Marine engines

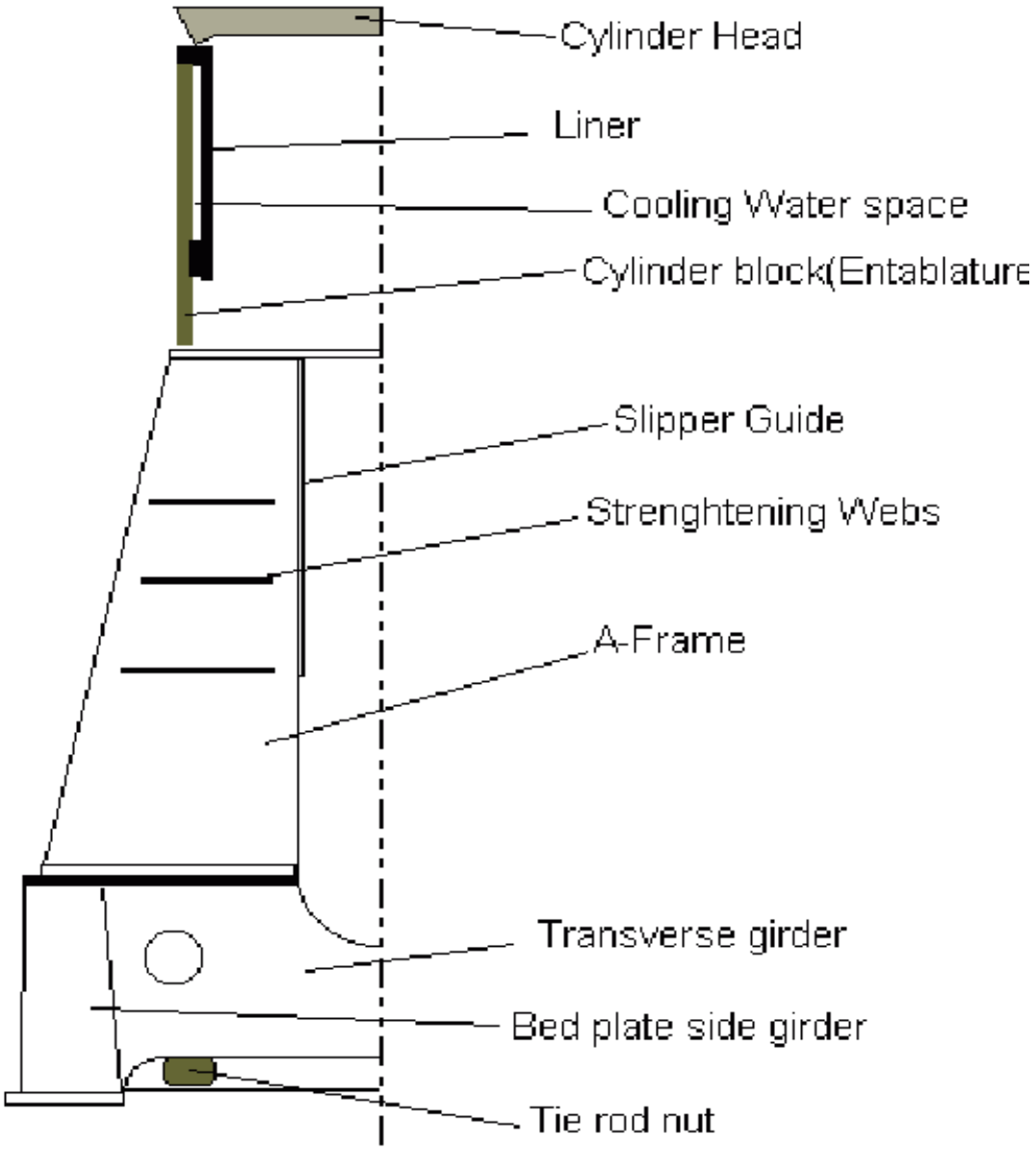
Cylinders, engine housing, crankcase etc.

Stationary components:

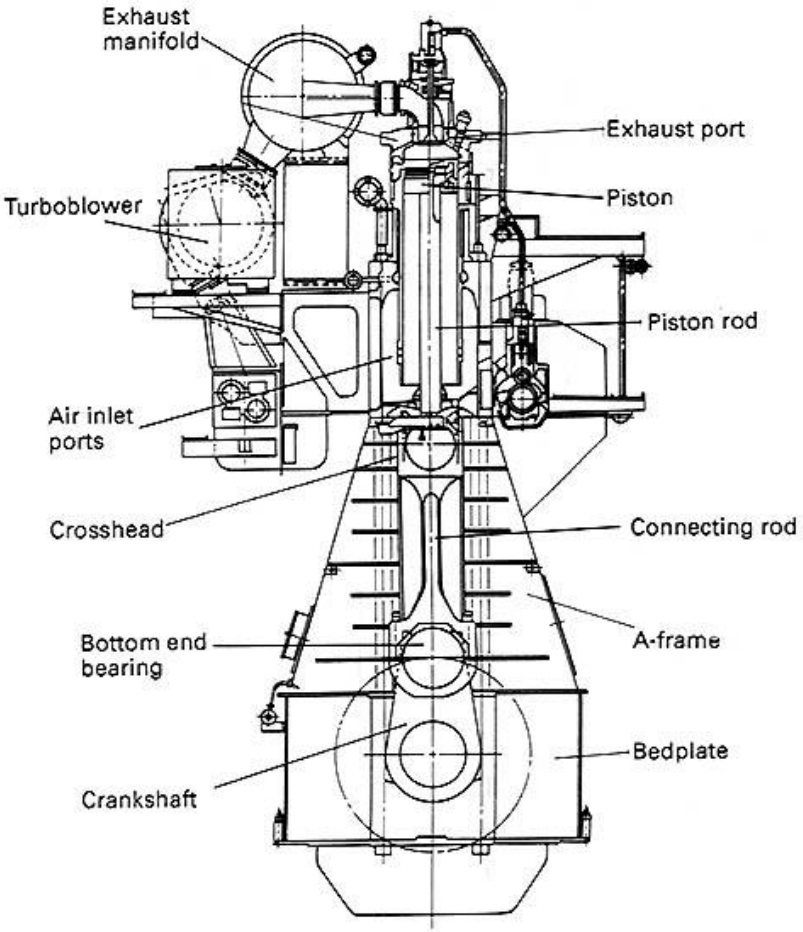
Cylinders, engine housing, crankcase,

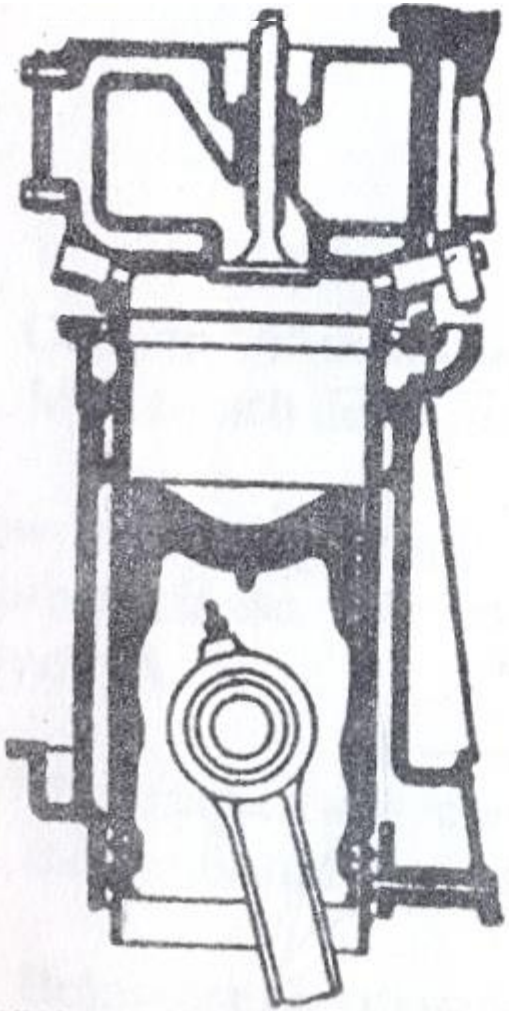
bedplate, frames, columns, cylinders, tie bolts, …

- A. Spinčić & B. Pritchard: Unit 1, Engine Parts http://www.pfri.uniri.hr/~bopri/documents/01CylinderandCrankcaseMB_001.pdf
- W. Buczkowska: ***MarEngine English Underway***, Unit 15, p. 144-147
- https://www.brighthubengineering.com/marine-engines-machinery/9600-marine-diesel-engines-and-their-use-on-board-ships/
- https://shipinsight.com/two-stroke-diesel-engines-ships/
- http://www.marineengineering.org.uk/page46.html
- https://www.slideshare.net/engineman/13-diesel-engine-stationary-components

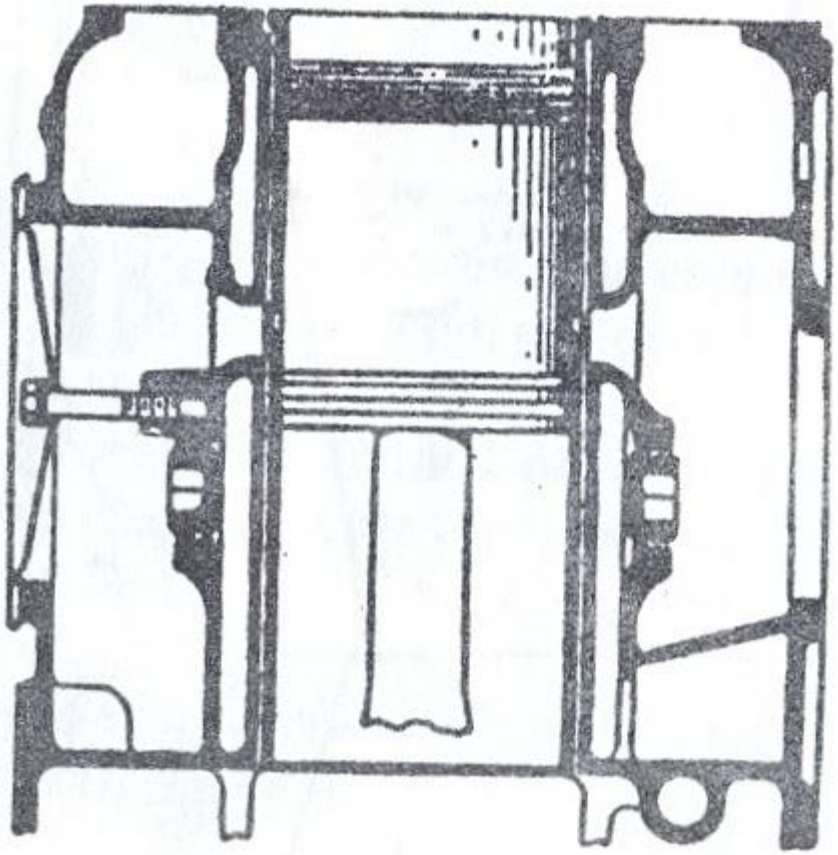

Cylinder Head
Liner
Cooling Water space
Cylinder block(Entablature
Slipper Guide
Strenghtening Webs
A-Frame
Transverse girder
Bed plate side girder
Tie rod nut

Marine diesel engine – cross section





"Wet" Liner. Liner is inserted into cylinder casting to form water jacket.
(Power Magazine)



"Dry" Liner. Liner makes metal-to-metal contact with cylinder casting containing water jacket.
(Power Magazine)

The **cylinders** of marine diesel engines are water cooled. The bore of each cylinder is formed in a liner which can be replaced when worn out and which is surrounded by a cooling water jacket. The water is in direct contact with the outer surface of the liner as a result of which it is termed a " wet " liner. In the most usual arrangement cylinder liners are enclosed in one cast iron casing forming a cylinder block.

Complete the sentences below

- The cylinders of marine diesel engines are …… .
- The bore of each cylinder is formed in a liner which …… when worn out and which is surrounded by a cooling water jacket.
- The water is in direct contact with the outer surface of the liner as a result of which ……
- In the most usual arrangement cylinder liners are enclosed ……forming a cylinder block.

