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; Millwright Level One; Millwright Level Two; Millwright Level Three; and Millwright Level Four.

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 and coupling 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.
7. Perform reverse dial indicator alignment, using the 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 demonstration rig(s)
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.


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 $2\frac{1}{2}$ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 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.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
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</thead>
<tbody>
<tr>
<td><strong>Session I. Introduction; Descriptive Terms and Conditions</strong></td>
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<tr>
<td>A. Introduction</td>
<td></td>
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<tr>
<td>B. Descriptive Terms and Conditions</td>
<td></td>
</tr>
<tr>
<td>C. Conditions</td>
<td></td>
</tr>
<tr>
<td>1. Checking for Soft Foot, Rough Alignment, and Shaft Runout</td>
<td></td>
</tr>
<tr>
<td>D. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Have trainees practice checking for shaft runout.</td>
<td></td>
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<tr>
<td><strong>Session II. Coupling Stress</strong></td>
<td></td>
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<tr>
<td>A. Coupling Stress</td>
<td></td>
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<tr>
<td>B. Causes of Coupling Stress</td>
<td></td>
</tr>
<tr>
<td>1. Incorrect Pipe Weldments</td>
<td></td>
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<tr>
<td>2. Improper Placement of Pipe Hangers</td>
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<tr>
<td>3. Defective Anchor Bolts</td>
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<tr>
<td>4. Bad Bearings</td>
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<tr>
<td>5. Improper Foundations</td>
<td></td>
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<tr>
<td><strong>Session III. Reverse Dial Indicator Jigs</strong></td>
<td></td>
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<tr>
<td>A. Reverse Dial Indicator Jigs</td>
<td></td>
</tr>
<tr>
<td>B. Alignment Demonstration Rig</td>
<td></td>
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<tr>
<td>C. Dial Indicators</td>
<td></td>
</tr>
<tr>
<td>D. Measuring Shaft Runout</td>
<td></td>
</tr>
<tr>
<td>E. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Have trainees measure shaft runout using a dial indicator jig. This laboratory corresponds to Performance Task 1.</td>
<td></td>
</tr>
<tr>
<td><strong>Session IV. Reverse Dial Indicator Alignment, Part One</strong></td>
<td></td>
</tr>
<tr>
<td>A. Setting Up Complex Reverse Dial Indicator Jigs</td>
<td></td>
</tr>
<tr>
<td>1. Same-Side Mounting</td>
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</tr>
<tr>
<td>2. Opposite-Side Mounting</td>
<td></td>
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<tr>
<td>3. Checking Indicator Sag</td>
<td></td>
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<tr>
<td>B. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Have trainees set up a complex reverse dial indicator jig and check for indicator sag. This laboratory corresponds to Performance Tasks 2 and 3.</td>
<td></td>
</tr>
</tbody>
</table>
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. 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 the basic principles of lasers, as well as laser alignment, laser/detector operation, and troubleshooting lasers. This module also covers conditions 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; Millwright Level One; Millwright Level Two; Millwright Level Three; Millwright Level Four; and Millwright Level Five, Module 15501-09.

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. Explain soft foot, thermal growth, and coupling stress.
4. 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 a laser alignment system.
2. Perform a rough alignment.
3. Set up the laser alignment equipment.
4. Check the initial alignment.
5. Perform a vertical alignment using a laser.
6. Perform a horizontal alignment using a laser.

