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Perkins engines

handbook

for marine diesel engines

6.354 M

H6.354 M

T6.354 M

HT6.354 M

In motor 354 U - 4521 HL.

handbook for 6.354M, H6.354M, T6.354M, HT6.354M diesel engines

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engine guarantee

The guarantee applies to new engines and spare parts only. It does not cover second hand engines or parts, spurious parts, accessories and proprietary fittings.

Perkins do not accept guarantee claims direct from Boat Owners. If a claim under guarantee becomes necessary, the Boat Owner should contact the nearest Perkins Marine Distributor, his approved Dealer or the Company from whom he purchased his craft.

The full terms of Perkins guarantee are set out in the Engine Guarantee Certificate which is issued with each engine and should be found with the ship's papers, having been passed by the Perkins Distributor to the Boatbuilder concerned.

It would assist if the Guarantee Certificate could be produced on any occasion that a claim is made.

contents

This handbook has been issued to guide operators in the correct use and maintenance of Perkins Marine Diesel engines. Providing an engine is correctly installed, correct maintenance and certain precautions are observed, then no operating difficulties or failures should be experienced. All matters relating to marine propulsion are covered, also fault diagnosis and remedy, and minor repairs which the average marine operator can undertake, whilst his craft is afloat.

ON BOARD TOOLS

An "on board" tool kit for engine work is available but the following tools and general spares are suggested to supplement the kit :—

Hose clips, assorted.

Hose, assorted (convoluted type useful).

Fresh water pump driving belt.

Sea water pump impeller.

Wire (20 SWG).

Insulating tape.

Jointing compound.

Magnet (keep away from compass).

Mechanical fingers.

Self-gripping wrench.

Asbestos lagging.

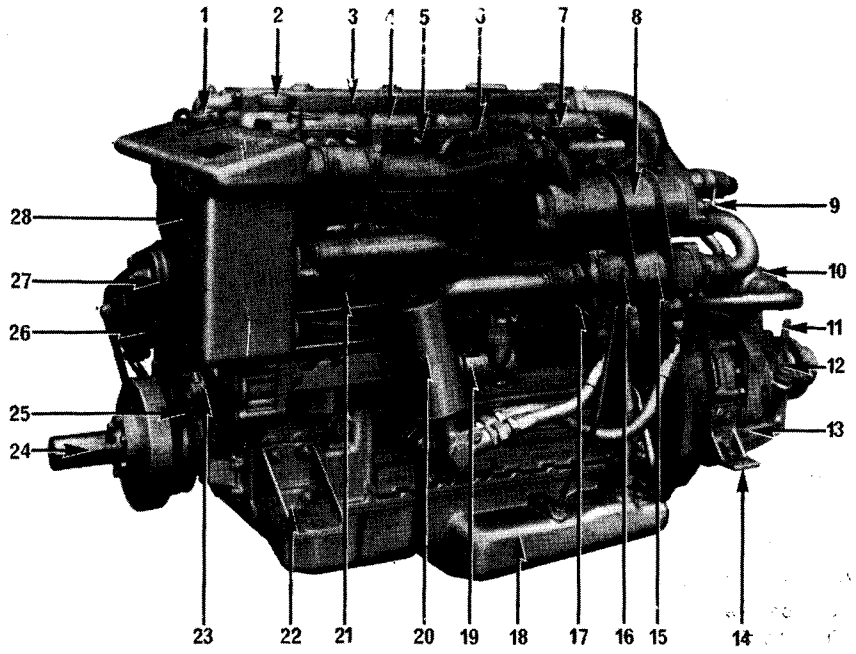
Low pressure fuel pipe olives.

Small hacksaw with spare blade.

Assorted files.

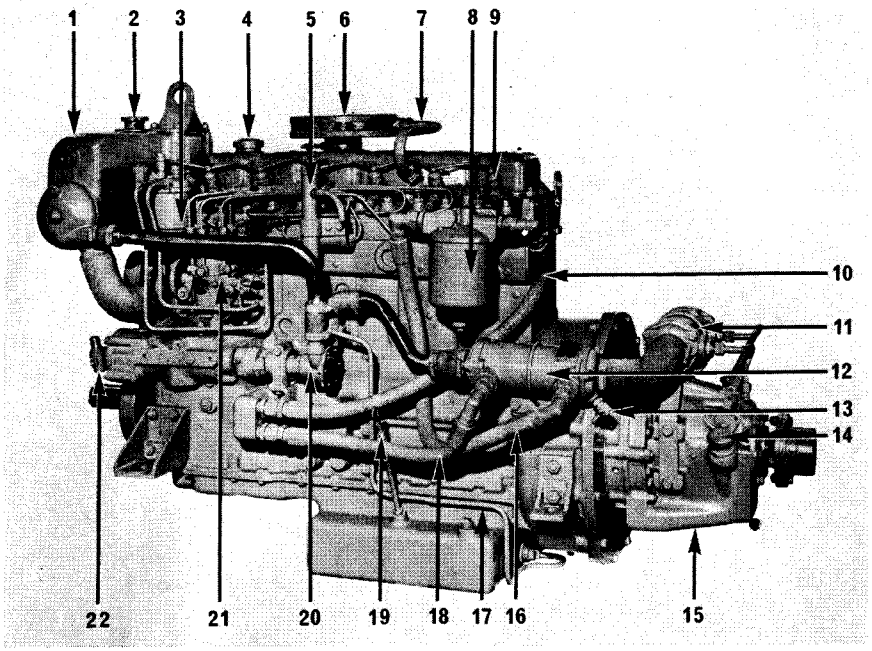
For some engines an on board spares kit can be purchased from your Perkins Marine Distributor.

Perkins Engines are built to individual requirements to suit the applications for which they are intended and the following engine views do not necessarily typify any particular specification.



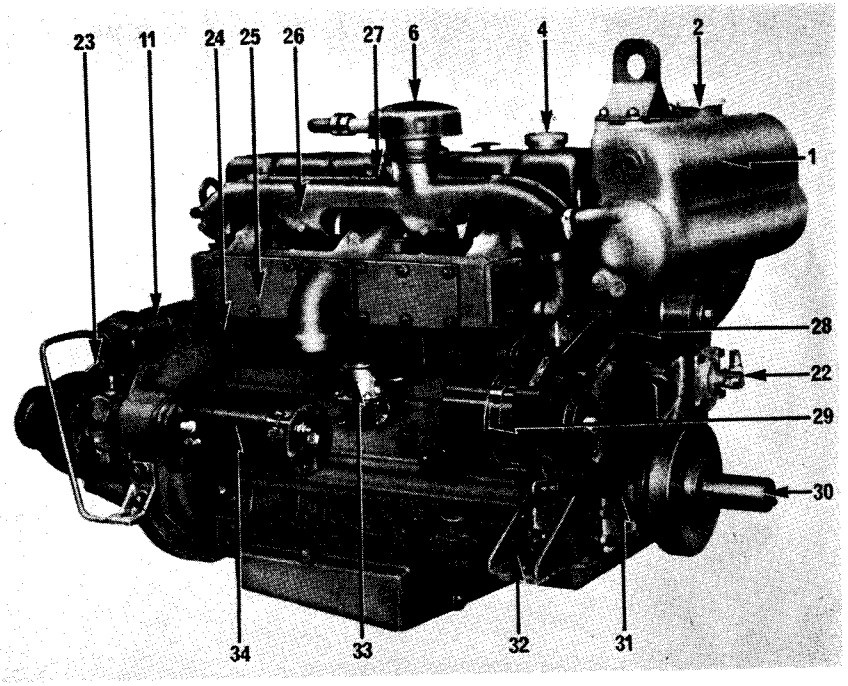
Lowline 6.354M Engine

1. Fresh Water Filler Cap
2. Lubricating Oil Filler Cap
3. Water Cooled Exhaust Manifold
4. Cylinder Head Top Cover
5. Atomiser
6. Lubricating Sump Drain Pump
7. Atomiser Leak-Off Pipe
8. Heat Exchanger
9. Heat Exhanger Air Bleed Vent
10. Gearbox Oil Cooler
11. Gearbox Control Lever
12. Gearbox Oil Filler Plug.
13. Gearbox
14. Rear Engine Support Bracket
15. Engine Lubricating Oil Cooler
16. Lubricating Oil Sump Dipstick
17. Oil Cooler Water Drain Tap
18. Lubricating Oil Sump
19. Sea Water Pump
20. Lubricating Oil Filter
21. Fuel Oil Injection Pump
22. Front Engine Support Bracket
23. Tachometer Drive Connection
24. Power Take-Off Shaft
25. Crankshaft Pulley
26. Generator
27. Fresh Water Pump Pulley
28. Fresh Water Header Tank



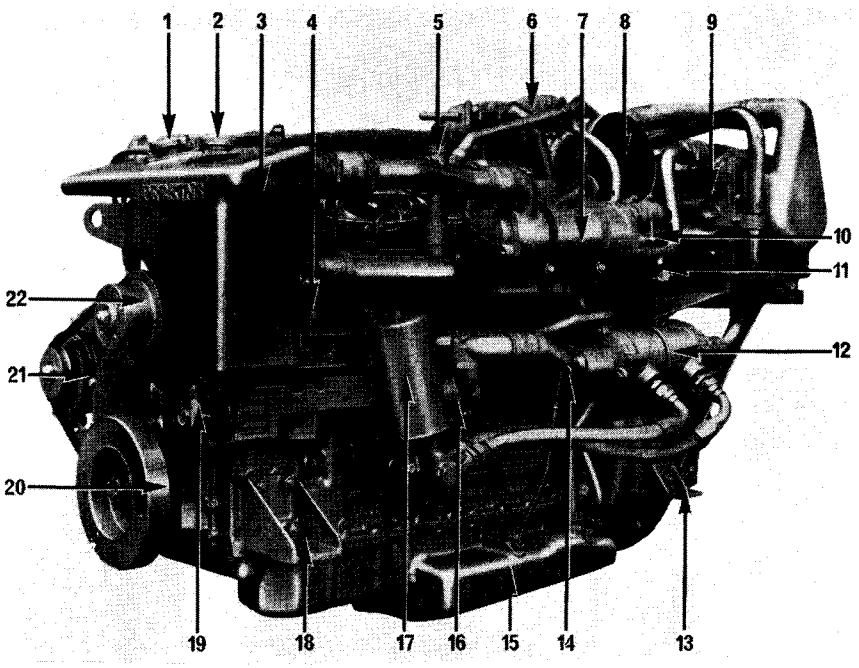
6.354M Engine

1. Fresh Water Heat Exchanger
2. Fresh Water Filler Cap
3. Fuel Oil Filter
4. Lubricating Oil Filler
5. Sump Drain Pump
6. Air Filter
7. Engine Breather Pipe
8. Lubricating Oil Filter
9. Atomiser
10. Lubricating Oil Pipe, Filter to Adaptor
11. Gearbox Oil Cooler
12. Engine Oil Cooler
13. Engine Oil Cooler Drain Tap
14. Gearbox Oil Filler
15. Gearbox
16. Lubricating Oil Pipe, Filter to Cooler.
17. Sump Drain Pump Pipe
18. Lubricating Oil Pipe, Adaptor to Filter



