TURBO
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TURBO COMPONENTS & ENGINEERING

INSTALLATION MANUAL

FOR TCE TILTING PAD

JOURNAL & THRUST BEARINGS

REVISION II 1/14/99

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INTRODUCTION

This manual covers the basic installation of TCE tilting pad journal and thrust bearings. Should any questions arise, please contact TCE Engineering at (713) 943-9100.

The first step is to obtain a copy of the bearing assembly drawing. Review the drawing and keep it handy for future reference.

TCE ball and socket tilt pad bearings utilize a spherical support at the pad pivot point. This provides a reduction in the contact stresses between the pad and shell as compared to the standard line or point contact design of support. The ball and socket designed pad is free to pivot in all directions for superior alignment and load carrying capability.

Standard maintenance procedures for journal and thrust bearing installation are applicable with the TCE design. All TCE bearings are inspected and set at the factory prior to shipment. **DISASSEMBLY OF THE BEARINGS SHOULD NOT BE ATTEMPTED IN THE FIELD.** Contact TCE Engineering if a problem is found with the assemblies.

SECTION I – PRE-INSTALLATION INSPECTION

Once the bearing has been removed from the storage package, inspect the bearing for cleanliness. If the bearing has been coated with a light preservative, spray the assembly with solvent and dry. Make sure that all the oil supply passages are blown clean with compressed air.

Select a work area free from debris and lay the bearing flat on a table. The bearing assembly should always be placed on a clean towel or a piece of cardboard to protect surface finishes.

1. Check each pad for freedom of movement. If binding is experienced with any one of the pads, check for the cause of the restriction. Primary causes of limited pad movement are binding pad temperature instrumentation leads and debris behind the pad.

2. Inspect all oil supply holes for restrictions. Orificed inlet holes are located between journal pads, and nozzle blocks are located between thrust pads. Make sure that all oil passages supplying these orifices and nozzles are free of obstruction.

3. Inspect the ball support screws and nozzle screws for tightness.

4. Once the bearing has been inspected and is ready for installation, apply a light coat of metal preservative.

SECTION II – TILTING PAD JOURNAL BEARING INSTALLATION

1. Prior to installation of the bearing assembly, inspect the bearing cavity and cover for cleanliness. Remove any debris or dirt from the journal area, the bearing fit and the oil sump areas of the bearing case. The rotor should be held in place by an overhead hand hoist.

2. Mic the journal areas. Check for tapers and/or out of roundness of the journal.

3. Coat the journal and the bearing fit in the lower half of the case with oil.

4. Place the lower half of the bearing shell on top of the journal. Check alignment of the oil supply hole in the case with the position of the oil supply in the bearing shell.

5. Align the bearing fit in the case with the shell O.D. and roll the bearing into the lower half of the case. It may be necessary to lift the rotor slightly to allow the bearing shell to roll in easily. Monitor the position of the temperature sensor lead wires when rolling in the bearing to ensure that the wire is not crimped or twisted.

6. With the bearing in the lower half of the bearing case, use a rubber head mallet to align the bearing shell split with the housing split. Both sides of the bearing should align flat with the case. Once the bearing to case split lines are correct, lower the shaft onto the bearing.

7. Verify that the anti-rotation dowel locations in the bearing are aligned with the dowel locations in the case. Gently lower the top half of the bearing onto the lower half. Check for any stand off between the two bearing halves. Do not attempt to tighten the split line bolts if the two halves are not flush. Check for the cause of the standoff and correct.

8. Install the bearing split line bolts and tighten securely.

9. It is recommended that a crush check be done to verify a proper bearing to case fit.

   a. Place shims along the case split line on either side of each bolt location. Note the shim thickness (T_s).

   b. Lay a strip of plastigage or lead wire parallel to the axis of the machine on the top of the bearing shell. The standard design specification for the bearing shell crush is metal to metal to .002" interference. The plastigage should be chosen such that the thickness of the shims at the case split line falls in the middle of the plastigage range.

   c. Install the bearing cap or strap and tighten all split line bolts.

   d. After the bearing cap has been seated, remove the cap and inspect the plastigage or lead wire. It should indicate a thickness (T_f) equal to or less than the shim thickness used at the split line (T_s). The amount of interference (crush) is equal to the difference between the indicated clearance (T_f) and the shim thickness (T_s).

$$\text{Crush} = T_s - T_f$$

   A negative crush indicates a loose bearing and the problem should be rectified before proceeding.

