EG LNG

On-the-Job Training

Mechanical Maintenance
Reverse Indicator Alignment

Mentor Guide

Equatorial Guinea LNG Holding Limited

Equatorial Guinea LNG Holding Limited
Courseware Release Version 1.8
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Reverse Dial Indicator Alignment

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Competency 3.5

Terminal Objective

Align couplings using the reverse dial indicator method to within the vendor specified tolerance.

Enabling Objectives

3.5.1 Measure and correct any soft foot.

3.5.2 Measure and plot pre-alignment dimensions.

3.5.3 Measure and record dial indicator sweep readings.

3.5.4 Calculate and plot vertical offset.

3.5.5 Calculate and plot horizontal offset.

3.5.6 Correct coupling misalignment.

3.5.7 Measure and record final dial indicator readings.

3.5.8 Determine motor magnetic center.

Reverse Dial Indicator Alignment

Practice Exercise
PE 3.5.1 - Measure and correct any soft foot

Development Technician: _____ **PIC:** _____

Mentor/OJD Supervisor: _____ **Date:** _____

1	=	Unskilled:	Unable to satisfactorily perform.
2	=	Limited Skill:	Requires coaching and additional practice to satisfactorily perform.
3	=	Skilled:	Can perform to an acceptable standard.

Directions:

As part of the coupling alignment, measure and correct any soft foot.

1.	Obtain Permit to Work and select the correct PPE, tools and equipment for the task.	1	2	3
2.	Locate and refer to the manufacturer's manual/instructions.	1	2	3
3.	Ensure any power supply is locked out and tagged out.	1	2	3
4.	Determine the amount of soft foot for motor inboard foot 1 and shim as required. – Tighten all four motor bolts. – Clean the indicator contact areas on the motor inboard and outboard feet. – Attach the dial indicator on a clean surface of the motor mounting plate. – Place the point of the dial indicator on the cleaned surface of inboard foot 1. – Set the dial indicator at zero. – Loosen the bolts holding down inboard foot 1 and the opposite inboard foot 2. – Read the dial indicator and determine the amount of spring that occurred. – Insert shims under inboard foot 1 to take up the amount of spring. – Record the soft foot reading and final shims added on Attachment A. – Tighten all four motor bolts.	1	2	3
5.	Determine the amount of soft foot for motor inboard foot 2 and shim as required. – Move the dial indicator to inboard foot 2. – Attach the dial indicator on a clean surface of the motor mounting plate. – Place the point of the dial indicator on the cleaned surface of inboard foot 2. – Set the dial indicator at zero. – Loosen the bolts holding down inboard foot 2 and the opposite inboard foot 1. – Read the dial indicator and determine the amount of spring that occurred. – Insert shims under inboard foot 2 to take up the amount of spring. – Record the soft foot reading and final shims added on Attachment A. – Tighten all four motor bolts.	1	2	3

Practice Exercise
PE 3.5.1 - Measure and correct any soft foot (cont.)

6. Determine the amount of soft foot for motor outboard foot 3. 1 2 3
   - Move the dial indicator to outboard foot 3.
   - Attach the dial indicator on a clean surface of the motor mounting plate.
   - Place the point of the dial indicator on the cleaned surface of outboard foot 3.
   - Set the dial indicator at zero.
   - Loosen the bolts holding down outboard foot 3 and the opposite outboard foot 4.
   - Read the dial indicator and determine the amount of spring that occurred.
   - Insert shims under outboard foot 3 to take up the amount of spring.
   - Record the soft foot reading and final shims added on Attachment A.
   - Tighten all four motor bolts.
7. Determine the amount of soft foot for motor outboard foot 4. 1 2 3
   - Move the dial indicator to outboard foot 4.
   - Attach the dial indicator on a clean surface of the motor mounting plate.
   - Place the point of the dial indicator on the cleaned surface of outboard foot 4.
   - Set the dial indicator at zero.
   - Loosen the bolts holding down outboard foot 4 and the opposite outboard foot 3.
   - Read the dial indicator and determine the amount of spring that occurred.
   - Insert shims under outboard foot 4 to take up the amount of spring.
   - Record the soft foot reading and final shims added on Attachment A.
   - Tighten all four motor bolts.

Overall Rating:

☐ Must repeat the Practice Exercise ☐ Approved for Performance Test

Evaluator Comments:

_____

_____

_____

Mentor/OJD Supervisor Signature: _____

Development Technician Signature: _____

Reverse Dial Indicator Alignment

Practice Exercise
PE 3.5.2 - Measure and plot pre-alignment dimensions

Development Technician: _____ **PIC:** _____

Mentor/OJD Supervisor: _____ **Date:** _____

1	=	Unskilled:	Unable to satisfactorily perform.
2	=	Limited Skill:	Requires coaching and additional practice to satisfactorily perform.
3	=	Skilled:	Can perform to an acceptable standard.

Directions:

As part of the coupling alignment using the reverse indicator method, measure and plot the pre-alignment dimensions.

1. Record equipment name and motor shaft diameter on Attachment A — 1 2 3
2. Remove coupling guard but do not break coupling at this time — 1 2 3
3. Measure for bar sag — 1 2 3
   - Determine coupling positions of indicators A and B
   - Measure distance between indicators and record as D1 on Attachment A
   - Select appropriate alignment fixtures needed.
   - Obtain a piece of pipe slightly longer than distance D1 and as close to shaft diameter as possible
   - Mount indicators with same mounting brackets that will be used for alignment at distance D1.
   - Zero out the indicators.
   - Roll pipe 180 degrees and read bottom indicator.
   - Record indicator readings.
     NOTE: Indicator sag will always read negative
   - Remove fixtures from pipe and install on the couplings.
4. Mount alignment fixtures on the equipment to be checked — 1 2 3

Practice Exercise

PE 3.5.2 - Measure and plot pre-alignment dimensions (cont.)

5. Plot D1, D2, D3 measurements 1 2 3
   - Measure and record distance between indicators “A” and “B” (D1)
   - Measure and record distance between motor front foot and indicator “A” (D2)
   - Measure and record distance between motor back feet and indicator “A” (D3)
   - Select the “A” and “B” horizontal line on Attachment A
   - Place a round mark on the far right of this line representing the rear foot of the movable machine.
   - Count (left) the number of squares for each inch (D3) on the horizontal line and place a vertical mark (this represents indicator “A”)
   - Count (right) the number squares for each inch (D2) on the horizontal line and place a round mark representing the front foot of the movable machine.
   - Count (right) again from the horizontal line of indicator “A” the number squares for D1 and place another horizontal mark representing indicator “B”.

