CATERPILLAR®

SEHS7654-00

General Instruction

ALIGNMENT - INDUSTRIAL AND MARINE DIESEL ENGINES

Use the bookmarks for navigation inside of the manual

Alignment - General Instructions {1000, 3000, 3300, 4450} 01/09/1980

CONTENT

Special Instruction
Alignment - General Instructions{1000, 3000, 3300, 4450}
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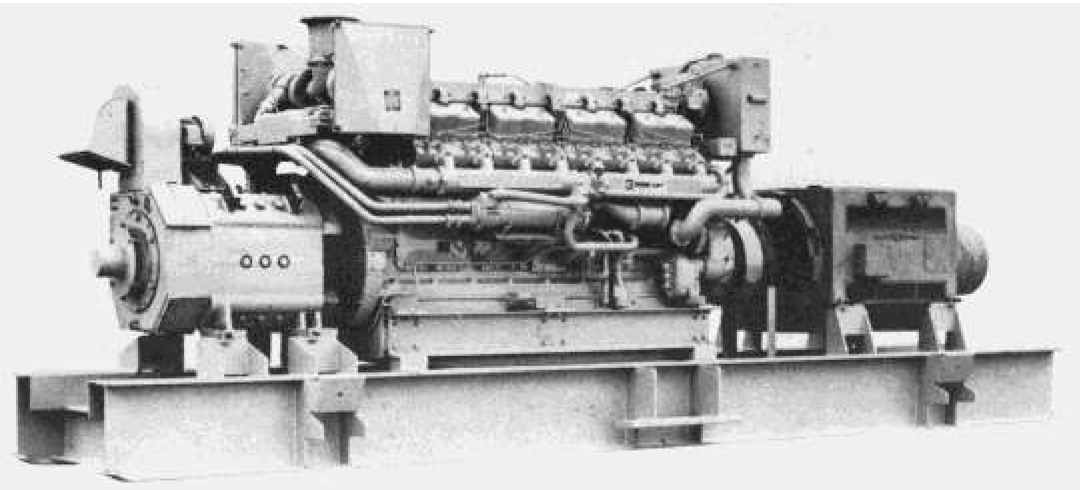
Alignment - General Instructions{1000, 3000, 3300, 4450}

SMCS - 1000; 3000; 3300; 4450

In order to obtain optimum service life from a Caterpillar Engine and its driven equipment, correct alignment between these units is a necessity. This instruction describes the general procedures and requirements needed to successfully install and align Caterpillar Engines with various types of driven equipment. Once the basic alignment procedure is understood, this information can be successfully applied to the installation and alignment of any Caterpillar Engine and any type of driven equipment.

The purpose of this Special Instruction is to give a basic understanding of the alignment procedure. This instruction does not replace existing Caterpillar Special Instructions which cover the alignment of specific models and types of driven units. Always use the appropriate Caterpillar Special Instruction and the instructions and specifications from the manufacturers of the coupling and driven equipment to install and align these units. The following is a list of currently available Caterpillar Special Instructions pertaining to alignment.

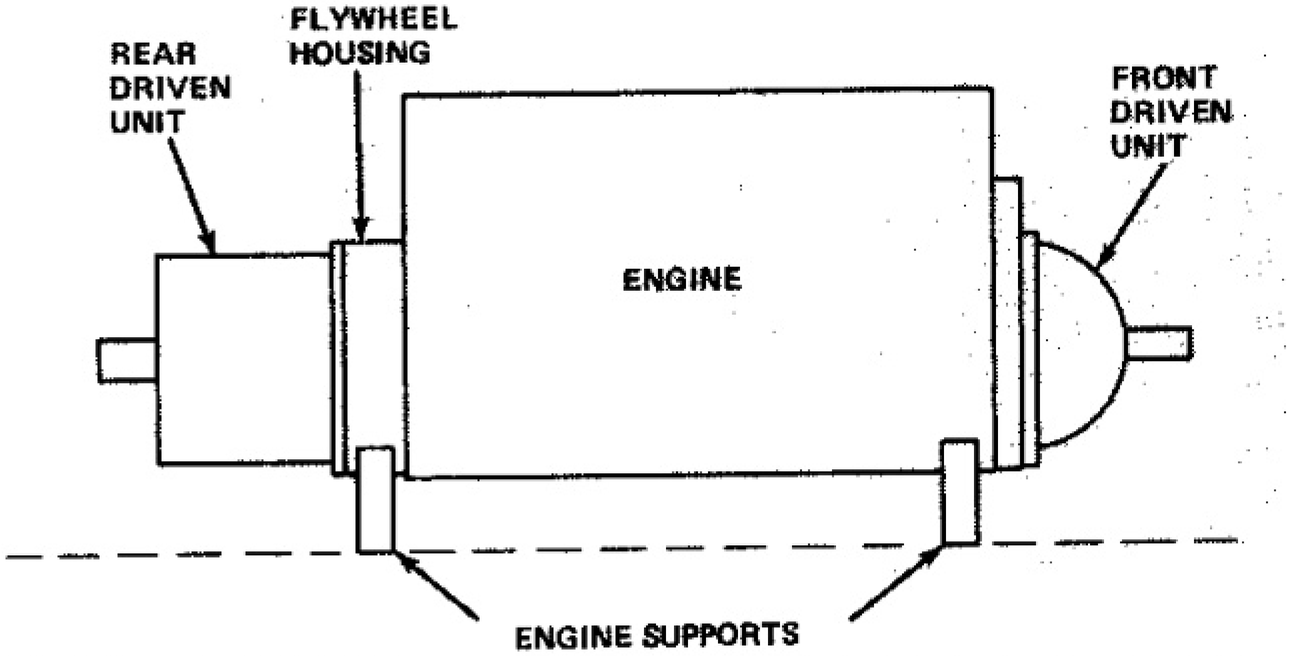
Form No.	Title
SMHS7044	INSTALLATION AND ALIGNMENT OF GENERAL ELECTRIC GE-603K GENERATORS, GTA-15 AND GTA-18 ALTERNATORS
SMHS7073	ALIGNMENT OF TWO BEARING GENERATORS
SMHS7259	ALIGNMENT OF SINGLE BEARING GENERATORS
SMHS7419	TANDEM ENGINE TIMING PROCEDURE
SEHS7456	ALIGNMENT OF CATERPILLAR MARINE TRANSMISSIONS AND MARINE ENGINES



Typical Configurations

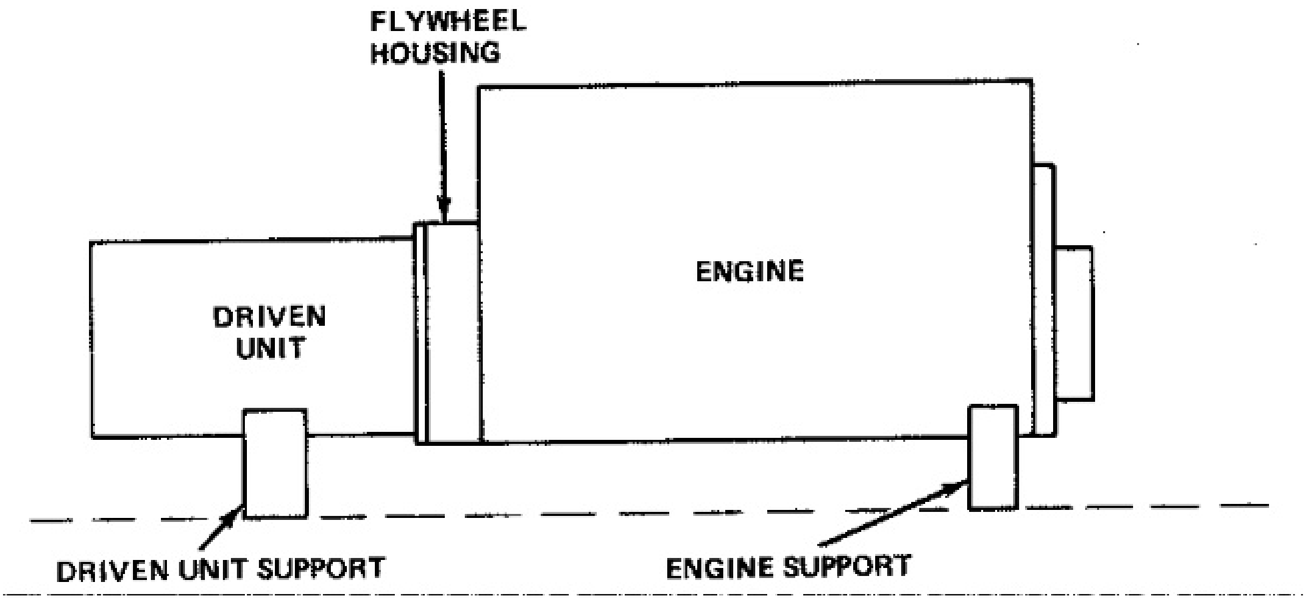
In order to correctly align a Caterpillar engine with mechanically driven equipment, a general understanding of the types of configurations of driving and driven units is necessary. Usually two types will be encountered: 1) driven units that are close coupled and 2) driven units that are remote mounted. Close coupled units are ones that are fastened directly to the engine flywheel housing or front accessory drive housing. Remote mounted units are not fastened directly to the engine and are driven from the front or rear of the crankshaft by means of a driveshaft and flexible coupling. Each type of configuration requires a different alignment procedure. Combination configurations (more than one driven unit and/or two engines) can also be successfully aligned once the basic alignment procedures are understood.

(A) Close Coupled Units - Type I



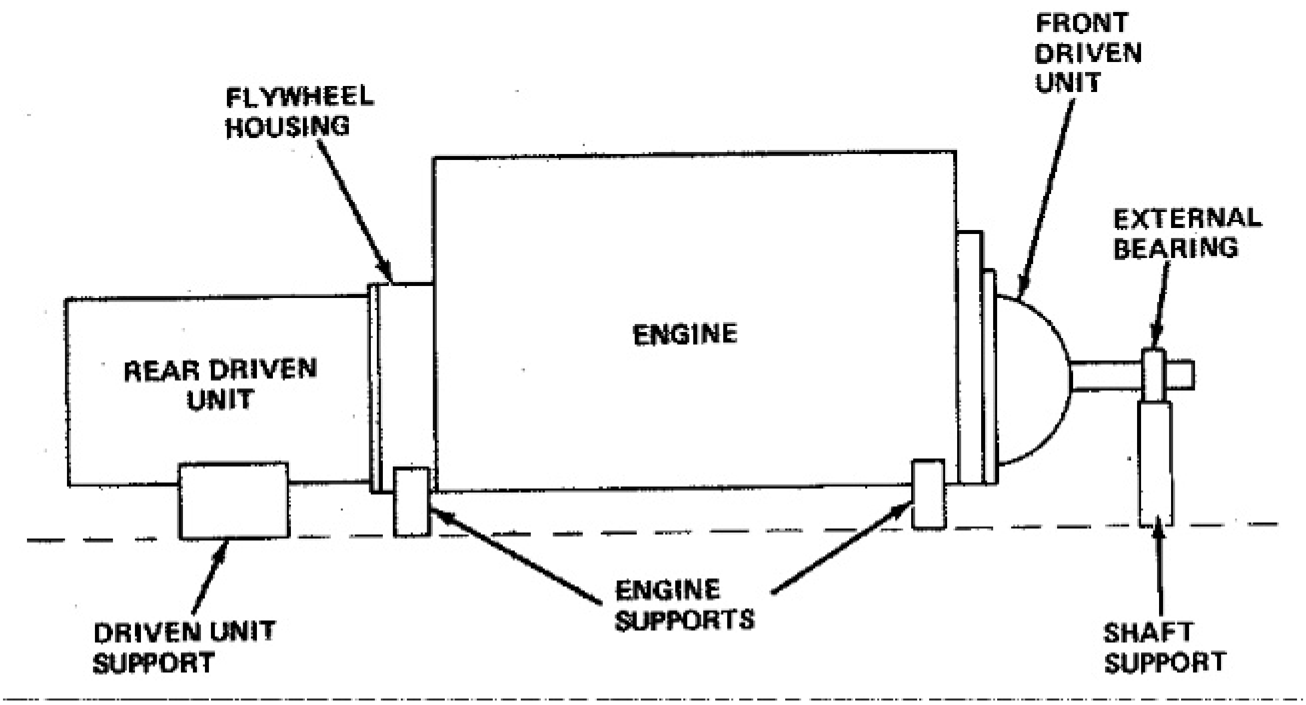
The driven unit is fastened directly to the engine flywheel housing or front accessory drive housing and has no external supports for the driven unit. Examples: Clutches, power take-off groups, transmissions and torque converters.

(B) Close Coupled Units - Type II



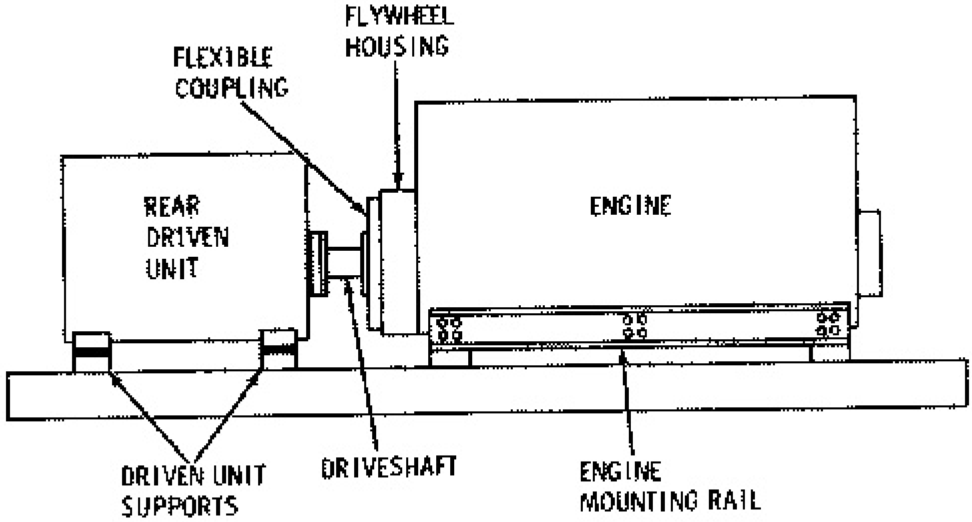
The driven unit is fastened directly to the engine flywheel housing. The supports for the driven unit serve as supports for the rear of the engine. Examples: Single bearing generators and marine transmissions.

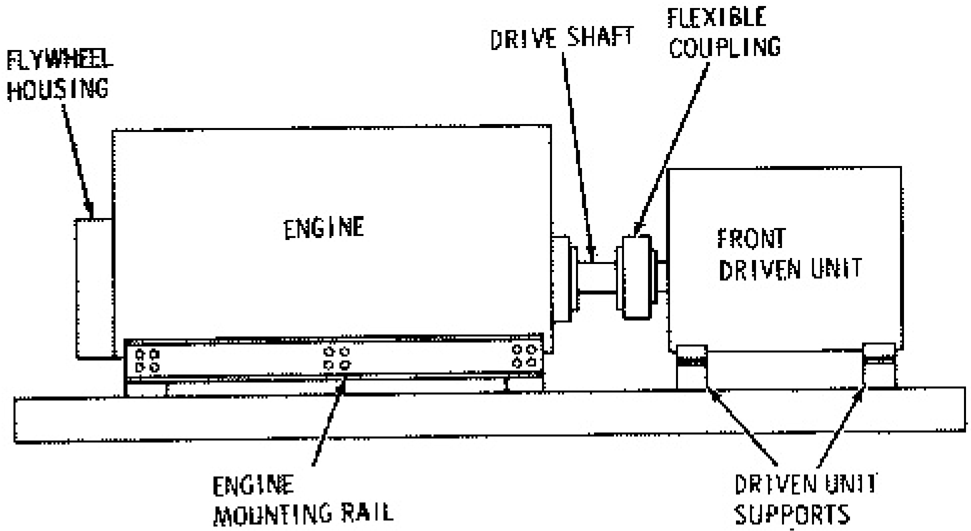
(C) Close Coupled Units - Type III



The driven unit is fastened directly to the engine flywheel housing or front accessory drive housing. The engine has front and rear supports. The driven unit has its own support. Examples: Single bearing generators, close coupled two bearing generators, marine transmissions and power take-off groups.

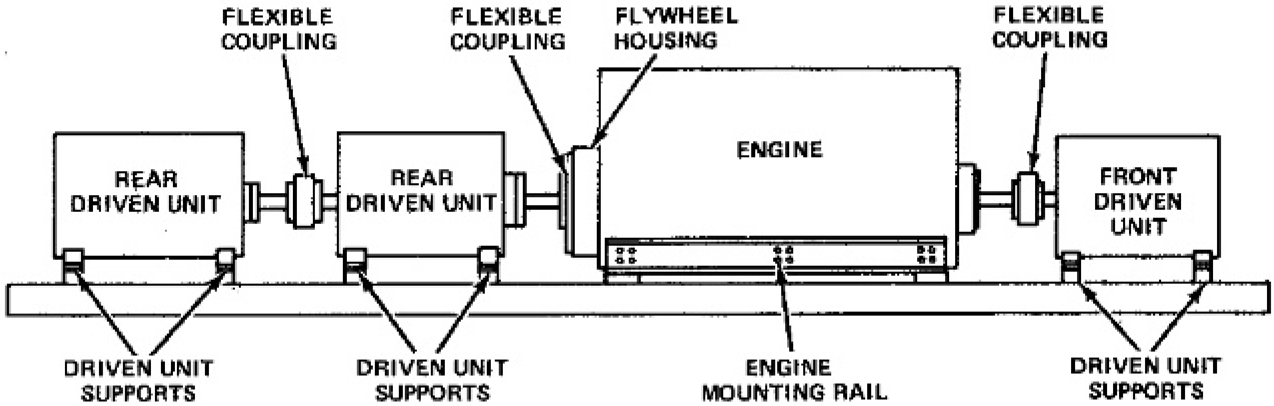
(D) Remote Mounted Units

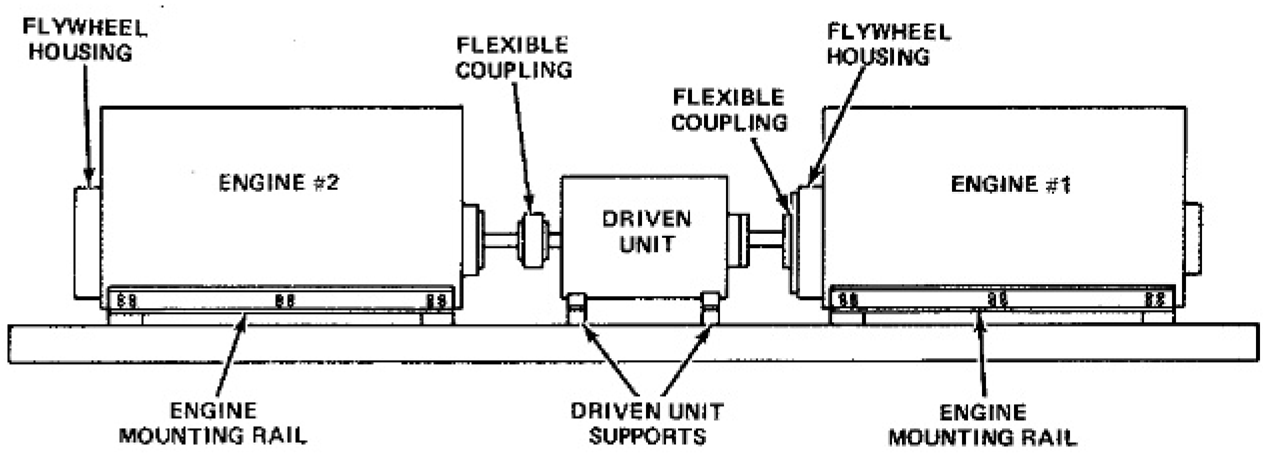


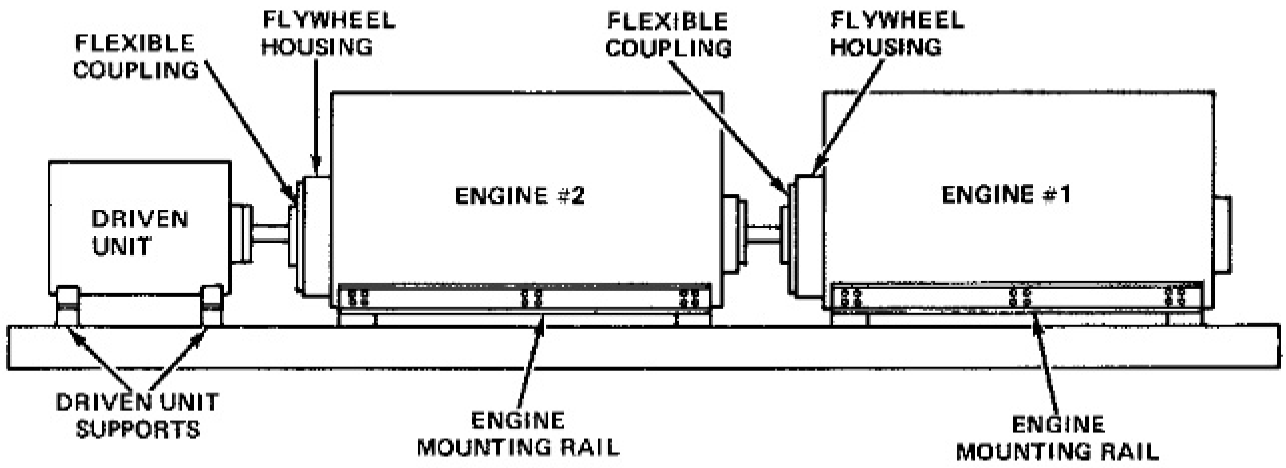


Remote mounted units are not supported by the engine. These units can be driven from either the front or the rear of the engine by means of a coupling and a driveshaft. Rear driven units have the coupling located within the flywheel. Front driven units use an external coupling. Examples: Two bearing generators, gears and large marine transmissions.

(E) Combination Remote Mounted Units







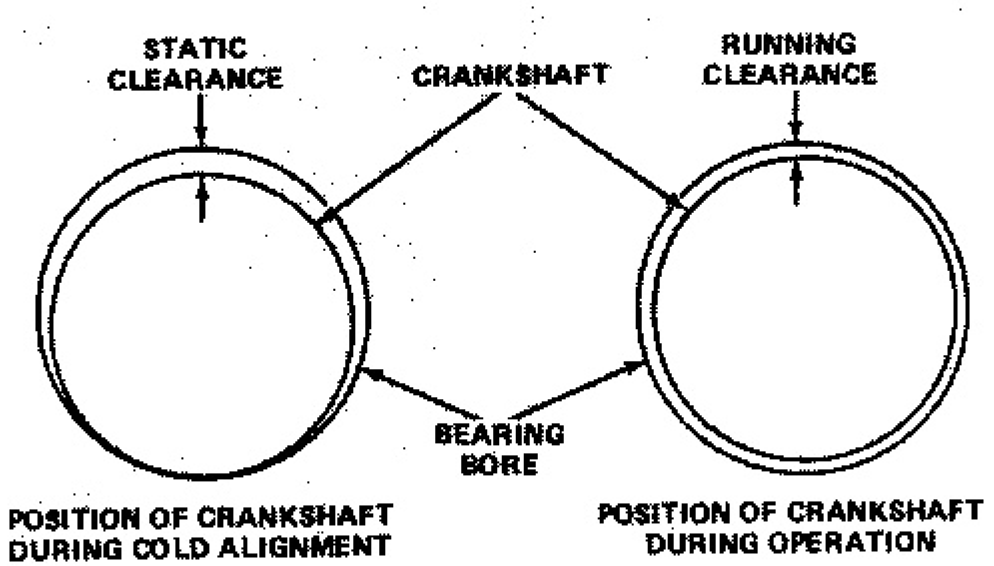
Combination arrangements may have one engine with several driven units or two engines with one driven unit. Examples: Tandem engine and generator combinations.

Principles Of Alignment

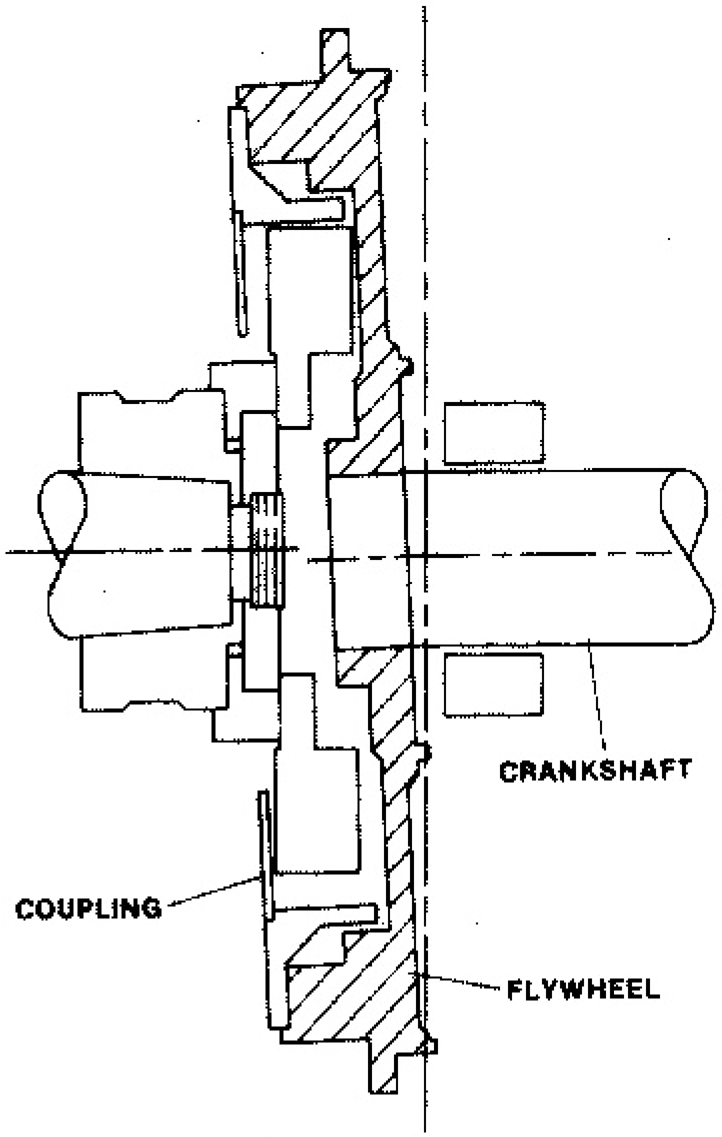
(A) Cold Alignment

In high speed applications, at normal operating temperatures and load, misalignment between the diesel engine and all mechanically driven equipment must be kept to a minimum. Many crankshaft and bearing failures can be traced to incorrect alignment of the drive systems. Misalignment at operating temperatures and under load will always result in vibration and/or stress loading.

Since there is no accurate and practical method for measuring alignment with the engine running at operating temperature and under load, all Caterpillar alignment procedures must be performed with the engine stopped and the engine and all driven equipment at ambient temperature. This is called cold alignment. In order to achieve correct operating alignment, certain factors must be taken into consideration in determining cold alignment specifications. Depending upon the type of application, some or all of the following factors will affect the cold alignment procedure.



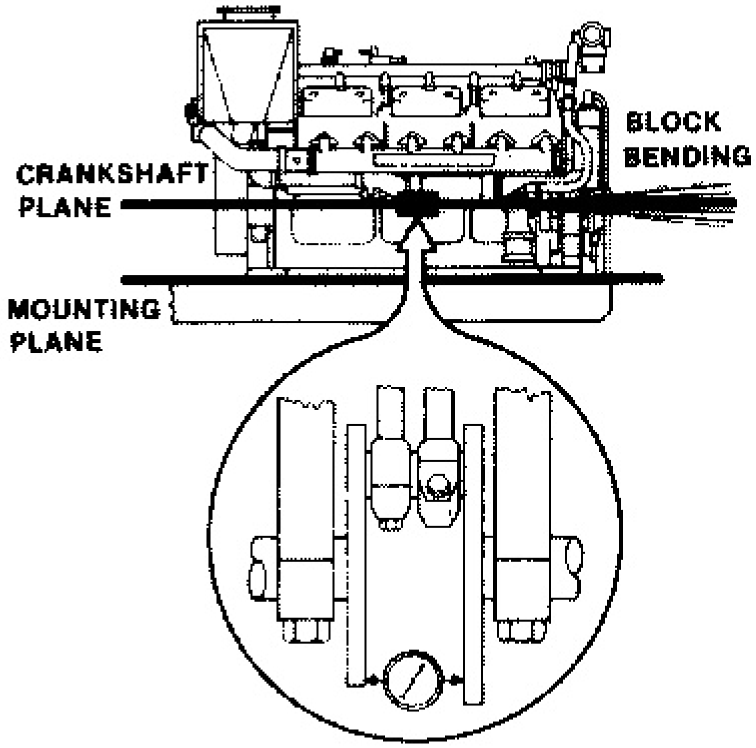
CRANKSHAFT POSITION Under static conditions, the crankshaft lies at the bottom of its main bearing bores. Under operating conditions, the firing pressures, centrifugal forces and engine oil pressure all tend to lift the crankshaft and cause it to rotate around the center of the main bearing bores. This change in crankshaft position has been compensated for in all cold alignment specifications where applicable.



(EXAGGERATED)

FLYWHEEL SAG OR DROOP Under static conditions, the weight of the flywheel and coupling (rear driven units) or coupling only (front driven units) causes a small deflection of the crankshaft. This deflection has been compensated for in all cold alignment specifications where applicable.

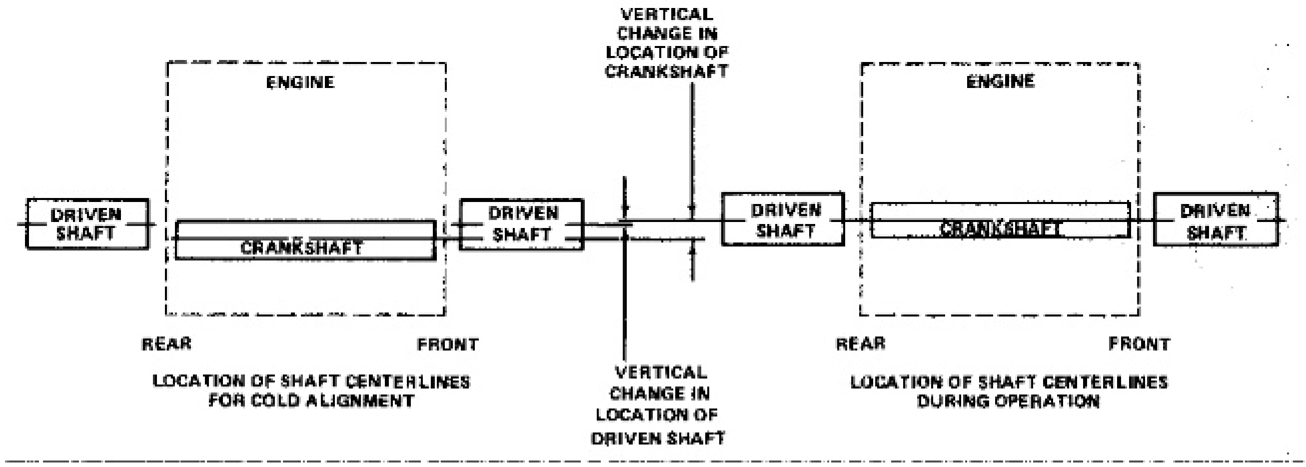
CRANKSHAFT END PLAY In all applications, the crankshaft end play must not be less after installation of the driven equipment than it was before installation of this equipment. Crankshaft end play should be checked during cold alignment and again after the engine is at operating temperature. End play at operating temperature must not be less than end play during cold alignment.



CRANKSHAFT DEFLECTION

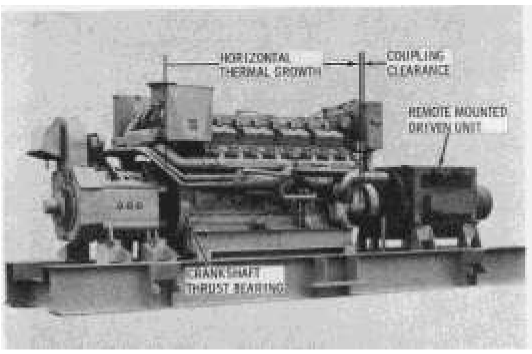
CRANKSHAFT DEFLECTION Large engines with side covers (D348, D349, D398, D399) must be checked for crankshaft deflection after alignment and installation of the shims and mounting bolts. The crankshaft deflection check during cold alignment will determine if the cylinder block has been stressed due to incorrect shimming under the mounting pads. Some applications also require a crankshaft deflection check with the engine at operating temperature. This check will determine if the cylinder block has been stressed by restricting the engine's thermal growth.

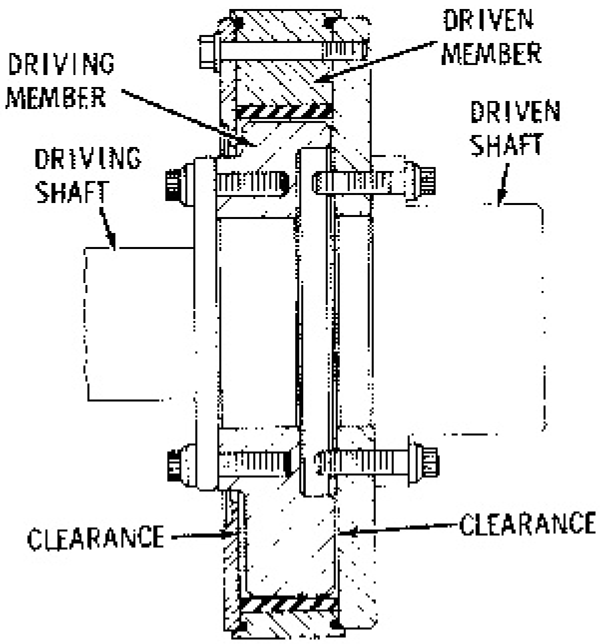
Since engines without side covers can also be subject to cylinder block stressing (although there is no practical method for checking crankshaft deflection), care must be taken to ensure correct shimming under the mounting pads and that there is no restriction to horizontal thermal growth.



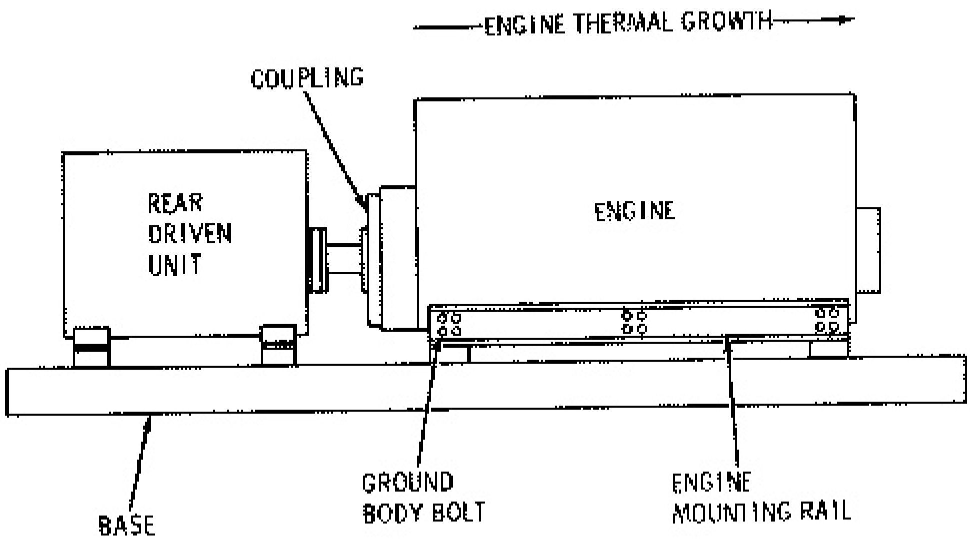
VERTICAL THERMAL GROWTH Under operating conditions, there is thermal expansion of the engine and driven unit. The result of this expansion (along with the change in crankshaft position during operation) is a change in vertical location of the centerlines of the crankshaft and driven unit shaft. When the driven unit is fastened directly to the flywheel housing or cylinder block (close coupled), the change in shaft centerline location does not significantly affect the cold alignment settings. However, when the driven unit is remote mounted, the thermal expansion of the engine will be greater than that of the driven unit. Therefore, the change in location of the crankshaft centerline will be greater than the change in location of the driven shaft centerline. The cold alignment of all remote mounted units must allow for this change in shaft centerline location by setting the centerline of the crankshaft slightly below the centerline of the driven unit as shown in the specifications.

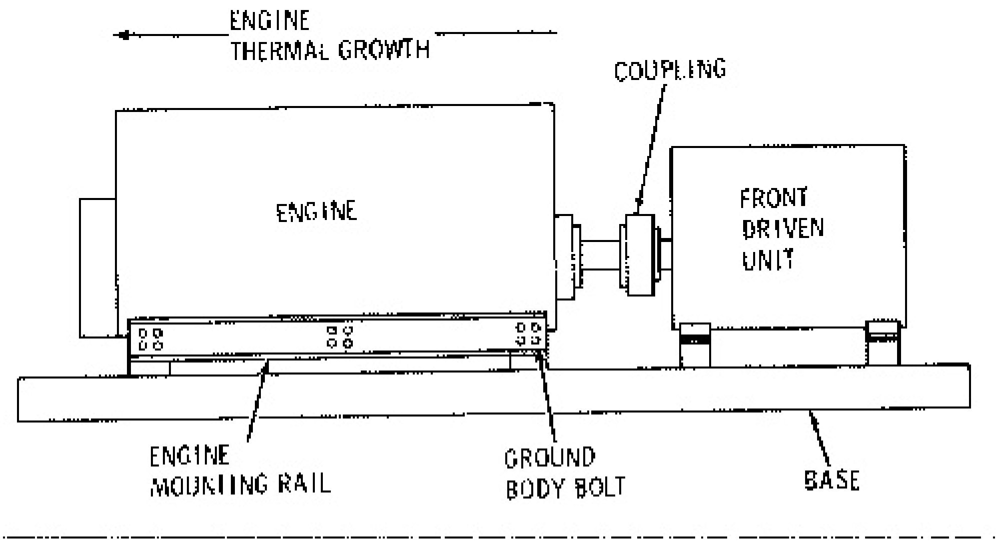
HORIZONTAL THERMAL GROWTH Under operating conditions, thermal expansion also causes horizontal growth of the engine. Caterpillar diesel engines can "grow" up to .090" (2.3) in length from a cold start to operating temperature. If the driven equipment is fastened directly to the engine (close coupled), horizontal growth of this equipment will be at approximately the same rate as that of the engine; therefore, no allowance is necessary for the horizontal thermal growth of the engine during the cold alignment procedure. For engines with mounting rails where the driven equipment is remote mounted, horizontal thermal growth of the engine must be compensated for and the direction of growth controlled during the cold alignment procedure. However, under no circumstances should this growth be restricted.