Cylinder Frame (Marine Engine)

8-Cylinder Marine Engine (500~720kW)

Technical Specification of 8-Cylinder Diesel Engine:

Model	Rated power (kW)	Rated rpm (r/min)	Fuel consumption(g/kW.h)	Oil consumption(g/kW.h)	Overall dimensions (mm)	Net weight (kg)
8190ZLCZ-R	720	1450	≤204	≤1.2	3175×1220×2055	5200
8190ZLC	720	1450	≤204	≤1.2	3175×1220×2055	5200
8190ZLCZ-1R	600	1200	≤202	≤1.2	3175×1220×2055	5200
8190ZLC-1	600	1200	≤202	≤1.2	3175×1220×2055	5200
8190ZLCZ-2R	500	1000	≤202	≤1.2	3175×1220×2055	5200
8190ZLC-2	500	1000	≤202	≤1.2	3175×1220×2055	5200
8190ZLCZ-3R	650	1300	≤202	≤1.2	3175×1220×2055	5200
8190ZLC-3	650	1300	≤202	≤1.2	3175×1220×2055	5200

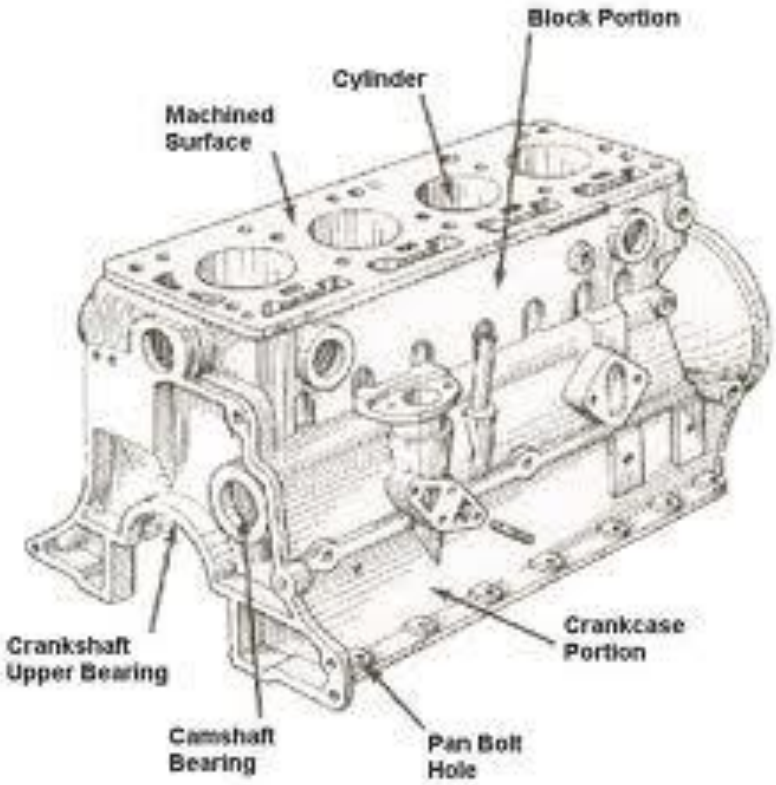
The **cooling water jacket** is common to all the cylinders, but there are often dividing walls to ensure that each cylinder receives the right amount and flow of water. Doors are provided on the **cylinder casing**, through which the water spaces may be cleaned and inspected when overhauling the engine.

In an alternative construction the liners do not come in direct touch with the cooling water but make a metal - to - metal contact with the cylinder casting which contains the water jackets and are known as " **dry " liners**. These can be made fairly thin as the cylinder casting itself withstands all stresses. Close contact between dry liner and casting is absolutely necessary ; if it is missing, considerable resistance to heat flow results.

Supply the missing term

The _____ is common to all the cylinders, but there are often dividing walls to ensure that each cylinder receives the right amount and _____ of water. Doors are provided on the _____, through which the water spaces may be cleaned and inspected when _____ the engine. In an alternative construction the _____ do not come in direct touch with the cooling water but make a metal - to - metal contact with the cylinder casting which contains the water jackets and are known as _____. These can be made fairly thin as the cylinder _____ itself withstands all _____. Close contact between dry liner and casting is absolutely necessary ; if it is missing, considerable _____ to heat flow results.

Cylinder block



The top of each cylinder is closed by a **cylinder head or cover** held down by **studs** and nuts to the **cylinder block** making a gas - tight seal between the head and the liner. The complete **cylinder block** is supported above the crankcase by a structure which may take one of several forms.

A typical design of a slow speed marine diesel engine is shown in Fig. 1.3. The crankshaft is carried in bearings formed in a **bedplate**. On the bedplate is mounted a **casting** termed the **column** or **frame** which forms the crankcase and supports the cylinder block.

The forces produced by the gas pressure in the cylinders are transmitted from the top of the cylinder block directly to the bedplate by the **tie bolts (tie rods).** These bolts pass through all the separate components of the structure, thus maintaining them in compression and ensuring that all major tensile loads are carried by the steel members.

Put the bolded phrases in the right place in the sentence

- The top of each cylinder a cylinder head or cover held down by studs and nuts to the cylinder block between the head and the liner. **is closed by / making a gas - tight seal**
- The complete cylinder block by a structure which may take one of several forms. **is supported above the crankcase**
- A typical design of a slow speed marine diesel engine in Fig. 1.3. **is shown**
- The crankshaft is carried formed in a bedplate. **in bearings**
- On the bedplate is mounted a casting termed the column or frame the crankcase and supports the cylinder block. **which forms**
- The forces produced by the gas pressure in the cylinders from the top of the cylinder block by the tie bolts (tie rods). **are transmitted / directly to the bedplate**
- These bolts pass through all the separate components of the structure, in compression and all major tensile loads are carried by the steel members. **thus maintaining them / ensuring that**

Questions and Discussion

- What are diesel engines cooled with ?
- Where does the cooling water circulate ?
- What does the cylinder block enclose ?
- What is the function of the dividing walls in the water spaces ?
- Why is a firm contact needed between a dry liner and the cylinder casting ?
- How is a gas - tight seal between a head and a cylinder ensured ?
- What other types of seal do you know ?
- Describe the type of crankcase shown in Fig. 1.3.
- What are tie bolts intended for ? What loads do they have to carry ?
- State the main structural features of petrol engines used in motor cars.

