

A Step by Step Guide to Overhauling Generators On Ships

The Complete Generator D'carb Procedure

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Introduction

The main power source on most ships is its electrical power generator engine, popularly known as the “Heart of the Ship.” Without these power generators, it's impossible to operate any engine room, deck, or bridge machinery.



Generator- Prime mover & Alternator

A wide range of marine generators are used on board ships, depending

on the vessel type, power requirement, and of course the owner's budget preferences.

Marine engineers working on ships are required to understand the construction and working of these power units in order to carry out maintenance and repair works.

Though the type and look of generators vary from ship to ship, the procedures for their overhauling and maintenance almost remain the same.

What is D'carb or Major Overhauling of Generators?

D'carb is a technical term used in the marine industry for cleaning and maintenance of engines. The process

includes removal of carbon particles, which are deposited on the internal parts such as piston, liner, cylinder head assembly etc. as a result of long hours of continuous operation.

D'carb is also carried out when the generator parts have completed their running hours, accident or break down has occurred, or while preparing for Continuous Survey Machinery (CSM). The process involves renewal of running parts such as bearings, rings etc.

This guide helps both aspiring and experienced marine engineers working on ships in learning the correct and sequential procedure for carrying out major overhauling of generators or auxiliary engines.

The guide has been categorized into different sub-processes, each explaining an important part of the D'carb procedure.

To better understand this e-book, let's learn some important terms which will be frequently used throughout the guide.

D'carb or de-carbonization is a non-technical term used when the combustion chamber of the generator which includes – piston, liner, rings, cylinder head, valves etc. are cleaned to remove the carbon deposits accumulated as a result of long running hours.

In technical language, the term is known as “**Major Overhauling**” of generators as it includes opening and maintenance of all important parts, along with cleaning and inspecting bearing and turbocharger (depending upon the running hours).

Technically, **Auxiliary engine**, also known as the **Generator**, is a combination of a **Prime mover** and an **Alternator**.

When doing major overhauling of an Aux. Engine, both alternator and prime mover maintenances are carried out as per running hours and condition of the equipment.

Prime mover is a mechanical part of the auxiliary engine which rotates the crankshaft by means of energy generated from fuel combustion. (I.C engine principle)

The crankshaft is connected via a coupling flange to the **alternator**, which consists of magnets and



Alternator connected to bus bars

windings for generating electricity.

The electricity generated is then carried through the bus bars to the main switch board which distributes it to all the essential systems of the ship.

CSM: The Continuous Machinery Survey (CMS) system is important to find out the condition of the machinery/equipment by opening up a part of the machinery following reasonable procedures in a continuous and systematic manner.

Under CSM all auxiliary engines driving the generators and other essential machinery together with their coolers and attached pumps are to be opened up and examined as considered necessary by the surveyor.

Alarms and safety devices fitted on these units are to be included in this survey.

Pre-Planning

Before opening a generator for a major overhaul, pre-planning of the same is a must.

Preparation has to be done by the management and operational level engineers. The management level engineers will decide in consent with the office ashore, whether to proceed with the process or not.

Following are the important points to be taken care of before doing a major overhauling of a four-stroke engine:

1. Power Availability: Ensure that enough power is available on board ship to carry out the normal sailing operation when one generator goes out of service.



Standby Generators

The d'carb of the generator should be planned with such time interval so that during d'carb operation, if any one of the running generators breakdowns, any other generator or means must be available to safely propel the ship.

2. Special Tools: Ensure all special tools are available and are in proper operating condition.

3. Measuring Tools: Ensure required measuring and gauging

tools are available.

Calculate the general condition of all measuring tools and zero error for micrometers, calipers and dial gauges.



Measuring Tools- Deflection gauge

4. Spare Parts: Ensure all spare parts are present onboard for renewal if necessary. If important spares are not onboard, requisition should be raised for the same.

5. Power Pack: Some ships are equipped with power packs kept on deck (container ship with reefer capacity may be provided with power pack). Ensure all the power packs are working fine, if used.

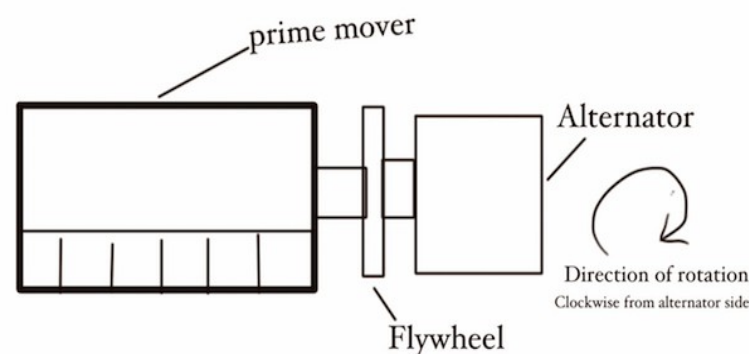
6. Team Preparedness: The team involve in the overhauling operation must know the correct and safe procedure as per the manual.

Remember

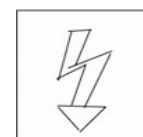
Every measuring unit has a different meaning, and if mixed-up or mis-read with any other unit, it can lead to loosening or breakage of parts causing fatal accidents

8. Signs & Symbols: Know the sign plates over generators which indicate safety of machine and operator. Know them correctly.

“Understand what your generator is trying to tell you, know the generator's nomenclature”



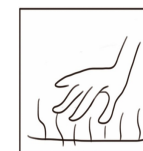
Caution / Warning / Danger



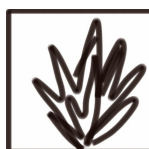
Caution of Electric Shock



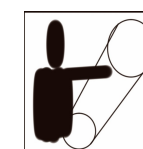
Caution of Fire



Caution of High Temperature



Caution of Explosion



Caution of Moving/ Rotating Parts

Real Life Incidences

1. “On a container carrier ship before the scheduled generator d'carb, engineer officers didn't take the inventory of spares available onboard. While the d'carb was on the way, they wanted to renew the big end bolt, which was found to have an elongation in one of the pairs after an inspection. However, as it was later found that they didn't have the spares onboard, the completion of d'carb got delayed and they had to wait for the next port of call to receive the required spares. This delay costed more to the company as they were unable to load refrigerated container units because of lack of power availability onboard the ship.”
 2. “ Before the d'carb, special tools to remove the main bearing in the underslung type crankshaft was never checked for operations. While removing the main bearing, the in-charge found out that the Securing nut for keep holding tool was missing. Hence they were not been able to remove the bearing keep without this tool and had to manufacture it in the ship's workshop which delayed the complete overhauling process.”
 3. “ It has been observed on many ships that important gauges, calipers and special measuring tools are not kept or maintained properly. Moreover, when they are required the most for taking measurements, many are found missing, which delays the process because of the inability to provide correct measuring data to the company.”
- *A delay in any type of maintenance procedure of ship's generators is a critical situation and can cause huge losses to the company.

Preparation

For carrying out a zero-error, cent percent safe d'carb procedure, it is very important to take out sufficient time for planning and preparation, taking important safety aspects in to consideration and following the correct procedure for the same.

Preparing a generator for overhaul not only includes selecting the right tools and gauges but also involves choosing the correct sequence of operations and isolation.

For a safe and smooth d'carb, following preparation needs to be done without fail-

- Isolation
- Tagging out

- Checks on special tools
- Knowing the operating procedure of tools
- Knowing the correct hydraulic and torque tightening values
- Knowing correct part assembly
- Safety preparation

Isolation

Before opening any machinery it is essential to isolate it first. Failure to do so may lead to oil spills, injury, or accidents.

For isolating an auxiliary engine, two separate parts of the machinery- the Alternator and the Prime mover needs to be isolated.

Follow the below mentioned steps:

- Isolate the power supply from the alternator to the bus bar by opening the Air Circuit Breaker



Open Air Circuit Breaker in MSB

- Isolate the power supply for Lube oil priming pump
- Isolate Lube oil supply to the prime mover
- Isolate cooling water supply to prime mover (also for Jacket and

Lube oil Cooling)

- Isolate fuel oil supply
- Isolate starting air supply to the prime mover
- Ensure to list all the valves and supply which are closed as a checklist to reopen once the maintenance is finished

While operating/closing any of the valves to the generators, especially cooling water and fuel oil valves, operate them slowly and in correct sequence so as not to fluctuate the pressure of other running generators.

Procedure for Operating Cooling Water Valves-

1. Close the line valves on the top of prime mover coming from the expansion tank.

2. Close the inlet valve slowly so as not to disturb the pressure of other running generators.

3. Close the Outlet valve.

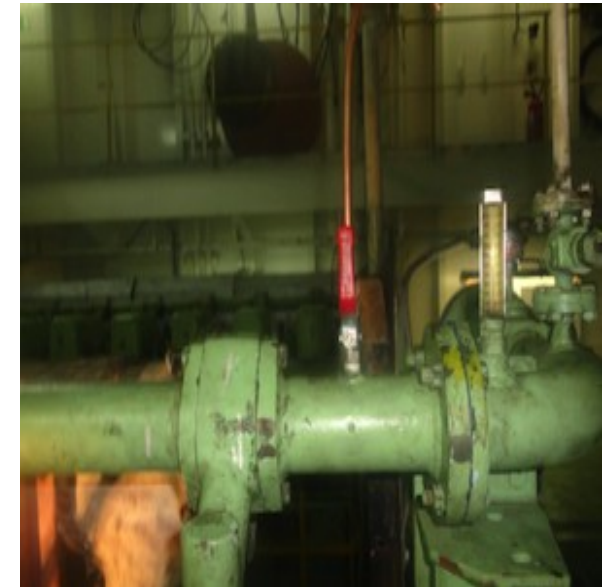
Procedure for operating Fuel Valves-

1. Close the fuel inlet valve to the engine
2. Close the fuel outlet valve after the pressure gauge shows minimum value
3. Check the fuel pressure of line and other generators

Remember

When fuel flow of one generator is isolated, remember to reduce the pressure of fuel line. One method is opening the pressure control valve near supply pump of the system

Once the alternator and prime-mover is completely isolated, start draining the jacket water by opening the drain valve and vent cock on J.C.W outlet line.



Vent cock on JCW outlet line

While doing so, keep an eye on the expansion tank level as sudden decrease in the tank level indicates leaky water valves (outlet or expansion cock valves).

Tagging Out

Tagging out is a process which is carried out as an add-on safety while the overhauling work is in the process.

If tagging out is not followed, any person may accidentally switch on the breaker of any power equipment associated with the generator under maintenance or operate any valve of the system, which can lead to a serious accident.



Remember

Always “Tag Out” all the switches, breakers, valves and every other system associated with the generator –
For e.g. MEN AT WORK- DO NOT OPERATE/ DO NOT SWITCH ON

Checks on Special Tools

For every big machinery the maker always supplies various set of special tools to open/close its parts.

These special tools may include :

- Special spanners
- Tools for opening injectors or starting air valves

- Tools for opening cylinder head
- Tools for overhauling cylinder head (Removing inlet / exhaust valves or seats)
- Tools for inserting piston
- Liner holding and removing tool
- Tools for opening main/ crank pin bearing
- Hydraulic jacks, hydraulic pipes, connections and pump
- Torque wrench
- Correct size I-bolt, D-shackle and rated chain block with rated capacity
- Special tools for opening and lifting turbocharger

- Stand for T/C rotor and pistons

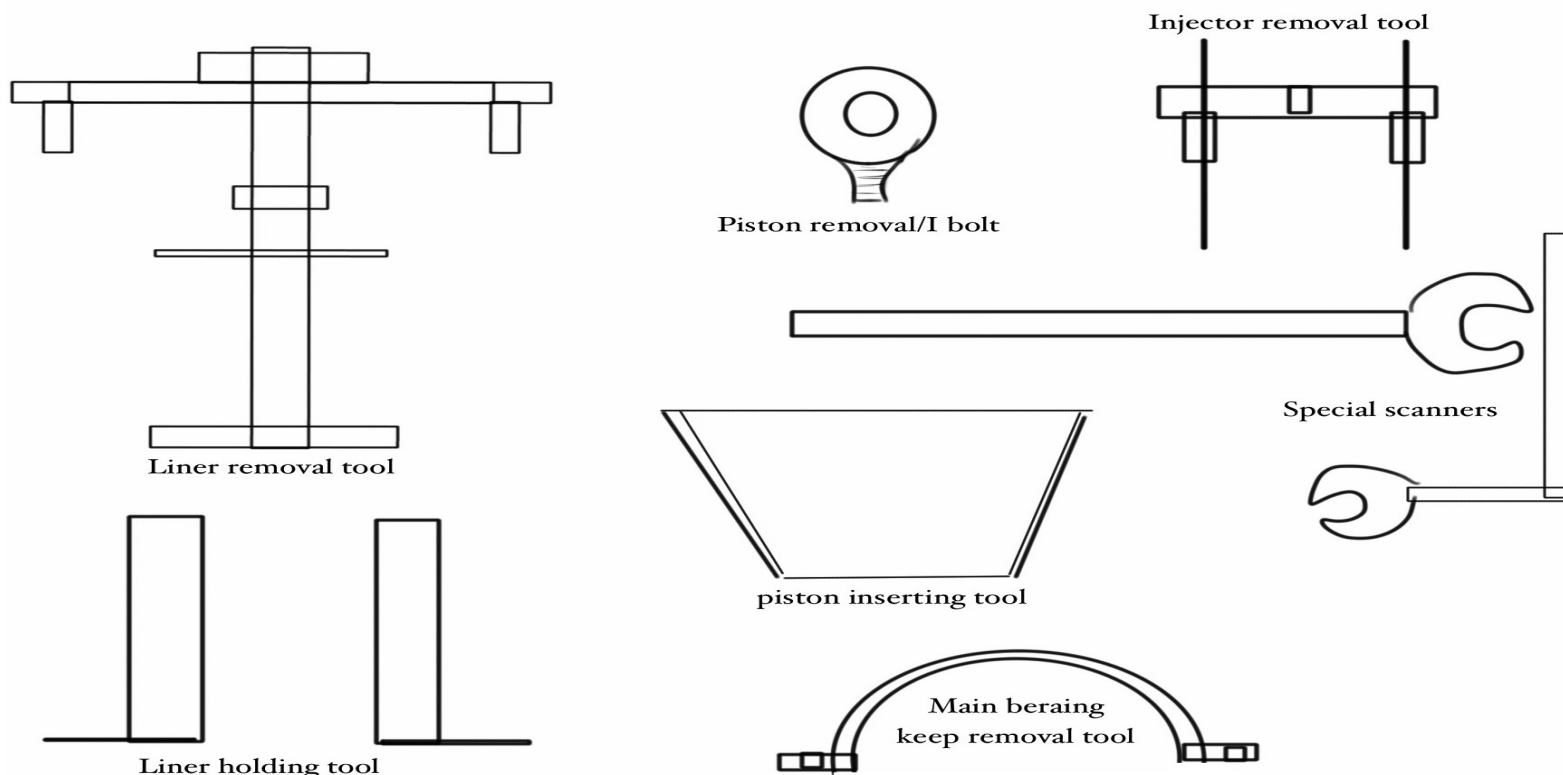
depending upon the make of the generator.