The direction of crankshaft horizontal growth is always away from the crankshaft thrust bearing. For example, if the thrust bearing is at the rear of the engine, thermal growth will be toward the front of the engine. If the driven unit is close coupled, no compensation is necessary during the cold alignment procedure. If the driven unit is remote mounted, compensation must be made by using a coupling that allows sufficient relative movement between the driving and driven members. The driven equipment must be positioned so there is clearance for this horizontal growth within the coupling. Failure to allow for this growth will result in excessive crankshaft thrust bearing loading and/or coupling failure. There is sufficient coupling clearance if the crankshaft end clearance at operating temperature is not less than the crankshaft end clearance during cold alignment.





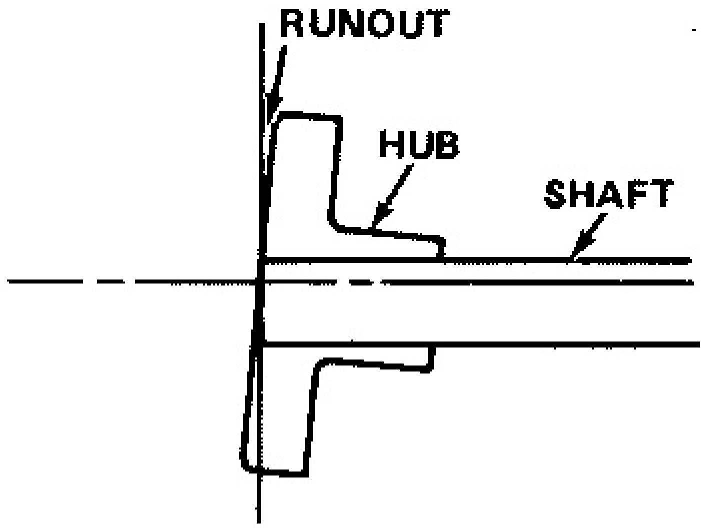
In applications where the engine uses mounting rails and the driven equipment is remote mounted, horizontal growth of the engine should be controlled by directing this growth away from the coupling. This is accomplished by using a ground body bolt (fitted bolt) to fasten the engine right mounting rail to the base at the same end of the engine as the coupling. Therefore, growth of the engine will be away from the coupling rather than into the coupling. If there is remote mounted equipment driven from both ends of the engine, the ground body bolt should be installed at the rear of the right mounting rail and allowance made for growth into the front coupling during the cold alignment procedure. For remote mounted marine transmissions, a ground body bolt is used at the rear of each mounting rail. For all other applications, only the right mounting rail uses a ground body bolt. (NOTE: In some oil field applications, the right mounting rail is spot welded to the base and to the engine instead of using a ground body bolt.) NEVER USE A GROUND BODY BOLT (OR SPOT WELD THE MOUNTING RAIL TO THE BASE AND ENGINE) AT MORE THAN ONE LOCATION ALONG THE SAME MOUNTING RAIL WITHIN THE LENGTH OF THE ENGINE. THIS WILL RESTRICT THERMAL GROWTH AND DAMAGE TO THE ENGINE AND/OR DRIVEN EQUIPMENT CAN RESULT. USE GROUND BODY BOLTS ONLY IF CALLED FOR IN THE ALIGNMENT PROCEDURE AND ONLY AT THE LOCATION SPECIFIED.

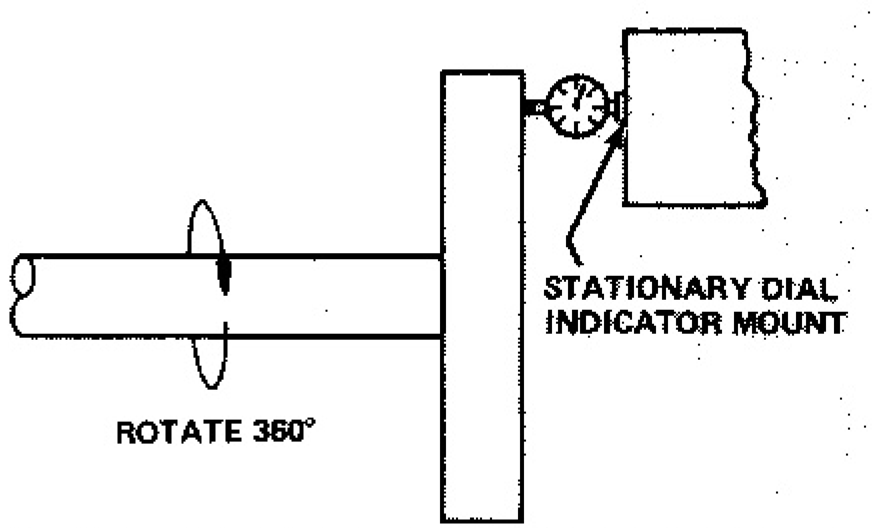
(B) Alignment Terms And Measurements

RUNOUT The runout of a hub, flange or flywheel can be measured by turning the part in question while measuring from any stationary point to the surface being checked. This can be done with a dial indicator. Always measure to the pilot surface being used, not to an adjacent surface. Surfaces not used for pilots are normally not machined to close tolerances. This runout check should be made first on the face of the component. After face runout has been checked, check bore runout.

NOTE: Excessive runout of a hub or flange can often be reduced to an acceptable amount by rotating the hub or flange with respect to its shaft (usually 90° at a time) until a position of minimum runout is attained.

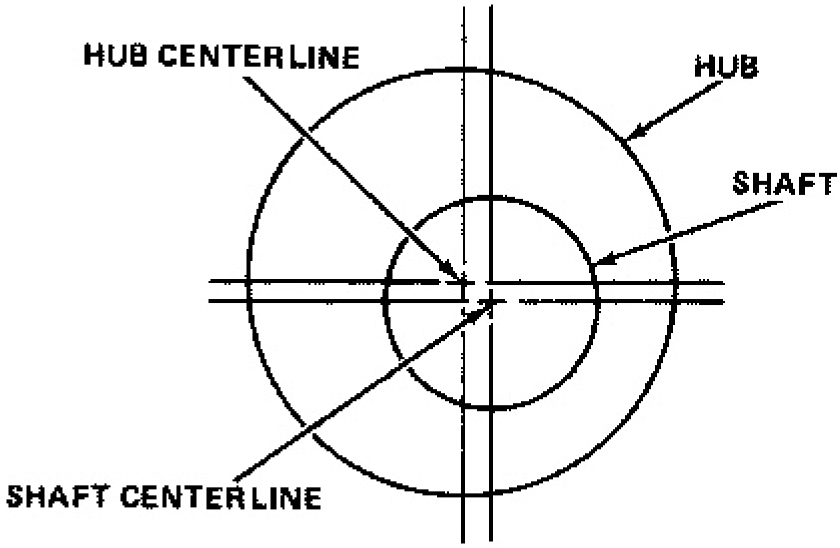
IMPORTANT: Before making any measurements for face or bore runout, it is imperative that all surfaces to be measured or mated together be completely clean and free from grease, paint, rust and dirt; all of these can cause inaccurate measurements. Make sure the parts being checked are not subject to external forces (such as tension caused by belt drives on the front of the engine crankshaft) which could affect runout measurements.

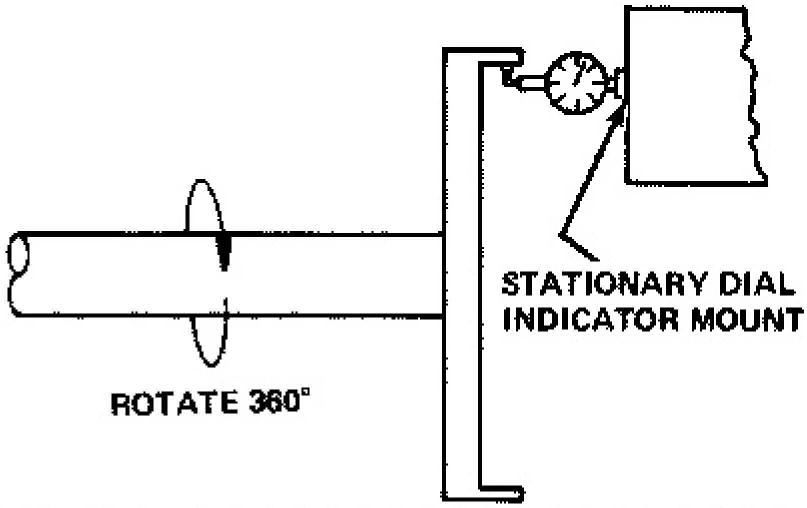




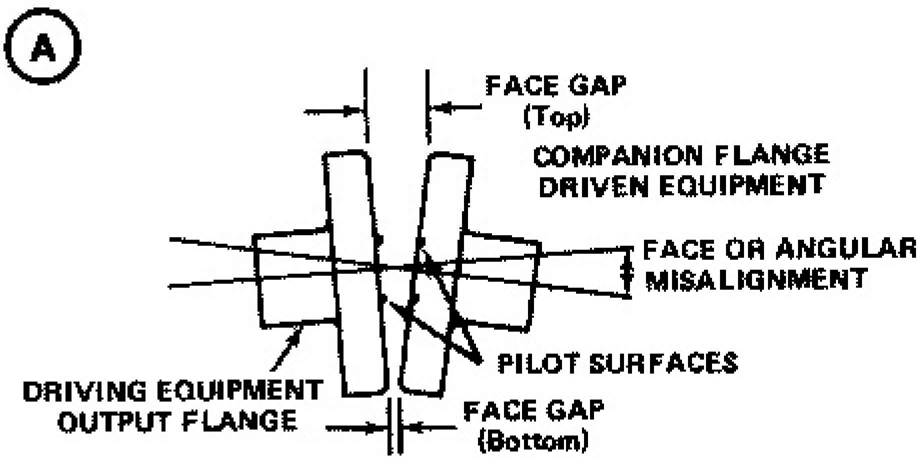
Face runout refers to the distance the face of the component is out of perpendicular to the shaft centerline as shown above. To check face runout with a dial indicator, put the tip of the indicator on the face of the component. Zero the indicator. Turn the component 360° and make a note of any change in the indicator reading from zero. Any change is caused by face runout. The total movement of the indicator needle (TIR), from the low reading to the high reading, is the face runout. Face runout can be caused by foreign material, uneven tightening of the mounting bolts or from machining tolerances. "Cocking" of the component being measured can cause indications of bore runout as well as face runout. For this reason, the face runout must be checked first. Refer to the specifications in the alignment procedure for the allowable face runout.

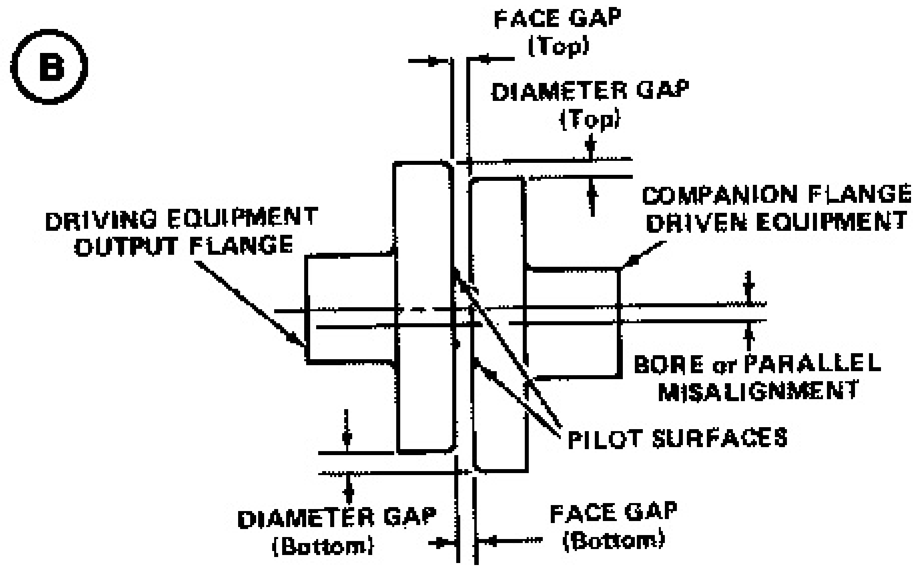
IMPORTANT: When checking face runout, always make sure the shaft end play doesn't change as the part is rotated. The shaft must be moved to the end of its end play and that position must be maintained while measuring runout.



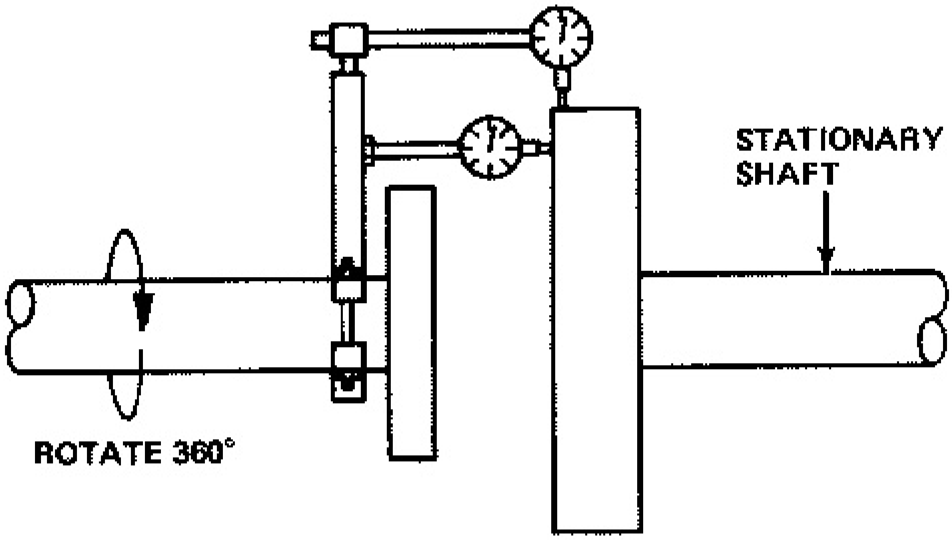


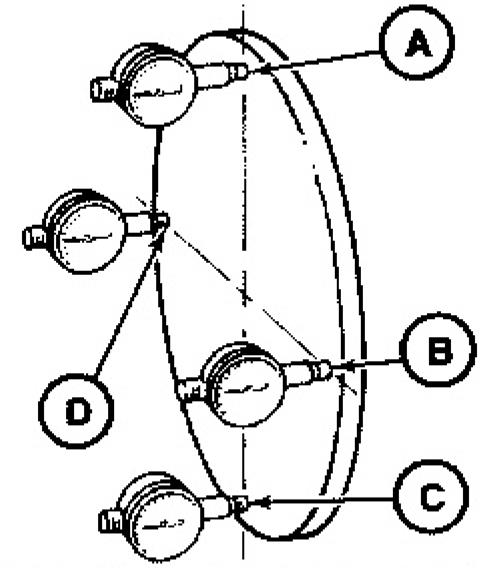
Bore runout refers to the distance the centerline of the bore of a component is out of concentricity with the centerline of the shaft as shown above. To check bore runout with a dial indicator, put the tip of the indicator on the bore of the component. Zero the indicator. Turn the component 360° and make a note of any change in the indicator reading from zero. The total movement of the indicator needle (TIR), from the low reading to the high reading, is the bore runout. Refer to the specifications in the alignment procedure for the allowable bore runout.

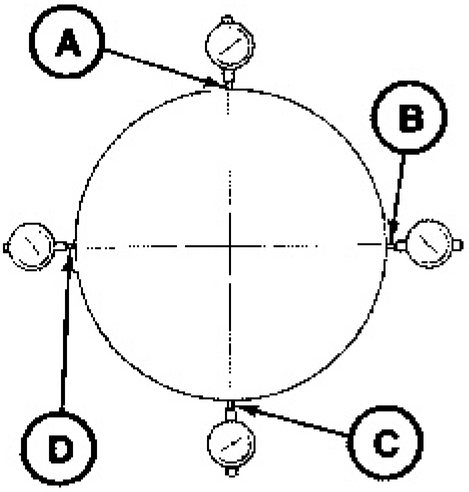




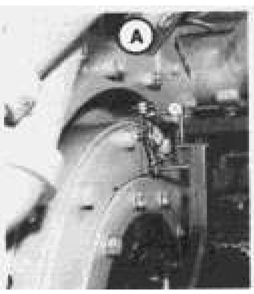
MISALIGNMENT Misalignment between the driving and driven unit can be detected by measuring face alignment and bore alignment. The terms angular alignment and face alignment (A) are synonymous, as are parallel alignment and bore alignment (B). Before making any measurements for face or bore alignment, make sure all surfaces to be measured are free from grease, paint, rust and dirt; all of these can cause inaccurate measurements. When checking alignment, it is best to check face alignment and bore alignment simultaneously by using two dial indicators fastened to one base. Since face misalignment can affect the bore readings, always recheck bore alignment after corrections have been made for face misalignment.

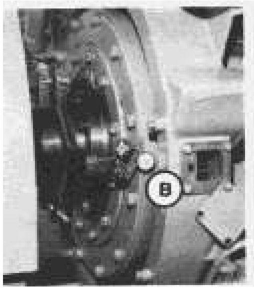


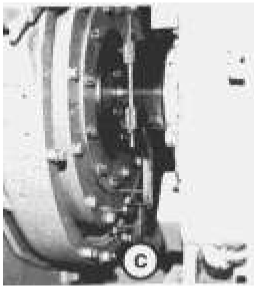




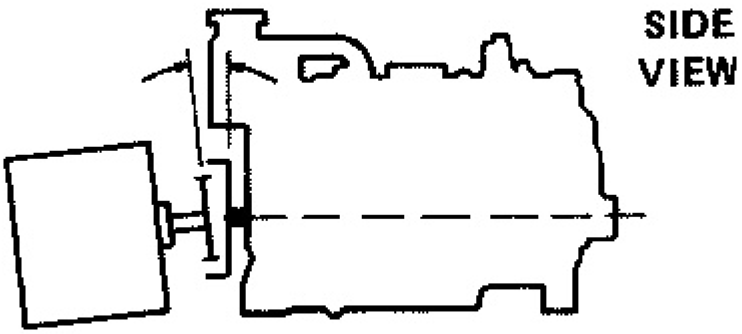
There are two methods for measuring face and bore alignment when using dial indicators. The first method requires rotating only the shaft on which the indicator base is mounted. The other shaft remains stationary. Readings should be taken 90° apart at locations A, B, C and D with the indicator set at zero at location A. When this method is used, the runout in the mating parts will affect the alignment readings. If the two shafts are to be connected by a coupling and the runout in the mating flanges is minimal, this method may be preferable since it is easier to rotate one shaft rather than two shafts at the same time.



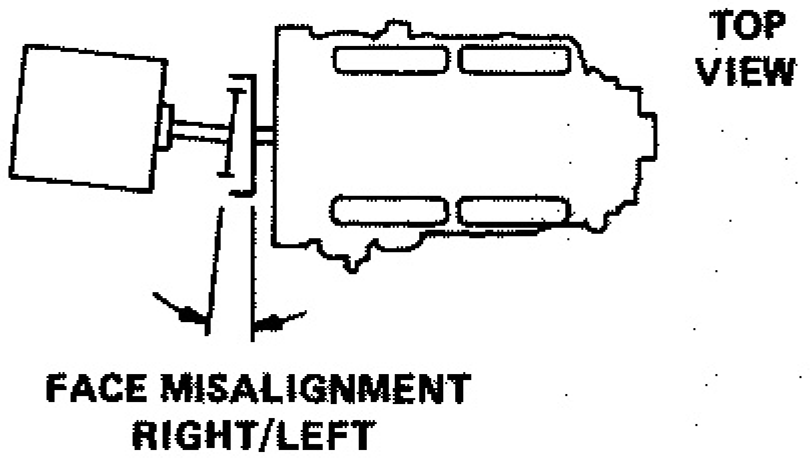


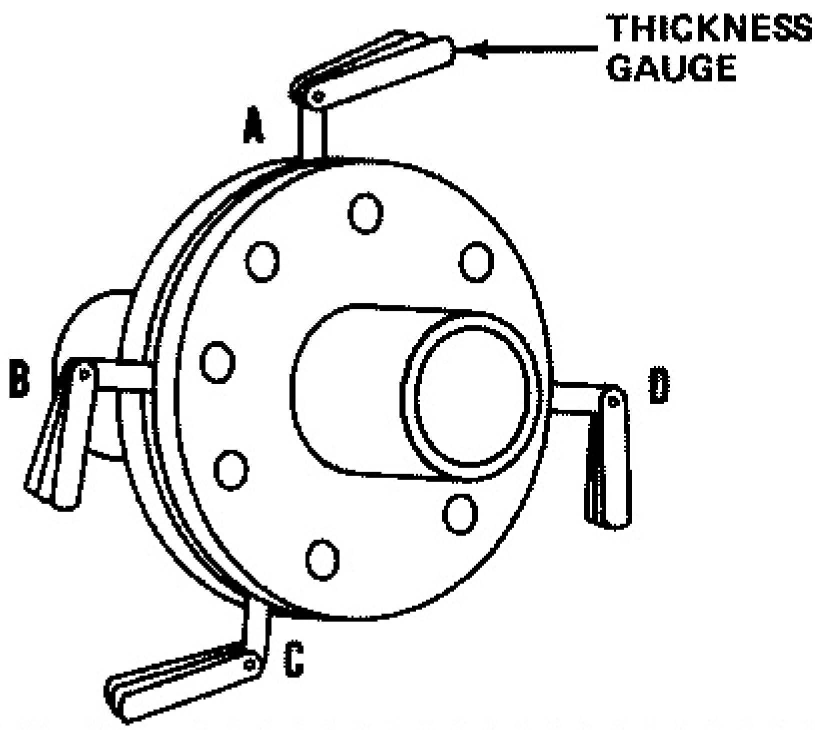


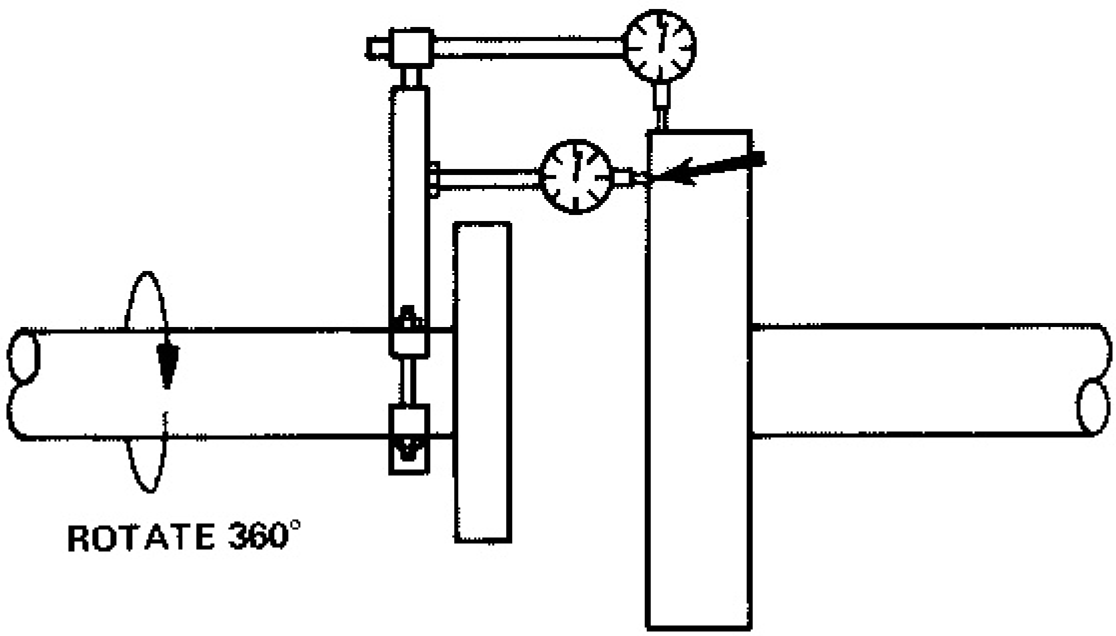
The second method is used if the two shafts are connected together with a flexible coupling. When both shafts are rotated together, readings should be taken 90° apart at locations A, B, C and D with the indicator set at zero at location A. When this method is used, runout in the mating parts will not affect the alignment readings. NOTE: This method can not be used for all types of couplings because some couplings cause sideload of the shafts. If this is the case, it will be necessary to remove the flexible element from the coupling before rotating the shafts together.

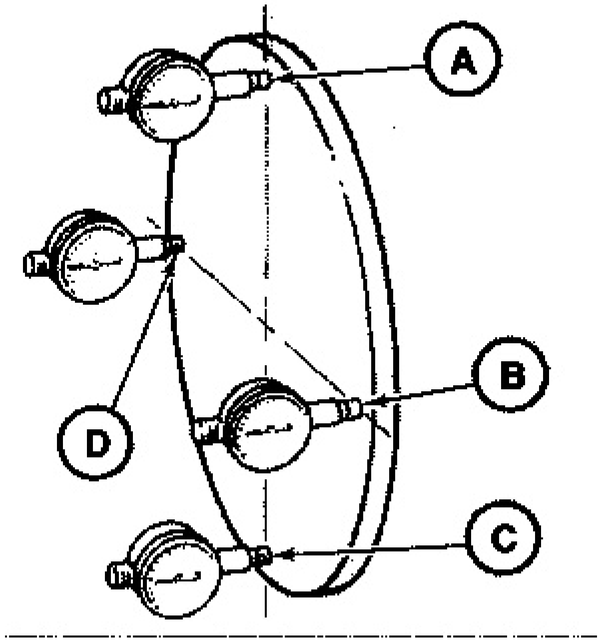


FACE MISALIGNMENT
UP/DOWN


TOP
VIEW
FACE MISALIGNMENT
RIGHT/LEFT

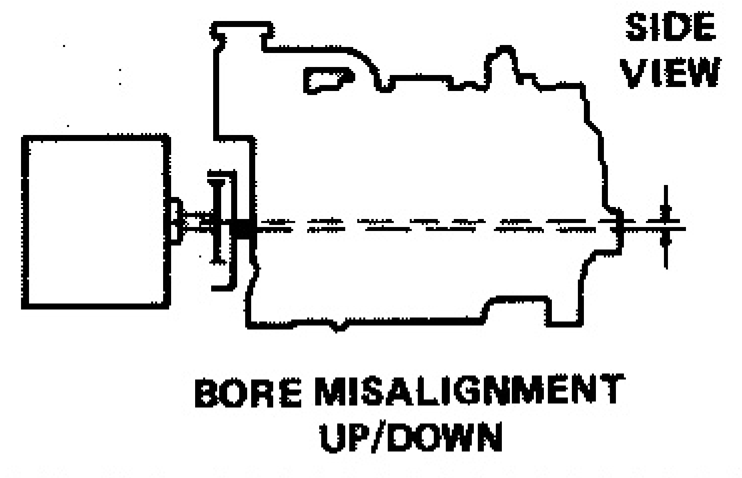

THICKNESS
GAUGE
A
B
C
D

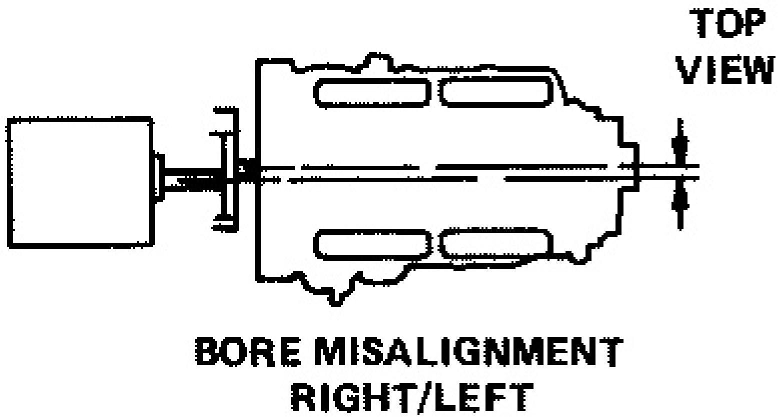

ROTATE 360°

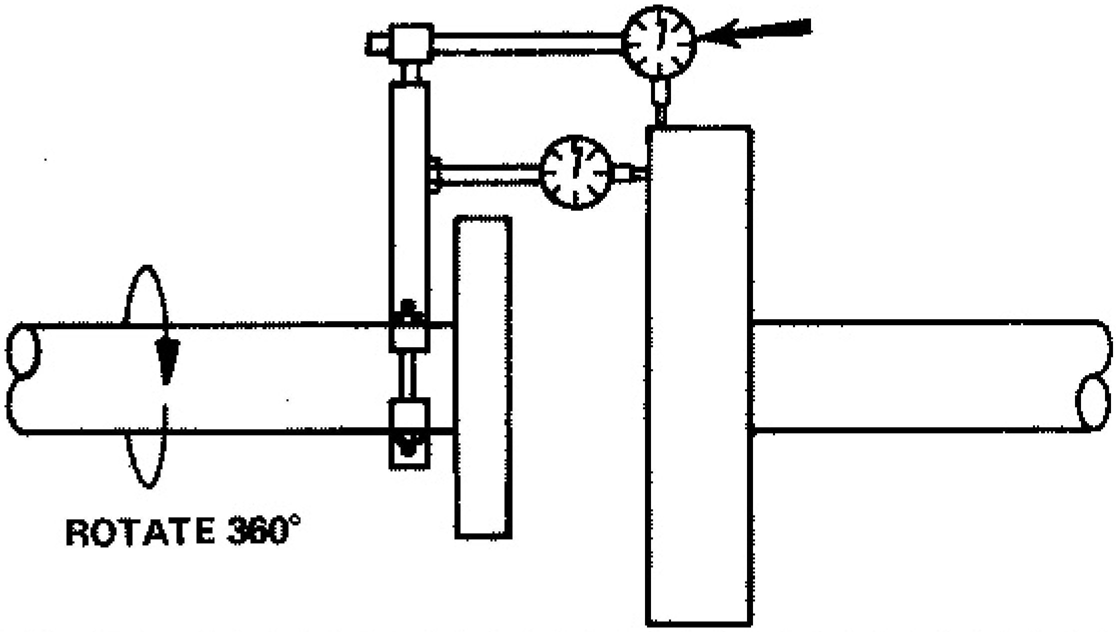


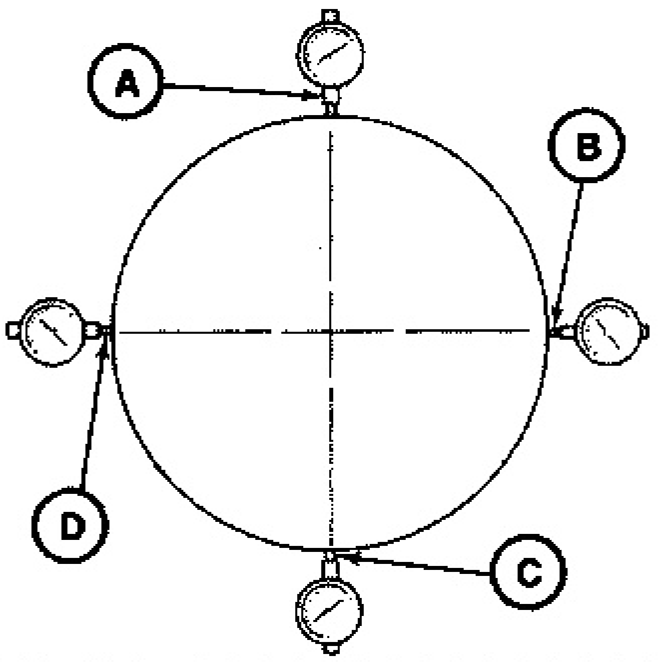
Face misalignment occurs when the centerlines of the driving shaft and the driven shaft are not parallel as shown above. Face alignment can be measured with either a thickness gauge or a dial indicator. Use a thickness gauge when the gap between the mating parts does not permit installation of a dial indicator. Use the gauge to measure the gap at locations A, B, C and D, 90° apart, as shown. To use a dial indicator, fasten the indicator base to one of the shafts. Put the tip of the indicator on the face of the mating flange. Zero the indicator. Rotate the shaft with the indicator (method No. 1) or both shafts together (method No. 2) through 360°, and make a note of the indicator reading at each of the four locations. Refer to the specifications in the cold alignment procedure for the allowable face misalignment.

IMPORTANT: When checking face alignment, always make sure the shaft end play does not change as the shaft is rotated. The shaft must be moved to the end of its end play and remain in that position while measuring face alignment.

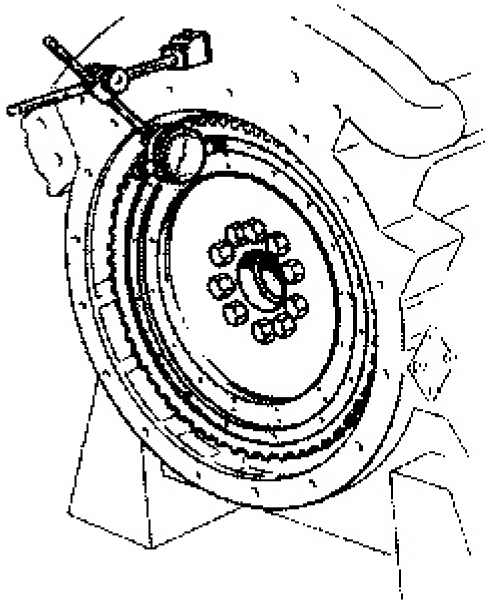






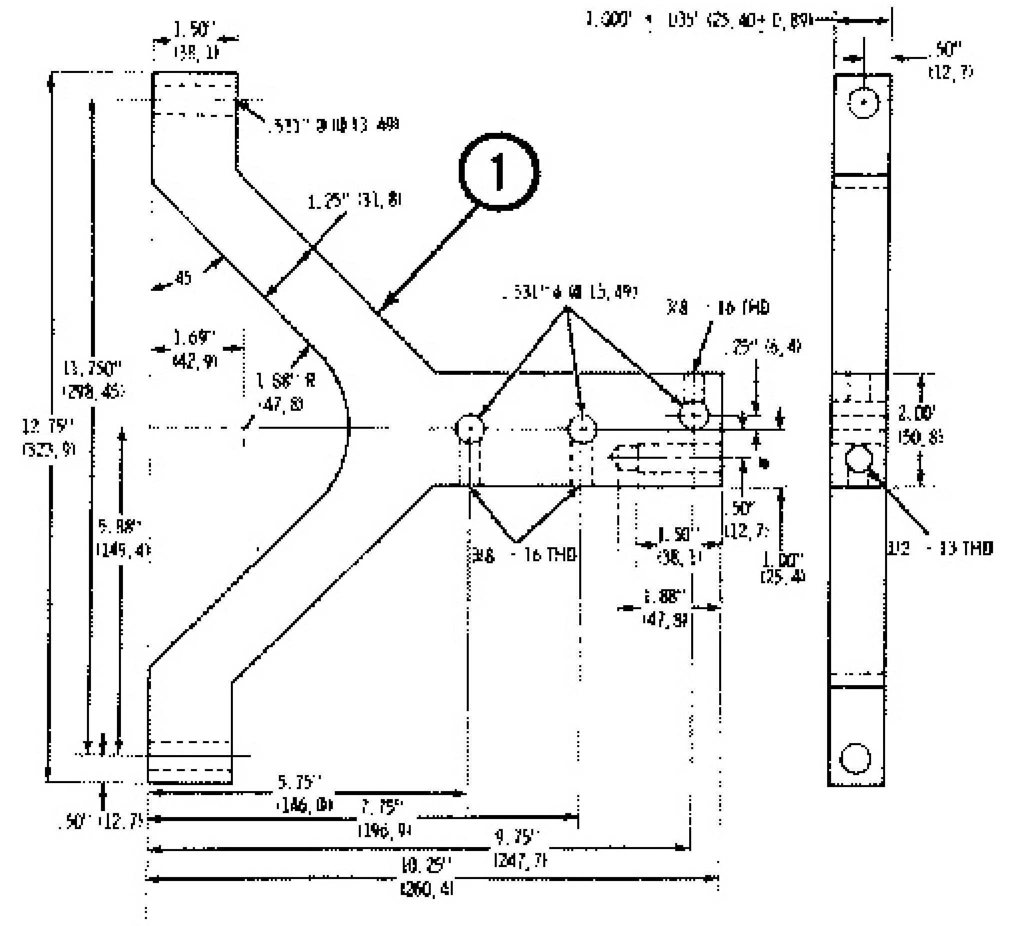


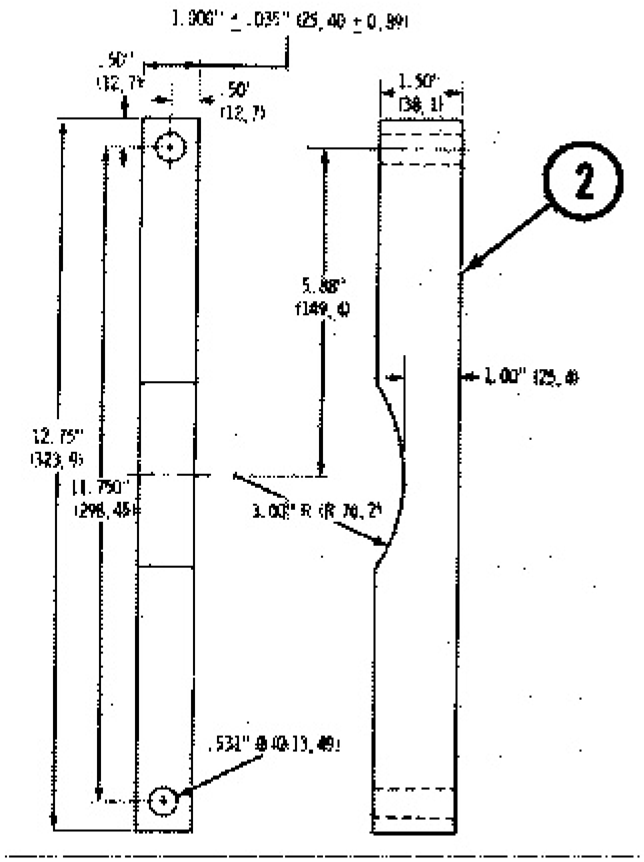
Bore misalignment occurs when the centerlines of the driving shaft and the driven shaft are parallel but not on the same line as shown above. Bore misalignment can be measured by using a dial indicator. Fasten the dial indicator base to one of the shafts. Put the tip of the indicator on the bore or outside diameter of the mating flange. Zero the indicator. Rotate the shaft with the indicator (method No. 1) or both shafts together (method No. 2) through 360°, and make a note of the indicator reading at each of the four locations A, B, C and D, 90° apart as shown. Compare the indicator readings with the specifications in the cold alignment procedure for the allowable bore misalignment.

