ELECTRO-MOTIVE

MAINTENANCE INSTRUCTION

M.I. 1753
*Rev. E

ALIGNMENT OF LOCOMOTIVE ROTATING EQUIPMENT

INTRODUCTION

Machines in a rotating power system, such as a diesel-electric locomotive, 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 effects the electrical characteristics. This maintenance instruction deals with the alignment of both mechanical and electrical components in locomotive 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 machine such as engines, traction 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 or locomotive deck. 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.

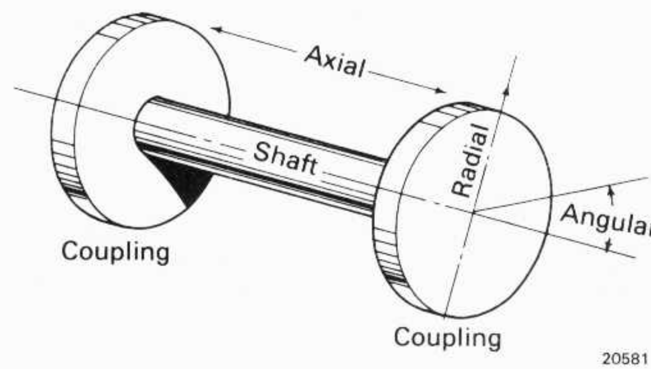

Fig.1 – Dimensions Used In Alignment Procedures

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.

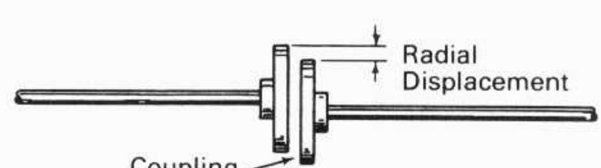

Fig.2 – Radial Misalignment

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

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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 shaft thrust on an end bearing. The shaft, because of its offset position, causes an axial load on the bearing.

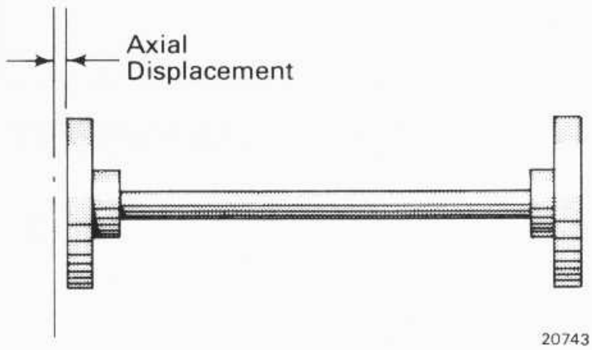


Fig.3 – Axial Misalignment

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.

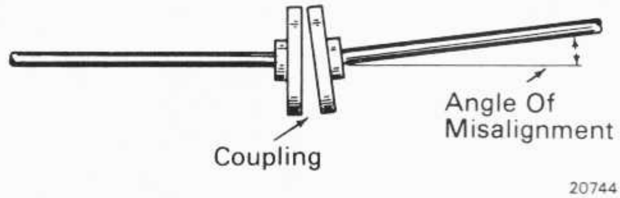


Fig.4 – Angular Misalignment

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 measurement. 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

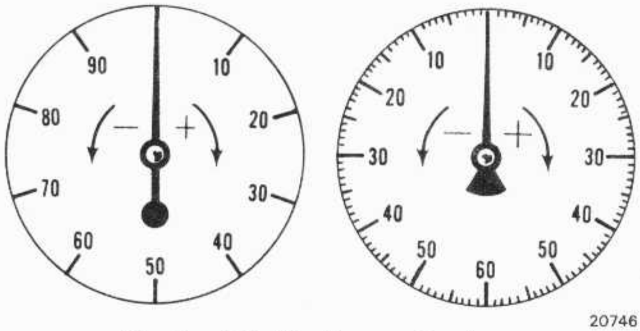


Fig.6 – Dial Indicator Scales

SHAFT AND COUPLING ALIGNMENT

COUPLINGS

Couplings are used to connect machines to machines, shafts to machines, and shaft 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.

METHOD 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).

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.

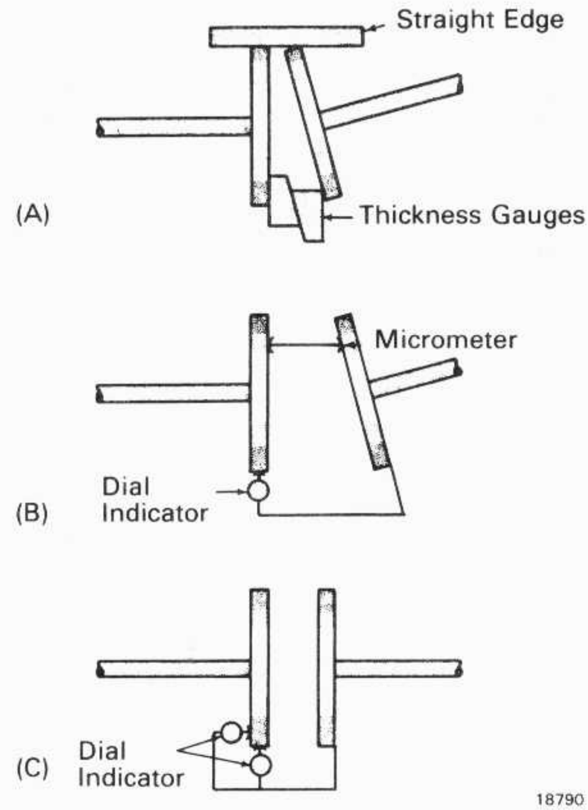


Fig.7 – Methods Of Checking Shaft Alignment

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.

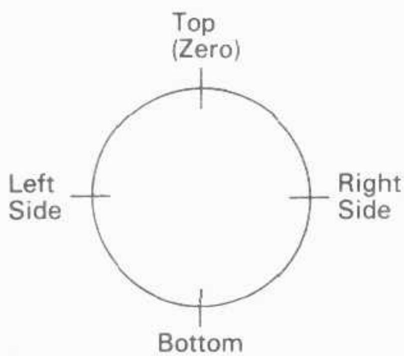
1. Depress indicator plungers about half of their total travel when they are being positioned. This allows the indicators to measure the widest range of plus and minus values.

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.

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.



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

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.

AIR COMPRESSOR COUPLING ALIGNMENT

The air compressor drive shaft couplings are installed, as shown in Fig. 9, with the coupling bolts torqued to 136 N·m (100 ft-lbs). Two inspections are required when aligning or checking alignment of these couplings. The first inspection is a length measurement, or the distance between the coupling and the shaft. The second inspection is of the angular misalignment which can be checked by either one of two methods. The first method employs a dial indicator, while the second method requires the use of feeler gauges.

LENGTH MEASUREMENT

The distance between the mating faces at the 6 o'clock or bottom vertical position, as shown in Fig. 9, must be held to 12.70 mm (.500") +0.51 mm (.020") -0 for applications where the compressor is coupled to the engine or 13.21 mm (.520") +0.51 mm (.020") -0 for applications where the compressor is coupled to the generator. The engine should be at room temperature. If the engine crankshaft is hot, that is, if the engine has been running, the measurement will be reduced and may be as low as 11.94 mm (.470") and 12.45 mm (.490") respectively.

