The Manufacturers Association

TRAINING PLAN – Maintenance Mechanic (YEAR 4)

Total Related Training Instruction (RTI) Hours: 144

Learning Unit	Hrs. of Instruction
Unit 4-1: Machine Shop: Mill and Lathe ➢ Manual Mill Set Up and Operation ➢ Engine Lathe Set Up and Operation ➢ CNC Machine Overview	43
Unit 4-2: Hydraulics/Pneumatics: Level 2 ➢ Hydraulic and Pneumatic Power Variables ➢ Hydraulic and Pneumatic Power Sources ➢ Hydraulic and Pneumatic Control Valves ➢ Actuator Applications ➢ Hydraulic and Pneumatic Circuit Design	38
Unit 4-3: Motor Controls ➢ Relays, contactors, and starters. ➢ Control Devices ➢ Distribution Systems ➢ Switches ➢ Electric Motors Logic and Line Diagrams ➢ DC and AC Motor Applications	23
Unit 4-4 PLCs ➢ Introduction to PLCs ➢ Basics of Ladder Logic ➢ Basic Programming	17
Unit 4-5: Automation ➢ Robot Components ➢ Systems and Controls ➢ Robot Axes ➢ Robot Maintenance ➢ Robot Troubleshooting.	23

Unit 4-1: Machine Shop: Mill and Lathe

The learning unit introduces the process of machining on a manual mill and engine lathe. Instruction covers the basic components of the engine lathe and column-and-knee mill and addresses how these components are used during the various cutting processes. The unit also focuses on the setup of the engine lathe and mill and instruction on how to perform a variety of cutting operations on sample parts. This unit concludes with a brief overview of CNC machining.

Learning Outcomes and Content

1. Describe various benchwork and layout processes that operators often need to perform during manual machining
2. Identify and describe the types of mills
3. Describe how to accurately select process variables and perform manual mill setup

4. List the steps of creating a part on the manual mill, including determining the order of operations, squaring the six sides, creating a step, grooving, center drilling, and drilling
5. Describe common holemaking operations on the manual mill
6. Identify and describe the types of lathes
7. Describe how to accurately select process variables and perform engine lathe setup
8. List the steps of creating a part on the engine lathe
9. Describe the manual lathe components used for threading
10. Describe methods for turning basic tapered parts on an engine lathe
11. Discuss the origin of today's CNC machines and explain how modern CNC evolved from its original designs
12. Describe common components of CNC machine tools and controls
13. Describe the basic functions and general machine components of a CNC lathe
14. Explain the purpose of frequently used controls on the control panel of a CNC lathe
15. Describe the general machine components of a CNC mill and their basic function
16. Explain the purpose of frequently used controls on the control panel of a CNC mill

Learning Modules

Module	Hrs. of Instruction	Provider
Benchwork and Layout Operations – This learning module provides a detailed overview of the various benchwork and layout processes that operators often need to perform during manual machining.	1.5	ToolingU-SME
Manual Mill Basics - This learning module introduces the machine components, cutting tools and workholding devices commonly used on milling machines.	1.5	ToolingU-SME
Manual Mill Setup – This learning module details important considerations that a mill operator must make before starting any cutting process as well as the steps an operator must follow to ensure proper manual mill setup.	1.5	ToolingU-SME
Manual Mill Operation – This learning module serves as a guide for manually machining various features onto a workpiece. The module takes the users through the steps of creating a part on the manual mill.	1.5	ToolingU-SME
Speed and Feed for the Mill - Speed and Feed for the Mill provides a thorough explanation of cutting variables for mill operations, including how these variables are measured, selected, and set.	1.5	ToolingU-SME
Holemaking on the Manual Mill – This learning module provides information on the principles and processes for various holemaking operations that the manual milling machine can perform. A manual mill is capable of a number of precise holemaking operations, including drilling, tapping, reaming, and counterboring.	1.5	ToolingU-SME