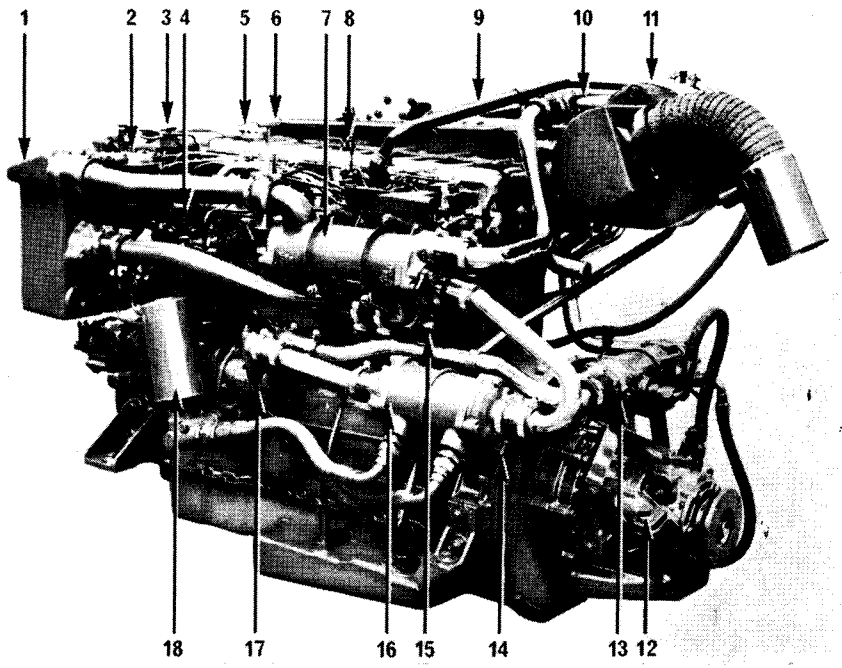
6.354M Engine

19. Dipstick
20. Sea Water Pump
21. Fuel Injection Pump
22. Tachometer Drive
23. Gearbox Oil Cooler Drain Tap
24. Exhaust Manifold Drain Tap
25. Water Cooled Exhaust Manifold
26. Inlet Manifold
27. Cold Starting Aid
28. Fresh Water Pump
29. Generator
30. Power Take-Off Shaft
31. Generator and Fresh Water Pump Drive Belt
32. Engine Front Support Bracket
33. Fuel Oil Lift Pump
34. Starter Motor



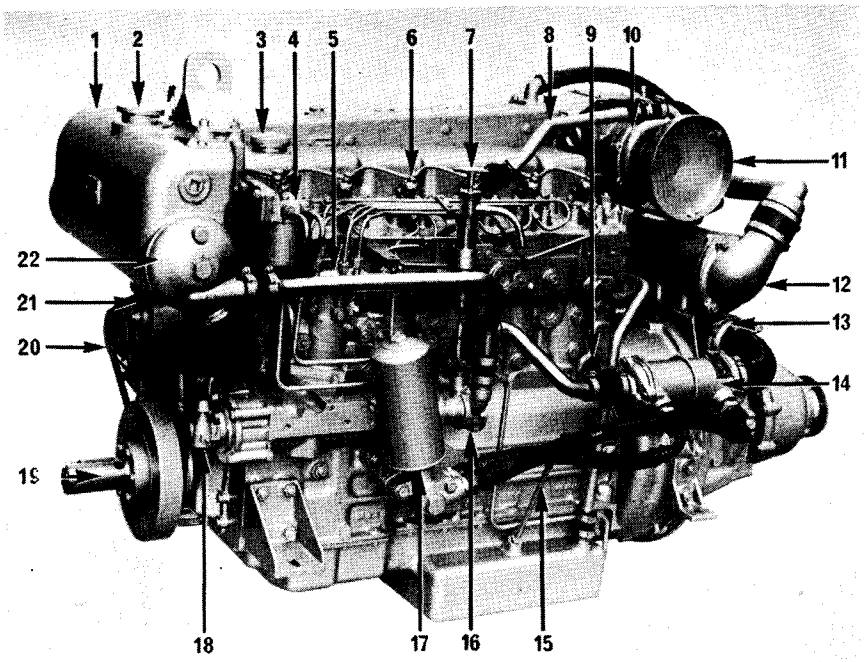
Lowline T6.354M Engine

1. Fresh Water Filler Cap
2. Lubricating Oil Filler Cap
3. Fresh Water Header Tank
4. Fuel Injection Pump
5. Lubricating Sump Drain Pump
6. Turbocharger
7. Heat Exchanger
8. Air Cleaner
9. Air Charge Cooler
10. Heat Exchanger Air Bleed Vent
11. Heat Exchanger Water Drain Plug
12. Oil Cooler
13. Rear Engine Support Bracket
14. Lubricating Oil Sump Dipstick
15. Lubricating Oil Sump
16. Sea Water Pump
17. Lubricating Oil Filter
18. Front Engine Support Bracket
19. Tachometer Drive Connection
20. Crankshaft Pulley
21. Generator
22. Fresh Water Pump Pulley



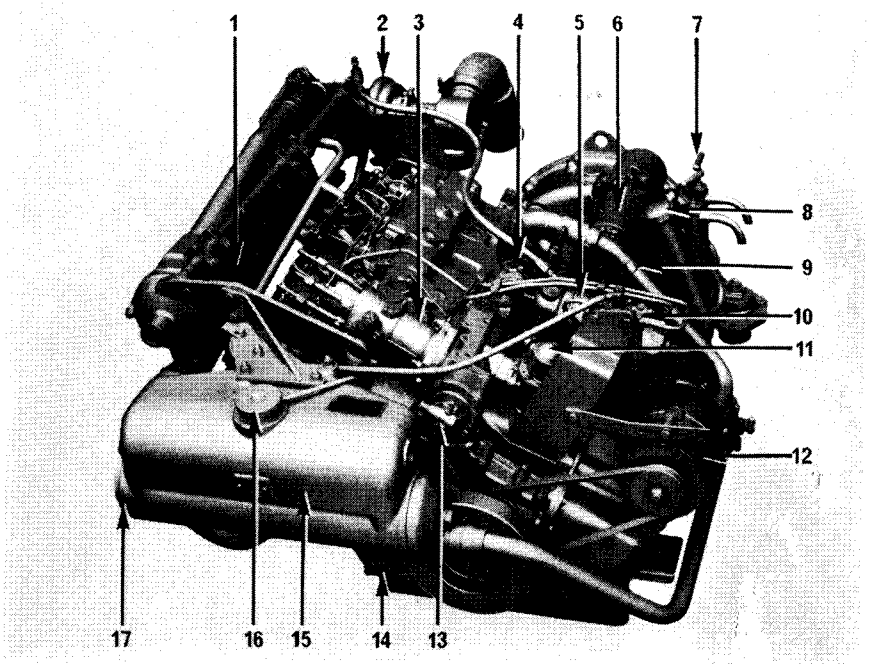
High Rated T6.354M Engine

1. Fresh Water Header Tank
2. Fuel Oil Filter
3. Fresh Water Filler Cap
4. Fuel Injection Pump
5. Lubricating Oil Filler Cap
6. Sump Drain Pump
7 Heat Exchanger
8. Lubricating Oil Dipstick
9. Engine Breather Pipe
10. Air Charge Cooler
11. Turbocharger
12. Gearbox Oil Filler Plug
13. Gearbox Oil Cooler
14. Engine Oil Cooler Water Drain Tap
15. Heat Exchanger Pipe Drain Tap
16. Engine Oil Cooler
17. Sea Water Pump
18. Lubricating Oil Filter



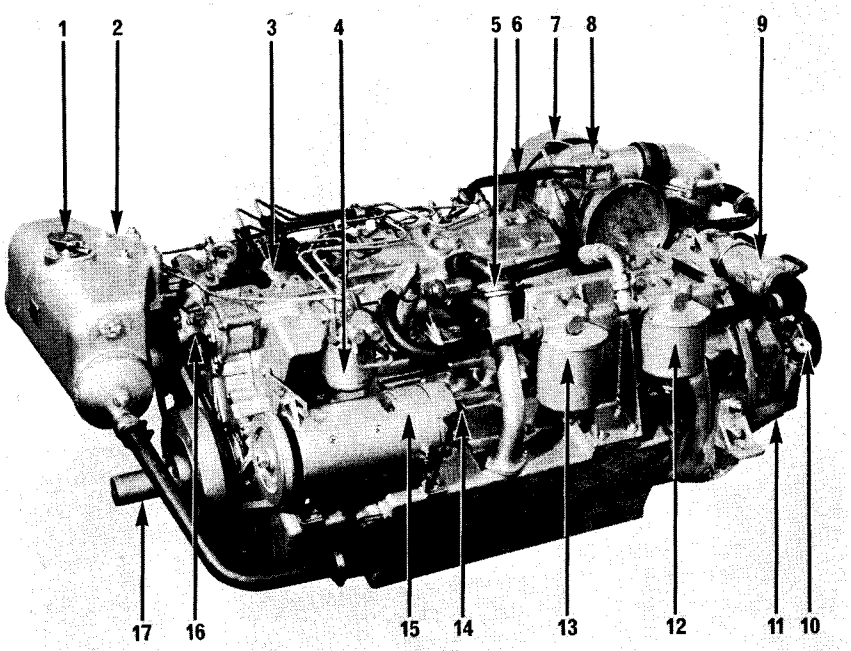
T6.354M Engine

1. Fresh Water Header Tank
2. Fresh Water Filler Cap
3. Lubricating Oil Filler Cap
4. Fuel Oil Filter
5. Fuel Injection Pump
6. Atomiser
7. Lubricating Oil Drain Pump
8. Engine Breather Pipe
9. Cylinder Block Drain Tap
10. Turbocharger
11. Air Cleaner
12. Air Charge Cooler
13. Gearbox Oil Cooler
14. Engine Oil Cooler
15. Lubricating Oil Dipstick
16. Sea Water Pump
17. Lubricating Oil Filter
18. Tachometer Drive Adaptor
19. Power Take-Off Shaft
20. Alternator Pulley
21. Fresh Water Pump Pulley
22. Heat Exchanger



