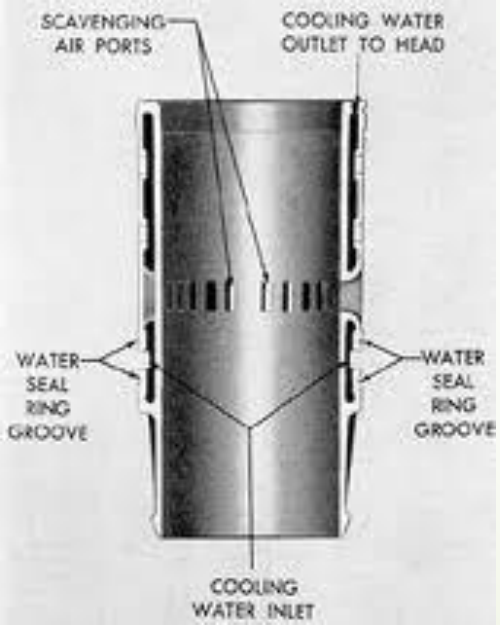
04

Cylinder liners

- https://www.slideshare.net/MarineStudy/the-cylinder-liner-of-diesel-engines


SCAVENGING AIR PORTS
COOLING WATER OUTLET TO HEAD
WATER SEAL RING GROOVE
WATER SEAL RING GROOVE
COOLING WATER INLET

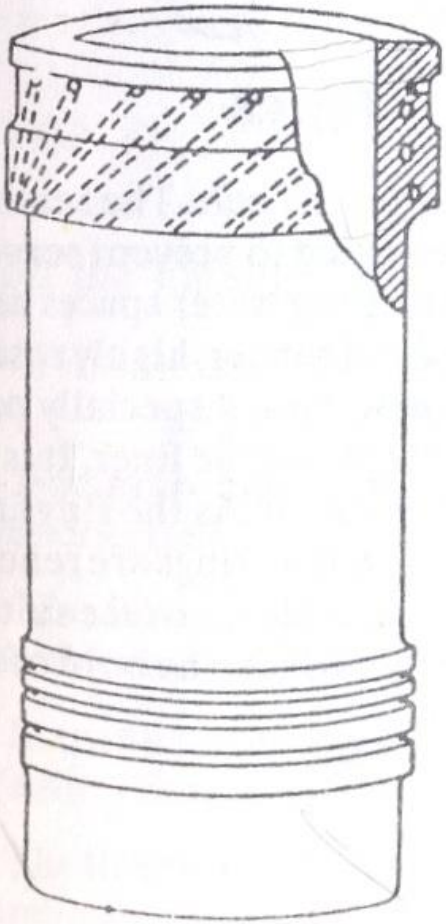


Fig.4.1 - Cylinder liner with bore cooling

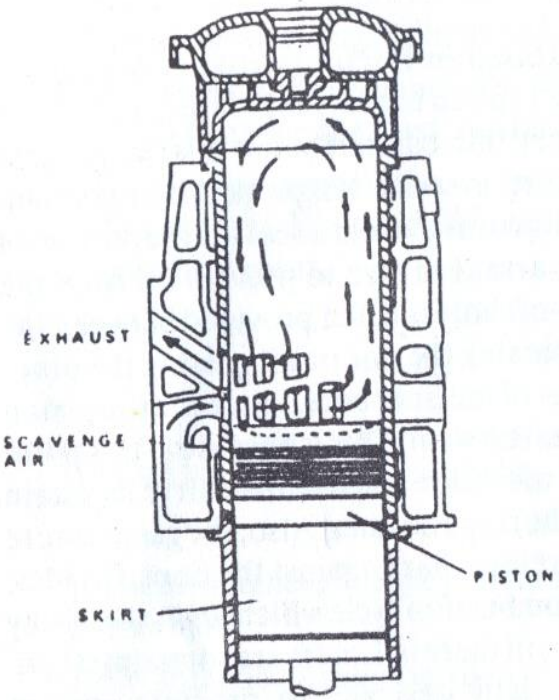

EXHAUST
SCAVENGE AIR
PISTON
SKIRT

Fig. 4.2

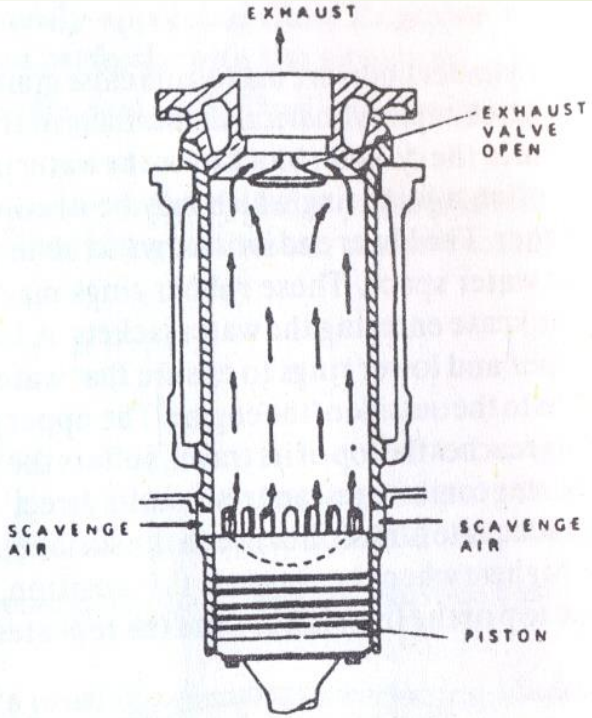

EXHAUST
EXHAUST VALVE OPEN
SCAVENGE AIR
SCAVENGE AIR
PISTON

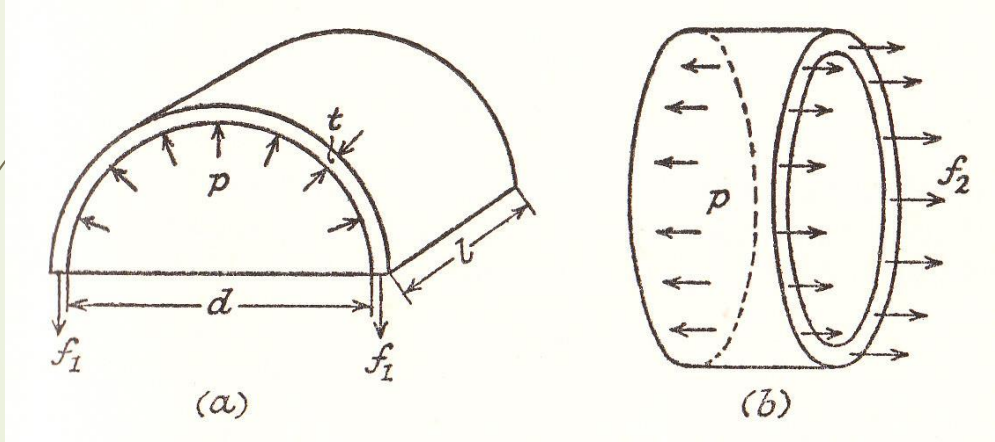
Fig. 4.3

The Cylinder Liner

- Basically the cylinder liner is a hollow cylindrical shell which acts as the enclosure in which the combustion takes place.
- Of course the word hollow does not imply that it is weak in strength for it is under the fluid pressure due to combustion and hence must *withstand* the high level of **hoop stress** induced in it.

cylinder stress

- **Circumferential stress** or **hoop stress**, a normal stress in the tangential (azimuth) direction;
- **Axial stress**, a normal stress parallel to the axis of cylindrical symmetry;
- **Radial stress**, a stress in directions coplanar with but perpendicular to the symmetry axis.
- The classical example (and namesake) of hoop stress is the tension applied to the iron bands, or hoops, of a wooden barrel. In a straight, closed pipe, any force applied to the cylindrical pipe wall by a pressure differential will ultimately give rise to hoop stresses