ANGULAR ALIGNMENT

USING DIAL INDICATOR

Angular alignment at each flexible member can be measured by attaching a dial indicator, Fig. 9, to coupling flange and indicating against the face of the mating flange. Both indicators should be in the same plane when checking at two couplings.

Mount the indicators on brackets and set the dials to zero with the indicator at the 12 o'clock position. During rotation of the shaft, record the indicator readings every 90° of rotation. Angular misalignment must not exceed 0.51 mm (.020") total indicator reading when indicating point is on not less than a 254 mm (10") diameter.

USING FEELER GAUGES

Angular alignment at each flexible member can be inspected by measuring the distance between the mating flanges at 90° intervals (four points). Rotate the shaft 180° and again measure at 90° intervals. The readings taken (8 for each coupling) must be within 0.51 mm (.020") of each other.

RUBBER BUSHING REPLACEMENT

The air compressor drive couplings, Fig. 9, do 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. 10, the tool parts are used on opposite sides of the coupling for removal and installation of the bushings.

When installing the rubber 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.

Storage time for pre-assembled couplings should not exceed one year as bushing axial stiffness increases while in a compressed non-operational state which may cause alignment difficulties.

The bushing must be installed past its normal location to properly seat the lips of the bushing. The bushing puller tool must be reversed and the bushing

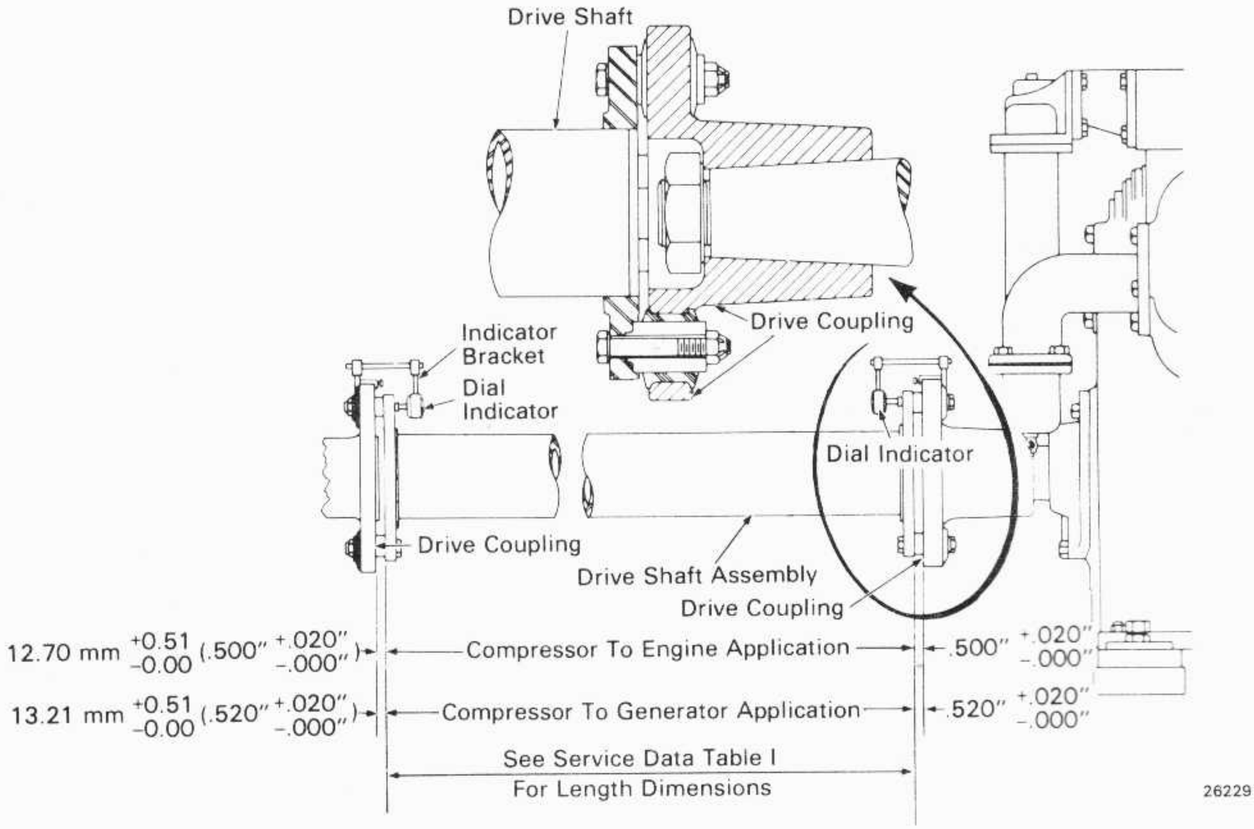


Fig.9 - Application And Alignment Of Air Compressor Couplings

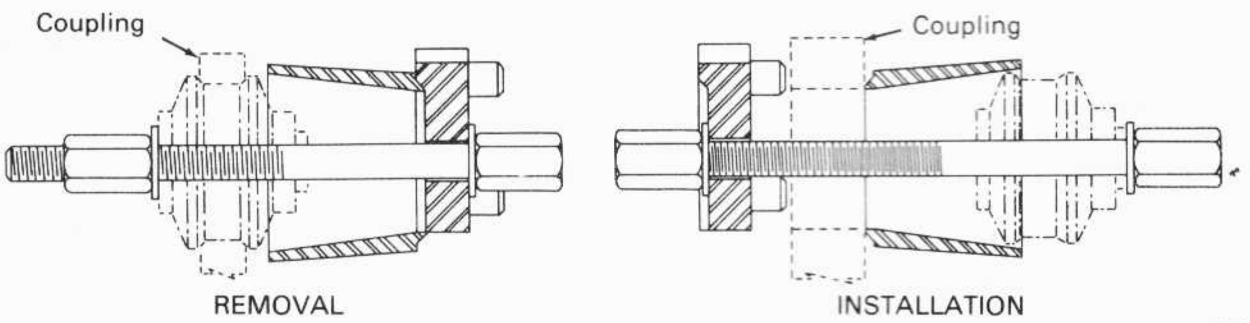


Fig.10 - Rubber Bushing Puller Tool Application

moved until the 11.94 mm ± 0.25 (.470" ± .010") dimension shown in Fig. 11 is obtained, to maintain the bushing faces in the same plane. If a tool is not available, a press may be used.

A bushing application gauge, Fig. 12, is available to measure the 11.94 mm ± 0.25 (.470 ± .010") dimension. This gauge consists of a tripod-legged base supporting a lever indicating arrangement at its center. To measure the 11.94 mm ± 0.25 (.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.

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.

COUPLING APPLICATION

The air compressor drive coupling is bolted and keyed to the tapered end of the compressor crankshaft. If the coupling has been removed for service, it is essential that the proper application procedure is used to avoid damage to the crankshaft.

