



Snead State *Community College* **Workforce Development**

Self-Pace Online Training
\$100.00 per student

Register Here:
www.snead.edu/tbiregistration

For more information:

Cherri Barnard, 256.840.4152, cbarnard@snead.edu

Teresa Walker, 256.840.4211, twalker@snead.edu

Fluid Power Systems for Manufacturing Technicians

This course in fluid power systems prepares learners to work intelligently in industry with pneumatic and hydraulic applications. It introduces basic pneumatic and hydraulic power and takes learners through key topics and skills in fluid power and safety, circuits, schematics, principles of fluid power pressure and flow, and speed control circuits. It covers pressure regulation, filtration, how to connect circuits, cylinders, valves, and actuators, pressure and cylinder force, volume, and flow resistance.

- Basic Pneumatic Circuits
- Principles of Pneumatic Pressure and Flow
- Air Logic
- Air Compressors
- Pneumatic Power Systems
- Pneumatic System Construction
- Tubing and Component Installation
- Moving Loads Pneumatically
- Accumulator Applications
- Pneumatic DCV Applications
- Hydraulic DCV Applications
- Pneumatic Maintenance
- Troubleshooting Vacuum Systems
- Troubleshooting Actuators and Valves
- Introduction to Hydraulic Systems
- Principles of Hydraulic Pressure and Flow
- Basic Hydraulic Circuits
- Hydraulic Power Systems
- Hydraulic Cylinder Applications
- Hydraulic Relief Valve Operation
- Hydraulic Check Valve Applications
- Hydraulic Motor Applications
- Hydraulic Pump and Motor Performance
- Hydraulic Speed Control
- Troubleshooting Hydraulic Actuators and DCVs
- Fluids and Conditioning
- Fittings and Seals
- Hose and Clamping Devices
- Hydraulic Filter Maintenance
- Hydraulic Pump Troubleshooting



Fluid Power Systems for Manufacturing Technicians

This course in fluid power systems prepares learners to work in industry with pneumatic and hydraulic applications. It introduces basic pneumatic and hydraulic power and takes learners through key topics and skills in fluid power and safety, circuits, schematics, principles of fluid power pressure and flow, and speed control circuits. It covers pressure regulation, filtration, how to connect circuits, cylinders, valves, and actuators, pressure and cylinder force, volume, and flow resistance.

Outline

1. Basic Pneumatic Circuits

Segment 1 - Single-Acting Cylinder Circuits

Objective 1 - Describe the Function of a Single-Acting Pneumatic Cylinder and Give an Application

Objective 2 - Describe the Operation of a Single-Acting, Spring-Return Cylinder and Give Its Schematic Symbol

Activity 1 - Basic Operation of a Single-Acting, Spring-Return Cylinder

Objective 3 - Describe the Function of a 3/2 Pneumatic DCV and Give an Application

Objective 4 - Describe the Operation of a 3/2 Pneumatic DCV and Give Its Schematic Symbol

Skill 1 - Connect and Operate a Single-Acting Pneumatic Cylinder Using a 3/2 Manually-Operated DCV

Self Review 1

Segment 2 - Basic Motor Circuits

Objective 5 - Describe the Function of a Pneumatic Motor and Give an Application

Objective 6 - Describe the Operation of a Pneumatic Motor and Give Its Schematic Symbol

Skill 2 - Connect and Operate a Uni-Directional Pneumatic Motor Using a 3-Port, Manually-Operated DCV

Objective 7 - Describe the Function of a Muffler and Give Its Schematic Symbol

Activity 2 - Air Muffler Operation

Objective 8 - List Three Common Pneumatic Motor Designs and Explain Where They Are Used

Self Review 2

Segment 3 - Pneumatic Schematics

Objective 9 - Describe the Line Symbols Used with Fluid Power Circuits

Skill 3 - Identify Pneumatic Symbols

Objective 10 - Describe Seven Basic Rules for Drawing Pneumatic Schematics

Skill 4 - Draw a Pneumatic Schematic from the Actual Circuit Connections on the Machine

Skill 5 - Connect a Pneumatic Circuit Given a Schematic

Skill 6 - Design a Multiple Actuator Pneumatic Circuit

Self Review 3

2. Principles of Pneumatic Pressure and Flow

Segment 1 - Pressure vs. Cylinder Force

Objective 1 - Describe How to Calculate the Force Output of an Extending Cylinder

Skill 1 - Calculate the Extension Force of a Cylinder Given Its Size and Pressure

Skill 2 - Measure the Force Output of an Extending Cylinder

Objective 2 - Describe How to Calculate the Force Output of a Cylinder in Retraction (Pull)

Skill 3 - Calculate the Retraction Force of a Cylinder Given Its Size and Pressure

Self Review 1

Segment 2 - Pneumatic Leverage

Objective 3 - State Pascal's Law and Explain Its Significance in Pneumatics

Activity 1 - Verification of Pascal's Law

Objective 4 - Explain How Force Is Multiplied Using Pascal's Law

Activity 2 - Demonstrate How Distance Is Sacrificed to Obtain Force Multiplication

Self Review 2

Segment 3 - Pressure and Volume

Objective 5 - Describe Two Methods of Representing Pressure

Skill 4 - Convert between Gauge and Absolute Pressures

Objective 6 - Explain How Air Pressure Is Created in a Pneumatic System

Objective 7 - State Boyle's Law and Explain Its Significance

Skill 5 - Use Boyle's Law to Calculate Changes in Pressure and Volume

Activity 3 - Verification of Boyle's Law

Self Review 3

Segment 4 - Air Flow and Resistance

Objective 8 - Explain How a Pneumatic System Creates Air Flow

Objective 9 - Describe Two Types of Resistance in a Pneumatic System

Objective 10 - Explain How Delta P Describes Pneumatic Resistance and Explain Its Importance

Skill 6 - Measure Delta P across Pneumatic Components

Objective 11 - Describe What Determines the Speed of a Pneumatic Actuator

Activity 4 - Effect of Pressure on Pneumatic Actuator Speed

Self Review 4

3. Air Logic

Segment 1 - Externally Piloted Valves

Objective 1 - Describe the Function of an Externally Air-Piloted DCV and Give an Application

Objective 2 - Describe the Function of a Detent and Give Its Schematic Symbol

Objective 3 - Describe Four Types of Pneumatic DCV Construction

Objective 4 - Describe the Operation of an Externally Air-Piloted DCV and Give Its Schematic Symbol

Skill 1 - Connect and Operate an Externally Air-Piloted DCV Using the Manual Override

Skill 2 - Design a Pneumatic Circuit That Uses an Externally Air-Piloted DCV

Self Review 1

Segment 2 - Introduction to Air Logic

Objective 5 - Define Air Logic and Give Two Applications

Objective 6 - List Four Advantages and Four Disadvantages of Air Logic

Objective 7 - Describe the Operation of an Air Logic Cylinder Sequence Circuit

Skill 3 - Connect and Operate a Cam-Operated Sequence Circuit

Self Review 2

Segment 3 - Air Logic Design

Objective 8 - Describe the Function of a Shuttle Valve and Give an Application

Objective 9 - Describe the Operation of a Shuttle Valve and Give Its Schematic Symbol

Objective 10 - Describe the Operation of a Pneumatic Seal-In Circuit

Skill 4 - Connect and Operate an Air Logic Circuit to Control a Reciprocating Cylinder

Self Review 3

4. Air Compressors

Segment 1 - Compressor Types

Objective 1 - Describe Two Categories of Air Compressors and Give an Application of Each

Objective 2 - List Two Types of Positive Displacement Air Compressors and Give an Application of Each

Objective 3 - List Two Types of Dynamic Compressors and Give an Application of Each

Objective 4 - Describe the Functions of Ten Basic Components of an Air Compressor System

