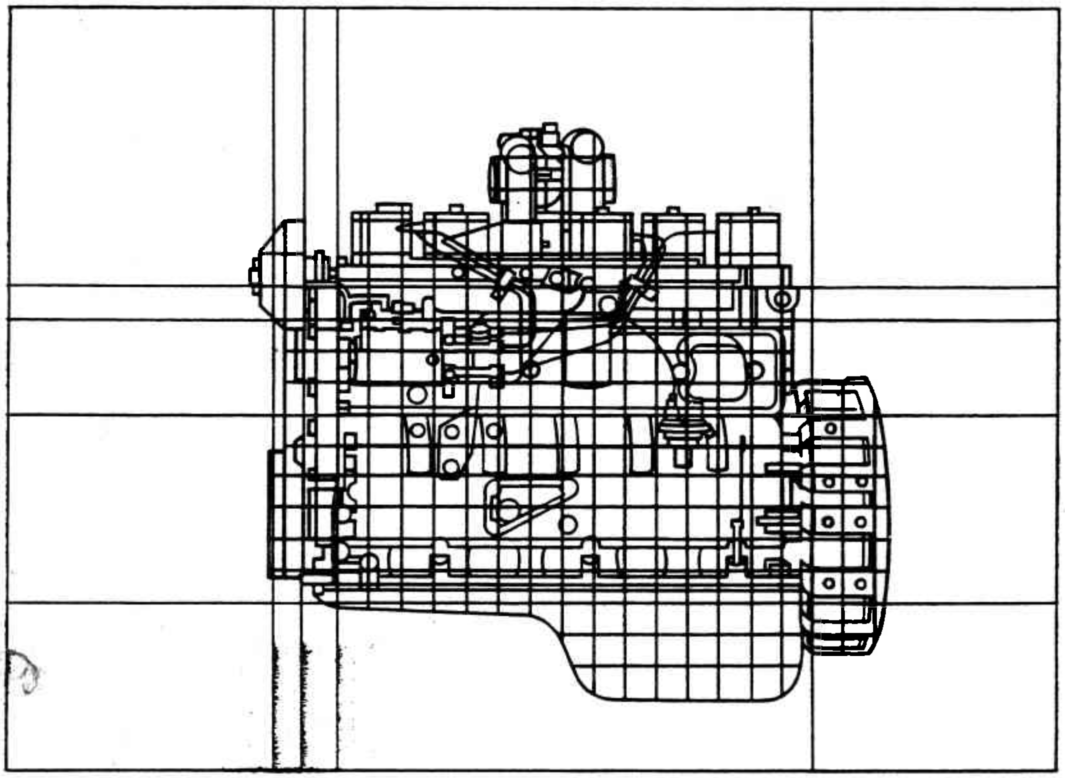
B & C Series Engines Installation Recommendations



Engine Mounting

The Engine Mounting System must:

Limit the static bending moment at the rear face of the block to the values in the bending moment section.

Limit the static bending moment at all mounting pads on the block to the values in the bending moment section.

Not solid mount a 4-cylinder engine unless the engine is equipped with an engine balancer.

Provide the vibration and noise isolation required by the application and/or regulation.

Isolate the engine from frame deflections.

Limit engine movement from shock, inertia or other forces so that the engine cannot make contact with chassis components.

1. Bending Moment Values

The maximum static bending moment at the rear face of the block is: 1000 ft.-lb. (1350 N•m).

The maximum static bending moment at the front support mounting surface is:

	Maximum Allowable Static Moment	Maximum Moment Arm (from mount face)
"B" Series	3840 in.-lb. (435 N•m)	4 in. (102mm)
"C" Series	4400 in.-lb. (495 N•m)	4 in. (102mm)

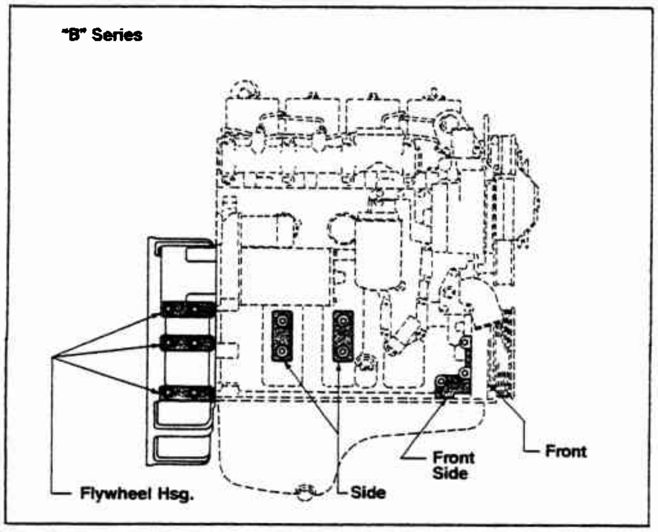
Note: C Series front supports mount on gear housing which is 1.4 in. (35 mm) thick.

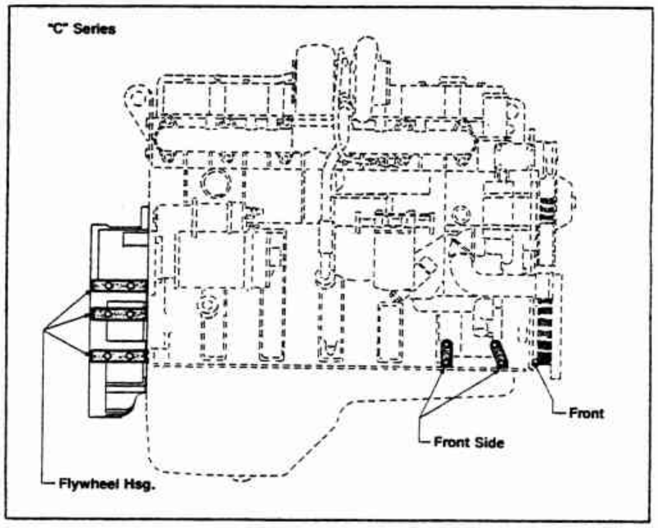
The maximum static bending moment at the side engine mounting pads is:

	Maximum Allowable Static Moment	Maximum Moment Arm (from mount face)
"B" Series		
Block—Front side pads	1250 in.-lb. (140 N•m)	5 in. (127mm)
Side pads	3250 in.-lb. (365 N•m)	5 in. (127mm)
Flywheel housing pads	1950 in.-lb. (220 N•m)	3 in. (76mm)
"C" Series		
Block—Front side pads	1800 in.-lb. (205 N•m)	5 in. (127mm)
Flywheel housing pads	2200 in.-lb. (250 N•m)	3 in. (76mm)

Note: All above limits are based on a maximum vertical dynamic load of 5 g's.

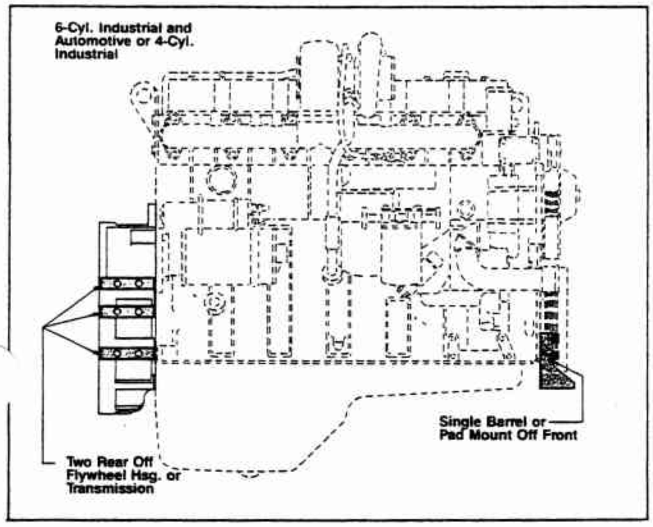
2. Mount Attachment Locations

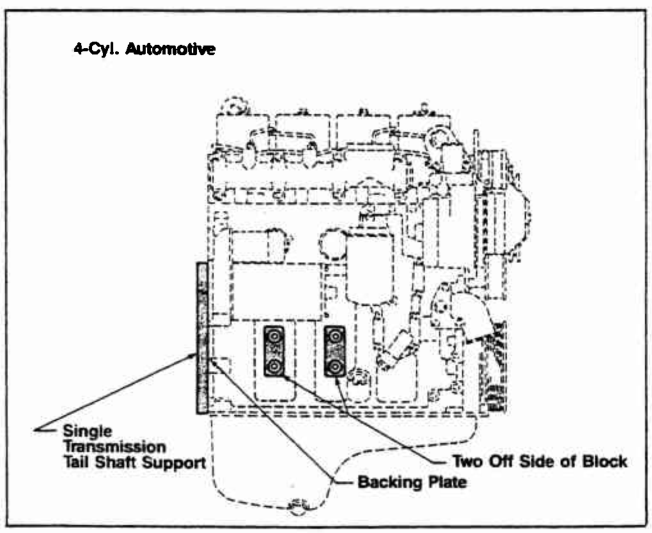




3. Engine Mount Arrangements

A three point mounting system is recommended for mobile applications. Generally, this may be accomplished with two rear mounts off the flywheel housing and a pad or barrel mount off the front support (off-highway and six cylinder automotive) or two pad-type mounts off the side of the engine and a third attachment off the transmission (automotive). Whatever arrangement is used, an isolator elastomer should be selected which will avoid engine or mount damage due to vibration amplification (this is particularly critical in 4-cylinder applications).





4. Special Mounting Considerations for 4-Cylinder Engines.

The major problem encountered in mounting any four cylinder in-line, four cycle engine is vibration isolation. The two major modes of vibration common to these engines are both second order and occur at opposite ends of the engine speed range. The more severe of these is caused by inertial forces and results in a vertical vibration occurring through the middle of the engine. Its magnitude is proportional to the square of the engine speed. The second vibration mode results from a combustion reaction at low engine speeds causing the engine package to rotate about the roll axis.

Although the vibratory input of the engine may be known, the effect of this vibration acting on a piece of equipment depends on several parameters and may not be easily determined. Equipment weight, operating environment, frame stiffness and equipment function all partially define the amount of isolation which must be provided by the mounting system to achieve an acceptable equipment vibration level.

A three-point mounting system with pad-type isolators used with a single front mount from the engine front support and rear mounts from each side of the engine flywheel housing or transmission cover will provide acceptable isolation of both major vibrations when the proper isolator material is used.

The selection of the isolator material will be dependent upon engine input frequency, mount loading, allowable engine movement, and required isolation level.

- Engine input frequency for a four cylinder "B" Series engine with a 700 rpm idle speed is 23 Hz.
- Individual mount loading will be dependent upon the total installed weight of the engine and transmission package. Typically, in these applications, loading will be as follows:

Front Mount	200-275 lbs.
Rear Mounts	325-400 lbs. each

- Allowable engine movement is based upon physical constraints of the installation such as drive alignment, fan shrouds, etc.
- The minimum suggested level of isolation is 60%.

