EMD SERVICE DEPARTMENT
ELECTRO-MOTIVE DIVISION • GENERAL MOTORS CORPORATION

MAINTENANCE INSTRUCTION

ALIGNMENT OF DRILL RIG 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 requires 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 the drilling rig system.

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. 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.

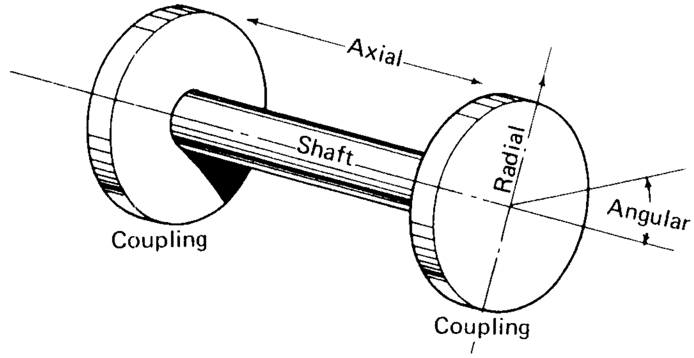

Fig. 1 – Dimensions Used In Alignment Procedures

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.

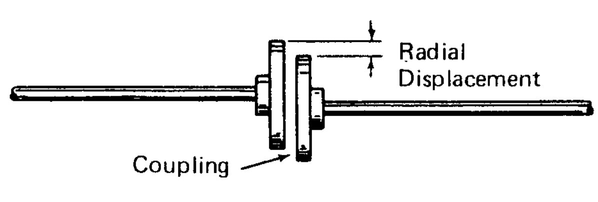

Fig. 2 – Radial Misalignment

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

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.

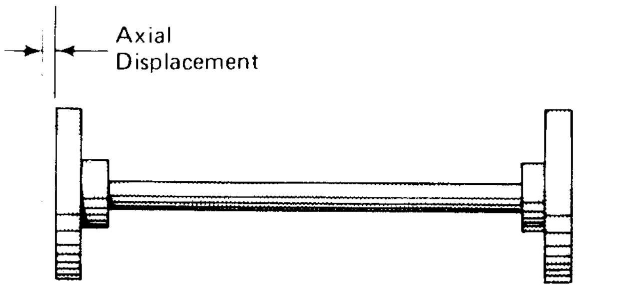

Fig. 3 - Axial Misalignment

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 or angular or a combination of both.

