Preventive and Predictive Maintenance
Annotated Instructor's Guide

Module 32401-09

MODULE OVERVIEW

This module provides an overview of the preventive and predictive maintenance processes. Information about nondestructive testing is also included.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Industrial Maintenance Mechanic Level One; Industrial Maintenance Mechanic Level Two;* and *Industrial Maintenance Mechanic Level Three.*

OBJECTIVES

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

1. Explain preventive and predictive maintenance.
2. Explain nondestructive testing.
3. Explain ultrasonics.
4. Explain radiography.
5. Explain eddy current inspection.
6. Explain visual and optical inspection.
7. Explain liquid penetrant inspection.
8. Explain magnetic particle inspection.
9. Explain acoustic emissions.
10. Explain infrared testing.
11. Explain vibration analysis.
12. Explain tribology.

PERFORMANCE TASKS

This is a knowledge-based module; there are no performance tasks.

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

Examples of flawed welds, stress cracks, etc.

NDT equipment, including:
- Ultrasonic tester
- Pyrometer
- Eddy current tester
- Borescope
- Liquid penetrant kit
- Magnetic particle yoke

Copies of the Quick Quizzes*

Module Examination**

* Located at 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.

An Introduction to Predictive Maintenance, 2002. R. Keith Mobley. Woburn, MA: Butterworth-Heinsmann.

Encyclopedia of Materials Science and Engineering – Supplementary, Vol. 1, 1989. Michael B. Bever and Robert W. Cahn, ed. Cambridge, MA: The MIT Press.

Encyclopedia of Materials Science and Engineering – Supplementary, *Vol. 2,* 1990. Robert W. Cahn, ed. Cambridge, MA: The MIT Press.

Nondestructive Evaluation and Quality Control Metals Handbook, *Vol. 17*, 9th Ed. 1989. Materials Park, OH: ASM International.

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 *Preventive and Predictive Maintenance*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic	**Planned Time**
Session I. Introduction; Preventive Maintenance; Predictive Maintenance	
A. Introduction	_____
B. Preventive Maintenance	_____
1. Program Benefits	_____
C. Predictive Maintenance	_____
1. Requirements and Priorities	_____
2. Documentation	_____
Session II. Nondestructive Testing and Evaluation, Part One	
A. Introduction	_____
B. Ultrasonics	_____
C. Radiography	_____
D. Eddy Current Inspection	_____
E. Visual and Optical Inspection	_____
Session III. Nondestructive Testing and Evaluation, Part Two	
A. Liquid Penetrant Inspection	_____
B. Magnetic Particle Inspection	_____
C. Acoustic Emission Testing	_____
D. Infrared Testing	_____
E. Vibration Analysis	_____
F. Tribology	_____

Session IV. Review and Testing

A. Trade Terms and Quick Quizzes _____

B. Module Review _____

C. 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.

Advanced Blueprint Reading
Annotated Instructor's Guide

Module 32402-09

MODULE OVERVIEW

This module builds on the skills developed in earlier training, providing the industrial maintenance mechanic with the information needed to determine the specific machine and parts required for a repair. Various facets of advanced blueprint reading are covered, including numbering systems, pipe drawings, drawing hierarchy, machine drawing information, and drawing system usage and practices.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Industrial Maintenance Mechanic Level One; Industrial Maintenance Mechanic Level Two; Industrial Maintenance Mechanic Level Three;* and *Industrial Maintenance Mechanic Level Four*, Module 32401-09.

OBJECTIVES

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

1. Explain the use of a drawing numbering system.
2. Read and interpret foundation layout drawings.
3. Read and interpret assembly drawings.
4. Read and interpret all title block and bill of materials information.
5. Read and interpret detail drawings.
6. Identify and explain the parts of a machine drawing.
7. Locate an assembly drawing using a detail part.
8. Read and interpret P&IDs, GAs, and ISO piping drawings.