Overall Rating:

☐ Must repeat the Practice Exercise ☐ Approved for Performance Test

Evaluator Comments:

Mentor/OJD Supervisor Signature: _____

Development Technician Signature: _____

Reverse Dial Indicator Alignment

Practice Exercise
PE 3.5.3 - Measure and record dial indicator sweep readings

Development Technician: _____ **PIC:** _____

Mentor/OJD Supervisor: _____ **Date:** _____

1	=	Unskilled:	Unable to satisfactorily perform.
2	=	Limited Skill:	Requires coaching and additional practice to satisfactorily perform.
3	=	Skilled:	Can perform to an acceptable standard.

Directions:

As part of the coupling alignment using the reverse indicator method, measure and record dial indicator sweep readings.

1. Check dial indicator setup. 1 2 3
   - Zero dial indicators at the top position for the “A” and “B” indicators.
   - Make a 360 degree sweep with dial indicators.
   - Verify that dial indicators “A” and “B” read zero at the top position.

   NOTE: If dial indicators do not zero, then check brackets and indicators for tightness and positioning.

2. Make a 360 degree sweep taking readings at 90 degree intervals for the “A” and “B” coupling. 1 2 3
   - Record the measurements in the As-Found Reading section on Attachment A
   - Verify the total of side readings equal the bottom reading

   NOTE: If side readings do not equal bottom reading, then check alignment fixture for tightness and equipment shafts for axial movement

Practice Exercise

PE 3.5.3 - Measure and record dial indicator sweep readings (cont.)

Overall Rating:

☐ Must repeat the Practice Exercise ☐ Approved for Performance Test

Evaluator Comments:

Mentor/OJD Supervisor Signature: _____

Development Technician Signature: _____

Reverse Dial Indicator Alignment

Practice Exercise
PE 3.5.4 - Calculate and plot vertical offset

Development Technician: _____ **PIC:** _____

Mentor/OJD Supervisor: _____ **Date:** _____

1	=	Unskilled:	Unable to satisfactorily perform.
2	=	Limited Skill:	Requires coaching and additional practice to satisfactorily perform.
3	=	Skilled:	Can perform to an acceptable standard.

Directions:

As part of the coupling alignment using the reverse indicator method, calculate and plot vertical offset.

1.	Calculate and record on Attachment A the vertical offset for the “A” dial indicator.	1	2	3
2.	Calculate and record on Attachment A the vertical offset for the “B” dial indicator.	1	2	3
3.	Plot point in the vertical plane of dial indicator “A” – Observe the sign plus or minus on the left hand portion of the sheet **NOTE:** If the sign is +, then the plot will be marked above the desired shaft centerline line. If the sign is -, then the plot will be marked below the desired shaft centerline line	1	2	3
4.	Plot point in the vertical plane of dial indicator “B” – Observe the sign plus or minus on the right hand portion of the sheet **NOTE:** If the sign is +, then the plot will be marked below the desired shaft centerline line. If the sign is -, then the plot will be marked above the desired shaft centerline line	1	2	3
5.	Using a straight edge, draw a line connecting the two points (A and B) plotted for vertical offset. – Extend the line past the vertical plane on the graph for the motor rear foot (D3) **NOTE:** If the line goes off the graph before it crosses the vertical line at the feet, then reposition the original line in a different area of the graph paper or use larger graph paper.	1	2	3
6.	Determine the amount of vertical offset.	1	2	3

Practice Exercise

PE 3.5.4 - Calculate and plot vertical offset (cont.)

Overall Rating:

☐ Must repeat the Practice Exercise ☐ Approved for Performance Test

Evaluator Comments:

Mentor/OJD Supervisor Signature: _____

Development Technician Signature: _____

Reverse Dial Indicator Alignment

Practice Exercise
PE 3.5.5 - Calculate and plot horizontal offset

Development Technician: _____ **PIC:** _____

Mentor/OJD Supervisor: _____ **Date:** _____

1	=	Unskilled:	Unable to satisfactorily perform.
2	=	Limited Skill:	Requires coaching and additional practice to satisfactorily perform.
3	=	Skilled:	Can perform to an acceptable standard.

Directions:

As part of the coupling alignment using the reverse indicator method, calculate and plot horizontal offset.

1.	Calculate and record on Attachment A the horizontal offset for the “A” dial indicator.	1	2	3
2.	Calculate and record on Attachment A the horizontal offset for the “B” dial indicator.	1	2	3
3.	Plot point in the horizontal plane of dial indicator “A” – Observe the sign plus or minus on the left hand portion of the sheet **NOTE:** If the sign is +, then the plot will be marked above the desired shaft centerline line. If the sign is -, then the plot will be marked below the desired shaft centerline line	1	2	3
4.	Plot point in the horizontal plane of dial indicator “B” – Observe the sign plus or minus on the right hand portion of the sheet **NOTE:** If the sign is +, then the plot will be marked below the desired shaft centerline line. If the sign is -, then the plot will be marked above the desired shaft centerline line	1	2	3
5.	Using a straight edge, draw a line connecting the two points (A and B) plotted for horizontal offset. – Extend the line past the horizontal plane on the graph for the motor rear foot (D3)	1	2	3
6.	Determine the amount of horizontal offset.	1	2	3

Practice Exercise

PE 3.5.5 - Calculate and plot horizontal offset (cont.)

Overall Rating:

☐ Must repeat the Practice Exercise ☐ Approved for Performance Test

Evaluator Comments:

Mentor/OJD Supervisor Signature: _____

Development Technician Signature: _____

Reverse Dial Indicator Alignment

Practice Exercise
PE 3.5.6 - Correct coupling misalignment

Development Technician: _____ **PIC:** _____

Mentor/OJD Supervisor: _____ **Date:** _____

1	**=**	**Unskilled:**	**Unable to satisfactorily perform.**
2	**=**	**Limited Skill:**	**Requires coaching and additional practice to satisfactorily perform.**
3	**=**	**Skilled:**	**Can perform to an acceptable standard.**

Directions:

As part of the coupling alignment, correct coupling misalignment.

