

ALIGNMENT OF ROTATING EQUIPMENT

I. INTRODUCTION

A. GENERAL ALIGNMENT INFORMATION

The purpose of aligning connected machines is to eliminate all unnecessary stresses in the shafts and couplings. Accurate alignment of coupled shafts of all types of rotating equipment is very important and must be maintained in order to assure trouble-free operation. Misalignment causes vibration, bending of shafts and unequal bearing loadings.

In addition to shaft alignment, other factors must be considered when installing equipment, which depend on the specific equipment. For example, in motors and generators, rotors must be correctly located in their stators to provide freedom of operation. Equal in importance is the positioning of the stator to the rotor radial clearance or air gap equalization. Also, bearings must be located so as to provide clearance for longitudinal shaft expansion and end play so as not to restrict normal positioning of the rotor during operation. Limiting dimensions governing these factors are given in this instruction covering the particular piece of equipment.

At the time of original installation, the preceding factors of alignment are applied to correctly align the equipment, and the various items are securely fastened and doweled to their base to maintain their correct position.

It is important to remember that it is the shafts of connected machines that require alignment, not the couplings. Coupling surfaces may be inaccurate and

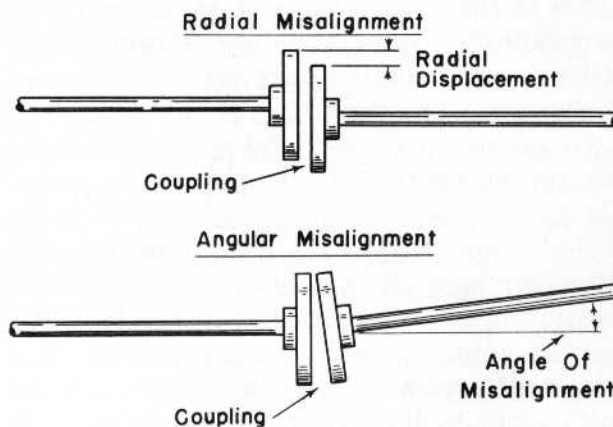


Fig. 1 - Parallel And Angular Shaft Misalignment

not at right angles to the respective shafts. Misalignment of the shafts may be radial or angular or a combination of these two.

Radial misalignment, Fig. 1, is indicated when the centers of the two shafts do not coincide. In addition to causing excessive vibration, this radial displacement also causes the two halves of the coupling to move radially in respect to each other. This movement results in excessive wear within the coupling. Radial displacement shortens bearing life by causing pulsating loads on the bearings. The magnitude of the pulsating load will depend upon the resistance of the coupling to radial movement.

Angular misalignment, Fig. 1, is indicated by the two shafts coming together at a slight angle. In addition to causing vibration, depending upon the type of coupling, angular misalignment causes bending stresses to be set up in the shafts, plus additional bearing loads. The amount of stress set up depends upon the resistance of the coupling to bending.

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The method of alignment will vary with the number of bearings on each shaft and the type of coupling used.

In general, where each shaft to be coupled has more than one bearing, a coupling must be used which will tolerate some angular and radial displacement. This is important since it is almost impossible to secure absolute alignment between two shafts carried in separate housings. The fact that such a coupling is used is no excuse for not aligning the shafts as accurately as possible.

When two shafts are to be coupled together and one has two or more bearings and the other one has a single bearing, a coupling must be used which does not have radial flexibility. Such a coupling must, however, be provided with angular flexibility. An example of this type of coupling is used between the main diesel engine and the single bearing generator. If two mating surfaces on each half of the coupling are coupled together and are concentric with their respective shafts, the shafts will be in radial alignment, and it will only be necessary to check angular alignment. However, in the case of generators, the rotor, stator, and bearing positions must be adjusted.

B. ALIGNMENT PRINCIPLES

Three possible methods to check shaft alignment are shown in Fig. 2, a, b and c. These methods respectively are:

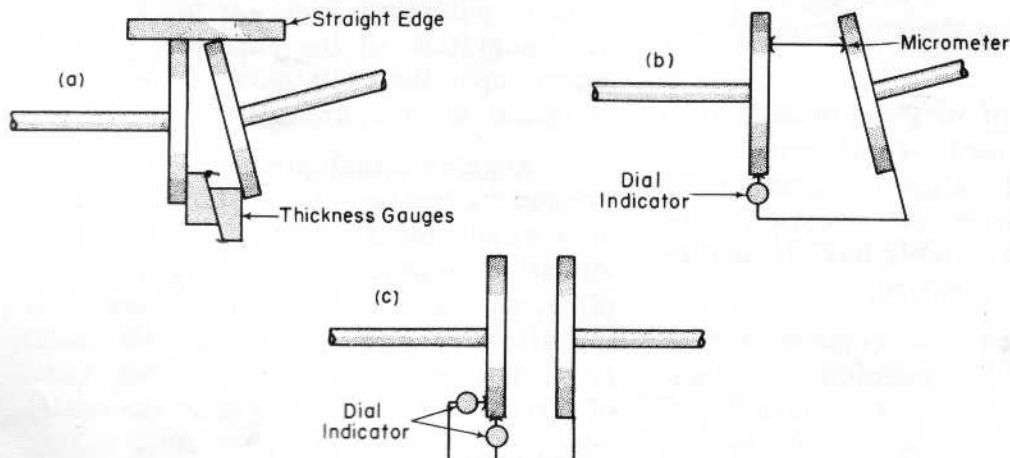


Fig. 2 - Methods Of Shaft Alignment

a) straight edge and thickness gauge, b) dial indicator and micrometer, and c) the recommended method using two dial indicators. The plunger of one indicator shown in Fig. 2 c, is parallel to the shaft with its button resting on the coupling face at a radius equal to or greater than the coupling disc. The plunger of the other indicator is at right angles to the shaft, with its button resting on the rim of the coupling.

The dial indicators used, similar to one shown in Fig. 3, should have a range of at least .200". This is desirable because when positioning the indicators, their plungers should be depressed about .100" or about half their total travel. This will permit the indicator pointer to move "in" or "out" when the shafts and couplings are rotated.

After the indicators are applied, the coupling halves should be rotated together and both indicators brought to the uppermost or top position. In this position the bezels or movable faces of the indicators should be turned so the indicator pointers register zero (0).

Two circles, Fig. 4, should be drawn on a sheet of paper with the figure "zero" written at the top of each circle. ("Zero," of course, is the reading on the dial indicator at the start of the check.)

One circle should be used to record the angular displacement and the other to record the radial displacement. The

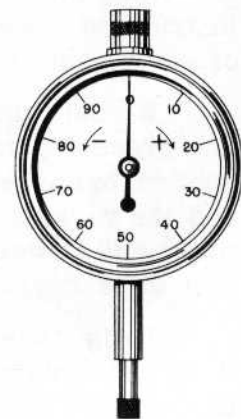


Fig. 3 - Dial Indicator

shafts, both driving and driven, should now be rotated together through 90° or one-fourth of a turn and a set of readings taken.

The reading on the indicator that is riding the face or back, as the case may be, of the driven flange will show the angular displacement in thousandths of an inch. This reading will be written either as a zero if the indicator does not show movement, or as a plus or minus value. If the pointer moves in the direction of increasing numbers, that is, 10-20-30 etc., it should be written as a plus value. If the indicator reads in the opposite direction such as 90-80-70 etc., it should be written as minus (-) 10, 20, 30 etc., respectively. We will assume it reads a + .003" for this example and therefore will record it as such.

Next the indicator riding on the rim of the driven coupling is read. The result shows the amount of radial displacement at this point and is recorded. For example we will assume it reads + .005".

This procedure is repeated at 90° intervals and the reading recorded until the indicators are back to the same point they were at the start of the check, that is, the top. At this point both indicators should again read zero. If they do not read zero, the readings just taken should be disregarded and the entire setup checked for tightness and a new set of readings taken. If the indicators return to zero, it may be assumed that the obtained indicator readings are accurate. A typical set of readings is shown in Fig. 4.

These readings show a maximum indicator reading of .004" for coupling angularity, and a maximum indicator reading of .005" for radial run-out.

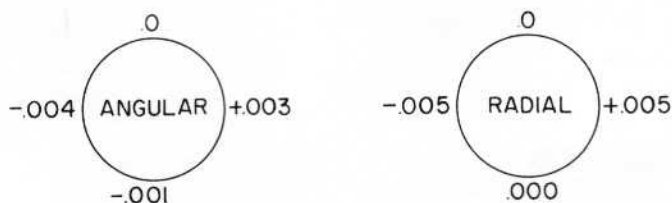


Fig. 4 - Typical Set Of Indicator Readings

Generally speaking, the alignment of this coupling would be satisfactory for service; in most cases limits of .010" total indicator reading for angular misalignment, and a .010" total indicator reading for radial misalignment are allowable.

In the above example, if it were desired to better the radial alignment, a look at the figures makes it evident that the shaft is satisfactory as far as the vertical plane is concerned; in other words, there is no need to raise or lower the shaft. It is apparent, however, that by moving the shaft a distance of .005" horizontally towards the side having the minus (-).005" reading, the total indicator reading for radial alignment will be reduced to zero; this is a very desirable reading but seldom attainable in actual practice.

Corrections for angular misalignment are made by moving the driven shaft so that its center line coincides with the center line of the driving shaft. In the case where the radial alignment is good and angular alignment is out of limits, it is apparent that the coupling end of the driven shaft is located properly, but that its remote end must be moved to correct angular misalignment.

Alignment correction is usually a combined operation calculated to correct both angular and radial misalignment at the same time. It is difficult to give a hard and fast rule governing the thickness in shims to be removed to make a certain correction in alignment because of the varying distances from the coupling to the point at which the shaft is supported. For the correction of radial misalignment when angular alignment is within limits, it is a fairly simple matter to move the shaft at right angles to its axis, the amount shown on the dial indicator where its reading is greatest. It is well worth a few extra minutes of study of the readings taken so that when the move to correct alignment is made it will be in the right direction.

There will be cases where no special tools or instructions are available to accomplish alignment of some particular piece of equipment. Some ingenuity on the part of the operator will take care of such situations. However, it should be remembered that the indicators must be securely mounted to read accurately and both shafts should be rotated together. Make a circle and record the indicator readings, and before making a move of the equipment be confident that the readings have been correctly evaluated.

In case a piece of equipment is being changed out, it is good practice to mount the replacement part on the original shims. This, generally speaking, will give the best possible starting point for alignment.

It is recommended that the alignment tools and dial indicator gauges listed in the latest revision of the Service Tools Catalog #91, should be obtained to facilitate alignment procedures used on EMD rotating equipment.

II. ALIGNMENT OF GENERAL COUPLINGS USED ON ELECTRO-MOTIVE EQUIPMENT

A. ELECTRO-MOTIVE DESIGN COUPLINGS 8198236 AND 8242730

Shown in Fig. 5 are two Electro-Motive design couplings identified by part numbers, 8198236 and 8242730. Coupling 8242730 replaces a previously used similar coupling 8211729, not shown.

Coupling 8242730 has a nominal free length of 6-3/4" compared to a nominal free length of 6-5/8" of coupling 8211729. Therefore, to apply coupling 8242730 in place of 8211729, it is necessary to shorten the drive shaft 1/8" or move the compressor so that the nominal free length of the coupling can be maintained within 1/32" of the 6-3/4" dimension. In addition, coupling 8242730 has provision for 12 bolts instead of 6 in coupling 8211729 at the engine flange. It is recommended that the additional six (6) 21/32" diameter

holes be drilled in the engine flange when applying the 8242730 coupling.

