CATERPILLAR®

3600 Marine Engine Application and Installation Guide

● **Mounting and Alignment**

LEKM8467 8-98

CATERPILLAR®

Mounting and Alignment

Foundation Design

Engines

This section deals with propulsion engine and marine gear foundations and their relationship to ship framing. Refer to *Mounting* and *Alignment* of this section for information on bolting, chocking, and alignment.

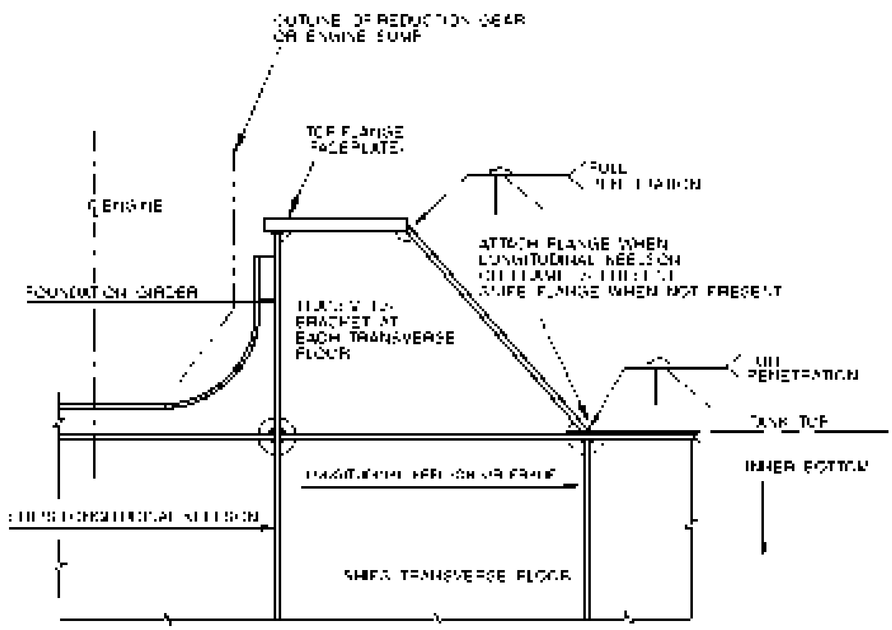
The majority of 3600 Marine applications will be classed by a Marine Classification Society. The contractor or engineering firm must submit structural drawings and/or modifications to the society for approval. Also, submit the drawings to Caterpillar for review. If required, engine foundation steel should be certified and approved by the classification society.

Frame line and floor spacing will depend on the ship type, classification society requirements, shipyard procedures, production and fabrication techniques, etc. From a machinery standpoint, it is desirable for floors and brackets to be aligned vertically with the engine crankshaft bearings and cylinder block bulkheads. This provides rigidity for the engine and reduction gear units.

Main bearing spacings on the Caterpillar 3600 Family of Engines are 410 mm (16.1 in.) and 460 mm, (18.1 in.) for the in-line and vee engines respectively. At this distance the frame and/or floor spacing may be too close for inspection and maintenance of the inner bottom structure. When this occurs the spacing requirement may increase to a maximum of 610 mm (24 in.).

Exact analytical methods cannot always be used to design engine foundations. The design is also influenced by several factors, including previous successful installations, the designer's experience, and the basic dimensions of the specific engine being installed. See the *Engine Data* section of this guide for specific information on 3600 Engine weights and dimensions.

The engine foundation must resist vertical, horizontal, and fore-and-aft deflection. Integrate the foundation into the reduction gear foundation to connect the overall structure to the ship's inner bottom structure as shown in Figure 1. The thrust from the propeller and the dynamic forces from the main engine and reduction gear are evenly distributed over a large area of the inner bottom structure.



Sectional View At A Ship's Transverse Frame

Figure 1

As shown in Figure 2 on page 28, the foundation's longitudinal foundation girders located on each side of the engine or gear box continue below the tank top as keelsons in the inner bottom structure. When it is not possible to use one piece girders and keelsons, they should at least be in alignment above and below the tank top.

The main engine foundation must have sufficient rigidity to transmit static and dynamic forces from the main engine into the foundation. The girder and face plate must:

- Increase bending inertia of the structure
- Facilitate chock installation
- Permit installation of side blocks and collision chocks
- Provide a *work shelf* for servicing the side of the engine

The main engine and reduction gear foundation must also be designed to absorb the loads from:

- Ship's vibration
- Propeller thrust
- Thrust and torque of the engine
- Ship's motion at sea
- Thermal, static and dynamic effects
- Crash reversals

Because the loads originate from sources other than the engine, the foundation sections should be uninterrupted and have adequate section strength.

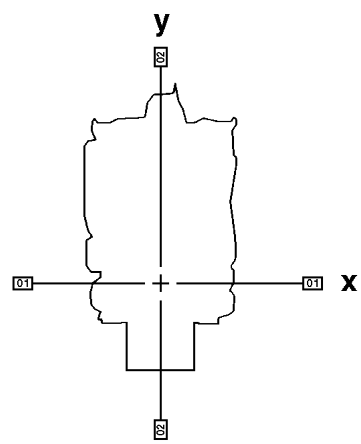
To avoid natural frequency resonance between engine and hull, the ship builder must ensure resonance between torque excitation and the natural transverse hull frequencies does not occur.

Foundation Deformations

The designer must assess the rigidity of the foundation versus the engine and gear deformation. The following engine bending inertias may be used to evaluate the foundation system:

Table of Bending Inertias

Engine Model	Bending Inertia (I_x)
3606	3.8 E11 mm^4
3608	3.8 E11 mm^4
3612	6.0 E11 mm^4
3616	6.0 E11 mm^4



I_X = Inertia About x Axis

Figure 3

Double continuous fillet welding must be used for the entire engine foundation and inner bottom structure in the proximity of the engine and gear box. Full penetration welds are recommended when heavy scantlings are required, such as longitudinal girders and engine foundation top flange. Submit details of the main engine scantlings and welding to the appropriate classification society.

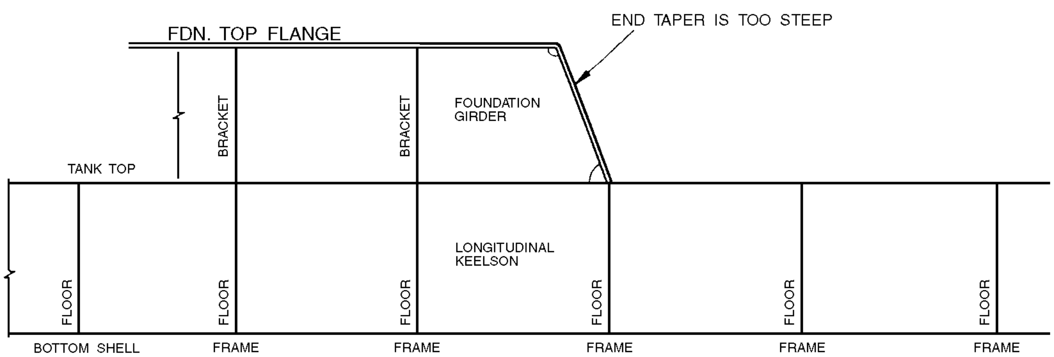
Engine foundation design involves:

- Engine position relative to the structure, either as new construction or repower. This may be the most important consideration.
- Bulkhead and deck locations.
- Depth of double bottom.
- Spacing and location of the transverse floor and longitudinal girders.
- Other engine room machinery.

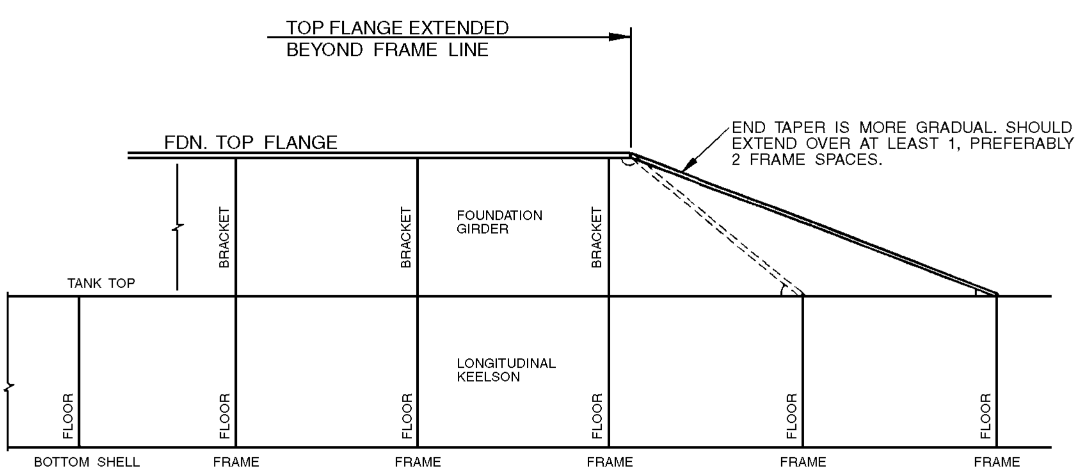
More engine location possibilities will be available in new ship construction. The main engine's location may be moved somewhat to facilitate optimum shafting positioning. Specific repowering is discussed in more detail in the *Repowering Applications* section of this guide. The foundation girders must be integral with the longitudinal keelsons within new engine room construction. The distance of the foundation girders from the engine centerline is determined by the engine mounting feet location shown in Figures 4 through 8 on pages 29 through 33 in the *Mounting* section. After allowing chocking clearance, the height of the mounting feet below the horizontal centerline of the engine determines the foundation height. See the *Mounting* section for chocking discussion.

Extend the engine foundation top flange beyond the forward engine mounting foot to allow room for collision blocks. At this point, taper the flange downward to meet the tank top at a floor. Review the top flange length and its location relative to the ship's framing. It must extend beyond a frame to accommodate one pair of brackets at the forward end before it tapers gradually downward to the tank top.

The forward taper is generally determined by the ship's transverse frame spacing. In closely spaced framing, the end taper should extend over two frame spaces while in ships with larger frame spaces, the forward taper would generally extend over one frame space, Figure 9. The taper should be gradual, but will depend on the floor spacing; approximately 30°- 45° above the horizontal.



Improper Tapering Off - Engine Foundation

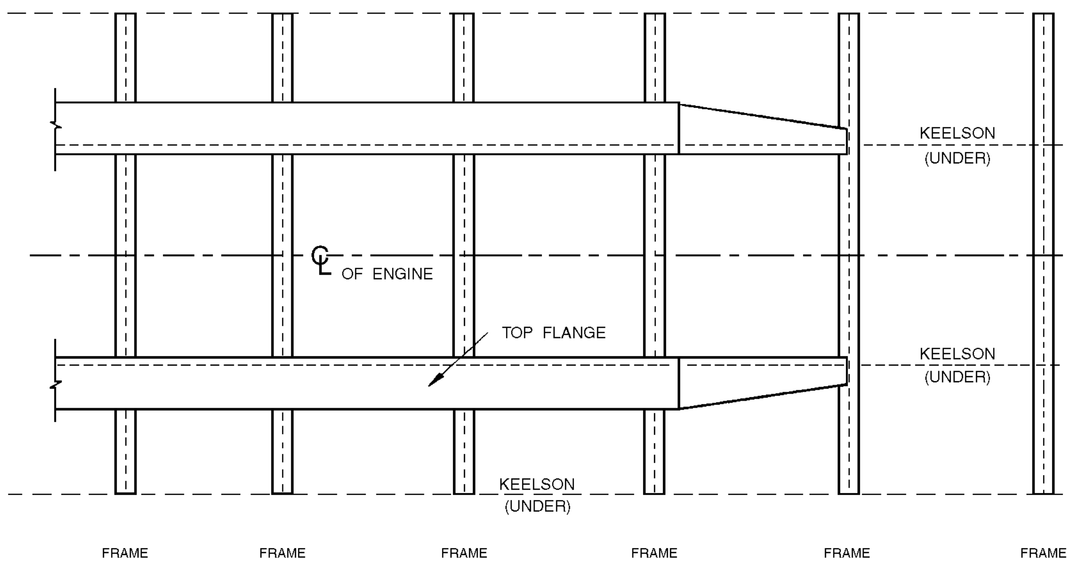


Proper Tapering Off - Engine Foundation **Figure 9**

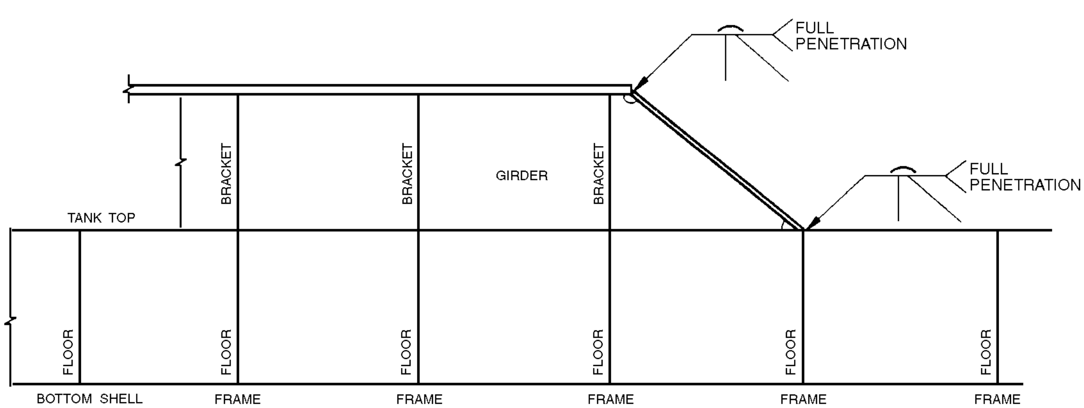
Also taper the foundation girder top flange down to the tank top. The sloping flange can be thinner than the foundation top flange, about 60 to 75% of the top flange thickness. Make the sloping flange from straight flat bar or flat bar tapered to a lesser width at the tank top end, Figure 10. The flange must have a full penetration weld at the tank top. Double continuous welds are generally used in the foundation and full penetration welds are used where thick plates (≥1/2 in.) join each other.

