MODULE OVERVIEW
This module explains and identifies the uses of conveyors, their operation, and the major parts of roller, belt, chain, screw, and pneumatic conveyors. It also describes the principles of conveyor safety.

PREREQUISITES
Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following: Core Curriculum; Millwright Level One; Millwright Level Two; and Millwright Level Three.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:

1. Explain conveyor safety.
2. Identify and explain the use of roller conveyors and their components.
3. Identify and explain the use of belt conveyors and their components.
4. Identify and explain the use of chain conveyors and their components.
5. Identify and explain the use of screw conveyors and their components.
6. Identify and explain the use of pneumatic conveyors and their components.

PERFORMANCE TASKS
This is a knowledge-based module; there are no Performance Tasks.

MATERIALS AND EQUIPMENT LIST

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead projector and screen</td>
<td></td>
</tr>
<tr>
<td>Transparencies</td>
<td></td>
</tr>
<tr>
<td>Blank acetate sheets</td>
<td></td>
</tr>
<tr>
<td>Transparency pens</td>
<td></td>
</tr>
<tr>
<td>Whiteboard/chalkboard</td>
<td></td>
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<tr>
<td>Markers/chalk</td>
<td></td>
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<tr>
<td>Pencils and scratch paper</td>
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<tr>
<td>Manufacturers’ literature for various types of conveyors</td>
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<tr>
<td>Safety videos or CD and appropriate devices for viewing, guest speaker, or online safety training</td>
<td></td>
</tr>
<tr>
<td>Photographs or illustrations of various types of conveyors</td>
<td></td>
</tr>
<tr>
<td>Appropriate personal protective equipment</td>
<td></td>
</tr>
<tr>
<td>Samples of conveyor chains</td>
<td></td>
</tr>
<tr>
<td>Copies of the Quick Quiz*</td>
<td></td>
</tr>
<tr>
<td>Module Examinations**</td>
<td></td>
</tr>
</tbody>
</table>

* Located in the back of this module.
** Located in the Test Booklet.

SAFETY CONSIDERATIONS
Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly.

ADDITIONAL RESOURCES
This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

* Rexnord Power Transmission and Conveying Components, Catalog #R85. Rexnord Inc. Atlanta, GA.
* Goodyear Conveyor Maintenance. Goodyear Tire and Rubber Co. Akron, OH.
Teaching Time for This Module

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2 1/2 hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 5 hours are suggested to cover Conveyors. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Session I. Introduction; Safety; Conveyors I</strong></td>
<td></td>
</tr>
<tr>
<td>A. Introduction</td>
<td></td>
</tr>
<tr>
<td>B. Conveyor Safety</td>
<td></td>
</tr>
<tr>
<td>C. Roller Conveyors</td>
<td></td>
</tr>
<tr>
<td>D. Belt Conveyors</td>
<td></td>
</tr>
<tr>
<td><strong>Session II. Conveyors II; Review and Testing</strong></td>
<td></td>
</tr>
<tr>
<td>A. Chain Conveyors</td>
<td></td>
</tr>
<tr>
<td>B. Screw Conveyors</td>
<td></td>
</tr>
<tr>
<td>C. Pneumatic Conveyors</td>
<td></td>
</tr>
<tr>
<td>D. Review</td>
<td></td>
</tr>
<tr>
<td>E. Module Examination</td>
<td></td>
</tr>
<tr>
<td>1. Trainees must score 70% or higher to receive recognition from NCCER.</td>
<td></td>
</tr>
<tr>
<td>2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.</td>
<td></td>
</tr>
</tbody>
</table>
Troubleshooting and Repairing Conveyors
Annotated Instructor’s Guide

MODULE OVERVIEW
This module explains how to maintain, troubleshoot, and repair conveyors, including how to splice belts and replace sprockets, bearings, and conveying devices.

PREREQUISITES
Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following: Core Curriculum; Millwright Level One; Millwright Level Two; Millwright Level Three; and Millwright Level Four, Module 15401-08.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:
1. Maintain, troubleshoot, and repair belt and roller conveyors.

PERFORMANCE TASKS
Under the supervision of the instructor, the trainee should be able to do the following:
1. Splice a belt.
2. Repair one of the following:
   • Belt conveyor
   • Chain conveyor
   • Screw conveyor
   • Pneumatic conveyor

MATERIALS AND EQUIPMENT LIST
Overhead projector and screen
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Appropriate personal protective equipment
Gloves
Straightedge
Tape measures
Plywood or other suitable surface on which to cut and repair belts
Mechanical belt fasteners or other splicing materials
Conveyor setups or broken or damaged conveyors for the repair of belt, chain, screw, or pneumatic conveyors
Damaged drive rollers, sprockets, and bearings
Damaged chains, sprockets, and carrying devices
Maintenance manuals for belt, chain, screw, and pneumatic conveyors
Replacement links for chain conveyors
Replacement belt materials
Sling and hardware for rigging
Tools for marking, measuring, cutting, and splicing conveyor belts
Tools for installing replacement links
Allen wrenches
Arbor press or length of pipe to install bearings
Assorted screwdrivers

continued
SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. This module requires trainees to repair conveyors. Ensure that all trainees are briefed on appropriate shop safety procedures. This module may require that the trainees visit job sites. Ensure that trainees are briefed on site safety policies prior to any site visits.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

