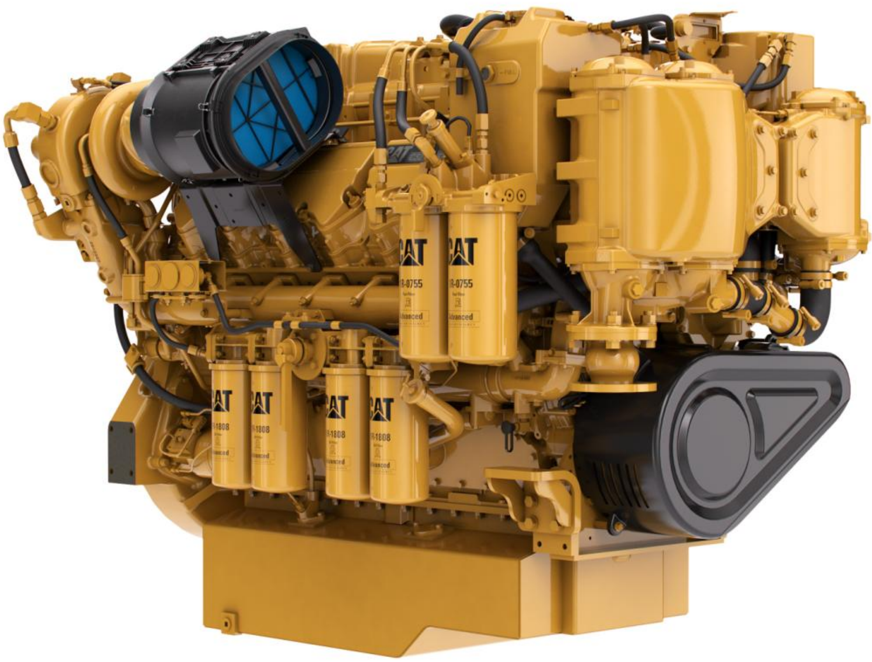
C32 SCAC

Marine Project Guide
EPA Marine Tier 3 / IMO Tier II Compliant



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General

C32 Engine Information

The C32 Tier 3, Separate Circuit Aftercooled (SCAC) engine is certified to 2013 EPA Tier 3 and IMO II Marine commercial emissions standards. All engines have SAE #0 flywheel housing; Caterpillar does not offer a SAE #1 option for this product. Details on standard and optional selections are listed by system in each product price list. The product price list can be accessed through Power Net. The Reference Materials section at the end this guide provides links to Power Net and other resources.

Product Identification Information

Marine Propulsion High Performance Price List C32 MP3MC

EPA T3 / IMO II Engine E-Model: EE086

EPA T3 / IMO II Engine S/N Prefix: SDN

IMO II Only Engine E-Model: EE086

IMO II Only Engine S/N Prefix: SDN

Marine (Auxiliary) Gen Set Engine Price List C32 MGE3MC

EPA T3 / IMO II Engine E-Model: EE128

EPA T3 / IMO II Engine S/N Prefix: RSD

IMO II Only Engine E-Model: EE128

IMO II Only Engine S/N Prefix: RSD

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Note: The following images may not reflect your engine.

Heat Exchanger Cooled Engine (Rear Mounted Sea Water Pump)

Figure 1: Front View

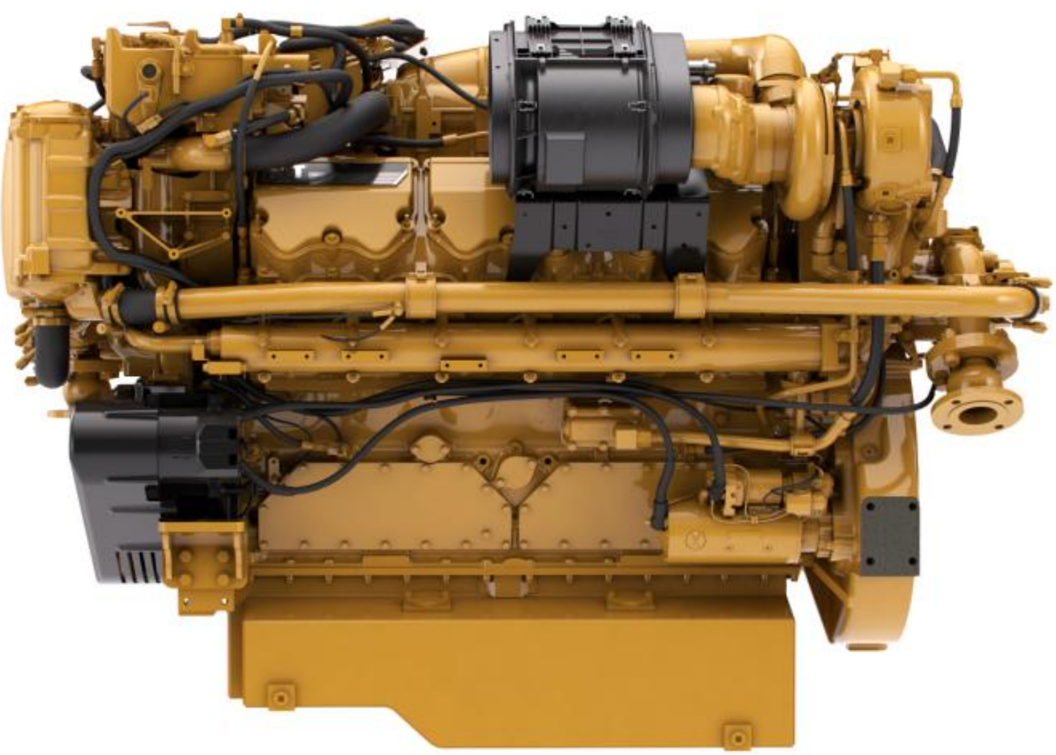

Figure 2: Left View

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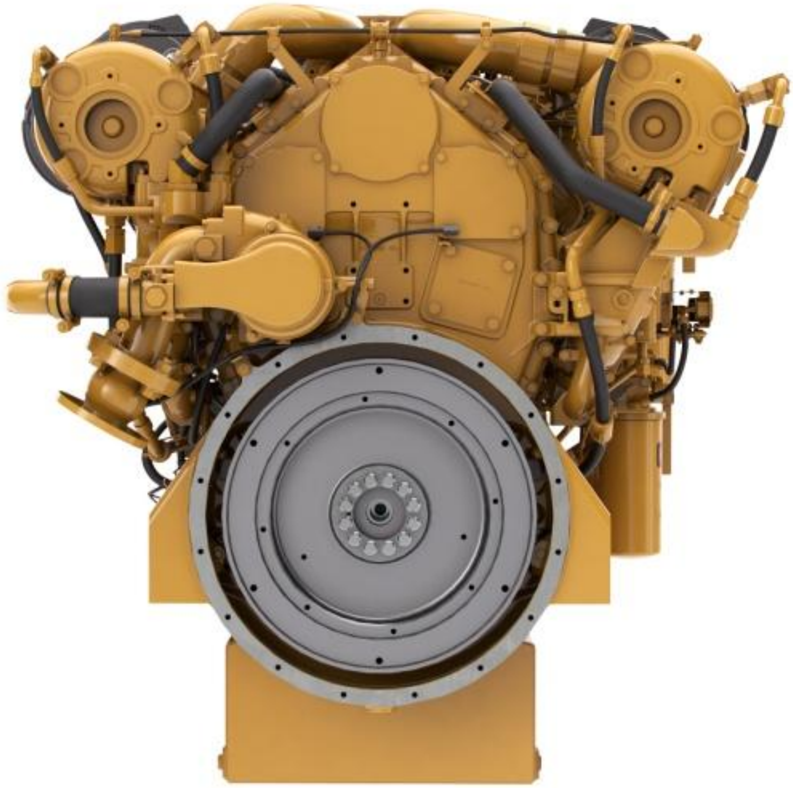

Figure 3: Rear View (Flywheel End of Engine)