VOCABULARY:

I Column "A" includes definitions of some of the terms listed in column "B". Match each definition with the right term forming a full sentence.

Ex. The *crankcase* may be defined as the housing that contains the crankshaft and provides the space for its rotation.

A	B
1. Replaceable “sleeve” inserted in the cylinder block directly surrounded by cooling water. 2. Steel rod running from the bedplate to the cylinder block to the tie the structure together in vertical direction. 3. Component closing the top end of the cylinder so as to make a confined space in which to compress air. 4. Base supporting the crankshaft bearing and enclosing the lower part of the crankcase. 5. Enclosed space surrounding the cylinder liner for the cooling water to circulate 6. Stretching force produced by firing pressures tending to push the cylinder head and the crankshaft bearings apart 7. Casting containing the cylinders.	a. **Crankcase** b. **Cylinder head** c. **Wet liner** d. **Dry liner** e. **Cylinder block** f. **Tensile loads** g. **Column** h. **Water jacket** i. **Tie bolt** j. **Bed plate** k. **Cylinder bore** l. **Bearings**

II. The two diagrams below represent the main stationary (i.e. fixed) parts of a marine diesel engine

- Complete the labeling against the letters (a - j).
- Give a description of each element with reference to its location, function, material or any feature you can think of.

III For each of the words in the list A find a word of similar meanings in List B (the words of the latter group are used in the text)

List A	List B
1. to carry	a. *to mount*
2. cover	b. *to surround*
3. circulation	c. *component*
4. contact	d. *to close*
5. to encircle	e. *flow*
6. to hold	f. *to maintain*
7. part	g. *head*
8. to place (on)	h. *to support*
9. to resist	i. *touch*
10. to shut	j. *to withstand*

IV. Choose suitable words from list B in the slide above to replace the underlined expressions

- The structure of most engines consists of three parts: the bedplate, frame and cylinder block all being held in compression by long tie bolts to resist the stresses created by the firing loads.
- A casting, known as the column, is placed on the bed plate and carries the cylinder block.
- In order to keep low temperature cylinder liners are encircled with a jacket and cooling is carried out by the circulation of fresh water.
- A liner is said to be wet when its outer surface is in direct contact with cooling water.
- A cover shuts the top end of cylinders; in some types of engine the cylinder cover is in two parts; a cast iron water - cooled lower half and a cast - steel uncooled upper half.

V. Find words of opposite meaning for the following using them in sentences your own:

thin, inner, minor, bottom, dry.

Ex. *A gas tight seal means a seal preventing any leak of gas.*

VI. Study the examples listed below:

a. ***Wear*** *in a cylinder liner is mainly due to friction, abrasion and corrosion.*

b. *After some time in service the bore of the liners* ***wears*** *unevenly.*

The word wear is used as a noun in (a) and as a verb in (b).

Fill in the blanks using the correct form of the word choosing among *WEAR* (noun or verb), *WORE* (past tense), *WORN* (past participle) and *WEARING* (gerund)

1. The use of wrong or _____ tools can cause damage.
2. When valve seat _____ , it must be renewed.
3. On the last voyage the liners _____ at an excessive rate due to the burning of low grade fuel.
4. Do cylinder liners _____ at constant rate during the life of an engine.

During the first few months there is a rapid _____ . After that, the rate is reduced, but _____ away of the liners and piston rings continues.

6. The usual practice is to renew cylinder liners when they have _____

5 - 6 mm on the diameter as a maximum.

Grammar:

ODNOSNE REČENICE (I)

(Relative Clauses, Adjectival Clauses)

- *The bore of the cylinder is formed in a liner which can be replaced when worn out and which is surrounded by a cooling water jacket.*

- *Dry liners … make metal - to - metal contact with the cylinder casting which contains the water jackets.*

Relative Clauses

- *Istaknute rečenice opisuju (specificiraju) i pobliže označuju značenje riječi na koje se odnose, tj. koju opisuju. Te su riječi uglavnom imenice kao npr. " liner " i " water jacket" u gornjim primjerima.*
- *Relativne rečenice uvode se odnosnim zamjenicama* ***WHICH*** *(za stvari),* ***WHO, WHOM, TO WHOM*** *(za ljude) te* ***THAT*** *(za stvari i ljude) i* ***WHAT*** *(u odnosu na čitavu rečenicu ispred relativne rečenice.*
- *Budući da se odnose samo na imenicu ili imeničku grupu koju opisuju, one se najčešće umeću u strukturu rečenice.*
- *Relativne rečenice vrlo se često javljaju u tehničkom tekstu.*

Relative Clauses

For cooling purposes the quantity of oil that flows through the piston is more important than the temperature.

Odnosne rečenice imaju ulogu sličnu pridjevu, pa se stoga i nazivaju pridjevskim rečenicama, usp.:

The auxiliary engine

= *The engine that is used for auxiliary purposes* (i.e. lighting, refrigeration, deck machinery, etc.)

Relative Clauses: exercises

II. Link the following pair of sentences with WHICH, WHO or THAT, omitting the unnecessary words

Eg. The junior engineer was urgently taken to the hospital. ***He had seriously injured his arm.***

The junior engineer, who had seriously injured his arm, was urgently taken to the hospital.

Relative Clauses: exercises

1. The cylinder block is covered by the cylinder head. In the cylinder block the liners are fitted.

2. In Vee engines the top of the column has two sloping surfaces. On these surfaces the cylinder blocks are placed.

3. The tie bolts connect the main parts of engine structure. They transmit the forces produced by the gas pressure in the combustion chamber.