This is not an exhaustive list, but a brief description of such special tools that must be checked before starting the maintenance operation. Many other special tools may be added

All such special tools must be checked for freeness and correct operation. Hydraulic jacks and pumps must be pre-operated to check any kind of leakage from them.

Remember

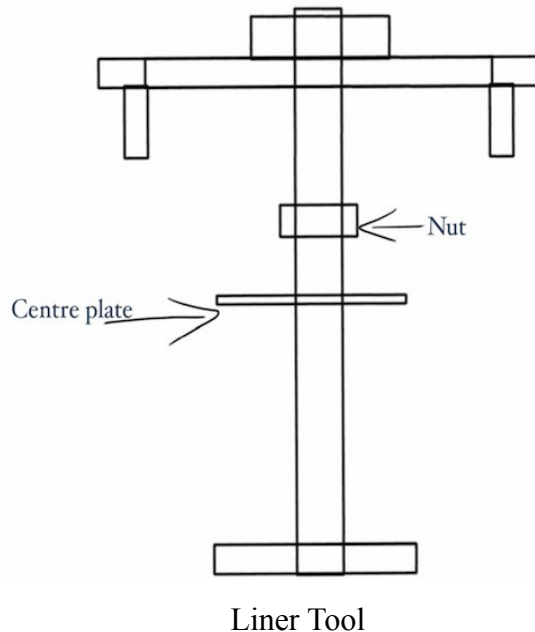
Before using any special measuring tool, lifting devices, hydraulic tools etc. ensure they are pre-calibrated and checked by a credited authority onshore



Operating Procedures of Tools

While handling any machinery, one must know the proper operating procedure. The same rule applies to the special tools used to dismantle or retighten the generators on ships.

Different parts of the generator such as cylinder head, liner piston etc.



require usage of separate tools in the correct order.

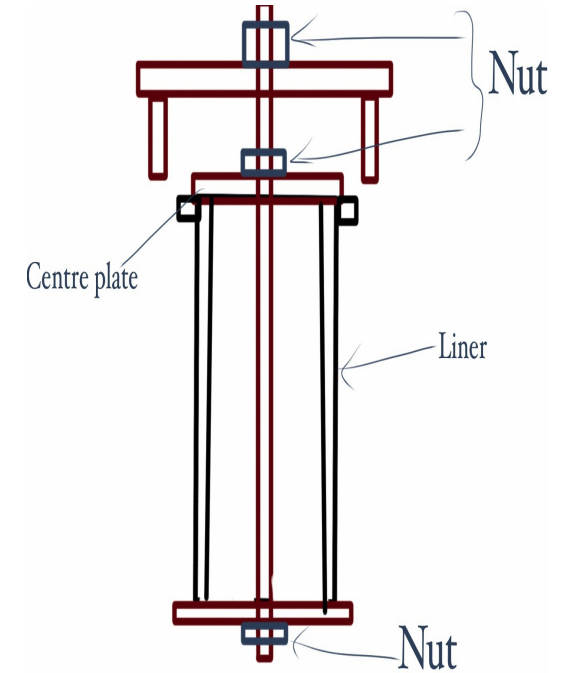
By knowing the handling procedure of tools, one can easily assemble/disassemble various parts of the auxiliary engine with utmost ease.

Mentioned below are examples on how wrong usage of generator tools can lead to problematic situations while doing major overhauling of the machine.

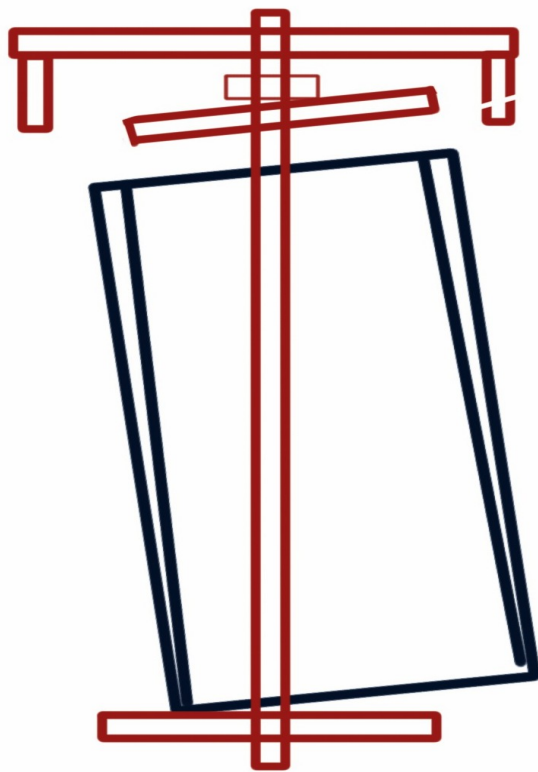
Example 1: Liner Drawing Tool:

Liner drawing tool seems very simple to use, but wrong usage of the same has lead to liner stuck or drawing/inserting of liner difficult at times.

When using such tools one should know the use of the centre plate provided with the nut.



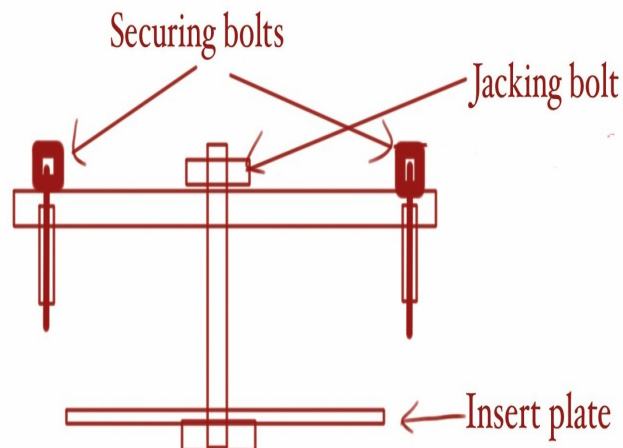
Never keep the centre plate or bar loose as it keeps the entire tool in the centre position of the liner, which means when drawing out or inserting the liner from the jacket of the generator, chances of the liner getting tilted and stuck reduces.



Wrongly adjusted centre plate.
Liner not in centre.

Example 2. Protecting ring tool: The protecting ring located in the top portion of the liner is removed by a special tool. After cleaning of the contact surface for

carbon deposits, the removal tool is inserted.

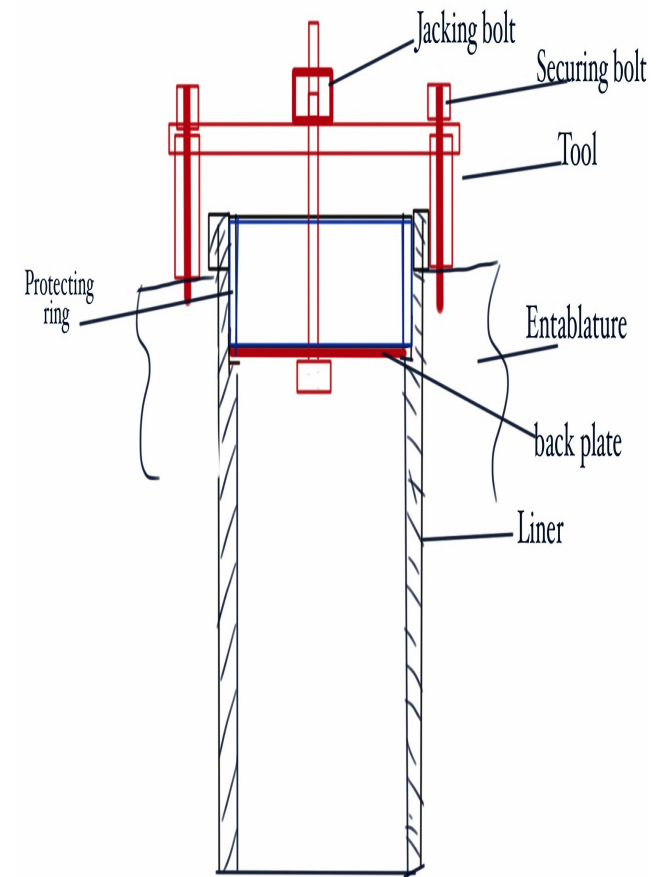


The removal tool is rested on the frame and the insert/ backup plate is inserted either at the bottom of the protecting ring or in the groove provided in the ring, depending on the generator's design.

It is important to secure the tool with the generator's frame through securing bolts, else the tool may slip

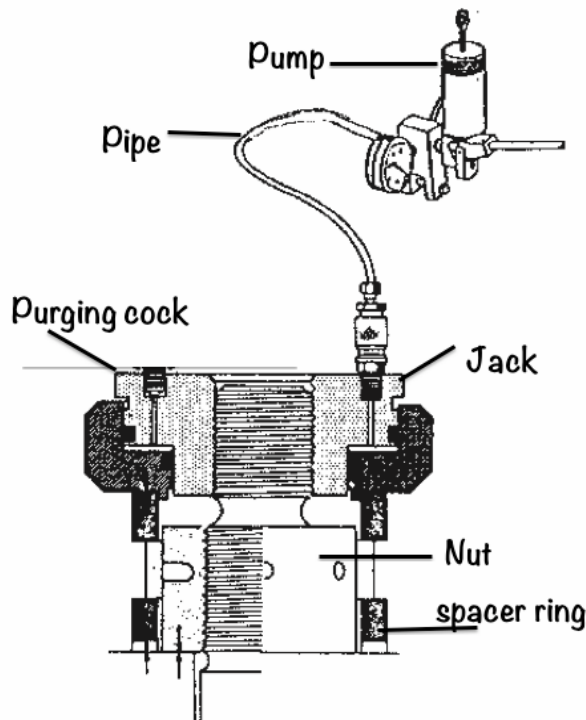
out leading to an accident.

If the protecting ring is badly stuck and the removal tool is excessively tightened, the ring may break, making it more difficult to remove from the liner with the help of the removal tool.



Operation of Hydraulic

Jack: It is very important to know the correct operating procedure of the hydraulic jack system, which includes hydraulic jack unit, spacer ring, hydraulic pump, and pipings.



For opening nuts with a hydraulic jack, ensure that the nut surface is

clean so as to avoid the jack and nut from getting stuck when the pressure is applied.

The hydraulic pump must be filled with clean hydraulic oil till the marked level and the hoses should be checked for leaks.

Before applying pressure through pumps, ensure jacks are purged by opening the purging screw on top.

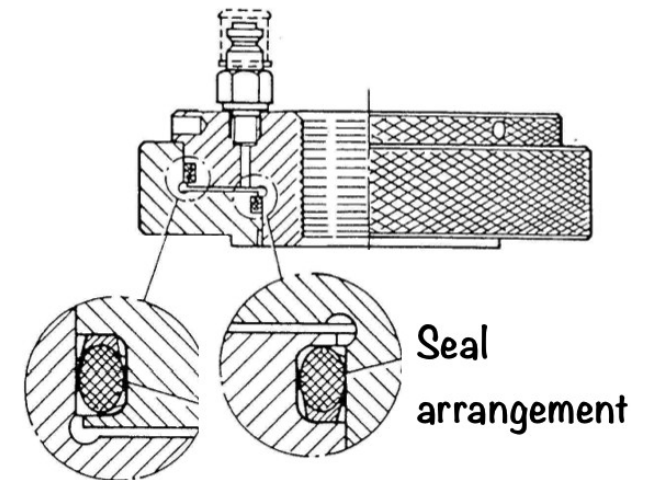
Tighten the jack body over cylinder head studs and purge till there is no gap between the sliding surface of the jack.

Tighten the purging screw and rotate the jack anti-clock wise (Open) by $\frac{3}{4}$ th of a turn.

This is done to avoid the nut from sticking inside the jack when the stud is stretched by hydraulic pressure and the nut is rotated in open direction.

If there is any leakage of oil, pressure must be reduced immediately but slowly without operating it further.

Rectify the leakage and renew seals within the jack if required.



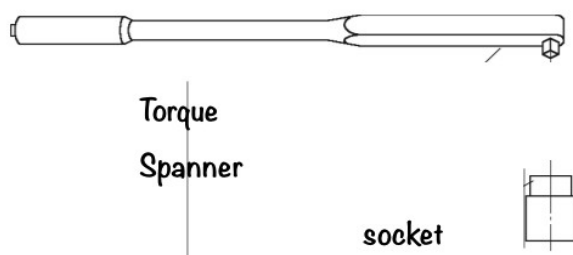
Remember

Never reduce the jack pressure suddenly as it may result in stalling of jack piston in its liner leading to stuck up of the complete jack

Operation of Torque

Wrench: A torque wrench is a type of spanner which when adjusted to a specified torque unit, will give a click sound indicating that the required tightness has been achieved.

Always check the unit specified in the manual for tightening and if it does not matches with the scale unit on torque spanner, convert the value and then set the required torque.



Remember

Always stand carefully while pulling the spanner as the same can bounce back and hit you causing injury

Values and Units

An auxiliary engine is a high speed rotating machine carrying several heavy weight parts connected to each other with stud bolts and nuts, which are torque or hydraulically tightened. These parts are installed and assembled by tightening them with each other or with the body of the generator.

If any of the parts become loose or is not tightened at the rated value, it can lead to devastating results such as breaking, explosion etc. Several such incidences in the past have resulted in casualty and loss of property.

The person in-charge/team must know all the values for different parts and similarly the measuring unit for the values. The unit may differ from maker to maker. For e.g. tightening

torque value may be in kgf-m or in N-m. Similarly hydraulic pressure units may be in kg/cm² or Mpa.