MATERIALS AND EQUIPMENT LIST

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

* 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.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
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<tbody>
<tr>
<td><strong>Session I. Introduction; Soft Foot; Thermal Growth; Coupling Stress</strong></td>
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</tr>
<tr>
<td>A. Introduction</td>
<td>_________</td>
</tr>
<tr>
<td>B. Soft Foot</td>
<td>_________</td>
</tr>
<tr>
<td>1. Types of Soft Foot</td>
<td>_________</td>
</tr>
<tr>
<td>C. Thermal Growth</td>
<td>_________</td>
</tr>
<tr>
<td>D. Coupling Stress</td>
<td>_________</td>
</tr>
<tr>
<td>1. Causes of Coupling Stress</td>
<td>_________</td>
</tr>
<tr>
<td><strong>Session II. Basic Laser Principles; Optalign® Laser Alignment</strong></td>
<td></td>
</tr>
<tr>
<td>A. Basic Laser Principles</td>
<td>_________</td>
</tr>
<tr>
<td>B. Laser Safety</td>
<td>_________</td>
</tr>
<tr>
<td>C. Optalign® Laser Alignment</td>
<td>_________</td>
</tr>
<tr>
<td>D. Descriptive Characteristics of Misalignment</td>
<td>_________</td>
</tr>
<tr>
<td>1. Optalign® System Capabilities/Limitations</td>
<td>_________</td>
</tr>
<tr>
<td>E. Laboratory</td>
<td>_________</td>
</tr>
<tr>
<td>Have trainees practice identifying the major components of a laser alignment system. This laboratory corresponds to Performance Task 1.</td>
<td></td>
</tr>
<tr>
<td><strong>Sessions III - V. Laser Detector Operation; Alignment Procedures, Part One</strong></td>
<td></td>
</tr>
<tr>
<td>A. Laser/Detector Operation</td>
<td>_________</td>
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<tr>
<td>B. Alignment Procedures</td>
<td>_________</td>
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<tr>
<td>C. Rough Alignment</td>
<td>_________</td>
</tr>
<tr>
<td>1. Laboratory</td>
<td>_________</td>
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<tr>
<td>Have trainees practice performing a rough alignment. This laboratory corresponds to Performance Task 2.</td>
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<tr>
<td>D. Setting Up Laser Equipment; Initial Laser Alignment</td>
<td>_________</td>
</tr>
<tr>
<td>1. Laboratory</td>
<td>_________</td>
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<tr>
<td>Have trainees practice setting up the laser alignment equipment and checking the initial alignment. This laboratory corresponds to Performance Tasks 3 and 4.</td>
<td></td>
</tr>
</tbody>
</table>
Sessions VI and VII. Laser Operation and Alignment Procedures, Part Two

A. Aligning Machinery Trains

B. Laboratory

Have the trainees practice performing a horizontal alignment using a laser.
This laboratory corresponds to Performance Task 6.

Session VIII. Laser Operation and Alignment Procedures, Part Three

A. Determining Targets

B. Aligning Vertical Machines

1. Laboratory

Have the trainees practice performing a vertical alignment using a laser.
This laboratory corresponds to Performance Task 5.

Session IX. Troubleshooting

A. Machinery Defects

B. Incorrectly Installed Brackets

C. System Failure or Defect

Session X. 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 builds on the skills developed in earlier training, providing the millwright 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, 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; Millwright Level One; Millwright Level Two; Millwright Level Three; Millwright Level Four; and Millwright Level Five, Modules 15501-09 and 15502-09.

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. Identify the types of drawings in a drawing package.
3. Read and interpret plant or foundation layout drawings.
4. Read and interpret assembly drawings.
5. Read and interpret detail drawings.
6. Identify and explain the parts of a machine drawing.
7. Locate individual components on a plant layout.
8. Locate an assembly drawing using a detail part.

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.

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
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.


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.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
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<tbody>
<tr>
<td>Sessions I and II. Introduction; Numbering System; Drawing Hierarchy</td>
<td></td>
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<tr>
<td>A. Introduction</td>
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<tr>
<td>B. Numbering System</td>
<td></td>
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<tr>
<td>C. Drawing Hierarchy</td>
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<tr>
<td>D. Laboratory</td>
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<tr>
<td>Have trainees practice identifying types of drawings from examples.</td>
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<tr>
<td>Sessions III and IV. Drawing Information</td>
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<tr>
<td>A. Lines</td>
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<tr>
<td>B. Dimensions</td>
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<tr>
<td>C. Notes and Symbols</td>
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<tr>
<td>D. Scale</td>
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<tr>
<td>E. Revisions</td>
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<tr>
<td>F. Vendor Information</td>
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<tr>
<td>G. Material Specifications</td>
<td></td>
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<tr>
<td>H. Laboratory</td>
<td></td>
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<tr>
<td>Have trainees practice reading various types of drawings.</td>
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<tr>
<td>Sessions V–VIII. Drawing System Usage</td>
<td></td>
</tr>
<tr>
<td>A. Finding Details</td>
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<tr>
<td>1. Laboratory</td>
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<tr>
<td>Trainees find detail drawings using assembly drawings. This laboratory corresponds to Performance Task 1.</td>
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<tr>
<td>B. Finding Assembly Drawings</td>
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<tr>
<td>1. Laboratory</td>
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</tr>
<tr>
<td>Have trainees find assembly drawings using detail drawings. This laboratory corresponds to Performance Task 2.</td>
<td></td>
</tr>
</tbody>
</table>
Session IX. Materials Takeoff
   A. Bill of Materials
      1. Laboratory
         Have trainees use a bill of materials to perform a materials takeoff. 
         This laboratory corresponds to Performance Task 3.