1. Alignment Tolerances

a. Coupling 8198236

Angular alignment of coupling 8198236 should be determined by attaching a dial indicator to a bracket attached to the engine flange as shown in Fig. 6. The

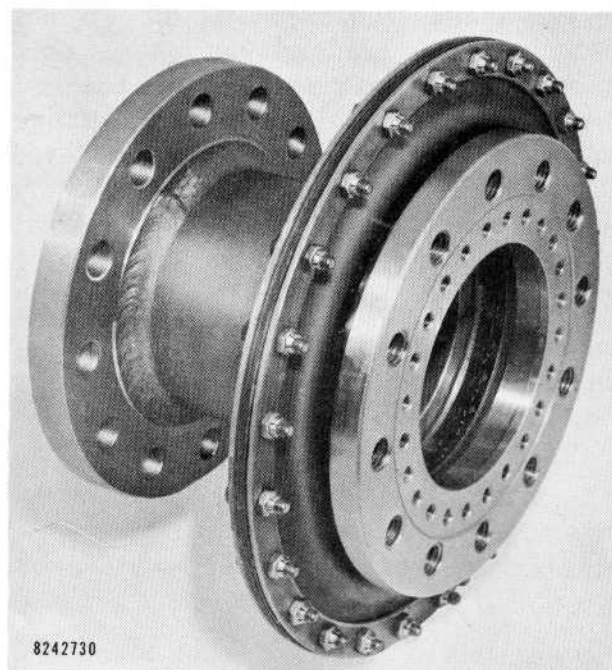
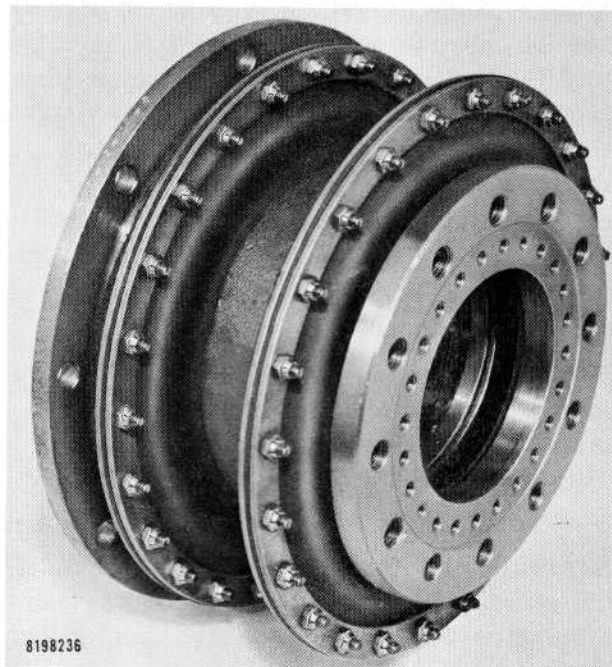


Fig. 5 - Electro-Motive Design Couplings

indicator button should contact the indicating plate attached to the opposite flange at a radius equivalent to or greater than that of the coupling outside diameter. Both flanges are to be revolved together. Angular misalignment should not exceed a .020" total indicator reading. Indicator readings should be taken every 90° of revolution.

Radial alignment should be determined by attaching an additional dial indicator to the indicator bracket attached to the engine flange. The indicator button should contact the indicating plate as shown in Fig. 6 or at the outside diameter of the end flange. Radial misalignment should not exceed .020" total indicator reading when revolving both shafts together. Indicator readings should be taken every 90° of a revolution.

Upon assembly of the coupling, sufficient clearance must be provided so as not to exceed a 6"

+ .131" - .081" dimension between the outside faces of the coupling.

To maintain the alignment within the limits given, the driven equipment must be positioned by moving or adding whatever shims are required. After securing proper alignment, recheck the readings after bolting the unit down and if satisfactory, apply the locating dowels.

b. Coupling 8242730 or 8211729

It is only necessary to inspect these couplings for angular alignment. The angular alignment should be determined by attaching a dial indicator to a bracket attached to one coupling flange, as shown in Fig. 7. The button of the indicator should contact the back side of the flange on the opposite end of the coupling. When the coupling is assembled and the shaft rotated, indicator readings should be taken

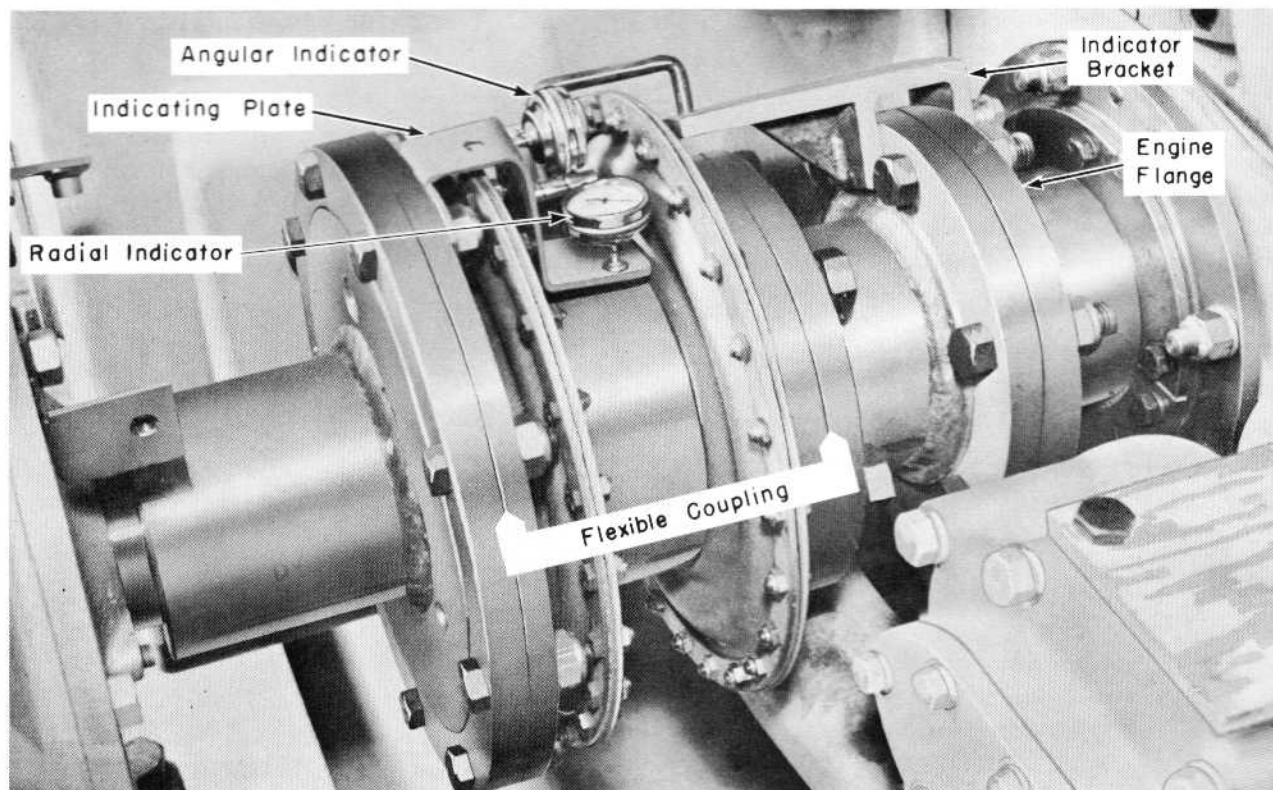


Fig. 6 - Dial Indicator Location For Alignment Of Coupling 8198236

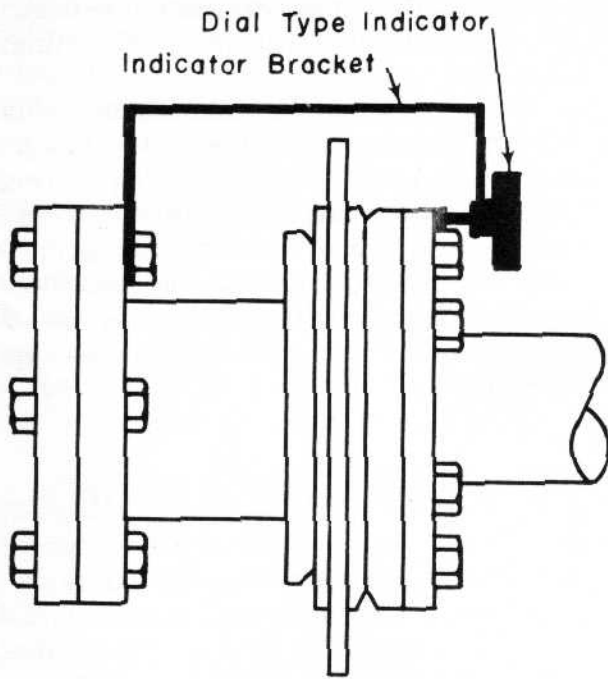


Fig. 7 - Dial Indicator Location
For Alignment Of Couplings 8242730
Or 8211729

every 90° of rotation. Indicator readings must not exceed .020" total indicator reading when indicating point is on not less than an 8" diameter circle.

An assembled coupling overall length between the outside faces of the coupling should not vary more than 1/32" for either the 6-3/4" length of coupling 8242730, or 6-5/8" length of coupling 8211729.

Positioning of the driven equipment with this coupling as with the coupling covered in (a) preceding is required for correct alignment.

B. RUBBER COUPLING 8234919, 8236433 AND 8236434

A representative application of the rubber drive coupling is shown in Fig. 8.

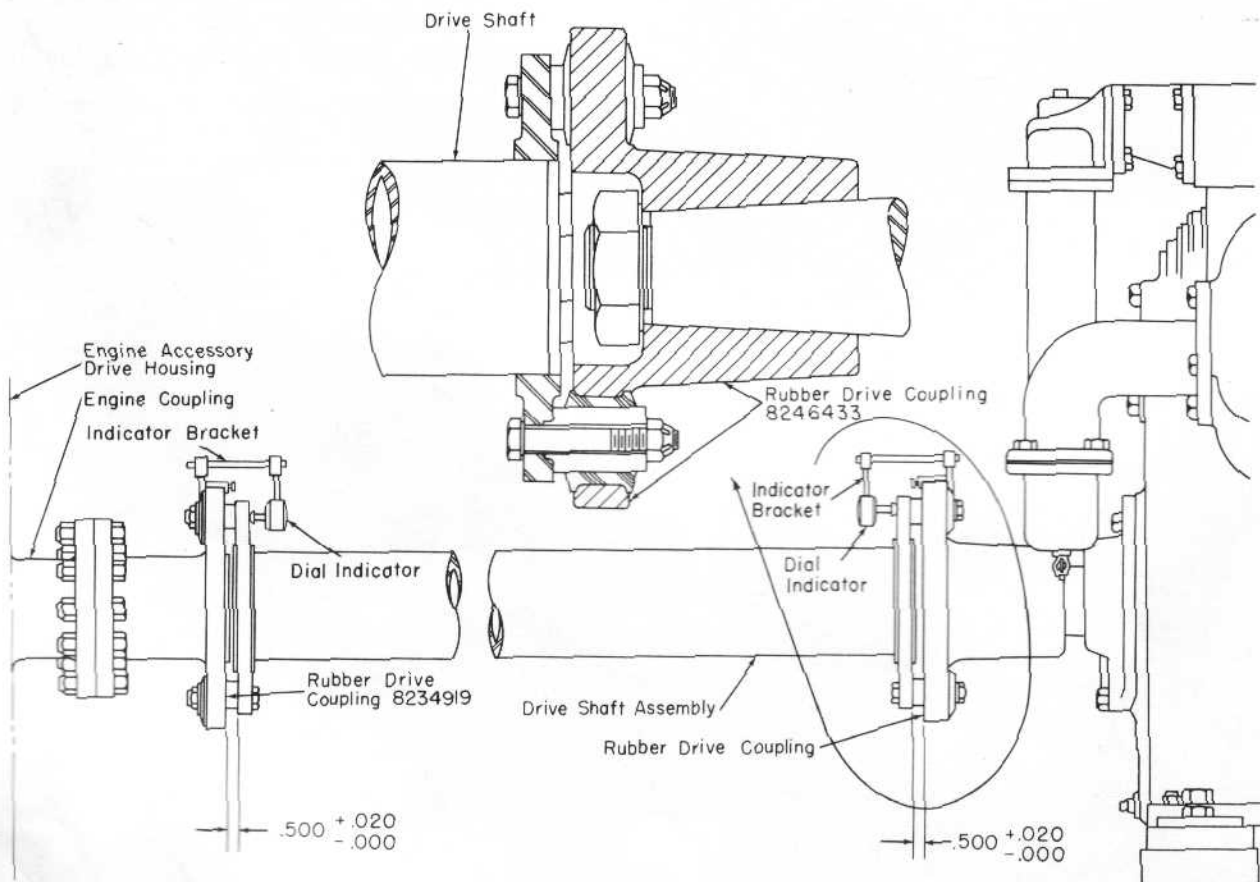


Fig. 8 - Representative Application Of Rubber Drive Coupling

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.

1. Length Measurement

The distance between the mating faces, as shown in Fig. 8, must be held to $.500'' + .020'' - .000''$, at the 6 o'clock or bottom vertical position, with the 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 $.470''$.

