CATERPILLAR®

Marine Engine Application and Installation Guide

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Application Guidelines

Knowledge of the engine's operating requirements is essential to establish a proper match of engine rating to boat operating requirements. To help determine the acceptability of a rating for a particular boat's application, the following parameters should be considered:

1. Time at full throttle
2. Annual operating hours
3. Propeller match

Time at Full Throttle

Time at full throttle is the amount of time the engine is operated at rated rpm without load cycling during a normal duty cycle. This is normally specified in terms of percent of total cycle time or in minutes per hour.

Annual Operating Hours

The annual operation hours are based on the accumulated service meter units during a 12-month period. Clock hours are the same as service meter units on all Caterpillar Engines using electric service meters. Some Caterpillar engines (D399, D398, D379 and earlier engines) used service meters which "counted" engine revolutions. One service meter unit on those engines corresponds to a clock hour only when the engine is operating at rated speed (rpm). The ratio between clock hours and service meter units is proportional to engine speed.

Propeller Match

The propeller must be sized to allow the engine to operate slightly above rated rpm under the boat's most severe load conditions: full fuel and water tanks, stores aboard for extended voyaging, and adverse sea conditions.

Engine Rating Definitions

Ratings are statements of the engine's power and speed capability under specified load conditions. The Caterpillar rating system simply matches engines to particular applications. It consists of the following standard ratings.

A Rating (Unrestricted Continuous)

Load factor: 80% to 100%. Up to 100% of the time at rated speed.
Typical hrs/yr: 5000 to 8000.
Typical applications: For vessels operating at rated load and rated speed up to 100% of the time without interruption or load cycling (80% to 100% load factor). Typical applications could include but are not limited to vessels such as freighters, tugboats, bottom drag trawlers, or deep river tugboats. Typical operation ranges from 5000 to 8000 hours per year.

B Rating (Heavy Duty)

Load factor: 40% to 80%. Up to 80% of the time at rated speed.
Typical time at full load: 10 hrs out of 12.
Typical hrs/yr: 3000 to 5000.
Typical applications: For vessels operating at rated load and speed up to 80% of the time with some load cycling (40% to 80% load factor). Typical applications could include but are not limited to vessels such as mid-water trawlers, purse seiner, crew and supply boats, ferries, or towboats. Typical operation ranges from 3000 to 5000 hours per year.

C Rating (Maximum Continuous)

Load factor: 20% to 80%. Up to 50% of the time at rated speed.
Typical time at full load: 6 hrs out of 12.
Typical hrs/yr: 2000 to 4000.
Typical applications: For vessels operating at rated load and rated speed up to 50% of the time with cyclical load and speed (20% to 80% load factor). Typical applications could include but are not limited to vessels such as ferries, harbor tugs, fishing boats, offshore service boats, displacement hull yachts, or short trip coastal freighters. Typical operation ranges from 2000 to 4000 hours per year.

D Rating (Intermittent Duty)

Load factor: Up to 50%. Up to 16% of the time at rated speed.
Typical time at full load: 2 hrs out of 12.
Typical hrs/yr: 1000 to 3000.
Typical applications: For vessels operating at rated load and rated speed up to 16% of the time (up to 50% load factor). Typical applications could include but are not limited to vessels such as offshore patrol boats, customs boats, police boats, some fishing boats, fireboats, or harbor tugs. Typical operation ranges from 1000 to 3000 hours per year.

E Rating (High Performance)

Load factor: Up to 30%. Up to 8% of the time at rated speed.
Typical time at full load: 1/2 hr out of 6.
Typical hrs/yr: 250 to 1000.
Typical applications: For vessels operating at rated load and rated speed up to 8% of the time (up to 30% load factor). Typical applications could include but are not limited to vessels such as pleasure craft, harbor patrol boats, harbor master boats, some fishing or patrol boats. Typical operation ranges from 250 to 1000 hours per year.

Rating Conditions

Ratings are based on SAE J1128/ISO 8665 standard ambient conditions of 100 kPa (29.61 in. Hg) and 25°C (77°F). Ratings also apply at AS1501, BS5514, DIN 6271 and ISO 3046/1 standard conditions of 100 kPa (29.61 in. Hg), 27°C (81°F) and 60% relative humidity.

Power is based on a 35° API [16°C (60°F)] fuel having a LHV of 42,780 kJ/kg (18,390 B/lb) used at 29°C (85°F) with a density of 838.9 g/L (7.001 lb/U.S. gal).

Ratings are gross output ratings: i.e., total output capability of the engine equipped with standard accessories: lube oil, fuel oil, and jacket water pumps. Power to drive auxiliaries must be deducted from the gross output to arrive at the net power available for the external (flywheel) load. Typical auxiliaries include cooling fans, air compressors, charging alternators, marine gears, and seawater pumps.

Marine Engine Ratings to DIN Standards

The DIN (Deutsche Industrie Norme) 6270 standard covers rated output data for internal combustion engines in general applications. When required, DIN 6270 main propulsion ratings can be quoted according to the following stipulations.