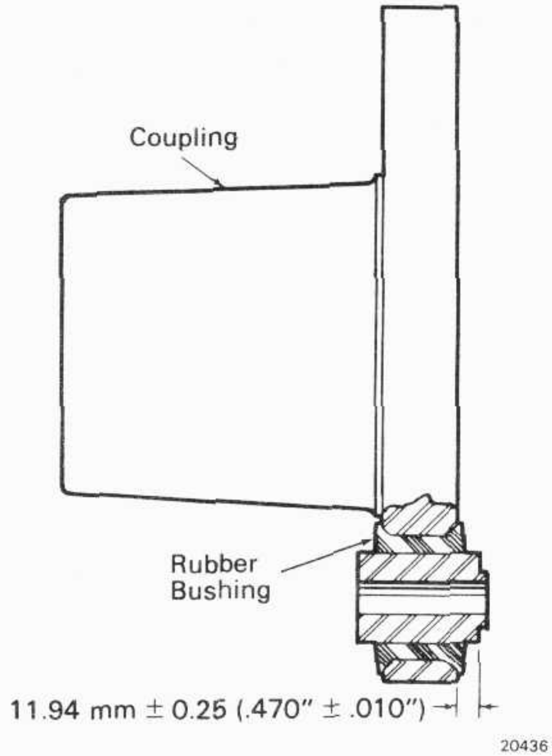


Fig.11 - Bushing To Coupling Application

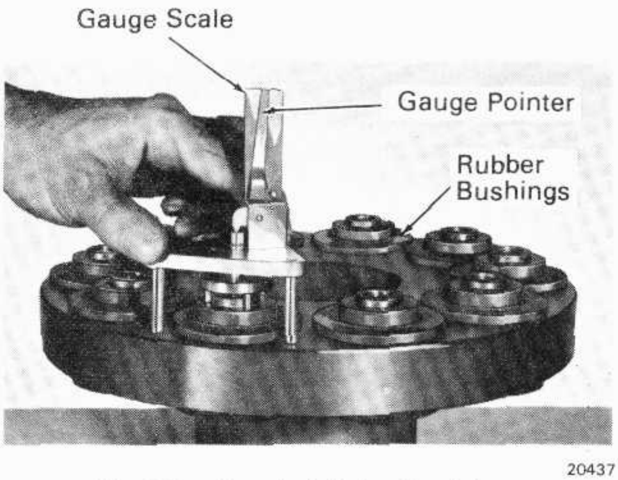


Fig.12 - Bonded Joint Bushing Application Gauge

1. Prior to mounting the coupling on the crankshaft, inspect the two tapered surfaces to ensure the mating surfaces are free of nicks or burrs. Use aluminum oxide cloth of a 180J grit to clean the tapered surfaces and the crankshaft key slot.

2. Hand fit 108 mm (4.25") key so it is tight in the compressor crankshaft key slot. Tap the key in the slot so the end of the key is flush with the end of the crankshaft.

3. Fit the coupling flange on the shaft, making sure that the key remains flush with the end of the shaft.

4. Apply Texaco Threadtex No. 2303 to threaded end of crankshaft, retainer nut and both sides of retainer washer. Torque the retaining nut to 136 N·m (100 ft-lbs).

5. Attach a dial indicator to the coupling with the button of the indicator on the compressor bearing cover or on one of the cover bolt heads. Zero the indicator.

6. Torque the retaining nut to 678 N·m (500 ft-lbs) and record the advance, measured to the nearest thousandth. The coupling advance is satisfactory if between 0.51 mm (.020") and 1.52 mm (.060"). Failure to obtain a reading within this range is usually caused by imperfections found on one of the tapered surfaces or within the keyway. These surfaces should be free of all nicks or burrs.

7. With a dial indicator button resting on the outside diameter of the coupling flange, record the T.I.R. This reading should be within 0.25 mm (.010") to be satisfactory.

AUXILIARY GENERATOR ALIGNMENT

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

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

1. Thrust - finding the axial position of the coupling with respect to the auxiliary generator drive assembly and the auxiliary generator.

2. Angular - correcting the angularity of the auxiliary generator to the drive assembly.

3. Radial - establish centerline alignment of auxiliary generator to the drive assembly.

BEARING THRUST ALIGNMENT

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

1. Auxiliary generator drive assembly applications on blower-type and turbocharged engines not having stamped axial thrust dimensions.

2. Auxiliary generator drive assembly applications on turbocharged engines having a single axial

thrust dimension stamped on the support housing.

3. Auxiliary generator drive assembly applications on turbocharged engines having two axial thrust dimensions stamped on the 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 flanges of the drive assembly and the auxiliary generator, Fig. 13. See Service Data, Table II, to find the correct distance for each specific coupling assembly.

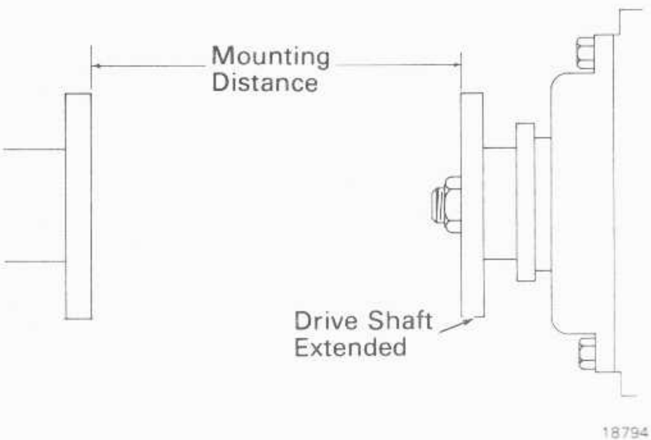


Fig. 13 - Auxiliary Generator Coupling Measurement

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

SINGLE-STAMPED DRIVE ASSEMBLY

1. Attach coupling shaft between auxiliary generator and drive assembly. Torque coupling bolts to 136 N·m (100 ft-lbs).

2. Subtract 1.27 mm (.050″) from the number stamped on the support housing and adjust the position of the auxiliary generator to establish this dimension, Fig. 14.

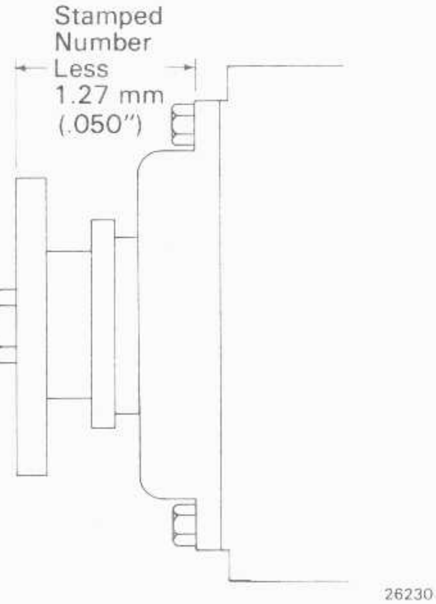


Fig. 14 - Auxiliary Generator Drive Thrust Measurement (Single Stamped)

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 auxiliary generator to frame and recheck thrust measurement. The final thrust measurement must be 0.51 mm (.020″) to 2.34 mm (.092″) less than the stamped number.