Section	Description		Thread	Tightening	
				Torque Nm	Pressure bar
505	Cylinder cover stud(in frame) Nur for cylinder cover stud Cooling jacket cylinder cover	Stud Nut Screw	M48 M45	200 22	750
506	Connecting rod (see section 506)				
507	Camshaft assembly Intermediate wheel shaft Intermediate wheel gear Gear wheel on camshaft	Nut Nut Nut Screw	M12 M 20 x 1.5 M 12 M 12	50 250 40 50	
508	Housing for valve gear Valve gear bracket rocker arm	Screw Nut	M 12 M 16	60 150	
510	Main bearing stud (in frame) Nut for main bearing stud Main bearing side screw Countweight on crankshaft	Stud Nut Screw Screw	M 48 M 45x3 M 24 M 30X2	200 300 200 + 60° turn	750
	Vibrationdamper on crankshaft Frame / baseframe Flywheel mounting (fitted bolt) Gear rim on flywheel Gear wheel on crankshaft	Nut Nut Nut Screw Nut	M 27 M 24 M 20 x 1.5 M 10	400 500 200 34 40	
514	Fuel pump distribution piece Fuel pump top flange (barrel) Fuel pump cavitation plugs Fuel priming mounting (bottom flange)	Screw Screw Plug Screw	M 8 M 10 M 20 x 1.5 M 16	25 - 30 55 - 65 100 - 120 150	
	Fuel valve (nozzle nut) Fuel valve mounting Fuel valve (cap nut) Fuel valve adjusting (lock nut) High pressure pipe	Nut Nut Nut Nut Nut	M 26 x 1.5 M 16 M 16 M 18 X 1.5	100 - 120 40 70 100 40	
515	Gear wheel on lub. oil pump	Nut		300	
519	Conical elements mounting Upper mounting Lower mounting	Screw Nut	M20 M 20	150 320	

Tightening values for MAN Generator with units

Remember

Keep handy a separate list of tightening values and tightening procedures at all times while doing the d'carb

Part Assembly and Arrangement

A correct part assembly procedure is the key to safe and timely finishing of the generator d'carb.

Person in charge of the d'carb must go through the manual and manage the team under him/her to fit the correct parts at the right place.

If at any point of time there is a doubt, just go through the manual and do not hesitate to ask advice from senior and experienced officers.

Each unit's parts must be kept in a separate wooden or cardboard plank with unit number written on the plank and all major parts with a permanent marker to avoid inter-mixing of parts.

It is advisable to keep an empty



Each Unit's Parts Kept separately

container for each unit so that all small nuts, bolts and connections can be placed in the container.

This will ensure all small connections and parts of every unit are kept properly and they will not go missing while performing overhauling of the machinery.

While removing the bearing covers and con-rod bolts/ tie bolts, they should be marked and kept separately in a box to prevent

damage to the threads.



Big end Bearing bottom half kept separately

If required, a piece of cloth can be tied up to cover the threaded portion of the stud or bottom half of the big end bearing after applying good amount of grease in threads.

Remember

7 out of 10 times, one or more parts goes missing due to lack of preparation in part arrangement causing delay in procedures

Real Life Incidences

1. “ While isolating and tagging out the generator, the lube oil priming pump switch was kept on without using a pycard. As the pump was fed from the emergency switch board, during black out, a crew by mistake switched on the lube oil priming pump of the “opened” generator, leading to oil spill in the generator platform. This caused delay in restoring the power and additional man hours requirement in cleaning the oil.”
2. “ When opening the cylinder head while doing d'carb, ample amount of jacket water went inside the crankcase suddenly. After checking, it was found that the vent cock was not opened, which prevented water from draining completely from the cylinder head and jacket.”
3. “ On a taker ship, accident occurred due to the bursting of high pressure pipe of a hydraulic jack, causing severe injuries to a motor man. It was later found that the pressure applied while opening the cylinder head was much higher in value than required. This caused rupture of the pipe.”
4. “ During running in of the engine, luckily it was identified that all the big end bolts were getting loosened. This was the result of misinterpretation of the tightening unit, which was provided in kgf-m but the torque applied was in N-m.”

Opening of Parts

Opening auxiliary engine for D'carb depends on the company policy and manufacturer running hours recommendation for overhauling of different parts of the generator.



Opening Marine Generator for D'carb

Cylinder head and piston (piston rings) have a shorter period of

running hours as compared to the liner and connecting rod.

Similarly, bearings have more running hour range when compared to the liner. Hence, it is not necessary to remove all major parts at the same time when doing the d'carb .

If the company insists, or due to some defects/ incident, d' carb may include opening of all major parts, including connecting rod bearing and main bearing.

The machinery attached to the generators such as turbochargers and pumps are also included in the manufacturer's maintenance program as per the running hours of the same.

For understanding the procedure for overhauling generators, we will describe opening of all major parts of the generator in this guide.

Sequence for Opening Generators

After taking due precautions and doing required preparations as discussed in the previous chapters, overhauling of auxiliary engine can be started.

Listed below is the order of the most generalized sequence followed globally in the marine industry for opening a marine generator:

1. Open rocker arm cover, crank case and cam case doors



Opened Crank case doors

2. Open cylinder head connections (water, lube oil, injector etc.)
3. Open fuel pump and connections to the head
4. Open cylinder head torque/hydraulic nuts
5. Remove cylinder head
6. Remove protecting ring if provided
7. Remove big end bolts and bottom connecting rod shell
8. Remove piston
9. Remove cam shaft bearing
10. Remove main bearing
11. Timing gear inspection

Sequence for fitting back parts will go in the reverse order of the above list.

Turbocharger and other attached equipment such as pumps can be opened up as per the convenience and requirement of the operator. They will have their own opening and closing sequence described in the manual.

Removal of Cylinder Head

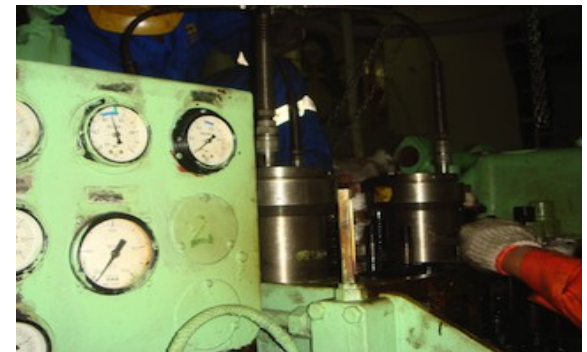
Cylinder head nuts may be tightened by hydraulic pressure or torque wrench depending upon the power rating/size of the primemover.

Hence for opening the same, you may be required to use a hydraulic jack or pneumatic/ mechanical spanner.



Removing all connections from Head

After opening water connections, lube oil connections, air connection etc. ensure that head is free from other parts. Use the hydraulic jack as described in the “operating procedures for tools” section.



Hydraulic jack to Open Cylinder head Nuts

Once all the nuts are loosened, remove and mark them for unit number and position.

Most of the cylinder heads have an arrangement where the lifting tool can be attached only after removing fuel valve. Hence jack out the fuel valve and insert the lifting tool.

After removing the nuts, clamp the head lifting device and with chain block lift the cylinder head and rest it in a wooden base to avoid damage to the seating surface.



Protect Head stud threads by putting back nuts

Remember

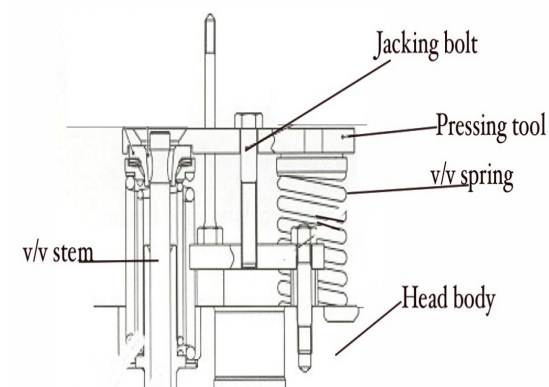
Once the head is out, ensure all the stud threads are protected by putting back the nuts on them. A piece of cloth can also be wrapped around threaded portion of each stud.

Removal of Cylinder Head Parts

Removal of Valves: Remove valves and valve spring by using valve removing tool, which compresses the spring and helps to draw out the cotter (two small identical halves used to lock the valve and rotator with the spring assembly), allowing removal of valve rotator and the valve itself.

Remember not to intermix the cotter

pairs (two cotters for 1 valve) of one valve with that of other.



Cylinder head valve removing tool

Removal of seat: If the seat is deeply scored, blown off or the angle between valve and seat is off limit, it is advisable to replace the seat.

For removal of the seat, some makers provide tools to jack out the seat from the head.

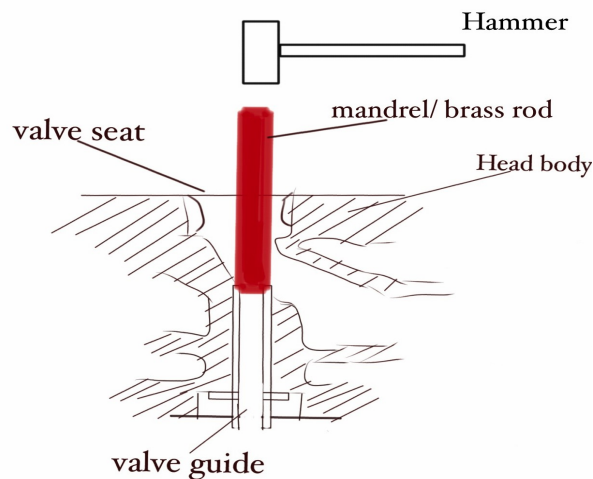
If no tool is provided, another method is to weld (Padded welding) with an old valve or iron plate to the

seat and quench it with water immediately and then hammer it out.

Removal of valve guide:

When it is required to replace the valve guide, turn the cylinder head in its working stand after removal of all the valves and spring.

Clean the valve guide area from carbon and soot deposits by means of diesel or kerosine.



Use mandrel or under size brass rod to remove the guide by punching the

guide from bottom side/valve side.

Removal of Starting Air valve:

Starting air valve from the cylinder can be removed on place or after removing head from the generator by means of a simple jacking tool.

Removing Piston, Connecting rod and Big end

Once the head is out of the generator frame, preparation for removing the piston can be carried out.

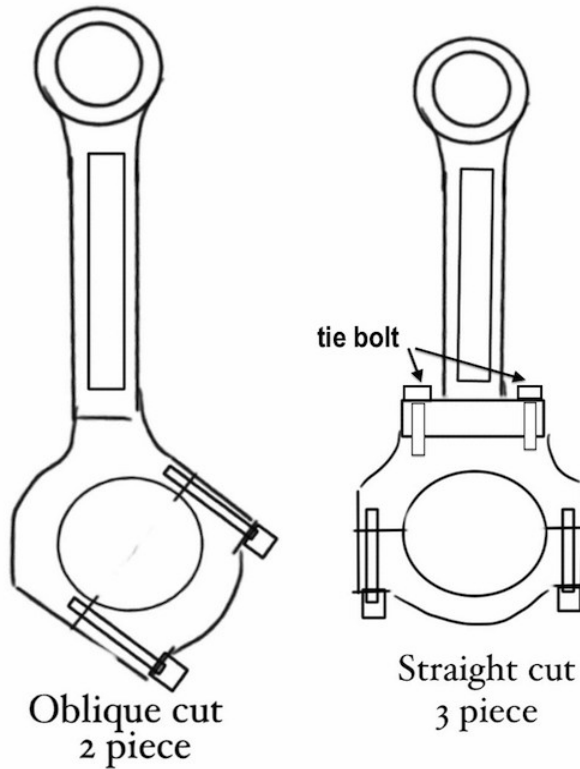
Piston can be drawn out by means of an I-bolt, screwed on the top of the piston that is connected to a chain block of rated capacity.



Piston out After Removing Head

Piston and connecting rod are tightened to the big end either by hydraulic/ torque tightened studs (Oblique cut connecting rod in two parts- YANMAR , MAN, SKL etc.) or by tie bolts. (Connecting rod in 3 parts such as big two stroke engines - DIAHATSU, SULZER etc.)

Depending upon the make, either only the piston is removed from the top without opening the bottom (3 piece con rod) end or first the bottom end is dismantled followed by the removal of piston.

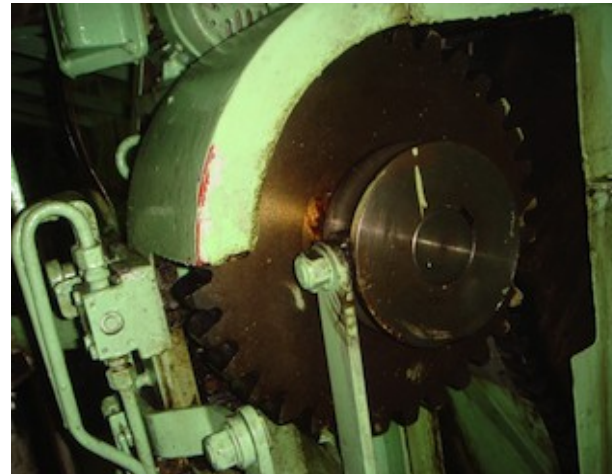


Most of the generators are equipped with fire ring or piston cleaning ring (also known as protecting ring) on the top of the liner for cleaning the carbon deposits on the upper area of the piston i.e. piston land.

This has to be removed first before

removing the piston.

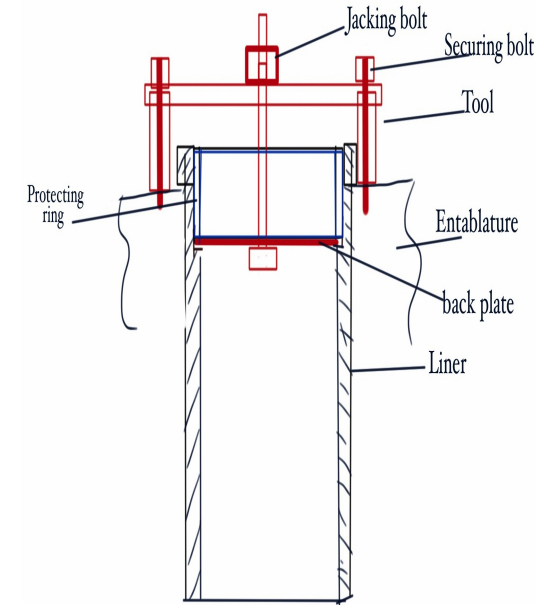
Engage turning gear (if provided) or manually turn the engine until the space is clear to remove the protecting ring (80-90 degree before TDC).



Turning Gear

Use Jacking tool for removing the protecting ring. Ensure to secure the tool properly with the engine frame and clean the carbon deposits at corners before taking out the ring as

a “stuck up” ring may break if uneven and excessive force is applied.



After removing the fire ring, turn the engine to get access on the top part of the piston i.e piston is around TDC.

Clean and tap the i-bolt hole provided on the top of the crown to lift the piston.

Clean the top part of the liner where

carbon accumulation is maximum, else while removing the piston its rings may get stuck up in that area.