4. The bedplate provides a support for the main bearings. The crankshaft is carried by the main bearings.

Relative Clauses: exercises

1. I have just talked to the Chief Engineer. He has been sailing for twenty years.
2. Doors are fitted to the cylinder casting. Through these doors the water spaces may be cleaned and inspected.
3. Second and the Third Assistant Engineers shall report to the First Assistant Engineer. He shall assign them the duty.
4. The general maintenance and repair works are to be done during the drydocking in Rotterdam. We discussed and planned them last night. (Passive Relative Clause)

Relative Clauses: exercises

5. Yesterday Mr. Brown joined ship to take over his duty. Mr. Brown had been appointed to the vacant post of Chief Engineer.

6. Ship's spares must immediately be re-ordered. We have used some spares in recent repairs. (Passive Relative Clause).

TRANSLATION

II Translate into English

- Poklopci, koji zatvaraju gornji kraj cilindra, su pričvršćeni usadnim vijcima na bloku motora.
- Vođa stroja koji je primjetio kvar (failiure) na kotlu, odmah je obavijestio oficira stroja.
- Kod brodskih motora koji su građeni u V - izvedbi (Vee - form) cilindarski blokovi smješteni su (place) pod određenim kutom jedan prema drugom.
- Voda koja se upotrebljava za hlađenje cilindra mora se prije ulaska u vodeni plašt pročistiti.
- Specijalni ručni moment-ključ (torque wrench) kojim se mogu pritezati (tighten) kotveni vijci, uštedio je mnogo sati neugodnog (unpleasant) rada ispod poda(platform) glavnog motora.

TEST:

Test 1. Supply the missing words

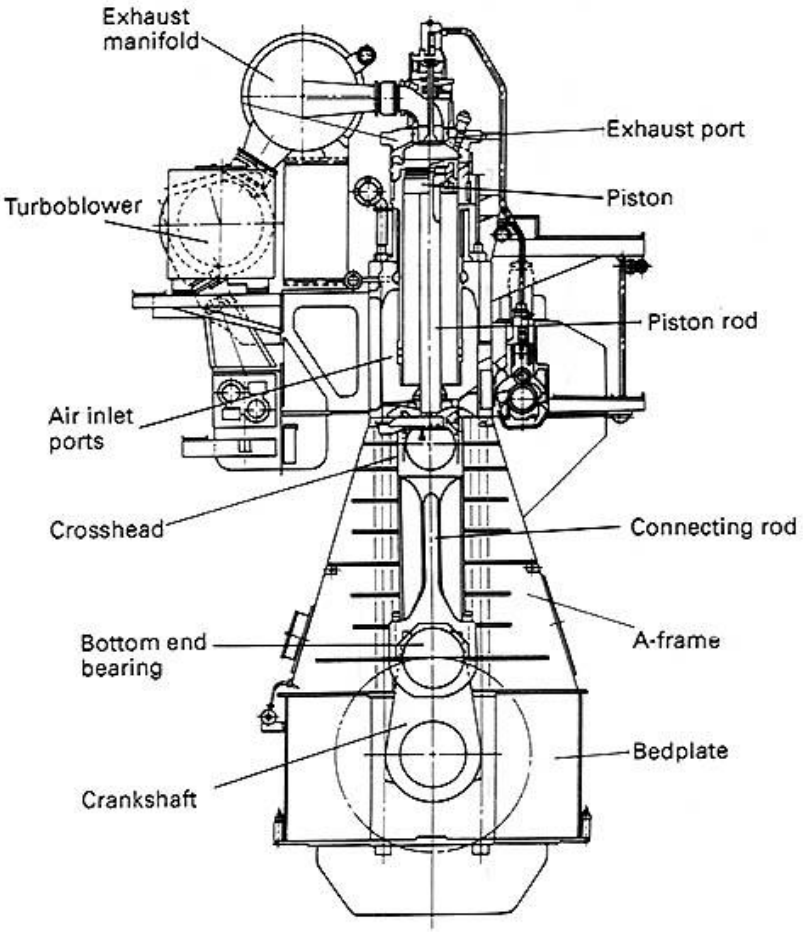
loads, bore, liner, wet, cylinder block, frame, cooling water jacket, casing, overhauling, metal - to - metal, dry, withstands, casting, cylinder head, studs, seal, crankcase, bearings, cylinders, bedplate, tie bolts, water jacket

The _____ of marine diesel engines are water cooled. The _____ of each cylinder is formed in a _____ which can be replaced when worn out and which is surrounded by a cooling _____. The water is in direct contact with the outer surface of the liner as a result of which it is termed a " _____ " liner. In the most usual arrangement cylinder liners are enclosed in one cast iron casing forming a _____.

loads, bore, liner, wet, cylinder block, frame, cooling water jacket, casing, overhauling, metal - to - metal, dry, withstands, casting, cylinder head, studs, seal, crankcase, bearings, cylinders, bedplate, tie bolts, water jacket

The _____ is common to all the cylinders, but there are often dividing walls to ensure that each cylinder receives the right amount and flow of water. Doors are provided on the cylinder _____, through which the water spaces may be cleaned and inspected when _____ the engine. In an alternative construction the liners do not come in direct touch with the cooling water but make a _____ contact with the cylinder casting which contains the water jackets and are known as " _____ " liners. These can be made fairly thin as the cylinder casting itself _____ all stresses. Close contact between dry liner and _____ is absolutely necessary ; if it is missing, considerable resistance to heat flow results.

Marine diesel engine – cross section



Buczkowska 2014, p144

- *Engine **housing** refers to all the stationary parts that support the entire engine loads and forces, hold the crankshaft, permit engine foundation work and accommodate cylinder blocks.*
*The design of the engine housing depends mainly on the engine type, size and weight. The most crucial factor, however, is the way the **crankshaft** is installed.*

- ***Engine housing** can include such **stationary parts** as: the **bedplate, frames, columns, crankcase** and **tie bolts**.*
*The **bedplate** is the foundation on which the engine is built. Sometimes it is defined as a **crankcase sub-base**.*
*The bedplate consists of two **longitudinal girders** which run along the length of the engine. The **transverse girders**, which connect them, are positioned between each crankshaft throw at both sides of the thrust collar.*

Buczkowska 2014, p144

- *Engine **housing** refers to …….. that support the entire engine loads and forces, hold the crankshaft, permit engine foundation work and accommodate …….. .*
*The design of the engine housing depends mainly on the engine …….. . The most …….. , however, is the way the **crankshaft** is installed.*

- ***Engine housing** can include such **stationary parts** as: the bedplate, …….. .*
*The **bedplate** is the foundation on which …….. .*
Sometimes it is defined as a …….. .