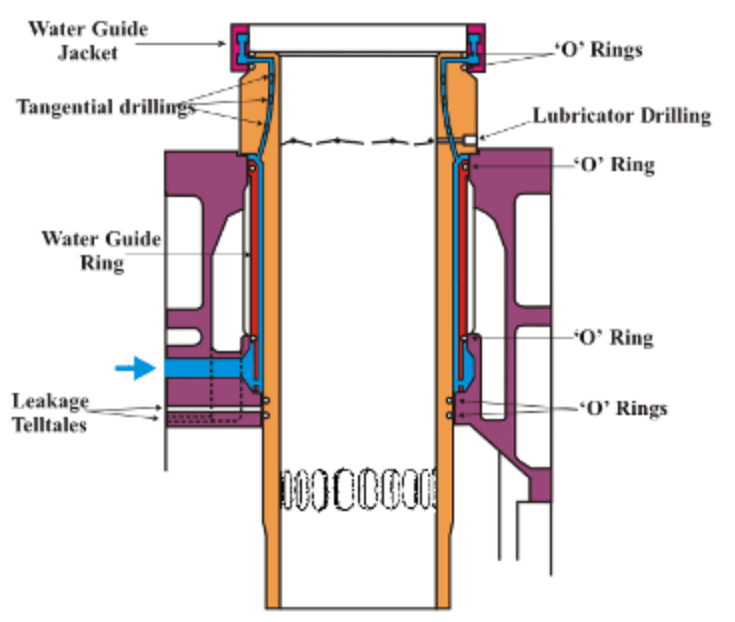

t
p
l
d
f_1
f_1
(a)
p
f_2
(b)

Supply the missing terms

- Basically the cylinder liner is a hollow _____ shell which acts as the enclosure in which the _____ takes place.
- Of course the word hollow does not imply that it is weak in _____ for it is under the fluid pressure due to combustion and hence must _____ the high level of hoop stress _____ in it.

Complete the text below

- Basically the cylinder liner is a hollow cylindrical shell which acts as the enclosure in which … … … .
- Of course the word hollow does not imply that it is weak in strength for it is under the fluid pressure due to combustion and hence must _____ the high level of _____ induced in it.


Water Guide Jacket
'O' Rings
Tangential drillings
Lubricator Drilling
'O' Ring
Water Guide Ring
'O' Ring
Leakage Telltales
'O' Rings

- Another factor is the big temperature difference on the outside and inside (being in proximity of the combustion chamber) of the liner which tends to induce thermal stresses and the liner has to *withstand* those as well. Apart from the liner surface is also resistant to wear and corrosion.
- The picture below shows the image of a typical cylinder liner which is resting on wooden blocks. As you can see from the picture it is made up of quite thick material and the empty slots which we see towards the middle are known as **scavenge ports**.

Supplythe missing word

- Another factor is the big temperature difference on the outside and inside (being in _____ of the combustion chamber) of the liner which _____ to induce thermal stresses and the liner has to _____ those as well.
- Apart from the liner surface is also _____ to wear and corrosion.
- The picture below shows the image of a typical cylinder liner which is _____ on wooden blocks.
- As you can see from the picture it is _____ of quite thick material and the empty _____ which we see towards the middle are known as **scavenge ports**.

Complete the parts ofthe text below

- Another factor is the big temperature difference ... ... (being in proximity of the combustion chamber) of the liner which tends to ... ... and the liner has to *withstand* those as well.
- Apart from the liner surface is also resistant to ... ...
- ... ... shows the image of a typical cylinder liner which is resting on wooden blocks.
- As you can see from the picture it is made up of quite thick material and ... ... which we see towards the middle are known as _____ .