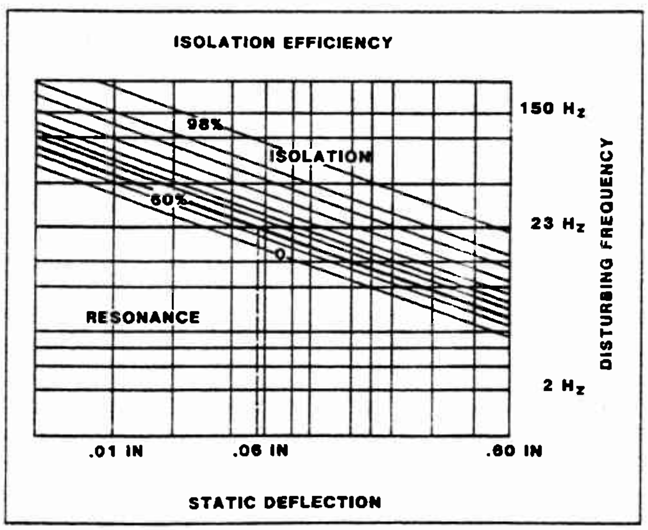
Based upon the isolation efficiency chart below, an efficiency of 60% for a 23 Hz disturbing frequency would require a static deflection of .060 inch (this would represent the stiffest suggested mounting for these applications). Using the typical mount loading shown above, and the static deflection just determined, the required mount spring rate can be calculated by dividing the mount loading by the static deflection. Therefore, for typical four-cylinder applications in the subject equipment, suggested mount spring rates would be in the ranges shown in the table below.

	Stiff		Semi-Soft		Soft	
Efficiency (%)						
Range	60-82		82-88		88-92	
Nominal	71		85		90	
Static Defl. (In.)						
Range	.060-.100		.100-.150		.150-.200	
Nominal	.080		.125		.175	
	Front	Rear	Front	Rear	Front	Rear
Suggested Spring Rate (lb/in)	3125	4525	2000	2900	1425	2075

The task of selecting the proper mounts for any application can be summarized as follows:

1. Determine the individual mount loading (mount reaction).
2. Select the desired static deflection (Based on isolation efficiency).
3. Choose a mount of sufficient load capacity which provides the required static deflection and/or spring rate.

Each individual mounting system will react uniquely, and some fine tuning may be required as a function of specific components and installation geometry.

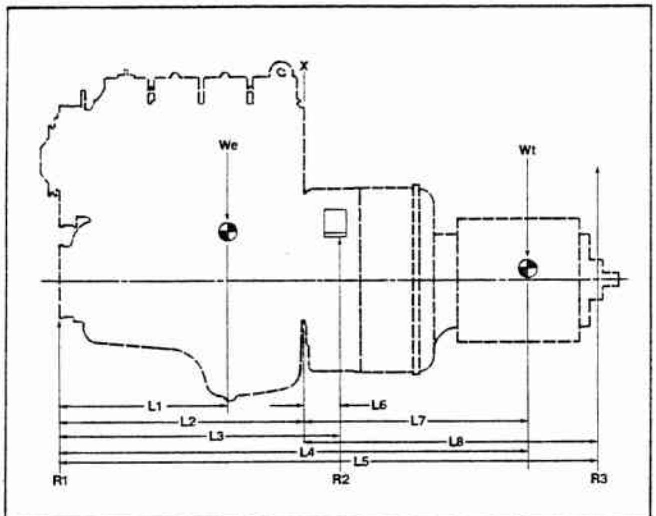


Four cylinder "B" Series unbalanced engines can cause severe transmission bending resonance leading to transmission or engine component failure with certain transmissions. Testing and approval is necessary before using any transmission mounted directly to an unbalanced four cylinder engine.

5. Consideration of Disturbing Forces for Selection of Mounting Isolators.

The major disturbing forces at engine idle speed are due to engine cylinder firing. A four cylinder, four cycle engine fires twice per crankshaft rotation. To insure adequate isolation at idle, the roll natural frequency of the engine/transmission package should be below 14 Hz. The six cylinder engine fires three times per revolution therefore, the roll natural frequency should be below 20Hz to insure adequate isolation.

6. Determination of Bending Moment for Transmission Tail Support Installation



We — is the wet weight of the engine in lb. (Kg) — made up from the dry weight of engine plus the weight of water and oil in the engine.

Wt — is the wet weight of the transmission package in lb. (Kg) — made up from the dry weight of the transmission, the weight of the clutch plus the weight of the oil in the transmission.

R1 — is the front support reaction in lb. (Kg).

R2 — is the combined flywheel housing supports' reaction in lb. (Kg).

R3 — is the tail support reaction in lb. (Kg).

X — is the plane of the rear face of the block.

L1 to L8 are horizontal distances between supports, centers of gravity and the rear face of the block (as illustrated in the diagram) in in. (mm).

The engine mount reactions, R1 and R2 must first be determined. To do this, the tail support reaction, R3, must be assumed to be zero or a predetermined value which may be built into the unit.

$$R2 = \frac{We\,L1 + Wt\,L4 - R3\,L5}{L3}\ \text{lb.(Kg)}$$

then

$$R1 = We + Wt - R2 - R3 \quad \text{lb.(Kg).}$$

The bending moment between the flywheel housing and the rear face of the block, Mx, can then be determined.

$$Mx = R2\,L6 + R3\,L8 - Wt\,L7 \quad \text{lb. - in. (kg-mm)}$$

This may then be checked by:

$$Mx = R1\,L2 - We\,(L2\text{-}L1) \quad \text{lb.-in. (Kg-mm)}$$

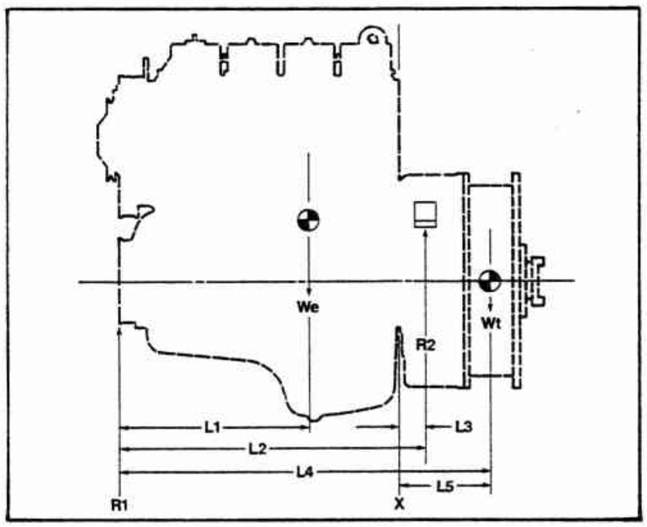
The result may then be divided by 12 (1,000) and compared to the 1,000 ft.-lb. (1 350 N•m) maximum allowable value established for the B and C Series engines.

When the locations of R1 and R2 are fixed, the transmission support preload required to give zero Mx may be determined as follows:

$$R3 = \frac{We\,L1 + Wt\,L4 - \dfrac{(Wt\,L7\,L3)}{L6}}{L5 - \dfrac{(L8\,L3)}{L6}}\ \text{Lb. (Kg)}$$

This may then be checked by inserting the value found for R3 in the formula for R2 above; then inserting the values of R3 and R2 in the formula for R1 above; and finally solving the formula for Mx above. The result for Mx should equal zero.

7. Determination of Bending Moment for Overhung Transmission Installation



We — is the wet weight of the engine.

Wt — is the weight of the transmission package — made up from the dry weight of the transmission, the weight of the clutch or drive adapter, plus the weight of the oil in the transmission.

R1 — is the front support reaction.

R2 — is the flywheel housing support reaction.

X — is the plane of the rear face of the block.

L1 to L5 are the horizontal distances between supports, centers of gravity and the rear face of the block.

$$R2 = \frac{We\,L1 + Wt\,L4}{L2}$$

$$R1 = We + Wt - R2$$

$$Mx = Wt\,L5 - R2\,L3$$

Air Intake System

Every installation must include effective provision for removing airborne dirt particles from the intake air.

The system restriction must not exceed 20 in. (508mm) H_2O on naturally aspirated engines or 25 in. (635mm) H_2O on turbocharged or turbocharged and aftercooled engines. The air cleaner should have the recommended dirt holding capacity for the classification selected.

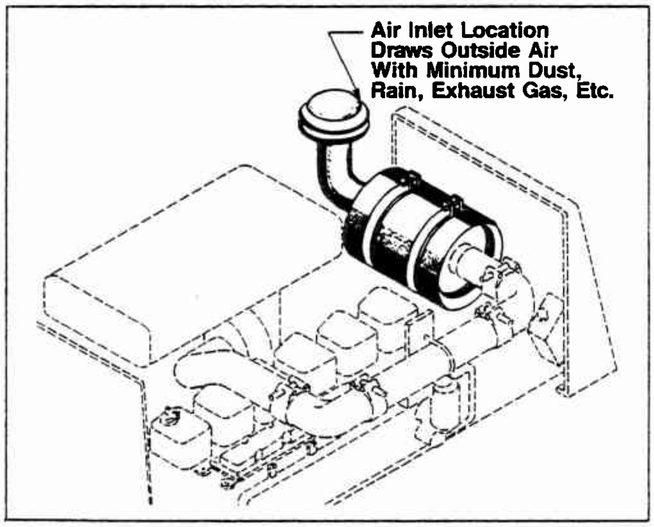
The air inlet location and piping arrangement must be selected to assure the air temperature rise from ambient to the engine air inlet does not exceed 30 degrees F (15 degrees C).

The air inlet must be located or shielded against direct ingestion of water or exhaust gas.

The integrity of the piping should not be broken during operation or routine maintenance functions.

1. Air Inlet Location

Choose a location which will pick up a minimum of rain, snow, dust, exhaust gas, etc., and will not draw heated or engine compartment air.



2. Air Cleaner

A normal duty air cleaner may be used only in those applications where the engine is operated indoors or in other similar clean environments.

A medium duty air cleaner will be suitable for most automotive applications.

A heavy duty air cleaner should be used in most construction/industrial applications or other operations exposed to high dirt content.

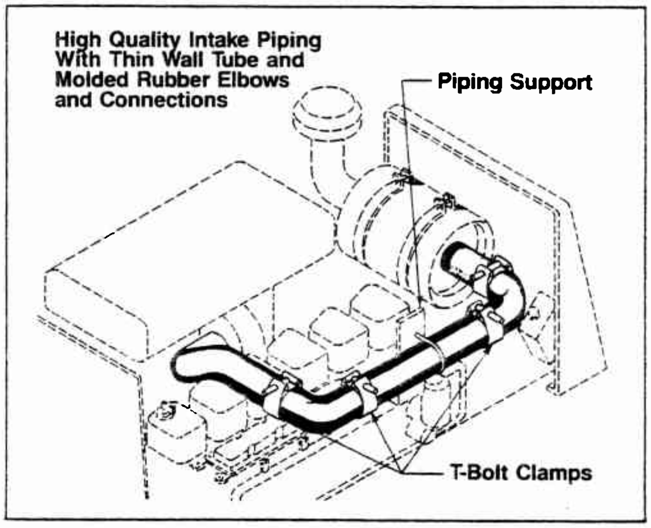
Air Cleaner Ratings

Duty	Type	Recommended Initial Restriction In. (mm) H_2O	Dirt Holding Capacity g/CFM	Maximum Rest. In. (mm) H_2O N.A.	Turbo
Normal	1-Stage	10 (254)	3	20 (508)	25 (635)
Medium	2-Stage	12 (305)	10	20 (508)	25 (635)
Heavy	2-Stage	15 (381)	25	20 (508)	25 (635)

Dirt holding capacity and initial restriction affect maintenance interval and are not an indication of filter efficiency.

3. Intake Piping

Mount the intake piping so that it does not impose excessive stresses on the intake manifold or turbocharger due to weight or relative motion. To minimize restriction, route the piping as directly as possible from the air cleaner to the engine air intake and use the pipe sizes recommended. Reductions in pipe size should occur at the engine.

