SECTION 13

OPERATING INSTRUCTIONS

CONTENTS

ENGINE OPERATING INSTRUCTIONS

PREPARATION FOR STARTING ENGINE FIRST TIME

Before starting an engine for the first time, carefully read and follow the instructions in Sections 13 and 14 of this manual. Attempting to run the engine before studying these instructions may result in serious damage to the engine.

NOTICE: When preparing to start a new or overhauled engine or an engine which has been in storage, perform all of the operations listed below. Before a routine start (at each shift), see *Daily Operations* in the *Lubrication and Preventive Maintenance Chart*, Section 15.1.

Cooling System

Install all of the drain cocks or plugs in the cooling system (drain cocks are removed for shipping).

Open the cooling system vents, if the engine is so equipped. Remove the filler cap and fill the cooling system with a coolant specified under *Coolant Specifications* in Section 13.3. Keep the liquid level about two inches below the filler neck to allow for fluid expansion.

Close the vents, if used, after filling the cooling system.

On marine installations, prime the raw water cooling system and open any sea cocks in the raw water pump intake line. Prime the raw water pump by removing the pipe plug or electrode provided in the pump outlet elbow and pour water in the pump.

NOTICE: Failure to prime the raw water pump may result in damage to the pump impeller.

Lubrication System

The lubricating oil film on the rotating parts and bearings of a new or overhauled engine, or one which has been in storage, may be insufficient for proper lubrication when the engine is started for the first time. Insufficient lubrication at start–up can cause serious damage to the engine components.

To ensure an immediate flow of oil to all bearing surfaces at initial engine start–up, DDC recommends that the engine lubrication system be charged with a commercially available pressure pre–lubricator. Use the following procedure:

1. Remove the pipe plug from the engine main oil gallery and attach the pre–lubricator hose.
2. Remove the valve rocker cover(s) and, using a positive displacement pump set at 25–35 psi (172–241 kPa), pump in the recommended grade of engine lubricating oil until it is observed flowing from the rocker arms.
3. If the engine is turbocharged, disconnect the oil supply lines at the turbo bearing (center) housings and fill the bearing housing cavities with approximately one pint of the recommended grade of clean engine oil. Turn the rotating assemblies by hand to coat all internal surfaces with oil and reinstall the turbo oil supply lines (refer to Section 3.5).
4. After 20 minutes, check the crankcase oil level. Add enough oil to bring the level to the "full" mark on the dipstick. *Do not overfill.*
5. Disconnect the pre–lubricator hose, plug the main oil gallery hole and replace all components previously removed.
6. Before initial engine start–up, DDC also recommends cranking the engine with the governor in the no–fuel position until oil pressure registers on the gage.

For engine lubricating oil recommendations, see *Lubrication Specifications* in Section 13.3 or contact a Detroit Diesel Corporation distributor.

If a pressure prelubricator is not available, fill the crankcase to the proper level with *heavy–duty* lubricating oil as specified under *Lubrication Specifications* in Section 13.3. Then, prelubricate the upper engine parts by removing the valve rocker covers and pouring lubricating oil, of the same grade and viscosity as used in the crankcase, over the rocker arms.

Turbocharger

1. Clean the area and disconnect the oil inlet line at the bearing housing.
2. Fill the bearing housing cavity with clean engine oil. Turn the rotating assembly by hand to coat all of the internal surfaces with oil.
3. Add additional engine oil to completely fill the bearing housing cavity and reinstall the oil line. Clean off any spilled oil.

CAUTION: Do not hold the compressor wheel, for any reason, while the engine is running. This could result in personal injury.

4. Start and run the engine at idle until oil pressure and supply has reached all of the turbocharger moving parts. A good indicator that all the moving parts are getting lubrication is when the oil pressure gage registers pressure (10 psi – 69 kPa at idle speed).

The free floating bearings in the turbocharger center housing require positive lubrication. This is provided by the above procedure *before the turbocharger reaches its maximum operating speed* which is produced by high engine speeds.

NOTICE: Starting any turbocharged engine and accelerating to any speed above idle before engine oil supply and pressure has reached the free floating bearings can cause severe damage to the shaft and bearings of the turbocharger.

Air Cleaner

If the engine is equipped with oil bath air cleaners, fill the air cleaner oil cups to the proper level with clean engine oil. *Do not overfill.*

Transmission

Check the oil level and, if necessary, fill the transmission case, marine gear or torque converter supply tank to the proper level with the lubricant specified under *Lubrication and Preventive Maintenance* in Section 15.1.

Fuel System

Fill the fuel tank with the fuel specified under *Fuel Specifications* in Section 13.3.

If the unit is equipped with a fuel valve, it must be opened.

To ensure prompt starting, fill the fuel system between the pump and the fuel return manifold with fuel. If the engine has been out of service for a considerable length of time, prime the fuel system between the fuel pump and the fuel return manifold. The fuel system may be primed by removing the plug in the top of the fuel filter cover and slowly filling the filter with fuel.

In addition to the above, on an engine equipped with a hydrostarter, use a priming pump to make sure the fuel lines and the injectors are full of fuel before attempting to start the engine.

NOTICE: The fuel system is filled with fuel before leaving the factory. If the fuel is still in the system when preparing to start the engine, priming should be unnecessary.

Lubrication Fittings

Fill all grease cups and lubricate at all fittings (except for fan hub pulley fitting — refer to Section 15.1) with an all purpose grease. Apply lubricating oil to the throttle linkage and other moving parts and fill the hinged cap oilers with a hand oiler.

Drive Belts

Adjust all drive belts as recommended under *Lubrication and Preventive Maintenance* in Section 15.1.

Storage Battery

Check the battery. The top should be clean and dry, the terminals tight and protected with a coat of petroleum jelly and the electrolyte must be at the proper level.

NOTICE: When necessary, check the battery with a hydrometer; the reading should be 1.265 or higher. However, hydrometer readings should always be corrected for the temperature of the electrolyte.

Generator Set

Where applicable, fill the generator end bearing housing with the same lubricating oil as used in the engine.

A generator set should be connected and grounded in accordance with the applicable local electrical codes.

NOTICE: The base of a generator set must be grounded.

Clutch

Disengage the clutch, if the unit is so equipped.

STARTING

Before starting the engine for the first time, perform the operations listed under *Preparation For Starting Engine First Time.*

Before a routine start, see *Daily Operations* in the *Lubrication and Preventive Maintenance Chart,* Section 15.1.

If a manual or an automatic shutdown system is incorporated in the unit, the control must be set in the open position before starting the engine. The blower will be seriously damaged if operated with the air shutoff valve in the closed position.

NOTICE: On engines with dual air shutdown housings, both air shutoff valves must be in the open position before starting the engine.

Starting at air temperatures below 40°F (4°C) requires the use of a cold weather starting aid.

CAUTION: Starting fluid used in capsules is highly inflammable, toxic and possesses sleep inducing properties.

The instructions for the use of a cold weather fluid starting aid will vary dependent on the type being used. Reference should be made to these instructions before attempting a cold weather start.

Initial Engine Start (Electric)

Start an engine equipped with an electric starting motor as follows: Set the speed control lever at part throttle, then bring it back to the desired no–load speed. In addition, on mechanical governors, make sure the stop lever on the governor cover is in the *run* position; on hydraulic governors, make sure the stop knob is pushed all the way in. Then, press the starting motor switch firmly. If the engine fails to start within 30 seconds, release the starting switch and allow the starting motor to cool a few minutes before trying again. If the engine fails to start after four attempts, an inspection should be made to determine the cause.

NOTICE: To prevent serious damage to the starter, if the engine does not start, do not press the starting switch again while the starting motor is running.

Initial Engine Start (Hydrostarter)

Start an engine equipped with a hydrostarter as follows:

Use the priming pump to make sure the fuel filter, fuel lines and injectors are full of fuel before attempting to start the engine.

Raise the hydrostarter accumulator pressure with the hand pump until the gage reads as indicated in Table 1.

Set the engine controls for starting with the throttle at least half open.

NOTICE: During cold weather, add starting fluid at the same time the hydrostarter motor lever is moved. Do not wait to add the fluid after the engine is turning over.

Push the hydrostarter control lever to simultaneously engage the starter pinion with the flywheel ring gear and to open the control valve. Close the valve as soon as the engine starts to conserve the accumulator pressure and to avoid excessive over–running of the starter drive clutch assembly.

RUNNING

Oil Pressure

Observe the oil pressure gage immediately after starting the engine. If there is no pressure indicated within 10 to 15 seconds, stop the engine and check the lubricating oil system. Refer to the *Troubleshooting Charts* in Section 15.2.

Warm–Up

Run the engine at part throttle and no–load for approximately five minutes, allowing it to warm–up before applying a load.

If the unit is operating in a closed room, start the room ventilating fan or open the windows, as weather conditions permit, so ample air is available for the engine.

Inspection

While the engine is running at operating temperature, check for coolant, fuel or lubricating oil leaks. Tighten the line connections where necessary to stop leaks.

Engine Temperature

See Section 13.2 for normal engine coolant temperature.

Ambient Temperature	Pressure Gage Reading	
	psi	kPa
Above 40° F (4.4° C)	1500	10 342
40 - 0° F (4.4 to -18° C)	2500	17 237
Below 0° F (-18° C)	3300	22 753

Table 1

Crankcase

If the engine crankcase was refilled, stop the engine after normal operating temperature has been reached, allow the oil to drain (approximately 20 minutes) back into the crankcase and check the oil level. Add oil, if necessary, to bring it to the proper level on the dipstick.

Use only the *heavy duty* lubricating oil specified under *Lubrication Specifications* in Section 13.3.

Clutch

Do not engage the clutch (with a sintered iron clutch plate) at engine speeds over 850 rpm. A clutch with an asbestos or vegetable fiber material clutch plate must not be engaged at speeds over 1000 rpm.

Cooling System

Remove the radiator or heat exchanger tank cap *slowly* after the engine has reached normal operating temperature and check the engine coolant level. The coolant level should be near the top of the opening. If necessary, add clean soft water or an ethylene glycol base antifreeze.

Transmission

Check the marine gear oil pressure. The operating oil pressure range at operating speed is 90–150 psi (621–1034 kPa) (Allison Torqmatic gear). The operating oil pressure varies with the different Twin Disc gears as noted in Table 2. Check and, if necessary, replenish the oil supply in the transmission.

Turbocharger

Make a visual inspection of the turbocharger for leaks and excessive vibration. Stop the engine immediately if there is an unusual noise in the turbocharger.

Avoid Unnecessary Engine Idling

During long engine idling periods, the engine coolant temperature will fall below the normal operating range. The incomplete combustion of fuel in a cold engine will cause crankcase dilution, formation of lacquer or gummy deposits on the valves, pistons and rings and rapid accumulation of sludge in the engine.

NOTICE: When prolonged engine idling is necessary, maintain at least 800 rpm.

Operating Oil Pressure at 180° F (82° C)*									
Marine Gear	Position	† Test rpm	Test Pressure		Marine Gear	Position	† Test rpm	Test Pressure	
			psi	kPa				psi	kPa
MG-506 (except 1.5:1 and 2:1 ratios)	Neutral and Engaged	600	280-315	1930-2170	MG-514 (less than 4:1 ratio) (shallow case)	Neutral	600	20-65	138-448
	Neutral and Engaged	1800	300-320	2067-2205		Neutral	1800	45-92	310-634
	Cruising	Min.	270	1861		Engaged	600	210-235	1447-1619
						Engaged	1800	228-237	1571-1633
						Cruising	Min.	215	1481
MG-506 (only 1.5:1 and 2:1 ratios)	Neutral and Engaged	600	330-365	2274-2515	MG-514 (4:1 and greater ratio) (deep case)	Neutral	600	35-65	241-448
	Neutral and Engaged	1800	350-370	2412-2550		Neutral	1800	50-85	379-586
	Cruising	Min.	335	2308		Engaged	600	187-215	1289-1481
						Engaged	1800	193-220	1330-1516
						Cruising	Min.	185	1275
MG-509	Neutral	600	35-70	241-483	MG-521	Neutral	600	45-85	310-586
	Neutral	1800	50-85	345-586		Neutral	1800	75-100	517-689
	Engaged	600	187-215	1289-1481		Engaged	600	180-215	1241-1481
	Engaged	1800	193-220	1330-1516		Engaged	1800	188-220	1296-1516
	Cruising	Min.	165	1137		Cruising	Min.	165	1137
MG-512	Neutral	600	45-70	310-483	MG-527	Neutral	600	45-85	310-586
	Neutral	1800	60-90	414-621		Neutral	1800	65-100	448-689
	Engaged	600	185-215	1275-1481		Engaged	600	180-215	1241-1481
	Engaged	1800	195-220	1344-1516		Engaged	1800	188-220	1296-1516
	Cruising	Min.	185	1275		Cruising	Min.	165	1137
MG-513	Neutral	600	70-110	483-758					
	Neutral	1800	90-130	621-896					
	Engaged	600	230-270	1585-1861					
	Engaged	1800	240-280	1654-1930					
	Cruising	Min.	234	1612					

* Sump or heat exchanger inlet 210° F (99° C) maximum. Normal operating range desired 140-180° F (60-82° C) minimum continuous duty.

† Sump or heat exchanger inlet 225° F (107° C) maximum intermittent permissable in pleasure craft.

TABLE 2 – Twin Disc Marine Gear Operating Conditions

STOPPING

Normal Stopping

1. Release the load and decrease the engine speed. Put all shift levers in the *neutral* position.

2. Allow the engine to run at half speed or slower with no load for four or five minutes, then move the stop lever to the *stop* position to stop the engine.

Emergency Stopping

To stop an engine (normal or emergency) equipped with the spring–loaded (one screw) design injector control tube, pull the governor stop lever to the stop position. If an engine equipped with the non–spring loaded (two screw) design injector control tube does not stop after using the normal stopping procedure, pull the *Emergency Stop* knob all the way out. This control cuts off the air to the engine. Do not try to restart again until the cause for the malfunction has been found and corrected.

> **NOTICE:** The emergency shutdown system should never be used except in an emergency. Use of the emergency shutdown can cause oil to be sucked past the oil seals and into the blower housing.

The air shutoff valve, located on the blower air inlet housing, must be reset by hand and the *Emergency Stop* knob pushed in before the engine is ready to start again.

Fuel System

If the unit is equipped with a fuel valve, close it. Fill the fuel tank; a full tank minimizes condensation.

Exhaust System

Drain the condensation from the exhaust line or silencer.

Cooling System

Drain the cooling system if it is not protected with antifreeze and freezing temperatures are expected. Leave the drains open. Open the raw water drains of a heat exchanger cooling system.

Crankcase

Check the oil level in the crankcase. Add oil, if necessary, to bring it to the proper level on the dipstick.

Transmission

Check and, if necessary, add sufficient oil to bring it to the proper level.

Inspection

Make a visual check for leaks in the fuel, lubricating and cooling systems.

Clean Engine

Clean and check the engine thoroughly to make certain it will be ready for the next run.

Refer to the *Lubrication and Preventive Maintenance Chart* in Section 15.1 and perform all of the daily maintenance operations. Also, perform the operations required for the number of hours or miles the engine has been in operation.

Make the necessary adjustments and minor repairs to correct difficulties which became apparent to the operator during the last run.

OPERATING CONDITIONS

The following charts are included as an aid to trouble shooting. Any variations from the conditions as listed may be indicative of an abnormal situation demanding correction. Make sure that readings represent true values and that instruments are accurate, before attempting to make corrections to the engine.