- Given the stringent requirements of strength and anti-corrosion property and provided there is a good surface for the piston rings to slide along its length. Cast Iron is the most widely used **material mainly because of its** lubricating properties which is a result of graphite present in its micro-structure.
- Cast Iron is also **porous** in nature and this helps to prevent or minimize the risk of **seizur**e of the piston during its operation and also is a remedial measure against extensive **galling** (rubbing painfully; chafing) which takes place during piston motion

Supply the missing terms

- Given the stringent requirements of strength and anti-corrosion _____ and provided there is a good surface for the piston rings to slide along its length, _____ is the most widely used **material mainly because of its** _____ which is a result of graphite present in its micro-structure.
- Cast Iron is also _____ in nature and this helps to prevent or minimize the risk of _____ of the piston during its operation and also is a remedial measure against extensive _____ (rubbing painfully; chafing) which takes place during piston motion

Complete the sentences below

- Given the stringent requirements of strength and anti-corrosion property and provided ...., cast Iron is the most widely used **material mainly because .....** which is a result of graphite present in its micro-structure.
- Cast Iron is also **porous** in nature and this helps to prevent or ..... during its operation and also is a remedial measure against extensive **galling** (rubbing painfully; chafing) which .....

- Yet cast iron is not strong enough a material so it is not used in its pure form but **alloyed** with small quantities of elements such as Chromium, Copper or Nickel and such alloying is of the order of 5%.
- Construction is done either by **centrifugal casting** in case of smaller liners and **sand casting** in case of larger liners. The inner surface of the cylinder liner is usually **chrome plated** to make it smooth but this smoothness also has its drawback that it does not allow oil to spread out properly thus affecting liner lubrication in a negative manner. This was rectified to a certain degree through the use of **porous chrome honing**.

Match the the sentences on the left with the ones on the right

Yet cast iron is not strong enough a material so it is not used in its pure form but **alloyed** with small quantities of	smooth but this smoothness also has its drawback that it does not allow oil to spread out properly thus affecting liner lubrication in a negative manner.
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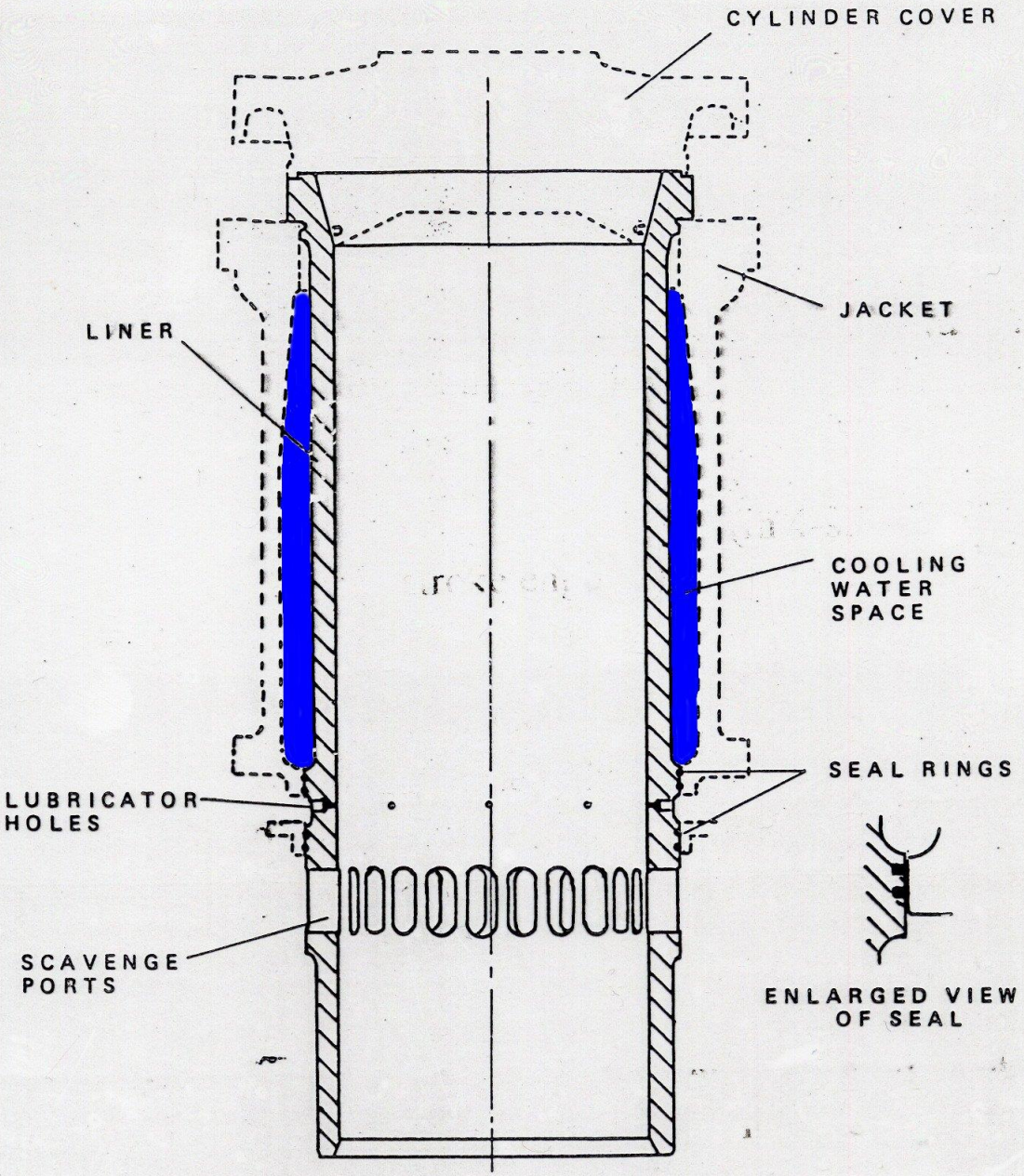
This was rectified to a	and **sand casting** in case of