1.	Disassemble the coupling – Measure and record gap on Attachment A	1	2	3
3.	Check shaft run out for “A” and “B” and record on Attachment A	1	2	3
4.	Measure motor shaft end play and record on Attachment A	1	2	3
5.	Measure pump shaft end play and record on Attachment A	1	2	3
6.	Correct vertical misalignment. – Loosen motor base bolts. – Add or remove shims under the feet as required. – Tighten bolts and recheck alignment.	1	2	3
7.	Correct horizontal misalignment – Loosen motor base bolts. – Move the motor to the left or right as required. – Tighten bolts and recheck alignment.	1	2	3

Practice Exercise
PE 3.5.6 - Correct coupling misalignment (cont.)

Overall Rating:

☐ Must repeat the Practice Exercise ☐ Approved for Performance Test

Evaluator Comments:

Mentor/OJD Supervisor Signature: _____

Development Technician Signature: _____

Reverse Dial Indicator Alignment

Practice Exercise
PE 3.5.7 - Determine motor magnetic center

Development Technician: _____ **PIC:** _____

Mentor/OJD Supervisor: _____ **Date:** _____

1	=	Unskilled:	Unable to satisfactorily perform.
2	=	Limited Skill:	Requires coaching and additional practice to satisfactorily perform.
3	=	Skilled:	Can perform to an acceptable standard.

Directions:

As part of the coupling alignment, determine motor magnetic center (only required for journal bearings without thrust bearing applications).

1.	Secure coupling flange so it will not contact rotating shaft/coupling hub during operation.	1 2 3
2.	Apply Dykem layout dye or equivalent to motor shaft in area where magnetic center is to be marked. **NOTE:** Notify operations to start the motor.	1 2 3
3.	Using a scribe, mark magnetic center on motor shaft. **NOTE:** Notify operations to stop the motor.	1 2 3
4.	Measure the distance between the scribed mark and the outside bearing housing lip and record on Attachment A.	1 2 3
5.	If the magnetic center scribe mark falls inside the motor housing, then scribe a mark in the rest position. – Run the motor and estimate the difference between the newly scribed mark and the magnetic center mark. – Record measurement on Attachment A.	1 2 3
6.	Set the coupling face gap. – Measure the gap between the coupling halves using a scale, feeler gauge, taper or an inside micrometer. – Compare the as-found gap with the manufacturer's specifications. – Minus the distance measured for the magnet center correction if the mark is outside the bearing housing. – Add the difference measured for the magnet center correction if the mark is inside the bearing housing. – Set the proper face gap by moving the motor backward or forward. – Tighten the motor mount bolts.	1 2 3

Practice Exercise
PE 3.5.7 - Determine motor magnetic center (cont.)

Overall Rating:

☐ Must repeat the Practice Exercise ☐ Approved for Performance Test

Evaluator Comments:

Mentor/OJD Supervisor Signature: _____

Development Technician Signature: _____

Reverse Dial Indicator Alignment

Practice Exercise
PE 3.5.8 - Measure and record final dial indicator readings

Development Technician: _____ **PIC:** _____

Mentor/OJD Supervisor: _____ **Date:** _____

1	=	Unskilled:	Unable to satisfactorily perform.
2	=	Limited Skill:	Requires coaching and additional practice to satisfactorily perform.
3	=	Skilled:	Can perform to an acceptable standard.

Directions:

As part of the coupling alignment, measure and record final dial indicator readings.

1.	Ensure motor mounting bolts are tight.	1	2	3
2.	Take a final set of dial indicator readings and record on Attachment A.	1	2	3
3.	Calculate final vertical offset for the A and B dial indicator positions and record on Attachment A	1	2	3
4.	Calculate final horizontal offset for the A and B dial indicator positions and record on Attachment A	1	2	3
5.	Verify the numbers are acceptable	1	2	3
6.	Re-couple the shafts.	1	2	3
7.	Replace coupling guard	1	2	3

Practice Exercise

PE 3.5.2 - Measure and record final dial indicator readings (cont.)

Overall Rating:

☐ Must repeat the Practice Exercise ☐ Approved for Performance Test

Evaluator Comments:

Mentor/OJD Supervisor Signature: _____

Development Technician Signature: _____

Reverse Dial Indicator Alignment

Performance Test
PT 3.5.1 - Measure and correct any soft foot

Development Technician: _____ **PIC:** _____

Mentor/OJD Supervisor: _____ **Date:** _____

Yes	=	Skilled:	Can perform to an acceptable standard.
No	=	Unskilled:	Unable to satisfactorily perform.
N/A	=	Not Applicable:	Some of the performance standards may not be applicable when the Performance Test is carried out under simulated conditions.

Directions:

As part of the coupling alignment, measure and correct any soft foot.

Performance Standards

1. Obtain Permit to Work and select the correct PPE, tools and equipment for the task. Yes No N/A
2. Locate and refer to the manufacturer's manual/instructions. Yes No N/A
3. Ensure any power supply is locked out and tagged out. Yes No N/A
4. Determine the amount of soft foot for motor inboard foot 1 and shim as required. Yes No N/A
   - Tighten all four motor bolts.
   - Clean the indicator contact areas on the motor inboard and outboard feet.
   - Attach the dial indicator on a clean surface of the motor mounting plate.
   - Place the point of the dial indicator on the cleaned surface of inboard foot 1.
   - Set the dial indicator at zero.
   - Loosen the bolts holding down inboard foot 1 and the opposite inboard foot 2.
   - Read the dial indicator and determine the amount of spring that occurred.
   - Insert shims under inboard foot 1 to take up the amount of spring.
   - Record the soft foot reading and final shims added on Attachment A.
   - Tighten all four motor bolts.

Performance Test

PT 3.5.1 - Measure and correct any soft foot (cont.)