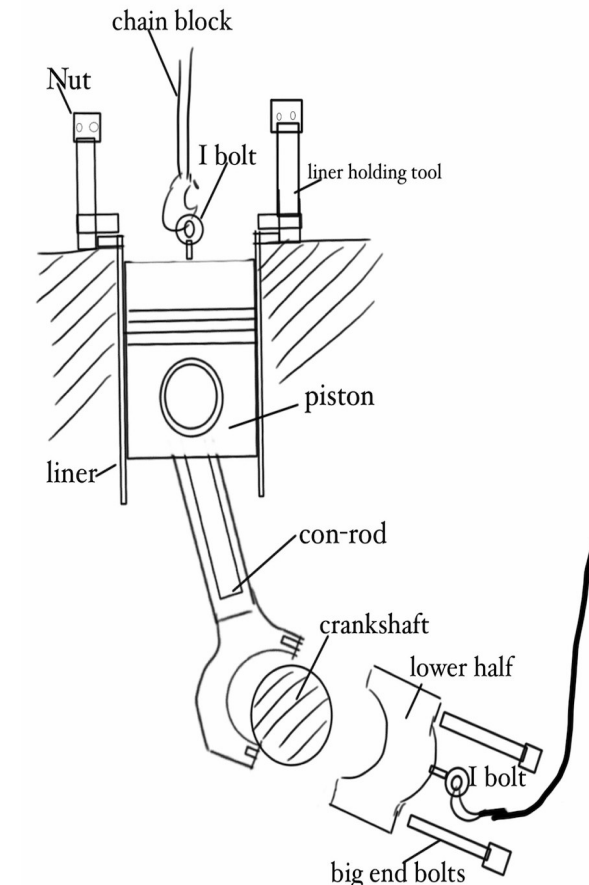
Once these preparation are done, put an i-bolt and keep the chain block ready to remove the piston.

Remember

If the protecting ring breaks while removing it from the liner and tool cannot be used further, another method is to weld a bar and pull it out with the chain block.

Piston With Oblique Cut Connecting Rod:

Connecting Rod: If there are only hydraulic/torque tightened studs in the big end (as provided in oblique cut-two piece con-rod), they have to be opened first before removing the piston.



Depending upon the size of the prime mover, it may be required to use a chain block and wooden plank to support the big end once the stud nuts are opened.

A threaded i-bolt hole will be provided in the big end housing for support.

Turn the crankshaft till the con-rod bolts are accessible for opening and removing the bottom housing (30 Deg after TDC or as prescribed in the manual). Take weight of the piston by a chain block from top as shown in the figure.

Use hydraulic jack as described in “Operating procedures for tools” section after checking the rated pressure of the big end nuts.

Once the nuts are loose, support the big end by chain block, rope, wooden plank etc., whatever is convenient to take out the bearing.

Take little weight on the top chain block to hang the piston and lift the piston by 20mm.

While removing the bottom half of the con-rod, tie the bearing shell to the half with a piece of cloth to avoid falling or slipping inside the crankcase.

Before removing the bottom bearing shell and bottom support, mark it with a permanent marker or by stamping.

After getting some space, remove the upper shell and mark it as “U” along with a unit number to avoid mixing up.

Install minimum two liner holding tools before removing the piston as a stuck piston may cause liner to come out from the jacket space.

Once the connecting rod is free to remove, rotate the crankshaft such that the web goes free of the con-rod upper half simultaneously taking the piston weight on the top chain block.

As the crankshaft is free of con-rod, start lifting the piston with the chain block and avoid damaging the crankpin surface. Remove piston and keep it on the piston stand table. Mark or stamp the unit number from where it is drawn out.

Remember

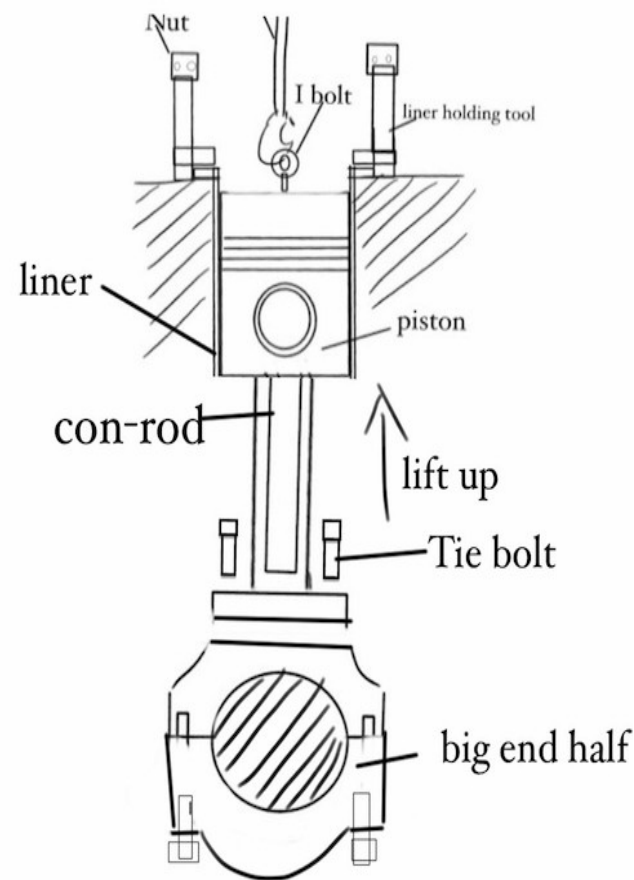
Some generators with oblique cut con-rod comes with piston cooling telescopic pipe which has to be removed first before coming to con-rod or piston.

Piston with Three Piece

Con-rod: Some generators are equipped with three piece straight con-rod like those found in Diahatsu, Sulzer etc. (And are similar to two stroke marine engine). For removing the piston in such models, it is not

necessary to remove the hydraulic bolts of the connecting rod.

The piston is attached to the crank pin housing of the connecting rod by means of tie bolts, which are generally torque tightened.



For removing the piston, open the cross wire lashing from the tie bolts. Follow the same procedure as described above for removing protecting ring and cleaning i-bolt hole, carbon deposits etc. before removing the piston.

Turn the engine so that the piston of the concerned unit is at **BDC** and with the help of torque wrench, open the tie bolts. Remember to mark the bolts as per their positions of removal.

With piston at **BDC**, fit i-bolt and chain block on top. Start lifting the piston and ensure that the liner is secured with the liner holding tool.

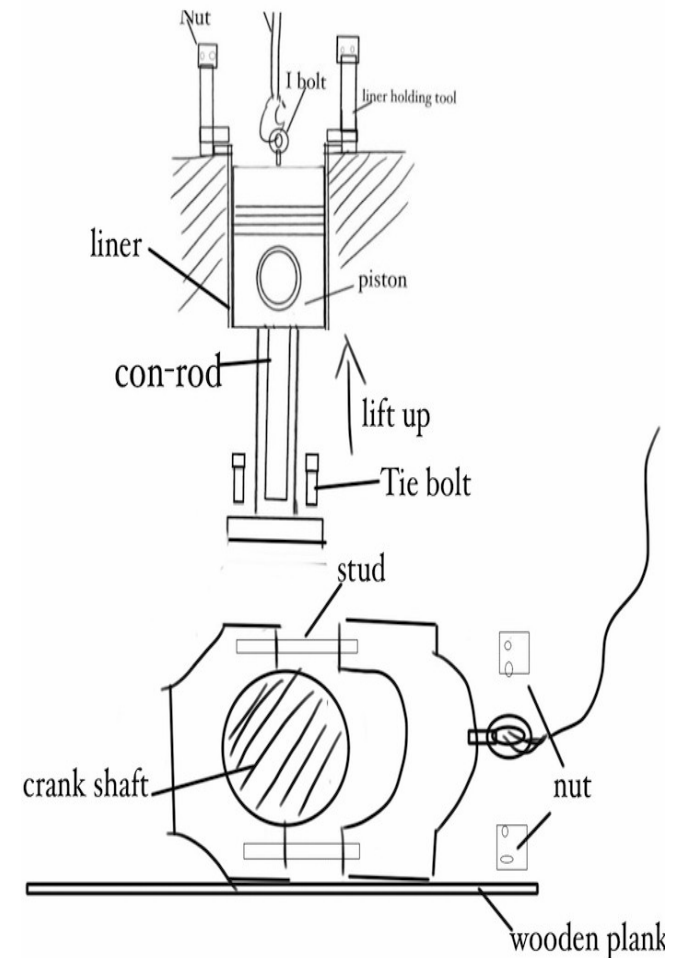
Once the piston is out along with the half part of connecting rod and is rested on the stand, prepare to remove the crankpin bearing assembly of the con rod.

Before opening the bottom end hydraulic bolt, make arrangement to support the bottom end housing either by chain block, rope or log of wood placed below the housing (resting on both the sides of the crankcase door).

Turn the big end assembly to 90 degree with respect to its **TDC** or **BDC** position as it will be easy to access the hydraulic nuts through crankcase door.

Insert hydraulic jack assembly over the nut and apply rated pressure. Once the nut is loose, remove the jack after removing the pressure completely from the system.

Be careful not to drop housing or bearing shell inside the crankcase. Use cloth or rag to tie up the shell with the body to avoid dropping of the same.



Once the bottom end bearing housing is out, ensure to cover the crank pin with a cloth to avoid any scratches on the same.

Also cover the liner opening with a hard board from top to avoid any tools or dust from falling inside the crank case or on crank pin.

Piston Ring: Once the piston is out of the generator, keep it in piston stand.

Remember that the edges of the piston ring are sharp enough to cause cuts to your skin. Wear gloves while removing them.

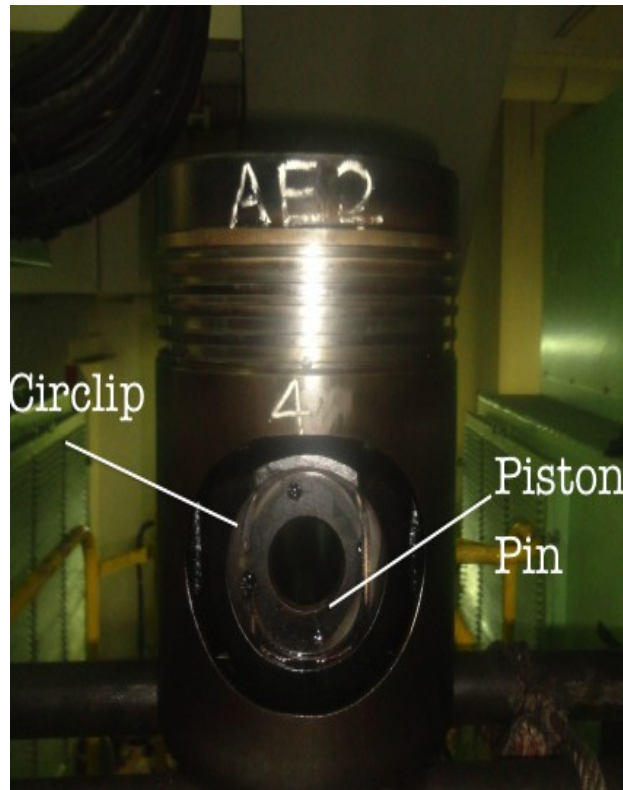
If ring removal tool is provided (Spreader with spring), use and start from the top ring.

If no tool is given, u can use synthetic ropes (2 piece) on both corners of the ring and then spreading the ring by applying outward force.

Once the ring is clear from the groove, draw out the same from the piston.

Piston Pin removal/ Con-Rod detachment: The connecting rod is attached to the piston with a piston pin.

To remove the connecting rod, the piston pin has to be removed.



Piston with pin and Circlip on stand

For easy removal of the pin, turn the piston upside down with the top face resting on the wooden plank.

Hold the connecting rod with a rope to avoid misbalance or topping off the complete assembly.

Further two small pieces of wood can be inserted in the void space between the rod and the piston to make it stiff while removing the connecting rod from the piston.

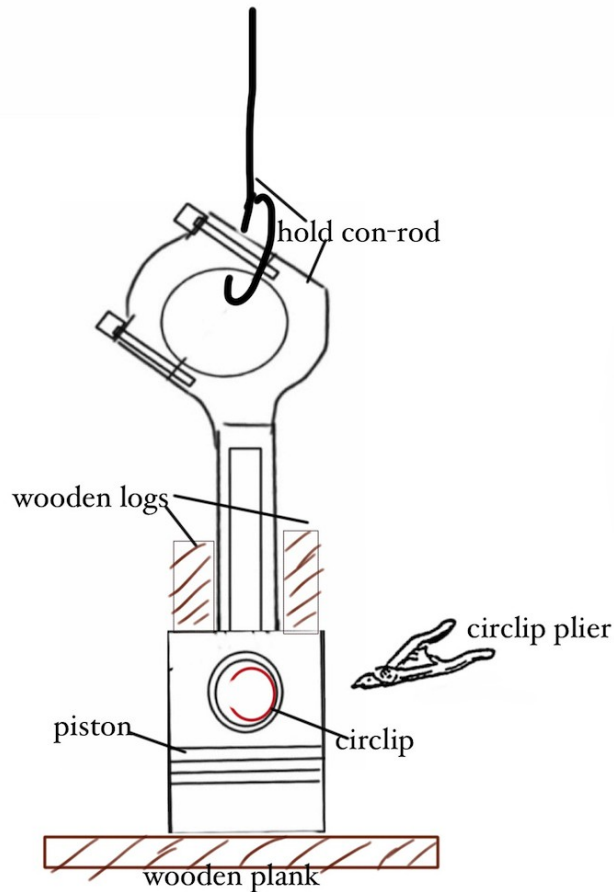
With a snap ring plier, remove the circlip which holds the pin inside the piston.

Once the circlip is out, support the connecting rod by a rope for easy removal of the pin by taking the con-rod weight off of the pin.

As the pin comes out, con-rod can be lifted out of the piston and kept in a separate wooden plank.

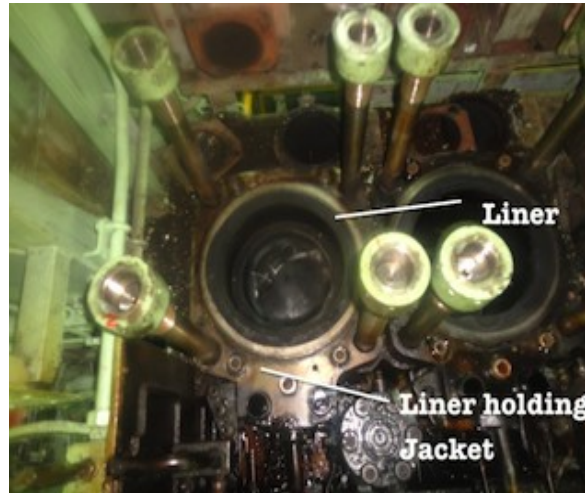
Liner

Liner of a generator is removed when it completes its running hour as prescribed by the manufacturer or when it has worn out and has cracks.