- *The bedplate consists of two **longitudinal girders** which …….. of the engine. The **transverse girders**, which …….. , are positioned between each …….. at both sides of the thrust collar.*

Buczkowska 2014, p. 144

- *The **bedplate** must be rigid enough to support the rest of the engine and hold the crankshaft in alignment with transverse girders. At the same time it must be flexible enough to hog and sag with the foundation plate to which it is attached and which forms part of the ship structure. If the bedplate were too rigid, the **holding down bolts**, which secure the engine and keep it firmly in one place, would most likely break and cause a danger of bedplate cracking.*
- *Modern bedplates are made of fabricated **longitudinal girders** with cast steel transverse sections.*

*The engine housing of a modern 4 stroke medium-speed diesel engine can be made either as a single **casting** or fabricated from **cast steel sections** welded with steel plates.*

- *Most of today's four-stroke marine engine housings are manufactured with the underslung **crankcase** which is held by a bedplate and ensures high stiffness to the engine block.*

Buczkowska 2014, p. 144

Supply the missing terms:

- *The **bedplate** must be rigid enough to _____ the rest of the engine and hold the crankshaft in _____ with transverse girders. At the same time it must be flexible enough to hog and sag with the _____ to which it is attached and which forms part of the ship structure. If the bedplate were too rigid, the **holding down bolts**, which _____ the engine and keep it firmly in one place, would most likely break and cause a danger of bedplate _____.*
- *Modern bedplates are made of fabricated **longitudinal** _____ with cast steel transverse sections. The engine housing of a modern 4 stroke medium-speed diesel engine can be made either as a single _____ or fabricated from _____ **sections** welded with steel plates.*
- *Most of today's four-stroke marine engine _____ are manufactured with the underslung _____ which is held by a bedplate and ensures high stiffness to the _____.*

Stationary components

- Each component design must not only be optimised for its own purpose, but also in some cases, to provide strength to the overall structure.
- An example of this is how the **bedplate** and **A-frame** combine to create a strong rigid box able to resist the forces of combustion and maintain essential alignment for the crankshaft and over moving parts.
- The **entablature** not only supports the cylinder liner and head it also creates areas for cooling water and scavenging air.
- **Cylinder blocks** must be cast, due to the difficulties in casting large components generally single cylinder blocks are created joined to each other and to a common fabricated A-frame/bedplate box.
- The most highly loaded pat of a bedplate is the **transverse girder.** Classification societies require that residual stress is removed after construction.

Stationary Components

- Each component design must not only be optimised for its own purpose, but also in some cases, to provide …… .
- An example of this is how the **bedplate** and **A-frame** combine to create a strong rigid box able to resist …… and maintain …… for the crankshaft and over moving parts.
- The **entablature** not only …… and head it also creates areas for cooling water and scavenging air.
- …… must be cast, due to the difficulties in casting large components generally single cylinder blocks are created joined to each other and to a ……