Cylinder liner

A **cylinder liner** is a removable component, cylindrical in shape, inserted into the engine block. It provides the surface for the piston to slide and carry out its **compression** task. It can be replaced when worn out.

Cylinder liners are made from **close grained** cast iron.

In four stroke cycle engines they are simple cylindrical shapes **flanged** at the top end to provide location and secure them in the **cylinder blocks** or to the **water jacket**. Immediately below this flange there is often a **joint ring** which may be of copper or in some designs of a heat resistant rubber. The lower end is fitted with **rubber rings** so as to form a **seal** for the bottom of the water space. These rubber rings may be arranged also to prevent oil from the **crankcase** entering the water jackets.

Supply the missing terms

A _____ is a removable component, cylindrical in shape, inserted into the engine block. It provides the surface for the piston to slide and carry out its _____ task. It can be replaced when worn out.

Cylinder liners are made from _____ cast iron.

In _____ cycle engines they are simple cylindrical shapes _____ at the top end to provide location and secure them in the **cylinder blocks** or to the _____ . Immediately below this flange there is often a _____ which may be of copper or in some designs of a heat resistant rubber. The lower end is fitted with **rubber rings** so as to form a _____ for the bottom of the water space. These rubber rings may be arranged also to prevent oil from the _____ entering the water jackets.

Supply the missing word

- A **cylinder liner** is a removable _____, cylindrical in shape, inserted into the engine block.
- It provides the surface for the piston to _____ and carry out its **compression** task.
- It can be _____ when worn out.

  Cylinder liners are_____from **close grained** cast iron.
- In four stroke cycle engines they are simple cylindrical _____ **flanged** at the top end to provide location and secure them in the **cylinder blocks** or to the **water jacket**.
- Immediately below this flange there is often a **joint ring** which may be of copper or in some _____ of a heat resistant rubber.
- The lower end is _____ with **rubber rings** so as to _____ a **seal** for the bottom of the water space.
- These rubber rings may be _____ also to prevent oil from the **crankcase** _____ the water jackets.