DOUBLE-STAMPED DRIVE ASSEMBLY

1. Attach coupling shaft to auxiliary generator and drive assembly. Torque coupling bolts to 136 N·m (100 ft-lbs).

2. Adjust position of the auxiliary generator 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. 15.

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

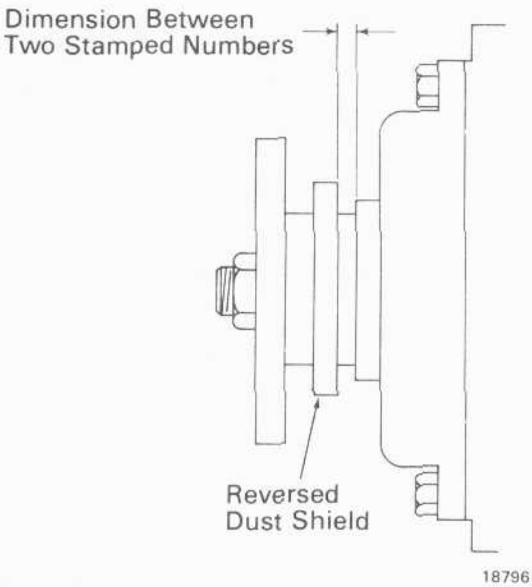


Fig.15 – Auxiliary Generator Drive Thrust Measurement (Double Stamped)

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. 16. 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.

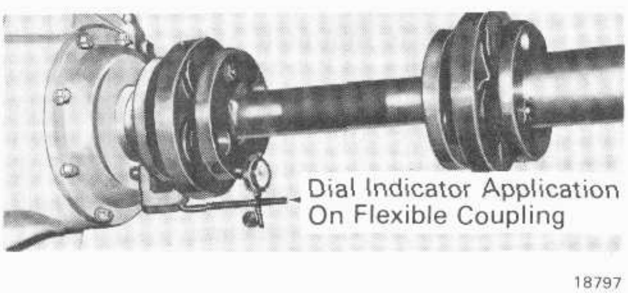


Fig.16 – Auxiliary Generator Drive Coupling Alignment

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 auxiliary generator affects alignment, thrust, radial, and angular alignments must be checked after each setting.

RUBBER BUSHINGS

The auxiliary generator 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.

FAN AND PEDESTAL ALIGNMENT

Any maintenance performed on a switcher locomotive which requires moving the compressor, or disassembly of the fan and pedestal assembly, will require an alignment check of the fan and pedestal assembly.

When the air compressor has been moved, it must be realigned so that the finished surfaces of the compressor drive sheave, and the fan and idler sheaves of the fan and pedestal assembly, are in the same plane within 1.52 mm (.060″), Fig. 17. If this alignment cannot be achieved without disturbing the alignment of the air compressor to the engine, it may be necessary to reposition the pedestal to accomplish the proper alignment.

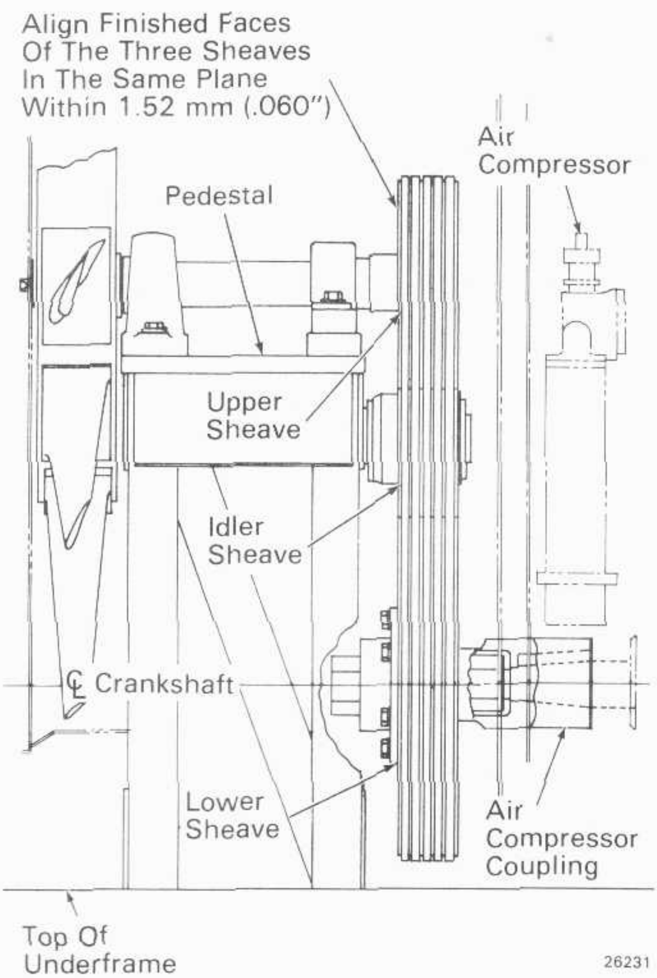


Fig.17 – Fan Drive Sheave Alignment

When maintenance requires disassembly of the fan and pedestal assembly, the drive shaft should be measured for lateral movement between the inner and outer races of the bearings. On older switcher locomotives with ball bearings supporting the fan drive shaft, this is accomplished by attaching a dial indicator to the pedestal with the plunger against the face of the fan drive sheave. Alternately push and pull shaft with 45 kg (100 lbs) of force, reading total shaft movement. Total movement should be 0.13 mm (.005") minimum. This amount of movement indicates that the bearing is not preloaded – a condition caused by improper assembly or mounting.

Newer switcher locomotives have a roller bearing at one or both ends of the fan drive shaft. The sheave end roller bearings have 9.5 mm (3/8") axial free play between the inner and outer races. Alignment consists of positioning the drive shaft in the middle of the 9.5 mm (3/8") axial free play at the sheave end before torquing down the bearing. Align the fan drive sheave and the idler sheave in the same plane with the drive sheave on the air compressor within 1.52 mm (.060"). If this alignment cannot be achieved, it may be necessary to reposition the pedestal to accomplish the proper alignment.

SPEED INCREASER COUPLING ALIGNMENT

The speed increaser drive shaft couplings are installed, as shown in Fig. 18, with the coupling bolts torqued to 312 N·m (230 ft-lbs). The shaft must be located in the taper bushing to provide the correct distance between shaft flange and face of speed increaser flywheel when the taper bushing is tight. See Service Data for specific model.

Angular alignment should be checked at each flexing member by attaching a dial indicator to the coupling flange and indicating against the face of the mating flange. Angular misalignment should not exceed 0.51 mm (.020") total indicator reading when revolving both shafts together.

RUBBER BUSHINGS

The speed increaser 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.