PERFORMANCE TASKS

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

1. Find detail drawings using assembly drawings.
2. Find assembly drawings using detail drawings.
3. Use a bill of materials to perform a materials takeoff.
4. Do a takeoff from an ISO drawing.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen

Transparencies

Blank acetate sheets

Transparency pens

Whiteboard / chalkboard

Markers / chalk

Pencils and scratch paper

Set of drawings to show hierarchy

Samples of various drawing types

Sketches of parts with different types of dimensioning

Detail drawings

Assembly drawings

Bill of materials

Pipe drawings

Copies of the Quick Quizzes*

Module Examinations**

Performance Profile Sheets**

* Located at 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 work is suggested for both instructors and motivated trainees interested in further study. This is optional material for continued education rather than for task training.

Geometrics II, The Application of Geometric Tolerancing Techniques. Lowell Foster. Reading, MA: Addison-Wesley Publishing Co., 1986.

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 25 hours are suggested to cover *Advanced Blueprint Reading*. 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.

Topic **Planned Time**

Session I. Introduction; Numbering System; Drawing Hierarchy

A. Introduction _____
B. Numbering System _____
C. Drawing Hierarchy _____
D. Laboratory _____

Have trainees practice identifying types of drawings from examples.

Sessions II and III. Drawing Information

A. Lines _____
B. Dimensions _____
C. Notes and Symbols _____
D. Scale _____
E. Revisions _____
F. Vendor Information _____
G. Material Specifications _____
H. Laboratory _____

Have trainees practice reading various types of drawings.

Sessions IV–VII. Drawing System Usage

A. Finding Details _____
   1. Laboratory _____

      Have trainees find detail drawings using assembly drawing. This laboratory corresponds to Performance Task 1.

B. Finding Assembly Drawings _____
   1. Laboratory _____

      Have trainees find assembly drawings using detail drawings. This laboratory corresponds to Performance Task 2.

C. Bill of Materials _____
   1. Laboratory _____

      Have trainees use a bill of materials to perform a materials takeoff. This laboratory corresponds to Performance Task 3.

Sessions VIII-IX. Pipe Drawings

A. Pipe Drawings _____

B. Process and Instrumentation Drawings _____

C. Isometric Pipe Drawings _____

D. Laboratory _____

Have trainees practice doing a takeoff from an ISO drawing. This laboratory corresponds to Performance Task 4.

E. General Arrangement Drawings _____

F. Laboratory _____

Have trainees practice following a line of pipe through the P&ID, isometric pipe drawing, and general arrangement drawing.

Session X. Review and Testing

A. Trade Terms Quick Quiz _____

B. Module Review _____

C. 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.

D. 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.

Compressors and Pneumatic Systems
Annotated Instructor's Guide

Module 32403-09

MODULE OVERVIEW

This module presents the basics of compressed air (pneumatic) systems, including descriptions of the machinery used in these systems. Procedures for troubleshooting pneumatic systems are also explained.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Industrial Maintenance Mechanic Level One; Industrial Maintenance Mechanic Level Two; Industrial Maintenance Mechanic Level Three;* and *Industrial Maintenance Mechanic Level Four,* Modules 32401-09 and 32402-09.

OBJECTIVES

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

1. Explain compressed-air treatment.
2. Identify and explain pneumatic system components and symbols.
3. Explain pneumatic safety.
4. Explain the physical characteristics of gases.
5. Explain compressing gases.
6. Explain the pneumatic transmission of energy.
7. Explain the principles of compressor operation.
8. Identify and explain types of compressors.

PERFORMANCE TASKS

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.
2. Identify various types of compressors.

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
Video/DVD player
Various types of compressors
Photographs or diagrams of different types of compressors
Manufacturers' maintenance and repair manuals
Compressor system setups
Old or broken compressors
Reciprocating compressors
Dry intake air filters
Mechanical filters
Pictures of coolers
Samples of various lubricants
Grease gun
Appropriate machine oil
Silicone lubricant
Allen wrenches
Flare nut wrenches
Shaft key wrenches
Pipe wrenches
Arbor press or length of pipe to install bearings
Assorted screwdrivers
Ball-peen hammers
Bearing pullers

(continued)

Carpenter's levels
Feeler gauges
Pressure gauges
Needle-nose pliers
Sharp knives
Torque wrenches
Anti-seize compound
Gaskets
O-rings
Teflon® tape
Copies of Quick Quizzes*
Module Examinations**
Performance Profile Sheets**

*Located at 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. Trainees will identify compressors and compressor components and may be asked to operate a compressor.