V–92 ALL (EXCEPT TURBOCHARGED) ENGINES

	1200 rpm	1800 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	32–47	50–70	50–70
Minimum for safe operation	25	28	30
†Lubricating oil temperature (deg. F) – Normal	200–235	200–235	200–235
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure	1.1	3.8	5.0
At max. full–load exhaust back pressure	2.3	6.4	8.2
Air inlet restriction (inches water) – full load max.:			
Dirty air cleaner – oil bath or dry type	12.4	25.0	25.0
Clean air cleaner:			
Oil bath type	8.7	13.4	15.9
Dry type with precleaner	8.7	13.4	15.9
Dry type less precleaner	5.2	9.1	11.5
Crankcase pressure (inches water) – max.	1.0	2.2	3.0
Exhaust back pressure (inches mercury) – max.:			
Full load	1.5	3.3	4.0
No load	1.0	2.1	2.6
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal with .080" restriction fitting (6, 8V)	45–70	45–70	45–70
Normal with .070" restriction fitting (12, 16V)	30–65	30–65	30–65
Minimum	30	30	30
Fuel spill (gpm) – min. at no load:			
6 and 8V engines	0.8	0.9	0.9
12 and 16V engines	1.2	1.4	1.4
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	160–185	160–185	160–185
Vehicle engines built 1976 and later	170–195	170–195	170–195
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm ... 550			
Minimum – at 600 rpm ... 500			

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

6V–92T ENGINE (with T18A40 TURBOCHARGER) (1.14 A/R* Turbine Housing)

	1800 rpm	2000 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	50–70	50–70	50–70
Minimum for safe operation	28	30	30
†Lubricating oil temperature (deg. F) – Normal	200–250	200–250	200–250
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure:			
9280 injector	21.0	25.5	28.0
9285 injector	22.5	27.0	29.5
9290 injector	24.0	29.0	31.5
9295 injector	25.5		
At max. full–load exhaust back pressure (clean ports):			
9280 injector	19.5	23.7	26.0
9285 injector	20.9	25.1	27.4
9290 injector	22.3	27.0	29.3
9295 injector	23.4		
Air inlet restriction (inches water) – full load max.:			
Dirty air cleaner – dry type	14.5	18.0	20.0
Clean air cleaner:			
Dry type with precleaner	8.7	10.8	12.0
Dry type less precleaner	5.8	7.2	8.0
Crankcase pressure (inches water) – max.	2.2	2.7	3.0
Exhaust back pressure (inches mercury) – max.:			
Full load	1.8	2.2	2.5
No load	1.3	1.6	1.8
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal with .080" restriction fitting	50–70	50–70	50–70
Minimum	30	30	30
Fuel spill (gpm) – min. at no load:			
.080" restriction fitting	0.9	0.9	0.9
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	160–185	160–185	160–185
Vehicle engines built 1976 and later	170–195	170–195	170–195
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm ... 500			
Minimum – at 600 rpm ... 450			

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

6V-92T (OTM) ENGINE (with TV8102 TURBOCHARGER) (1.23 A/R* Turbine Housing) – 9290 INJECTORS

	1200 rpm	1800 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	32–52	49–70	49–70
Minimum for safe operation	25	28	30
†Lubricating oil temperature (deg. F) – Normal	200–235	200–235	200–235
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure	12.5	25.9	33.9
At max. exhaust back pressure (clean ports)	11.8	24.4	32.0
Air inlet restriction (inches water) – max.:			
Dirty air cleaner – dry type:			
Full–load speed	6.5	14.4	20.0
No–load speed	4.0	8.7	12.0
Clean air cleaner – dry type:			
Full–load speed	4.0	8.7	12.0
No–load speed	2.0	5.1	7.2
Crankcase pressure (inches water) – max.	1.3	2.1	3.0
Exhaust back pressure (inches mercury) – max.:			
Full load	0.7	2.0	2.5
No load	0.7	1.4	1.8
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal	50–70	50–70	50–70
Minimum	30	30	30
Fuel spill (gpm) – min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	160–185	160–185	160–185
Vehicle engines built 1976 and later	170–195	170–195	170–195
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm ... 500			
Minimum – at 600 rpm ... 450			

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

6V-92TA and 6V-92TAC ENGINE (with TV7101 TURBOCHARGER) (1.23 A/R* Turbine Housing) – California Coach

	1900 rpm	2000 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	49–70	49–70	49–70
Minimum for safe operation	28	29	30
†Lubricating oil temperature (deg. F) – Normal	200–250	200–250	200–250
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure:			
9E65 injector – No. 1 Fuel	35.3	38.4	41.5
9E70 injector – No. 1 Fuel	37.3	40.5	43.7
9E65 injector – No. 2 Fuel	34.6	41.1	44.3
9E70 injector – No. 2 Fuel	37.0	43.7	47.0
At max. exhaust back pressure (clean ports):			
9E65 injector – No. 1 Fuel	33.0	36.1	39.2
9E70 injector – No. 1 Fuel	35.0	38.2	41.4
9E65 injector – No. 2 Fuel	32.3	38.8	42.0
9E70 injector – No. 2 Fuel	34.7	41.4	44.7
Air inlet restriction (inches water) – full load max.:			
Dirty air cleaner – dry type	20.0	20.0	20.0
Clean air cleaner – dry type	12.0	12.0	12.0
Crankcase pressure (inches water) – max.:			
Both breathers	2.1	2.3	3.0
Left bank breather	2.6	2.8	3.0
Exhaust back pressure (inches mercury) – max.:			
Full load	3.0	3.0	3.0
Fuel System			
Fuel pressure at inlet manifold (psi) – Normal	50–70	50–70	50–70
Fuel spill (gpm) – min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	170–195	170–195	170–195
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm ... 500			
Minimum – at 600 rpm ... 450			

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

6V-92TA and 6V-92TAC ENGINE (with TV7101 TURBOCHARGER) (1.39 A/R* Turbine Housing) – Coach

	1800 rpm	2000 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	49–70	49–70	49–70
Minimum for safe operation	28	29	30
†Lubricating oil temperature (deg. F) – Normal	200–250	200–250	200–250
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure:			
7G65 injector – Fed. – No. 1 Fuel	24.4	30.1	33.0
7G70 injector – Fed. – No. 1 Fuel	26.4	32.1	34.9
7G75 injector – Fed. – No. 1 Fuel	28.3	33.9	36.8
7G65 injector – Fed. – No. 2 Fuel	26.3	31.7	34.4
7G70 injector – Fed. – No. 2 Fuel	28.3	33.7	36.4
7G75 injector – Fed. – No. 2 Fuel	30.3	35.7	38.4
7G65 injector – Calif. – No. 1 Fuel	30.7	33.7	36.8
7G70 injector – Calif. – No. 1 Fuel	32.8	35.9	39.0
7G75 injector – Calif. – No. 1 Fuel	34.9	38.0	41.2
7G65 injector – Calif. – No. 2 Fuel	31.9	34.9	38.0
7G70 injector – Calif. – No. 2 Fuel	33.9	36.9	40.0
7G75 injector – Calif. – No. 2 Fuel	35.9	38.9	42.0
At max. exhaust back pressure (clean ports):			
7G65 injector – Fed. – No. 1 Fuel	22.1	27.8	30.7
7G70 injector – Fed. – No. 1 Fuel	24.1	29.8	32.6
7G75 injector – Fed. – No. 1 Fuel	26.0	31.6	34.5
7G65 injector – Fed. – No. 2 Fuel	24.0	29.4	32.1
7G70 injector – Fed. – No. 2 Fuel	26.0	31.4	34.1
7G75 injector – Fed. – No. 2 Fuel	28.0	33.4	36.1
7G65 injector – Calif. – No. 1 Fuel	28.4	31.4	34.5
7G70 injector – Calif. – No. 1 Fuel	30.5	33.6	36.7
7G75 injector – Calif. – No. 1 Fuel	32.6	35.7	38.9
7G65 injector – Calif. – No. 2 Fuel	29.6	32.6	35.7
7G70 injector – Calif. – No. 2 Fuel	31.6	34.6	37.7
7G75 injector – Calif. – No. 2 Fuel	33.6	36.6	39.7
Air inlet restriction (inches water) – full load max.:			
Dirty air cleaner – dry type	20.0	20.0	20.0
Clean air cleaner – dry type	12.0	12.0	12.0
Crankcase pressure (inches water) – max.	2.1	2.3	3.0
Exhaust back pressure (inches mercury) – max.:			
Full load	3.0	3.0	3.0
Fuel System			
Fuel pressure at inlet manifold (psi) – Normal	50–70	50–70	50–70
Fuel spill (gpm) – min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0

6V–92TA and 6V–92TAC ENGINE (with TV7101 TURBOCHARGER) (1.39 A/R* Turbine Housing) – Coach (Cont'd.)

	1800 rpm	2000 rpm	2100 rpm
Cooling System			
Coolant temperature (deg. F) – Normal	170–195	170–195	170–195
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm ... 500			
Minimum – at 600 rpm ... 450			

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

6V–92TA and 6V–92TAC ENGINE (with TV7111 TURBOCHARGER) (1.23 A/R* Turbine Housing) – 1981 and 1982 Automotive

	1800 rpm	1950 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	49–70	49–70	49–70
Minimum for safe operation	28	29	30
†Lubricating oil temperature (deg. F) – Normal	200–250	200–250	200–250
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure:			
9B90 injector – 1.470 timing – Fed.	34.4	40.3	46.4
9F90 injector – 1.520 timing – Calif.	38.1	43.9	49.8
At max. exhaust back pressure (clean ports):			
9B90 injector – 1.470 timing – Fed.	32.2	38.1	44.2
9F90 injector – 1.520 timing – Calif.	35.8	41.6	47.5
Air inlet restriction (inches water) – full load max.:			
Dirty air cleaner – dry type	20.0	20.0	20.0
Clean air cleaner – dry type	12.0	12.0	12.0
Crankcase pressure (inches water) – max.	2.1	2.3	3.0
Exhaust back pressure (inches mercury) – max.:			
Full load	3.0	3.0	3.0
Fuel System			
Fuel pressure at inlet manifold (psi) – Normal	50–70	50–70	50–70
Fuel spill (gpm) – min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	170–195	170–195	170–195
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm	500		
Minimum – at 600 rpm	450		

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

6V–92TA ENGINE (with TV7301 TURBOCHARGER) (1.08 A/R* Turbine Housing) – 9B90 – 1.464 Timing

	1800 rpm	1950 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	49–70	49–70	49–70
Minimum for safe operation	28	29	30
†Lubricating oil temperature (deg. F) – Normal	200–250	200–250	200–250
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure	36.3	39.9	43.2
At max. exhaust back pressure	34.8	38.2	41.3
Air inlet restriction (inches water) – full load max.:			
Dirty air cleaner	20.0	20.0	20.0
Clean air cleaner	12.0	12.0	12.0
Crankcase pressure (inches water) – max.:			
Both breather	2.1	2.3	3.0
Left bank breather	2.6	2.8	3.0
Exhaust back pressure (inches mercury) – max.:			
Full load	2.0	2.3	2.5
Fuel System			
Fuel pressure at inlet manifold (psi) – Normal	50–70	50–70	50–70
Fuel spill (gpm) – min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	170–195	170–195	170–195
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm	500		
Minimum – at 600 rpm	450		

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

6V-92TA ENGINE (with TV8102 TURBOCHARGER) (1.08 A/R* Turbine Housing) – 9A90 INJECTORS

	1200 rpm	1800 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	32–52	49–70	49–70
Minimum for safe operation	25	28	30
†Lubricating oil temperature (deg. F) – Normal	200–235	200–235	200–235
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure	16.1	32.2	40.4
At max. exhaust back pressure (clean ports)	15.4	30.7	38.5
Air inlet restriction (inches water) – max.:			
Dirty air cleaner – dry type:			
Full–load speed	6.5	20.0	20.0
No–load speed	4.0	8.7	12.0
Clean air cleaner – dry type:			
Full–load speed	4.0	12.0	12.0
No–load speed	2.0	5.1	7.2
Crankcase pressure (inches water) – max.	1.3	2.1	3.0
Exhaust back pressure (inches mercury) – max.:			
Full load	0.9	3.0	3.0
No load	0.7	1.4	1.8
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal	50–70	50–70	50–70
Minimum	25	28	30
Fuel spill (gpm) – min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	160–185	160–185	160–185
Vehicle engines built 1976 and later	170–195	170–195	170–195
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm	500		
Minimum – at 600 rpm	450		

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

6V-92TA and 6V-92TAC ENGINE (with TV8102 TURBOCHARGER) (1.23 A/R* Turbine Housing) – 1979 Federal and California

	1800 rpm	1950 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	49–70	49–70	49–70
Minimum for safe operation	28	29	30
†Lubricating oil temperature (deg. F) – Normal	200–250	200–250	200–250
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure (clean ports):			
9B80 injector – 1.470 timing – Fed.	26.5	31.7	37.2
9B85 injector – 1.470 timing – Fed.	28.1	33.4	38.9
9B90 injector – 1.470 timing – Fed.	29.7	35.1	40.5
9B80 injector – 1.470 timing – Calif.	26.9	32.2	37.5
9B85 injector – 1.470 timing – Calif.	28.7	34.0	39.4
9B90 injector – 1.470 timing – Calif.	30.3	35.8	41.3
At max. exhaust back pressure (clean ports):			
9B80 injector – 1.470 timing – Fed.	24.2	29.4	34.9
9B85 injector – 1.470 timing – Fed.	25.8	31.1	36.6
9B90 injector – 1.470 timing – Fed.	27.4	32.8	38.2
9B80 injector – 1.470 timing – Calif.	24.6	29.9	35.2
9B85 injector – 1.470 timing – Calif.	26.4	31.7	37.1
9B90 injector – 1.470 timing – Calif.	28.0	33.5	39.0
Air inlet restriction (inches water) – full load max.:			
Dirty air cleaner – dry type	20.0	20.0	20.0
Clean air cleaner – dry type	12.0	12.0	12.0
Crankcase pressure (inches water) – max.	2.1	2.3	3.0
Exhaust back pressure (inches mercury) – max.:			
Full load	3.0	3.0	3.0
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal	50–70	50–70	50–70
Minimum	30	30	30
Fuel spill (gpm) – min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	170–195	170–195	170–195
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm ... 500			
Minimum – at 600 rpm ... 450			

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

6V–92TT ENGINE (with TV8102 TURBOCHARGER) (1.23 A/R* Turbine Housing) – 9290 INJECTORS

	1200 rpm	1800 rpm	1950 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	32–52	49–70	49–70
Minimum for safe operation	25	28	30
†Lubricating oil temperature (deg. F) – Normal	200–235	200–235	200–235
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure:			
270 BHP	12.5	22.2	25.4
240 BHP	12.5	20.4	23.4
At max. exhaust back pressure (clean ports):			
270 BHP	11.8	20.7	23.7
240 BHP	11.8	18.9	21.7
Air inlet restriction (inches water) – max.:			
Dirty air cleaner – dry type:			
Full–load speed	6.5	14.5	17.0
No–load speed	4.0	8.7	10.3
Clean air cleaner – dry type:			
Full–load speed	4.0	8.7	10.2
No–load speed	2.0	5.1	6.0
Crankcase pressure (inches water) – max.	1.3	2.1	3.0
Exhaust back pressure (inches mercury) – max.:			
Full load	0.9	2.0	2.4
No load	0.7	1.4	1.7
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal	50–70	50–70	50–70
Minimum	30	30	30
Fuel spill (gpm) – min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	160–185	160–185	160–185
Vehicle engines built 1976 and later	170–195	170–195	170–195
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm ... 500			
Minimum – at 600 rpm ... 450			

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

6V–92TTA and 6V–92TTAC ENGINE (with TV7111 TURBOCHARGER) (1.23 A/R* Turbine Housing) – 1981 and 1982 Automotive

	1800 rpm	1900/1950 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	49–70	49–70	49–70
Minimum for safe operation	28	29	30
†Lubricating oil temperature (deg. F) – Normal	200–250	200–250	200–250
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure:			
9B90 injector – 1.470 timing – Fed.:			
270 BHP	30.1	33.2/—	39.5
307 BHP	34.4	37.5/—	43.6
9F90 injector – 1.520 timing – Calif.:			
270 BHP	30.6	—/35.1	39.3
307 BHP	34.0	—/38.6	42.9
At max. exhaust back pressure (clean ports):			
9B90 injector – 1.470 timing – Fed.:			
270 BHP	27.8	20.9/—	37.2
307 BHP	32.1	35.2/—	41.3
9F90 injector – 1.520 timing – Calif.:			
270 BHP	28.3	—/32.8	37.0
307 BHP	31.7	—/36.3	40.6
Air inlet restriction (inches water) – full load max.:			
Dirty air cleaner – dry type	20.0	20.0	20.0
Clean air cleaner – dry type	12.0	12.0	12.0
Crankcase pressure (inches water) – max.	2.1	2.2/2.3	3.0
Exhaust back pressure (inches mercury) – max.:			
Full load	3.0	3.0	3.0
Fuel System			
Fuel pressure at inlet manifold (psi) – Normal	50–70	50–70	50–70
Fuel spill (gpm) – min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	170–195	170–195	170–195
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm	500		
Minimum – at 600 rpm	450		

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

6V–92TTA ENGINE (with TV7301 TURBOCHARGER) (1.08 A/R* Turbine Housing) – 9B90 – 1.470 Timing

	1800 rpm	1900 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	49–70	49–70	49–70
Minimum for safe operation	28	29	30
†Lubricating oil temperature (deg. F) – Normal	200–250	200–250	200–250
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure (clean ports):			
270 BHP	30.1	30.5	33.3
307 BHP	36.3	36.5	38.2
At max. exhaust back pressure (clean ports):			
270 BHP	28.6	28.8	31.4
307 BHP	34.8	34.8	36.3
Air inlet restriction (inches water) – full load max.:			
Dirty air cleaner	20.0	20.0	20.0
Clean air cleaner	12.0	12.0	12.0
Crankcase pressure (inches water) – max.:			
Both breather	2.1	2.2	3.0
Left bank breather	2.6	2.8	3.0
Exhaust back pressure (inches mercury) – max.:			
Full load	2.0	2.2	2.5
Fuel System			
Fuel pressure at inlet manifold (psi) – Normal	50–70	50–70	50–70
Fuel spill (gpm) – min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	170–195	170–195	170–195
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm	500		
Minimum – at 600 rpm	450		

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

6V-92TTA ENGINE (with TV8102 TURBOCHARGER) (1.08 A/R* Turbine Housing) – 9A90 INJECTORS

	1200 rpm	1800 rpm	1950 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	32–52	49–70	49–70
Minimum for safe operation	25	28	30
†Lubricating oil temperature (deg. F) – Normal	200–235	200–235	200–235
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure	16.1	28.5	31.7
At max. exhaust back pressure (clean ports)	15.4	27.0	30.0
Air inlet restriction (inches water) – max.:			
Dirty air cleaner – dry type:			
Full–load speed	6.5	20.0	20.0
No–load speed	4.0	8.7	10.2
Clean air cleaner – dry type:			
Full–load speed	4.0	12.0	12.0
No–load speed	2.0	5.1	7.2
Crankcase pressure (inches water) – max.	1.3	2.1	3.0
Exhaust back pressure (inches mercury) – max.:			
Full load	0.9	3.0	3.0
No load	0.7	1.4	1.7
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal	50–70	50–70	50–70
Minimum	30	30	30
Fuel spill (gpm) – min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	160–185	160–185	160–185
Vehicle engines built 1976 and later	170–195	170–195	170–195
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm	500		
Minimum – at 600 rpm	450		