The foundation top flange must be wider than required for engine mounting feet. Include requirements for side guide blocks and damming when using poured chocking.

The aft end foundation location is determined in a similar manner to the forward using the last set of mounting foot bolts and the need for rear collision blocks. The engine top flange should have a transition into the reduction gear foundation.



Plan View Of Main Engine Girders



Foundation Girders-Tapered Brackets

Figure 10

Transverse brackets must be provided at each frame. In general, the brackets are welded at the top to the top flange, and at the bottom to the tank top unless there is no longitudinal structure under the tank top. Where no longitudinal keelson or frame is present, the bracket flange must be cut to clear the tank top. See Figure 11. Brackets and bracket flanges must never be placed on unsupported *soft* plating. The transverse width of each bracket is generally determined by the space between the longitudinal keelson at the foundation girder and the next outboard longitudinal keelson or frame. The bracket shape is in general terms about 45°, but is determined by the geometry of the structure. Where widely spaced transverse floors are present on the ship, intermediate brackets with intermediate frames under the tank top must be installed. See Figure 12.

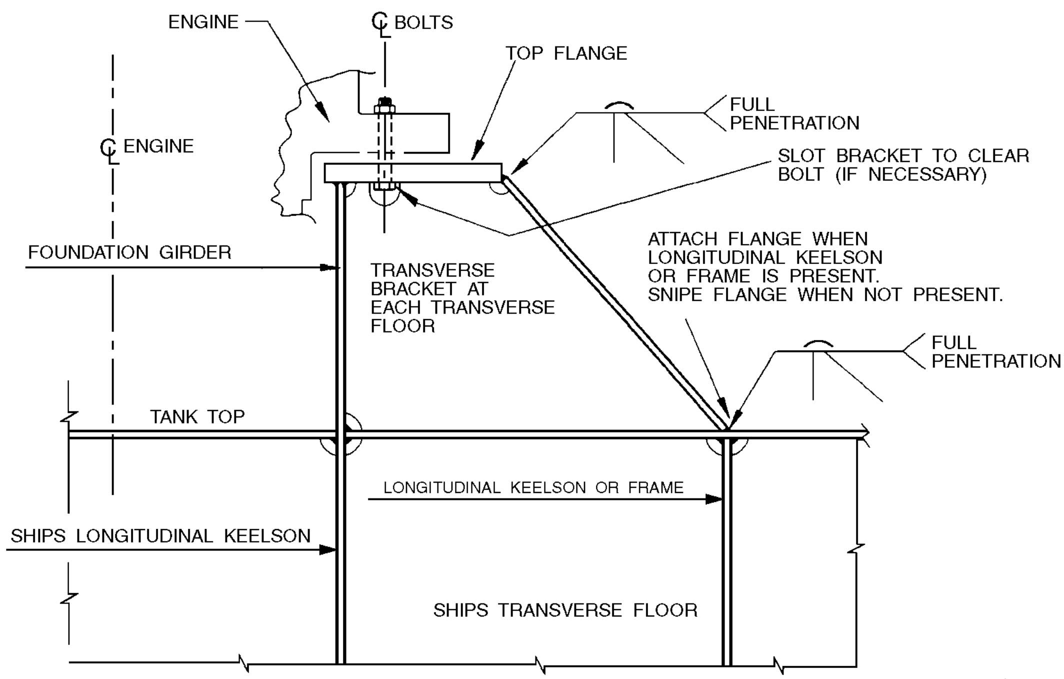


Figure 11

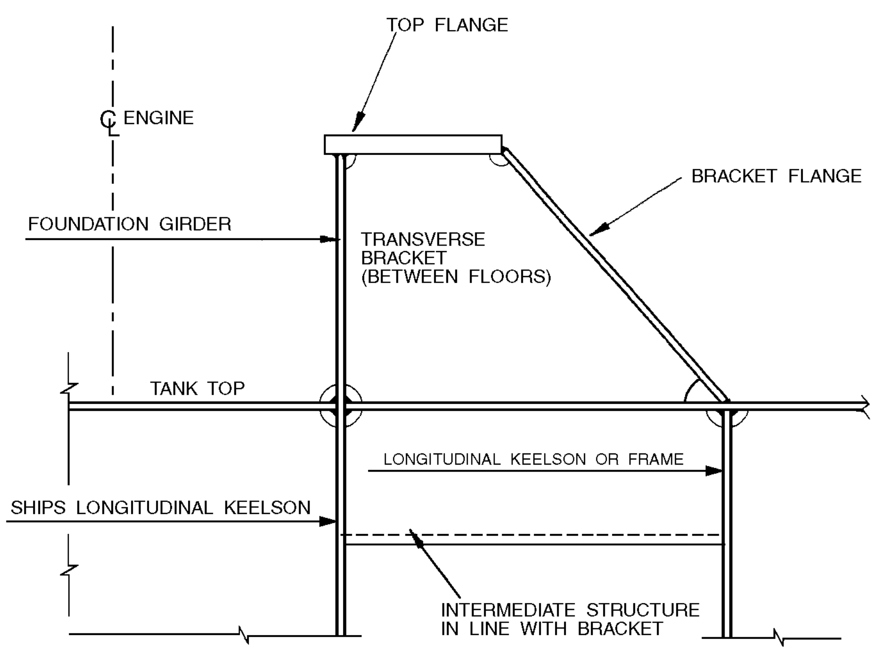


Figure 12

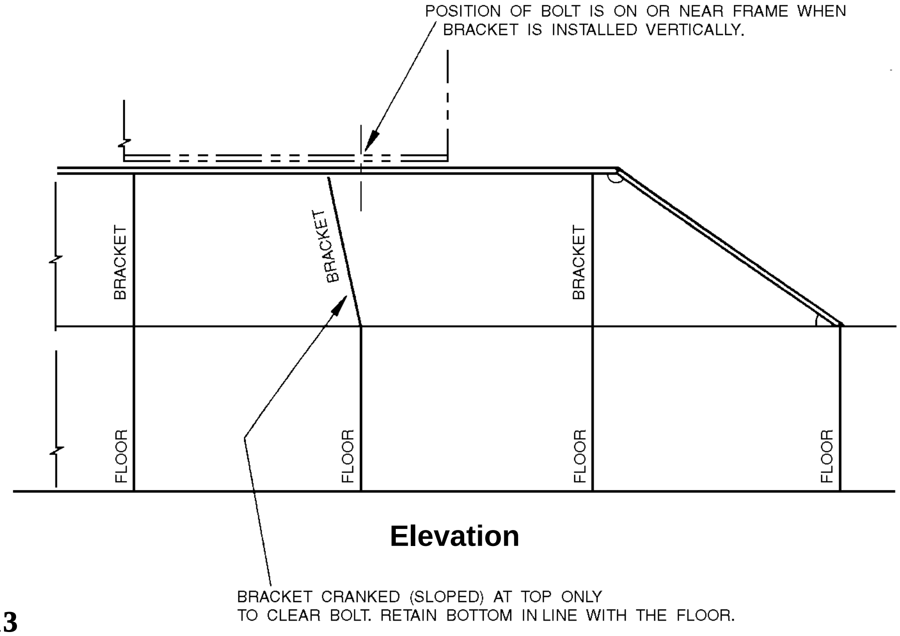


Figure 13

Brackets, whether at frames or at intermediate frames, will occasionally interfere with engine hold down bolts. When this occurs two options are:

- Slot the transverse bracket to permit inserting the bolt. See Figure 11
- *Crank* (slope) the bracket to clear the bolt. See Figure 13.

Marine Gear Foundation Design

The marine gear fore and aft position is determined by the propeller shaft coupling flange location. The height above baseline is established by the propeller shaft elevation. Elevation and geometry above baseline of the reduction gear input shaft establishes the engine crankshaft centerline.

The reduction gear mounting flange is generally much wider than the mounting flange under the main engine. In many installations they are located at differing distances from the engine centerline. Consequently, the reduction gear foundation has a different configuration than the engine foundation. As mentioned previously, the engine and gear box foundations must be integrated into one unit. This allows the combined foundation to be connected to the ship's inner bottom structure for engine and gear support.

With the reduction gear positioned, the forward and aft ends of the gear foundation top flange can be determined.

The elevation of the top flange above baseline can also be established by allowing 25 to 40 mm (1 to 1 1/2 in.) for chocking below the reduction gear mounting flange. Join the two foundations to form one unit integral with the ship's structure. In new ship construction, the longitudinal girders in the engine room are usually positioned to accommodate the main engine foundation requirements, Figure 14. In new ship construction, the girders would be *cranked* (sloped) to match the position needed for the engine and gear box foundation. This may not be true on repowers, as the girders were positioned to suit the original engine. See the section on *Repowering Applications*.

Avoid cutouts through the foundation longitudinal girder where possible. Occasionally, an opening will be required in a foundation girder for access or for piping. When this occurs the opening should be circular in shape or have rounded corners to eliminate stress concentrations. Openings in foundation girders should be as small as practical and near the neutral axis of the girder.

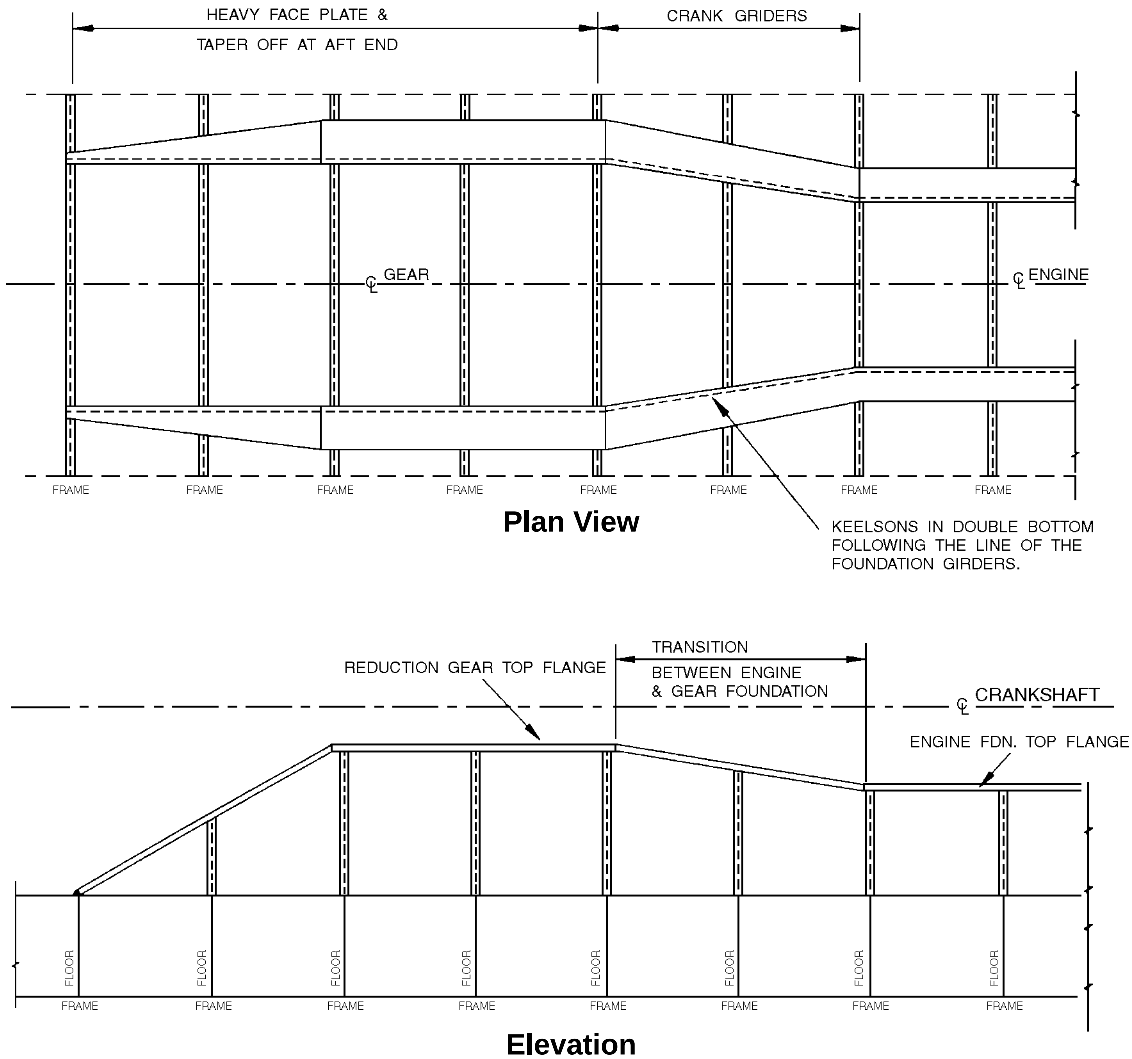


Figure 14

In cases where the cutout becomes too large (about 1/3 the depth of the girder) weld a reinforcing ring or doubler plate to the girder to compensate for the removed material.