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.

Industrial Fluid Power, vols. 1, 2, and 3. Dallas, TX: Womack Educational Publications, ©2005.

Industrial Pneumatic Technology, Bulletin 0275-B1. Cleveland, OH: Parker Hannifin Corporation, ©1980.

Ingersoll-Rand Company for hydraulic and pneumatic products and product information
(literature, specifications, drawings)
http://fluids.ingersollrand.com

MFD Pneumatics, for pneumatic products and product information
(literature, specifications, drawings)
http://www.mfdpneumatics.com

Parker Hannifin Corporation, for training materials, products, and product information
(literature, specifications, drawings)
http://www.parker.com

Quincy Compressor, for training materials, products, and product information
(literature, specifications, drawings)
http://www.quincycompressor.com

Womack Machine Supply Company, for training materials
http://www.womackmachine.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 35 hours are suggested to cover *Compressors and 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.

Topic	**Planned Time**
Session I. Introduction; Pneumatic System Safety	
A. Introduction	_____
B. Pneumatic System Safety	_____
Session II. Physical Characteristics of Gases; Effects of Atmospheric Pressure; Compressing Gases; Pneumatic Transmission of Energy	
A. Physical Characteristics of Gases	_____
B. Effects of Atmospheric Pressure	_____
C. Compressing Gases	_____
D. Pneumatic Transmission of Energy	_____
Sessions III and IV. Compressor Operation and Types	
A. Positive-Displacement Compressors	_____
B. Continuous-Flow Compressors	_____
C. Laboratory	_____
Have trainees identify various types of compressors. This laboratory corresponds to Performance Task 2.	
D. Compressor Controls	_____
Sessions V–VIII. Treatment of Compressed Air	
A. Intake Filters	_____
B. Intercoolers and Aftercoolers	_____
C. Separators and Chemical Dryers	_____
D. Receivers, In-Line Filters, and Pressure Regulators	_____
E. Lubricators, F-R-Ls, and Air Treatment Controls	_____
Sessions IX and X. Pneumatic System Components; Pneumatic Symbols	
A. Valves	_____
B. Actuators	_____
C. Mufflers	_____
D. Laboratory	_____
Have trainees identify at least four components of basic pneumatic equipment. This laboratory corresponds to Performance Task 1.	
E. Pneumatic Symbols	_____

Sessions XI–XIII. Troubleshooting Pneumatic Systems

A. Drive Section Problems _____
B. Compression Section Problems _____
C. Pre-Storage Problems _____
D. Storage Section Problems _____
E. Post-Storage Problems _____
F. Troubleshooting Air-Driven Devices _____

Session XIV. Review and Testing

A. Trade Terms Quick Quiz _____
B. Module Review _____
C. 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.
D. 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.

Reverse Alignment
Annotated Instructor's Guide

Module 32404-09

MODULE OVERVIEW

This module covers setting up reverse dial indicator jigs and performing reverse dial alignment using both the chart and mathematical methods. Basic information about shaft alignment and coupling stress is also presented.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Industrial Maintenance Mechanic Level One; Industrial Maintenance Mechanic Level Two; Industrial Maintenance Mechanic Level Three;* and *Industrial Maintenance Mechanic Level Four,* Modules 32401-09 through 32403-09.

OBJECTIVES

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

1. Explain how machinery can be misaligned.
2. Explain the conditions that can cause misalignment.
3. Measure shaft runout, using a dial indicator.
4. Set up complex reverse dial indicator jigs.
5. Measure indicator sag using complex reverse dial indicator jigs.
6. Perform reverse dial indicator alignment, using a graphical alignment chart and using a mathematical equation.