5. Determine the amount of soft foot for motor inboard foot 2 and shim as required. Yes No N/A
   - Move the dial indicator to inboard foot 2.
   - Attach the dial indicator on a clean surface of the motor mounting plate.
   - Place the point of the dial indicator on the cleaned surface of inboard foot 2.
   - Set the dial indicator at zero.
   - Loosen the bolts holding down inboard foot 2 and the opposite inboard foot 1.
   - Read the dial indicator and determine the amount of spring that occurred.
   - Insert shims under inboard foot 2 to take up the amount of spring.
   - Record the soft foot reading and final shims added on Attachment A.
   - Tighten all four motor bolts.
6. Determine the amount of soft foot for motor outboard foot 3. Yes No N/A
   - Move the dial indicator to outboard foot 3.
   - Attach the dial indicator on a clean surface of the motor mounting plate.
   - Place the point of the dial indicator on the cleaned surface of outboard foot 3.
   - Set the dial indicator at zero.
   - Loosen the bolts holding down outboard foot 3 and the opposite outboard foot 4.
   - Read the dial indicator and determine the amount of spring that occurred.
   - Insert shims under outboard foot 3 to take up the amount of spring.
   - Record the soft foot reading and final shims added on Attachment A.
   - Tighten all four motor bolts.
7. Determine the amount of soft foot for motor outboard foot 4. Yes No N/A
   - Move the dial indicator to outboard foot 4.
   - Attach the dial indicator on a clean surface of the motor mounting plate.
   - Place the point of the dial indicator on the cleaned surface of outboard foot 4.
   - Set the dial indicator at zero.
   - Loosen the bolts holding down outboard foot 4 and the opposite outboard foot 3.
   - Read the dial indicator and determine the amount of spring that occurred.
   - Insert shims under outboard foot 4 to take up the amount of spring.
   - Record the soft foot reading and final shims added on Attachment A.
   - Tighten all four motor bolts.

Performance Test

PT 3.5.1 - Measure and correct any soft foot (cont.)

Overall Rating:

☐ Pass ☐ Fail

Evaluator Comments:

Mentor/OJD Supervisor Signature: _____

Development Technician Signature: _____

Reverse Dial Indicator Alignment

Performance Test
PT 3.5.2 - Measure and plot pre-alignment dimensions

Development Technician: _____ **PIC:** _____

Mentor/OJD Supervisor: _____ **Date:** _____

Yes	=	Skilled:	Can perform to an acceptable standard.
No	=	Unskilled:	Unable to satisfactorily perform.
N/A	=	Not Applicable:	Some of the performance standards may not be applicable when the Performance Test is carried out under simulated conditions.

Directions:

As part of the coupling alignment using the reverse indicator method, measure and plot the pre-alignment dimensions.

Performance Standards

1. Record equipment name and motor shaft diameter on Attachment A — Yes No N/A
2. Remove coupling guard but do not break coupling at this time — Yes No N/A
3. Measure for bar sag — Yes No N/A
   - Determine coupling positions of indicators A and B
   - Measure distance between indicators and record as D1 on Attachment A
   - Select appropriate alignment fixtures needed.
   - Obtain a piece of pipe slightly longer than distance D1 and as close to shaft diameter as possible
   - Mount indicators with same mounting brackets that will be used for alignment at
   - distance D1.
   - Zero out the indicators.
   - Roll pipe 180 degrees and read bottom indicator.
   - Record indicator readings.
     NOTE: Indicator sag will always read negative
   - Remove fixtures from pipe and install on the couplings.
4. Mount alignment fixtures on the equipment to be checked — Yes No N/A

Performance Test
PT 3.5.2 - Measure and plot pre-alignment dimensions (cont.)

5. Plot D1, D2, D3 measurements — Yes No N/A
   - Measure and record distance between indicators “A” and “B” (D1)
   - Measure and record distance between motor front foot and indicator “A” (D2)
   - Measure and record distance between motor back feet and indicator “A” (D3)
   - Select the “A” and “B” horizontal line on Attachment A
   - Place a round mark on the far right of this line representing the rear foot of the movable machine.
   - Count (left) the number of squares for each inch (D3) on the horizontal line and place a vertical mark (this represents indicator “A”)
   - Count (right) the number squares for each inch (D2) on the horizontal line and place a round mark representing the front foot of the movable machine.
   - Count (right) again from the horizontal line of indicator “A” the number squares for D1 and place another horizontal mark representing indicator “B”.

Overall Rating:

☐ Pass ☐ Fail

Evaluator Comments:

Mentor/OJD Supervisor Signature: _____

Development Technician Signature: _____

Reverse Dial Indicator Alignment

Performance Test
PT 3.5.3 - Measure and record dial indicator sweep readings

Development Technician: _____ **PIC:** _____

Mentor/OJD Supervisor: _____ **Date:** _____

Yes	=	Skilled:	Can perform to an acceptable standard.
No	=	Unskilled:	Unable to satisfactorily perform.
N/A	=	Not Applicable:	Some of the performance standards may not be applicable when the Performance Test is carried out under simulated conditions.

Directions:

As part of the coupling alignment using the reverse indicator method, measure and record dial indicator sweep readings.

Performance Standards

1. Check dial indicator setup. Yes No N/A
   - Zero dial indicators at the top position for the “A” and “B” indicators.
   - Make a 360 degree sweep with dial indicators.
   - Verify that dial indicators “A” and “B” read zero at the top position.

   NOTE: If dial indicators do not zero, then check brackets and indicators for tightness and positioning.
2. Make a 360 degree sweep taking readings at 90 degree intervals for the “A” and “B” coupling. Yes No N/A
   - Record the measurements in the As-Found Reading section on Attachment A
   - Verify the total of side readings equal the bottom reading

   NOTE: If side readings do not equal bottom reading, then check alignment fixture for tightness and equipment shafts for axial movement

Performance Test

PT 3.5.3 - Measure and record dial indicator sweep readings (cont.)

Overall Rating:

☐ Pass ☐ Fail

Evaluator Comments:

Mentor/OJD Supervisor Signature: _____

Development Technician Signature: _____

Reverse Dial Indicator Alignment

Performance Test
PT 3.5.4 - Calculate and plot vertical offset

Development Technician: _____ **PIC:** _____

Mentor/OJD Supervisor: _____ **Date:** _____

Yes	=	Skilled:	Can perform to an acceptable standard.
No	=	Unskilled:	Unable to satisfactorily perform.
N/A	=	Not Applicable:	Some of the performance standards may not be applicable when the Performance Test is carried out under simulated conditions.

Directions:

As part of the coupling alignment using the reverse indicator method, calculate and plot vertical offset.

