CATERPILLAR®

3600 Marine Engine Application and Installation Guide

● Ancillary Equipment

LEKM8470 8-98

CATERPILLAR®

Ancillary Equipment

- Marine Gears
- Couplings
  - Torsional Limits
- Propellers
  - Fixed Pitch
  - Controllable Pitch

Marine Gears

Reversing marine gears are used:

- To match relatively small, economical medium speed engines to the low propeller rpm necessary for high efficiency.
- To reverse the propeller rotation for the non-reversing 3600 Family of Engines.

Marine gears are selected to transmit rated engine horsepower (plus overload if required) at rated rpm. Design the gear to meet appropriate classification society rules. Inspection and Certification may be required. Advise the gear manufacturer of expected adverse conditions, such as operation in ice.

Main engine marine gears are normally single or double reduction, with the ratio of input and output speeds selected to meet the propeller design rpm. The gears are either uni-directional or reverse reduction depending on the type of propeller selected (either fixed or controllable pitch).

Pinion and bull gear bearings are either sleeve or antifriction. The thrust bearing is normally built into the gear casing and sized to take the reactive thrust of the propeller.

Clutches are normally pneumatic or hydraulically actuated, straight engagement, or slip type. Ahead and astern clutches are required if a reversing gear is used.

The gear box lubrication and cooling oil system is normally self-contained and fitted on the gearbox assembly. It is also used for hydraulic clutch actuation.

The marine gear is mounted to a rugged fabricated steel foundation securely welded to the ship's structure; refer to the Mounting and Alignment section of this guide. The gearbox is bolted to its foundation using either steel or epoxy resin chocks to ensure alignment between the shafting, gearbox, and main engines. Collision chocks are normally fitted at the corners of the gearbox mounting flange to maintain alignment in the event of an accident.

Care should be taken in selecting the capacity of the low speed output bearing. It must be capable of carrying loads imposed by the line shaft or tail shaft directly connected to the low speed coupling. Advise the gear manufacturer if a propeller blade actuating box is to be mounted on the gearbox, or if auxiliary equipment is to be driven from power takeoffs on the gear housing.

Carefully review the final arrangement of the gearbox in the engine room for the best overall installation. Space must be available for service and maintenance. The following are examples of typical arrangements used with the 3600 Family of Engines:

- Single input/single output, horizontal offset, reversing. See Figure 1.
- Single input/single output, vertical offset, reversing. See Figure 2.
- Single input/single output, concentric, reversing. See Figure 3.
- Twin input/single output, horizontal-vertical offset, non-reversing. See Figure 4.
- Twin input/single output, horizontal offset, non-reversing. See Figure 5.

The Torsional and System Stability Analysis section within *General Information* in this guide describes the required torsional analysis. The marine gear manufacturer must provide data.