Generator Set Foundations

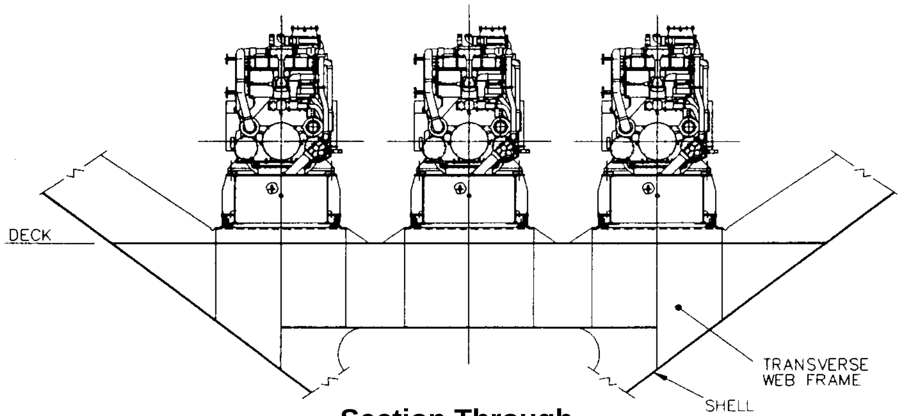
The principals of propulsion engine foundations at the tank top level apply to generator sets as well. Align the generator foundation with longitudinal girders. It must be supported by transverse brackets or chocks between the foundation flange and the tank top. Align the brackets with the floors or frames.

Generators mounted on Caterpillar's rigid base and sitting on spring isolators do not need the foundation depth required by propulsion engines. They are often constructed of two heavy angles tied together by several transverse angles.

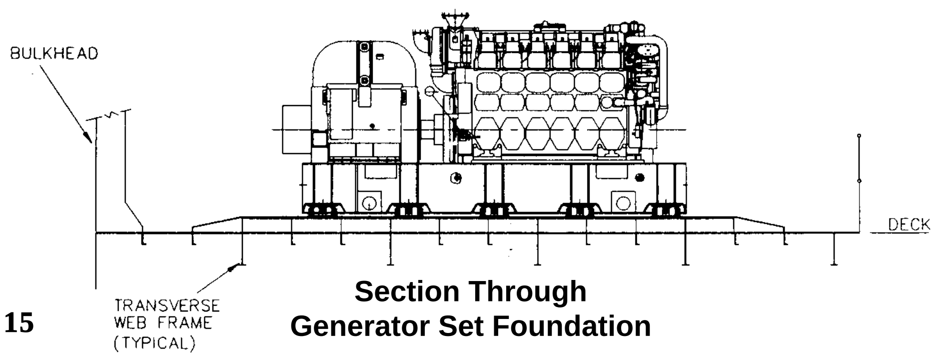
Figure 15 illustrates generator sets located on intermediate deck levels above the tank top; the same foundation principals apply.

Deep transverse web frames tied into the hull or supported by columns are optimum for intermediate deck level mounting.

Use continuous welding at all foundation locations.



**Section Through
Generator Set Foundation**



**Section Through
Generator Set Foundation**

Figure 15

Construction Materials

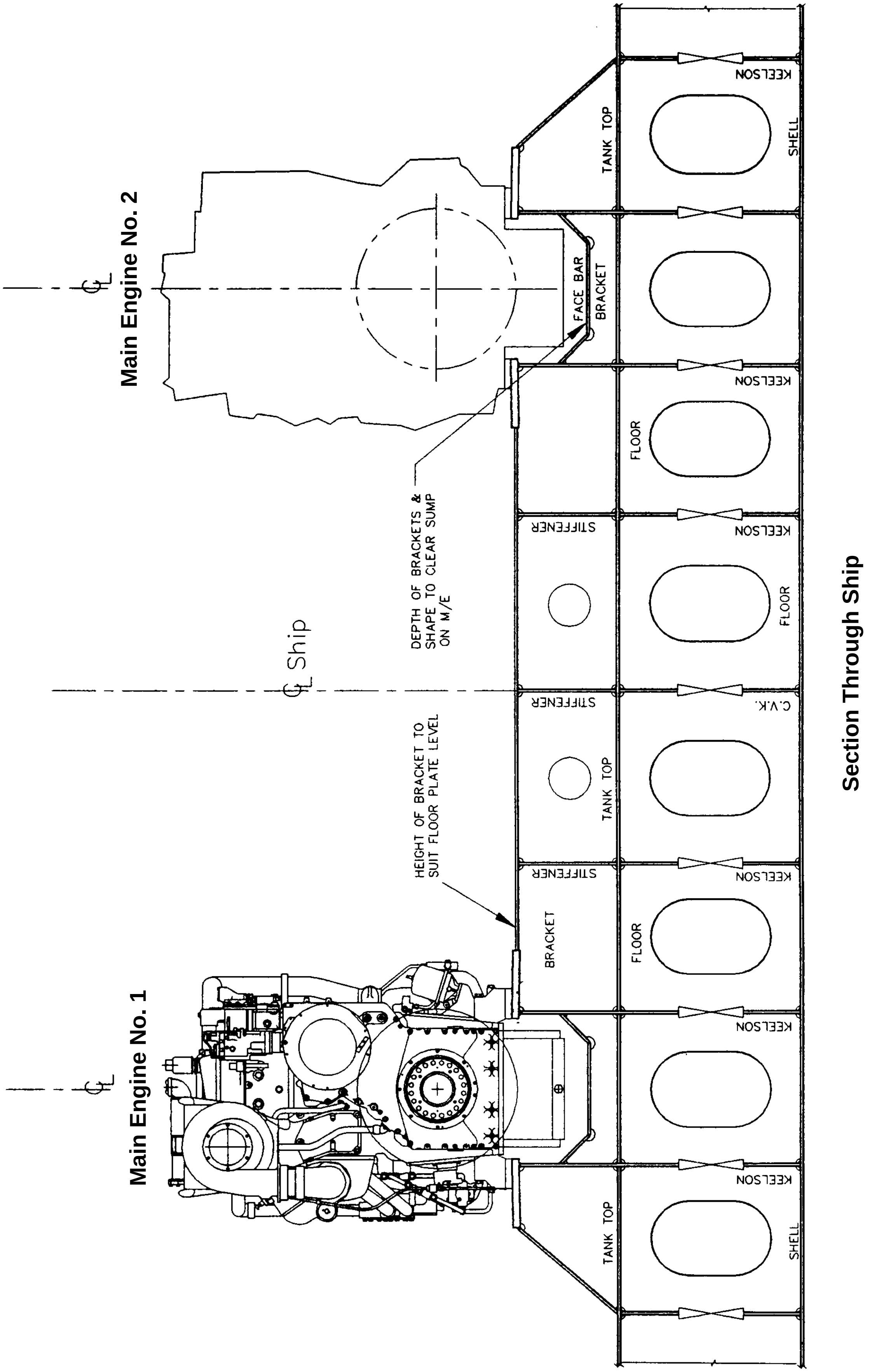
Fabricated foundation steel must meet classification society requirements. Society requirements are also a good guide for unclassed vessels. Higher strength steels are normally not used in engine and gear box foundations as thinner scantlings may lead to potential problems with foundation buckling.

Plate thicknesses of the various structural components may vary with the selection of the engine. In general, the following *minimum* plate thicknesses are provided for guidance.

- Engine foundation top flange - 38 mm (1 1/2 in.)
- Engine foundation girders - 19 mm (3/4 in.)
- Reduction gear top flange - 44 mm (1 3/4 in.)
- Reduction gear girder - 22 mm (7/8 in.)
- Transverse brackets - Same as girder thickness or at least equal to the thickness of the floors in the double bottom.
- Bracket flange - No less than 60% of the bracket thickness but at least 13 mm (1/2 in.). Brackets may be flanged or have a flat bar welded to the web of the bracket. In either instance, the free bar width should be a minimum of 152 mm (6 in.).

Dual Engine Installation

The principles outlined previously for single main engine installations are applicable for multiple main engines. One further recommendation is to join the main engine foundations together with a bracket extending between the two inboard foundation girders, Figure 16. The bracket depth is determined by the desired floor plate height. The thickness and scantlings are determined by the depth and span of the bracket between the two girders. Where deep brackets or long spans are present, stiffen the bracket between the two longitudinal girders by a standard size rolled beam or flat bar. The center brackets may have small lightening holes for piping, etc.



Main Engine No. 2
Main Engine No. 1
℄ Ship
DEPTH OF BRACKETS & SHAPE TO CLEAR SUMP ON M/E
HEIGHT OF BRACKET TO SUIT FLOOR PLATE LEVEL
FACE BAR
BRACKET
TANK TOP
KEELSON
SHELL
FLOOR
STIFFENER
C.V.K.
Section Through Ship

Figure 16

Installations Near the Ship's Side

In small ships or where twin screw/twin engines are used, the main engine girders may be close to the ship's side. When this occurs the outboard engine girder may be bracketed directly to the ship's web framing as shown in Figure 17.

The bracket web would usually be of a thickness equivalent to the web frame thickness. The face bar of the bracket may be sniped or welded directly to the web frame face plate. A welded connection is preferable. However, when welded directly a flat bar chock must be provided on both sides of the web frame.

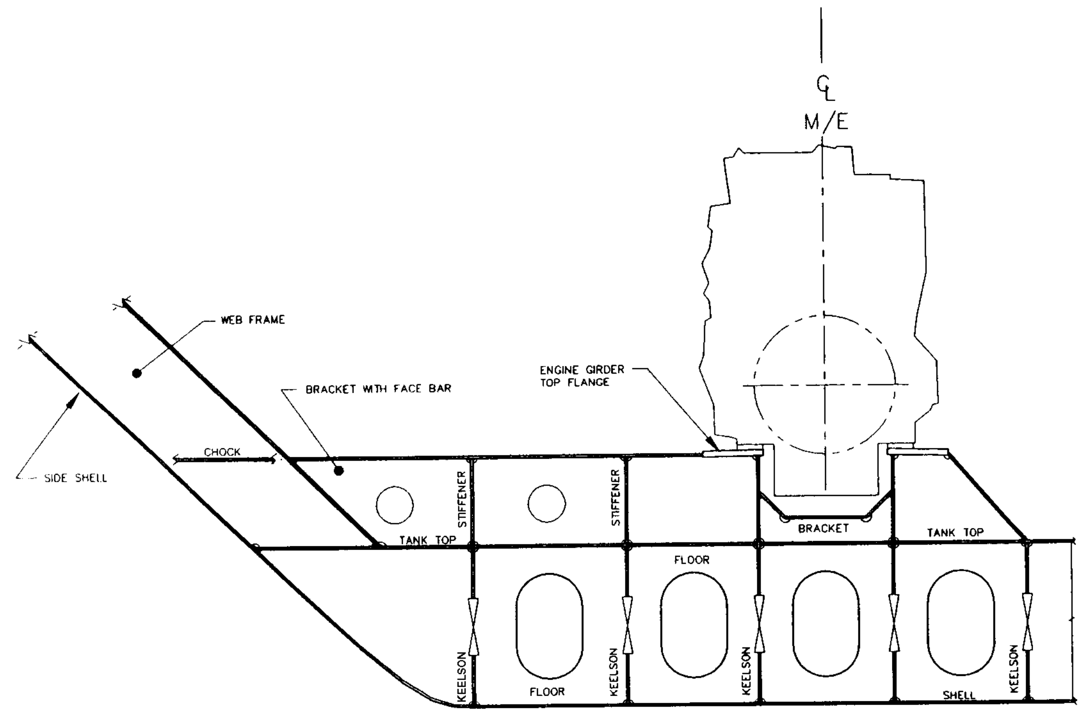


Figure 17 **Section Thru Ship**

Mounting

Main propulsion engines are normally bolted directly to the engine foundation using resin chocks. Steel shims can also be used. Isolation mounting is also available from Caterpillar. Engine mounting "*Footprints*" are shown in Figures 4 through 8, pages 29 through 33.

This section primarily deals with propulsion engine mounting systems. Mount marine auxiliary engines used for ship's service generator set applications on the factory supplied rigid base setting on factory supplied spring isolators. See the *3600 EPG Application and Installation Guide*, Form No. LEKX1002 for further details.

Hard Mounting

Resin Chocking

Marine Classification Society rules may apply on specific installations using poured resin chocks. *Do not use lead as a shim material. It is easily deformed and has poor support characteristics.* Figure 18 is an example of a poured resin chock.

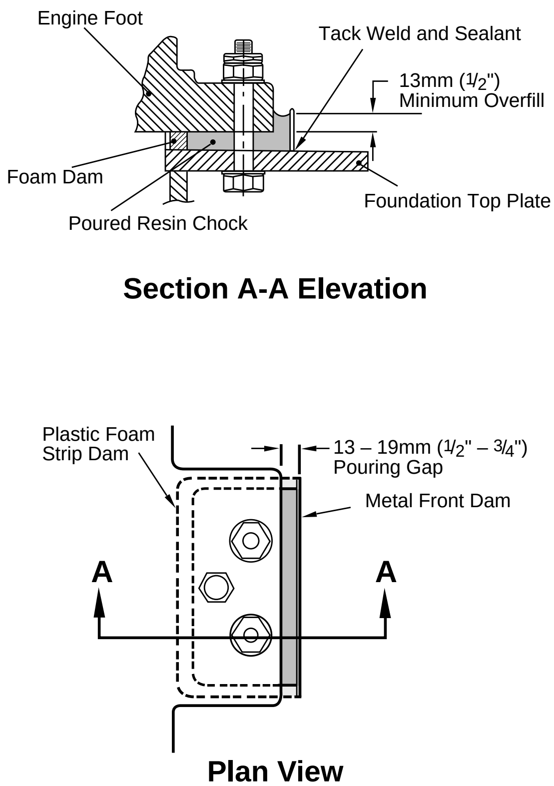


Figure 18

Use the following criteria:

- Normally six mounting feet (3 per engine side) are used for resin chocking. However, four mounting feet have sufficient area for resin chocks on the 3606 and the 3608 Engines. The 3612 and 3616 Engines require 6 feet.
- The chocking arrangement, planning and pouring should be reviewed by an approved resin manufacturer.
- The shipyard normally has final responsibility for chocking material installation.