10. Once the proper crush is confirmed, the bearing clearance should be checked. It is recommended that two separate checks be performed to assure the proper installation of the bearing. The first check (Step 10) with the bearing case cap and/or strongback off, will confirm the free clearance of the bearing with no external affects (such as bearing case seals, crush etc.). The second check (Step 11) is with the bearing case cap and/or strongback installed and tightened down to account for the crush effect on the bearing clearance.

   a. Place the base of two dial indicators on a portion of the machine unaffected by rotor or bearing movement, such as the bearing case horizontal joint.

   b. Place one of the indicator's styluses on top of the shaft as near the bearing as possible. It is important that this stylus be located at the top dead center of the shaft to get an accurate reading.

   c. Place the other indicator's stylus on top of the bearing shell.

   d. Slowly lift the rotor noting the shaft rise on the appropriate indicator. Be careful not to raise the rotor to an internal obstruction. Do not lift the rotor more than twice the set clearance.

   e. Observe the indicator on the bearing. Once the bearing starts to rise, stop lifting the shaft.

   f. The lift is the difference between the two indicator readings. Note that the lift with tilt pad bearings will always be more than the bearing set clearance due to shaft movement between pads. See Appendix A for a discussion on lift check readings with tilting pad journal bearings. If you are unsure about what an acceptable lift value is, contact TCE Engineering.

11. This check will account for the effect that the crush has in reducing the bearing clearance.

   a. Install the bearing cap or strap and tighten all split line bolts.

   b. Place an indicator on top of the shaft near the bearing and another on top of the bearing case strap or cap.

   c. Slowly lift the rotor noting the shaft rise on the appropriate indicator. Be careful not to raise the rotor to an internal obstruction.

   d. When the rotor stops rising or when the indicator on the cap indicates movement, do not lift the rotor any further.

   e. **NOTE:** Be extremely careful not to overload the bearing or shaft by excessively loading the hoist.

7. With the collar seated against the active thrust bearing, measure and record the distance between the back of the inactive side cavity and the thrust collar face with a telescoping gauge and/or micrometer.

8. Refer to the manufacturer's manual for the required axial float, or use the value noted on the assembly drawing, or contact TCE Engineering for a proper float value.

9. The final thickness of the inactive bearing should be equal to the distance measured in Step 7, less the required float. Subtract required thickness from the actual thickness of the inactive thrust bearing. The difference is the amount of material that must be added or removed at the inactive thrust shim.

10. Adjust the inactive thrust shim and reinstall the bearing. With the collar against the active thrust bearing, the indicator should read zero. When the collar is seated against the inactive bearing, the indicator should read the required float value. Bump two more times to ensure position of float is correct.

11. Install the upper cap of the thrust bearing housing. Make sure that all thermocouple or RTD wires are properly routed and will not be pinched when the cap is lowered.

12. Securely bolt the two housing halves together.

13. Recheck the rotor float and running position.

SECTION IV – FINAL INSTALLATION ITEMS

1. Check all oil supply and drain lines for possible obstructions.

2. Proceed with installation of outer bearing covers, thermometers and oil supply and drain pipe work.

3. Instrument personnel may now proceed with installation and hook up of axial position probes, radial probes, and RTDs or thermocouples.

4. Circulate oil and check drain flow if possible. Check for oil leaks.

5. Proceed with start up.

SECTION V – SPECIAL INSTRUCTIONS FOR DISASSEMBLY OF TILTING PAD JOURNAL BEARINGS

If it is necessary to disassemble the journal bearing, certain precautions must be taken to ensure that the bore of the bearing is correct on reassembly.

12. After the clearance has been checked, install the bearing cap and tighten the split line bolts on the bearing.

13. On a combination thrust/journal bearing, remove the bearing shell top half. Use a telescoping gauge or ID micrometer and take several readings between the thrust collar and the thrust seat area on both sides of the bearing. There should be no more than .001" to .002" run out. Use a rubber head mallet to square spherically seated bearings, if required.

14. Once the bearing has been squared, install the active and inactive thrust bearings.

15. After the thrust bearings have been installed, replace the top half of the bearing and secure the bearing split line bolts. Install strongback or top half of bearing bracket and secure with split line bolts.

16. Proceed with the axial float adjustment of the machine as recommended by the manufacturer.

SECTION III – TILTING PAD THRUST BEARING INSTALLATION

1. Choose a clean, smooth, hard working surface (preferably a surface plate). Be careful not to damage the babbitted surfaces. Lay the active and inactive thrust bearings face down and measure the thickness of each bearing assembly. Measure the thickness in several locations and average. Compare the recorded thicknesses with the assembly drawings.