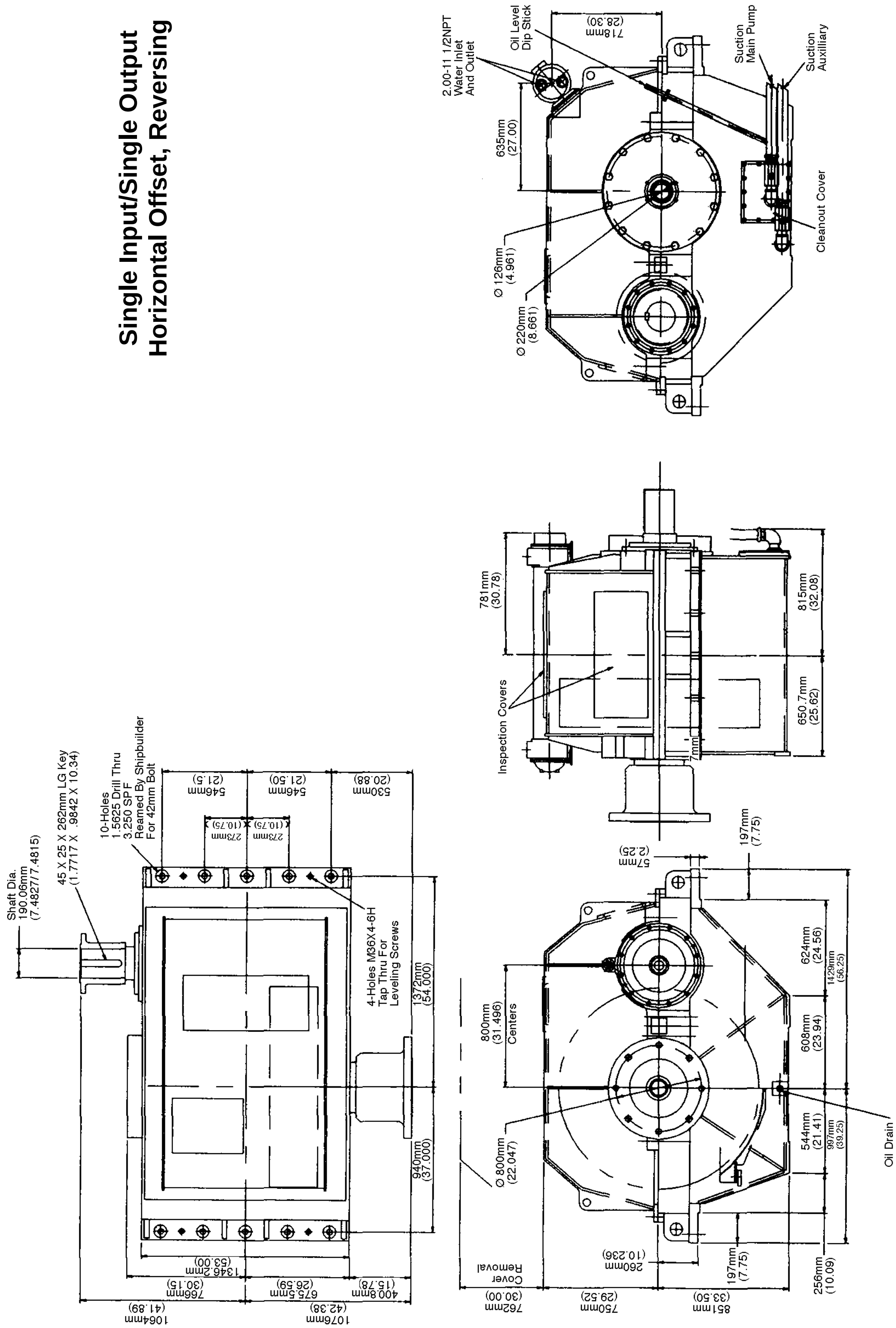

Single Input/Single Output
Horizontal Offset, Reversing
2.00-11 1/2NPT
Water Inlet
And Outlet
Oil Level
Dip Stick
718mm
(28.30)
635mm
(27.00)
Ø 126mm
(4.961)
Ø 220mm
(8.661)
Suction
Main Pump
Suction
Auxilliary
Cleanout Cover
781mm
(30.78)
Inspection Covers
815mm
(32.08)
650.7mm
(25.62)
Shaft Dia.
190.06mm
(7.4827/7.4815)
45 X 25 X 262mm LG Key
(1.7717 X .9842 X 10.34)
10-Holes
1.5625 Drill Thru
3.250 SP F
Reamed By Shipbuilder
For 42mm Bolt
546mm
(21.5)
546mm
(21.50)
530mm
(20.88)
273mm
(10.75)
4-Holes M36X4-6H
Tap Thru For
Leveling Screws
1372mm
(54.000)
940mm
(37.000)
1346.2mm
(53.00)
766mm
(30.15)
675.5mm
(26.59)
400.8mm
(15.78)
1064mm
(41.89)
1076mm
(42.38)
57mm
(2.25)
197mm
(7.75)
800mm
(31.496)
Centers
Ø 800mm
(22.047)
624mm
(24.56)
608mm
(23.94)
544mm
(21.41)
Oil Drain
1.25-11 1/2NPT
Cover
Removal
260mm
(10.236)
256mm
(10.09)
762mm
(30.00)
750mm
(29.52)
851mm
(33.50)

Figure 1

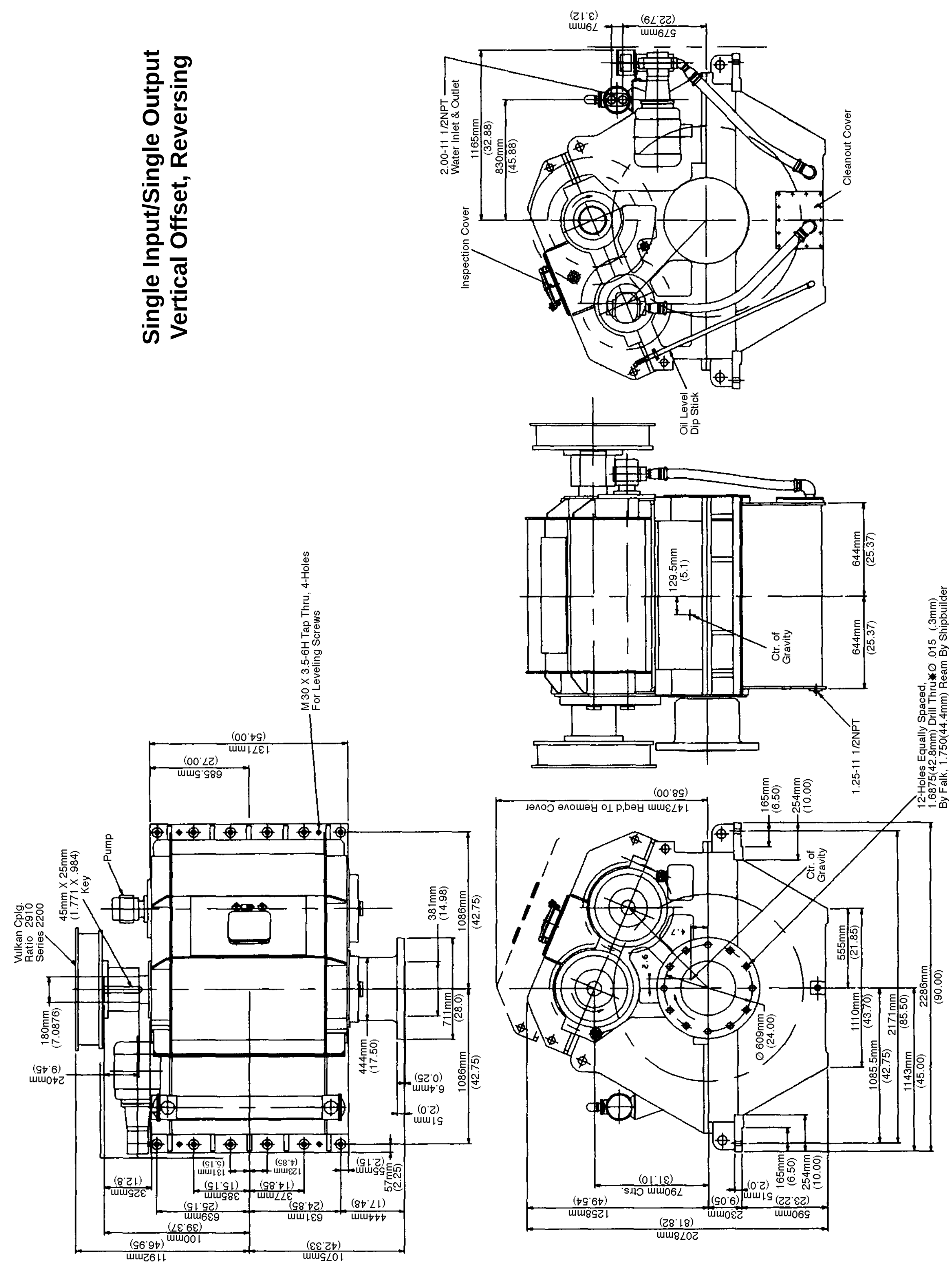

Single Input/Single Output
Vertical Offset, Reversing
Inspection Cover
2.00-11 1/2NPT Water Inlet & Outlet
Cleanout Cover
Oil Level Dip Stick
Ctr. of Gravity
1.25-11 1/2NPT
12-Holes Equally Spaced, 1.6875(42.8mm) Drill Thru Ø .015 (.3mm) By Falk, 1.750(44.4mm) Ream By Shipbuilder
M30 X 3.5-6H Tap Thru, 4-Holes For Leveling Screws
Vulkan Cplg. Ratio 2910 Series 2200
45mm X 25mm (1.771 X .984) Key
Pump
1473mm Req'd To Remove Cover (58.00)
Ø 609mm (24.00)
790mm Ctrs. (31.10)