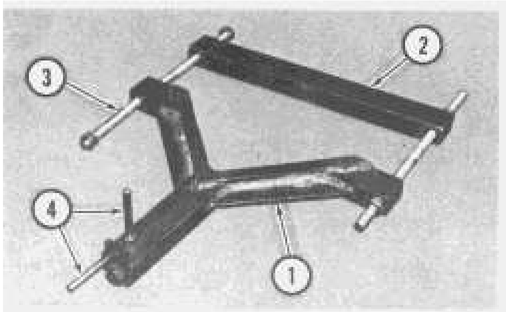


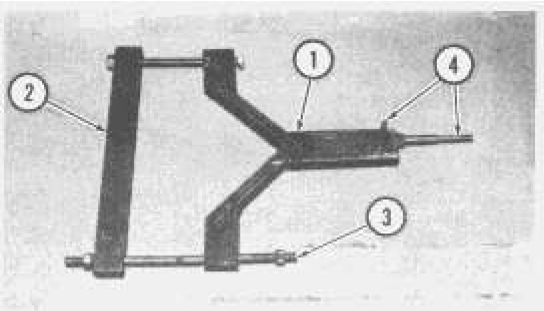
CRANKSHAFT END PLAY Crankshaft end play must be checked during the cold alignment procedure both before and after installation of the driven unit. End play must not be less than before installation of this equipment. End play should again be checked after the engine is at operating temperature. End play must not be less than end play during cold alignment. To check crankshaft end play, mount a dial indicator on the flywheel housing with the tip of the indicator on the face of the flywheel. Use a bar to push the crankshaft toward the rear of the engine as far as possible. Zero the indicator. Use the bar to push the crankshaft toward the front of the engine as far as possible. The total movement of the indicator needle (TIR) is the crankshaft end play. When checking crankshaft end play, do not use the bar to keep pressure against the crankshaft; erroneous readings will result. Do not pry against the crankshaft vibration damper as this can cause damage to the damper.

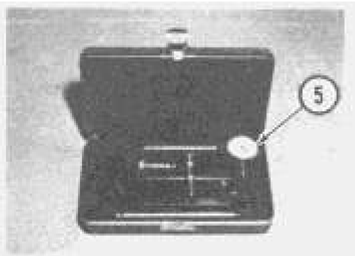
(C) Tools Needed For Checking Alignment

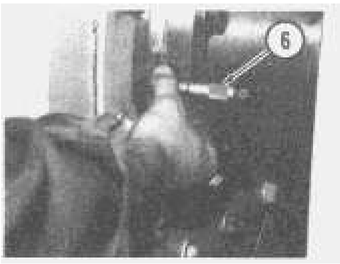

1
1.50" (38,1)
.531" Φ (Φ 13.49)
1.25" (31,8)
45
1.69" (42,9)
1.88" R (47,8)
13.750" (298,45)
12.75" (323,9)
5.88" (149,4)
.531" Φ (Φ 13.49)
3/8 - 16 THD
.25" (6,4)
.50" (12,7)
1.50" (38,1)
1.00" (25,4)
1.88" (47,9)
5.75" (146,0)
7.75" (196,9)
9.75" (247,7)
10.25" (260,4)
.50" (12,7)
1.000" ± .035" (25,40 ± 0,89)
.50" (12,7)
2.00" (50,8)
1/2 - 13 THD

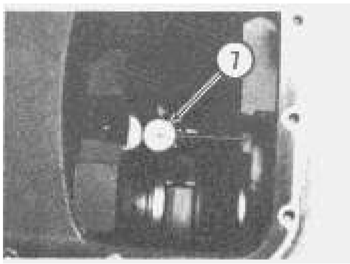

2
1.000" ± .035" (25,40 ± 0,89)
.50" (12,7)
.50" (12,7)
1.50" (38,1)
5.88" (149,4)
1.00" (25,4)
12.75" (323,9)
11.750" (298,45)
3.00" R (R 76,2)
.531" Φ (Φ 13,49)











(1) 6V2042 Alignment Yoke.

(2) 6V2043 Alignment Bar.

(3) 1/2" Diameter x 12" long threaded rod with nuts.

(4) Adapters to mount dial indicators on alignment yoke (if necessary, fabricate to fit dial indicators used).

(5) Starrett Dial Indicator Set No. 196 or Caterpillar 8S2328 Dial Indicator Group or equivalent. (Two dial indicators are required).

(6) Caterpillar 6F6922 Depth Micrometer or equivalent.

(7) Starrett Dial Gauge No. 696 and Balancer Attachment 696B or equivalent.

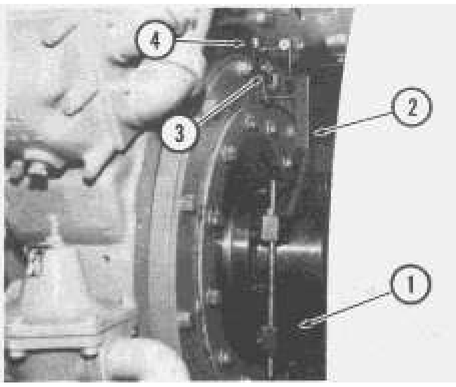
(8) Thickness Gauge

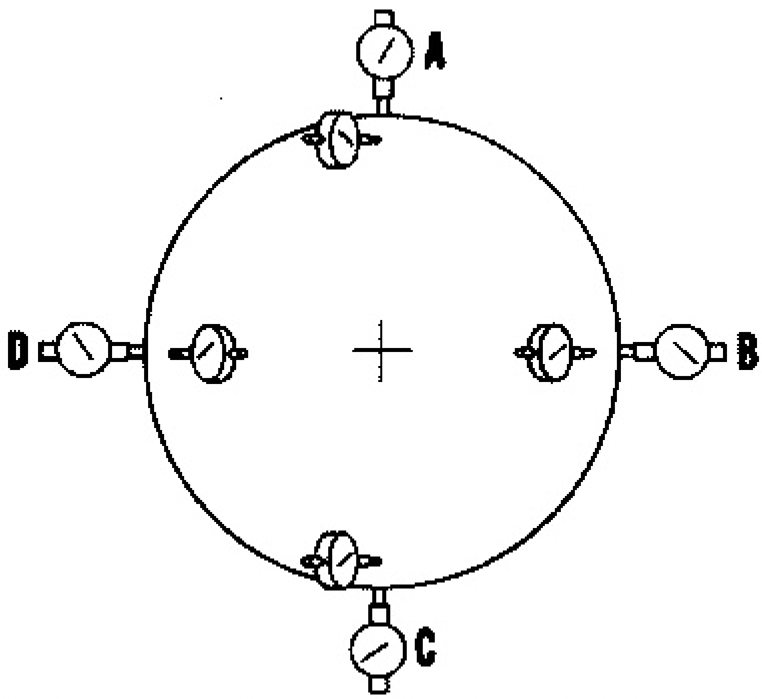
(D) Taking Dial Indicator Readings

Since all dial indicators do not indicate plus (+) in the same direction, it is necessary that a standard be established for the purpose of clarity in this instruction. In this instruction, a plus (+) reading means that the tip of the indicator moved into the dial indicator; a minus (-) reading means that the tip of the indicator moved out of the dial indicator. Before taking any indicator readings, check the dial indicators being used to determine which is the plus (+) direction. If the plus (+) direction is different than the standard used in this instruction, keep this in mind when taking dial indicator readings.

When comparing two plus (+) indicator readings, the larger numerical reading is more than the smaller numerical reading. However, when comparing two minus (-) indicator readings, the larger numerical reading is less than the smaller numerical reading. In both cases, the indicator reading becomes less as the tip of the indicator moves out of the dial indicator.

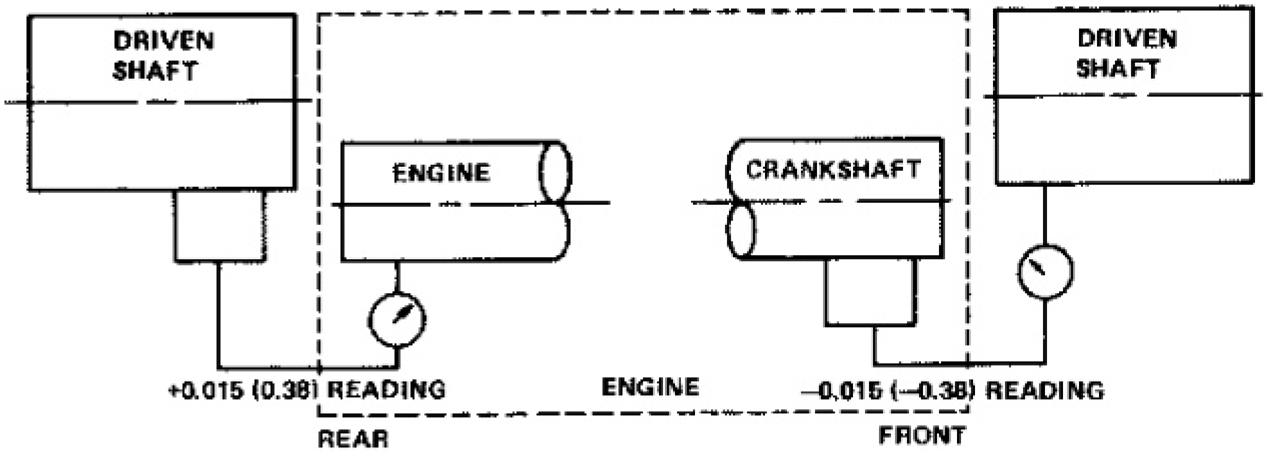
The Total Indicator Reading (TIR) is the total amount of movement of the indicator needle. The TIR is always a positive value even though one or both or the readings are negative. For example: if the indicator reading varied from -.010" to +.005", the TIR was .015". If the indicator reading varied from -.005" to -.015", the TIR was .010".





Install alignment bar (1), alignment yoke (2), face indicator (3) and bore indicator (4) on the shaft to be rotated as shown. Take indicator readings at four locations A, B, C and D as shown above. The dial indicator is always "zeroed" at location A before taking any readings. When taking readings, the indicator must be returned to location A to make sure the indicator reading returns to zero. A quick way to check the validity of the readings is to remember that the reading of B + D should equal the reading at C. This is valid where the driving and driven shafts are rotated together while checking alignment.

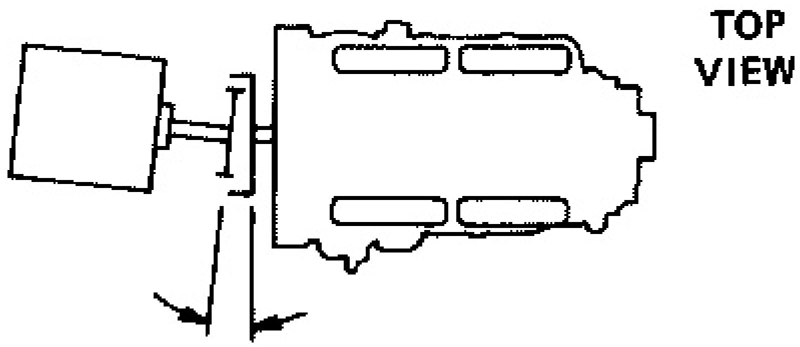
IMPORTANT: Do not use a dial indicator with a magnetic base to take face and bore misalignment readings. The weight of the indicator setup can cause the magnetic base to deflect and give false readings when the shaft is rotated to the B, C and D positions.



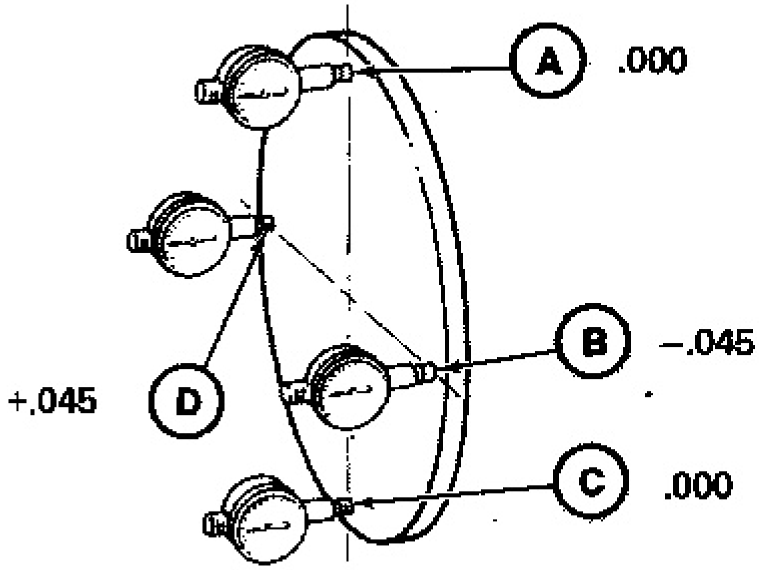
When checking the alignment of front driven remote mounted units, the indicator reading will be a negative value as shown above. However, this does not mean that the driven shaft is lower than the engine crankshaft. This occurs because the indicator is mounted on the crankshaft side of the coupling, thereby reversing the indicator reference point from that of rear driven remote mounted units. On rear driven units, the indicator is mounted on the driven side of the coupling.

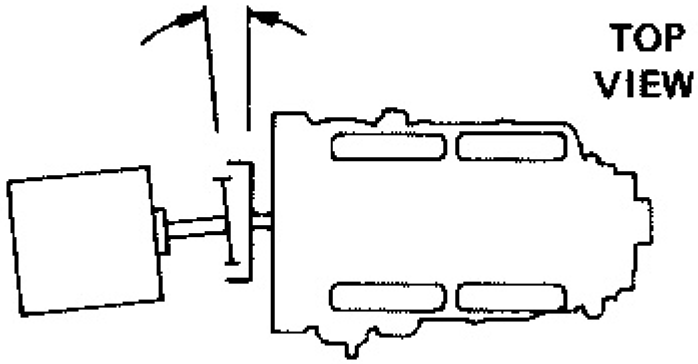
(E) Typical Indicator Readings Showing Misalignment

The following are examples of misalignment of a remote mounted rear driven unit. In all cases, the dial indicator is zeroed at the "A" position and both shafts are rotated together. Bore misalignment in the vertical direction for remote mounted front driven units will have indicator readings that are opposite in sign from those shown (plus instead of minus and minus instead of plus).

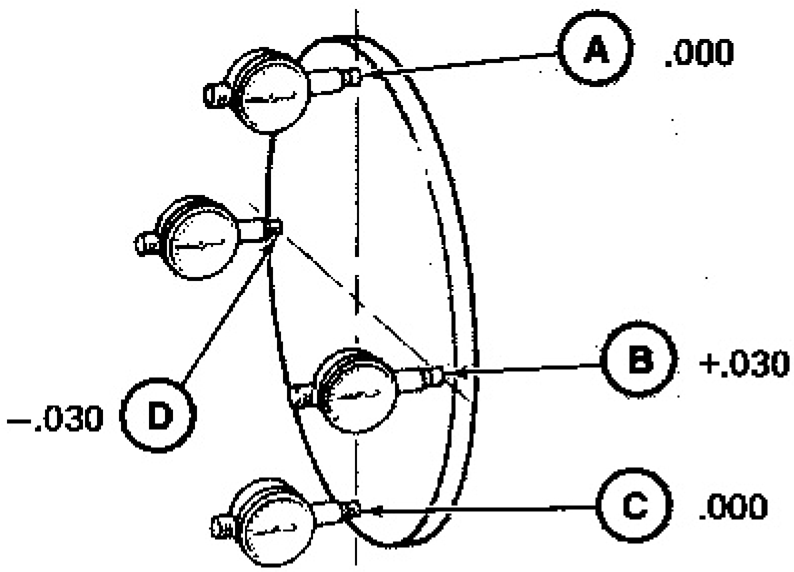


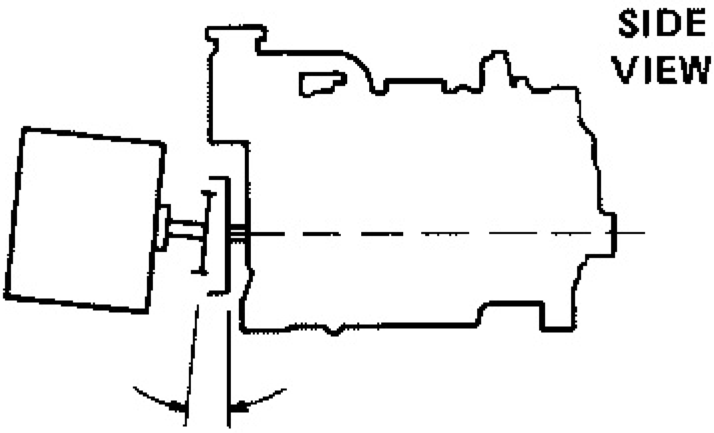
FACE MISALIGNMENT HORIZONTAL
(REAR OF DRIVEN UNIT TOO FAR LEFT)



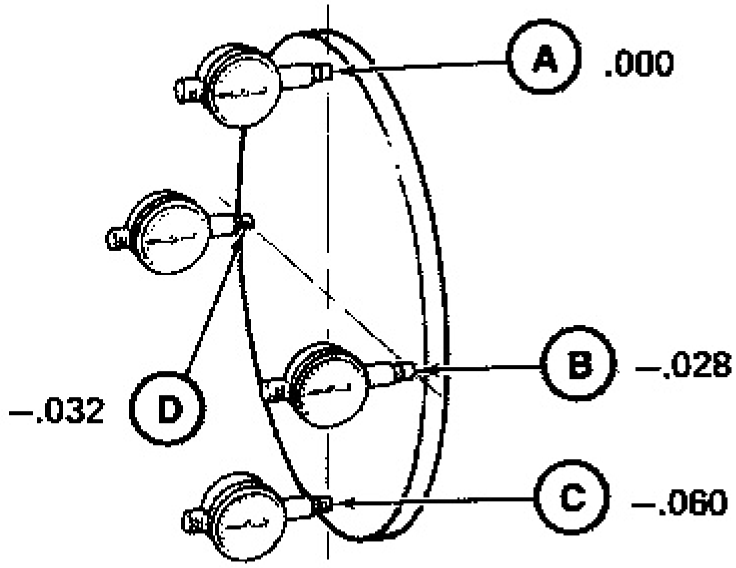


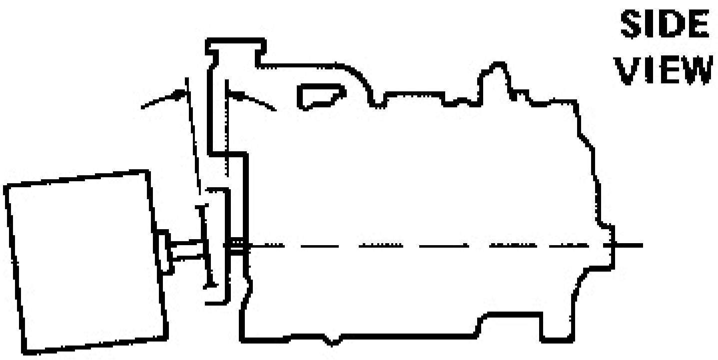
FACE MISALIGNMENT HORIZONTAL
(REAR OF DRIVEN UNIT TOO FAR RIGHT)



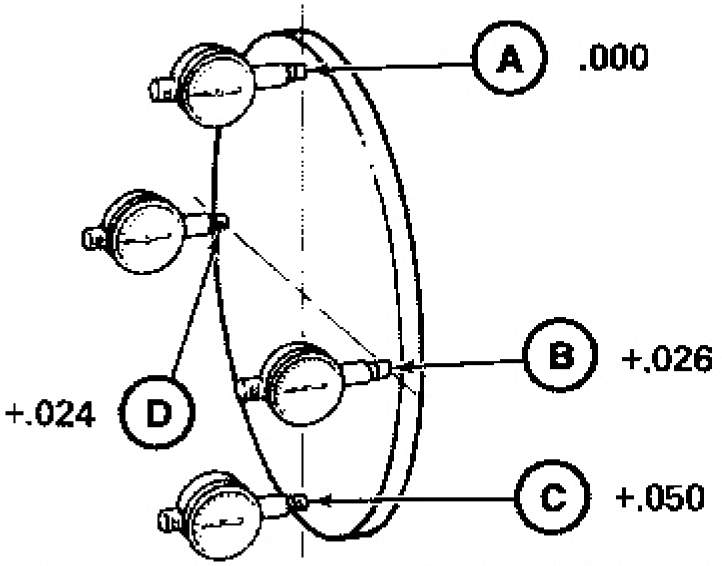


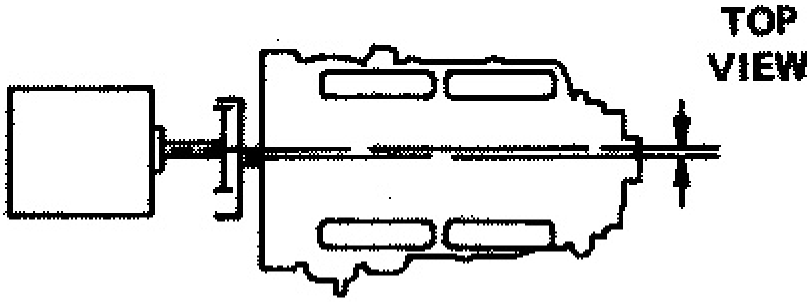
FACE MISALIGNMENT VERTICAL
(REAR OF DRIVEN UNIT TOO HIGH)



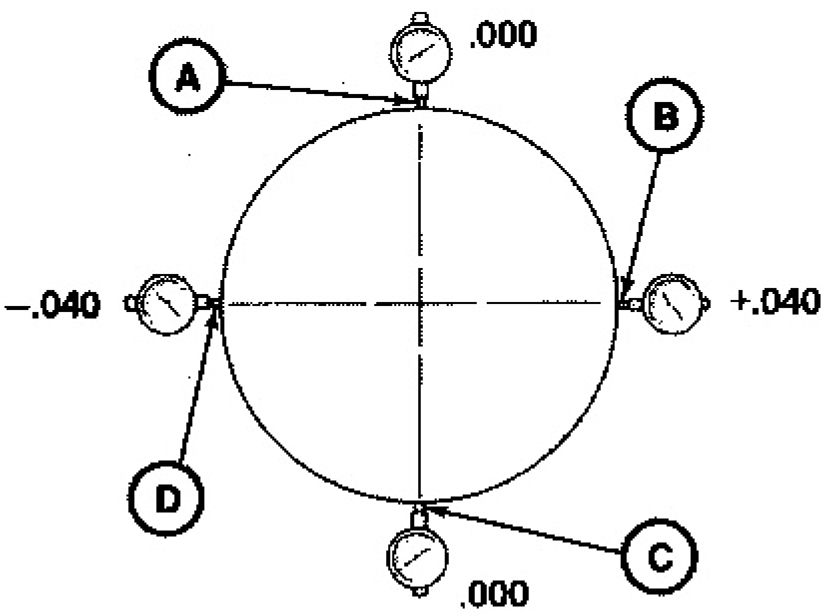


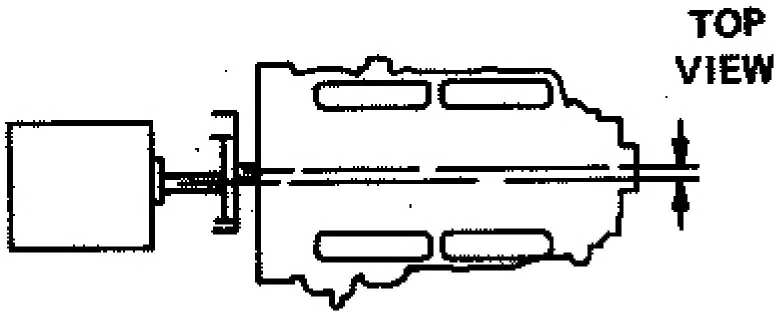
FACE MISALIGNMENT VERTICAL
(REAR OF DRIVEN UNIT TOO LOW)



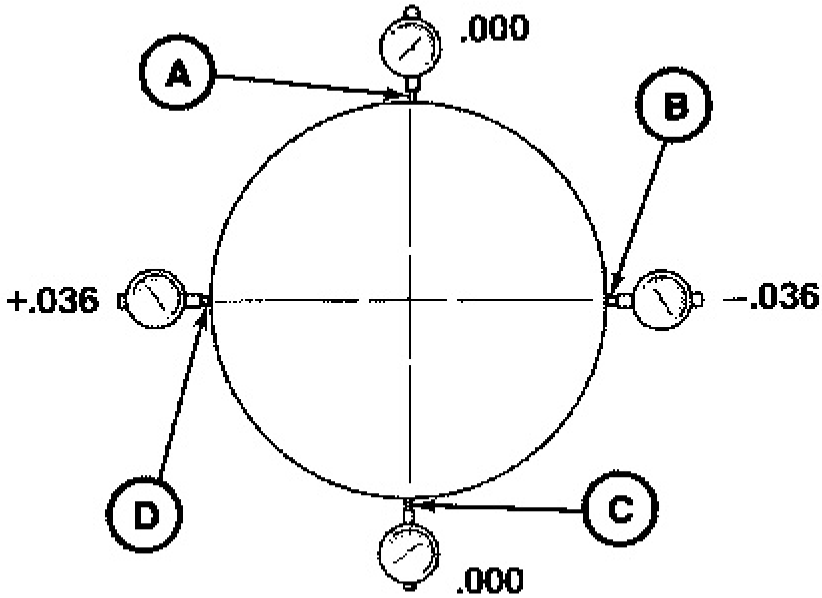


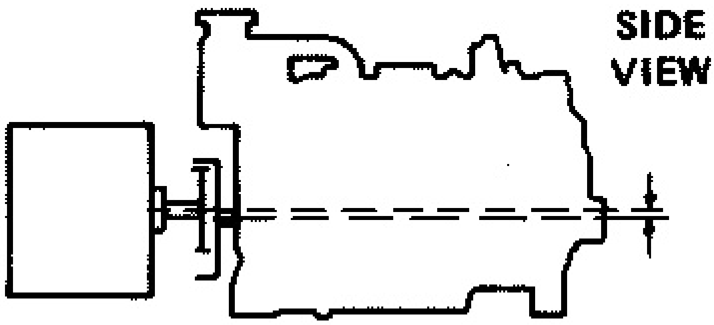
BORE MISALIGNMENT HORIZONTAL
(DRIVEN UNIT TOO FAR LEFT)



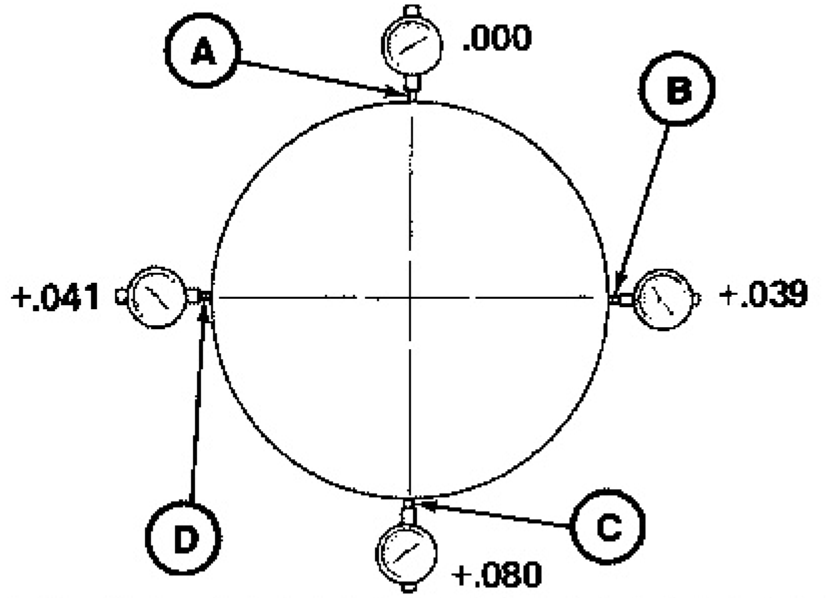


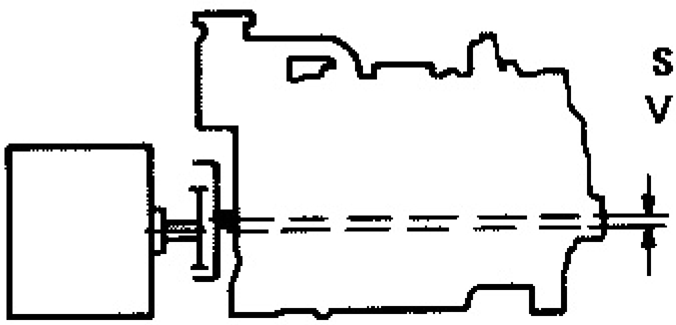
BORE MISALIGNMENT HORIZONTAL
(DRIVEN UNIT TOO FAR RIGHT)



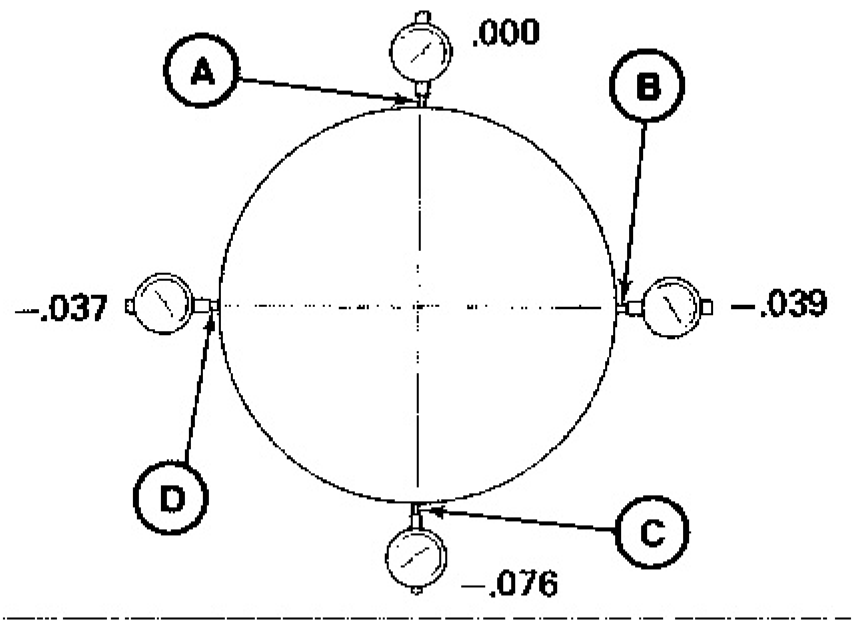


BORE MISALIGNMENT VERTICAL
(DRIVEN UNIT TOO HIGH)



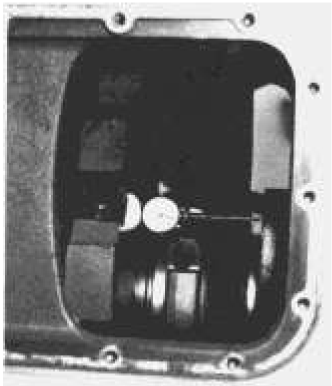


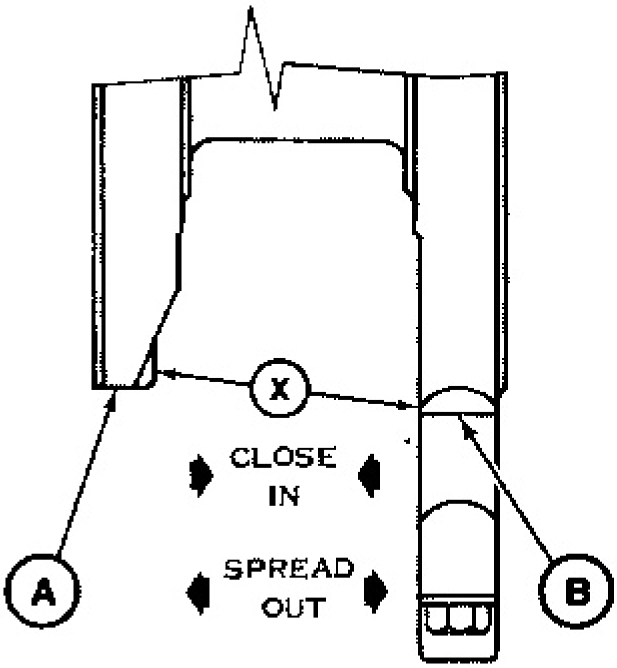
BORE MISALIGNMENT VERTICAL
(DRIVEN UNIT TOO LOW)

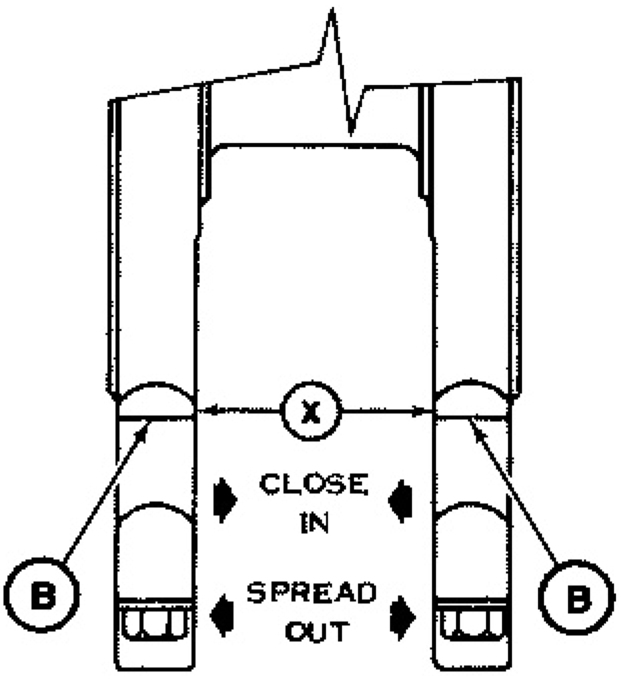


(F) Checking Engine Crankshaft Deflection

NOTE: The following procedure must be used on all D348, D349, D398 and D399 Engines after alignment of the marine transmission and engine, and after installation of the shims and anchor bolts. Do this procedure with both a cold engine and a hot engine.





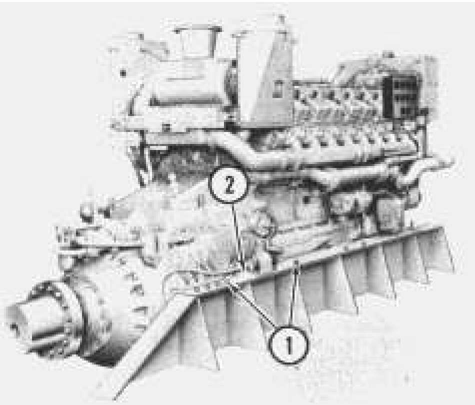


(1) Remove the inspection cover from the side of the cylinder block to expose the crankshaft center main bearing journal. Rotate the crankshaft until the counterweights on the center throw are at the 3 o'clock or 9 o'clock position. Install a Starrett Crankshaft Distortion Dial Gauge No. 696 with a No. 696B Balancer Attachment on either side of the center main bearing journal with the indicator pivot points positioned approximately .25" (6.4) from faces (A) and/or (B).

(2) Zero the dial indicator. Make sure the indicator pivot points are seated properly by rotating the gauge about its own axis until it will hold a zero reading. Rotate the crankshaft until it is within approximately .25" (6.4) of the connecting rod (at the 11 o'clock or 1 o'clock position). Zero the indicator. Rotate the crankshaft from the starting (11 o'clock or 1 o'clock) position until the gauge approaches interference with the connecting rod on the opposite side. Continuously observe the gauge reading while rotating the crankshaft through approximately 300° of rotation.

IMPORTANT: The Starrett Dial Gauge used in this procedure will show a plus (+) reading when the tip of the indicator moves out and a minus (-) reading when the tip of the indicator moves in. This is the opposite of usual indicator movement.

(3) Rotate the crankshaft back to the starting position. The indicator reading must return to zero at the original starting position in order to make a valid test. If the indicator did not return to a zero reading, the indicator shaft points were not seated and the test procedure must be repeated.



(4) The change in dimension (X) is the amount of crankshaft deflection. With the indicator set at zero at 11 o'clock or 1 o'clock, the bottom reading (at 6 o'clock) must be between -.0005" (0.013) and +.001" (0.025). If the change in dimension (X) exceeded these values, cylinder block distortion has occurred due to improper shimming under the mounting rails. Loosen bolts (1) that fasten engine rails (2) to the ship's engine bed. Install the correct thickness of shims as necessary between the rails and engine bed to ensure that each mounting point is carrying its portion of the load. Check face and bore alignment again to be sure that they are correct. Repeat the crankshaft deflection check if the thickness of any of the shims was changed.

Flexible Couplings

(A) General Requirements

A flexible coupling is a device used to transmit power from one shaft to another while accommodating some shaft misalignment. Some typical flexible couplings are:

1. Couplings with rubber or elastomer elements.
2. Couplings with flexible steel plates or discs.
3. Couplings with spring-type elements.
4. Gear-type couplings.
5. Roller chain-type couplings.

Flexible couplings can be used to connect an engine to a driven unit, two engines together, or several driven units together. Four distinct characteristics must be considered in the selection of a coupling:

Misalignment capability: The coupling must be capable of compensating for some misalignment between the two connected shafts. Every flexible coupling has its own misalignment capabilities. It is important that the coupling be aligned as close to specification as possible during initial alignment. The closer the initial alignment, the more reserve margin a coupling has to compensate for misalignment during operation. A coupling that operates with more than its designed maximum amount of misalignment will have a less than satisfactory service life. When selecting a coupling, always make sure the misalignment capability is compatible with the application.

IMPORTANT: Flexible couplings are not intended to correct for shaft misalignment. However, they must be able to compensate for small amounts of shaft misalignment normally present due to temperature fluctuation and operating loads. In high speed applications, this misalignment must be kept to a minimum. Excessive misalignment may cause vibration, noise, and can reduce the service life of the engine and/or driven unit. Flexible couplings, when properly aligned, will permit some temporary changes (misalignment) in shaft position during start-up or during some unusual momentary load condition. Two rotating shafts connected by a flexible coupling are considered to be in correct alignment when the relative position of the two shafts is such that during normal operation (and temperature) no flexing occurs at the coupling.