Remember

Hand tight the big end nut else while lifting the con-rod, the other half may open leading to slippage and accident.

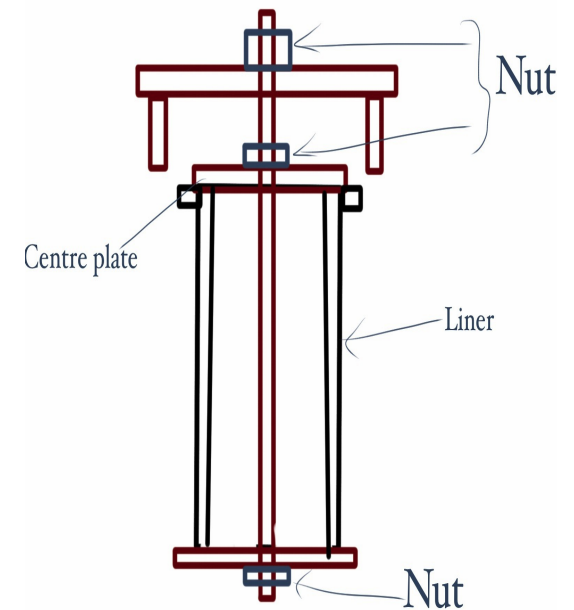


Liner

Some generators are equipped with liner holding jacket which is connected to the liner by means of 'O' rings. It is not necessary to remove these holding jacket in order to take out the liner .

However, as liners are generally removed after a long running period, it is advised to remove the jacket prior to removing the liner.

This is done to prevent O'ring in this area from making the liner removal difficult and time consuming. Liner removing tool is provided with a jacking arrangement to pull out the liner from the jacket.



When removing the liner, first clean the seating surface of the liner. Use liner removing tool which is attached on the top and bottom part of the liner and which can be jacked out by tightening the nut provided in the tool.

Ensure not to apply excess force if the liner is not coming out even by jacking. It may lead to bending or breaking of liner removing tool.

If such situation arise wherein the liner is stuck, use unconventional methods such as- make arrangements to cool the liner (by blanking the bottom and pouring ICE), or by using hydraulic jack from the bottom.

Both these methods may only be used if the liner is badly stuck in the jacket and not coming out by using the liner removing tool.

When using ice, liner has to be fully

covered by filling up to the bore area (combustion chamber). Put a plate at the bottom of the liner so that ice cannot go into the crankcase. Once the liner is cold, remove it by using the removing tool. (Due to low temperature, liner will shrink leading to removal of the same).

When using hydraulic jack, be absolutely sure not to damage crankshaft or any other part of the generator.

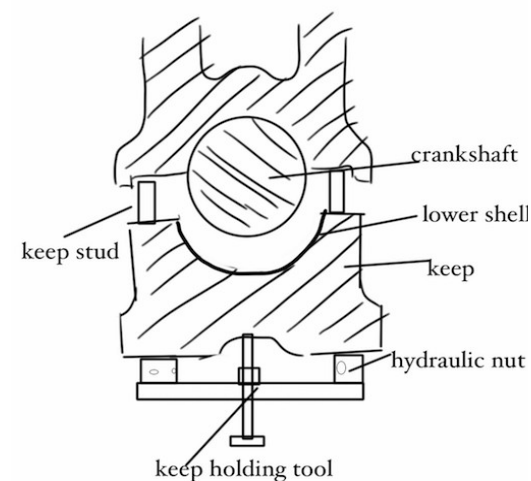
The hydraulic jack is to be put in such a position that it may help in removing the tool to pull out the liner (apply jack below the removing tool resting on a plate leveled either on the door or the web).

Use removing tool and hydraulic jack pressure together to remove the liner and never apply excessive hydraulic pressure if the liner is still not coming out as it may damage the crankshaft or the engine frame.

Main Bearing

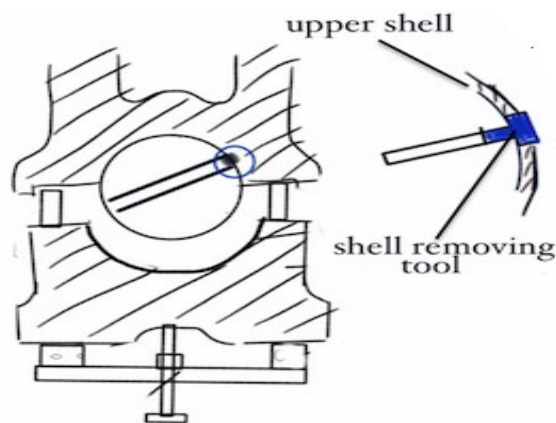
For overhauling the main bearing, it is not necessary to open any other part. The crankshaft where the main bearing is attached can be bottom supported or under slung type.

First open the side bolts near the crank case doors in underslung type. Special tool is provided to open and support the bearing keep so that the bearing shell can be held/supported or removed.



Keep caution while removing the accessible keep i.e top keep for normal supported crankshaft or bottom keep in case of underslung crankshaft, so as to prevent slipping of the the bearing shell in the crankcase. Turn the crankshaft so that you have enough space to put hydraulic jacks over the main bearing keep bolts.

Once the accessible keep is removed along with the shell, as the other part is fixed, the other shell is removed by rotating the shaft and using a shell pull out tool which is a small “T” shaped tool inserted in the oil hole.



For normal bottom supported crankshaft, a bearing keep lifting tool is provided.

For underslung crankshaft, keep holding tool is provided which ensures that the keep should not fall inside the oil sump.

Thrust bearing

The thrust bearing are normally mounted on the forward-aft of the main bearing, which is on the flywheel side, to accommodate axial thrust of the crankshaft.

The thrust bearing metal also comes in two parts - upper and lower. The lower part is normally attached with main bearing keep with knock pins. Removal of thrust bearing can easily be done while opening the main bearing.

Remember

Ensure not to interchange positions of the 2 halves as both upper and lower bearings look the same.

Gears

Engine comprises of several gears, which transmit the rotary motion from the crankshaft to the pumps and camshaft. The location of the gear train is at the opposite end of the flywheel or alternator.

The camshaft then operates the governor drive and also incorporates fuel pump and valve drives.

The main gears in the engine- **Crank gear and Idle gear**, which drive all the pumps, are free from crank or camshaft, and the **cam gear** which operates the governor drive.

Crank Gear: Removal of crank gear is normally done by maker's technician when there is a major problem and when the gear has to be replaced.

The normal procedure for removal of crank gear is:

- as the crank gear is fitted on the crankshaft, the gear assembly has to be loosened by drilling hole at the bottom land of the gear
- Insert a chisel through this hole to loosen the gear assembly
- Draw out the crank gear carefully

Removing Cam Gear:

- Remove timing gear case cover

- Remove the governor from the body
- Remove the governor drive gear. Ensure that no load or thrust is applied on the same before hand
- Normally Allen bolts are provided to power lock the governor drive with the cam gear. Open the same with an allen key of proper size
- Put strong wire rope in the holes provided in the cam gear body and draw out the gear from the timing gear inspection cover with the help of a chain block

Removing Idle Gear: Before removing the Idle gear, all related drives to be removed first.

- Remove all the pumps (lube oil, cooling water, fuel oil etc) fitted on the drive
- Open the timing gear cover/ gear case
- If tachometer is attached at the same side, remove it
- Remove the cam gear before removing the idle gear
- Remove the idle gear mounting bolts and with the help of wire rope, draw out the idle gears

Camshaft:

- Remove the cam gear drive and cam gear shaft with it
- Ensure fuel pump and fuel tappet is out from the top of cam shaft

- Ensure inlet/exhaust valve drives (push rods) are removed
- Remove starting air rotary valve from the end
- Camshaft are tighten together by bolts, open them and remove the cam shaft in parts from anti-flywheel side

Attached Parts

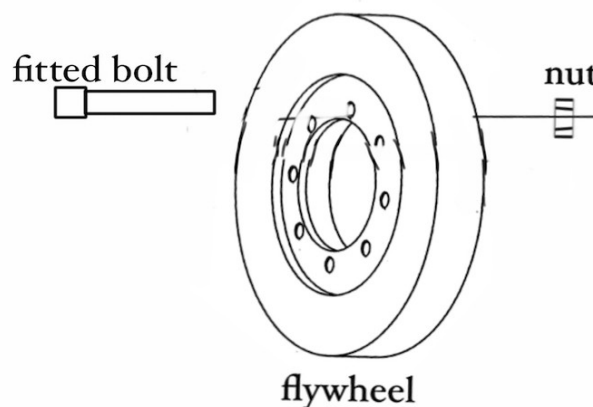
Attached pumps: All the attached pumps such as lube oil, jacket water or fuel pump are removed for overhauling separately. Before disassembling any pump, do the marking of the parts.

Remove all the piping attached to the pumps. Open the cover by removing the bolts and nuts.

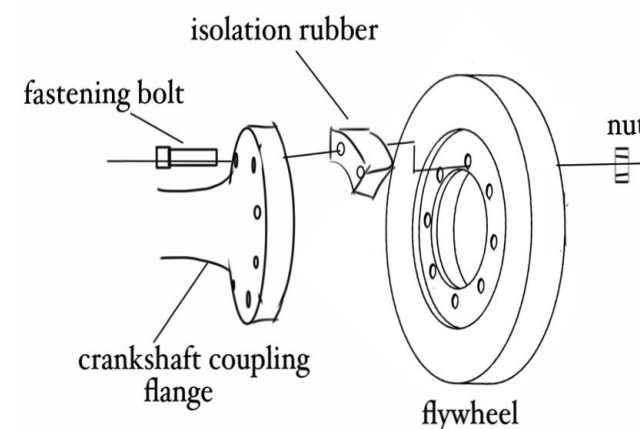
Remove the seal cover and the mechanical seal. Open all the bolts of the bearing cover and remove the outer bearing.

Take out the rotary portion of the mechanical seal and remove the rotor and rotor housing, which gives access to draw out inner rotor and shaft. Proceed by removing the inner bearing and the collar.

Flywheel Coupling: The prime mover is attached to the alternator via flywheel. This flywheel is secured with either fitted bolts or with



isolation rubber and bolts. After a certain period of time, it is important to check the tightness of the fitted bolts or the condition of isolation rubber.



Opening of isolation rubber:

- remove the flywheel cover
- engage turning gear and rotate flywheel so that access and removal of bolts is easy
- Once the bolt is loose, carefully remove the attached rubber
- Slowly rotate the flywheel and take all rubber pads and bolts

Governor: Before removing the governor, it is very important to measure the distance and angle of the linkage arm from the governor connection to the rack connection when the engine lever is at stop position.



Governor

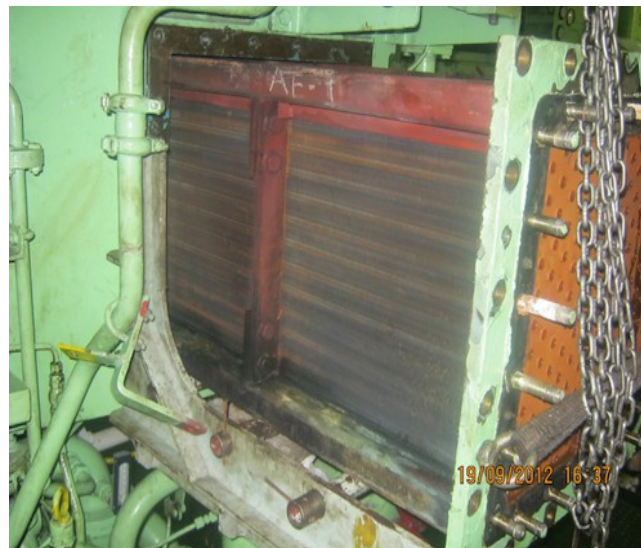
Drain the oil from inside of the governor. Remove the wiring and connections coming from the control room which regulates the synchro-motor on top of the governor.

Open the foundation bolts of the

governor and lift the governor out of generator frame and keep it in a wooden plank.

Ensure not to damage the shaft which sits on the slot of the driving assembly.

Air Cooler: The air cooler unit is mounted on the generator after the turbocharger and before the scavenge air box.



Air cooler element

Before opening the air cooler, ensure:

- All pipes and connections are removed from the cooler. Arrange chain blocks and attach them such as to make easy the removal of the cooler unit
- Start opening the securing bolts on the frame of the cooler to detach it from the generator
- Once all the bolts are loosened, take load on the chain block and remove all the bolts and draw out the cooler element carefully
- Jack the cooler through jacking holes and bolts if required
- Keep the unit in a wooden plank and clean the element by using chemicals

Real Life Incidences

1. “ While opening the cylinder head, one out of the four hydraulic nuts was stuck and was not opening even when the hydraulic pressure was raised to 940 bar (required pressure was 920 bar). To solve this problem, an experienced chief engineer instructed to re-tighten all the nuts to rated pressure and then open the nut which was stuck with a pressure up to 950 bar. The “stuck” bolt got loosened at 950 bar and was re- tightened at 920 bar. Again all four nuts were opened together by applying the rated hydraulic pressure .”
2. “ When the piston was taken out in a three piece con-rod, the liner holding tool was not inserted. Due to this, the complete liner got out of its seat, along with the piston when it was pulled out by the chain block, as the piston was stuck inside the liner.”
3. “ When all the units' pistons were removed in a Diahatsu engine (3 piece straight cut con-rod) the big end part was free to rotate. To remove the big end bearing of a unit, the crankshaft was rotated through the turning gear without checking on other units' big end housing. In the process one of the big end assembly got stuck in the engine frame and a crack got generated near crankcase door. The company had to pay thousands of dollars to repair the frame.”

Cleaning and Checks

After opening up major parts, thorough cleaning and checks to be performed over different parts of the generator.