2. Place an indicator on the shaft in a location that will not interfere with the bearing installation.

3. Position the rotor at the manufacturer's recommended running position. Once the rotor has been positioned, zero the indicator.

4. Bump the rotor toward the inactive side and install first, the lower half and then the upper half of the active thrust bearing. Take care throughout the installation not to pinch or crush any thermocouple or RTD wires. Support the back side of the active thrust bearing. Equalized bearings require 360° support for accurate measurements. Gently push the rotor toward the active thrust bearing until the thrust collar is seated hard against the bearing. Check for freedom of movement of the thrust pads in the bearing upper half. If the pads are free to move, the collar is not fully seated against the bearing.

5. Once the collar is firmly seated, record the value on the rotor position dial indicator. This value is the amount of material that must be removed or added to the active thrust bearing to bring the rotor back to the zeroed position. Make the required adjustments to the active thrust bearing shim.

6. After the active shim has been adjusted, repeat Steps 4 and 5. The indicator should now read within one or two thousandths of zero when the collar is seated firmly against the bearing.

The clearance bore on the ball and socket tilt pad journal bearing is set at the factory. The shim behind each half ball support in the bearing shell is individually adjusted to set the bearing clearance bore. The radial thickness from the pad face to the shell O.D. is within .0005" at each pad location. Likewise, the pads and ball supports are manufactured as a matched set in order to maintain a .0005" tolerance on the stack height of each pad and ball assembly. It is therefore important that each pad and ball support assembly be kept together as a set.

1. Choose a work area that is free from debris with adequate space to lay out parts. Lay the bearing flat on a clean towel or piece of cardboard to protect surface finishes.

2. Split the bearing by removing the split line bolts.

3. One face of the bearing shell will be stamped with letters or numbers to indicate each pad location. Lay the bearing halves so that this numbered face is up.

4. The pads are held in place by the end seals. Remove the seal retention bolts and roll the end seal out of the bearing shell. The end seals are match marked at their split lines. Keep each end seal with its matched pair.

5. Beginning at pad location #1 (or A), remove each pad from the housing. The pads will be stamped with the corresponding location number. Place the pads face down on a piece of clean cloth to protect the babbitt surface.

6. If it is required to remove the balls from the housing, be careful to **ENSURE THAT THE PADS AND BALLS ARE KEPT AS MATCHED SETS**. The balls are retained by a single bolt accessible from the shell O.D. When a ball is removed, place it in the spherical seat of the pad it was installed with. Note that the shims are staked into the spotfaces in the bearing shell. **DO NOT REMOVE THE SHIMS**. The shims are individually ground to set the bearing clearance, they must remain in their respective spotfaces.

7. Clean parts as required.

8. The bearing is assembled in reverse order. Be sure that the number stamped on each pad corresponds to the location marked on the bearing shell during assembly. Before installing a shim, check the thickness against that recorded during disassembly for that location.

9. With the pads in place, roll the end seal into the shell. Install the seal retention bolts, but do not tighten completely. Assemble the two bearing halves and tighten the split line bolts. Once the bearing has been assembled, tighten the oil seal retention bolts.

SECTION VI – SPECIAL INSTRUCTIONS FOR DISASSEMBLY OF TILTING PAD THRUST BEARINGS

1. If it is necessary to disassemble the thrust bearings for repair, refer to the appropriate drawings for the specific number, location and sizing of all bolting.

2. Choose a clean work area and cover with clean cloth. Place the two thrust bearing halves face down on the table and remove the backing shim. Always take care when handling thermocouple wires to avoid breakage.

3. Remove the nozzle retention bolts from the back of the retainer in one bearing half. Once all the bolts have been removed, insert an Allen wrench in each of the bolt holes and knock the nozzles free from the nozzle positioning slot in the retainer.

4. Once all the nozzles are loose, lift the retainer leaving the nozzles, pads and links on the table. Repeat for the other bearing half.

5. Clean and inspect all the wear parts and replace if required.

6. Place the retainers on the table with the shim side down. Assemble the bearing in the following order:

    a. Install the hardened link support plates.

    b. Install the lower leveling links.

    c. Install the upper leveling links.

    d. Install the thrust pads.

    e. Install the nozzle blocks. Make sure that all the nozzles have been blown free of any debris before installation.

    f. Slide the bearing to the edge of the work table so that one of the nozzle retention holes is accessible from below and install the retention bolts.

    g. Repeat Step e. for each of the nozzle blocks.

    h. Once all the nozzle retention bolts are in place, turn the bearing over and snug in all the bolts.

    i. Check to ensure that the nozzle blocks do not stick out past the retainer O.D.