Stiffness: The coupling must be of proper torsional stiffness to prevent critical orders of torsional vibration from occurring within the operating speed range. To ensure coupling compatibility, have a complete torsional analysis performed by qualified personnel or obtain a complete torsional vibration analysis from Caterpillar.

Many types of flexible couplings use a flexible element to connect the driving hub to the driven hub. The stiffness of these elements can vary considerably. If the element has a high degree of stiffness, it may be necessary in some applications to remove these elements while rotating the shafts in order to get valid indicator readings. NOTE: It is not necessary to remove these elements on Caterpillar viscous damped couplings.

Serviceability: Ease of installation and service is a significant factor when selecting a coupling. If spacers can be used to permit removal and installation of the coupling without disturbing the engine-to-driven unit alignment, sufficient time will be saved should the coupling ever need servicing or replacement.

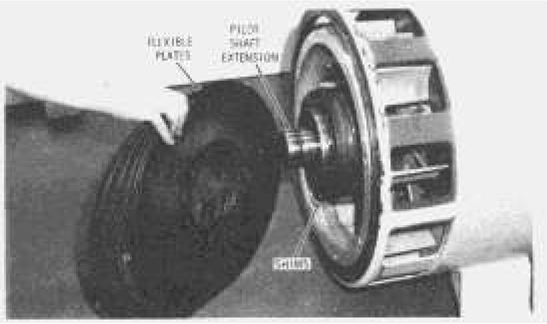
Coupling Selection: In an installation, the coupling should be the design weak link or first part to fail. When failure occurs, the chance of damage to the engine and driven unit is minimized. Safety measures must be considered to prevent major damage should coupling failure occur. The use of a standard, commercially available coupling offers the benefit of parts availability and reduced downtime in case of failure. When selecting a coupling, always follow the coupling manufacturer's recommendation as to the best coupling for your application.

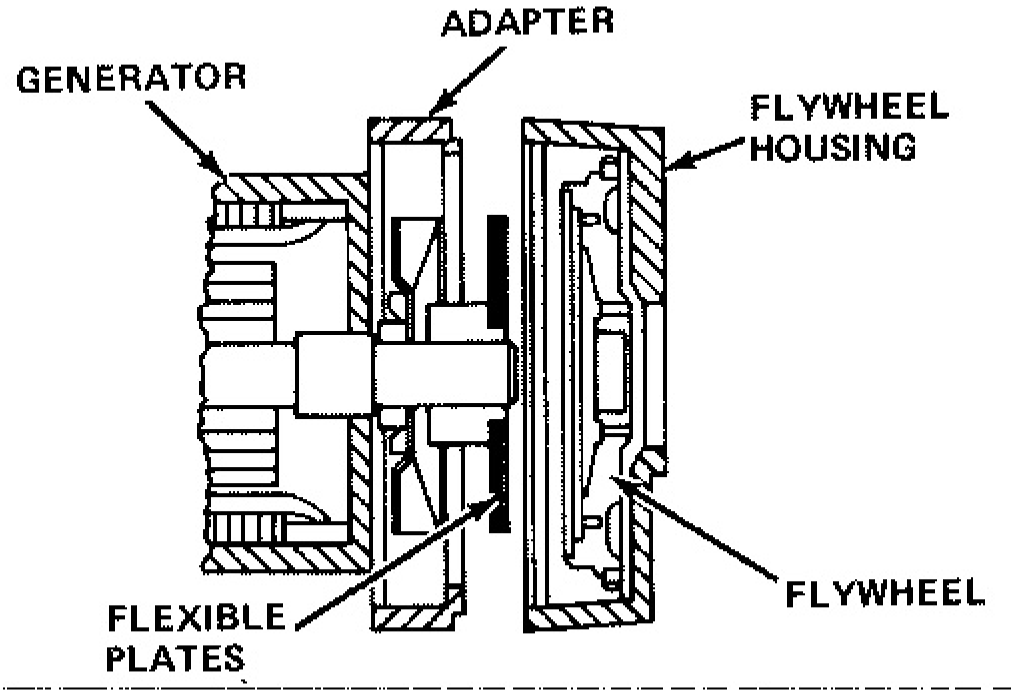
(B) Caterpillar Couplings

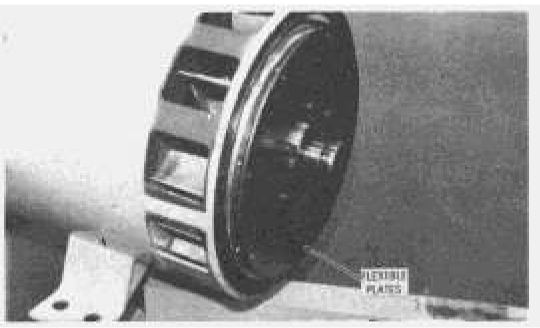
The three types of flexible couplings supplied by Caterpillar are:

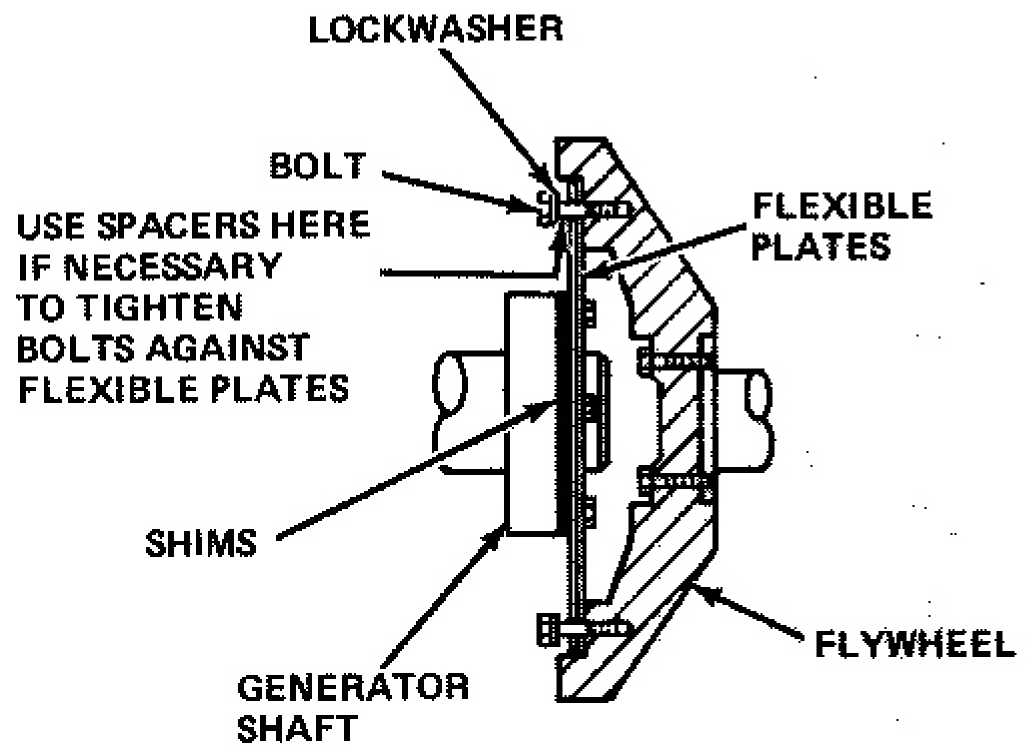
1. The flexible steel plate coupling - used in single bearing generator applications.
2. The spider and ring with rubber blocks - used in close coupled marine transmission applications.
3. Viscous damped coupling - used with remote mounted marine transmissions and two bearing generators.

Flexible steel plates

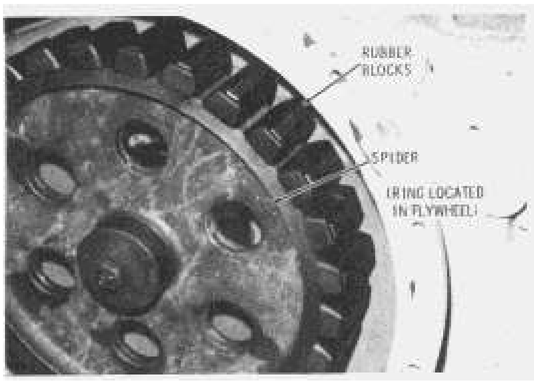

FLEXIBLE PLATES
PILOT SHAFT EXTENSION
SHIMS

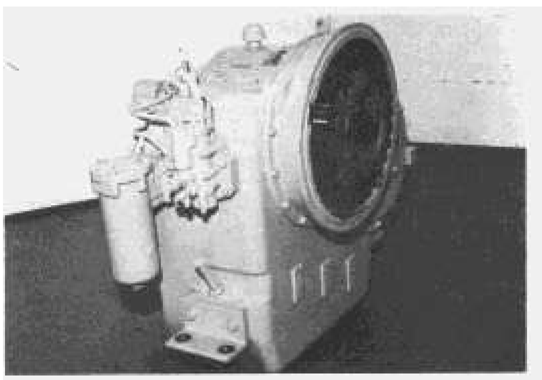

ADAPTER
GENERATOR
FLYWHEEL HOUSING
FLEXIBLE PLATES
FLYWHEEL


FLEXIBLE PLATES

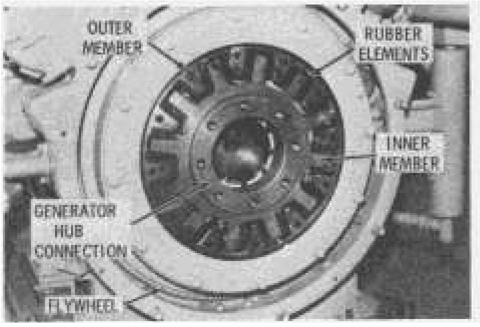


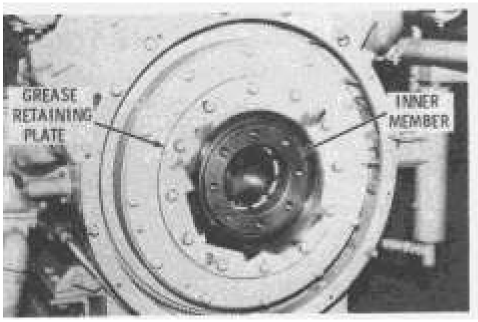
Spider and ring with rubber blocks

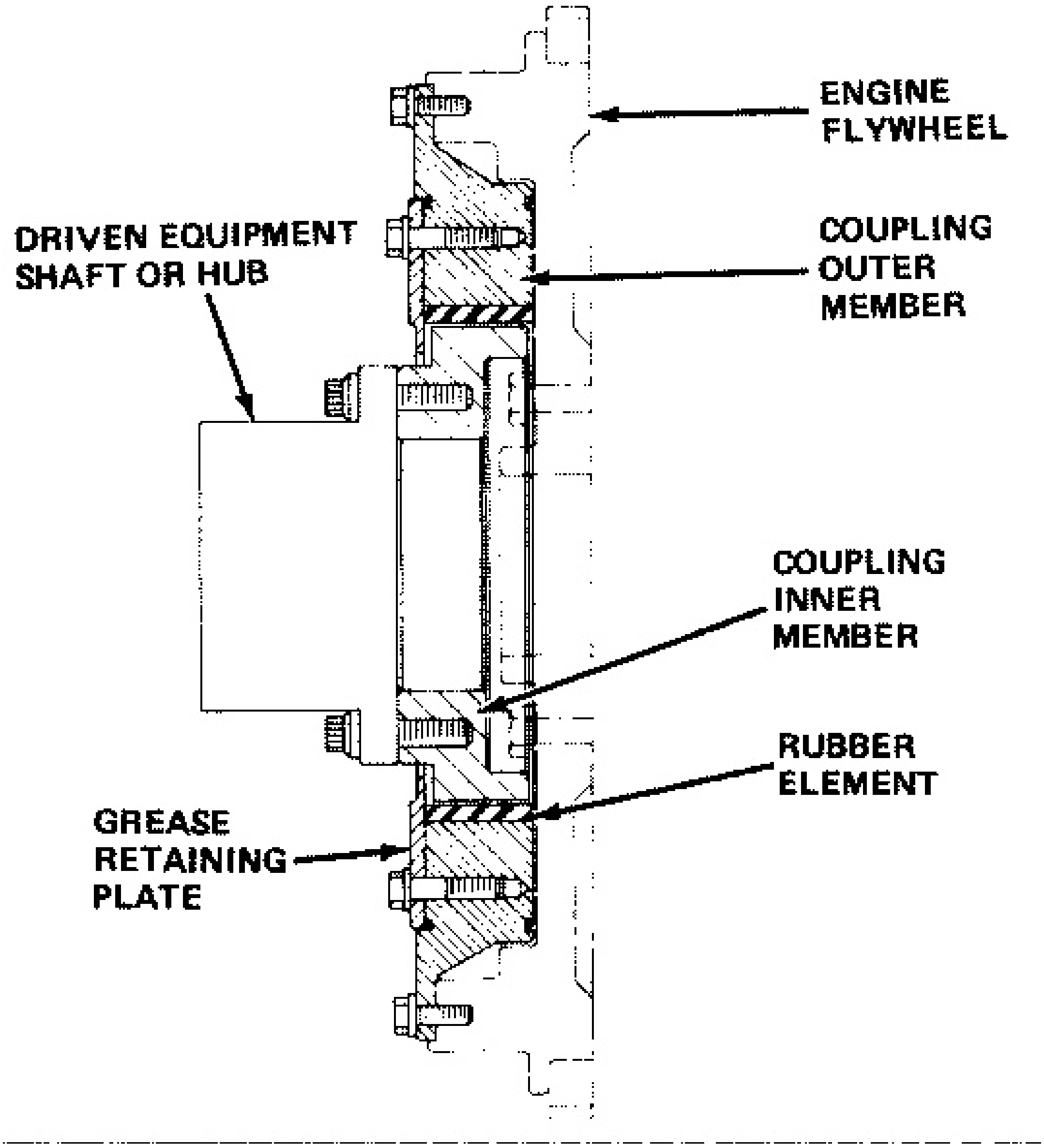




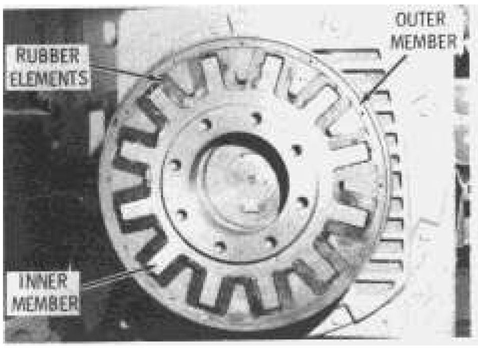
Caterpillar viscous damped coupling - flywheel housing contained

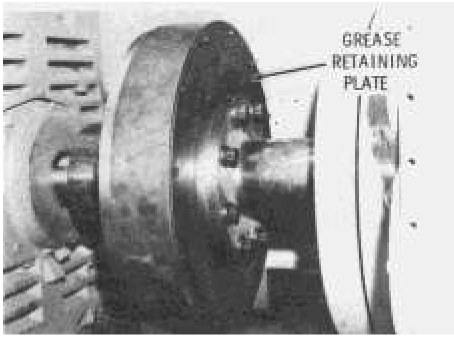


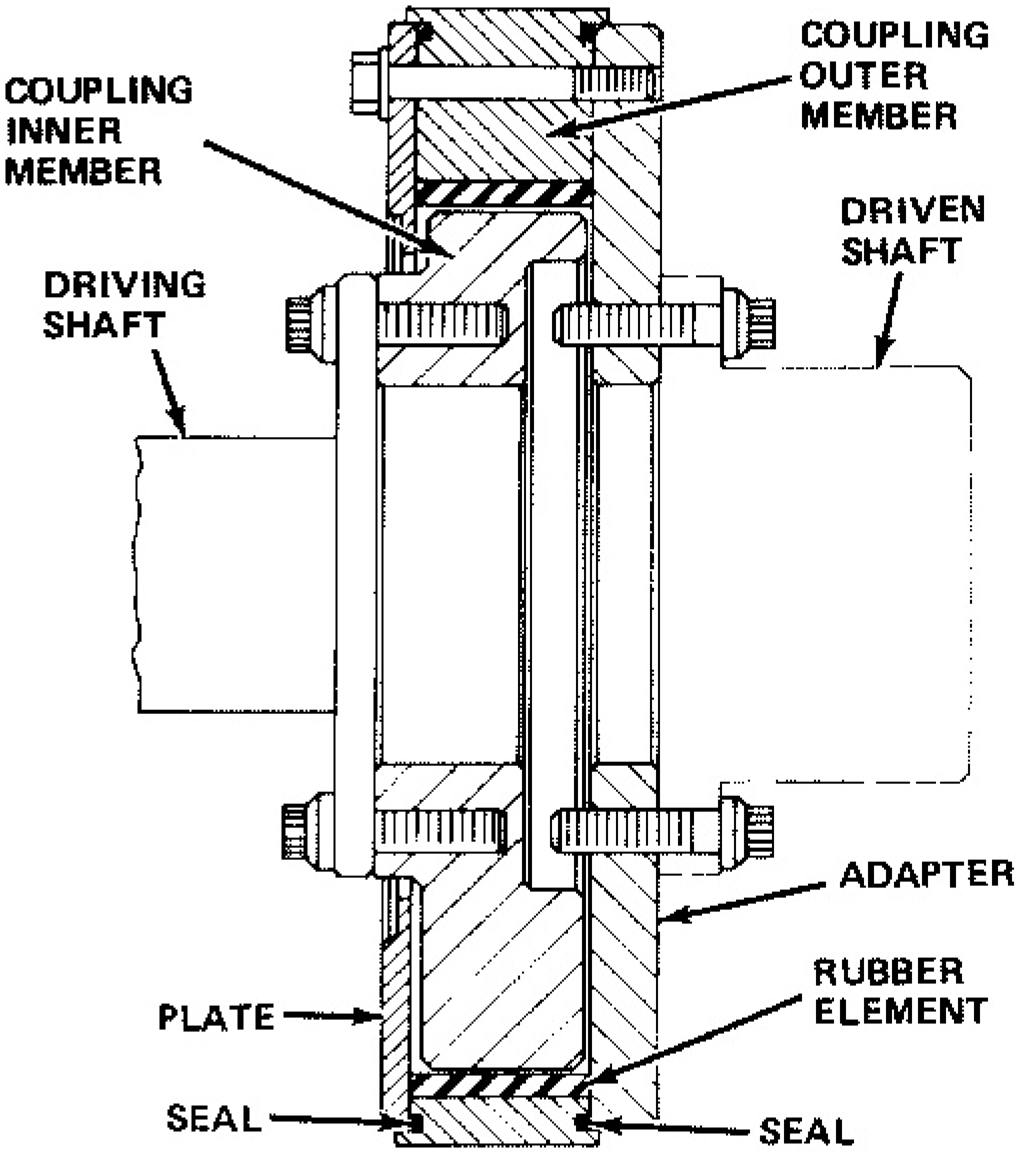




Caterpillar viscous damped coupling - external housing

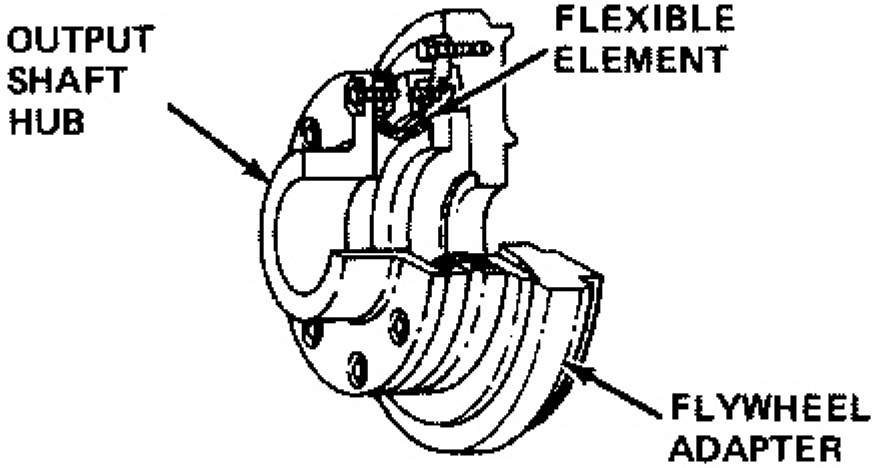


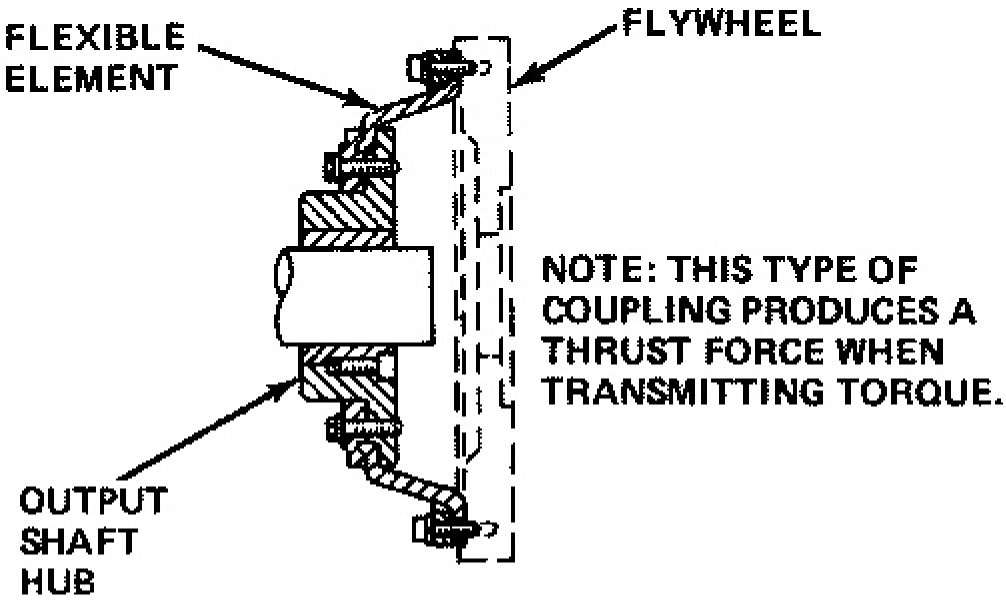


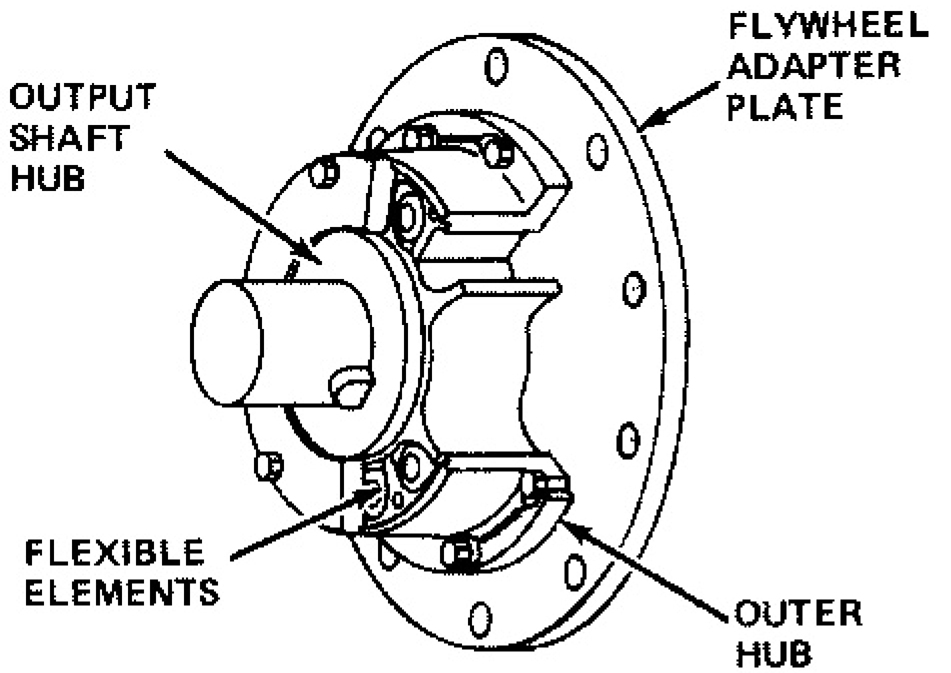


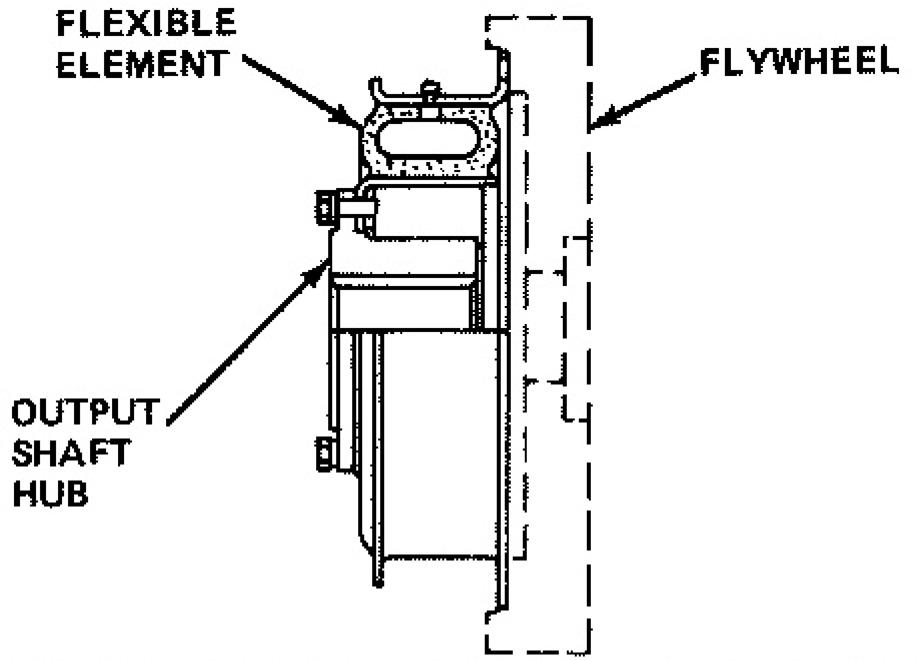
(C) Couplings By Other Manufacturers

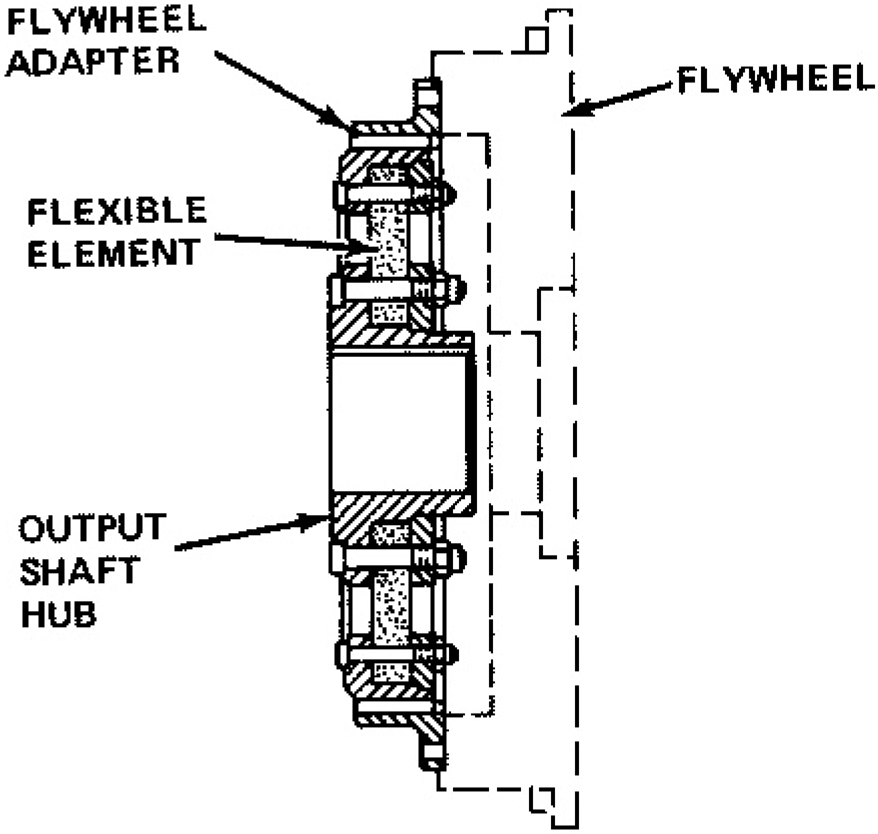
The typical couplings shown below all use flexible elements made of rubber or elastomer. Because the stiffness of these flexible elements can vary considerably, it may be necessary to remove the flexible elements from the coupling in order to get valid indicator readings for face and bore misalignment. When installing these couplings on Caterpillar Engines and driven units, always use the appropriate Caterpillar Special Instruction in conjunction with the coupling manufacturer's installation and alignment instructions.

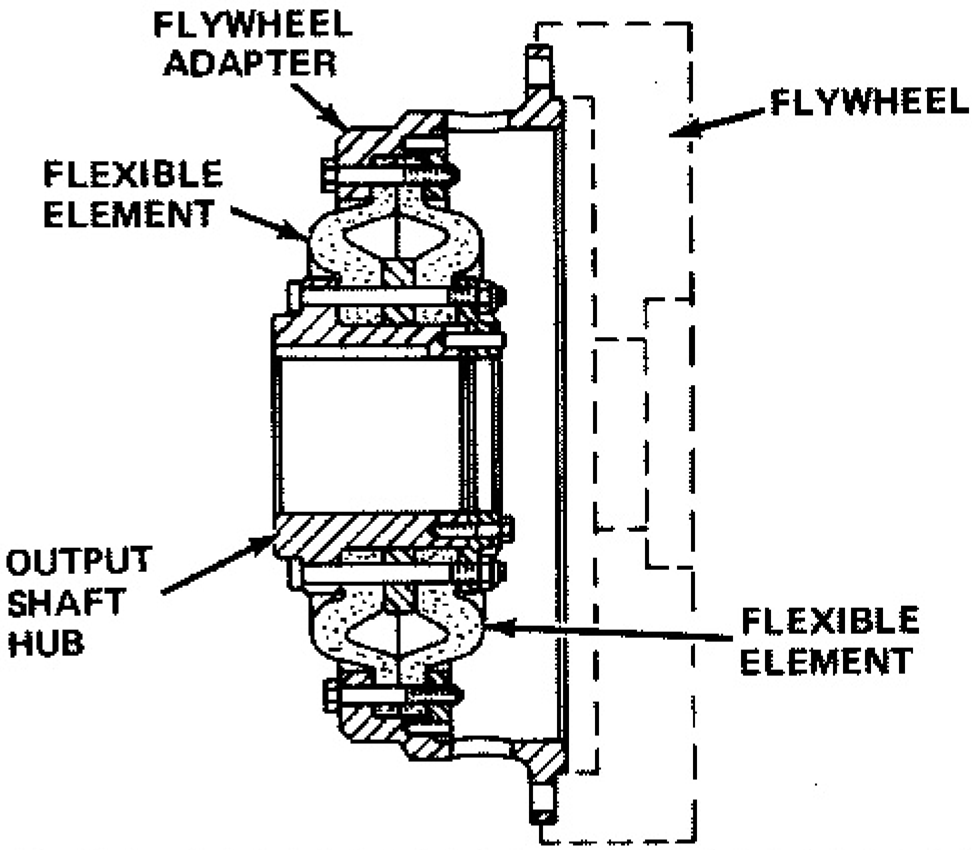





FLYWHEEL ADAPTER PLATE
OUTPUT SHAFT HUB
FLEXIBLE ELEMENTS
OUTER HUB


FLEXIBLE ELEMENT
FLYWHEEL
OUTPUT SHAFT HUB





Bases

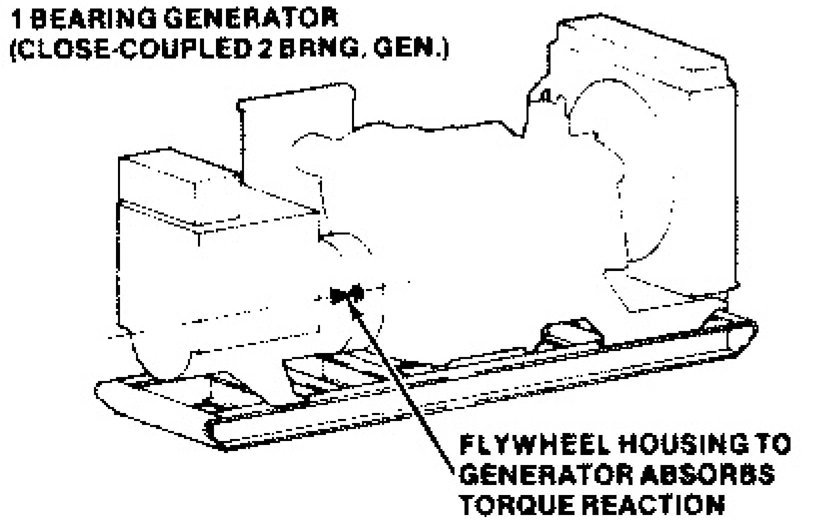
(A) Caterpillar Bases

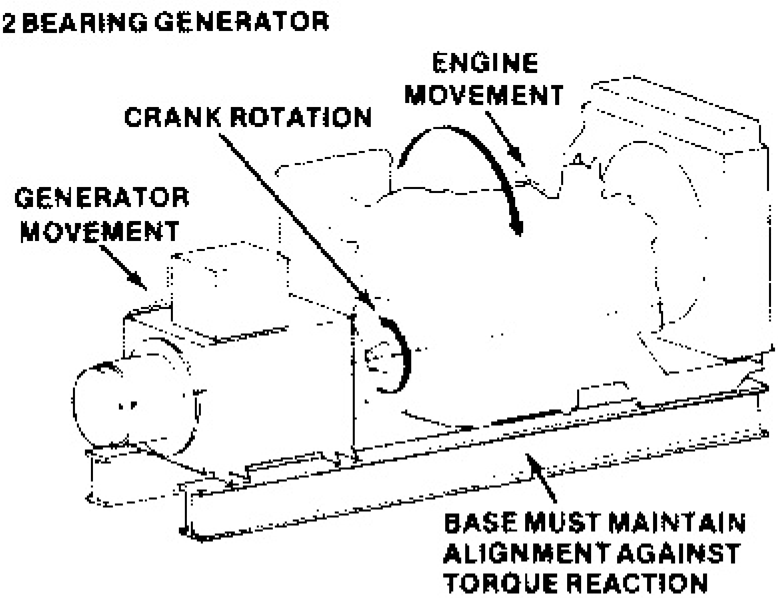
When the engine and driven unit are mounted on a base, it is essential that the base be properly designed.

The base must maintain the original alignment under all operational and environmental conditions.

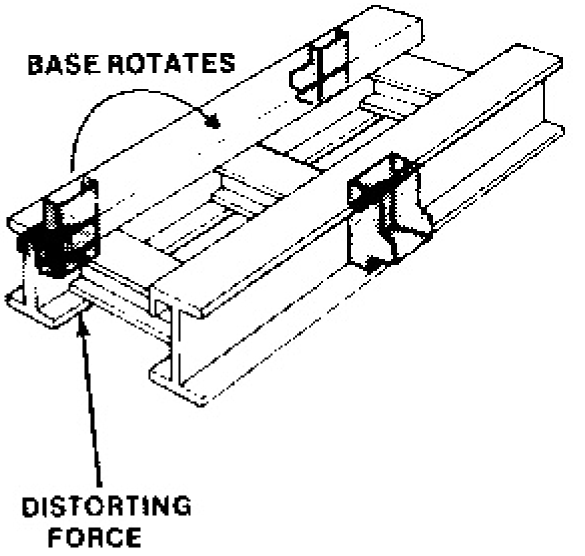
Caterpillar bases are designed to eliminate frequent, periodic realignment of the engine and driven unit. A properly installed Caterpillar base will meet the following criteria:

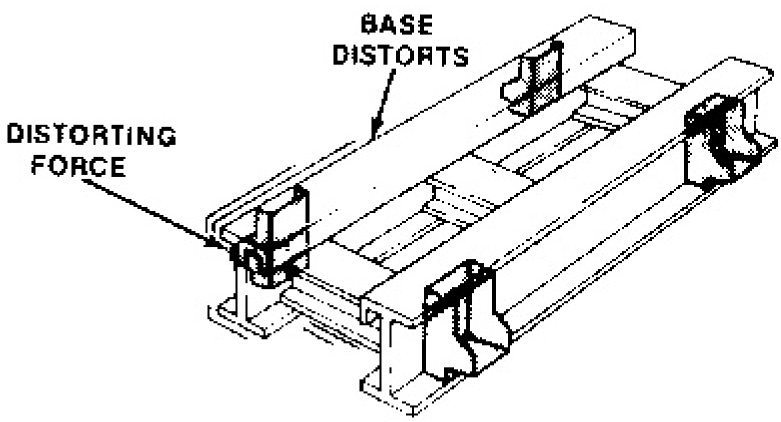
1. Engine torque does not cause excessive misalignment.
2. Flexing of the foundation or substructure under the base during operation does not cause bending of the base.
3. When the engine and driven unit are mounted on a Caterpillar base, the entire package is able to withstand normal handling during transportation without permanently distorting the base or causing misalignment of the driven unit.
4. A Caterpillar base is free of torsional or linear vibrations in the operating speed range of the engine.





Caterpillar offers different bases for close coupled units (such as single bearing generators) and for remote mounted units (such as two bearing generators). The base for a remote mounted two bearing generator must be sturdy enough to provide support and maintain alignment. The base for a close coupled single bearing generator can be lighter because the base does not have to withstand torque reaction. Fastening the driven unit housing to the flywheel housing eliminates the need for the base to have to absorb the torque of the engine. On remote mounted units, the frame of the driven equipment tries to rotate in the same direction as the engine crankshaft. If the base were not rigid enough, engine torque would cause the base to flex excessively. The result would be misalignment proportional to the amount of load. This misalignment would not be evident during a static alignment check.





A Caterpillar base for remote mounted equipment is a torsionally rigid structure for mounting the engine and driven unit. The three point suspension design maintains proper relationship and alignment of all equipment by isolating external forces.

The three point suspension system must be used when there is a possibility that the foundation or substructure that supports the base can deflect due to external forces or settling. Suspending the power unit on three points isolates the unit from deflection of the substructure. More than three mounting points can cause base distortion.