Figure 4: Right View

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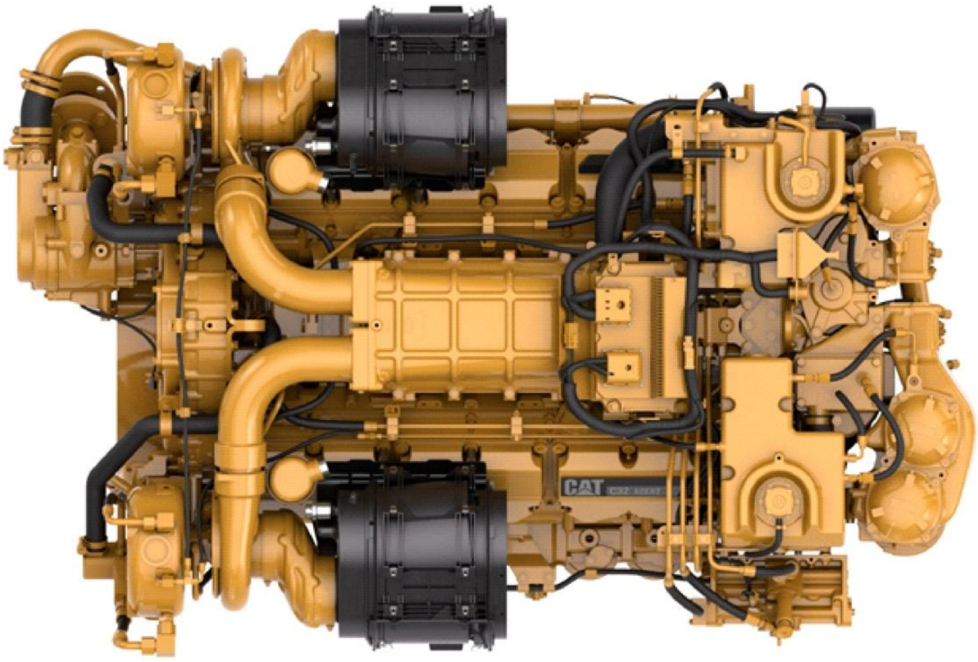

Figure 5: Top View

Note: The following image may not reflect your engine.

Heat Exchanger Cooled Engine (Front Mounted Sea Water Pump)

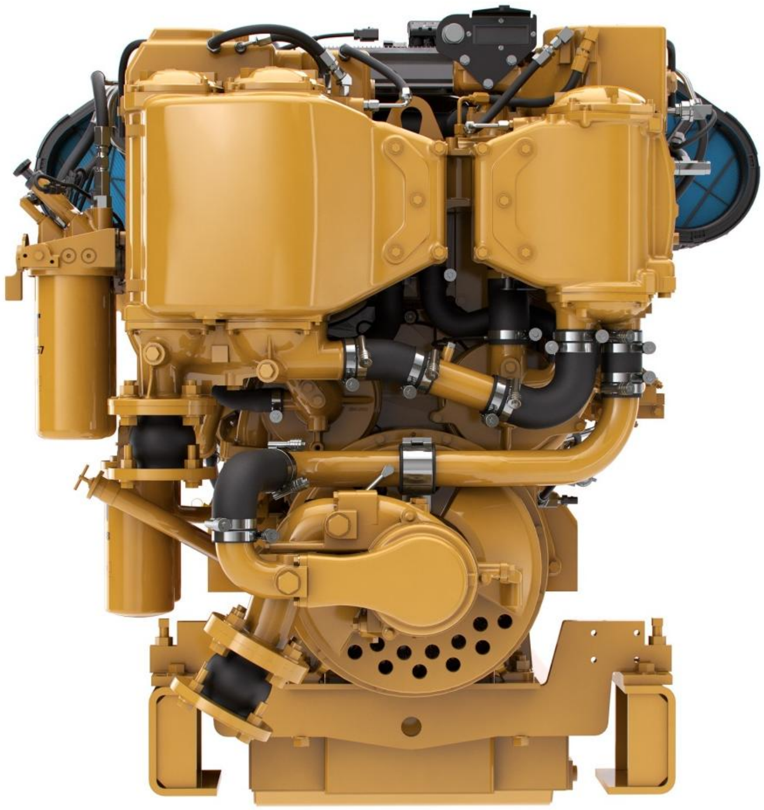

Figure 6: Front View

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Note: The following images may not reflect your engine.

Keel Cooled Engine

Figure 7: Front View

Figure 8: Left View

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Figure 9: Rear View (Flywheel End of Engine)

Figure 10: Right View

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Air System

Engine Protection Strategy

The engine protection strategy is in place to protect engine components from being damaged due to thermal wear caused by high inlet air temperatures. The Engine Protection Strategy is only implemented on EPA Tier 3 Ratings; this strategy is not active on IMO II only ratings. The engine protection strategy is based on inlet manifold air temperature; which is a function of cooling water temperature to the aftercooler and ambient air temperature to the turbo compressor. The sea water temperature and fouling levels of the heat exchanger or keel cooler both have a direct impact on Inlet Manifold Temperature [IMAT].

The inlet air temperature to the turbo compressor is measured by a new temperature sensor located in the air cleaner housing.

The Engine Protection Strategy Chart which is also referred to as the ambient capability chart is published in TMI. This data is stored under Performance Data but within the Supplementary Data tab.

If you have trouble viewing the Ambient Capability Chart, select the metric units toggle before retrieving the data.

Air Cleaner

The inlet air cleaners system is standard on each engine configuration; however, it is considered an optional attachment. There is an option in the price list to remove the cleaner group if a customer wants to provide an aftermarket air cleaner system.

The Cat filter elements are disposable. The filter elements can be removed from the bottom of the cleaner housing as illustrated in the installation drawings on EDDC.

Crankcase Fumes Disposal

Normal combustion pressures of an internal combustion engine cause pressure buildup within the crankcase due to blowby. Vent tubes and crankcase breathers are provided to allow this gas to escape.

Do not vent crankcase fumes into the engine room or any other indoor/enclosed spaces.

Crankcase fumes should be discharged directly to the atmosphere through a venting system individual for each engine.

If Closed Crankcase is not selected; loops in a crankcase vent pipe should be avoided. The vent pipe should be installed with a horizontal run at a gradual decline, approximately 41.7 mm/m (1/2 in/ft), as the pipe is routed away from the engine. A drain should be installed at the lowest point and checked daily to prevent liquid locks from the condensation in the pipe and thus restricting discharge of fumes. The weight of the vent pipes will require separate off-engine supports as part of the installation design. Further additional flexible connections will need to be installed to accommodate the engine movement.

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Crankcase Piping System

Vent the pipe out of the vessel directly into the atmosphere at a well considered location and be fitted with a gooseneck or similar arrangement to keep rain or water spray from entering the engine. Consideration should also be given to other equipment located near the discharge area. If not located properly, the oil carryover can accumulate over time and become unsightly.

An oil condensate trap will minimize the amount of oil discharged from the vent pipe.

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Cooling System

Introduction

The cooling system configuration for the C32 EPA Tier 3 Commercial Propulsion and Auxiliary engines are identified as Separate Circuit Aftercooled (SCAC) Engines.

The maximum glycol concentration for the jacket water circuit is 50/50 water-to-glycol concentration. The recommended glycol concentration for the aftercooler SCAC circuit is 80/20 water-to-glycol concentration.

The cooling system was designed to operate properly with the following temperatures supplied to the engine:

- 52 deg C (125.6 deg F) maximum Treated Water temperature to the aftercooler.
- 99 deg C (210 deg F) maximum Jacket Water temperature from engine to external cooler.

Sacrificial anodes are not included on the SCAC product. The SCAC engines were designed to be used with a zinc bonding system, where the zinc is installed on the vessel. Instructions for installing the bonding system are illustrated in the C7 - C32 Marine Engine Electronics Application and Installation Guide.

Coolant Flow Control

The external circuit resistance setting establishes the total circuit flow by balancing total circuit losses with the characteristic pump performance curves. Correct external resistance is very important. Too high a resistance will result in reduced flows to the aftercooler and/or jacket water circuit, causing their effectiveness to decrease. If there is too low a resistance, the fluid velocity may increase and exceed fluid velocity limits, and cavitation/early wear could be the result.

The Pump Performance Curves in TMI illustrates the maximum recommended external resistance versus coolant flow at specific engine speeds.

Coolant Temperature Control

The Tier 3 SCAC engines use inlet control temperature regulators/thermostats to provide uniform coolant temperature to the jacket water circuit and aftercooler circuit.

The jacket water circuit has two regulators. The aftercooler circuit SCAC has one regulator.

Treated Water Pumps

The C32 Tier 3 Commercial Propulsion and Auxiliary engines have two gear-driven centrifugal water pumps mounted on the front housing. The right-hand pump (viewed from the flywheel end) is the jacket water pump and supplies coolant to the oil cooler, block, and heads. The left-hand pump, referred to as the SCAC pump, supplies coolant to the fuel cooler and aftercooler. Each pump is equipped with pump covers that have two service ports available for measuring coolant temperature and pressure at pump inlet, and one service port on the pump housing for measuring at the pump outlet.

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Sea Water Pump

A Cat engine driven sea water pump supplies sea water to the aftercooler heat exchanger, jacket water heat exchanger, and gear/transmission oil cooler. This is not a self-priming sea water pump; pump performance data is published in TMI under Component Data. Some systems may require an auxiliary priming system to meet the application requirements.