7. Once the bearing halves have been assembled, slide the two halves together and check the assembly for freedom of movement. This is done by alternately applying pressure to the faces of two adjacent pads to verify that the pads and links do not bind. This procedure should be repeated at all pad locations.

8. Install the backing shim. Turn the bearing face down on the work table and verify the assembled stack height of the bearing.

7. The bearing is now ready for installation.

Should you have any questions or need additional information, please feel free to contact TCE Engineering at (713) 943-9100.

APPENDIX A

NOTES ON LIFT/BUMP CHECK VALUES FOR TILTING PAD JOURNAL BEARINGS

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LIFT CHECK CALCULATIONS FOR TILT PAD JOURNAL BEARINGS

The following table is to be used to determine expected lift or bump check values for tilting pad journal (TPJ) bearings.

Please note the following assumptions:

1. For bearings with an odd number of pads, the weight vector is either directly on a pad or directly between pads.
2. For bearings with an even number of pads, the weight vector is **between** pads. (For load on pad bearings with an even number of pads, the lift/bump value **is** the set clearance.)
3. Any mandrel used to check the set bore will be a shaft sized mandrel.

# of Pads	# to Multiply Lift By	# to Multiply Clearance By
3	.6667	1.5000
4	.7071	1.4142
5	.8944	1.1180
6	.8660	1.1547
7	.9479	1.0550

Examples:

1. 5 Pad TPJ, measured lift of 7.5 mils
   Actual clearance = 7.5 x 0.8944 = 6.7 mils

2. 4 Pad set bore = 6.009 +.001/-.000 Shaft diameter – 6.000 +.000/-.001
   Clearance = 9 to 11 mils

   9.0 x 1.4142 = 12.7
   11.0 x 1.4142 – 15.6

   Acceptable lift = 12.7 to 15.6 mils

3. 6 Pad LOP bearing lift = 6 mils, therefore actual clearance = 6 mils since the lift is going from on pad to on pad.

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FIELD LIFT CHECKS TO VERIFY BEARING SET BORES

Bearing set bores are inspected in our shop by verifying the stack height dimensions and by performing bump checks on a shaft sized mandrel. It is important to realize that these two procedures are totally independent of each other and have correlated very well, as expected. Both methods are accurate and accepted means of checking the set bore of a tilting pad journal bearing.

Lift checks in the field are not accurate. The reasons for this are many and I would like to take this opportunity to address a few. The field lift check is only meant to catch obvious problems as may be encountered with excessive bearing crush or lack of crush, errors in shaft diameter or errors with the expected set clearance. The field lift check, by design, can only be expected to catch gross, potentially dangerous, clearance problems. It is not meant to be a third check of the set bore to verify that it is within specification.

There are many factors in the field that will lead to erroneous readings. Some of these are listed below:

1. With the exception of bearings that have an even number of pads and the load is between pads, the rotor will, upon lifting, move both vertically, as expected, **and** horizontally. If the indicator reading the shaft lift is not exactly on the top dead center of the shaft, or is not perpendicular to the shaft, it may pick up the horizontal movement, resulting in an apparent excessive lift. This will also occur if the shaft is not lifted straight up, but is also moved horizontally.

2. The stiffness of the structure supporting the bearing and rotor can also come into play. For example, if the support stiffness is 5 million lbs/in (a typical value for an industrial turbomachine) and the supported weight is 5000 lbs, the support will deflect .001 inches. This will manifest itself in excessive readings if care is not taken to account for this affect. This problem can be magnified significantly if the support has a "soft foot" condition.

3. Temperature effects can also contribute to inaccurate lift readings. For instance, a 5 inch shaft in a refrigeration compressor may be 65°F cooler than when the bearing was set. This will increase the lift by .002 inches if it is not correctly accounted for.

4. Accuracy of instrumentation will, or course, influence the outcome of a lift check. A sticking indicator will give erroneous readings both over and under predicting the actual measurement. Uncalibrated indicators may also yield inaccurate results. It must be kept in mind that these delicate instruments are being used on a compressor deck while the TCE units are used in a clean, climate controlled environment.

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5. Placement of indicators can also contribute to errors in lift measurement. Indicators located away from the bearing centerline will give biased readings due to the angle the shaft takes when it pivots on the other bearing. Also, if the indicator and lifting strap are placed outboard of the bearing, the rotor can be lifted with enough force to bow the shaft resulting in excessive lift values.

These are the most common problems encountered in the field. Most of the above cannot be properly accounted for. As discussed earlier, the actual reason for a lift check is for avoidance of possible gross clearance problems. They are not intended as an inspection of a bearing's conformance to specification.