PERFORMANCE TASKS

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

1. Measure shaft runout, using a dial indicator jig.
2. Set up a complex reverse alignment jig.
3. Measure indicator sag, using a complex reverse dial indicator jig.
4. Perform reverse alignment, using the alignment demonstration rig and the graphical chart.
5. Perform reverse alignment, using the alignment demonstration rig and the mathematical equation.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Dial indicator on a base
Complex reverse dial indicator jig
Dial indicators
Alignment simulators or equipment to be aligned
Graph paper
Calculators
Reverse dial indicator plotting guide
Graphical alignment chart
Copies of Quick Quizzes*
Module Examinations**
Performance Profile Sheets**

* Located at the back of this module.

**Located in the Test Booklet.

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.

A Millwright's Guide to Motor/Pump Alignment, 2nd ed. Tommy B. Harlon. New York, NY: Industrial Press, 2008.

The Optalign Training Book. Galen Evans and Pedro Casanova. Miami, FL: Ludeca, 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 30 hours are suggested to cover *Reverse 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.

Topic	**Planned Time**
Session I. Introduction; Descriptive Terms and Conditions	
A. Introduction	_____
B. Descriptive Terms and Conditions	_____
C. Conditions	_____
1. Checking for Soft Foot, Rough Alignment, and Shaft Runout	_____
D. Laboratory	_____
Have trainees practice checking for shaft runout.	
Session II. Coupling Stress	
A. Coupling Stress	_____
B. Causes of Coupling Stress	_____
1. Incorrect Pipe Weldments	_____
2. Improper Placement of Pipe Hangers	_____
3. Defective Anchor Bolts	_____
4. Bad Bearings	_____
5. Improper Foundations	_____
Session III. Reverse Dial Indicator Jigs	
A. Introduction	_____
B. Alignment Demonstration Rig	_____
C. Dial Indicators	_____
D. Measuring Shaft Runout	_____
E. Laboratory	_____
Have trainees measure shaft runout using a dial indicator jig. This laboratory corresponds to Performance Task 1.	
Session IV. Reverse Dial Indicator Alignment, Part One	
A. Setting Up Complex Reverse Dial Indicator Jigs	_____
1. Same-Side Mounting	_____
2. Opposite-Side Mounting	_____
3. Checking Indicator Sag	_____
B. Laboratory	_____
Have trainees set up a complex reverse dial indicator jig and check for indicator sag. This laboratory corresponds to Performance Tasks 2 and 3.	

Sessions V–VII. Reverse Dial Indicator Alignment, Part Two

A. Performing Reverse Dial Indicator Alignment _____
   1. Charting Alignment _____
   2. Performing Alignment _____

B. Alignment Equation _____

C. Recording Alignment _____

Sessions VIII–XI. Reverse Dial Indicator Alignment, Part Three

A. Laboratory _____

   Have trainees perform reverse alignment using the alignment demonstration rig, graphical chart, and mathematical equation. This laboratory corresponds to Performance Tasks 4 and 5.

Session XII. 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.

Laser Alignment
Annotated Instructor's Guide

Module 32405-09

MODULE OVERVIEW

This module covers the basic principles of lasers, laser alignment, laser/detector operation, and troubleshooting lasers. This module also covers conditions that affect alignment, such as soft foot and coupling stress.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Industrial Maintenance Mechanic Level One; Industrial Maintenance Mechanic Level Two; Industrial Maintenance Mechanic Level Three;* and *Industrial Maintenance Mechanic Level Four,* Modules 32401-09 through 32404-09.

OBJECTIVES

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

1. Explain lasers and laser alignment systems.
2. Operate a laser alignment system.
3. Align machinery trains.
4. Perform vertical alignment.
5. Explain soft foot, thermal growth, and coupling stress.
6. Troubleshoot repeatability and laser problems.