Session X. Review and Testing
   A. Trade Terms Quick Quiz
   B. 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.
MODULE OVERVIEW
This module covers optical alignment and the leveling instruments commonly used for accurately installing equipment. Basic procedures for setting up and using various types of leveling instruments are also introduced.

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 Core Curriculum; Millwright Level One; Millwright Level Two; Millwright Level Three; Millwright Level Four; and Millwright Level Five, Modules 15501-09 through 15503-09.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:
1. Explain how to use a theodolite, a precision tilting level, a total station, and an auto level.
2. Level equipment using optical alignment.

PERFORMANCE TASKS
Under the supervision of the instructor, the trainee should be able to do the following:
1. Check level using one of the following:
   - Theodolite
   - Precision tilting level
   - Total station
   - Auto level

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
- Levels, including:
  - Spirit level
  - Coincidence level
  - Plate level
  - Circular level
  - Laser level
  - Precision tilting level
  - Builder’s level
  - Automatic level
- Optical tooling scales
- Telescopic sights
- Optical micrometer
- Magnifying glasses
- Tripods, mounting plates and rings
- Double direct vernier
- Theodolite
- Theodolite with a digital display/optical plummet
- Equipment needed for a plate bubble test, crosshair test, and optical plummet check
- EDMI
- Total station
- Prism assembly
- Wrenches
- 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 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.

- Brunson Instrument Company
  www.brunson.us
- Topcon Corporation
  www.topcon.com
- Trimble Navigation Limited
  www.trimble.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 25 hours are suggested to cover Optical 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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<tbody>
<tr>
<td><strong>Sessions I and II. Introduction; Establishing Line of Sight</strong></td>
<td></td>
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<tr>
<td>A. Introduction</td>
<td></td>
</tr>
<tr>
<td>B. Establishing Line of Sight</td>
<td></td>
</tr>
<tr>
<td>1. Collimation and Auto-Collimation</td>
<td></td>
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<tr>
<td>2. Optical Instruments</td>
<td></td>
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<tr>
<td>3. Builder’s Level</td>
<td></td>
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<tr>
<td>4. Tripods</td>
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<tr>
<td>C. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Have trainees practice checking level using an auto level. This laboratory corresponds to Performance Task 1.</td>
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</tr>
<tr>
<td><strong>Session III. Reading Theodolite Scales and Verniers; Initial Setup, Adjustment, and Checkout of a Transit/Theodolite</strong></td>
<td></td>
</tr>
<tr>
<td>A. Reading Theodolite Scales and Verniers</td>
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</tr>
<tr>
<td>1. Understanding Degrees, Minutes, and Seconds</td>
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</tr>
<tr>
<td>2. Reading Vernier Scales</td>
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<tr>
<td>3. Reading Optical Scales and Digital Displays</td>
<td></td>
</tr>
<tr>
<td>B. Initial Setup, Adjustment, and Checkout of a Transit/Theodolite</td>
<td></td>
</tr>
<tr>
<td>1. Setting Up Using an Instrument with an Optical Plummet</td>
<td></td>
</tr>
<tr>
<td>2. Checking Theodolite Calibration</td>
<td></td>
</tr>
</tbody>
</table>
Sessions IV and V. Horizontal and Vertical Angle Measurements
A. Basic Horizontal and Vertical Angle Measurements
   1. Turning 90-Degree Angles
   2. Measuring Horizontal Angles
   3. Measuring Vertical Angles
   4. Mistakes Made When Making Angular Measurements
B. Laboratory
   Have trainees practice checking level using a theodolite. This laboratory
   corresponds to Performance Task 1.