Activity 1 - Air Compressor Component Identification

Objective 5 - Describe the Eight Air Compressor Safety Rules

Objective 6 - Describe How to Start and Shut Down a Small Reciprocating Piston Air Compressor

Skill 1 - Start Up and Shut a Small Reciprocating Piston Air Compressor

Self Review 1

Segment 2 - Reciprocating Compressor Components

Objective 7 - Describe the Operation of a Single-Stage Reciprocating Piston Compressor
Objective 8 - Describe the Operation of a Two-Stage Reciprocating Piston Air Compressor
Activity 2 - Hand Pump Operation
Objective 9 - Describe the Function of Start/Stop Control
Objective 10 - Describe the Operation of an Air Compressor Pressure Switch
Objective 11 - Describe How to Set Air Compressor Cut-In and Cut-Out Pressures
Skill 2 - Determine the Cut-In and Cut-Out Pressures on a Compressor Pressure Switch
Skill 3 - Set Air Compressor Cut-In and Cut-Out Pressures
Objective 12 - Describe the Operation of a Pneumatic Safety Relief Valve and Explain Its Importance
Skill 4 - Test the Operation of a Safety Relief Valve
Self Review 2

Segment 3 - Compressor Flow Concepts

Objective 13 - Define the Ideal Gas Law and Explain Its Importance
Objective 14 - Define Two Temperature Scales, Gauge and Absolute, and Give an Application of Each
Skill 5 - Convert between Gauge and Absolute Temperatures
Activity 3 - Effect of Temperature Change on Compressed Air
Skill 6 - Use the Ideal Gas Law to Calculate the Effect of Changes in Air Temperature, Pressure, and Volume
Objective 15 - Describe Two Methods of Measuring Air Compressor Flow Rates
Skill 7 - Use a Pump-Up Test to Measure Compressor Flow
Skill 8 - Use an Orifice Plate Flow Meter to Determine Flow Rate
Self Review 3

Segment 4 - Compressor Performance

Objective 16 - Describe Five Factors Used in the Selection of an Air Compressor
Objective 17 - Describe the Types of Data Found on a Compressor Name Plate
Skill 9 - Interpret an Air Compressor Name Plate
Objective 18 - Describe How to Size an Air Compressor
Skill 10 - Size an Air Compressor Given Application Data
Self Review 4

5. Pneumatic Power Systems

Segment 1 - Introduction to Pneumatics

Objective 1 - Define Pneumatics and Give an Application
Objective 2 - Describe the Functions of Basic Components of a Pneumatic System
Activity 1 - Pneumatic Trainer
Objective 3 - Define Pneumatic Pressure and Give Its Units of Measurement
Objective 4 - Describe How to Read a Pressure Gauge
Skill 1 - Read a Pneumatic Pressure Gauge
Objective 5 - Describe the Function of a Pneumatic Schematic
Self Review 1

Segment 2 - Pneumatic Power

Objective 6 - Explain Six Pneumatic Safety Rules
Objective 7 - Describe the Function of a Pressure Regulator Valve and Give an Application
Objective 8 - Describe the Operation of a Pressure Regulator and Give Its Schematic Symbol
Skill 2 - Connect and Adjust a Pressure Regulator
Objective 9 - Describe the Function of an Air Filter
Objective 10 - Describe the Operation of an Air Filter and Give Its Schematic Symbol
Skill 3 - Drain a Pneumatic Filter
Self Review 2

Segment 3 - Circuit Connections

Objective 11 - Describe the Function of a Pneumatic Quick-Connect Fitting and Give Its Schematic Symbol
Skill 4 - Connect a Pneumatic Hose That Uses Quick-Connect Fittings
Objective 12 - Describe the Function of a Tee and a Cross and Give Their Schematic Symbols
Skill 5 - Use a Tee to Connect Two Circuit Branches Together
Skill 6 - Use a Cross to Connect Three Circuit Branches Together

Self Review 3

Segment 4 - Basic Cylinder Circuits

Objective 13 - Describe the Function of a Pneumatic Cylinder and Give an Application

Objective 14 - Describe the Operation of a Double-Acting Pneumatic Cylinder and Give Its Schematic Symbol

Activity 2 - Basic Operation of a Double-Acting Cylinder

Objective 15 - Describe the Function of a 5-Port, 3-Position Pneumatic DCV and Give an Application

Objective 16 - Describe the Operation of a 5-Port, 3-Position Pneumatic DCV and Give Its Schematic Symbol

Objective 17 - Describe How DCVs Are Classified

Objective 18 - Describe the Function of a DCV Schematic

Skill 7 - Connect and Operate a Double-Acting Pneumatic Cylinder Using a 3-Position, Manually-Operated DCV

Skill 8 - Design a Multiple Cylinder Pneumatic Circuit

Self Review 4

6. Pneumatic System Construction

Segment 1 - Air Supply Connections

Objective 1 - Describe the Three Functions of an Air Line

Objective 2 - Describe the Construction of Pneumatic Rubber Hose and Give an Application

Objective 3 - Describe Three Methods of Connecting Rubber Hose to a Fitting

Skill 1 - Install a Rubber Hose onto a Push-On Type Fitting

Objective 4 - Describe the Construction and Give an Application of Three Types of Pneumatic Fitting Threads

Objective 5 - Describe the Operation of Dryseal Tapered Pipe Threads (NPTF)

Skill 2 - Install and Seal Tapered Pipe Fittings Using Teflon Sealing Tape

Objective 6 - Describe How to Identify and Specify Pipe Size

Skill 3 - Identify the Nominal Pipe Size of a Fitting Given an Example

Self Review 1

Segment 2 - Control Air Connections

Objective 7 - Describe the Function of a Reducing Bushing and Give an Application

Objective 8 - Describe How to Specify the Size of a Reducing Bushing

Skill 4 - Install a Reducing Bushing to Connect an Oversized Port

Objective 9 - Describe the Operation of Straight Threaded Fittings

Objective 10 - Describe the UNF Thread Size Used for Pneumatic Fittings

Objective 11 - Describe the Function of an Adapter and Give an Application

Skill 5 - Install and Seal a Straight Thread Fitting

Objective 12 - Describe the Functions of Four Types of Flexible Plastic Conductors and Give an Application of Each

Objective 13 - Describe How to Specify Flexible Tubing

Objective 14 - Describe the Function of Three Pneumatic Tubing Fittings and Give an Application of Each

Skill 6 - Connect Polyurethane Ether Tubing to a Barbed Fitting

Skill 7 - Connect Tubing Using a Ferrule Type Fitting

Skill 8 - Connect Tubing Using a Push-On Type Fitting

Self Review 2

Segment 3 - Power Air Connections

Objective 15 - Describe the Function of a Bulkhead Fitting and Give an Application

Skill 9 - Install a Bulkhead Fitting

Objective 16 - Describe the Function of Six Fitting Shapes

Skill 10 - Identify the Shape, Type and Size of Tubing Connectors

Objective 17 - Describe the Function of a Subplate and Give an Application

Skill 11 - Install and Replace a DCV on Its Subplate

Objective 18 - Give Five Guidelines Used in the Construction of Pneumatic Circuits

Skill 12 - Size, Select, and Install the Fittings and Tubing for an Application

Self Review 3

7. Tubing and Component Installation

Segment 1 - Hydraulic Tubing

Objective 1 - Describe the Function and Construction of Hydraulic Tubing

Objective 2 - Describe How Hydraulic Tubing Is Specified

Skill 1 - Identify Hydraulic Tubing Given a Sample

Skill 2 - Select Hydraulic Tubing Based on Specifications

Self Review 1

Segment 2 - Installing Hydraulic Tubing

Objective 3 - Describe How to Install Steel Tubing in a Hydraulic System

Objective 4 - Describe the Function and Construction of a Ferrule Fitting

Objective 5 - Describe the Function of Thread Sealant in a Hydraulic System

Objective 6 - Describe How to Install Steel Tubing Using Thread Sealant and Ferrule Fittings