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

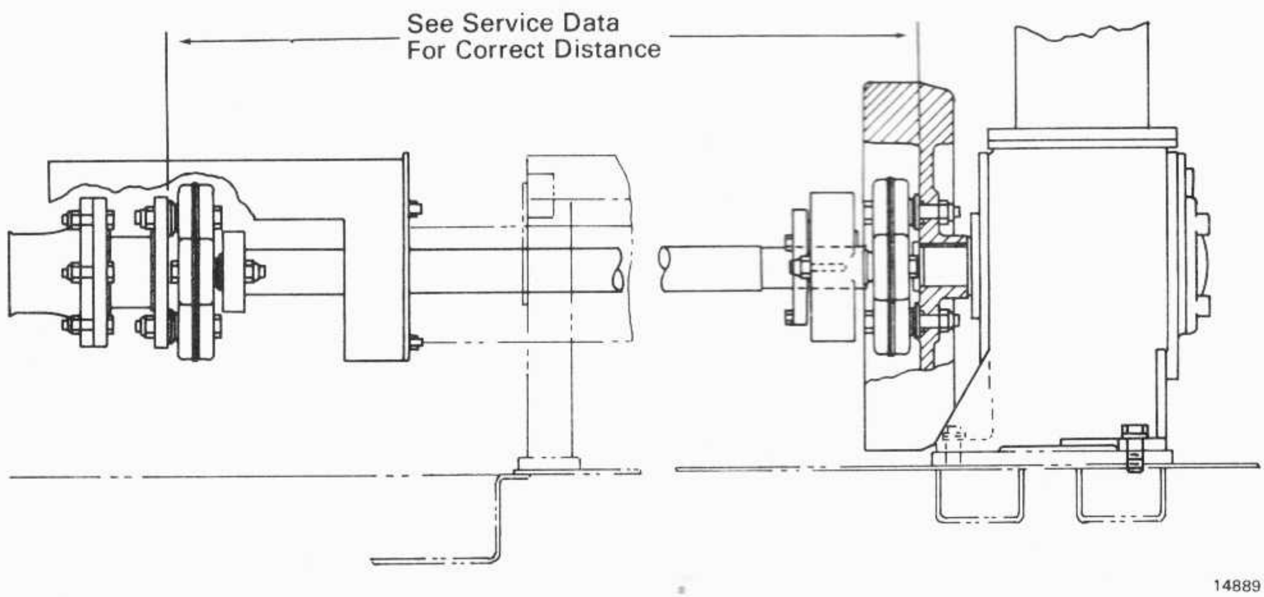


Fig.18 – Speed Increaser Drive Coupling Alignment

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 cover or the 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 plus 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. Mounting and positioning of the dial indicators will vary for specific generator models. See Fig. 21 for dial indicator location. 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 a finished surface of the generator frame.

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.

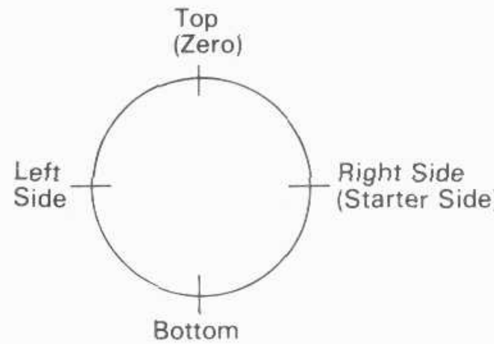
4. Check installation of indicators to see that they are firmly mounted. A light finger tap on the indicators and/or support rods will serve to qualify the zero setting and reveal any lost motion in the indicator linkage.

NOTE

A tabular record of indicator readings should be kept during the alignment procedure, as shown by example in Fig. 19. 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.



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. 19 - Typical Table Of Indicator Readings

7. With the indicator set, turn the flywheel with the engine turning jack, 180° in a clockwise direction, when facing the bearing end of the generator. Then rotate the flywheel 270° in a counterclockwise direction. The counterclockwise rotation instead of continued clockwise rotation is necessary to prevent the indicators from striking the alternator terminal board, if so equipped. As the indicators revolve around the generator, readings should be taken at each 90° increment.

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. 19.

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. 20, the second corrective step shows an attempt to reduce the misalignment as much as possible by moving the generator slightly to one side.

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

Upon completion of main generator alignment the auxiliary generator must be aligned.

