ELECTRO-MOTIVE

M.I.1765
*Rev. C

MAINTENANCE INSTRUCTION

ALIGNMENT OF ROTATING EQUIPMENT

INTRODUCTION

Machines in a rotating power system generally are connected together by means of direct coupling or a shaft and coupling arrangement. The proper alignment of these interconnected machines is necessary for a number of reasons. In mechanical systems, precise alignment reduces stresses in shafts and couplings thereby minimizing vibration, unequal bearing loads, and the bending of shafts. Electrical rotating equipment, such as motors and generators, also require special consideration because of the critical positioning of the rotor relative to the stator – both axially and radially. Axial positioning is important to avoid rotor thrust loads on the end bearings. Radial positioning or air gap equalization is necessary for the proper interaction of rotor and stator fields which affects the electrical characteristics. This maintenance instruction deals with the alignment of both mechanical and electrical components in rotating power systems.

ALIGNMENT IN GENERAL

Although alignment in a rotating system is usually performed with respect to the coupling surfaces, the real concern is the alignment of the shafts. It is generally more convenient to attach gauges or indicators on a coupling face or on the edge of a flywheel than to position them directly on the machine shaft. This is particularly true when dealing with large machines such as engines, generators, etc., where the main shaft might be physically inaccessible. In a rotating system, a measurement of edge variations on a flywheel or coupling face is related to the orientation of the shaft center with respect to a reference point – the other shaft centerline or some fixed surface such as the generator housing, locomotive deck, etc. In this way indicator readings on the edge of a flywheel or coupling are valid means of determining shaft rotational alignment.

DIMENSIONS

Alignment techniques make use of a specific set of terms that apply when dealing with rotating systems. Fig. 1 illustrates three of the most significant dimensions and an explanation of each is provided.

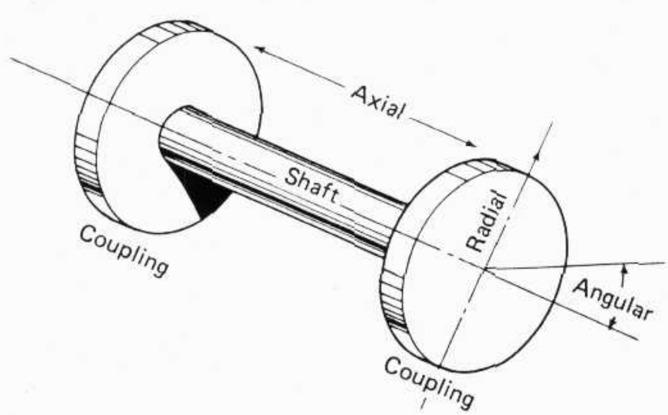

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Fig. 1 - Dimensions Used In Alignment Procedures

RADIAL – This dimension is measured outward from the center of the shaft in a plane perpendicular to the main axis of the shaft. Misalignment in the radial dimension, Fig. 2, means a difference in position of the rotating axis of one shaft from a reference point. Where two shafts are coupled together, the reference point is the center of rotation of one of the shafts.

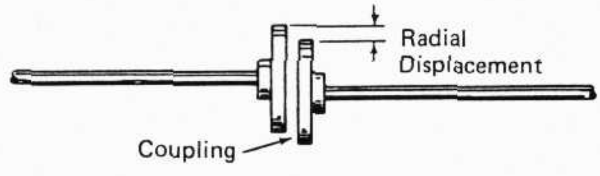

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Fig. 2 - Radial Misalignment

*This bulletin is revised and supersedes previous issues of this number.

AXIAL – This dimension is measured back and forth along the rotating axis of the shaft. Axial misalignment illustrated in Fig. 3, means that the position of the whole shaft must be shifted in the direction of its length. This dimension is usually used in reference to a shaft thrust on an end bearing. The shaft, because of its offset position, causes an axial load on the bearing.

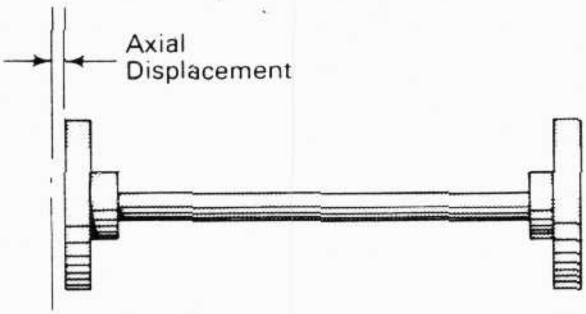


Fig. 3 - Axial Misalignment

ANGULAR – This dimension is measured from a reference axial centerline to the actual shaft or coupling rotational axis. Angular misalignment, Fig. 4, refers to the angle that one shaft makes with another shaft at their coupling interface.

NOTE

Misalignment of shafts may be radial, axial or angular, or a combination of all three dimensions.

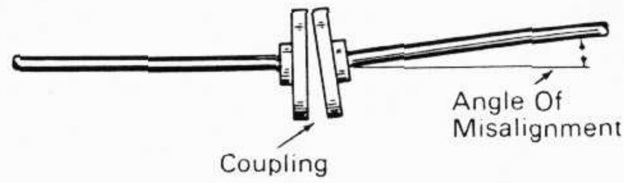


Fig. 4 - Angular Misalignment

INDICATORS

The dial indicator is the most commonly used instrument in rotational alignment work. These instruments are designed to be as versatile as possible so their actual application may require some adaptation. Miscellaneous supports and adapters can be obtained to suit individual requirements. Refer to Fig. 5.

Some dial indicator scales read from 0 up to a number such as 100 and some read plus and minus values on both sides of zero. Refer to Fig. 6.

Dial indicator scales are calibrated to read in thousandths of an inch. The maximum indicator reading refers to the highest reading, plus or *minus, attained while performing the measure*ment. The total indicator reading (T.I.R.) is the whole change in indicator reading disregarding the indicator reference.

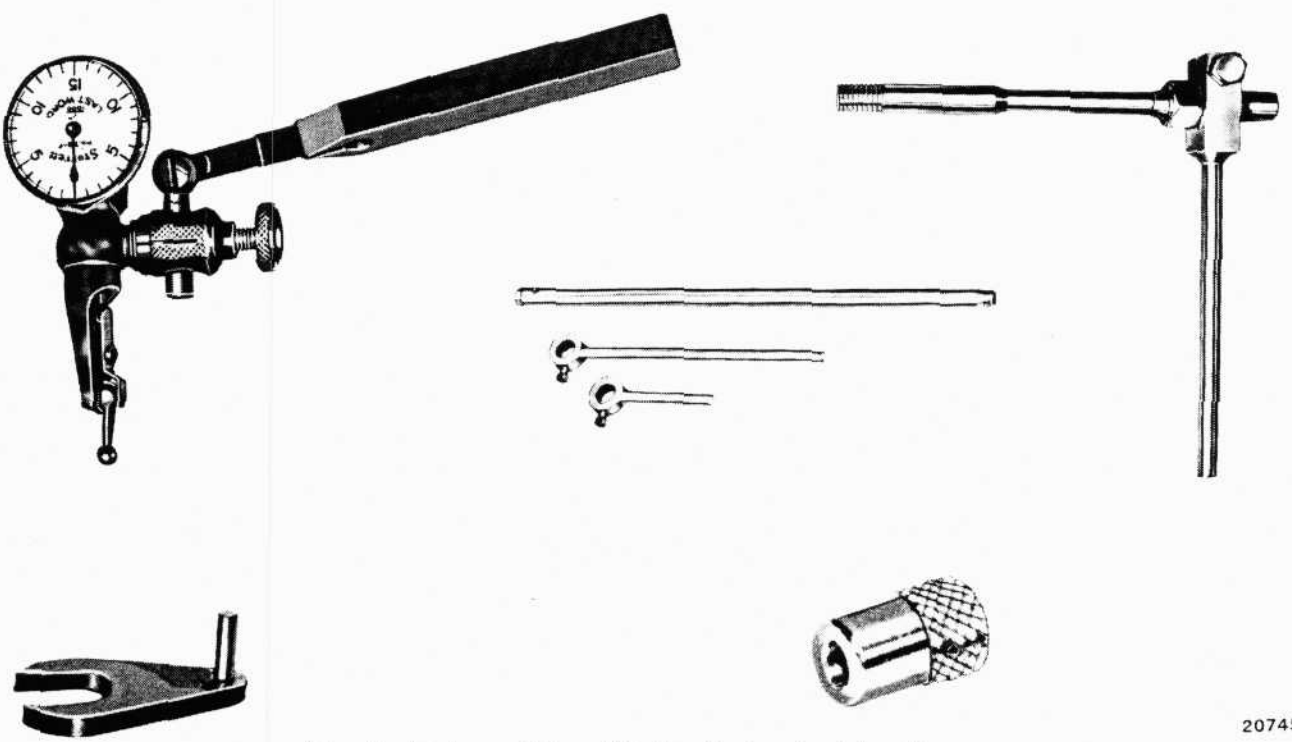


Fig. 5 - Universal Type Dial Indicator And Auxiliary Support Rods, Adapters, And Brackets