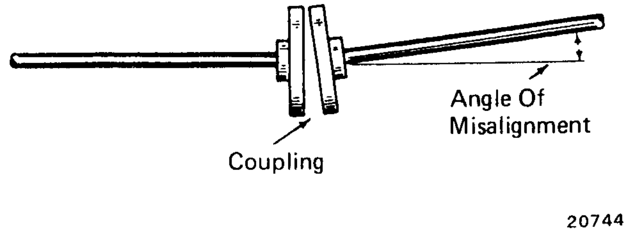

Fig. 4 - Angular Misalignment

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

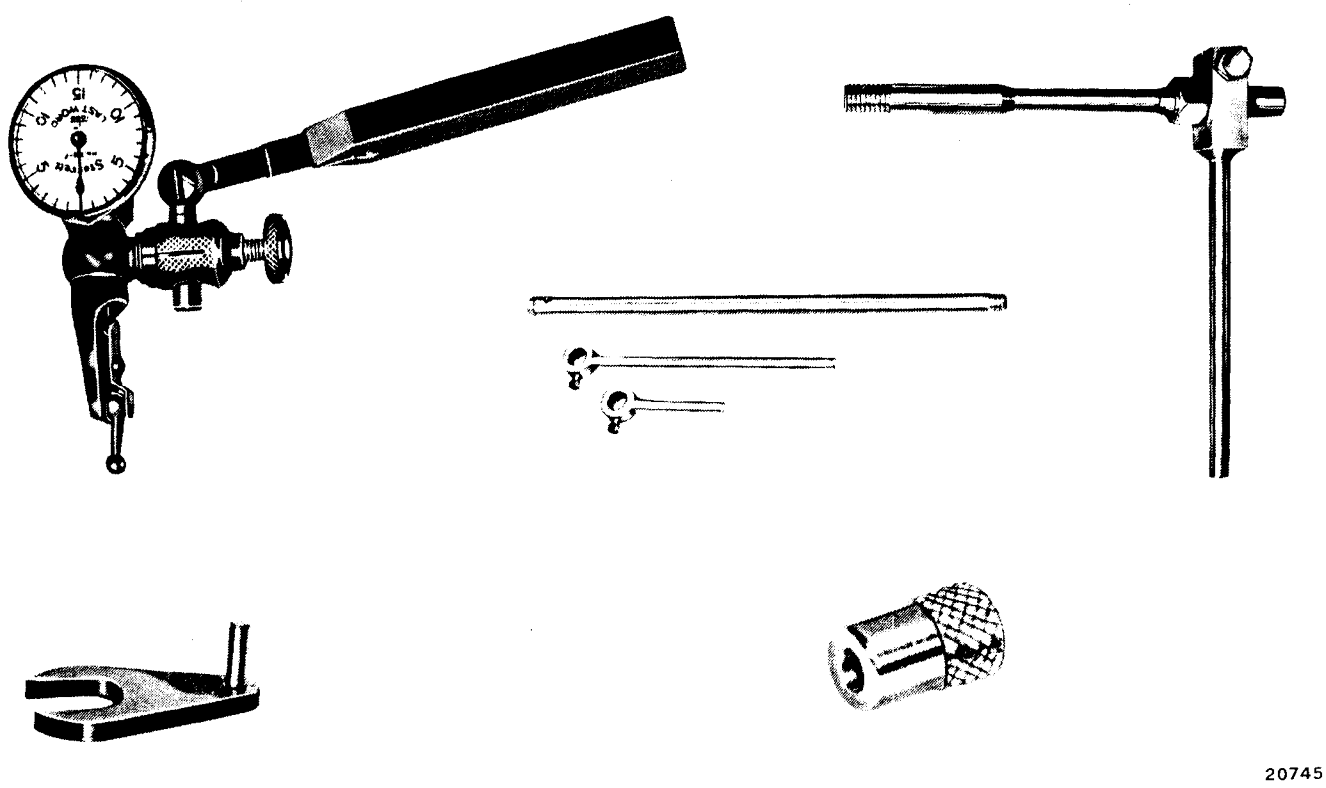

Fig. 5 - Universal Type Dial Indicator And Auxiliary Support Rods, Adapters, And Brackets

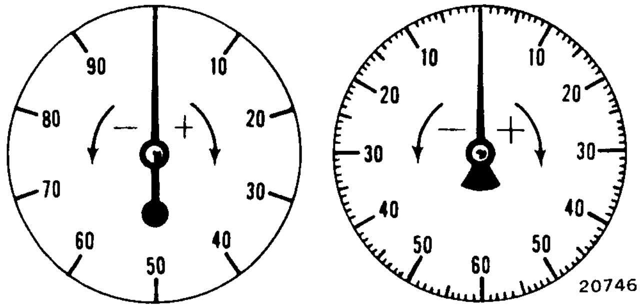

Fig. 6 – Dial Indicator Scales

minus, attained while performing the measurement. The total indicator reading (T.I.R.) is the whole change in indicator reading disregarding the indicator reference.

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 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).

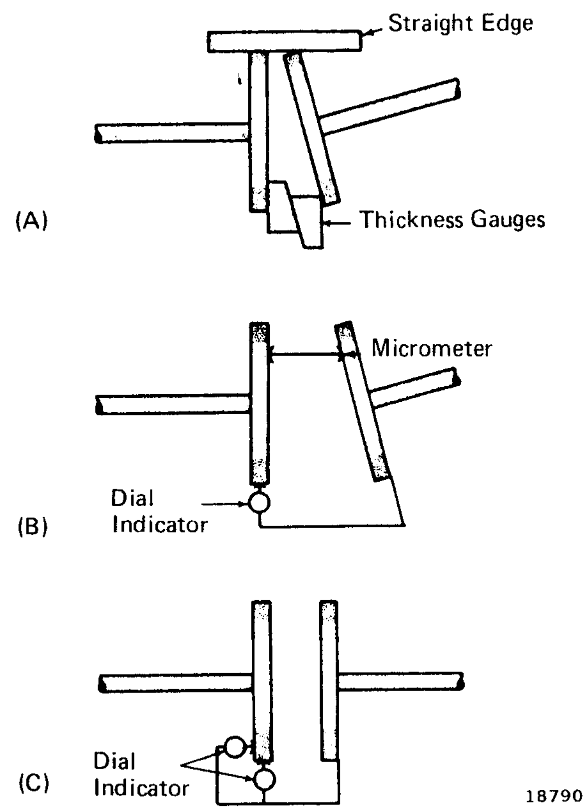

Fig. 7 – Methods of Checking Shaft Alignment

PROCEDURES

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. The indicator button should be located on the face of the coupling 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.

