodes.
Describe how to size and install grounding electrode conductors.
Describe NEC requirements for grounding and bonding electrical equipment and enclosures.
Describe how to size an equipment grounding conductor.
Describe how to size the bonding jumpers for a variety of applications.
Describe the importance of an effectively grounded system.
Describe NEC requirements for grounding in different types of systems.
Describe what a ground resistance tester is.
Describe how a ground resistance tester can be used to test for effective grounds.

SUBJECTS

Basics
Purpose of Grounding
Common Problems
System Grounding
Types of Systems
Grounding Electrodes
Grounding Electrode Conductors
Equipment Grounding
Grounding and Bonding Requirements
Equipment Grounding Conductors
Bonding Jumpers
Effective Grounds
Fundamentals
System Requirements
Testing for Effective Grounds

CONDUIT BENDING
(AEECB)

OVERVIEW

Conduit Bending is an interactive training module designed to familiarize trainees with the use of various types of benders to bend conduit for common applications. After completing this module, the trainees should be able to calculate the measurements required for conduit bending and properly bend conduit using any or all of the following types of benders: mechanical benders, electric benders, hydraulic benders, and PVC heater/benders.

OBJECTIVES

Recognize and identify each of the following types of bends: elbow, back-to-back, offset, saddle, and kick.
Explain the relationship between a right triangle and conduit bending.
Explain the relationship between a circle and 90º bends.
Use equations to calculate measurements required for conduit bending.
Describe safety considerations associated with conduit bending.
Describe NEC requirements for conduit bending.
Identify the parts of a typical mechanical bender.
Use a mechanical bender to bend conduit for specific applications.
Identify the parts of a typical electric bender.
Use an electric bender to bend conduit for specific applications.
Identify the parts of a typical hydraulic bender.
Use a hydraulic bender to bend conduit for specific applications.
Properly make a solvent-cemented PVC joint.
Use a PVC heater/bender to bend PVC conduit for a specific application.

SUBJECTS

Bending Considerations
Types of Bends
Shapes and Equations
Safety and NEC Requirements
Using Conduit Benders
Mechanical Benders
Electric Benders
Hydraulic Benders
PVC Heater/Benders

BOXES AND FITTINGS
(AEEBF)

OVERVIEW

Boxes and Fittings is an interactive training module designed to familiarize trainees with various types of boxes and fittings used in electrical installations. After completing this module, the trainees should be able to identify different types of boxes and explain how to properly size outlet boxes, pull boxes, and junction boxes. They should also be able to identify different types of couplings, locknuts, and bushings, and explain what seal-off fittings are and how they are installed. In addition, they should be able to describe the three classes of hazardous locations that are identified in the NEC and describe requirements for safely installing boxes and fittings in hazardous locations.

OBJECTIVES

Describe different types of boxes that are used in electrical installations and typical applications for which each type is appropriate.
Describe how to properly size outlet boxes, pull boxes, and junction boxes.
Describe concerns that are associated with installing pull boxes and junction boxes.
Describe types of couplings that are used to connect different types of conduit in electrical installations.
Describe different types of locknuts and bushings that are used in electrical installations.
Describe what seal-off fittings are and explain how they are installed.
Describe environmental conditions and equipment requirements that are associated with installing boxes and fittings in damp or wet locations.
Describe the conditions that make an area a "hazardous location" for electrical installations.
Describe the three classes of hazardous locations that are identified in the NEC.
Describe requirements for safely installing boxes and fittings in hazardous locations.

SUBJECTS

Boxes
Types of Boxes
Sizing and Installing Boxes
Fittings
Couplings
Seal-Off Fittings
Special Locations
Types of Locations
Hazardous Location Installations

CONDUCTOR INSTALLATIONS
(AEECD)

OVERVIEW

Conductor Installations is an interactive training module designed to familiarize trainees with general procedures for properly planning and carrying out conductor installations. After completing this module, the trainees should be able to plan the steps of a cable pulling operation, calculate the tension for a pull, properly set up a cable puller, and correctly use pulling equipment.