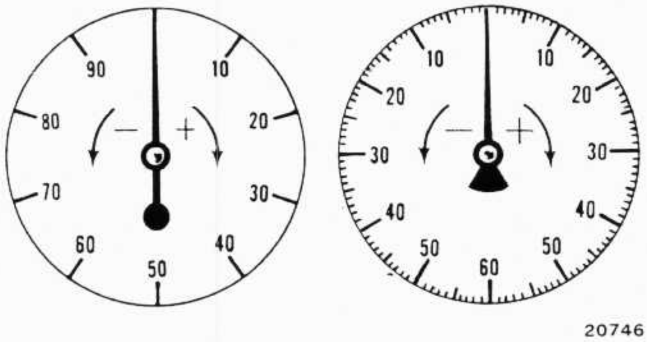


Fig. 6 - Dial Indicator Scales

SHAFT AND COUPLING ALIGNMENT

COUPLINGS

Couplings are used to connect machines to machines, shafts to machines, and shafts to shafts. Coupling faces may be rigidly bolted together or they may have a rubber bushing between them. Variations in coupling face and bushing design allow couplings to have some freedom of movement in the radial and/or angular dimension. In general, where each shaft to be coupled together has more than one bearing, a coupling must be used that will tolerate some angular and radial movement. This is necessary because of the difficulty in obtaining absolute alignment between two shafts carried in separate housings.

A coupling that has no radial flexibility, but some angular flexibility, must be used when coupling one shaft supported by two or more bearings to another shaft with only one support bearing.

NOTE

Even though a particular coupling can withstand some misalignment, the shafts must still be aligned as accurately as possible.

METHODS OF SHAFT ALIGNMENT

There is a variety of ways to check or measure the alignment of two interconnected shafts. Three different methods are listed below and illustrated in Fig. 7, but only the last one, 7C, is recommended.

A. Straight edge and thickness gauge.

B. Dial indicator and micrometer.

C. Two dial indicators (recommended method).

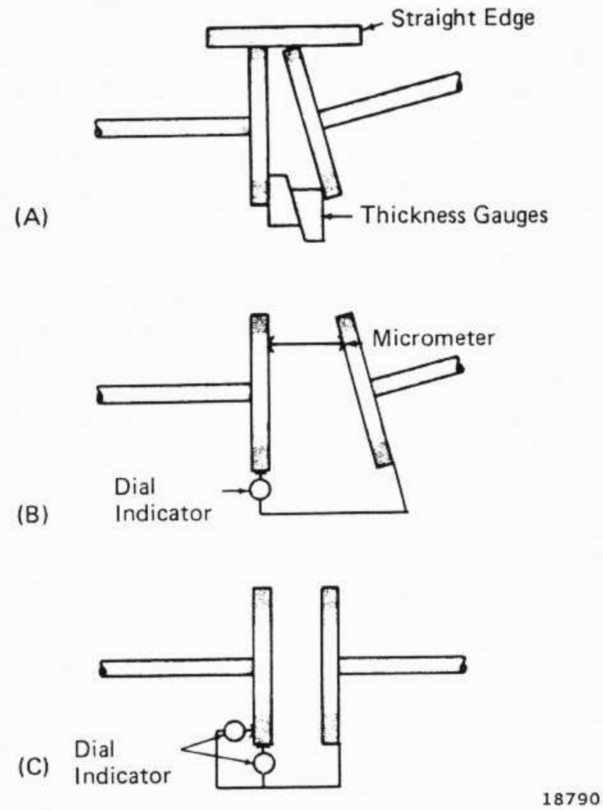


Fig. 7 - Methods Of Checking Shaft Alignment

PROCEDURE

Both halves of the coupling must be bolted together before shaft alignment is performed. Refer to the applicable section of this publication to obtain torque values for a specific coupling.

The recommended method uses two dial indicators rigidly attached to one of the coupling faces (usually on the driving shaft) while measuring the surfaces of the other coupling. The plunger of one indicator is placed parallel to the shaft with its button resting on the coupling face at a distance beyond the coupling bolts, as close to the edge as possible.

This indicator will read the angular misalignment of the coupling. The plunger of the other indicator is located against the edge of the coupling perpendicular to the shaft. This indicator reads the radial misalignment of the coupling.

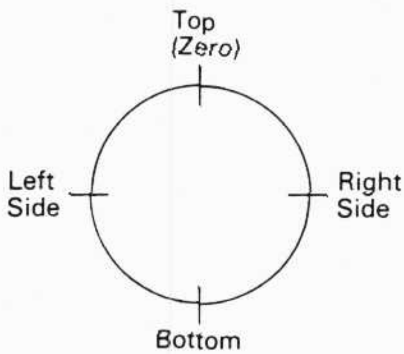
1. Depress indicator plungers about half of their total travel when they are being positioned. This allows the indicators to measure the widest range of plus and minus values.

2. With indicators applied, rotate the shaft until the indicators are brought up to the top vertical position. At this position, set the

movable face of each indicator to zero. This establishes the indicator to a reference setting from which misalignment can be measured.

NOTE

A tabular record of indicator readings should be kept during the alignment procedure, as shown by example in Fig. 8. This method provides a permanent record of maintenance and is recommended when numerous correction steps are anticipated.



COUPLING FACE OF DRIVEN SHAFT
Example

Alignment Correction Step	Measurement	Top	Right Side	Bottom	Left Side
Initial	Angular	.000"	+.003"	-.001"	-.004"
Readings	Radial	.000"	+.005"	.000"	-.005"
Shaft moved	Angular	.000"	-.002"	-.001"	+.001"
left .005"	Radial	.000"	.000"	.000"	.000"
Shaft remote end	Angular	.000"	.000"	-.001"	-.001"
moved left .002"*	Radial	.000"	.000"	.000"	.000"
	Angular				
	Radial				

*Last values recorded above would be considered final. Signature of acceptance applied immediately below these readings would complete a permanent record.

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Fig. 8 - Typical Table Of Indicator Readings

3. Draw a circle and label the top, sides and bottom to graphically reference indicator reading positions to the coupling face of the "driven" shaft. The top or vertical position is designated as the zero reference for the alignment procedure.

4. Draw a line table with one space to record angular measurements and another to record radial measurements at each indicator position during each alignment correction step.

5. Rotate the shaft to obtain indicator measurements at each quarter turn (90°) and record these readings as the initial values in the table.

NOTE

If indicators were to read zero through a full shaft rotation, shaft would be perfectly aligned in the angular dimension. Usually though, there will be some variation (plus or minus value) with each alignment operation. If indicator pointer moves in direction of increasing numbers, then reading is recorded as a plus value. If pointer moves in direction of decreasing numbers, reading is assigned a minus value.

6. When indicators have traveled a full circle around the coupling, both indicators should read zero as they return to their original starting point. If they do not, readings should be discarded and source of error investigated.

   - Indicators may not be firmly mounted allowing slight shift, changing indicator reference.
   - Coupled equipment may have shifted during check.
   - Plunger movements exceeded range of indicator.
   - Indicator may be defective.