Performance Standards

1.	Calculate and record on Attachment A the vertical offset for the “A” dial indicator.	Yes	No	N/A
2.	Calculate and record on Attachment A the vertical offset for the “B” dial indicator.	Yes	No	N/A
3.	Plot point in the vertical plane of dial indicator “A” – Observe the sign plus or minus on the left hand portion of the sheet **NOTE:** If the sign is +, then the plot will be marked above the desired shaft centerline line. If the sign is -, then the plot will be marked below the desired shaft centerline line	Yes	No	N/A
4.	Plot point in the vertical plane of dial indicator “B” – Observe the sign plus or minus on the right hand portion of the sheet **NOTE:** If the sign is +, then the plot will be marked below the desired shaft centerline line. If the sign is -, then the plot will be marked above the desired shaft centerline line	Yes	No	N/A
5.	Using a straight edge, draw a line connecting the two points (A and B) plotted for vertical offset. – Extend the line past the vertical plane on the graph for the motor rear foot (D3) **NOTE:** If the line goes off the graph before it crosses the vertical line at the feet, then reposition the original line in a different area of the graph paper or use larger graph paper.	Yes	No	N/A
6.	Determine the amount of vertical offset.	Yes	No	N/A

Performance Test

PT 3.5.4 - Calculate and plot vertical offset (cont.)

Overall Rating:

☐ Pass ☐ Fail

Evaluator Comments:

Mentor/OJD Supervisor Signature: _____

Development Technician Signature: _____

Reverse Dial Indicator Alignment

Performance Test
PT 3.5.5 - Calculate and plot horizontal offset

Development Technician: _____ **PIC:** _____

Mentor/OJD Supervisor: _____ **Date:** _____

Yes	=	Skilled:	Can perform to an acceptable standard.
No	=	Unskilled:	Unable to satisfactorily perform.
N/A	=	Not Applicable:	Some of the performance standards may not be applicable when the Performance Test is carried out under simulated conditions.

Directions:

As part of the coupling alignment using the reverse indicator method, calculate and plot horizontal offset.

Performance Standards

1.	Calculate and record on Attachment A the horizontal offset for the “A” dial indicator.	Yes	No	N/A
2.	Calculate and record on Attachment A the horizontal offset for the “B” dial indicator.	Yes	No	N/A
3.	Plot point in the horizontal plane of dial indicator “A” – Observe the sign plus or minus on the left hand portion of the sheet **NOTE:** If the sign is +, then the plot will be marked above the desired shaft centerline line. If the sign is -, then the plot will be marked below the desired shaft centerline line	Yes	No	N/A
4.	Plot point in the horizontal plane of dial indicator “B” – Observe the sign plus or minus on the right hand portion of the sheet **NOTE:** If the sign is +, then the plot will be marked below the desired shaft centerline line. If the sign is -, then the plot will be marked above the desired shaft centerline line	Yes	No	N/A
5.	Using a straight edge, draw a line connecting the two points (A and B) plotted for horizontal offset. – Extend the line past the horizontal plane on the graph for the motor rear foot (D3)	Yes	No	N/A
6.	Determine the amount of horizontal offset.	Yes	No	N/A

Performance Test

PT 3.5.5 - Calculate and plot horizontal offset (cont.)

Overall Rating:

☐ Pass ☐ Fail

Evaluator Comments:

Mentor/OJD Supervisor Signature: _____

Development Technician Signature: _____

Reverse Dial Indicator Alignment

Performance Test
PT 3.5.6 - Correct coupling misalignment

Development Technician: _____ **PIC:** _____

Mentor/OJD Supervisor: _____ **Date:** _____

Yes	=	Skilled:	Can perform to an acceptable standard.
No	=	Unskilled:	Unable to satisfactorily perform.
N/A	=	Not Applicable:	Some of the performance standards may not be applicable when the Performance Test is carried out under simulated conditions.

Directions:

As part of the coupling alignment, correct coupling misalignment.

Performance Standards

1.	Disassemble the coupling Measure and record gap on Attachment A	Yes	No	N/A
3.	Check shaft run out for “A” and “B” and record on Attachment A	Yes	No	N/A
4.	Measure motor shaft end play and record on Attachment A	Yes	No	N/A
5.	Measure pump shaft end play and record on Attachment A	Yes	No	N/A
6.	Correct vertical misalignment. – Loosen motor base bolts. – Add or remove shims under the feet as required. – Tighten bolts and recheck alignment.	Yes	No	N/A
7.	Correct horizontal misalignment – Loosen motor base bolts. – Move the motor to the left or right as required. – Tighten bolts and recheck alignment.	Yes	No	N/A

Performance Test
PT 3.5.6 - Correct coupling misalignment (cont.)

6. Set the coupling face gap. Yes No N/A
   - Measure the gap between the coupling halves using a scale, feeler gauge, taper or an inside micrometer.
   - Compare the as-found gap with the manufacturer's specifications.
   - Minus the distance measured for the magnet center correction if the mark is outside the bearing housing.
   - Add the difference measured for the magnet center correction if the mark is inside the bearing housing.
   - Set the proper face gap by moving the motor backward or forward.
   - Tighten the motor mount bolts.

Overall Rating:

☐ Pass ☐ Fail

Evaluator Comments:

Mentor/OJD Supervisor Signature: _____

Development Technician Signature: _____

Reverse Dial Indicator Alignment

Performance Test
PT 3.5.7 - Determine motor magnetic center

Development Technician: _____ **PIC:** _____

Mentor/OJD Supervisor: _____ **Date:** _____

Yes	=	Skilled:	Can perform to an acceptable standard.
No	=	Unskilled:	Unable to satisfactorily perform.
N/A	=	Not Applicable:	Some of the performance standards may not be applicable when the Performance Test is carried out under simulated conditions.

Directions:

As part of the coupling alignment, determine motor magnetic center
NOTE: Only required for motors with journal bearings.

Performance Standards

1.	Secure coupling flange so it will not contact rotating shaft/coupling hub during operation.	Yes	No	N/A
2.	Apply Dykem layout dye or equivalent to motor shaft in area where magnetic center is to be marked. **NOTE:** Notify operations to start the motor.	Yes	No	N/A
3.	Using a scribe, mark magnetic center on motor shaft. **NOTE:** Notify operations to stop the motor.	Yes	No	N/A
4.	Measure the distance between the scribed mark and the outside bearing housing lip and record on Attachment A.	Yes	No	N/A
5.	If the magnetic center scribe mark falls inside the motor housing, then scribe a mark in the rest position. – Run the motor and estimate the difference between the newly scribed mark and the magnetic center mark. – Record measurement on Attachment A.	Yes	No	N/A

Performance Test

PT 3.5.7 - Determine motor magnetic center (cont.)