2. Angular Alignment

a. Using Dial Indicator

Angular alignment at each flexing member can be measured by attaching a dial indicator, Fig. 8, 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 at zero (0) 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 $.020''$ total indicator reading when indicating point is on not less than a 10" diameter.

b. 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 remeasure at 90° intervals. The readings taken (8 for each coupling) must be within $.020''$ of each other.

3. Replacement Of Rubber Bonded Bushing

The rubber couplings outlined in the preceding, 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 application of the rubber bonded bushing, puller tool 8239562 may be used. As shown in Fig. 9, the tool parts are used in opposite sides of the coupling depending upon removal or application of the bushings.

When installing the rubber bonded joint bushing(s), a small amount of rubber lubricant 8251651 should be applied on the leading pressed rubber

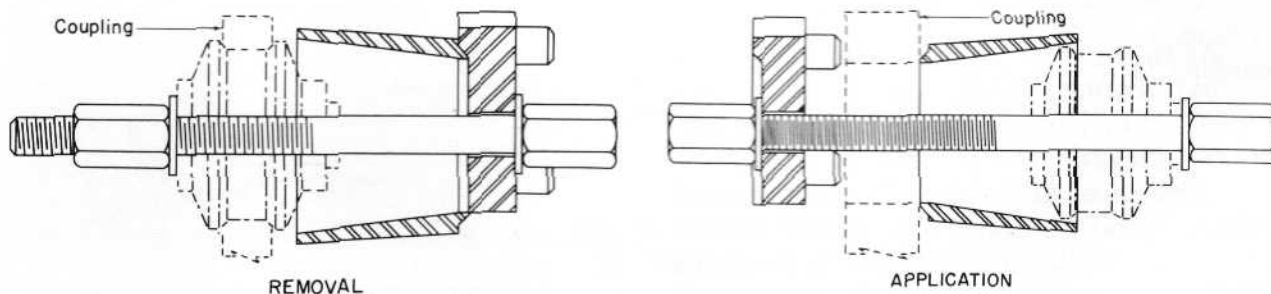


Fig. 9 - Rubber Coupling Bonded Joint Puller

edge of the bushing. (When ordering this lubricant, it is recommended that quantity desired be specified.) This lubricant is mixed with three to five parts of water before use, and should be stirred occasionally while in use. Other lubricant may be used, which is not detrimental to the bushing.

NOTE: After bushing application, it is recommended that at least 72 hours elapse before installing the coupling. This waiting 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 bonded joint bushing must be installed past its normal location to properly seat the lips of the bushing. Bonded joint bushing installing and removing tool 8239562 must be reversed and the bushing centered or until a $.470'' \pm .010''$ dimension shown in Fig. 10 is obtained to maintain the bushing faces in the same plane. If tool 8239562 is not available, a press may be used to install the bushing(s).

Special gauge 8254465, Fig. 11, is available to measure the $.470'' \pm .010''$ dimension. This gauge consists of a tripod-legged base supporting a lever indicating arrangement at its center. To measure the $.470'' \pm .010''$ dimension, the gauge is positioned so its large tripod legs rest on the flange of the coupling and its center actuating disc contacting the metal center sleeve of the bushing, inside the locating prongs. If the bonded joint 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, $.460''$, $.470''$ and $.480''$ 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. Gauge 8254465 is placed on this assembly to check the pointer positioning.

C. MORFLEX DESIGN COUPLING

1. General Coupling Applications

Fig. 12 shows an application of dial indicators for checking the auxiliary generator drive coupling alignment.

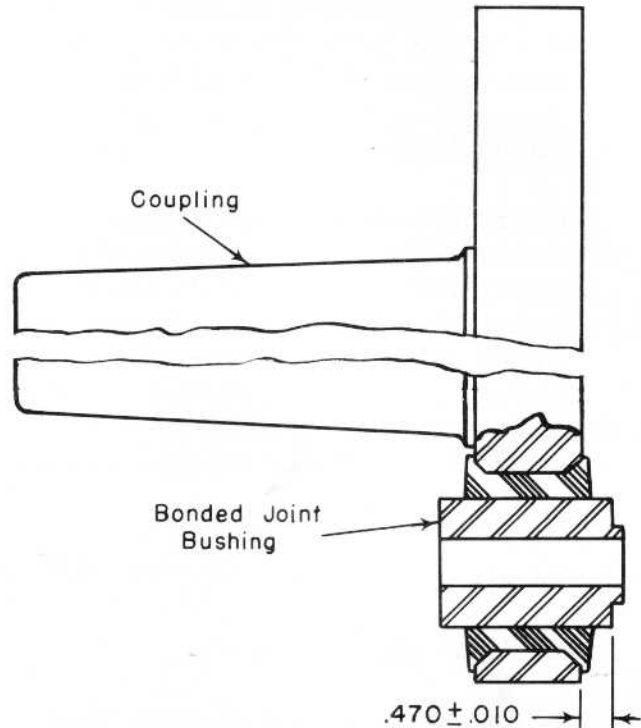


Fig. 10 - Application Dimension Bonded Joint Bushing To Coupling

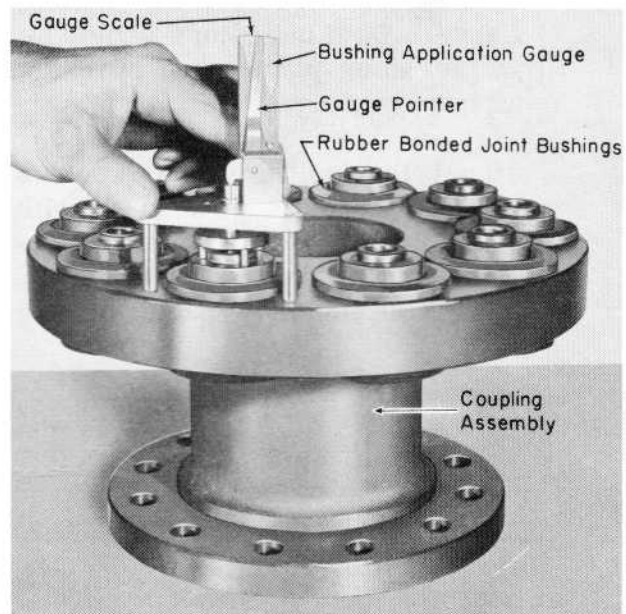


Fig. 11 - Bonded Joint Bushing Gauge 8254465 Application

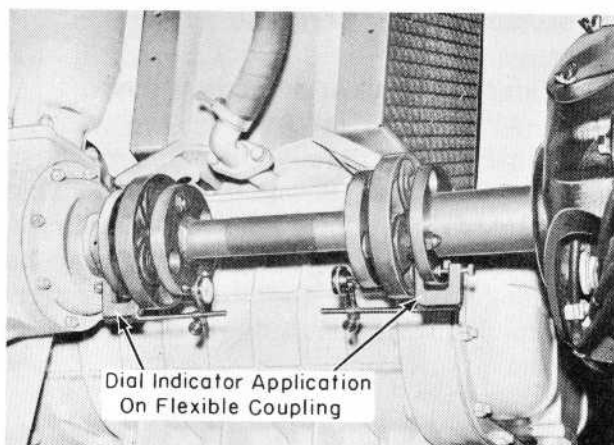


Fig. 12 - Auxiliary Generator Drive Coupling Alignment

The auxiliary generator must be installed so that the mounting distance between the coupling flanges on driving and driven assembly do not vary from the coupling assembly free length more than $1/32''$. This information is pertinent to all general installations of this design coupling.

Angular alignment is checked by the indicators 8039138 mounted as shown in Fig. 12. The indicators are attached to brackets secured to the respective drive flange with the button of the indicators contacting the inner face of the inside coupling flange. Position the indicators directly across from each other at the 12 o'clock position and set the dials to zero (0). Rotate the coupling by turning the engine crankshaft, taking indicator readings every 90° of rotation. The auxiliary generator should be positioned and/or shims added or removed so an angular deflection shown on either indicator does not exceed $.020''$ total indicator reading.

2. Traction Motor Blower Drive - Switcher Locomotives

In this application, the traction motor blower is driven from the generator by a belt drive. The belt sheave at the generator end transmits rotative force to the blower through a drive

shaft having a flexible coupling at the blower end and at the generator end. At the sheave or generator end, the shaft is supported in a pillow block bearing which may be adjusted transversely to permit belt tension adjustment. Angular alignment should be measured with the pillow block in the center of its transverse adjustment.

Dial type indicators are attached to respective flanges so that the indicator button contacts the inner face of each mating coupling flange, similar to indicator location shown in Fig. 12. The blower housing must be positioned to align the drive shaft.

Using the engine turning bar, rotate the generator armature and the blower drive shaft. Record the indicator reading at each coupling. Position the blower housing so that the angular indicator reading on either indicator does not exceed $.020''$ total indicator reading.

NOTE: This alignment will permit pillow block relocation to either extremity of slotted adjustment for application of belts or adjusting belt tension, without exceeding the limits of the coupling.

D. STEEL DISC COUPLINGS (ALL EXCEPT GENERATOR COUPLINGS WHICH ARE OUTLINED IN THEIR RESPECTIVE APPLICATIONS)

A representative steel disc coupling is shown in Fig. 13, as used for the air compressor drive. The alignment of this coupling is generally made in conjunction with another different design coupling at the drive end of the connecting shaft. In this event, the indicators used should be in the same plane so readings of respective locations will coincide.

Steel disc coupling angular alignment should be determined by attaching a dial type indicator to the shaft coupling as shown in Fig. 13, and the indicator button contacting against the face of the connecting flange at a radius equal to or

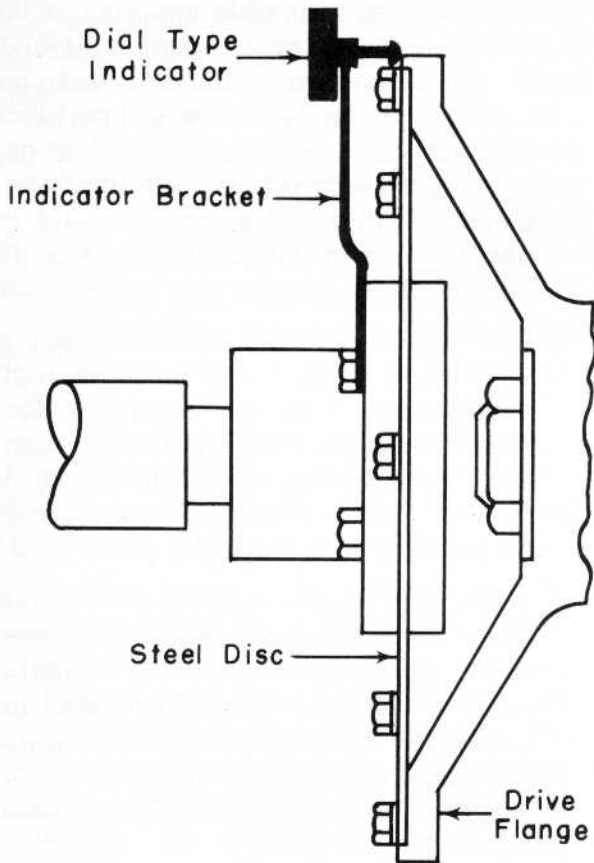


Fig. 13 - Steel Disc Coupling Alignment

greater than that of the disc. The equipment aligned must be positioned so that the angular alignment as shown on the indicator does not exceed a .010" total indicator reading when revolving both shafts together.

E. FALK TYPE COUPLINGS

1. General Coupling Applications

A representative application of these couplings is shown in Fig. 14. This illustration shows two Falk couplings, however, the Falk couplings may be used with other coupling designs outlined in this instruction depending on the application.

Upon assembly of the couplings to the shaft, it is first necessary to provide for a clearance between the hubs of each coupling as shown in Fig. 14. The gap between the hubs of this type of coupling is a minimum of 1/8" and a maximum of 5/16".

Couplings driving a shaft unsupported except by the couplings themselves need not be aligned radially. Couplings connecting shafts both supported in bearings should be aligned radially. In either event, the couplings must be aligned angularly.