   After reason for discrepancy is found and corrected, a new set of indicator readings must be taken. A typical set of alignment readings is shown in Fig. 8.

These readings show a maximum angular misalignment of 0.10 mm (.004") and a maximum radial misalignment of 0.13 mm (.005"). Even though this is within the limits established for this equipment, correction should be attempted to reduce the misalignment as much as possible. The readings in the table example show that in the vertical plane the shaft needs no adjustment – it is not necessary to move the shaft up or down. However, if the shaft is moved a distance of 0.13 mm (.005") horizontally towards the side with the minus 0.13 mm (.005") reading, the total indicator reading for misalignment should be reduced to zero. Although this degree of alignment is desirable, it is rarely attainable in actual practice.

NOTE

The indicators are usually fixed to the "driving" shaft while measuring the "driven" shaft.

Corrections for angular misalignment are made by moving one end of the driven shaft so that its entire rotating axis is parallel to the rotating axis of the driving shaft.

Most alignment situations make it advantageous to correct for radial and angular misalignment simultaneously.

Circumstances may arise where the radial alignment is satisfactory but the angular alignment is in need of correction. This means that the shaft end being aligned is properly located but the remote end of the shaft must be repositioned, as shown in table example.

If the angular alignment is within the specified limits but the radial alignment is incorrect then the shaft should be moved in a direction perpendicular to its rotating axis. It must be moved a distance equal to the highest positive dial indicator readings toward the opposite side of the coupling. The proper distance and direction of movement can be determined through careful interpretation of the readings.

If a piece of equipment is replaced, then the replacement part should be mounted on the original shims as a starting point in the alignment process.

GENERATOR BLOWER/EXCITER ASSEMBLY ALIGNMENT

NOTE

The following alignment procedures also apply to units equipped with an exciter.

Before attempting to align the generator blower, the main generator must be coupled and aligned to the engine.

The alignment of the generator blower to the engine is divided into three operations:

1. Thrust - finding the axial position of the coupling with respect to the drive assembly and the generator blower.
2. Angular - correcting the angularity of the generator blower to the drive assembly.
3. Radial - establish centerline alignment of the generator blower to the drive assembly.

BEARING THRUST ALIGNMENT

There is an alignment procedure for the different types of generator blower drive assemblies. The types are as follows:

1. Generator blower drive assembly applications on blower-type and turbocharged engines not having stamped axial thrust dimensions.
2. Generator blower drive assembly applications on turbocharged engines having a single axial thrust dimension stamped on the drive support housing.
3. Generator blower drive assembly applications on blower-type and turbocharged engines having two axial thrust dimensions stamped on the right side of the drive support housing.

NON-STAMPED DRIVE ASSEMBLY

1. Pull the driving shaft out from engine to take up end play of the drive assembly.
2. Establish the mounting distance between the coupling flange of the drive assembly and the generator blower, Fig. 9. See Service Data, Table I to find the correct distance for each specific coupling assembly.

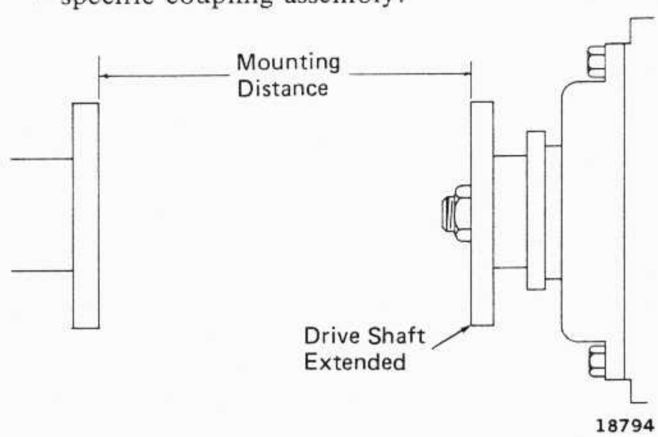


Fig. 9 - Generator Blower Coupling Arrangement

3. Secure generator blower to frame and install couplings. Torque coupling bolts to 136 N·m (100 ft-lbs).

SINGLE-STAMPED DRIVE ASSEMBLY

1. Attach coupling shaft between generator blower and drive assembly. Torque coupling bolts to 136 N·m (100 ft-lbs).
2. Subtract .050" from the number stamped on the support housing and adjust the position of the generator blower to establish this dimension, Fig. 10.

NOTE

Only the decimal portion, following 4, of the entire dimension is stamped on the housing. (Example: 4.260" will be stamped .260".)

3. Secure generator blower to frame and recheck thrust measurement. The final thrust measurement must be .020" to .092" less than the stamped number.

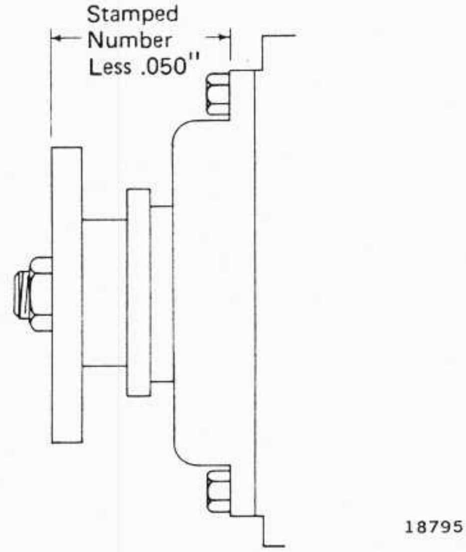


Fig. 10 - Generator Blower Drive Thrust Measurement (Single Stamped)

DOUBLE-STAMPED DRIVE ASSEMBLY

1. Attach coupling shaft to generator blower and drive assembly. Torque coupling bolts to 136 N·m (100 ft-lbs).
2. Adjust position of the generator blower to obtain a thrust clearance midway between the two numbers stamped on the drive housing.

NOTE

The dust shield on the drive assembly has been reversed to position the cupped surface toward the coupling to enable the thrust measurement to be taken with a feeler gauge, Fig. 11.

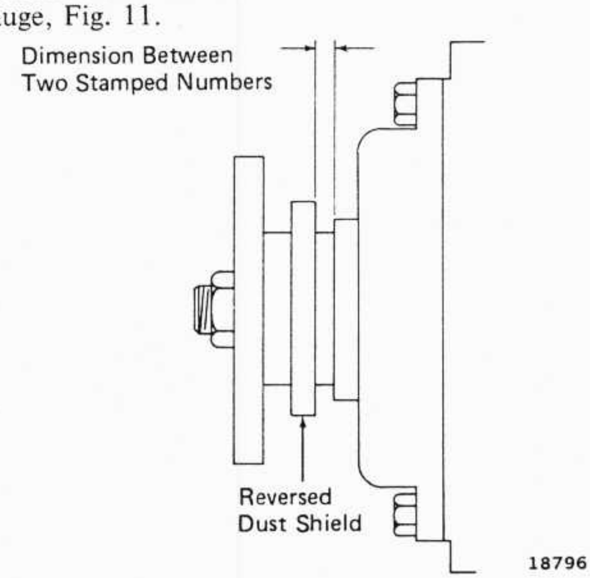


Fig. 11 - Generator Blower Drive Thrust Measurement (Double Stamped)

3. Secure generator blower to frame and recheck thrust measurement. The final thrust measurement must be between the two stamped numbers.

RADIAL AND ANGULAR ALIGNMENT

Radial and angular alignment are interdependent and are determined simultaneously by the use of a dial indicator as shown in Fig. 12. The indicator is attached to a bracket secured to the drive flange with the indicating button contacting the inner face of the inside coupling flange.