For commercial propulsion product the sea water pump is only mounted on the left rear of the engine when viewed from the flywheel end. The sea water pump is supplied as standard equipment on heat exchanger cooled engines.

Auxiliary/genset engines have a sea water pump option.

For auxiliary engines there are three options:

Left Rear Mounted Sea Water Pump (viewed from the flywheel end).

Front Mounted Sea Water Pump driven off the crankshaft by way of the hydraulic pump drive adapter.

No Factory Sea Water Pump. The customer will supply their own sea water pump.

The front mounted sea water pump option exists to avoid interference issues with the rear mounted sea water pump auxiliary equipment (generator, pump, etc.) packaged by the dealer/customer.

The rear pump has a 0.933:1 pump to engine speed ratio. The front pump has a 1:1 pump to engine ratio.

The no pump option is available for those customers who prefer to provide their own sea water pump.

Engine Mounted Shunt Tanks and Venting

The engine mounted shunt tanks are standard on all C32 commercial Tier 3 products. Each shunt tank for heat exchanger cooled arrangements has a sight glass installed on the outboard side of the engine. The sight glass is for visual inspection purposes only and does not indicate that the system is full. Do not assume the tank is full when the sight glass partially or completely submerged. Consider the variation when taking into account installation angles and/or operating conditions.

The coolant system is full when the coolant level is in contact with the bottom of the fill neck, the most accurate way to verify the system is full is by removing the fill cap and confirm the coolant level is in contact with the bottom of the fill neck. (Flashlight maybe needed.)

The sight glass on the jacket water expansion tank is located above the low level sensor, in a zero degree installation condition there is approximately 8 liters (8.5 quarts) of coolant difference between the sight glass and low level sensor. The Jacket Water coolant sight glass will be partially submerged when the coolant level is in contact with the bottom of the fill neck, this is normal.

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The sight glass on the aftercooler SCAC expansion tank is located above the low level sensor, in a zero degree installation condition. There is approximately 3 liters (3.2 quarts) difference between the sight glass and low level sensor. At a zero degree installation condition the SCAC coolant sight glass will be completely submerged when the coolant level is in contact with the bottom of the fill neck, this is normal.

Jacket water and aftercooler SCAC tank volumes are published in TMI under the Physical Data Tab for each system. You can find information on other components within the cooling system in this location as well, such as details on the regulators, aftercooler, and heat exchangers.

The small lines routed to the top SCAC tank and the top of the jacket water tank are vent lines.

Heat Exchanger Cooled Engines

Heat exchanger cooled engines were designed to accommodate thermal expansion of the coolant in the closed engine circuit.

Keel Cooled Engines

In a keel cooled application the shunt tanks cannot accommodate any external expansion volume. An external vessel mounted expansion tank must connect to the engine at the top of the shunt tanks in place of the engine mounted fill neck and cap. (Each engine is shipped with two flanges explained in the Cooling Connections section.)

Proper venting is required for all applications. The vent lines that shipped with the engine should be removed. The dealer/ customer must route vent lines from the engine to the dealer/ customer supplied auxiliary expansion tank at a constant upward slope. The ports on the engine mounted shunt tanks must be plugged. Port/plug size and locations are called out on the engine installation drawings, published on EDDC.

Combined Cooling

Combined cooling can be achieved with the keel cooled engine arrangement.

- Maximum Inlet Coolant Temperature Combined Cooling:
  52 deg C (125.6 deg F)
- Maximum Combined Engine Outlet Temperature:
  98 deg C (208.4 deg F)

Cold Starting (Jacket Water Heaters)

Jacket water heaters may be required to meet cold starting and load acceptance criteria. Caterpillar offers 120V and 240V jacket water heater options for C32 SCAC product, both options deliver 1500W.

System Monitoring

During the design and preparation phase, it is important that provisions are made to measure pressure and temperature differentials across major system components.

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This allows accurate documentation of the cooling system during the commissioning sea trial. Future system problems or component deterioration (such as fouling) are easier to identify if baseline data is available.

Safety Advisory

The engine treated water systems are pressurized; hot coolant can cause serious burns. Before opening any treated water system stop the engine, wait until the engine is cool and proceed with CAUTION.

Serviceability

Suitable access should be provided for cleaning, removal, or replacement of all system components. Isolation valves should be installed as deemed necessary to facilitate such work.

Caterpillar recommends removing the heat exchanger cores and cleaning them in a hydrosolv solution. If necessary the heat exchanger tubes in both the jacket water and aftercooler heat exchangers can be inspected and brush-cleaned without removing the tube bundles from the heat exchanger housings, or draining the treated water circuits. The sea water circuit must be drained from the jacket water and aftercooler heat exchangers. Drain plugs are located on the jacket water heat exchanger and the sea water pump. The treated water circuits DO NOT have to be drained. (When conducting this inspection with the tube bundles installed and the treated water circuit filled with coolant, the technician should never attempt to remove the tube bundle. The respective treated water circuit will leak uncontrollably into the engine room once the seal is compromised.)

The top and bottom bonnets must be removed from the heat exchanger housing after the sea water is drained.

Service Ports

Service ports can be found on the Engine Installation Drawings, published in EDDC.

Ports on Jacket Water (JW) Heat Exchanger

- Sea Water Drains
- Treated Water Drain

Port on Aftercooler SCAC Heat Exchanger

- Treated Water Drain

Water Quality, Rust Inhibitors, and Antifreeze

Maintaining water quality is very important in closed cooling systems. Excessive hardness will cause deposits, fouling, and reduced effectiveness of cooling system components. Caterpillar has coolant inhibitor available to properly condition the cooling water. When using Cat inhibitor, the cooling water piping must not be a galvanized material, and aluminum should not be used. If the piping is galvanized, the zinc will react with the coolant inhibitor causing material to deposits in the treated water system which may lead to fouling in the treated water circuit.

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Cooling Connections

Caterpillar supplies flex connections for both the heat exchanger and keel cooled engine configurations for external water connections. Flange connection options include standard 3 inch 4 bolt ANSI English flanges and an 80 mm standard 8 bolt DIN flange connection.

Optional flexible connections with standard European 8 Bolt ANSI DIN flanges are also available.

The heat exchanger cooled engines ship with two flex connections (Figure 12 and Figure 13) for the sea water circuit; one is located on the sea water pump inlet, and one on the jacket water heat exchanger outlet.

The keel cooled engines (Figure 13) ship with four flex connections. Each flex connection must be mounted to the keel cooler adapters prior to installing the vessel supply and return piping to the engine. The keel cooler adapters are attached to the respective jacket water and SCAC regulator housings (deaerators).

Note: Pay close attention to the Supply and Return for the respective cooling circuits. Viewed from the front of the engine the Jacket Water Supply is the upper left connection. The SCAC Water Supply is the lower right connection.

The vessel mounted coolant expansion tanks must be piped directly to the engine mounted shunt tanks to maintain positive head pressure on the pump inlet. Keel cooled engines include two 6-bolt weld flange adapters to be used for connecting dealer/customer supplied auxiliary expansion tanks to engine mounted tanks.

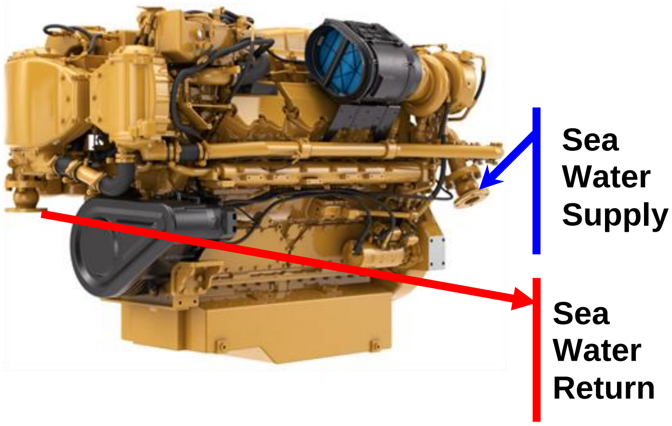

Figure 11: Heat Exchanger Cooled Connections, Rear Pump Arrangement (Sea Water)

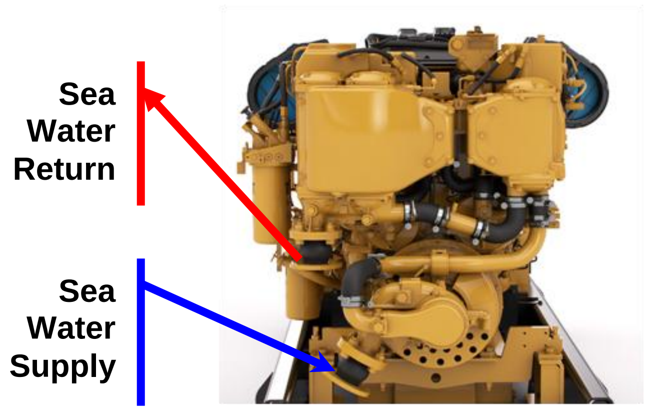

Figure 12: Heat Exchanger Cooled Connections, Front Pump Arrangement (Sea Water)

