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B  Components of the Alignment and Coupling Systems
C  Unit Conversion Table
D  Post-Test

We Value Your Opinion!
Courseware Outline

ALIGNMENT AND COUPLINGS – WORK ORDERS

Work Order 1  Dial Indicator Method
Work Order 2  Reverse Indicator Method
Work Order 3  Flange Couplings
Work Order 4  Flexible Sleeve Couplings
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Appendices
A  Equipment Utilization Chart
B  Components of the Alignment and Couplings System
C  Unit Conversion Table
D  Safety Procedures
E  Lockout/Tagout Procedure
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We Value Your Opinion!
Sample Job Sheet

Extracted from

Alignment and Couplings
The reverse indicator method is another shaft alignment method. It uses two dial indicators, one on each shaft, to measure the parallel and angular misalignment as shown in Figure 2-1.

![Figure 2-1. Reverse indicator setup.](image)

All measurements are taken on the rim of the coupling hubs. The parallel and angular measurements, made in the vertical plane, are taken at the same time. The same is true for the measurements taken in the horizontal plane.

The reverse indicator method is more accurate than the straightedge and feeler gauge method and the dial indicator method. Since the measurements are taken only on the rim of the coupling, they can be performed without disassembling the coupling.
OBJECTIVES

In this job, you will align two shafts using the reverse indicator method.

EQUIPMENT REQUIRED

- Universal Base Assembly, model 46603
- Motor Package, model 46609
- Couplings – Shafts Panel, model 46610
- Pillow Block Bearings Panel, model 46611
- Alignment and Couplings Package, model 46615
- Test/Measurement Package, model 46630
- Test/Measurement Package 2, model 46630-10
- Tool Box Component Package, model 46631
- Tool Box Component Package 2, model 46631-10

SAFETY PROCEDURES

Before proceeding with this job, complete the following check list.

☐ You are wearing safety glasses.
☐ You are wearing safety shoes.
☐ You are not wearing anything that might get caught such as a tie, jewelry, or loose clothes.
☐ If your hair is long, tie it out of the way.
☐ The working area is clean and free of oil.
☐ The floor is not wet.
☐ Your sleeves are rolled up.

PROCEDURE

Lockout/Tagout Procedure

☐ 1. Perform a lockout/tagout procedure as described in Job Sheet 1.
REVERSE INDICATOR METHOD

Note: The Universal Base should be set up from Job Sheet 1. Repeat Job Sheet 1 if necessary.

Rough Alignment

☐ 2. Align the shafts using the straightedge and feeler gauge method as described in the manual titled Introduction to Mechanical Drive Systems, p/n 36737-20.

Coupling Installation

Note: The following steps refer to the flange coupling only. Consult the Coupling Installation procedure of the coupling you are installing.

☐ 3. Take the flange coupling from the Couplings 1 Panel.

☐ 4. Perform the following steps if the bushings are not assembled into the coupling hubs:
   
   - Slide a 5/8-in. bore, size H split taper bushings into both hubs. The bushing should slide freely. If not, install it on the opposite side of the hub.
   
   - Line up the unthreaded bushing holes with the threaded holes on the hubs.
   
   - Slide and hand-tighten the capscrews to lock the bushings into the hubs.

☐ 5. Install a key into each shaft keyseat.

Note: The edges of the keyseats are sharp.

☐ 6. Slide hub 1 and hub 2 on the shafts as shown in Figure 2-2, leaving a 1/8-in. gap between the two hubs.
7. Slightly tighten the bushing hub capscrews to lock them on the shaft.

8. Tighten the pillow block bearing setscrews on the flat surface of the shaft.

9. Tighten the pillow block bearing screws to the extrusions.

10. Tighten the mounting base screws to the extrusions.

11. Tighten the motor screws to the mounting base.

Dial Indicator Setup

12. Mount the two dial indicators on the motor shaft as shown in Figure 2-3 using the clamp attachments, swivel clamps, and rods.

13. Make sure you can freely rotate the dial indicators around the shafts. If not, reposition the arms so that you can.
Vertical Alignment

☐ 14. Rotate the couplings so that the dial indicator 1 is at the 12 o'clock position and the dial indicator 2 is at the 6 o'clock position.

☐ 15. Make sure the probe of the dial indicators touch a smooth surface on the rim of the coupling hubs.

☐ 16. Set the indicators to zero by turning the dial.

☐ 17. Rotate the coupling hubs so that the dial indicator 1 is at the 6 o'clock position and the dial indicator 2 is at the 12 o'clock position.

☐ 18. Record the dial indicator readings. This corresponds to the vertical Total Indicator Reading (TIR).