Skill 3 - Install Hydraulic Tubing Using Thread Sealant and Ferrule Fittings

Self Review 2

Segment 3 - Component Replacement

Objective 7 - Describe How to Mount and Align a Hydraulic Cylinder

Skill 4 - Mount and Align a Hydraulic Cylinder

Objective 8 - Describe How to Replace a Subplate-Mounted Valve in a Hydraulic System

Skill 5 - Replace a Subplate-Mounted Valve in a Hydraulic System

Self Review 3

Segment 4 - Component Replacement II

Objective 9 - Describe How to Replace a Cartridge Valve

Objective 10 - Describe How to Replace a Body-Ported Valve

Skill 6 - Replace a Body-Ported Valve

Self Review 4

8. Moving Loads Pneumatically

Segment 1 - Pneumatic Cylinder Loads

Objective 1 - Describe the Two Types of Pneumatic Cylinder Loads

Objective 2 - Describe Four Forces That Act against Cylinder Movement

Activity 1 - Effect of Load on Cylinder Operation

Objective 3 - Describe Three Load Factors That Affect a Pneumatic Cylinder Circuit Operation

Objective 4 - Describe How Cylinder Sizes Are Specified

Objective 5 - Describe Five Common Tie Rod Cylinder Mounting Styles and Give an Application of Each

Skill 1 - Select a Cylinder Mounting Style for a Given Application

Self Review 1

Segment 2 - Cylinder Applications

Objective 6 - Describe the Function of a Quick Exhaust Valve and Give an Application

Objective 7 - Describe the Operation of a Quick Exhaust Valve and Give Its Schematic Symbol

Skill 2 - Connect and Operate a Quick Exhaust Valve

Objective 8 - Describe the Operation of a Pressure Regulator under Flow Conditions

Activity 2 - Dynamic Operation of a Pressure Regulator

Objective 9 - Explain How a Regulator and a 3-Way Valve Can Be Used in a Double-Acting Cylinder Application

Skill 3 - Connect and Operate a 3-Way Valve and Regulator in a Double-Acting Cylinder Application

Self Review 2

Segment 3 - Component Sizing

Objective 10 - Describe How to Size a Pneumatic Cylinder

Skill 4 - Size a Pneumatic Cylinder Given a Load

Objective 11 - Describe the Function of an Oversized Cylinder Rod

Objective 12 - Describe the Function of a Stop Tube and Give an Application

Objective 13 - Explain How to Determine Pneumatic Cylinder Air Flow Rate for a Given Speed

Skill 5 - Calculate the Air Flow Rate Needed to Cycle a Pneumatic Cylinder

Self Review 3

Segment 4 - Pneumatic Motor Loads

Objective 14 - Describe the Operation of Two Types of Handheld Tachometers Used to Measure Motor Speed

Skill 6 - Measure Pneumatic Motor Speed Using a Photo Tachometer

Objective 15 - Define Pneumatic Motor Torque and Give Its Units of Measurement

Objective 16 - Define Three Types of Torque Specifications: Starting, Breakaway, and Running

Objective 17 - Describe How to Use a Torque-Speed Curve to Determine Pneumatic Motor Speed

Activity 3 - Effect of Load on Motor Speed

Objective 18 - Describe How to Size a Pneumatic Motor

Skill 7 - Select a Pneumatic Motor

Objective 19 - Explain How to Calculate the Flow Rate Needed for a Pneumatic Motor

Skill 8 - Calculate the Air Flow Needed for a Pneumatic Motor

Self Review 4

Segment 5 - Air Bearings

Objective 20 - Describe the Function of an Air Bearing and Give an Application

Objective 21 - Describe How to Size an Air Bearing

Skill 9 - Size an Air Bearing Given a Load

Skill 10 - Connect and Operate an Air Bearing

Self Review 5

9. Accumulator Applications

Segment 1 - Accumulator Operation

Objective 1 - Describe the Function of an Accumulator and Give an Application

Objective 2 - Describe the Operation of Three Types of Accumulators and Give Their Schematic Symbols

Objective 3 - Describe the Operation of the Four Types of Gas-Loaded Accumulators

Objective 4 - Describe How to Pre-Charge a Gas-Loaded Accumulator

Skill 1 - Pre-Charge an Accumulator

Skill 2 - Determine Accumulator Pre-Charge Pressure

Self Review 1

Segment 2 - Accumulator Circuits

Objective 5 - List Four Accumulator Safety Rules

Objective 6 - Describe How to Mount an Accumulator

Objective 7 - Describe the Function and Operation of Two Types of Safety Bleed-down Circuits

Skill 3 - Connect and Operate an Accumulator Bleed-down Circuit

Objective 8 - Describe the Function and Operation of Two Accumulator Unloading Circuits

Activity 1 - Pump Unloading in an Accumulator Circuit

Self Review 2

Segment 3 - Accumulator Applications

Objective 9 - Describe the Operation of a Circuit That Uses an Accumulator for Auxiliary Power

Objective 10 - Describe the Operation of a Circuit That Uses an Accumulator for Emergency Power

Skill 4 - Connect and Operate an Accumulator to Safely Provide Auxiliary and/or Emergency Power

Objective 11 - Describe the Operation of a Circuit That Uses an Accumulator for Pulsation Dampening

Objective 12 - Describe the Operation of an Accumulator Leakage/Temperature Compensation Circuit

Skill 5 - Design an Accumulator Circuit to Compensate for Leakage

Objective 13 - Describe the Operation of a Circuit That Uses an Accumulator for Fluid Dispensing

Objective 14 - Describe the Operation of a Circuit That Uses an Accumulator for Energy Savings

Self Review 3

Segment 4 - Accumulator Sizing

Objective 15 - Explain How Bladder-Type Accumulators Are Specified

Objective 16 - Explain How to Size a Bladder-Type Accumulator

Skill 6 - Size a Bladder-Type Accumulator

Objective 17 - Describe the Effect of Pre-Charge Pressure on Accumulator Operation

Activity 2 - Measurement of Accumulator Oil Storage

Self Review 4

10. Pneumatic DCV Applications

Segment 1 - Cam Valves

Objective 1 - Describe the Function of a Pneumatic Cam-Operated Valve and Give an Application
Objective 2 - Describe the Operation of a Pneumatic Cam-Operated DCV and Give Its Schematic Symbol
Skill 1 - Connect and Operate a Pneumatic Cam-Operated 4/2 DCV
Skill 2 - Connect and Operate a Pneumatic Cam-Operated 3/2 DCV
Self Review 1

Segment 2 - Cam Valve Applications

Objective 3 - Describe the Operation of a 2-Speed Pneumatic Circuit Using a Cam Valve
Skill 3 - Design a Rapid Traverse-Slow Feed Pneumatic Circuit
Skill 4 - Design a Pneumatic Circuit to Sequence Two Cylinders
Objective 4 - Describe Three Methods of Decelerating a Pneumatic Cylinder
Skill 5 - Connect and Operate a Cylinder Deceleration Circuit Using Power Braking
Self Review 2

Segment 3 - Two-Way Valves

Objective 5 - Describe the Function of Two-Way Valves
Objective 6 - Describe the Construction and Operation of Five Types of Two-Way Valves
Skill 6 - Connect and Operate a Two-Way DCV
Self Review 3

11. Hydraulic DCV Applications**Segment 1 - Overview of the DCV**

Objective 1 - Describe and Explain the Terms Used to Specify DCVs
Skill 1 - Connect and Operate a Hydraulic DCV with a Tandem Center
Skill 2 - Select the Spool Option for a Hydraulic DCV Based on the Application Information
Self Review 1