Rexnord Power Transmission and Conveying Components, Catalog #R85, 1984. Atlanta, GA: Rexnord Inc.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 12½ hours are suggested to cover Troubleshooting and Repairing Conveyors. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sessions I and II. Introduction; Maintaining, Troubleshooting, and Repairing Belt and Roller Conveyors</td>
<td></td>
</tr>
<tr>
<td>A. Introduction</td>
<td></td>
</tr>
<tr>
<td>B. Maintaining and Repairing Belt and Roller Conveyors</td>
<td></td>
</tr>
<tr>
<td>C. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Have trainees practice splicing a belt. This laboratory corresponds to Performance Task 1.</td>
<td></td>
</tr>
<tr>
<td>D. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Have trainees practice repairing a belt conveyor. This laboratory corresponds to Performance Task 2.</td>
<td></td>
</tr>
<tr>
<td>Sessions III and IV. Maintaining, Troubleshooting, and Repairing Chain, Screw, and Pneumatic Conveyors</td>
<td></td>
</tr>
<tr>
<td>A. Chain Conveyors</td>
<td></td>
</tr>
<tr>
<td>B. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Have trainees practice repairing a chain conveyor. This laboratory corresponds to Performance Task 2.</td>
<td></td>
</tr>
<tr>
<td>C. Screw Conveyors</td>
<td></td>
</tr>
</tbody>
</table>

Bearing pullers
Grease gun and lubricant
Needle-nose pliers
Torque wrenches

* Located in the back of this module
**Located in the Test Booklet
D. Laboratory
   Have trainees practice repairing a screw conveyor. This laboratory corresponds to Performance Task 2.
E. Pneumatic Conveyors
F. Laboratory
   Have trainees practice repairing a pneumatic conveyor. This laboratory corresponds to Performance Task 2.

Session V. Review and Testing
A. Module Review
B. Module Examination
   1. Trainees must score 70% or higher to receive recognition from NCCER.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.
C. Performance Testing
   1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.
This module explains the importance of precise alignment of machinery and equipment. It describes the various types of misalignment and covers aligning couplings using a straightedge and feeler gauge. It also covers adjusting face and OD alignment using a dial indicator, and eliminating coupling stress.

PREREQUISITES
Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following: Core Curriculum; Millwright Level One; Millwright Level Two; Millwright Level Three; and Millwright Level Four, Modules 15401-08 and 15402-08.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:
1. Explain types of misalignment.
2. Align couplings, using the straightedge and feeler gauge method.
3. Identify and eliminate coupling stress.
4. Align couplings, using the dial indicator method.

PERFORMANCE TASKS
Under the supervision of the instructor, the trainee should be able to do the following:
1. Check for coupling stress.
2. Eliminate coupling stress.
3. Set up dial indicators.
4. Determine sag of a conventional alignment jig.
5. Level and align the driven on a base.
6. Adjust vertical offset and angularity using the straightedge and feeler gauge method.
7. Adjust horizontal offset and angularity using the straightedge and feeler gauge method.
8. Adjust vertical offset and angularity using dial indicators.
9. Adjust horizontal offset and angularity using dial indicators.

MATERIALS AND EQUIPMENT LIST
Overhead projector and screen
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Appropriate personal protective equipment
Old or broken equipment to demonstrate misalignment and coupling stress
Alignment simulator
Instruction manual for an alignment simulator
Samples of machines that have coupling stress from various causes
Dial indicators and bases
Instruction manual for dial indicators
Feeler gauges
Straightedges
Levels
Soft-faced hammers
Dial calipers
Copies of the Quick Quiz*
Module Examinations**
Performance Profile Sheets**

* Located in the back of this module.
** Located in the Test Booklet.
SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. This module requires trainees to work with alignment simulators and other equipment. Ensure that trainees are properly briefed on applicable safety procedures including the use of guards and emergency shut-offs, and precautions to take when working around rotating equipment.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

Ludeca, Inc.: http://www.ludeca.com

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 30 hours are suggested to cover Conventional Alignment. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
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</thead>
<tbody>
<tr>
<td><strong>Sessions I through III. Introduction; Misalignment; Coupling Stress</strong></td>
<td></td>
</tr>
<tr>
<td>A. Introduction</td>
<td></td>
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<tr>
<td>B. Types of Misalignment</td>
<td></td>
</tr>
<tr>
<td>C. Coupling Stress</td>
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</tr>
<tr>
<td>D. Laboratory</td>
<td>Have trainees practice checking for coupling stress. This laboratory corresponds to Performance Task 1.</td>
</tr>
<tr>
<td>E. Laboratory</td>
<td>Have trainees practice eliminating coupling stress. This laboratory corresponds to Performance Task 2.</td>
</tr>
<tr>
<td><strong>Sessions IV through VII. Alignment: Straightedge and Feeler Gauge Method</strong></td>
<td></td>
</tr>
<tr>
<td>A. Adjusting Vertical Angularity</td>
<td></td>
</tr>
<tr>
<td>B. Adjusting Vertical Offset</td>
<td></td>
</tr>
<tr>
<td>C. Laboratory</td>
<td>Have trainees practice leveling and aligning the driven on a base. This laboratory corresponds to Performance Task 5.</td>
</tr>
<tr>
<td>D. Laboratory</td>
<td>Have trainees practice adjusting vertical offset and angularity using the straightedge and feeler gauge method. This laboratory corresponds to Performance Task 6.</td>
</tr>
<tr>
<td>E. Adjusting Horizontal Angularity</td>
<td></td>
</tr>
<tr>
<td>F. Adjusting Horizontal Offset</td>
<td></td>
</tr>
<tr>
<td>G. Laboratory</td>
<td>Have trainees practice adjusting horizontal offset and angularity using the straightedge and feeler gauge method. This laboratory corresponds to Performance Task 7.</td>
</tr>
<tr>
<td>H. Adjusting Vertical Angularity and Offset</td>
<td></td>
</tr>
<tr>
<td>I. Adjusting Horizontal Angularity and Offset</td>
<td></td>
</tr>
</tbody>
</table>
Sessions VIII through XI. Alignment: Dial Indicator Method

A. Setting Up Dial Indicators

B. Laboratory
   Have trainees practice setting up dial indicators. This laboratory corresponds to Performance Task 3.

C. Laboratory
   Have trainees practice determining the sag on a conventional alignment jig. This laboratory corresponds to Performance Task 4.