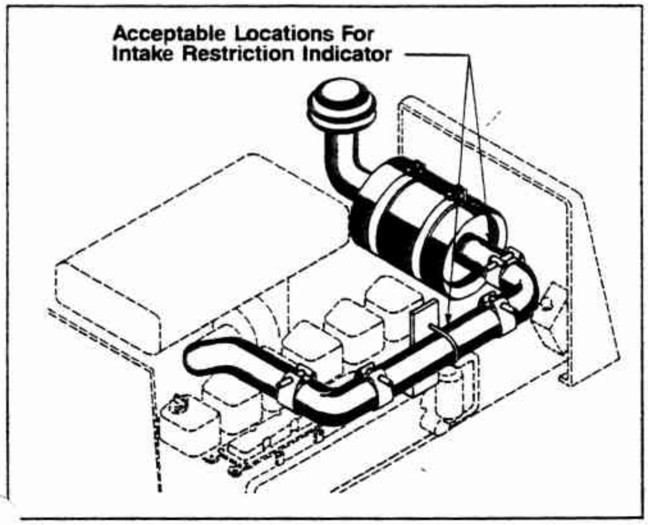


Recommended Pipe Sizes

4B(T/A)3.9 & 6B5.9	3 in. (75mm)
6BT(A)5.9	4 in. (100mm)
6C(T/A)8.3	5 in. (125mm)

4. Intake Restriction

The restriction level with a clean element should not exceed the value specified in the "Air Cleaner Rating Tabulation" for acceptable element life (check intake restriction at the maximum rated speed and load). To simplify air cleaner service, provide an attachment point for an intake restriction indicator.



Exhaust System

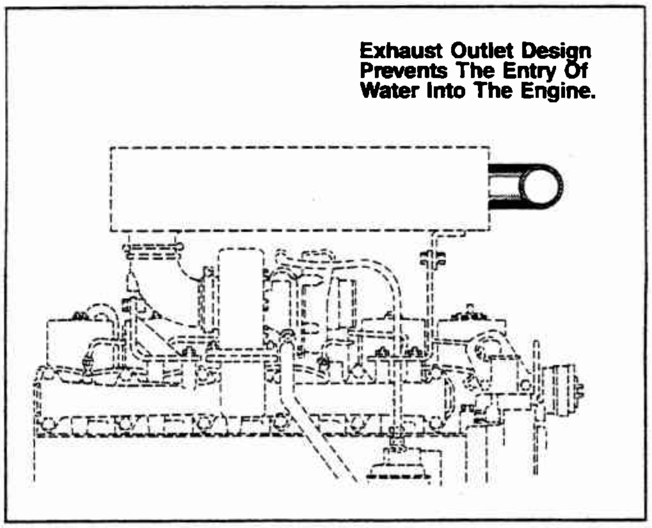
The exhaust back pressure must not exceed 3.0 in. (76mm) Hg. (Exhaust back pressure of up to 4.5 in. (114 mm) Hg is allowed for all EPA certified "B" Series engines.)

The exhaust system components must not impose excessive stresses on the exhaust manifold or turbocharger due to weight, relative motion of components or dimensional change due to thermal growth.

The exhaust system must be designed to prevent the entrance of water into the engine and/or the turbocharger.

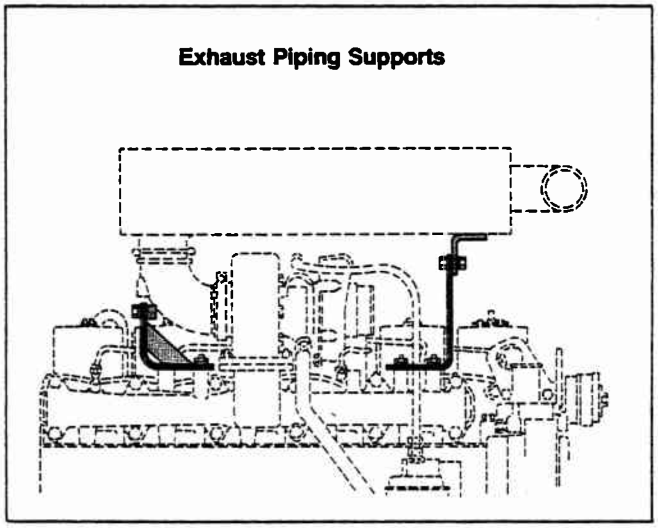
1. Exhaust Outlet Location

Position the exhaust outlet to prevent the entry of water into the engine. Use rain caps or similar devices if required.



2. Exhaust Piping

Mount the exhaust piping so that it does not impose excessive stresses on the exhaust manifold or turbocharger due to weight, relative motion or thermal expansion. The maximum allowable bending moment is 37 N•m (27 ft.-lb.) at the exhaust manifold outlet flange and 13.5 N•m (10 ft.-lb.) at the turbocharger exhaust outlet. Remote (off-engine) mounted mufflers may require the use of flexible sections in the exhaust piping to prevent overstressing exhaust system components.



To minimize exhaust restriction, route the piping as directly as possible and use the recommended exhaust pipe sizes.

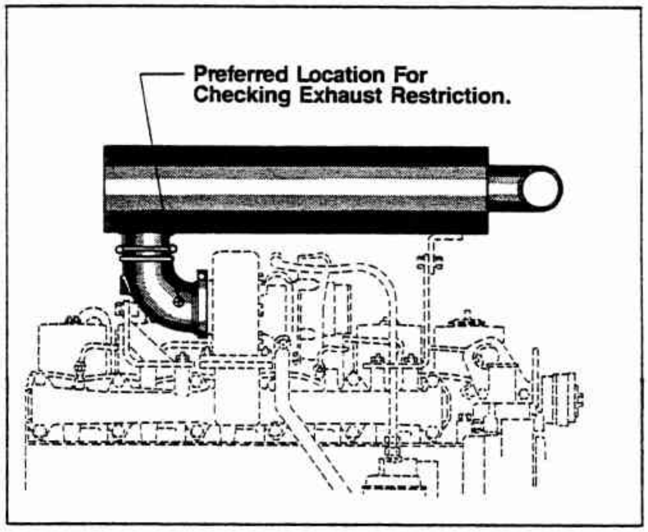
Recommended Exhaust Pipe Sizes	
"B" Series	3.0 in. (75 mm) ID
"C" Series	4.0 in. (100 mm) ID

3. Exhaust Silencer (Muffler)

Select a muffler design and location based upon the physical and noise attenuation requirements of the application. The silencer manufacturer can provide assistance with this selection. The minimum silencer size should be based on the engine exhaust gas flow as listed on the Engine Data Sheets.

4. Exhaust Restriction

Maximum allowable exhaust restriction level at maximum engine rated speed and load is 3.0 in. (76.0 mm) Hg. (Exhaust back pressure of up to 4.5 in. (114mm) Hg is allowed for all EPA certified "B" Series engines.) Exhaust back pressure should be checked in a straight section of tube as close to the engine as possible.



Cooling Systems

The cooling system must be designed to assure the maximum top tank temperature of 210 degrees F (99 degrees C) is not exceeded.

Intermittent operation up to 230 degrees F (110 degrees C) is acceptable for up to 50 hours per year if a 15 psi (105 kPa) pressure cap is used.

Coolant expansion space equal to 6% of total system capacity must be provided.

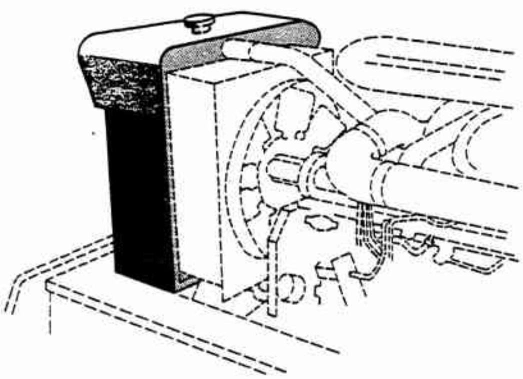
The system must fill at a minimum 5 gpm (19 l/min) rate to a level that assures positive cylinder block coolant pressure is maintained under all operating conditions.

The C Series engine must incorporate a corrosion resistor that contains adequate content to properly treat a new system and maintain the proper concentrations with normal service intervals.

1. Radiator

Mount the radiator so that it receives an adequate supply of fresh air. The mounting should isolate the radiator core from unnecessary vibration and frame deflections.

Properly Sized Radiator Isolated From Vibration and Frame Deflections



The efficiency of the fan and radiator combination is highest when the unswept area of the radiator core is minimized; therefore radiators that are nearly square are preferred.

The precise size and style of radiator and fan should be verified by test or calculation, however, for general guidance 2½ - 3 sq. ft. of frontal area per 100 hp (310 - 375 sq. mm/100 kW) may be used.

Equipment operating in dirty environments should use radiator cores with in-line or canted tubes and widely spaced, straight-thru fins with 6-8 fins/inch (3-4 mm/fin) to minimize clogging problems.

2. Cooling Fan

Locate the fan at least 0.75 inch (20mm) away from engine components to minimize noise, reduce fan blade vibration and improve air flow past the engine. For optimum air flow the fan should be located as far from the core as practical. Sucker fans should be located at least 2 inches (50 mm) away from the core and blower fans should be located at least 4 inches (100 mm) from the core.

Lockwashers should never be used when mounting fans as they may induce stress cracks in the fan spider.

The bending moment imposed on the front of the fan hub should not exceed 60 in.-lbs. (7.0 N•m). (Total weight of the fan and spacers x total length of spacing). Total spacer thickness should not exceed 3.00 inches (75 mm).

Fan mountings on unbalanced 4 cylinder engines require special attention. In general, fans on these engines should be as light as practical and should be mounted as close to the engine as sound installation practices allow. As a guideline, the overhung moment imposed on the front of the fan hub on these engines should not exceed 20 in.-lbs. (2.5 N•m).

As a guideline, fan tip speeds should be limited to a maximum of 18,000 ft./min. (91 m/s).

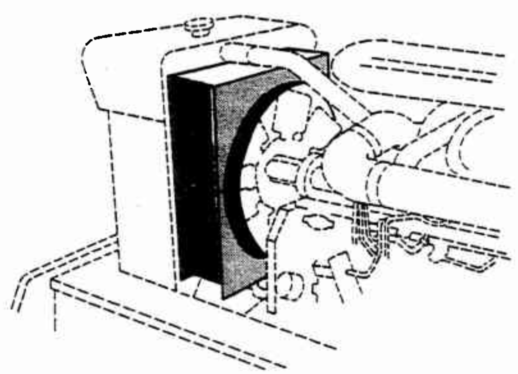
3. Fan Shroud

The B and C Series engines feature fixed position fan brackets to allow for closer fan to shroud positions to optimize air flow. For maximum air flow, fan tip to shroud clearance should not exceed 2.5% of the fan diameter with box or ring type shrouds and 1.5% for venturi-type shrouds.

In general the fore and aft relationship of the fan to the shroud should be ⅔ of the fan projected width into the shroud on sucker fans and ⅓ into the shroud with blower fans.

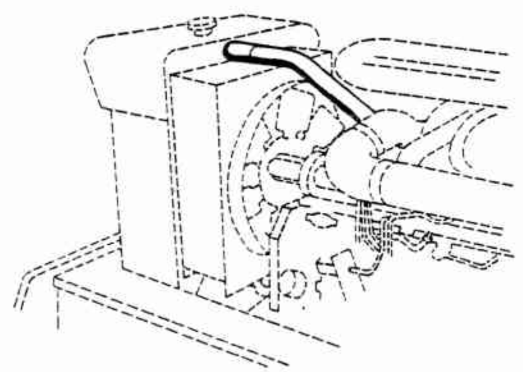
It is common practice in many installations to incorporate baffles between the radiator and the machine body work to eliminate the recirculation of heated air that has passed through the radiator.

Fan to shroud clearances should be checked to assure that no contact occurs due to relative motion between the engine and the radiator.



4. Radiator Plumbing

The piping between the engine and the radiator should be as direct and include as few bends as possible. All piping should be flexible enough to provide for relative motion between the engine and the radiator.



If an engine vent is utilized it must be plumbed to the radiator top tank or auxiliary tank above the normal coolant level or to the engine coolant outlet.