Session VI. Electronic Distance Measurement; Measuring Errors in Parts per Million;
       History of Total Stations; Prisms and Reflective Targets
A. Electronic Distance Measurement
   1. History
   2. Instruments
B. Measuring Errors in Parts per Million
C. History of Total Stations
D. Prisms and Reflective Targets

Session VII. Setup and Checkout of a Total Station
A. Total Station Controls
B. Initial Setup and Coarse Centering
C. Initializing the Total Station for Measurements
D. Laboratory
   Have trainees practice checking level using a total station. This laboratory
   corresponds to Performance Task 1.

Session VIII. Alignment Instrument Field Checks; Trigonometric Leveling
A. Alignment Instrument Field Checks
   1. Geometry of Angle Measuring Instruments
   2. Instrument Field Checks
   3. Laser Beam Level Check
B. Trigonometric Leveling

Session IX. Checking Height; Using Optical Levels
A. Checking Height
   1. Coincident Lines of Sight
   2. Bucking-In
   3. Care of Optical Instruments
B. Using Optical Levels
C. Laboratory
   Have trainees practice checking level using a precision tilting level. This
   laboratory corresponds to Performance Task 1.
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.
Turbines
Annotated Instructor’s Guide

MODULE OVERVIEW
This module describes steam, gas, and hydraulic turbines. Trainees will become familiar with turbine components as they learn the principles by which turbines operate.

PREREQUISITES
Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Millwright Level One; Millwright Level Two; Millwright Level Three; Millwright Level Four; and Millwright Level Five, Modules 15501-09 through 15504-09.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:
1. Identify and explain impulse and reaction blades.
2. Identify and explain types of turbines.
3. Identify and explain steam turbine components.
4. Identify and explain gas turbine components.
5. Explain types of water turbines.

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
- Photos or videos/DVDs showing the components and/or operation of steam, gas, and water turbines
- TV/VCR/DVD player
- Examples or pictures of impulse and reaction blades
- Examples, photos, videos, or DVDs of Pelton wheels, Francis Wheels, and Kaplan wheels
- Examples or pictures of turbine components: Compressor parts, Combustor parts, Turbine section parts, Auxiliary support systems, Bearings
- Copies of the Quick Quiz*
- Module Examinations**

*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.

Environmental Protection Agency

General Electric Company
www.gepower.com/home/index.htm

Siemens Corporation
www.powergeneration.siemens.com/home

http://mysite.du.edu/~jcalvert/tech/fluids/turbine.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 Turbines. 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>
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<td>Session I. Introduction; Turbine Operating Principles; Types of Turbines</td>
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<td>C. Types of Turbines</td>
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<td>1. Steam Turbines</td>
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<td>3. Hydroelectric Turbines</td>
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<td>A. Inlet Parts</td>
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<td>C. Extraction and Exhaust</td>
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<td>D. Safety</td>
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<td>E. Bearings</td>
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<td>F. Seals</td>
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<td>Session III. Steam Turbine Rotor Parts</td>
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<td>A. Turbine Rotor</td>
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<td>B. Blades</td>
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<td>C. Turning Gear and Coupling</td>
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<td>D. Lube Oil Gear Pump</td>
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<td>Session IV. Steam Turbine Auxiliary Systems</td>
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<tr>
<td>A. Lubrication and Jacking Oil Equipment</td>
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<td>B. Turbine Control and Protection System</td>
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<td>C. Electrohydraulic Governor Equipment</td>
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<td>D. Seal Steam System</td>
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<tr>
<td>E. Steam Distribution System</td>
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<tr>
<td>F. Condensate System</td>
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</tbody>
</table>
Session V. Gas Turbine Compressor Parts
   A. Inlet Guide Vanes
   B. Rotor and Stator Blades
   C. Discharge Section
   D. Bleed-Off Lines