D. Taking Top View Measurements

E. Taking Side View Measurements

F. Taking Angularity and Offset Measurements

G. Laboratory
   Have trainees practice adjusting vertical offset and angularity using the dial indicator method. This laboratory corresponds to Performance Task 8.

H. Laboratory
   Have trainees practice adjusting horizontal offset and angularity using the dial indicator method. This laboratory corresponds to Performance Task 9.

Session XII. Review and Testing

A. Review

B. Module Examination
   1. Trainees must score 70% or higher to receive recognition from NCCER.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

C. Performance Testing
   1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.
Module Overview

This module explains centrifugal, rotary, reciprocating, metering, and vacuum pump operation and installation methods, as well as types of drivers. It also covers net positive suction head and cavitation.

Prerequisites

Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following: Core Curriculum; Millwright Level One; Millwright Level Two; Millwright Level Three; and Millwright Level Four, Modules 15401-08 through 15403-08.

Objectives

Upon completion of this module, the trainee will be able to do the following:

1. Identify and explain centrifugal pumps.
2. Identify and explain rotary pumps.
3. Identify and explain reciprocating pumps.
4. Identify and explain metering pumps.
5. Identify and explain vacuum pumps.
6. Explain net positive suction head and cavitation.
7. Install pumps.

Performance Tasks

Under the supervision of the instructor, the trainee should be able to do the following:

1. Identify centrifugal pumps.
2. Identify rotary pumps.
3. Identify reciprocating pumps.
4. Identify metering pumps.
5. Identify vacuum pumps.
6. Install a pump.

Materials and Equipment List

Overhead projector and screen
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Appropriate personal protective equipment
Hot water bottle with small hose
Pump setups
Manufacturers’ installation instructions for various types of pumps

Examples of of the following types of pumps:
Centrifugal
Rotary
Reciprocating
Metering
Vacuum

Assorted screwdrivers
Ball-peen hammer
Needle-nose pliers
Allen wrenches
Copies of the Quick Quizzes*
Module Examinations**
Performance Profile Sheets**

* Located in the back of this module.
**Located in the Test Booklet.
SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. This module may require trainees to visit power plants or utility areas. Ensure that they are briefed on site safety procedures. This module requires trainees to install pumps. Ensure that they are briefed on appropriate shop safety procedures.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

- ITT Fluid Technology: http://www.ittfluidbusiness.com
- Flowserve: http://www.flowserve.com
- Goulds Pumps: http://www.goulds.com
- Siemens Corporation: http://www.usa.siemens.com

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 20 hours are suggested to cover Pumps. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Session I. Introduction; Centrifugal Pumps</strong></td>
<td></td>
</tr>
<tr>
<td>A. Introduction</td>
<td></td>
</tr>
<tr>
<td>B. Centrifugal Pumps</td>
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</tr>
<tr>
<td>C. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Have trainees practice identifying centrifugal pumps. This laboratory corresponds to Performance Task 1.</td>
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<tr>
<td><strong>Session II. Rotary Pumps</strong></td>
<td></td>
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<tr>
<td>A. Rotary Pumps</td>
<td></td>
</tr>
<tr>
<td>B. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Have trainees practice identifying rotary pumps. This laboratory corresponds to Performance Task 2.</td>
<td></td>
</tr>
<tr>
<td><strong>Session III. Reciprocating Pumps</strong></td>
<td></td>
</tr>
<tr>
<td>A. Reciprocating Pumps</td>
<td></td>
</tr>
<tr>
<td>B. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Have trainees practice identifying reciprocating pumps. This laboratory corresponds to Performance Task 3.</td>
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<tr>
<td><strong>Session IV. Metering Pumps</strong></td>
<td></td>
</tr>
<tr>
<td>A. Metering Pumps</td>
<td></td>
</tr>
<tr>
<td>B. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Have trainees practice identifying metering pumps. This laboratory corresponds to Performance Task 4.</td>
<td></td>
</tr>
</tbody>
</table>
Session V. Vacuum Pumps

A. Vacuum Pumps

B. Laboratory
   Have trainees practice identifying vacuum pumps. This laboratory
corresponds to Performance Task 5.

Sessions VI and VII. Cavitation; Pump Installation

A. Cavitation

B. Installing Pumps

C. Laboratory
   Have trainees practice installing a pump. This laboratory corresponds
to Performance Task 6.

Session VIII. Review and Testing

A. Module Review

B. Examination
   1. Trainees must score 70% or higher to receive recognition from NCCER.
   2. Record the testing results on Craft Training Report Form 200, and submit
      the results to the Training Program Sponsor.

C. Performance Testing
   1. Trainees must perform each task to the satisfaction of the instructor
to receive recognition from NCCER. If applicable, proficiency noted during
laboratory exercises can be used to satisfy the Performance
Testing requirements.
   2. Record the testing results on Craft Training Report Form 200, and submit the
results to the Training Program Sponsor.
MODULE OVERVIEW
This module covers how to inspect, troubleshoot, and prepare pumps for shutdown. It also covers removing pumps from the system, disassembly, and reassembly.