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

6V–92TTA AND 6V–92TTAC ENGINE (WITH TV8102 TURBOCHARGER) (1.23 A/R* TURBINE HOUSING) – 9B90 INJECTOR

	1800 rpm	1950 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	49–70	49–70	49–70
Minimum for safe operation	28	29	30
†Lubricating oil temperature (deg. F) – Normal	200–250	200–250	200–250
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure (clean ports):			
240 (Fed.) – 1.470 timing	23.1	—	—
270 (Fed.) – 1.470 timing	25.7	31.3	35.3
307 (Fed.) – 1.470 timing	29.7	34.5	38.3
240 (Calif.) – 1.490 timing	24.1	—	—
270 (Calif.) – 1.490 timing	26.6	31.4	35.6
307 (Calif.) – 1.490 timing	30.3	34.8	38.8
At max. exhaust back pressure (clean ports):			
240 (Fed.) – 1.470 timing	20.8	—	—
270 (Fed.) – 1.470 timing	23.4	29.0	33.0
307 (Fed.) – 1.470 timing	27.4	32.2	36.0
240 (Calif.) – 1.490 timing	21.8	—	—
270 (Calif.) – 1.490 timing	24.3	29.1	33.3
307 (Calif.) – 1.490 timing	28.0	32.5	36.5
Air inlet restriction (inches water) – full load max.:			
Dirty air cleaner – dry type	20.0	20.0	20.0
Clean air cleaner – dry type	12.0	12.0	12.0
Crankcase pressure (inches water) – max.	2.1	2.3	3.0
Exhaust back pressure (inches mercury) – max.:			
Full load	3.0	3.0	3.0
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal	50–70	50–70	50–70
Minimum	30	30	30
Fuel spill (gpm) – min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	170–195	170–195	170–195
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm	500		
Minimum – at 600 rpm	450		

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

8V–92T AND 16V–92T ENGINE (WITH T18A90 TURBOCHARGER) (1.50 A/R* TURBINE HOUSING)

	1800 rpm	2000 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	50–70	50–70	50–70
Minimum for safe operation	28	30	30
†Lubricating oil temperature (deg. F) – Normal	200–250	200–250	200–250
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure:			
9280 injector	22.5	27.5	29.5
9285 injector	24.0	29.0	31.0
9290 injector	25.5	31.0	33.0
9295 injector	27.5		
At max. full–load exhaust back pressure (clean ports):			
9280 injector	20.9	25.6	27.4
9285 injector	22.3	27.0	28.8
9290 injector	23.7	28.8	30.7
9295 injector	25.6		
Air inlet restriction (inches water) – full load max.:			
Dirty air cleaner – dry type	14.5	18.0	20.0
Clean air cleaner:			
Dry type with precleaner	8.7	10.8	12.0
Dry type less precleaner	6.3	7.7	8.5
Crankcase pressure (inches water) – max.	2.2	2.7	3.0
Exhaust back pressure (inches mercury) – max.:			
Full load	2.0	2.5	2.5
No load	1.3	1.6	1.8
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal with .080" restriction fitting (8V)	50–70	50–70	50–70
Normal with .070" restriction fitting (two for 16V)	50–70	50–70	50–70
Minimum	30	30	30
Fuel spill (gpm) – min. at no load:			
.080" restriction fitting (8V)	0.9	0.9	0.9
.070" restriction fitting (two for 16V)	1.4	1.4	1.4
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	160–185	160–185	160–185
Vehicle engines built 1976 and later	170–195	170–195	170–195

8V–92T AND 16V–92T ENGINE (WITH T18A90 TURBOCHARGER) (1.50 A/R* TURBINE HOUSING) (Cont'd.)

	1800 rpm	2000 rpm	2100 rpm
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm 500			
Minimum – at 600 rpm 450			

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

8V–92T (OTM) ENGINE (with TV8101 TURBOCHARGER) (1.84 A/R* Turbine Housing) – 9290 INJECTORS

	1200 rpm	1800 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	32–52	49–70	49–70
Minimum for safe operation	25	28	30
†Lubricating oil temperature (deg. F) – Normal	200–235	200–235	200–235
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure	13.6	27.0	35.0
At max. full–load exhaust back pressure (clean ports)	12.9	25.5	33.1
Air inlet restriction (inches water) – max.:			
Dirty air cleaner – dry type:			
Full–load speed	6.5	14.4	20.0
No–load speed	4.0	8.7	12.0
Clean air cleaner – dry type:			
Full–load speed	4.0	8.7	12.0
No–load speed	2.0	5.1	7.2
Crankcase pressure (inches water) – max.	2.3	3.1	3.5
Exhaust back pressure (inches mercury) – max.:			
Full load	0.7	2.0	2.5
No load	0.7	1.4	1.8
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal	50–70	50–70	50–70
Minimum	30	30	30
Fuel spill (gpm) – min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	160–185	160–185	160–185
Vehicle engines built 1976 and later	170–195	170–195	170–195
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm	500		
Minimum – at 600 rpm	450		

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

8V-92TA and 8V-92TAC ENGINE (with TV7111 TURBOCHARGER) (1.39 A/R* Turbine Housing) – 1981 and 1982 Automotive

	1800 rpm	2000 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	49–70	49–70	49–70
Minimum for safe operation	28	29	30
†Lubricating oil temperature (deg. F) – Normal	200–250	200–250	200–250
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure:			
7G75 injector – 1.470 timing – Fed.	38.1	—	—
7G75 injector – 1.508 timing – Calif.	39.2	—	—
9E65 injector – 1.466 timing – Fed. Transit	32.7	37.9	40.4
9E70 injector – 1.466 timing – Fed. Transit	35.0	40.1	41.4
At max. exhaust back pressure (clean ports):			
7G75 injector – 1.470 timing – Fed.	35.8	—	—
7G75 injector – 1.508 timing – Calif.	36.9	—	—
9E65 injector – 1.466 timing – Fed. Transit	30.4	35.6	38.1
9E70 injector – 1.466 timing – Fed. Transit	32.7	37.8	39.1
Air inlet restriction (inches water) – full load max.:			
Dirty air cleaner – dry type	20.0	20.0	20.0
Clean air cleaner – dry type	12.0	12.0	12.0
Crankcase pressure (inches water) – max.	3.1	3.3	3.5
Exhaust back pressure (inches mercury) – max.:			
Full load	3.0	3.0	3.0
Fuel System			
Fuel pressure at inlet manifold (psi) – normal	50–70	50–70	50–70
Fuel spill (gpm) – min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	170–195	170–195	170–195
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm	500		
Minimum – at 600 rpm	450		

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

8V-92TA and 8V-92TAC ENGINE (with TV7301 TURBOCHARGER) (1.39 A/R* Turbine Housing) – 355 BHP

	1800 rpm
Lubrication System	
Lubricating oil pressure (psi):	
Normal	49–70
Minimum for safe operation	28
†Lubricating oil temperature (deg. F) – Normal	200–250
Air System	
Air box pressure (inches mercury) – full load min.:	
At zero exhaust back pressure:	
9E70 injector – 1.470 timing – Fed.	39.5
9G75 injector – 1.508 timing – Calif.	41.0
At max. exhaust back pressure (clean ports)	
9E70 injector – 1.470 timing – Fed.	37.7
9G75 injector – 1.508 timing – Calif.	39.2
Air inlet restriction (inches water) – full load max.:	
Dirty air cleaner	20.0
Clean air cleaner	12.0
Crankcase pressure (inches water) – max.	3.1
Exhaust back pressure (inches mercury) – max.:	
Full load	2.4
Fuel System	
Fuel pressure at inlet manifold (psi) – Normal	50–70
Fuel spill (gpm) – min. at no load	0.9
Pump suction at inlet (inches mercury) – max.:	
Clean system	6.0
Dirty system	12.0
Cooling System	
Coolant temperature (deg. F) – Normal	170–195
Compression	
Compression pressure (psi at sea level):	
Average – new engine – at 600 rpm ... 500	
Minimum – at 600 rpm ... 450	

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

8V–92TA ENGINE (with TV8101 TURBOCHARGER) (1.60 A/R* Turbine Housing)

	1200 rpm	1800 rpm	1950/2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	32–52	49–70	49–70
Minimum for safe operation	25	28	30
†Lubricating oil temperature (deg. F) – Normal	200–235	200–235	200–235
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure:			
9290 Injector	15.0	29.8	—/36.9
9A90 Injector	18.7	35.4	44.0/—
At max. exhaust back pressure (clean ports):			
9290 Injector	14.3	28.3	—/35.0
9A90 Injector	18.0	33.9	42.1/—
Air inlet restriction (inches water) – full load max.:			
Dirty air cleaner – dry type:			
Full–load speed	6.5	20.0	20.0
No–load speed	4.0	8.7	12.0
Clean air cleaner – dry type:			
Full–load speed	4.0	12.0	12.0
No–load speed	2.0	5.1	7.2
Crankcase pressure (inches water) – max.	2.3	3.1	3.5
Exhaust back pressure (inches mercury) – max.:			
Full load	0.9	3.0	3.0
No load	0.7	1.4	1.8
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal	50–70	50–70	50–70
Minimum	30	30	30
Fuel spill (gpm) – min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	170–195	170–195	170–195

Compression

Compression pressure (psi at sea level):

Average – new engine – at 600 rpm 500

Minimum – at 600 rpm 450

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

8V-92TA ENGINE (with TV8101 TURBOCHARGER) (1.60 A/R* Turbine Housing)1979 Federal and California

	1800 rpm	1950 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	49–70	49–70	49–70
Minimum for safe operation	28	29	30
†Lubricating oil temperature (deg. F) – Normal	200–250	200–250	200–250
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure (clean ports):			
9A80 injector – Fed.	29.3	33.1	36.8
9A80 injector – Calif.	31.0	34.8	38.6
9A85 injector – Fed.	31.2	35.1	38.7
9A85 injector – Calif.	32.8	36.7	40.6
9A90 injector – Fed.	33.1	37.0	40.6
9A90 injector – Calif.	34.6	38.7	42.6
At max. exhaust back pressure (clean ports):			
9A80 injector – Fed.	27.0	30.8	34.5
9A80 injector – Calif.	28.7	32.5	36.3
9A85 injector – Fed.	28.9	32.8	36.4
9A85 injector – Calif.	30.5	34.4	38.3
9A90 injector – Fed.	30.8	34.7	38.3
9A90 injector – Calif.	32.3	36.4	40.3
Air inlet restriction (inches water) – full load max.:			
Dirty air cleaner – dry type	20.0	20.0	20.0
Clean air cleaner – dry type	12.0	12.0	12.0
Crankcase pressure (inches water) – max.	3.1	3.3	3.5
Exhaust back pressure (inches mercury) – max.:			
Full load	3.0	3.0	3.0
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal	50–70	50–70	50–70
Minimum	30	30	30
Fuel spill (gpm) – min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	170–195	170–195	170–195
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm	500		
Minimum – at 600 rpm	450		

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

8V–92TA and 8V–92TAC ENGINE (with TV8117 TURBOCHARGER) (1.39 A/R* Turbine Housing) – 1981 and 1982 Automotive

	1800 rpm	1950 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	49–70	49–70	49–70
Minimum for safe operation	28	29	30
†Lubricating oil temperature (deg. F) – Normal	200–250	200–250	200–250
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure:			
9A90 injector – 1.466 timing – Fed.	29.8	34.0	38.2
9F90 injector – 1.520 timing – Calif.	36.9	40.8	44.7
At max. exhaust back pressure (clean ports):			
9A90 injector – 1.466 timing – Fed.	27.5	31.7	35.9
9F90 injector – 1.520 timing – Calif.	34.6	38.5	42.4
Air inlet restriction (inches water) – full load max.:			
Dirty air cleaner – dry type	20.0	20.0	20.0
Clean air cleaner – dry type	12.0	12.0	12.0
Crankcase pressure (inches water) – max.	3.1	3.3	3.5
Exhaust back pressure (inches mercury) – max.:			
Full load	3.0	3.0	3.0
Fuel System			
Fuel pressure at inlet manifold (psi) – Normal	50–70	50–70	50–70
Fuel spill (gpm) – min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	170–195	170–195	170–195
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm 500			
Minimum – at 600 rpm 450			

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

8V-92TA and 8V-92TAC ENGINE (with TV8301 TURBOCHARGER) (1.39 A/R* Turbine Housing)

	1800 rpm	1950 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	49–70	49–70	49–70
Minimum for safe operation	28	29	30
†Lubricating oil temperature (deg. F) – Normal	200–250	200–250	200–250
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure:			
TTA 365 BHP – 9A90 – 1.460 timing	24.6	26.8	29.0
TA 445 BHP – 9A90 – 1.460 timing	29.1	34.7	36.4
TTAC 365 BHP – 9F90 – 1.515 timing	26.4	28.2	30.4
TAC 440 BHP – 9F90 – 1.515 timing	31.6	34.6	37.2
At max. exhaust back pressure (clean ports):			
TTA 365 BHP – 9A90 – 1.460 timing	22.8	24.8	26.7
TA 445 BHP – 9A90 – 1.460 timing	27.3	32.7	34.1
TTAC 365 BHP – 9F90 – 1.515 timing	24.6	26.2	28.1
TAC 440 BHP – 9F90 – 1.515 timing	29.8	32.6	34.9
Air inlet restriction (inches water) – full load max.:			
Dirty air cleaner – dry type	20.0	20.0	20.0
Clean air cleaner – dry type	12.0	12.0	12.0
Crankcase pressure (inches water) – max.	3.1	3.3	3.5
Exhaust back pressure (inches mercury) – max.:			
Full load	2.4	2.7	3.0
Fuel System			
Fuel pressure at inlet manifold (psi) – Normal	50–70	50–70	50–70
Fuel spill (gpm) – min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	170–195	170–195	170–195
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm	500		
Minimum – at 600 rpm	450		

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

downloaded from the Boatdiesel.com PDF Library by Dmb993@earthlink.net on 11-Nov-12

8V-92TT ENGINE (WITH TV8101 TURBOCHARGER) (1.84 A/R* TURBINE HOUSING) – 9290 INJECTORS

	1200 rpm	1800 rpm	1950 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	32–52	49–70	49–70
Minimum for safe operation	25	28	30
†Lubricating oil temperature (deg. F) – Normal	200–235	200–235	200–235
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure	13.6	25.4	28.6
At max. exhaust back pressure (clean ports)	12.9	23.9	26.9
Air inlet restriction (inches water) – max.:			
Dirty air cleaner – dry type:			
Full–load speed	6.5	14.5	17.0
No–load speed	4.0	8.7	10.3
Clean air cleaner – dry type:			
Full–load speed	4.0	8.7	10.2
No–load speed	2.0	5.1	6.0
Crankcase pressure (inches water) – max.	2.3	3.1	3.3
Exhaust back pressure (inches mercury) – max.:			
Full load	0.9	2.0	2.4
No load	0.7	1.4	1.7
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal	50–70	50–70	50–70
Minimum	30	30	30
Fuel spill (gpm) – min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	160–185	160–185	160–185
Vehicle engines built 1976 and later	170–195	170–195	170–195
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm	500		
Minimum – at 600 rpm	450		

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

8V-92TTA ENGINE (with TV8101 TURBOCHARGER) (1.60 A/R* Turbine Housing)

	1200 rpm	1800 rpm	1950 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	32–52	49–70	49–70
Minimum for safe operation	25	28	30
†Lubricating oil temperature (deg. F) – Normal	200–235	200–235	200–235
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure:			
9290 injector	15.0	27.0	29.3
9A90 injector	18.7	35.4	39.5
At max. exhaust back pressure (clean ports):			
9290 injector	14.3	25.5	27.6
9A90 injector	18.0	33.9	37.8
Air inlet restriction (inches water) – max.:			
Dirty air cleaner – dry type:			
Full-load speed	6.5	20.0	20.0
No-load speed (9290 injector)	4.0	8.7	12.0
No-load speed (9A90 injector)	4.0	8.7	10.3
Clean air cleaner – dry type:			
Full-load speed	4.0	12.0	12.0
No-load speed (9290 injector)	2.0	5.1	7.2
No-load speed (9A90 injector)	2.0	5.1	6.0
Crankcase pressure (inches water) – max.	2.3	3.1	3.3
Exhaust back pressure (inches mercury) – max.:			
Full load	0.9	3.0	3.0
No load	0.7	1.4	1.7
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal	50–70	50–70	50–70
Minimum	30	30	30
Fuel spill (gpm) – min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	170–195	170–195	170–195

Compression

Compression pressure (psi at sea level):

Average – new engine – at 600 rpm 500

Minimum – at 600 rpm 450

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

8V-92TTA and 8V-92TTAC ENGINE (with TV8101 TURBOCHARGER) (1.60 A/R* Turbine Housing) – 9A90 INJECTOR