Overall Rating:

☐ Pass ☐ Fail

Evaluator Comments:

Mentor/OJD Supervisor Signature: _____

Development Technician Signature: _____

Reverse Dial Indicator Alignment

Performance Test
PT 3.5.8 - Measure and record final dial indicator readings

Development Technician: _____ **PIC:** _____

Mentor/OJD Supervisor: _____ **Date:** _____

Yes	=	Skilled:	Can perform to an acceptable standard.
No	=	Unskilled:	Unable to satisfactorily perform.
N/A	=	Not Applicable:	Some of the performance standards may not be applicable when the Performance Test is carried out under simulated conditions.

Directions:

As part of the coupling alignment, measure and record final dial indicator readings.

Performance Standards

1.	Ensure motor mounting bolts are tight.	Yes	No	N/A
2.	Take a final set of dial indicator readings and record on Attachment A.	Yes	No	N/A
3.	Calculate final vertical offset for the A and B dial indicator positions and record on Attachment A	Yes	No	N/A
4.	Calculate final horizontal offset for the A and B dial indicator positions and record on Attachment A	Yes	No	N/A
5.	Verify the numbers are acceptable	Yes	No	N/A
6.	Re-couple the shafts.	Yes	No	N/A
7.	Replace coupling guard	Yes	No	N/A

Performance Test

PT 3.5.8 - Measure and record final dial indicator readings (cont.)

Overall Rating:

☐ Pass ☐ Fail

Evaluator Comments:

Mentor/OJD Supervisor Signature: _____

Development Technician Signature: _____

Reverse Dial Indicator Alignment

Information Sheet
IS 3.5.2 - Reverse dial indicator alignment method

Reverse Indicator Method (RIM) is the most accurate method of performing alignment between two direct-coupled shafts. Even the laser technique is based upon RIM. The real value lies in being able to perform alignment without using sophisticated tools while achieving the same accuracy. This is achieved through only training and knowledge.

Symptoms of misalignment

Misalignment is not easy to detect on machinery that is running. Misalignment will be only obvious trough secondary effects of the following symptoms:

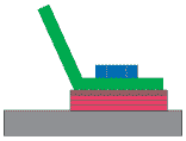
- Premature bearing, seal, shaft, or coupling failures

  NOTE: Some flexible coupling designs run hot under misalignment conditions. If it is an elastomeric type, look for rubber powder inside the coupling
- Excessive vibration
- High casing temperatures at or near the bearings or high oil temperatures
- Excessive amount of oil leakage at the bearing seals
- Loose foundation bolts
- Loose or broken coupling bolts
- Unusually high number of coupling failures or they wear quickly
- The shafts are breaking (or cracking) at or close to the inboard bearings or coupling hubs

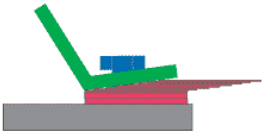
Soft foot correction

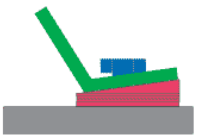
A soft foot is caused when one or more of the machine feet do not rest firmly on the base plate. Soft foot is a condition that could cause a lot of problem with repeatability in the positioning of the machine during the alignment process. When a machine with a soft foot is bolted down to the base, the machine casing is exposed to tension forces. This can affect bearing positions and result in the premature wear of bearing and other machine components.

One type of soft foot is called "short foot" or "parallel soft foot". This problem is solved by adding shims to the "short foot".



A second type of soft foot occurs as "angled foot". It can be solved by adding shims under the foot as shown to the right, but it is better to correct the angle of the foot or making a steel wedge.



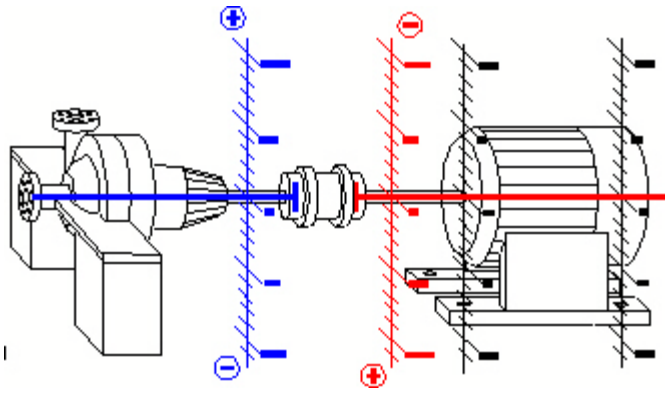


Reverse Dial Indicator Alignment

Information Sheet

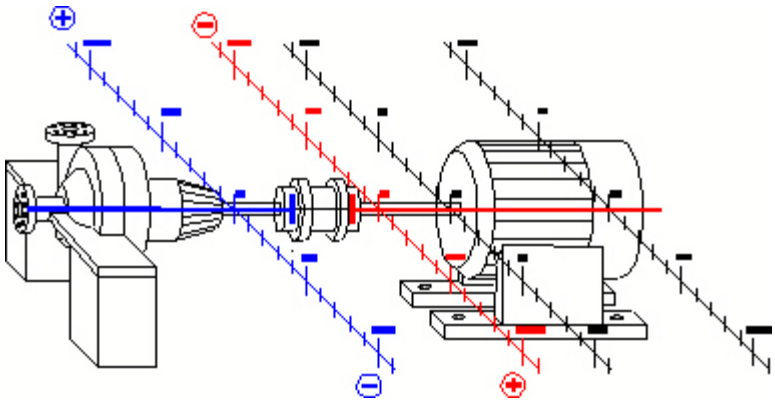
PT 3.5.8 - Reverse dial indicator alignment method (cont.)

Vertical move



The vertical move is the part of the alignment process that aligns the two shaft's centerlines into their proper up and down position. Usually you will have to add or remove shims in this step. The indicators are zeroed on the top and read at the bottom. Start with a plus + reading if you need to compensate for sag.

Horizontal move



The horizontal move is the part of the alignment process that aligns the shaft's centerlines from side to side. View the machine from the pump end, zero the indicators on the left, and then rotate and read on the right. Make sure that you always view the pump from the same direction in order for you to keep the left and right directions correct. There is no sag compensation on the horizontal move.

Information Sheet

PT 3.5.8 - Reverse dial indicator alignment method (cont.)

Alignment Tolerances

These suggested tolerances are the maximum allowable deviations from desired values (targets), whether such values are zero or nonzero. These recommended tolerances should be used in the absence of in-house specifications or tighter tolerances from the machinery manufacturer.