Most classification societies permit the use of Chockfast Orange, manufactured by the Philadelphia Resins Corp., USA. The following guidelines apply:

- A maximum dead weight loading of 7 kg/cm^2 (100 psi).
- A maximum total loading, deadweight plus bolt tension, of 35 kg/cm^2 (500 psi).
- The combined bolt tension should exceed 2.5 times deadweight, but cannot exceed the requirement above.
- Permanently lock the hold-down bolts.
- The chock operating temperature must not exceed 80°C (176°F).
- The chock area should be greater than 130 cm^2 (20 in^2).
- Increase the amount of resin used by 10% to provide allowances for damming. The seating must have enough footprint to facilitate foam rubber damming strips.
- The resin thickness must be 12 mm to 45 mm (0.5 in. to 1.75 in.). *Also see section on Isolation Mounts.*
- Do not allow resin material to flow between the engine and the foundation mounting plate.

Mounting surfaces must be free of dirt, grease and rust. Spray adjoining surfaces and bolts with a release agent for future removal of machinery bolts, jacking screws, etc.. For detailed information contact the resin manufacturer.

Steel Chocking

Caterpillar does not offer steel mounting plates for marine propulsion engines. Plates available for generator set engines can be modified to fit. They are 50 mm (2 in.) thick. An example of typical plates is shown in Figure 19.

The following can be used for guidance:

- Chocks must be manufactured from steel plate or cast steel material. Use the same type of material for all chocking on an engine. They are also required at each mounting foot.
- The recommended finished machined chock thickness is 38 mm (1.5 in.). Minimum thickness is 25 mm (1 in.). *Using several loose metal shims is not recommended.*
- Dirt, grease, paint and rust must be removed from the mounting surfaces prior to installing the chocks.
- The chock and top plate surface smoothness should be at least 3.2 micrometer (125√) finish and have a minimum of 80% contact surface on each side of the chock.

- Do not weld chocks in place. They must be removable for inspection.
- The final location of hold down bolt holes is determined with the engine in place on the foundation. See guide section, *Hold Down Bolts*, on page 18.
- For easy positioning, the top flange of the engine foundation should allow for tapered chocks. Taper the chock approximately 1°, see Figure 20. An alternative is a parallel top flange and tapered steel pads welded to the engine top flange, Figure 20.

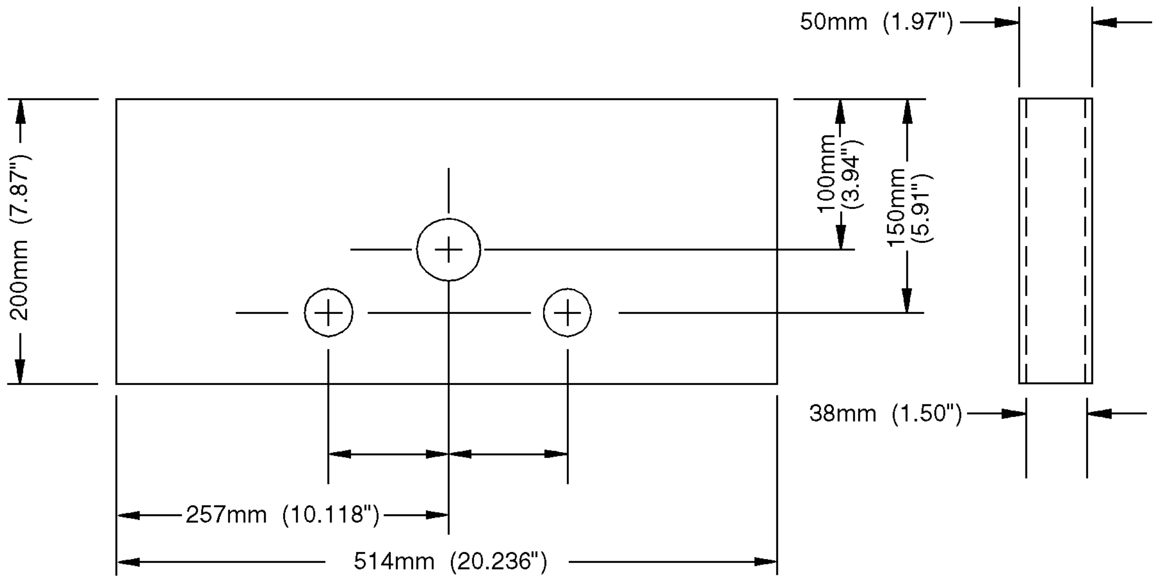


Figure 19

Typical Steel Chock

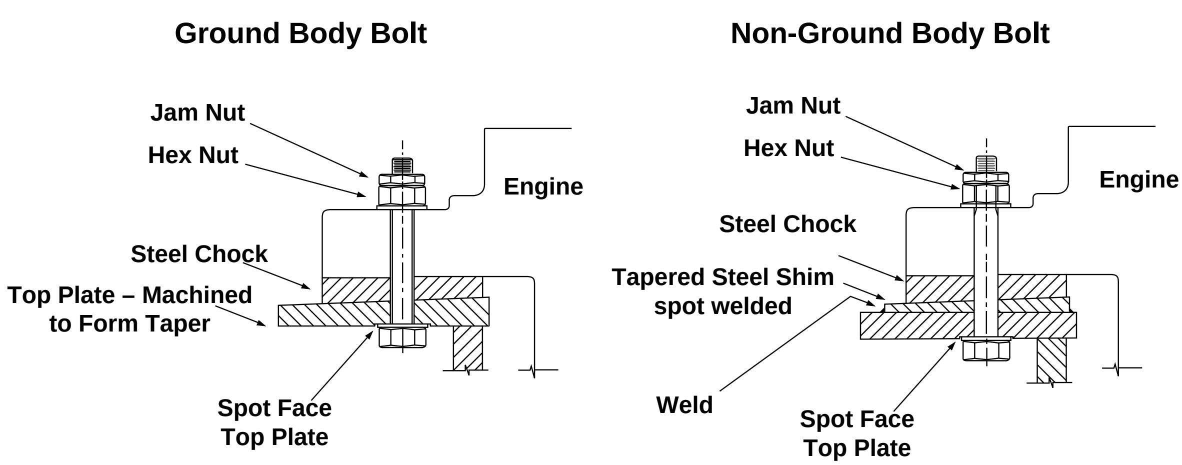


Figure 20

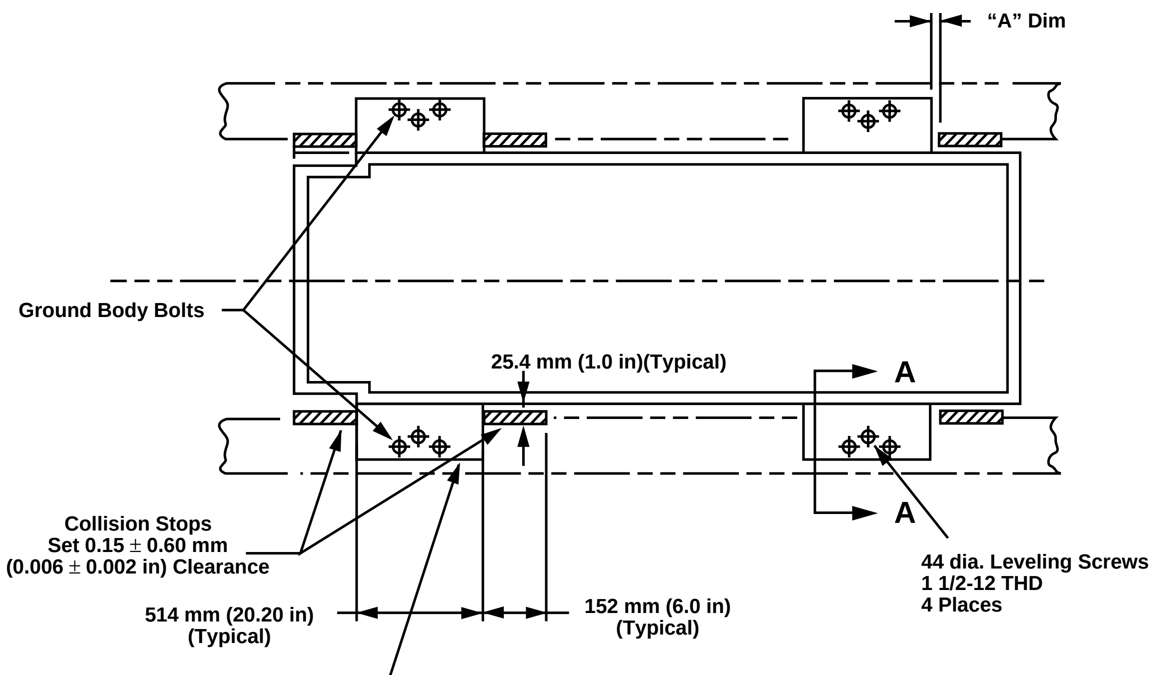
Collision Blocks

Collision blocks are normally required on marine installations. Guide blocks are optional when using the recommended bolting method described below. For location, see Figure 21. The figure also shows hole and bolt size detail of the normal hold down bolts as well as the ground body bolts used at the rear of the engine.

Collision blocks are normally manufactured by the engine installer. Use steel plates 25-38 mm (1 to 1.5 in.) thick. Extend the top of the plate to the top of the engine mounting foot. The base must be welded to the top plate of the engine foundation. Collision blocks must have clearance to allow for thermal growth of the engine. At engine operating temperature, the rear collision blocks should have a 0.15 mm (0.006 in.) gap between the feet and the blocks. See Figure 21. Use the following values for engine thermal expansion:

- The thermal expansion coefficient for the 3600 Engine block is equal to: $10 E^{-6}$ mm/mm/°C ($5.6 E^{-6}$ in./in./°F)

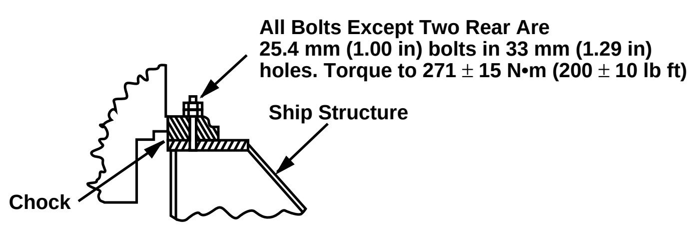
Optional collision blocks can also be located at the front of each of the front mounting feet. Allow enough clearance for thermal growth of the engine. Locate them close enough to be used as an alignment reference point. See Figure 21.



Plan View
(Viewed from top of engine)

After final alignment of the marine transmission and engine, secure the two rear engine mounting feet to the ship structure with ground body bolts. Use the existing holes in the engine mounting feet as drill guides for drilling and reaming to a nominal size of 35 mm dia. (1.38 in). Maximum clearance between the ground body bolt and reamed hole to be 0.020 mm (.0008 in). Torque to 338±3N•m (250±10 LB FT).

Front Chock Spacing	
Engine Type	"A" dim
3606	2 mm (0.08 in.)
3608	2.5 mm (0.10 in.)
3612	2 mm (0.08 in.)
3616	3 mm (0.12 in.)



Section A-A

Figure 21

Guide Blocks
Front guide blocks are not required if ground body bolts are used in *both* rear mounting feet. See *Hold Down Bolts*. If guide blocks are used, permanently secure them at the sides of each front mounting foot with 0.50 ± 0.05 mm (0.02 ± 0.002 in.) clearance.

Hold Down Bolts
After final alignment of the marine gear and engine, secure both rear engine mounting feet to the ship structure with one ground body bolt per foot. Use the rear and outermost existing holes in the feet as a guide for drilling and reaming to a nominal size of 35 mm (1.38 in.) diameter. Maximum clearance between the ground body bolt and reamed hole is 0.020 mm (0.0008 in.). Torque the bolts to 338 ± 13 N•m (250 ± 10 lb-ft) (see Figure 20).

The ground body bolts should be torqued to 338 ± 13 N•m (250 ± 10 lb-ft) when the engine is mounted on resin chocking (see figure 18). The ground bolt torque should be increased to 900± 20 N•m (665± 15 lb-ft) when the engine is mounted on steel chocks (see figure 20).

The two front bolts in the outermost hole of each rear foot and the two bolts in the outermost holes of each of the remaining mounting feet are 25.4 mm (1.00 in.) bolts in a 33 mm (1.29 in.) clearance hole. The torque value for bolts which are installed in these locations is 271± 15 N•m (200± 10 lb-ft) when the engine is mounted on resin chocking and should be increased to 800± 20 N•m (590± 15 lb-ft) when the engine is mounted on steel chocks. The mounting feet holes can be used as a drill guide. The clearance allowed is sufficient to accommodate thermal growth of the engine.