NOTE: Indicator plungers should be depressed about one half of their total movement when they are being positioned. This allows the indicator to measure the widest range of plus and minus values.

After the indicators are applied, the coupling should be rotated until the indicators are brought up to the top or vertical position. At this position the movable faces of each indicator should be set to zero. This establishes the indicators to a reference setting from which the misalignment can be measured. An easy way to keep track of alignment readings is to use two circles drawn on a sheet of paper. Use one circle to record angular measurements and the other for radial measurements. Refer to Fig. 8. Each circle graphically represents the physical position of the indicators relative to the coupling of the driven shaft. In this way the vertical or top position is designated as the zero reference for the alignment procedure.

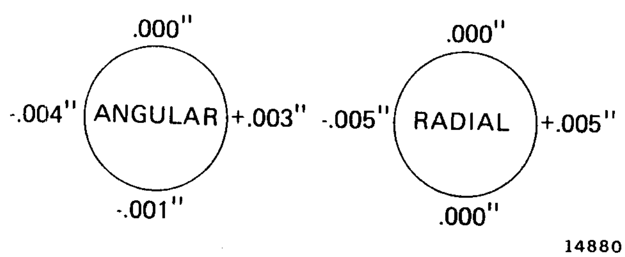

Fig. 8 - Typical Indicator Readings

The shafts are then rotated one quarter turn (90°) and the readings on both indicators recorded. The indicator on the face or back of the coupling will show the angular displacement of the shaft. If the angular displacement reading is zero through a full rotation of the shaft, then the shafts are aligned in the angular dimension. Usually though there is some variation, plus or minus values, for each alignment operation. If the indicator pointer moves in the direction of increasing numbers (10, 20, 30, etc.) then the reading is recorded as a plus value. If the pointer moves in the direction of decreasing numbers (90, 80, 70, etc.) then the reading is assigned a minus value. These values are recorded on the circles as the shafts are rotated in one quarter turn increments.

When the indicators have travelled the full circle around the coupling, both indicators should read zero as they return to the vertical position. If both indicators do not return to zero as they reach their original starting point, then all the readings should be discarded and the source of error investigated. Possibly one of the indicators was not firmly mounted which allowed it to shift slightly changing the indicator reference. Once the reason for the discrepancy is found and corrected, a new set of readings must be taken. A typical set of 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 could be attempted to reduce the misalignment as much as possible. The readings in the 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 toward the side with the minus 0.13 mm (.005") reading, the total indicator reading for radial 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.

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 reading 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.

D32 GENERATOR BLOWER ALIGNMENT

After the main generator is coupled and aligned to the engine, the generator blower is aligned.

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 blower-type and turbocharged engines having two axial thrust dimensions stamped on the right side of 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.

Axial alignment procedures for the different types of generator blower drive assemblies is provided.

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 of 524.7 mm ± 0.8 (20-21/32" ± 1/32") between the coupling flanges of the drive assembly and the generator blower, Fig. 9.
3. Secure generator blower to frame and install couplings. Torque coupling bolts to 136 N·m (100 ft-lbs).

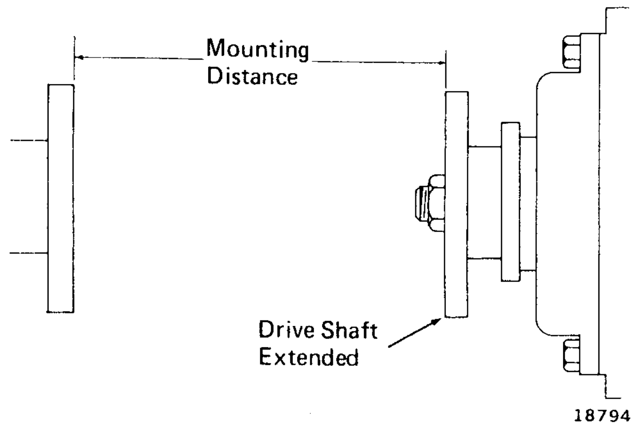

Fig. 9 - Generator Blower Coupling Measurement

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.