Figure 2

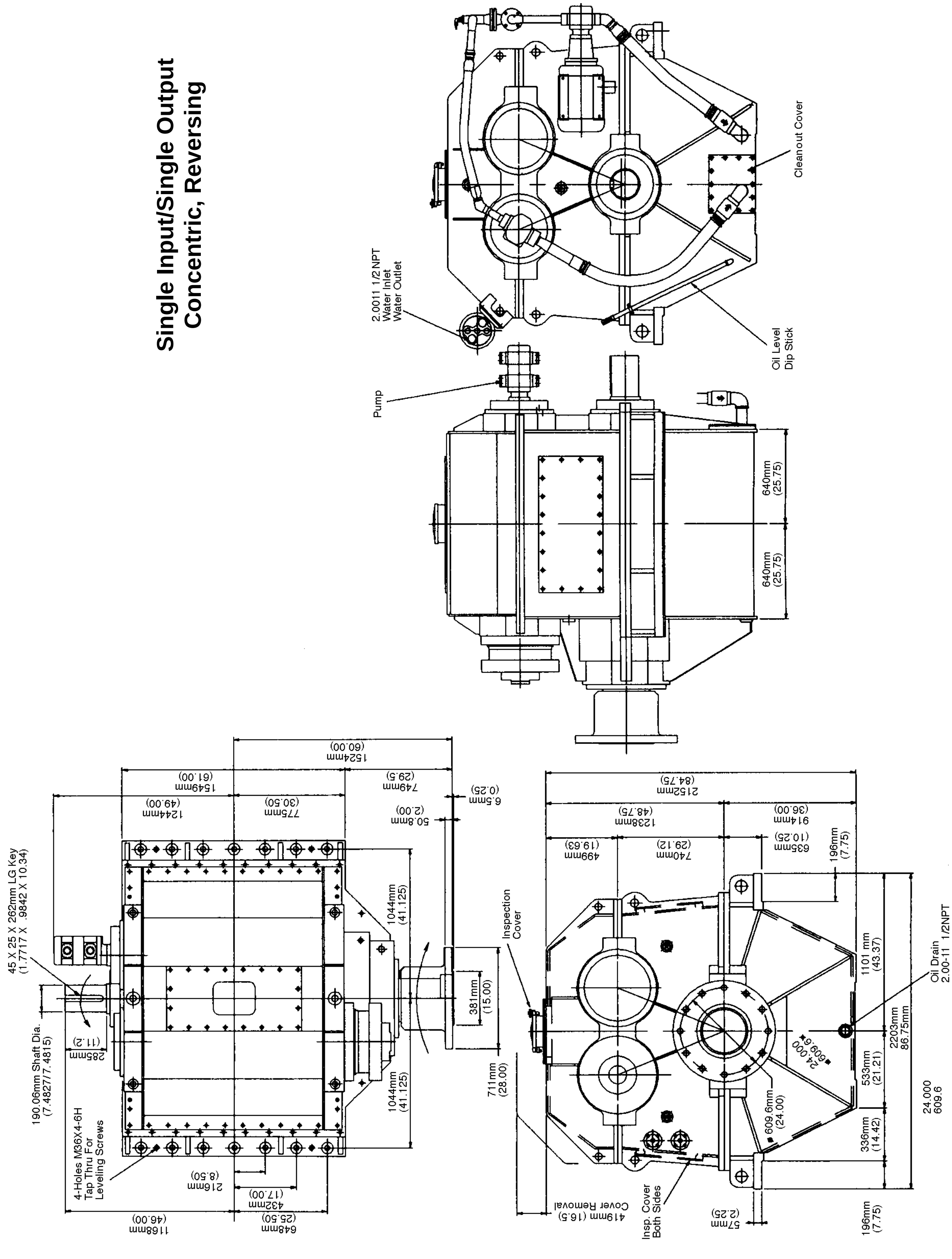

Single Input/Single Output
Concentric, Reversing
2.0011 1/2 NPT
Water Inlet
Water Outlet
Oil Level
Dip Stick
Cleanout Cover
Pump
640mm
(25.75)
Inspection
Cover
Insp. Cover
Both Sides
Oil Drain
2.00-11 1/2NPT
45 X 25 X 262mm LG Key
(1.7717 X .9842 X 10.34)
190.06mm Shaft Dia.
(7.4827/7.4815)
4-Holes M36X4-6H
Tap Thru For
Leveling Screws
1044mm
(41.125)
381mm
(15.00)
711mm
(28.00)
1101 mm
(43.37)
2203mm
86.75mm
533mm
(21.21)
336mm
(14.42)
196mm
(7.75)
609.6mm
(24.00)
24.000
609.6