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Engine Lathe Basics - This learning module introduces the components and controls used on a manual lathe. The lathe creates cylindrical parts by producing a round diameter on a part by rotating a workpiece against a stationary single-point cutting tool.	1.5	ToolingU-SME
Engine Lathe Setup – This learning module details important considerations that a lathe operator must take before starting any cutting process as well as the steps to ensure proper engine lathe setup. Lathe setup requires operators to know how to select appropriate cutting variables.	1.5	ToolingU-SME
Engine Lathe Operation – This learning module guides you through the machining of a cylindrical part using inner- and outer-diameter cutting operations as well as explains general principles surrounding each operation	1.5	ToolingU-SME
Speed and Feed for the Lathe – This learning module provides a thorough explanation of cutting variables for lathe operations, including how these variables are measured, selected, and set.	1.5	ToolingU-SME
Threading on the Engine Lathe – This learning module describes the manual lathe components used for threading and explains how to cut and inspect an external and internal thread.	1.5	ToolingU-SME
Taper Turning on the Engine Lathe – This learning module is an introductory class covering methods for turning basic tapered parts on an engine lathe.	1.5	ToolingU-SME
History and Definitions of CNC -This learning module outlines the origin of today's CNC machines and explains how modern CNC evolved from its original designs.	1.5	ToolingU-SME
Introduction to CNC Machines -This learning module provides a comprehensive introduction to computer numerical control (CNC), which uses numerical data to control a machine. CNC machines rely on a system of three linear and three rotational axes in order to calculate the motion.	1.5	ToolingU-SME
Basics of the CNC Lathe – This learning module explains the components and functions of both the chucker and bar machine CNC lathe varieties. CNC lathes have spindles that spin workpieces held in chucks or collets	1.5	ToolingU-SME
Control Panel Functions for the CNC Lathe - This learning module explains how operators use the machine and control panel functions to operate a CNC lathe. Operators use the handle and jog modes to move a turret or machine spindle incrementally or steadily.	1.5	ToolingU-SME

Basics of the CNC Mill – This learning module explains the components and function of CNC mills. A CNC mill produces flat or curved surfaces on square or rectangular workpieces.	1.5	ToolingU-SME
Control Panel Functions for the CNC Mill - This learning module explains how operators use the machine and control panel functions to operate a CNC mill. Operators use the handle and jog mode to move mill axes incrementally or steadily.	1.5	ToolingU-SME
Manual Mill Practical - This learning module offers practical instruction time that will allow trainees to apply knowledge from previously completed eLearning courses towards the demonstration of skills under close instructional guidance.	8	Facility
Engine Lathe Practical - This learning module offers practical instruction time that will allow trainees to apply knowledge from previously completed eLearning courses towards the demonstration of skills under close instructional guidance.	8	Facility

Unit 4-2: Hydraulics and Pneumatics: Level 2

The learning unit continues to explore advanced hydraulic and pneumatic concepts by addressing how to quantify and compare power variables, and exploring the specific applications for components within each major category.

Learning Outcomes and Content

1. Describe how the variables of a hydraulic system contribute to the manipulation of pressurized fluid in order to transmit power.
2. Identify and describe hydraulic pumps and pump ratings
3. Identify the most common types of hydraulic control valves and explain how each type functions within a hydraulic system
4. Describe the different variables of a system that affect the transmission of power in a pneumatic system
5. Identify the different types of compressors that compress air, and the power sources that compressors to perform work
6. Identify the most common types of pneumatic control valves and explain how each type functions within a pneumatic system
7. List the types of actuators used in fluid power systems
8. Describe basic hydraulic circuits and how they are designed to perform basic tasks
9. Describe basic pneumatic circuits and how they are designed to perform basic tasks

Learning Modules

Module	Hrs. of Instruction	Provider
Hydraulic Power Variables – This learning module provides workers with a foundational knowledge of variable factors in hydraulic power and how the variables affect hydraulic systems.	1.5	ToolingU-SME