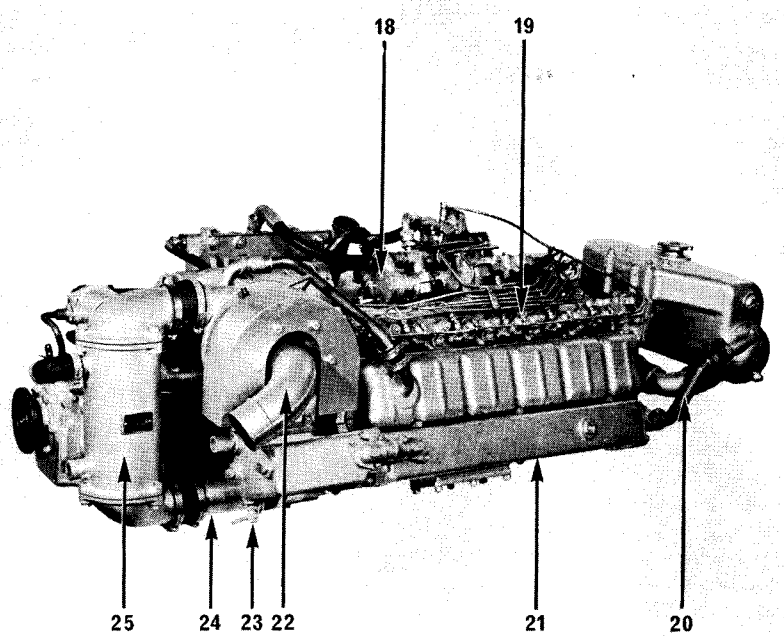
Lowline HT6.354M Engine

1. Air Charge Cooler
2. Turbocharger
3. Fuel Injection Pump
4. Sea Water Pump
5. Lubricating Oil Filter
6. Starter Motor
7. Lubricating Oil Drain Pumps
8. Lubricating Oil Filler Cap
9. Lubricating Oil Dipstick
10. Fuel Oil Filter
11. Fuel Lift Pump
12. Alternator
13. Tachometer Drive Adaptor
14. Fresh Water Pump Pulley
15. Fresh Water Header Tank
16. Fresh Water Filler Cap
17. Heat Exchanger



HT6.354M Engine

1. Fresh Water Filler Cap
2. Fresh Water Header Tank
3. Fuel Injection Pump
4. Fuel Filter
5. Lubricating Oil Filler
6. Engine Breather Pipe
7. Lubricating Oil Pressure Feed Pipe to Turbocharger
8. Turbocharger
9. Gearbox Oil Cooler
10. Gearbox Oil Filler
11. Gearbox
12. Turbocharger Oil Filter
13. Engine Oil Filter
14. Dipstick
15. Dynamo
16. Tachometer
17. Power Take-Off Shaft



HT6.354M Engine

18. Sea Water Pump
19. Atomiser
20. Heat Exchanger to Exhaust Manifold Water Pipe
21. Exhaust Manifold
22. Turbocharger Exhaust Outlet
23. Exhaust Manifold Drain Tap
24. Turbocharger to Inlet Manifold Pipe
25. Air Charge Cooler

engine identification

The engine types with which this handbook is associated are designated 6.354M, H6.354M, T6.354M or HT6.354M.

The first figure in the engine designation denotes the number of cylinders. The second group of figures denotes the engine capacity in cubic inches. The letter "H" preceeding the engine type denotes a horizontally inclined engine.

The letter "T" signifies that the engine is turbocharged.

The letter "M" is for "marine".

engine serial number

The serial number is stamped on the fuel pump mounting flange of the cylinder block as shown in Fig. 1. The first three figures represent the cubic capacity: the letter "U" signifies that the engine was built in the U.K. The second group of figures comprises the engine serial number. Further letters can be included in the combination — a letter "H" indicates a horizontal engine — a letter "T" indicates a turbocharged engine — a letter "X" indicates a contra-rotating engine.

Where information, spare parts or assistance is required, this number should always be quoted in full.

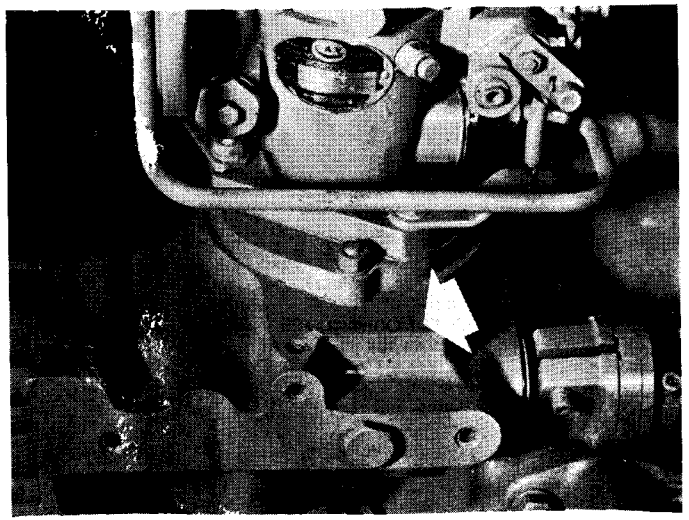


Fig. 1.
Engine No. Location 6.354, H6.354, T6.354 and HT6.354

engine data

Type	Four Stroke, Direct Injection. Vertical and Inclined
No. of Cylinders	6
Nominal Bore	3.875 in (98,4 mm)
Stroke	5 in (127 mm)
Cubic Capacity	354 in³ (5,8 litres)
Compression Ratio	16 :1
Firing Order (normal rotation)	1, 5, 3, 6, 2, 4
Firing Order (contra-rotation)	1, 4, 2, 6, 3, 5
Valve Tip Clearance	0.012 in (0,30 mm)
Oil Pressure	30-60 lbf/in² (2,1 - 4,2 kgf/cm²) at maximum speed and normal operating temperature.
Sump Capacity	
Vertical Engines	18 IMP pints (10,2 litres) 22 U.S. pints
Horizontal Engines	23 IMP pints (13,1 litres) 27 U.S. pints
Rating Details	
Early T6.354M	
125 shp at 2,400 rev/min	Maximum Intermittent
Current T.6354 and Early HT6.354M	
135 shp at 2,400 rev/min	Maximum Intermittent
Current T6.354M and HT6.354M	
120 shp at 2,250 rev/min	Maximum Continuous
Current T6.354 and HT6.354M (for fast planing craft only)	
145 shp at 2,400 rev/min	Maximum Intermittent
Current T6.354M (High Rated for fast planing craft)	
175 shp at 2,400 rev/min	Maximum Intermittent
175 shp at 2,600 rev/min	Maximum Intermittent
Early 6.354M	
105 shp at 2,400 rev/min	Maximum Intermittent
Current 6.354M	
115 shp at 2,800 rev/min	Maximum Intermittent
Current 6.354M	
95 shp at 2,400 rev/min	Maximum Continuous

operating instructions

PREPARATION FOR STARTING

ENSURE FUEL IS TURNED ON !

Open engine coolant seacocks.

Check coolant level in header tank.

Check engine and gearbox lubricating oil levels (see page 36 for approved oils). When checking oil level on H6.354 and HT6.354 engines, the procedure given on page 34 should be observed.

Ensure that the fuel tank contains considerably more than sufficient fuel for the intended voyage. The fuel oil should conform to one of the specifications given on page 27.

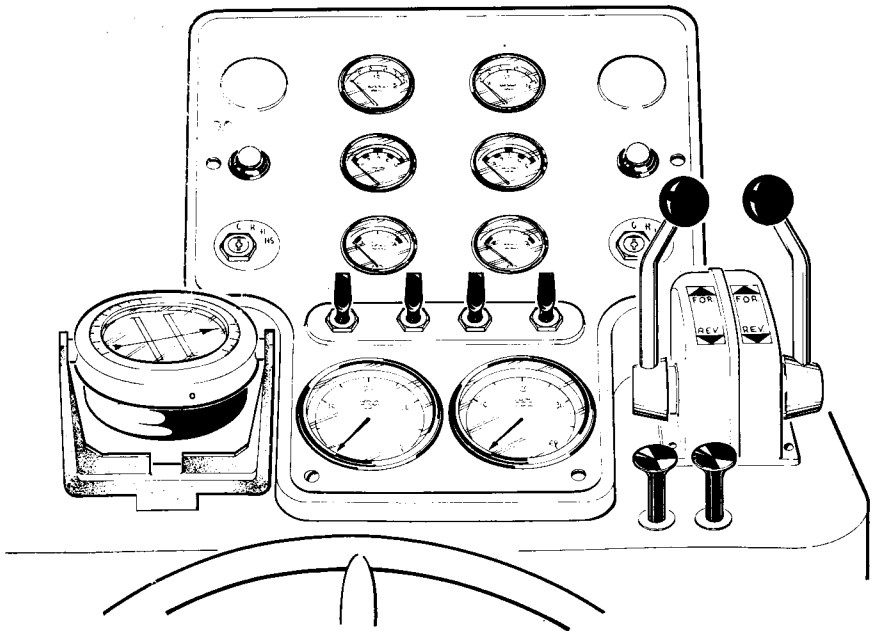


Fig. 2. Typical engine control panel.

Starting the Engine

Place gearbox control in neutral gear.