Figure 3

Twin Input/Single Output Horizontal Vertical Offset Non-Reversing

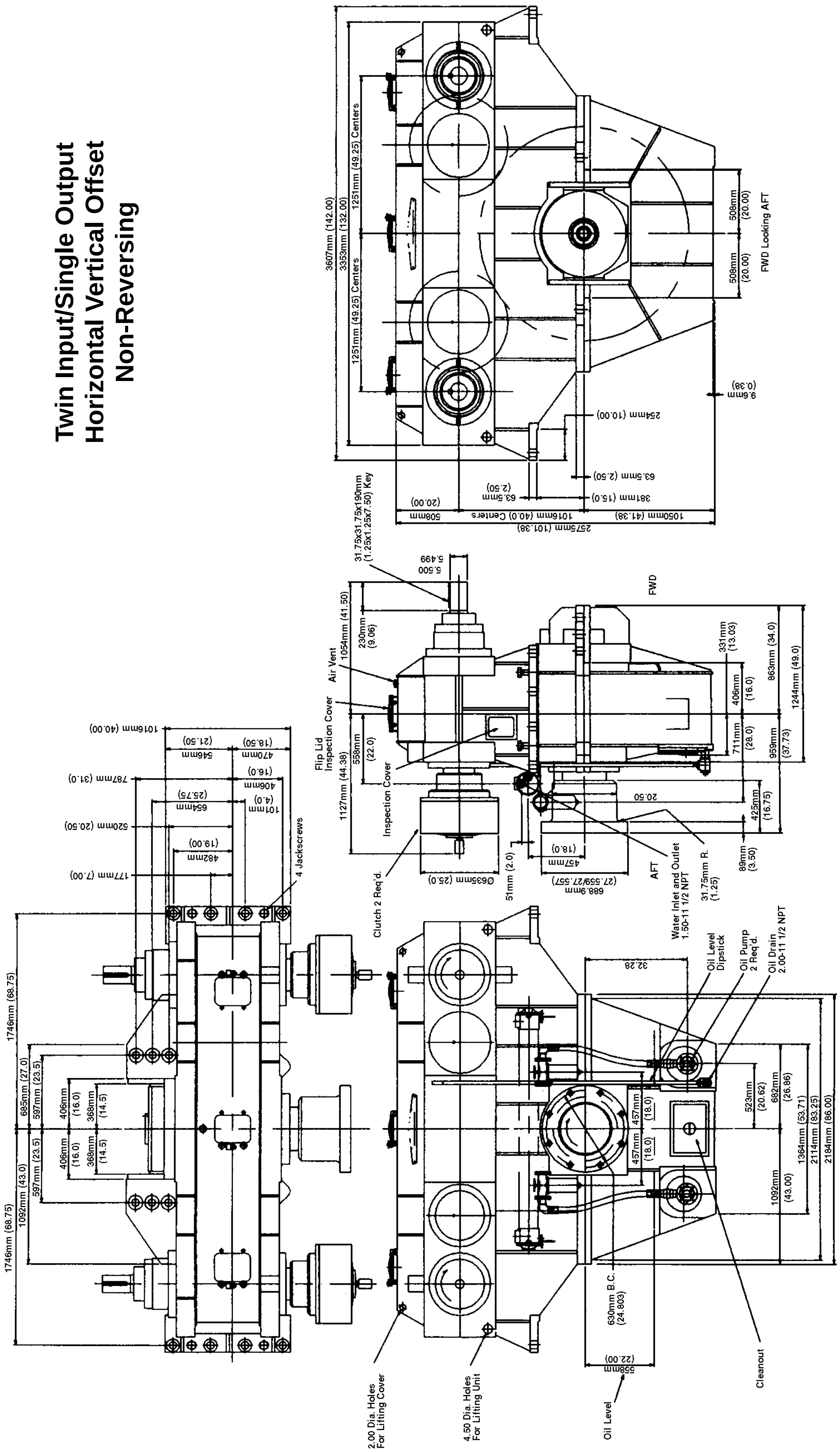


Figure 4

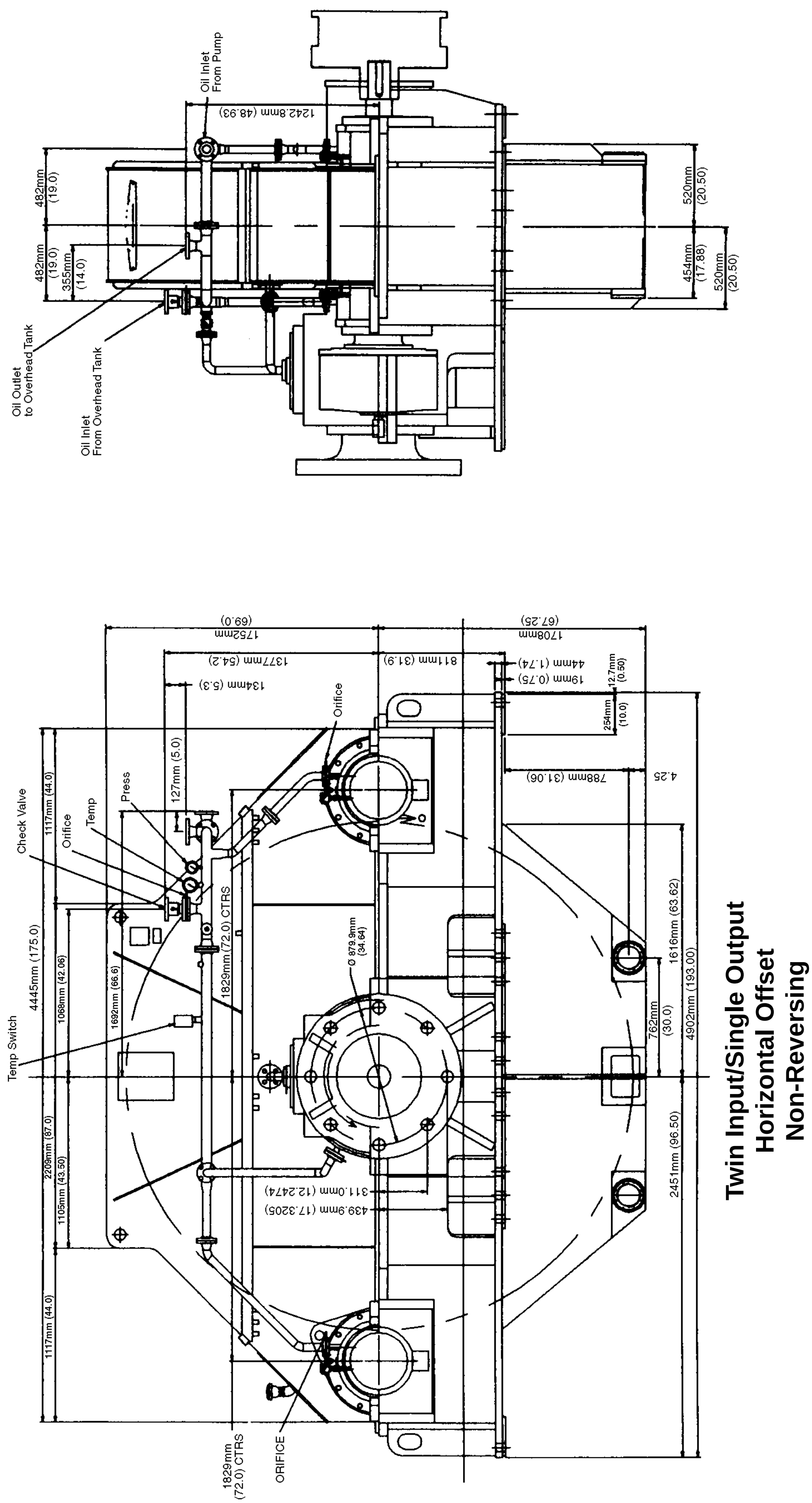
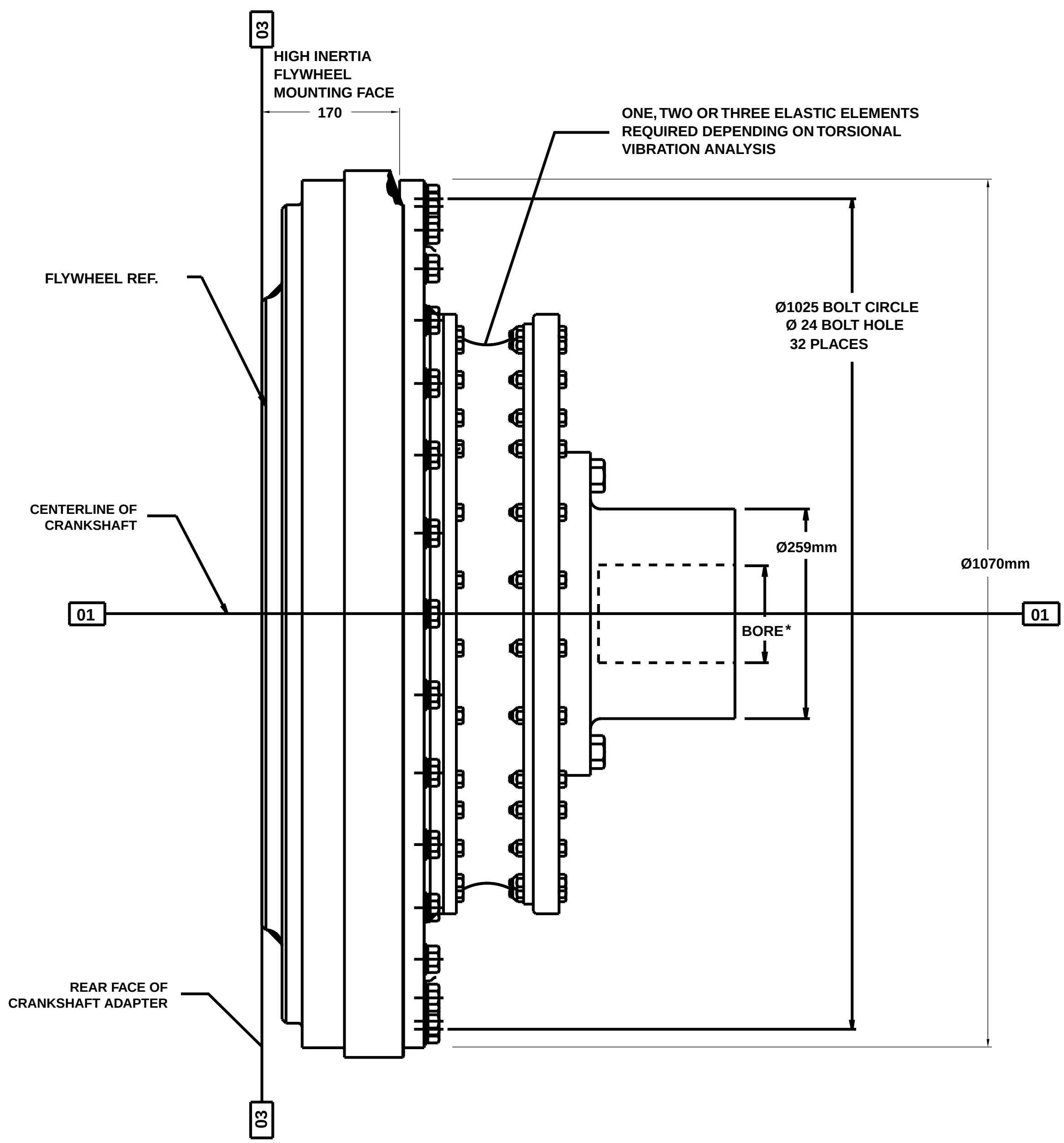

Twin Input/Single Output
Horizontal Offset
Non-Reversing
Oil Inlet From Pump
1242.8mm (48.93)
482mm (19.0)
355mm (14.0)
520mm (20.50)
454mm (17.88)
Oil Outlet to Overhead Tank
Oil Inlet From Overhead Tank
1752mm (69.0)
1708mm (67.25)
1377mm (54.2)
811mm (31.9)
134mm (5.3)
44mm (1.74)
19mm (0.75)
12.7mm (0.50)
254mm (10.0)
788mm (31.06)
4.25
127mm (5.0)
Orifice
Press
Temp
Check Valve
1117mm (44.0)
4445mm (175.0)
1068mm (42.06)
1692mm (66.6)
Temp Switch
2209mm (87.0)
1105mm (43.50)
1829mm (72.0) CTRS
Ø 879.9mm (34.64)
311.0mm (12.2474)
439.9mm (17.3205)
1616mm (63.62)
762mm (30.0)
4902mm (193.00)
2451mm (96.50)
ORIFICE

Figure 5

Couplings

A propulsion engine's power transmission is through a flexible coupling, or a combined flexible coupling and clutch mounted on the flywheel. A heavy coupling can be mounted on the flywheel or shaft flange without intermediate bearings. The type of flexible coupling to be used for each installation must be determined on the basis of torsional vibration calculations. Two fundamental coupling types are used. The first uses elastomer elements to provide both torsional flexibility and damping. Figure 6 illustrates a *typical* example of this coupling design. The number of required elements depends on the torsional vibration calculation. In addition, engines with a resilient mounting system require a balanced coupling.