PREREQUISITES
Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following: Core Curriculum; Millwright Level One; Millwright Level Two; Millwright Level Three; and Millwright Level Four, Modules 15401-08 through 15404-08.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:
1. Inspect a pump.
2. Troubleshoot a pump.
3. Prepare a pump for shutdown and repair.
4. Remove a pump from the system.
5. Disassemble a pump.
6. Reassemble a pump.
7. Install a pump.
8. Use a checklist for pump start-up.

PERFORMANCE TASKS
Under the supervision of the instructor, the trainee should be able to do the following:
1. Inspect and troubleshoot a pump.
2. Disassemble and reassemble a pump.

MATERIALS AND EQUIPMENT LIST

<table>
<thead>
<tr>
<th>Overhead projector and screen</th>
<th>Arbor press or length of pipe to install bearings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transparencies</td>
<td>Dial indicators</td>
</tr>
<tr>
<td>Blank acetate sheets</td>
<td>Assorted screwdrivers</td>
</tr>
<tr>
<td>Transparency pens</td>
<td>Ball-pee hammer</td>
</tr>
<tr>
<td>Whiteboard/chalkboard</td>
<td>Needle-nose pliers</td>
</tr>
<tr>
<td>Markers/chalk</td>
<td>Allen wrenches</td>
</tr>
<tr>
<td>Pencils and scratch paper</td>
<td>Bearing pullers</td>
</tr>
<tr>
<td>Appropriate personal protective equipment</td>
<td>Combination wrench sets</td>
</tr>
<tr>
<td>Company safety manual</td>
<td>Emery cloths and hones</td>
</tr>
<tr>
<td>Lock washers</td>
<td>Feeler gauges</td>
</tr>
<tr>
<td>Gaskets</td>
<td>Flare nut wrenches</td>
</tr>
<tr>
<td>O-rings</td>
<td>Grease gun</td>
</tr>
<tr>
<td>Various types of pumps</td>
<td>Snap-ring pliers</td>
</tr>
<tr>
<td>Pump setups</td>
<td>Socket sets</td>
</tr>
<tr>
<td>Old or broken pumps</td>
<td>Torque wrenches</td>
</tr>
</tbody>
</table>

continued
SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. This module requires trainees to work with pumps. Ensure that they are briefed on appropriate shop safety procedures.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

Flowserve: http://www.flowserve.com/eim/Literature

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 7½ hours are suggested to cover Troubleshooting and Repairing Pumps. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session I. Introduction; Inspecting and Troubleshooting Pumps</td>
<td></td>
</tr>
<tr>
<td>A. Introduction</td>
<td></td>
</tr>
<tr>
<td>B. Inspecting Pumps</td>
<td></td>
</tr>
<tr>
<td>C. Performing Preventive Maintenance on Pumps</td>
<td></td>
</tr>
<tr>
<td>D. Troubleshooting Pumps</td>
<td></td>
</tr>
<tr>
<td>E. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Have trainees practice inspecting and troubleshooting a pump. This laboratory corresponds to Performance Task 1.</td>
<td></td>
</tr>
<tr>
<td>Session II. Disassembling and Reassembling Pumps</td>
<td></td>
</tr>
<tr>
<td>A. Preparing a Pump for Shutdown and Repair</td>
<td></td>
</tr>
<tr>
<td>B. Removing a Pump from the System</td>
<td></td>
</tr>
<tr>
<td>C. Disassembling a Split-Casing Pump</td>
<td></td>
</tr>
<tr>
<td>D. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Have trainees practice disassembling a pump. This laboratory corresponds to Performance Task 2.</td>
<td></td>
</tr>
<tr>
<td>E. Reassembling a Pump</td>
<td></td>
</tr>
<tr>
<td>F. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Have trainees practice reassembling a pump. This laboratory corresponds to Performance Task 2.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Item</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Shaft key wrenches</td>
<td>Silicone lubricant</td>
</tr>
<tr>
<td>Portable crane/rigging device</td>
<td>Manufacturers’ maintenance and repair manuals</td>
</tr>
<tr>
<td>Sling and hardware for rigging</td>
<td>Copies of the Quick Quizzes*</td>
</tr>
<tr>
<td>600-grit sandpaper</td>
<td>Module Examinations**</td>
</tr>
<tr>
<td>Appropriate machine oil</td>
<td>Performance Profile Sheets**</td>
</tr>
</tbody>
</table>

* Located in the back of this module.
** Located in the Test Booklet.
Session III. Pump Start-Up Procedures; Review and Testing

A. Installing a New or Removed Pump

B. Pump Start-Up Procedures and Operational Testing

C. Review

D. Module Examination
   1. Trainees must score 70% or higher to receive recognition from NCCER.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

E. Performance Testing
   1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.
MODULE OVERVIEW
This module describes different types of compressors and explains how they operate. It includes information about intake filters, intercoolers, and aftercoolers, and discusses how to troubleshoot and repair air compressors.

PREREQUISITES
Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following: Core Curriculum; Millwright Level One; Millwright Level Two; Millwright Level Three; and Millwright Level Four, Modules 15401-08 through 15405-08.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:
1. Explain pneumatic safety.
2. Explain the principles of compressor operation.
3. Identify and explain types of compressors.
4. Troubleshoot compressors.
5. Replace compressor components.

PERFORMANCE TASKS
Under the supervision of the instructor, the trainee should be able to do the following:
1. Identify various types of compressors.
2. Troubleshoot compressors.
3. Replace compressor components.