Tolerances for Shaft Alignment

	Short Couplings						Spacer Shafts	
	Excellent			Acceptable			Excellent	Acceptable
	Offset	Angularity		Offset	Angularity			
	(mils)	(mils)	(mils)	(mils)	(mils)	(mils)	(mils of offset per inch of space length) (or spacer to shaft angle)	
RPM		(inch)	(10")		(inch)	(10")		
600	5.0	1.0	10.0	9.0	1.5	15.0	1.8	3.0
900	3.0	0.7	7.0	6.0	1.0	10.0	1.2	2.0
1200	2.5	0.5	5.0	4.0	0.8	8.0	0.9	1.5
1800	2.0	0.3	3.0	3.0	0.5	5.0	0.6	1.0
3600	1.0	0.2	2.0	1.5	0.3	3.0	0.3	0.5
7200	0.5	0.1	1.0	1.0	0.2	2.0	0.15	0.25

Information Sheet
IS 3.5.3 - Required equipment and tools

Equipment:

The tools and equipment you will typically need to align couplings:

- Dial indicators (0.000" - 1.000") and mounting brackets
- Feeler gauges
- Mandrill or pipe to determine bar sag
- Micrometer (0.000" - 1.000")
- Pencil and paper
- Scotchbrite®
- Shim Pack
- Standard issue tool box
- Straight edge

NOTE: If you cannot locate any of the Equipment or Tools, ask your Mentor or On-the-Job Development Supervisor.

Reverse Dial Indicator Alignment

Reference Materials

Listed below are the documents you will need to prepare for your Practice Exercises and Performance Tests.

Reference Materials	Document No. / Type	Location

NOTE: If you cannot locate any of the Reference Materials ask a Mentor or your On-the-Job Development Supervisor.

Self-Assessment

SA 3.5 - Coupling alignment using reverse dial indicator

1. **Q.** **Reverse dial indicator alignment is defined as:**

   A. Using 2 dial indicators, one on either side of each machine's faces.

   B. Using 2 dial indicators on each machine's face and calculating the misalignment from those readings.

   C. Using 2 dial indicators, and inverting the readings so that they apply directly to each machine's shaft.

   D. Using 2 dial indicators on each machine's rim and calculating the misalignment from those readings.

   A. D. Using 2 dial indicators on each machine's rim and calculating the misalignment from those readings

2. **Q.** **Which of the following is true of the dial readings for indicator bar sag?**

   A. Sag on the “A” dial is negative, sag on the “B” dial is positive

   B. Indicator bar sag is always positive

   C. Indicator bar sag is always negative

   D. Sag on the “A” dial is positive, sag on the “B” dial is negative

   A. C. Indicator bar sag is always negative

3. **Q.** **Which type of misalignment always requires the addition or subtraction of shims?**

   A. Parallel misalignment

   B. Vertical misalignment

   C. Angular misalignment

   D. Skewed misalignment

   A. B. Vertical misalignment

Self-Assessment

SA 3.5. - Coupling alignment using reverse dial indicator (cont.)

4. Q. During an alignment procedure, a mechanic determines that the motor's coupling hub is 24 mils lower than the pump's hub. Select the choice that best describes how shims should be used to correct the gap.

A. Insert 24 mils at coupling end and 24 mils at back end.

B. Insert 24 mils at coupling end, none at back end.

C. Insert 24 mils at back end, none at coupling end.

D. Insert 12 mils at coupling end and 12 mils at back end.

A. A. Insert 24 mils at coupling end and 24 mils at back end.

5. Q. During a reverse dial procedure, the dial indicators were set to compensate for bar sag and the shafts were rotated to measure misalignment in the vertical plane. If the dial indicator at the 6 o'clock position reads +6 mils, what is the vertical misalignment measured by the indicator?

A. +3 mils

B. +6 mils

C. -3 mils

D. -6 mils

A. A. +3 mils

6. Q. Suppose your calculations showed that, to correct for misalignment, you had to remove .008" shim from both the front and back feet. But the technical manual states that you must allow for .004" heat rise on the stationary machine. How much total shim should you add or subtract from the movable machine?

A. Subtract .012"

B. Add .012"

C. Subtract .004"

D. Add .004"

A. C. Subtract .004"

Self-Assessment
SE 3.5. - Coupling alignment using reverse dial indicator (cont.)

7. Q. How is end thrust measured on a machine?

A. Run the machine until hot, then mark the shaft

B. Subtract the magnetic center of the motor from the fully extended position

C. Subtract the specified coupling gap from the true coupling gap

D. Measure the distance between the shaft pushed in versus pushed out

A. D. Measure the distance between the shaft pushed in versus pushed out

8. Q. What must be maintained to prevent damage to a coupling from axial movement of the shafts?

A. Collinear run out

B. The proper face gap

C. Adequate pipe strain

D. Ample soft foot

A. B. The proper face gap

9. Q. Which of these measurements is most likely to be used to determine if a shaft or bearing problem exists on a piece of rotating equipment?

A. Run out readings

B. Magnetic center settings

C. Soft foot specifications

D. Thermal growth calculations

A. A. Run out readings

Self-Assessment

SE 3.5. - Coupling alignment using reverse dial indicator (cont.)

10. Q. After brackets and dial indicators are attached to a pump and motor, and each indicator is adjusted, how is vertical misalignment measured using the reverse dial method?

A. Rotate motor shaft only, 90 degrees.

B. Rotate both shafts 180 degrees.

C. Rotate pump shaft only, 270 degrees.

D. Rotate motor shaft only, 360 degrees.

A. B. Rotate both shafts 180 degrees.

Next Step:

Review your answers to the questions with your Mentor or On-the-Job Development Supervisor. If you have answered all of the questions correctly, you are ready to begin your Practice Exercises.

Attachment A – Alignment Performance Worksheet

REVERSE, DIAL INDICATOR METHOD

AS-FOUND READING

T 1. _____ .000" T 2. _____ .000"

L 1. _____ Ⓐ _____ R 1. L 2. _____ Ⓑ _____ R 2.