Vertical TIR indicator 1 ________

Vertical TIR indicator 2 ________

Note: Make sure you keep the sign of your readings.
19. Calculate the vertical misalignment ($V_m$) for each dial indicator using the following formulas:

$V_m, \text{ indicator 1} = -0.5 \times \text{Vertical TIR indicator 1}$

**Note:** Notice the minus sign in the calculation of the $V_m, \text{ indicator 1}$.

$V_m, \text{ indicator 2} = 0.5 \times \text{Vertical TIR indicator 2}$

20. Measure the distances shown in Figure 2-4.

![Figure 2-4. Measurement of the distances.](image)

Distance 1-2: ______

Distance 1-3: ______

Distance 1-4: ______

**Plot of the Measurements**

21. Draw a horizontal line in the middle of the graph in Figure 2-6. This line represents the center line of the driven shaft, as shown in Figure 2-5.
22. Choose a scale for the horizontal line and plot accurately the distances 1-2, 1-3 and 1-4 you measured previously. Point 1 represents the position of the dial indicator 1, point 2 the dial indicator 2, point 3 the front of the motor, and point 4 the rear of the motor.

23. Choose a vertical scale and record it. For example, one square is equal to 0.05 in.

   Vertical scale: _____

24. Plot the measurement of the dial indicator 1 in line with point 1. If the value is positive, plot it below the horizontal line. If it is negative, plot it above the horizontal line.

25. Plot the measurement of the dial indicator 2 in line with point 2. If the value is positive, plot it above the horizontal line. If it is negative, plot it below the horizontal line.

26. Draw a line that connects the two previous measurements and extend it above point 3 and 4. The height (H3) above the horizontal line at point 3 represents the amount by which the front of the motor must be shimmed and the height (H4) above point 4 represents the amount by which the rear of the motor must be shimmed.

   **Note:** If the line is below the horizontal, shims must be removed.
Figure 2-6. Plot of the measurements.
REVERSE INDICATOR METHOD

☐ 27. Measure the heights (H3) and (H4) and convert them in shim thickness using the vertical scale you determined previously.

Shim thickness H3: _____

Shim thickness H4: _____

☐ 28. Add shims as required under the motor base plate.

Note: The vertical misalignment should be below 0.002 in.

☐ 29. Tighten the motor screws.

Horizontal Alignment

☐ 30. Rotate the coupling so that the dial indicator 1 is at the 9 o'clock position and the dial indicator 2 is at the 3 o'clock position as shown in Figure 2-7.

Figure 2-7. Dial indicator positions.

☐ 31. Make sure the probe of the dial indicators touches a smooth surface on the rim of the coupling hubs.

☐ 32. Set the indicators to zero by turning the dial.

☐ 33. Rotate the coupling hubs so that the dial indicator 1 is at the 3 o'clock position and the dial indicator 2 is at the 9 o'clock position.
34. Record the dial indicator readings. This corresponds to the horizontal Total Indicator Reading (TIR).

Horizontal TIR\textsubscript{indicator 1} ______

Horizontal TIR\textsubscript{indicator 2} ______

\textbf{Note:} Make sure to note the sign of your readings.

35. Calculate the horizontal misalignment ($H_m$) for each dial indicator using the following formulas:

\[ H_m, \text{ indicator 1} = -0.5 \times \text{Horizontal TIR}_{\text{indicator 1}} = \] ______

\[ H_m, \text{ indicator 2} = 0.5 \times \text{Horizontal TIR}_{\text{indicator 2}} = \] ______

\textbf{Note:} Notice the minus sign in the calculation of the $V_m, \text{ indicator 1}$.

36. Loosen the motor bolts and move the motor as follows:

- If $H_m, \text{ indicator 1}$ is positive and $H_m, \text{ indicator 2}$ is negative, move the motor to the left as you stand behind it.
- If $H_m, \text{ indicator 2}$ is positive and $H_m, \text{ indicator 1}$ is negative, move the motor to the right as you stand behind it
- Also, if $H_m, \text{ indicator 2}$ is greater than $H_m, \text{ indicator 1}$, the rear of the motor must be moved more than the front.

\textbf{Note:} The horizontal misalignment should be below 0.002 inch.

37. Tighten the motor screws.

38. Dismount the dial indicators and rod assemblies from the shafts.

39. Slide the coupling hubs away from each other.

40. Slide hub 1 until it is flush with the end of the motor shaft.
REVERSE INDICATOR METHOD

Coupling Assembly

Note: The following steps refer to the flange coupling only. Consult the Coupling Assembly procedure of the coupling you are installing.

☐ 41. Tighten the hub 1 bushing capscrews up to 95 lbf-in. using a torque wrench to lock the assembly on the motor shaft.

☐ 42. Slide hub 2 until it mates with hub 1 and lock the hubs together with the coupling screws.

☐ 43. Tighten the hub 2 bushing capscrews up to 95 lbf-in. using a torque wrench to lock the assembly on the driven shaft.

☐ 44. Ask the instructor to check your work.