Cylinder Head & Mountings

Cylinder head:

- For cleaning the cylinder heads it is advised to keep them submerged inside water for at least 2-3 hours (carbon removing chemical can be added)

- Pressure test of the cylinder head by plugging all the cooling water inlets and filling the head completely with

water should be done. When the arrangement is done, supply air to the head from the cooling water outlet with a pressure of +2 to 3 bar of jacket cooling water pressure of the generator



Pressure test

- Lapping of valve seat and checking the general condition of the seating



Valve and Seat after lapping

surface of both the valve and the seat should be carried out

Starting air valve:

- Check the condition of the spring for its tension
- Check the surface of the seat. Lap it if required

Fuel injector:

- Overhaul the fuel injector by cleaning all the parts in diesel or kerosine oil
- Check the condition of the spring (specially for generator with heavy oil as spring tends to cease and break)
 - After assembly of injector, check and set the fuel valve for its opening pressure in the fuel injection testing machine



Fuel injector

- Check injector for leaks and dripping. Once the fuel injector is set at rated pressure, ensure to lock the pressure setting nut properly

Relief valve and Indicator

cock: In most of the generators, indicator cocks and relief valve are integrated together.

- Check for cleared holes and leaky cock seat by blowing air from one side
- Check for lifting pressure of the relief valve as prescribed in the user manual

Exhaust, inlet valve and springs:

- Check for the sign of sulfuric acid corrosion and bend on exhaust/ inlet valve stem
- Check for high temperature corrosion of the valve poppet
- Check the seat and valve for scoring and blow by marking. Do valve lapping if required



Valve seat corrosion & Scoring

- Check the spring for tension by bouncing it on a flat plate and measuring its length after compression

Piston

- Clean the top surface and piston land by buffing machine or wire brush to remove the carbon deposits from the same
- Do not use metal brush or buffing machine on the below part of ring grooves or piston skirt as it may be coated with a special compound
- Clean the bore for gudgeon pin and clear the oil holes provided for cooling and lubrication by air
- Clean piston ring grooves with rough paper dipped in diesel oil for efficient and fast results



Cleaned Piston and ring groove

- Ensure to clean carbon deposits from the cut provided in the groove's corner. This cut diverts the gas pressure at the back of the ring to form a proper surface contact/sealing between the ring and the liner
- Check for any abnormal contact between the piston pin and piston bore
- Check for any abnormal contact between piston pin and con-rod small end bore
- Check for cracks at top surface and

ring grooves with the dye penetrant test kit

Liner

- Clean the liner with diesel oil
- Clean the O'ring grooves of the liner
- Check for cracks, scoring marks, pitting surface
- Check for mirror polishing / glazing of liner
- If mirror polishing appears, liner has to be honed by honing tool

Honing tool is a type of rubber ball tree i.e. at the end of several branches, rubber balls are attached. For honing the liner, the liner is kept at upright position and the honing tool is held with a drilling machine at

the end.

As the drilling machine starts, the complete rubber ball tree (honing tool) rotates and is inserted inside the bore of the liner from top to bottom and then in reverse order to take out the tool from the top.

This procedure is repeated for 1 or 2 times which makes the liner surface a bit rough to hold the lubricating oil and to avoid mirror polishing.

Jacket Frame

- Clean the jacket area with deposited mud or sign of corrosion
- Check for any cracks or damages
- Check for loose cylinder head studs
- Check condition of boost air space for fretting or corrosion

Connecting Rod, Big End Parts

- Check connecting rod for any scoring or damage



DP test for big end halves

- Check big end halves for any cracks by doing dye penetrant crack test for minor cracks
- Check for bend in the connecting rod- if there is a slight bend it will not be visible by eye

Take a brass rod or drill of such a diameter that it can go inside the oil hole.

If the rod is bent, the bar or drill will not travel completely inside the bore and will get stuck at the bent point.

Con Rod Hydraulic and Tie bolts

- Check tie bolt/ hydraulic bolt length and compare it with the value given by the maker
- Check for any scoring marks damage, crack etc.
- Perform dye penetrant test on the tie/ hydraulic bolt to check cracks
- Hit tie/ hydraulic bolt with spanner and check for ringing sound
- Check condition of threads for any damage
- Replace the bolts if the running hours are completed even if the bolt

seems normal

Checks on Crank pin

- Check for any scoring or damage



Crankpin

- Check for the shining of the crankpin
- Check for any abnormal contact of pin with piston and con-rod
- Check for taper of the pin by measuring its diameter with outside micro-meter

Bearing Shells

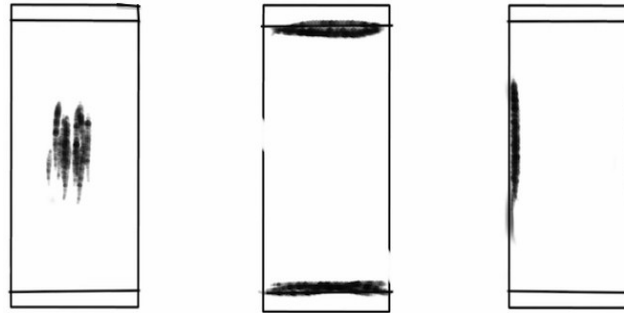
Once the bearing shells are out it is important to inspect them before deciding to reuse them.

One must replace the bearing shells if the following inspection shows wear out of limit as prescribed in the manual:

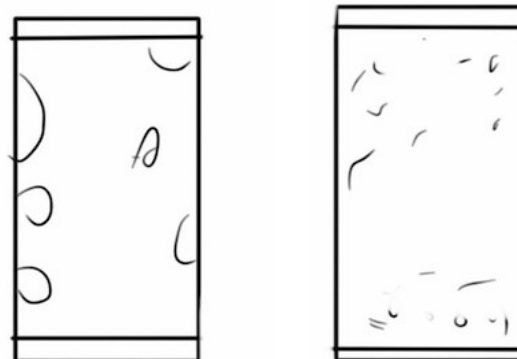


Bearing Shell inspection

- Check for wiped off white metal from mid, corner or side areas of the shell

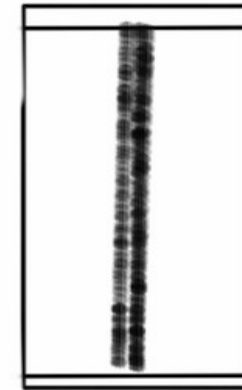


- Check for pitting, flake or removal of white metal from the shell



- Check for scoring of white

metal in the oil flow area



Remember

Never renew only one shell, always change bearing shell in pair with the new one

Air Cooler

Clean the air cooler and its element in water mixed with chemical (Air cooler cleaner).

A hot pipe of steam or heated circulating water will result in the efficient cleaning of the element.

Real Life Incidences

1. “A spare cylinder head, which was overhauled from a long time, was used as a replacement for one unit's cylinder head without pressure testing. The concerned engineer assumed it must have been done by the previous engineer after overhauling since no record of the test was found. As soon as the generator water was started, the cylinder head started leaking due to a crack in the valve jacket. Additional man hours were required to replace the head with a pressure tested one.”
2. “Severe cracks and pitting were found in a liner of one of the units. Same was removed by the liner removing tool to be replaced with new spare liner. While fitting back the new liner, the liner got stuck in the jacket frame as thorough cleaning was not performed prior fitting the liner. The mud deposits in the jacket started sticking with the o'ring and eventually the new o'ring also got damaged. The complete liner was removed again for jacket cleaning and o'ring renewal.”
3. “After a complete d'carb, the generator was started for running in and it was found that all units' exhaust temperature were still on the higher side. This was because no maintenance and cleaning was performed on the air cooler element during the d'carb.”

Measurement & Calibration

After all the checks and cleaning has been performed on various parts of the generator, it is essential to take the measurements of components or calibrating various clearance and dimensions to ensure that all the values are within the limits as prescribed by the maker.

If not, the concerned part must be replace with new spares.

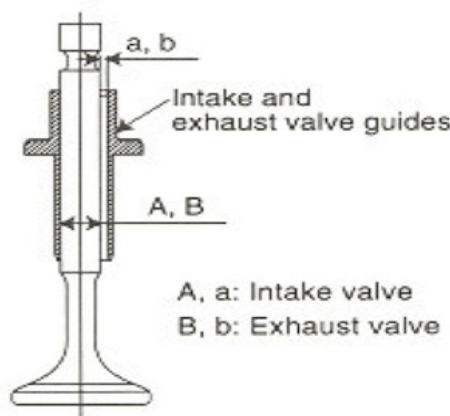
Please check the gauging sheets of generator parts provided with this eBook.

Cylinder Head

Valve stem and valve guide clearance: If the clearance

between the valve stem and guide increases, exhaust can leak out from the cylinder or the valve itself can break. Measure valve stem by outside vernier caliper and the valve guide by inside vernier caliper.

The difference between the two values gives the clearance value.



- Measure valve and seat angles
- Measure the contact dimensions of valve seat, and if it is off limit, replace the seat

Piston

Measure the diameter of the piston at three different parts by outside micrometer and compare the same with the rated values.

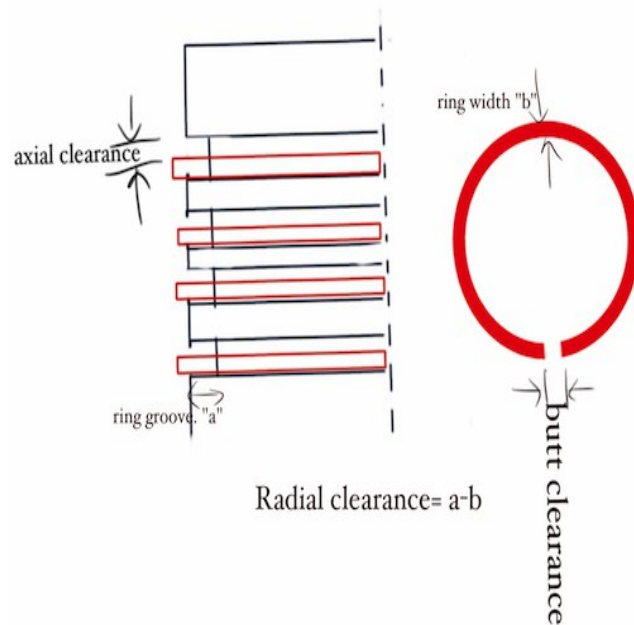
Piston ring grooves: If the piston groove value increases, it will lead to fluttering of ring inside the groove resulting in ring breakage. This is to be measured by inside vernier caliper to measure the groove's height and depth.

Axial Clearance: It is the axial clearance between the ring and the groove to be measured by feeler gauge. This clearance is to be measured at four different points for each ring.

Radial Clearance: The radial clearance is the difference between the groove depth and ring width

which can be measured by the vernier caliper.

Butt clearance: It is the clearance between the end but of the ring inside the liner.



The ring is placed inside the liner and the impression can be taken on paper by applying Prussian blue paste at the butt ends. The gap between the impression can then be measured.

Piston pin and Piston bore :

The connecting rod is attached to the piston by means of piston pin/ gudgeon pin fitted in the piston bore.

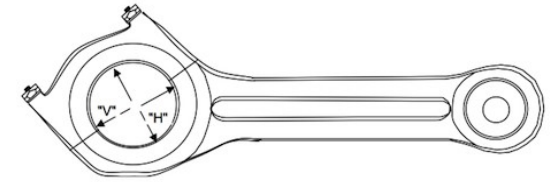
Gudgeon pin dimensions to be measured by outside micrometer at 2-3 places both in port-starboard and top-bottom directions. Piston bore to be measured by inside micrometer at 2-3 places as done for the pin.

Connecting Rod Big End Ovality

For connecting rod with two pieces (oblique cut), first tighten the bottom shell hydraulic bolts at its rated tightening pressure.

Hold the con-rod in the vice so that the big end is in horizontal position. Ensure the inner surface is properly

cleaned for measurement.

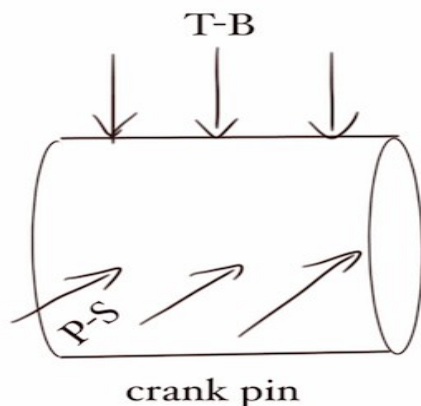


Measure the big end ovality by means of inside micrometer at six different positions.

For connecting rod with three pieces, the big end part can be separately tightened and the same procedure as above to be applied.

Crank pin measurement

Crank pin to be measured by outside micrometer at two different position. Handle the micrometer carefully as not to scratch the pin with it.



At each position, pin dimension to be measured at port-starboard and top-bottom parts.

Bearing clearance

Main bearing clearance:

When main bearing keep is removed, insert a lead wire of 0.5 mm thickness in between the shell and crankshaft journal.

Tighten the keep at its rated hydraulic pressure and then reopen to draw out the lead wire.

Measure the thickness of the lead wire to get the clearance.

Crank pin bearing

clearance: For crank pin bearing clearance, measure the inner dimension of big end housing “D”, the thickness of bearing shells “S”, and piston pin diameter “P”.

By calculating with these three units, crank pin bearing clearance can be found out – Crank pin bearing clearance = $D - P - S$ (mm).

Unconventional Method: Crank pin bearing clearance can be measured at bottom part of the bearing by means of feeler gauge.

Thrust bearing: For measuring the thrust clearance, put a dial gauge magnet attached on the engine frame with the dial touching the crankshaft web.

With the help of a bar inserted in the crank web, shift the crankshaft axially forward and measure the dial gauge reading.

Now shift the crankshaft axially aft again and measure the reading which will indicate the thrust clearance.

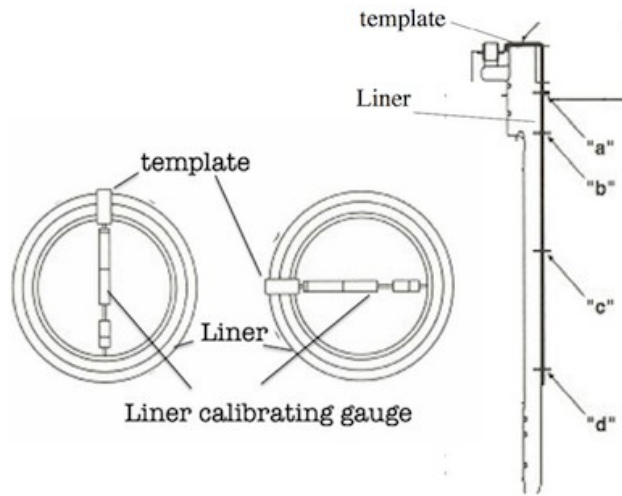
Remember not to put bar in between the counter weight instead of the web.

Liner Calibration

Cylinder liner has to be gauged at regular intervals as specified in the maintenance manual. The records of gauging are kept for each cylinder and the wear rate is calculated.