PERFORMANCE TASKS

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

1. Identify the major components of the Optalign® laser alignment system.
2. Perform a rough alignment.
3. Set up the laser alignment equipment.
4. Check the initial alignment.
5. Draw a scale graphical plot of a machinery train.
6. Align the machinery train.
7. Vertically align a machine.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Graph paper
Appropriate personal protective equipment
Alignment simulators or equipment to be aligned
Wrenches
Laser alignment equipment
Copies of the Quick Quizzes*
Module Examinations**
Performance Profile Sheets**

* Located at 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 align machinery using laser alignment equipment. Ensure that all trainees are briefed on the appropriate shop safety procedures.

ADDITIONAL RESOURCES

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

The Optalign Training Book. Galen Evans and Pedro Casanova. Miami, FL: Ludeca, 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 25 hours are suggested to cover *Laser 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.

Topic **Planned Time**

Session I. Introduction; Soft Foot; Thermal Growth; Coupling Stress

A. Introduction _____
B. Soft Foot _____
   1. Types of Soft Foot _____
C. Thermal Growth _____
D. Coupling Stress _____
   1. Causes of Coupling Stress _____

Sessions II. Basic Laser Principles; Optalign® Laser Alignment

A. Basic Laser Principles _____
B. Laser Safety _____
C. Optalign® Laser Alignment _____
D. Descriptive Characteristics of Misalignment _____
   1. Optalign® System Capabilities/Limitations _____
E. Laboratory _____

   Have trainees practice identifying the major components of the Optalign® laser alignment system. This laboratory corresponds to Performance Task 1.

Sessions III -V. Laser Detector Operation; Alignment Procedures, Part One

A. Laser/Detector Operation _____
B. Alignment Procedures _____
C. Rough Alignment _____
   1. Laboratory _____

      Have trainees practice performing a rough alignment. This laboratory corresponds to Performance Task 2.

D. Setting Up Laser Equipment; Initial Laser Alignment _____
   1. Laboratory _____

      Have trainees practice setting up the laser alignment equipment and checking the initial alignment. This laboratory corresponds to Performance Tasks 3 and 4.

Sessions VI and VII. Laser Operation and Alignment Procedures, Part Two

A. Aligning Machinery Trains _____

B. Laboratory _____

Have the trainees practice drawing a scale graphical plot of a machinery train, then aligning a machinery train. This laboratory corresponds to Performance Tasks 5 and 6.

Session VIII. Laser Operation and Alignment Procedures, Part Three

A. Determining Targets _____

B. Aligning Vertical Machines _____

C. Laboratory _____

Have the trainees perform a vertical alignment. This laboratory corresponds to Performance Task 7.

Session IX. Troubleshooting

A. Machinery Defects _____

B. Incorrectly Installed Brackets _____

C. System Failure or Defect _____

Session X. 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.

Introduction to Supervisory Skills
Annotated Instructor's Guide

Module 32406-09

MODULE OVERVIEW

This module explains many of the skills needed to become an effective supervisor. Issues covered include those related to leadership, gender and culture, problem solving/decision making, and safety.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Industrial Maintenance Mechanic Level One; Industrial Maintenance Mechanic Level Two; Industrial Maintenance Mechanic Level Three;* and *Industrial Maintenance Mechanic Level Four,* Modules 32401-09 through 32405-09.

OBJECTIVES

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

1. Describe the skills necessary to be a supervisor.
2. List the characteristics and behavior of effective leaders, as well as the different leadership styles.
3. Explain the difference between problem solving and decision making.
4. Describe ways to deal with common leadership problems, such as absenteeism and turnover.
5. Identify a supervisor's safety responsibilities.
6. Describe the signals of substance abuse.
7. List the essential parts of an accident investigation.

PERFORMANCE TASKS

This is a knowledge-based module; there are no performance tasks.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Quick Quizzes*
Module Examinations**

* Located at the back of this module.