(B) Other Bases

Bases not manufactured by Caterpillar must meet several design criteria. These bases must be rigid enough to limit torsional and bending forces caused by torque reaction and sub base flexing. They must prevent excessive bending forces from passing to the engine block, couplings and driven unit during shipment. To prevent resonance, they must have a natural frequency out of the operating speed range. They must allow sufficient space for shimming so proper alignment can be accomplished.

Bases For Engines With Close Coupled Units

Caterpillar does not recommend a specific section modulus for the longitudinal girders or cross members. Usually "I" beams or channel section steel beams in a ladder type arrangement are acceptable.

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1. Bases for foot mounted engines should have cross members that are as substantial as the longitudinal beams. These cross members should be placed beneath each engine and driven unit support location.

2. Do not mount the engine and driven unit directly to a base that has a deck plate surface. Use steel pads between the mounting feet and the base beams, and cut out the deck plates at the pad locations.

3. Do not fasten the engine and driven unit mounting feet to the base by welding.

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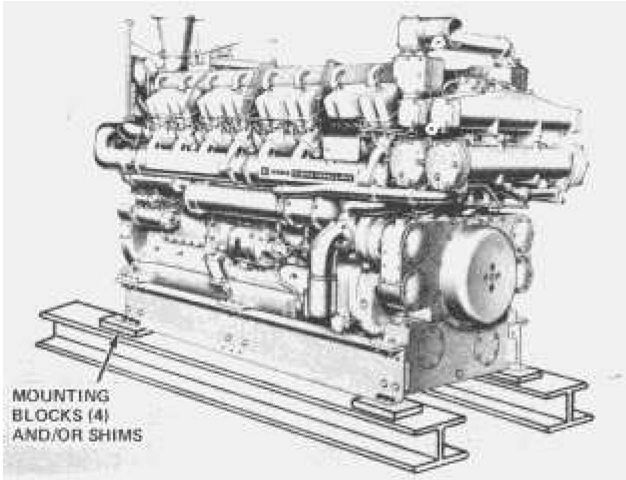
1. Standard Caterpillar mounting rails must be used between the engine and the base.
2. Cross members of the base provide the greatest support when located at the mounting locations between the engine mounting rails and the base.



3. Four threaded mounting blocks are usually used between the engine mounting rails and the base to provide sufficient space for shimming. These blocks must be welded to the base. Shims are used as necessary between the blocks and the mounting rails to put the parallel mounting surfaces in the same plane.
4. No welding of the engine mounting rail to the base is permitted.
5. The mounting rails must be bolted to the mounting blocks. There must be clearance between these bolts and the holes in the mounting rails except at the right rear or right front corner where a doweled bolt is used.

Bases For Engines With Remote Mounted Driven Equipment

The design requirements for bases used with engines with close coupled units also apply to bases used with engines with remote mounted units. In addition, bases for use with remote mounted units must be more rigid. The full load torque between the engine and driven unit has to be absorbed by the base without causing excessive deflection in the coupling.

Shim Material

Shims can be used to get correct alignment between the engine and the driven unit. Depending upon the application, shims are required under the engine only, under the driven unit only or under the engine and driven unit. Certain metal and poured resin shims are acceptable in marine propulsion applications provided the major marine classification societies have approved the material and the manufacturer's installation recommendations are followed. In applications other than marine propulsion, brass or other non-rusting metal shims are usually preferable. Under no circumstances should lead be used as a shim material. Lead is easily deformed under weight and vibration and has poor support characteristics.

Metal Shims

Marine Propulsion Applications After the engine and/or marine transmission have been aligned, metal shims can be made to fit between the mounting feet or mounting pads of the engine or transmission and the engine bed of the ship. Usually mild steel plates that are 10 to 12 square inches (6450 to 7740 sq.mm) in area are used. These plates must be machined to specific thicknesses for each pad or mounting foot location. Identification must be put on the shims and their matching location on the engine bed. The machining of these shims must provide a uniform zero clearance fit under each pad or support. Alignment must be maintained between the engine and transmission or between the transmission and propeller shaft when the shims are inserted in their respective positions and the anchor bolts are installed.

IMPORTANT: When metal shims are used between the mounting pads or supports and the engine bed, the mounting surfaces must be flat, free of burrs and parallel to the bottom surface of the mounting pads or supports.

Other Applications After the engine and driven equipment have been aligned, brass or some other type of non-rusting metal shims should be installed between the mounting feet or mounting pads of the engine or driven unit and the base or other mounting surface. The minimum thickness of each shim pack under each mounting location should be at least .200" (5 mm) to prevent later corrections requiring the removal of shims when there are too few or no shims remaining. After installation of the shims, each mounting location must carry its portion of the load.

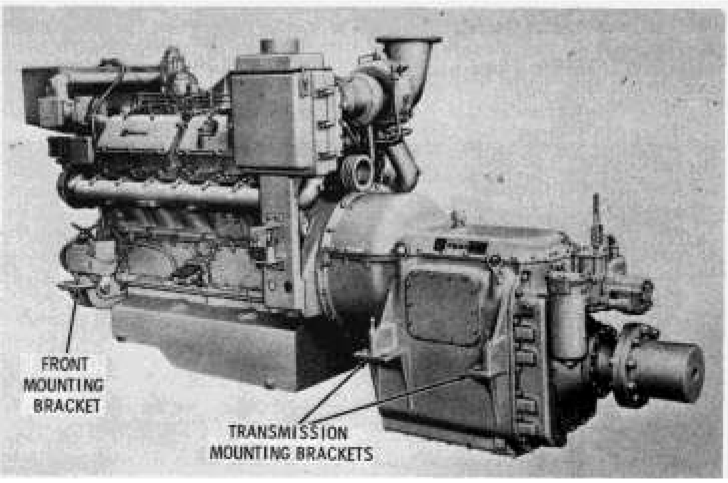
IMPORTANT: When metal shims are used between the mounting pads or feet and the base or mounting surface, the mounting surfaces must be flat, free of burrs and parallel to the bottom surface of the mounting pads or feet.

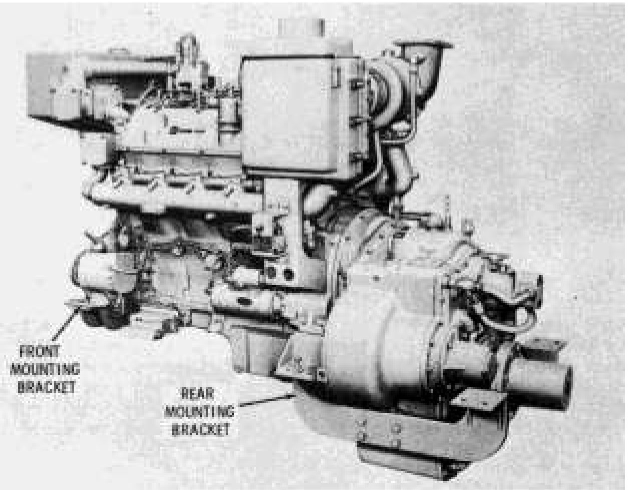
Poured Resin Shims

Poured resin shims are usually used in marine propulsion applications only. For close coupled marine engines and transmissions, the shim material is poured between the engine bed and the mounting rails of the engine and transmission. For remote mounted units, the shim material is poured between the engine bed and engine mounting rails and between the engine bed and the transmission support surfaces. When this shim material is used, the shim area must be a minimum of 45 sq. inches (29,000 sq.mm) per anchor bolt. This large area is necessary to prevent excessive unit loading of the shim material. For more information on the installation of poured shim material, see the mounting of marine engines and marine transmissions in the next section.

Equipment Mounting

(A) Marine Propulsion Engines With Mounting Feet



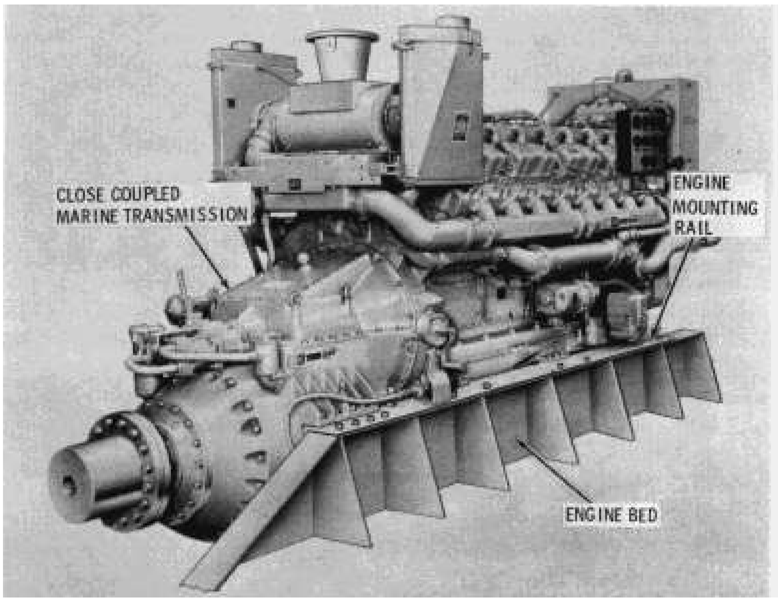


The mounting of Caterpillar marine propulsion engines with mounting brackets or feet is much simpler than the mounting of engines with mounting rails. Because the front mounting brackets are designed to flex, thermal growth of the engine is not a factor during alignment. The front mounting brackets are bolted to the ship's structure. Do not weld these brackets in position or distortion will result. Sufficient holes are provided for in the transmission mounting brackets to restrain the propeller thrust. However, to ensure that alignment remains intact, fitted bolts or dowels can be used in the transmission mounting brackets.

Use metal shims as necessary between the mounting surface of the ship's structure and the mounting brackets to get the engine and transmission in correct alignment with the propeller shaft. Make sure the engine and transmission mounting brackets are in equal contact with the shims at all locations. If the brackets are not in solid contact with the shims before the anchor bolts are installed, undue stressing of the engine and/or transmission will result when the anchor bolts are tightened.

(B) Marine Propulsion Engines With Mounting Rails

The standard Caterpillar mounting rails must be used to properly support, align and anchor the larger V-type marine propulsion engines and close coupled transmissions or marine propulsion engines with remote mounted transmission. These engines and transmissions must be mounted and anchored to meet the following conditions:



1. The bottom of the machined pads on the underside of the mounting rails must be in equal solid contact at all mounting locations. In other words, the tops of the shims at all mounting locations must lie in the same plane. If there is not zero clearance between the bottom of the mounting pads and the top of the shims, the engine and transmission will be stressed when the anchor bolts are tightened. If steel shims are used, the top mounting surfaces of the ship's engine bed must be flat, free of burrs and parallel to the bottom surface of the mounting pads. If poured resin shim material is used, the condition of the top mounting surfaces of the engine bed is not as critical. For this reason, poured shim material is often preferable in marine propulsion applications.

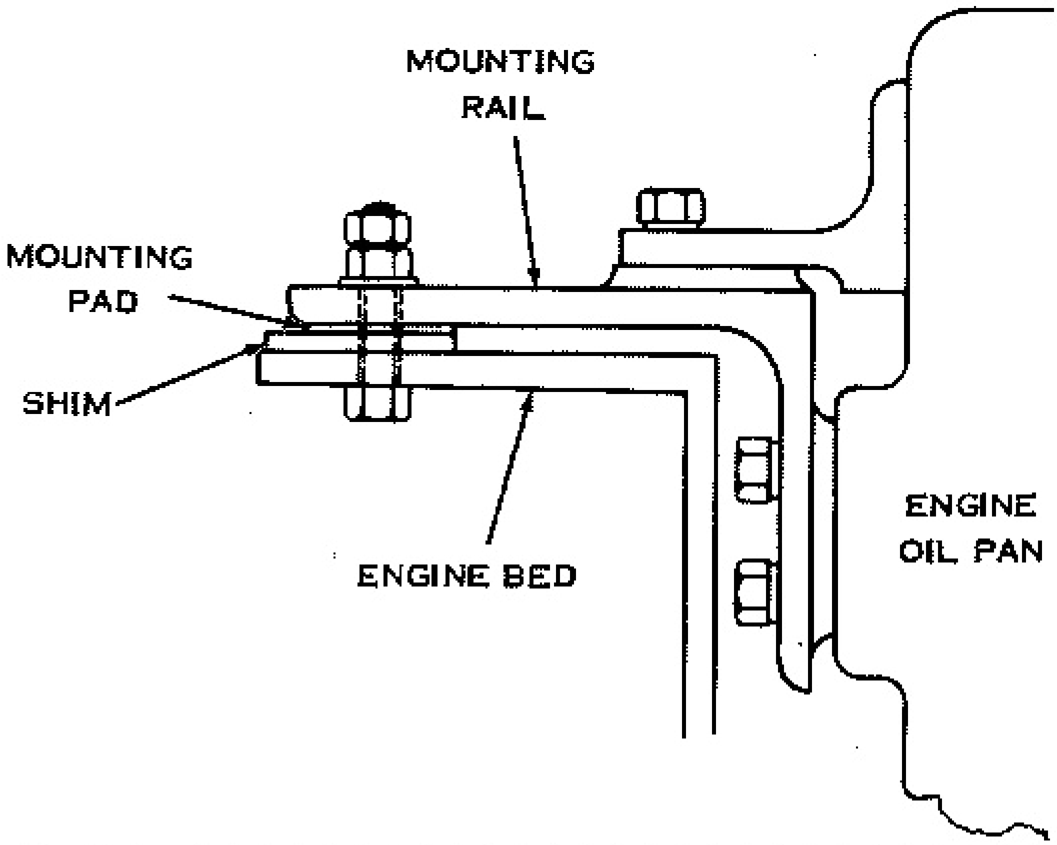
2. The anchoring system must hold the engine and transmission in place against vibration and propeller thrust but still allow the engine enough clearance for thermal growth.

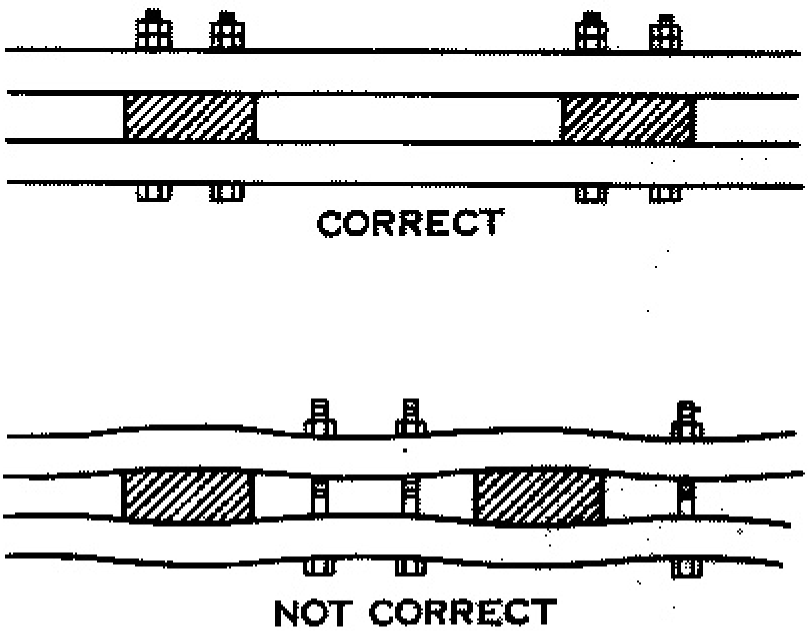
3. The engine mounting must be flexible enough to absorb minute movements of the supporting structure regardless of the way the vessel is loaded or sea conditions encountered during service. If the engine is too rigidly mounted to the ship's structure, the engine will be subjected to the stresses caused by any movement of the engine bed. For this reason, the standard Caterpillar mounting rails must be used to provide the needed flexibility to isolate the engine from the hull.

4. Alignment between the propeller shaft and the transmission must be maintained at all times. On remote mounted transmissions, the flexible coupling in the engine flywheel must be capable of accepting temporary misalignment between the transmission and engine without transmitting destructive forces to the crankshaft.

Mounting with metal shims

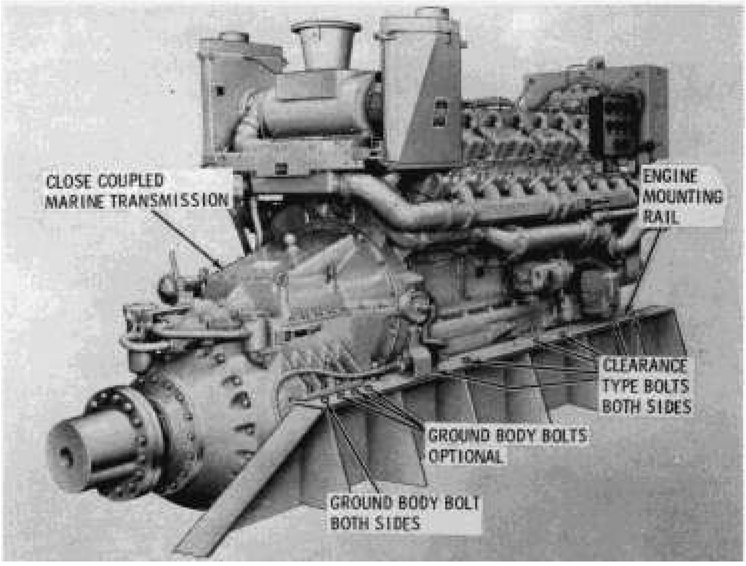
After the marine transmission and engine have been aligned to the propeller shaft, shims made from mild steel must be machined to provide a uniform zero clearance fit between the engine bed and the mounting pads of the rails.





The shims must be installed only at the bolt hole locations in the mounting rail.

The shim area must not exceed 12 square inches (7740 sq.mm) per bolt hole or extend inboard of the mounting pad.



On close coupled transmissions, use at least one ground body bolt at the rear on each side to fasten the mounting rail to the engine bed at the transmission bolt hole locations. Do not use any other ground body bolts forward of the transmission.

On engines with a remote mounted transmission, use a ground body bolt on each side of the engine at the rear of the mounting rails. Do not use any other ground body bolt forward of the flywheel housing.

All bolts except the ground body bolts must be .06 inches (1.5) less in diameter than the diameter of the holes in the mounting rails.

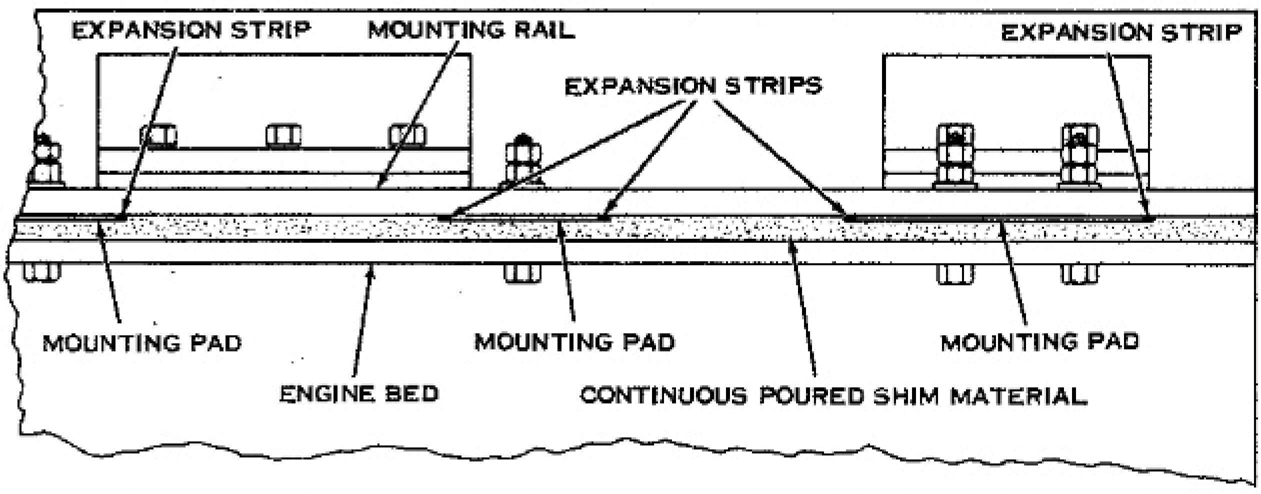
Tighten all mounting bolts to a torque of 360 lb.ft. (490 N·m). Use two nuts on each bolt to make sure the bolts hold this torque.

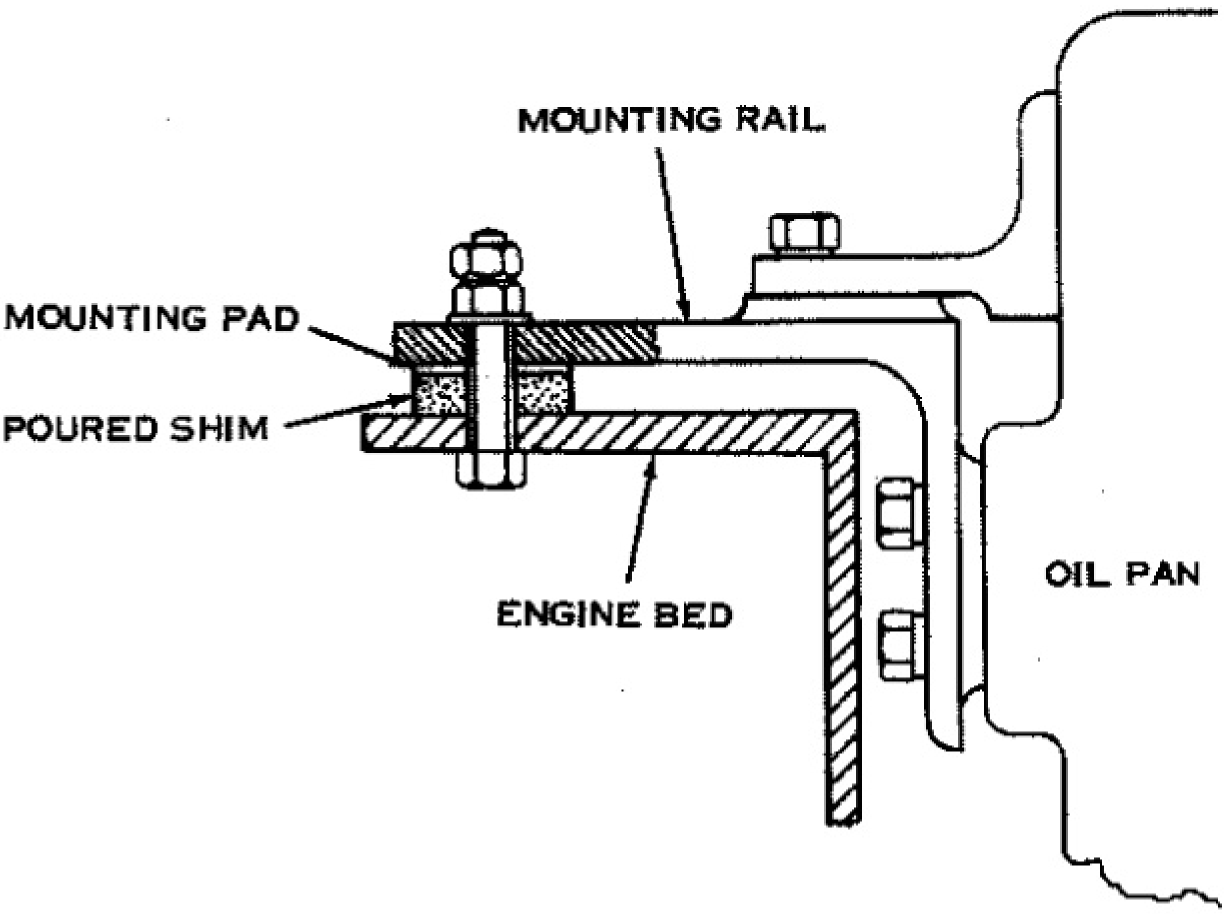
Mounting engines with poured resin shims

After the engine and close coupled transmission have been aligned to the propeller shaft or the engine has been aligned to the remote mounted transmission, poured resin shim material can be used between the mounting pads of the engine mounting rails and the engine bed. When using poured resin shim material, always follow the manufacturer's installation recommendations. The following are some general guidelines that should also be used.

Use foam rubber strips of the appropriate thickness to form the dams for pouring the shim material.

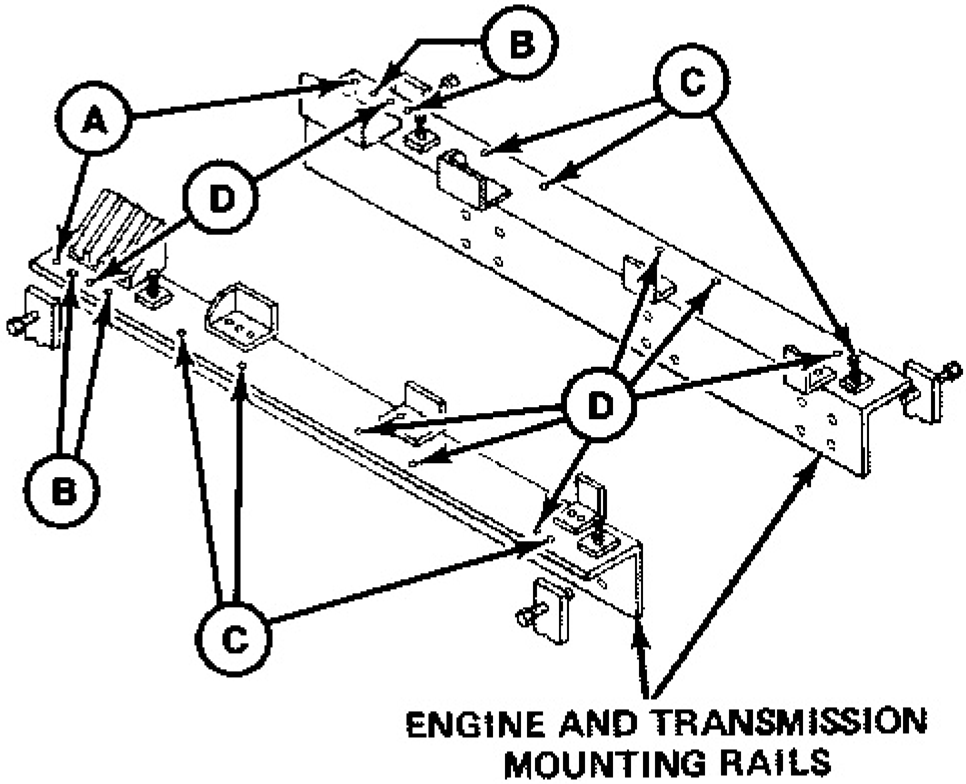
Do not pour shim material inboard of the machined pad on the bottom of the mounting rail.

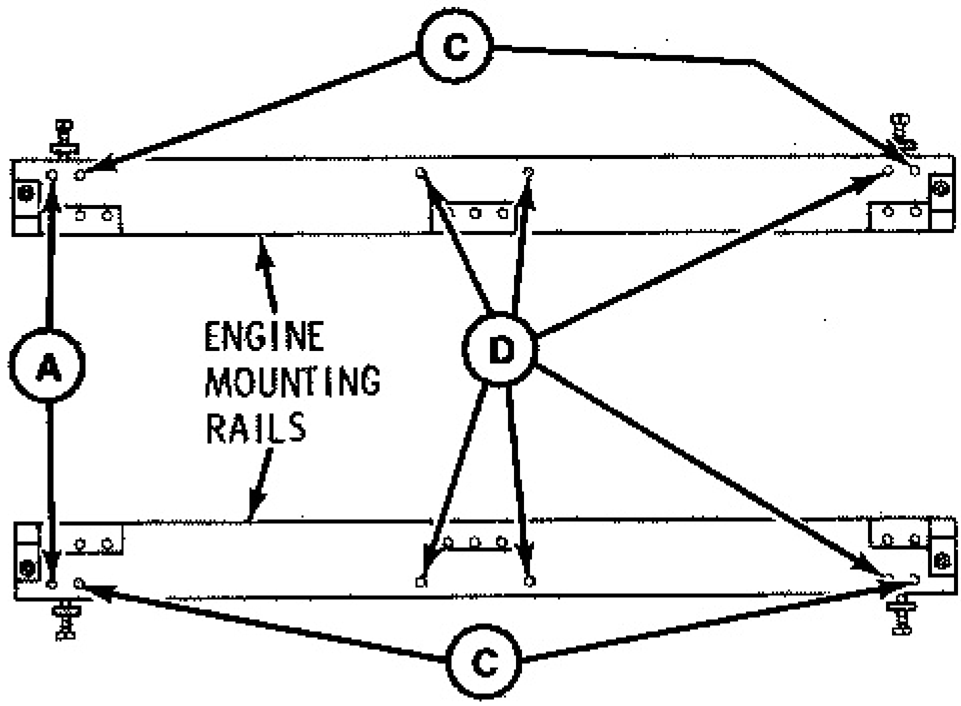




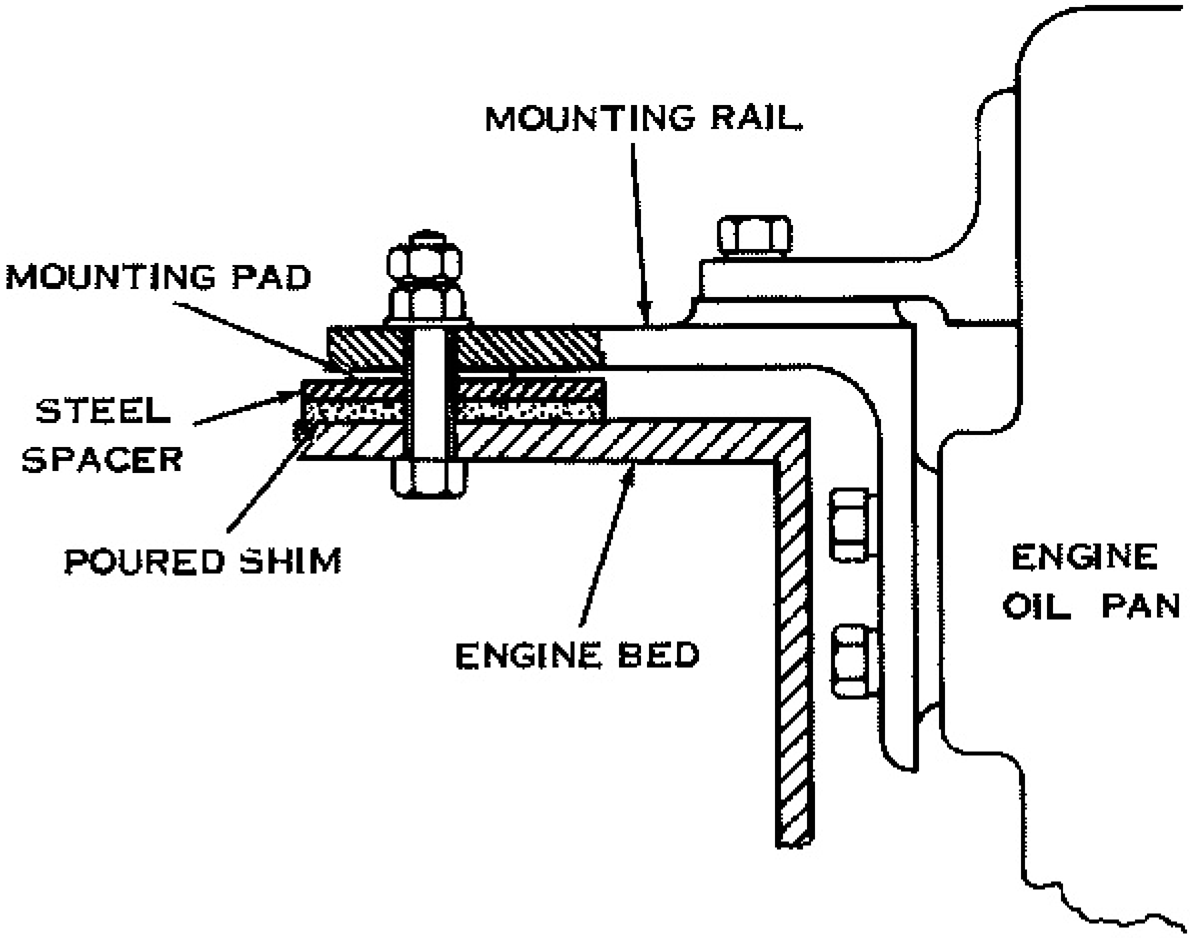
The shim material can be poured the full length of the mounting rail (a continuous pour) or it can be poured only at the mounting pad locations (an interrupted pour). If an interrupted pour is used, the minimum area of shim material must be 45 sq. inches (29,000 sq.mm) per mounting bolt. If the mounting rails have mounting pads only at the bolt hole locations, foam rubber strips must be installed on both sides of each pad on all pads forward of the flywheel housing to provide for expansion. These expansion strips permit thermal expansion of the mounting rails at operating temperature. On engines whose mounting rails have full length mounting pads, no expansion strips are necessary.

NOTE: When realigning an existing installation, installation of the full length foam rubber strips for a continuous pour can often be difficult because of limited access. Therefore, it is recommended that a full length continuous pour be used only for new installations where the engine can be raised to install the foam rubber strips.





IMPORTANT: When poured shim material is used, do not use mounting bolts in all of the bolt holes in the engine mounting rails. Use bolts only at locations (A), (B) and (C). Do not use bolts at locations (D). Use fitted bolts at locations (A). Fitted bolts are optional at locations (B). Use clearance type bolts at locations (C). See page 35 for the mounting of remote mounted marine transmissions using poured shim material.



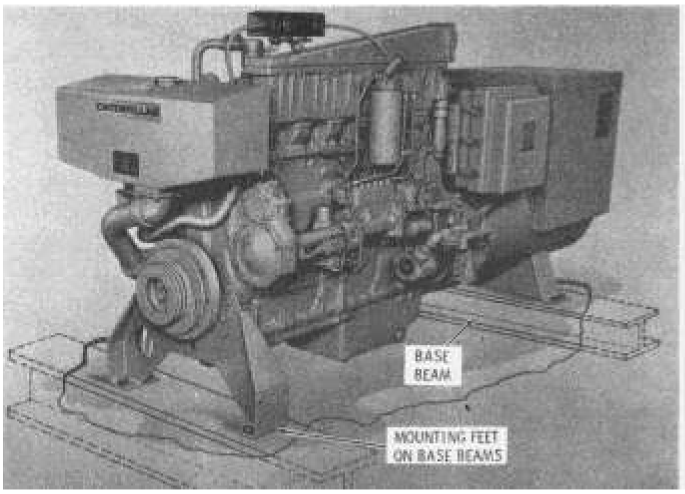
Do not pour the shim material thicker or thinner than the manufacturer's recommendation. If the clearance between the bottom of the mounting pad and the top of the engine bed is more than the maximum allowable thickness of the shim material, use steel spacers. The spacers must be a minimum of 45 sq. inches (29,000 sq.mm) in area per mounting bolt.

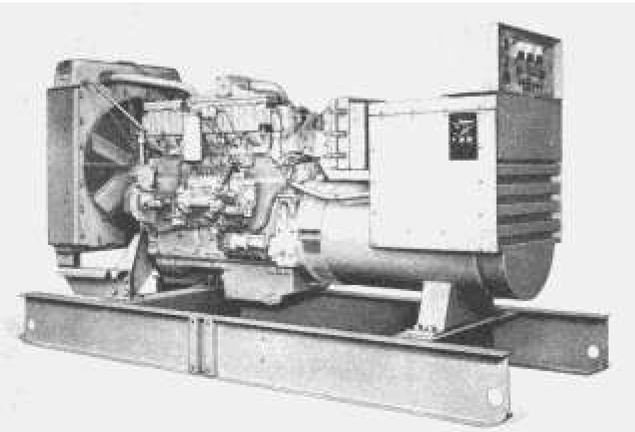
Before pouring the shim material, install all anchor bolts finger tight. Put sealing material around the bolt at the bottom of the mounting pad to prevent the shim material from filling the bolt holes in the mounting rails. If shim material is allowed to enter the bolt holes in the mounting rails, this will prevent thermal expansion of the rails.

After the shim material has sufficiently hardened according to the manufacturer's specification, the anchor bolts can be tightened to a torque of 360 lb.ft. (490 N·m). Use two nuts on each bolt.

(C) Engines With Mounting Feet (Applications Other Than Marine Propulsion)

Engine/Single Bearing Generator





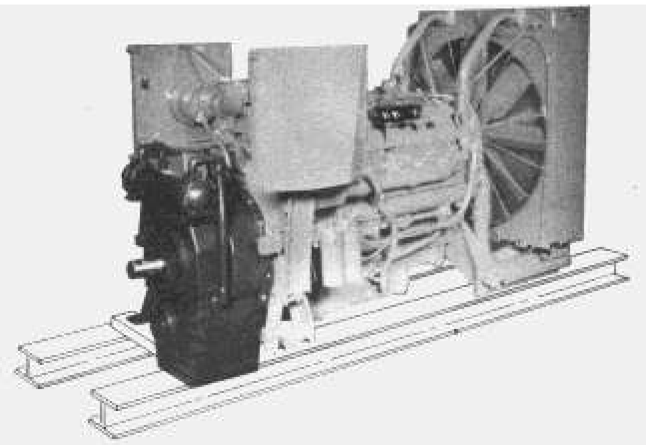
Caterpillar Engines and single bearing generators with mounting feet similar to those shown above can either be mounted on a base or directly on a pair of beams without a base. The mounting feet must be bolted in place (do not weld the feet to the base or beams). If support beams are used, the beams must be flat and lie in the same plane. Use shims as necessary between the feet and the base or support beams so all mounting feet are in solid contact at all locations. If the mounting feet are not in equal contact with the base or beams before the anchor bolts are installed, the engine and/or generator can be stressed when the anchor bolts are tightened.

Engine/Close Coupled Two Bearing Generator

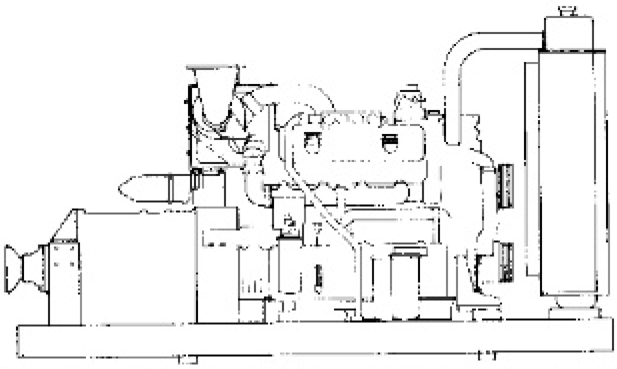
Caterpillar Engines with close coupled two bearing generators can be mounted on a base or directly on a pair of beams without a base. The mounting feet of the engine and generator must be bolted in place (do not weld the feet to the base or beams). If support beams are used, the beams must be flat and lie in the same plane. Use shims as necessary between the mounting feet and the base or beams so all mounting feet are in solid contact at all locations. If the mounting feet are not in equal contact with the base or beams before the anchor bolts are installed, the engine and/or generator can be stressed when the anchor bolts are tightened.