Hydraulic Power Sources – This learning module provides a detailed overview of the most common hydraulic pumps used in hydraulic systems.	1.5	ToolingU-SME
Hydraulic Control Valves – This learning module surveys the most common types of hydraulic control valves and explains how each type functions within a hydraulic system.	1.5	ToolingU-SME
Pneumatic Power Variables – This learning module provides users with a foundational knowledge of pneumatic power and the pneumatic systems that generate it.	1.5	ToolingU-SME
Pneumatic Power Sources – This learning module provides a comprehensive overview of the compressors that allow a pneumatic system to perform work.	1.5	ToolingU-SME
Pneumatic Control Valves – This learning module provides an overview of different common pneumatic valves, including regulating, directional control, relief, flow control, and sequence valves.	1.5	ToolingU-SME
Actuator Applications – This learning module provides an overview of actuators for fluid power systems, including cylinders, rotary actuators, and fluid motors.	1.5	ToolingU-SME
Basic Hydraulic Circuit Design -This learning module provides an overview of basic hydraulic circuits and how they are designed to perform basic tasks.	1.5	ToolingU-SME
Basic Pneumatic Circuit Design – This learning module provides an overview of basic pneumatic circuits and how they are designed to perform basic tasks.	1.5	ToolingU-SME
Contamination and Filter Selection – This learning module provides an overview of contamination, hydraulic filters, and fluid maintenance.	1.5	ToolingU-SME
Pnematic Systems Practical – This learning module covers the fundamentals and principles of pneumatics with emphasis on hands-on exercises. Students will obtain a strong foundation in compressed air production and preparation in pneumatic systems as well as a thorough look at basic pneumatic components. The course begins with safety followed by basic fluid power principles. Air compression, preparation, and distribution are then covered. The construction, operation, and specific use of pneumatic components then become the focus of the class. Specific components covered in this course are compressors, air motors, flow controls, directional valves, actuators,	8	Facility

aftercoolers, and driers. In addition, seals and gaskets, filtration, and circuit basics are discussed.		
Hydraulic Systems Practical: Part 2 – This learning module incorporates component symbols learned in Part 1 into complete schematics. Remote control of pressure valves using pilot valves, bleed off orifices, and proportional controls will be discussed. Simultaneous control of multiple actuators while maintaining pressure and flow requirements will be reviewed. Operation and setup of load sense pumps will be demonstrated. Slip-in and screw-in cartridge valve design and operation will be presented. Proportional directional control valve function and use will be introduced.	7	Facility
Hydraulic Troublshooting Using Scematics – This learning module begins with a brief review of fundamental fluid power principles and hydraulic schematic symbols. Various types of hydraulic circuits are covered so the students develop a broader understanding of symbol (component) arrangements and feel comfortable explaining them. Troubleshooting methodology is provided using the hydraulic circuit to group and isolate potential problems when symptoms such as improper speed, pressure, heat, noise, leaks, and specific failures have been identified. It also covers the reason for failures.	8	Facility

Unit 4-3: Motor Controls

The learning unit introduces the worker to motor controls. This unit explains the fundamental concepts of designing, providing, and maintaining electrical control for motors. Instruction addresses the main elements of motors and the principles that make motors work, with several modules devoted to reading the symbols and line diagrams used to represent electrical circuits. Advanced-level modules focus on simple to complex control devices--the physical switches, contactors, and relays that open and close electrical circuits, allowing motors to perform useful work.