Using ground body bolts in both rear feet does not pose thermal expansion problems across the engine width. An optional bolting method allows one ground body bolt to be used at the rear outermost hole of the right rear mounting foot. With this option, all the remaining hold down bolts would be treated the same as in the paragraph above. ***Note****: This method does require guide blocks at the front of the engine.*

If practical, insert the bolts with the bolt head down and the nuts on top. This permits periodic inspection of the bolted connection. After drilling the bolt holes in the foundation, spot face the lower contact face of the top flange normal to the bolt hole.

Eight or twelve hold down bolts will be required based on four or six mounting feet. *The bolt material should be SAE grade 8 steel or better.*

Isolation Mounts
Caterpillar's isolation mounting systems:
- Transfer steady state engine torque reaction to the ship structure.
- Allow alignment of the engine to the marine gear.
- Isolate the ship from engine vibration.
- Isolate the engine from ship vibration.

Caterpillar offers two types of isolation mounting systems:

Caterpillar silicone shear pads and the Christie and Grey system. For either, locate the six engine rigid body modes at the mounts within the following constraints:

- Keep the roll mode below 70% of the engine firing frequency at low idle. Isolate excitation pulses from torque reaction.
- One-half order resonances, particularly the side-side and roll modes, are excited at speeds close to low idle when the engine is operating under no load conditions. This must be considered.
- In general, keep modes away from typical one-half and first order resonances.

Contact Caterpillar for the suitability of a soft mount design for a particular installation.

Caterpillar Silicone Shear Pad

The silicone shear pads, Figures 22 and 23, provide isolation for higher frequency vibration, such as the vibration causing structureborne noise. At the same time they restrain overall engine motion. *Large engine displacements need not be accommodated at the torsional coupling and other engine/installation interfaces.*

***Note:** The Caterpillar shear pad mounting system is not recommended for 3606 engines rated or operated below 900 rpm for an extended period of time.*

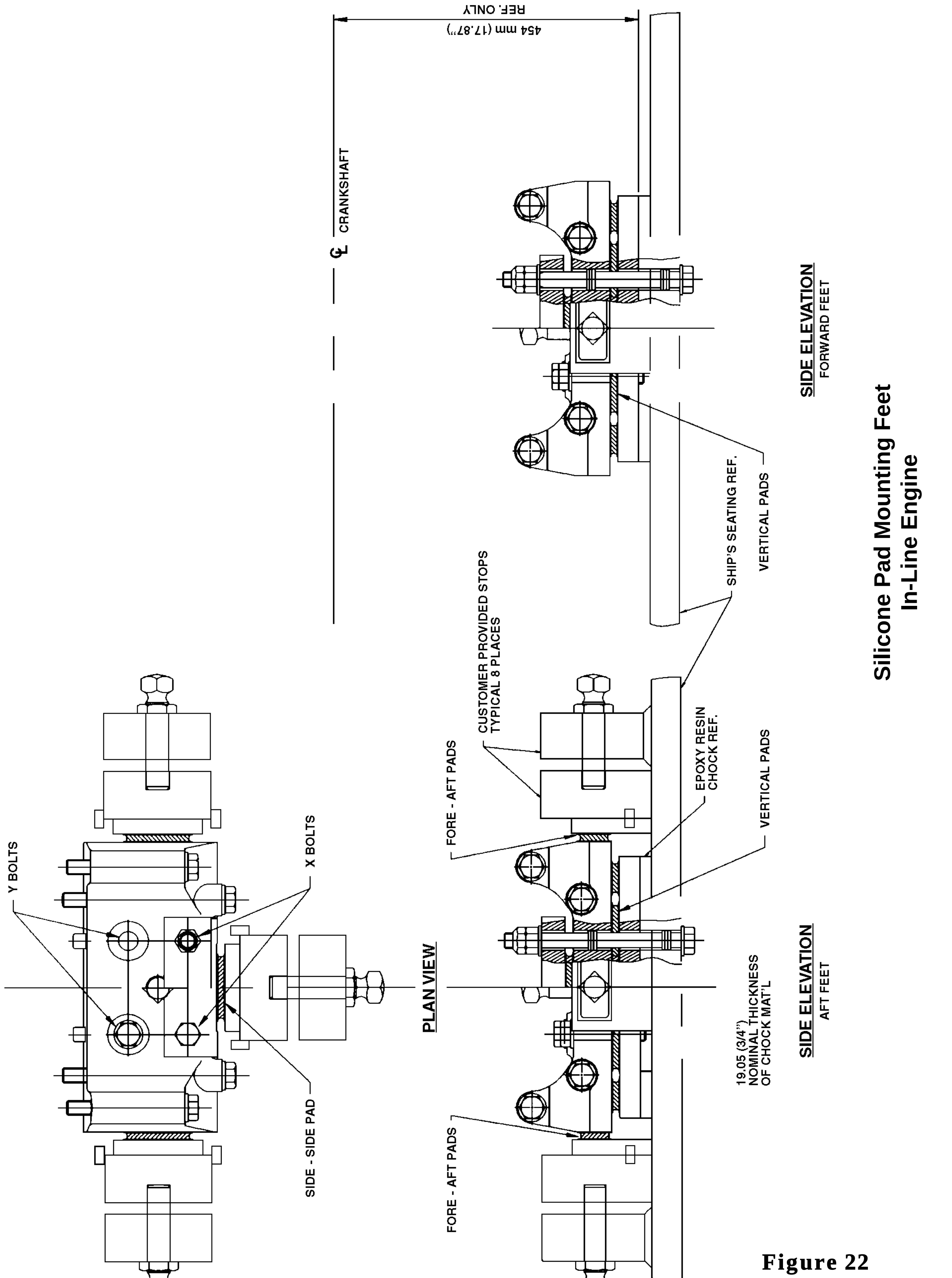
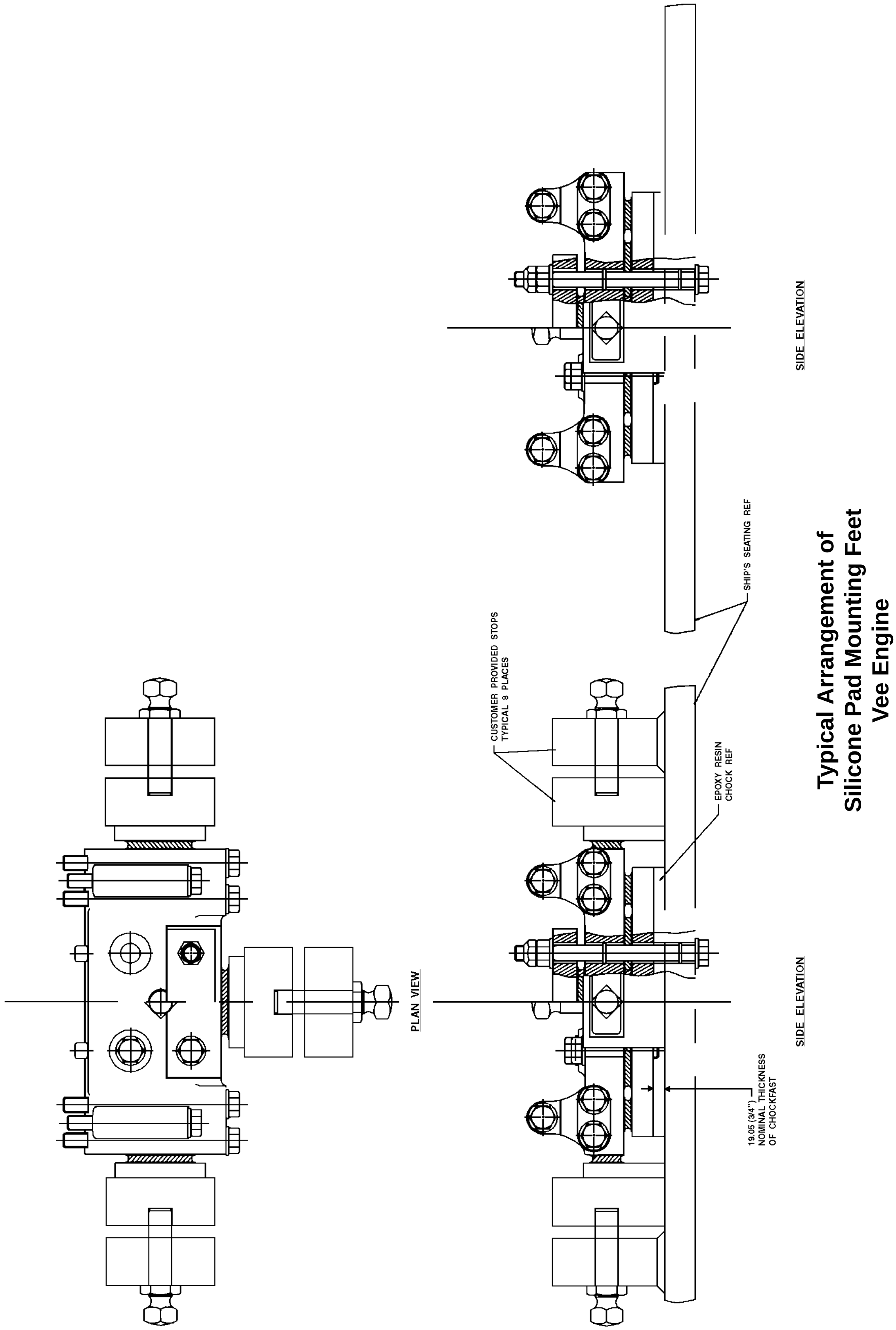


Figure 22



PLAN VIEW
SIDE ELEVATION
SIDE ELEVATION
CUSTOMER PROVIDED STOPS
TYPICAL 8 PLACES
SHIP'S SEATING REF
EPOXY RESIN
CHOCK REF
19.05 (3/4") NOMINAL THICKNESS
OF CHOCKFAST
Typical Arrangement of
Silicone Pad Mounting Feet
Vee Engine

Figure 23

A thin layer of high silicone rubber is sandwiched between two metal plates, eliminating metal-to-metal contact between the engine and the ship structure. The pads are also used between the mounting feet and restraining stops on the engine foundation plates. This prevents excessive movement forward, aft, and side-to-side. Shear pads on top of the feet are used for vertical restraint. The following table lists the shear pad mounting configurations for all four 3600 engines:

3600 Shear Pad Mounting Configurations

Engine Total Number of Feet	Rear Foot Configuration	Middle Foot Configuration	Front Foot Configuration
3606 Four (4) Mounting Feet	5 pads vertically Fore-Aft collision pad Side-to-side pad Top pad	Not Required	5 pads vertically Top pad Side-to-side pad
3608 Six (6) Mounting Feet	5 pads vertically Fore-Aft collision pad Side-to-side pad Top pad	5 pads vertically Top pad (vertical restraint)	5 pads vertically Top pad Side-to-side pad
3612 Six (6) Mounting Feet	5 pads vertically Fore-Aft collision pad Side-to-side pad Top pad	5 pads vertically Top pad (vertical restraint)	5 pads vertically Top pad Side-to-side pad
3616 Eight (8) Mounting Feet	5 pads vertically Fore-Aft collision pad Side-to-side pad Top pad	5 pads vertically Top pad (vertical restraint)	5 pads vertically Top pad Side-to-side pad

Christie & Grey Mounts
This mounting system, Figure 24, uses six spring-rubber combination isolators to isolate vibration and noise. *During operation the engine is "free" to move. The torsional coupling, water, oil, fuel lines and exhaust connections must accommodate greater engine motion.* In addition, the engine coupling and/or output drive line must be flexible enough to maintain the engine bearing loads, as well as driven equipment bearing loads below appropriate limits.

Christie & Grey isolators are built with an internal buffer unit to eliminate the need for collision blocks on most applications.

Installation and Alignment

This section provides the basis of the alignment process and alignment variables. *Always use the appropriate Caterpillar Special Instruction, Service Literature and Instructions. Use the specifications from the coupling and driven equipment manufacturer to install and align the components.*

When the engine transitions from an at rest condition to normal operating temperatures, the thermal growth of the engine and the driven equipment must be compensated for during the alignment process. As an example, the total engine crankshaft centerline change due to thermal growth and oil film lift can be expected to be approximately 0.38 mm (0.015 in.)

Hard Mounting

These recommendations cover the installation and alignment of couplings to the 3600 Family of Engines engines driving free standing marine reduction gears. These recommendations apply specifically to hard mounted engines. The recommendations offered are a guideline only. Correct alignment of the equipment is the responsibility of the person performing the alignment.