Coupling angular alignment should be determined by attaching the dial indicator to a bracket secured to either the hub or shaft as shown in Fig. 14. The indicator button may contact either the coupling cover or the face of the opposite coupling half at a radius

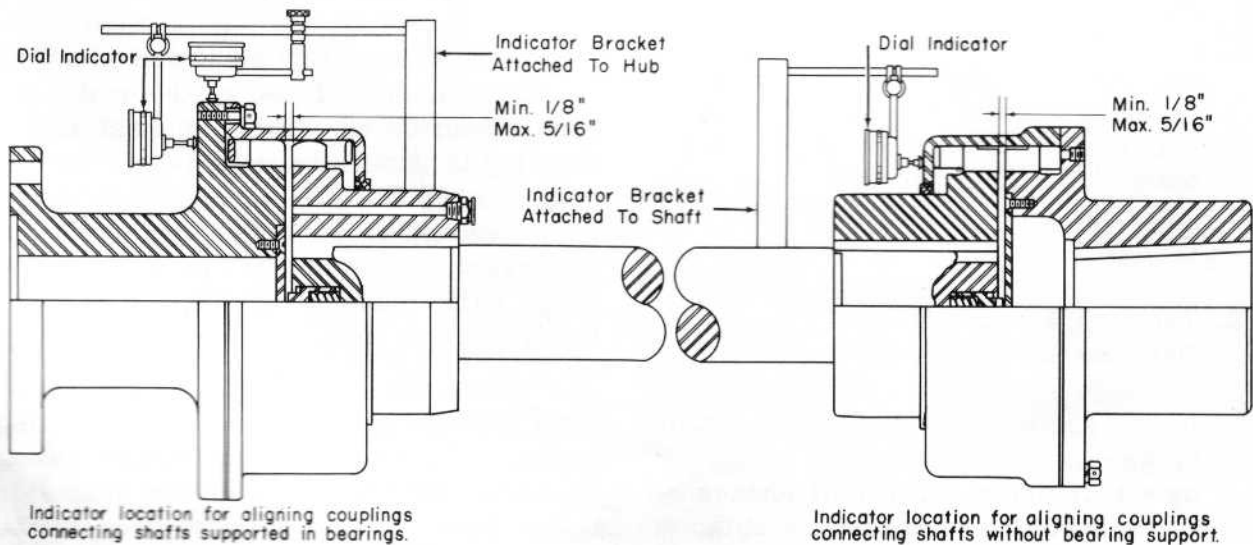


Fig. 14 - Representative Application Of Falk Type Coupling

equivalent to that of the grid member. Both coupling halves should be rotated together with indicator readings taken at every 90° of rotation. Angular misalignment is not to exceed .010" total indicator reading when revolving both shafts together.

Coupling radial alignment should be determined by attaching the dial indicator to the same bracket used to hold the indicator for angular alignment. The button of the indicator used for radial alignment should contact the outside of the opposite coupling half as shown in Fig. 14. Readings of both angular and radial indicators should be taken together at each 90° of rotation. Radial misalignment is not to exceed .010" total indicator reading when revolving both shafts together.

When couplings are assembled to floating shafts, the overall length of the assembly must be maintained within $\pm 1/32"$, to insure the centering plungers and spring operate properly. After proper alignment, lubricate the coupling as outlined in Item 3, and complete final assembly.

2. Falk Coupling 8190186 For Air Compressor Drive On F Model Locomotives

The alignment of the generator to compressor drive coupling is made after the generator to engine alignment has been completed.

A gap or space must be maintained between the mating faces of the coupling, which as shown in Fig. 15 should not be less than 3/16", nor more than 5/16". The compressor is moved either toward or away from the generator to provide this gap measurement. After the gap measurement is obtained, check the alignment of the coupling.

Coupling radial alignment is determined by mounting a dial indicator to a bracket attached to the generator half of the coupling. The button of this indicator, Fig. 15, should contact the outside of the opposite half of the coupling. Radial misalignment should not exceed .010" total indicator reading when revolving both shafts together.

Angular alignment, Fig. 15, should be determined by measuring the gap between coupling halves at 90° intervals about the coupling circumference, using a block and feeler gauge. Coupling gap is not to vary more than .010".

After positioning the compressor to bring the alignment within limits, secure the mounting bolts, recheck the alignment, and if satisfactory, apply the mounting locating dowels.

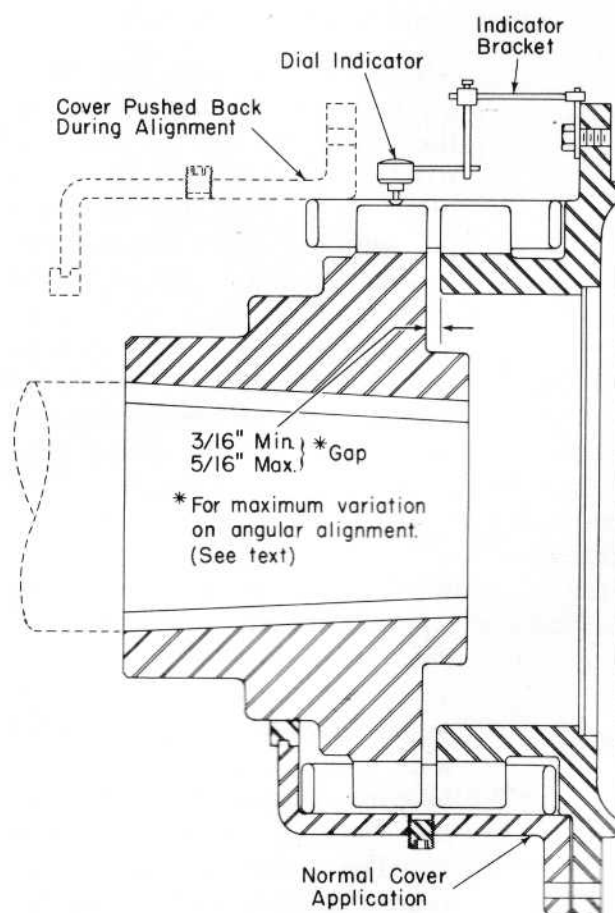


Fig. 15 - Coupling 8109186 Alignment Details

3. Lubrication Of Falk Couplings

To insure proper operation and service life the Falk couplings should be lubricated according to the following procedure.

When the coupling is in operation, all of the lubricant is thrown outward. Therefore, it is essential that the coupling contain sufficient lubricant to completely surround the grid springs and prevent excessive wear. The lubricant also expands, and if sufficient space is not retained for this expansion, gaskets and seals may be ruptured. The correct lubricant capacity of the coupling is half the volume of the lubrication cavity. Use a lubricant having specifications similar to N.L.G.I. (National Lubricating Grease Institute) #3.

a. Lubrication At Installation

(1) Hand Pack

After the coupling has been aligned, and before inserting the grid spring into the grooves, fill the gap between the coupling faces with lubricant and pack the lubricant into the grid grooves. After installing the grid springs, pack the spaces between and around the springs with lubricant. Add lubricant to the ends of the springs to completely fill the cover when in a closed position.

(2) Pressure Fill

Where pressure lubricating equipment with a meter for determining quantity is available, the coupling may be assembled dry and then filled with a specified amount of lubricant, as given under following Table I. The lubricant is applied through one of two tapped openings in the coupling. The other tapped opening must be opened during filling to vent the coupling.

b. Routine Lubrication

To replenish the supply of lubricant during regular maintenance operations, the coupling should be rotated to place the plugged openings on the horizontal center line. Remove both pipe plugs and apply pressure fitting to one opening only. Add lubricant until level with vent opening. Then remove pressure fitting and reinstall pipe plugs in both openings.

Table I

Coupling Size	Gap Between Faces		Lubricant Req'd - Lbs.
	Min.	Max.	
4	1/8"	3/16"	1/8
7	1/8"	5/16"	1/2
11	1/8"	5/16"	1-1/4
12	1/8"	5/16"	1-1/2
13	3/16"	5/16"	1-7/8
14	1/8"	5/16"	2-1/8
15	1/8"	5/16"	2-1/2

III. ALIGNMENT OF LOCOMOTIVE GENERATORS

The maintenance information contained in this instruction will enable a qualified person to align the generators to the engines on Electro-Motive locomotives. General information on the alignment of coupled shafts of rotating machinery is given in the first section of this instruction, and it is suggested that it be studied before attempting the actual alignment procedure.

The engines and generators installed in locomotives at Electro-Motive are correctly aligned and tested before the locomotive is delivered. It is recommended that the alignment be checked or inspected at intervals specified in the Scheduled Maintenance Instruction. In either event of aligning or checking alignment, the limits given for each particular generator in this instruction should be followed.

In order to make the assembly of the generator and engine revolve true and comparatively free from vibration, the alignment through the coupling must be exact. Also, 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. It is necessary that the armature run free, that is, so that the shaft does not cramp the rollers of the spherical bearing. This condition is obtained by assuring that the proper bearing and clearance is maintained.

A. ENGINE TO GENERATOR FLEXIBLE COUPLING INFORMATION

The main 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 half disc and a generator half disc comprise the flexible coupling. Each disc is mounted at its center to its respective part by six mounting bolts and both halves joined at the rim or outer circumference by twelve bolts. The engine disc support or 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, Fig. 16, connecting the engine and generator are the same, however, they do differ somewhat in design. The principle difference is at the rim or disc support connection.

Early couplings were "rim" piloted, either two or three piece. Original couplings were three piece having body bound bolts both at the rim and center mounting bolts. An oversize bolt at the rim served to correctly position the disc support to the engine half disc. The two piece coupling replaced the three piece coupling. This coupling is equipped with through bolts at the rim, retaining a larger locating rim bolt. Body bound bolts at the center mounting were later replaced to provide clearance at the disc to mounting bolt.

Current couplings have a "V" channel in the engine half and a "V" serration in the generator half disc, and are identified as a "serrated" design. Mounting bolts, both rim and center have clearance holes at the couplings. This design of coupling provides for interchange between units not possible with earlier body bound or reamed fit mounting bolts. However, the following recommendations should be adhered to in the application of the serrated coupling.

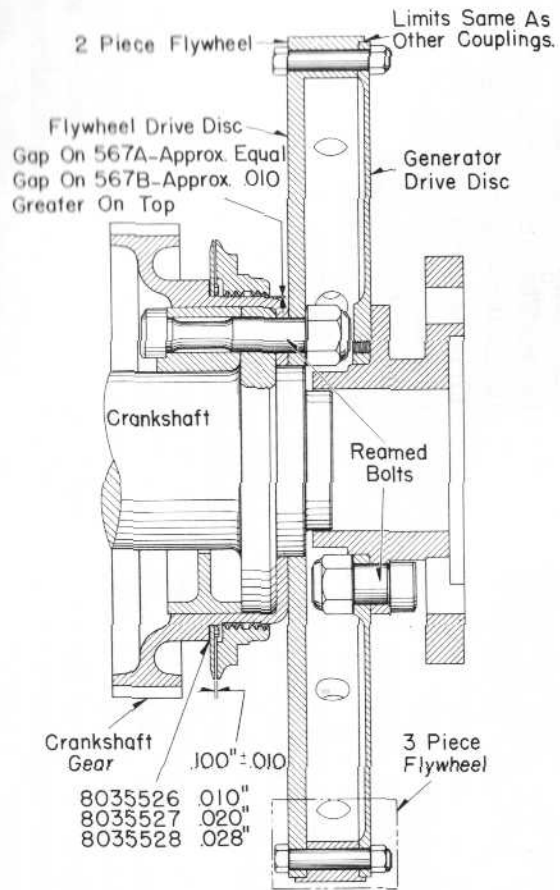
1. Serrated Coupling Instructions

Upon installation of the generator, the generator disc is matched up to the engine coupling and the rim bolts applied and properly torqued to 295 foot-pounds. The coupling is then checked as follows:

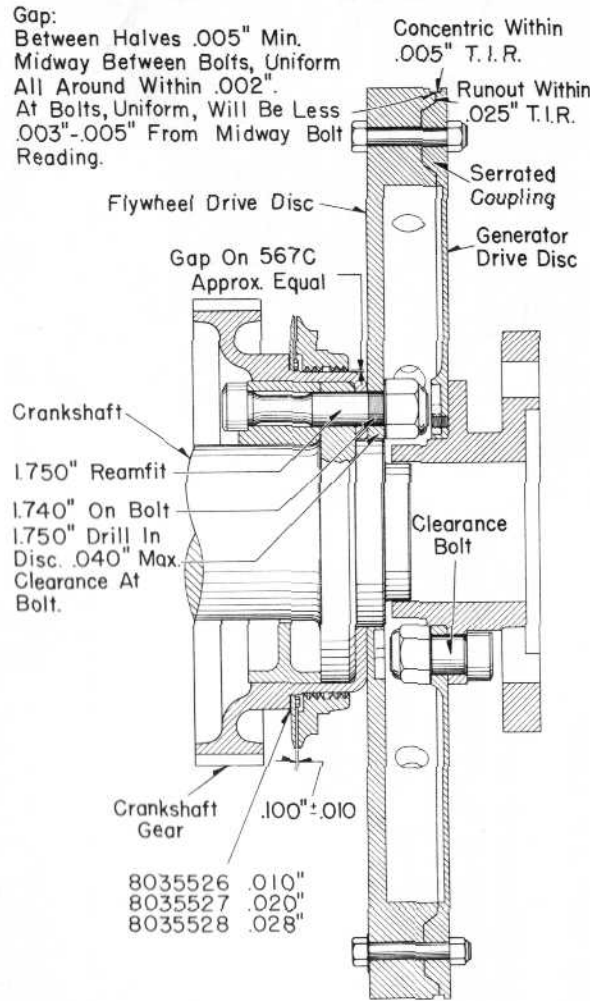
- a. The gap between engine and generator coupling halves should not be less than .005". The gap as measured midway between the bolts must be uniform within .002" around the entire periphery of the coupling joint. The gap at the bolts must also be uniform, but will be .003" to .005" less than between the bolts. Care should be taken to tighten all coupling bolts uniformly to avoid cocking of the coupling on the serrations.
- b. 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 run-out 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 switcher locomotives.