Generally while taking the measurement the temperature of the liner and micrometer should be kept at the same temperature. If the

temperature exceeds than that of the liner or vice versa then the readings have to be corrected by multiplying the value with the correction factor and deducting the value obtained from the reading taken. The reading obtained at the end will be the correct readings.



The cylinder liner wear is measured by a standard template, which consists of strategically positioned holes, wherein the micrometer is placed and the readings are taken.

The readings are taken for both port - starboard and forward - aft positions.

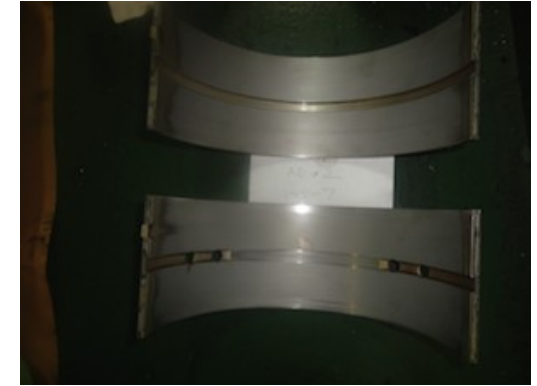
This is done because the wear is not same in both directions and the ovality is to be checked.

The wear rate will be different in the liner. The wear will be more in the top one third part as combustion takes place there and temperatures and pressures are also very high at the top.

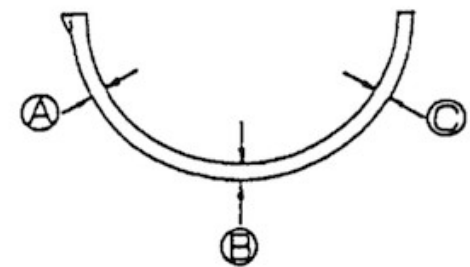
An approximate normal wear rate of the liner is about 0.1 mm per 1000 running hours.

The wear rate increases if the engine is overloaded. Generally the liner has to be replaced when the wear is about 0.6-0.8% of the bore diameter or as per the manufacturer's recommendation.

Shell Thickness Measurement



The bearing shell removed from the connecting rod or the main bearing is to be measured with the help of a vernier caliper at three points both forward and aft.



If the difference between the two point values exceeds 0.4 to 0.5 mm, replace both the shells.

Gear Backlash

Backlash of gears to be measure by means of a lead wire.

Place a lead wire of 0.5 mm diameter in between two mating surfaces of the gears. Apply grease so as the wire should not slip out of the surface.

Turn the crankshaft so the lead wire gets trapped in between the gear. Once the wire is completely compressed till the end, turn the crankshaft in opposite direction and take out the lead wire.

Measure the thickness of the thinnest point in the wire which is collapsed by both the tooth surfaces of the gear

and recored it as “X” and “Y”. The backlash will be addition of the two. i.e. “x”+”y”.

Tappet Clearance

Tappet clearance is the distance between the valve stem top and the rocker arm tappet.

It is a very important and critical clearance responsible for the optimal performance of the engine because with change in temperature, the valve stem also expands and contracts.

If the distance between the stem and the tappet increases, a banging sound will come which may result in breaking of valve stem or rocker area.

The value of tappet clearance varies from maker to maker. Average value is generally 0.5 mm between the

tappet and T yoke measure by means of feeler gauge.

First the concerned unit piston is brought to TDC and in firing position where the pushrods of both inlet and exhaust valves are off cam. Then clearance between T yoke and valve stem is removed i.e. made “0”.



The clearance between T yoke and rocker arm tappet is adjusted to approx. 0.5 mm by loosening or tightening the tappet adjusting screw on top of rocker arm.

Crankshaft Deflection

Crankshaft deflection must be taken twice- before starting the d'carb and after completion of d'carb.

This is done to ascertain whether the crankshaft journal is deviated from the theoretical axis or not.



Measuring Tools- Deflection gauge

The deflection is recorded by using dial deflection gauge which is fitted between the webs of the crankshaft in each unit.

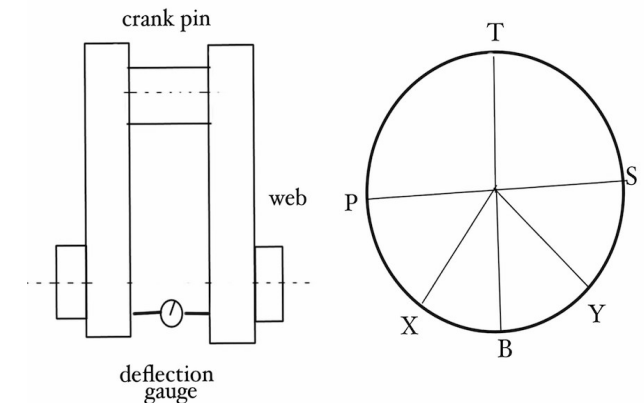
The complete shaft is then rotated in the direction of the operational rotation of the generator which may be clock or anti-clock wise.

The reading of the dial gauge is noted while turning the crankshaft which indicates opening and closing of the webs. Smaller the reading better is the crankshaft deflection.

Procedure: With the running gear in place, the crank to be measured has to be turned towards (before or after) B.D.C until the dial gauge can be fitted next to the connecting rod at the position indicated.

Pre-tension the dial gauge slightly and set it to "0".

Turn the crankshaft with the turning gear, and record the dial gauge reading in the crank positions as shown in the figure.



The difference between the indicated values at B.D.C. and T.D.C. shows the amount of crank deflection during one revolution.

When measured values lie above the maximum permissible limits, the cause has to be found and the necessary remedial measures taken (defective main bearing, engine support altered due to hull deformation, loose holding-down bolts, defective shaft line bearings, etc.).

Real Life Incidences

1. “ A cylinder head was overhauled and used as a spare in the d'carb process. During operation, after a successful D'carb, the same unit had a loud knocking sound and as a result the generator was stopped immediately. After inspection it was found out that the valve stem was broken and the exhaust valve was inside the combustion chamber, damaging the piston top and cylinder head. This was due to excessive clearance between the valve and the guide which was not measured during d'carb, leading to fluttering of the valve and breakage of the same.”
2. “While carrying out the running in of a generator, all units' crank pin bearing temperature were noted high and slight traces of white metal were found out in the sump oil. Later on it was discovered that the bearing shells used as replacement were all undersized shells.”
3. “ Following the procedure to take crankshaft deflection before and after the d'carb, the third engineer noted two units out of eight showing higher values of deflection. Same was reported to the C/E and after checking, it was found out that the concerned unit's bearing keeps' hydraulic nuts were in loose condition.”

Closing & Assembling

Assembling the overhauled parts of the generator requires both accuracy and correct skills to ensure a trouble-free operation when the engine is restarted. The sequence is in reverse order of opening, starting with crankshaft parts i.e. main bearing and crank pin bearing.

Main Bearing

If the main bearing is opened up for renewal or inspection, it is to be assembled first.

Cleaning the pin surface is of utmost importance as any foreign particle may lead to scratching of the shell and pin. Depending upon the type of

crankshaft (underslung or regular supported) top or bottom shell is inserted. Same “T” tool can be used to insert the shell with rotation of the crankshaft.

Apply clean lube oil in the pin surface and bearing shells to ensure smooth fitting. Fit the shell in correct position, as described in the manual, in to the keep of the shell.

With the help of keep fitting tool, lift the keep in its position and insert the holding nuts. Tight the nuts, both keep securing and side bolts, with hydraulic jacks at its rated pressure given in the manual.

Liner

If liner is removed, ensure that the jacket is de-mucked from mud deposits. Renew all the O-rings of

the liner.

Lift the liner with its lifting/ insertion tool and once the liner is in position for insertion, apply some soft soap solution in the O' rings of the liner for smooth insertion.

Take care to put the liner in correct direction. Marking is provided in the liner body and the generator frames, hence both these markings are to be matched while the liner is fitted back.

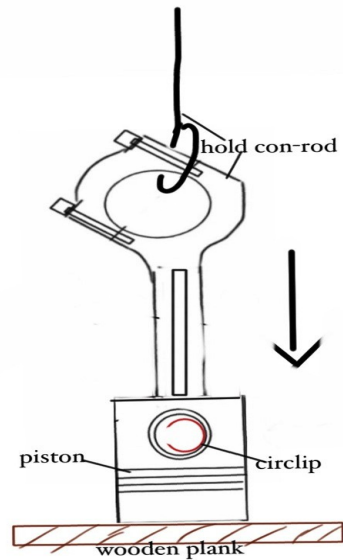
Piston and Connecting Rod

Once all the checks and test were performed on piston and connecting rod, they should be assembled back. Clean the piston pin and piston bore and apply lube oil at all the mating surfaces.

On a plank of wood with piston held

vertically, insert the connecting rod with the help of chain block/ strong wire sling.

Make sure the con-rod is inserted on correct side by checking the stamping marks as the oil holes of the rod should come in correct position for effective lubrication.

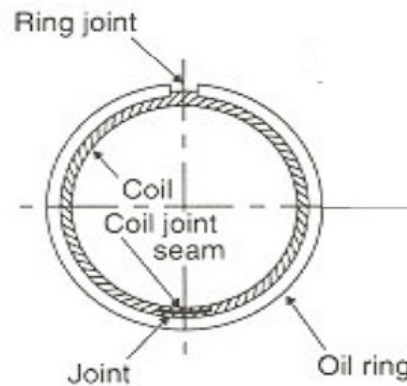


As the small end bore of connecting rod matches with piston pin bore, inset the pin and if required use mallet to hammer the pin.

When it is ensured that the assembly is correct, with the help of a circlip plier insert the locking circlip over the pin.

After completing the assembly of piston and con-rod, lift and keep the piston in the stand.

Clean the ring groove with compressed air and prepare to insert the ring.



If ring expander tool is provided, insert all the rings starting from the bottom ring (oil ring with spring coil).

Make sure the oil spring joint for the last ring is in opposite direction of the ring but.

Remember

Stagger all the rings by 90 degree with respect to each other to avoid in line blow past

Crank Pin Bearing

Depending upon the type of the connecting rod, the shell is either fitted in the connecting rod bottom half and the connecting rod itself (oblique cut two piece type) or in the crankpin keeps (three piece type).

Cleaning is by far the most important point before fitting bearing shells. Ensure that no foreign particles are

present either in pin or in the shells.

Two piece oblique cut con-

rod: Apply clean lube oil in the crank pin and bearing shells. Turn the crankshaft so that the pin is in appropriate position to fit the bearing shells.

Fit the shell in the bottom half of the keep in the correct position. Take load of bottom half with the help of strong wire rope or wooden plank resting on both sides of the crankcase door for support.

For two piece con rod, the complete piston is inserted along with con rod fitted with upper shell (If the liner of that unit is removed, it is required to fit the liner first).

Please check what points to be ensured before inserting piston in our next section- “Piston”.

Tie a piece of cloth so that the

bearing shell is properly held while transferring piston con-rod assembly in to the generator for fitting.

Once the bottom shell is held in place and the piston is inserted in the position, remove the tied cloth and slowly lower the piston- con rod over the crank pin.

Fit the bottom half and secure both pieces together with bottom stud and nuts.

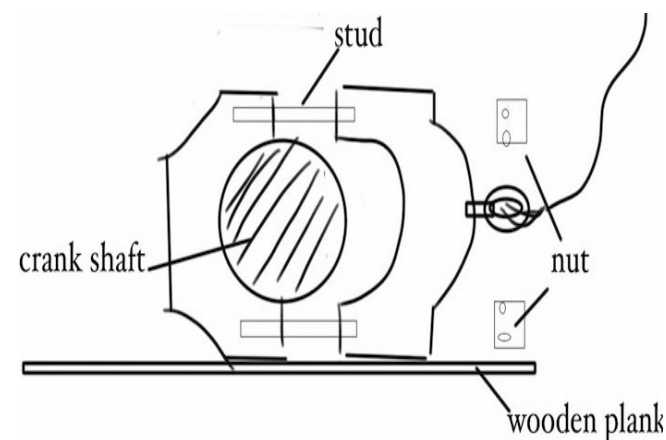
Tight the nut using hydraulic jack at rated pressure described in the manual.

Three piece straight cut

Con-rod: For three piece straight con-rod, the crankpin shell keep is in two pieces without con-rod.

After cleaning thoroughly both the pin and the shell, apply clean lube oil on the pin and shells.

First put the bottom half of the two piece keep with the help of strong rope/ chain block or a flat log of wood for support.



Once the bottom half keep and shell is in position, the upper half with fitted shell is inserted (care to be taken not to drop/loose/misalign the fitted shell) and stud bolt is fitted to secure the two keeps together. With hydraulic jacks, tighten the nut at rated pressure as stated in the manual.

Piston

Before inserting piston ensure that-

- ✓ Liner is cleaned
- ✓ All calibration linked with liner and piston are taken
- ✓ Piston rings are staggered so that the butt end of any two rings does not coincide with each other
- ✓ Piston inserting tool is placed and secured on top of the liner
- ✓ Liner itself is secured with liner holding tool as in the event of piston stuck up, the liner should not draw out accidentally
- ✓ Apply lube oil for smooth insertion both in piston rings and liner
- ✓ Gudgeon / piston pin is properly secured by circlip

As discussed above for two piece oblique cut con-rod, piston is inserted

while securing the crank pin bearing.

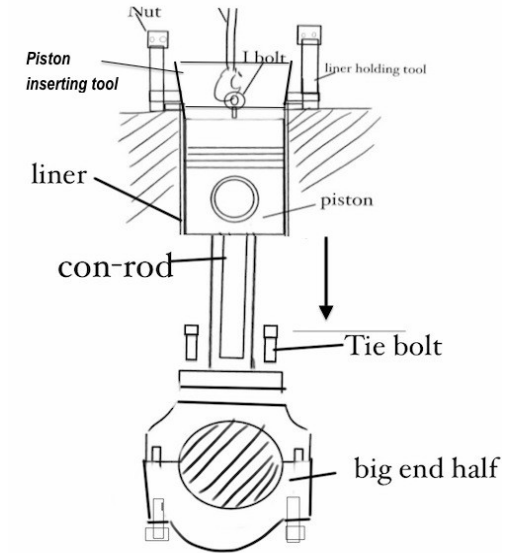
For three piece straight cut con rod, piston is inserted after fitting the crankpin bearing assembly.

Once the crank pin assembly is secured, all the above points to be taken care of before inserting the piston.

Also turn the crankshaft so that the crank pin and the web is in BDC position.

Insert the piston slowly with the help of a chain block. Once the piston reaches its seat over the crank pin shell top keep, ensure that the surface is clean and free of oil.

Sit the piston over its matching holes and insert the tie bolts (normally four in nos.) to secure the piston con rod assembly with crank pin shell keep assembly.