OBJECTIVES

Explain the importance of careful planning for cable pulls.
Explain the importance of measuring to determine the required lengths of cable.
Explain the importance of selecting the proper location for cable pulls.
Describe the steps common to cable pulling operations.
Identify steps missing from cable pulling procedures.
Plan the steps of a cable pulling operation in the proper order.
Recognize guidelines that protect cable before, during, and after a pull.
Determine the allowable tension on a pulling device.
Determine the tension on a conductor in an installation.
Determine the sidewall load in a conductor installation.
Receive cable reels at a job site.
Transport cable reels to specific areas within a site.
Select the equipment necessary for setting up the cable reels.
Set up cable reels for a pull.
Identify tooling required to inspect and measure a raceway.
Inspect a raceway.
Measure a raceway.
Identify tooling required to install pull lines.
Use power fishing equipment to help measure a raceway.
Use power fishing equipment to install a pull line.
Prepare cables for pulling.
Identify unsafe work practices and procedures prior to and during a cable pulling operation.
Perform inspections of equipment to determine if they can be used safely.
Determine if the equipment being used for a pull is adequately rated for the job.
Determine if the available communication resources are adequate for the job.
Set up a cable puller for an up or a down pull.
Set up a cable puller for sealed conduit and exposed conduit.
Correctly set up reels and sheaves for a variety of pulls.
Provide the proper support and control of conductors during a cable pull.
Plan for the pulling of cables in cable trays.

continued

CONDUCTOR INSTALLATIONS (CONTINUED)

(AEECD)

SUBJECTS

- Planning Conductor Installations
- Typical Preparations
- Typical Operations Overview
- Determining Pulling Tension
- General Guidelines
- Calculating Tension in a Pull
- Setting Up for Cable Pulling
- Setting Up Reels
- Preparing Raceways
- Preparing Pull Lines and Cables
- Using Pulling Equipment
- Safety
- Setting Up Cable Pullers
- Pulling Cable

CABLE TRAY
(AEECT)

OVERVIEW

Cable Tray is an interactive training module designed to familiarize trainees with cable tray components and installation techniques. After completing this module, the trainees should be able to identify the types of sections and the types of fittings used in cable tray assemblies, explain how cable tray is supported, and explain how cable tray sections are spliced. They should also be able to size cable tray for specific numbers and types of conductors.

OBJECTIVES

Describe the sections used in cable tray assembly.
Describe the NEC requirements for cable tray construction.
Select the proper cable tray sections for specific applications.
Identify cable tray sections on working drawings.
Describe the effects of improper tray loading.
Describe the connectors, barrier strips and covers used in cable tray assemblies.
Select the proper cable tray fittings for the situation.
Identify cable tray fittings on working drawings.
Describe the splice plates used in cable tray assembly.
Select the proper cable tray fittings for the situations.
Explain the methods used to hang and secure cable tray.
Describe where splices in straight tray sections should be located.
Describe a method used to fabricate an offset in cable tray.
Describe the NEC requirements for cable tray installation and grounding.
Select the required fittings to ensure equipment-grounding continuity in cable tray systems.
Size cable tray for the number and types of conductors contained in the system.
Describe the NEC requirements for cable tray conductors.
Describe the general requirements for pulling cable in tray systems.
Describe how cable is supported in vertical tray.
Describe how cable exits cable tray.

SUBJECTS

Sections
Section Types
Effects of Loading
Fittings
Connectors, Barrier Strips, and Covers
Splice Plates
Installation
Types of Support
Splicing Sections and Fabricating Offsets
Conductors
Determining the Number of Conductors
Installing Conductors

CONDUCTOR TERMINATIONS AND SPLICES
(AEETS)

OVERVIEW

Conductor Terminations and Splices is an interactive training module designed to familiarize trainees with devices, tools, and procedures commonly used to terminate and splice conductors in electrical installations. After completing this module, the trainees should be able to properly strip conductors, train or bend cable, and choose connectors for specific applications. They should also be able to properly install twist-on wire connectors, crimp-type connectors, and mechanical-type connectors; and properly insulate terminations and splices.