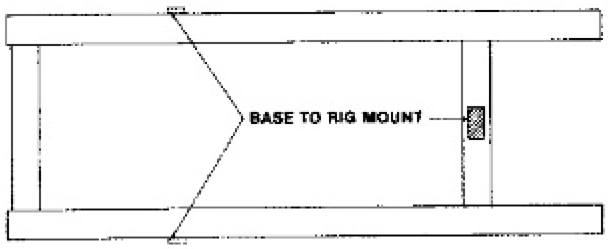
Engine/Driven Unit For Mechanical Drive

An engine and close coupled driven unit (for example, a transmission) used to mechanically drive other equipment can be mounted on a pair of longitudinal beams.



The tops of the beams must be flat and in the same plane. If the tops of the beams are not flat and in the same plane, use shims as necessary to correct this condition. All mounting feet of the engine and driven unit must be in solid contact with the mounting beams before the anchor bolts are installed. If the engine and driven unit are fastened to an uneven surface, this can cause distortion in the engine and driven unit when the anchor bolts are tightened.

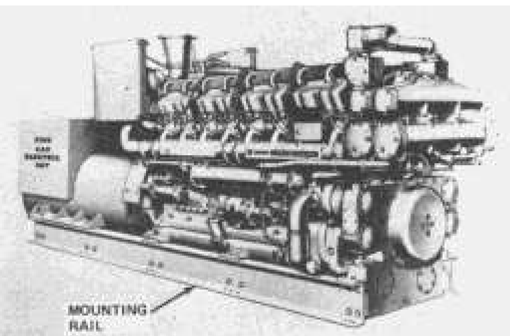


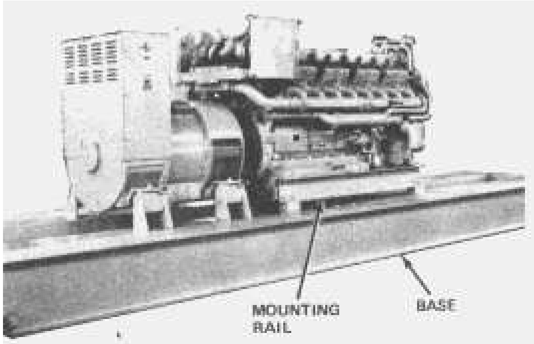


If the mounting beams will be subjected to external bending forces (such as frame flexing of the chassis in mobile applications), the engine and driven unit must be mounted to the beams with a three point mounting system. This type of mounting system supports the engine at a single point at the front and at two points (one on each side) at the rear of the engine or driven unit. This mounting system is capable of efficiently allowing large amounts of frame deflection without imparting stresses to the mounting or engine and driven unit.

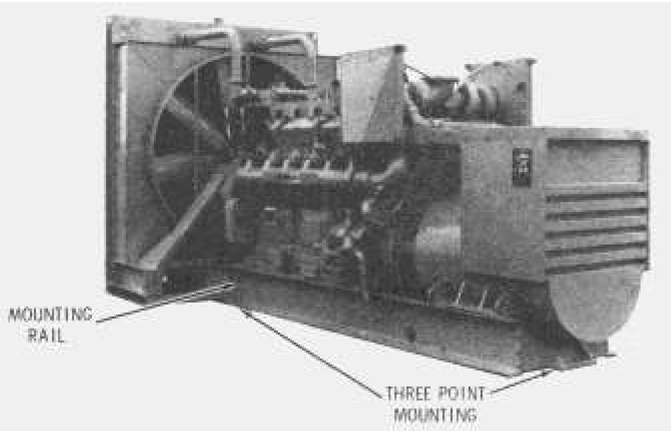
(D) Engines With Mounting Rails (Applications Other Than Marine Propulsion)

The standard Caterpillar mounting rails must be used. Two types of mounting rails are available depending upon application:





Four point mounting rails are used if the rails are to be secured to a base or foundation that will not be subjected to external forces that could cause distortion of the mounting rails. These rails can be used for either remote mounted or close coupled driven units. For close coupled driven units, extended mounting rails are available so the driven equipment can be fastened directly to the rails.

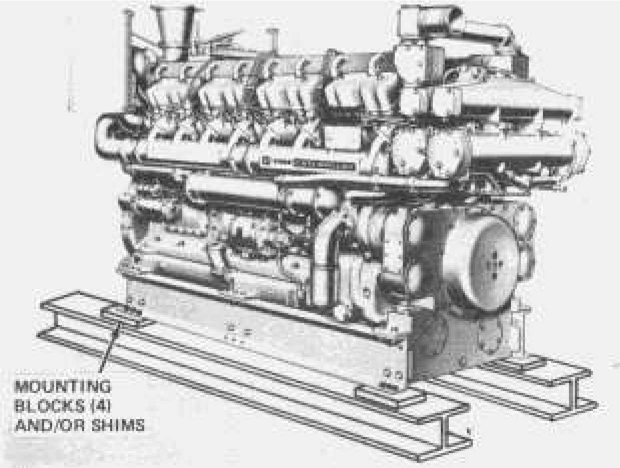


Three point mounting rails are used if the rails are to be secured to a base or foundation that may cause the mounting rails to be subjected to distorting forces. The three point mounting rails can only be used for close coupled driven units where the rails are extended for the mounting of these units.

Mounting of engine to mounting rails: Lugs or brackets have been welded to the sides of the oil pan at the factory and hold the engine to the mounting rails. No shimming is allowed between the engine oil pan and the mounting rails.

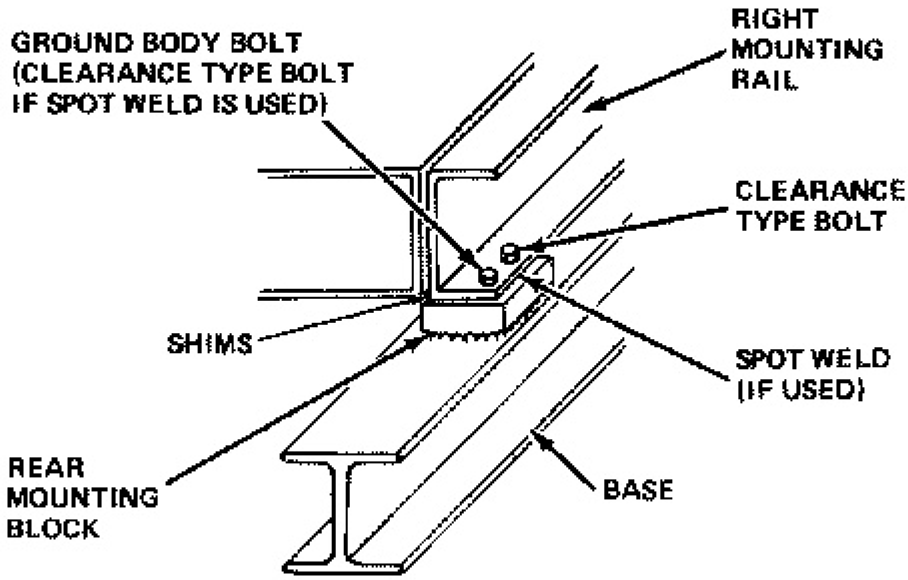
Mounting of close coupled driven units to mounting rails: On engines whose mounting rails are extended to mount close coupled driven units, these rails must not be notched or the cross braces removed to provide clearance for the driven unit. Shims are used as necessary between the mounting feet of the driven unit and the mounting rails to get correct alignment with the engine. Bolts must be used to fasten the driven unit to the engine mounting rails.

Mounting of four point mounting rails to the base

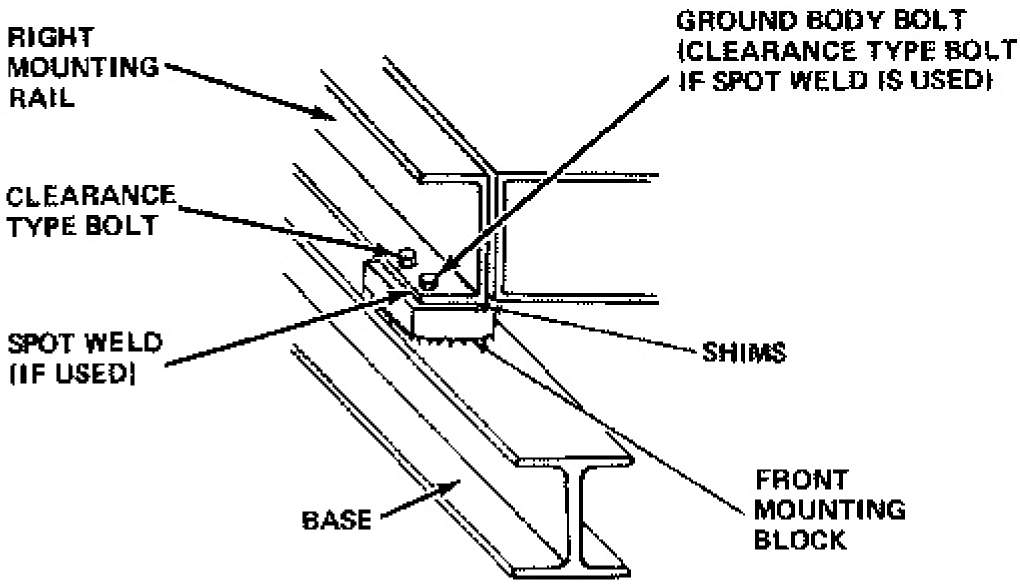


1. Shims only or four drilled and threaded mounting blocks and shims can be used between the engine rails and the base at the four corner locations. If mounting blocks are used, these blocks must be welded to the base. The blocks are first fastened to the bottom of the rails at the four corners. Bolt clearance with the rails should be removed by driving the blocks toward the end of each rail. This will provide clearance for thermal growth at operating temperature. The engine is then put in position on the base and the blocks tack welded to the base. If necessary, remove the engine to complete welding of the blocks to the base.

2. Use shims as necessary to make sure the mounting rails are in solid contact with the mounting blocks or base at all four mounting locations. If the mounting rails are not in solid contact, distortion of the mounting rails will result when the anchor bolts are tightened.



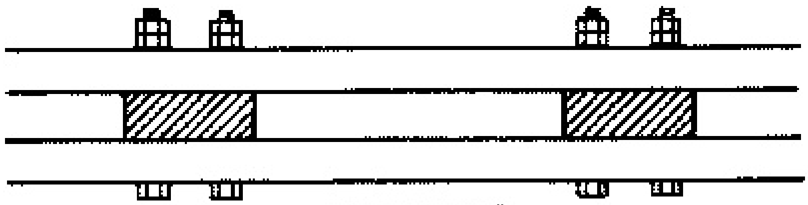
REAR ONLY OR FRONT AND REAR DRIVEN REMOTE MOUNTED UNITS



FRONT DRIVEN REMOTE MOUNTED UNITS

3. If the driven equipment is close coupled to the engine, use clearance type bolts at all locations to fasten the mounting rails to the mounting blocks or base. These bolts must have a diameter .06" (1.5) less than the diameter of the holes in the mounting rails.

4. If the driven equipment is remote mounted, use clearance type bolts at all mounting locations in the left mounting rail. If a ground body bolt is to be used to control the direction of horizontal thermal growth, install this bolt in the right rail at the end of the rail next to the coupling (or at the rear of the rail if remote mounted equipment is driven from both ends of the engine). Install clearance type bolts at all other locations in the right rail. If a spot weld is to be used to control the direction of thermal growth, spot weld the right rail to the mounting block and/or shims on the side of the rail next to the coupling; install clearance type bolts at all mounting locations in the right mounting rail. All clearance type bolts must have a diameter .06" (1.5) less than the diameter of the holes in the mounting rails.



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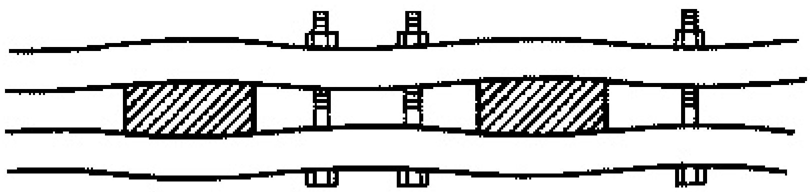

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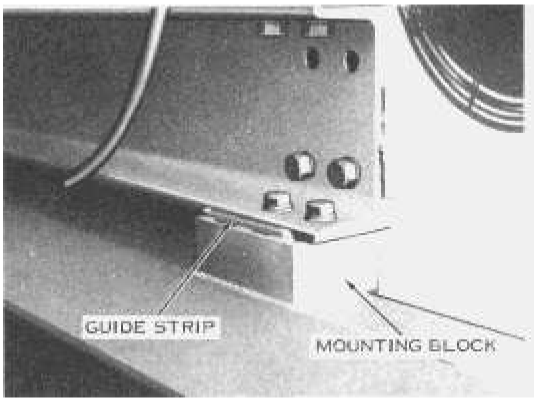
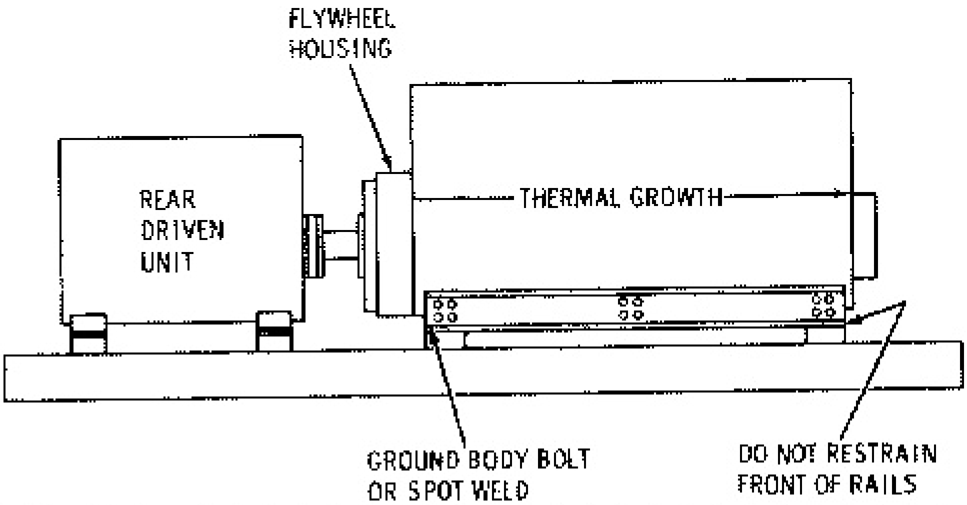
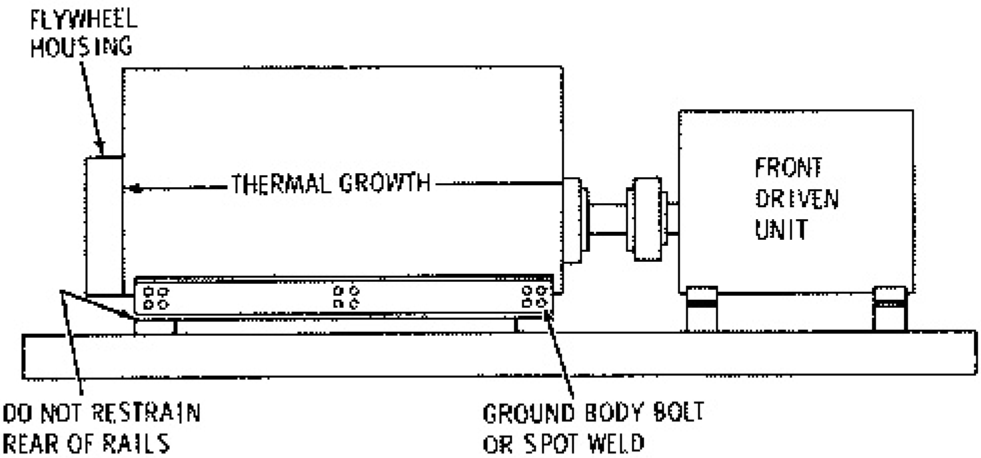


5. Each anchor bolt between the mounting rail and the base must be bolted into a mounting block. Distortion of the mounting rails will result if these bolts are fastened directly from the rails into the base.

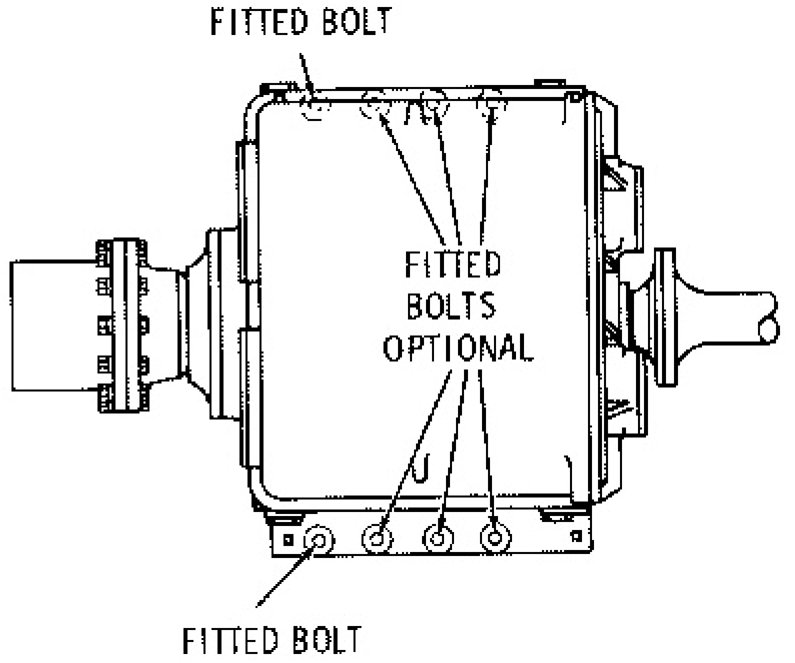
6. For engines driving remote mounted equipment, the mounting rails should be cradled between guide strips which keep the expansion of the rails always parallel to the output shaft centerline. The guide strips are welded to the top of the mounting blocks at the opposite end of the rails from the ground body bolt or spot weld.

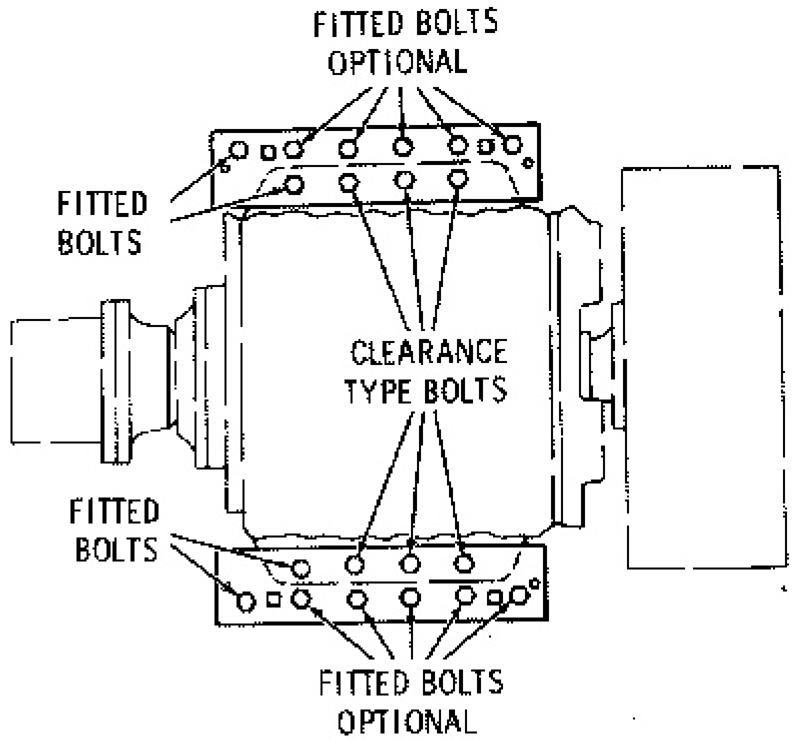




7. Because horizontal thermal growth of the engine and mounting rails will always be away from the ground body bolt or spot weld, never weld stops or chocks against the opposite end of the mounting rails from the ground body bolt or spot weld. If chocks or stops are to be used, there must be a minimum of .005" (0.13) clearance between them and the ends of the rails <u>when the engine is at operating temperature</u>.

(E) Mounting Of Remote Mounted Marine Transmissions

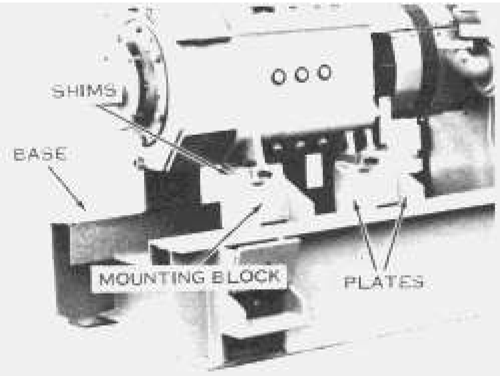


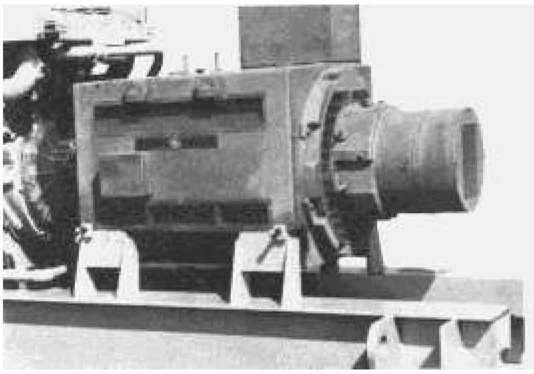


After the marine transmission has been aligned with the propeller shaft, make steel shims or use poured shim material to fit between the engine bed and the transmission. If steel shims are used, the shims must be in full contact with the engine bed and the transmission must be in full contact with the shims along the entire length of the mounting surface.

Use fitted bolts to fasten the transmission to the engine bed as shown above. Fitted bolts must be used to transmit propeller thrust to the ship's structure. Tighten all bolts to a torque of 360 lb.ft. (490 N·m). Use two nuts on each bolt.

(F) Mounting Of Remote Mounted Generators And Other Equipment





After the engine has been permanently installed on the base and all anchor bolts have been tightened, the remote driven unit must be temporarily aligned with the engine to determine the correct height of the fabricated supports. The fabricated supports consist of mounting blocks and plates. Four drilled and threaded mounting blocks are used to support the driven unit. The blocks are welded to fabricated plates which in turn are welded to the base. Only two mounting blocks are used on each side of the driven unit, one at each end. The final height of the mounting blocks must allow for approximately .090" (2.3) of shims between each mounting block and the driven unit during original installation. Allowance for this shim thickness will permit replacement of the original driven unit without modification to the fabricated supports.

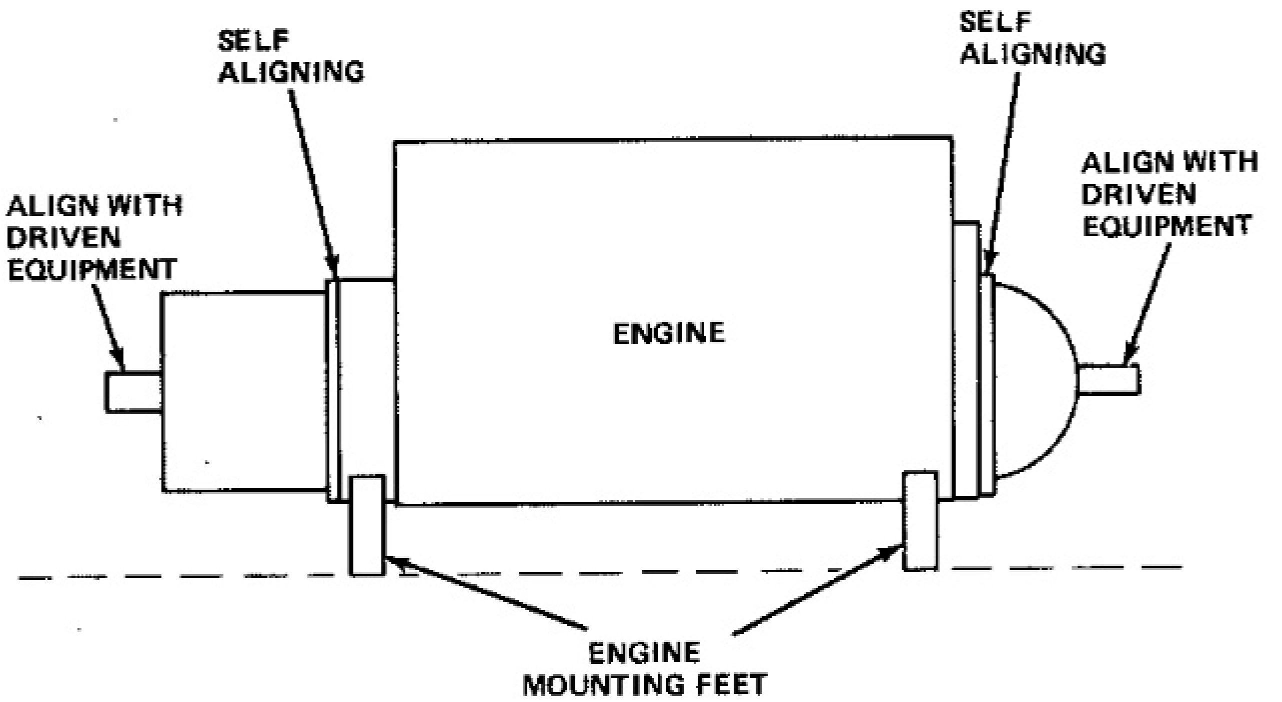
With the coupling and driveshaft in place, temporarily align the remote driven unit with the engine. Fasten .090" (2.3) of shims and a mounting block to each mounting foot of the driven unit. Put the fabricated plates in position on the base against the mounting blocks. Tack weld the plates to the base and to the mounting blocks. Remove the driven unit and complete the welding of the plates to the base and mounting blocks.

After all fabricated supports have been welded, install the driven unit and complete the final alignment with the engine.

Alignment Considerations

(A) Close Coupled Units - Type I

This type of driven unit is fastened directly to the engine flywheel housing or front accessory drive housing. These units have no external supports.



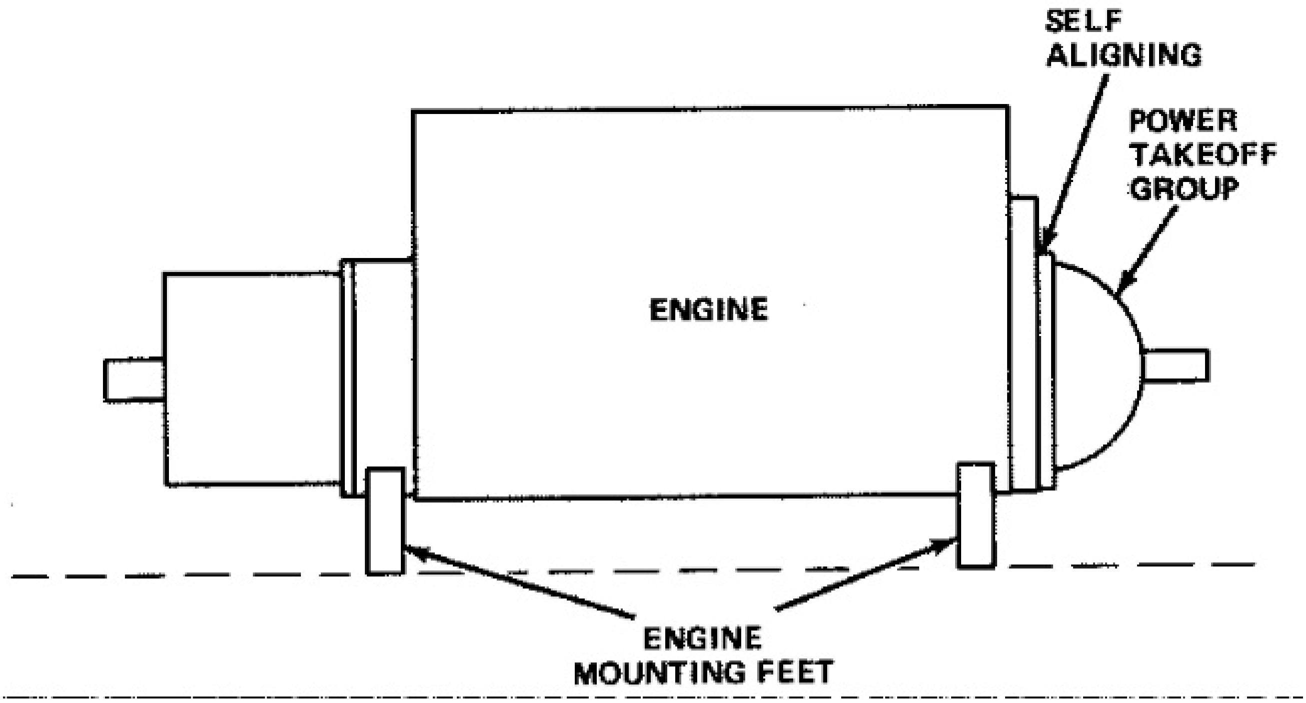
Alignment between the engine and close coupled units of this type is determined by the bolting together of the two piloted housings (flywheel housing and unit housing). When the two piloted housings are joined together in a parallel manner, they are in alignment. In some cases, alignment is also controlled by the piloting of the coupling into the flywheel.

Close coupled units of this type are usually used to mechanically drive other equipment. If this is the case, alignment between the close coupled unit and the mechanically driven equipment must be taken into consideration if the two units are rigidly connected.

Use care when mounting the engine to the supporting structure. The supporting members must be flat and lie in the same plane. Use shims as necessary between the mounting feet and supporting structure so all mounting feet are in solid contact. If the mounting feet are not in solid contact before the anchor bolts are installed, the engine and/or driven unit can be stressed when the bolts are tightened.

Clutches - Plate Type

Plate type clutches can operate with a limited amount of sideload. However, excessive sideloading of the clutch can cause the driven plates to rotate off center with the drive plates. The result will be the destruction of the teeth and failure of the clutch plates. Consult the clutch manufacturers specifications for the allowable sideloading. If necessary, clutch supports or pillow block bearings can be used to permit greater sideloads (see CLOSE COUPLED UNITS - TYPE III).

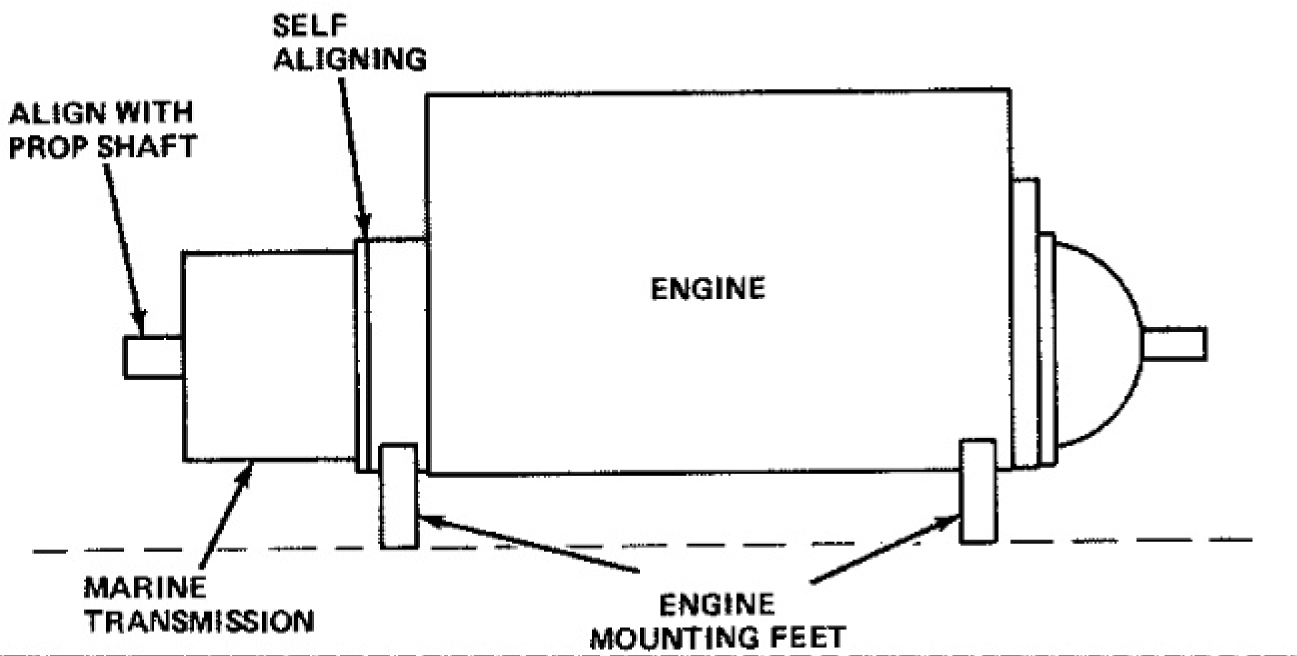


Power Takeoff Groups

Excessive sideloading of the power takeoff group can cause the driven plates to rotate off center with the drive plates. The result is destruction of the teeth and failure of the plates. Always consult the power takeoff group manufacturer regarding allowable sideloading. If necessary, external pillow block bearings can be used to permit greater sideloads (see CLOSE COUPLED UNITS - TYPE III).

If the power takeoff group drives other equipment through belt or chain drives, these drives can cause the engine or driven equipment to shift under heavy load due to torque reaction plus belt or chain preload tension. Belts or chains can cause the power takeoff shaft or engine crankshaft to deflect resulting in bearing and shaft failures. The driven sprocket or pulley should always be mounted as close as possible to the supporting bearing.

If it is suspected that an engine or driven unit is shifting under load, it can be checked by measuring from a fixed point with a dial indicator while loading and unloading the engine. Torque reactive vibrations and torque reactive misalignment will always occur under engine load.



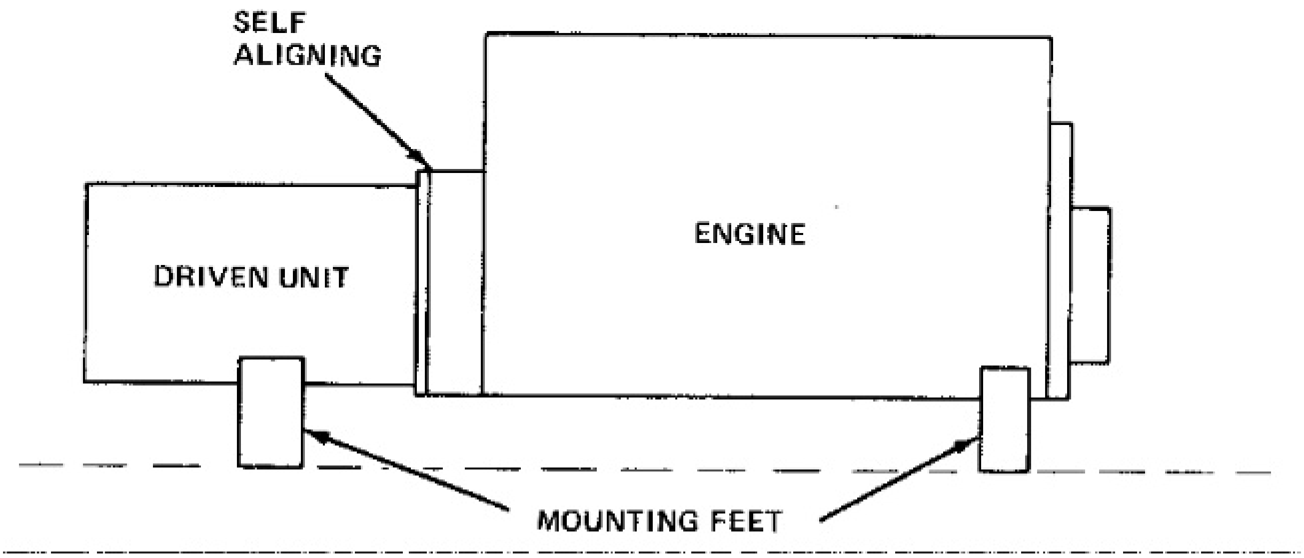
Marine Transmissions

With the propeller shaft in its normal running position, use a thickness gauge and dial indicators to put the engine and transmission in alignment with the propeller shaft. Install shims under each mounting foot of the engine to maintain this alignment. All mounting feet must be in solid contact with the shims and supporting surface. If the mounting feet are not in solid contact before the anchor bolts are installed, excessive stressing of the engine and transmission can result when the anchor bolts are tightened.

Do not weld the mounting feet to the ship's structure as this will cause distortion of the mounting feet. There are sufficient bolt holes in the rear mounting feet to restrain propeller thrust. However, to ensure that alignment remains intact, fitted bolts can be used to fasten the rear mounting feet in position. Use clearance type bolts to fasten the front mounting feet in place.

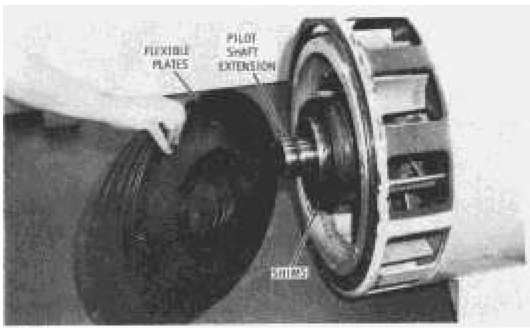
(B) Close Coupled Units - Type II

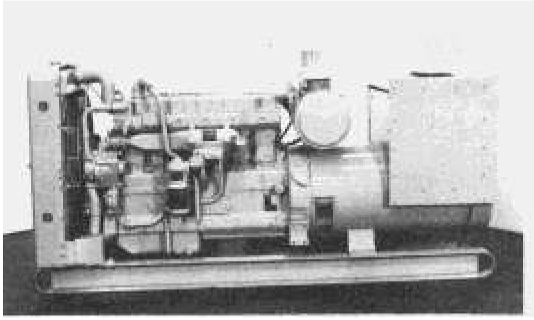
This type of driven unit is fastened directly to the engine flywheel housing. The supports for the driven unit serve as support for the rear of the engine.