5. Pressure Cap

The maximum top tank temperatures and design ambient temperatures stated in the Cooling System Guidelines require a 15 psi (105 kPa) pressure cap. The pressure cap requirement is reduced to 7 psi (50 kPa) in light duty and normal duty applications where the additional operating range for emergency situations is not required. The maximum allowable operating temperature with a 7 psi (50 kPa) pressure cap must not exceed 210 degrees F (99 degrees C).

6. Coolant

The maximum top tank temperatures and design ambient temperatures stated in the Cooling System Guidelines are based on the use of a 50/50 water/ethylene glycol solution. This solution aids in reducing cavitation and erosion as well as raising the boiling temperature in warm weather and functioning as anti-freeze in cold weather.

7. Corrosion Resistor

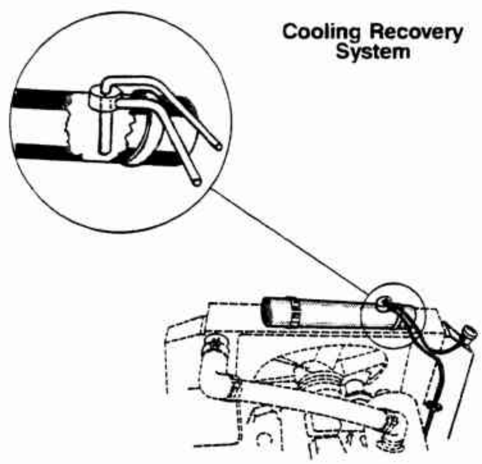
The C Series engine must be equipped with a corrosion resistor containing an adequate concentration of chemicals to inhibit corrosion or erosion of the engine coolant passage surfaces for reasonable servicing intervals. The coolant must be filtered to remove dirt, metallic, and mineral contaminants. (REF: "Cooling System Maintenance" service bulletin #3387363)

8. Expansion Space and Reserve Capacity

The cooling system must incorporate a method of providing 6% of the total system capacity for expansion plus a "reserve volume" of coolant. This "reserve volume" must be sufficient to assure normal cylinder block pressures will be maintained after minor losses of coolant due to evaporation and minor undetected leaks. The combined expansion space and "reserve volume" should be 10% of total system capacity.

Reserve capacity should be determined by running a fully topped off system to establish normal cylinder block pressure and slowly draining coolant into a container until a 10% loss of block pressure is noted. A measure of the amount removed is the reserve capacity of the system.

The recommended system for providing reserve capacity on both B and C Series engines is a coolant recovery system with the reservoir mounted above the coolant level in the top tank. The reservoir must have a capacity equal to or greater than 10% of the total system capacity. The use of this size and type system eliminates the necessity for 6% expansion space in the top tank.



Cooling Recovery System

Conventional, baffled radiator top tanks may be used. Both the slotted baffle type and the fully sealed baffle type are acceptable. When a baffled top tank is used the recommended reserve capacity must be provided above the baffle. The recommended expansion space must be provided via an extended fill neck with a vent hole in the extension just inside the top tank or with an appropriately sized coolant recovery system.

If a continuous venting, fully deaerating system is utilized, special attention will be required in the proper sizing of both the engine vent and make-up lines to assure that vent line flow does not exceed make-up line flow.

The cooling system must fill at a minimum 5 gpm (19 l/min.) fill rate to a level that assures a positive cylinder block coolant pressure is maintained under all operating conditions. The B Series engines are equipped with an internally vented thermostat. However in some installations it may be necessary to utilize an optional external "jiggle pin" vent valve plumbed to the radiator top tank above the normal coolant level to obtain adequate initial fill. C Series engines are not equipped with a vented thermostat. Acceptable fill may be obtained on the C Series engine by connecting the optional "jiggle pin" vent (when specified) to the radiator top tank above the normal coolant level or by opening the optional petcock vent during fill until a solid flow of coolant is obtained.

9. Water Pump

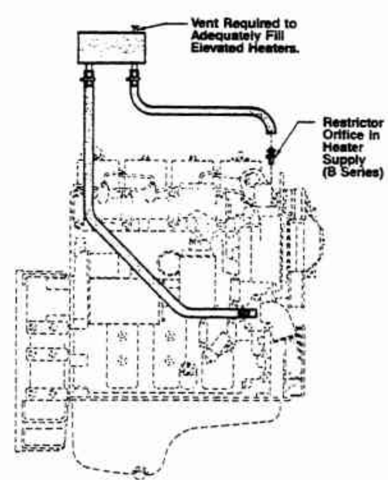
A positive head is desirable at the water pump inlet. This can be achieved by locating the top tank as high as possible and/or using a free flowing radiator. The maximum external pressure drop from engine water outlet to the engine water inlet is 5 psi (35 kPa).

10. Heater Plumbing and Location

Coolant pressures on the B Series may reach 50-60 PSI (345-415 kPa) and may exceed the heater manufacturer's pressure limitations. Therefore care must be exercised to properly restrict the pressure with a restrictor orifice in the coolant supply line to the heater. Experience has indicated that a ¼ in. (6 mm) restrictor is satisfactory on engines rated up to 2500 RPM and a 3/16 in. (5 mm) restrictor is adequate for engines rated up to 2800 RPM. Properly sized fittings are available from Cummins Engine Co., Inc.

Large elevated heaters may cause problems in obtaining adequate system fill and should be evaluated to assure large quantities of air are not trapped in the system. In some installations it may be necessary to vent the heater during fill to prevent this occurrence.

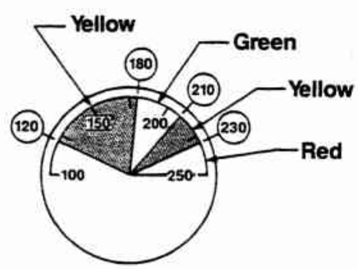
Cab Heater Plumbing



Operating Temperature Guidelines

The cooling system should be designed to maintain an engine operation temperature in the 190 - 210 degrees F (88 - 99 degrees C) range under normal operating conditions. However, under temporary extreme load or ambient conditions, operation at temperatures up to 230 degrees F (110 degrees C) is permissable if a 15 psi (105 kPa) pressure cap is used.

Sustained operation above 210 degrees F (99 degrees C) causes rapid deterioration of the lube oil and accelerated age hardening of the elastomers in the engine and cooling system. Individual cycle times at these temperatures should be held to a minimum, and total operation should be limited to less than 50 hours per year. Under no conditions should the engine operating temperature exceed 230 degrees F (110 degrees C)! Temperature shutdown systems should be set to provide a warning light and/or buzzer at 210 degrees F (99 degrees C) and shut down the engine at 230 degrees F (110 degrees C).



Recommended Coolant Temperature Gauge Markings

Design ambient temperatures for 210 degrees F (99 degrees C) maximum operating temperature:

– Severe Duty Applications

Operate in dirty environments and/or where sustained full load operation is possible. Design ambient temperature is 110 degrees F (43 degrees C).

Includes:

Ag Tractors	Crawler Tractors
Log Skidders	Compactors
Hydraulic Excavators	Irrigation Pumps
Trenchers	Rough Terrain Cranes (roading)

– Normal Duty Applications

Typical average load factors of 40 - 70%. Design ambient temperature is 100 degrees F (38 degrees C).

Includes:

Wheel Loaders	On-Highway Trucks above 35,000 lb. (16,000 kg) GVW
Scrapers	

– Light Duty Applications

Typical average load factors below 40%. Design ambient temperature is 90 degrees F (32 degrees C).

Includes:

Loader/Backhoes	On-Highway Trucks below 35,000 lb. (16,000 kg) GVW
Cranes	
Lift Trucks/Fork Lifts	

Lubrication System

Every engine must be equipped with a full flow lubricating oil filter. The only acceptable full flow filter is that furnished by Cummins Engine Company with the engine.

Hoses used in any part of the lubricating oil system must be of the type specified in the hose section of these Installation Recommendations.

An oil pressure gauge, low oil pressure warning system or a low oil pressure shutdown device is required on all applications.

1. Full Flow Lube Oil Filters

All B and C Series engines are supplied with a full flow oil filter as standard equipment. The engine mounted filter should be used whenever possible because it has minimum flow resistance, the least possibility for oil leaks, and provides the best oil system priming situation. However, a remote mounted full flow filter can be provided when absolutely necessary.

Special care is required when remote mounting the full 'low oil filter.

"B" Series — Remote Filter Guidelines

Minimum hose size: # 12 Wire braid reinforced
Maximum hose length: 40 inches (1016 mm)

Filter mounting location:
The filter inlet and outlet ports should not be more than 6 inches above or below the engine supply and return ports. The filter should be mounted in a vertical position.

"C" Series — Remote Filter Guidelines

Minimum hose size: # 16 Wire braid reinforced
Maximum hose length: 40 inches (1016 mm)

Filter mounting location:
The filter inlet and outlet ports should not be more than 6 inches above or below the engine supply and return ports. The filter should be mounted in a vertical position.

2. Operational Tilt Capability

The allowable angularity of engine operation with the standard oil pan is given on the Engine Data Sheet for each engine model. The maximum angularity of optional oil pans may vary. The permissible operational angle of the vehicle is this value minus any power angle ~r installation tilt.

3. Lube Oil Piping

Hose Specification

Flexible hose is recommended for lube oil plumbing. Currently, two types of hose construction are marketed which are suitable for this service. One is an extruded Teflon hose reinforced with corrosion resistant wire braid. The other is a multiple ply construction consisting of a seamless Buna N synthetic rubber inner tube reinforced with one fabric or synthetic rubber layer and at least one wire braid layer, with an oil resistant cover of impregnated fabric braid.

All hose used for lube oil plumbing must be rated by the manufacturer as suitable for a temperature range of at least −40 deg. F (−40 deg. C) to +275 deg. F (+135 deg C) and a working or operating pressure of a minimum of 250 psi (1720 kPa). In addition, it must be certified by the manufacturer to have a minimum burst pressure of 1000 PSI (6890 kPa).

4. Oil Pressure Gauge

An oil pressure gauge, low oil pressure warning system, or a low oil pressure shutdown device is required on all installations. The tap for the oil pressure gauge is specified on the engine installation drawing. Optional locations are available on most engine models. Normal oil pressure ranges are given on the Engine Data Sheet. These pressures are to be expected when the engine is at operating temperature. The pressure with cold oil may be as much as 150% more than the maximum for a warm engine, and this should be considered when selecting a gauge.

Fuel System

Maximum inlet restriction to the fuel lift pump must not exceed 4 in. (100 mm) Hg.

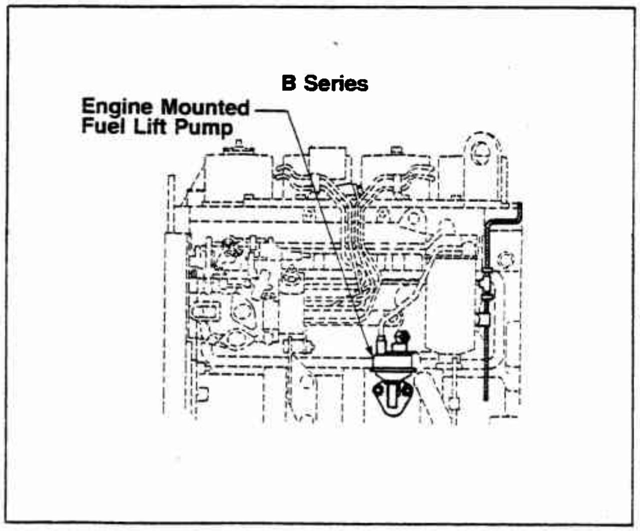
Maximum inlet pressure to the injection pump must not exceed 10 PSI (70 kPa) on B Series engines.