OBJECTIVES

State the basic requirements for a good electrical connection.
Describe NEC requirements for the termination of conductors.
Describe NEC requirements for the installation of enclosures containing conductors.
Explain why the ends of conductors must be properly stripped and cleaned before connections are made.
Use appropriate tools to strip various types of conductors.
Explain the differences between training cable and bending cable.
Describe requirements associated with bending cable.
Identify factors involved in selecting connectors.
Describe precautions that apply to aluminum connections.
Select twist-on wire connectors for specific applications.
Splice wires using twist-on wire connectors.
Select crimp-type connectors for specific applications.
Describe various types of crimping tools.
Properly use a hand-operated crimping tool.
Properly use a hydraulic crimping tool.
Terminate wires using crimp-type connectors.
Select mechanical-type connectors for specific applications.
Terminate wires using mechanical-type connectors.
Identify a typical specialized cable connector.
Select and install a heat-shrink insulator.
Select and use electrical insulating tape to insulate an electrical joint.
Describe the purpose and use of motor connection kits.

SUBJECTS

Preparation
Basic Requirements
Stripping Conductors
Bending Cable
Making Terminations and Splices
Choosing Connectors
Twist-On Wire Connectors
Crimp-and Mechanical-Type Connectors
Specialized Cable Connectors
Insulating Connections

INSTALLATION OF ELECTRIC SERVICES
(AEEIS)

OVERVIEW

Installation of Electric Services is an interactive training module designed to familiarize trainees with considerations associated with installing a commercial or industrial electric service. After completing this module, the trainees should be able to describe various types of electric services for commercial and industrial installations, and they should be able to identify and describe the main components of those services. They should also be able to explain how to select and install equipment for a single-phase service and a three-phase service.

OBJECTIVES

Describe the essential elements of an AC electrical system.
Describe various types of electrical services for commercial and industrial installations.
Describe single-phase service connections.
Describe wye-connected and delta-connected three-phase services.
Describe the function of each part of a typical electric service.
Read electrical blueprints and diagrams describing service installations.
Explain the role of the NEC in service installations.
Calculate and select service entrance equipment.
Identify the circuit loads, number of circuits required, and installation requirements for distribution panels.
Explain the types and purposes of service grounding.
Identify the main difference between installing a single-phase service and installing a three-phase service.
Describe considerations associated with installing panelboards.
Install a panelboard.
Identify various types of safety switches.
Install a safety switch.
Describe the basic requirements of a maintenance program for electrical panelboards and switches.

SUBJECTS

Transmission & Distribution Review
Power Generation and Delivery
Common Power Supplies
Service Installation
Service Components
Equipment Selection and Installation
Three-Phase Services
Panelboards, Load Centers, and Switches
Panelboards and Load Centers
Switches
Maintenance

CIRCUIT BREAKERS AND FUSES

(AEECF)

OVERVIEW

Circuit Breakers and Fuses is an interactive training module designed to familiarize trainees with the use of overcurrent protective devices in electrical installations. After completing this module, the trainees should be able to describe hazards associated with faults and overloads, describe the operation and common types of circuit breakers and fuses, and describe basic procedures for troubleshooting problems with circuit breakers and fuses.

OBJECTIVES

Describe the following types of overcurrent: short circuit, ground fault, arc fault, overload.
Identify different types of overcurrent protective devices and describe appropriate uses for each type.
Describe some general safety practices that are associated with the use of overcurrent protective devices.
Describe the use of selective coordination of overcurrent protective devices in electrical systems.
Describe the basic steps of the point-to-point method for calculating short circuit currents.
Describe the basic operation of a standard molded-case circuit breaker.
Identify and describe the following types of circuit breakers: standard molded case circuit breakers, multipole circuit breakers, GFCI circuit breakers, and current-limiting circuit breakers.
Describe classifications, ratings, and labeling requirements for circuit breakers.
Describe basic procedures involved in troubleshooting a standard molded-case circuit breaker.
Describe the function and basic components of fuses.
Describe the ratings that apply to fuses.
Describe the basic components, markings, UL classes, and appropriate uses for single-element cartridge fuses and dual-element cartridge fuses.
Identify the basic features and appropriate uses of Edison-base plug fuses and Type S plug fuses.
List some guidelines for sizing dual-element time-delay fuses and non-time-delay fuses.
Describe basic procedures for troubleshooting cartridge fuses.