Caution*: The person performing the alignment procedure should be familiar with basic alignment terminology as well as the basic alignment tooling and its use. Improper alignment may result in loss of life, serious injury, and/or equipment damage. Alignment should be performed by trained and qualified personnel.*

Before the final alignment procedure can be started the following conditions must be met:

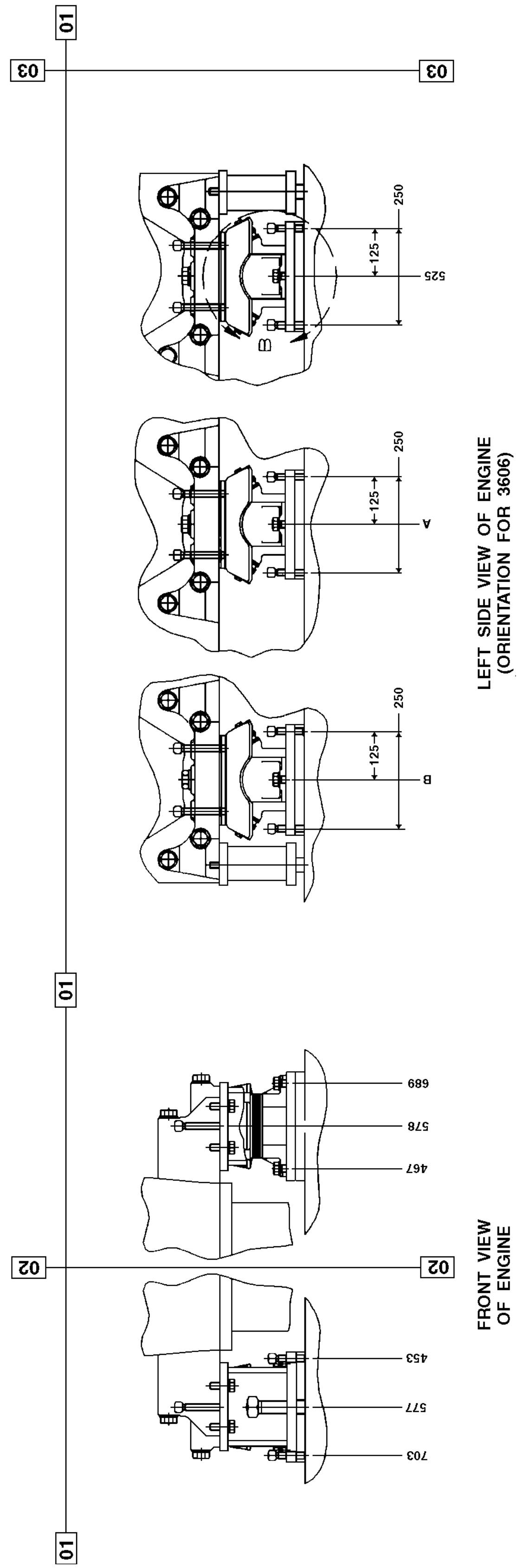
- Per manufacturer's installation instructions, install and align the propeller shaft and marine gear to each other.
- Permanently anchor the marine gear.
- The ship must be in the water with all permanent ballast in place.
- Fuel, water, and temporary ballast tanks must be filled to normal operating levels (generally 1/2 to 3/4 full).
- All major machinery weighing over 450 kg (1000 lb) must be installed or simulated by equivalent weights appropriately located.

Preparation and Cleaning
Remove all dirt, burrs, grease and paint from:

- Mating surfaces of the engine mounting feet and the mounting pads.
- Matching surfaces of the engine flywheel and coupling.
- Mating surfaces of the marine gear input shaft and the coupling.
- Mounting surfaces of the Caterpillar split spacer ring, if applicable.

Engine Installation

- Locate the approximate location of each engine mounting foot on the engine foundation rails. This can be done by referring to the ship installation drawings and using the centerline of the marine gear input shaft as a reference. Mark a rough outline of the mounting feet locations on the engine foundation rails.



Typical Christie and Grey Mounting Feet

Figure 24

- Inspect the engine foundation rails. The engine mounting feet areas must be rust free, smooth, and free from weld splatter, etc.
- Move the engine into place over the foundation.
  Caution: *Use lifting equipment with sufficient capacity to handle the weight of the engine.*
- Position the engine flywheel face relatively parallel to the marine gear's input flange. Exact parallelism is not necessary at this point.
- Lower engine onto the foundation with the mounting feet on the previously marked outlines.
- *Lightly* lubricate the engine foundation under the vertical alignment jacking bolts with oil or grease.
- Install horizontal jacking screws and brackets. Note the screws and brackets are not part of the normal engine supply. Typically the brackets are installed on the four corner feet and they must be positioned to allow sufficient travel of the jacking bolts for movement of the engine to its final aligned position.
- Prior to the coupling installation, check flywheel face and bore runout according to the procedures and specifications outlined in the engine service manual. See the guide section on *Service and Maintenance.*

Note: *Damage to the main and rod bearings may occur if they are not prelubed prior to rotating the engine.*

Marine Gear Input Shaft Runout (Face and Bore)

Follow the marine gear manufacturer's procedures for installation and alignment. Check the input shaft face and bore runout. Dimensions must meet the marine gear manufacturer's specifications.

Axial Alignment

The exact axial spacing between the face of the engine flywheel and the gear input flange must be checked and adjusted prior to final placement of the engine and coupling installation.

a. Measure Crankshaft End Play

   Prior to performing the axial alignment the crankshaft end play must be measured.

- Remove one crankcase inspection cover.
- Use a 1524 mm (5 ft) pry bar between the crankshaft and the cylinder block. *Do not pry on the damper.* Move (thrust) the crankshaft all the way towards the front of the engine. A definite *klunk* can be heard when the crankshaft bottoms out against the thrust washer.
- Install a dial indicator with the tip on the flywheel face.
- Preload the dial indicator stem a minimum of one turn. Adjust the indicator bezel so the pointer is set on zero. Do not rotate the flywheel or runout error may be introduced resulting in incorrect readings.
- Move (thrust) the crankshaft all the way towards the rear of the engine and record the reading on the dial indicator. This measurement is known as crankshaft end play.
- Move (thrust) the crankshaft forward again. The dial indicator should return to zero.
- Repeat this procedure two or three times to verify results.
- Verify that the measured end play is within 0.4 ± 0.2 mm (0.016 ± 0.008 in.). See the service manual for the latest specifications.

Note: *Do not remove the dial indicator at this time. Periodically check to ensure the crankshaft does not move while positioning the engine to the appropriate axial spacing dimension.*

b. Measure the Marine Gear Input Shaft End Play

- Follow the marine gear manufacturer's procedure to accurately measure total input shaft end play.
- Record input shaft total end play.
- Verify that the end play measured meets the tolerances specified by the manufacturer.

c. Calculate the modified axial spacing dimension.

To accurately place the engine, the engine crankshaft and marine gear input shaft must remain fixed. Ideally the shafts would be placed in their normal axial operating positions while positioning the engine. This is not easily done, and once set they tend to move one way or the other. It is suggested that both shafts be thrusted completely forward or completely aft and axial spacing be modified accordingly.

For example:

Coupling overall length
(mating surface to mating surface) =
431.8 mm (17 in.)

Split spacer ring width =
63.5 mm (2.5 in.)

Total measured crankshaft end play =
0.36 mm (0.014 in.)

Total measured input shaft end play =
0.10 mm (0.004 in.)

Assume that both the crankshaft and the input shaft normally center themselves in the middle of their total end play when rotating (this must be verified with the marine gear supplier).

If both shafts are thrusted fully aft, 0.05 mm (0.002 in.) must be added to the axial spacing dimension. This compensates for the marine gear input shaft movement that will occur once the shaft is rotating. To compensate for the engine crankshaft movement that will occur, 0.18 mm (0.007 in.) must be subtracted from the axial spacing dimension.
Axial spacing dimension = coupling length + split spacer ring length.

Axial spacing dimension =
431.8 mm (17 in.) + 63.5 mm (2.5 in.) =
495.3 mm (19.5 in.).

Modified Axial Spacing Dimension =
495.3 mm (19.5 in.) + 0.05 mm (0.002 in.)
- 0.18 mm (0.007 in.) =
495.17 mm (19.495 in.).

Position the Engine

- Thrust the engine crankshaft and gear input shaft fully forward or aft.
- Mount a dial indicator with the tip on the marine gear input flange face.
- Preload the indicator a minimum of one revolution.
- Adjust the indicator dial to zero.
- Preload the dial indicator (previously installed on the engine flywheel) a minimum of one revolution and set the indicator to zero.
- Use an inside micrometer to measure the distance between the engin flywheel face and the pilot of the marine gear input flange. Measure along a line perpendicular to the marine gear input flange.
- Compare the figure to the modified axial dimension calculated previously. If this number is not within the tolerances specified by the coupling supplier, use the fore and aft jacking screws to position the engine accurately.
- After the engine is accurately placed, check the dial indicators on the flywheel and the marine gear input flange making sure the crankshaft or the marine gear input shaft has not moved. If the dial indicators are not on zero, the engine must be moved in the correct direction by the amount shown on the dial indicators.

Coupling Installation

Install and align the coupling according to instructions and specifications supplied by the coupling manufacturer. *The coupling must have enough axial tolerance to avoid restricting movement of the engine crankshaft and marine gear input shaft within their respective end play allowances.* The tolerances must be met in both cold and hot conditions. Allowance must be made for a change in crankshaft centerline from cold alignment conditions to hot running conditions. Vertical thermal growth changes the location of the crankshaft centerline as the engine's block temperature increases. Typically the growth of the engine will be greater than the driven equipment. Vertical growth of the engine and driven equipment must be evaluated to determine the cold alignment crank offsets.

The total engine crankshaft centerline change due to thermal growth and oil film lift can be expected to be approximately 0.38 mm (0.015 in.). Obtain the driven equipment growth from the manufacturer.

Note: *Damage to the main and rod bearings may occur if they are not prelubed prior to rotating the engine.*

Final Axial Alignment
Measure the axial space dimension and crankshaft end play. If these dimensions are not within appropriate tolerances, they must be corrected and the entire alignment procedure repeated.

Shimming, Bolting, Dowelling, Guide & Collision Stop Recommendations
After final cold alignment is completed and checked, the engine must be shimmed and dowelled in position. Collision stops may also be required. See guide section on *Mounting*.

Cold Crankshaft Deflection Check
The crankshaft deflection must be checked to verify stress has not been induced into the engine cylinder block as a result of engine mounting and alignment. Follow the engine service manual procedure to perform this check. Refer to the service manual to verify that crankshaft deflection is within specified limits.

Hot Alignment
Repeat the cold alignment procedure after the engine has been run and water and oil temperatures have reached normal operating points. Record the temperatures every 15 minutes as the alignment is being checked.

Record the dial indicator readings and verify they are within specified coupling limits in the hot condition.

Hot Crankshaft Deflection Check
Follow the engine service manual procedure to check crankshaft deflection after the engine has been run and the water and oil temperatures have reached their normal operating point.

Note: *Attention must be given to the warning statements in the service manual concerning the removal of crankcase access covers when the engine is hot. Explosions in the crankcase can occur, resulting in injury or damage if the covers are removed too soon after operating the engine.*

The combined overhung weight of the flywheel and coupling influences the static deflection of the crankshaft. Figure 25 shows the allowable cantilevered crankshaft loads.

Crankshaft Maximum Cantilever Load

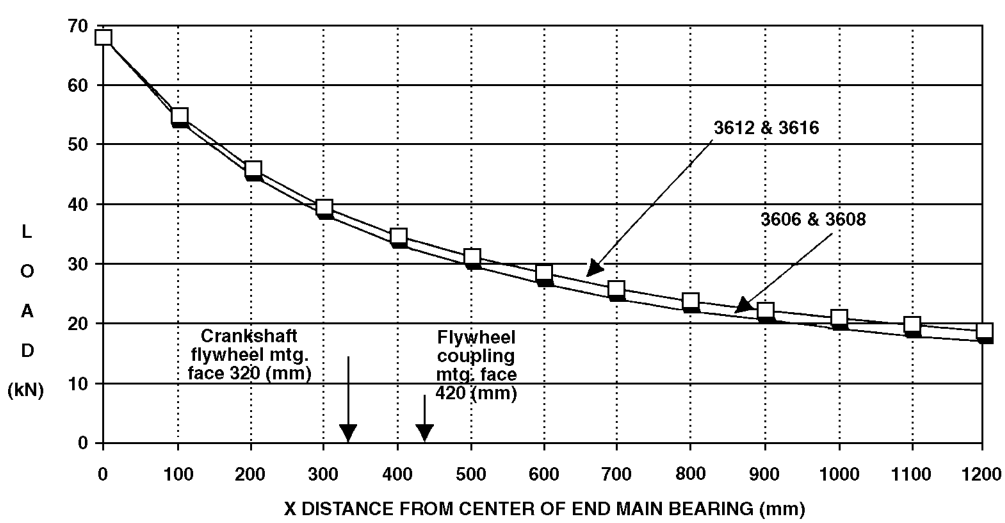


Figure 25 For a given X distance the cantilever load must not exceed the allowable load limit.

Isolation Mounting

Caterpillar Silicone Shear Pads

The procedure for this mounting system is very similar to the alignment used for the hard mounted system described above. Read that section before beginning the alignment of shear pad mounting system.