When only fuel filter/water separators plumbed after the lift pump are utilized, lift pump protection from fuel tank debris and sediment must be provided.

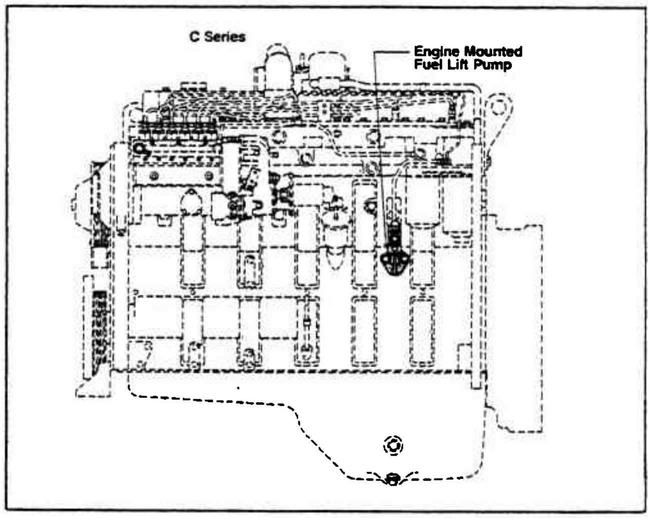
The fuel tank must be vented. The vent must be capable of handling 12 cu. ft. (340 l)/hr. air flow without exceeding 1.5 in. (40 mm) Hg restriction. The vent must be protected from the entry of dirt and water.

1. Fuel Lift Pump

All B Series installations except those with elevated fuel tanks should use a lift pump. The inlet pressure to the fuel filter head must be positive under all operating conditions before the lift pump can be eliminated.



All C Series installations require a lift pump.



Care must be taken to assure that the maximum inlet restriction to the lift pump and the maximum pressure to the injection pump is not exceeded.

2. Fuel Filters

Protection of the fuel system from damage or abnormal wear from dirt or water is critical to the acceptability of any application. To assure adequate protection is provided, the following recommendations should be observed.

Application

Light Duty — Includes:
On-highway Trucks, Stationary Gen Set and Power Unit.

Recommendation

Single-stage Fuel Filtration Options

A. Cummins supplied combination fuel filter/water separator.

B. Cummins supplied spin on fuel filter and customer supplied water separator.

NOTE: In applications that will operate mainly in areas where fuel quality is questionable, two-stage filtration should be installed regardless of the application.

Application

Heavy Duty — Includes:
Off-highway Trucks, Construction, Ag, Job Site Gen Sets and Power Units.

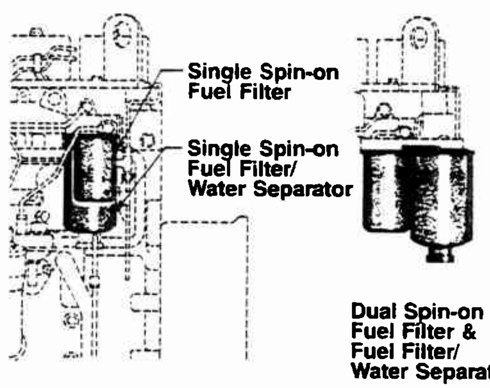
Recommendation

Two-stage Filtration Options

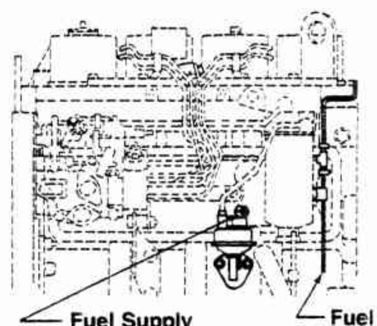
A. Cummins supplied dual filters (fuel filter and combination fuel filter/water separator).

B. Cummins supplied spin-on filter and customer supplied fuel filter and water separator with a maximum rating of 25 microns absolute.

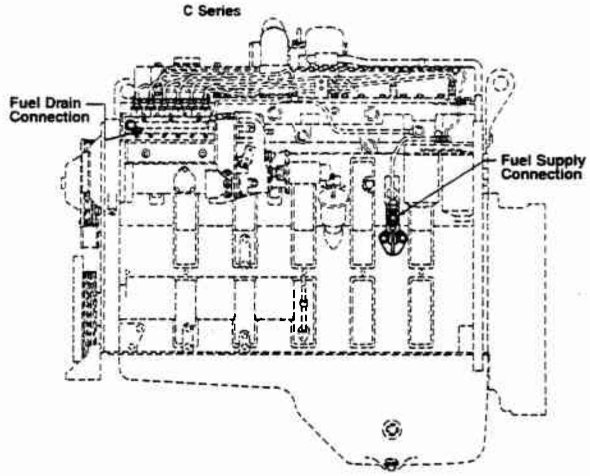
Engine Mounted
Fuel Filter Arrangements



B Series



C Series



NOTE: Remember, when only fuel filters plumbed after the lift pump are supplied, the lift pump must be protected from fuel tank debris and sediment by a prefilter or sediment bowl with a 100 to 120 mesh element.

In installations requiring remote mounted fuel filters, a single spin-on filter must be installed on the engine. Maintenance and filtration requirements of the application must be met by the customer supplied remote arrangement (not including the Cummins filter). The engine mounted filter need not be changed at regular service intervals if proper servicing of the remote element(s) is maintained.

3. Fuel System Plumbing

The fuel plumbing from the fuel tank to the engine should be of adequate size to assure that the maximum inlet restriction to the lift pump is not exceeded. As a general rule the supply line should be a minimum $\frac{5}{16}$ in. (8 mm) ID. Larger diameter plumbing may be required in installations where the fuel tank is located far away (greater than approximately 10 ft. (3 m)) from the engine, or there are numerous bends in the plumbing.

Fuel injection pump leakage or bleed fuel is teed into the injector drain line (factory plumbing) on all B Series engines and must be returned to the fuel tank. On C Series engines the injector drain line is plumbed to the fuel filter inlet, so only the fuel injection pump bleed fuel must be returned to the tank. The return fuel hose or tubing should be at least $\frac{3}{16}$ in. (5 mm) ID on B Series engines and $\frac{5}{16}$ in. (8 mm) ID on C Series engines. The maximum fuel drain restriction or static head (with elevated tanks) must not exceed 10 psi (70 kPa).

The return connection at the fuel tank should be located a sufficient distance from the supply pick-up to prevent aeration of the supply fuel. On installations with the fuel tank located below the fuel pump the fuel return should be plumbed to the tank below the fuel level. This will prevent fuel drainback to the tank when the engine is shut down which can cause loss of system prime resulting in hard starting.

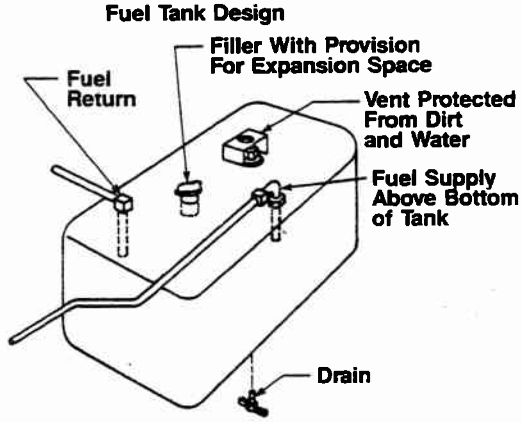
To prevent damage to the fuel drain tube on B Series engines no more than 3 ft. (1 m) of unsupported hose should be attached to the fuel drain/return tube.

4. Fuel Tank Design

The fuel tank should be designed to provide 5% of its capacity as expansion space above the maximum level of fuel in the tank. The fuel tank must be vented adequately so that the tank is not pressurized during operation of the engine. The vent must be protected against the entry of dirt and water. Normally a 1⁄16 in. (1.5 mm) diameter orifice is adequate for a fuel tank vent.

The fuel supply point should be located approximately 1 inch (25 mm) above the bottom of the tank to provide space for the collection of water and sediment. The fuel tank should be equipped with a drain so that water and sediment can be periodically drained from the tank.

Fuel Tank Design



The fuel tank must be designed to meet all legal requirements for the application.

Starting and Electrical Systems

The installed battery capacity must not be less than that specified in paragraph 2.

The starting motor circuit resistance must not exceed the value given in paragraph 3.

1. Starting System

The engines are designed to provide unaided starting at temperatures down to 10 degrees F (– 12 degrees C). To achieve this capability, it is necessary that the starting system provide cranking speeds above 125 rpm.

2. Recommended Battery Capacities (to provide design starting capability)

12 Volt System

Engine Model	Light Accessories*	Heavy Accessories**
4B	625 CCA	800 CCA
6B	800 CCA	950 CCA
6C	950 CCA	1250 CCA

24 Volt System

Engine Model	Light Accessories*	Heavy Accessories**
4B	312 CCA	400 CCA
6B	400 CCA	475 CCA
6C	475 CCA	625 CCA

*Typical light accessories include alternator, small steering pump, and disengaged clutch.
**Typical heavy accessories include hydraulic pump and torque converter.

NOTE: The above battery capacity ratings are at SAE J537 test conditions. (30 second discharge to 1.2 volts per cell at 0 deg F (–18 deg C))

3. Starting Circuit Resistance

System Voltage	System Type	Maximum Circuit Resistance
12	Light/Medium Duty*	0.0012 Ohm
24	Light/Medium Duty*	0.004 Ohm
12	Heavy Duty**	0.00075 Ohm
24	Heavy Duty**	0.002 Ohm

*Starting systems normally used on B Series engines utilizing Nippondenso, Delco Remy 27 MT, or equivalent starters are considered light/medium duty.
**Starting systems normally used on C Series engines utilizing Delco Remy 37 MT, 42 MT, or equivalent starters are considered heavy duty.

4. Charging System

Various alternators and alternator mountings are available from Cummins Engine Company. Alternator selection should be based upon both the starting and accessory power requirements and the amount of time the particular piece of equipment is likely to spend idling or operating at low rpm.

In order to assure recharging the starting load, the maximum electrical rating of the alternator should be at least 25% greater than the maximum connected continuous load in any type of service.

For operation below 10 degrees F (−12 degrees C), see the section on "Cold Weather Operation".

Power Train

The power train components must not mechanically load the engine thrust bearing in a static condition.

The below stated intermittent and continuous thrust bearing limits must not be exceeded.

The power train components must be torsionally compatible with the engine in the operating speed range.

1. Component Selection

Power train component selection will vary greatly with the specific requirements of the individual application. Flywheels and flexplates which cover the majority of all power train configurations are available from Cummins.

2. Crankshaft and Thrust Bearing Loading

Check the crankshaft end play after installing any direct-mounted clutch, torque converter or transmission to ensure that the crankshaft is not being mechanically loaded.

Crankshaft end play values are:

	Minimum	Maximum
"B" Series	.005 in. (.127 mm)	.010 in. (.254 mm)
"C" Series	.006 in. (.157 mm)	.013 in. (.334 mm)

The drive train components must not load the thrust bearing in excess of the following values.

	Intermittent Load	Continuous Load
"B" Series	850 lb. (3780 N)	400 lb. (1780 N)
"C" Series	800 lb. (3560 N)	600 lb. (2670 N)

3. Driveline Compatibility

To avoid engine or driveline damage due to torsional vibration in any of the following applications, details should be supplied to Cummins for analysis:

- Any remote mounted transmission with relatively large mass driven from the engine with a non-rigid drive such as splines, couplings, or gears.
- Any mass with inertia equal to or greater than the inertia of the engine which is attached directly to the engine (generator set).
- Any relatively large mass directly attached to the front of the engine such as a power take-off clutch, heavy coupling or unusually heavy pulley.