Segment 2 - Two-Position DCVs

Objective 2 - Describe the Function of a Hydraulic 4/2 DCV and Name One Application
Objective 3 - Describe the Operation of a Hydraulic 4/2 DCV and Give Its Schematic Symbol
Skill 3 - Connect and Operate a Hydraulic 4/2 DCV
Objective 4 - Describe the Function of a Hydraulic 3/2 DCV and Name One Application
Objective 5 - Describe the Operation of a Hydraulic 3/2 DCV and Give Its Schematic Symbol
Skill 4 - Connect and Operate a 4/2 DCV to Function as a 3/2 DCV
Skill 5 - Design a Hydraulic Circuit Using a 2-Position DCV
Self Review 2

Segment 3 - Pilot-Operated DCVs

Objective 6 - Describe the Function of a Hydraulic Pilot-Operated DCV and Name One Application
Objective 7 - Describe the Operation of a Hydraulic Pilot-Operated DCV and Give a Schematic Symbol
Skill 6 - Connect and Operate a Hydraulic Pilot-Operated DCV
Self Review 3

Segment 4 - Cam-Operated DCVs

Objective 8 - Describe the Function of a Hydraulic Cam-Operated Valve and Name One Application
Objective 9 - List Two Types of Hydraulic Cam-Operated Valves and Describe Their Application
Objective 10 - Describe the Operation of a Hydraulic 4/2 Cam-Operated Valve and Give Its Schematic Symbol
Skill 7 - Connect, Adjust, and Operate a Cam-Operated Hydraulic Valve
Skill 8 - Design a Hydraulic Sequence Circuit Using a Cam-Operated Hydraulic Valve
Skill 9 - Design a Rapid Traverse-Slow Feed Hydraulic Circuit Using a Cam-Operated Valve
Self Review 4

12. Pneumatic Maintenance**Segment 1 - Air Filtration**

Objective 1 - List Four Sources of Compressed Air Contamination and Explain Their Effect
Objective 2 - Describe the Operation of Three Common Filter Elements
Objective 3 - Describe the Function of a Coalescing Filter and Give an Application
Objective 4 - Describe the Operation of a Coalescing Filter and Give Its Schematic Symbol
Skill 1 - Change an Air Filter Element

Objective 5 - Explain How Air Filter Elements Are Rated

Activity 1 - Measurement of Filter Element Flow Rate and Pressure Drop

Objective 6 - Describe How to Select a Filter for an Application

Skill 2 - Select an Air Filter for an Application

Self Review 1

Segment 2 - Water Removal

Objective 7 - Define Dew Point and Relative Humidity and Explain Their Importance

Objective 8 - Explain How Water Condenses in a Pneumatic System and Its Effect

Activity 2 - Air Filter Removal of Free Water

Objective 9 - Describe Two Methods of Removing Water Vapor from a Pneumatic System

Objective 10 - Describe the Function of an Aftercooler and Give an Application

Objective 11 - Describe the Function of a Dryer and Give an Application

Objective 12 - Describe the Principle of Operation of Three Types of Dryers and Give an Advantage of Each

Objective 13 - Describe the Operation of a Refrigeration Type Air Dryer

Activity 3 - Effect of Cooling below Dew Point

Objective 14 - Describe the Function of Pneumatic System Trap

Objective 15 - Describe the Operation of Two Types of Pneumatic Traps and Give the Schematic Symbol of Each

Self Review 2

Segment 3 - Lubrication

Objective 16 - Describe the Function of Air Lubrication and List Three Lubrication Methods

Objective 17 - Describe the Function of a Lubricator and Give Its Schematic Symbol

Objective 18 - Describe the Operation of Three Types of Pneumatic Lubricators and Give an Application of Each

Objective 19 - Describe the Types of Oils Used in Lubricators

Skill 3 - Connect, Fill, and Adjust a Lubricator

Self Review 3

Segment 4 - Servicing Pneumatic Components

Objective 20 - Describe How Pressure Gauges Are Calibrated

Objective 21 - Describe How Acrylic Flow Meters Are Cleaned

Objective 22 - Describe the Importance of Eliminating Air Leaks

Objective 23 - Describe How to Locate Air Leaks

Objective 24 - Describe Four Common Pneumatic Component Failures and Their Probable Causes

Self Review 4

13. Troubleshooting Vacuum Systems

Segment 1 - Troubleshooting Vacuum Cups and Generators

Objective 1 - Describe Three Symptoms of Vacuum Cup Failure

Objective 2 - Describe How to Inspect and Troubleshoot a Vacuum Cup

Objective 3 - Describe Three Symptoms of Vacuum Generator Failure

Objective 4 - Describe How to Troubleshoot a Vacuum Generator

Skill 1 - Troubleshoot a Vacuum Generator Using an In-Circuit Test

Self Review 1

Segment 2 - Vacuum Switch Operation

Objective 5 - Describe the Function of a Vacuum Switch and Give an Application

Objective 6 - Describe the Operation of a Vacuum Switch

Objective 7 - Describe How to Set the Setpoint of a Vacuum Switch

Skill 2 - Adjust the Setpoint of a Vacuum Switch

Self Review 2

Segment 3 - Vacuum Switch Troubleshooting

Objective 8 - Describe Two Symptoms of Vacuum Switch Failure

Objective 9 - Describe How to Troubleshoot a Vacuum Switch

Skill 3 - Troubleshoot a Vacuum Switch

Self Review 3

14. Troubleshooting Actuators and Valves

Segment 1 - Pneumatic Cylinder Troubleshooting

Objective 1 - Describe Six Symptoms of Pneumatic Cylinder Failure

Objective 2 - Describe How to Troubleshoot a Pneumatic Cylinder

Skill 1 - Troubleshoot a Cylinder Using an In-Circuit Test

Self Review 1

Segment 2 - Rotary Actuator Troubleshooting

Objective 3 - Describe the Function of a Rotary Actuator and Give an Application

Objective 4 - Describe the Operation of a Vane-Type Rotary Actuator and Give Its Schematic Symbol

Objective 5 - Describe Five Symptoms of Rotary Actuator Failure

Objective 6 - Describe How to Troubleshoot a Rotary Actuator

Skill 2 - Troubleshoot a Rotary Actuator Using an In-Circuit Test

Self Review 2

Segment 3 - Directional Control Valve Troubleshooting

Objective 7 - Describe the Operation of an Internal Pilot-Operated DCV and Give an Application

Objective 8 - Describe Six Symptoms of Pilot-Operated DCV Failure and Their Causes

Objective 9 - Describe How to Troubleshoot a Pilot-Operated DCV

Skill 3 - Troubleshoot a Pilot-Operated DCV Using an In-Circuit Test

Self Review 3

Segment 4 - Flow Control Valve Troubleshooting

Objective 10 - Describe Six Symptoms of Flow Control Valve Failure and Their Causes

Objective 11 - Describe How to Troubleshoot a Flow Control Valve

Skill 4 - Troubleshoot a Flow Control Valve Using an In-Circuit Test

Self Review 4

Segment 5 - Quick Exhaust Valves

Objective 12 - Describe Three Symptoms of Quick Exhaust Valve Failure and Their Causes

Objective 13 - Describe How to Troubleshoot a Quick Exhaust Valve

Self Review 5

15. Introduction to Hydraulic Systems

Segment 1 - Introduction to Hydraulics

Objective 1 - Define Hydraulics and Describe the Relationship between Force and Pressure

Objective 2 - Describe Pascal's Law

Objective 3 - Describe a Brief History of Hydraulics

Objective 4 - Describe Five Manufacturing Operations Powered by Hydraulics

Segment 2 - Hydraulic Components

Objective 5 - Explain the Importance of a Hydraulic Schematic

Objective 6 - Describe Six Types of Hydraulic Components

Objective 7 - Describe Eight Types of Hydraulic Valves

Objective 8 - Describe Three Types of Actuators

Segment 3 - Hydraulic Safety

Objective 9 - Describe the Hazards Associated with Hydraulic Systems

Objective 10 - Describe How to Reduce the Dangers Associated with Hydraulic Systems