Alignment between the engine and close coupled driven units of this type is determined by the bolting together of the two piloted housings (flywheel housing and unit housing). When the two piloted housings are joined together in a parallel manner, they are in alignment. For single bearing generators, the alignment is also controlled by the piloting of the flexible coupling plates or the generator shaft into the flywheel.

Single Bearing Generators





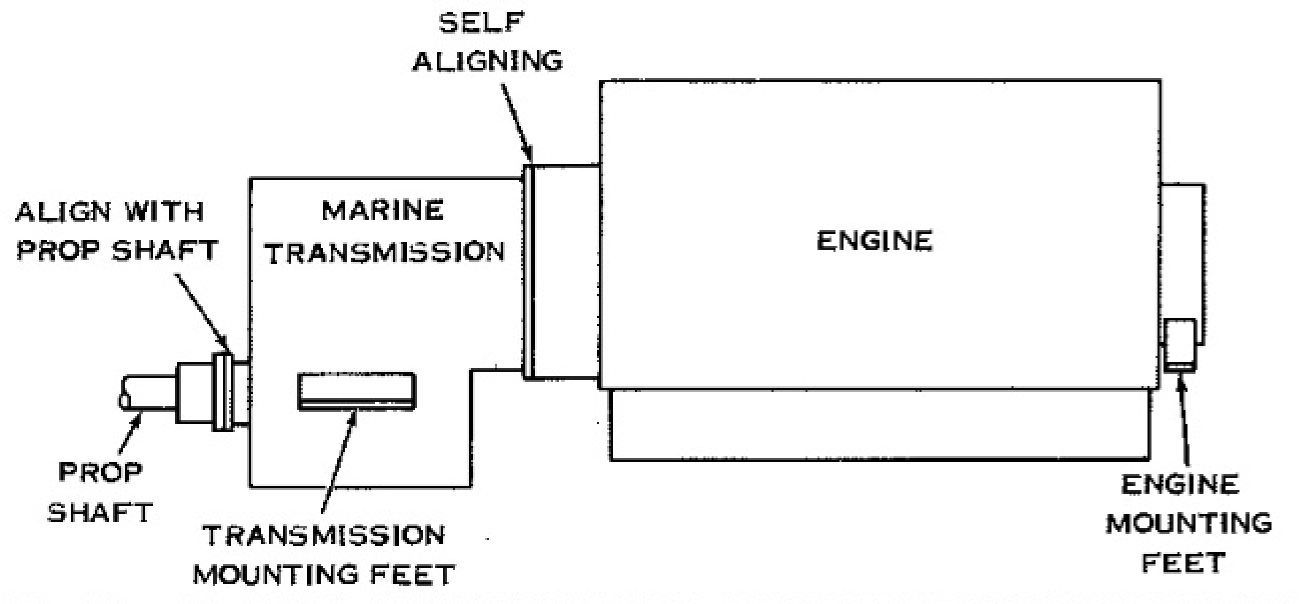
Single bearing generators use a flexible plate type coupling. Before installation of the generator on the engine, the correct thickness of shims for installation between the generator hub and the flexible plates must be determined. The correct shim thickness will allow the plates to seat in the flywheel and the generator housing to seat against the flywheel housing, both without reducing the amount of crankshaft end play when the generator is installed.

It is recommended that a pilot shaft extension be used on the generator shaft along with loose fitting flexible plates. Flexible plates that pilot off the flywheel bore are tighter fitting and do not maintain alignment as well as the loose fitting plates and pilot shaft extension.

If vibration is noted after assembly of a generator with coupling plates that pilot into the flywheel, correction can often be made by repositioning the coupling plates 1/4 of a turn with respect to the original location. Start the unit and observe the change in vibration. A second or third relocation may be necessary to find the position of lowest vibration. Always locate the plates at the point of lowest vibration.

Use care when mounting the engine and generator to the supporting structure. The supporting members must be flat and lie in the same plane. Use shims as necessary between the mounting feet of the engine and generator and supporting structure so all mounting feet are in solid contact. If the mounting feet are not in solid contact before the anchor bolts are installed, the engine and/or generator can be stressed when the bolts are tightened.

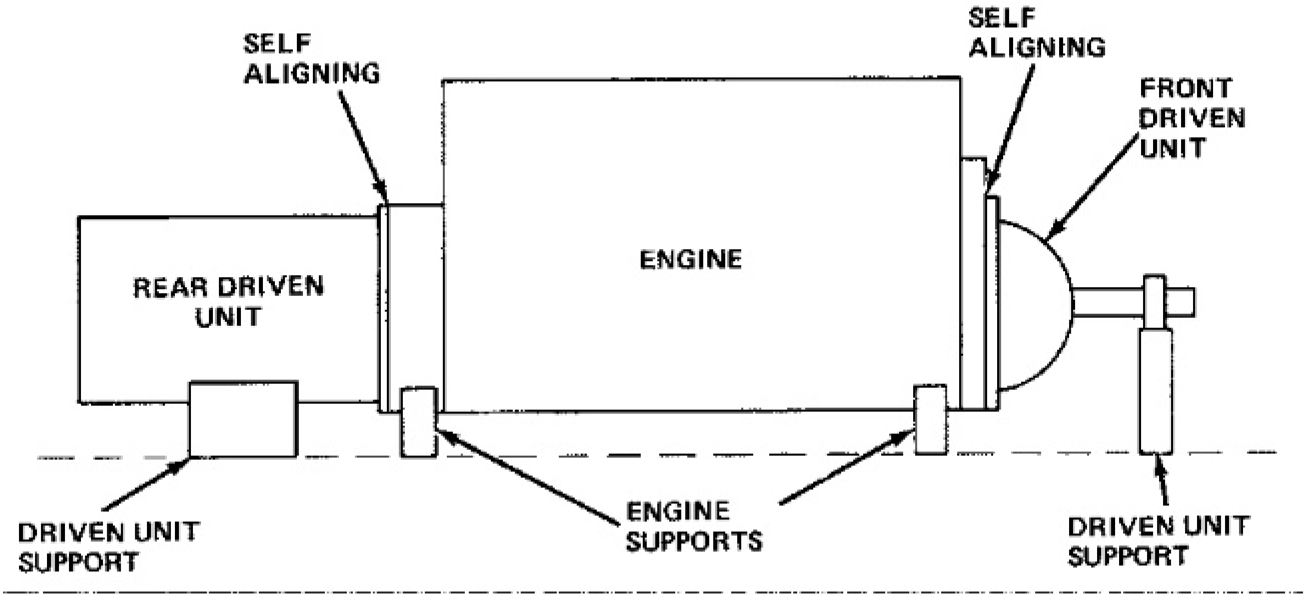
Marine Transmissions



With the propeller shaft in its normal running position, use a thickness gauge and dial indicators to put the engine and transmission in alignment with the propeller shaft. Install shims under each mounting foot of the engine and transmission to maintain this alignment. All mounting feet must be in solid contact with the shims and supporting surface. If the mounting feet are not in solid contact before the anchor bolts are installed, the engine and/or transmission can be stressed when the bolts are tightened.

Do not weld the mounting feet to the ship's structure as this will cause distortion of the mounting feet. There are sufficient bolt holes in the transmission mounting feet to restrain propeller thrust. However, to ensure that alignment remains intact, fitted bolts can be used to fasten the transmission mounting feet in position. Use clearance type bolts to fasten the engine mounting feet in place.

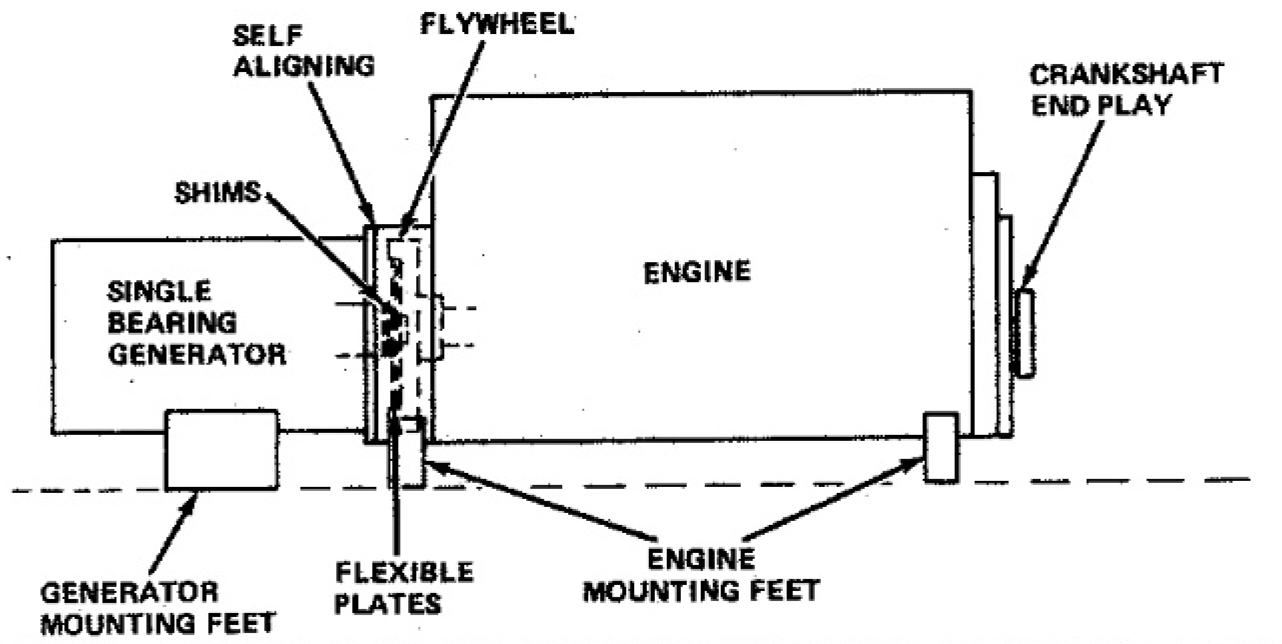
(C) Close Coupled Units-Type III



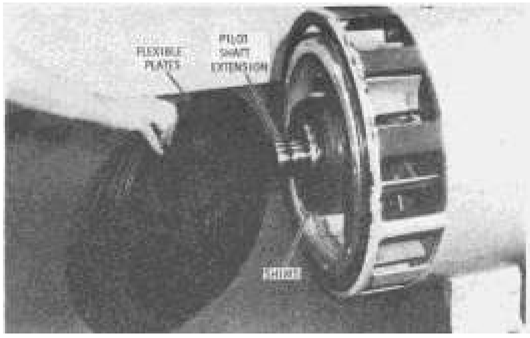
This type of driven unit is fastened directly to the engine flywheel housing or front accessory drive housing. The engine has front and rear supports. The driven unit has its own supports.

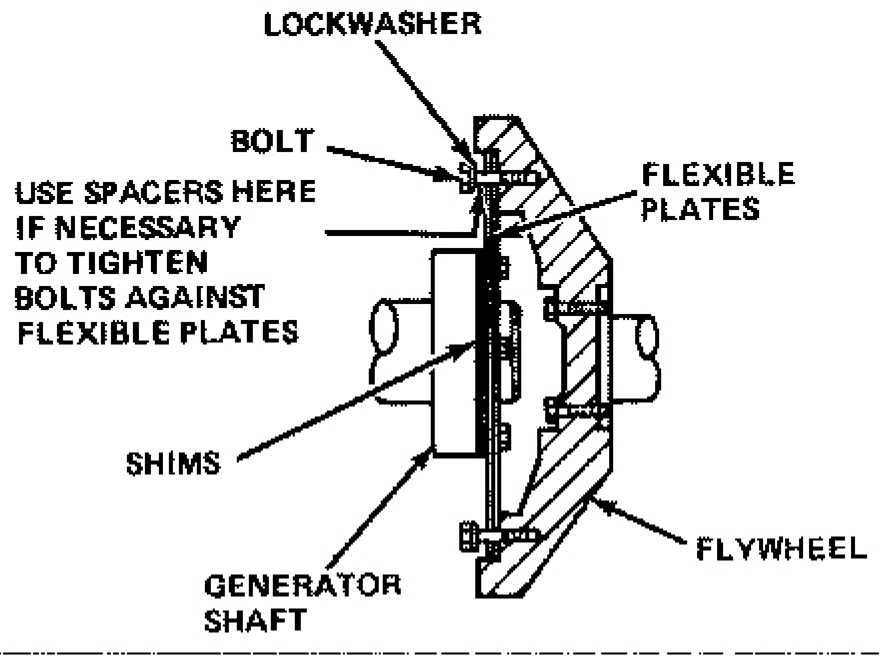
Alignment between the engine and close coupled driven units of this type is determined by the bolting together of the two piloted housings (flywheel housing to unit housing or front accessory housing to unit housing). When the two piloted housings are joined together in a parallel manner, they are in alignment. However, because the driven unit has its own supports, care must be taken when mounting these external supports to prevent stressing of the engine and/or driven unit. Alignment may also be controlled by the piloting of the coupling or driven shaft into the flywheel or crankshaft.

Single Bearing Generators



Although alignment between a single bearing generator and an engine is basically controlled by the bolting together of the piloted flywheel housing and generator housing, successful alignment also requires that no outside stresses be put on the engine crankshaft, the flywheel housing or the generator housing. Outside stresses can be introduced by incorrect shimming of the coupling and by incorrect mounting of the generator feet.





Coupling: To ensure that no outside stress is put on the crankshaft, the flexible plates of the coupling must maintain alignment and must not restrict crankshaft end play.

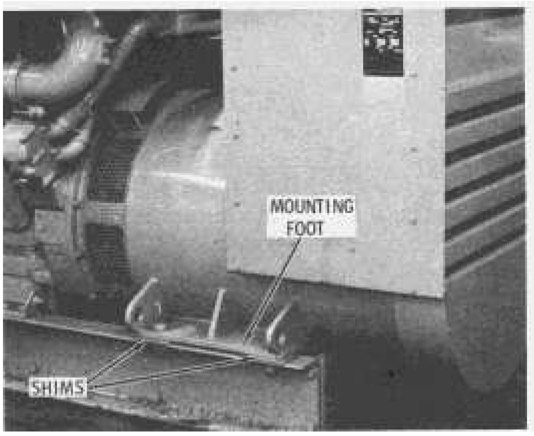
It is recommended that a pilot shaft extension be used on the generator shaft along with loose fitting coupling plates. Flexible plates that pilot in the flywheel bore are tighter fitting and do not maintain alignment as well as loose fitting plates and pilot shaft extension. Never grind the outside diameter of the plates to make them fit in the flywheel bore. Order new plates or use loose fitting plates and a pilot shaft extension.

If there is vibration after assembly of a generator with coupling plates that pilot in the flywheel bore, correction can often be made by repositioning the coupling plates 1/4of a turn with respect to the original location. Start the unit and observe the change in vibration. A second or third relocation may be necessary to find the position of lowest vibration. Always locate the plates at the point of lowest vibration.

Before installation of the generator on the engine, the correct thickness of shims must be determined for installation between the generator hub and the flexible plates. The correct shim thickness will allow the plates to seat in the flywheel and the generator housing to seat against the flywheel housing, both without reducing the original amount of crankshaft end play.

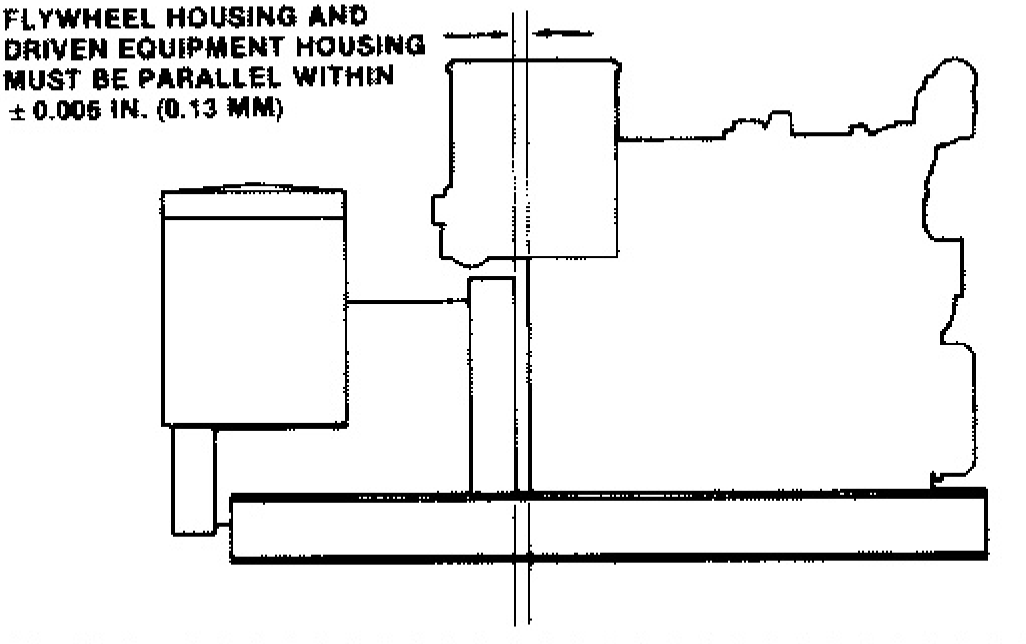
Generator Mounting: To ensure that no outside stress is put on the flywheel housing and/or generator housing, the generator must be correctly mounted to the base.

The mounting surfaces of the base must be flat and lie in the same plane. If the generator is fastened to an uneven surface, this can result in distortion of the flywheel housing and/or generator housing.



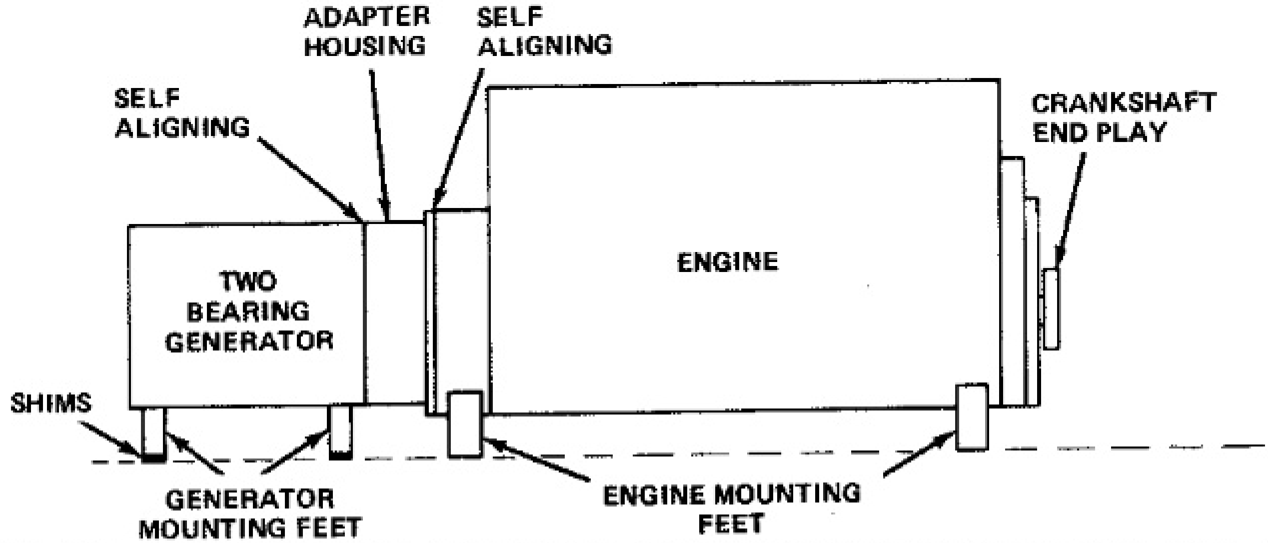
Shims should be used between the generator mounting feet and base as necessary to put the generator in correct vertical alignment with the flywheel housing. It may be necessary to use shims of different thicknesses at each end of the same mounting foot (especially on generators with long mounting feet).

After the generator-to-flywheel housing bolts have been installed, make sure there is a minimum of .06" (1.5) clearance between each anchor bolt and its bolt hole in the generator mounting foot.



To check for correct generator mounting, tighten all bolts in the generator mounting feet to one half of standard torque. Loosen all bolts that fasten the generator to the flywheel housing. Check the gap between the flywheel housing and the generator housing with a thickness gauge. The gap must be uniform within .005" (0.13). If it is not, install shims as necessary between the generator mounting feet and base until the gap is within specification. Tighten all bolts to the specified torque.

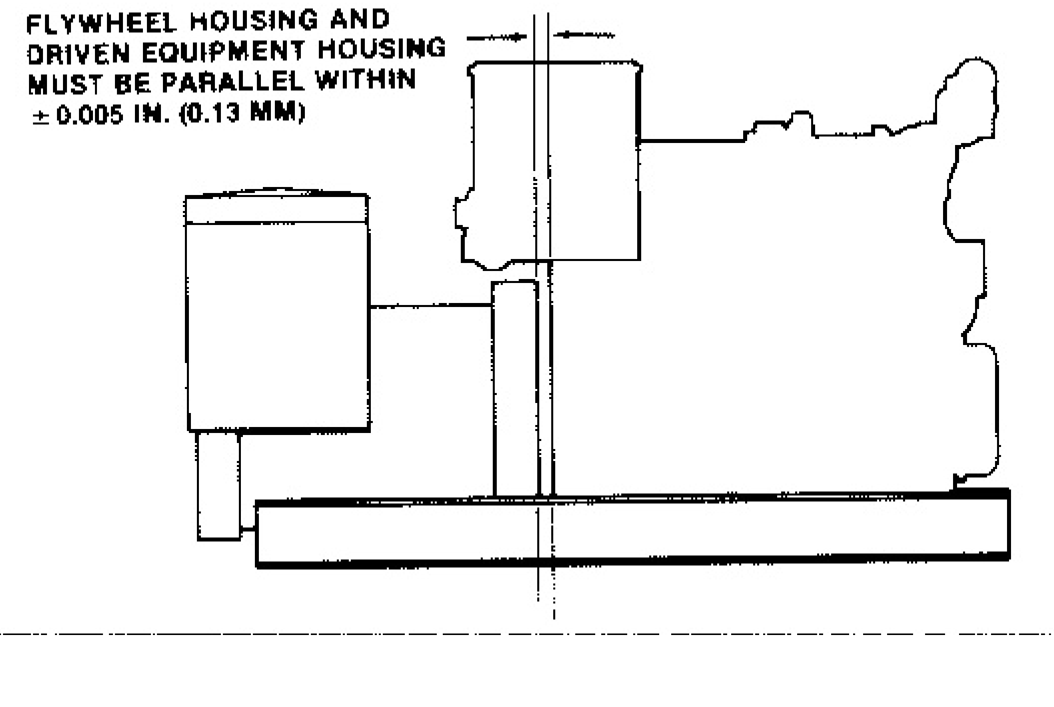
Close Coupled Two Bearing Generators



Close coupled two bearing generators use a piloted adapter housing between the generator housing and the flywheel housing to determine alignment. Although alignment is controlled by the bolting together of these housings, care must be taken not to introduce stresses caused by incorrect installation of the generator on the engine. Stresses can be introduced by: 1) incorrect end clearance within the coupling with the generator installed, and 2) incorrect mounting of the generator to the base.

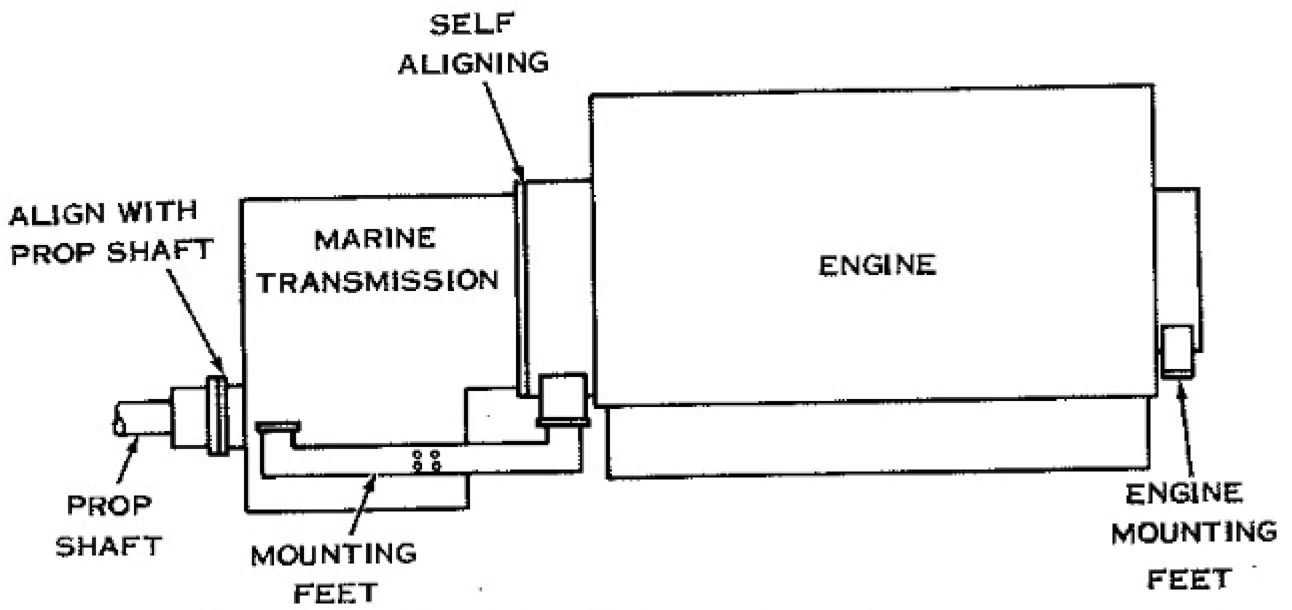
There must be sufficient end clearance within the coupling, as specified by the coupling manufacturer, when the generator is installed on the engine. Under no circumstances can the end play of the engine crankshaft be less with the generator installed than it was before the generator was installed. Correct end clearance within the coupling is controlled by the position of the hub on the generator shaft. This position must be determined by actual measurement and calculation by taking into consideration the relative positions of the flywheel housing mounting face and the inner face of the flywheel.

When mounting the generator to the base, the generator mounting surfaces of the base must be flat and lie in the same plane. Use shims as necessary between the generator mounting feet and the base to put the generator and adapter housing in correct vertical alignment with the flywheel housing. All generator mounting feet must be in solid contact with the base before installation of the anchor bolts. If the mounting feet are not in solid contact, distortion of the generator housing, adapter housing and/or flywheel housing can result.

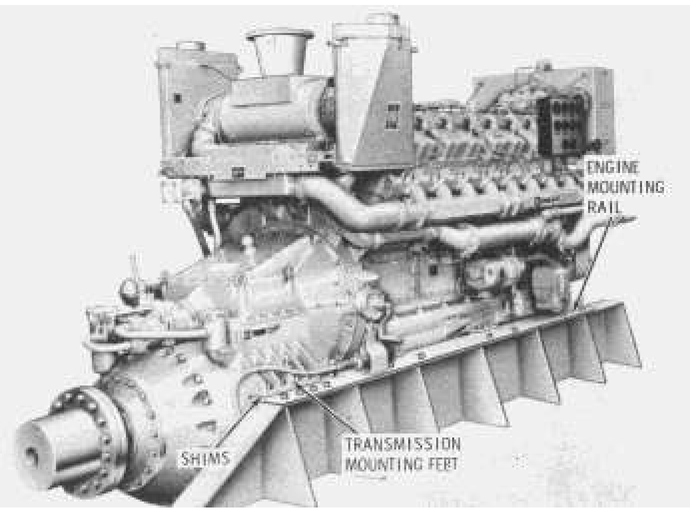


With the shims in position under the generator mounting feet, fasten the generator and adapter housing to the flywheel housing. Make sure there is a minimum of .06" (1.5) clearance between each anchor bolt and its bolt hole in the mounting foot. Check initial alignment by tightening all anchor bolts in the generator mounting feet to one half of the standard torque. Loosen all bolts that fasten the generator adapter housing to the flywheel housing. Check the gap between the flywheel housing and adapter housing at several locations with a thickness gauge. The gap must be uniform within .005" (0.13). If it is not, adjust the thickness of the shims under the mounting feet as necessary until the gap is within specification. Tighten all mounting and anchor bolts to their standard torque. Check the crankshaft end play. The end play must not be less than it was before installation of the generator. If necessary, adjust the position of the hub on the generator shaft to get the correct crankshaft end play.

Marine Transmissions



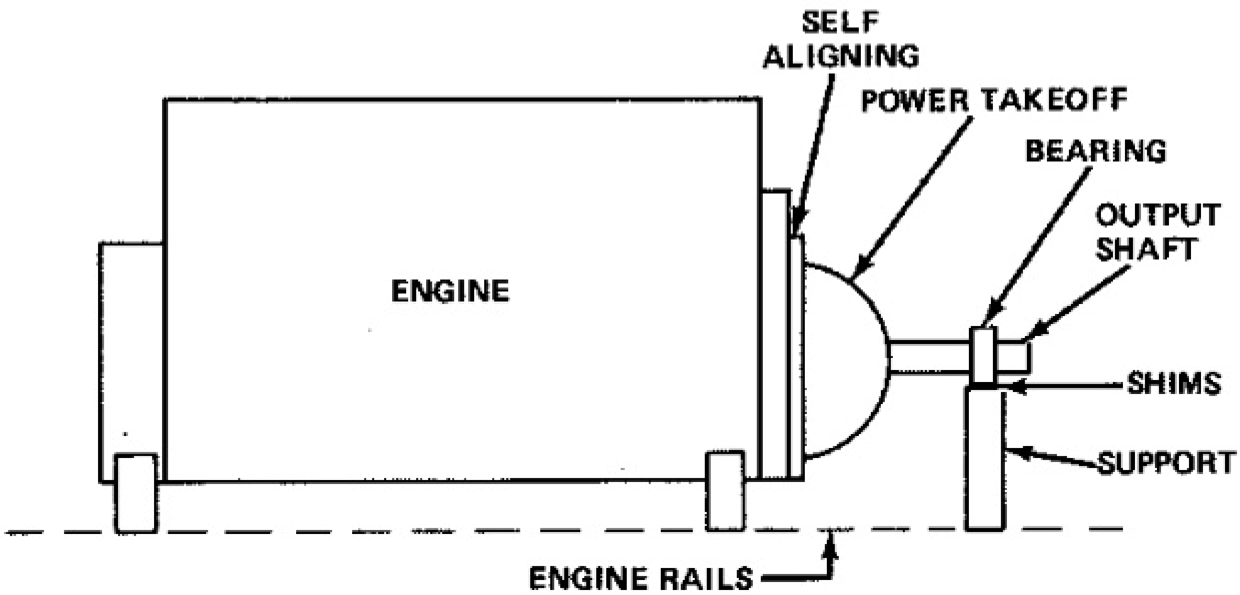
Transmission-to-engine alignment for engines with mounting feet is controlled by the bolting together of the piloted transmission housing and flywheel housing. However, care must be taken not to introduce outside stresses on the flywheel housing and transmission housing by incorrect mounting procedures during alignment of the engine and transmission to the propeller shaft. All mounting feet must be in solid contact with the ship's engine bed before installation of the mounting bolts.



Transmission-to-engine alignment for engines with mounting rails is controlled by the bolting together of the piloted flywheel housing and transmission housing. Successful alignment also requires that no outside stresses be put on the transmission housing or flywheel housing by incorrect mounting of the transmission to the engine mounting rails. Use shims as necessary between the transmission mounting feet and the engine mounting rails to put the transmission in correct vertical alignment with the flywheel housing. There must be solid contact with the mounting rails along the entire length of the transmission mounting feet before installation of the mounting bolts.

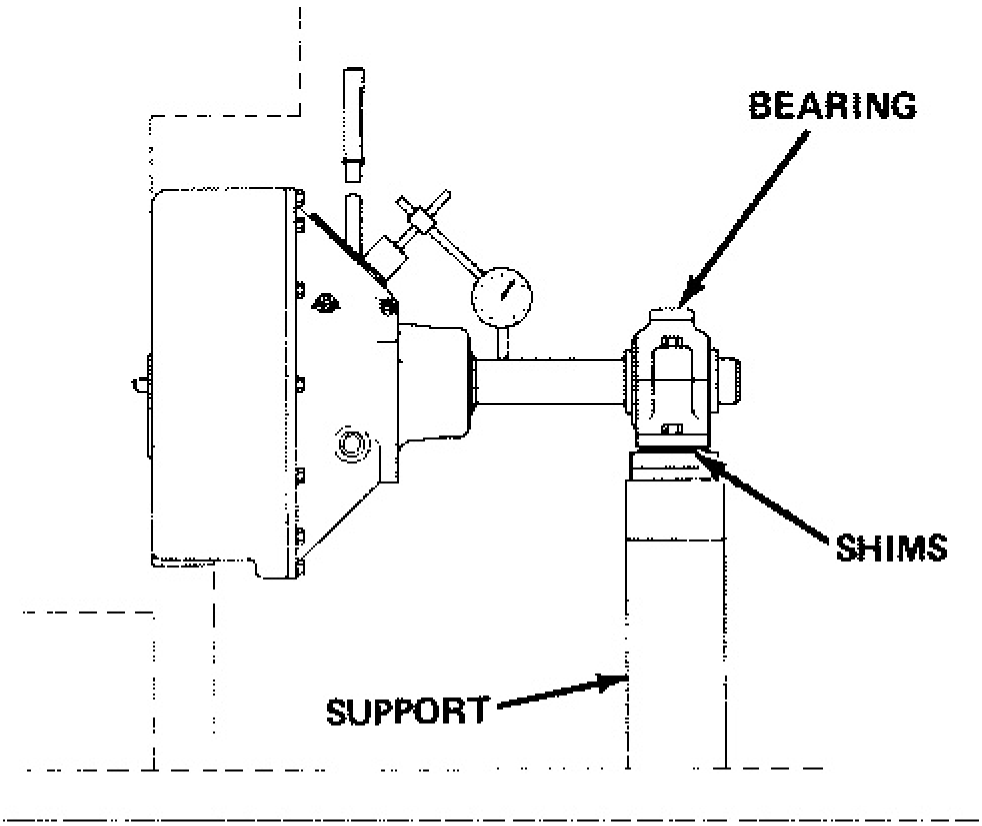
To align the transmission to the propeller shaft, put the propeller shaft in its normal running position. Use a thickness gauge and dial indicators to put the transmission and engine in alignment with the propeller shaft. Install shims as necessary under the mounting feet or mounting rails. There must be solid contact at all mounting locations before the mounting bolts are installed. For more information on the mounting of marine transmissions, see the section EQUIPMENT MOUNTING.

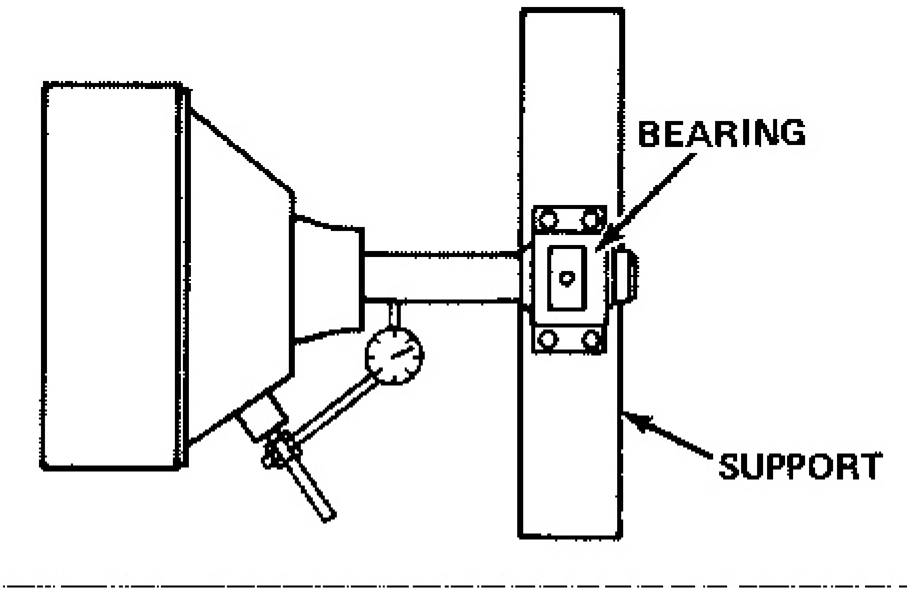
Power Takeoff Groups



Power takeoff groups use an external support in applications where there is a substantial amount of sideloading of the output shaft. These units are self aligning since alignment is determined by the bolting together of the two piloted housings. However, because of the external support, the output shaft must be secured in its normal running position. This position is controlled by the thickness of the shims between the bearing and support and by the lateral location of the bearing.

IMPORTANT: Supports for the external bearings must always be mounted to the same rails as the engine.