**Located in the Test Booklet.

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 15 hours are suggested to cover *Introduction to Supervisory Skills*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic **Planned Time**

Sessions I and II. Introduction to Supervision; Becoming a Leader

A. Introduction to Supervision _____
B. Becoming a Leader _____
   1. Characteristics of Effective Leaders _____
   2. Leadership Behavior _____
   3. Functions of a Leader _____
   4. Leadership Styles _____
   5. Ethics in Leadership _____

Session III. Gender and Cultural Issues

A. Communication Styles of Men and Women _____
B. Language Barriers _____
C. Cultural Differences _____
D. Sexual Harassment _____
E. Gender and Minority Discrimination _____

Session IV. Problem Solving and Decision Making

A. Types of Decisions _____
B. Formal Problem Solving Techniques _____
C. Dealing with Leadership Problems _____

Session V. Supervisors and Safety; Supervisor Involvement in Safety

A. Supervisors and Safety _____
   1. Safety Responsibilities, Programs, and Policies/Procedures _____
   2. Hazard Identification and Safety Training _____
B. Supervisor Involvement in Safety _____
   1. Safety Meetings and Inspections _____
   2. Substance Abuse _____
   3. Accident Investigation _____

Session VI. 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.

Troubleshooting and Repairing Pumps
Annotated Instructor's Guide

Module 32407-09

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

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Industrial Maintenance Mechanic Level One; Industrial Maintenance Mechanic Level Two; Industrial Maintenance Mechanic Level Three; and Industrial Maintenance Mechanic Level Four,* Modules 32401-09 through 32406-09.

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. Prepare a checklist for pump startup.

PERFORMANCE TASKS

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

1. Inspect and/or troubleshoot a pump.
2. Disassemble and reassemble 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
Company safety manual
Manufacturers' maintenance and repair manuals
Lock washers
Gaskets
O-rings
Various types of pumps
Pump setups
Old or broken pumps
Assorted screwdrivers
Ball-peen hammer
Needle-nose pliers
Snap-ring pliers
Arbor press or length of pipe to install bearings
Bearing pullers
Combination wrench sets
Torque wrenches
Allen wrenches
Shaft key wrenches
Flare nut wrenches
Socket sets
Emery cloths and hones
600-grit sandpaper
Feeler gauges

(continued)

Dial indicators
Portable crane/rigging device
Sling and hardware for rigging
Grease gun
Appropriate machine oil
Silicone lubricant
Copies of the Quick Quizzes*
Module Examinations**
Performance Profile Sheets**

* Located at 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 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

Goulds Pumps: http://www.gouldspumps.com/literature_ioms.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 10 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.

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

Session IV. Installing a Pump; Startup Procedures; Review and Testing

A. Installing a New or Removed Pump _____

B. Pump Startup Procedures and Operational Tests _____

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.

Troubleshooting and Repairing Gearboxes
Annotated Instructor's Guide

Module 32408-09

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

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum*; *Industrial Maintenance Mechanic Level One*; *Industrial Maintenance Mechanic Level Two*; *Industrial Maintenance Mechanic Level Three*; and *Industrial Maintenance Mechanic Level Four*, Modules 32401-09 through 32407-09.

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 and use diagnostic charts.
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. Inspect and/or 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

Manufacturers' service and repair manuals

Non-working gearboxes for troubleshooting and disassembly

Lockout/tagout devices

Ultrasonic tester

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)

Wrenches
Pans for oil
Cleaning solvent
Rags
Solvent MSDS
High-spot blue and applicator
Dead-blow hammer
Dial indicator
Feeler gauge
Gear pullers
Heating torch
Hydraulic press
Lifting devices
Bearing heater
Video or DVD on chemical safety
Video or DVD player
Copies of the Quick Quizzes*
Module Examinations**
Performance Profile Sheets**

* Located at 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 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

Maintenance Resources, Inc.: http://www.maintenanceresources.com/referencelibrary/gears/gearing.htm

Plant Services: http://www. plantservices.com/articles/2004/393.htm

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.

Topic	**Planned Time**
Session I. Introduction to Gearboxes	
A. Introduction	_____
B. Understanding Gearboxes	_____
C. Gear Types	_____
D. Laboratory Have trainees practice identifying gear types. This laboratory corresponds to Performance Task 1.	_____
E. Types of Gearboxes	_____
F. Laboratory Have trainees practice identifying types of gearboxes. This laboratory corresponds to Performance Task 2.	_____

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. 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.