Segment 4 - Hydraulic System Maintenance

Objective 11 - Describe How to Maintain a Hydraulic System

Objective 12 - Describe How to Inspect a Hydraulic System during Operation

16. Principles of Hydraulic Pressure and Flow

Segment 1 - Pressure vs. Cylinder Force

Objective 1 - Describe How to Calculate the Force Output of an Extending Cylinder

Skill 1 - Calculate the Extension Force of a Cylinder Given Its Size and Pressure

Skill 2 - Measure the Force Output of an Extending Cylinder

Objective 2 - Describe How to Calculate the Force Output of a Hydraulic Cylinder in Retraction (Pull)

Skill 3 - Calculate the Retraction Force of a Cylinder Given Its Size and Pressure

Skill 4 - Measure the Force Output of a Retracting Cylinder

Self Review 1

Segment 2 - Hydraulic Leverage

Objective 3 - State Pascal's Law and Explain Its Significance in Hydraulics

Activity 1 - Verification of Pascal's Law for Hydraulics

Objective 4 - Explain How Force Is Multiplied Using Pascal's Law

Activity 2 - Demonstrate How Distance Is Sacrificed to Obtain Force Multiplication

Self Review 2

Segment 3 - Fluid Friction

Objective 5 - Describe Two Types of Resistance in a Hydraulic System

Objective 6 - Explain How ΔP Describes Hydraulic Resistance

Skill 5 - Measure Delta P across a Hydraulic Component

Activity 3 - Effect of Flow and Orifice Size on Delta P

Objective 7 - Explain How Pressure Is Distributed in a Hydraulic System

Activity 4 - Characteristics of Circuit Pressure Drops

Self Review 3

Segment 4 - Absolute vs. Gauge Pressure

Objective 8 - Describe Two Methods of Representing Hydraulic Pressure

Skill 6 - Convert between Absolute Pressure and Gauge Hydraulic Pressure

Objective 9 - Describe How Oil Flows on the Suction Side of the Pump

Self Review 4

17. Basic Hydraulic Circuits

Segment 1 - Pumps

Objective 1 - Define Flow Rate and Explain How It Can Be Measured

Objective 2 - Describe the Operation of Two Types of Flow Meters and Give Their Schematic Symbol

Skill 1 - Connect and Read a Flow Meter

Activity 1 - Flow Meter Accuracy

Objective 3 - Describe the Operation of a Fixed-Displacement Pump and Give Its Schematic Symbol

Activity 2 - Fixed-Displacement Pump Operation

Objective 4 - Describe the Operation of Four Types of Fixed-Displacement Pumps and Give an Application of Each

Self Review 1

Segment 2 - Needle Valves

Objective 5 - Describe the Main Function of a Needle Valve

Objective 6 - Describe the Operation of a Needle Valve and Give Its Schematic Symbol

Activity 3 - Needle Valve Operation

Skill 2 - Connect and Operate a Needle Valve to Control the Speed of an Actuator

Skill 3 - Control the Speed of an Actuator Using a Manually-Operated DCV

Self Review 2

Segment 3 - Basic Motor Circuits

Objective 7 - Describe the Function of a Hydraulic Motor and Give an Application

Objective 8 - Describe the Operation of a Hydraulic Motor and Give Its Schematic Symbol

Skill 4 - Connect and Operate a Bi-Directional Hydraulic Motor Using a 3-Position, Manually-Operated DCV

Objective 9 - List Three Types of Hydraulic Motors and Give an Application of Each

Self Review 3

Segment 4 - Hydraulic Schematics

Objective 10 - Describe the Eight Basic Rules for Drawing Hydraulic Schematics

Skill 5 - Draw a Hydraulic Schematic from the Actual Circuit Connections on a Pictorial

Skill 6 - Draw a Hydraulic Circuit Given a Schematic

Skill 7 - Design a Multiple Actuator Hydraulic Circuit

Self Review 4

18. Hydraulic Power Systems

Segment 1 - Introduction to Hydraulics

Objective 1 - Define Hydraulics and Give an Application

Objective 2 - Describe the Function of Five Basic Components of a Hydraulic System

Activity 1 - Hydraulic Trainer Component Identification

Objective 3 - Define Hydraulic Pressure and Give Its Units of Measurement

Objective 4 - Describe How to Read a Pressure Gauge

Skill 1 - Read a Hydraulic Pressure Gauge

Self Review 1

Segment 2 - Power Unit Operation

Objective 5 - Describe the Operation of a Hydraulic Power Unit

Activity 2 - Identification of 850 Power Unit Components

Skill 2 - Read the Liquid Level and Temperature in the Reservoir

Skill 3 - Operate a Hydraulic Power Unit

Self Review 2

Segment 3 - Circuit Connections

Objective 6 - Describe the Function of a Hydraulic Schematic

Objective 7 - Describe the Function of a Hydraulic Quick-Connect Fitting and Give Its Schematic Symbol

Skill 4 - Connect and Disconnect a Hydraulic Hose That Uses Quick-Connect Fittings

Objective 8 - Describe the Function of a Tee and Give Its Schematic Symbol

Skill 5 - Use a Tee to Connect Two Circuit Branches Together

Objective 9 - Describe the Operation of a Pressure Gauge and Give Its Schematic Symbol

Self Review 3

Segment 4 - Basic Cylinder Circuits

Objective 10 - Describe the Function of a Hydraulic Cylinder and Give an Application

Objective 11 - Describe the Operation of a Double-Acting Cylinder and Give Its Schematic Symbol

Activity 3 - Basic Operation of a Double-Acting Cylinder

Objective 12 - Describe the Function of a 4-Way, 3-Position DCV and Give an Application

Objective 13 - Describe the Operation of a 4-Way, 3-Position DCV and Give Its Schematic Symbol

Activity 4 - Flow Paths of a 4-Way, 3-Position DCV

Skill 6 - Connect and Operate a Double-Acting Hydraulic Cylinder Using a 3-Position, Manually-Operated DCV

Skill 7 - Design a Dual Cylinder Hydraulic Circuit

Self Review 4

19. Hydraulic Cylinder Applications

Segment 1 - Cylinder Types

Objective 1 - Describe the Operation of Four Types of Cylinders and Give an Application of Each

Objective 2 - Describe the Construction of Two Types of Cylinders and Give an Application of Each

Objective 3 - Describe Three Common Cylinder Mounting Styles and Give an Application of Each

Objective 4 - Describe Three Common Cylinder Feature Options

Skill 1 - Select a Cylinder Mounting Style for a Given Application

Self Review 1

Segment 2 - Regeneration Circuits

Objective 5 - Describe the Principle of Cylinder Regeneration and Name an Application

Activity 1 - Principle of Regeneration

Objective 6 - Describe the Operation of a Basic Regeneration Circuit

Skill 2 - Connect and Operate a Basic Regeneration Circuit

Objective 7 - Describe How to Calculate the Extend Speed of a Cylinder in Regeneration

Skill 3 - Calculate the Extend Speed of a Cylinder in Regeneration

Objective 8 - Describe How to Calculate the Extend Force of a Cylinder in Regeneration

Skill 4 - Calculate the Extend Force of a Cylinder in Regeneration

Self Review 2

Segment 3 - Pressure-Compensated Flow Control Valves

Objective 9 - Describe the Function of a Pressure-Compensated Flow Control Valve and Name One Application

Objective 10 - Describe the Operation of a Pressure-Compensated Flow Control Valve and Give Its Schematic Symbol

Activity 2 - Effect of Upstream Pressure on Flow Control Valve Operation

Activity 3 - Effect of Downstream Pressure Changes on Flow Control Operation

Skill 5 - Connect and Adjust a Pressure-Compensated Flow Control Valve

Self Review 3

Segment 4 - Synchronization Circuits

Objective 11 - Describe the Function of a Double-Rod Cylinder and Name One Application