continued

CIRCUIT BREAKERS AND FUSES (CONTINUED)

(AEECF)

SUBJECTS

- Improper Current Flow
- Overcurrents
- Overcurrent Protection
- Selective Coordination
- Short Circuit Calculations
- Circuit Breakers
- Operation and Types
- Identification
- Troubleshooting Circuit Breakers
- Fuses
- Functions and Ratings
- Types and Sizing
- Troubleshooting Fuses

CONTACTORS AND RELAYS
(AEECR)

OVERVIEW

Contactors and Relays is an interactive training module designed to familiarize trainees with the operation and use of magnetic contactors and relays. After completing this module, the trainees should be able to describe the operating principles of magnetic contactors and relays, and explain how both types of devices are used in electrical systems. They should also be able to describe the components and operation of low-voltage remote control switching systems.

OBJECTIVES

Describe the operating principles of magnetic contactors.
Explain how mechanical contactors operate.
Describe the operating principles of contactors used as motor starters.
Explain how a motor starter operates.
Read wiring diagrams involving contactors.
Describe the operation of contactors in lighting circuits.
Read wiring diagrams involving lighting contactors.
Select protective enclosures to match the surrounding environment.
Describe the operating principles of relays.
Explain the functions of control relays in electrical systems.
Read wiring diagrams involving control relays.
Explain how solid-state relays operate.
Explain the functions of solid-state relays in electrical systems.
Read wiring diagrams involving solid-state relays.
Explain the functions of overload relays in motor circuits.
Describe the operation of thermal overload relays.
Troubleshoot contactor/relay problems.
List the advantages of low-voltage remote control switching.
Design and draw a wiring diagram of a simple remote control circuit.
Explain the operation of a low-voltage remote control switching system.

SUBJECTS

Magnetic Contactors
Operating Principles
Motor Starters
Lighting Contactors
Protective Enclosures
Relays
Control Relays
Solid-State Relays
Overload Relays
Relay Troubleshooting
Low-Voltage Remote Control Switching
Components
Operation

ELECTRIC LIGHTING
(AEEEL)

OVERVIEW

Electric Lighting is an interactive training module designed to familiarize trainees with various types of lamps and lighting fixtures and how install them. After completing this module, the trainees should be able to explain how the human eye sees and describe the characteristics of light. They should also be able to compare and contrast various types of lamps, and they should be able to explain how to install various types of light fixtures.

OBJECTIVES

Explain how the human eye works.
Describe the characteristics of light.
Recognize the different kinds of lamps and explain the advantages and disadvantages of each type.
Recognize the different kinds of incandescent lamps and explain the advantages and disadvantages of each type.
Recognize the different kinds of fluorescent lamps and explain the advantages and disadvantages of each type.
Recognize the different kinds of HID lamps and explain the advantages and disadvantages of each type.
Properly select and install lamps into lighting fixtures.
Recognize and install various types of light fixtures.
Recognize and install surface-mounted fixtures.
Recognize and install recessed fixtures.
Recognize and install suspended fixtures.
Recognize and install track-mounted fixtures.
Electrically connect various types of lighting fixtures.

SUBJECTS

Lighting Principles
The Eye and Vision
Light Characteristics

Lamps
Lamp Characteristics
Incandescent Lamps
Fluorescent Lamps
High-Intensity Discharge Lamps
Lamp Handling

Fixtures and Installation
Handling and Installation
Surface-Mounted Fixtures
Recessed Fixtures
Suspended Fixtures
Track-Mounted Fixtures
Light Fixture Wiring

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