Session VI. Gas Turbine Combustor and Turbine Section Components
   A. Combustor Components
      1. Combustion Chambers
      2. Fuel Nozzles
      3. Igniters and Crossfire Tubes
      4. Flame Detectors
      5. Transition Pieces
   B. Turbine Section Components
      1. Nozzles
      2. Rotor Blades
      3. Exhaust Silencer

Session VII. Gas Turbine Auxiliary Support Systems
   A. Starting Systems
   B. Lube Oil System
   C. Fuel System
   D. Water Cooling System

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.
Maintaining and Repairing Turbine Components
Annotated Instructor’s Guide

MODULE OVERVIEW
This module covers basic turbine components, typical problems encountered when working with turbines, and guidelines for maintaining and repairing various types of turbines. Techniques for gaining access to components and replacing them are also covered.

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 Core Curriculum; Millwright Level One; Millwright Level Two; Millwright Level Three; Millwright Level Four; and Millwright Level Five, Modules 15501-09 through 15505-09.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:
1. Inspect sealing glands and carbon rings.
2. Replace nozzle rings and reversing blade assemblies.
3. Inspect governor systems.
4. Replace rotor bearings.
5. Adjust overspeed trip mechanisms.
6. Inspect rotor assemblies.

PERFORMANCE TASKS
Under the supervision of the instructor, the trainee should be able to do the following:
1. Identify six of the following pieces of turbine equipment:
   • Sealing glands
   • Carbon rings
   • Rotor bearings
   • Nozzle rings
   • Governor
   • Trip linkage
   • Rotor
   • Oil pump

MATERIALS AND EQUIPMENT LIST

| Overhead projector and screen                     | Paste sealing compound          |
| Transparencies                                    | Antigalling compound            |
| Blank acetate sheets                              | Silicone grease                 |
| Transparency pens                                 | Bearing puller                  |
| Whiteboard/chalkboard                            | Dial indicator                  |
| Markers/chalk                                     | Sleeve-type bearing driver      |
| Pencils and scratch paper                         | Torch                           |
| Appropriate personal protective equipment         | Hot oil or bearing heater        |
| Toolbox with common mechanic tools                | Shims                           |
| Plastic sealing compound                          | Compressed air                  |

continued
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.

- Environmental Protection Agency
- General Electric Company
  www.gepower.com/home/index.htm
- Siemens Corporation
  www.powergeneration.siemens.com
- http://mysite.du.edu/~jcalvert/tech/fluids/turbine.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 15 hours are suggested to cover *Maintaining and Repairing Steam Turbine Components*. 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; Maintaining and Repairing Turbine Casings, Sealing Glands, and Carbon Rings</strong></td>
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<tr>
<td>A. Introduction</td>
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<tr>
<td>B. Maintaining and Repairing Turbine Casings</td>
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<tr>
<td>C. Maintaining and Repairing Sealing Glands and Carbon Rings</td>
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</tr>
<tr>
<td>1. Disassembling Sealing Glands</td>
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<tr>
<td>2. Replacing Carbon Rings</td>
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<tr>
<td>3. Assembling Sealing Glands</td>
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</tbody>
</table>

Examples of the following turbine components:
- Hydraulic jack or wooden blocks
- Applicable rigging equipment
- Hand-held grinder
- Dry ice
- Prussian blue
- Photos or videos/DVDs showing the components and/or operation of large turbines
- Copies of the Quick Quizzes*
- Module Examinations**
- Performance Profile Sheets**
Session II. Maintaining Governor Systems; Replacing Nozzle Rings, Reversing Blade Assemblies, and Rotor Locating Bearings

A. Maintaining Governor Systems
   1. Removing and Replacing Governor Components
B. Replacing Nozzle Rings and Reversing Blade Assemblies
C. Replacing Rotor Locating Bearings

Session III. Replacing Bearing Pedestals and Housings; Maintaining Overspeed Trip Mechanisms, Part One

A. Replacing Bearing Pedestals and Housings
   1. Replacing Exhaust-End Bearing Pedestals
   2. Replacing Steam-End Bearing Housings
   3. Aligning Exhaust-End Bearing Pedestals and Steam-End Housings
B. Maintaining Overspeed Trip Mechanisms
   1. Disassembling/Assembling Overspeed Trip Mechanisms
   2. Replacing Plunger Assemblies and Trip Bodies