Learning Outcomes and Content

1. Describe the design and function of common relays, contactors, and motor starters, as well as the applications for each device
2. Describe the design and function of commonly used mechanical control devices, along with applications appropriate for each device
3. Describe how power enters a facility and is distributed to electrical equipment, as well as best practices for safely working with electrical power distribution systems
4. Understand the function, application, and installation considerations for commonly used limit switches and proximity sensors
5. Describe electric motors and the principles on which they operate
6. Identify different diagrams used to represent motor circuits and symbols that circuit diagrams commonly contain

Learning Module

Module	Hrs. of Instruction	Provider

Relays, Contactors, and Motor Starters -This learning module provides an overview of the primary components involved in electric motor control. Relays are electrical switches that control a circuit.	1.5	ToolingU-SME
Control Devices - This learning module covers the fundamental components of motor controls, devices that control the flow of current in circuits. Dangers of electric shock and other safety risks are significantly heightened when working with control devices.	1.5	ToolingU-SME
Distribution Systems - This learning module describes power distribution systems and their components. Distribution systems are integral parts of motor control systems because they consist of all generators, transformers, wires, and other devices used to transport power from the source to end use.	1.5	ToolingU-SME
Limit Switches and Proximity Switches - This learning module introduces users to commonly used manufacturing sensors that detect the presence or absence of an object. Limit switches are mechanical sensors that require physical contact to be actuated.	1.5	ToolingU-SME
Introduction to Electric Motors - This learning module provides a comprehensive overview of electric motors and the principles on which they operate. Electric motors use magnetic induction to turn electricity into mechanical motion.	1.5	ToolingU-SME
Symbols and Diagrams for Motors - This learning module introduces different diagrams used to represent motor circuits and symbols that circuit diagrams commonly contain such as pictorial and schematic diagrams.	1.5	ToolingU-SME
Logic and Line Diagrams - This learning module provides a comprehensive look at circuit logic and diagrams. The way a circuit functions depends on its circuit logic, which can be AND, OR, NAND, or NOR.	1.5	ToolingU-SME
DC Motor Applications - This learning module Applications provides a comprehensive overview of DC motors and their uses in industry. DC motors generally consist of an armature, a commutator, brushes, and field windings	1.5	ToolingU-SME
AC Motor Applications - This learning module provides a comprehensive overview of different types of AC motors and how they operate. The main components of AC motors are stators and rotors. The two basic types of AC motors are induction and synchronous motors.	1.5	ToolingU-SME

Solenoids - This learning module introduces different types of solenoids and their uses. Solenoids use magnetic induction to produce linear motion. Common solenoid types are direct action, plunger, bell-crank, and clapper. Solenoids are rated by their voltage and current characteristics	1.5	ToolingU-SME
Motor Control Fundamentals – This hands-on learning module introduces a worker to the basics of motor controls and provides a comprehinsive review and application of vaious motor control topics such as relays, starters, control devices, and swithces	8	Facility

Unit 4-4: Programmable Logic Controllers (PLCs)

The learning unit teaches the worker about Programmable Logic Controller (PLC). -A PLC is a processor-driven, software-based device that uses circuit logic to process inputs and signal the correct outputs. This learning unit covers the basics of ladder logic, binary numbering, and basic programming principles. Workers will also learn about the hardware involved in PLC setups and the networking options. Instruction also covers greater detail by focusing on common PLC functions and more sophisticated tasks such as data manipulation and shift registers.

Learning Outcomes and Content

1. Identify the parts and operations of programmable logic controllers (PLCs).
2. Describe the functions and different programming languages you will find on most PLCs
3. Describe the characteristics and functions of different types of PLC hardware
4. Describe basic PLC hardware troubleshooting procedures and maintenance tips
5. Describe the basic principles of ladder logic
6. Identify the symbols used to program a PLC
7. Explain the primary logic functions of symbols
8. Explain how to convert between binary, decimal, octal, and hexadecimal number systems
9. Describe how numbering systems are used to convey information for PLCs
10. Identify different types, configurations, capacities, and current conversions for PLC I/Os
11. Identify common PLC commands and describe how those commands can be used to program a controller

Learning Modules

Module	Hrs. of Instruction	Provider
Intro to PLCs – This learning module introduces the parts and operations of programmable logic controllers (PLCs) and describes the functions and different programming languages you will find on most PLCs.	1.5	ToolingU-SME