Continuous Output A

This is the published Caterpillar "Continuous 'A' Rating" rating in kW units. No additional reference is necessary.

A condition in the "Continuous Output A" definition is that the output-limiting device must be set to provide a margin of extra capacity. This overload capability can be demonstrated, if required, by increasing the fuel setting from the factory-set continuous output value to the value corresponding to our "B" rating level. With a few exceptions, this increased fuel setting will correspond to an overload capability of approximately 10%. The propeller should be sized for the continuous rating with the appropriate safety margins from the Technical Marketing Information file (TMI). The fuel setting must be readjusted to the nameplate value upon completion of the demonstration test.

Output B

Output B is defined as the maximum useful output that the engine can deliver for a definite time limit corresponding to the engine application. The fuel setting is pre-set such that output B cannot be exceeded, so no overload capability need be demonstrated.

On the basis of this definition, we can offer two output B ratings with kW values corresponding to the Caterpillar B Rating (Heavy Duty) or C Rating (Maximum Continuous).

In each case, it is mandatory that reference be made to the applicable rating definitions.

General Comments

DIN 6270 conditions are slightly different from the SAE conditions used in the U.S. We believe that they are virtually equivalent for all practical purposes. No correction to ratings should be made to account for the slightly different reference conditions.

Useful output as described under DIN 6270 is defined as the output available to drive the load after suitable deductions are made for engine driven accessories. This is equivalent to the net rating. Caterpillar ratings indicate gross output. At the kW requirement to drive such accessories as charging alternator and sea water pump are low and well within our rating tolerance, no deductions for main propulsion engine driven accessory loads need to be made.

Performance Curves

Following are format samples of Caterpillar Performance Curves:

Marine Engine Performance
C18 DITA
533 kW (715 hp) @ 2100 rpm
C-RATING - DM7562-00

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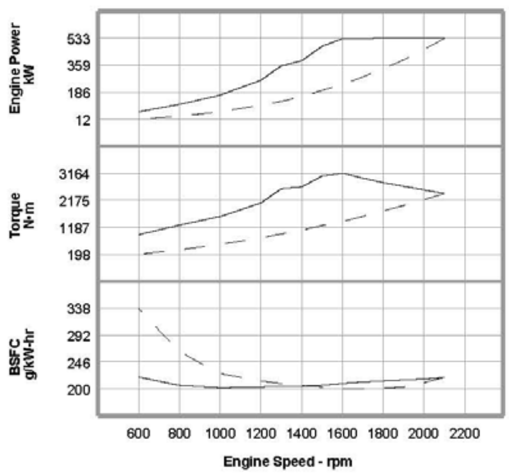
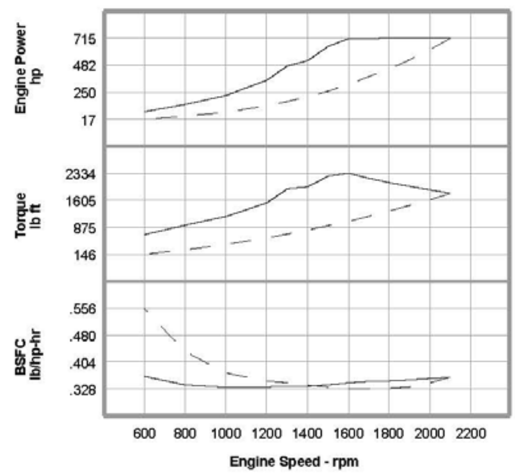


Metric | Maximum Power —— / Prop Demand — — | 533 kW

Performance Data

	Engine Speed rpm	Engine Power kW	Engine Torque N•m	BSFC g/kW-hr	Fuel Rate L/hr
Maximum Power Data	2100	533	2424	219.0	139.4
	2000	533	2545	217.0	137.6
	1900	533	2679	215.0	136.3
	1800	533	2828	213.0	135.4
	1700	530	2978	212.0	133.8
	1500	479	3050	206.0	117.9
	1400	389	2653	204.0	94.8
	1300	353	2593	204.0	85.7
	1200	260	2069	203.0	62.9
	800	106	1265	206.0	26.1
	600	58	923	220.0	15.2
Prop Demand Data	2100	533	2424	219.0	139.4
	2000	460	2198	210.0	115.1
	1900	395	1984	203.0	95.7
	1800	336	1781	201.0	80.3
	1700	283	1588	200.0	67.5
	1500	194	1237	203.0	47.0
	1400	158	1077	205.0	38.7
	1300	126	929	209.0	31.4
	1200	100	791	213.0	25.2
	800	30	352	264.0	9.3
	600	12	198	338.0	5.0

Cubic prop demand curve with 3.0 exponent for displacement hulls only.