MATERIALS AND EQUIPMENT LIST
Overhead projector and screen
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Appropriate personal protective equipment
Safety video or DVD, or guest speaker
Video or DVD player
Various types of compressors, including:
  Continuous flow
  Reciprocating
Compressor system setups
Old or broken compressors
Air filters
Grease gun
Samples of various lubricants, including:
  Machine oil
  Silicone lubricant
  Assorted screwdrivers
  Ball-peen hammers
  Bearing pullers
  Carpenter’s levels
  Pressure gauges
  Feeler gauges
  Wrenches
  Flare nut
  Allen
  Pipe
  Shaft key
  Torque
  Needle-nose pliers
  Sharp knives
  Antiseize compound

continued
SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. This module requires trainees to work with compressors. Ensure that they are briefed on appropriate shop safety procedures.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following references are suggested for both instructors and motivated trainees interested in further study. These are optional resources for continued education rather than for task training.


TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 20 hours are suggested to cover *Compressors and Compressor Maintenance*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session I. Introduction; Compressor Safety</td>
<td></td>
</tr>
<tr>
<td>A. Introduction</td>
<td></td>
</tr>
<tr>
<td>B. Pneumatic (Compressed Air) Safety</td>
<td></td>
</tr>
<tr>
<td>Session II. Principles of Compressor Operation</td>
<td></td>
</tr>
<tr>
<td>A. Physical Characteristics of Gases</td>
<td></td>
</tr>
<tr>
<td>B. Pneumatic Transmission of Energy</td>
<td></td>
</tr>
<tr>
<td>C. Principles of Compressor Operation</td>
<td></td>
</tr>
<tr>
<td>Sessions III and IV. Compressor Types</td>
<td></td>
</tr>
<tr>
<td>A. Positive-Displacement Compressors</td>
<td></td>
</tr>
<tr>
<td>B. Continuous Flow Compressors</td>
<td></td>
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<tr>
<td>C. Compressor Support Systems</td>
<td></td>
</tr>
<tr>
<td>D. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Have trainees practice identifying various types of compressors. This laboratory corresponds to Performance Task 1.</td>
<td></td>
</tr>
</tbody>
</table>
Session V. Troubleshooting Compressors
   A. Drive Section Problems
   B. Compressor Section Problems
   C. Overall System
   D. Troubleshooting Reciprocating Compressors
   E. Laboratory
      Have trainees practice troubleshooting compressors. This laboratory corresponds to Performance Task 2.

Sessions VI and VII. Repairing Compressors
   A. General Maintenance
   B. Preparing to Repair Components
   C. Removing Components
   D. Replacing Components
   E. Laboratory
      Have trainees practice replacing compressor components. This laboratory corresponds to Performance Task 3.
   F. Performing Post-Repair Actions

Session VIII. Review and Testing
   A. Review
   B. Module Examination
      1. Trainees must score 70% or higher to receive recognition from NCCER.
      2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.
   C. Performance Testing
      1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
      2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.
MODULE OVERVIEW
This module covers pneumatic safety, characteristics of gases and how they are compressed, pneumatic transmission of energy, and pneumatic system components and their symbols.

PREREQUISITES
Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following: Core Curriculum; Millwright Level One; Millwright Level Two; Millwright Level Three; and Millwright Level Four, Modules 15401-08 through 15406-08.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:

2. Identify and explain pneumatic system components and symbols.

PERFORMANCE TASK
Under the supervision of the instructor, the trainee should be able to do the following:

1. Identify at least four components of basic pneumatic equipment.

MATERIALS AND EQUIPMENT LIST

- Overhead projector and screen
- Transparencies
- Blank acetate sheets
- Transparency pens
- Whiteboard/chalkboard
- Markers/chalk
- Pencils and scratch paper
- Appropriate personal protective equipment
- Pressure gauges
- Manufacturer’s literature on intercoolers and aftercoolers
- Company safety manual, including lockout/tagout procedures
- In-line filters or manufacturer’s literature on in-line filters
- Compressed-air treatment devices
- Pneumatic system actuators
- Pneumatic system mufflers
- Pneumatic system valves
- Pneumatic system intake filters
- Schematic diagram of a pneumatic system with pneumatic symbols
- Copies of the Quick Quizzes*
- Module Examinations**
- Performance Profile Sheets**

* Located in the back of this module.
**Located in the Test Booklet.

SAFETY CONSIDERATIONS
Ensure that the trainees are equipped with appropriate personal protective equipment and know how to
ADDITIONAL RESOURCES
This module is intended to present thorough resources for task training. The following references are suggested for both instructors and motivated trainees interested in further study. These are optional resources for continued education rather than for task training.


TEACHING TIME FOR THIS MODULE
An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 7½ hours are suggested to cover Basic Pneumatic Systems. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Session I. Introduction; Pneumatic Safety; Physical Characteristics of Gases</strong></td>
<td></td>
</tr>
<tr>
<td>A. Introduction</td>
<td></td>
</tr>
<tr>
<td>B. Pneumatic Safety</td>
<td></td>
</tr>
<tr>
<td>C. Physical Characteristics of Gases</td>
<td></td>
</tr>
<tr>
<td><strong>Session II. Pneumatic Systems</strong></td>
<td></td>
</tr>
<tr>
<td>A. Distribution and Treatment of Compressed Air</td>
<td></td>
</tr>
<tr>
<td>B. Pneumatic System Components</td>
<td></td>
</tr>
<tr>
<td>C. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Have trainees practice identifying pneumatic equipment components. This laboratory corresponds to Performance Task 1.</td>
<td></td>
</tr>
<tr>
<td><strong>Session III. Pneumatic Symbols; Review and Testing</strong></td>
<td></td>
</tr>
<tr>
<td>A. Pneumatic Symbols</td>
<td></td>
</tr>
<tr>
<td>B. Review</td>
<td></td>
</tr>
<tr>
<td>C. Module Examination</td>
<td></td>
</tr>
<tr>
<td>1. Trainees must score 70% or higher to receive recognition from NCCER.</td>
<td></td>
</tr>
<tr>
<td>2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.</td>
<td></td>
</tr>
<tr>
<td>D. Performance Testing</td>
<td></td>
</tr>
<tr>
<td>1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.</td>
<td></td>
</tr>
<tr>
<td>2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.</td>
<td></td>
</tr>
</tbody>
</table>
MODULE OVERVIEW
This module teaches trainees how to perform preventive maintenance on pneumatic equipment, inspect components, and read schematic diagrams. It includes troubleshooting and repair procedures for pneumatic systems.