Session IV. Maintaining Overspeed Trip Mechanisms, Part Two

A. Maintaining Overspeed Trip Mechanisms
   1. Adjusting Trip Pin and Plunger Clearance
   2. Adjusting Turbine Trip Speeds
   3. Disassembling/Assembling Trip Valves
   4. Backseating Trip Valves
   5. Maintaining Governor Valves

Session V. Maintaining Rotor Assemblies and Large Steam Turbines

A. Maintaining Rotor Assemblies
B. Maintaining Large Steam Turbines
C. Laboratory
   Have trainees practice identifying turbine components. This laboratory corresponds to Performance Task 1.

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.
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.
Installing Electric Motors
Annotated Instructor’s Guide

MODULE OVERVIEW
In this module, the trainee will learn to rig, move, and store motors properly. The trainee will also learn how to properly install the motor, and will gain a basic understanding of maintenance procedures. Because installation requires basic alignment to a driven machine, information on couplings and shaft alignment is also included.

PREREQUISITES
Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Millwright Level One; Millwright Level Two; Millwright Level Three, Millwright Level Four; and Millwright Level Five, Modules 15501-09 through 15506-09.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:
1. Explain the proper methods for motor storage.
2. Explain the proper rigging and handling of motors.
3. Determine if a motor has a thrust bearing or relies on electromagnetic force to determine rotor location.
4. Properly align the motor to the specified equipment.
5. Verify rotation and coupling gap.

PERFORMANCE TASKS
Under the supervision of the instructor, the trainee should be able to do the following:
1. Demonstrate proper storage methods for a motor.
2. Properly install a motor.

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
Wrenches
Allen wrenches
Bluing
Dial indicators
Assortment of different types of bearings
Tachometer
Ammeter
Feeler gauge
Thickness gauge
Straightedge
Drift punch
Oil, grease, and lubrication devices
Rags
Manufacturers’ literature for various types of motors
Safety video or DVD, and appropriate devices for viewing, or online safety training
Photographs/illustrations of electric motors
Samples of AC and DC motors, including motors with damaged bearings, if possible
Appropriate rigging equipment for lifting motors
Copies of the Quick Quiz*
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 rig and lift motors for storage, and safely install a motor. Be sure trainees are briefed on site 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.

- R + W America L.P.
  www.rw-america.com
- Coupling Corporation of America
  www.couplingcorp.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 10 hours are suggested to cover Installing Electric Motors. 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><strong>Session I. Introduction; Inspecting Equipment; Setting the Motor</strong></td>
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<tr>
<td>A. Introduction</td>
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<tr>
<td>B. Inspecting Equipment</td>
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<tr>
<td>C. Setting the Motor</td>
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<tr>
<td>D. Laboratory</td>
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<tr>
<td>Have trainees practice installing a motor. This laboratory corresponds to Performance Task 2.</td>
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<tr>
<td><strong>Session II. Motor Maintenance</strong></td>
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<td>A. Motor Maintenance</td>
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<td>B. Practical Maintenance Techniques</td>
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<td>C. Motor Bearing Maintenance</td>
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<tr>
<td><strong>Session III. Lubrication; Troubleshooting; Storage; Recordkeeping</strong></td>
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<tr>
<td>A. Lubrication</td>
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<tr>
<td>B. Troubleshooting</td>
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<tr>
<td>C. Storing Motors</td>
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<tr>
<td>D. Recordkeeping</td>
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<tr>
<td>E. Laboratory</td>
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<tr>
<td>Have trainees practice rigging and storing a motor. This laboratory corresponds to Performance Task 1.</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.
Preventive and Predictive Maintenance
Annotated Instructor’s Guide

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; Millwright Level One; Millwright Level Two; Millwright Level Three; Millwright Level Four; and Millwright Level Five, Modules 15501-09 through 15507-09.

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 visual and optical inspection.
4. Explain liquid penetrant inspection.
5. Explain magnetic particle inspection.
6. Explain infrared testing.