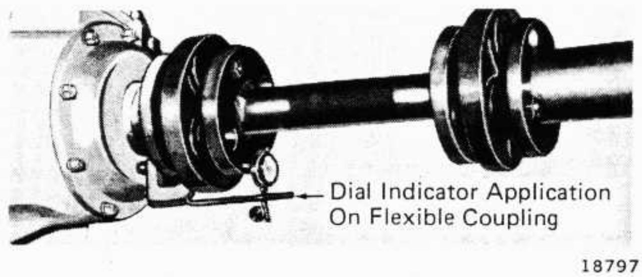


Fig. 12 - Generator Blower Drive Coupling Alignment

Set the dial indicator to zero and rotate the coupling one revolution by turning the engine crankshaft. If the total indicator reading is within 3.81 mm (.150") maximum, the generator is considered aligned.

Since any movement of the generator blower affects alignment-thrust, radial, and angular alignments must be checked after each setting.

RUBBER BUSHINGS

The generator blower couplings do not require any routine maintenance or lubrication. If rubber bushings have torn flanges, excessive stiffness, or cracks, the coupling assembly should be replaced. Do not replace just the rubber bushings.

COOLING FAN AND DRIVE ASSEMBLY ALIGNMENT

After replacement of an engine or cooling fan and drive assembly components, it is necessary to check alignment of the drive train.

Before attempting to check alignment of the cooling fan and drive assembly, remove the V-belts from the drive sheaves by loosening the pillow block mounting bolts from the pedestal and raising the pillow block.

LOWER DRIVE SHAFT ALIGNMENT

Raise the lower pillow block on its mounting bolts, using the pillow block adjusting bolt, until the distance between the mating faces of the flexible coupling is 11.94 mm ± 0.25 mm (.470" ± .010") at the 6 o'clock position. Perform angular alignment as follows:

1. Measure and record the distance between the mating flanges of the flexible coupling at the 3, 6, 9, and 12 o'clock positions.

2. Rotate the shaft 180° and measure again at the same points. All readings must be within .51 mm (.020") of each other.

3. If this alignment cannot be obtained, it may be necessary to add shims behind the pillow block, or to reposition the pedestal.

LOWER DRIVE SHEAVE TO UPPER DRIVE SHEAVE ALIGNMENT

When maintenance requires movement of the lower or upper drive assembly, the lower and upper drive sheaves must be aligned in parallel planes, Fig. 13, to the dimensions specified in the Service Data, Table II. If this alignment cannot be achieved, it may be necessary to reposition the fan pedestal assembly to obtain the proper alignment.

NOTE

For MP45 fan alignment refer to Maintenance Instruction M.I. 1200.

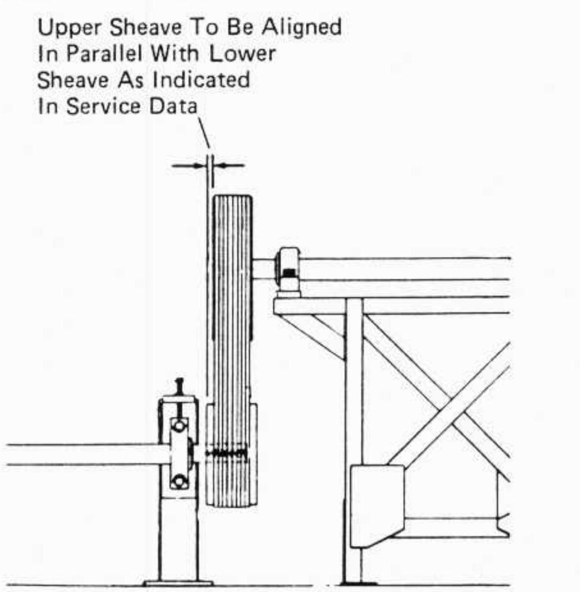


Fig. 13 - Fan Drive Sheave Alignment

RUBBER BUSHING REPLACEMENT

The fan drive flexible coupling does not require any routine maintenance or lubrication. However, it may be necessary or desirable to replace the bonded rubber bushings. The need for replacement is evidenced by accumulations of small rubber particles directly under the coupling.

To facilitate the removal and installation of the rubber bushings, a puller tool may be used. As shown in Fig. 14, the tool parts are used on opposite sides of the coupling for removal and installation of the bushings.

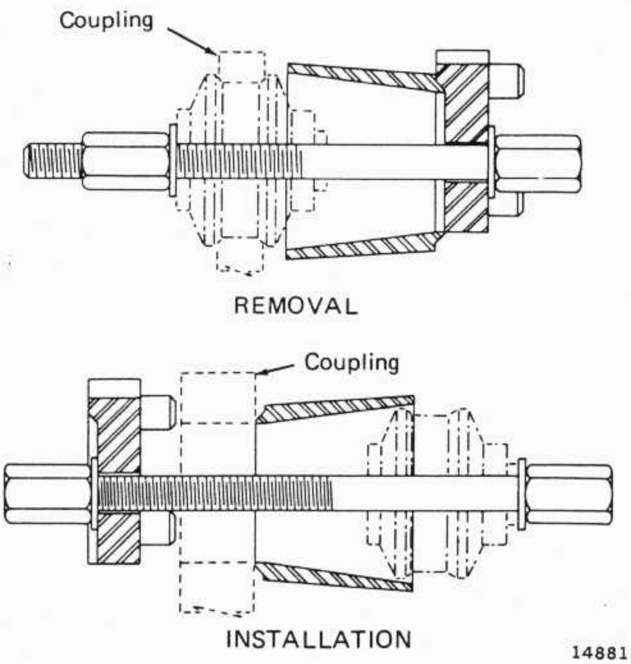


Fig. 14 - Rubber Bushing Joint Puller Tool Application

When installing the rubber joint bushings, a small amount of rubber lubricant should be applied on the leading pressed rubber edge of the bushing. This lubricant is mixed with three to five parts of water before use, and should be stirred occasionally while in use. Other lubricants, which are not detrimental to the rubber bushing, may be used.

NOTE

After bushing installation, it is recommended that at least 24 hours elapse before attaching the coupling. This period is required to allow the rubber lubricant to dry. When the lubricant is still wet, the bushing can easily move from its desired location.

The bushing must be installed past its normal location to properly seat the lips of the bushing. The bushing puller tool must then be reversed and the bushing moved until the 11.94 mm ± 0.25 mm (.470" ± .010") dimension shown in Fig. 15 is obtained, to maintain the bushing faces in the same plane. If a tool is not available, a press may be used.

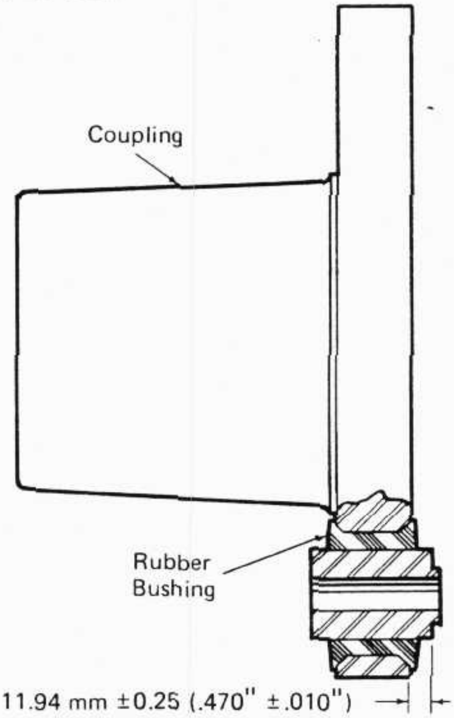


Fig. 15 - Bushing To Coupling Application

A bushing application gauge, Fig. 16, is available to measure the 11.94 mm ± 0.25 mm (.470" ± .010") dimension. This gauge consists of a three-legged base supporting a lever indicating arrangement at its center. To measure the 11.94 mm ± 0.25 mm (.470" ± .010") dimension, the gauge is positioned so its large tripod legs rest on the flange of the coupling and its center actuating disc contacts the metal center sleeve of the bushing, inside the locating prongs. If the bushing is properly located, the pointer of the gauge will be within the limiting scribe marks on the gauge scale.