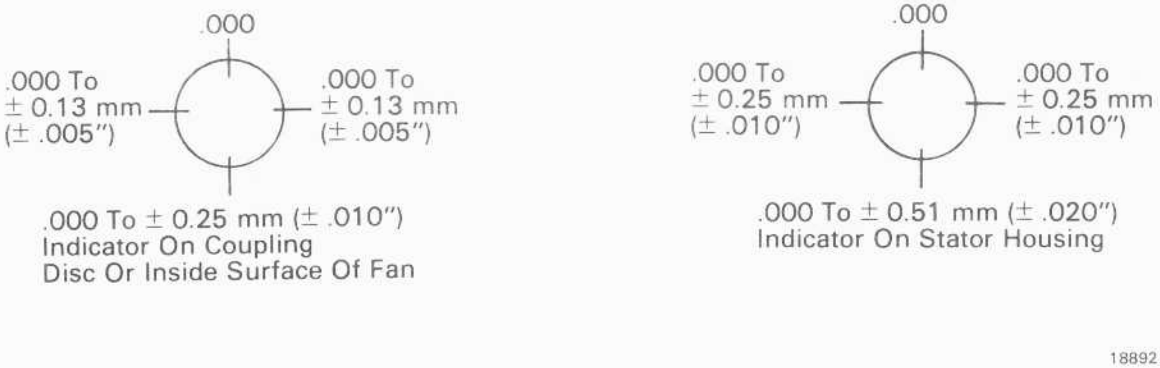


Fig.20 - Dial Indicator Alignment Tolerances

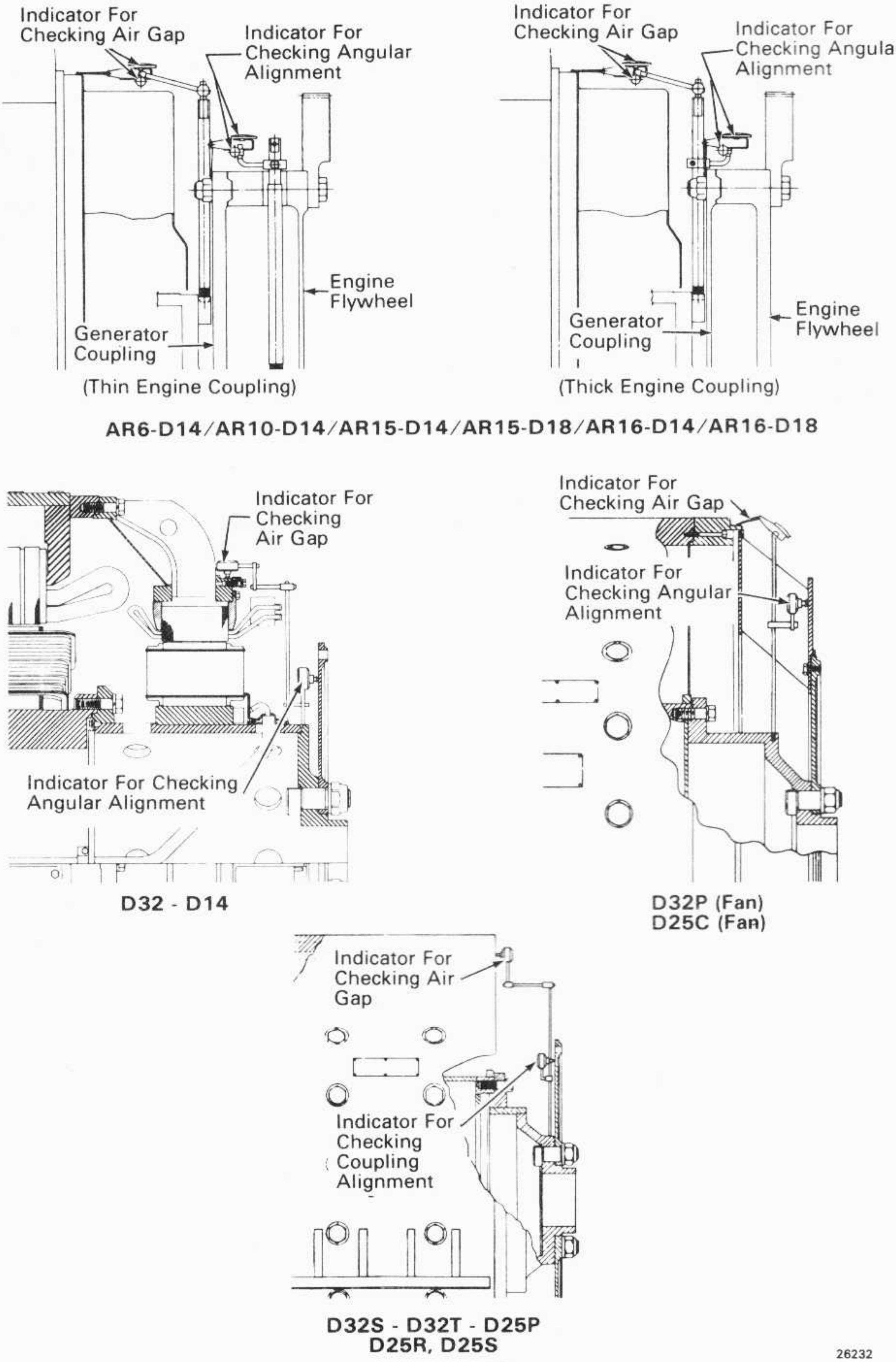


Fig.21 – Generator Alignment Indicator Locations

DIRECT DRIVE HEAD END GENERATOR ALIGNMENT

This section details the steps necessary to align a direct drive head end power generator to a main generator.

NOTE

Before attempting to align the head end power generator, the main generator must be coupled and aligned to the engine as described in the previous section.

Two adjustments are required to ensure proper alignment of the flexible coupling between the two generators. One adjustment sets the axial spacing between the flanges of the flexible coupling to allow for thermal expansion. The other adjustment limits the angular and radial misalignment between the flexible coupling flanges for the purpose of limiting the axial displacement of the coupling rubber bushings per revolution.

COUPLING AXIAL ALIGNMENT

Check axial spacing at each of the three coupling gaps, Fig. 22, at 90° increments (4 places each gap at 12, 3, 6, and 9 o'clock positions). Record measurements on a data sheet relative to a coupling face circle – similar to the method previously described in this instruction. The average axial spacing measurements should be between 12.70 mm (.500″) and 12.83 mm (.505″) with engine at room temperature. If the engine crankshaft is hot, that is, if the engine has been running, the measurement will be reduced and may be as low as 11.68 mm (.460″).

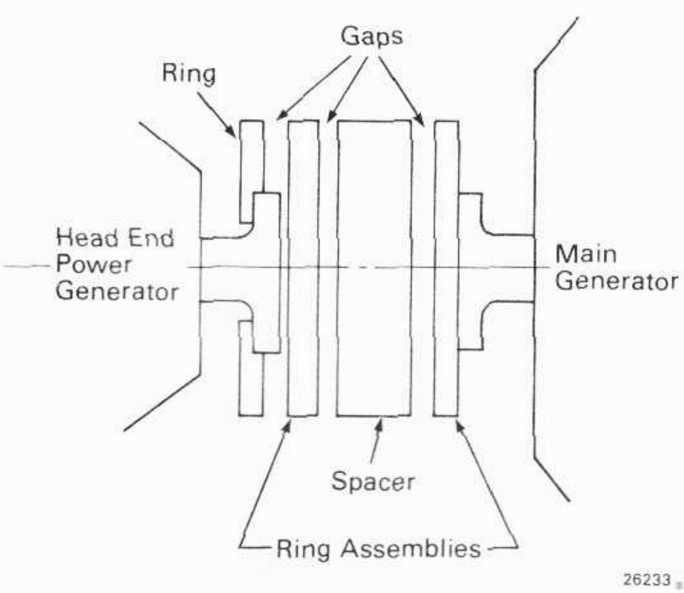


Fig.22 – Coupling Flange Gap Locations

RADIAL AND ANGULAR ALIGNMENT

The angular misalignment between the ring on the head end generator coupling hub and the ring assembly on the main generator hub should not exceed 0.38 mm (.015″) total indicator reading (TIR). The radial misalignment should be within 0.13 mm (.005″) total indicator reading (TIR).

The radial and angular alignment can be determined by either of the following methods.

USING DIAL INDICATORS

Attach a dial indicator base to the ring assembly on the main generator hub with indicators adjusted to read against the face and the outside diameter of the ring on the head end generator coupling, as shown in Fig. 23. The indicator reading on the face of the ring should have its pointer located within 0.4375 mm (7/16″) of the outside diameter. During rotation of the coupling, check and record indicator readings at every 90°.