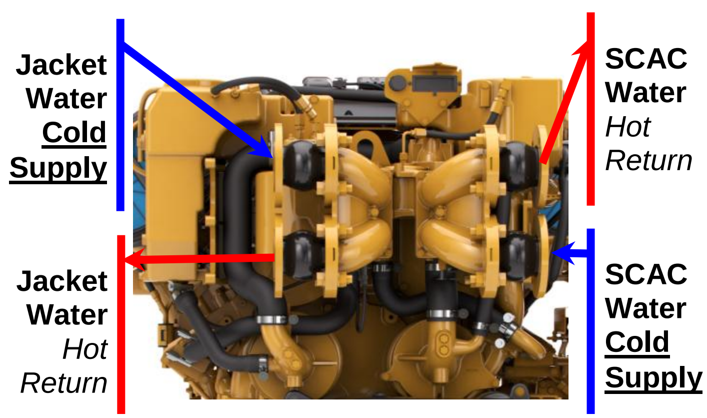

Figure 13: Keel Cooler Connections (Treated Water)

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The vessel mounted expansion tanks should NOT be connected in-line with the keel cooler supply and return connections.

The vessel expansion tanks must be sized to account for the total system expansion volume (engine, piping, keel coolers, etc).

Engine cooling system volumes are available in TMI under the physical data tab of the jacket water and/or SCAC tank groups. The tank group number is the item that should be searched.

Gear Oil Cooling

For marine propulsion applications, the engine's cooling system can be used to help cool the customer's marine gear / transmission oil. Some marine gears have integrated oil coolers included from the transmission supplier, and some require separate remote mounted oil coolers. In either case, engine driven cooling water can be used to remove the heat from the transmission oil.

For a keel cooled engine, a gear oil cooler can be installed within the aftercooler circuit to provide the coolest possible water flow and should be sized using the SCAC pump's water flow vs. external restriction curve available in TMI under Component Data. This should be done off-engine and is typically placed before the engine's aftercooler or at the outlet of the keel cooler. Because of the warmer treated water available in a keel cooled application, a full flow cooler is typically required to meet the marine transmission's cooling requirements. If installed prior to the aftercooler, the keel cooler should be sized accordingly to account for the additional temperature rise through the gear oil cooler in order to not exceed the published maximum treated water temperature to the engine's aftercooler.

For a HEX (heat exchanger) cooled engine, raw sea water is used to provide cooling water flow through the cooler. The engine's sea water circuit on this C32 SCAC engine can be used in two different ways to provide raw water flow through a gear cooler. It can be configured as partial flow or full flow.

Partial Flow (Before Engine Heat Exchangers)

For gear oil coolers requiring up to 30kW of heat rejection, partial sea water flow to the gear oil cooler can be routed from the port located at the sea water pump discharge as indicated in Figure 14. This should be configured by removing the plug and plumbing the inlet side of the gear oil cooler to the sea water pump outlet port shown. The return side

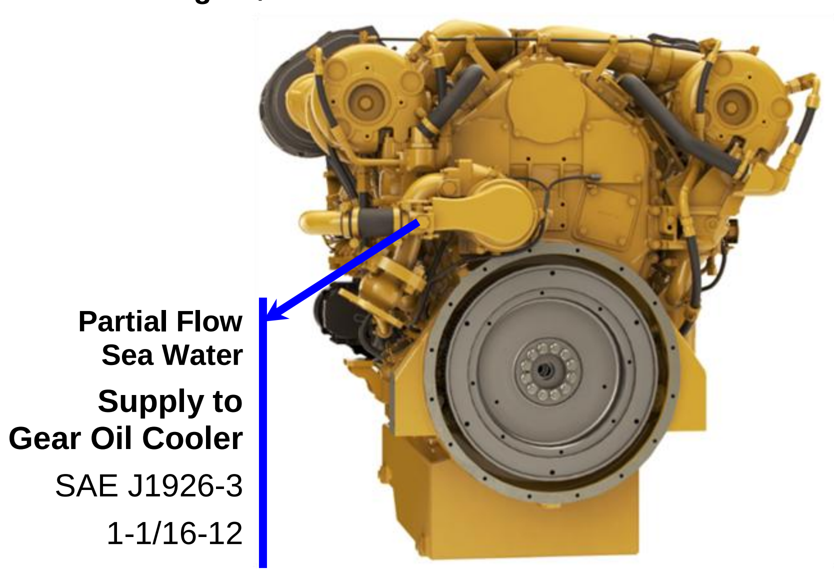

Figure 14: Partial Flow Sea Water Supply to Gear oil Cooler

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of the gear oil cooler then must be plumbed to the sea water overboard return and should not be connected back to the engine's sea water circuit at any location upstream of the engine mounted heat exchangers. Partial sea water flow vs. gear oil cooler restriction data is available in TMI under Component Data and should be referenced when designing the partial flow gear oil cooling circuit. Please also see Figure 14 (Heat Exchanger Schematic) which shows this partial flow option indicated with a dotted line in the schematic.

Full Flow (After Engine Heat Exchangers)

For gear oil coolers requiring greater than 30kW of heat rejection, full sea water flow from the engine's heat exchangers to the inlet side of the gear oil cooler should be provided as indicated in Figure 15. The return side of the gear oil cooler should then be plumbed to the sea water overboard return. Full sea water pump flow vs. external restriction data is available in TMI under Component Data and should be referenced when designing the full flow gear oil cooling circuit. Please also see Figure 16 (Heat Exchanger Schematic) which shows this full flow option in the schematic indicated with a solid line between the JW HEX outlet and the "To Sea" overboard return.

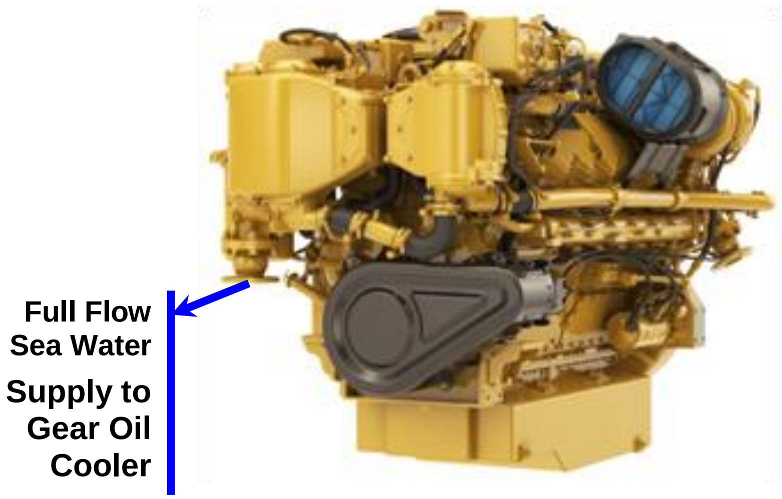

Figure 15: Full Flow Sea Water Supply to Gear Oil Cooler

Heat Recovery (Cabin Heater)

Caterpillar does not offer a heat recovery system or cabin heater options.

If aftermarket system is required Caterpillar recommends installing shut off valves on the supply and return lines from the engine to the system. Be sure to include the coolant volume in the cabin heater loop in the total coolant system volume. Adding coolant to the total system volume will increase required expansion volume. This volume is not accounted for in the expansion volume designed into the heat exchanger cooled engine arrangement. Please see the installation drawing to identify the supply and return locations from the engine to the vessel cabin heater.

Commission the engine first without the heat recovery system active to ensure the engine meets application requirements. Once complete operate the engine with the heat recovery system active. To ensure the engine is protected from over-cooling as a result of the heat recovery system being implemented, the measured jacket water temperature should be 70 deg C (158 deg F) or above.