B. INSTALLING THE GENERATOR

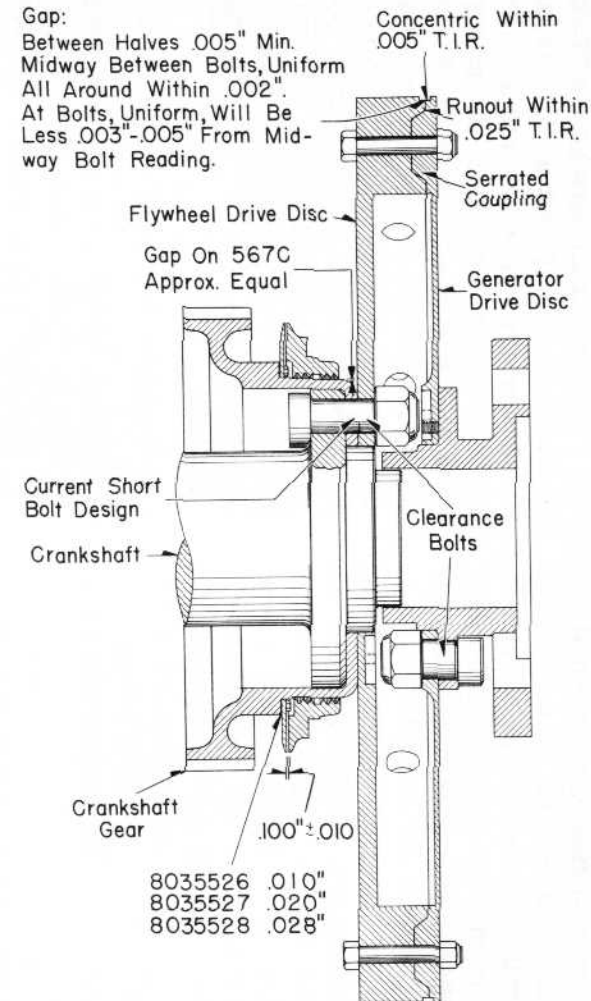
Although each of the generators which will be covered in the following instructions will differ somewhat in general arrangement, the installation of each will be similar. To avoid installation



Prior Used Rim Pilot Design Coupling



Original Serrated Coupling



Current Serrated Coupling Arrangement

Fig. 16 - Engine To Generator Flexible Coupling Details

procedure repetition, the installation procedure given here can apply to all locomotive generators.

1. Before attempting to install the generator, inspect its general condition, that it is satisfactory for the installation.
2. Inspect the mounting pads of the generator and mounting bases on the locomotive to see that they are clean, smooth and free from raised nicks or burrs.
3. Inspect the mounting shims that are to be used to align the generators to see that they are smooth and clean.
4. Just before installation, lightly oil the mounting bases, pads and shims to ease workability.
5. Check tightness of center mounting bolt nuts of both the engine half disc and the generator half disc. Torque value of the generator disc mounting bolts is 1200 foot-pounds with lubrication.
6. Inspect the mating fit at the engine and generator disc rim that surfaces are smooth and clean. Apply a small quantity of white lead to the fitting surfaces. Check bolt holes that they are clean.
7. Place two 1/8" shims on the generator base and using a suitable hoist, place the generator on its base with its coupling disc close to but not contacting the engine half disc. Weights of Electro-Motive generators are approximately: D12-D14, 18,000 lbs. and D15-D16 about 13,000 lbs.
8. Move the generator close to the engine disc. Examine the line up of the rim mounting bolt hubs of the two discs and center pilot that the two discs may be brought together without interference. Also, check the center mounting nuts on the opposite disc that they will cause no interference when the discs are brought together. Use jacking screws 8164036 in the tapped holes provided in the generator base to adjust the position

of the generator to provide alignment. Apply or remove shims if required, to provide correct position.

9. After making sure that the discs can be brought together satisfactorily, move the generator toward the engine disc to permit rim bolt application. If line up is necessary between the two discs, rotate the engine disc. Do not rotate the generator disc until the armature supporting shims have been removed.
10. Apply two rim bolts 180° apart, one bolt being the large diameter locating bolt, if used. After the armature is supported at the coupling, remove the armature supporting shims.
11. After the armature is free to be turned, apply the remaining rim bolts. Torque value of the rim bolt nuts is 295 foot-pounds. Open the engine cylinder test valves to relieve compression to make turning easier. It is suggested also that the information given under A-1 should be reviewed regarding the serrated coupling, if used.
12. Line up holes in the generator base and apply the generator mounting bolts with lockwashers, in preparation for aligning the generator.

C. GENERAL ALIGNMENT INFORMATION

Instructions covering the alignment of specific generators will be given in the following, to include particulars affecting each generator or group of generators. In general each instruction will follow a set operational procedure outlined as follows:

1. Bearing Positioning, Thrust Clearance Or End Play
 - a. This is the longitudinal positioning of the bearing in its housing and armature location in reference to the stator frame.

During the armature-frame assembly the armature is purposely positioned so that its end movement

is taken up in the direction toward the engine coupling disc to determine the total longitudinal end play. This permits a bearing dimension to be obtained so that proper thrust clearance is provided at each end of the bearing. Thrust clearance on most locomotive generator bearings is $1/16''$ at the engine end and $1/8''$ at the opposite end. Positioning of the armature to obtain these clearances is made by reference measuring points on each respective model generator. These reference places will be given for each generator. Proper positioning of the single bearing also automatically positions the armature in relation to the frame.

2. Generator Shaft Alignment And Air Gap Equalization

a. Radial Alignment

Radial alignment of the armature is required to equalize the air gap between the armature and the field poles.

b. Angular Shaft Alignment

Angular shaft alignment provides for the coaxial positioning of the generator shaft with the engine crankshaft to neutralize any incline of the generator shaft.

Operations "a" and "b" under Item 2 are carried out at the same time after first completing Item 1.

D. ALIGNMENT OF D12, D12A, D12B, D12C AND D12D GENERATORS

After completing preceding steps "A" and "B," the alignment procedure outlined in "C" is carried out as follows:

1. Bearing Positioning, Thrust Clearance Or End Play Adjustment

- a. The total end play of the bearing of D12 generators is about $5/16''$. (This $5/16''$ dimension may change if bearing parts are replaced.) A thrust clearance or end play of

$1/16'' + 3/64'' - 1/64''$ between the bearing outer race and inside bearing cap must be maintained on these generators.

- b. The $1/16'' + 3/64'' - 1/64''$ bearing end clearance is determined by positioning the generator frame in respect to the armature, equal to a reference measurement "x," Fig. 17, plus the $1/16'' + 3/64'' - 1/64''$ clearance. Reference dimension "x" varies on different generators depending upon generator equipment. Dimension "x" is determined by moving the armature as far as possible toward the engine coupling end of the generator and measuring between reference points on the generator. This permits determination of the longitudinal position of the armature in respect to the generator frame at all times.

- (1) On D12 generators equipped with coupling adapter 8140426 the reference measurement "x," Fig. 17, is taken from the top right bolt spot face of the outer bearing cover to the outer end surface of the coupling adapter. Dimension "x" in this case is about $7-15/32''$ and is stamped in $1/2''$ numbers on top one of the horizontal ribs of the generator end bell. Thus to provide $1/16''$ clearance at the engine end of the bearing, the stator must be positioned so that a dimension at "x" equals $7-15/32'' + (1/16'' + 3/64'' - 1/64'')$. After obtaining this dimension tighten the generator base bolts.

- (2) On D12A, B, C and D generators which do not have a drive flange, a measurement dimension "x," Fig. 17, is taken from the top right bolt hole spot face of the outer bearing cover to the outer end surface of the slip ring hub assembly. In this

case, dimension "x" will be about 5-29/32". This number will be stamped on top one of the horizontal ribs of the end bell. Consequently, to provide the 1/16" clearance at the engine end of the bearing the stator must be positioned so that dimension "x" equals $5-29/32" + (1/16" + 3/64" - 1/64")$. After obtaining this dimension tighten the generator base bolts.

2. Generator Shaft Alignment And Air Gap Equalization

- a. The aligning procedure is divided into two operations, both of which are carried out at the same time.

Any angularity of the generator shaft as indicated at the engine disc coupling is neutralized and air gap is balanced between the armature and the stator poles.

- b. Two dial type indicators, Fig. 17, are used to check alignment. The plunger of one indicator contacts the generator disc to indicate shaft angularity. The plunger of the second indicator rides the outside machined diameter of the alternator aluminum housing to indicate air gap. The indicators are mounted on supports attached to a rod having 1/4" pipe threads which is screwed into a tapped hole in the alternator spider. Both indicators will revolve together.