Note: *The application will determine the coupling size.*



DETAIL OF COUPLING
SCALE NONE
* HUB MACHINED TO CUSTOMER SPECIFICATION

Figure 6

A second type of coupling utilizes leaf or coil springs for torsional flexibility. Hydrodynamic damping is accomplished by oil displacement (dash pot). Figure 7 illustrates a *typical* example of this coupling type.

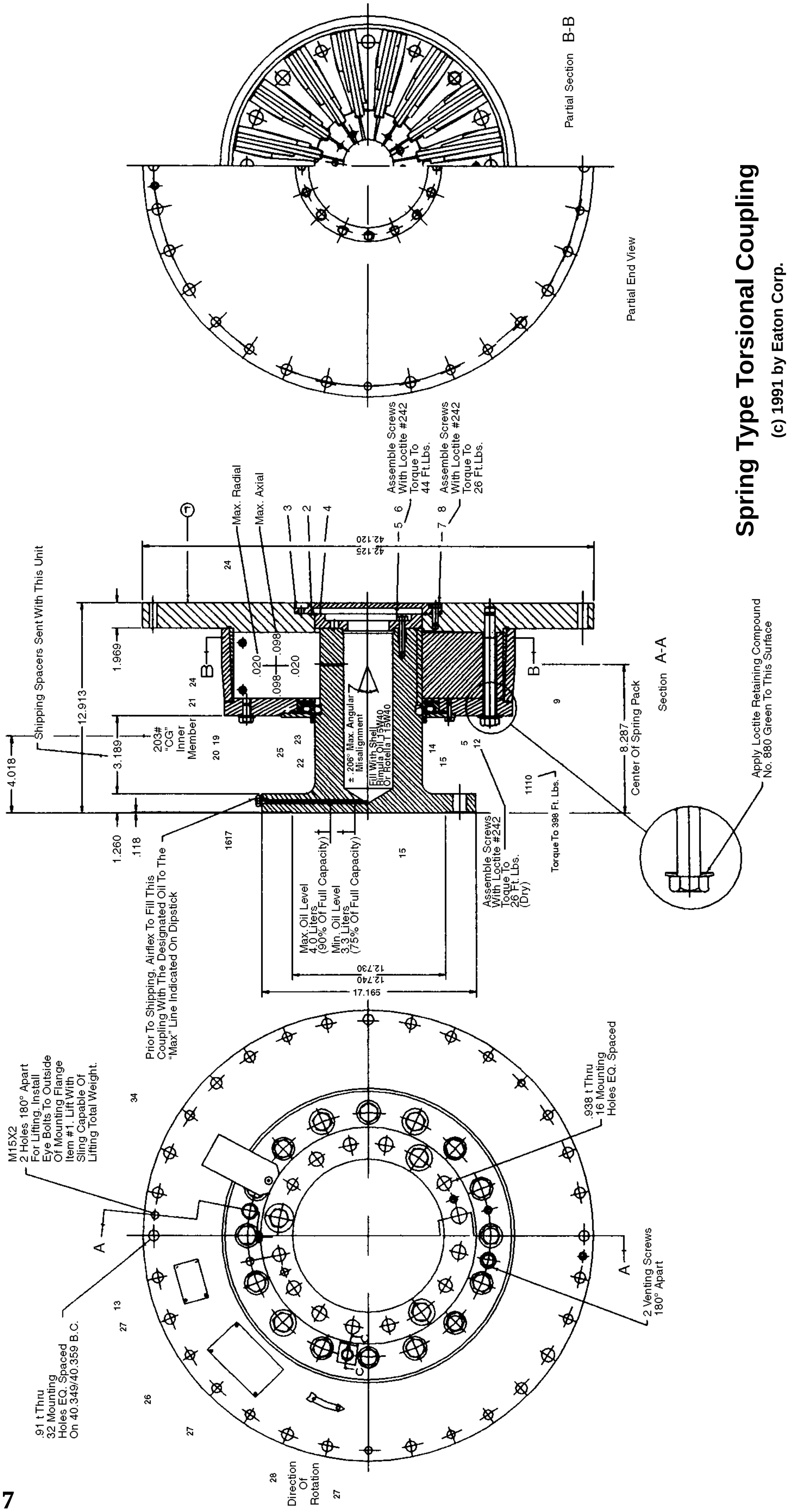


Figure 7

The selection of a coupling depends on the driveline configuration (gearbox, shafting, propeller, etc.). A complete set of driveline data is required to properly select a coupling. A Torsional Vibration Analysis (TVA) must be performed to confirm the coupling selection. The information required by Caterpillar to perform a TVA is shown in Figure 8. Also see *Torsional Vibration Analysis* under the *General Information* section of this guide.

Torsional Limits

The following guidelines should be used in the coupling selection process:

- Crankshaft Amplitude Limits: Misfire calculated using #1 engine cylinder misfiring. Individual order analysis with or without misfire.

  Amplitude limits at front of crank
  - Do not exceed ± 1.0° for 0.5 order
  - Do not exceed ± 1.0° for 1st order
  - Do not exceed ± 0.25° for 1.5 order
  - Do not exceed ± 0.15° for all orders above 1.5 at front of crank
  - Do not exceed ± 21 MPa (3000 psi) crankshaft stress for each engine order
  - Vibratory Torque: Limit of coupling with #1 cylinder misfire
  - Coupling Power Loss: Limit of coupling with #1 cylinder misfire

Coupling Selection

- Develop a coupling selection matrix based on:
  - Engine model
  - Power
  - Inertia - driveline data
  - Ambient temperature
    - 45°C
    - 60°C
  - Application
    - Main Propulsion or Ship Service Generator Set
- Select coupling that meets all the following criteria:
  - Coupling vibratory torque limits
  - Crankshaft vibration limits
- Analyze alternative couplings until all of the above conditions are met.