Objective 12 - Describe the Operation of a Double-Rod Cylinder and Give Its Symbol

Objective 13 - Define Cylinder Synchronization and Name Three Applications

Objective 14 - Explain Why Cylinders Do Not Operate in Synchronization

Activity 4 - Operation of Non-Synchronized Cylinders

Objective 15 - List and Describe the Operation of Five Methods Used to Synchronize Cylinders

Skill 6 - Set Up, Adjust and Operate a Cylinder Synchronization Circuit Using Flow Control Valves

Activity 5 - Effect of Load Changes on Cylinder Synchronization

Skill 7 - Set Up and Operate a Synchronization Circuit Using Series Actuators

Self Review 4

20. Hydraulic Relief Valve Operation

Segment 1 - Pilot-Operated Relief Valve Operation

Objective 1 - Explain the Advantage of a Pilot-Operated Relief Valve

Objective 2 - Describe the Operation of a Pilot-Operated Relief Valve and Give Its Complete Schematic Symbol

Activity 1 - Relief Valve Performance

Self Review 1

Segment 2 - Pump Unloading Applications

Objective 3 - Describe the Function of the Vent Port of a Pilot-Operated Relief Valve

Objective 4 - Describe Two Methods of Pump Unloading and Give an Application of Each

Skill 1 - Connect a Pilot-Operated Relief Valve to Unload a Pump by Venting

Self Review 2

Segment 3 - Remote Pressure Control

Objective 5 - Describe the Operation of a Remote-Controlled Relief Valve Circuit

Skill 2 - Connect and Operate a Remotely Controlled Pilot-Operated Relief Valve Circuit

Objective 6 - Describe Multiple Pressure Relief Valve Operation and Give One Application

Skill 3 - Design a Circuit to Provide a Two-Pressure Control with Unloading

Self Review 3

21. Hydraulic Check Valve Applications

Segment 1 - Pressure Port Check Valve Circuit

Objective 1 - Explain How Actuator Relaxation Occurs in a Multi-Actuator Circuit

Objective 2 - Describe the Operation of a P-Port Check Valve Circuit

Skill 1 - Connect and Operate a P-Port Check Valve Circuit

Objective 3 - Describe the Construction of an Integral P-Port Check Valve

Self Review 1

Segment 2 - Pilot-Operated Check Valves

Objective 4 - Describe the Function of a Pilot-Operated Check Valve and Give an Application

Objective 5 - Describe the Operation of a Pilot-Operated Check Valve and Give Its Symbol

Skill 2 - Connect and Operate a Pilot-Operated Check Valve

Self Review 2

Segment 3 - Pilot-Operated Check Valve Applications

Objective 6 - Describe the Operation of Load-Lock Circuits Using One POC Valve

Skill 3 - Connect and Operate a Load-Lock Circuit

Objective 7 - Describe the Operation of Load-Lock Circuits That Use Two POC Valves

Objective 8 - Describe the Operation of a Double POC Valve

Objective 9 - Describe the Function of a Prefill Valve and Give an Application

Self Review 3

Segment 4 - Pilot-Operated Check Valve Circuit Design

Objective 10 - Define POC Valve Pilot Ratio and Explain Its Importance

Skill 4 - Measure Pilot-Operated Check Valve Pilot Pressure

Objective 11 - Describe How to Calculate the Pressure Required to Open a POC Valve

Skill 5 - Calculate the Pilot Pressure Required to Open a POC Valve

Objective 12 - Define Pressure Intensification and Explain Its Importance

Objective 13 - Describe How to Calculate the Maximum Pressure in a POC Valve Circuit

Skill 6 - Calculate the Maximum Pressure in a POC Valve Circuit

Activity 1 - Measurement of Pilot Pressure and Pressure Intensification in a POC Valve Circuit

Objective 14 - Describe the Function and Operation of a POC Valve with Decompression Poppet

Objective 15 - List Five Application Guidelines for POC Valves

Skill 7 - Design a POC Valve Circuit

Self Review 4

22. Hydraulic Motor Applications

Segment 1 - Hydraulic Motor Types

Objective 1 - Describe the Function of HSLT and LSHT Motors and Give an Example

Objective 2 - Describe the Operation of an External Gear Motor and Give an Application

Objective 3 - Describe the Operation of Two Types of Internal Gear Motors and Give an Application of Each

Objective 4 - Describe the Operation of Two Types of Fixed Vane Motors and Give an Application of Each

Objective 5 - Describe the Operation of Three Types of Fixed Displacement Piston Motors

Skill 1 - Select a Hydraulic Motor Type for a Given Application

Self Review 1

Segment 2 - Motor Applications

Objective 6 - Describe the Advantages and Disadvantages of Hydraulic Motors

Skill 2 - Identify the Correct Application for a Hydraulic Motor

Objective 7 - Describe the Operation of Two Types of Handheld Tachometers Used in Motor Speed

Skill 3 - Measure Hydraulic Motor Speed Using the Photo Tachometer

Objective 8 - List Three Methods of Synchronizing Hydraulic Motors and Give an Application of Each

Objective 9 - Describe the Operation of a Parallel Motor Synchronization Circuit

Skill 4 - Connect and Operate a Parallel Motor Synchronization Circuit

Objective 10 - Describe the Operation of a Series Motor Synchronization Circuit

Skill 5 - Connect and Operate a Series Motor Circuit

Self Review 2

Segment 3 - Free-Wheeling Motor Circuits

Objective 11 - Describe Three General Methods of Stopping a Hydraulic Motor and Give an Advantage of Each

Objective 12 - Explain the Basic Design Rule for Hydraulic Motor Braking Circuits

Objective 13 - Describe the Function of a Make-up Check Valve

Activity 1 - Motor Cavitation Demonstration

Objective 14 - Describe the Operation of a Free-Wheeling Motor Circuit and Give an Application

Skill 6 - Connect and Operate a Free-Wheeling Motor Circuit

Objective 15 - Describe the Operation of a Bidirectional Free-Wheeling Motor Circuit

Self Review 3

Segment 4 - Unidirectional Motor Braking

Objective 16 - Describe How Motors Are Stopped Hydraulically

Objective 17 - Describe the Function of a Hydraulic Drain and Give Its Schematic Symbol

Objective 18 - Describe the Operation of a Unidirectional Motor Circuit with Braking Relief Valve

Skill 7 - Connect and Operate a Unidirectional Motor Braking Circuit Using a Relief Valve

Objective 19 - Describe the Function of a Spool Crossover Condition and Give Its Schematic Symbol

Self Review 4

Segment 5 - Bidirectional Motor Braking

Objective 20 - Describe the Operation of a Bidirectional Motor Circuit with Two Braking Relief Valves

Objective 21 - Describe the Operation of a Cross Cushion Relief Valve and Give Its Schematic Symbol
Skill 8 - Connect and Operate a Motor Circuit with Cross Cushion Relief Valve Braking
Objective 22 - Describe the Operation of a Bidirectional Motor Circuit with One Braking Relief Valve
Objective 23 - Describe the Function of a Hydraulic Brake Valve and Give an Application
Objective 24 - Describe the Operation of a Hydraulic Brake Valve and Give Its Schematic Symbol
Self Review 5

23. Hydraulic Pump and Motor Performance

Segment 1 - Pump Flow Rate

Objective 1 - Define Hydraulic Pump Displacement and Explain How It Is Used
Objective 2 - Describe How to Calculate the Theoretical Flow Rate of a Pump Given Displacement
Skill 1 - Calculate the Theoretical Pump Flow Rate Given Displacement
Objective 3 - Define Pump Volumetric Efficiency and Explain How It Is Used
Objective 4 - Describe How to Calculate Actual Pump Flow Rate Given Volumetric Efficiency
Skill 2 - Calculate Actual Pump Flow Rate Given Volumetric Efficiency
Activity 1 - Measurement of Pump Volumetric Efficiency
Self Review 1