PREREQUISITES
Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following: Core Curriculum; Millwright Level One; Millwright Level Two; Millwright Level Three; and Millwright Level Four, Modules 15401-08 through 15407-08.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:
1. Perform pneumatic system preventive maintenance procedures.
2. Inspect pneumatic system components.
3. Read pneumatic system schematic diagrams.
4. Troubleshoot pneumatic systems.
5. Repair pneumatic system components.

PERFORMANCE TASKS
Under the supervision of the instructor, the trainee should be able to do the following:
1. Inspect pneumatic system components.
2. Disassemble components.
3. Reassemble components.

MATERIALS AND EQUIPMENT LIST

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead projector and screen</td>
<td>Set of flare nut wrenches</td>
</tr>
<tr>
<td>Transparencies</td>
<td>Assorted screwdrivers</td>
</tr>
<tr>
<td>Blank acetate sheets</td>
<td>Emery cloths and hones</td>
</tr>
<tr>
<td>Transparency pens</td>
<td>Needle-nose pliers</td>
</tr>
<tr>
<td>Whiteboard/chalkboard</td>
<td>Set of Allen wrenches</td>
</tr>
<tr>
<td>Markers/chalk</td>
<td>Manufacturers’ maintenance and repair manuals</td>
</tr>
<tr>
<td>Pencils and scratch paper</td>
<td>Sample troubleshooting charts</td>
</tr>
<tr>
<td>Appropriate personal protective equipment</td>
<td>Copies of the Quick Quiz*</td>
</tr>
<tr>
<td>Company safety manual</td>
<td>Module Examinations**</td>
</tr>
<tr>
<td>Pneumatic system to inspect</td>
<td>Performance Profile Sheets**</td>
</tr>
<tr>
<td>Pneumatic system components to disable/repair</td>
<td></td>
</tr>
</tbody>
</table>

* Located in the back of this module.
**Located in the Test Booklet.
SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. This module requires trainees to disassemble and reassemble pneumatic system components. Ensure that they are briefed on appropriate shop safety procedures.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following references are suggested for both instructors and motivated trainees interested in further study. These are optional resources for continued education rather than for task training.


TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 10 hours are suggested to cover Troubleshooting and Repairing Pneumatic Equipment. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Session I. Introduction; Preventive Maintenance; Inspection of Pneumatic Equipment</strong></td>
<td></td>
</tr>
<tr>
<td>A. Introduction</td>
<td></td>
</tr>
<tr>
<td>B. Preventive Maintenance</td>
<td></td>
</tr>
<tr>
<td>C. Inspecting Pneumatic System Components</td>
<td></td>
</tr>
<tr>
<td>D. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Have trainees practice inspecting pneumatic system components. This laboratory corresponds to Performance Task 1.</td>
<td></td>
</tr>
<tr>
<td><strong>Session II. Reading Pneumatic Schematic Diagrams; Troubleshooting</strong></td>
<td></td>
</tr>
<tr>
<td>A. Reading Pneumatic Schematic Diagrams</td>
<td></td>
</tr>
<tr>
<td>B. Troubleshooting Pneumatic Systems</td>
<td></td>
</tr>
<tr>
<td>C. Pneumatic System Troubleshooting Charts</td>
<td></td>
</tr>
<tr>
<td><strong>Session III. Repairing Pneumatic System Components</strong></td>
<td></td>
</tr>
<tr>
<td>A. Preparing the System for Shutdown and Repair</td>
<td></td>
</tr>
<tr>
<td>B. Repairing and Overhauling Components</td>
<td></td>
</tr>
<tr>
<td>1. Removing Components from the System</td>
<td></td>
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<tr>
<td>2. Disassembling Components</td>
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<tr>
<td>3. Reassembling Components</td>
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<tr>
<td>C. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Have trainees practice disassembling and reassembling pneumatic system components. This laboratory corresponds to Performance Tasks 2 and 3.</td>
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<tr>
<td>D. Replacing Pneumatic Gauges</td>
<td></td>
</tr>
</tbody>
</table>
Session IV. Review and Testing

A. Review

B. Module Examination

1. Trainees must score 70% or higher to receive recognition from NCCER.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

C. Performance Testing

1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.
MODULE OVERVIEW
This module covers hydraulic system safety and the basic principles of hydraulics, including Pascal’s law and Bernoulli’s principle. It also explains the function of hydraulic fluids, system parts, pumps, and motors.

PREREQUISITES
Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following: Core Curriculum; Millwright Level One; Millwright Level Two; Millwright Level Three; and Millwright Level Four, Modules 15401-08 through 15408-08.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:

1. Explain hydraulic system safety.
2. Explain the principles of hydraulics.
3. Identify and explain hydraulic fluids.
4. Identify and explain hydraulic system parts.
5. Identify and explain hydraulic pumps.
6. Identify and explain hydraulic motors.