Complete the sentences below

- A **cylinder liner** is a removable component, cylindrical in shape, ...
- It ... ... to slide and carry out its **compression** task.
- ... ... when worn out.
- Cylinder liners are ... ...
- ... ... they are simple cylindrical shapes **flanged** at the top end to provide location and secure them ... ...
- ... ... there is often a **joint ring** which may be of copper or in some designs of a heat resistant rubber.
- The lower end is fitted with **rubber rings** so as to ... ...
- These rubber rings may be arranged also to ... ...

Guided writing – Read the slide above once again and describe the cylinder liner using the following prompts

- **cylindrical, inserted**
- **surface, slide, compression task.**
- **worn out**
- **close grained**
- **In four stroke cycle engines**
- **a joint ring**
- **lower end, seal**
- **arranged to prevent**

Insert the missing terms

A **cylinder liner** is a removable component, c..... in shape, inserted into the engine b..... . It provides the surface for the piston to s..... and carry out its c..... task. It can be replaced when w..... out.

Cylinder liners are made from close g..... cast iron.

In four stroke cycle engines they are simple cylindrical shapes f ..... at the top end to provide location and s..... them in the cylinder b..... or to the water j..... . Immediately below this flange there is often a j..... ring which may be of copper or in some designs of a heat r.... rubber. The lower end is f..... with rubber rings so as to form a s..... for the bottom of the water space. These rubber rings may be arranged also to prevent oil from the crankcase e..... the w..... jackets.

Complete the sentences below

- Cylinder liners are made from ... ...
- In four stroke cycle engines they are simple cylindrical shapes flanged at the top end

  to ... ...

  and to ... ...
- Immediately below this flange there is often a joint ring which may be of ... or ... ...
- The lower end is fitted with rubber rings so as to ... ...
- These rubber rings may be arranged also to ... ...