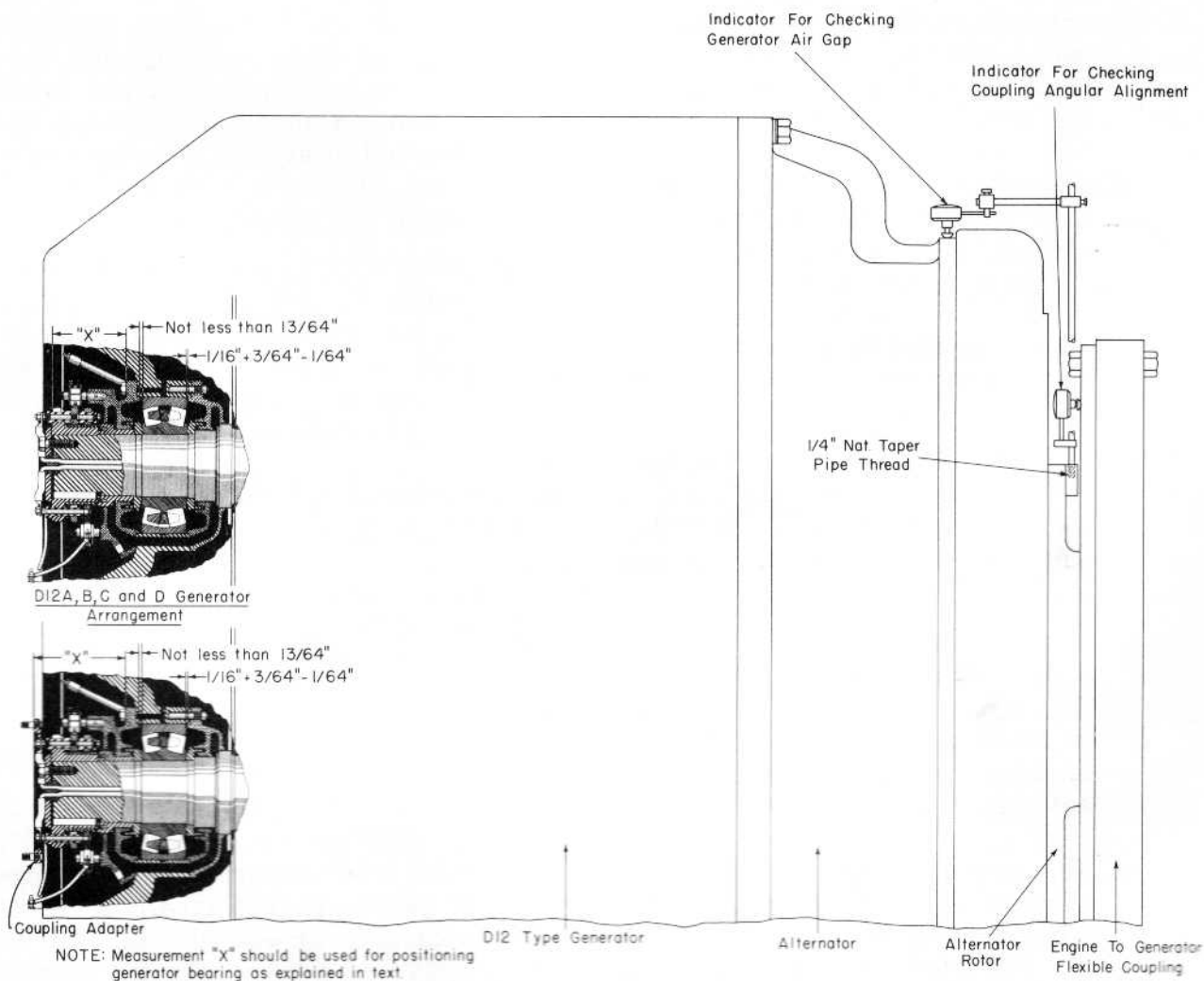


Fig. 17 - Generator Alignment Information Model D12A, B, C And D Generators

c. After clamping the indicators on the rods, and it is ascertained the armature and crankshaft are free to rotate, coupling bolted securely, turn the armature to place the indicator rod in the top vertical position. Depress the indicators to make the pointer complete one turn, then secure it and adjust the knurled bezel to locate the pointer at zero (0). Check indicator installation that it is satisfactory. Depress indicator button and release to check pointer action. Turn the armature 180° clockwise, facing the commutator, using a turning bar or jack at the coupling disc, then return to starting point, to check indicator application. When the indicators are returned to their original position the pointer should again indicate zero (0). If not, further adjustment is required or the indicator is defective.

d. Starting again from the top vertical position, the alignment and air gap are checked and the required adjustments made to bring them within the alignment tolerances. Record the indicator readings every 90° as suggested in Section I.

Turn the armature clockwise, facing the commutator, 180°, taking indicator readings at the coupling and generator frame for air gap every 90°.

Reverse rotation 270° from the preceding 180° position and record the readings taken. It is necessary to reverse rotation, since the alternator terminal board prevents a complete revolution.

e. The generator alignment is considered satisfactory when the indicator readings are to or within the indicator tolerances given in Fig. 18. To accomplish this condition will likely require slight relocation and/or shim adjustment

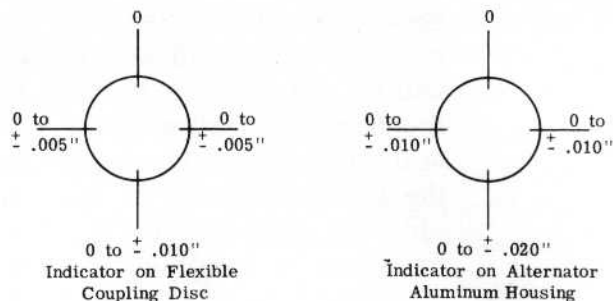


Fig. 18 - Dial Indicator Alignment Tolerances Model D12A, B, C and D Generators

under the generator supports. Full length shims should be used if possible, however, spotshims may be used to conform to the limits given. Since any movement of the generator frame affects both the air gap and the coupling, readings must be taken following any correction. Also, the bearing thrust dimension should be carefully rechecked after final coupling alignment to be sure that it also is within the limits given.

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

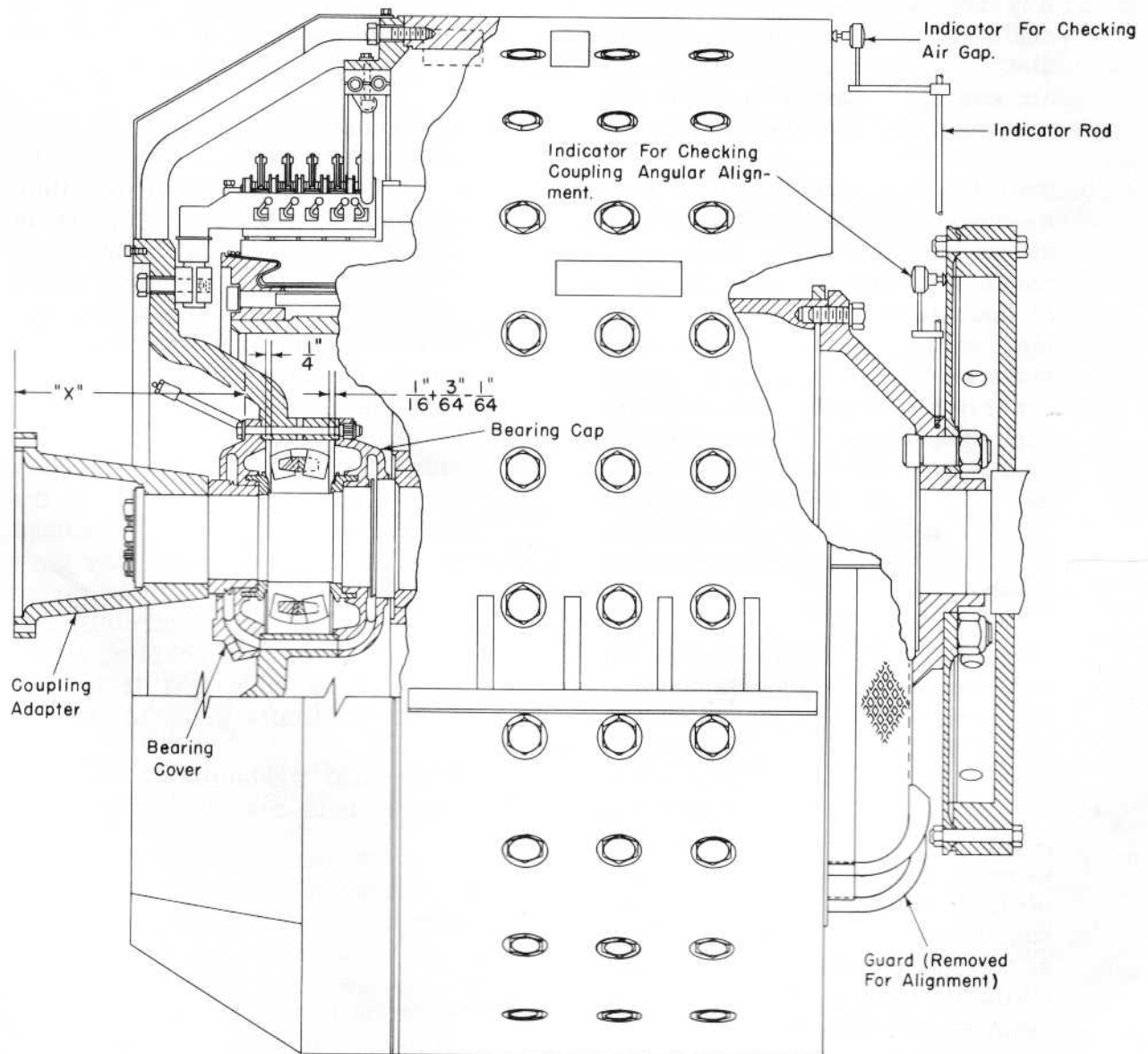
E. ALIGNMENT OF D12F MODEL GENERATORS

After completing preceding steps "A" and "B," the alignment procedure outlined in "C" is carried out as follows:

1. Bearing Positioning, Thrust Clearance Or End Play Adjustment
 - a. The total end play of the bearing of the D12F generator is about 5/16". (The 5/16" dimension may change if parts are replaced.) A thrust clearance or end play of 1/16" + 3/64" - 1/64" between the bearing outer race and the inside bearing cap must be maintained on this generator.

- b. To determine this clearance the armature is moved as far as possible toward the coupling disc end of the generator, and a reference measurement "x," Fig. 19, is made. To this reference measurement is added the $\frac{1}{16}'' + \frac{3}{64}'' - \frac{1}{64}''$ end clearance. The generator stator is then positioned to obtain this total measurement.
- c. On D12F generators equipped with

coupling adapter 8210803, the reference measurement "x" is taken as shown in Fig. 19. This measurement is between the top right bolt spot face of outer bearing cover to the outer surface of the coupling adapter. Dimension "x" for the D12F generators is about 14" and is stamped in 1/2" numbers on top one of the horizontal ribs of the generator end bell. Thus to provide 1/16" clearance



NOTE:

Measurement "X" should be used for positioning bearing as explained in text.

Fig. 19 - Generator Alignment Information Model D12F Generator

at the inside end of the bearing, the stator must be positioned so that dimension "x" equals $14'' + (1/16'' + 3/64'' - 1/64'')$. After obtaining this dimension, tighten the generator base bolts.

2. Generator Shaft Alignment And Air Gap Equalization

- a. The aligning procedure is divided into two operations, both of which are carried out at the same time. Any angularity of the generator shaft as indicated at the engine disc coupling is neutralized and air gap is balanced between the armature and the stator poles.
- b. Two dial type indicators are used to check alignment. The plunger of one indicator contacts the generator disc opposite the serration to indicate shaft angularity. The plunger of the second indicator rides on the finished face of the generator frame to indicate for air gap. The indicators are mounted on supports attached to a rod having $1/4''$ pipe threads, which is screwed into the drive hub as shown in Fig. 19. Both indicators revolve together.
- c. After clamping the indicators on the rods, and it is ascertained that the armature and crankshaft are free to rotate, coupling bolted securely, turn the armature to place the indicators in the top vertical position. Depress the indicators to make the pointer complete one turn, then secure it and adjust the knurled bezel to locate the pointer at zero (0). Check indicator installation that it is satisfactory. Depress indicator button and release, to check pointer action. Turn the armature 180° counterclockwise (facing the rear of the generator) using a turning bar or jack, then return to starting point, to check indicator operation. When the in-

dicators are returned to their original position, the pointer should again indicate zero (0).

- d. Starting again at the top vertical position, the alignment and air gap are checked and the required adjustments made to bring them within the alignment tolerances. Record the indicator readings every 90° as suggested in Section I.

Turn the armature counterclockwise, facing the rear of the generator, 270° , taking readings at both indicators at the coupling and generator frame every 90° .

- e. The generator alignment is considered satisfactory when the indicator readings are to or within the indicator tolerances given in Fig. 20. To accomplish this condition will likely require slight relocation and/or shim adjustment under the generator supports. Full length shims should be used if possible, however, spot shims may be used to conform to the limits given. Since any movement of the generator frame affects both the air gap and the coupling, readings must be taken following any correction. Also, the bearing thrust dimension should be carefully rechecked after final coupling alignment to be sure that it is still within the limits given in Item 1.
- f. After final tightening of the generator hold-down bolts, recheck

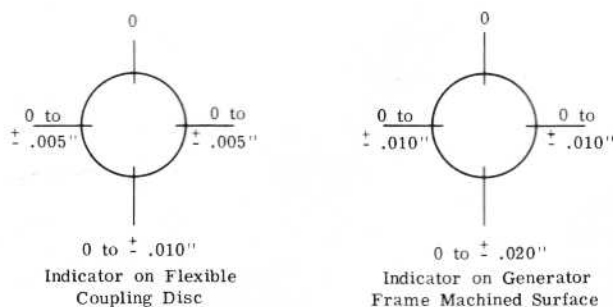


Fig. 20 - Dial Indicator Tolerances
Model D12F Generator

all the alignment tolerances to be sure they have not changed. If all tolerances are satisfactory, dowel the generator to its mounting base.