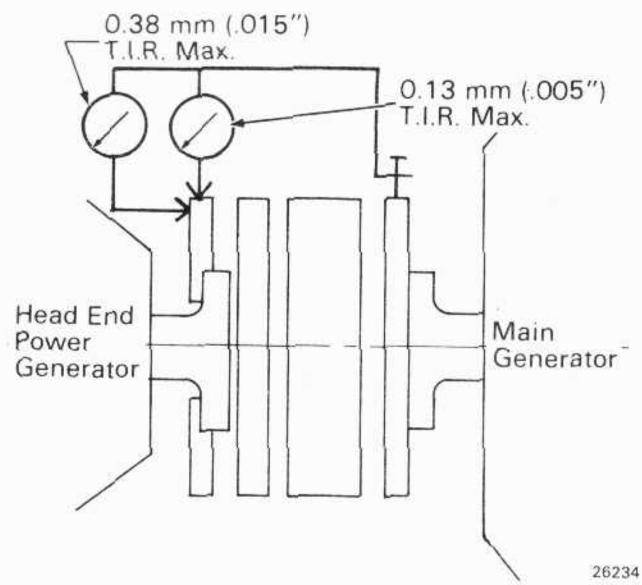


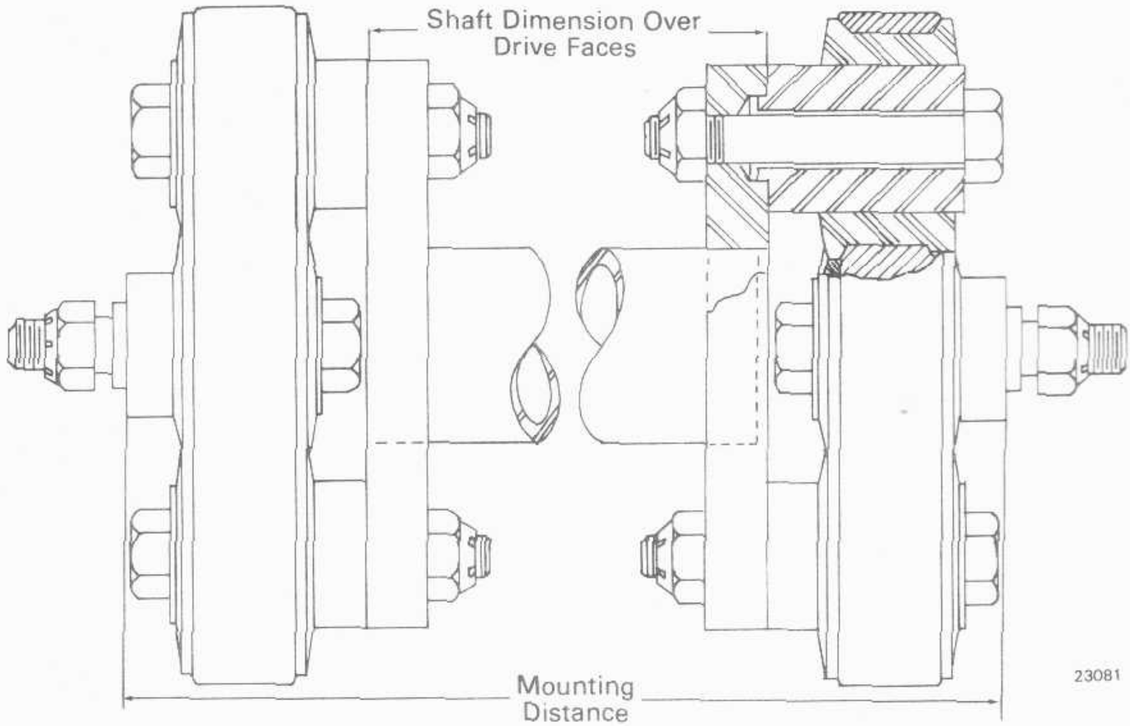
Fig.23 – Alignment Indicator Application

USING FEELER GAUGES

Measure each of the three coupling gaps at the 12, 3, 6, and 9 o'clock positions (12 points). Sum the readings at each position and record the totals on a data sheet. Rotate the coupling 180° and again measure the gaps at 90° positions (total 24 points). Sum and record these readings. Using the 12 o'clock (top vertical) readings as the baseline dimensions, assign a positive value to any measurement greater than the base dimension and a negative value to those less than the base dimension. Generator is considered aligned when all reading sums are within 0.38 mm (.015″) of each other while maintaining correct axial spacing.

Install and tighten generator hold down bolts, then recheck all alignment readings to be certain they remain within limits. If tolerances are satisfactory, dowel generator to its mounting base.

SERVICE DATA



Distance between shaft flange and speed increaser flange or flywheel
G22 . . . . 2.0518 m (6′ 8-25/32″)
G26 . . . . 2.2685 m (7′ 5-5/16″)

Fig.24 – Speed Increaser Drive Coupling Distances

Drive Shaft Assembly Number	Shaft Dimension Over Drive Faces		Drive Shaft Assembly Number	Shaft Dimension Over Drive Faces	
	Inches	Millimetres		Inches	Millimetres
8234923	61.750±.031	1568.45±0.79	8296287	64.250±.031	1631.95±0.79
8235035	46.188±.031	1173.18±0.79	8310665	17.250±.031	438.15±0.79
8243398	45.906±.031	1166.01±0.79	8311088	49.094±.031	1246.99±0.79
8247443	60.938±.031	1547.83±0.79	8339937	37.625±.031	955.68±0.79
8252861	82.813±.031	2103.45±0.79	8349931	39.531±.031	1004.09±0.79
8255042	37.875±.031	962.03±0.79	8367822	59.000±.031	1498.60±0.79
8255043	48.313±.031	1227.15±0.79	8385682	48.562±.031	1233.47±0.79
8256813	12.281±.031	311.94±0.79	8408871	74.375±.031	1889.13±0.79
8262635	54.906±.031	1394.61±0.79	8456600	63.218±.031	1605.74±0.79
8269023	45.500±.031	1155.70±0.79	9321799	85.250±.031	2165.35±0.79
8269119	5.875±.031	149.23±0.79	9325486	36.687±.031	931.85±0.79
8272063	56.906±.031	1445.41±0.79	9512635	51.813±.031	1316.05±0.79
8292671	41.406±.031	1051.71±0.79	9516265	76.750±.031	1949.45±0.79

Table I – Air Compressor Drive Shaft Lengths

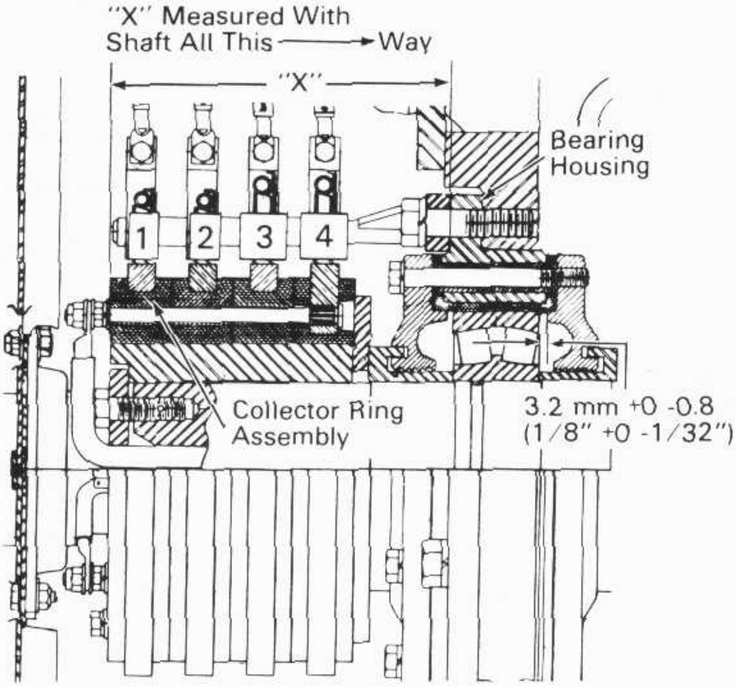
Coupling Assembly Number*	Mounting Distance		Drive Shaft Number	Shaft Dimension Over Drive Faces	
	Inches	Millimetres		Inches	Millimetres
8082348	10.75±0.06	273±1.6	8184471	5.875±.010	149.23±0.25
8144824	24.00±0.06	610±1.6	8184472	19.125±.010	485.78±0.25
8179815	16.31±0.06	414±1.6	8184473	11.437±.010	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	8227020	9.344±.010	237.34±0.25
8227099	14.22±0.06	361±1.6	8227021	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.