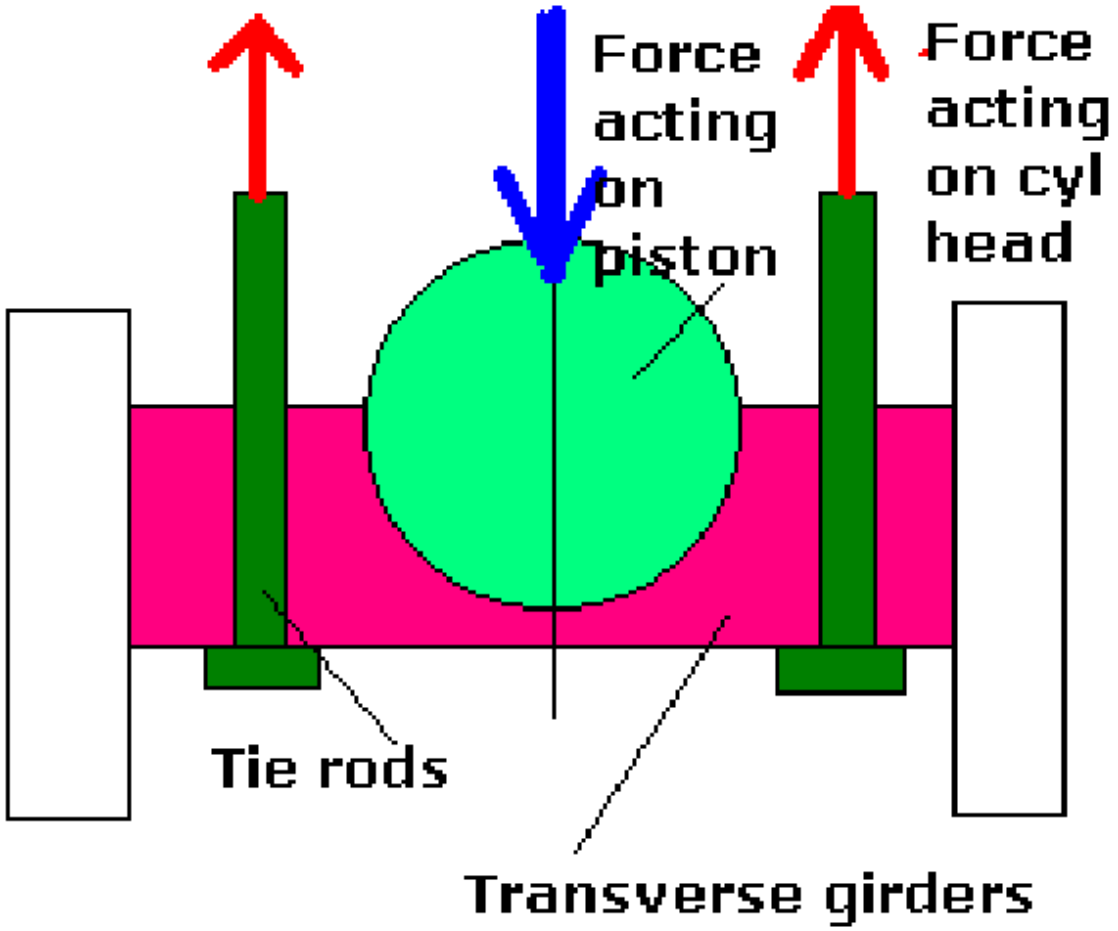
Bedplate

- The **bedplate** acts as the main strength member, maintains correct alignment and supports the weight of the components. it must be capable of withstanding the fluctuating forces created during operation and transmit them to the ships structure. In addition it may also collect lubricating oil. In slow speed engine design, it consists of a deep longitudinal box section with stiffening in the form of members and webs.
- **Transverse members** are fitted between each throw of the crankshaft. These support the main bearing saddles and Tie -rod connection. They are attached to the structure by substantial butt welds.
- To reduce the engine height the **sump of the bedplate** may be sunken allowing it to fitted into a recess in the ships structure.
- Plate and weld preparation is required with welds of the double butt type if possible. Regular internal inspection of the parts especially the **transverse girder** is required for fatigue cracking.
- **Tie bolts** should be checked for tightness.

Box girders

- A box girder is stronger and more rigid then I or H section girder of the same c.s.a.
  - From the simple beam bending equation we have;
  - M /I = s /y = E/R
  - **M**=Bending moment
    I=2nd moment of area of the cross section
    s =Stress
    y=distance from the axis of bending to the outer face
    E= modulus of elasticity
    R-radius of curvature of the bending.

- This can be arranged into s = (M/I) .Y


Force acting on piston
Force acting on cyl head
Tie rods
Transverse girders

Tie rods

- **The transverse girder** acts as a simple beam with the forces of combustion acting on the piston passing down through the bearing. The forces acting on the head are passed through the Tie rods.
- It can be seen that to reduce the bending moment the tie rods have to be brought closer to the crankshaft. The limit to this is the securing arrangement required for the main bearing keep. One method is to use two instead of one bolts which can be made of smaller diameter. Sulzer use an alternative and very successful method in the form of jacking bolts. These jack against the bottom of the A-frame.
-

The bedplate

- A typical marine diesel engine of a normal sized ship easily resembles the appearance of building having several **floors** in height and a sufficient covered area.
- A solid foundation is necessary for any structure, be it on the ground or meant for the sea. No doubt this axiom applies equally well to marine diesel engines which are huge and gigantic structures and have a lot of forces apart from their weight, such as the reactive forces when the huge piston rush up and down through the cylinders.
- It goes without saying that a very strong base is required to support such load and forces and the bedplate of the engine servers as the structural base of the engine. It acts as **housing** for the huge **crankshaft** while it also supports the **cylinder block**.

- The bed plate consists of two **longitudinal girders**, braced by cast steel traverse cross sections. At selected cross sections, the main bearing pockets are line-bored and two vertical holes drilled through them and the section. The main tie-rods are fitted through these into the bedplate.
- The bed plate is lowered into position onto the supports that form part of the ship's hull, then shimmed level and caulked before being fitted with hold-down bolts that run right around the bottom support frame. The **crankshaft main bearing bottom halves** are then fitted to the bed plate bearing pockets and the crankshaft lowered into them. The **top halves** of the main bearing are then fitted and checked for clearance and alignment.

- The **“A" frames** and **entablatures** follow, being bolted together using fitted bolts, before other components are quickly fitted until the engine is completely rebuilt.
- Nowadays, modern diesel engines being manufactured by Wartsila Sulzer and MAN/B&W have recorded a thermal efficiency of over 50 percent of the world’s largest marine diesel engines: the14-cylinder model produces 108,000 horse power.

Tie bolts

- These are positioned at each transverse girder. They are intended to keep the transverse girder in compression at all times thus minimising risk of fatigue cracking. Correct tension is therefore important and this should be checked regularly in accordance with the engine manufacturers instructions, this normally means retensioning the bolts in pairs from the centre of the engine. alternately for'd and aft.
- Tie-rods are often in two parts for ease of manufacture and fitting when head room is restricted. This also makes changing the bolt in the event of breakage simpler
- Pinch bolts are fitted at certain points to prevent vibration which can induce stress and cause fatigue. These must be released before the bolts are retensioned
- Tension should be checked at set intervals, following a scavenge fire, after application of an excessive load, following grounding or collision, or where the landing face have become suspect. Tiebolts are susceptible to fretting, often indicated by the presence of red dust (sometimes called cocoa) around the nut. In the event of this it is important to check the condition of the nut landing and to ensure before retightening that the surface is clean and free from moisture.
- The most common method for applying the correct tension to the bolt is by use of hydraulic jacks. These are mounted on the tiebolt thread above teh nut. The jack stretches the bolt by acting on a removable sleeve surrounding the nut. Once the bolt has been extended the nut may be rotated via slots cut into the sleeve allowing access. Pressure is applied as per manufacturers requirements which extends the bolt within its elastic limit, the nut is screwed down hand tight and the pressure released. A second method involves the nut turning to handtight, then by use of a gauge the nut is rotated a further angle.

Camshaftless engines

- The camshaftless two stroke crosshead engine has two main advantages;
- Firstly it simplifies engine design in particular negating the need for chain or gear driven camshafts. This allows a net reduction in weight, simplifies engine erection and removes some physical constraints for future engine design.