B 1. _____ B 2. _____

CALCULATE AS-FOUND OFFSET = $\frac{B - (SAG)}{2}$

VERTICAL OFFSET:
ACTUAL VERTICAL READING: A _____

ACTUAL VERTICAL READING: B _____

CALCULATE AS-FOUND OFFSET = $\frac{R - L}{2}$

HORIZONTAL OFFSET:
ACTUAL HORIZONTAL READING: A _____

ACTUAL HORIZONTAL READING: B _____

FINAL READING

T 3. _____ .000" T 4. _____ .000"

L 3. _____ Ⓐ _____ R 3. L 4. _____ Ⓑ _____ R 4.

B 3. _____ B 4. _____

CALCULATE FINAL OFFSET = $\frac{B - (SAG)}{2}$

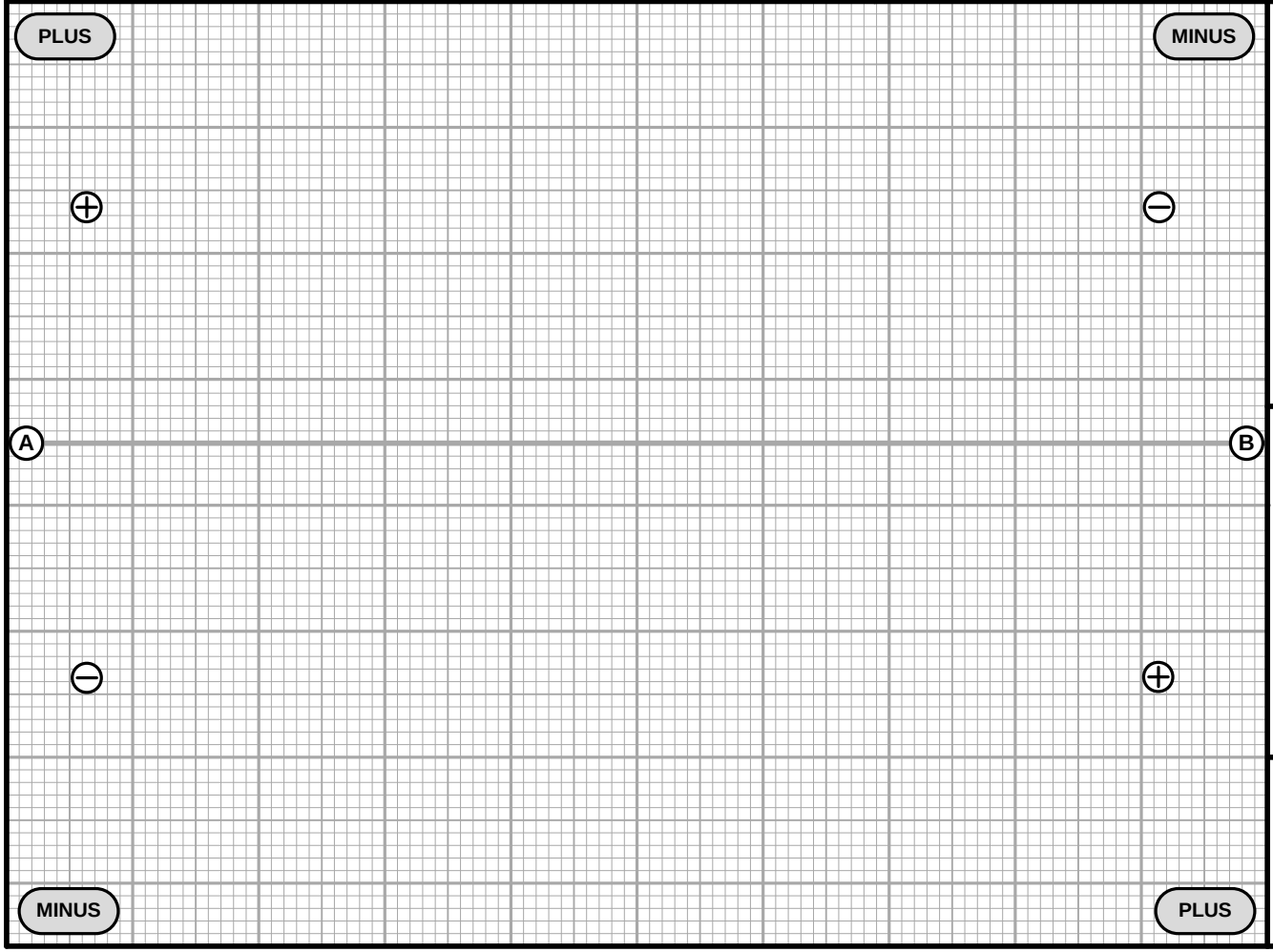
VERTICAL OFFSET:
ACTUAL VERTICAL READING: A _____

ACTUAL VERTICAL READING: B _____

CALCULATE FINAL OFFSET = $\frac{R - L}{2}$

HORIZONTAL OFFSET:
ACTUAL HORIZONTAL READING: A _____

ACTUAL HORIZONTAL READING: B _____



ALIGNMENT PERFORMANCE WORKSHEET

EQUIPMENT NAME: _____

MOTOR SHAFT DIAMETER: _____

UNCOUPLED SHAFT RUNOUT – A: _____

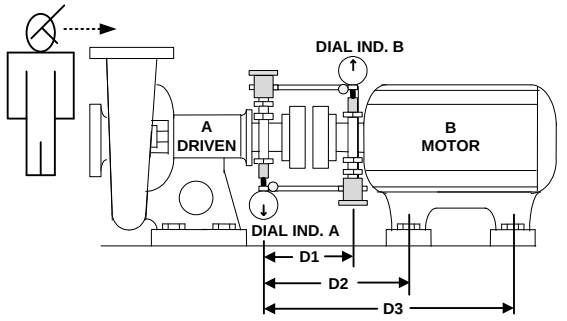
UNCOUPLED SHAFT RUNOUT – B: _____

MOTOR SHAFT END PLAY: _____

PUMP SHAFT END PLAY: _____

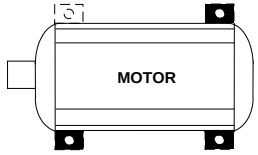
COUPLING GAP: _____ AS-FOUND _____ AS-LEFT

D1 _____ D2 _____ D3 _____



FINAL SHIMS _____ FINAL SHIMS _____

SOFT FOOT _____ SOFT FOOT _____



FINAL SHIMS _____ FINAL SHIMS _____

SOFT FOOT _____ SOFT FOOT _____

PERFORMED BY: _____

WITNESSED BY: _____

DATE: _____