The natural frequencies of the engine/transmission combination must be outside the range of the exciting frequencies of the engine and driveline. The lowest natural frequency of the engine/transmission package is bending of the engine and transmission together.

For a 4 cylinder engine, 1st order unbalance and 2nd order inertia forces should be avoided. Therefore, the natural frequency of a 4 cylinder engine/transmission combination should be above 125 Hz.

The natural frequency for a 6 cylinder engine, should be above 60 Hz to stay out of the range of 1st order exciting forces.

4. Performance Criteria

The engine must be able to accelerate from low idle speed to operating speed with the highest combination of applied loads for each specific application. The engine must also be able to meet this acceleration requirement at its maximum altitude rating.

Engine Driven Accessories

Any engine driven accessory must be mounted and driven such that the magnitude, direction, and type of loads imposed on the engine will not be detrimental to the engine performance or reliability.

The natural frequency of any engine mounted accessory must be out of the critical frequency range of the engine. (See table at the end of this section for engine critical frequency ranges.)

Cummins Application Engineering should be consulted anytime an accessory is mounted or driven from the engine with components other than those supplied by Cummins Engine Company.

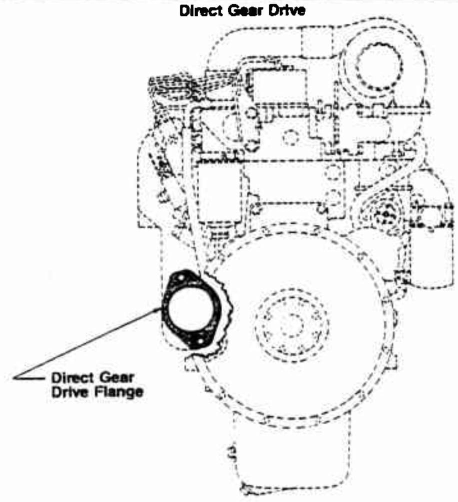
1. Front Power Take-Off

Generally, torque taken from the front of the crankshaft should be limited to 210 lb.-ft. (285 N•m) on B Series and 420 lb.-ft. (570 N•m) on C Series applications. Applications requiring in excess of these levels (up to full engine output) may be approved on an individual basis. Details of those applications should be submitted to Cummins Application Engineering for review.

2. Direct Gear Drive

Up to 105 lb.-ft. (142 N•m) may be taken from the rear of the gear housing by means of a direct gear drive with provision for SAE "A" or "B" flange mounting.

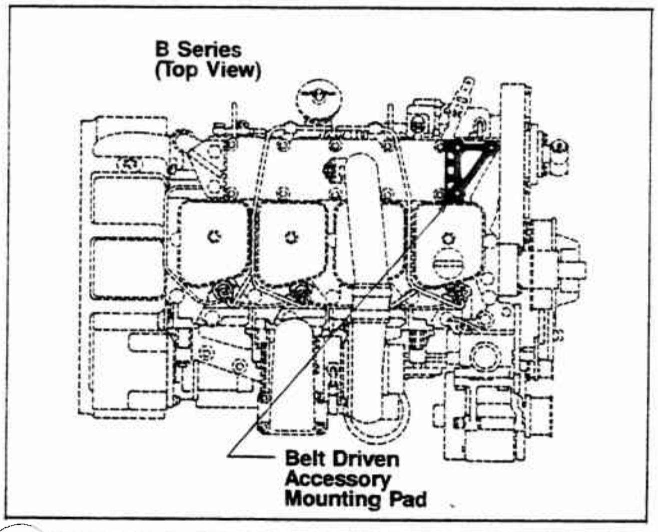
Direct Gear Drive

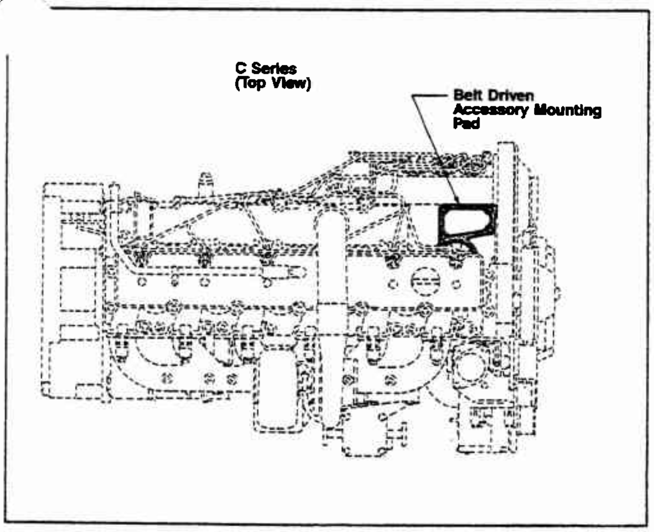


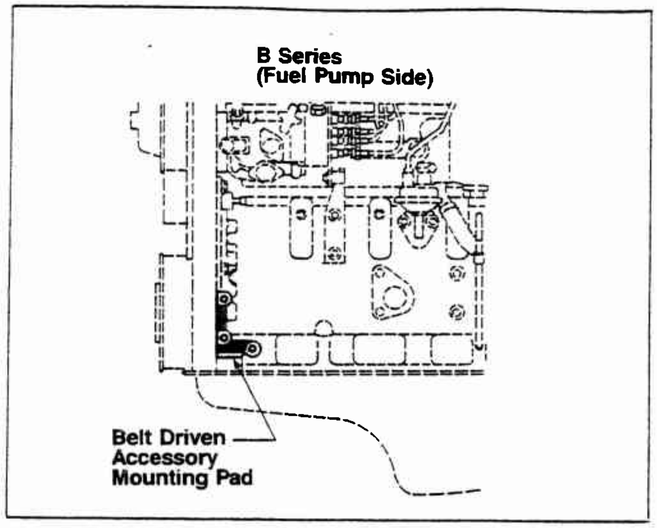
It is essential that gear driven accessories be properly supported to avoid damage to the gear housing. The maximum allowable bending moment at the rear of the gear housing for direct driven accessories is 10 ft.-lb. (14 N•m). Any arrangement that has a customer designed support with a gear driven accessory should be reviewed by Cummins Engine Company.

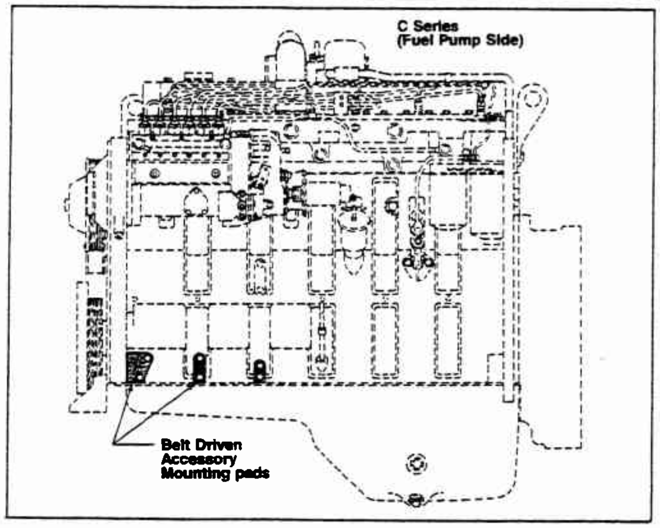
Belt Driven Accessories

Mounting arrangements for selected belt driven accessories can be provided with the engine. Customer supplied mountings should meet the component manufacturer's guidelines and should avoid attachment to gasketed surfaces. Accessory mounting pads are provided on the engine.

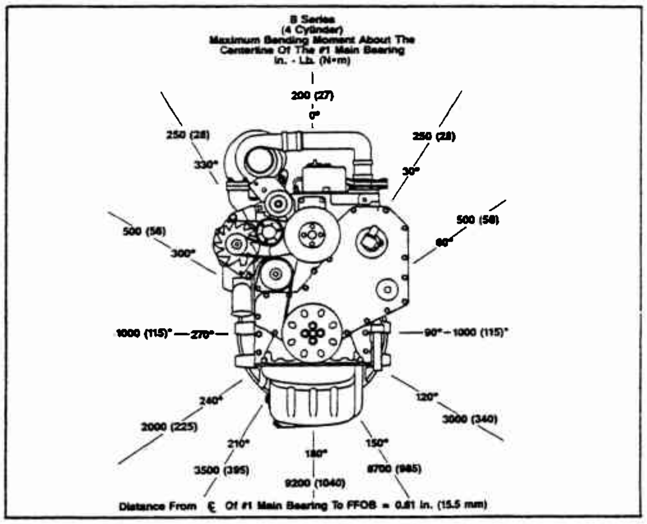


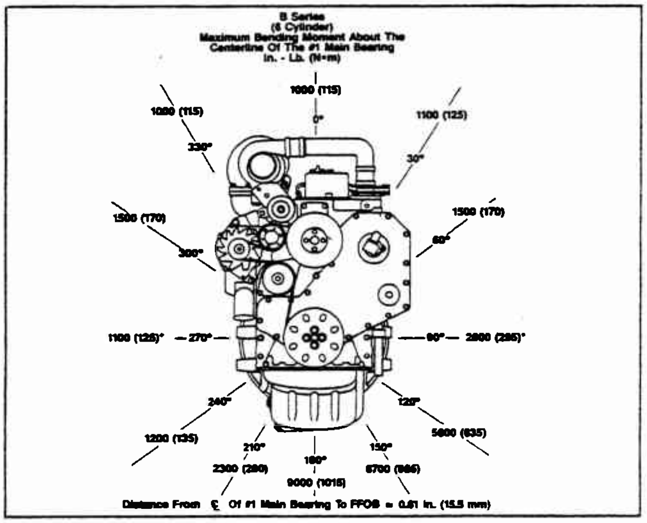


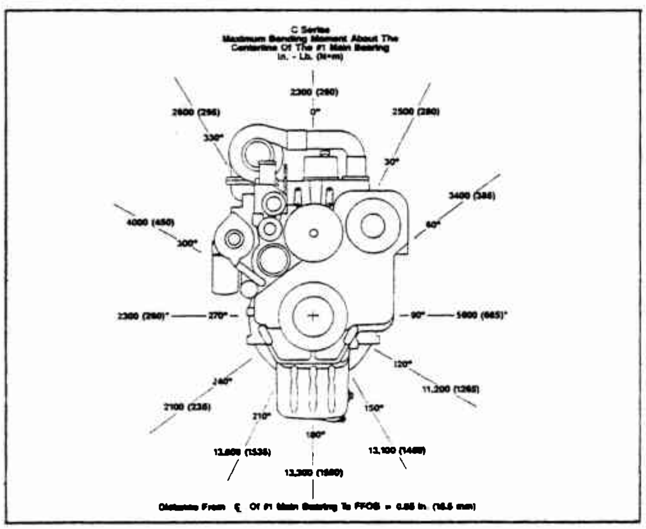




Maximum belt drive power take-off capability from the front of the crankshaft will vary with the location and geometry of the specific arrangements. General limits for the bending moment imposed by belt drives about the centerline of the #1 main bearing are given in the following charts:







*Belt drives mounted horizontally from the crankshaft should be avoided due to reduced oil film thickness at the split line of the main bearing.

Maximum belt drive power taken from the front of the crankshaft should not exceed 100 hp (75 kW) under any circumstances.

4. Air Compressor

Engine driven air compressors should be regulated by an air governor set at a discharge air pressure not exceeding the compressor manufacturer's limits. System pressure should be sensed upstream of any check valve in the system.