Turn starter switch to position "R" fig. 3 and ensure that the engine stop control is in the run position (i.e., pushed fully home).

Place engine speed control in maximum speed position.

If the engine or weather is warm, turn starter switch in a clockwise direction to the "HS" position.

As soon as the engine starts, release the switch to the "R" position.

Be sure that the starter pinion and engine have stopped rotating before re-engaging the starter motor, otherwise damage may result.

If weather is cold, ensure cold start aid reservoir contains fuel oil. Turn on tap between reservoir and cold start aid.

Turn starter switch to the "H" position and hold it there for fifteen to twenty seconds.

Then turn the starter switch to the "HS" position, thereby engaging the starter motor.

If the engine does not start after twenty seconds, return the switch to the "H" position for ten seconds and then re-engage the starter motor by switching to the "HS" position.

As soon as the engine starts, release the switch to the "R" position and turn off the tap on the cold start aid reservoir.

Earlier Heat Start Switch

The cold start switch supplied with earlier engines is shown in fig. 4.

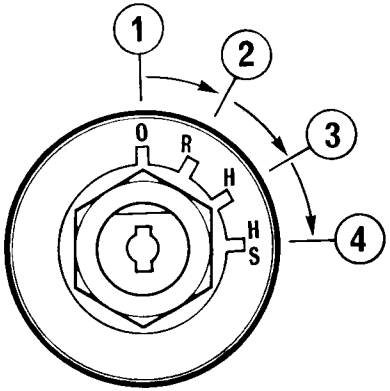


Fig. 3.

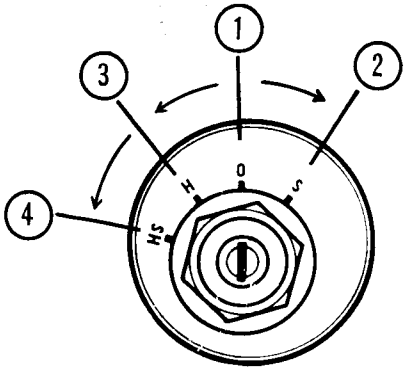


Fig. 4.

With this switch, starting a warm engine is effected by turning the switch in a clockwise direction to the "S" position.

In cold weather, the switch should be turned to the "H" position for fifteen to twenty seconds and then to the "HS" position in order to engage the starter motor.

As soon as the engine starts, the switch should be returned to the "O" position.

Where this type of switch is used, it was sometimes customary to have a separate switch for the electrical circuits and this should be turned on before starting the engine and turned off after stopping the engine.

Starting the Engine (Alternative Method)

With some engines, a different starter switch is provided and the cold start aid is operated by means of a separate push button switch.

The cold starting procedure however is the same, i.e.
Switch on by turning the starter switch in a clockwise direction to the first position.

Press the heater button for fifteen to twenty seconds and then, with the heater button still pressed, turn the starter switch in a further clockwise direction to engage the starter motor. As soon as the engine starts, release both starter switch and heater button.

TO STOP ENGINE

A spring loaded stop control is located near the normal engine controls and functions by cutting off the fuel at the fuel injection pump.

To operate, pull the knob and hold in this position until the engine ceases to rotate. Ensure that the control returns to the run position, otherwise difficulty may be experienced in restarting the engine.

Switch off by turning switch to position "O".

Things to Note

When the engine starts, check the following points :

(a) That oil pressure is registered on gauge(s).

(b) That charging rate is indicated on ammeter/generator light goes out.

(c) That coolant is discharging overboard.

Care should be taken not to operate the engine at maximum speed for long periods. The following table gives maximum intermittent and continuous speeds for the respective engine types.

Engines should not be operated at maximum intermittent speeds for periods in excess of one hour after which, the engine speed should be reduced by 150 rev/min for at least fifteen minutes before returning to maximum speed.

Where engines are loaded down to speeds less than maximum intermittent when on full throttle, then the same procedure applies and the maximum continuous or cruising speed is 150 rev/min below maximum possible engine speed.

Engine Type	Maximum Intermittent Speed (rev/min)	Maximum Continuous Speed (rev/min)
6.354(M) H6.354(M)	2,800	2,400
T6.354(M) HT6.354(M)	2,400 and 2,600	2,250

Instruments

These serve to give the operator important information about the running of the engine, fuel state, temperature etc.

Generally speaking instruments have not the accuracy that a laboratory meter has and this should be borne in mind when reading them ; nevertheless they may be used to ensure correct functioning of the engine(s).

Engine Oil Pressure Gauge

This is one of the most important instruments and should be checked for correct operation as soon as the engine starts. Normal oil pressure is 30/60 lbf/in^2 (2,1/4,2 kgf/cm^2) at maximum engine speed and normal operating temperature. However it should be remembered that during the life of the engine there will be a gradual drop in oil pressure. This is perfectly normal as bearing surfaces wear. There will also be a slight drop in pressure when the oil is hot or if the wrong grade of oil is used in certain climatic conditions. See page 36 for correct oil grades.

Gearbox Oil Pressure Gauge

Where this is fitted the pressure should be within the ranges given on pages 37 and 38.

Here again there will be a slight pressure drop when the oil is hot.

Tachometer

This provides the operator with the engine revolutions per minute (rev/min). The number indicated has usually to be multiplied by one hundred to give engine rev/min, e.g. 20 x 100 = 2,000 rev/min.

Water Temperature Gauge

This indicates the temperature of engine coolant. Coolant temperatures should remain within the ranges given on page 31. If high temperatures are experienced investigate the cause immediately (see page 44).

preventive maintenance

If a Perkins marine diesel engine is to give long and trouble free service, it is imperative that it be maintained in accordance with the following Periodical Attentions :—

Daily

Check coolant level.

Check sump oil level.

Check oil pressure (where g fitted).

Check gearbox oil level.

Check boost pressure (wher uge fitted).

Every 150 hours or 3 m s (whichever occurs first)

Clean air intake gauze sc

Grease tachometer angle dr connections (where nipple fitted).

Every 200 hours or 4 months (whichever occurs first)

Drain and renew engine lubricating oil (see page 36).

Renew lubricating oil filter element.

Check drive belt tension.

Clean water trap.

Check engine for leakage of oil and water.

Lubricate dynamo rear bush (where fitted).

Every 400 hours or 12 months (whichever occurs first)

Clean lift pump gauze strainer.

Renew final fuel filter element.

Check hoses and clips.

Drain and clean fuel tank.

Renew gearbox lubricating oil. (Borg-Warner).

Every 800 hours

Clean turbocharger impeller, diffuser and oil drain pipe.

Renew gearbox lubricating oil. (MRF 350).

Every 2,400 hours

Arrange for examination and service of proprietary equipment, i.e. starter, generator, etc.

*Service atomisers.
Check and adjust valve tip clearances.

NOTE for engines fitted with air charge coolers see page 33.

*The atomisers fitted to 175 shp T6.354M engines for fast planing craft should be serviced every 100 hours.

post delivery checkover

After a customer has taken delivery of his Perkins e Diesel engine, a general checkover of the engine must be carried out after t rst 25/50 hours in service.

The checkover should comprise the following :—

1. Drain lubricating oil, renew lubricating oil filter ref sump to full mark on dipstick with new oil.
2. Remove rocker assembly and check cylinder h a uts and/or setscrews are to the correct torque of 100 lbf ft (13,8 kgf m). (See fi).
3. Refit rocker assembly and set valve clearance to 0 12 in (0,30 mm) cold.

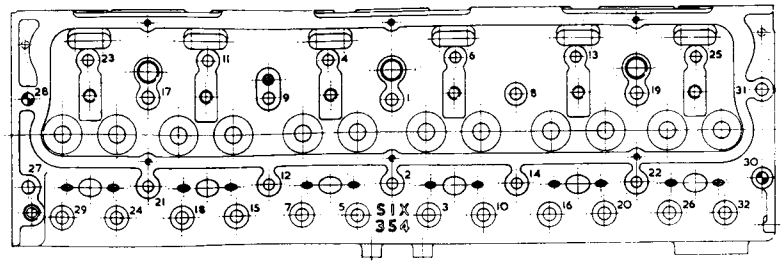


Fig. 5. Tightening Sequences for Cylinder Head Nuts and/or Setscrews.
6.354(M), H6.354(M), T6.354(M), HT6.354(M)

4. Check coolant level in header tank and inspect for coolant leaks.
5. Check external nuts, setscrews, mountings, etc. for tightness.
6. Check water pump drive belt tension.
7. Check electrical equipment and connections.
8. Check for lubricating and fuel oil leaks.
9. Check engine idling speed (see page 31).
10. Check general performance of engine.

preservation of laid up engine

Where a boat is to be laid up for several months, the engine should be protected as follows :—

1. Clean all external parts.
2. Run engine until warm. Stop and drain the lubricating oil sump.
3. Renew the lubricating oil filter canister or throw away the dirty element, clean bowl and fit a new element.
4. Clean out engine breather pipe.
5. Fill lubricating oil sump to correct level with new oil of an approved grade.
6. Drain all fuel oil from fuel tanks and filters. Put into the fuel tank at least one gallon of one of the oils listed under "Recommended Oils for the Fuel System" (see page 24). If, because of the construction of the fuel tank, this quantity of oil is inadequate, break the fuel feed line before the first filter and connect a small capacity auxiliary tank. If the fuel tank(s) cannot be drained they should be filled with fuel and an inhibiting oil put into a temporary tank inserted in the fuel feed line.
7. Prime the system as detailed on page 28.

8. Start engine and run it at half speed for 15 minutes when the oil will have circulated through the injection pump, pipes and atomisers.

9. Seal the air vent in the tank or filler cap with waterproof adhesive tape.

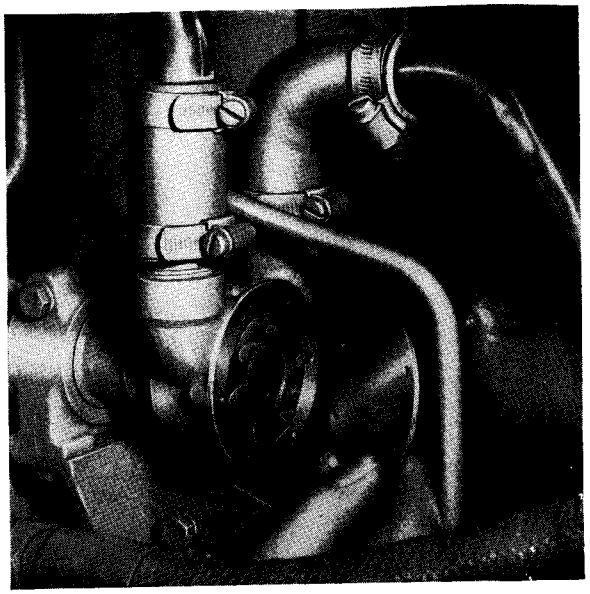


Fig. 6
Removing Sea Water Pump End Plate.