	1800 rpm	1950 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	49–70	49–70	49–70
Minimum for safe operation	28	29	30
†Lubricating oil temperature (deg. F) – Normal	200–250	200–250	200–250
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure (clean ports):			
335 BHP (Fed.) – 1.480 timing	27.7	—	—
335 BHP (Calif.) – 1.500 timing	30.7	—	—
365 BHP (Fed.) – 1.480 timing	30.1	32.4	35.6
365 BHP (Calif.) – 1.500 timing	33.3	34.7	37.8
At max. exhaust back pressure (clean ports):			
335 BHP (Fed.) – 1.480 timing	25.4	—	—
335 BHP (Calif.) – 1.500 timing	28.4	—	—
365 BHP (Fed.) – 1.480 timing	27.8	30.1	33.3
365 BHP (Calif.) – 1.500 timing	31.0	32.4	35.5
Air inlet restriction (inches water) – full load max.:			
Dirty air cleaner – dry type	20.0	20.0	20.0
Clean air cleaner – dry type	12.0	12.0	12.0
Crankcase pressure (inches water) – max.	2.1	3.3	3.5
Exhaust back pressure (inches mercury) – max.:			
Full load	3.0	3.0	3.0
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal	50–70	50–70	50–70
Minimum	30	30	30
Fuel spill (gpm) – min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	170–195	170–195	170–195

Compression
Compression pressure (psi at sea level):
Average – new engine – at 600 rpm 500
Minimum – at 600 rpm 450

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

8V–92TTA and TTAC ENGINE (with TV8117 TURBOCHARGER) (1.39 A/R* Turbine Housing) – 1981 and 1982 Automotive

	1800 rpm	1950 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	49–70	49–70	49–70
Minimum for safe operation	28	29	30
†Lubricating oil temperature (deg. F) – Normal	200–250	200–250	200–250
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure:			
9A90 injector – 1.466 timing – Fed.	26.4	29.1	31.0
9F90 injector – 1.520 timing – Calif.	32.5	34.3	37.3
At max. exhaust back pressure (clean ports):			
9A90 injector – 1.466 timing – Fed.	24.1	26.8	28.7
9F90 injector – 1.520 timing – Calif.	30.2	32.0	35.0
Air inlet restriction (inches water) – full load max.:			
Dirty air cleaner – dry type	20.0	20.0	20.0
Clean air cleaner – dry type	12.0	12.0	12.0
Crankcase pressure (inches water) – max.	—	—	—
Exhaust back pressure (inches mercury) – max.:			
Full load	3.0	3.0	3.0
Fuel System			
Fuel pressure at inlet manifold (psi) – Normal	50–70	50–70	50–70
Fuel spill (gpm) – min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	170–195	170–195	170–195
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm 500			
Minimum – at 600 rpm 450			

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

8V–92T and 16V–92T ENGINE (with TV8101 TURBOCHARGER) (1.39 A/R* Turbine Housing) – GEN SET

	1200 rpm	1500 rpm	1800 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal (8V–92)	32–52	41–61	49–70
Normal (16V–92)	40–60	46–66	50–70
Minimum for safe operation	20	27	28
†Lubricating oil temperature (deg. F) – Normal	200–250	200–250	200–250
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure:			
9285 injector	15.5	26.0	35.0
9200 injector	20.8	31.4	40.5
9215 injector	25.6	36.3	45.2
At max. exhaust back pressure (clean ports):			
9285 injector	14.8	25.0	33.5
9200 injector	20.1	30.4	39.0
9215 injector	24.9	35.3	43.7
Air inlet restriction (inches water) – full load max.:			
Dirty air cleaner – dry type:			
Full–load speed	6.5	10.3	14.4
No–load speed	4.0	6.1	8.7
Clean air cleaner – dry type:			
Full–load speed	4.0	6.2	8.7
No–load speed	2.0	3.4	5.1
Crankcase pressure (inches water) – max.	2.3	2.7	3.1
Exhaust back pressure (inches mercury) – max.:			
Full load	0.9	1.4	2.0
No load	0.7	1.0	1.45
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal	50–70	50–70	50–70
Minimum	30	30	30
Fuel spill (gpm) – min. at no load:			
(8V–92)	0.9	0.9	0.9
(16V–92)	1.4	1.4	1.4
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	160–185	160–185	160–185
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm ... 500			
Minimum – at 600 rpm ... 450			

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

8V-92TI ENGINE (with TH08A TURBOCHARGER) (.096 A/R* Turbine Housing) – MARINE

	1800 rpm	2100 rpm	2300 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	49–70	49–70	49–70
Minimum for safe operation	28	30	31
†Lubricating oil temperature (deg. F) – Normal	200–250	200–250	200–250
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure:			
9290 injector	20.0	27.9	33.3
9200 injector	23.0	31.3	37.0
9215 injector	26.2	35.3	41.5
At max. exhaust back pressure (clean ports):			
9290 injector	17.7	25.6	31.0
9200 injector	20.7	29.0	34.7
9215 injector	23.9	33.0	39.2
Air inlet restriction (inches water) – full load max.:			
Dirty air cleaner – dry type	20.0	20.0	20.0
Clean air cleaner – dry type	12.0	12.0	12.0
Crankcase pressure (inches water) – max.	2.5	2.8	3.0
Exhaust back pressure (inches mercury) – max.:			
Full load	3.0	3.0	3.0
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal	50–70	50–70	50–70
Minimum	30	30	30
Fuel spill (gpm) – min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	160–185	160–185	160–185
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm	500		
Minimum – at 600 rpm	450		

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

12V-92TAB ENGINE (with TW-83 TURBOCHARGER) (1.19 A/R* Turbine Housing) – MARINE

	2300 rpm
Lubrication System	
Lubricating oil pressure (psi):	
Normal	Greater than 60
Minimum for safe operation	40
†Lubricating oil temperature (deg. F) – max.	
Full load	250
Air System	
Air box pressure (inches mercury) – full load min.:	
145 injector	
Front block	54.0
Rear block	51.0
Turbocharger pressure (inches mercury) – full load min.:	
Front block	44.0
Rear block	41.0
Air inlet restriction (inches water) – full load max.:	
Dirty air cleaner – dry type	14.5
Crankcase pressure (inches water) – full load max.	3.0
Exhaust back pressure (inches mercury) – max.:	
Full load	2.5
Exhaust temperature at full load (approx.) (deg. F) (taken at turbo outlet)	650
Fuel System	
Fuel pressure at inlet manifold (psi):	
Normal	50–70
Fuel spill (gpm) – min. at no load	1.4
Pump suction at inlet (inches mercury) – no load max.:	
Clean system	6.0
Dirty system	12.0
Cooling System	
Coolant temperature (deg. F) – Normal–full load	185
Max.	200
Compression	
Compression pressure (psi at sea level):	
Average – new engine – at 600 rpm 500	
Minimum – at 600 rpm 450	

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

16V–92TA ENGINE (with T18A90 TURBOCHARGERS) (1.32 A/R* Turbine Housing) – 9290 INJECTORS

	1800 rpm	2000 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	50–70	50–70	50–70
Minimum for safe operation	28	30	30
†Lubricating oil temperature (deg. F) – Normal	200–250	200–250	200–250
Air System			
Air box pressure (inches mercury) – full load min.:			
At zero exhaust back pressure	18.3	42.6	45.6
At max. exhaust back pressure (clean ports)	16.8	40.7	43.7
Air inlet restriction (inches water) – full load max.:			
Dirty air cleaner – dry type	14.5	18.0	20.0
Clean air cleaner:			
Dry type with precleaner	8.7	10.8	12.0
Dry type less precleaner	6.3	7.7	8.5
Crankcase pressure (inches water) – max.	2.6	2.9	3.0
Exhaust back pressure (inches mercury) – max.:			
Full load	2.0	2.5	2.5
No load	1.3	1.6	1.8
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal with .080" restriction fitting	50–70	50–70	50–70
Minimum	30	30	30
Fuel spill (gpm) – min. at no load	1.4	1.4	1.4
Pump suction at inlet (inches mercury) – max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) – Normal	160–185	160–185	160–185
Compression			
Compression pressure (psi at sea level):			
Average – new engine – at 600 rpm 500			
Minimum – at 600 rpm 450			

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

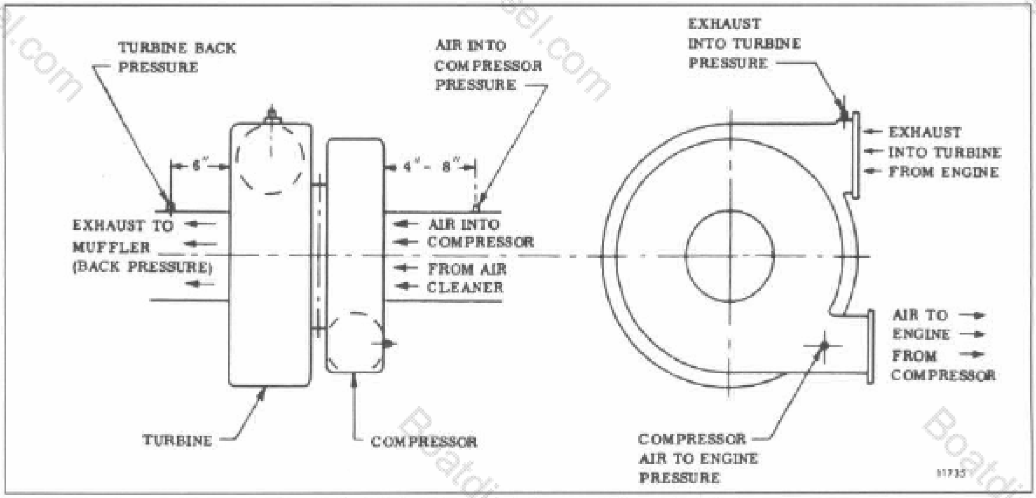

Fig. 1 – Points to Measure Intake and Exhaust Restriction

ENGINE RUN–IN INSTRUCTIONS

Following a complete overhaul or any major repair job involving the installation of piston rings, pistons, cylinder liners or bearings, the engine should be "Run–In" on a dynamometer prior to release for service.

The dynamometer is a device for applying specific loads to an engine. It permits the serviceman to physically and visually inspect and check the engine while it is operating. It is an excellent method of detecting improper tune–up, misfiring injectors, low compression and other malfunctions, and may save an engine from damage at a later date.

The operating temperature within the engine affects the operating clearances between the various moving parts of the engine and determines to a degree how the parts will wear. Normal coolant temperature (see section 13.2) should be maintained throughout the Run–In.

The rate of water circulation through the engine on a dynamometer should be sufficient to avoid having the engine outlet water temperature more than 10°F or 6°C higher than the water inlet temperature. Though a 10°F or 6°C rise across an engine is recommended, it has been found that a 15°F or 8°C temperature rise maximum can be permitted.

Thermostats are used in the engine to control the coolant flow. Therefore, be sure they are in place and fully operative or the engine will overheat during the Run–In. However, if the dynamometer has a water standpipe with a temperature control regulator, such as a Taylor valve or equivalent, the engine should be tested without thermostats.

NOTICE: Because of the wet cylinder liners in the V–92 engine, it is desirable that the engine Run–In be made on a closed (heat exchanger type) cooling system where the coolant can be treated with a rust inhibitor (refer to Section 13.3). Use of a good rust inhibitor in the coolant system during engine Run–In will prevent the rusting of the outside diameter of the cylinder liners after the engine has been removed from the dynamometer test stand.

The Run–In Schedules are shown in Tables 1 and 2. The horsepower shown is at SAE conditions: dry air density .0705 lb/cu. ft. (1.129 Kg/cu. m), air temperature of 85°F (29.4°C) and 500 ft. elevation.

DYNAMOMETER TEST AND RUN–IN PROCEDURES

The Basic Engine

The great number of engine applications make any attempt to establish comparisons for each individual model impractical. For this reason, each model has a basic engine rating for comparison purposes.

A basic engine includes only those items actually required to run the engine. The addition of any engine driven accessories will result in a brake horsepower figure less than the values shown in the *Basic Engine Run–In Schedule*. The following items are included on the basic engine: blower, fuel pump, water pump and governor. The fan and battery–charging alternator typify accessories not considered on the basic engine.

In situations where other than basic engine equipment is used during the test, proper record of this fact should be made on the *Engine Test Report*. The effects of this additional equipment on engine performance should then be considered when evaluating test results.

Dynamometer

The function of the dynamometer is to absorb and measure the engine output. Its basic components are a frame, engine mounts, the absorption unit, a heat exchanger, and a torque loading and measuring device.

The engine is connected through a universal coupling to the absorption unit. The load on the engine may be varied from zero to maximum by decreasing or increasing the resistance in the unit. The amount of power absorbed in a water brake type dynamometer, as an example, is governed by the volume of fluid within the working system. The fluid offers resistance to a rotating motion. By controlling the volume of water in the absorption unit, the load may be increased or decreased as required.

The power absorbed is generally measured in torque (lb–ft) on a suitable scale. This value for a given engine speed will show the brake horsepower developed in the engine by the following formula:

$$BHP = (T \times RPM)/5250$$

Where:

BHP = brake horsepower

T = torque in lb–ft

RPM = revolutions per minute

BASIC ENGINE RUN-IN SCHEDULE

Time Minutes	Speed RPM	Injectors	Engine Brake Horsepower					
			6V	6VT	8V	8VT	16V	16VT
10	1200	All	54	54	72	72	144	144
30	1800	All	195	225	260	300	520	600
30*	2100	70	216	—	288	—	576	—
30*	2100	75	230	—	306	—	612	—
30*	2100	80	243	—	324	—	648	—
30*	2100	85	257	—	342	—	684	—
30*	2100	80	—	252	—	338	—	675
30*	2100	85	—	270	—	360	—	720
30*	2100	90	—	290	—	387	—	774

*Use speed-injector combination applicable to engine on test.

TABLE 1

Some dynamometers indicate direct brake horsepower readings. Therefore, the use of the formula is not required when using these units.

During the actual operation, all data taken should be recorded immediately on an *Engine Test Report* (see sample in this section).

Instrumentation

Certain instrumentation is necessary so that data required to complete the *Engine Test Report* may be obtained. The following list contains both the minimum amount of instruments and the proper location of the fittings on the engine so that the readings represent a true evaluation of engine conditions.

a. Oil pressure gage installed in one of the engine main oil galleries.

b. Oil temperature gage installed in the oil pan, or thermometer installed in the dipstick hole in the oil pan.

c. Adaptor for connecting a pressure gage or mercury manometer to the engine air box.

d. Water temperature gage installed in the thermostat housing or water outlet manifold.

e. Adaptor for connecting a pressure gage or water manometer to the crankcase.

FINAL ENGINE RUN-IN SCHEDULE

Time Minutes	Speed RPM	Injectors	† Engine Brake Horsepower					
			6V	6VT	8V	8VT	16V	16VT
30*	2100	70	240	—	320	—	640	—
30*	2100	75	255	—	340	—	680	—
30*	2100	80	270	280	360	375	720	750
30*	2100	85	285	300	380	400	760	800
30*	2100	90	—	322	—	430	—	860

*Use speed-injector combination applicable to engine on test.
† Within 5% of brake horsepower rating shown above at governor speed.

TABLE 2

ENGINE TEST REPORT

Date ______________ Unit Number ______________
Repair Order Number ______________ Model Number ______________

A PRE-STARTING

1. PRIME LUBE OIL SYSTEM	2. PRIME FUEL SYSTEM	3. ADJUST VALVES	4. TIME INJ.	5. ADJ. GOV.	6. ADJUST INJ. RACKS

B BASIC ENGINE RUN-IN

TIME AT SPEED	TIME		RPM	BHP	WATER TEMP.	LUBE OIL PRESS.
	START	STOP				

C BASIC RUN-IN INSPECTION

1. Check oil at rocker arm mechanism	
2. Inspect for lube oil leaks	
3. Inspect for fuel oil leaks	
4. Inspect for water leaks	
5. Check and tighten all external bolts	
6.	

D INSPECTION AFTER BASIC RUN-IN

1. Tighten Cylinder Head & Rocker Shaft Bolts		4. Adjust Governor Gap	
2. Adjust Valves (Hot)		5. Adjust Injector Racks	
3. Time Injectors		6.	

E FINAL RUN-IN

TIME		TOP RPM		BHP	AIR BOX PRESSURE FULL LOAD	EXHAUST BACK PRESSURE F/L	CRANKCASE PRESSURE F/L
START	STOP	NO LOAD	FULL LOAD				

BLOWER INTAKE RES. - F/L	FUEL OIL PRESSURE RET. MAN. F/L	WATER TEMP. FULL LOAD	LUBE OIL TEMP. F/L	LUBE OIL PRESSURE		IDLE SPEED
				FULL LOAD	IDLE	

F INSPECTION AFTER FINAL RUN

1. Inspect Air Box, Pistons, Liners, Rings	6. Tighten Oil Pump Bolts
2. Inspect Blower	7. Inspect Oil Pump Drive
3. Check Generator Charging Plate	8. Replace Lube Filter Elements
4. Wash Oil Pan, Check Gasket	9. Tighten Flywheel Bolts
5. Clean Oil Pump Screen	10. Rust Proof Cooling System

REMARKS:

Final Run OK'd ______________ Dynamometer Operator ______________ Date ______________

NOTE: Operator must initial each check and sign this report.

f. Adaptor for connecting a pressure gage or mercury manometer to the exhaust manifold at the flange.

g. Adaptor for connecting a vacuum gage or water manometer to the blower inlet.

h. Adaptor for connecting a fuel pressure gage to the fuel manifold inlet passage.

i. Adaptor for connecting a pressure gage or mercury manometer to the turbocharger.