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Heat Exchanger Schematic

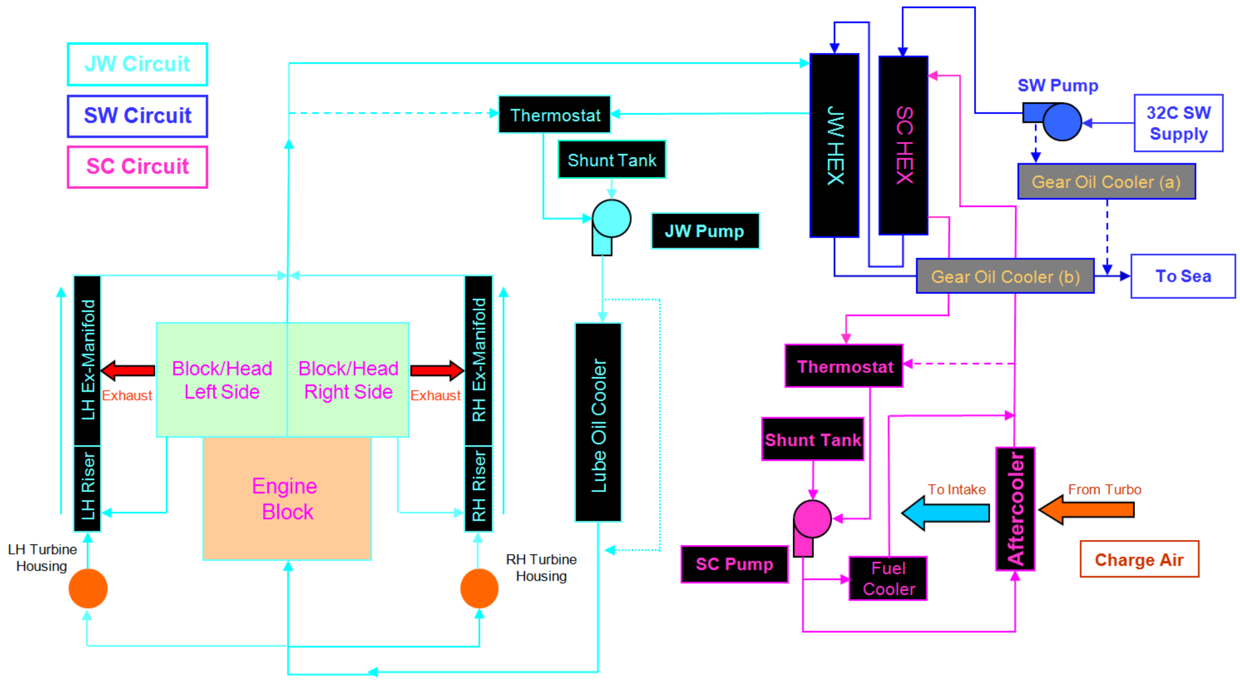

Figure 16: Heat Exchanger Schematic

Keel Cooled Schematic

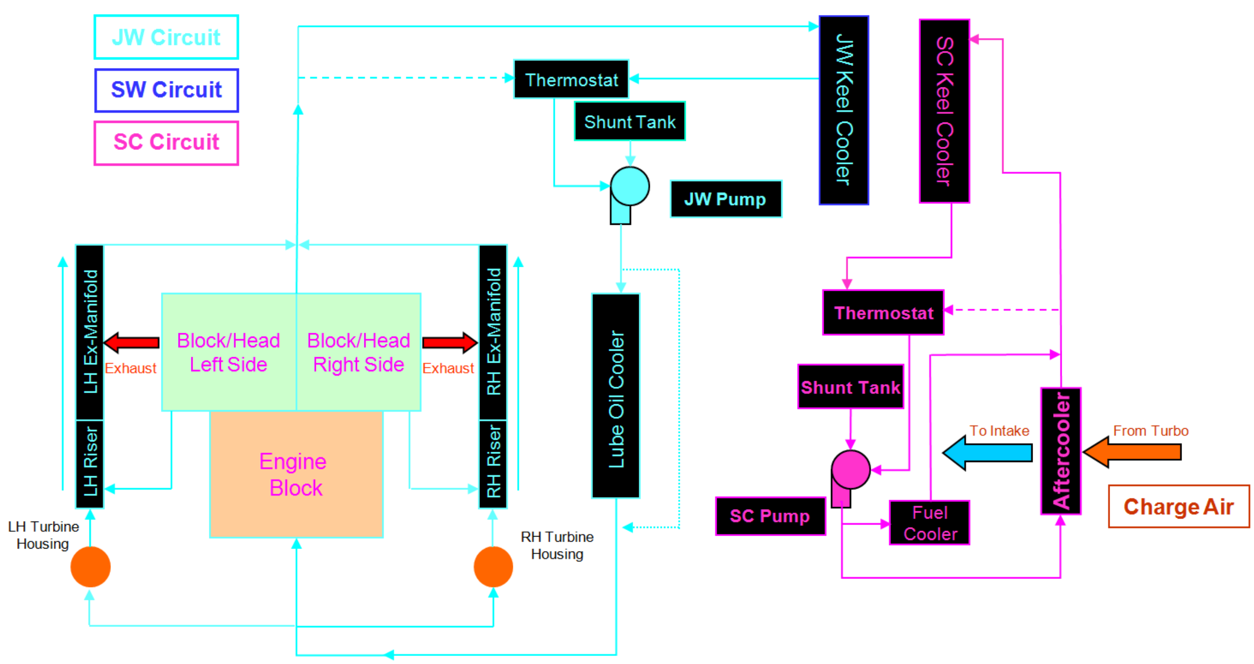

Figure 17: Keel Cooled Schematic

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Engine Bonding System

An engine bonding system is implemented to protect the engine from galvanic corrosion while installed in the vessel.

The engine must be bonded to zinc submerged in sea water. The bonding wire should be a minimum size of #8 American Wire Gauge (AWG). The zinc and the engine must share the same body of water. To achieve this we recommend installing the zinc inside the sea chest, as illustrated below.

To protect the engine from galvanic corrosion there must be a continuous column of sea water to the engine. If there is an air gap in the sea water line between the engine and the zinc, the bonding system will not be protecting the engine.

A check valve or an equivalent is required before the sea chest to ensure that an air gap is not created if the sea water drains back down from the engine.

The major point here is to make sure the zinc and engine have a continuous column of water from the zinc to the engine.

The bonding wire must be secured to both the engine and the zinc. Do not introduce any other systems in contact with the engine bonding system.

Do not bond the engine to the hull.

If the engine will be out of operation for a significant period of time (4 weeks or more) we recommend draining the sea water from the engine.