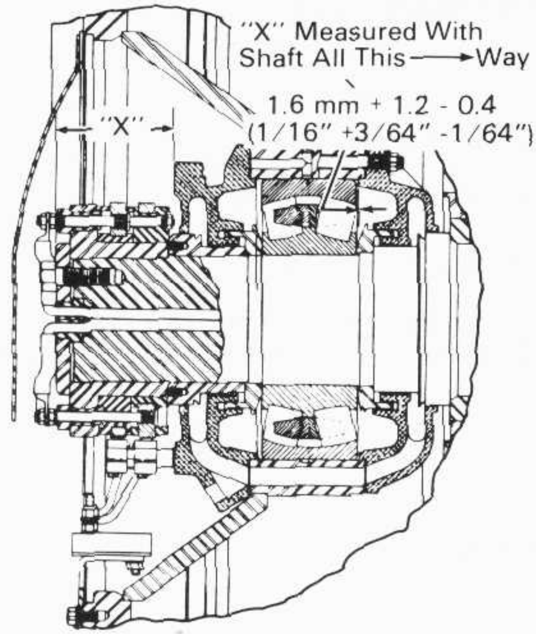
TABLE II – Auxiliary Generator Drive Coupling Flange Distances

Generator	"X" Dimension Measured From (See Fig. 25)	Stamped "X" Dimension	Bearing Thrust Dimension	
			Inches	Millimetres
AR6-D14 AR10-D14 AR15-D14 AR15-D18 AR16-D14 AR16-D18	Bearing housing bolt head at 1 o'clock position to outer face surface of collector ring assembly. (Generator equipped with large bearing).	End Housing	1/8+0-1/32	3.2+0-0.8
AR10-D14	Machined face of bearing housing to outer face surface of collector ring assembly. (Generator equipped with small bearing).	End Housing	1/8+0-1/32	3.2+0-0.8
D32-D14	Top right spot face surface of outer bearing cover to outer end surface of collector ring assembly.	End Housing	1/16+3/64-1/64	1.6+1.2-0.4
D32P (Fan) D32S D32T	Top right spot face surface of outer bearing cover to end surface of armature shaft.	Top of horizontal spoke of end housing.	1/16+3/64-1/64	1.6+1.2-0.4
D25C (Fan) D25P D25R D25S	Bearing cover face or chisel marks to outside end face of bearing retainer.	End housing under one of commutator. covers.	1/16+0-1/64	1.6+0-0.4

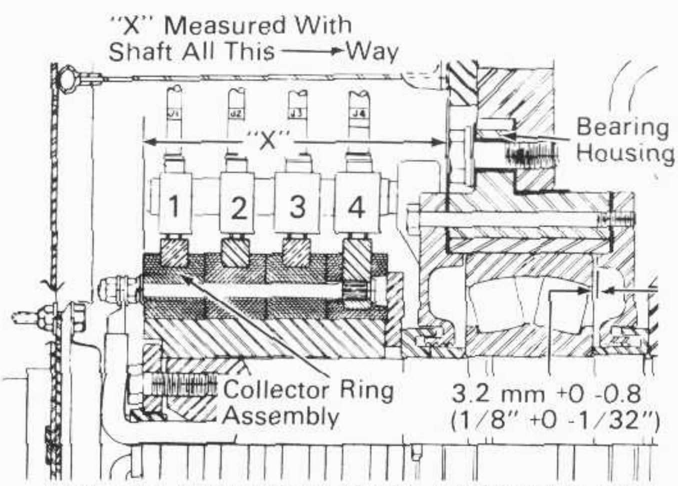
TABLE III – Generator Alignment Data



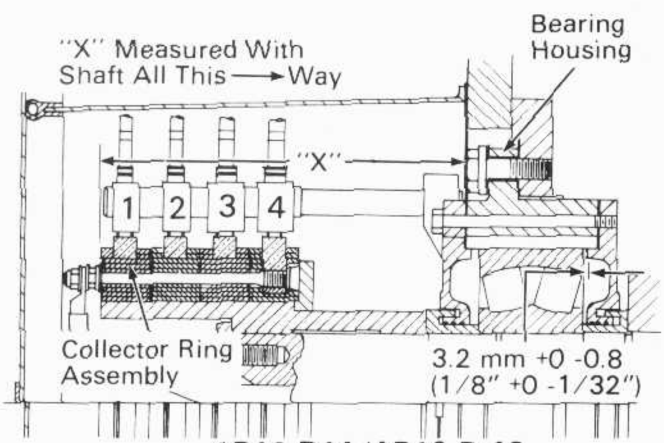
AR10-D14 (W/SMALL BEARING)



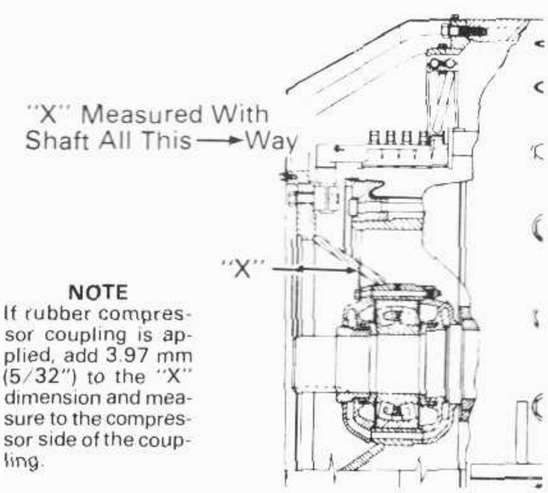
D32-D14



AR6-D14/AR10-D14/AR15-D14/AR15-D18
(ALL W/LARGE BEARING)

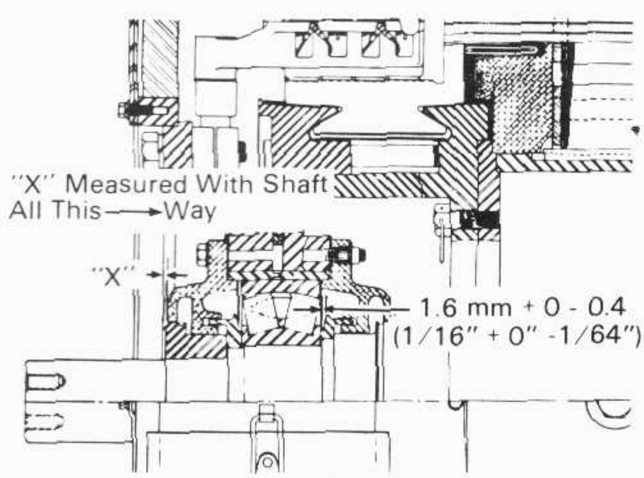


AR16-D14/AR16-D-18



NOTE
If rubber compressor coupling is applied, add 3.97 mm (5/32") to the "X" dimension and measure to the compressor side of the coupling.

D32P, D32S, AND D32T



D25C, D25P, D25R AND D25S

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Fig.25 – Generator 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 set	8255423
Dial indicator (low profile) set	8460472
Support Rod	8122000

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