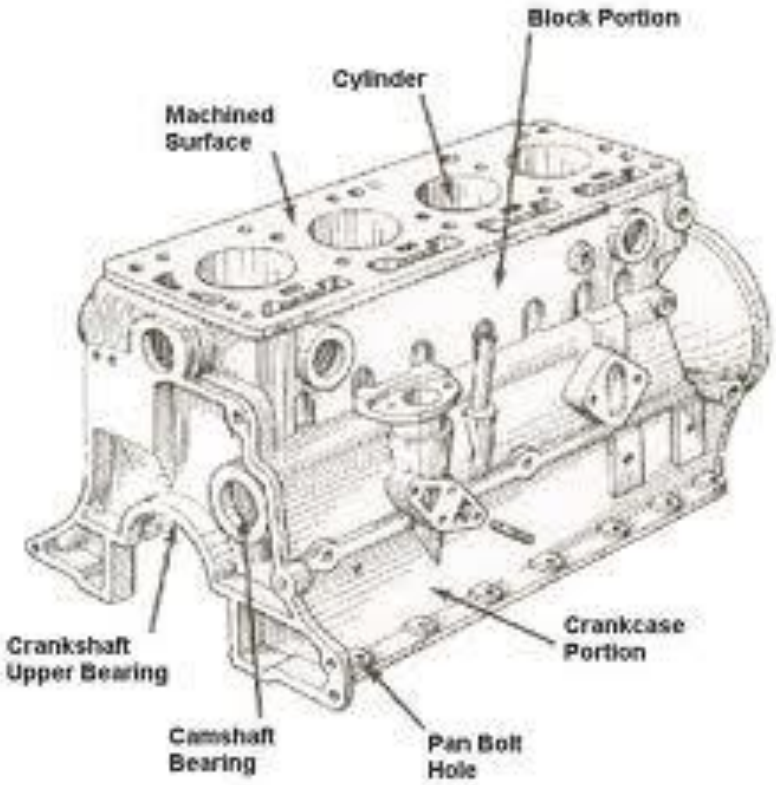
- Secondly, it allows for finite control of parameters such as fuel delivery volume and timing, and exhaust valve opening and closing times.

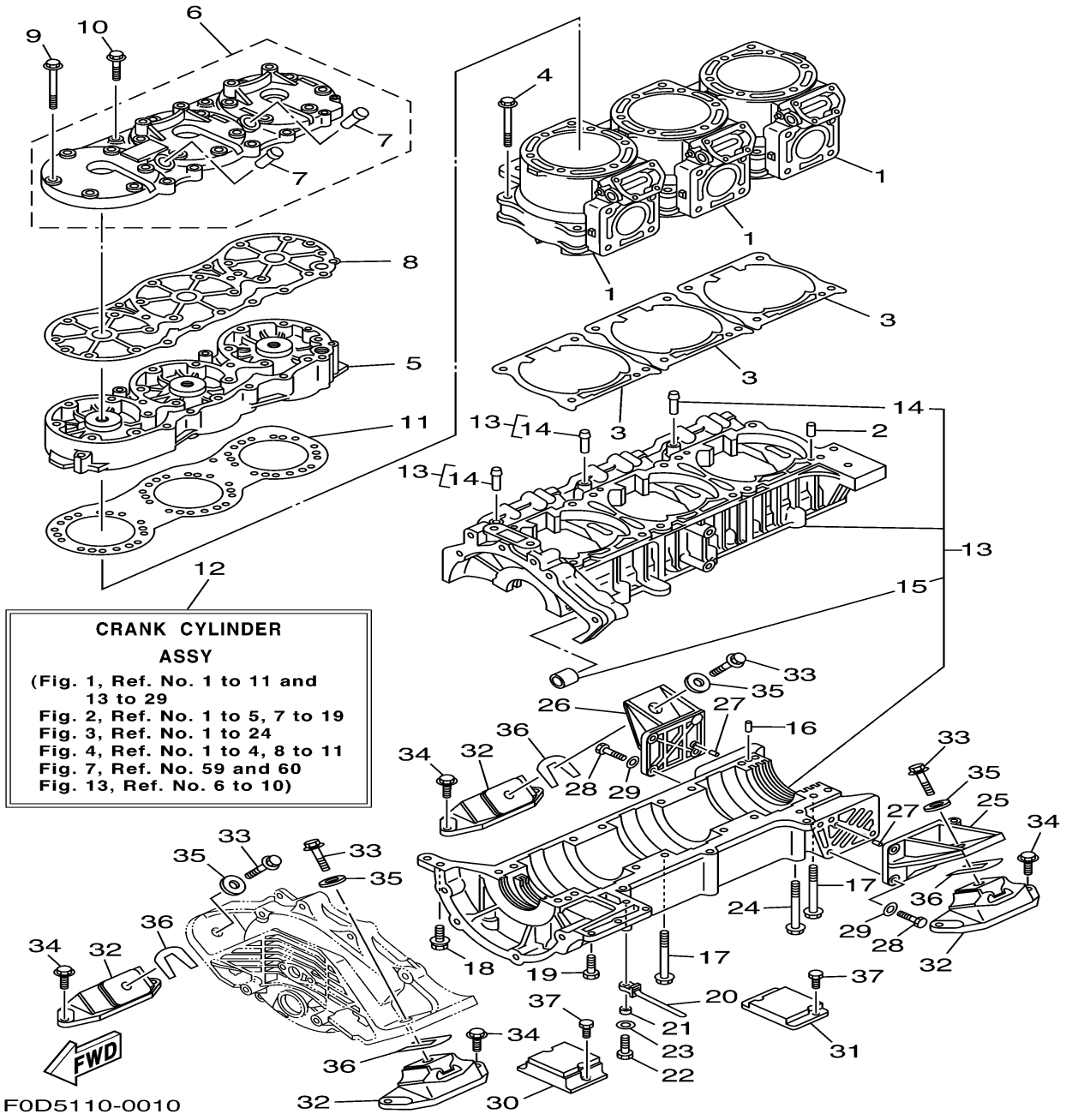
- Traditionally fuel, exhaust valve opening, starting air and cylinder lube oil delivery are all controlled by camshaft lobe design. It is possible now to control these using high reliability solenoid valves. This method is used on the sulzer RT-flex engine
-

Cylinder Frame (Marine Engine)

8-Cylinder Marine Engine (500~720kW)

Cylinder block




CRANK CYLINDER
ASSY
(Fig. 1, Ref. No. 1 to 11 and
13 to 29
Fig. 2, Ref. No. 1 to 5, 7 to 19
Fig. 3, Ref. No. 1 to 24
Fig. 4, Ref. No. 1 to 4, 8 to 11
Fig. 7, Ref. No. 59 and 60
Fig. 13, Ref. No. 6 to 10)
FWD
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