F. ALIGNMENT OF MODEL D12G, D12H AND D12L GENERATORS

After completing preceding steps "A" and "B," the alignment procedure outlined in "C" is carried out as follows:

1. Bearing Positioning, Thrust Clearance Or End Play

- a. The total end play of the bearing of the D12G, D12H and D12L generators is about $5/16"$. (The $5/16"$ dimension may change if parts are replaced.) A thrust clearance or end play of $1/16" + .000" - 1/64"$ between the bearing outer race and inside cover, as shown in Fig. 21, must be maintained on these generators.
- b. The $1/16" + .000" - 1/64"$ bearing end clearance is determined by positioning the generator frame in respect to the armature equal to a reference measurement "x," Fig. 21, plus the $1/16" + .000" - 1/64"$ clearance. Dimension "x" is determined at original generator assembly by moving the armature as far as possible toward the engine coupling end of the generator, stamping chisel marks at four locations where the bearing cover meets the retainer, then measuring from the chisel marks or bearing cover to the outside face of the shaft retainer. Dimension "x" is about $1/4"$ and is stamped on top one of the horizontal ribs of the generator end housing. After obtaining the $1/16" + .000" - 1/64"$ between the chisel marks and bearing cover face, or dimension "x" ($1/4"$) plus $1/16" + .000" - 1/64"$, the generator base bolts are tightened, in preparation for alignment.

2. Generator Shaft Alignment And Air Gap Equalization

- a. The aligning procedure is divided into two operations, both of which are carried out at the same time. Any angularity of the generator shaft as indicated at the engine disc coupling is neutralized and air gap is balanced between the armature and the stator poles.
- b. Two dial type indicators are used to check alignment. The plunger of one indicator contacts the radial surface of the fan, Fig. 21, to indicate shaft angularity. The plunger of the second indicator rides the outside surface of the ring attached to the generator frame to indicate air gap. (To permit indicator application on the ring the fan housing must be removed on D12G and D12H generators.) The indicators are mounted on supports attached to a rod screwed into a tapped hole in the adapter shown in Fig. 21. Both indicators revolve together.
- c. After clamping the indicators on the rods, and it is ascertained that the armature and crankshaft are free to rotate, coupling bolted securely, turn the armature to place the indicators in the top vertical position. Depress the indicators to make the pointer complete one turn, then secure it and adjust the knurled bezel to locate the pointer at zero (0). Check indicator installation that it is satisfactory. Depress indicator button and release to check pointer action. Turn the armature 180° counterclockwise (facing the rear of the generator) using a turning bar or jack, then return to the starting point, to check indicator operation. When the indicators are returned to their original position, the pointer should again indicate zero (0). If pointer does not return to zero, further positioning or securing of the indicator is necessary.

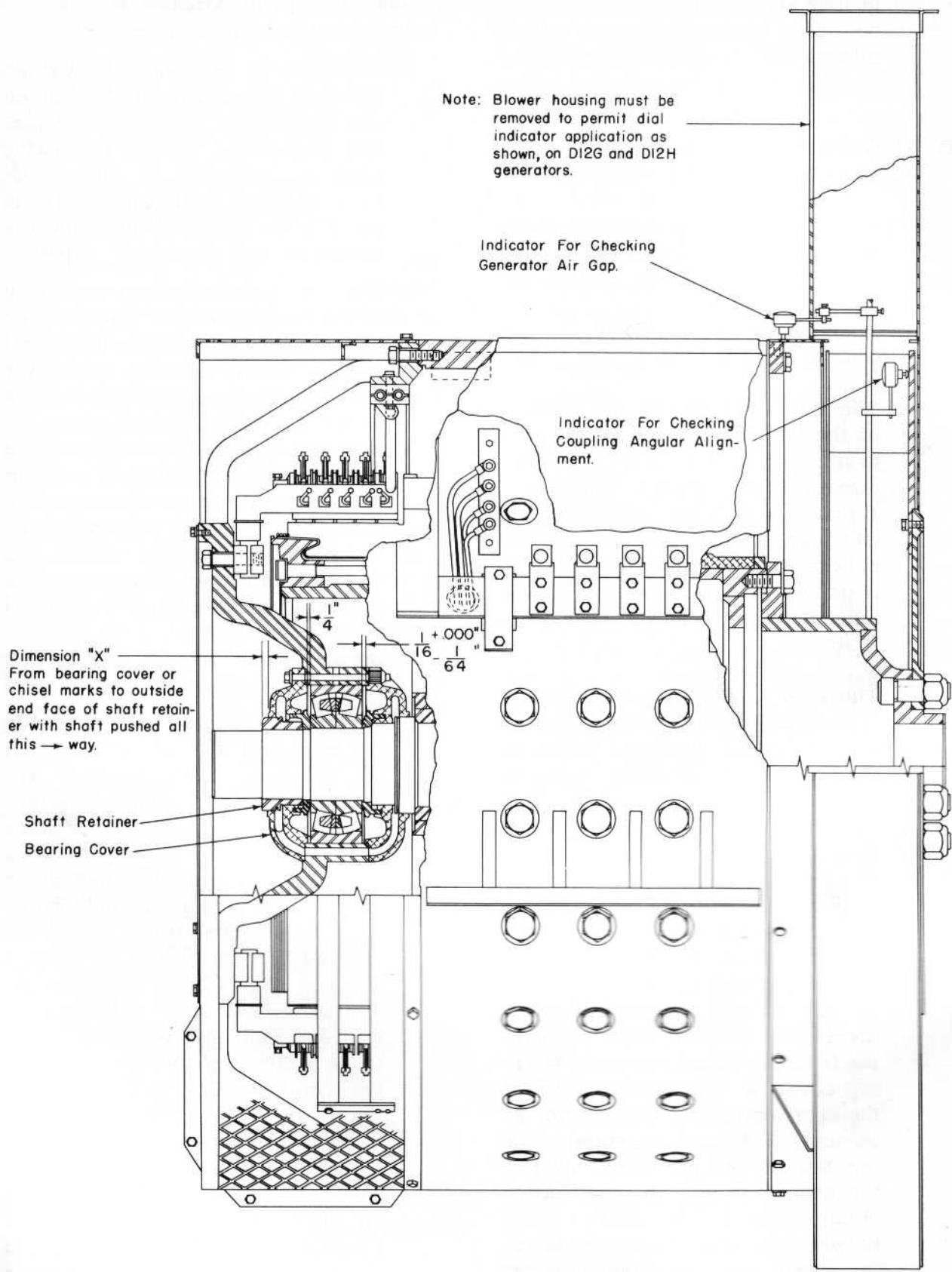


Fig. 21 - Generator Alignment Information Model D12G, D12H, D12L Generators

- d. Starting again at the top vertical position, the alignment and air gap are checked and the required adjustments made to bring them within the alignment tolerances. Turn the armature counterclockwise 270° , facing the rear of the generator. Take readings at both indicators every 90° .
- e. The generator alignment is considered satisfactory when the indicator readings are to or within the indicator tolerances given in Fig. 22. To conform to these tolerances it will likely require slight relocation and/or shim adjustment under the generator supports. Full length shims should be used if possible, however, spot shims may be used to conform to the limits. Since any movement of the generator frame affects both the air gap and the coupling, readings must be taken following any correction. Also, the bearing thrust dimension should be carefully rechecked after final coupling alignment, to be sure that it is still within the limits given under Item 1.
- f. After final tightening of the generator hold-down bolts, recheck all the alignment tolerances to be sure they have not changed. If all tolerances are satisfactory, dowel the generator to its mounting base.

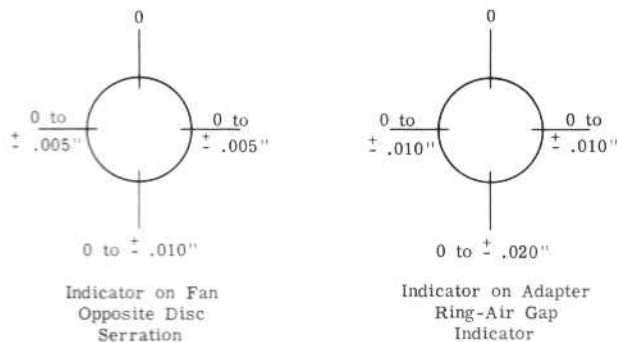


Fig. 22 - Dial Indicator Alignment Tolerances Model D12G and D12H

G. ALIGNMENT OF MODELS D15A, D15C, D15D, D15E, D15F, D15G, D15H, D15J

After completing preceding steps "A" and "B," the alignment procedure outlined in "C" is carried out as follows:

1. Bearing Positioning, Thrust Clearance Or End Play

- a. The total end play of the bearings of these generators is about $3/16"$. (The $3/16"$ dimension may change if parts are replaced.) A thrust clearance or end play of $1/16"$ + $.000"$ - $1/64"$ between the bearing outer race and the inside bearing cap must be maintained on these generators.
- b. The total clearance is determined at original assembly by moving the armature shaft as far as possible toward the fan end of the generators. The shaft retainer is then stamped with chisel marks at four quarter locations where the bearing cover meets the retainer. A reference measurement "x," Fig. 23, is then made from the chisel marks or bearing cover face to the outside end face of the shaft retainer. (This measurement is about $3/16"$ for these generators.) This reference measurement is stamped in $1/2"$ numbers on the end bell, beneath one of the end bell sheet metal covers. To this reference measurement is added the $1/16"$ + $.000"$ - $1/64"$ end clearance. The generator stator must then be positioned to obtain this total measurement so that dimension "x" equals approximately $3/16"$ + $(1/16"$ + $.000"$ - $1/64"$) from the machined face of the bearing cover to the end face of the shaft retainer, or $1/16"$ + $.000"$ - $1/64"$ between chisel marks and bearing cover.

2. Generator Shaft Alignment And Air Gap Equalization

- a. The aligning procedure is divided into two operations, both of which are carried out at the same time. Any angularity of the generator shaft as indicated at the engine disc coupling is neutralized and air gap is balanced between the armature and field poles.
- b. Generator shaft angularity is determined by a dial indicator contacting the inside surface of the fan as shown in Fig. 23. The indicator is secured to a bracket attached to a rod screwed into a tapped hole in the armature shaft hub. The indicator revolves with the fan as the armature is turned.
- c. To determine air gap, a measurement is taken between the outside rim surface of the fan and inside surface of the generator frame. A chalk mark is placed on the fan at some suitable place so that when the indicator readings are taken

a feeler gauge measurement can also be taken between the fan and the inside of the generator frame as shown in Fig. 23. The chalk mark on the fan will assure that the air gap measurement is taken from the same place on the fan.

- d. After clamping the indicator on the rod and it is ascertained that the armature and crankshaft are free to rotate, coupling bolted securely, turn the armature to place the indicator at the top vertical position. Depress the indicator one turn, then secure it and adjust the knurled bezel to locate the pointer at zero (0). Depress the indicator button and release to check indicator action. Turn the armature one revolution and return to starting point, to check indicator operation. When the indicator is returned to its original position, the pointer should again indicate zero (0). If not, further positioning of the indicator is necessary.

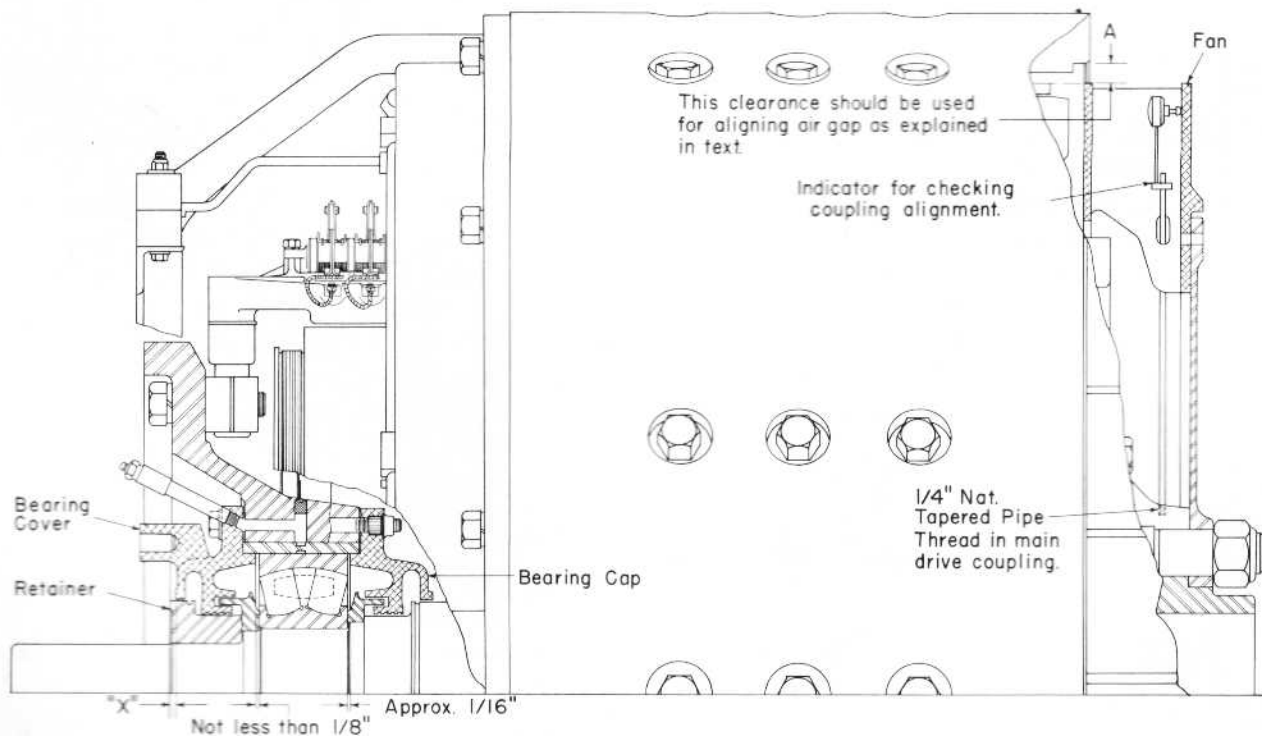
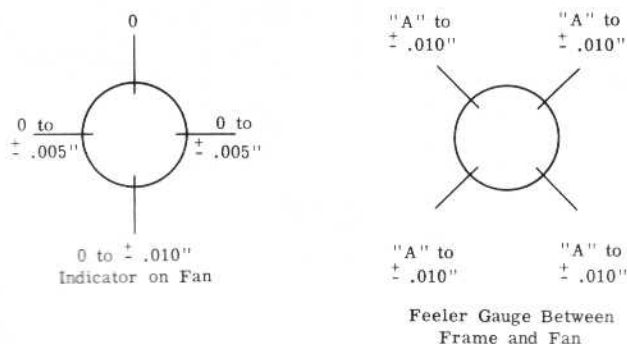