Note: *Before beginning the alignment procedure, read and understand the entire procedure. Improper alignment of this machinery may result in loss of life, serious injury, and/or equipment damage.*

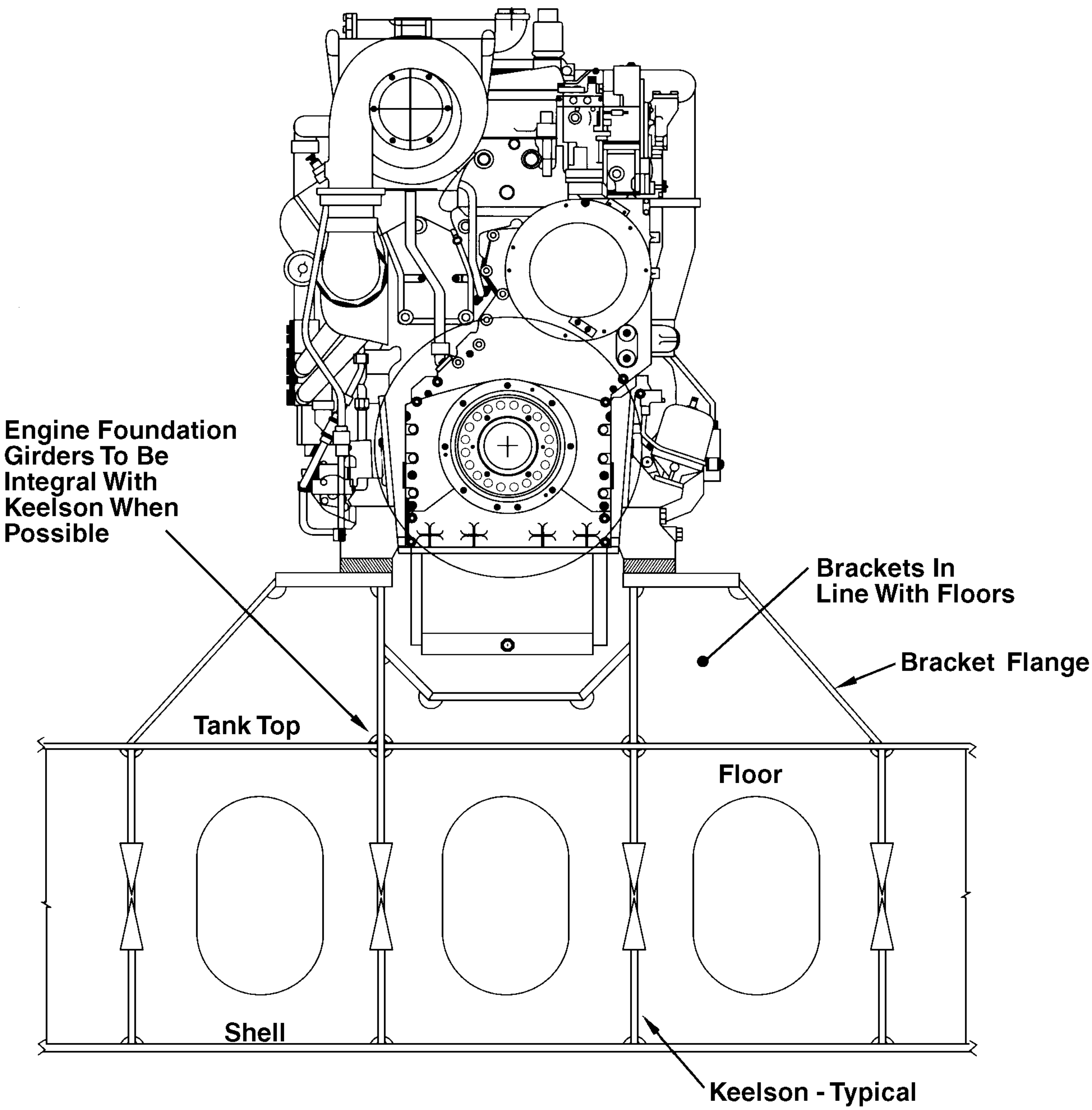
Contact a Caterpillar 3600 Marine Project Engineer at (765) 448-5000 to receive a copy of the installation procedures for the silicone shear pads.

Christie & Grey Alignment

With this mounting system, the engine is free to move during engine operation. It is necessary to select the torsional coupling, water, oil, fuel, and exhaust connections to accommodate increased engine motion. The engine coupling and/or output drive line must be flexible enough to maintain the engine bearing loads, as well as driven equipment bearing loads, below appropriate limits.

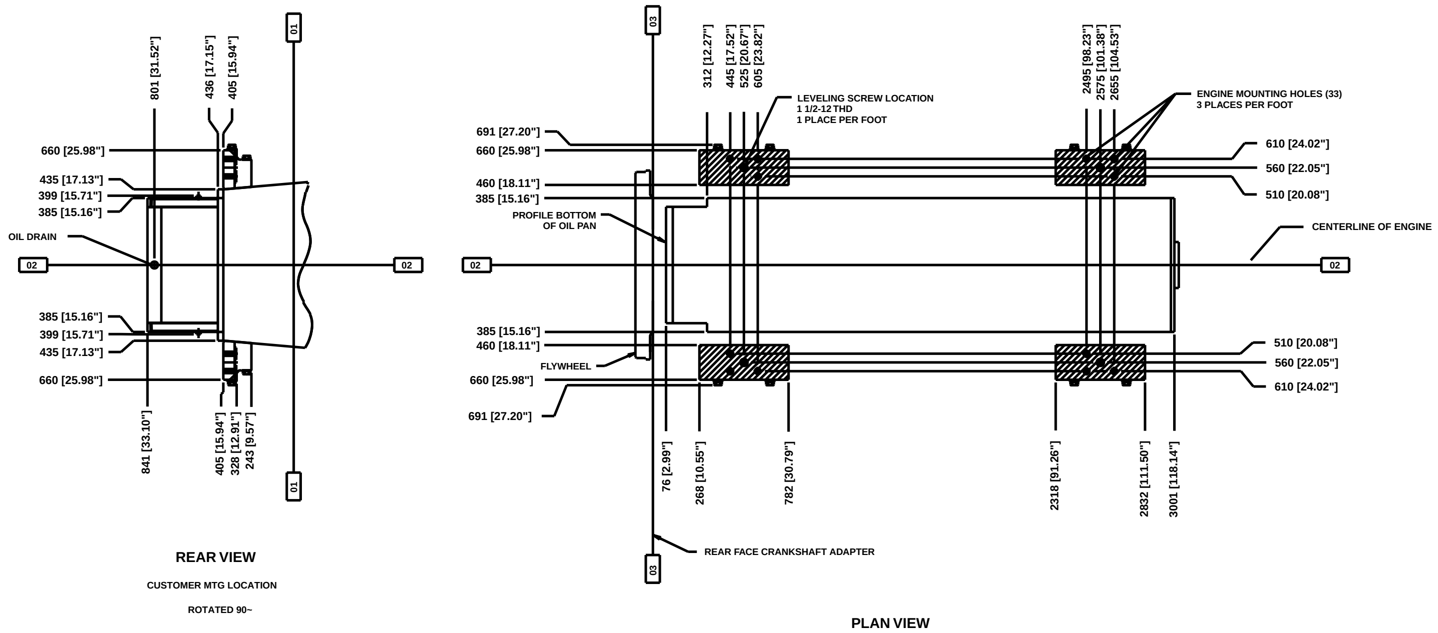
The engine torque reaction will cause the isolators to compress/decompress and the crankshaft centerline to change; this must be compensated for during engine alignment. This alignment value is established for each application. Engine power rating, the type of isolators, operating temperature, and the coupling used are major factors affecting engine alignment values.

Christie & Grey isolators are built with an internal buffer unit to eliminate the need for collision blocks on most applications.