In some cases, gages reading in pounds per square inch are used for determining pressures while standard characteristics are given in inches of mercury or inches of water. It is extremely important that the scale of such a gage be of low range and finely divided if accuracy is desired. This is especially true of a gage reading in psi, the reading of which is to be converted to inches of water. The following conversion factors may be helpful.

Inches of water = psi x 27.7"

Inches of mercury = psi x 2.04"

Inches of water = kPa x 4.02"

Inches of mercury = kPa x 0.30"

NOTICE: Before starting the Run–In or starting the engine for any reason following an overhaul, it is of extreme importance to observe the instructions on *Preparation for Starting Engine First Time* in Section 13.1.

Block Oil Filter Bypass Before Initial Start–Up and Dynamometer Test of Rebuilt Engines

Cold engine start–up causes the lubricating oil filter bypass valve to open until oil temperature increases. When an engine is rebuilt and then dynamometer tested, this bypass condition may result in the circulation of abrasive (harmful) debris introduced into the engine during rebuild.

To prevent unnecessary circulation of debris through the lube oil system, DDC recommends plugging the filter bypass before start–up and during basic engine run–in. This allows all the lube oil to flow through the filter(s), trapping contaminants. To plug the bypass, proceed as follows:

Drill and tap a 1/4" – 20 hole in a filter bypass valve plug. Install a bolt long enough to contact the valve and keep it from opening and a nut to lock the bolt in position (Fig. 1). When the dynamometer test is completed, replace the modified plug with a standard plug and change the filter(s).

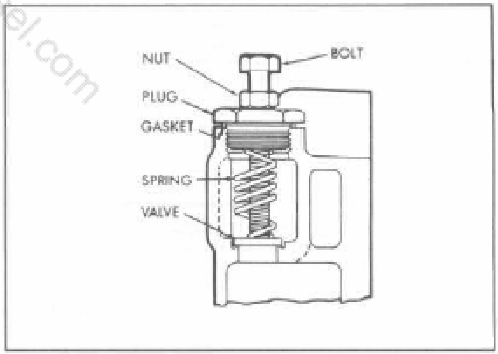

Fig. 1 – Bypass Valve with Modified Valve Plug Installed

NOTICE: To avoid damaging the phenolic bypass valve, the bolt should be finger–tightened only and then secured in place with the lock nut. On filter adaptors with more than one bypass valve, install modified valve plugs in all valve openings before starting or dynamometer testing the engine.

DDC recommends bringing lube oil temperature up to at least 60°F (15.6°C) before starting the engine prior to testing. If the lube oil is too cold when the engine is started, the resistance to the flow of the heavier oil may cause filter gasket leakage or bearing surface damage from inadequate oil film.

Run–In Procedure

The procedure outlined below will follow the order of the sample *Engine Test Report*.

A. PRE–STARTING

1. Fill the lubrication system as outlined under *Lubrication System — Preparation for Starting Engine First Time* in Section 13.1.
2. Prime the fuel system as outlined under *Fuel System — Preparation for Starting Engine First Time* in Section 13.1.
3. A preliminary valve clearance adjustment must be made before the engine is started. See *Valve Clearance Adjustment* in Section 14.1.
4. A preliminary injector timing check must be made before starting the engine. See *Fuel Injector Timing* in Section 14.2.
5. Preliminary governor adjustments must be made as outlined in Section 14.

6. Preliminary injector rack adjustment must be made (Section 14).

NOTICE: Prior to starting a turbocharged engine, remove the oil supply line at each turbocharger and add clean engine oil to the oil inlet to ensure pre–lubrication of the turbochargers. Reconnect the oil lines and idle the engine for at least one minute after starting and before increasing the speed.

B. BASIC ENGINE RUN–IN

The operator should be observant at all times, so that any malfunction which may develop will be detected. Since the engine has just been reconditioned, this Run–In will be a test of the workmanship of the serviceman who performed the overhaul. Minor difficulties should be detected and corrected so that a major problem will not develop.

After performing the preliminary steps, be sure all water valves, fuel valves, etc. are open. Also inspect the exhaust system, air cleaner and air inlet piping to insure that it is properly connected to the engine. Always start the engine with minimum dynamometer resistance.

After the engine starts, if using a water brake type dynamometer, allow sufficient water, by means of the control loading valves, into the dynamometer absorption unit to show a reading of approximately 5 lb–ft (7 N•m) on the torque gage (or 10–15 HP on a horsepower gage). This is necessary, on some units, to lubricate the absorption unit seals and to protect them from damage.

Set the engine throttle at idle speed, check the lubricating oil pressure and check all connections to be sure there are no leaks.

Refer to the *Engine Test Report* sample which establishes the sequence of events for the Test and Run–In, and to the *Basic Engine Run–In Schedule* which indicates the speed (rpm), length of time and the brake horsepower required for each phase of the test. Also refer to the *Operating Conditions* in Section 13.2 which presents the engine operating characteristics. These characteristics will be a guide for tracing faulty operation or lack of power.

Engine governors in most cases must be reset at the maximum full–load speed designated for the Run–In. If a governor is encountered which cannot be adjusted to this speed, a stock governor should be installed for the Run–In.

After checking the engine performance at idle speed and being certain the engine and dynamometer are operating properly, increase the engine speed to half speed and apply the load indicated on the *Basic Engine Run–In Schedule*.

The engine should be run at this speed and load for 10 minutes to allow sufficient time for the coolant temperature to reach the normal operating range. Record length of time, speed, brake horsepower, coolant temperature and lubricating oil pressure on the *Engine Test Report*.

Run the engine at each speed and rating for the length of time indicated in the *Basic Engine Run–In Schedule*. This is the Basic Run–In. During this time, engine performance will improve as new parts begin to "seat in". Record all of the required data.

C. BASIC RUN–IN INSPECTION

While the engine is undergoing the Basic Run–In, check each item indicated in Section "C" of the *Engine Test Report*. Check for fuel oil or water leaks in the rocker arm compartment.

During the final portion of the Basic Run–In, the engine should be inspected for fuel oil, lubricating oil and water leaks.

Upon completion of the Basic Run–In and Inspection, remove the load from the dynamometer and reduce the engine speed gradually to idle and then stop the engine.

D. INSPECTION AFTER BASIC RUN–IN

The primary purpose of this inspection is to provide a fine engine tune–up. First, tighten the cylinder head and rocker arm shaft bolts to the proper torque. Next, complete the applicable tune–up procedure. Refer to Section 14.

E. FINAL RUN–IN

After all of the tests have been made and the *Engine Test Report* is completed through Section "D", the engine is ready for final test. This portion of the test and Run–in procedure will assure the engine owner that his engine has been rebuilt to deliver factory rated performance at the same maximum speed and load which will be experienced in the installation.

If the engine has been shut down for one hour or longer, it will be necessary to have a warm–up period of 10 minutes at the same speed and load used for warm–up in the Basic Run–In. If piston rings, cylinder liners or bearings have been replaced as a result of findings in the Basic Run–In, the entire Basic Run–In must be repeated as though the Run–In and test procedure were started anew.

All readings observed during the Final Run–In should fall within the range specified in the *Operating Conditions* in Section 13.2 and should be taken at full load unless otherwise specified. Following is a brief discussion of each condition to be observed.

The engine *water temperature* should be taken during the last portion of the Basic Run–In at full load. It should be recorded and should be within the specified range.

The *lubricating oil temperature* reading must be taken while the engine is operating at full load and after it has been operating long enough for the temperature to stabilize. This temperature should be recorded and should be within the specified range.

The *lubricating oil pressure* should be recorded in *psi* after being taken at engine speeds indicated in the *Operating Conditions*, Section 13.2.

The *fuel oil pressure* at the fuel manifold inlet passage should be recorded and should fall within the specified range. Fuel pressure should be recorded at maximum engine speed during the Final Run-In.

Check the *air box pressure* while the engine is operating at maximum speed and load. This check may be made by attaching a suitable gage (0–15 psi) or manometer (15–0–15) to an air box drain or to a hand hole plate prepared for this purpose. If an air box drain is used as a source for this check, it must be clean. The air box pressure should be recorded in inches of mercury.

Check the *crankcase pressure* while the engine is operating at maximum Run-In speed. Attach a manometer, calibrated to read in inches of water, to the oil level dipstick opening. Normally, crankcase pressure should decrease during the Run-In indicating that new rings are beginning to "seat-in".

Check the *air inlet restriction* with a water manometer connected to a fitting in the air inlet ducting located 2" above the air inlet housing. When practicability prevents the insertion of a fitting at this point, the manometer may be connected to a fitting installed in the 1/4" pipe tapped hole in the engine air inlet housing on naturally aspirated engines. If a hole is not provided, a stock housing should be drilled, tapped and kept on hand for future use.

The restriction at this point should be checked at full-load engine speed. Then the air cleaner and ducting should be removed from the air inlet housing and the engine again operated at the same speed while noting the manometer reading. On turbocharged engines, take the reading on the inlet side of one of the turbochargers (see Chart at the end of Section 13.2). The difference between the two readings, with and without the air cleaner and ducting, is the actual restriction caused by the air cleaner and ducting.

Check the normal *air intake vacuum* at various speeds (at no-load) and compare the results with the *Engine Operating Conditions* in section 13.2. Record these readings on the *Engine Test Report*.

Check the *exhaust back pressure* (except turbocharged engines) at the exhaust manifold companion flange or within one inch of this location. This check should be made with a mercury manometer through a tube adaptor installed at the tapped hole. If the exhaust manifold does not provide a 1/8" pipe tapped hole, such a hole can be incorporated by reworking the exhaust manifold. Install a fitting for a pressure gage or manometer in this hole. Care should be exercised so that the fitting does not protrude into the stack. On turbocharged engines, check the exhaust back pressure in the exhaust piping 6" to 12" from the turbine outlet. The tapped hole must be in a comparatively straight area for an accurate measurement. The manometer check should produce a reading in inches that is below the *Maximum Exhaust Back Pressure* for the engine (refer to Section 13.2).

Turbocharger compressor outlet pressure and turbine inlet pressures are taken at full-load and no-load speeds.

Refer to the *Final Engine Run-In Schedule* and determine the maximum rated brake horsepower and the full-load speed to be used during the Final Run-In. Apply the load thus determined to the dynamometer. If a hydraulic governor is used, the droop may be adjusted at this time by following the prescribed procedure. The engine should be run at this speed and load for 1/2 hour. While making the Final Run-In, the engine should develop, within 5%, the maximum rated brake horsepower indicated for the speed at which it is operating. If this brake horsepower is not developed, the cause should be determined and corrections made.

When the above conditions have been met, adjust the maximum no-load speed to conform with that specified for the particular engine. This speed may be either higher or lower than the maximum speed used during the Basic Run-In. This will ordinarily require a governor adjustment.

All information required in Section "E", Final Run-In, of the *Engine Test Report* should be determined and filled in. After the prescribed time for the Final Run-In has elapsed, remove the load from the dynamometer and reduce the engine speed gradually to idle speed and then stop the engine. The Final Run-In is complete.

F. INSPECTION AFTER FINAL RUN-IN

After the Final Run-In and before the *Engine Test Report* is completed, a final inspection must be made. This inspection will provide final assurance that the engine is in proper working order. During this inspection, the engine is also made ready for any brief delay in delivery or installation which may occur. This is accomplished by rustproofing the fuel system as outlined in Section 15.3 and adding a rust inhibitor into the cooling system (refer to Section 13.3). The lubricating oil filters should also be changed.

> **NOTICE:** A rust inhibitor in the coolant system of the V-92 engine is particularly important because of the wet cylinder liners. Omission of a rust inhibitor will cause rusting of the outside diameter of the cylinder liners and interference with liner heat transfer.

downloaded from the Boatdiesel.com PDF Library by Dmb993@earthlink.net on 11-Nov-12

.AUTOMOTIVE ENGINE CHARGE COOLING SYSTEMS

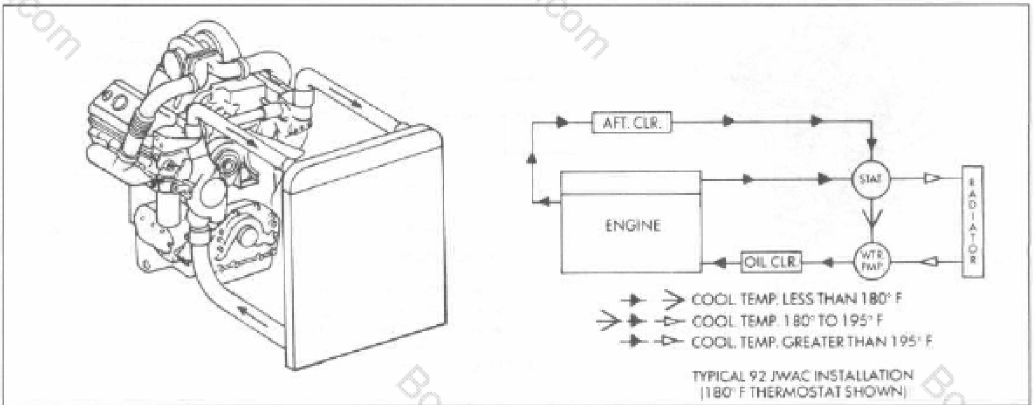

Fig. 2 – 92 TA JWAC Coolant Flow Path

The emphasis placed on improved fuel economy and the need to meet lower emissions levels both now and in the future has resulted in the development of two new "charge cooling" systems on Detroit Diesel engines. In addition to current JWAC (jacket water aftercooled) engines released in 1979, ALCC (advanced liquid charge cooled) and AACC (air–to–air charge cooled) engines have been added to the lineup.

The objective of these systems is to substantially reduce the temperature of the air supplied to the engine for combustion. Cooler, denser air provides improved air/fuel ratios and, when coupled with engine component changes, improved fuel economy.

Jacket Water Aftercooling (JWAC)

In JWAC V–92 models, coolant circulates from the water pump through the oil cooler, to the cylinder block where approximately 10% is shunted to the aftercooler and returned to the left–bank thermostat housing (see Fig. 2).

Inlet air is compressed by the turbocharger and directed to the blower. After passing through the blower, the air travels through the aftercooler. "Air in" is cooled from over 300°F (148°C) to approximately 200°F (93.3°C) at 85°F (29.4°C) ambient temperature under full–load conditions. The cool, dense air then travels from the aftercooler into the air box and cylinders for combustion. Other aspects of the JWAC cooling systems are identical to the standard non–aftercooled engines.

Advanced Liquid Charge Cooling (ALCC)

The ALCC cooling system is designed to provide cool charge air to Series 92TA engine cylinders using a single radiator or heat exchanger. Principally, this is accomplished by reducing the radiator coolant flow to increase its temperature drop and supplying the cooled coolant from the radiator directly to the aftercooler for maximum charge air cooling.

V–92TA ALCC Operation

The 6V–92TA ALCC cooling system (Fig. 3) consists of a water pump that flows coolant past the non–blocking thermostat S1 (160°F or 71°C) and through the engine oil cooler, cylinder block, and head and then past the S2 full blocking stat (180°F or 82°C) under cold or hot conditions. When the water temperature reaches 160°F (71°C), the S1 thermostat begins to open, flowing some coolant through the radiator to the aftercooler and into the inlet of the water pump where it mixes with coolant flowing through the engine. As the S1 thermostat opens more with the rise in engine water temperature, the flow of coolant through the radiator and aftercooler is increased, while the bypass flow through the oil cooler and engine is decreased slightly. At no time does the bypass flow fall below 84%.

At high load and under high ambient temperature conditions when engine coolant–out temperature exceeds the opening temperature of the S2 thermostat (180°F or 82°C), this thermostat will open, allowing part of the coolant from radiator discharge to flow into the water pump inlet, bypassing the aftercooler. The addition of this flow path lowers the radiator discharge pressure, resulting in a higher radiator flow which enhances engine cooling.

ALCC System Design Requirements

Rapid warm–up cooling systems with either an integral or separate surge tank *must* be used with all ALCC engines to ensure positive water pump inlet pressure under

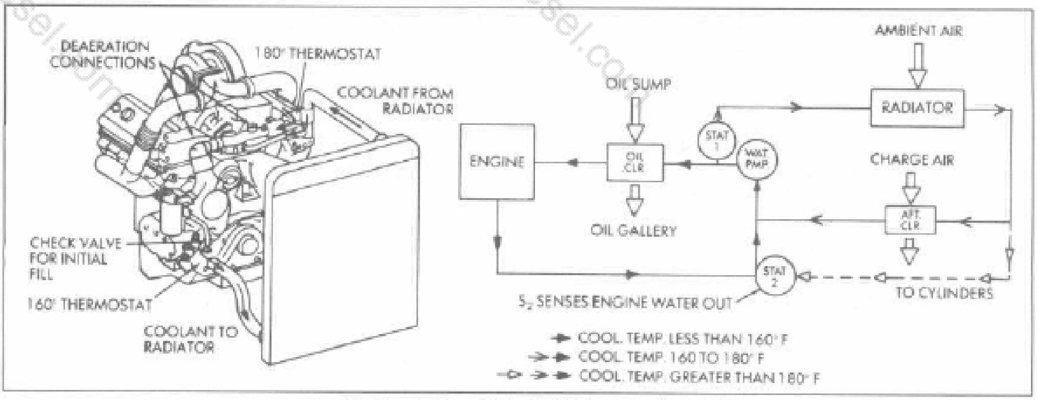

Fig. 3 – Typical V–92TA ALCC Coolant Flow Path

all conditions. The system must meet all the present cooling requirements of on–highway vehicle engines regarding fill, drawdown, and deaeration. The maximum engine water temperature and air–to–water temperature differential remain at 210°F (98.8°C) and 100°F (73.7°C), respectively, when both thermostats are fully open. A maximum temperature differential between the *radiator* coolant–out temperature and the ambient temperature (60°F or 15.6°C for 92TA engines) must also be met with both thermostats open to assure adequate charge air cooling under all conditions.