Tighten the tie bolts in cross sequence as per the rated torque or hydraulic pressure.

If new tie bolts are used, remember to tight all the bolts in correct sequence and loosen them up again.

This procedure to be repeated 2 to 3 times to ensure that the new tie bolts are properly elongated. Ensure to do wire lashing of tie bolts for all the units.

Cylinder Head

Fit piston cleaning ring/ fire ring/ protecting ring inside the liner before fitting the head and ensure that all the cylinder head mountings are completed including-

- **Start air valve:** It has to be fitted with new o'rings and washers.

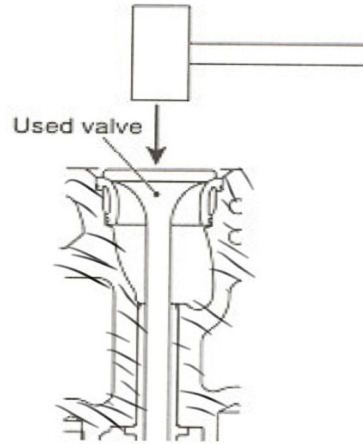
- **Indicator Cock and Relief Valves:** Tested indicator cock and relief valves to be fitted with new washers.

- **Valve seat to be fitted if renewed:** For fitting the valve seat, first cool down the seat in liquid nitrogen which will shrink the size.

Renew the o'ring for valve seat and with the help of seat fitting tool, push down the seat in place.

If a tool is not provided, use old valve

which will act as tool to fit the seat.



- Valves with spring and roto caps to be fitted with their original cotters

- Fit plugs and temperature gauge

- **Fuel injector:** Pressure tested injectors to be fitted with new o'rings and washers after the head is fitted on the generator frame.

Before fitting the head, test all the roto-caps over the valves are working

properly by hitting the upper portion of the valve by mallet.

Once the valve is hit, due to the roto-cap it will rotate and stop. This will ensure that the roto-cap is working fine.

Once all the head fittings are completed, Cylinder Head is to be lifted up with its lifting tool and the chain block over the generator frame. Ensure to apply molycote (Hi-temperature anti seize compound) in the exhaust side joints and bolts, injector seating area etc.

Once the head is ready to fit, apply silicon in the water o'rings. Make sure all o'rings (water side and lube oil sides) are fitted properly. Put the cylinder head gasket on top of the liner and apply molycote.

Slowly put down the head on top of the liner without damaging any stud

or without misaligning any o'rings and gaskets.

Check that the head is in equal level over the liner from all directions.

Once every thing is ok, put nut over studs and with the help of hydraulic jack or torque wrench, tighten the head as per the rated press or torque described in the maker's book.



Remember to do all the cylinder head connections only after the head is tightened at its rated torque.

Start with all the water connection first and once the water connection is complete, open water and check for leakage. If no water leakage, adjust the tappet clearance of all the units exhaust and inlet valve.

Remember

Put the thread protecting cap over the threads after head nuts are tightened completely

Fuel Pump and connections:

The overhauled fuel pumps to be fitted and the high pressure pipe connecting pump to the injector to be fitted back.

Fit all the other connections such as leak off line, return line etc. which were removed before lifting the head from the frame.

Fit all the protection shield covers such as fly wheel cover, fuel pump case area protection cover etc.

Isolation rubber: If the rubber is renewed, the new rubber pad will be difficult to go inside the slot in the flywheel. To insert the rubber:

- Turn the flywheel such as the rubber is easy to insert
- While holding the rubber, put a wooden plank in the face of the pad and with small jack, apply hydraulic pressure to inset the pad inside the slot
- Tighten the bolt and nut and repeat the procedure for other pads

Real Life Incidences

1. “ The crank pin bearing shells were changed for all the units. While doing this, the upper and lower shells were inserted correctly but before tightening the big end bolts, the crankshaft was rotated by the turning gear which resulted in shifting and misalignment of the bearing shell. While doing the crank case inspection same was identified and rectified.”
2. “For fitting the connecting rod to the piston (small end to be fitted in piston bore with gudgeon pin), the piston was inverted and rested in a wooden plank. The crew decided to insert the connecting rod without attaching the bottom half and by lifting the con-rod manually. While inserting the rod, due to the weight of the same, it slipped and the serration surface got damaged. The complete con-rod was changed with a spare one.”
3. “ After fitting the cylinder head and tightening it with the rated torque, the team decided to complete all the connections as fast as possible. The engineers never tested the water leak by opening the water. After all the connections were completed, Jacket Cooling water was opened and leakages were found in two units. The team had to open all the connections again to rectify the leakage.”

Alternator Maintenance

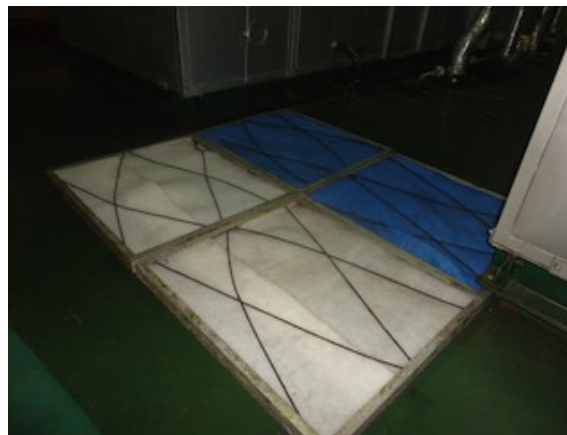
Alternator on the ship is exposed to harsh weather and sea conditions, due to which, its capacity and efficiency tends to reduce. It is therefore very important to have proper maintenance on the alternator part of the generator as per planned maintenance or as and when it is required.



Following points are to be considered while carrying out maintenance on Alternators:

Before starting any maintenance work on the alternator, all safety precaution should be taken and the alternator should be shut and locked down. Post notice and ply cards on relevant places. Also, alternator heater is to be isolated.

→ Clean the alternator ventilation passage and the air filter



- Check the Insulation resistance of the stator and rotor windings
- Air gap between stator and rotor to be checked and maintained between 1.5 to 2 mm
- Slip rings to be checked for wear down and must be renewed if required
- Carbon brushes to be cleaned and checked for free movement
- The brush contacting pressure to be checked by spring balance
- Automatic Voltage Regulator to be checked and cleaned off oil and dust
- Alternator sensors to be cleaned

Maintenance:

- ➔ A vacuum cleaner can be used to remove dust accumulated in the inner parts of the alternator
- ➔ The terminal box cover gasket to be checked for proper oil and water tightness
- ➔ All the connection in the terminal box to be tightened properly
- ➔ Cable gland to be checked for integrity
- ➔ Forced ventilation around alternator must be maintained all the time
- ➔ Check heater for proper operation

- ➔ Check and do contactor routine of Air Circuit Breaker at Main switch board (MSB)



- ➔ The foundation bolts of the alternator to be checked for tightness

Remember

Ensure that the power supply for the heater of the alternator is switched off before performing any kind of maintenance

After completion of maintenance, ensure that all tools and equipment are taken out of the alternator to prevent short circuit or burning of windings

Starting Preparation

After thorough inspection of all the assembled parts, the generator is prepared for starting. If working in a team, ensure to give proper signaling signs before starting the engine even if it is for short duration.

Ensure no one is near by the crankcase door or on top of the engine when starting. But for starting the generator, all the isolated systems are to be brought to normal condition first. Starting with-

Water system

- Check all the connections are proper and tight
- Close the water drain valve

- Open vent provided in the jacket water outlet for air purging
- Open the line valve for water coming from the expansion tank
- Keep an eye on any leakages from cylinder head connections and liner/ head surface where water o'rings are placed
- Keep checking for water from the vent
- If you found any leakages, shut the expansion line valve and drain the water to rectify the leakage
- Ensure all trapped air is purged and once water comes out from the vent, shut the vent valve after ensuring no leakages

After above checks, start opening the water outlet valve slowly keeping an eye on the jacket water pressure of the running machinery.

After the outlet valve is fully open, start opening the inlet valve very slowly as sudden opening of the same will fluctuate the water pressure of the line i.e. in other running generators.

Lubricating system

Before starting the generator after a major overhaul, the sump has to be drained of contaminated oil and cleaned thoroughly. Check the sump for any left over tools or rags. Take fresh charge of lube oil till appropriate level.

All the filters in the system which includes duplex lube oil filter, turbocharger lube oil filter and

centrifuge filter must be cleaned before activating the lube oil system.



Following checks to be performed in the lube oil system:

- Check all the connections are proper and tight
- Start the lube oil priming pump and initially do the purging through the lube oil filter vent or purging cock
- Once the oil starts coming out of the purging cock, shut the

cock

- Check for any lube oil leakages and if seen stop the pump and rectify the leakages
- Check the lube oil flow from the piston and con-rod
- Before starting the engine, engage turning gear and turn the engine for at least 30 mins with priming pump on



- Check the flow of oil over the connecting rod
- Check the ampere of turning gear motor
- If the current is higher than normal, there is some problem or obstruction for crankshaft while turning. Rectify the fault before starting the engine

Fuel System

Ensure that all valves in the diesel oil lines are open to the generator including oil outlet returning to the diesel oil service tank.

If booster and circulating pump is provided in the line, ensure that all the valves of the pumping system are in open position and then start the

pumps.

Always start booster pump first then the circulating pump. Check pressure on local gauges located near both the pumps and on the local panel of generator.

Air System

- Drain the air line and the air bottle which provide starting air to the generator
- Check all the air line connections
- Slowly open the starting air valve to the generator
- If any leakage is found, shut the air valve and rectify the leakages

- Open the indicator cock, remove or disengage the turning gear and blow through the engine
- To check starting air valve leakage, while the engine is blown through, feel the leakage at every starting air valve in each head

Once all the above checks are done, the generator is ready to start.

General checks and precautions

- Be sure to disengage the turning gear or remove tommy bar before starting the engine
- Check all the oil levels i.e in sump, pedestal bearing,

governor and in turbocharger

- Ensure to pre-lubricate the engine either by priming pump or hand driven pump
- Turn on the power supply of the engine protecting devices
- Ensure all trips are correctly set
- Ensure overspeed mechanical trip is correctly set
- Never start the engine from remote position. Always start it from local side with enough man power for observation purpose
- If while starting any abnormal noise comes or engine picks up speed very rapidly, immediately stop the engine and remove the cause of the trouble

Real Life Incidences

1. “ When doing the running in of the engine, after 2-3 times of starting, the engine tripped on low lube oil pressure. This was due to the dirty lube oil filters which were not renewed before starting the engine for running-in.”
2. “After satisfactory d'carb of the engine, the engineer officer started opening all valves for various systems. On fresh water system, he opened the outlet valve first (correct sequence) and while opening the inlet valve, he operated the valve very quickly which resulted in drop of jacket water pressure of the running generator, leading to trip and blackout. ”
3. “ It has been seen in many ships that the turning gear and the fly wheel gear wheel got damaged due to sudden start of the generator, without the removal of the turning gear and safety interlock not in working condition. Few causalities and damages has also been noted due to tommy bar, which was forgotten to be removed from the flywheel before starting the generator.”
4. “ On one ship, the d'carb procedure was carried out for a long period of time. While re-starting the generator, no one drained the starting air line of the generator. This lead to the passage of water from the starting air line to the inside of the cylinder head through the starting air valves.”

Running In

The newly fitted liner, piston, or piston rings are machined prepared in the workshop ashore. They have surface asperities and there is no bedding between the moving surface i.e. liner and rings.

Under such situations, if proper step by step running is not followed then it may lead to heavy blow past of combustion gases. The blow past can be dangerous as it can lead to contamination of expensive crankcase lube oil and may lead to crankcase fire.

Hence initially a step running program is required for newly fitted piston, piston rings and liner.

After a complete d'carb of the engine, it is important to keep an eye on various parameters of the engine under increasing load which can be

achieved by Running in.

Running In is a program followed after overhauling and it is a long run program with step by step increase in the load and in some generators, speed of the engine (for initial start).

The running in schedules are provided in the engine manuals and differ from part to part. The most general running in sequence is as followed-

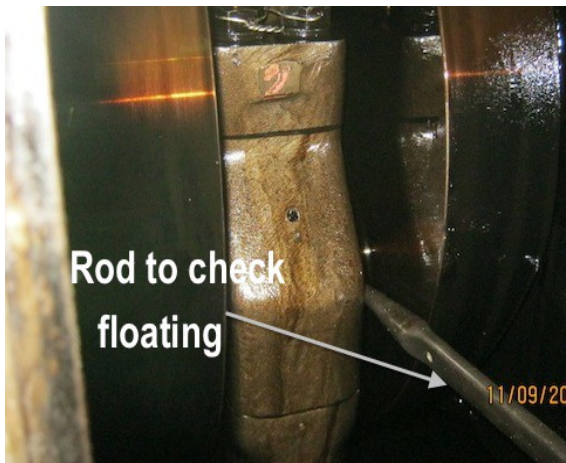
After all the checks are complete on the generator:

- Ensure that the generator is in diesel fuel
- Check that the turning gear is disengage
- Start the generator from local and ensure enough manpower is present

- Ensure the “auto-synchro” option is off in the ECR else generator will come on load automatically
- Run the generator for 5 mins in no load condition and stop it from local
- While the generator is running, record all parameters
- After the crankcase is cooled down and safe to open, remove all the crankcase door and perform a crank case inspection



- Check temperature of con-rod bearing
- Floating of the connecting rod and oil condition for white metal or check for hotspot



- When every thing is confirmed “OK” put back the crank case doors
- Check for any loose wire lashing or locking washer

Start the generator again for next 10 minutes and repeat the above inspection process.

Start and run the generator for 30 minutes on low load (25%) and repeat the crank case inspection. Ensure that before opening, the crank case is cooled down within safe limits.

Start and run the generator for 3 hour at 25% load and after stopping, perform crankcase inspection.

If the crankcase inspection until now is satisfactory, start and run the generator for 3 hours at 50% load.

Keep monitoring all engine parameters including crankcase temperature.

Increase the load of the generator to 75% for next 3 hours followed by an

increase in load to 85% for 3 hours.

Finally run the generator for 4 hours at 90-100% load and this time record the Pmax by peak pressure gauge or by digital pressure indicator to check the combustion of each cylinder.

Once the running is completed, do a thorough crankcase inspection.

The generator to be run at diesel for more time (at least 48 hour but depending upon maker's instruction) and after 100 hrs of running a crank case inspection is performed along with tightness checking of all the bolts (big end and tie bolts).

The running hour period as per increasing load may differ according to “generators” make.

Please refer manual for proper running hour period.