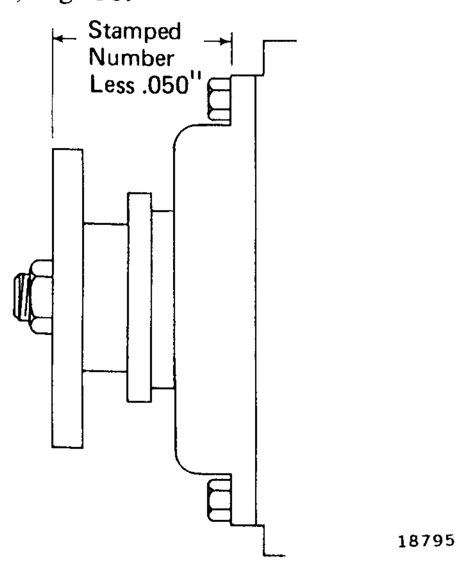

Fig. 10 - Generator Blower Drive Thrust Measurement

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 .080" less than the stamped number.

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.

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

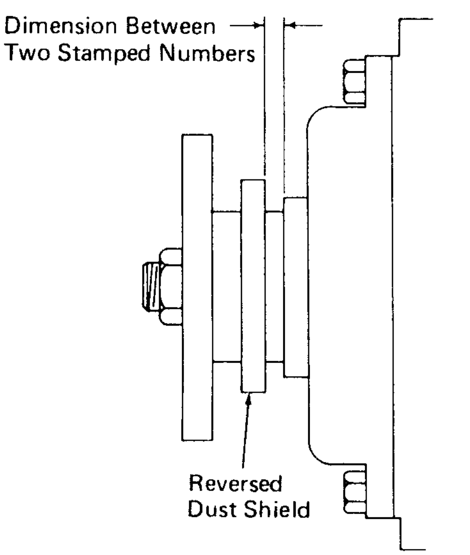

Fig. 11 - Generator Blower Drive Bearing Clearance

RADIAL AND ANGULAR ALIGNMENT

Radial and angular alignment is 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.

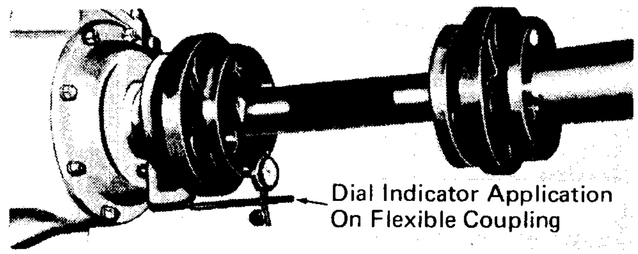

Fig. 12 - Generator Blower Drive Coupling Alignment

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 blower 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.

D79 GENERATOR ALIGNMENT

Perform the following alignment checks during the assembly of the D79 generators and gear box.

1. Place a straight edge across the front machined surfaces of the generators to determine that they are parallel, Fig. 13.

2. Measure the distance between the machined surfaces and the front face of the mounting bracket assembly between the two generators, Fig. 13. This measurement must be 54.8 mm ± 0.4 (2-5/32" ± 1/64").

3. With the gears in place, measure the backlash between each generator gear and the drive gear, using either a feeler gauge or by taking a lead reading. The backlash between gears must be a minimum of 0.38 mm (.015"). If this condition is not met, the generator may be moved away from the rig centerline to gain additional tooth clearance.