Segment 2 - Pump Power

Objective 5 - Define Mechanical Power and Give Its Units of Measurement
Objective 6 - Define Hydraulic Power and Give Its Units of Measurement
Skill 3 - Calculate Hydraulic Power
Objective 7 - Define Overall Pump Efficiency and Explain How It Is Used
Skill 4 - Size a Prime Mover Given Pump Overall Efficiency
Objective 8 - Describe How to Use a Pump Efficiency Curve to Determine Overall Efficiency
Skill 5 - Determine Overall Efficiency Given a Pump Efficiency Curve
Self Review 2

Segment 3 - Hydraulic Motor Displacement

Objective 9 - Define Hydraulic Motor Displacement and Explain How It Is Used
Activity 2 - Measurement of Hydraulic Motor Displacement
Objective 10 - Describe How to Calculate Theoretical Motor Speed
Skill 6 - Calculate the Theoretical Speed of a Motor Given Its Displacement and Flow Rate
Objective 11 - Define Motor Volumetric Efficiency and Explain How It Is Used
Objective 12 - Describe How to Calculate Actual Hydraulic Motor Speed Given Volumetric Efficiency
Skill 7 - Calculate Actual Hydraulic Motor Speed Given Volumetric Efficiency
Self Review 3

Segment 4 - Hydraulic Motor Torque

Objective 13 - Define Hydraulic Motor Torque and Give Its Units of Measurement
Objective 14 - Describe How to Calculate Theoretical Hydraulic Motor Torque Given Displacement
Skill 8 - Calculate Theoretical Hydraulic Motor Torque Given Displacement
Objective 15 - Describe How to Calculate Hydraulic Motor Torque Given a Torque Specification
Skill 9 - Calculate the Theoretical Hydraulic Motor Torque Given Torque Specification
Objective 16 - Define Hydraulic Motor Mechanical Efficiency and Explain How It Is Used
Skill 10 - Calculate Actual Motor Torque Given Mechanical Efficiency
Objective 17 - Define Three Types of Torque Specifications: Starting, Breakaway, and Running
Objective 18 - Describe How to Use a Manufacturer's Torque-Speed Curve to Determine Actual Torque
Skill 11 - Determine Actual Motor Torque Using a Torque-Speed Curve
Self Review 4

24. Hydraulic Speed Control

Segment 1 - Relief Valves

Objective 1 - Describe the Function of a Relief Valve and Give an Application
Objective 2 - Describe the Operation of a Direct-Acting Relief Valve and Give Its Schematic Symbol
Objective 3 - Describe How a Relief Valve Is Used for System Protection
Skill 1 - Connect a Relief Valve in a Circuit to Limit Pressure in the System
Objective 4 - Describe How a Relief Valve Is Used for Speed Control Assistance

Activity 1 - Relief Valve Operation with Speed Control

Self Review 1

Segment 2 - Check Valves

Objective 5 - Describe the Function of a Check Valve and Give an Application

Objective 6 - Describe the Operation of Three Types of Check Valves and Give Their Schematic Symbol

Activity 2 - Check Valve Operation

Skill 2 - Design a Circuit to Provide Bypass Flow

Self Review 2

Segment 3 - Flow Control Valves

Objective 7 - Describe the Function of the Flow Control Valve and Give an Application

Objective 8 - Describe the Operation of a Flow Control Valve and Give Its Schematic Symbol

Skill 3 - Connect and Adjust a Flow Control Valve to Control Speed of an Actuator

Objective 9 - Describe the Effect of Actuator Load Changes on Flow Control Valve Operation

Activity 3 - Effect of Actuator Load Changes on Flow Control Valve Operation

Self Review 3

Segment 4 - Meter-In and Meter-Out Circuits

Objective 10 - Describe the Operation of a Meter-In Flow Control Circuit and Give an Application

Skill 4 - Connect and Operate a Meter-In Flow Control Circuit

Objective 11 - Describe the Operation of a Meter-Out Flow Control Circuit and Give an Application

Skill 5 - Connect and Operate a Meter-Out Flow Control Circuit

Self Review 4

Segment 5 - Flow Control Circuit Design

Objective 12 - Define Independent Speed Control and Give an Application

Skill 6 - Design an Independent Speed Control Circuit

Objective 13 - Explain How Speed Control Valves Can Be Used to Provide Multiple Speeds

Skill 7 - Design a Two-Speed Actuator Circuit

Self Review 5

Segment 6 - Flow Rate vs. Cylinder Speed

Objective 14 - Describe How to Calculate the Extend Speed of a Hydraulic Cylinder

Skill 8 - Calculate the Extend Speed of a Hydraulic Cylinder Given Its Size and a Flow Rate

Objective 15 - Describe How to Calculate the Retract Speed of a Cylinder

Skill 9 - Calculate the Retract Speed of a Cylinder Given Its Size and a Flow Rate

Objective 16 - Describe How to Calculate the Stroke Time of a Cylinder

Skill 10 - Calculate the Cylinder Stroke Time Given Its Size and a Flow Rate

Self Review 6

25. Troubleshooting Hydraulic Actuators and DCVs

Segment 1 - Cylinder Cushions and Boots

Objective 1 - Describe the Operation of a Cylinder Cushion and Give Its Schematic Symbol

Objective 2 - Describe How to Adjust a Cylinder Cushion

Skill 1 - Adjust a Cylinder Cushion

Objective 3 - Describe the Operation of a Cylinder Rod Boot

Objective 4 - Describe How to Install a Cylinder Rod Boot

Self Review 1

Segment 2 - Cylinder Troubleshooting

Objective 5 - Describe Five Symptoms of Hydraulic Cylinder Failure and Their Causes

Objective 6 - Describe How to Troubleshoot a Hydraulic Cylinder

Skill 2 - Troubleshoot a Cylinder Using an In-Circuit Test

Self Review 2

Segment 3 - Motor Troubleshooting

Objective 7 - Describe Five Symptoms of Motor Failure and Their Causes

Objective 8 - Describe How to Troubleshoot a Hydraulic Motor

Skill 3 - Troubleshoot a Motor Using an In-Circuit Test

Self Review 3

Segment 4 - Direct-Operated DCV Troubleshooting

Objective 9 - Describe Five Symptoms of Direct-Operated DCV Failure and Their Causes

Objective 10 - Describe How to Troubleshoot a Direct-Operated DCV

Skill 4 - Troubleshoot a Direct-Operated DCV Using an In-Circuit Test

Self Review 4

26. Fluids and Conditioning

Segment 1 - Conductors

Objective 1 - List Three Types of Hydraulic Fluid Conductors and Give an Application of Each

Objective 2 - Describe How Each Type of Hydraulic Conductor Is Specified

Objective 3 - Describe the Effect Size Has on Conductor Properties

Objective 4 - Explain How to Size a Conductor

Skill 1 - Size a Conductor

Self Review 1

Segment 2 - Fluid Viscosity

Objective 5 - Describe the Four Main Functions of Hydraulic Fluid

Objective 6 - Define Viscosity and Give Its Units of Measurement

Skill 2 - Measure the Viscosity of a Fluid

Objective 7 - Describe How Viscosity Affects Circuit Operation and the Guidelines Used in the Selection of Oils

Activity 1 - Effects of Viscosity on Internal Leakage and Pressure Settings

Self Review 2

Segment 3 - Fluid Compressibility

Objective 8 - Define Fluid Compressibility and Explain How It Affects Hydraulic System Operation

Objective 9 - Define Bulk Modulus and Give the Rule-of-Thumb for Oil Compressibility

Activity 2 - Compressibility of Fluids

Objective 10 - Describe Three Fire-Resistant Fluids Used in Hydraulic Systems

Objective 11 - Describe How Seal Materials Are Determined by Hydraulic Fluid Type