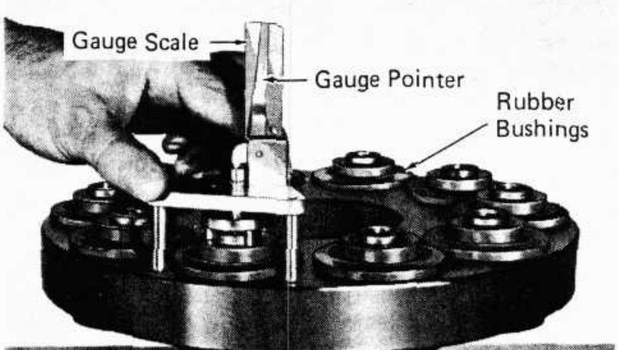


Fig. 16 - Bonded Joint Bushing Application Gauge

A calibration fixture having three calibrating discs 11.68 mm (.460"), 11.94 mm (.470"), and 12.19 mm (.480") is part of this gauge to provide a check on the pointer accuracy. A large disc simulates the coupling and the smaller discs are placed on the large disc. The gauge is placed on this assembly to check the pointer positioning.

GENERATOR TO ENGINE ALIGNMENT

To make the engine and generator revolve true and free from vibration, the alignment through the coupling must be exact. In order that the generator may perform correctly in its electrical phase of operation, the air gap between the main poles and the armature (or rotor) must be held to the correct dimension and be evenly distributed at all poles.

The generator armature (or rotor) is, in effect, the flywheel for the engine and is joined to the engine crankshaft by means of a flexible coupling comprised of an engine coupling disc and a generator coupling disc. Each disc is mounted at its center to its respective part by mounting bolts and both discs are joined at the rim or outer circumference by coupling bolts. The engine coupling disc rim has degree markings around its circumference and holes provided for an engine jack or turning bar for rotating the crankshaft.

All flexible couplings connecting the engine and generator are basically the same. Minor differences in construction are incorporated to provide for specialized applications or increased interchangeability between models.

Current couplings have a "V" channel in the engine coupling disc and a "V" serration in the generator disc. Mounting bolts, both rim and center, have clearance holes at the couplings. This design provides for interchange between earlier units with body bound or reamed fit mounting bolts.

After installation of the generator, the generator coupling disc is mated to the engine coupling disc and rim bolts applied.

1. Check gap between coupling discs at the outer rim to be certain it is equalized around the circumference, then tighten all coupling bolts evenly to avoid cocking the coupling on the serrations.

2. Final torque coupling bolts to 400 N·m (295 ft-lbs). Remove fish paper or fiber shim supports from bottom air gap of the generator at this time.

3. Measure final gap between coupling discs to be sure it is uniform and no less than 0.038 mm (0.0015").

The finished indicator surface on the generator frame (stator housing) and the serrations on the generator coupling are held concentric with the center bore. The entire rotating assembly is balanced about this same center. Therefore, any deviation (runout) detected at the indicator surface is a measure of out of balance. Concentricity is not held at the outside rim of the generator coupling disc.

The alignment of generator with engine is divided into three operations:

1. Thrust - finding the axial position of armature (or rotor) with respect to the generator frame.

2. Angular - correcting the angularity of generator to engine coupling.

3. Radial - balancing and setting the air gap between the generator armature (or rotor) and the field poles.

Angular and radial alignment are carried out simultaneously.

GENERATOR THRUST ALIGNMENT

After the generator is coupled to the engine, generator frame (stator housing) must be located axially to avoid a thrust load on the bearing from either direction. The bearing float (total end play) for each generator is stamped on the bearing housing flange or end housing, depending on the type of generator.

1. Take out all crankshaft thrust at generator end of engine by prying the crankshaft toward the generator. This may be done by removing one oil pan hand hole cover and prying between a crankshaft web and a crankcase "A" frame.

NOTE

To move crankshaft on some 16 and 20 cylinder engines, it may be necessary to rotate engine flywheel slightly with a turning bar while prying crankshaft toward generator.

2. Locate the "X" dimension stamped on the generator with 13 mm (1/2") numbers at the location noted in Service Data, Table III. This measurement was determined during final generator assembly with the armature (rotor) positioned so that end play is taken up in the direction of the engine coupling.

3. Move the generator frame either away from or toward the engine until a measurement is obtained which is the total of the "X" dimension minus (plus on AR5 models) the bearing thrust dimension listed in Table III.

GENERATOR RADIAL AND ANGULAR ALIGNMENT

Proper operation of the power plant requires that both the generator armature (rotor) shaft and the generator frame (stator housing) be in alignment with the engine crankshaft, and that the air gap under each main pole be balanced to obtain proper generator electrical characteristics.

Since the generator has only one roller bearing, radial and angular alignment is determined at the engine end of the generator by using two dial indicators mounted on support rods which are threaded into 1/4" pipe size holes in the coupling adapter, Fig. 17. Both indicators revolve with the coupling adapter. The plunger of one indicator will rest on the back of the coupling disc at or near the outer bolt circle to measure the angular alignment. The plunger of the other indicator will check the radial alignment as it rides on the recessed surface of the generator frame on A20 Models, or on the inside machined diameter of the generator frame pilot on other models.

NOTE

Any guards over generator armature (rotor) must be removed before mounting dial indicators. A special indicator with an offset pickup arm may be required to permit rotation on certain applications.

1. Depress indicator plungers about half of their total travel as they are being positioned. This allows the indicators to measure the widest range of plus and minus values.

2. Using an engine jack or turning bar, rotate engine flywheel until indicator rods are in the top vertical position.

3. Set the movable faces of both indicators to zero. This establishes the indicator to a reference setting from which misalignment can be measured.