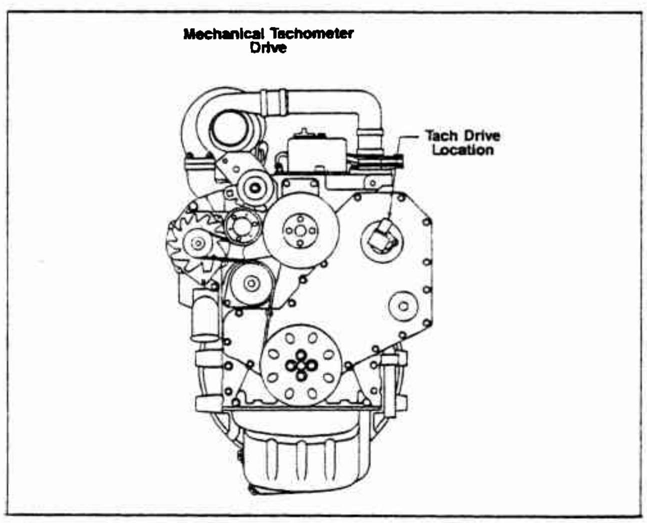
Compressor air intake can be taken from the engine intake manifold, the air cleaner to engine intake piping, or through a separate breather mounted on the compressor. On turbocharged engines, if the intake air is taken from the intake manifold, the compressor manufacturer's limits for turbocharging the compressor should not be exceeded.

The compressor air discharge line should provide enough flexibility to meet the engine mounting requirements and should be routed to avoid low spots where moisture could collect. The discharge line should be capable of handling air at temperatures of up to 450 deg F (250 deg C). As a general guideline compressor discharge lines should be sized as follows:

Compressor Capacity	Minimum Discharge Line ID	
	Length < 10 ft. (3 m)	Length > 10 ft. (3 m)
< 15 cfm (7 l/s)	½ in. (13 mm)	⅝ in. (16 mm)
> 15 cfm (7 l/s)	⅝ in. (16 mm)	¾ in. (19 mm)

5. Mechanical Tachometer Drive

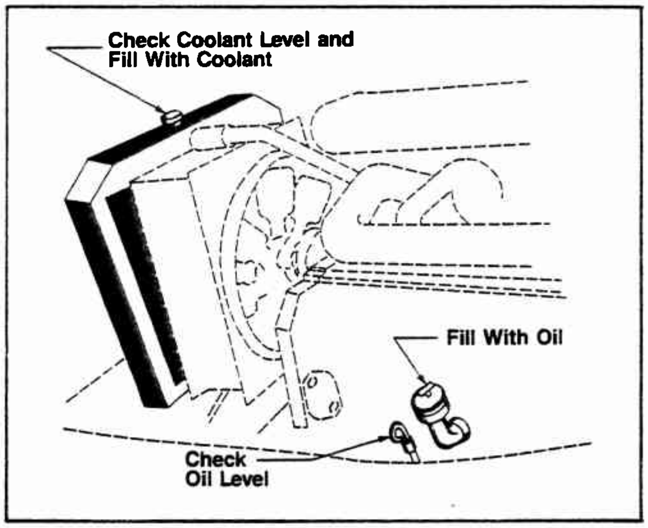
Drive provisions for various mechanical tachometer arrangements are available on the engine gear cover. The load imposed on this drive by the tachometer and cable must not exceed 25 in.-lb. (3 N•m).



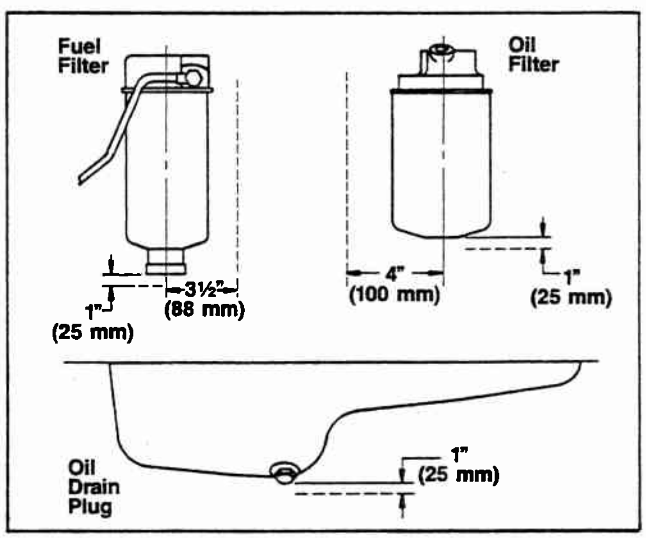
Engine Critical Frequency Ranges	
Engine Model	**Critical Frequency Ranges (Hz)**
4B	20 - 125
6B	0 - 60, 160 - 300
6C	0 - 60, 160 - 280

Service Accessibility

1. **Daily Engine Maintenance**
   Provide ample access to allow for easy performance of daily maintenance.
   - Check oil level
   - Fill with oil
   - Check coolant level
   - Fill with coolant



2. **Scheduled Maintenance**
   Provide sufficient clearance to permit removal and installation of:
   - Fuel filter and water separator
   - Oil Filter
   - Oil pan drain plug
   - Water filter
   - Air cleaner element
   - Belts

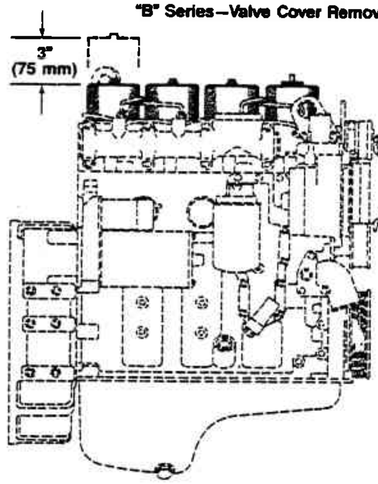


3. Inspection Regarding Service Repair

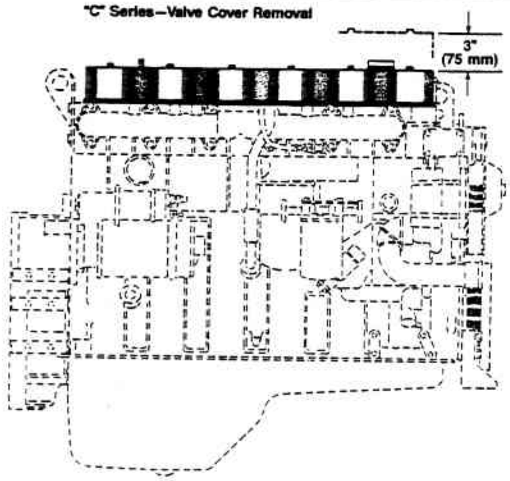
Provide clearance to permit removal and installation of:

- Valve covers
- Oil pan
- Lift pump
- Turbocharger

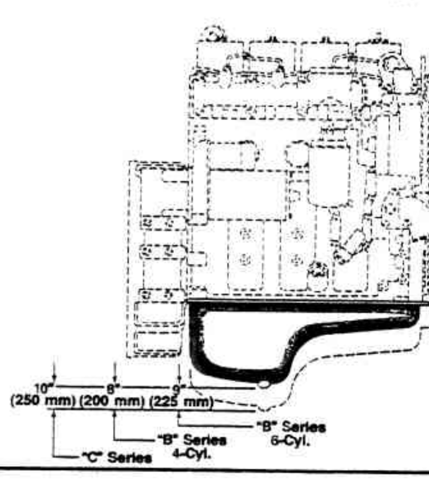
"B" Series—Valve Cover Removal



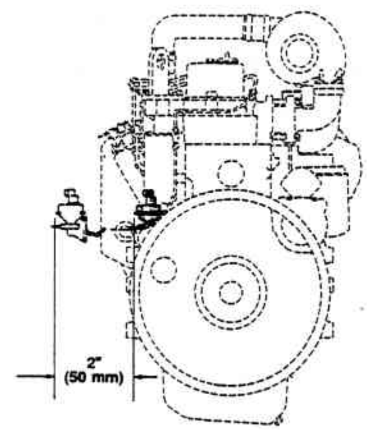
"C" Series—Valve Cover Removal



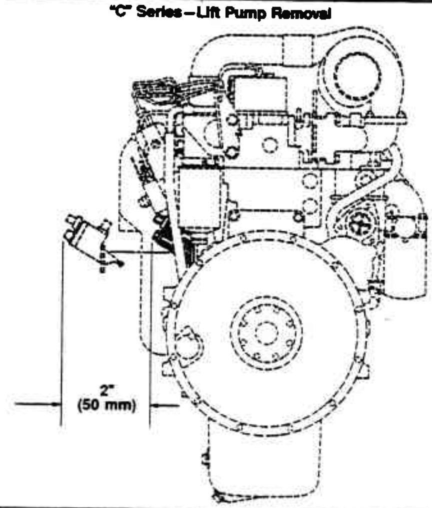
"B" & "C" Series—Oil Pan Removal



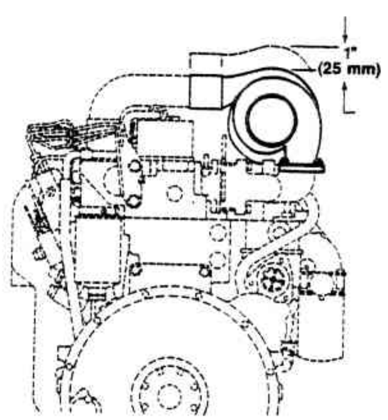
"B" Series—Lift Pump Removal



"C" Series—Lift Pump Removal



"B" & "C" Series—Turbocharger Removal

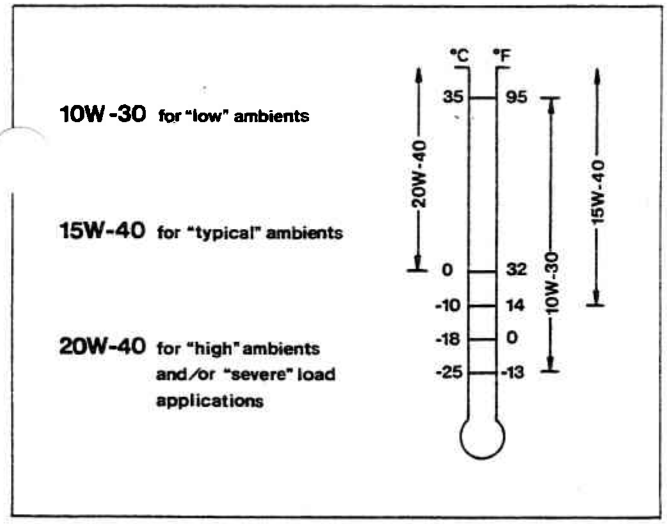


Lubricant, Fuel and Coolant Specifications

The performance and life of the engine in any installation can be significantly affected by the lubricant, fuel and coolant that are specified for use in that application. The following guidelines should be observed in the selection of these items:

1. Lubricating Oil

Lubricating oils meeting API Class CE/SF or CE/SG as classified by the American Petroleum Institute are recommended for use in B & C Series engines. Multigraded oils that meet the requirements of the API classifications and the viscosity grades at various ambient temperatures as shown in the following chart are recommended. Synthetic oils may be used in each ambient range and may provide better starting characteristics in low ambient temperatures.



CAUTION: The use of low viscosity oil such as 10W-30 will aid in starting the engine and provide sufficient oil flow at low ambient temperatures. However, the continuous use of low viscosity oils may decrease engine life.

2. Fuel Oil

The B & C Series engines were designed to operate on commercially available #2 diesel fuels that meet the requirements of the ASTM D975 Standard Specifications for Diesel Fuel Oils.

The engine will also operate on lower viscosity, lower t content fuels such as #1 diesel, JET A, JP-5, rosene, or blends of these with #2 diesel. Blends are commonly used during the winter to improve starting and reduce filter plugging due to wax formation.