Sea Water Pump Above Water Line

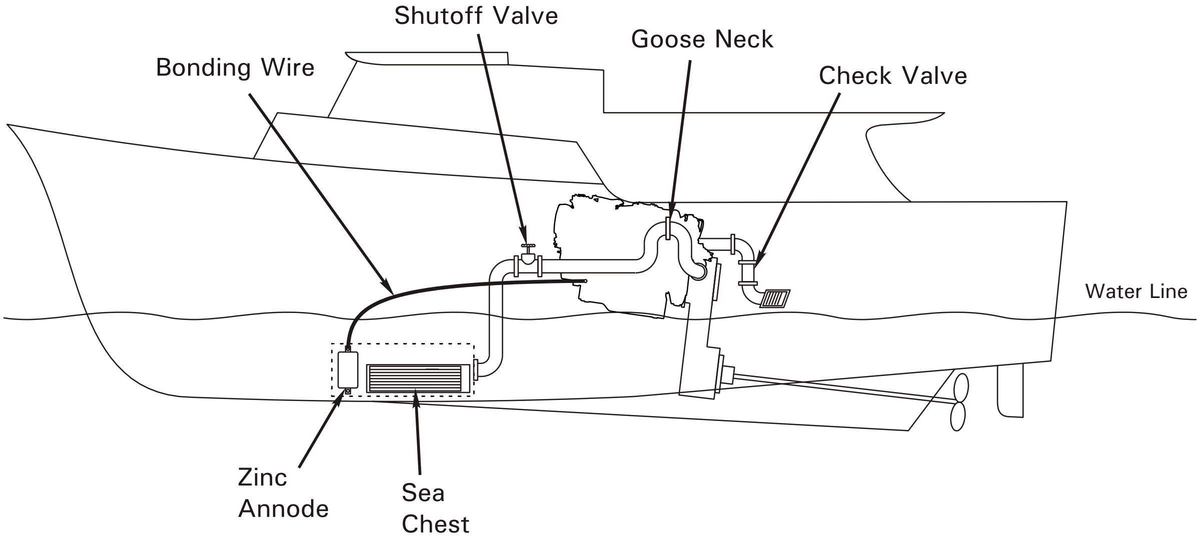

Figure 18: Bonding System Components with Sea Water Pump Above Water Line

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Bonding Stud Location

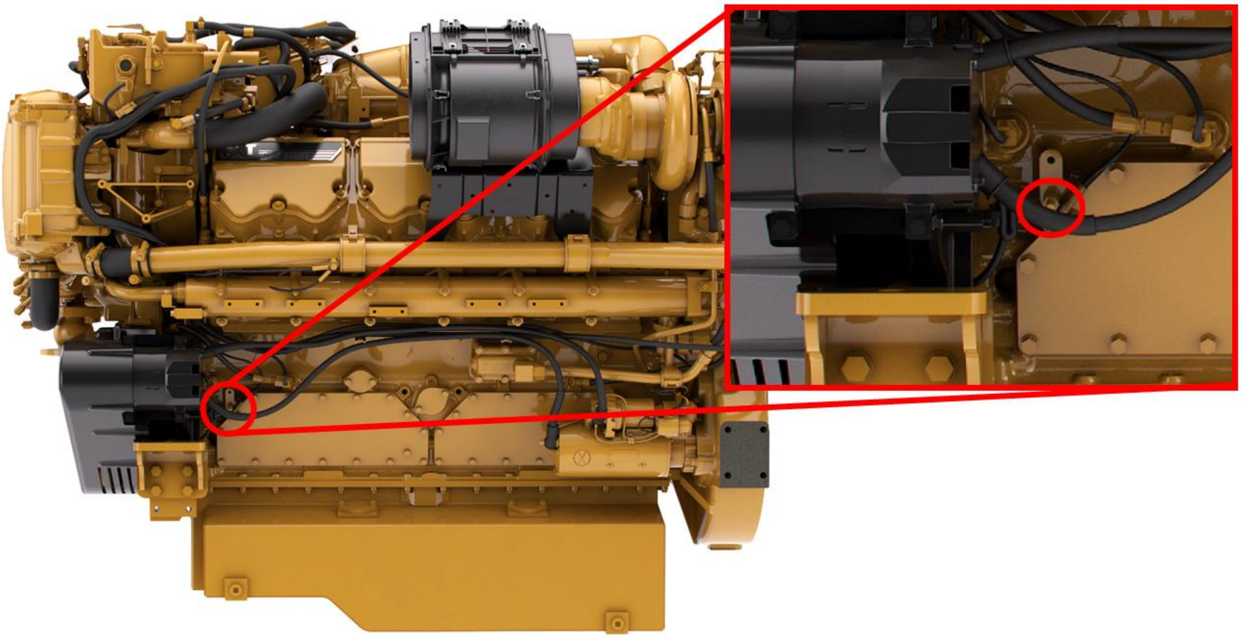

Figure 19: C32 Bonding Stud Location

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Exhaust System

The C32 SCAC Engines have water cooled exhaust manifolds and turbine housings.

Exhaust Backpressure Limits

The total exhaust backpressure limit is published in TMI under Systems Data. This level was established with an emphasis on low specific fuel consumption and exhaust valve temperatures. Therefore, to achieve proper performance of the engine, the exhaust backpressures must be kept below the published limit.

Vee engine exhaust piping should be designed with equal restrictions on each bank to prevent unequal bank-to-bank backpressure.

System backpressure should be measured in a straight length of the exhaust pipe at least three to five pipe diameters away from the last size transition from the turbocharger outlet. System backpressure measurement is part of the engine commissioning.

Measuring the exhaust pressure is a difficult task to get accurate. If the probe is not perpendicular to the flow you can get higher or lower values due to a venturi or static pressure affect across the probe. In addition if you just have a pipe probe entering the stream it should be a minimum diameter. Probes larger than 9.5 mm (3/8 in.) diameter can also get a venturi effect and can make the pressures read low.

Turbochargers

Turbocharger outlet connections and geometry illustrated on the engine installation drawings. Optional attachments such as flexible fittings (bellows), 90 degree elbows, mufflers and spark arresting mufflers (silencers) can be ordered with the engine.

The exhaust bellows are intended to compensate for thermal growth and movement of the engine. The vessel exhaust system structure immediately after the engine exhaust bellows must be a fixed/rigid point, and should not be supported by the engine. The supplied exhaust bellows will only handle the engine movement and thermal growth. No additional external loading is allowed on the turbochargers.

Exhaust Piping

A common exhaust system for multiple installations is not acceptable. An exhaust system combined with other engines allows operating engines to force exhaust gases into engines not operating. The water vapor condenses in the cold engines and may cause engine damage. Additionally, soot clogs turbochargers, aftercoolers, and cleaner elements. Valves separating engines' exhaust systems are also discouraged. High temperatures warp valve seats and soot deposit causes leakage.

The exhaust pipe diameter is based on engine output, gas flow, and length of pipe and number of bends. Sharp bends should be avoided and, where necessary, should have the largest possible radius. The minimum radius should be 1-1/2 pipe diameters. The piping should be as short as possible and insulated. The insulation

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should be protected by mechanical lagging to keep it intact. All flexible exhaust fittings should be insulated using removable quilted blankets. It is recommended to provide the system with a valve drain arrangement to prevent rainwater from entering the engine during prolonged shutdown periods. For testing purposes, the exhaust system must have a test port installed after the combined turbocharger outlets. This test port should be a 10 to 13 mm (0.4 to 0.5 in.) plugged pipe welded to the exhaust piping.

Exhaust piping must be able to expand and contract. It is required that one fixed point be installed directly after the flexible exhaust fitting at the turbocharger outlet. This will prevent the transmission of forces resulting from weight, thermal expansion, or lateral displacement of the external exhaust piping from acting on the turbocharger.

Water cooled exhaust systems are commonly used in the fast vessel industry. The systems are designed by the yard or consultants and vary somewhat from installation to installation. Caterpillar has no objections to these systems provided that the engine is properly protected and the parameters as outlined are adhered to. This is the shipyard’s responsibility.

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Fuel System

Tank Position

The fuel supply system must assure a continuous, clean supply of fuel. The tanks should not exceed the height of the engine fuel injectors in order to prevent possible leakage of fuel into the cylinders. If a higher position is required, check valves with backpressures set to the fuel column height must be installed.

Cat fuel transfer pumps lifting capability is published in TMI under Systems Data.

Line Restriction

The internal diameter of the piping/line size supplying fuel to the engine, and the fuel return line to the tank should be equal to or greater than the line size at the engine connections.

Maximum inlet restriction before the transfer pump is published in Systems Data in TMI under Systems Data.

Purge all air from the fuel system prior to starting the engine. Air in the system causes hard starting and erratic engine operation, and can erode injectors.

Flexible Connections

Connections to the engine must be flexible, and must be connected directly at the engine inlet and outlet to accommodate engine motion. The maximum recommended hose length is 30 inches.

The fuel supply location on the engine is NOT service side specific. The supply is always located on the right hand side of the engine near the water cooled engine exhaust riser. The fuel supply fitting is a male 7/8-14 JIC.

The fuel return location on the engine is service side specific and is located on the fuel filter base. The fuel return is always located in the aft position on the fuel filter base. The fuel return fitting is a male 3/4-16 JIC.

The fuel line connections are located on the Engine Installation Drawings.

Fuel Cooler

The fuel cooler is standard on all commercial engines. The fuel cooler is a plate type brazed cooler in the treated water aftercooler circuit and is located in the cavity behind the coolant tank for the aftercooler system.

Fuel Filters

A Cat standard engine mounted fuel filtration system should be considered as a secondary fuel filter system to the primary vessel mounted fuel filter system installed by the vessel builder or customer. The engine mounted fuel filter system has a duplex fuel filtration system with spin on type fuel filters. Caterpillar does not offer a simplex fuel filter system on this product.

- Duplex fuel filter systems are equipped with a diverter valve that allows the engine operator to change the fuel filter while the engine in operation.
- Refer to SISweb for fuel filter maintenance intervals.

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Lubrication Oil System

General

Standard engine mounted oil filters are equipped with a simplex oil filtration system, a duplex oil filter system is optional. Each engine is equipped with one engine mounted shell and tube oil cooler. The oil is cooled by treated water from the jacket water circuit.

Lubrication oil filters are available as service side specific and is selected by the dealer.

Oil Pan

All commercial ratings are equipped with a deep sump oil pan. This product does not have a shallow sump option. The oil pan itself contains an "oil cross-over tube," this tube is the conduit used for transferring oil from the right side of the engine to the left side. This tube is needed to supply oil to the filters mounted on the left side of the starboard engine.

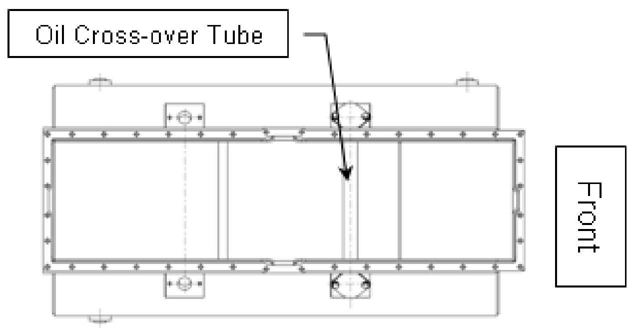

Figure 20: Top View of Oil Pan

Oil Change Intervals	
Engine Rating	**Interval (Hours)**
All Auxiliary Ratings	750
A - Rating	1000
B - Rating	750
C - Rating	500

Oil Filters

The lubrication oil filters are high efficient spin-on type filters.