English | Maximum Power —— / Prop Demand — — | 715 hp

Performance Data

	Engine Speed rpm	Engine Power hp	Engine Torque lb ft	BSFC lb/hp-hr	Fuel Rate gph
Maximum Power Data	2100	715	1788	.360	36.8
	2000	715	1877	.357	36.4
	1900	715	1976	.353	36.0
	1800	715	2086	.350	35.8
	1700	711	2196	.349	35.3
	1500	642	2249	.339	31.1
	1400	522	1957	.335	25.0
	1300	473	1912	.335	22.6
	1200	349	1526	.334	16.6
	800	142	933	.339	6.9
	600	78	681	.362	4.0
Prop Demand Data	2100	715	1788	.360	36.8
	2000	617	1621	.345	30.4
	1900	529	1463	.334	25.3
	1800	450	1314	.330	21.2
	1700	379	1171	.329	17.8
	1500	260	912	.334	12.4
	1400	212	794	.337	10.2
	1300	170	685	.344	8.3
	1200	133	583	.350	6.7
	800	40	260	.434	2.5
	600	17	146	.556	1.3

Power produced at the flywheel will be within standard tolerances up to 50°C (122°F) combustion air temperature measured at the air cleaner inlet, and fuel temperature up to 52°C (125°F) measured at the fuel filter base. Power rated in accordance with NMMA procedure as crankshaft power. Reduce crankshaft power by 3% for propeller shaft power.

PD-DM7562-00.pdf Created on 04/25/2004 01:00

Features of the Performance Curve

Vertical Axis [left side] — Graduated in units of Power [Brake kW or Brake Horsepower]

Horizontal Axis — Graduated in units of Engine Speed [Revolutions per Minute]

Propeller Demand Curve: describes the power demanded by a fixed pitch propeller used in a displacement hull. Semi-displacement and planing hulls will have higher load demand than shown in the "P" curve. Each semi-displacement and planing hull has different demand, which makes it impossible to show the load demand for each hull. Semi-displacement and planing hulls will need to be sea trialed with fuel measurements taken at different engine speeds to determine actual fuel and load demand.

Maximum Power Curve: the maximum power capability of the engine without regard to the rating development limits.

Each standard rating of the engines will have its performance documented as shown above. There can be a delay of the formal version of the data in the case of new ratings or engine configurations.

Engine Configuration Effects on Ratings

Engine configurations can be altered to allow efficient use of larger amounts of fuel. This is done by increasing the amount of air that can be utilized by the engine. Airflow through an engine is called aspiration. Caterpillar engines have one of the following methods of aspiration:

Naturally Aspirated

In a naturally aspirated engine, the volume of air drawn into each cylinder is moderate, since only atmospheric pressure is forcing air through the cylinder’s intake valve. There is no pressurization of the engine’s intake manifold by an external device and engine intake manifold pressure is always a partial vacuum.

Turbocharged

Greater amounts of air can be forced into an engine’s cylinders by installing a turbocharger. Turbochargers are turbine-like devices that use exhaust energy (which naturally aspirated engines waste) to compress outside air and force it into the intake manifold. The increased amount of air flowing through turbocharged engines does two good things:

- The greater airflow cools the valves, piston crowns, and cylinder walls, making them better able to resist the firing forces.
- Fuel can be burned more efficiently, due to the increased amount of air for combustion.

This makes the engine more powerful. Compression does increase the temperature of the intake air, however. It is very useful to remove the heat-of-compression from the intake air, upstream of the combustion chambers. Cooling the air before it enters the combustion chambers makes the air more dense and increases cooling of the combustion chamber components.

Turbocharged/Aftercooled

An air-cooling heat exchanger (aftercooler) is installed between the turbocharger and the combustion chamber on turbocharged/aftercooled engines. The aftercooler cools the incoming air, carrying the heat away with a flow of water. The water can come from two sources. If jacket water (the same water that cools the cylinder head and block) is used in the aftercooler, then the air can only be cooled to approximately 93°C (200°F). Jacket water temperature is thermostatically controlled at approximately 82°C (180°F). Even cooler air can be obtained by cooling the aftercooler with water from a separate circuit, such as seawater or some other circuit, with colder water than the engine jacket water. Lower aftercooler water temperatures permit higher engine ratings because cooler, denser air permits burning more fuel.

Extended Periods of Low Load

Prolonged low load operation should be followed by periodic operation at higher load to consume exhaust deposits. Low load operation is defined as below approximately 20% load. The engine should be operated above 40% load periodically to consume the exhaust deposits. Caterpillar engines can be run well over 24 hours before exhaust slobber becomes significant. The amount of additional time depends upon the engine configuration, water temperature to the aftercooler, inlet air temperature to the engine and type of fuel.

Auxiliary Engine Ratings

Marine engines used for auxiliary power are of the same general configuration as propulsion engines. Their power output is limited by the same design factors. Horsepower ratings are also determined by the type of aspiration, the aftercooling system and by engine application.

Caterpillar prime power ratings are used for marine generator sets when applied as ship-board power and as emergency power at both 60 Hz and 50 Hz. The engine is set at the factory to provide 110% of rated output as required by Marine Classification Societies (MCS).

Normally, other auxiliary power requirements, such as hydraulic pumps, winches, fire and cargo pumps, and compressors, are applied at a rating based on their duty cycle and load factor.