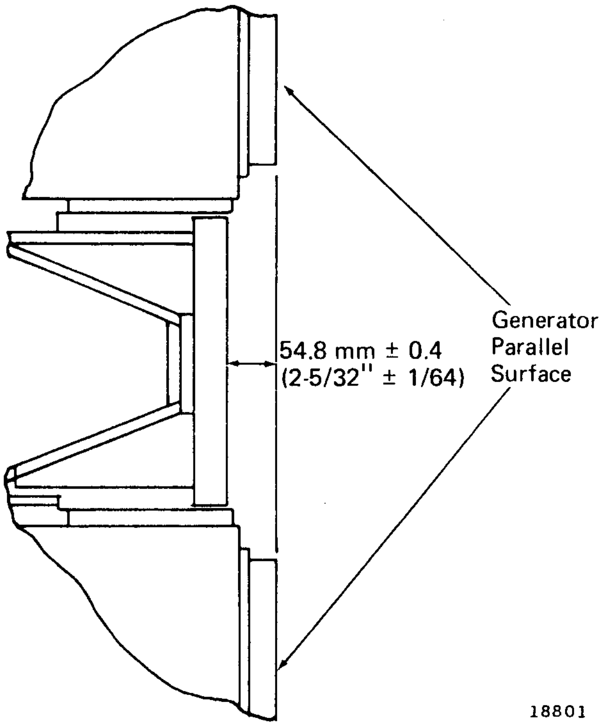

Fig. 13 - D79 Generator Alignment

GEAR BOX ALIGNMENT

Before attempting to align the gear box to either the D32 generator or the engine, the two D79 generators must be mounted to the generator sub-base and aligned to the gear box. If the gear box is to be aligned to a D32 generator, the generator must first be aligned to the engine.

The following instructions for alignment of the gear box to the engine are also applicable to the alignment of the gear box to the D32 generator.

The alignment of the gear box to the engine is divided into three operations:

1. Thrust - finding the axial position of the coupling with respect to the gear box and the engine.

2. Angular - correcting the angularity of the gear box to the engine.

3. Radial - establish plane alignment of the gear box to the engine.

THRUST ALIGNMENT

With the gear box connected to the engine through the flexible coupling, place a straight edge across the face of the driving gear and the driven gears in the gear box. The gears must be flush within ± 0.8 mm (1/32"). If this measurement cannot be obtained, move the generator sub-base either toward or away from the engine until the gear faces are flush.

RADIAL AND ANGULAR ALIGNMENT

Radial and angular alignment is determined simultaneously by the use of two dial indicators. The indicators are attached to brackets secured to the respective drive flanges with the indicating button contacting the inner face of the inside coupling flange. Mount indicators directly across from each other so the indicating buttons are on a flange diameter of 508 mm (20") minimum.

Set the dial indicators to zero and rotate the coupling by turning the engine crankshaft one full revolution. If the total indicator reading of each indicator does not exceed 1.02 mm (.040") the gear box is considered aligned.

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

RUBBER BUSHING REPLACEMENT

The flexible couplings 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. 14, the tool parts are used on opposite sides of the coupling for removal and installation of the bushings.

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.

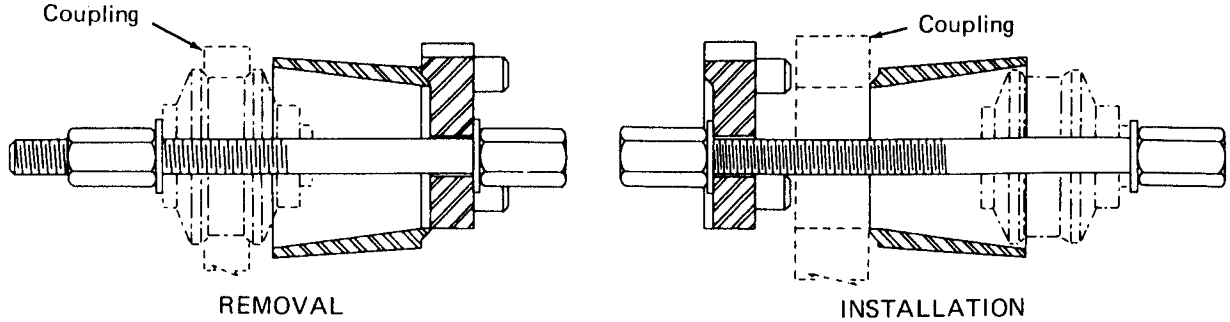

Fig. 14 - Rubber Bushing Puller
Tool Application

The bushing puller tool must then be reversed and the bushing moved until the 11.94 mm ± 0.25 (.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.