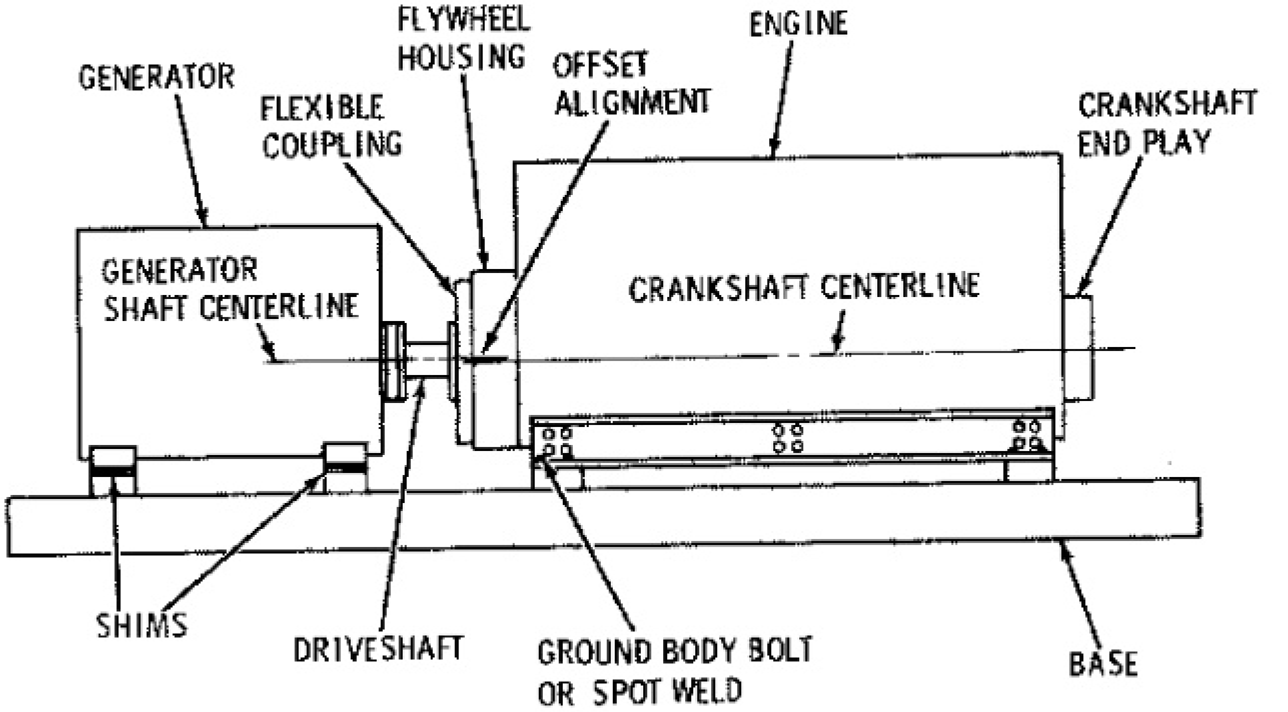


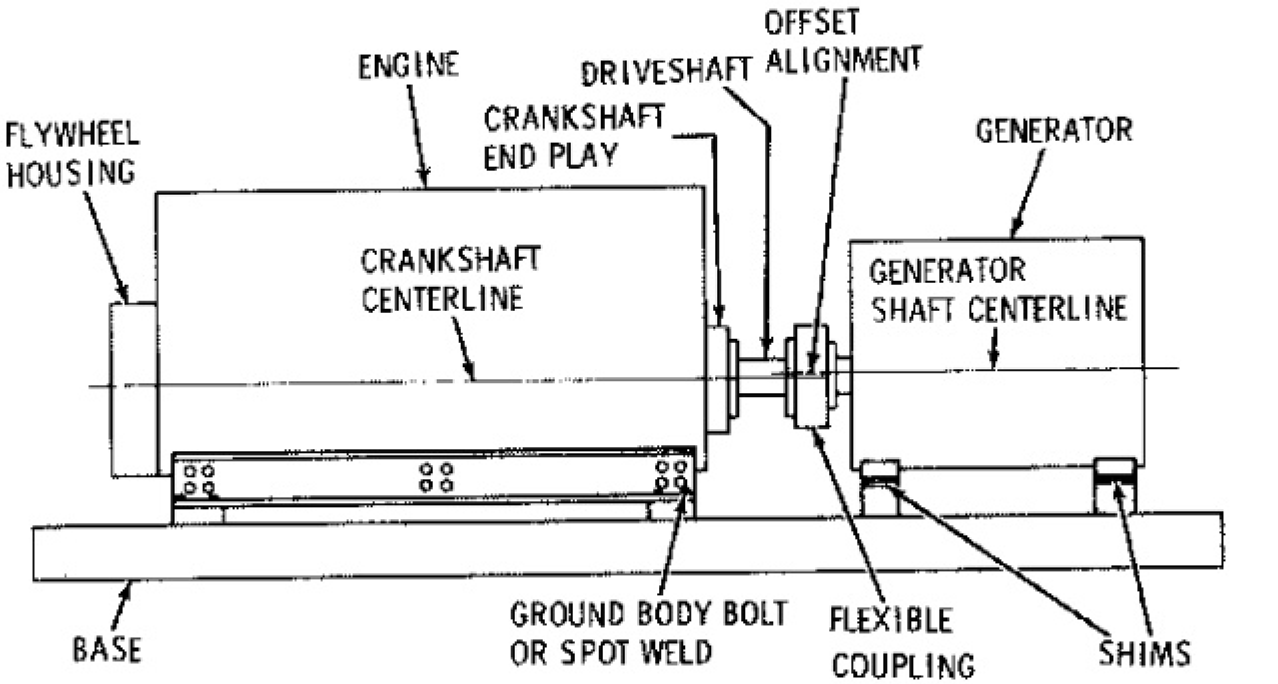
To determine the correct vertical position of the output shaft, it is necessary to find the shaft's normal running position. Mount a dial indicator on a stationary support with the tip of the indicator on the top of the shaft as shown above on the left. Push down on the end of the shaft until it will move no further. Zero the dial indicator with the shaft in this position. Pull up on the shaft until it will move no further, and observe the reading on the dial indicator. Divide the total indicator reading (TIR) by two. Move the shaft until this reading is on the dial indicator. This is the normal vertical running position of the output shaft. Use shims as necessary between the external support and the external bearing to keep the shaft in this position.

To determine the correct horizontal position of the shaft, mount the dial indicator on a stationary support with the tip of the indicator on one side of the shaft as shown above on the right. Move the shaft all the way to one side and zero the indicator at this location. Move the shaft all the way to the other side and observe the indicator reading. Divide the TIR by two. Move the shaft until this reading is on the dial indicator. This is the normal horizontal running position of the shaft. Fasten the bearing to the support with the shaft in this position.

(D) Remote Mounted Units

Two Bearing Generators





Remote mounted two bearing generators are mounted on the same base as the engine but are not fastened to the engine except through a driveshaft and flexible coupling. These generators can be driven from either the front or the rear of the engine. Rear driven generators have the coupling located within the flywheel. Front driven generators use an external coupling. Regardless of the type of coupling used, the following conditions must exist if there is to be correct alignment of the generator with the engine.

When aligning remote mounted two bearing generators, always remember that the centerline of the generator shaft must be positioned above the centerline of the engine crankshaft. This compensates for vertical thermal growth of he engine, flywheel sag and main bearing clearances during the cold alignment procedure. With this vertical "offset" in the cold condition, the generator shaft and the crankshaft will be in correct alignment at operating temperature.

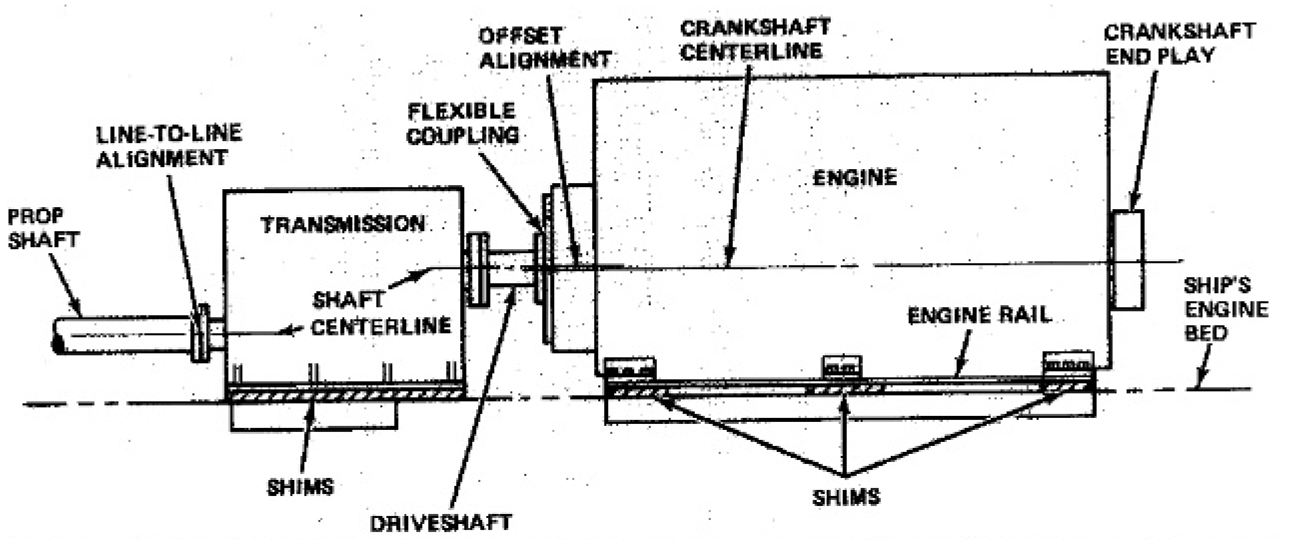
The end play of the crankshaft must not be less after installation of the generator than it was before installation of the generator.

Horizontal thermal growth of the engine must be directed away from the coupling. This is done by using a ground body bolt (fitted bolt) or a spot weld between the engine right rail and the support block closest to the coupling.

Before the generator can be aligned to the engine, the engine must be permanently installed on its base. After installation of the engine, put the generator in position on the base. Use dial indicators to check the face and bore alignment.

Use shims as necessary between the generator mounting feet and the generator supports to maintain correct vertical alignment with the engine. All generator mounting feet must be in solid contact with the supports before installation of the anchor bolts. If the mounting feet are not in solid contact, distortion of the generator housing can result.

Marine Transmissions



Remote mounted marine transmissions are supported by the ship's engine bed but are not fastened to the engine except through a driveshaft and coupling. To install a remote mounted transmission, the transmission must first be aligned with the propeller shaft and then the engine aligned to the transmission. Alignment between the propeller shaft and the transmission is line-to-line (the centerline of the prop shaft is in line with the centerline of the transmission output shaft). Alignment between the engine and the transmission is "offset" (the centerline of the transmission driveshaft is above the centerline of the engine crankshaft).

With the propeller shaft in its normal running position, use a thickness gauge and dial indicators to put the transmission in alignment with the propeller shaft. Install shims as necessary between the engine bed and the transmission to maintain this alignment. There must be solid contact with the shims and engine bed along the entire length of the transmission's mounting brackets without the anchor bolts installed. If there is not solid contact, the transmission can be stressed when the anchor bolts are installed. Use fitted bolts to fasten the transmission to the engine bed.

After the transmission has been aligned and mounted in position, align the engine to the transmission. Use dial indicators mounted to the driveshaft to check for correct bore and face alignment.

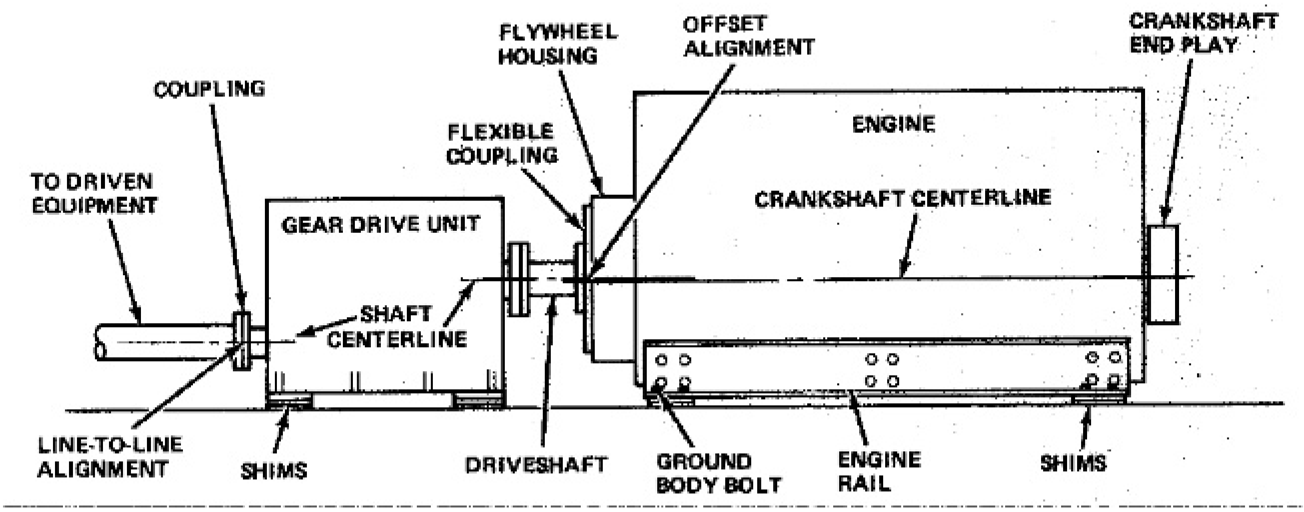
When aligning the engine to the transmission, the centerline of the crankshaft must be positioned below the centerline of the transmission driveshaft. This compensates for thermal growth of the engine, flywheel sag and main bearing clearances during the cold alignment procedure. With this vertical "offset" in the cold condition, the transmission driveshaft and crankshaft will be in correct line-to-line alignment at operating temperature.

Check crankshaft end play before and after alignment of the engine to the transmission, and again at operating temperature. There must be no reduction in end play after alignment of the engine or at operating temperature.

After the engine is in correct alignment with the transmission, install shims as necessary between the engine rails and the engine bed to maintain alignment. There must be solid contact between the rails and engine bed at all mounting locations before installation of the anchor bolts. If there is not solid contact, the engine cylinder block can be stressed when the anchor bolts are tightened. Use fitted bolts in the rear bolt holes of the rail; use clearance bolts at all other locations.

IMPORTANT: If, at any time in the future, it becomes necessary to replace the cylinder block after the engine and transmission have been aligned, always recheck the alignment between the engine and transmission after installation of the replacement cylinder block.

Gear Drive Units



Remote mounted gear drive units must be supported by the same base or rails as the engine. These units are not fastened to the engine except through a driveshaft and flexible coupling. To install these units, the gear drive must first be aligned with the equipment that is driving; and then the engine must be aligned with the gear drive unit.

Alignment between the gear drive unit and its driven equipment is usually line-to-line alignment. The centerline of the gear drive output shaft is in line with the centerline of the input shaft of the driven equipment. Depending upon the application, it may be necessary to use a flexible coupling between the gear drive unit and the driven equipment.

Alignment between the gear drive unit and the engine is always an "offset" alignment. The centerline of the engine crankshaft is positioned below the centerline of the gear drive input shaft. This compensates for the thermal growth of the engine, flywheel sag and main bearing clearances during cold alignment. With this vertical "offset" in the cold condition, the crankshaft and gear drive input shaft will be in correct alignment at operating temperature. Because of this "offset" alignment, the coupling between the engine and gear drive unit must be a flexible coupling.

Use shims as necessary between the mounting pads of the gear drive unit and the base to put the gear drive unit in alignment with the driven equipment. There must be solid contact between the mounting pads and the base at all locations without the anchor bolts installed. If all mounting pads are not solidly supported, distortion of the gear drive unit may result when the anchor bolts are tightened.

Install a ground body bolt (fitted bolt) at the rear of the engine right rail to direct horizontal thermal growth of the engine away from the coupling. Use clearance type bolts at all other mounting locations.

The allowable misalignment between the output shaft of the gear drive unit and the input shaft of the driven equipment must be within the coupling manufacturer's tolerances.

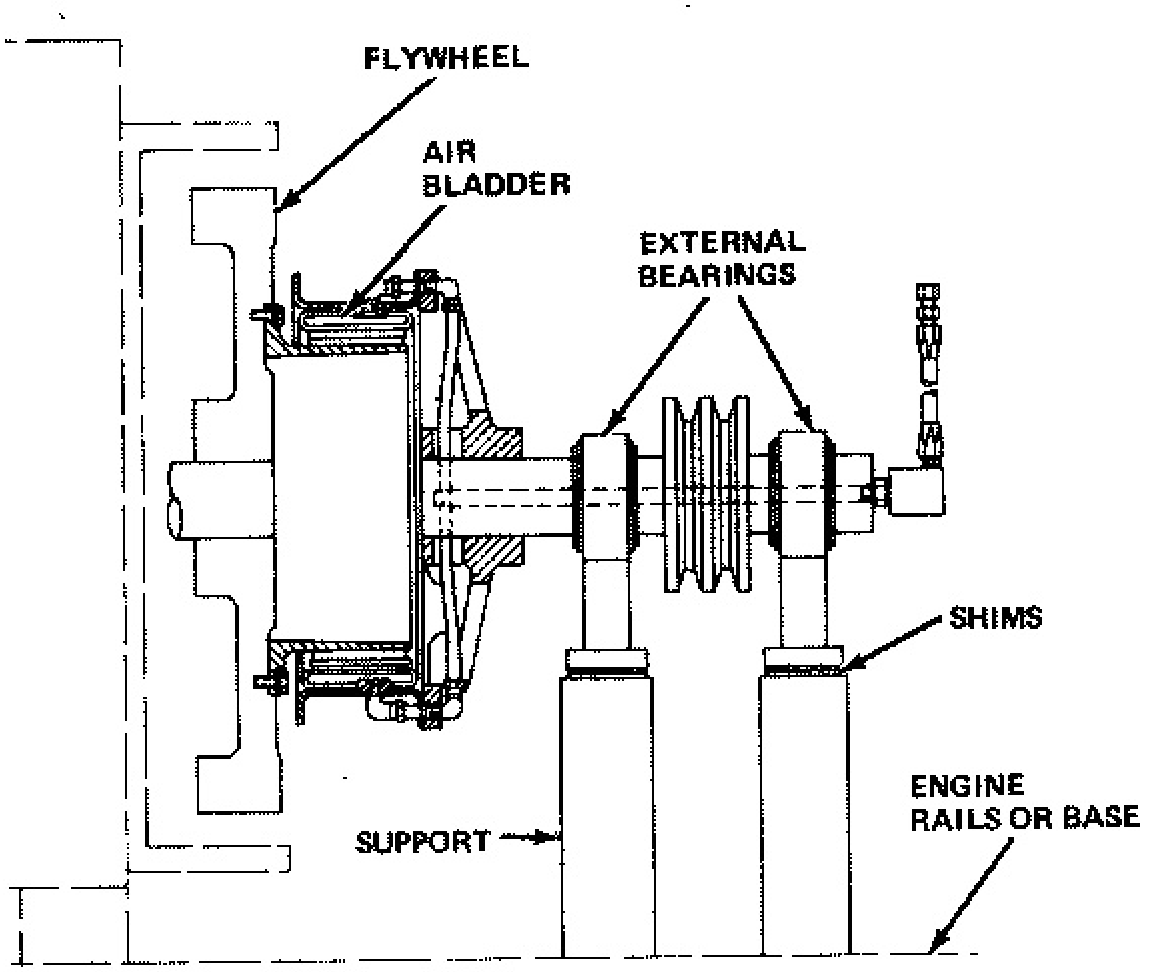
After the gear drive unit is aligned and mounted, align the engine with the gear drive unit. Use dial indicators fastened to the input shaft of the gear drive unit to check for correct bore and face alignment with the engine.

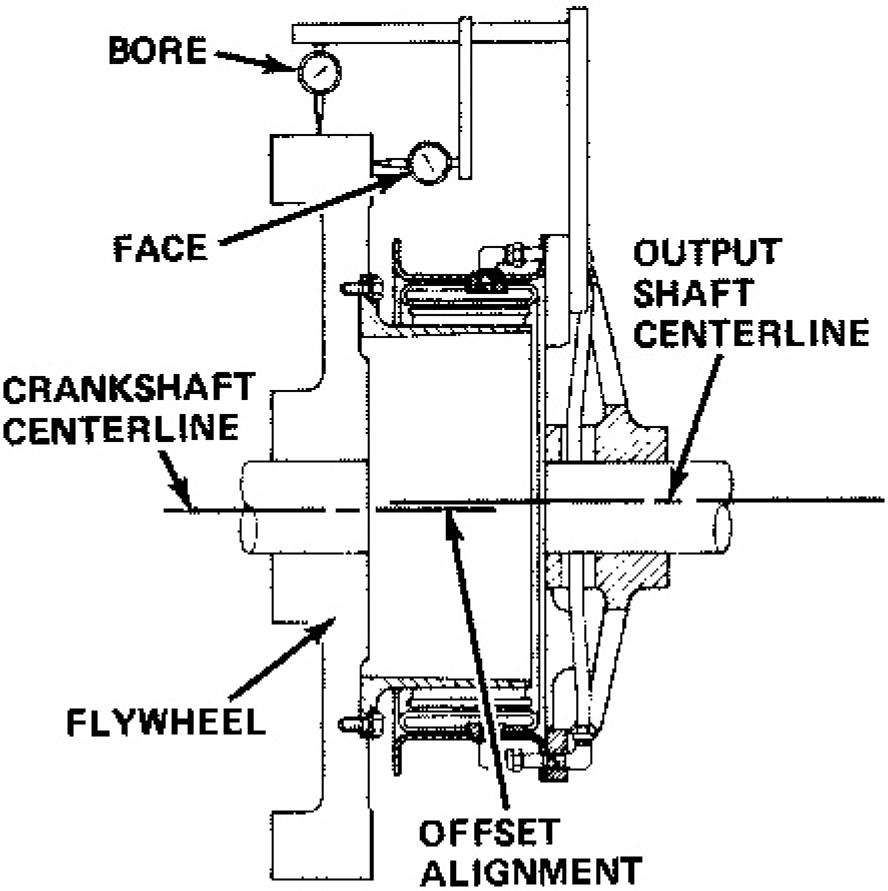
When aligning the engine to the gear drive unit, the coupling misalignment limits must not exceed the limits established for a Caterpillar viscous damped coupling. See Special Instruction Form SEHS7073, "ALIGNMENT OF TWO BEARING GENERATORS" for specifications on the Caterpillar viscous damped coupling.

Check crankshaft end play before and after alignment with the gear drive unit, and again with the units at operating temperature. There must be no reduction in end play after alignment of the engine or at operating temperature.

After the engine is in correct alignment with the gear drive unit, install shims as necessary between the engine rails and base to maintain this alignment. There must be solid contact between the rails and base at all mounting locations before installation of the anchor bolts. If there is not solid contact, the engine cylinder block can be stressed when the anchor bolts are tightened. Use a fitted bolt at the right rear corner between the rail and the base. Use clearance bolts at all other locations.

Air Clutches





Air clutches use two external bearings to support the output shaft. The supports for these bearings must be mounted on the same base or rails as the engine. Alignment of these units is similar to alignment of other remote mounted two bearing units.

Air clutches use an expanding air bladder for the clutch element. The air bladder acts much like a flexible coupling in that it can tolerate some misalignment. However, as the air pressure to the clutch increases, clutch misalignment tolerances are reduced. The misalignment limits must not exceed the limits established for Caterpillar viscous damped couplings or for the clutch, whichever is smaller. For alignment tolerances of Caterpillar viscous damped couplings, see Special Instruction Form SEHS7073, "ALIGNMENT OF TWO BEARING GENERATORS".

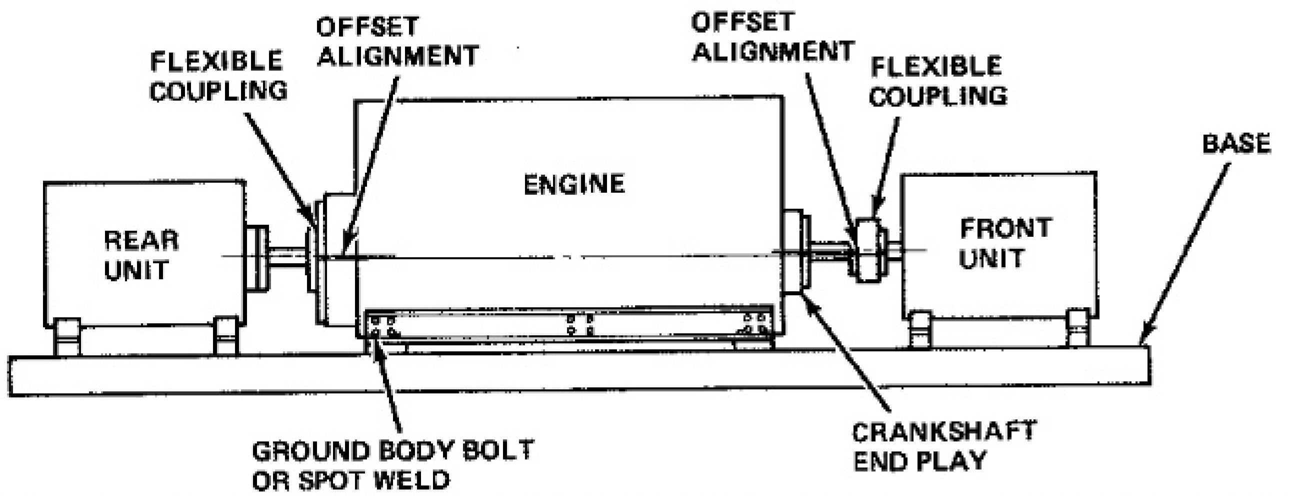
Alignment between the air clutch and the engine is an "offset" alignment. The centerline of the engine crankshaft is below the centerline of the clutch output shaft. This compensates for the thermal growth of the engine, flywheel sag and main bearing clearances during cold alignment. With this vertical "offset" in the cold condition, the crankshaft and clutch output shaft will be in correct alignment at operating temperature.

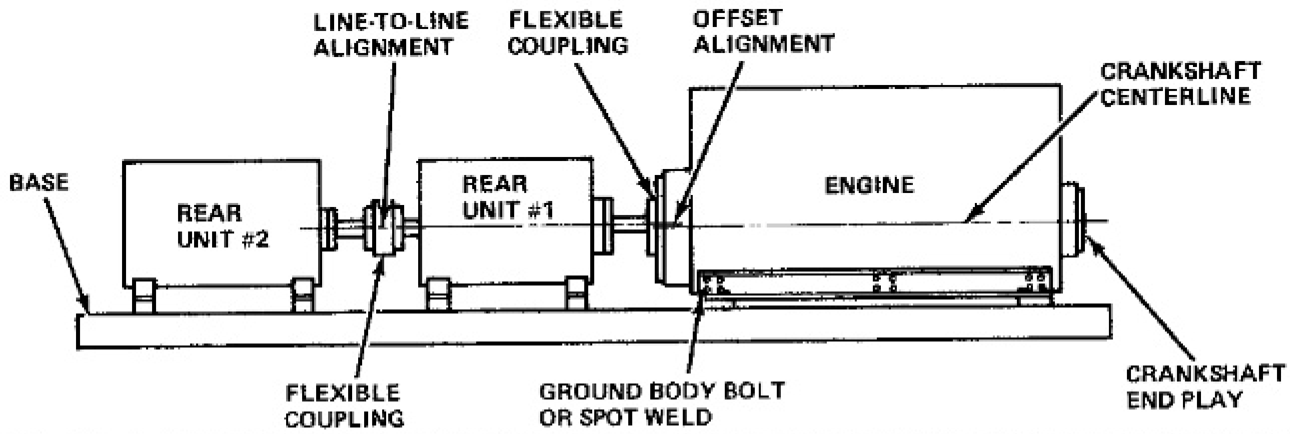
To align the clutch to the engine, first disengage the clutch. Mount dial indicators on the output side of the clutch with the tips of the indicators on the flywheel as shown. Zero the indicators at the 12 o'clock position shown. Rotate the clutch slowly through 360° and make a record of the readings 90° apart. Compare the readings with the coupling manufacturer's specifications and the specifications of a Caterpillar viscous damped coupling. Use shims as necessary between the bearings and the supports to put the clutch in correct alignment with the engine. Install the mounting bolts between the bearings and the supports.

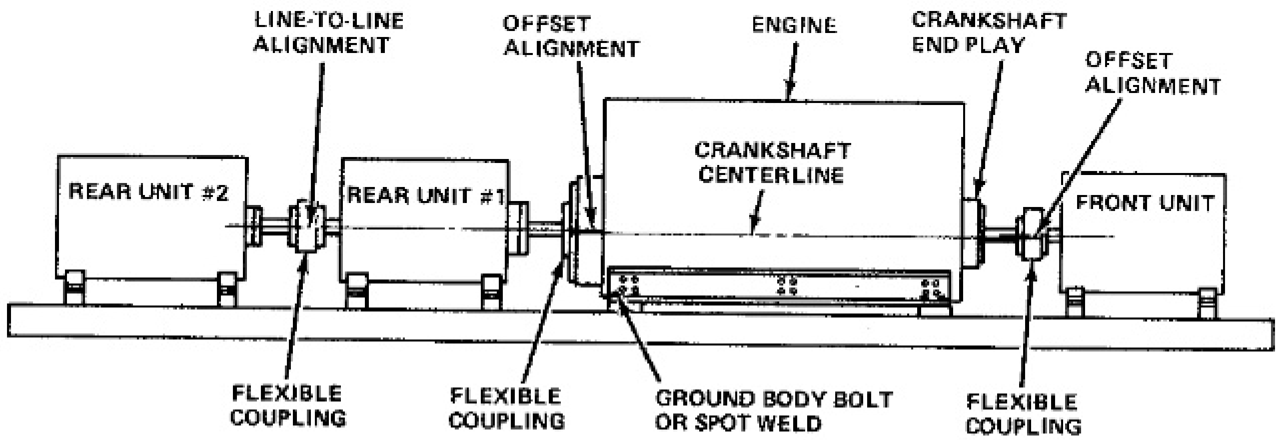
NOTE: Because the flywheel and clutch were not rotated together when taking the dial indicator readings, the readings will include an error due to runout of the clutch or flywheel. If excessive runout is suspected, check and correct as necessary.

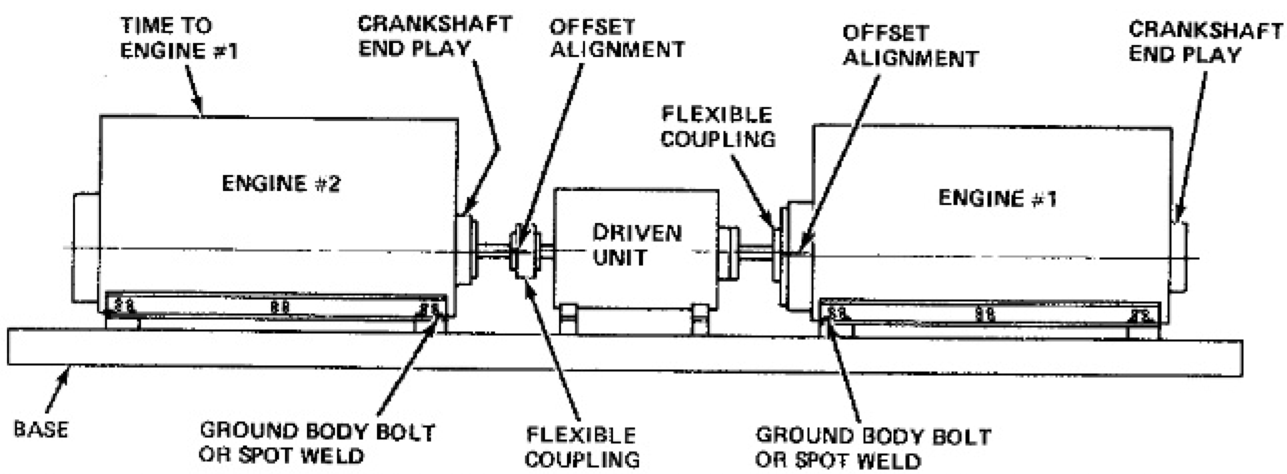
(E) Combination Remote Mounted Units

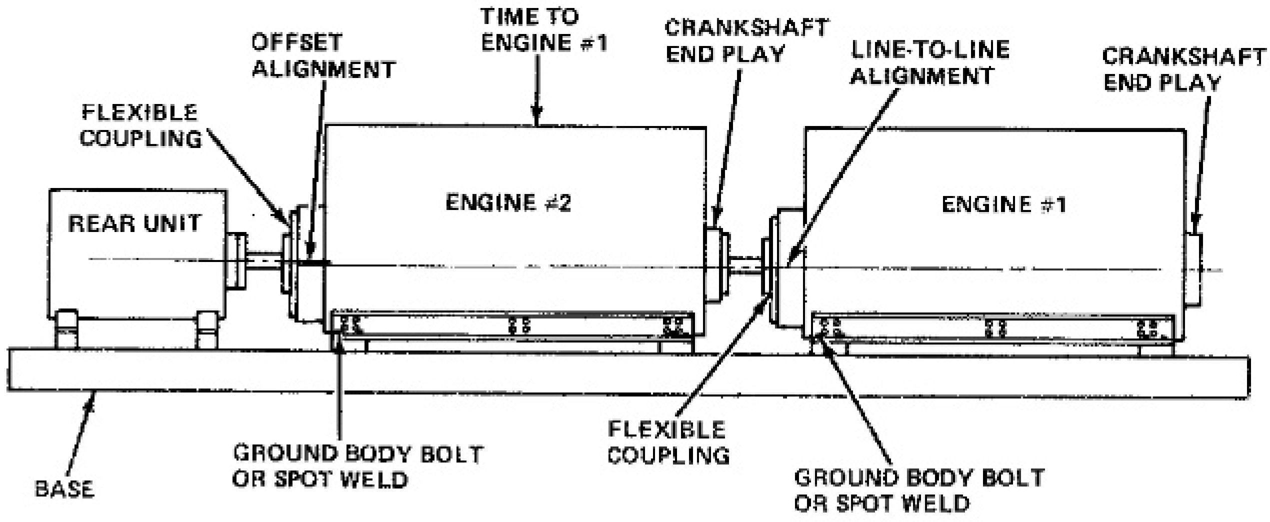
1. All driven units and engines must be mounted on the same base.
2. One driven unit or engine is installed on the base first, and all remaining driven units or engine are aligned to this unit. Which unit or engine is installed first depends on the application.
3. When more than one engine is connected together, either directly indirectly (through a driven unit), a special timing procedure must be used. See Special Instruction Form SMHS7419, "TANDEM ENGINE TIMING PROCEDURE".
4. Alignment between two engines directly connected together in tandem (no driven unit between them) is line-to-line alignment. The centerlines of the two crankshafts are in line with each other.
5. Alignment between two driven units directly connected together (no engine between them) is line-to-line alignment. The centerlines of the output and input shafts are in line with each other.
6. Alignment between a driven unit and an engine is always an "offset" alignment. The centerline of the crankshaft must be below the centerline of the driven shaft.
7. Always check the crankshaft end play of each engine before installation and alignment. Check the crankshaft end play after installation and alignment of each additional unit or engine on the base. Crankshaft end play must never be less after installation and alignment of an additional driven unit or engine than the original end play.
8. Each engine must be permanently located with respect to the base by using either a ground body bolt (fitted bolt) or by spot welding the engine rail to the base. The location of the ground body bolt (or spot weld) depends on the location of the driven units with respect to the engine. If the driven equipment is located at both ends of the engine, or if this equipment is driven from the rear of the engine only, use a ground body bolt (or spot weld) at the rear of the right mounting rail. If the equipment is driven from the front of the engine only, use a ground body bolt (or spot weld) at the front of the right mounting rail. Use clearance type bolts at all other mounting locations.


FLEXIBLE COUPLING
OFFSET ALIGNMENT
OFFSET ALIGNMENT
FLEXIBLE COUPLING
BASE
ENGINE
REAR UNIT
FRONT UNIT
GROUND BODY BOLT OR SPOT WELD
CRANKSHAFT END PLAY


LINE-TO-LINE ALIGNMENT
FLEXIBLE COUPLING
OFFSET ALIGNMENT
CRANKSHAFT CENTERLINE
BASE
REAR UNIT #2
REAR UNIT #1
ENGINE
FLEXIBLE COUPLING
GROUND BODY BOLT OR SPOT WELD
CRANKSHAFT END PLAY


LINE-TO-LINE ALIGNMENT
OFFSET ALIGNMENT
ENGINE
CRANKSHAFT END PLAY
OFFSET ALIGNMENT
CRANKSHAFT CENTERLINE
REAR UNIT #2
REAR UNIT #1
FRONT UNIT
FLEXIBLE COUPLING
FLEXIBLE COUPLING
GROUND BODY BOLT OR SPOT WELD
FLEXIBLE COUPLING


TIME TO ENGINE #1
CRANKSHAFT END PLAY
OFFSET ALIGNMENT
OFFSET ALIGNMENT
CRANKSHAFT END PLAY
FLEXIBLE COUPLING
ENGINE #2
DRIVEN UNIT
ENGINE #1
BASE
GROUND BODY BOLT OR SPOT WELD
FLEXIBLE COUPLING
GROUND BODY BOLT OR SPOT WELD


TIME TO
ENGINE #1
OFFSET
ALIGNMENT
CRANKSHAFT
END PLAY
LINE-TO-LINE
ALIGNMENT
CRANKSHAFT
END PLAY
FLEXIBLE
COUPLING
REAR UNIT
ENGINE #2
ENGINE #1
BASE
GROUND BODY BOLT
OR SPOT WELD
FLEXIBLE
COUPLING
GROUND BODY BOLT
OR SPOT WELD

Diesel Engines			Machinery	
ABS	Agco-Sisu		Drott	Dynapack
Akasaka	Baudouin		Extec	Faun
BMW	Bukh		Fendt	Fiat
Caterpillar	CHN 25/34		Fiatallis	Flexicoil
Cummins	Daihatsu		Furukawa	Gehl
Detroit	Deutz		Genie	Grove-gmk
Doosan-Daewoo	Fiat		Halla	Hamm
Ford	GE		Hangcha	Hanix
Grenaa	Guascor		Hanomag	Hartl
Hanshin	Hatz		Haulpack	Hiab
Hino	Honda		Hidromek	Hino truck
Hyundai	Isotta		Hitachi	Hyster
Isuzu	Iveco		Hyundai	IHI
John-Deere	Kelvin		Ingersoll-rand	JCB
Kioti	Komatsu		JLG	John-Deere
Kubota	Liebherr		Jungheinrich	Kalmar
Lister	Lombardini		Kato	Kioti
MAK	MAN B&W		Kleeman	Kobelco
Mercedes	Mercruiser		Komatsu	Kramer
Mirrlees BS	Mitsubishi		Kubota	Lamborghini
MTU	MWM		Landini	Liebherr
Niigata	Paxman		Linde	Link-belt
Perkins	Pielstick		Manitou	Massey-Ferg.
Rolls / Bergen	Ruggerini		Mccormick	MDI-Yutani
Ruston	Scania		Mitsubishi	Moxy
Shibaura	Sisu-Valmet		Mustang	Neusson
SKL	Smit-Bolnes		New-Holland	Nichiyu
Sole	Stork		Nissan	OK
VM-Motori	Volvo		OM-Pimespo	others-tech
Volvo Penta	Westerbeke		Pel-Job	PH-mining
Wichmann	Yanmar		Poclain	Powerscreen
Machinery			Same	Samsung
ABG	Airman		Sandvik	Scania
Akerman	Ammann		Schaefer	Schramm
Astra	Atlas Copco		Sennebogen	Shangli
Atlas Weyha.	Atlet		Shibaura	Steiger
Bell	Bendi		Steinbock	Steyr
Bigjoe	Bobcat		Still	Sumitomo
Bomag	BT		Super-pac	Tadano
Carelift	Case		Takeuchi	TCM
Caterpillar	Cesab		Terex	Toyota
Challenger	Champion		Valpadana	Venieri
Claas	Clark		Versatile	Vogele
Combilift	Crown		Volvo	Weidemann
Daewoo-Doosan	Demag		Wirtgen	Yale
Deutz-Fahr	Dressta		YAM	Yanmar