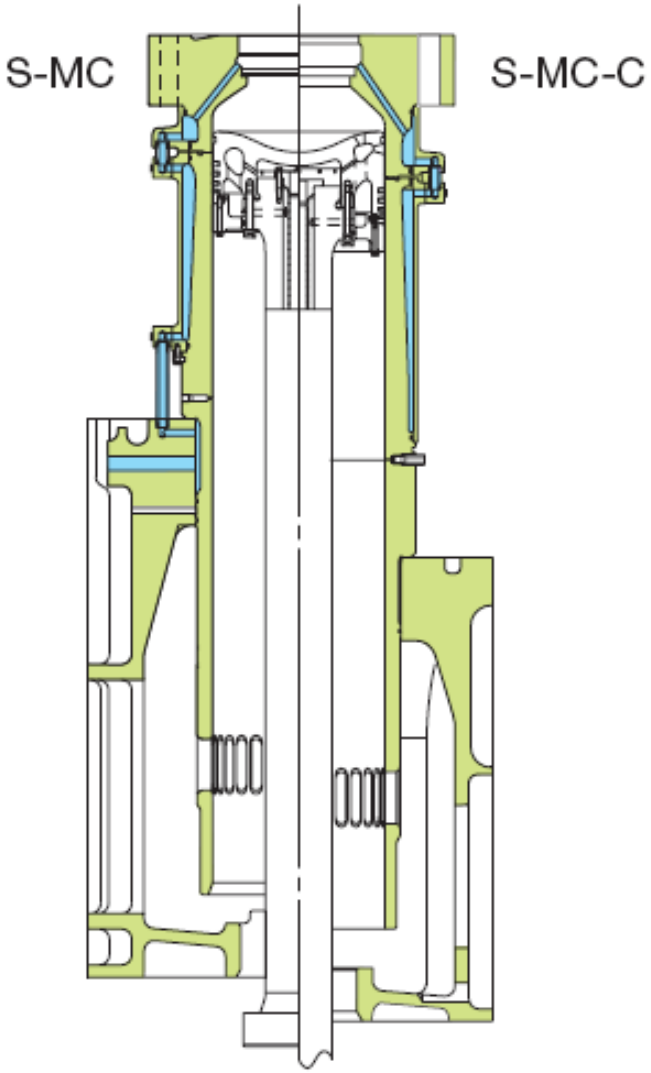
Insert the missing terms

A _____ is often provided between the **upper** and **lower** _____ to ensure that water passing the one or oil passing the other _____ to the outside of the engine. The upper part of the **liner** _____ , where the top piston ring reaches the top of its travel, **suffers** the greatest _____ . This is because at this point the ring comes to rest and _____ its direction of motion and it is difficult to maintain an adequate _____ between the surface of the ring and liner. Also, the _____ pressure is highest when the ring is in this position, forcing it **hard** _____ the liner. Besides, the top of the liner is hot from the repeated _____ **cycle** which tends to dry any oil there is. Liners are sometimes **specially** _____ to promote cooling without sacrificing _____ .

Complete the text below

- A leak-off hole is often provided between ... ... to ensure that water passing the one or oil passing the other runs to ... ...
- ... ..., where the top piston ring reaches the top of its travel, suffers the greatest ..... .
- This is because at this point the ring comes to rest and reverses its ... ... and it is difficult to maintain ... ... between the surface of the ring and liner.
- Also, the gas pressure is highest when the ring is in this position, forcing ... ...
- Besides, the top of the liner is hot ... ... which tends to dry any oil there is.
- Liners are sometimes ... ... to promote cooling without sacrificing strength.

Cylinder Liner and Frame Configuration



Cylinder liner:

- Low position of mating surface cylinder cover/cylinder liner
- Slim cylinder liner
- Straightforward cooling jacket

Cylinder frame:

- Smaller and lighter
- Uncooled and straightforward design

- In **wet liners** the water is in direct contact with outer surface of the liner whereas in **dry liners** the water is in indirect contact with outer surface of the liner, i.e. **cylinder casting** contains wet jackets.

- A **leak-off hole** is often provided between the **upper** and **lower rings** to ensure that water passing the one or oil passing the other runs to the outside of the engine. The upper part of the **liner bore**, where the top piston ring reaches the top of its travel, **suffers** the greatest **wear**. This is because at this point the ring comes to rest and **reverses** its direction of motion and it is difficult to maintain an adequate **film of oil** between the surface of the ring and liner.

- Also, the gas pressure is highest when the ring is in this position, forcing it **hard against** the liner. Besides, the top of the liner is hot from the repeated **combustion cycle** which tends to dry any oil there is. Liners are sometimes **specially designed** to promote cooling without sacrificing strength.

Insert the missing terms

A _____ **hole** is often provided between the **upper** and **lower rings** to ensure that water passing the one or oil passing the other runs to the outside of the engine. The upper part of the _____, where the top piston ring reaches the top of its travel, **suffers** the greatest _____. This is because at this point the ring comes to rest and **reverses** its direction of motion and it is difficult to maintain an adequate _____ **of oil** between the surface of the ring and liner. Also, the gas pressure is highest when the ring is in this position, forcing it _____ **against** the liner. Besides, the top of the liner is hot from the repeated **combustion cycle** which tends to dry any oil there is. Liners are sometimes **specially** _____ to promote cooling without sacrificing strength.

Complete the following

- In wet liners the water is ..... outer surface of the liner whereas in dry liners the water is in indirect contact ....., i.e. cylinder casting contains wet jackets.
- A leak-off hole is often provided between the upper and lower rings to ensure that water passing the one or oil passing the other runs .....
- The upper part of the liner bore, where the top piston ring ....., suffers the greatest wear.

- This is because at this point the ring comes to rest and reverses its direction of motion and it is difficult to ..... between the surface of the ring and liner.
- Also, the gas pressure is highest when the ring is in this position, forcing it .....the liner.
- Besides, the top of the liner is hot from the repeated combustion cycle which tends to .....
- Liners are sometimes ..... to promote cooling without sacrificing strength.