10. Drain water from heat exchanger and engine cylinder block. The heat exchanger should be removed and serviced ; the cylinder block may be flushed back through the drain points with the thermostat removed. If it is decided to refill the fresh water system with antifreeze the precaution on page 26 should be followed.

11. Remove end plate from the sea water circulating pump and lubricate the interior of the pump body with Glycerine or MARFAK 2HD grease (see fig. 6), or remove impeller for lay-up period.

12. Remove the atomisers and spray into the cylinder bores $\frac{1}{4}$ pint (0,14 litre) of lubricating oil divided between all cylinders. Rotate the crankshaft one complete revolution and replace atomisers.

13. Remove the air cleaner and any piping. Seal the air intake with water-proofed adhesive tape.

14. Remove the exhaust pipe and seal the manifold port.

15. Remove cylinder head cover, lubricate the rocker assembly and replace cover(s).

16. Remove water pump driving belt.

17. **Batteries**
    (a) Remove the batteries and top up cells with distilled water.
    (b) Recharge.
    (c) Clean the terminals and lightly smear with petroleum jelly.
    (d) Store in a cool, dry, dust free place. Avoid freezing risk.
    (e) Recharge once a month.

18. **Starters and Generators**
    Clean terminals and lightly smear with petroleum jelly. The generator, starter and control board must be protected against rain.

OILS COMMENDED FOR PRESERVATION OF FUEL SYSTEM

	Lowest Temperature to be expected during lay-up
Esso IL815	25°F (— 4°C)
Esso IL1047	0°F (—18°C)
Shell Calibration Fluid "C" (U.K.)	0°F (—18°C)
Shell Calibration Fluid "B" (Overseas)	—70°F (—57°C)
Shell Fusus "A"	—15°F (—26°C)
Shell Fusus "A" R1476 (Old Type)	25°F (— 4°C)

No attempt should be made to restart the engine until the temperature has been at least 15°F (9°C) above that shown in the table, for not less than 24 hours, otherwise there may be difficulty in obtaining a free flow of fuel.

The proprietary brands of oils listed are recommended for the purpose by the oil companies. They may not be available in all parts of the world, but suitable oils may be obtained by reference to the oil companies. The specification should include the following :—

Viscosity : Should not be greater than 22 centistokes at the lowest ambient temperature likely to be experienced on re-starting.

Pour Point : Must be at least 15°F (9°C) lower than the lowest ambient temperature to be experienced on restarting and should be lower than the lowest temperature likely to be met during the lay-up period.

The oils selected are not necessarily suitable for calibrating or testing pumps.

PREPARING THE ENGINE FOR RETURN TO SERVICE

When the engine is to be returned to service, the following procedure must be observed :—

1. Thoroughly clean all external parts and refit sea-water pump impeller (where applicable).

2. Remove adhesive tape from the fuel tank vent or filler cap.

3. Drain fuel tank to remove any remaining oil and condensed water and refill the tank with fuel oil. If tanks have been filled, drain water from trap if this has been provided by the boat builder.

4. Fit new fuel filter element and vent the filter (see page 28).

5. Vent and prime the fuel injection pump (see page 28).

6. Close all coolant drain taps and fill the system with clean coolant. Check for leaks. Remember that if a coolant solution of 25% anti-freeze manufactured to BS3151 has been left in the system, then a life expectation of one year can be expected of the solution.

7. Rotate fresh water pump by hand to ensure freedom of water pump seals.
   If the pump will not rotate with a reasonable amount of persuasion then it will have to be removed to determine the cause.

8. Refit water pump driving belt.

9. Remove the rocker cover, lubricate rocker assembly with engine oil. Replace cover.

10. Remove adhesive tape from the air intake, refit the air cleaner and any intake pipe. Clean the gauze and if it is the oil bath type, fill with engine oil to the correct level.

11. Remove adhesive tape from the exhaust manifold port and refit exhaust pipe.

12. **Starter and Generator**
    Wipe the grease from the terminals and check that all connections are sound. If the starter is fitted with a Bendix type of drive, lubricate with a little light engine oil. CA45 co-axial starters, except where they are fitted with dust covers, should be given the same treatment.

13. Connect the batteries.

14. Check the level and condition of the oil in the sump. Change the oil if necessary.

15. Start the engine in the normal manner checking for oil pressure and electrical rate of charge. Whilst the engine is reaching its normal running temperature, check that it is free from water and oil leaks.

Note :
If the foregoing instructions are observed, the laying-up and returning to service should be carried out efficiently and without adverse effect on the engine. However, Perkins Engines Ltd., cannot accept liability for direct or consequential damage that might arise following periods of lay-up.

frost precautions

Precautions against damage by frost should be taken if the engine is to be left exposed to inclement weather either by adequately draining the cooling system or where this is not convenient, an anti-freeze of reputable make and incorporating a suitable corrosion inhibitor may be used.

Should it be the policy to protect engines from frost damage by adding anti-freeze to the cooling system, it is advisable that the manufacturers of the relevant mixture be contacted to ascertain whether their products are suitable for use in Perkins Engines and also to ensure that their products will have no harmful effect on the cooling system generally.

It is our experience that the best results are obtained from anti-freeze which conforms to British Standard 3151.

When draining the water circulating system, the tap on the cylinder block must be opened. There may be other drain taps on exhaust manifolds, oil coolers etc., all of which must be opened.

When the engine is drained, the fresh water pump is also drained, but moisture may remain around the pump seal or, if the pump leakage drain hole is blocked, a quantity of water may remain in the pump.

Operators are therefore advised to take these precautions when operating in temperatures below freezing point.

1. Before starting the engine turn the fresh water pump by hand : this will indicate if freezing has taken place. If freezing has taken place, this should free any ice formation.

2. If it is impossible to turn the pump by hand, the engine should be filled with warm water.

3. To avoid this trouble, it is advisable when all water has been drained to run the engine for a few seconds at idling speed, thus dispersing any moisture remaining in the pump.

After an anti-freeze solution has been used, the cooling system should be thoroughly flushed in accordance with the manufacturers instructions before refilling with normal coolant.

If the foregoing action is taken, no harmful effects should be experienced but Perkins Engines Ltd., cannot be held responsible for any frost damage or corrosion which may be incurred.

fuel system

The importance of cleanliness in all parts of the fuel system cannot be overstressed. Dirt and sludge are killers to the engine life blood.

FUEL OIL SPECIFICATION

The fuel oil used in Perkins Marine Engines should conform to the following **specifications :—**...

United Kingdom
BS.2869 : 1967 — Class A1 and A2.

United States
A.S.T.M/D.975 — 66T — Nos. 1-D and 2-D.
Federal Specification VV-F-800a : Grades DF-A, DF-1 and DF2 (according to operating ambient temperature).

Germany
DIN-51601 (1967).

France
J.O. 14/9/57 Gas Oil or Fuel Domestique.

Italy
Cuna-Gas Oil NC-630-01 (1957).

India
IS : 1460/1968 — Grade Special and Grade A.

Sweden
SIS. 15 54 32 (1969).

Switzerland
Federal Military Specification 9140-335-1404 (1965).
Fuel oils available in territories other than those listed above which are to an equivalent specification may be used.

BLEEDING THE FUEL SYSTEM

Should the operator be unfortunate enough to run out of fuel, or whenever any part of the system between the fuel tank and fuel injection pump has been disconnected, the fuel system will have to be bled.

Ensure there is sufficient fuel in tank and **that the fuel tank cock, where fitted, is turned on.**

1. Slacken air vent valve on side of control gear housing (see fig. 7). For engines with mechanical governor, see fig. 8.

2. Slacken vent valve fitted on one of the two hydraulic head locking screws (see fig. 9). Unscrew vent plug on top of fuel filter where fitted.

3. Operate priming lever on fuel feed pump (if this is not possible, the camshaft driving the lift pump lever may be on maximum lift; turn engine one revolution) and when fuel, free from air bubbles, issues from each venting point, tighten the screws in the following order :—
   1. Fuel filter cover vent screw.
   2. Head locking screw.
   3. Governor vent screw.

4. Slacken the pipe union nut (see fig. 10) at the pump inlet, operate the priming lever and retighten when fuel, free from air bubbles, issues from around the threads.