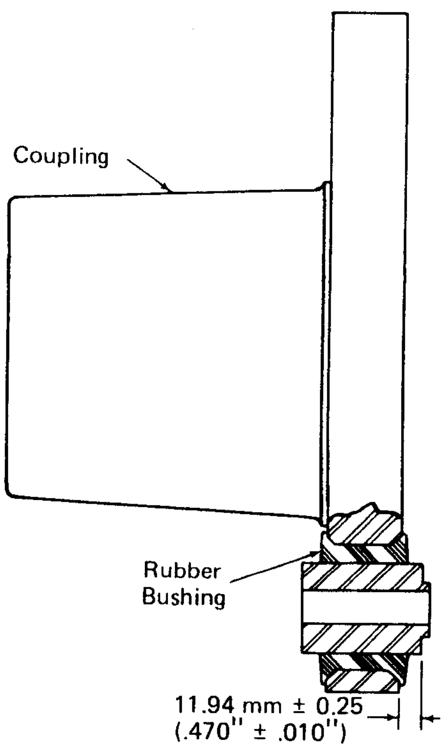

Fig. 15 - Bushing To Coupling Application

A bushing application gauge, Fig. 16, is available to measure the 11.94 mm ± 0.25 (.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.

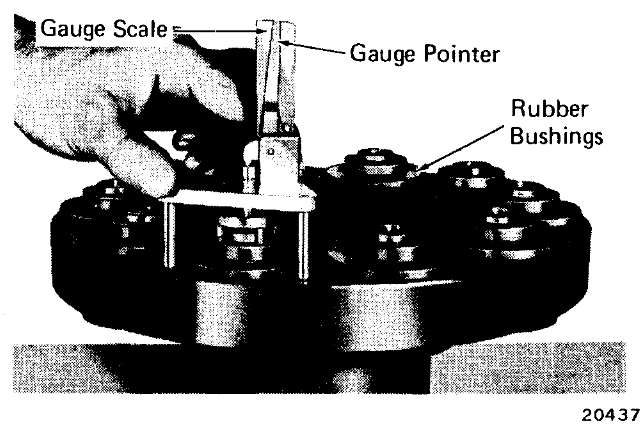

Fig. 16 - Bonded Joint Bushing Application

COOLING COMPARTMENT ALIGNMENT

The alignment of the cooling compartment to the engine is divided into three operations:

1. Thrust - finding the axial position of the coupling with respect to the cooling compartment and the engine.

2. Angular - correcting the angularity of the cooling compartment to the engine.

3. Radial - establish centerline alignment of the cooling compartment to the engine.

THRUST ALIGNMENT

With the driving shaft pulled out from the engine, attach the flexible coupling shaft between the engine and the cooling compartment.

Position the cooling compartment either toward or away from the engine to obtain a measurement of 0.25 mm (.010") between the bearing snap ring and the front face of the bearing housing of the cooling compartment, Fig. 17. This measurement must be taken with the engine driving shaft fully extended toward the cooling compartment.

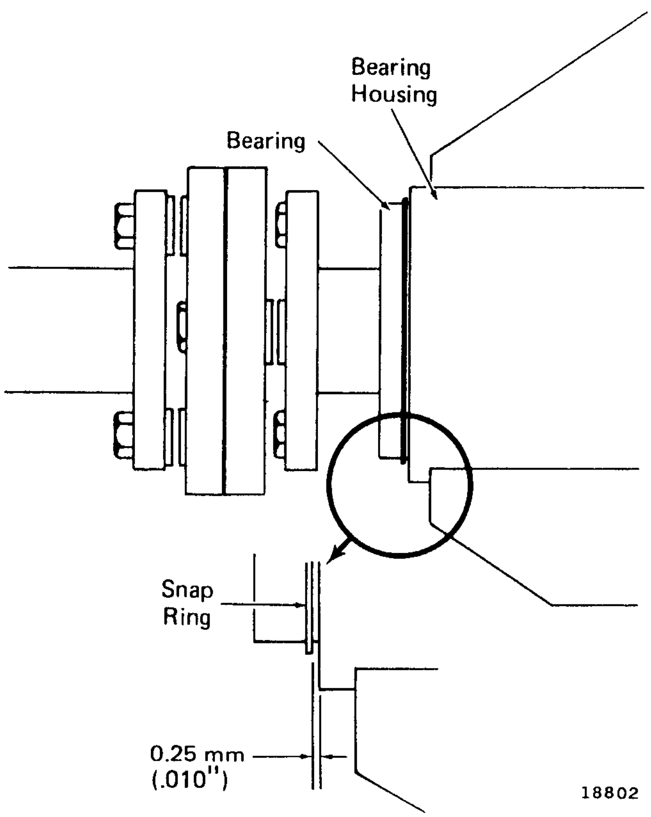

Fig. 17 - Cooling Compartment Bearing Thrust

RADIAL AND ANGULAR ALIGNMENT

Radial and angular alignment is determined simultaneously by the use of a dial indicator attached to a bracket secured to the drive flange with the indicating button contacting the inner face of the inside coupling flange.