ALCC Radiators

The radiators used with ALCC cooling systems are designed for high effectiveness with low coolant flow when compared to conventional radiators. Presently, this is accomplished with the use of turbulated radiator tubes that have dimples or ridges in the tubes to increase scrubbing and/or a multi–pass radiator design that increases flow velocity and lengthens the flow path.

NOTICE: Radiators with turbulated tubes cannot be conventionally cleaned or rodded, because the dimple design results in narrower tubes. Radiators *must* be ultrasonically cleaned. Failure to observe this precaution can result in radiator damage.

Different vehicle installations may have peculiarities because of installation constraints or the type of radiator used. These should be addressed on an individual basis.

Series 92 Air–to–Air Charge Cooling (AACC)

An air–to–air charge cooling system provides much cooler charge air than an ALCC system by directing the turbocharger compressor discharge air through a heat exchanger which is cooled by ambient air. The heat exchanger is chassis mounted, most commonly in front of the conventional coolant radiator (Fig. 4). Since the AACC system eliminates the need for an intercooler or in–block aftercooler, its space in the cylinder block air box is occupied by an air deflector which improves air flow into the cylinders.

The AACC system cools the compressor air from over 250°F (121°C) to 110°F (43.3°C) at an ambient air temperature of 77°F (25°C) under full–load conditions. Air–to–air charge cooling offers the greatest improvement in fuel economy when compared to conventional jacket water aftercooling.

NOTICE: Radiator winter fronts are not recommended with air–to–air charge cooling systems, because they adversely affect engine performance.

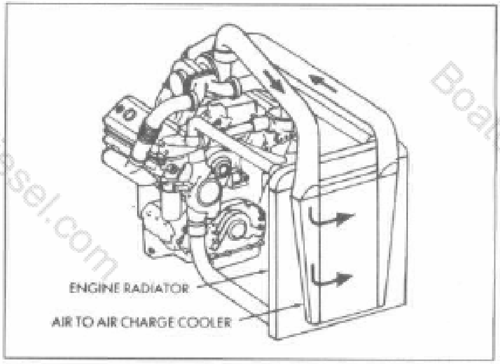

Fig. 4 – 6V–92 AACC Engine Showing Air Flow Through Heat Exchanger

downloaded from the Boatdiesel.com PDF Library by Dmb993@earthlink.net on 11-Nov-12

.COOLING SYSTEM REQUIREMENTS FOR TESTING JWAC, ALCC AND AACC ENGINES ON A DYNAMOMETER

Jacket Water Aftercooled (JWAC) Engine

The cooling system needed to cool a JWAC engine on an engine dynamometer is the same as a standard engine. No special connections are required, and all of the aftercooler piping is built into the engine.

Advanced Liquid Charge Cooled (ALCC) Engine

The cooling system required to cool an ALCC engine dynamometer must meet the following requirements:

- To properly fill a Series 92 ALCC cooling system, a 1" fill line *must* be connected from the heat exchanger or radiator to the 3/4" NPTF boss on the water pump.
- To properly vent a Series 92 ALCC cooling system, 1/4" tubes or No. 4 flexible hose lines must be connected as follows: one line should run from the deaeration housing* on the front of the right–bank cylinder head to the heat exchanger or radiator surge tank. A second line should be connected from the water crossover tube connector (between the left–bank and right–bank) to the heat exchanger or radiator surge tank. *Do not tee the two bleed lines together.*

There are no air vents or bleed holes in the thermostats or thermostat housings used on any DDC automotive engines. Therefore, a deaeration line is required to provide air venting during initial system fill and engine operation.

*Previously R.B. thermostat housing.

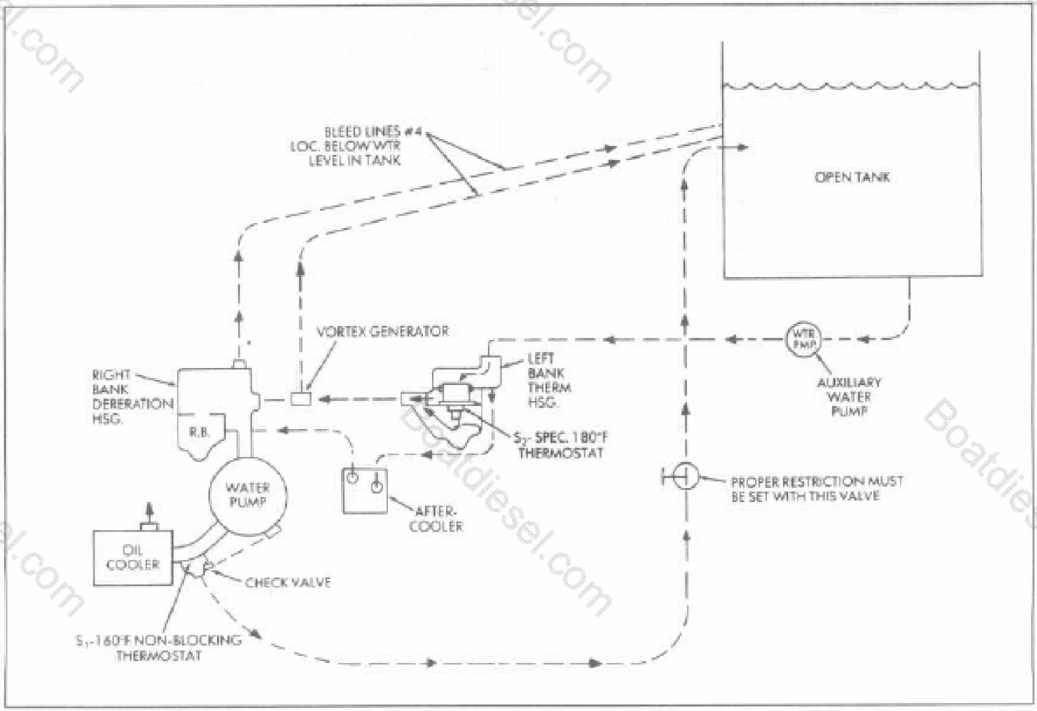

Fig. 5 – V–92TA ALCC Open Loop Test Stand Cooling System

92TA ALCC Engine

A closed loop cooling system is preferred because it will maintain the required positive coolant pressure at the engine coolant inlet (left–bank thermostat housing).

If an open loop cooling system (one that is open to atmosphere or dumps into a day tank) is used, *a restriction is required* at the engine water outlet connection (oil cooler elbow – see Fig. 5). The restriction should be sized to provide 11–12 psi (76–83 kPa) coolant pressure in the oil cooler elbow at 1800 RPM. This simulates the restriction of a cooling system installed in a vehicle or machine. *This is very important since, otherwise, an engine overheat condition is likely to occur during engine testing.*

A 10 psi (69 kPa) coolant pressure into the left–bank thermostat housing is required on open loop cooling systems. An auxiliary water pump must be used to meet this requirement.

A power evaluation of 92TA ALCC engines in a vehicle/machine is run identical to the JWAC engine.

Air–to–Air Charge Cooled (AACC) Engine

The same cooling system used with JWAC engines can be used with AACC engines. However, if an air–to–air chassis–mounted cooler cannot be used, it can be simulated by bolting two DDC intercoolers (Part No. 5148426) together, side by side, with air inlet elbows such as Part Nos. 5148026 or 5148329. Intercooler Part. Nos. 5124107 or 5144485 are also suitable from a heat dissipation standpoint. The air piping from the turbo compressor to the cooler and back to the engine should be 4" diameter tubing. This will have to be reduced at the cooler air inlet elbows, which are 3 1/2" diameter.

The air restriction of the two intercoolers is comparable to a chassis–mounted cooler. However, tubing and tubing bends should be kept to a minimum.

The water side of the two intercooler cores should be piped in series or in parallel with a source of cool coolant. The coolant temperature/flow requirement for the intercoolers is 80°F (26.6°C) maximum at 55 GPM.

The performance of the charge air cooler system should meet the guidelines shown on the DDC charge air cooler performance chart (Fig. 6).

A power evaluation of an air–to–air charge cooled engine in a vehicle is run identical to a standard or JWAC engine.

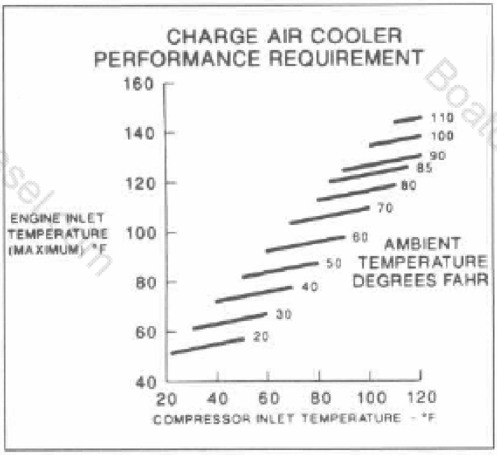

Fig. 6 – Charge Air Cooler Performance Requirement

LUBRICATING OIL, FUEL OIL AND FILTER RECOMMENDATIONS

Selection of the proper quality of fuel and lubricating oil is important to achieve the long and trouble-free service for which Detroit Diesel engines are designed. Conversely, operation with improper fuels and lubricants can cause problems. The manufacturer's warranty applicable to Detroit Diesel engines provides, in part, that warranty shall not apply to any engine which has been subject to misuse, negligence or accident. Accordingly, malfunctions attributable to neglect or failure to follow manufacturer's fuel or lubricating recommendations may not be covered by the warranty.

A requirement of Detroit Diesel Corporation's extended warranty program (Power Protection Plan) is that the customer use the lubricants, fuels and filters recommended in this publication.

It is Detroit Diesel's policy to build engines which will operate satisfactorily with fuels and lubricants available in the commercial market. However, not all fuels and lubricants are adequate. Product selection should be made based on these recommendations and in consultation with a reliable supplier who understands the equipment and its application.

LUBRICATING OIL

Engine service life depends upon selecting the proper lubricating oil and maintaining proper oil drain and filter change intervals.

LUBRICANT SELECTION

There are hundreds of commercial oils marketed today, but labeling terminology differs among suppliers and can be confusing. Some marketers may claim that their lubricant is suitable for all makes of diesel engines and may list engine makes and types, including Detroit Diesel, on their containers. Such claims by themselves are insufficient as a method of lubricant selection for Detroit Diesel engines.

The proper lubricating oil for all Detroit Diesel engines is selected based on SAE Viscosity Grade and API (American Petroleum Institute) Service Designation. Both of these properties are displayed on oil containers in the API symbol. In addition, military specifications may be used for selecting engine lubricants. Mil-L-2104D represents the most current military specification for diesel lubricants and the only one recommended for Detroit Diesel engines. For two-cycle Detroit Diesel engines, the proper lubricant must also possess a sulfated ash content below 1.0% mass. Refer to the following specific recommendations.

TWO-CYCLE ENGINES
Detroit Diesel Series 53, 71, 92, 149

LUBRICANT RECOMMENDATION

API Symbol:

SAE Viscosity Grade: 40
API Classification: CD-II
Military Spec.: Mil-L-2104D
Sulfated Ash: less than 1.0%

This is the only engine oil recommended for Detroit Diesel two-cycle engines. Lubricants meeting these criteria have provided maximum engine life when used in conjunction with recommended oil drain and filter maintenance schedules.

A more detailed description of each of these selection criteria may be found in a further section of this publication. Certain engine operating conditions may require exceptions to this recommendation. They are as follows:

1. For continuous high temperature operation (over 100°F ambient or 200°F Coolant Out) the use of an SAE grade 50 lubricant in all series two-cycle DDC engines is recommended.

2. At ambient temperatures below freezing where starting aids are not available or at very cold temperatures (0 to -25°F), the use of multiviscosity grade 15W-40 or monograde SAE 30 lubricants will improve startability. **Exception: Do not use these lubricants in two-cycle marine engines or DDC series 149 engines under any circumstances.**

3. The API category CD-II is relatively new and may not be fully in use at the time of this publication. API category CD may be used provided the recommended military specification is satisfied. Oils with API designation CE are not recommended in DDC two-cycle engines unless accompanied by CD-II.

4. When the use of high sulfur fuel is unavoidable, lubricants with a Total Base Number exceeding 10 are recommended. Such a lubricant may have a Sulfated Ash content above 1.0% mass. High sulfur fuels require modification to oil drain intervals. For further information refer to that section of this publication.

FOUR-CYCLE ENGINES
Detroit Diesel Series 60 and 8.2L

LUBRICANT RECOMMENDATION

API Symbol:

SAE Viscosity Grade: 15W-40
API Classification: CE
Military Spec.: Mil-L-2104D

This is the only engine oil recommended for Detroit Diesel Series 60 and 8.2L engines. Lubricants meeting these criteria have provided maximum engine life when used in conjunction with recommended oil drain and filter maintenance schedules.

When the use of high sulfur fuel is unavoidable, lubricants with a TBN exceeding 10 are recommended. High sulfur fuels require modification to oil drain intervals. For further information refer to that section of this publication.

LUBRICATING OIL SELECTION CRITERIA

SAE VISCOSITY GRADE

Viscosity is a measure of an oil's ability to flow at various temperatures. The SAE Viscosity Grade system is defined in SAE Standard J300 which designates a viscosity range with a grade number. Lubricants with two grade numbers separated by a "W" are classified as multigrade, while those with a single number are monograde. The higher the number the higher the viscosity.

API SERVICE CLASSIFICATION

The American Petroleum Institute has established a means of classifying lubricant performance suitable for different types of engines and types of service. The higher performance or quality API classifications for diesel engines include CD, CE (for four-cycle diesel engines) and CD-II (for two-cycle diesel engines). Detroit Diesel does not recommend the use of the older and lower performance classifications such as CC, CB and CA.

Multiple API Service Classifications such as "API SERVICE CD, CE" or "API SERVICE CE/CD-II" are frequently listed. Additional classifications not listed here may also be included. It is important that the DDC recommended classification be among those listed.

API SYMBOL

Lubricant marketers have adopted a uniform method of displaying the SAE viscosity grade and API service classification information on product containers and in product literature. The three segment "donut" contains the SAE grade number in the center, and the API service in the top segment. The lower segment is used to designate energy conserving status for gasoline engine use and has no significance for diesel engine use.

MILITARY SPECIFICATION

U.S. Military specifications are another means of classifying the performance of lubricants. As with the API system, lubricants must meet performance criteria before approval is given. The essential difference, however, is that lubricants meeting military specifications, particularly those possessing Qualified Products Listing (QPL) Numbers, have been reviewed by a committee consisting of engine manufacturers, including Detroit Diesel.

Military Specification Mil-L-2104D represents the current specification for heavy-duty diesel engines and the only one recommended by Detroit Diesel Corporation.

SULFATED ASH AND TOTAL BASE NUMBER

This is a lubricant property obtained by a laboratory test (ASTM D874) to determine potential for the formation of metallic ash. The ash residue is related to the oil's additive composition and is significant in predicting lubricants which may cause valve distress under certain operating conditions. Sulfated ash is related to Total Base Number (TBN), also a laboratory test (ASTM D2896) which measures an oil's ability to neutralize acids. As TBN increases, sulfated ash also increases to where lubricants with TBNs above 10 will likely have sulfated ash contents above 1.0% mass.

Total Base Number is important to deposit control in four-cycle diesel engines and to neutralize the effects of high sulfur fuel in all diesel engines. In general, Detroit Diesel recommends lubricants with sulfated ash contents below 1.0% mass and TBNs between 7 and 10 for all Series engines operating on low sulfur fuel.

UNIVERSAL OILS

Universal oils are designed for use in both gasoline and diesel engines and provide an operational convenience in mixed fuel engine fleets. These products are identified with combination API category designations such as SF/CD or SG/CE. Although such products can be used in Detroit Diesel engines (provided they satisfy all DDC requirements), their use is not as desirable as lubricants formulated specifically for diesel engines, and bearing only the API CD-II or CE designations.

SYNTHETIC OILS

Synthetic oils may be used in Detroit Diesel engines provided they meet the viscosity, performance classification and chemical recommendations listed for non–synthetic lubricants. Product information about synthetic oils should be reviewed carefully since these lubricants are often claimed to be of monograde viscosity. Their use does not permit extension of recommended oil drain intervals.

MARINE LUBRICANTS, RAILROAD DIESEL LUBRICANTS

The petroleum industry markets specialty lubricants for use in diesel engines designed specifically for marine propulsion or railroad locomotive use. These lubricants take into consideration the unique environments and operational characteristics of this type of duty, and consequently, they are formulated quite differently from the types of lubricants recommended by Detroit Diesel. Although in some cases they may be suitable in Detroit Diesel engines, they should not be used without specific consultation with your Detroit Diesel distributor or regional office and the lubricant supplier.