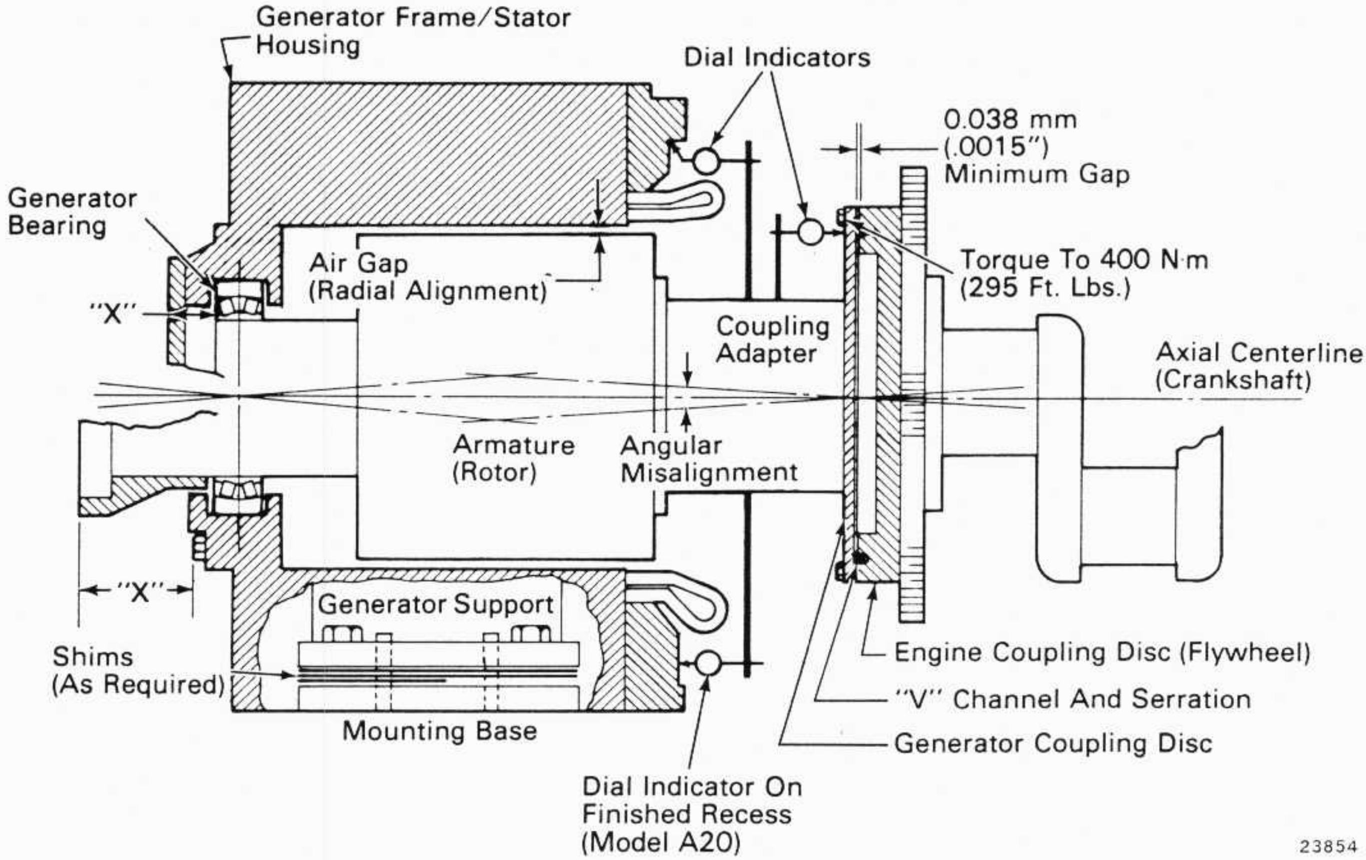


Fig. 17 - Typical Generator Shaft Alignment And Air Gap Equalization

4. Check installation of indicators to see that they are firmly mounted. A light finger tap on the indicators and/or support rods will serve to qualify the zero setting and reveal any lost motion in the indicator linkages.

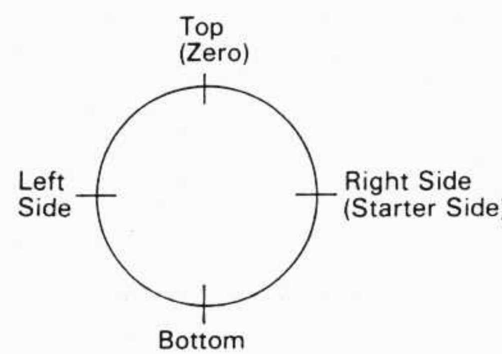
NOTE

A tabular record of indicator readings should be kept during the alignment procedure, as shown by example in Fig. 18. This method provides a permanent record of maintenance and is recommended when numerous correction steps are anticipated.

5. Draw a circle and label the top, sides and bottom to graphically reference the indicator reading positions to the face of the engine coupling disc. The top or vertical position is designated as the zero reference for the alignment procedure.

6. Draw a line table with spaces to record measurements from the indicators at each reading position during each alignment correction step.

7. Rotate engine flywheel in a clockwise direction, when facing engine end of generator. As



ENGINE COUPLING DISC FACE
Example

Alignment Correction Step	Measurement	Top	Right Side	Bottom	Left Side
Initial	Coupling	.000"	+.012"	+.016"	-.004"
Readings	Generator	.000"	+.025"	+.045"	+.020"
.060" full shims	Coupling	.000"	+.004"	+.006"	-.002"
added, both sides	Generator	.000"	+.005"	+.008"	.000"
Generator remote	Coupling	.000"	.000"	+.002"	+.002"
end moved left*	Generator	.000"	+.002"	+.004"	-.002"
	Coupling				
	Generator				

*Last values recorded above would be considered final. Signature of acceptance applied immediately below these readings would complete a permanent record.

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Fig. 18 - Typical Table Of Indicator Readings

indicators revolve, check indicator readings at each quarter turn (90°) and record as the initial values in the table.

NOTE

Readings from indicator on generator frame must be taken from clean areas on the machined surface (free from paint or varnish).

8. When indicators return to their original starting point, they should again register zero. If they do not, readings should be discarded and source of error investigated. Check to be certain indicators are rigidly mounted. Replace indicators if defective. After discrepancy is corrected, a new set of readings must be taken. A typical set of alignment readings is shown in Fig. 18.

These readings show a typical misalignment in both the vertical and horizontal planes at the coupling (angular) and the generator frame (radial). The first sample corrective step shows the addition of shims under generator side supports to improve the alignment in the vertical plane. Due to the interdependence of angular and radial alignment, this step also reflects an alignment change in the horizontal plane. Although the new readings are within the limits established for this equipment, as shown in Fig. 19, the second corrective step shows an attempt to reduce the misalignment as much as possible by moving the generator slightly to one side.

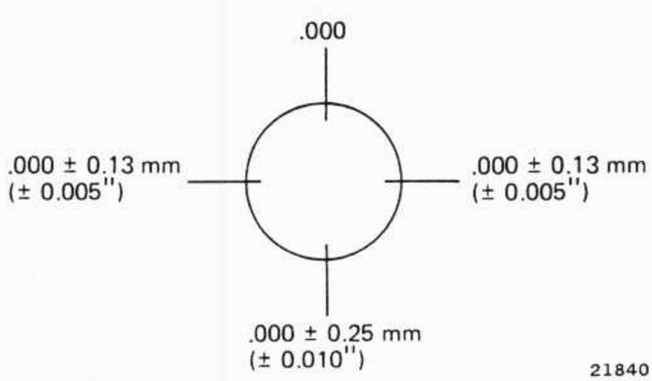


Fig. 19 - Generator Alignment Tolerances

9. With generator hold down bolts removed, install jacking bolts in tapped holes of side supports to raise generator for shim adjustments. A pry bar can be used for any side to side repositioning. Experience will indicate the proper shim thickness and location to produce accurate alignment. Full length shims should be used where possible, although spot shims (half lengths) may be necessary to conform to the limits.

10. Since any movement of the generator frame will affect the coupling and the air gap, readings from both indicators must be taken after each correction step occurs.

11. When indicator readings are within the limits, install and tighten generator hold down bolts. Recheck all alignment readings, including the bearing thrust dimension, to be certain they remain within the limits. If tolerances are satisfactory, generator can be considered aligned.

12. Dowel generator to its mounting base and replace guards over armature (rotor), if so equipped.

NOTE

Generator alignment tolerances given in Fig. 19 are limits established for factory assembled equipment. Accuracy in leveling the power plant during installation can affect alignment enough to put it outside these limits. Therefore, if angular and radial alignment are both within a total indicator reading of 0.76 mm (0.030") after installation, it is not necessary to disturb the alignment. If either reading exceeds this limit, generator should be realigned back to the factory limits.

SYNCHRONOUS GENERATORS WITH SINGLE PEDESTAL BEARING

THRUST

The single bearing is located in a pedestal separate from the end housing of the generator. Because of this, the positioning of the bearing and the relative axial positioning of the stator to the rotor requires two separate operations.

LOCATING THE BEARING IN ITS PEDESTAL

There is a designed total clearance or end play of 4.8 mm (3/16") +0.4 mm (1/64") -0 between the bearing race and its housing. The rotor is properly positioned relative to the bearing assembly when there is a clearance of 3.2 mm (1/8") +0.4 mm (1/64") -0 between the bearing outer race and the housing at the outboard end and at the generator end a 1.6 mm (1/16") clearance.

After the generator disc has been coupled to the engine disc, rim bolts applied and torqued, and rotor free, the rotor is positioned relative to the bearing as follows:

1. Remove an engine oil pan inspection cover. Using a suitable bar, force the engine crankshaft toward the generator to remove crankshaft thrust in this direction.

2. Relieve rotor shaft weight from the bearing pedestal. Without moving the rotor, position the bearing pedestal as far as possible axially toward the engine.

3. Scribe or otherwise mark the rotor shaft where the bearing cap meets the shaft.

4. Then move the bearing pedestal away from the engine until there is a measured distance between the shaft marks and bearing cap of 3.2 mm (1/8") +0.4 mm (1/64") -0. This will provide the bearing clearance dimensions given.

STATOR TO ROTOR POSITIONING

After obtaining the axial position of the rotor with respect to the bearing, the axial positioning of the stator with respect to the rotor must be established. This can be accomplished by moving the stator axially until the rotor poles protrude on both sides an equal distance from the stator laminations and is to be held within ± 3.2 mm (1/8").

When the stator is correctly positioned relative to the rotor, tighten the base bolts in preparation for shaft and air gap alignment.