Name: ___________________________ Date: ______________________

Instructor’s approval: ___________________________
Sample Work Order
Extracted from
Alignment and Couplings
Task: Align two shafts using the reverse indicator method.

PROCEDURE

☐ 1. Perform the Safety Procedures listed in Appendix D.

☐ 2. Perform the Lockout/Tagout Procedure described in Appendix E.

☐ 3. Should the probe of the dial indicator be placed on the rim or face of the coupling hub when taking the measurements with the reverse indicator method?

   Position of the probe: ______

☐ 4. Take the flange coupling from the Couplings 1 panel, and install it as shown in Figure 2-1.

![Figure 2-1. Installation of the flange coupling.](image)

☐ 5. Perform a rough alignment using the straightedge and feeler gauge method.
6. Assemble the dial indicator on the motor shaft as shown in Figure 2-2 using the clamp attachments, swivel clamps, and rods.

Vertical Alignment

7. Record the following parameters:

- Vertical TIR\(_{\text{indicator 1}}\): 
- Vertical TIR\(_{\text{indicator 2}}\): 

**Note:** Make sure you keep the sign of your readings.

- \(V_{m, \text{indicator 1}}\): 

**Note:** Notice the minus sign in the calculation of the \(V_{m, \text{indicator 1}}\).

- \(V_{m, \text{indicator 2}}\): 

8. Measure the lengths shown in Figure 2-3.
Figure 2-3. Measurement of the lengths.

Length 1-2: _____
Length 1-3: _____
Length 1-4: _____

Plot of the Measurements

☐ 9. Plot your measurements on Figure 2-5. Refer to Figure 2-4 for the details of the elements to plot.
Figure 2-5. Plot of the measurements.
REVERSE INDICATOR METHOD

10. Measure the heights $H_3$ and $H_4$, and convert them in shim thickness.

   Shim thickness $H_3$: _____
   Shim thickness $H_4$: _____

11. Install the shims.

12. Repeat the procedure until the vertical parallel misalignment is less than 0.002 in.

Horizontal Alignment

13. Record the following parameters:

   Horizontal TIR$_{\text{indicator 1}}$: _____
   Horizontal TIR$_{\text{indicator 2}}$: _____

   Note: Make sure you keep the sign of your readings.

   $H_{m, \text{indicator 1}}$: _____

   Note: Notice the minus sign in the calculation of the $H_{m, \text{indicator 1}}$.

   $H_{m, \text{indicator 2}}$: _____


15. Repeat the procedure until the horizontal misalignment is less than 0.002 in.

16. Complete the coupling assembly.

17. Ask the instructor to check your work.

Name: ___________________________________________ Date: __________

Instructor's approval: ___________________________________________
Other Sample

Extracted from

Alignment and Couplings
Post-Test

1. What is the most precise shaft alignment method?
   a. Dial indicator method
   b. Reverse indicator method
   c. Straightedge and feeler gauge method
   d. Coupling method

2. Which of the following couplings does not require lubrication?
   a. Chain coupling
   b. Grid coupling
   c. Gear coupling with a steel sleeve
   d. Flange coupling

3. Which of the following alignment procedures involves the installation of shims?
   a. Horizontal angular alignment
   b. Horizontal parallel alignment
   c. Vertical parallel alignment
   d. Gap adjustment

4. What is the Total Indicator Reading?
   a. The sum of measurements taken 180° apart
   b. The difference between measurements taken 180° apart
   c. The difference between measurements taken 90° apart
   d. None of the above

5. The misalignment is one half of the Total Indicator Reading when the measurements are taken
   a. on the rim of the coupling hub.
   b. on the face of the coupling hub.
   c. on the rim and the face of the coupling hub.
   d. at the 12 o'clock and 6 o'clock positions only.

6. Which of the following couplings can have their connecting component (between the hubs) replaced without disturbing the shaft alignment?
   a. Chain couplings and universal joints
   b. Gear and flexible sleeve couplings
   c. Grid and flange couplings
   d. Chain and grid couplings
7. What should be the angle between the probe of the dial indicator and the surface when taking measurements on the coupling hubs?
   a. 60°
   b. 90°
   c. 45°
   d. 15°

8. Which of the following couplings allows no room for misalignment?
   a. Flange coupling
   b. Grid coupling
   c. Chain coupling
   d. Flexible sleeve coupling

9. Single universal joints can accommodate
   a. parallel misalignment only.
   b. angular misalignment only.
   c. angular and parallel misalignment.
   d. vertical angular misalignment only.

10. Which of the following lubricants would be most appropriate for a gear coupling having a steel sleeve, if it is installed on shafts rotating at a very high speed?
    a. SAE grade 30 oil
    b. NLGI grade 1 grease
    c. NLGI grade 2 grease
    d. SAE grade 20 oil