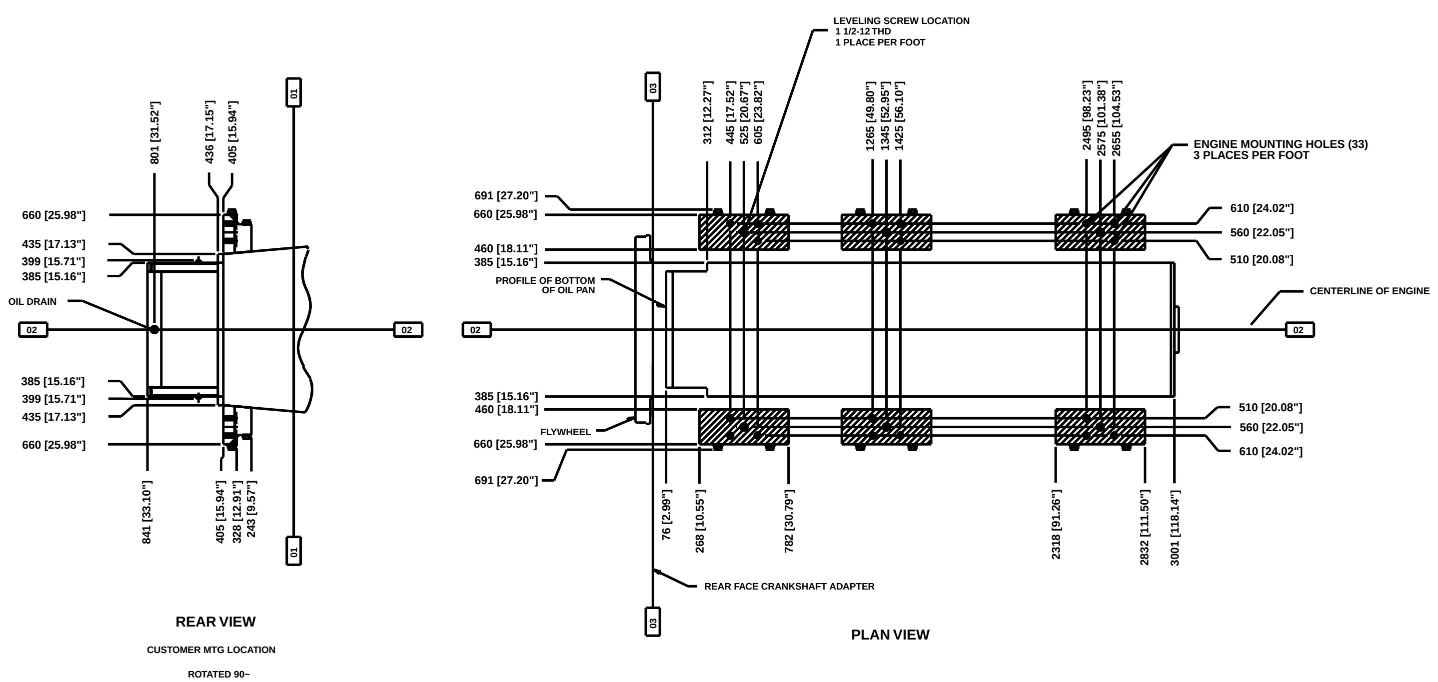


Typical Section Through Main Engine Foundation

Figure 2



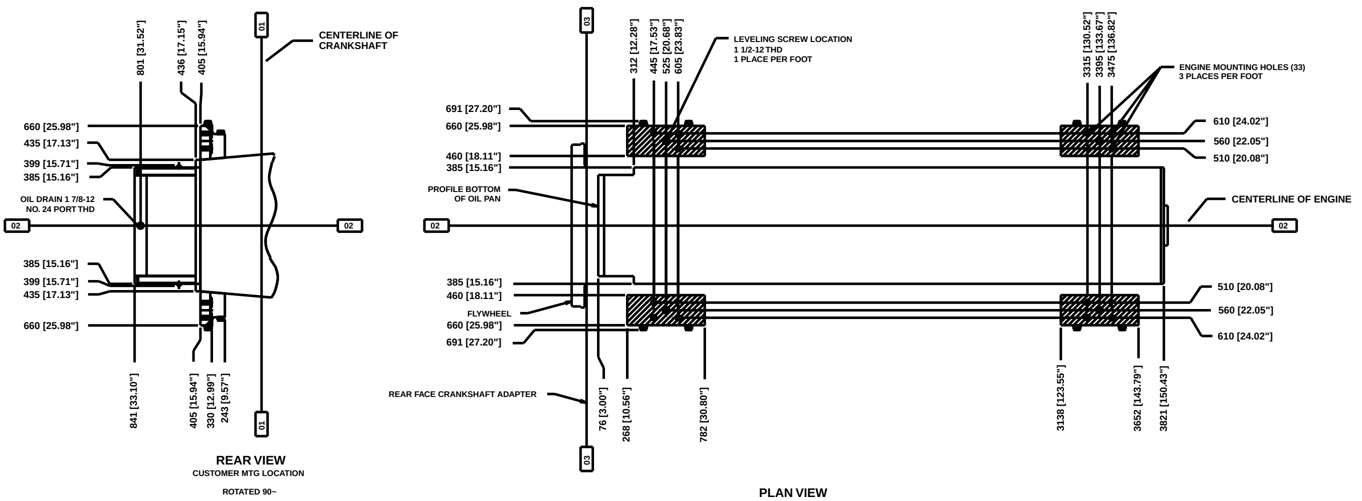
4 Pads-Plan View



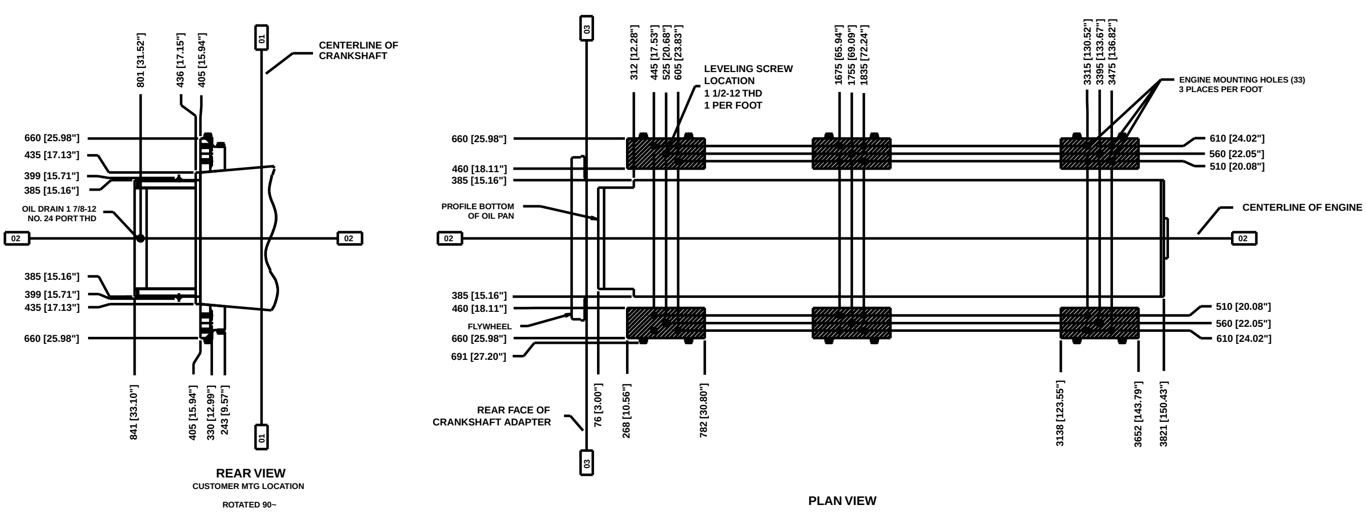
6 Pads-Plan View

Mounting Feet Arrangement
3606 Marine Engine

Figure 4



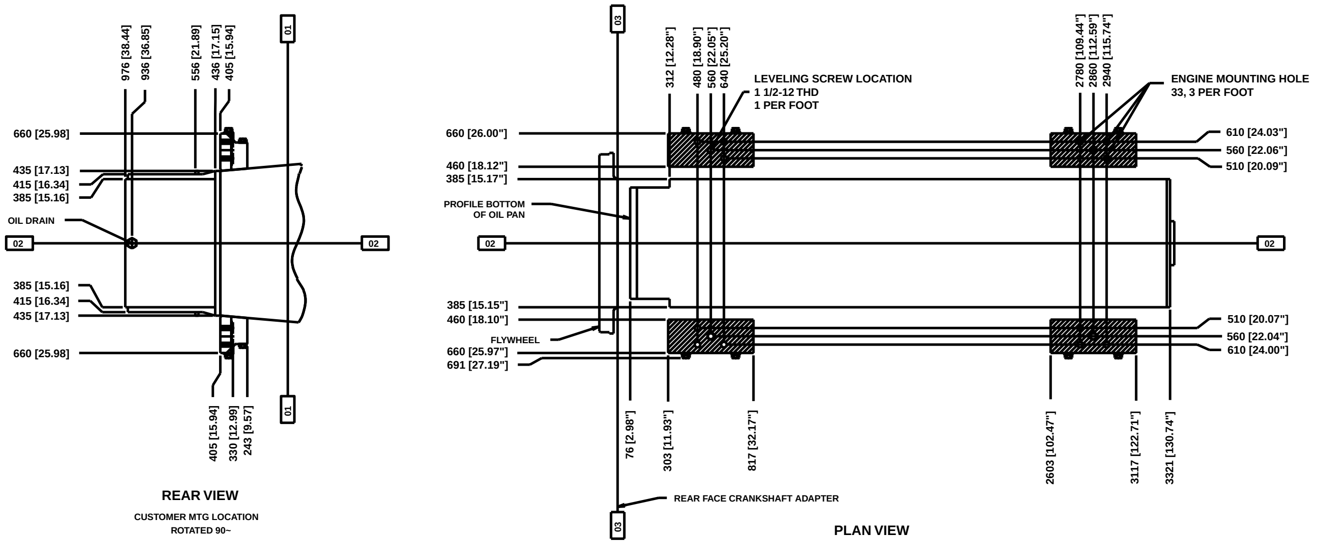
4 Pads-Plan View



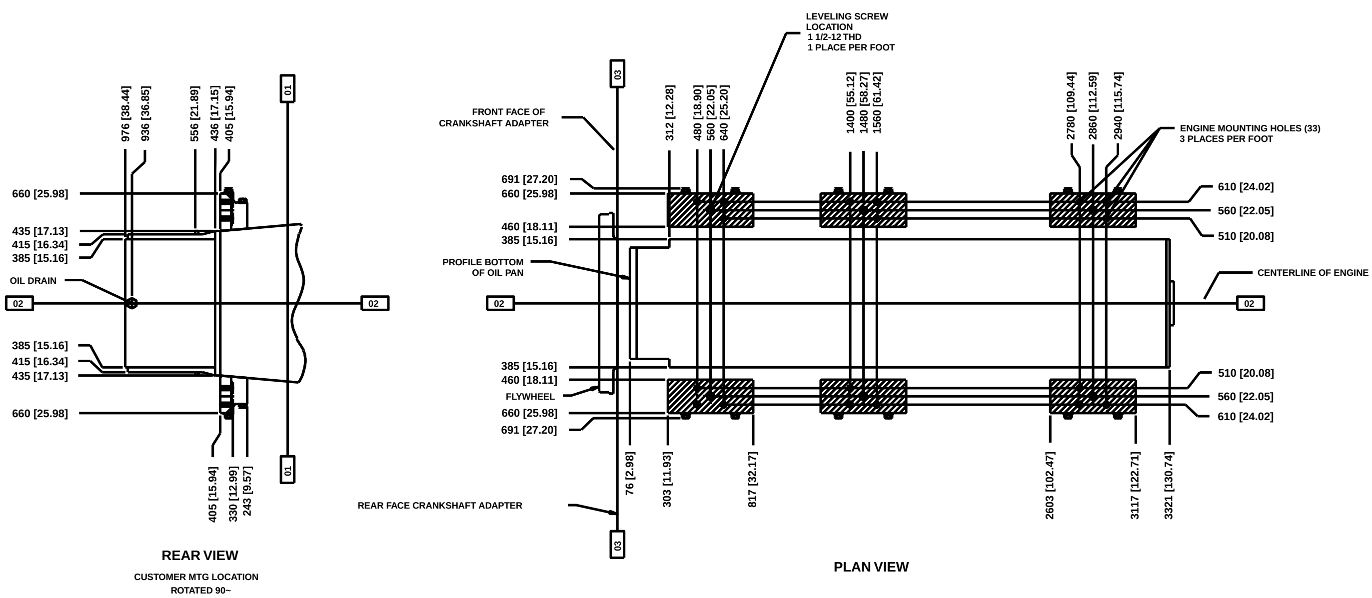
6 Pads-Plan View

Mounting Feet Arrangement
3608 Marine Engine

Figure 5



4 Pads-Plan View



6 Pads-Plan View

Mounting Feet Arrangement
3612 Marine Engine

Figure 6

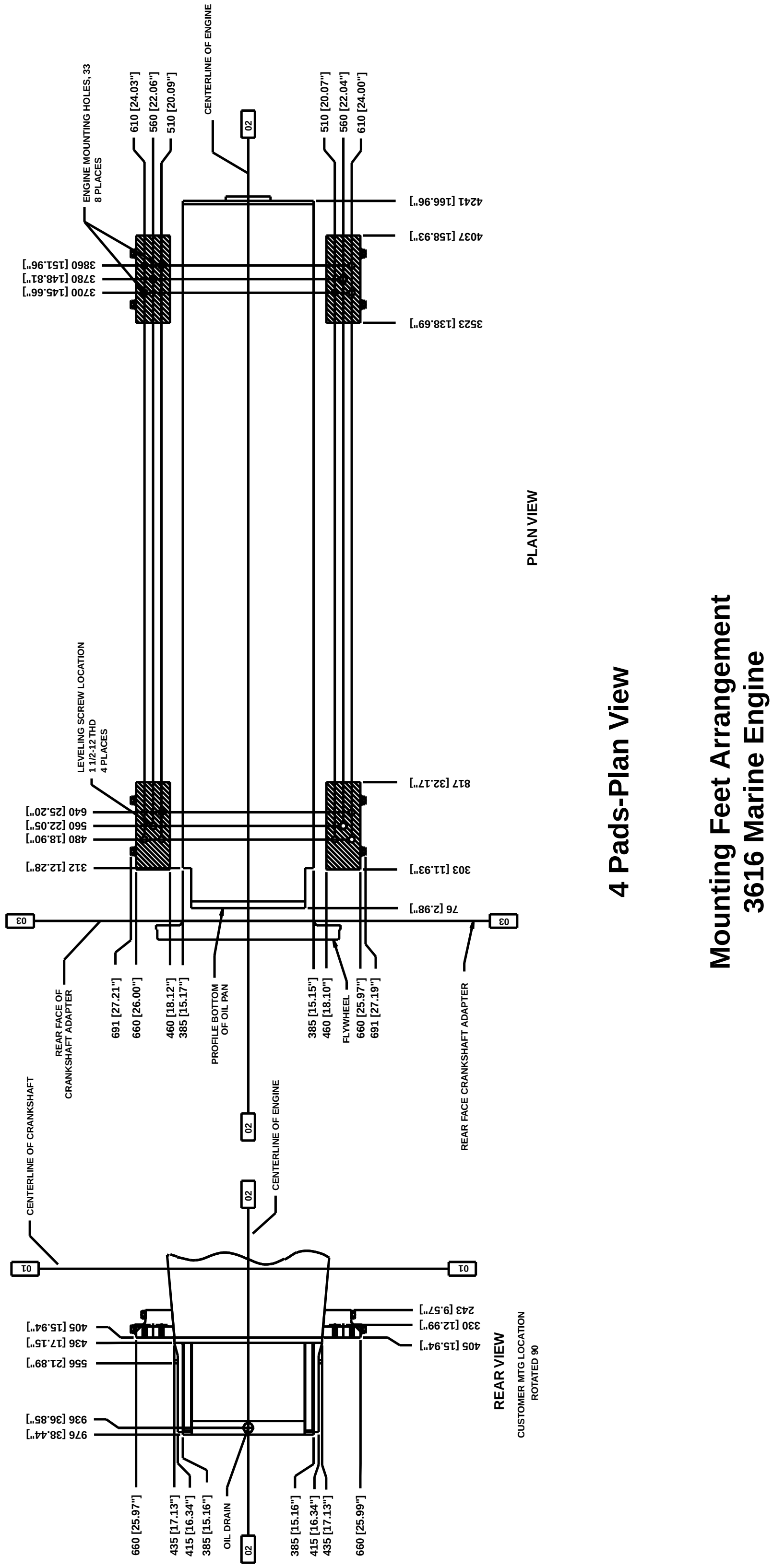
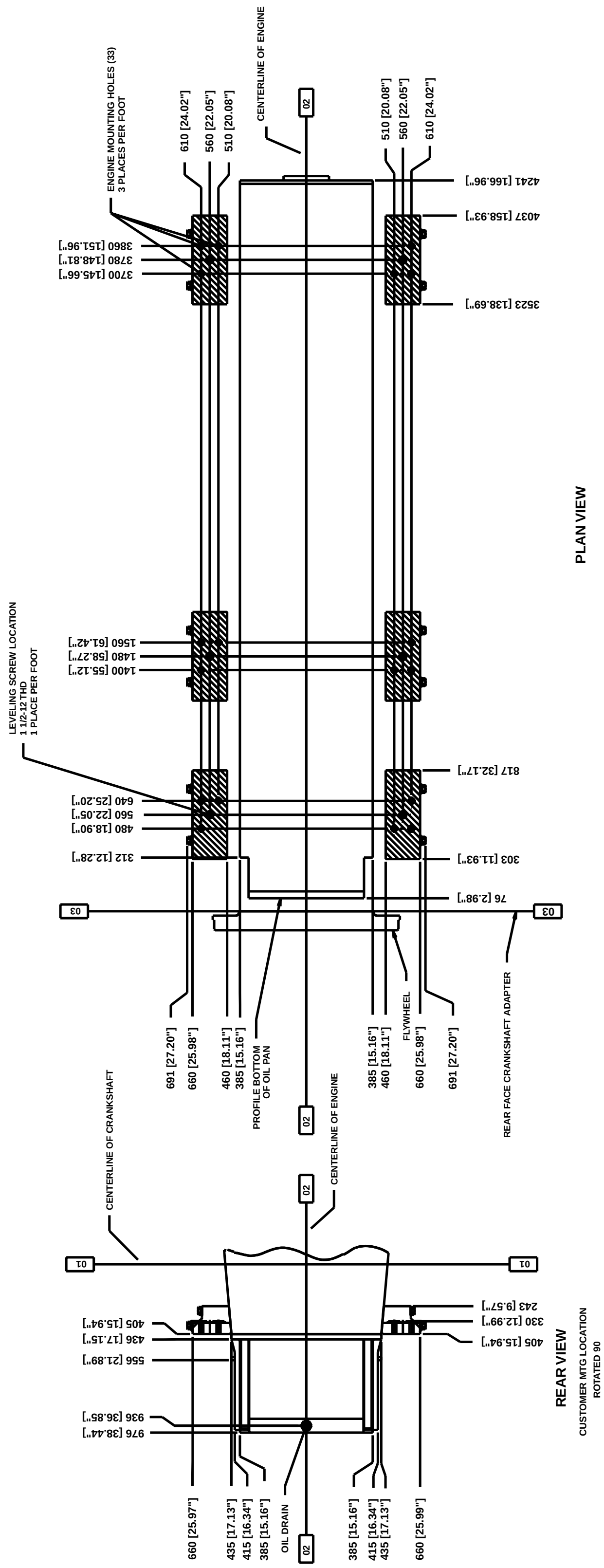

Mounting Feet Arrangement
3616 Marine Engine
4 Pads-Plan View
PLAN VIEW
REAR VIEW
CUSTOMER MTG LOCATION
ROTATED 90

Figure 7



6 Pads-Plan View

Mounting Feet Arrangement
3616 Marine Engine

Figure 8

Materials and specifications are
subject to change without notice.