- Simplex oil filter systems provide standard engine oil filtration.
- Duplex oil filter systems are equipped with a diverter valve that allows the engine operator to change the lubrication oil filter while the engine is in operation.
- Filters have a 5 micron filter media.

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Pre-Lubrication Recommendations

Pre-Lubrication systems can be installed by the dealer or customer as needed. Pre-Lubrication systems are often used on large engines but they are not required for C32 engines.

- Minimize size of the external system
- Do not introduce any foreign objects or debris to the system
- Install a check valve on the external pump outlet to engine
- Install two-way valves near the engine on the oil inlet and outlet to the external oil pump
- Ensure lines/connections to and from the external system are leak free
- Include the added external system oil volume when filling the engine with oil
- Ensure the inlet and outlet to the pump are connected in the correct locations from the engine the external pump
- Do not run the pre-lube oil system while the engine is running
- Use hose that is compatible with lubrication oil

Caterpillar offers a pre-lube pump and motor through Cat Parts. Part number 6N-5599 can be used and provides a flow of 49L/min (13 gal/min).

Illustrations of external oil pump supply and return locations on the engine are identified on the engine installation drawings.

Power Take Offs

Rear Hydraulic Pump Drives

The rear hydraulic pump drives are optional plug in drives. If rear PTO's are required but were not selected when the engine was ordered they can be installed by the dealer without having to remove the flywheel housing and updating the gear train. An SAE A and SAE B drive is available for the left and right hand side of the engine.

Engines equipped with a Cat rear mounted sea water pump cannot be equipped with left hand service rear hydraulic pump drives. Caterpillar does not offer auxiliary equipment (power steering pumps, etc.) for use with the drive adapters.

The rear hydraulic pump drives rotate clockwise when viewed from the rear and operates at 0.933 times engine speed.

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Starting System

Air Starter Description

This air starter is a turbine driven starter motor that does not require fuel or oil lubrication. It is supplied as a fully integrated module that includes the following features and/or components:

- Integral Controls and Solenoid Valves
- Integral Exhaust Muffler
- Integral Electronic Controller
- Electronic Starter Protection (ESP) Logic
- Pre-Engaged Starter Pinion Gear Drive and Over-Running Clutch

The starter pinion gear is fully engaged (to the engine ring gear) before the starter motor runs (cranks the engine). An over-running clutch provides maximum torque delivery and added protection of the starter pinion and engine ring gear.

The integral controls include a main air relay valve, and pilot-air solenoid w/manual bypass feature.

Integral muffler, center-diffused 360 degree muffler exhausts air at low velocity, through three replaceable sound dampening elements, each located under a metal guard screen.

The Integral electronic controller shares control with the engines control system, to provide consistent, error free operation and greatest starter reliability.

Air Quality and Filtration

Upstream installation and use of a filter or Y-strainer is recommended to protect the air starter from contaminants. Before running the starter, purge the upstream air system to remove debris. Inspect the condition of the filter on a monthly basis or as needed based on air quality and/or environment. Clean or replace filter as needed to prevent flow restrictions, reduced air starter power output, and contamination of starter controls.

Lubrication

The air starter does NOT require lubrication supply air. Therefore, the starter exhaust does not produce an oil or diesel mist, yet may contain condensed air system moisture and/or site air system chemicals/additives. The starter's internal gearbox and bearings are grease-packed and sealed.

Emergency Starting

The air starter has a manual bypass button, located on the pilot air solenoid. This allows the starter to be operated manually (without electrical power/control voltage). Continuous manual (pneumatic) control of the starter could potentially result in improper starter engagement. To minimize risk, it is strongly recommended for this feature to be used only in emergencies. DO NOT routinely use the manual bypass to operate the starter.

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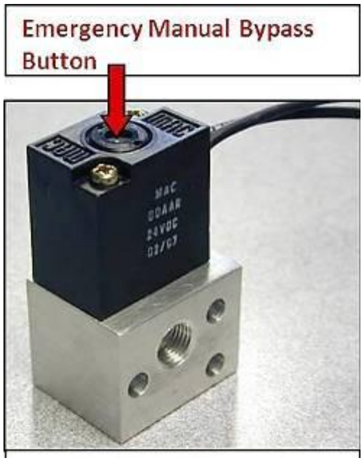
If the starter will only operate using the manual bypass, this likely indicates a problem originating with the following:

- Pilot Air Solenoid
- Electronic Controller
- Communication with the ECM



Emergency Starting Procedure:

(a) Locate the starter's pilot air solenoid

Locate the button on top of the coil.

Using a pointed object (pen, paper clip, screw driver), depress the button to actuate the starter.

CAUTION: The starter must never be engaged to a running engine.

In the event of emergencies (or loss of control voltage), use the manual bypass feature on the control solenoid to manually start the engine.

DO NOT repeatedly use the manual bypass to defeat the air starter's control module and engine control module. Make necessary repairs as soon as possible to avoid repeated use of the bypass feature, as this may result in air starter or engine damage. The starter should never be used to "bump" or "bar" the engine.

Air Starter Capacities			
	Minimum	**Recommended**	**Maximum**
Operating Air Pressure	2.7 Bar (90 psig)	6.89 Bar (100 psig)	10.3 Bar (150 psig)
Controller/Solenoid Elect Power Required.	24-volt (VDC)	24-volt (VDC)	26-volt (VDC)
Consumption	1337 m^3/hr (787 scfm)	1437 m^3/hr (846 scfm)	2111 m^3/h (1241 scfm)
Operating Temp (Ambient)	-28 deg C (-20 deg F) - 93 deg C (200 deg F)		

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Air Starter Installation Example

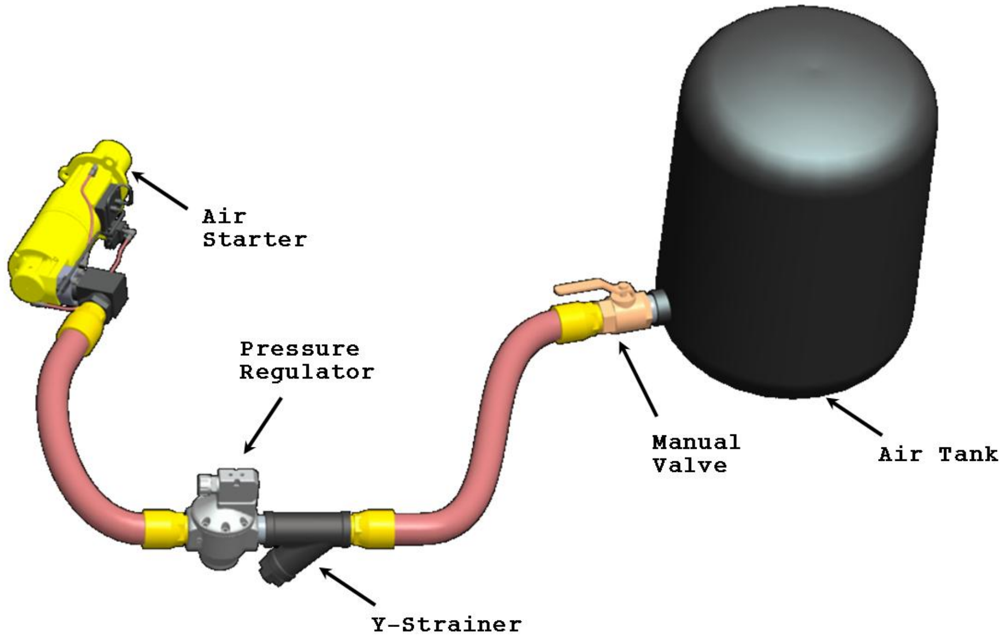

Figure 21: Air Starter Installation Example

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Mounting System

Isolator Mounts

Caterpillar offers two types of isolator mounts. A conical (non-thrust) mount and thrust/torque mount (TT).

The non-thrust conical mount is recommended for use in non-thrust applications, typically free standing engine arrangements with a remote gearbox (transmission). The engine should be isolated from all thrust loads in this application. Shore hardness or durometer for the non-thrust mount is 50.

Non-Thrust Mounts Mount Characteristics

Maximum Vertical Deflection..................... 14 mm

Maximum Load... 19 kN

Maximum Shock Load (All Directions) .... 70 kN

Thrust mounts are recommended in applications that transmit thrust into the mounting system, for example, close-coupled engine and gearbox (transmission) applications. In this circumstance the mounting system for the engine and gearbox is subject to thrust load being transmitted through the driveline. Durometer for the thrust mount is 70.