5. Slacken unions at atomiser ends of two of the high pressure pipes.

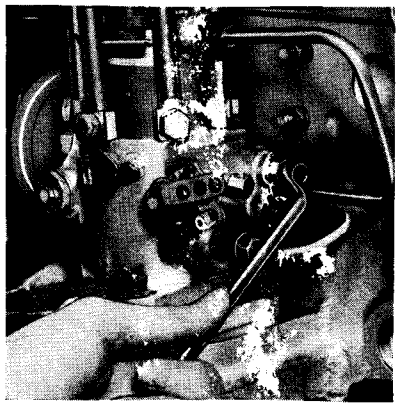


Fig. 7

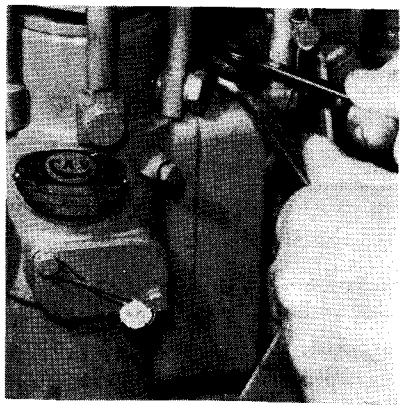


Fig. 8

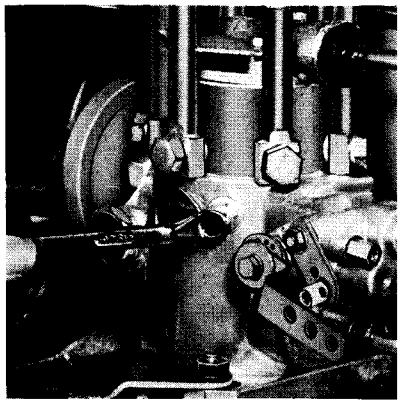


Fig. 9

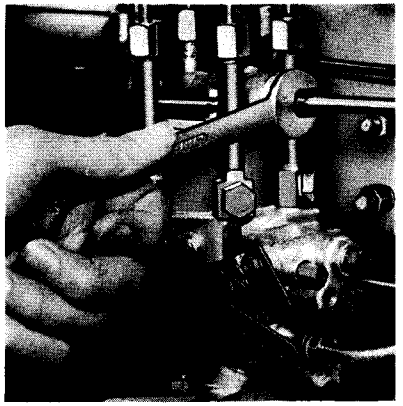


Fig. 10

6. Set accelerator to the fully open position ensuring that the stop control is in the "run" position.

7. Turn engine until fuel, free from air bubbles, issues from both fuel pipes.

8. Tighten the unions on both fuel pipes, and the engine is ready for starting. In the unhappy event of the batteries becoming flattened during the above operation, look to your flare locker (did you check its contents before leaving port?). If in any doubt about battery condition the load on the battery can be eased during cranking by preventing air being drawn into the air intake. Remove air filter and close off intake by pressing a large sheet of stiff cardboard or similar over intake, or remove atomisers.

FUEL FILTERS

Two fuel filters are usually fitted to Perkins Marine Engines, one in the fuel lift pump and the other, a self contained unit with renewable element, mounted on the engine. A fine mesh gauze filter should always be fitted to the fuel tank filler.

To renew filter elements

1. Clean exterior of filter assembly.

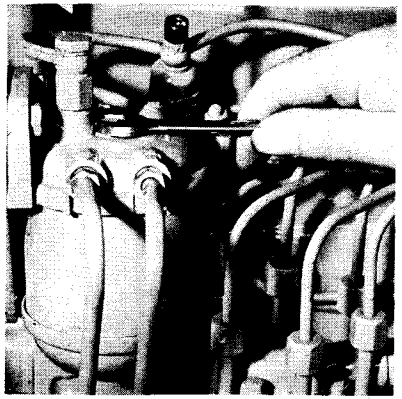


Fig. 11

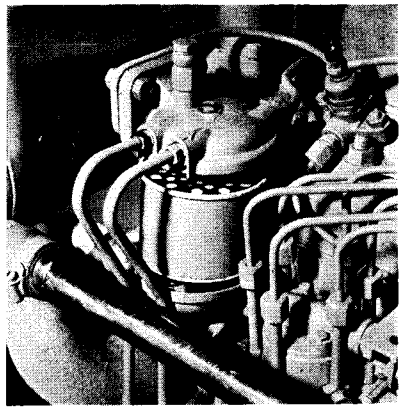


Fig. 12

2. Unscrew setscrew at top of filter bowl. (See fig. 11).
3. Either lower filter bowl clear and discard element or lower base and discard element. (See fig. 12).
4. Clean filter head and bowl or base in suitable cleaning fluid.
5. Check sealing rings and, if damaged, renew.
6. Fit new element to filter bowl or new element to base.
7. Place square against filter head and tighten setscrew.
8. Bleed fuel system as described previously.

Fig. 13

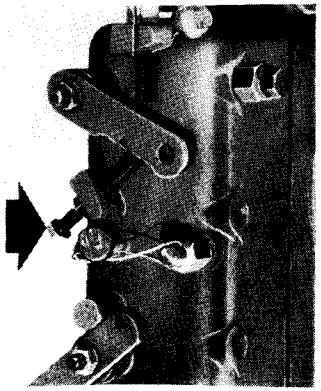


Fig. 14

IDLING SPEED SETTING

With hydraulically governed pumps, the adjusting screw is a spring loaded screw (see Fig. 13). Turn clockwise to increase engine speed or anti-clockwise to decrease.

With mechanically governed pumps, adjustment is by setscrew and locking nut (see Fig. 14).

ATOMISER TESTING AND REPLACEMENT

Often a particular atomiser or atomisers causing trouble may be determined by releasing the pipe union nut on each atomiser in turn, with the engine running at a fast "tick-over". This will prevent fuel being pumped through the nozzle to the engine cylinder, thereby altering the engine revolutions. If after slackening a pipe union nut, the engine revolutions remain constant, this denotes a faulty atomiser.

When fitting a replacement atomiser it should be noted that the joint between the atomiser and cylinder head is made by a special copper washer. Care should be taken to ensure that only this type of copper washer is used. The recess in the cylinder head, the faces of the copper washer and the corresponding face of the nozzle holder cap must be perfectly clean if a leakproof joint is to result. Fit new copper washers each time an atomiser is replaced. The nuts on the flange should be tightened down evenly to prevent the atomiser nozzle being canted and so nipped in the cylinder head. Uneven tightening will almost certainly result in blowby. Over tightening high pressure fuel pipe nuts will result in split olives.

cooling system

The system incorporates a heat exchanger, cooling water in a closed circuit, using raw water as the cooling medium. The raw water discharge can be used for normal water injection into the silencing system. A thermostat fitted into the closed circuit system keeps the engine at optimum temperature of 168-197°F (75-91°C). Two water pumps are used.

Coolant Capacities. Engine only

6.354M, H6.354M, T6.354M, HT6.354M.
34 Imp. pts. (19,28 litres) 41 U.S. pints.

Cooling System Maintenance

Rubber Impeller Type Water Pump

The pump should **never** be run in a dry condition (impeller blades will tear) and if the engine is to be withdrawn from service for any length of time, it will be necessary to pack the water pump with MARFAK 2HD grease. (Where this is not available, glycerine may be used). This is effected by removing the pump end plate, giving access to the interior of the pump, which can then be packed with grease, or glycerine introduced through the top-most pipe connection after removing the rubber hose. Turn engine over to spread the lubricant.

This treatment is usually effective for about three months, and should be repeated prior to recommencement of service if laid up for a longer period than this.

ALWAYS CARRY A SPARE IMPELLER

Water Pump Drive Belt

Check tension of water pump drive belts (see Page 21). When correctly adjusted, sideways movement of belt between water pump and crankshaft pulley should be $\frac{3}{8}$ in (10 mm).

Heat Exchangers, Oil Coolers and Air Charge Coolers

Heat exchanger tube stacks can be removed for servicing by unscrewing the tie rod nut in the end cover and removing both end covers. Both "O" Seals can now be removed and the tube stack withdrawn from the casing.

If the tube stacks are badly choked the best method of cleaning is to place the assembly in a boiling caustic soda solution. This will loosen all foreign matter adhering to the unit. Generally speaking, however, the fresh water side i.e. the outside of the tubes, should be fairly clean as these are on the closed circuit. The inside of these tubes which may have salt water passing through them are more likely to require cleaning. If these are not badly scaled enough to require the caustic soda solution treatment described above, they can be cleaned by pushing a length of $\frac{1}{8}$ in (3,2 mm) diameter steel rod down the tubes to dislodge any foreign matter. It is IMPORTANT when doing this, that the rod is pushed through the tubes in the opposite direction to that in which the water flows also that the rod does not damage tube walls. When replacing tie rods, do not overtighten nut. Torque to 25 lbf ft (3,46 kgf m).

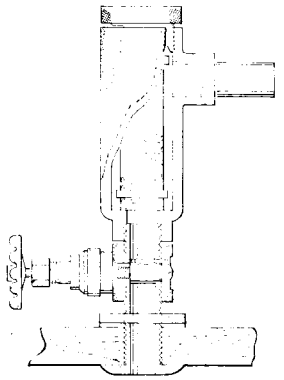


Fig. 15

Air Charge Coolers should be serviced every season in the same way as heat exchangers. However, it is stressed that according to operating conditions, this period may have to be reduced.

Seacocks and Strainers

Ensure that seacocks are open prior to starting the engine and that, after the engine has started, there is a flow of water from the discharge pipe. The operator knows his home water so cleaning of the strainer is left to his discretion, but regular checks should be made of the engine water temperature gauge. Fig. 15 shows a typical seacock position.

lubricating system

The importance of correct and clean lubrication cannot be stressed too highly and references to engine oil should be taken to mean lubricating oil which falls within the specification given in this section. Care should be taken that the oil chosen is that specified for the climatic conditions under which the engine is operated. The sump should be filled to the correct level but DO NOT overfill above the full mark.

Due to the variance in delivery of the lubricating oil pump and scavenge pump, the following procedure is recommended with horizontal 6.354 engines when renewing the lubricating oil.

1. Fill engine sump well to full mark on dipstick.
2. Run engine until oil temperature is at normal operating temperature, idle engine for two minutes and shut down.
3. Top up sump well to full mark on dipstick. This replaces residual oil remaining in the crankcase.

For routine oil level checks, horizontal engines should be idled for two minutes and then shut down before reading the dipstick.

The oil level should not be checked with the engine running at speeds in excess of 1,000 rev/min, or if the engine has been shut down from speeds of over 1,000 rev/min without the two minutes idling period.

As, in most cases, the sump cannot be drained by unscrewing the drain plugs due to the installation, a sump pump can be provided if it is not already fitted, to facilitate removal of sump oil.

Oil Pressure

This should be 30/60 lbf/in² (2,1/4,2 kgf/cm²) at normal working speed and temperature. The pressure will drop whilst the engine is idling also a slight drop will be experienced when the oil is hot, this is quite normal.

Oil Filters

The lubricating oil filters fitted to Perkins marine engines can be either the renewable element type in which the filtering element is housed in a separate bowl or the screw type in which the element is an integral part of the bowl or canister. In the latter type, the canister is secured to the filter head by a threaded adaptor or, in some instances, a threaded standpipe.

Where the filter has two elements, both should be changed at the appropriate time.