USE OF SUPPLEMENTAL ADDITIVES

Lubricants meeting the Detroit Diesel recommendations outlined in this publication already contain a balanced additive treatment. The use of supplemental additives, such as break–in oils, top oils, graphitizers, and friction–reducing compounds, is generally unnecessary and can even be harmful. Never use a lubricant supplement to "fix" a mechanical problem, and be cautious of products purporting to prevent one. The best approach is to follow DDC's lubricant recommendations.

EVIDENCE OF SATISFACTORY LUBRICANT PERFORMANCE

These recommendations are intended to provide a guideline for lubricating oil selection based on favorable service history in typical applications of Detroit Diesel engines. Specific situations may warrant consideration of a lubricant that does not fit these guidelines. Such a lubricant may perform satisfactorily in certain circumstances, and be inappropriate for others.

For such products, evidence of satisfactory performance should be obtained from the oil supplier on the specific lube oil blend being considered and compared with the performance of a DDC recommended lubricant as reference. Comparative performance evidence would include stationary engine tests and field testing in a similar application and severity.

The type of field test used by the oil supplier depends on the series engine in which the candidate oil will be used and the service application. The candidate test oil engines should all operate for the mileage/hours indicated in the table below. Any serious mechanical problems should be recorded. At the conclusion of the test, the engines should be disassembled and quantitatively compared with reference oil engines for:

- Ring conditions (broken, stuck and wear)
- Cylinder liner and piston skirt scuffing
- Exhaust valve face and seat deposits and distress
- Piston pin and slipper bushing wear
- Piston ring land deposits
- Overall valve train and bearing wear

Several stationary engine tests have been designed by and utilized by Detroit Diesel for evaluation of lubricants. These tests include:

100 Hour Series 92 Accelerated Engine Test
– evaluates liners, rings and slipper bushings

Series 71 Valve Guttering Test
– evaluates effects of high ash on valve distress

100 Hour Series 60 Truck Cycle Test
– evaluates deposit and ring sticking

240 Hour 6V53T Endurance Test (FTM 355)
– evaluates liner and ring wear (used for CD–II)

LUBRICATING OIL FIELD TESTING GUIDELINES

ENGINE SERIES	SERVICE APPLICATION	TEST DURATION	NO. ENGINES ON CANDIDATE TEST OIL	NO. ENGINES ON REFERENCE BASELINE OIL
53	Pickup & Delivery	50,000 Miles	5	5
60, 71, 92	Highway Truck, GVW 78,000 lbs	200,000 Miles	5	5
149	Off–Road 120 Ton Rear Dump	10,000 Hours	3	3

Although stationary engine testing provides important lubricant performance evaluation, it should be considered secondary to a properly conducted field test evaluation.

Upon completion of the field and stationary testing of products which meet or exceed the performance of lubricants recommended in this publication, Detroit Diesel will issue a written approval for their use in the application field tested. Such approval will be limited to the specific formulation (identical basestock and additive treatment) in which the testing was conducted.

OIL CHANGE INTERVALS

During use, engine lubricating oil undergoes deterioration from combustion by-products and contamination. For this reason, regular oil drain intervals are necessary. These intervals however, may vary in length depending upon engine operation, fuel quality, and lubricant quality. The oil drain interval may be established on recommendations of a Detroit Diesel Oil Analysis Program until the most practical oil change interval has been determined. Under no circumstances, however, should the drain intervals in the chart be exceeded. Refer to the "Used Lubricating Oil Analysis" section of this publication for more information. All engine oil filters should be changed when the lube oil is changed.

MAXIMUM RECOMMENDED OIL DRAIN INTERVALS (Normal Operation)

SERVICE APPLICATION	ENGINE SERIES	OIL DRAIN INTERVAL
Highway Truck	60, 71 & 92	20,000 Miles (32,000 kM)
City Transit Coaches	53, 71 & 92	6,000 Miles (9,600 kM)
Pick-up & Delivery, Stop & Go, Short Trip	53, 71, 92	12,000 Miles (19,000 kM)
	8.2L	6,000 Miles (9,600 kM)
Industrial, Agricultural and Marine	149NA	500 Hrs. or 1 Yr.
	149T	300 Hrs. or 1 Yr.
	53, 60, 71, 92 & 8.2L	150 Hrs.
Stationary Units Full Time	53, 71, 92 & 149	500 Hrs. or 1 Mo.
Standby	53, 71, 92, 149 & 8.2L	150 Hrs. or 1 Yr.

OIL CHANGE INTERVALS WHEN USING HIGH SULFUR FUEL

When the continuous use of high sulfur fuel (greater than 0.5%) is unavoidable, lubricant selection and oil drain interval must be modified. A lubricant with a Total Base Number (TBN per ASTM D 2896) above 10 is recommended. It is likely that such a lubricant will also exhibit a sulfated ash above 1.0%. The proper oil drain interval must be determined by oil analysis when operating on high sulfur fuel. A reduction in TBN (D 2896) to one third of the initial value provides a general drain interval guideline.

MAXIMUM RECOMMENDED OIL DRAIN INTERVALS

FUEL SULFUR 0.5% TO 1.0%
Use a lubricant with TBN (ASTM D 2896) 10 to 30

SERVICE APPLICATION	ENGINE SERIES	OIL DRAIN INTERVAL 10–19 TBN	OIL DRAIN INTERVAL 20–30 TBN
Highway Truck	60, 71 & 92	15,000 Mi. (24,000 kM)	20,000 Mi. (32,000 kM)
City Transit Coaches	53, 71 & 92	4,000 Mi. (6,400 kM)	6,000 Mi. (9,600 kM)
Pick-up & Delivery Stop & Go, Short Trip	53, 71 & 92	8,000 Mi. (12,500 kM)	12,000 Mi. (20,000 kM)
	8.2L	4,000 Mi. (6,400 kM)	6,000 Mi. (9,600 kM)
Industrial, Agricultural and Marine	149NA	300 Hrs.	500 Hrs.
	149T	200 Hrs.	300 Hrs.
		(or 1 Yr. Maximum)	
	53, 60, 71, 92 & 8.2L	100 Hrs.	150 Hrs.
Stationary Units Full Time	53, 71, 92 & 149	300 Hrs.	500 Hrs.
		(or 1 Mo. Maximum)	
Standby	53, 71, 92, 149 & 8.2L	100 Hrs.	150 Hrs.
		(or 1 Yr. Maximum)	

MAXIMUM RECOMMENDED OIL DRAIN INTERVALS

FUEL SULFUR ABOVE 1.0%
Use a lubricant with TBN (ASTM D 2896) 10 to 30

SERVICE APPLICATION	ENGINE SERIES	OIL DRAIN INTERVAL 10–19 TBN	OIL DRAIN INTERVAL 20–30 TBN
Highway Truck	60, 71 & 92	7,500 Mi. (12,000 kM)	15,000 Mi. (24,000 kM)
City Transit Coaches	53, 71 & 92	2,000 Mi. (3,000 kM)	4,000 Mi. (6,400 kM)
Pick-up & Delivery Stop & Go, Short Trip	53, 71 & 92	4,000 Mi. (6,500 kM)	8,000 Mi. (12,500 kM)
	8.2L	2,000 Mi. (3,000 kM)	4,000 Mi. (6,400 kM)
Industrial, Agricultural and Marine	149NA	150 Hrs.	300 Hrs.
	149T	100 Hrs.	200 Hrs.
		(or 6 Mos. Maximum)	
	53, 60, 71, 92 & 8.2L	50 Hrs.	100 Hrs.
Stationary Units Full Time	53, 71, 92 & 149	150 Hrs.	300 Hrs.
Standby	53, 71, 92, 149 & 8.2L	50 Hrs.	100 Hrs.
		(or 6 Mos. Maximum)	

USED LUBRICATING OIL ANALYSIS

A used lubricating oil analysis program such as the Detroit Diesel Oil Analysis Program is recommended for the monitoring of crankcase oil in all engines. Since an oil analysis indicates the condition of the engine, not the lubricating oil, it should not be used to extend oil drain intervals. The oil should be changed immediately if any contamination is present in concentrations exceeding the warning limits shown in the table. It should not however, be concluded that the engine is worn out based on *a single* measurement that exceeds the warning level. Imminent engine wearout can only be determined through a *continuous* oil analysis program wherein the change in data or deviation from baseline data can be used to interpret condition of engine parts.

Characteristics relating to lubricating oil dilution should trigger corrective action to identify and fix the source(s).

Confirmation of the need for engine overhaul should be based on operational data (increasing oil consumption and crankcase pressure, for example) and physical inspection of parts.

USED LUBRICATING OIL ANALYSIS WARNING LIMITS

These values indicate the need for an immediate oil change, but do not necessarily indicate internal engine problems requiring engine teardown.

WARNING LIMITS

	ASTM Designation	Two Cycle		Four Cycle
		53, 71, 92	149	60, 8.2
Pentane Insolubles Mass % Max.	D 893	1.0	1.0	1.0
Carbon (Soot) Content, TGA Mass % Max.	E 1131	0.8		1.5
Viscosity at 40°c St % Max. Increase % Max. Decrease	D 445 & D 2161	40.0 15.0	40.0 15.0	40.0 15.0
Total Base Number (TBN) Min. Min.	D 664 D 2986	1.0 2.0	1.0 2.0	1.0 2.0
Water Content (dilution) Vol. % Max.	D 95	0.30	0.30	0.30
Flash Point °C Reduction Max.	D 92	40.0	40.0	40.0
Fuel Dilution Vol. % Max.	*	2.5	1.0	2.5
Glycol Dilution PPM Max.	D 2982	1000	1000	1000
Iron Content PPM Fe Max.	**	150	35	60=150 8.2=250
Copper Content PPM Cu Max.	**	25	25	60=90 8.2=30
Sodium Content PPM Na Over Baseline Max.	**	50	50	50
Boron Content PPM B Over Baseline Max.	**	20	20	20

* No ASTM Designation
** Elemental Analysis are conducted using either emission or atomic absorption spectroscopy. Neither method has an ASTM designation.

FUEL OIL

QUALITY AND SELECTION

The quality of fuel used is a very important factor in obtaining satisfactory engine performance, long engine life, and acceptable exhaust emission levels. DDC engines are designed to operate on most diesel fuels marketed today. In general, fuels meeting the properties of ASTM Designation D 975 (grades 1–D and 2–D) have provided satisfactory performance. The ASTM D 975 specification however does not in itself adequately define the fuel characteristics necessary for assurance of fuel quality. The properties listed in the Fuel Oil Selection Chart have provided optimum engine performance.

FUEL OIL SELECTION CHART

General Fuel Classification	ASTM Test	No. 1 ASTM 1–D	No. 2* ASTM 2–D
Gravity, °API #	D 287	40–44	33–37
Flash Point Min. °F (°C)	D 93	100 (38)	125 (52)
Viscosity, Kinematic cST @ 100°F (40°C)	D 445	1.3–2.4	1.9–4.1
Cloud Point °F #	D 2500	See Note 1	See Note 1
Sulfur Content wt%, Max.	D 129	0.5	0.5
Carbon Residue on 10%, wt%, Max.	D 524	0.15	0.35
Accelerated Stability Total Insolubles mg/100 ml, Max. #	D 2274	1.5	1.5
Ash, wt%, Max.	D 482	0.01	0.01
Cetane Number, Min. +	D 613	45	45
Distillation Temperature, °F (°C)	D 86		
IBP, Typical #		350 (177)	375 (191)
10% Typical #		385 (196)	430 (221)
50% Typical #		425 (218)	510 (266)
90% +		500 (260) Max.	625 (329) Max.
End Point #		550 (288) Max.	675 (357) Max.
Water & Sediment %, Max.	D 1796	0.05	0.05

Not specified in ASTM D 975

+ Differs from ASTM D 975

* No. 1 diesel fuel is recommended for use in city coach engine models. No. 2 diesel fuel may be used in city coach engine models which have been certified to pass Federal and California emission standards.

Note 1: The cloud point should be 10°F (6°C) below the lowest expected fuel temperature to prevent clogging of fuel filters by wax crystals.

Note 2: When prolonged idling periods or cold weather conditions below 32°F (0°C) are encountered, the use of 1–D fuel is recommended. Number 1–D fuels should also be considered when operating continuously at altitudes above 5000 ft.

FUEL OIL SELECTION CRITERIA

DISTILLATION

The boiling range is a very important property in consideration of diesel fuel quality. The determination of boiling range is made using ASTM Test Method D 86. Many specifications contain a partial listing of the distillation results, ie., Distillation Temperature At 90% Recovered. Many diesel fuels are blended products which may contain constituents with boiling ranges much different than the majority of the fuel composition. The full boiling range as shown in the Fuel Oil Selection Chart should be used for proper selection.

FINAL BOILING POINT

Fuel can be burned in an engine only after it has been vaporized. The temperature at which fuel is completely vaporized is described as the End point Temperature in ASTM D 86 Distillation Test Method. This temperature must be low enough to permit complete vaporization at combustion chamber temperatures. The combustion chamber temperature depends on ambient temperature, engine speed and load. Poor vaporization is more apt to occur during severe cold weather, prolonged idling, and/or light load operation. Therefore engines operating under these conditions should utilize fuels with lower distillation end point temperatures.

COMPLETELY DISTILLED FLUID

Fuel selected should be completely distilled material. That is, the fuel should exhibit no less than 98% recovery when subjected to the ASTM D 86 Distillation Test Method.

CETANE NUMBER

Cetane Number is mistakenly used to indicate fuel quality. However, Cetane Number is most useful in predicting engine startup. A high Cetane Number should not be considered alone when evaluating fuel quality. Other properties such as end point distillation temperature and carbon residue should also be considered. Calculated Cetane Index is sometimes reported instead of Cetane Number. Cetane Index is an empirical property determined through the use of a mathematical equation whereas Cetane Number is determined through an engine test.

FUEL STABILITY

Diesel Fuel oxidizes in the presence of air and water, particularly if the fuel contains cracked products which are relatively unstable. The oxidation of fuel can result in the formation of undesirable gums and sediment. Such undesirable products can cause filter plugging, combustion chamber deposit formation and gumming or lacquering of injection system components with resultant sticking or wear.

ASTM Test Method D 2274 measures diesel fuel oxidative stability. Although the results of the test may vary with actual field storage, it does measure characteristics which will effect fuel storage stability for periods up to 12 months.

FUEL SULFUR CONTENT

The sulfur content of the fuel should be as low as possible to avoid premature wear and excessive deposit formation. Fuel containing no more than 0.5% sulfur are recommended. If the use of fuels with sulfur contents above 0.5% are unavoidable, lube oil drain intervals and lubricant selection need to be changed. Detroit Diesel recommends that the Total Base Number (TBN D 2896) of the lubricant be monitored and the oil drain interval be reduced.

FUEL OPERATING TEMPERATURE AND VISCOSITY

Since Diesel Fuel provides cooling of the injection system, the temperature of the fuel may vary considerably due to the ambient temperature, engine operating temperature, and the amount of fuel remaining in the tank. As fuel temperature increases, the fuel viscosity and therfore the lubrication capabilities of the fuel diminish. Maintaining proper fuel temperatures in combination with selection of fuels with the viscosity ranges shown in the Fuel Oil Selection Chart will assure proper injection system functioning.

DIESEL FUEL STORAGE

Fuel oil should be clean and free of contamination. Storage tanks and stored fuel should be inspected regularly for dirt, water, and sludge; and cleaned if contaminated. Diesel fuel tanks can be made of aluminum, monel stainless steel, black iron, welded steel or reinforced (non–reactive) plastic.

NOTICE: Galvanized steel or sheet metal tanks and galvanized pipes or fittings should never be used in any diesel fuel storage, delivery or fuel system. The fuel oil will react chemically with the zinc coating, forming a compound which can clog the filters and can cause engine damage.

FUEL ADDITIVES

Detroit Diesel engines operate satisfactorily on a wide range of diesel fuels without the addition of supplemental additives. Such additives increase operating costs without providing benefit.

Fuel additives specifically NOT recommended include:

- Used Lubricating Oil
- Gasoline

Detroit Diesel does NOT recommend the use of drained lubricating oil or gasoline in diesel fuel. Furthermore Detroit Diesel Corporation will not be responsible for any detrimental effects which it determines resulted form this practice.

Some fuel additives provide temporary benefits but do not replace good fuel handling practices. Such additives are helpful when water contamination is suspected:

- Isopropyl Alcohol—1 pint per 125 gallons of fuel for winter freeze up protection.
- Biocide—For treatment of microbe growth or black "slime". Follow manufacturers' instructions for treatment.

Other fuel additives are of questionable benefit. These include a variety of independently marketed products which claim to be:

- Cetane Improvers
- Combustion Improvers
- Cold Weather Flow Improvers

These products should be accompanied with performance data supporting their merit. It is not the policy of Detroit Diesel Corporation to approve or endorse such products.

FILTER RECOMMENDATIONS

Filters make up an integral part of fuel and lubricating oil systems. Proper filter selection and maintenence are important to satisfactory engine operation and service life. Filters should be utilized for maintaining a clean system, not for cleaning up a contaminated system.