Set the dial indicator to zero and rotate the coupling by turning the engine crankshaft until the cooling compartment drive shaft makes one full revolution. If the total indicator reading is within 3.81 mm (.150") maximum, the cooling compartment is considered aligned.

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

RUBBER BUSHINGS

The cooling compartment 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.

D32 GENERATOR TO ENGINE ALIGNMENT

To make the engine and generator revolve true and comparatively 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 must be held to the correct dimension and be evenly distributed at all poles.

The generator armature is, in effect, the flywheel for the engine and is joined to the engine crankshaft by means of a flexible coupling. An engine coupling disc and a generator coupling disc comprise the flexible coupling. 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.

Fundamentally all flexible couplings connecting the engine and generator are the same, however, they do differ somewhat in construction.

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 body-bound or reamed-fit mounting bolts. However, the following recommendations should be adhered to in the application of the serrated coupling.

After installation of the generator, the generator coupling disc is mated to the engine coupling disc and the rim bolts applied and properly torqued to 400 N·m (295 ft-lbs). The coupling is then checked as follows:

1. The gap between engine and generator coupling disc at the rim bolts should not be less than 0.038 mm (.0015"). Care should be taken to tighten all coupling bolts uniformly to avoid cocking the coupling on the serrations.

2. The recessed indicator surface and the serrations on the coupling are held concentric with the center bore. The entire rotating assembly is balanced about this same center. Thus the runout of the indicator surface is a measure of out of balance. Concentricity is not held at the outside rim of the coupling disc, except at the fan pilot on generators equipped with fans.

GENERATOR ALIGNMENT INFORMATION

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

1. Thrust - finding the axial position of armature 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 and field poles.

Angular and radial alignment is carried out simultaneously.

GENERATOR BEARING ALIGNMENT

After the generator is coupled to the engine, it is very important to locate the generator frame to have the bearing located axially to avoid a thrust load in 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 removing one oil pan handhole cover and prying against a crankshaft web and crankshaft.

2. Locate the "x" measurement number stamped with 13 mm (1/2") numbers on the top of the horizontal spoke of the end housing. This measurement is determined during final generator assembly with the armature positioned so end play is taken up in the direction of the engine coupling, Fig. 18.

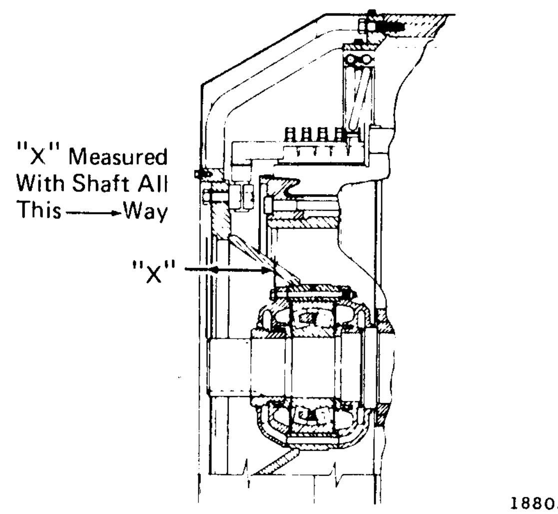

Fig. 18 – Thrust Alignment Cross-Section

3. Move the generator frame either away from or toward the engine to obtain a measurement, which is the total of the "x" measurement plus 1/16" + 3/64" - 1/64".

GENERATOR ALIGNMENT

The proper operation of the power plant requires that the generator armature or rotor shaft and generator frame be in line with the engine crankshaft, and that the air gap be equally spaced. It is equally important that eccentricity at the coupling be held to a minimum as this directly affects balance, brush wear, and bearing wear.