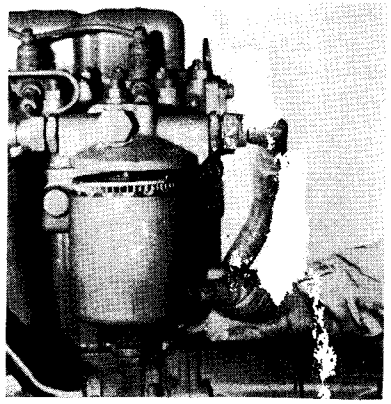


Fig. 16

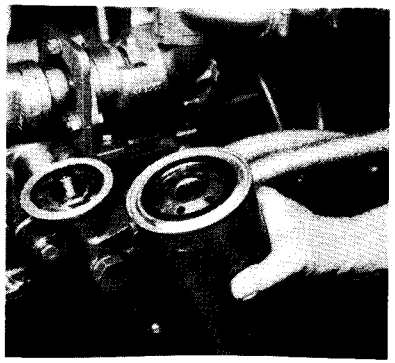


Fig. 17

Renewing Oil Filter Elements

1. Clean exterior of filter bowl.
2. Unscrew filter bowl securing setscrew (this is either on the head casting or at the base of the bowl).
3. Lower filter bowl clear (see fig. 16), remove element and discard.
4. Clean inside bowl before fitting new element.
5. Renew bowl to head casting sealing ring.
6. Offer bowl to head casting squarely and firmly, locate securing setscrew and tighten carefully.
7. After the engine has been run and the filter assembly checked for leaks, restore oil in sump to its correct level.

Renewing Screw Type Oil Filter Canisters

1. Clean exterior of filter.
2. Unscrew canister from filter head, before disposal check that threaded adaptor or standpipe is secure in filter head (see Fig. 17).
3. Using clean engine oil, lightly oil top seal of replacement canister.
4. Screw replacement canister on to filter head until canister seal just touches head and then tighten by hand a further half turn. If canister is overtightened, difficulty may be experienced in its removal.
5. Run engine and check for leaks — do not run engine at high speed until oil pressure has built up. Recheck oil level and top up as necessary.

Oil Coolers

Under normal circumstances, oil coolers will require little attention, providing the sea water inlet strainer is efficient and kept clean.

After a lengthy period of service it may be necessary to clean the tube stack and this may be effected in a similar manner to that given for the heat exchanger. Servicing of the earlier horizontal 6.354 engine oil cooler entails removal of the sump.

LUBRICATING OILS

Lubricating oils for normally aspirated engines should meet the requirements of the U.S. Ordnance Specifications MIL-L-46152 or MIL-L-2104C. Lubricating oils for turbo-charged engines should meet the U.S. Ordnance Specification MIL-L-2104C.

Some of these oils are listed below. Any other oils which meet these specifications are also suitable.

MIL-L-46152 OILS

Company	Brand	SAE Designation		
		0°F (-18°C) to 30°F (-1°C)	30°F (-1°C) to 80°F (27°C)	Over 80°F (27°C)
B.P. Ltd.	Vanellus M	10W	20W	30
	Vanellus M		20W-50	20W-50
Castrol Ltd.	Castrol/Deusol CRB	10W	20	30
	Castrol/Deusol CRB	5W/20		
	Castrol/Deusol CRB	10W/30	10W/30	10W/30
	Castrol/Deusol CRB		20W/50	20W/50
A. Duckham & Co. Ltd.	Fleetol HDX	10	20	30
	Q Motor Oil		20W/50	20W/50
	Fleetol Multi V		20W/50	20W/50
	Fleetol Multilite	10W/30	10W/30	10W/30
	Farmadcol HDX		20	30
Mobil Oil Co. Ltd.	Delvac 1200 Series	1210	1220	1230
	Delvac Special	10W/30	10W/30	10W/30
Shell	Rotella TX	10W	20W/20	30
	Rotella TX		20W/40	20W/40

MIL-L-2104C OILS

Company	Brand	SAE Designation		
		0°F (-18°C) to 30°F (-1°C)	30°F (-1°C) to 80°F (27°C)	Over 80°F (27°C)
B.P. Ltd.	Vanellus C3	10W	20W/20	30
Castrol Ltd.	Castrol/Deusol CRD	10W	20	30
	Agricastrol HDD	10W	20	30
A. Duckham & Co. Ltd.	Fleetol 3	3/10	3/20	3/30
	Farmadcol 3	3/10	3/20	3/30
Esso Petroleum Co. Ltd.	Essolube D-3 HP	10W	20W	30
Mobil Oil Co. Ltd.	Delvac 1300 Series	1310	1320	1330
Shell	Rimula CT	10W	20W/20	30
	Rotella TX	10W	20W/20	30
	Rotella TX		20W/40	20W/40

Where oils to the MIL-L-46152 or MIL-L-2104C specification are not available, then oils to the previous specification MIL-L-2104B for normally aspirated engines and MIL-L-45199B or Series 3 specification for turbocharged engines may continue to be used providing they give satisfactory service.

Lubricating oils for use in Perkins Diesel engines should have a minimum viscosity index of 80.

The above specifications are subject to alteration without notice.

Gearboxes

The gearboxes supplied and fitted to 6.354M, H6.354M, T6.354M and HT6.354M engines are the Borg Warner 72C or the Self Changing Gears MRF 350. Other boxes may be fitted outside the United Kingdom.

BORG-WARNER

Filling

Transmission fluid Type "A" should be added until it reaches the full mark on the dipstick. The unit should be turned over at idling speed for a short time to fill all circuits.

Procedure for checking oil level

The oil level should be checked immediately after shut-down and sufficient oil added to bring the level to the full mark on the dipstick. The dipstick assembly need not be threaded into the case to determine oil level. Later boxes have a plug type dipstick.

Oil Capacities

	Level			Inclined		
Type	U.S. Quarts	Imp. Pints	Litres	U.S. Quarts	Imp. Pints	Litres
72CR	2.1	3.5	2.00	1.7	2.8	1.55
1.523 : 1, 1.91 : 1, 2.100 : 1	2.7	4.5	2.56	2.8	4.6	2.55
2.57 : 1, 2.91 : 1	2.7	4.5	2.56	2.8	4.6	2.55

Oil Temperatures and Pressures

Oil pressure 110 - 150 lbf/in² (7,73 - 10,55 kgf/cm²) at normal operating temperatures of 150 - 165°F (65,55 - 73,8°C). At low temperature or excessive speeds, pressures of 200 - 250 lbf/in² (14,06 - 17,58 kgf/cm²) may be obtained. A maximum transmission oil temperature of 190°F (87,6°C) is recommended.

SELF CHANGING GEARS MRF 350

Filling

Stop the engine. After unit number UM1212 fill gearbox to "full" mark on the dipstick with SAE 90 EP gear oil for tropical and temperate regions, and SAE 80 EP

gear oil for arctic regions. Earlier gearboxes should be filled with any high grade engine oil of SAE 30 specification.

Oil Capacity

Imp. Pints	U.S. Pints	Litres
16	19	9,08

Oil Pressure

Standard Control	110 lbf/in² (7,73 kgf/cm²) approx.
Sequent Control	90 lbf/in² (6,33 kgf/cm²) approx.

PROPELLER SHAFT TRAILING (auxiliary yacht installations)

When oil operated reverse gears are used on auxiliary yacht installations care must be exercised when trailing the propeller with the engine or engines out of use.

On the Self Changing Gears gearboxes, it is necessary to run the engine after trailing the propeller for 12 hours to lubricate the gearbox.

With the Borg Warner gearbox it is permissible to trail for 8 hours providing the following shaft speeds are not exceeded :—

Direct Drive	1,500 rev/min
1.5	1,000 rev/min
1.9	790 rev/min
2.0	750 rev/min
2.1	715 rev/min
2.5	600 rev/min
2.9	520 rev/min
3.0	500 rev/min

Transmissions incorporating reduction gear must have means of stopping the transmission output shaft from prolonged or continuous freewheeling. This is because the engine, being stopped, does not drive the oil pump in the gearbox. The box therefore is not being properly lubricated.

Propeller shaft brakes are available and the boat builder or stern gear specialist should be contacted for further details.

Checking Tappet Clearances fig. 18

Note : When turning engines they should always be turned in their normal direction of rotation, i.e. anti-clockwise when viewing from the gearbox end. The exception is contra-rotating engines which is clockwise from the gearbox end.

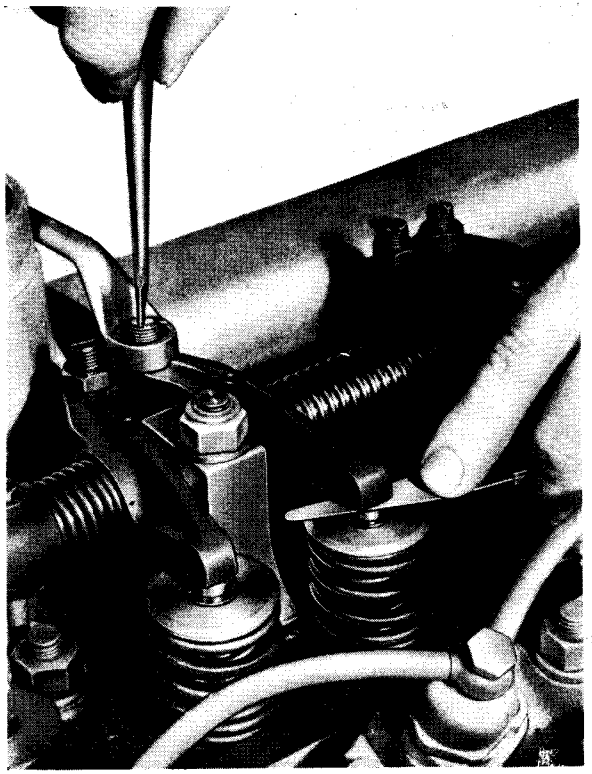


Fig. 18

This is set between the top of the valve stem and rocker arm and should be 0.012 in (0,30 mm) cold.