Fig. 23 - Generator Alignment Information
Representative Illustration For Generators Listed Under Item G

- e. Starting again at the top vertical position, the alignment and air gap measurements are taken and recorded. Readings are taken at the indicator and at the chalk mark every 90°.
- f. The generator alignment is considered satisfactory when the indicator readings and air gap measurements are to or within the tolerances given in Fig. 24. To conform to these tolerances will likely require slight relocation and/or shim adjustment under the generator supports. Full length shims should be used if possible, however, spot shims may be used to conform to the limits given. Since any movement of the generator frame affects both the air gap and the coupling, readings must be taken following any correction. Also, the bearing thrust dimension should be carefully rechecked after final coupling alignment, to be sure that it is still within the limits given under Item 1.
- g. After final tightening of the generator hold-down bolts, recheck all the alignment tolerances to be sure they have not changed. If all tolerances are satisfactory, dowel the generator to its mounting base.



Note: "A" is the diametrical nominal difference between frame and fan.

Fig. 24 - Dial Indicator And Fan To Generator Frame Alignment Tolerances For Generators Given In Item G

H. ALIGNMENT OF MODELS D15 AND D15B GENERATORS

After completing preceding steps "A" and "B," the alignment procedure outlined in "C" is carried out as follows:

1. Bearing Positioning, Thrust Clearance Or End Play

- a. The total end play of the bearings of these generators is about $3/16''$. (The $3/16''$ dimension may change if parts are replaced.) A thrust clearance or end play of $1/16'' + .000'' - 1/64''$ between the bearing outer race and the inside bearing cap must be maintained on these generators.
- b. The total clearance of $3/16''$ is determined at original assembly by moving the armature shaft as far as possible toward the coupling disc end of the generator. The shaft retainer is then stamped with chisel marks at four quarter locations where the bearing cover meets the retainer. A reference measurement "x," Fig. 25, is then made from the chisel marks or bearing to the outer end face of the shaft retainer. This reference measurement or total end play is stamped in $1/2''$ numbers on the end bell beneath a sheet metal cover. To this reference measurement "x" is added the $1/16'' + .000'' - 1/64''$ end clearance. The generator stator must then be positioned to obtain this total measurement so that the dimension "x" equals approximately $3/16'' + (1/16'' + .000'' - 1/64'')$ from the machined face of the bearing cover to the end face of the shaft retainer. This will also equal $1/16'' + .000'' - 1/64''$ between the chisel marks and the machined face of the bearing cover.

2. Generator Shaft Alignment And Air Gap Equalization

- a. The aligning procedure is divided into two operations which are

carried out at the same time. Any angularity of the generator shaft as indicated at the engine disc coupling is neutralized and the air gap is balanced between the armature and field poles.

- b. Two dial type indicators are used to check alignment. The plunger of one indicator contacts the back of the generator coupling disc opposite the serration at the bolt circle. The plunger of the second indicator rides on the outside machined diameter of the alternator housing as shown in Fig. 25, to indicate air gap. Both indicators revolve together. The indicators are mounted on supports attached to a rod screwed into a tapped hole in the coupling adapter.
- c. After clamping the indicators on the rod, and it is ascertained that

the armature is free to turn, coupling bolted securely, rotate the armature to place the indicators in a top vertical position. Depress the indicators to make the pointer complete one turn, then secure it and adjust the knurled bezels to locate the pointers at zero (0). Check indicator installation that it is satisfactory. Depress the indicator button and release it to check pointer action. Turn the armature 180° in a clockwise direction (facing the commutator) using an engine turning bar or jack, then return the indicators to the original position. If the indicators are working correctly, the pointer of each indicator will return to zero (0).

- d. Starting again at the top vertical position, the alignment and air gap are checked and adjustments made

Note: Measurement "X" should be used for aligning generator bearing as explained in text.

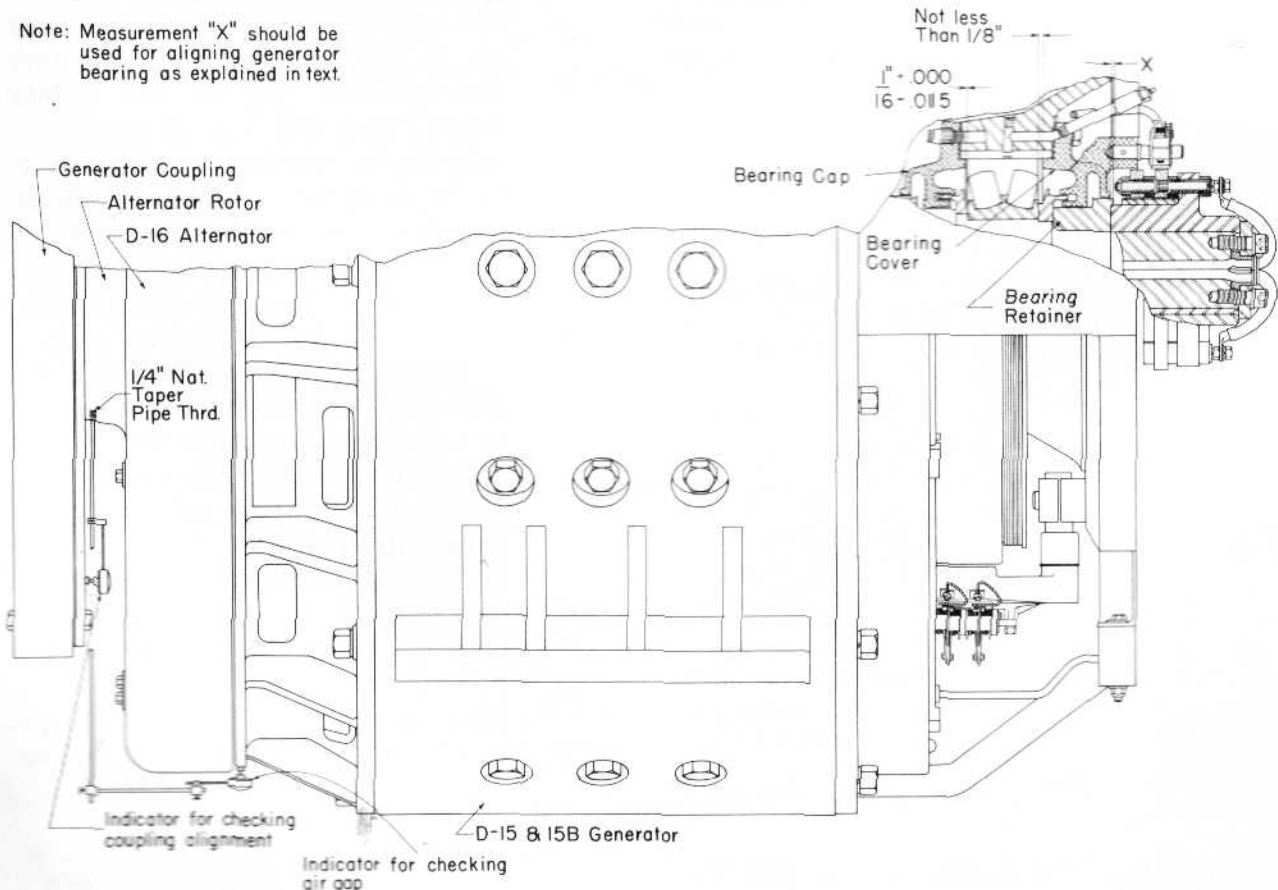


Fig. 25 - Generator Alignment Information D15 And D15B Generators

to bring them within the alignment tolerances. Record the indicator readings for each 90° position. Turn the armature 180° clockwise (facing the commutator) taking readings at the 90° and 180° positions. Then rotate the armature 270° counterclockwise (facing the commutator) recording the reading for each position.

- e. The generator alignment is considered satisfactory when the indicator readings are to or within the indicator tolerances given in Fig. 26. To accomplish this condition will likely require slight relocation and/or shim adjustment under the generator support. Full length shims should be used if possible, however, spot shims may be used to conform to the limits given. Since any movement of the generator frame affects both air gap and the coupling, readings must be taken following any cor-

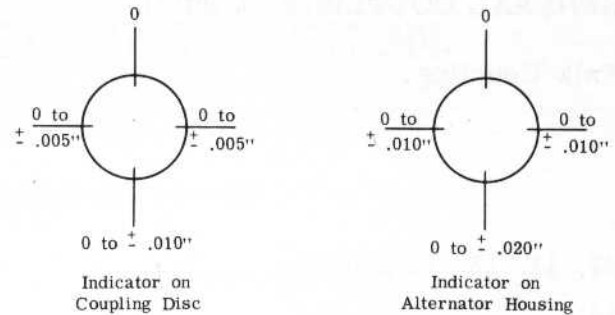


Fig. 26 - Dial Indicator Alignment Tolerances Model D15 And D15B Generators

rection. Also, the bearing thrust dimension should be carefully rechecked after final coupling alignment to be sure that it is still within the limits given under Item 1.

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

IV. SPECIFICATIONS

COUPLING ALIGNMENT TOLERANCES

GENERAL COUPLINGS

	Limits	
	Radial	Angular
EMD Design 8198236	.020"	.020"
8242730 or 8211729	Not Req'd	.020"
Rubber Couplings		
8234919, 8236433	See Item II-B for distance between faces	.020"
8246434		
Morflex Couplings	Not Req'd	.020"
	Mounting distance between faces of coupling should not exceed free length more than 1/32".	
Steel Disc Couplings (Not Generator Coupling)		.010"

GENERAL COUPLINGS (Cont'd)

Falk Coupling	Radial	Limits	Angular
	.010"		.010"
	Gap Between Faces		
	Min.		Max.
#7, 11, 12, 14 and 15	1/8"		5/16"
#4	1/8"		3/16"
#13	3/16"		5/16"

LOCOMOTIVE GENERATORS

Model	Bearing Clearance		Alignment			
	Outboard	Inboard	Air Gap (Top "0") - Angular-Coupling		Sides	Bottom
D12, A, B, C, D and F	Approx. 1/4"	1/16" + 3/64" - 1/64"	±.010"	±.020"	±.005"	±.010"
D12G, D12H And D12L	Approx. 1/4"	1/16" +.000" - 1/64"	±.010"	±.020"	±.005"	±.010"
D15A, C, D, E, F, G, H and J	Approx. 1/8"	1/16" +.000" - 1/64"	Feeler gauge between frame and fan nominal distance -.010" at 4 equally spaced locations		±.005"	±.010"
D15, D15B	Approx. 1/8"	1/16" +.000" - 1/64"	±.010"	±.020"	±.005"	±.010"