The air gap of the generator must be uniform under each main pole, as well as under each commutating pole and, also from the front to rear of each pole, to obtain the proper electrical characteristics of the generator.

Since the generator has only one roller bearing, the recommended method for aligning the air gap and coupling is at the engine end of the generator.

The radial and angular alignment can be accomplished by using two dial indicators mounted on support rod which is screwed into a 1/4" hole in the coupling adapter. Both indicators revolve with the coupling adapter. The plunger of one indicator rides on the back of the coupling disc, and the plunger of the other indicator on the outside vertical face of the stator housing, Fig. 19. Any generators equipped with a guard over the rotor must have the guard removed before applying the dial indicator rods.

1. Mount and position dial indicators, Fig. 19.

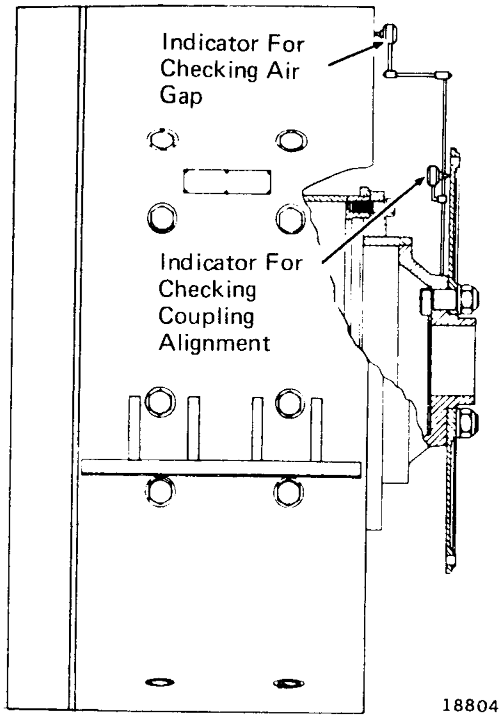

Fig. 19 – Alignment Indicator Locations

2. With the engine turning jack assembly, the flywheel should be turned so that the indicator rod is in a vertical position. This will place both indicators near the top of the generator.

3. After clamping the indicators on the rod, the indicator buttons are brought to bear upon the surfaces on which they will ride. To set the indicators, depress the plungers about half of their total travel. This will permit the indicator to show plus or minus readings as the coupling is rotated.

4. With the indicator set, turn the flywheel, with the engine turning jack, 180° clockwise direction, when facing the bearing end of the generator. Then rotate the flywheel 270° in a counterclockwise direction. The counterclockwise 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. When the indicators return to the original starting point they should register zero. If they do not register zero, reset and make another check or replace indicators if defective.

If the indicator readings are within the limits shown in Fig. 20, the generator is considered aligned and the mounting and coupling bolts can be tightened to the specified torque.

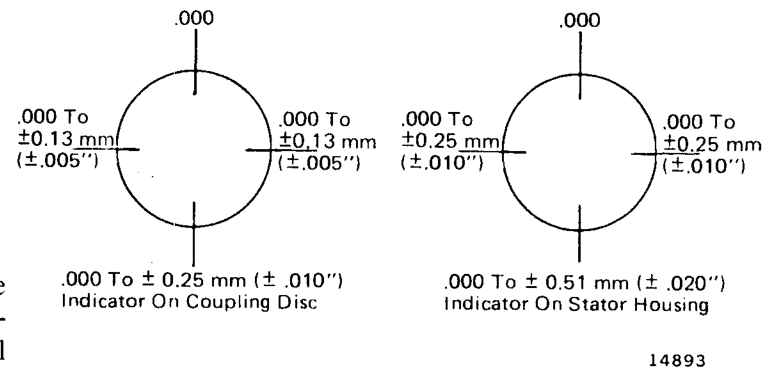

Fig. 20 – Dial Indicator Alignment Tolerances

Since any movement of the generator frame affects both the coupling and air gap, readings for both must be taken after each setting. Experience will indicate the proper shim thickness to bring the readings within the specified limits. Full length shims should be used when possible, although spot shims may be necessary to conform to the limits.

Upon completion of main generator alignment, the blower and gear box generator must be aligned.

SERVICE DATA

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"), 12.19 mm (.480") pointer calibration discs)	8254466
Dial indicator	8255423