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 on parts, etc. |
| NDT equipment, including: |
| Ultrasonic tester |
| Pyrometer |
| Eddy current tester |
| Borescope |
| Liquid penetrant kit |
| Magnetic particle yoke |
| Copies of the Quick Quizzes* |
| Module Examinations** |

*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.


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.

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<td>A. Introduction</td>
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<td>B. Preventive Maintenance</td>
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<td>C. Predictive Maintenance</td>
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<td>B. Ultrasonics</td>
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<td>C. Radiography</td>
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<td>D. Eddy Current Inspection</td>
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<td>E. Visual and Optical Inspection</td>
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<tr>
<td><strong>Session III. Nondestructive Testing and Evaluation, Part Two</strong></td>
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<td>A. Liquid Penetrant Inspection</td>
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<td>B. Magnetic Particle Inspection</td>
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<td>C. Acoustic Emission Testing</td>
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<td>D. Infrared Testing</td>
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<td>E. Vibration Analysis</td>
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<td>F. Tribology</td>
<td>_________</td>
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</tbody>
</table>
Session IV. Review and Testing

A. Trade Terms and Quick Quizzes

B. 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.
Vibration Analysis
Annotated Instructor’s Guide

MODULE OVERVIEW
This module covers the causes of vibration, vibration analysis and monitoring techniques, vibration test equipment, and field balancing of machines.

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; Millwright Level Four; and Millwright Level Five, Modules 15501-09 through 15508-09.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:
1. List four causes of vibration.
2. Identify characteristics of a vibration cycle.
3. Identify and explain the different kinds of basic vibration test equipment.
4. Explain vibration monitoring.
5. Explain field balancing of machines.

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 equipment with the following causes of vibration:
  Unbalance
  Misalignment
  Bent drive shafts
  Loose mounting bolts
  Worn or damaged bearings
  Improper gear meshing

Loose drive belts
Insufficient lubrication
Electrical problems
Examples of the following vibration test equipment, as available:
  Transducers
  Vibration meter
  Oscilloscope
  Spectrum analyzer
  Electronic filters
  Stroboscope
  Strip chart recorders
  Data collectors
  Balancing machine
  Copies of the Quick Quizzes*
  Module Examinations**

* 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.

http://www.reliabilityweb.com/fa/vibration.htm (for vibration analysis testing resources and links).

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 5 hours are suggested to cover Vibration Analysis. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

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<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
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<tr>
<td>Session I. Introduction; Causes of Vibration; Vibration Analysis, Test Equipment, and Monitoring</td>
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<tr>
<td>A. Introduction</td>
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<tr>
<td>B. Causes of Vibration</td>
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<tr>
<td>1. Unbalance, Misalignment, Bent Drive Shafts, Loose Mounting Bolts</td>
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</tr>
<tr>
<td>2. Worn/Damaged Bearings, Improper Gear Meshing, Loose Drive Belts</td>
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<tr>
<td>3. Insufficient Lubrication, Electrical Problems, Destructive Resonant Frequencies</td>
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<tr>
<td>C. Vibration Analysis</td>
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<tr>
<td>1. Frequency</td>
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<td>2. Velocity</td>
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<td>3. Acceleration</td>
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<td>4. Displacement</td>
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<td>D. Vibration Test Equipment</td>
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<tr>
<td>1. Transducers</td>
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<td>2. Vibration Analysis Equipment</td>
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<tr>
<td>3. Vibration Recording Instruments</td>
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<tr>
<td>E. Vibration Monitoring</td>
<td></td>
</tr>
<tr>
<td>1. Identifying Equipment to be Monitored</td>
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<tr>
<td>2. Establishing Schedules and Determining Monitoring Point Locations</td>
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</tr>
<tr>
<td>3. Setting Up Record Keeping and Continuous Monitoring Systems</td>
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</tr>
</tbody>
</table>
Session II. Field Balancing of Machines; Review and Testing

A. Field Balancing of Machines
   1. Determining Causes of Unbalance
   2. Calculating Unbalance Force
   3. Determining Corrective Action

B. Trade Terms Quick Quiz

C. Module 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.