FUEL FILTER RECOMMENDATION
Regular Service

Filter Type	Micron Rating	Beta Ratio	Manufacturer	Filter No.
Primary	30	—	AC Spark Plug Div. GM	T552 T553 T541 T632 T915 T936 T958
Secondary	12	—	AC Spark Plug Div. GM	TP509 TP540X TP624 TP916 TP928 TP959

FUEL FILTER RECOMMENDATION
Severe Duty Service

Filter Type	Micron Rating	Beta Ratio	Manufacturer	Filter No.
Primary	—	—	Racor	B32002
Secondary	3	200	Pall Corp.	Head HH7400A12UPRBP Element HC7400SUP-4H
Secondary (Alternate)	5	—	AC Spark Plug	TP916L TP928L TP959L

LUBRICATING OIL FILTER RECOMMENDATION
Series 53, 71, 92, 149

Filter Type	Micron Rating	Beta Ratio	Manufacturer	Filter No.
Full Flow	12	75	AC Spark Plug Div. GM	PF911L P/N 25013192

LUBRICATING OIL FILTER RECOMMENDATION
Series 60

Filter Type	Micron Rating	Beta Ratio	Manufacturer	Filter No.
Full Flow	45	80	AC Spark Plug Div. GM	PF911 P/N 25010495
By-Pass	10	90	AC Spark Plug Div. GM	P-940 P/N 25011188

LUBRICATING OIL FILTER RECOMMENDATION
Series 8.2L

Filter Type	Micron Rating	Beta Ratio	Manufacturer	Filter No.
Full Flow	25	88	AC Spark Plug Div. GM	PF35 P/N 6438384

COOLANT SPECIFICATIONS

The coolant provides a medium for heat transfer and controls the internal temperature of the engine during operation. In an engine having proper coolant flow, the heat of combustion is conveyed through the cylinder walls and the cylinder head into the coolant. Without adequate coolant, normal heat transfer cannot take place within the engine, and engine temperature rapidly rises. In general, water containing various materials in solution is used for this purpose.

	PARTS PER MILLION	GRAINS PER GALLON
Chlorides (Maximum)	40	2.5
Sulfates (Maximum)	100	5.8
Total Dissolved Solids (Maximum)	340	20
Total Hardness (Maximum)	170	10

TABLE 1

COOLANT REQUIREMENTS

Coolant solutions used in Detroit Diesel engines must meet the following basic requirements:

1. Provide for adequate heat transfer.
2. Provide a corrosion–resistant environment within the cooling system.
3. Prevent formation of scale or sludge deposits in the cooling system.
4. Be compatible with the cooling system hose and seal materials.
5. Provide adequate freeze protection during cold weather operation and boil–over protection in hot weather.

The first four requirements are satisfied by combining a suitable water with reliable inhibitors. When freeze protection is required, a solution of suitable water and an antifreeze containing adequate inhibitors will provide a satisfactory coolant. Ethylene glycol–based antifreeze solutions are recommended for year–round use in Detroit Diesel engines.

WATER

Whether of drinking quality or not, any water will produce a corrosive environment in the cooling system, and the mineral content may permit scale deposits to form on internal cooling system surfaces. Therefore, water selected as a coolant must be properly treated with inhibitors to control corrosion and scale deposition.

To determine if a particular water is suitable for use as a coolant when properly inhibited, the following characteristics must be considered: the concentration of chlorides and sulfates, total hardness and dissolved solids.

Chlorides and/or sulfates tend to accelerate corrosion, while hardness (percentage of magnesium and calcium salts broadly classified as carbonates) causes deposits of scale. Total dissolved solids may cause scale deposits, sludge deposits, corrosion or a combination of these. Chlorides, sulfates, magnesium and calcium are among the materials which make up dissolved solids. Water within the limits specified in Table 1 is satisfactory as an engine coolant when proper inhibitors are added. The procedure for evaluating water intended for use in a coolant solution is shown in Table 2.

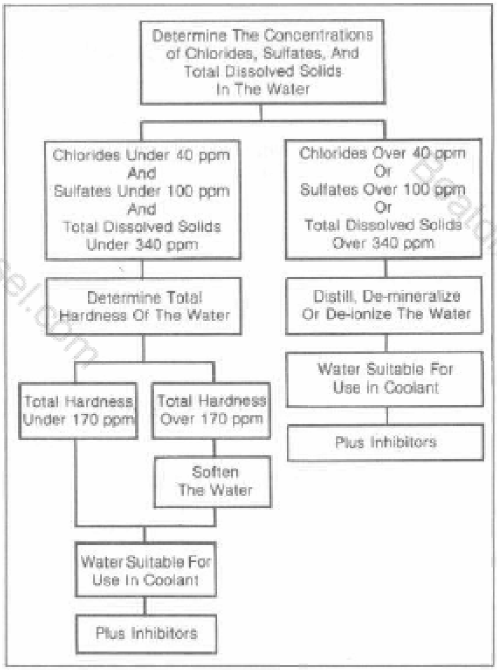

TABLE 2

CORROSION INHIBITORS VITAL

A corrosion inhibitor is a water–soluble chemical compound which protects the metallic surfaces of the cooling system against corrosive attack. Some of the more commonly used corrosion inhibitors are chromates, borates, nitrates, nitrites and soluble oil. (Soluble oil is not recommended as a corrosion inhibitor). Depletion of all types of inhibitors occurs through normal operation.

Therefore, strength levels must be maintained by adding inhibitors as required after testing the coolant.

The importance of a properly inhibited coolant cannot be overstressed. A coolant which has insufficient inhibitors, the wrong inhibitors, or no inhibitors at all invites the formation of rust and scale deposits within the cooling system. Rust, scale, and mineral deposits can wear out water pump seals and coat the walls of the cylinder block water jackets and the outside walls of the cylinder liners. As these deposits build up, they insulate the metal and reduce the rate of heat transfer. For example, a 1/16" deposit of rust or scale on 1" of cast iron is equivalent to 4–1/4" of cast iron in heat transferability (Fig. 1).

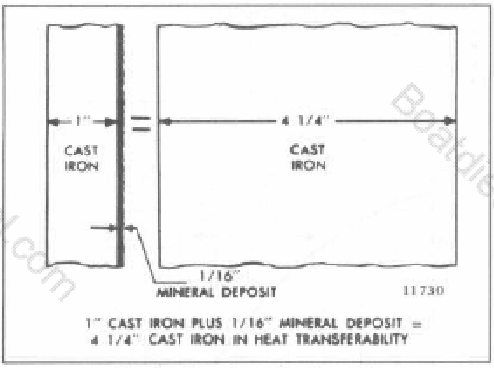

Fig. 1 – Heat Transfer Capacity

An engine affected in this manner overheats gradually over a period of weeks or months. Liner scuffing, scoring, piston seizure and cylinder head cracking are the inevitable results. An improperly inhibited coolant can also become corrosive enough to "eat away" coolant passages and seal ring grooves and cause coolant leaks to develop. If sufficient coolant accumulates on top of a piston, a hydrostatic lock can occur while the engine is being started. This, in turn, can result in a bent connecting rod.

An improperly inhibited coolant can also contribute to *cavitation erosion*. Cavitation erosion is caused by the collapse of bubbles (vapor pockets) formed at the coolant side of an engine component. The collapse results from a pressure differential in the liquid caused by the vibration of the engine part. As bubbles collapse, they form pin points of very high pressure. Over a period of time, the rapid succession of millions of tiny bursting bubbles can wear away (erode) internal engine surfaces.

Components such as fresh water pump impellers and cylinder liners are especially susceptible to cavitation erosion. In extreme cases their surfaces can become so deeply pitted that they appear to be spongy, and holes can develop completely through them.

Chromates

Sodium chromate and potassium dichromate are two of the best and most commonly used *water* system corrosion inhibitors. Care should be exercised in handling these materials due to their toxic nature.

Chromate inhibitors should *not* be used in antifreeze solutions. Chromium hydroxide, commonly called "green slime", can result from the use of chromate inhibitors with antifreeze. This material deposits on the cooling system passages, reducing the heat transfer rate (Fig. 1) and resulting in engine overheating. Engines which have operated with a chromate–inhibited water must be chemically cleaned before the addition of antifreeze. A commercial heavy–duty descaler should be used in accordance with the manufacturer's recommendation for this purpose.

Soluble Oil

Soluble oil has been used as a corrosion inhibitor for many years. It has, however, required very close attention relative to the concentration level due to adverse effects on heat transfer if the concentration exceeds 1% by volume. For example: 1.25% of soluble oil in the cooling system increases fire deck temperatures 6% and a 2.50% concentration raises fire deck temperatures up to 15%. *Soluble oil is not recommended as a corrosion inhibitor.*

Non–Chromates

Non–chromate inhibitors (borates, nitrates, nitrites, etc.) provide corrosion protection in the cooling system with the basic advantage that they can be used with either water or a water–and–antifreeze solution.

INHIBITOR SYSTEMS

An inhibitor system is a combination of chemical compounds which provide corrosion protection, pH control and water–softening ability. Corrosion protection is discussed under the heading *Corrosion Inhibitors Vital*. pH control is used to maintain an acid–free solution. The water–softening ability deters formation of mineral deposits. Inhibitor systems are available in various forms such as coolant filter elements, liquid and dry bulk inhibitor additives and as integral parts of antifreeze.

Coolant Filter Elements

Replaceable elements are available with various chemical inhibitor systems. Compatibility of the element with other ingredients of the coolant solution cannot always be taken for granted.

Problems have developed from the use of the magnesium lower support plate used by some manufacturers in their coolant filters. The magnesium plate will be attacked by solutions which will not be detrimental to other metals in the cooling system. The dissolved magnesium will be deposited in the hottest zones of the engine where heat transfer is most critical. The use of an aluminum or zinc support plate in preference to magnesium is recommended to eliminate the potential of this type of deposit.

High chloride coolants will have a detrimental effect on the water-softening capabilities of systems using ion-exchange resins. Accumulations of calcium and magnesium ions removed from the coolant and held captive by the zeolite resin can be released into the coolant by a regenerative process caused by high chloride-content solutions.

Inhibitor Additives

Commercially packaged inhibitor systems are available which can be added directly to the engine coolant. Both chromate and non-chromate systems are available and care should be taken regarding inhibitor compatibility with other coolant constituents.

Non-chromate inhibitor systems are recommended for use in Detroit Diesel engines. These systems can be used with either water or water-and-antifreeze solutions and provide corrosion protection, pH control and water softening. Most non-chromate inhibitor systems offer the additional advantage of a simple on-site test to determine protection level. Since they are added directly to the coolant, they require no additional hardware or plumbing.

All inhibitors become depleted through normal operation and additional inhibitor must be added to the coolant as required to maintain original strength levels.

NOTICE: Over-inhibiting antifreeze solutions can cause silicate dropout. Always follow the supplier's recommendations on inhibitor usage and handling.

TEST METHODS

Test kits and test strips are commercially available to check engine coolant for corrosion inhibitor strength level. Coolant should be tested to determine the need for corrosion inhibitor supplements and the amount required. Do not use one manufacturer's test to measure the inhibitor strength level of another manufacturer's product. Always follow the manufacturer's recommended test procedures.

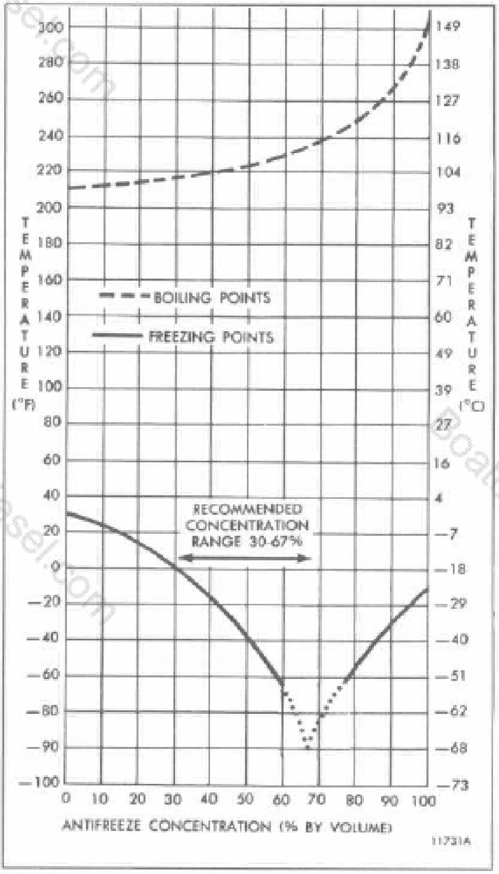

Fig. 2 – Coolant Freezing and Boiling Temperatures vs. Antifreeze Concentration (Sea Level)

ANTIFREEZE

When freeze protection is required, use an antifreeze that meets the GM 6038M formulation, which limits silicate to 0.15% maximum or an equivalent formulation meeting the 0.15% maximum silicate and GM 1899M performance requirements.

Solutions of less than 30% do not provide adequate corrosion protection. Concentrations over 67% adversely affect freeze protection, heat transfer rates and silicate stability. A 50% antifreeze solution is normally used as factory-fill.

Ethylene glycol base antifreeze is recommended for use in all Detroit Diesel engines. Methyl alcohol base antifreeze is not recommended because of its effect on the non-metallic components of the cooling system and because of its low boiling point. Methoxy propanol base antifreeze is not recommended for use in Detroit Diesel engines due to the presence of fluoroelastomer seals in the cooling system.

Antifreeze solutions should be used year-round to provide freeze protection in the winter, boil-over protection in the summer and a stable environment for seals and hoses in the cooling system of the engine.

The inhibitors in antifreeze solutions should be replenished with a non-chromate corrosion inhibitor supplement when indicated by testing the coolant. Engine coolant should be checked at approximately 500 hour or 20,000 mile intervals.

A cooling system properly maintained and protected with supplemental corrosion inhibitors can be operated up to two years, 200,000 miles, or 6000 hours, whichever comes first. At this interval the antifreeze should be drained and the cooling system cleaned thoroughly. The cooling system should then be replenished with an ethylene glycol-base antifreeze/water solution in the required concentration (see graph).

> **NOTICE:** Failure to maintain inhibitors at proper levels can result in damage to the cooling system and its related components. Conversely, *overinhibiting antifreeze solutions can cause silicate dropout.* Always follow the supplier's recommendations on inhibitor usage and handling.

SILICATE DROPOUT

Excessive amounts of chemicals in the engine coolant can cause silicate dropout, which creates a gel-type deposit that reduces heat transfer and coolant flow.

The gel takes on the color of the coolant solution in the wet state but appears as a white powdery deposit when dry. Although silica gel is non-abrasive, it can pick up solid particles in the coolant and become a gritty abrasive deposit that can cause excessive wear of water pump seals and other cooling system components. The wet gel can be removed by non-acid (alkali) type heavy-duty cleaners, while the dried silicate requires engine disassembly and caustic solution or mechanical cleaning of individual components.

The total amount of chemicals in the coolant can be minimized by using GM 6038M formulation antifreeze at the required freeze protection level, corrosion inhibitor supplements as needed to maintain protection and water that meets Detroit Diesel requirements.

GENERAL RECOMMENDATIONS

All Detroit Diesel engines incorporate pressurized cooling systems which permit operation at temperatures higher than non-pressurized systems. It is essential that these systems be kept clean and leak-free, that filler caps and pressure relief mechanisms be correctly installed at all times and that coolant levels be maintained.

Always maintain engine coolant at the proper level. A low coolant level allows the water pump to mix air with the coolant. Air bubbles in the coolant can "insulate" the cylinder walls, preventing normal heat transfer. An abnormally low coolant level can cause the water pump to become "air-bound," a condition in which it works feverishly but pumps nothing. Without proper heat transfer, silicone elastomer head-to-block water hole seals can deteriorate and cylinder components can expand so that pistons rapidly cut through the lubricant on the liner walls. Scuffing and piston seizure may follow.

> **CAUTION: Use extreme care when removing a radiator pressure-control cap from an engine. The sudden release of pressure from a heated cooling system can result in a loss of coolant and possible personal injury (scalding) from the hot liquid.**

An engine may contain the correct amount of properly inhibited coolant, but still fail to adequately cool the engine. In cases where this occurs, other causes of low coolant flow, either engine or cooling system related, should be investigated.

1. Always use a properly inhibited coolant.
2. Do not use soluble oil.
3. Maintain the prescribed inhibitor strength level by adding inhibitors as needed after testing the coolant.
4. Always follow the manufacturer's recommendations on inhibitor usage and handling.
5. If freeze protection is required, use a solution of water and antifreeze that meets the GM 6038M formulation or an equivalent antifreeze with a 0.15% maximum silicate content that meets GM 1899M performance specifications.
6. Reinhibit antifreeze with a non-chromate inhibitor system.
7. Do not use a chromate inhibitor with antifreeze.
8. Do not use methoxy propanol base antifreeze.

9. Do not mix ethylene glycol base antifreeze with methoxy propanol base antifreeze in the cooling system.

10. Antifreeze makeup solutions should be mixed at the same concentration as the original coolant.

11. Do not use sealer additives or antifreeze containing sealer additives.

12. Do not use methyl alcohol base antifreeze.

13. Use extreme care when removing the radiator pressure–control cap.

14. Do not add inhibitor supplements to *new* antifreeze solutions, except for the *initial fill* to provide optimum cavitation protection.

15. Use an antifreeze solution year–round for freeze and boil–over protection. Seasonal changing of coolant from an antifreeze solution to an inhibitor–water solution is *not recommended*.

16. A cooling system properly maintained and protected with supplemental corrosion inhibitors can be operated up to two years, 200,000 miles, or 6000 hours, whichever comes first. At this interval the antifreeze should be drained and the cooling system cleaned thoroughly.