Use torsional limit stops (coupling locks if operated beyond limits) on couplings providing the sole source of transmitting propulsive power. A single screw vessel is an example. The vessels should have a take-home feature if the coupling fails.

Note: *Germanischer Lloyd and Bureau Veritas may not permit a torsional limit stop because of potentially severe torsional problems when the propulsion system is operated with a failed coupling.*

Propellers

Fixed Pitch

The dimensions of fixed pitch (FP) propellers must be carefully reviewed for each application. They control the level of engine power that can be used in a ship installation.

Factors influencing the design are:

- Propulsion resistance of the ship increases with time.
- Wake factor for the ship increases with time.
- Propeller blade frictional resistance in water increases with time.
- Bollard pull requires higher torque than free running.
- Propellers rotating in ice require higher torque.

Fixed pitch propellers are normally designed to absorb 85% of the Maximum Continuous Rating (MCR), or 90% of the Continuous Service Rating (CSR) at normal speed when the ship is on trial at specified speed and draft (see Figure 9).

Consider the accessory equipment power requirements for shaft generators or hydraulic pumps when sizing FP propellers.

3600 Torsional Vibration Analysis Request

Project Number ______________________________

Project/Customer Name ______________________________

Dealer Name ______________________________

The information on this form is to be used for a specific request for a torsional vibration analysis on the above 3600 Diesel Engine application. Please provide a timely verbal response followed by a written report to the responsible project engineer. The following information describes the major components and performance data for this application:

Engine Model and Rating:

E29 ________ (36 ________); ________ kW (________ bhp)

Low Idle rpm ________ Rated Speed rpm ________

Engine Regulation: Isochronous (Y/N) ________, or Percent Droop ________ %

Application Specifics: ______________________________

____

____

(quantity engines -- custom base -- front driven equipment, etc.)

Engine Room Maximum Ambient Temperature ______________________________

Generator (____); and/or **Marine Gear** (____); plus **Other Driven Equipment** (____)

Supplier Name and Model Number ______________________________

Rotating Inertia/Drawing(s) ______________________________

Rotating Stiffness/Shaft Drawing(s) ______________________________

Gearbox Drawing ____________________ Propeller Inertia ____________________

Description (e.g. two bearing or single bearing) ______________________________

____

(attached are supplier data sheets)

Part Numbers of Components:

Flywheel Group	___________	Coupling Group	___________
Drive Group	___________	Damper Group	___________
Ring Gear Group	___________	Other Groups	___________
3161 Governor Group	___________	Heinzmann Governor	___________
EGB29P Actuator Assembly	___________	Electronic Control Group	___________

Engine Ship Date (RTS) ______________________________

Torsional Completion Date Required ______________________________

Caterpillar Project Engineer ______________________________

(Revised 4-25-97)

Figure 8

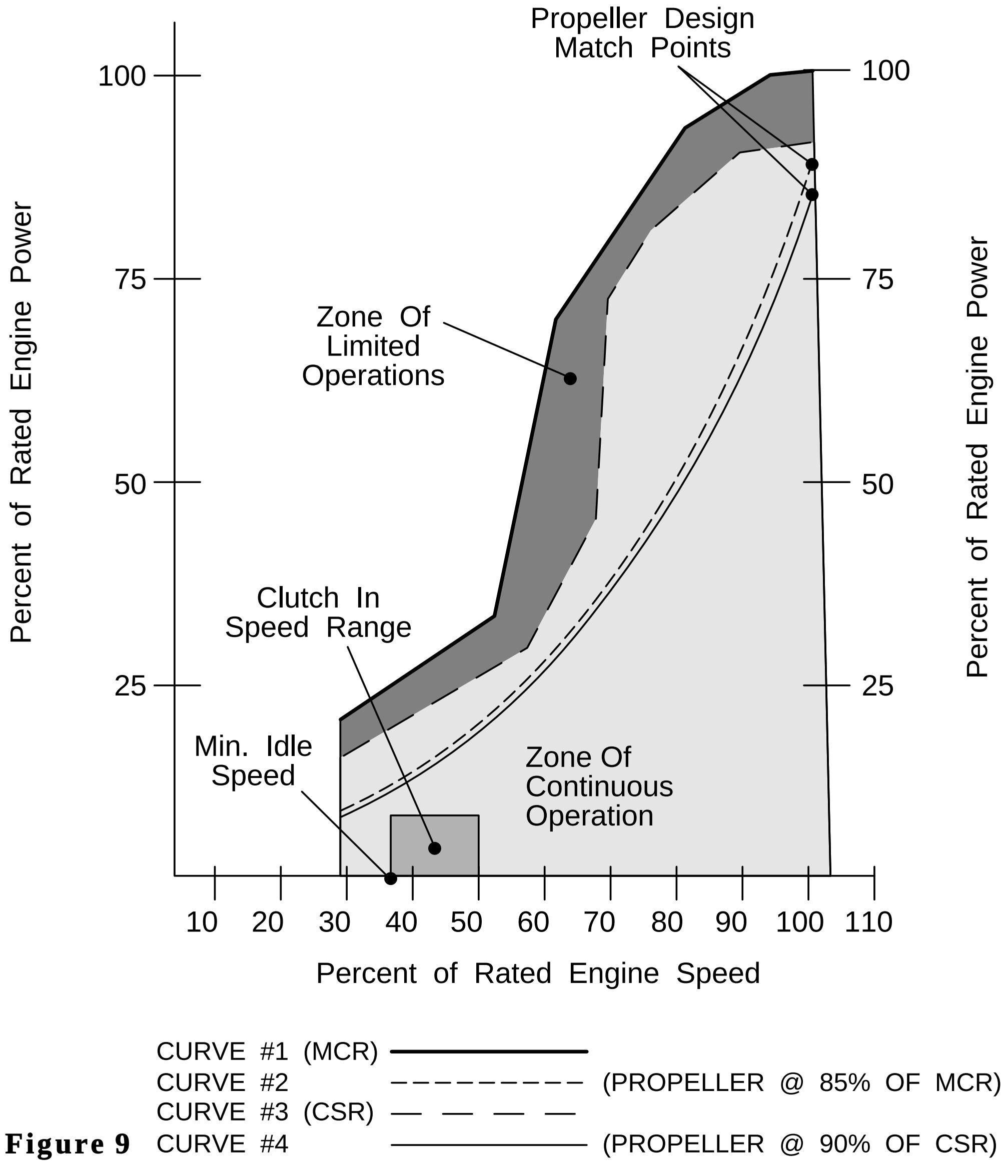


Figure 9

Fishing or towing ships should use a propeller designed for 85% MCR of the engine, the normal speed for fishing or bollard pull or at towing speed. The absorbed power at free running and normal speed is usually lower (about 65% to 85%) than the output at fishing or bollard pull.