Thrust Mounts Mount Characteristics

Initial Load Limit

(4 mm vertical Compression).................. 13.25 kN

Maximum Vertical Compression.............. 26.75 kN

Maximum Vertical Tension.......................... 10 kN

Maximum Thrust Load........................... 29.75 kN

Maximum Fore Aft Shock Load .... +/- 85 kN

Maximum Athwartship Shock Load........ +/- 60 kN

Maximum Vertical Shock Load .... +75/ -200 kN

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C32 SCAC Marine Engine Hardware Summary

<table>
<tr><th rowspan="2">Application</th><th rowspan="2">Emissions Certification</th><th rowspan="2">Power Rating</th><th rowspan="2">Rated Speed (rpm)</th><th rowspan="2">S/N Prefix</th><th rowspan="2">Engine Sales Model / Price List</th><th colspan="5">Hardware</th></tr>
<tr><th>Turbo</th><th>Damper Group</th><th>Piston</th><th>Fuel Injector</th><th>Cam Shaft</th></tr>
<tr><td>Prop (A-Tier)</td><td rowspan="9">IMO II</td><td>660 bhp (492 bkW)</td><td rowspan="3">1600-1800</td><td rowspan="9">SDN</td><td>C32 MP3MC</td><td rowspan="5">T1</td><td rowspan="5">D1</td><td rowspan="5">P1</td><td rowspan="5">F1</td><td rowspan="5">C1</td></tr>
<tr><td>Prop (A-Tier)</td><td>750 bhp (559 bkW)</td><td>C32 MP3MC</td></tr>
<tr><td>Prop (A-Tier)</td><td>850 bhp (634 bkW)</td><td>C32 MP3MC</td></tr>
<tr><td>Prop (A-Tier)</td><td>950 bhp (708 bkW)</td><td>1600</td><td>C32 MP3MC</td></tr>
<tr><td>Prop (A-Tier)</td><td>1000 bhp (746 bkW)</td><td>1600-1800</td><td>C32 MP3MC</td></tr>
<tr><td>Prop (B-Tier)</td><td>1200 bhp (895 bkW)</td><td>1800-2000</td><td>C32 MP3MC</td><td rowspan="2">T2</td><td rowspan="2">D2</td><td rowspan="2">P2</td><td>F2</td><td rowspan="2">C2</td></tr>
<tr><td>Prop (B-Tier)</td><td>1300 bhp (971 bkW)</td><td>2100</td><td>C32 MP3MC</td><td>F3</td></tr>
<tr><td>Prop (C-Tier)</td><td>1300 bhp (971 bkW)</td><td>1800</td><td>C32 MP3MC</td><td rowspan="2">T2</td><td rowspan="2">D2</td><td rowspan="2">P2</td><td rowspan="2">F3</td><td rowspan="2">C2</td></tr>
<tr><td>Prop (C-Tier)</td><td>1450 bhp (1081 bkW)</td><td>2000-2300</td><td>C32 MP3MC</td></tr>
<tr><td>Aux / Genset</td><td rowspan="6">IMO II</td><td>791 bhp (590 bkW)</td><td rowspan="3">1500</td><td rowspan="6">RSD</td><td>C32MGE3MC</td><td rowspan="2">T1</td><td rowspan="2">D1</td><td rowspan="2">P1</td><td rowspan="2">F1</td><td rowspan="2">C1</td></tr>
<tr><td>Aux / Genset</td><td>923 bhp (688 bkW)</td><td>C32MGE3MC</td></tr>
<tr><td>Aux / Genset</td><td>1172 bhp (874 bkW)</td><td>C32MGE3MC</td><td>T2</td><td>D2</td><td>P1</td><td>F3</td><td>C2</td></tr>
<tr><td>Aux / Genset</td><td>916 bhp (683 bkW)</td><td rowspan="3">1800</td><td>C32MGE3MC</td><td rowspan="2">T1</td><td rowspan="2">D1</td><td rowspan="2">P1</td><td rowspan="2">F1</td><td rowspan="2">C1</td></tr>
<tr><td>Aux / Genset</td><td>1047 bhp (781 bkW)</td><td>C32MGE3MC</td></tr>
<tr><td>Aux / Genset</td><td>1333 bhp (994 bkW)</td><td>C32MGE3MC</td><td>T2</td><td>D2</td><td>P2</td><td>F3</td><td>C2</td></tr>
<tr><td>Prop (A-Tier)</td><td rowspan="9">EPA T3</td><td>750 bhp (559 bkW)</td><td rowspan="2">1600-1800</td><td rowspan="7">SDN</td><td>C32 MP3MC</td><td rowspan="4">T3</td><td rowspan="4">D1</td><td rowspan="4">P3</td><td rowspan="4">F4</td><td rowspan="4">C3</td></tr>
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<tr><td>Prop (C-Tier)</td><td>1300 bhp (970 bkW)</td><td>C32 MP3MC</td></tr>
<tr><td>Prop (C-Tier)</td><td>1450 bhp (1081 bkW)</td><td>2100-2300</td><td>C32 MP3MC</td><td>T5</td><td>F3</td></tr>
<tr><td>Aux / Genset</td><td>1047 bhp (781 bkW)</td><td rowspan="2">1800</td><td rowspan="2">RSD</td><td>C32MGE3MC</td><td rowspan="2">T4</td><td rowspan="2">D2</td><td rowspan="2">P4</td><td rowspan="2">F5</td><td rowspan="2">C4</td></tr>
<tr><td>Aux / Genset</td><td>1333 bhp (994 bkW)</td><td>C32MGE3MC</td></tr>
</table>

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Engine Preservation and Packaging

The Caterpillar factory has several standard levels of engine preservation and shipment protection. All engines that ship from the factory have plastic wrap protection. The plastic wrap provides approximately 6 to 12 months of external protection from moisture, sun and wind under storage conditions. If the engine is to be stored for longer periods of time, consider specifying Storage Preservation as described below.

Storage Preservation protects the engine and accessories from functional deterioration for a minimum of one year. It includes standard protective measures plus vapor corrosion inhibitor (VCI) in all internal compartments and glycol solution in the cooling system.

Export boxing protects the engine and accessories from functional deterioration for a minimum of one year under outside storage conditions. Including standard protective measures, vapor corrosion inhibitor in all internal compartments. The exterior box provides protection against mechanical damage during shipment and storage. All marine engines are placed upon wooden skids prior to shipment. All ship loose parts are painted and oiled and placed ship loose boxes. On arrival, open all boxes and review their contents against the packing list. The parts should then be repackaged and preserved for protection.

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Shipbuilder's Responsibility

Unless otherwise specified, the engine buyer shall be responsible for the following:

- Ensure all coolant, lube oil piping, fuel oil piping, exhaust piping and intake air ducting are free of rust, scale, weld spatter and foreign material prior to startup of the engines.
- Provide electrical wiring and the necessary piping to the engine, i.e., exhaust piping, fuel oil piping to and from the engine, air piping to the starting motor(s), air filter ducting/piping, crankcase fumes disposal ducting, etc. All of the above noted interconnections need to be designed in such a way so as to comply with acceptable vibratory levels of excitation throughout the entire range of engine operation. No primary resonances in the interface hardware are acceptable.
- Furnish and install standby pumps as required by Marine classification societies.
- Install adequate engine foundation and provide proper chocking and alignment between the engine and marine gear.
- Provide adequate clearance for disassembly of engine (i.e. overhead clearance for connecting rods and piston removal can be found in the Serviceability Considerations Application and Installation (A&I) Guide LEGM4735).
- Provide primary fuel filtration system.
- Provide all labor, equipment and hardware to install the equipment.
- Furnish accurate data for a torsional vibration analysis.
- Provide all coolants, water treatment chemicals (if used), lubricating oil, and fuel oils necessary to operate the engine.
- Warehouse and protect engines, accessories and miscellaneous ship loose equipment until their installation. Cat engines are protected against corrosion for inside dry storage for a period up to six months. Provisions for additional storage periods are available from the factory.

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Reference Material

The following information is provided as additional reference to subjects discussed in this guide.

LEGM4735
Serviceability Considerations Application and Installation (A&I) Guide

The product price list can be accessed online through Power Net.	https://engines.cat.com/marine
Marine Product Application and Installation webpage can also be accessed via Power Net.	https://engines.cat.com/marine/application
Engine Installation drawings can be retrieved from the Engine Drawing Design Center (EDDC). A paid subscription is required to download drawings from this site.	https://enginedrawings.cat.com/
Technical Marketing Information (TMI) / engine performance data can be obtained from TMI Web.	http://tmiweb.cat.com/
Service and maintenance information can be obtained from the Service Information System (SIS Web)	https://sis.cat.com/

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