PERFORMANCE TASKS
Under the supervision of the instructor, the trainee should be able to do the following:

1. Identify hydraulic pumps and motors.
2. Identify at least four hydraulic system components.

MATERIALS AND EQUIPMENT LIST
Overhead projector and screen
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Appropriate personal protective equipment
Samples of hydraulic fluids
MSDS for several hydraulic fluids
Hydraulic accumulators or manufacturers’ literature on accumulators
Hydraulic reservoirs or manufacturers’ literature on hydraulic reservoirs
Various types of hydraulic pumps or manufacturers’ literature on pumps
Various types of hydraulic motors or manufacturers’ literature on motors
Hydraulic hoses
Hydraulic valves
Hydraulic cylinders and seals
Various types of piping, tubing, and fittings
Specialty fittings
Strainers and filters
Copies of the Quick Quizzes*
Module Examinations**
Performance Profile Sheets**

* Located in the back of this module.
**Located in the Test Booklet.
SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. This module requires trainees to work with hydraulic system components. Ensure that they are briefed on appropriate shop safety procedures.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following references are suggested for both instructors and motivated trainees interested in further study. These are optional resources for continued education rather than for task training.


TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 10 hours are suggested to cover *Basic Hydraulic Systems*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
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</thead>
<tbody>
<tr>
<td><strong>Session I. Introduction to Hydraulic Systems; Hydraulic Fluids</strong></td>
<td></td>
</tr>
<tr>
<td>A. Introduction</td>
<td></td>
</tr>
<tr>
<td>B. Hydraulic System Safety</td>
<td></td>
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<tr>
<td>C. Principles of Hydraulics</td>
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<tr>
<td>D. Hydraulic Fluids</td>
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<tr>
<td><strong>Session II. Hydraulic System Parts</strong></td>
<td></td>
</tr>
<tr>
<td>A. Strainers and Filters</td>
<td></td>
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<tr>
<td>B. Reservoirs</td>
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<tr>
<td>C. Accumulators</td>
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<tr>
<td>D. Piping, Tubing, and Fittings</td>
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<tr>
<td>E. Directional-Control Valves</td>
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<tr>
<td>F. Pressure-Control Valves</td>
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<tr>
<td>G. Cylinders</td>
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<tr>
<td>H. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Have trainees practice identifying hydraulic system components. This laboratory corresponds to Performance Task 2.</td>
<td></td>
</tr>
</tbody>
</table>
Session III. Hydraulic Pumps and Motors

A. Hydraulic Pumps
C. Hydraulic Motors
D. Laboratory
   Have trainees practice identifying hydraulic pumps and motors. This laboratory corresponds to Performance Task 1.

Session IV. Review and Testing

A. Review
B. Module Examination
   1. Trainees must score 70% or higher to receive recognition from NCCER.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.
C. Performance Testing
   1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.
Troubleshooting and Repairing Hydraulic Equipment
Annotated Instructor’s Guide

MODULE OVERVIEW
This module explains how to inspect, troubleshoot, and repair hydraulic systems and components. It also includes information about reading system schematic diagrams.

PREREQUISITES
Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following: Core Curriculum; Millwright Level One; Millwright Level Two; Millwright Level Three; and Millwright Level Four, Modules 15401-08 through 15409-08.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:

1. Inspect hydraulic system equipment.
2. Read hydraulic system schematic diagrams.
3. Explain the basic hydraulic principles that must be considered before troubleshooting.
4. Troubleshoot hydraulic systems.
5. Repair or replace hydraulic system components.

PERFORMANCE TASKS
Under the supervision of the instructor, the trainee should be able to do the following:

1. Inspect hydraulic system components.
2. Troubleshoot and repair or replace at least three of the following:
   • Hydraulic fluid reservoirs
   • Filters and strainers
   • Hydraulic pumps
   • Hydraulic motors
   • Control valves
   • Cylinders
   • Hoses
   • Fittings
   • Gauges

MATERIALS AND EQUIPMENT LIST

<table>
<thead>
<tr>
<th>Overhead projector and screen</th>
<th>Hydraulic system components to inspect and troubleshoot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transparencies</td>
<td>Hydraulic system components to repair/replace</td>
</tr>
<tr>
<td>Blank acetate sheets</td>
<td>Set of flare nut wrenches</td>
</tr>
<tr>
<td>Transparency pens</td>
<td>Assorted screwdrivers</td>
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<tr>
<td>Whiteboard/chalkboard</td>
<td>Emery cloths and hones</td>
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<td>Markers/chalk</td>
<td>Needle-nose pliers</td>
</tr>
<tr>
<td>Pencils and scratch paper</td>
<td>Set of Allen wrenches</td>
</tr>
<tr>
<td>Appropriate personal protective equipment</td>
<td>Copies of the Quick Quiz*</td>
</tr>
<tr>
<td>Manufacturers’ maintenance and repair manuals</td>
<td>Module Examinations**</td>
</tr>
<tr>
<td>Sample troubleshooting charts</td>
<td>Performance Profile Sheets**</td>
</tr>
<tr>
<td>Hydraulic schematic diagrams</td>
<td></td>
</tr>
</tbody>
</table>

* Located in the back of this module.
**Located in the Test Booklet.
SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. This module requires trainees to inspect, troubleshoot, and repair or replace hydraulic system components. Ensure that they are briefed on appropriate shop safety procedures.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following references are suggested for both instructors and motivated trainees interested in further study. These are optional resources for continued education rather than for task training.


TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 7½ hours are suggested to cover Troubleshooting and Repairing Hydraulic Equipment. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
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<tbody>
<tr>
<td><strong>Session I. Introduction; Inspecting Hydraulic System Components; Schematic Diagrams</strong></td>
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<tr>
<td>A. Introduction</td>
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<tr>
<td>B. Inspecting Hydraulic System Components</td>
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<tr>
<td>C. Laboratory</td>
<td>Have trainees practice inspecting hydraulic system components. This laboratory corresponds to Performance Task 1.</td>
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<tr>
<td>D. Reading Hydraulic System Schematic Diagrams</td>
<td></td>
</tr>
<tr>
<td><strong>Session II. Troubleshooting and Repairing</strong></td>
<td></td>
</tr>
<tr>
<td>A. Troubleshooting Hydraulic Systems</td>
<td></td>
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<tr>
<td>B. Repairing Hydraulic System Components</td>
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</tr>
<tr>
<td>C. Laboratory</td>
<td>Have trainees practice troubleshooting and repairing or replacing hydraulic system components. This laboratory corresponds to Performance Task 2.</td>
</tr>
</tbody>
</table>
Session III. Review and Testing

A. Review

B. Module Examination
   1. Trainees must score 70% or higher to receive recognition from NCCER.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

C. Performance Testing
   1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.
Troubleshooting and Repairing Gearboxes
Annotated Instructor’s Guide

MODULE OVERVIEW
This module covers gearboxes and how to inspect, remove, reassemble, install, and maintain them. It also includes information about gear types, gear operation, and measuring and adjusting backlash and bearing clearance.

PREREQUISITES
Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following: Core Curriculum; Millwright Level One; Millwright Level Two; Millwright Level Three; and Millwright Level Four, Modules 15401-08 through 15410-08.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:
1. Identify and explain gearboxes.
2. Explain how gears operate and identify types of gears.
3. Identify types of gearboxes.
4. Troubleshoot gearboxes.
5. Remove and disassemble gearboxes.
6. Identify gear wear patterns.
7. Measure and adjust backlash and bearing clearance.
8. Install and maintain gearboxes.

PERFORMANCE TASKS
Under the supervision of the instructor, the trainee should be able to do the following:
1. Identify types of gears.
2. Identify types of gearboxes.
3. Troubleshoot a gearbox.
4. Disassemble and reassemble a gearbox.
5. Identify gear wear patterns.
6. Measure backlash and bearing clearance.

MATERIALS AND EQUIPMENT LIST
Overhead projector and screen
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Appropriate personal protective equipment
Manufacturer’s service manuals
Non-working gearboxes for troubleshooting and disassembly
Rags
Lockout/tagout devices

Various types of gears, including:
- Spur
- Helical
- Double helical
- Herringbone
- Worm
- Bevel
- Spiral bevel
- Hypoid bevel
- Zerol bevel

Various types of gearboxes, including:
- Parallel
- In-line
- Right angle drive
- Shaft mount

continued
SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. This module requires trainees to troubleshoot, disassemble, and reassemble gearboxes. Ensure that they are briefed on appropriate shop safety procedures.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following references are suggested for both instructors and motivated trainees interested in further study. These are optional resources for continued education rather than for task training.

- Mobil Brief Product Descriptions, Mobil Oil Corporation, published annually.
- Plant Services: http://www.plantservices.com/articles/2004/393.html

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 20 hours are suggested to cover Troubleshooting and Repairing Gearboxes. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

<table>
<thead>
<tr>
<th>Topic</th>
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<tbody>
<tr>
<td>Session I. Introduction to Gearboxes</td>
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<tr>
<td>A. Introduction</td>
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<td>B. Understanding Gearboxes</td>
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<td>C. Gear Types</td>
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<td>D. Laboratory</td>
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<tr>
<td>Have trainees practice identifying gear types. This laboratory corresponds to Performance Task 1.</td>
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<tr>
<td>E. Types of Gearboxes</td>
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<tr>
<td>F. Laboratory</td>
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<tr>
<td>Have trainees practice identifying types of gearboxes. This laboratory corresponds to Performance Task 2.</td>
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<tr>
<th>Tools</th>
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<tr>
<td>Wrenches</td>
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<tr>
<td>Pans for oil</td>
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<td>Cleaning solvent</td>
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<td>Solvent MSDS</td>
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<td>High-spot blue and applicator</td>
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<td>Dead-blow hammer</td>
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<td>Dial indicator</td>
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<td>Feeler gauge</td>
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<td>Gear pullers</td>
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<td>Heating torch</td>
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<td>Hydraulic press</td>
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<td>Lifting devices</td>
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<td>Bearing heater</td>
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<td>Video or DVD player</td>
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<tr>
<td>Video or DVD on chemical safety</td>
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<tr>
<td>Copies of the Quick Quizzes*</td>
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<tr>
<td>Module Examinations**</td>
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<tr>
<td>Performance Profile Sheets**</td>
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</tbody>
</table>
Session II. Troubleshooting Gearboxes
   A. Troubleshooting Gearboxes
   B. Laboratory
      Have trainees practice troubleshooting gearboxes. This laboratory corresponds to Performance Task 3.

Sessions III and IV. Disassembling and Reassembling Gearboxes
   A. Repairing Gearboxes
   B. Removing Gearboxes
   C. Disassembling and Reassembling Gearboxes
   D. Laboratory
      Have trainees practice disassembling and reassembling gearboxes. This laboratory corresponds to Performance Task 4.

Session V. Gear Wear Patterns
   A. Identifying Gear Wear Patterns
   B. Laboratory
      Have trainees practice identifying gear wear patterns. This laboratory corresponds to Performance Task 5.

Sessions VI and VII. Repairing Gearboxes
   A. Measuring and Adjusting Backlash
   B. Measuring and Setting Bearing Clearance
   C. Laboratory
      Have trainees practice measuring backlash and bearing clearance. This laboratory corresponds to Performance Task 6.
   D. Installing Gearboxes
   E. Maintaining Gearboxes

Session VIII. Review and Testing
   A. Review
   B. Module Examination
      1. Trainees must score 70% or higher to receive recognition from NCCER.
      2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.
   C. Performance Testing
      1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
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