ANGULAR ALIGNMENT

Generator shaft angularity is checked by using a dial indicator mounted on a support rod which is threaded into a tapped hole in the hub of the rotor shaft. The indicator revolves with the rotor with plunger resting on the inside face of the coupling disc at or near the bolt circle.

1. Depress indicator plunger about half of its total travel as it is being positioned. This allows the indicator to measure the widest range of plus and minus values.

2. Using an engine jack or turning bar, rotate engine flywheel until indicator rod is at the top vertical position.

3. Adjust movable face of indicator to locate pointer to zero. This establishes the indicator to a reference setting from which misalignment can be measured.

4. Check indicator installation to see that it is rigid. A light finger tap on the indicator and/or support rod will serve to qualify the zero setting and reveal any lost motion in the indicator linkage.

NOTE

A tabular record of indicator readings should be kept during the alignment procedure, as previously shown by examples in Fig. 8 and Fig. 18 of this instruction.

5. With indicator set, rotate the engine flywheel one complete revolution. When indicator returns to the original starting point, it should again register zero. If not, further adjustment of indicator mounting is required to correct discrepancy. Replace indicator if defective and recheck zero.

6. Starting again from the top vertical position, rotate flywheel and record indicator readings at each 90° increment. At each reading point, gap between bearing cap labyrinth and the rotor shaft should be measured.

7. Angularity of the generator to engine coupling is neutralized and bearing labyrinth clearances adjusted by shifting the bearing pedestal and/or placing shims under the pedestal, to bring the indicator readings within the limits for these locations, as shown in Fig. 20.

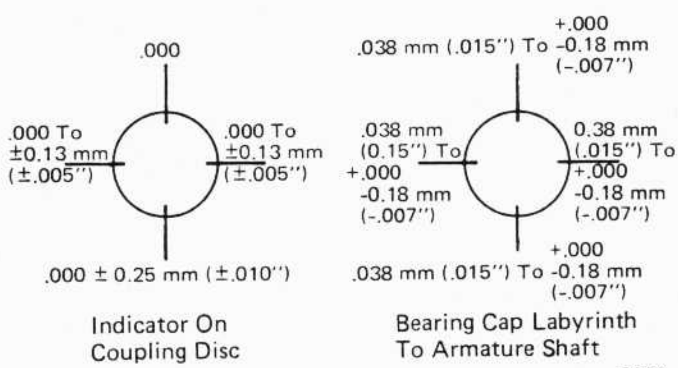


Fig. 20 - Dial Indicator Alignment Tolerances

RADIAL ALIGNMENT

The air gap can only be measured to a close tolerance by removing the paint from the stator and rotor where the measurements are to be taken and it should be done in the following locations:

1. The paint should be removed from the inside diameter of the stator laminations in a patch four inches wide and six inches deep, the depth running from both ends of the stator lamination assembly inward and located on a radial line, Fig. 21, 36° either side of the stator diameter vertical centerline, top and bottom. This will provide eight measurement points on stator.

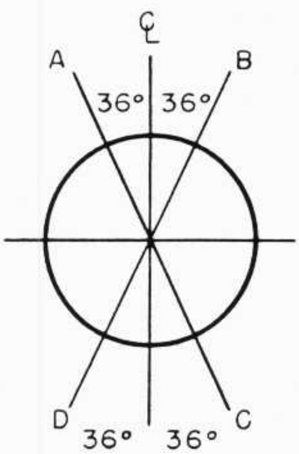


Fig. 21 - Air Gap Measurement Points

2. The paint should be removed from the outside diameter of one pole in a patch three inches wide and six inches deep, the depth starting at both ends of the pole, and the width located symmetrically about radial centerline of pole. This will provide two measurement points on the rotor.

3. After the paint is cleaned off as indicated, number the scraped poles (and the stator frame) with chalk, placing the numbers in a visible position on the slip ring side of the generator so that the pole location, with respect to the stator, is known at all times.

4. The air gap between the rotor and stator should be obtained by placing a feeler gauge between the rotor and stator at the points where the paint has been removed. The feeler gauges must extend to a minimum depth of 4 inches from the outer edge of the pole end piece and the measurements should be taken at both ends of the poles.

5. Clearances for points A, B, C, and D of Fig. 21 are to be held to within 0.25 mm (.010") of each other. The total variation between any of the four readings should not be more than 0.25 mm (.010"). The difference in air gap at either end of the pole piece cannot vary over 0.13 mm (.005").

6. The shaft should be rotated so that the pole which is marked No. 1 will stop at points A, B, C, and D where readings are taken. The necessary adjustments should be made by shifting the stator frame and/or placing shims under the mounting feet to raise it.

7. After final tightening of the generator hold-down bolts, recheck the alignment readings to be sure they have not changed. If tolerances are satisfactory, dowel the generator to its mounting base.

SERVICE DATA

Coupling Assembly Number*	Mounting Distance		Drive Shaft Number	Shaft Dimension Over Drive Faces	
	Inches	Millimetres		Inches	Millimetres
8082348	10.75±0.06	273±1.6	8184471	5.875±.010	149.23±0.2
8144824	24.00±0.06	610±1.6	8184472	19.125±.010	485.78±0.25
8179815	16.31±0.06	414±1.6	8184473	11.437±.010	290.50±0.25
8198385	21.50±0.06	546±1.6	8204546	16.625±.010	422.28±0.25
8203185	30.16±0.06	766±1.6	8203232	25.281±.010	642.14±0.25
8215545	9.00±0.06	229±1.6	8215544	4.125±.010	104.77±0.25
8227098	15.97±0.06	406±1.6	8227021	9.344±.010	237.34±0.25
8227099	14.22±0.06	361±1.6	8227020	11.094±.010	281.79±0.25
8253885	14.75±0.06	375±1.6	8253884	9.870±.010	250.70±0.25
8263653	22.13±0.06	562±1.6	8263652	17.250±.010	438.15±0.25
8268343	19.50±0.06	495±1.6	8268344	14.625±.010	371.48±0.25
8273769	16.56±0.06	421±1.6	8273768	11.687±.010	296.85±0.25
8290092	12.38±0.06	314±1.6	8290091	7.500±.010	190.50±0.25
8318348	21.12±0.06	537±1.6	8318349	16.250±.010	412.75±0.25
8324611	20.66±0.06	525±1.6	8324610	15.781±.010	400.84±0.25
8336942	31.91±0.06	810±1.6	8336941	27.000±.010	685.80±0.25
8337051	13.31±0.06	338±1.6	8337050	8.437±.010	214.30±0.25
8342084	30.53±0.06	775±1.6	8342083	25.656±.010	651.66±0.25
8365007	23.81±0.06	605±1.6	8365012	18.938±.010	481.03±0.25
8368151	27.50±0.06	699±1.6	8368150	22.625±.010	574.67±0.25
8376054	13.75±0.06	349±1.6	8376053	8.870±.010	225.30±0.25
8376234	26.50±0.06	673±1.6	8376233	21.620±.010	549.15±0.25
8420621	32.22±0.06	818±1.6	8420620	27.343±.010	694.51±0.25
8426510	26.84±0.06	682±1.6	8426509	21.969±.010	558.01±0.25
8432314	36.53±0.06	928±1.6	8432313	36.656±.010	931.06±0.25
8449583	14.66±0.06	372±1.6	8449582	9.781±.010	248.44±0.25
8476945	20.53±0.06	521±1.6	8476944	15.625±.010	396.87±0.25
8481592	28.56±0.06	725±1.6	8481591	23.687±.010	601.65±0.25
8484230	27.44±0.06	697±1.6	8484229	22.562±.010	573.07±0.25
8484483	20.38±0.06	518±1.6	8484484	15.500±.010	393.70±0.25
8486494	22.28±0.06	566±1.6	8486493	17.406±.010	442.11±0.25
9093077	12.00±0.06	305±1.6	9093076	7.120±.010	180.85±0.25
9097499	12.22±0.06	310±1.6	9097500	7.340±.010	186.44±0.25
9506637	35.75±0.06	908±1.6	9506636	30.875±.010	784.22±0.25
9509580	14.50±0.06	368±1.6	9509579	9.620±.010	244.34±0.25

*Shown on power plant equipped mounting assembly drawing supplied to customer.