Consult Caterpillar for special applications with additional torque requirements, such as dredges or ships operating in thick ice.

Figure 8 shows the permissible operating range for a FP propeller installation and the design point at 85% MCR at nominal speed. The minimum speed is decided separately for each application. The speed control system should give a boost signal to the speed actuator to prevent engine speed from decreasing when clutching in. Select the clutch to provide a slip time of 5-7 sec. Install a propeller shaft brake to facilitate fast maneuvering (ahead, astern, stop). See the *Engine Performance* section of this guide for a full explanation of the rating curve. Also see the section for *Controls*.

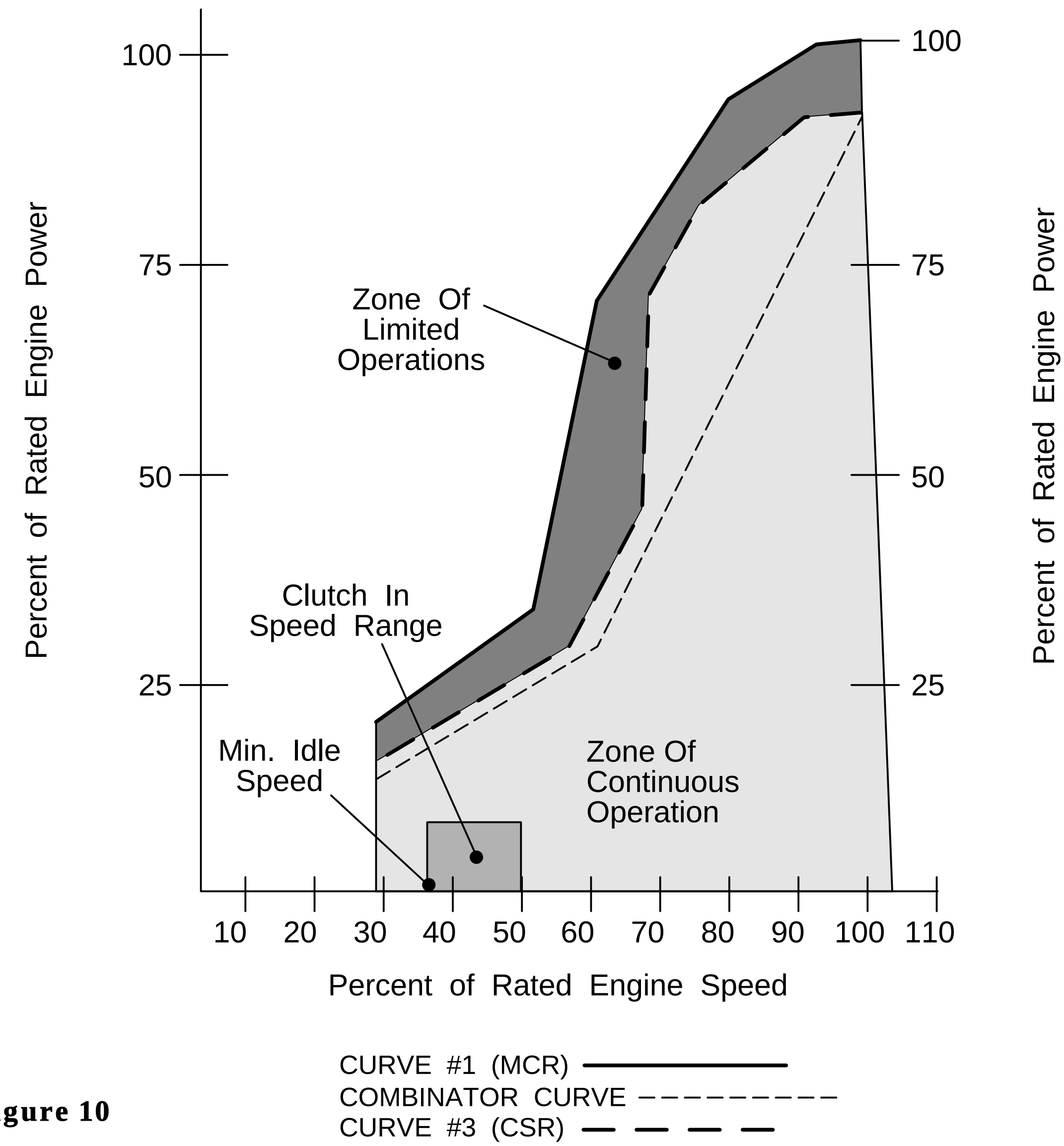


Figure 10

Controllable Pitch

Controllable pitch (CP) propellers are normally designed at 90 to 100% of the Continuous Service Rating (CSR) at rated rpm. See the Engine Performance section of this guide. This power level is used when the ship is on trial with a clean hull at specified speed and draft. Consider the shaft generators or generators connected to the free end of the engine when dimensioning CP propellers if continuous generator output is used at sea. Overload protection or load control is recommended in all installations.

Figure 10 shows the operating range for a typical CP propeller installation, see the Engine Performance section for a full explanation of the rating curve. The recommended combinator curve is valid for single engine installations. In installations where several engines are connected to the same propeller, overload protection or load control is necessary. Loads close to the combinator curve are also recommended when all engines are not operating. The idle (clutch-in) speed will be determined separately in each case.

Materials and specifications are
subject to change without notice.