Skill 3 - Inspect the Seals of a Subplated Directional Control Valve

Self Review 3

Segment 4 - Filtration

Objective 12 - Describe the Function of a Filter and Give Its Symbol

Objective 13 - List Four Filter Placement Locations and Explain When Each Is Used

Objective 14 - Describe the Construction and Operation of a Suction Strainer

Objective 15 - Describe the Construction and Operation of a Pressure Line Filter

Objective 16 - Describe the Construction and Operation of a Cartridge-Type Filter

Objective 17 - Describe the Construction and Operation of a Spin-on Filter

Objective 18 - Explain How Hydraulic Filters Are Rated

Objective 19 - Define Filter Dirt Holding Capacity

Objective 20 - Describe How to Determine When a Filter Element Needs Changing

Skill 4 - Change a Filter Element

Self Review 4

Segment 5 - Reservoirs and Heat Exchangers

Objective 21 - Describe the Function of a Reservoir

Objective 22 - Describe the Construction of a Reservoir

Objective 23 - Describe How a Reservoir Is Sized

Skill 5 - Size and Select a Reservoir

Objective 24 - Explain the Function of a Hydraulic System Heat Exchanger

Objective 25 - List Two Types of Heat Exchangers and Give an Example of Each

Objective 26 - Explain How Heat Exchangers Are Sized

Skill 6 - Size a Heat Exchanger

Self Review 5

27. Fittings and Seals

Segment 1 - Cylinder Bleeding

Objective 1 - Describe the Function of Cylinder Bleeding
Objective 2 - Describe How to Bleed a Hydraulic Cylinder
Skill 1 - Bleed a Hydraulic Cylinder
Self Review 1

Segment 2 - O-Ring Seals

Objective 3 - Describe the Function of an O-Ring Seal
Objective 4 - Describe the Operation of an O-Ring Seal
Objective 5 - Describe How to Perform a Basic O-Ring Installation
Objective 6 - Describe How to Replace an O-Ring Using an O-Ring Pick
Skill 2 - Install an O-Ring Seal
Self Review 2

Segment 3 - Straight Thread O-Ring (STOR) Fitting Identification

Objective 7 - Describe the Functions of Eight Types of Hydraulic Fittings
Objective 8 - Describe the Functions of Seven Styles of Hydraulic Fittings and Couplings
Objective 9 - Describe the Operation of a Straight Thread O-Ring (STOR) Fitting
Objective 10 - Describe How Straight Thread O-Ring (STOR) Fittings Are Specified
Skill 3 - Identify and Select a Straight Thread O-Ring (STOR) Fitting Given a Specification
Self Review 3

Segment 4 - Straight Thread O-Ring (STOR) Fitting Installation

Objective 11 - Describe How to Handle and Store a Straight Thread O-Ring (STOR) Fitting
Skill 4 - Handle and Store a Straight Thread O-Ring (STOR) Fitting
Objective 12 - Describe How to Install Adjustable and Non-Adjustable Straight Thread O-Ring (STOR) Fittings
Skill 5 - Install Adjustable and Non-Adjustable Straight Thread O-Ring (STOR) Fittings
Self Review 4

28. Hose and Clamping Devices

Segment 1 - Hydraulic Hose

Objective 1 - Describe the Function and Construction of Hydraulic Hose
Objective 2 - Describe How Hydraulic Hose Is Specified
Skill 1 - Identify Hydraulic Hose Given a Sample
Self Review 1

Segment 2 - Hose Clamps, Brackets, and Clips

Objective 3 - Describe the Function of Three Types of Hose Clamping Devices
Objective 4 - Describe the Function of Hose Brackets and Hose Clips
Objective 5 - Describe How to Install a Hydraulic Hose Using Brackets and Clips
Skill 2 - Install Hydraulic Hoses with Brackets
Self Review 2

Segment 3 - Push-Lock Hose Fittings

Objective 6 - Describe the Function of Push-Lock Hose Fittings
Objective 7 - Describe How to Install a Hydraulic Hose with a Push-Lock Hose Fitting
Skill 3 - Install a Hydraulic Hose with a Push-Lock Hose Fitting
Self Review 3

29. Hydraulic Filter Maintenance

Segment 1 - Filter Specifications

Objective 1 - Describe the Function of a Filter and Give Its Schematic Symbol
Objective 2 - List Four Filter Placement Locations and Explain When Each Is Used
Objective 3 - Describe the ISO 4406 Contamination Code and Explain Its Importance
Objective 4 - Define the Filter Beta Ratio and Explain Its Importance
Objective 5 - Describe How Filters Are Specified
Skill 1 - Interpret a Filter Specification
Skill 2 - Select a Filter Given System Requirements

Self Review 1

Segment 2 - Filter Operation

Objective 6 - Describe the Operation of a Spin-On Filter

Objective 7 - Describe the Operation of a Cartridge-Type Filter

Objective 8 - Describe the Operation of a Strainer

Objective 9 - Describe How to Determine When a Filter Element Needs Changing or Cleaning

Skill 3 - Determine If a Filter Should Be Replaced by Measuring the Pressure Differential

Self Review 2

Segment 3 - Filter Maintenance

Objective 10 - Describe How to Replace a Spin-On Filter

Skill 4 - Replace a Spin-On Filter

Objective 11 - Describe How to Replace a Cartridge Filter

Skill 5 - Replace a Cartridge Filter

Objective 12 - Describe How to Clean and Replace a Strainer

Skill 6 - Clean and Replace a Strainer

Self Review 3

30. Hydraulic Pump Troubleshooting

Segment 1 - Hydraulic Troubleshooting Concepts

Objective 1 - Define Hydraulic Troubleshooting and Explain Its Importance

Objective 2 - Describe Two Levels of Hydraulic Troubleshooting and Give an Application of Each

Objective 3 - Describe Two Methods of Testing a Hydraulic Component and Give an Application of Each

Objective 4 - Describe Six Hydraulic Safe Dress Rules

Objective 5 - Describe Eight Hydraulic Troubleshooting Safety Rules

Self Review 1

Segment 2 - In-Circuit Hydraulic Component Testing

Objective 6 - Describe Four Types of In-Circuit Component Tests and Give an Application of Each

Objective 7 - Describe Three Hydraulic Troubleshooting Measurements and Give an Application of Each

Objective 8 - Describe the Construction of Three Types of Pressure Test Points and Give an Application of Each

Objective 9 - Name the Two Typical Locations of Pressure Test Points

Skill 1 - Use a Pressure Test Point to Troubleshoot a Hydraulic System

Self Review 2

Segment 3 - Flow Measurement

Objective 10 - Describe Three Ways to Use a Flow Meter to Troubleshoot a Hydraulic System

Objective 11 - Describe Two Methods of Measuring Flow

Skill 2 - Test a Hydraulic System by Measuring Fluid Flow

Self Review 3

Segment 4 - Pump Failure - Cavitation and Pseudo-Cavitation

Objective 12 - Define Cavitation and Explain Its Effect

Objective 13 - Describe Eight Causes of Cavitation

Objective 14 - Define Pseudo-Cavitation and Explain Its Effect

Objective 15 - Describe Four Causes of Pseudo-Cavitation

Skill 3 - Recognize the Sound of Cavitation

Skill 4 - Recognize the Sound of Pseudo-Cavitation

Self Review 4

Segment 5 - Fixed-Displacement Pump Troubleshooting

Objective 16 - Describe Nine Symptoms of Fixed-Displacement Pump Failure and Their Causes

Objective 17 - Describe How to Use a Hydraulic Troubleshooting Chart

Objective 18 - Describe How to Troubleshoot a Fixed Displacement Hydraulic Pump

Skill 5 - Troubleshoot a Fixed-Displacement Pump Using an In-Circuit Test

Self Review 5