TABLE I – BLOWER/EXCITER DRIVE COUPLING FLANGE DISTANCES

Cooling Fan/Drive Assembly	Parallel Plane Distance
Lower Sheave (8444353) Plane To Upper Sheave Plane (MP45)	23.47 mm ± 0.51 mm (.924" ± .020")
Lower Sheave (8394106) Plane To Upper Sheave Plane (MP45)	2.03 mm ± 0.51 mm (.080" ± .020")
Lower Sheave Plane To Upper Sheave Plane (MP36)	Within 0.76 mm (.030")

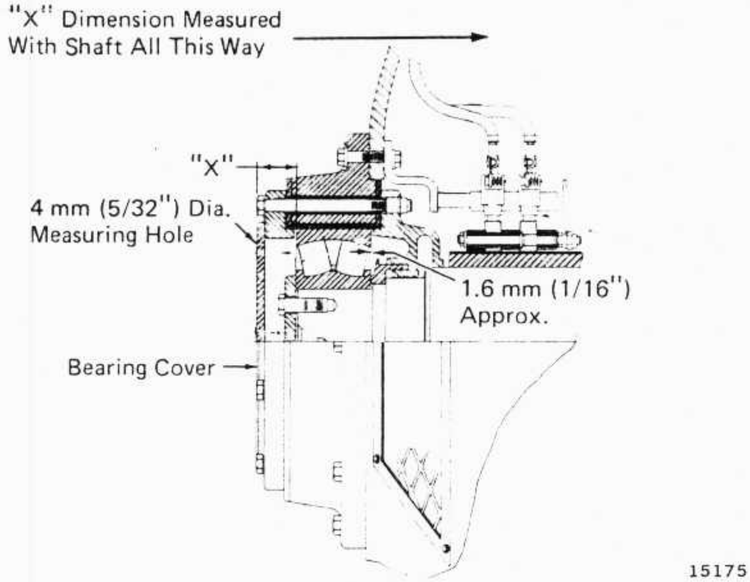
TABLE II – COOLING FAN/DRIVE ASSEMBLY SHEAVE PARALLEL PLANE DISTANCES

Generator	"X"* Dim.	"X" Measured From	"X" Dim. Location	Bearing Thrust Dim.	Bearing End Movement
A5A	38 mm (1-1/2")	Bearing Cover Face To Bearing Outer Race	Bearing Housing Mounting Flange	1.6 mm $^{+0\ mm}_{-0.4\ mm}$ (1/16" $^{+0"}_{-1/64"}$)	6 mm ± 0.8 mm (15/64" ± 1/32")
A7	48 mm (1-7/8")	Bearing Cover Face To Bearing Outer Race	Bearing Housing Mounting Flange	1.6 mm $^{+0\ mm}_{-0.4\ mm}$ (1/16" $^{+0"}_{-1/64"}$)	6.7 mm $^{+0.8\ mm}_{-0.4\ mm}$ (17/64" $^{+1/32"}_{-1/64"}$)
A11	48 mm (1-7/8")	Bearing Cover Face To Bearing Outer Race	Bearing Housing Mounting Flange	1.6 mm $^{+0\ mm}_{-0.4\ mm}$ (1/16" $^{+0"}_{-1/64"}$)	6.7 mm $^{+0.8\ mm}_{-0.4\ mm}$ (17/64" $^{+1/32"}_{-1/64"}$)
A15	48 mm (1-7/8")	Bearing Cover Face To Bearing Outer Race	Bearing Housing Mounting Flange	1.6 mm $^{+0\ mm}_{-0.4\ mm}$ (1/16" $^{+0"}_{-1/64"}$)	6.7 mm $^{+0.8\ mm}_{-0.4\ mm}$ (17/64" $^{+1/32"}_{-1/64"}$)
A20	48 mm (1-7/8")	Bearing Cover Face To Bearing Outer Race	Bearing Housing Mounting Flange	1.6 mm $^{+0\ mm}_{-0.4\ mm}$ (1/16" $^{+0"}_{-1/64"}$)	6.7 mm $^{+0.8\ mm}_{-0.4\ mm}$ (17/64" $^{+1/32"}_{-1/64"}$)
AB20	50 mm (1-31/32")	Bearing Cover Face To Bearing Outer Race	Bearing Housing Mounting Flange	3.2 mm ± 0.8 mm (1/8" ± 1/32")	9.5 mm ± 0.8 mm (3/8" ± 1/32")
A33	50 mm (1-31/32")	Bearing Cover Face To Bearing Outer Race	Bearing Housing Mounting Flange	3.2 mm ± 0.8 mm (1/8" ± 1/32")	9.5 mm ± 0.8 mm (3/8" ± 1/32")
AR5	298 mm (11-3/4")	Bearing housing bolt head at 1 o'clock position to outer face surface of collector ring assembly.	End Housing	3.2 mm $^{+0\ mm}_{-0.8\ mm}$ (1/8" $^{+0"}_{-1/32"}$)	9.5 mm ± 0.4 mm (3/8" ± 1/64")

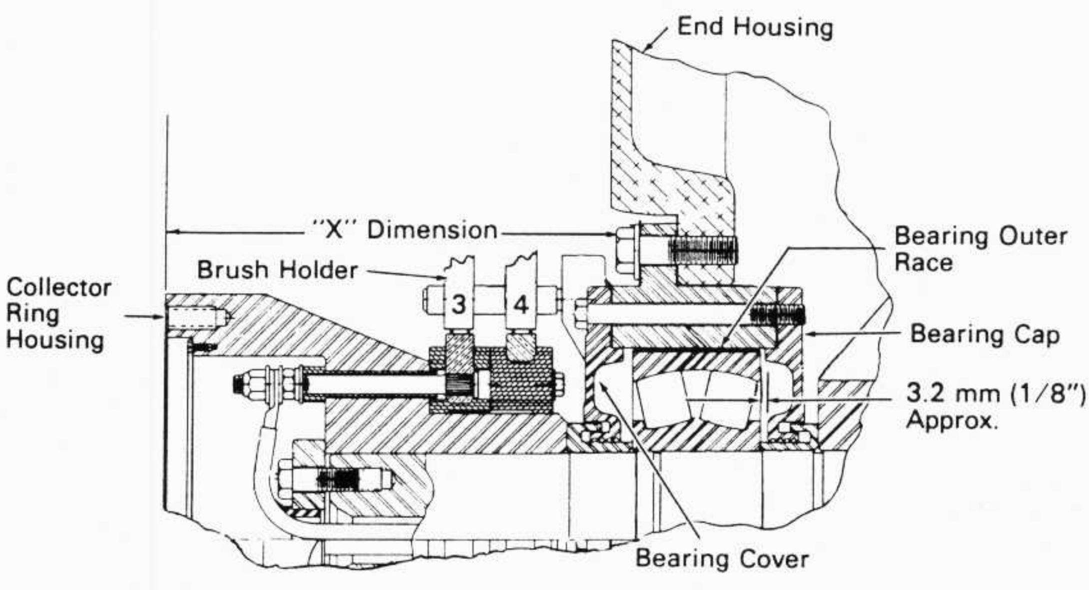
* "X" dimension listed is approximate -- included for reference only.

TABLE III – ALIGNMENT DATA

SERVICE DATA (CONT'D)



A5A, A7, A11. A15, A20, AB20, And A33



NOTE: "X" Dimension Measured With Shaft All This Way. →

23798

AR5

Fig. 22 - Thrust Alignment Cross Sections

EQUIPMENT LIST

	Part No.
Bushing puller tool	8239562
Rubber lubricant	8251651
Bushing application gauge	8254465
Gauge set, master (base plate and 11.68 mm (.460"), 11.94 mm (.470") and 12.19 mm (.480") pointer calibration discs	8254466
Dial indicator	8255423
Dial indicator (low profile)	8460472
Support Rod	8122000

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