However, with the rotary pump used on the B Series engine, as fuel viscosity decreases the fuel flow to the engine also decreases resulting in power loss of up to 25 - 30%. Also engine response, load pick-up and starting time are adversely affected. In addition, the reduced lubrication properties of lower viscosity fuels will cause reduced pump life.

The inline pump used on the C Series engine is also sensitive to fuel viscosity. Power loss of up to 20 - 25% can be expected when using lower viscosity fuels. Pump life is not as sensitive to fuel viscosity since the governor and cam are engine oil lubricated.

Operation of the engine using extremely low viscosity fuels such as JP-4 or CITE is NOT recommended due to significant acceleration of fuel injection equipment wear resulting from the use of fuels having viscosity below 2.0 centistokes. When these fuels must be used, the viscosity must be raised to above 2.0 centistokes by adding lube oil or viscosity improver. However, even with acceptable viscosity, a performance loss of 20 - 25% should be expected.

3. Coolant

Engine coolant should be a 50/50 mixture of ethylene glycol base antifreeze and water, as covered by SAE J1034. The only exception to this is for operation below −34 degrees F (−37 degrees C) where the concentration may be increased to a maximum of a 60% ethylene glycol.

The "C" Series engine is equipped with a DCA4 coolant filter. DCA4 is a formulation of supplemental coolant additives specifically designed for use in Cummins engines. The antifreeze used in the C Series engine should contain less than 0.1% silicate to avoid the formation of silica-gel (hydro-gel). This gel formation can occur when the cooling system contains an overconcentration of high silicate antifreeze and/or DCA4 supplemental coolant additive.

The coolant is intended for year-around use with a maximum two-year service life.

Cold Weather Operation

Engine operation in ambient temperatures lower than 32 deg F (0 deg C) requires that special consideration be given to engine starting and that additional steps be taken to ensure against engine damage due to lack of lubrication, incomplete combustion or thermal shock.

The following recommendations are given as guidelines for "cold proofing" the engine installation.

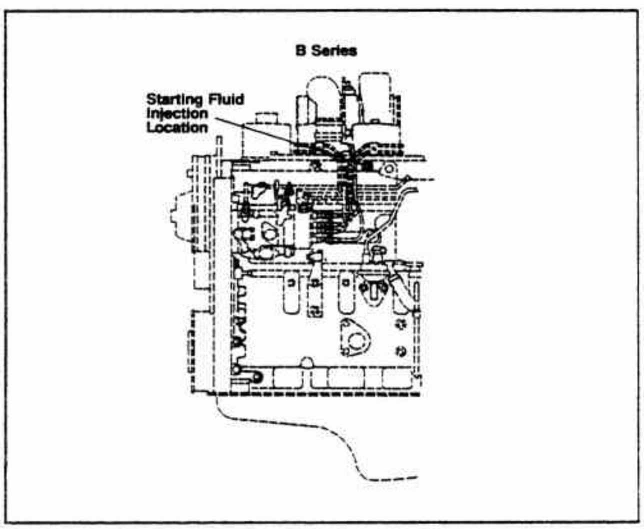
1. Batteries

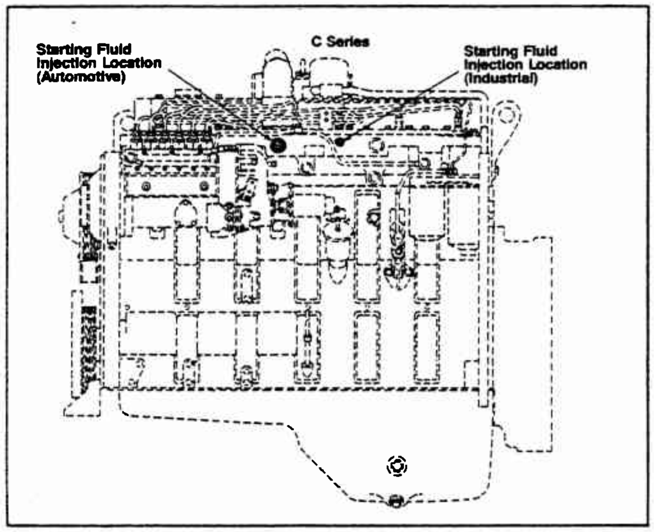
The battery capacities shown in the Starting and Electrical System Section of this publication will provide acceptable current for cranking the engine down to 10 deg F (−12 deg C).

On engines that will operate below 10 deg F (−12 deg C), higher capacity batteries, additional batteries or battery heaters may be required to offset the loss of cranking amperage due to the reduced temperature.

2. Engine Starting Aids

On engines that will operate below 10 deg F (−12 deg C), a starting fluid injection system or an air intake heater may be required. Use of one of these systems may be advantageous below 32 deg F (0 deg C), in that it will provide more rapid, consistent starting.





Only a measured shot starting fluid injection system like those available from Cummins should be used. Only 3 cc measured shot systems should be used on B Series engines and only 6 cc measured shot systems should be used on C Series engines. The use of continuous flow fluid injection systems or hand held starting fluid spray are not recommended.

3. Engine Lubricating Oil

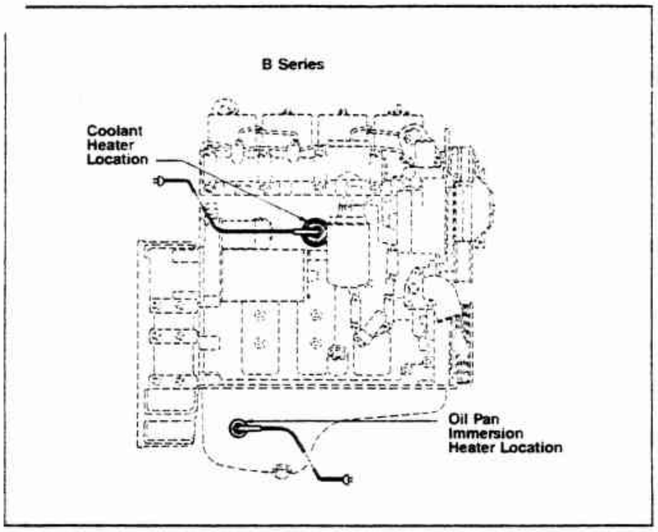
The lube oil specifications shown in the Lubricant, Fuel and Coolant Section of this publication should be followed.

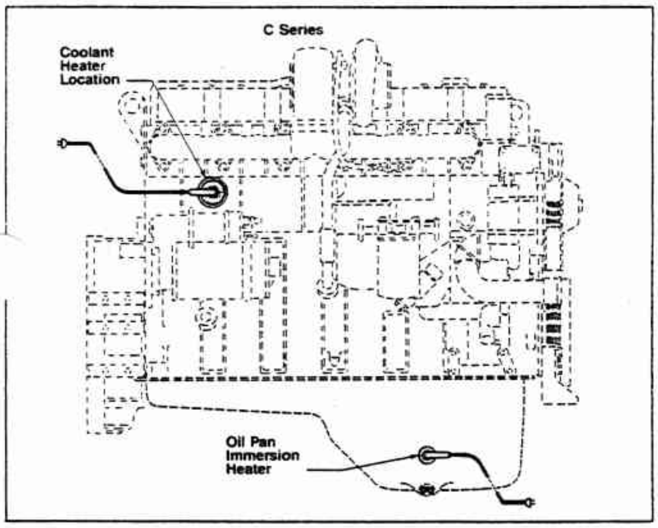
On engines that will operate below 0 deg F (−18 deg C), the use of an oil pan immersion heater is recommended to maintain oil temperature and viscosity in a range acceptable for adequate cranking and lubrication.

4. Engine Coolant

The recommendation for engine coolant shown in the Lubricant, Fuel and Coolant Section of this publication should be followed.

On engines that will operate below 10 deg F (−12 deg C), the use of a coolant heater is recommended to maintain higher, more even engine temperatures. This will promote more complete combustion which will significantly improve starting, reduce white smoke, and reduce the potential for engine damage from thermal shock in extremely low ambient temperatures.





5. Engine Fuel System

The recommendation for fuel specifications shown in the Lubricant, Fuel and Coolant Section of this publication should be followed.

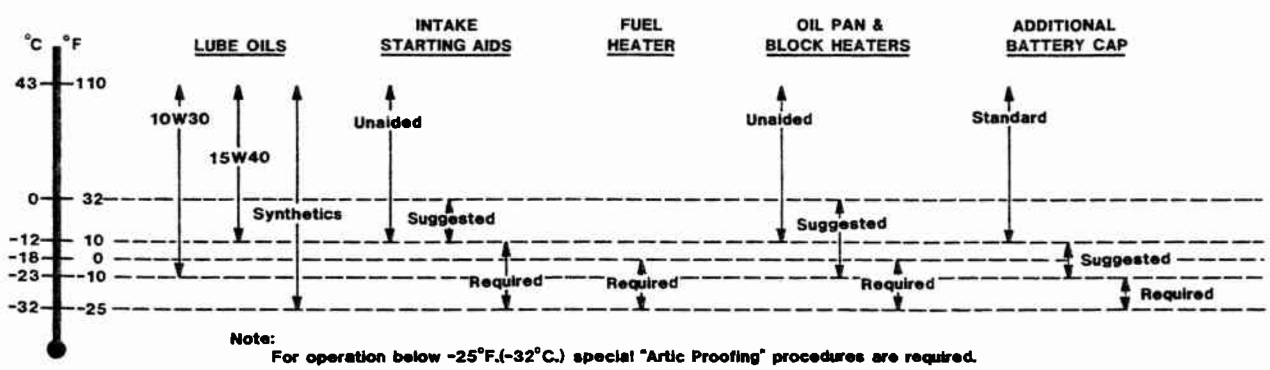
On engines that will operate below 0 deg F (−18 deg C), the use of a fuel heater may be required to maintain the fuel temperature at 20 to 40 deg F (10 to 20 deg C) above the cloud point of the fuel. This will prevent the formation of wax crystals in the fuel that can cause plugging of the fuel filter and subsequent disruption of fuel flow to the engine.

For more detailed information concerning operation of diesel engines in cold weather refer to Cummins Service Bulletin No. 3379009-03 or Cummins Training Bulletin No. 3387266-R.

COLD WEATHER OPERATION

TEMPERATURE RANGE RECOMMENDATIONS

OF VARIOUS COLD WEATHER PROCEDURES



Note:
For operation below -25°F.(-32°C.) special "Artic Proofing" procedures are required.

Application Classifications

*Application classifications do not take into consideration operating environment. Severe operating conditions may necessitate that heavier duty components (air cleaners, cooling systems, etc.) be selected.

1. **Light Duty (Average load factor of 40% or less)**
   - Automotive Applications Under 35,000 lb. (16,000 kg) GVW
   - Cranes
   - Lift Trucks
   - Tow Tractors
   - Windrowers*
   - Stand-By Generator Sets

2. **Normal Duty (Average load factor of 40 - 70%)**
   - Ag Tractors*
   - Automotive Applications Over 35,000 lb. (16,000 kg) GVW
   - Intercity Transit Buses
   - School Buses
   - Combines*
   - Compactors*
   - Compressors
   - Concrete Mixers
   - Crawler Tractors*
   - Dozers*
   - Forage Harvesters*
   - Front End Loaders (Wheeled or Tracked)*
   - Graders*
   - Loader - Backhoes*
   - Log Skidders*
   - Refrigeration Units
   - Rollers (Static or Vibratory)
   - Scrapers*
   - Street Sweepers
   - Welding Sets
   - Wood Chippers*
   - Prime Power Generator Sets

3. **Heavy Duty (Average load factor greater than 70%)**
   - Conveyors
   - Drilling Equipment
   - Hydraulic Excavators
   - Pavers
   - Pump Sets
   - Road Surface Planers
   - Stone Crushers
   - Trenchers
   - Base Load Generator Sets