Hardware for PLCs -This learning module covers the characteristics and functions of different types of PLC hardware, and provides basic troubleshooting procedures and maintenance tips.	1.5	ToolingU-SME
Basics of Ladder Logic – This learning module describes the basic principles of ladder logic, identifies the symbols used to program a PLC and explains the primary logic functions those symbols create.	1.5	ToolingU-SME
Numberings Systems and Codes – This learning module explains how to convert between binary, decimal, octal, and hexadecimal number systems and describes how these systems are used to convey information for PLC	1.5	ToolingU-SME
PLC Inputs and Outputs – This learning module covers different types, configurations, capacities, and current conversions for PLC I/Os.	1.5	ToolingU-SME
Basic Programming – This learning module introduces the basics of PLC programming using ladder logic. The class will identify common PLC commands and describe how those commands can be used to program a controller.	1.5	ToolingU-SME
PLC Fundamentals – This learning module covers the fundamentals and principles of Industrial Programmable Logic Controller (PLC). The focus is on how PLC's work and gives practical information on maintaining PLC systems. Workers will examine the control of systems with a PLC simulator and laptops. Emphasis will be on using the PLC as a diagnostic tool for troubleshooting the processing system.	8	Facility

Unit 4-5: Automation

The learning unit introduces a worker to automation in the manufacturing environment, with a focus on robotic systems. This instruction covers the major components of industrial robots, the common applications for robots, and axis movement. Instruction also addresses vision systems, effective preventive maintenance for robots, as well as common causes of robot failure along with the ways to identify those causes.

Learning Outcomes and Content

1. Describe the classifications, characteristics, and functions of industrial robots
2. Explain the functions and characteristics of the different components of an industrial robot
3. Describe the various types of end effectors and their uses
4. Describe the most common applications of industrial robots
5. Identify common methods of industrial automation
6. Describe the most common robot axes
7. Describe the various types of sensors that provide feedback data to robots
8. Discuss various approaches and methods used by maintenance workers today to keep industrial robots performing optimally
9. Discuss different ways to prevent robot accidents

10. Describe the basic troubleshooting process, useful troubleshooting tools, and common robotic malfunction root causes and corrective actions

Learning Modules

Module	Hrs. of Instruction	Provider
Intro to Robotics -This learning module covers the classifications, characteristics, and functions of industrial robots as well as basic safety precautions for working with robots.	1.5	ToolingU-SME
Robot Components -This learning module covers the functions and characteristics of the different components of an industrial robot.	1.5	ToolingU-SME
End Effectors -This learning module describes the various types of end effectors and their uses. It also explains the issue of compliance and describes how to maintain end effectors.	1.5	ToolingU-SME
Applications for Robots -This learning module covers the most common applications of industrial robots.	1.5	ToolingU-SME
Automated Systems and Control -This learning module identifies common methods of industrial automation. It describes the available technologies and explains how they are applied in manufacturing.	1.5	ToolingU-SME
Robot Axes -This learning module describe the most common robot axes. It will explain how to understand these axes, and how they are used to control robot movement.	1.5	ToolingU-SME
Robot Sensors -This learning module describes the various types of sensors that provide feedback data to robots. It also explains the categories of sensors and shows how sensors are used in industrial robotics.	1.5	ToolingU-SME
Robot Maintenance -This learning module will teach you about the importance of maintenance, as well as the various approaches and methods used by maintenance workers today to keep industrial robots performing optimally.	1.5	ToolingU-SME

Robot Safety -This learning module discusses the different ways to prevent robot accidents. Robot accidents can result in serious injuries or fatalities.	1.5	ToolingU-SME
Robot Troubleshooting -This learning module describes the systematic approach of solving issues that cause robotic malfunction. Robots are complex assemblies that have many components that may require troubleshooting, including motors, end effectors, and joints.	1.5	ToolingU-SME
Robotics Practical- This hands-on instruction focuses on the various aspects of robotics including safety, controls, and troubleshooting.	8	Facility