Reverse Alignment
Annotated Instructor's Guide

Module 15501-09

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*; *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.

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. Reverse Dial Indicator Jigs	_____
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. 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 15502-09

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

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	_____
Session 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 a 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 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.

Advanced Blueprint Reading
Annotated Instructor's Guide

Module 15503-09

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.

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**

Sessions I and II. 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 III and IV. 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 V–VIII. Drawing System Usage

A. Finding Details _____
   1. Laboratory _____

      Trainees find detail drawings using assembly drawings. 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.

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.

Optical Alignment
Annotated Instructor's Guide

Module 15504-09

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.

Topic	**Planned Time**
Sessions I and II. Introduction; Establishing Line of Sight	
A. Introduction	_____
B. Establishing Line of Sight	_____
1. Collimation and Auto-Collimation	_____
2. Optical Instruments	_____
3. Builder's Level	_____
4. Tripods	_____
C. Laboratory	_____
Have trainees practice checking level using an auto level. This laboratory corresponds to Performance Task 1.	
Session III. Reading Theodolite Scales and Verniers; Initial Setup, Adjustment, and Checkout of a Transit/Theodolite	
A. Reading Theodolite Scales and Verniers	_____
1. Understanding Degrees, Minutes, and Seconds	_____
2. Reading Vernier Scales	_____
3. Reading Optical Scales and Digital Displays	_____
B. Initial Setup, Adjustment, and Checkout of a Transit/Theodolite	_____
1. Setting Up Using an Instrument with an Optical Plummet	_____
2. Checking Theodolite Calibration	_____

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 15505-09

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
www.epa.gov/CHP/documents/tech_turbines.pdf

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.

Topic	**Planned Time**
Session I. Introduction; Turbine Operating Principles; Types of Turbines	
A. Introduction	_____
B. Turbine Operating Principles	_____
1. Impulse Turbines	_____
2. Reaction Turbines	_____
C. Types of Turbines	_____
1. Steam Turbines	_____
2. Gas Turbines	_____
3. Hydroelectric Turbines	_____
Session II. Steam Turbine Casing Parts	
A. Inlet Parts	_____
B. Blade Supports	_____
C. Extraction and Exhaust	_____
D. Safety	_____
E. Bearings	_____
F. Seals	_____
Session III. Steam Turbine Rotor Parts	
A. Turbine Rotor	_____
B. Blades	_____
C. Turning Gear and Coupling	_____
D. Lube Oil Gear Pump	_____
Session IV. Steam Turbine Auxiliary Systems	
A. Lubrication and Jacking Oil Equipment	_____
B. Turbine Control and Protection System	_____
C. Electrohydraulic Governor Equipment	_____
D. Seal Steam System	_____
E. Steam Distribution System	_____
F. Condensate System	_____

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 15506-09

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

continued

Examples of the following turbine components:

- Turbine casing
- Sealing glands
- Carbon rings
- Rotor bearing
- Nozzle rings
- Governor
- Trip linkage
- Bearing pedestals and housings
- Rotor assembly

- 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**

* 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
www.epa.gov/CHP/documents/tech_turbines.pdf

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.

Topic	**Planned Time**
Session I. Introduction; Maintaining and Repairing Turbine Casings, Sealing Glands, and Carbon Rings	
A. Introduction	_____
B. Maintaining and Repairing Turbine Casings	_____
C. Maintaining and Repairing Sealing Glands and Carbon Rings	_____
1. Disassembling Sealing Glands	_____
2. Replacing Carbon Rings	_____
3. Assembling Sealing Glands	_____

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 15507-09

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.

Topic	**Planned Time**
Session I. Introduction; Inspecting Equipment; Setting the Motor	
A. Introduction	_____
B. Inspecting Equipment	_____
C. Setting the Motor	_____
D. Laboratory	_____
Have trainees practice installing a motor. This laboratory corresponds to Performance Task 2.	
Session II. Motor Maintenance	
A. Motor Maintenance	_____
B. Practical Maintenance Techniques	_____
C. Motor Bearing Maintenance	_____
Session III. Lubrication; Troubleshooting; Storage; Recordkeeping	
A. Lubrication	_____
B. Troubleshooting	_____
C. Storing Motors	_____
D. Recordkeeping	_____
E. Laboratory	_____
Have trainees practice rigging and storing a motor. This laboratory corresponds to Performance Task 1.	

Session IV. Review and Testing

A. Review _____

B. Module Examination _____

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

C. Performance Testing _____

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

Preventive and Predictive Maintenance
Annotated Instructor's Guide

Module 15508-09

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; 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.

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. 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 15509-09

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).

http://www.plant-maintenance.com/maintenance_articles_vibration.shtml

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.

Topic **Planned Time**

Session I. Introduction; Causes of Vibration; Vibration Analysis, Test Equipment, and Monitoring

A. Introduction _____
B. Causes of Vibration _____
   1. Unbalance, Misalignment, Bent Drive Shafts, Loose Mounting Bolts _____
   2. Worn/Damaged Bearings, Improper Gear Meshing, Loose Drive Belts _____
   3. Insufficient Lubrication, Electrical Problems, Destructive Resonant Frequencies _____
C. Vibration Analysis _____
   1. Frequency _____
   2. Velocity _____
   3. Acceleration _____
   4. Displacement _____
D. Vibration Test Equipment _____
   1. Transducers _____
   2. Vibration Analysis Equipment _____
   3. Vibration Recording Instruments _____
E. Vibration Monitoring _____
   1. Identifying Equipment to be Monitored _____
   2. Establishing Schedules and Determining Monitoring Point Locations _____
   3. Setting Up Record Keeping and Continuous Monitoring Systems _____

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.