When setting valve clearances the following procedure should be adopted :—

1. With the valves rocking on No. 6 cylinder (i.e. the period between the opening of the inlet valve and the closing of the exhaust valve), set the valve clearances on No. 1 cylinder.
2. With the valves rocking on No. 2 cylinder, set the valve clearances on No. 5 cylinder.
3. With the valves rocking on No. 4 cylinder, set the valve clearances on No. 3 cylinder.
4. With the valves rocking on No. 1 cylinder, set the valve clearances on No. 6 cylinder.
5. With the valves rocking on No. 5 cylinder, set the valve clearances on No. 2 cylinder.
6. With the valve rocking on No. 3 cylinder, set the valve clearances on No. 4 cylinder.

electrics

Dynamo

The output of the dynamo is controlled by the regulator unit and is dependent on the state of charge of the battery and the loading of the electrical equipment in use. When the battery is in a low state of charge, the dynamo gives a high output, whereas if the battery is fully charged, the dynamo gives only sufficient output to keep the battery in good condition without any possibility of over-charging. An increase in output is given to balance the current taken by lamps and accessories when in use. The type can be found stamped on the dynamo body e.g. C40A.

Alternator

The alterator has two parts, a stator and a rotor. When the rotor rotates inside the stator windings, alternating current (AC) is produced. This is unsuitable for charging the battery so a rectification unit comprising of diodes is built into the alternator. These are connected in such a manner that the alternator output is direct current (DC) when it is delivered to the battery. The alternator output is controlled by a fully transistorised regulator which requires no servicing and is non-repairable. The alternator type can be found stamped on the alternator body or identification plate e.g. AC5.

Starter Motors

The starter motor is of a similar construction to the dynamo with the solenoid and main switch assemblies contained inside the drive end-shield. No maintenance is required between periodic overhaul (see page 21). The machine type is stamped on the body or identification plate e.g. CA45.

Electronics Screening (radar etc.)

Many pieces of equipment on board generate interference signals and these are picked up by the radio receiver indiscriminately. It is therefore desirable to screen these signals if possible. Radio interference suppression is a very wide and variable subject and it is suggested that a specialist is contacted to advise on this sometimes difficult problem.

Electrolytic Corrosion

This can occur when two dissimilar metals are brought together in the presence of sea water. Care is taken to avoid this in the design of the engine although different metals are necessary, but a brass or bronze pipe fitting attached to aluminium parts for example will result in rapid corrosion.

Particular care is necessary when installing an engine in an aluminium hull. Zinc anodes can be fitted to hulls where corrosion cannot be entirely avoided, and specialist firms will advise on the use of these.

Corrosion can also be caused by current leaking from the battery and other parts of the electrical system to the hull via the engine or metal fittings.

Battery Maintenance

WARNING. Batteries under charge give off an **explosive** gas. Ensure therefore that the batteries are properly and securely sited with plenty of ventilation and have access for maintenance. Isolate battery when not in use (isolation switch) and maintain correct electrolyte level i.e. just above top of separators.

Keep battery clean and dry to avoid possible corrosion and current leakage.

Ensure connections are clean and tight and that cable size is adequate for the installation, to avoid overheating.

Any component that may cause arcing must not be fitted in the battery space.

GENERAL PRECAUTIONS

When alternators are used in the charging circuit the following precautions must be taken :—

NEVER disconnect the battery or switch 'off' at the starter switch whilst the alternator is running. This will cause a voltage surge in the system damaging diodes and transistors.

NEVER disconnect any electrical lead without first stopping the alternator and turning all switches to the 'OFF' position. ALWAYS identify a lead to its correct terminal before disconnection. A short circuit or reversed polarity will destroy diodes and transistors.

NEVER connect a battery into the system without checking for correct polarity and correct voltage.

NEVER 'Flash' connections to check for current flow. No matter how brief the 'flash', the transistors may be destroyed.

NEVER experiment to try and adjust or repair the system unless you have had training on alternators and you have the correct test equipment and technical data.

NEVER earth the field circuit.

NEVER run the alternator on an open circuit.

NEVER attempt to polarize an alternator. When using a battery charger disconnect battery cables.

NEVER apply a battery voltage direct to the regulator or alternator field terminals as this will damage the transistors.

Disconnect the alternator terminals before carrying out any electrical welding on the boat as the intense magnetic field created by the 'make' and 'break' of the arc may cause damage to the diodes.

Do not check for continuity of the alternator or regulator with an insulation tester, such as a 'Wee Megger' etc.

Always disconnect the battery before connecting test instruments (except voltmeter) or before replacing any unit or wiring.

emergency measures

If the engine stops the first thing to do is check that the fuel supply is ON. If the fuel valves or taps are open then check level in fuel tank. If the engine has been run until the fuel tank is completely empty there is a very good chance that there is a lot of dirt in the fuel lines. Change the fuel filter and having refuelled, bleed the system and re-start the engine.

If the engine slows down or loses power there could be something wrapped round the propeller. Always check this first. Check air intake for obstruction and engine compartment for good supply of air. The air intake mesh on turbocharged engines may be clogged with foreign matter sucked from a dirty engine compartment or hose and clips may be loose, causing low boost and high exhaust temperatures.

If the engine coolant boils ease down the throttle and try to ascertain the cause. The first check here is at the sea cock to ensure adequate cooling water supply, if satisfactory, check raw water pump operation, perhaps the impeller has failed ; if so, replace with the spare impeller which should **always** be carried as an on board spare.

Should one engine be shut down on a twin engined installation ensure that the propeller shaft of the shut down engine is braked so that the speeds given for the type of gearbox are not exceeded (see page 38).

If a serious leak occurs on a high pressure fuel pipe, disconnect and direct flow into a can or other receptacle and run on remaining cylinders. On NO account attempt to flatten the pipe as this will ruin the fuel injection pump. Leaks in low pressure fuel pipes can be temporarily repaired by the use of adhesive tape, hose and clips.

Auxiliary yacht installations may require the engine to be run while beating to windward. Under these conditions the boat may heel up to 30° for vertical engines without adverse effect on the lubrication system providing the boat is righted occasionally, in order to lubricate the valve gear. With horizontal engines, the maximum heel is 23° starboard side down and 36° port side down when looking forward from the rear of the engine.

Coolant leaks can normally be dealt with by adhesive tape, hose and clips.

If a serious oil leaks occurs shut down the engine immediately and try to find the cause. Oil leaks are a lot harder to cure temporarily, because of the pressure involved. However if the main flow can be stemmed to a drip or dribble place a can underneath the leak and replenish the engine with new oil (from the spare oil can) at the same rate as the loss.

Drip trays of metal or glass fibre should be used beneath the engine to stop lubricating oil or fuel oil dripping into the bilges. Care must be taken to avoid galvanic action with the drip tray e.g. a copper tray should not be used under an aluminium alloy sump. Remember to keep the drip tray clean as this gives an early indication of leakages.

fault finding chart

Fault	Possible Cause
Low cranking speed	1, 2, 3, 4.
Will not start	5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 31, 32, 33.
Difficult starting	5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 24, 29, 31, 32, 33.
Lack of power	8, 9, 10, 11, 12, 13, 14, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 31, 32, 33.
Misfiring	8, 9, 10, 12, 13, 14, 16, 18, 19, 20, 25, 26, 28, 29, 30, 32.
Excessive fuel consumption	11, 13, 14, 16, 18, 19, 20, 22, 23, 24, 25, 27, 28, 29, 31, 32, 33.
Black exhaust	11, 13, 14, 16, 18, 19, 20, 22, 24, 25, 27, 28, 29, 31, 32, 33.
Blue/white exhaust	4, 16, 18, 19, 20, 25, 27, 31, 33, 34, 35, 45, 56.
Low oil pressure	4, 36, 37, 38, 39, 40, 42, 43, 44, 58.
Knocking	9, 14, 16, 18, 19, 22, 26, 28, 29, 31, 33, 35, 36, 45, 46, 59.
Erratic running	7, 8, 9, 10, 11 12, 13, 14, 16, 20, 21, 23, 26, 28, 29, 30, 33, 35, 45, 59.
Vibration	13, 14, 20, 23, 25, 26, 29, 30, 33, 45, 48, 49.
High oil pressure	4, 38, 41.
Overheating	11, 13, 14, 16, 18, 19, 24, 25, 45, 47, 50, 51, 52, 53, 54, 57.
Excessive crankcase pressure	25, 31, 33, 34, 45, 55.
Poor compression	11, 19, 25, 28, 29, 31, 32, 33, 34, 46, 59.
Starts and stops	10, 11, 12.

KEY TO FAULT FINDING CHART

1. Battery capacity low.
2. Bad electrical connections.
3. Faulty starter motor.
4. Incorrect grade of lubricating oil.
5. Low cranking speed.
6. Fuel tank empty.
7. Faulty stop control operation.
8. Blocked fuel feed pipe.
9. Faulty fuel lift pump.
10. Choked fuel filter.
11. Restriction in air cleaner.
12. Air in fuel system.
13. Faulty fuel injection pump.
14. Faulty atomisers or incorrect type.
15. Incorrect use of cold start equipment.
16. Faulty cold starting equipment.
17. Broken fuel injection pump drive.
18. Incorrect fuel pump timing.
19. Incorrect valve timing.
20. Poor compression.
21. Blocked fuel tank vent.
22. Incorrect type or grade of fuel.
23. Sticking throttle or restricted movement.
24. Exhaust pipe restriction.
25. Cylinder head gasket leaking.
26. Overheating.
27. Cold running.
28. Incorrect tappet adjustment.
29. Sticking valves.
30. Incorrect high pressure pipes.
31. Worn cylinder bores.
32. Pitted valves and seats.
33. Broken, worn or sticking piston ring(s).
34. Worn valve stems and guides.
35. Overfull air cleaner or use of incorrect grade of oil.
36. Worn or damaged bearings.
37. Insufficient oil in sump.
38. Inaccurate gauge.
39. Oil pump worn.
40. Pressure relief valve sticking open.
41. Pressure relief valve sticking closed.
42. Broken relief valve spring.
43. Faulty suction pipe.
44. Choked oil filter.
45. Piston seizure/pick up.
46. Incorrect piston height.
47. Open circuit strainer or weed trap blocked.
48. Faulty engine mounting (housing).
49. Incorrectly aligned flywheel housing or flywheel.
50. Faulty thermostat.
51. Restriction in water jacket
52. Loose water pump drive belts.
53. Gearbox or engine oil cooler choked.
54. Faulty water pump.
55. Choked breather pipe.
56. Damaged valve stem oil deflectors (if fitted).
57. Coolant level too low.
58. Blocked sump strainer.
59. Broken valve spring.

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