- In the diesel engines that are used as **propulsion plants** for ships, the cylinder liner **scavenge air ports** are machined into the liner. If exhaust ports are used these are machined above the inlet ports. The position of the scavenge ports on the cylinder liner, or the addition of an exhaust valve in the cylinder head depends on the design of the scavenging air system used by engine manufacturer.
- **R**ead more: http://www.brighthub.com/engineering/marine/articles/54062.aspx#ixzz1cOQgs5nf

- In the diesel engines that are used as propulsion plants for ships, the cylinder liner scavenge air ports are _____ into the liner.
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- **R**ead more: http://www.brighthub.com/engineering/marine/articles/54062.aspx#ixzz1cOQgs5nf

Complete the text below

In ... ... the water is in direct contact with outer surface of the liner whereas in ... ... the water is in indirect contact with outer surface of the liner, i.e. **cylinder casting** contains wet jackets.

A **leak-off hole** is often provided between ... ... to ensure that water passing the one or oil passing the other runs ... ...

... ..., where the top piston ring reaches the top of its travel, **suffers** the greatest **wear**.

This is because at this point ... ... and **reverses** its direction of motion and it is difficult to ... ... between the surface of the ring and liner.

Also, the gas pressure is highest when the ring is in this position, forcing it ... ...

Besides, the top of the liner is hot from ... ... which tends to dry any oil there is.

Liners are sometimes ... ... to promote cooling without sacrificing strength.

Scavenging techniques

Efficient scavenging is required to *ensure an adequate supply of combustion air* to the engine. There are three basic types of scavenging techniques in a two-stroke marine diesel engine used to supply fresh air to the **combustion chamber** and extract the resultant **exhaust gasses**: loop scavenging, cross-flow scavenging and uniflow scavenging

Loop Scavenging

- In loop scavenging the **inlet** and **exhaust ports** are machined in the same side of the cylinder liner; the exhaust scavenge ports being above the inlet ports.

Scavenging techniques – complete the text

- Efficient scavenging is required to ensure an adequate ..... to the engine.
- There are three basic types of scavenging techniques in a two-stroke marine diesel engine used to ..... to the combustion chamber and .....: loop scavenging, cross-flow scavenging and uniflow scavenging
- Loop Scavenging: ..... the inlet and exhaust ports are machined in the same side of the cylinder liner; the exhaust scavenge ports are are the ..... .

Cross-flow Scavenging

- In this technique, the inlet and exhaust scavenge ports are machined into the opposite sides of the cylinder; the exhaust ports being above the inlet ports.

Uniflow Scavenging

- This is quickly becoming the most common technique used in scavenging. Here the inlet ports are machined around the liner about 1/3rd of the way up from the bottom. Instead of the usual exhaust ports, an exhaust valve can be used. This is the current method of scavenging employed by the major manufacturers of large two-stroke marine diesel engines.

Cross-flow Scavenging

- In this technique, the inlet and exhaust scavenge ports are machined into the .....; the exhaust ports being ..... .

Uniflow Scavenging

- This is quickly becoming the ..... used in scavenging. Here the inlet ports are machined around the liner about ..... from the bottom.
- ..... the usual exhaust ports, an exhaust valve can be used.
- This is the current method of scavenging employed by the major manufacturers of large ..... .

- Several designs of high output engines have cylinder liners with **deep flanges** in which a large number of small passages is drilled to carry **coolant** close to the cylinder bore. This is so called **bore cooled liner**. (see Fig.4.1). There is a special tube inside the bore for thermal **insulation**. Cylinder liners for the two stroke engines have ports about midway along their length for **admission** of air and for exhaust in case of **loop scavenge engines** (Fig. 4.3).

Insert the missing words

- Several designs of **high** _____ **engines** have cylinder liners with **deep** _____ in which a large number of small **passages** is drilled to carry **coolant** close to the cylinder bore. This is so called _____. (see Fig.4.1). There is a special tube inside the bore for thermal _____ . Cylinder liners for the two stroke engines have _____ about midway along their length for _____ of air and for exhaust in case _____ scavenge engines (Fig. 4.3).

- Modern designs of two stroke engines are provided with **uniflow scavenging system**
- (Fig. 4.3).

The water jackets does not usually extend below the **port belt**. The **sealing rings** are therefore situated just above the ports and are designed to prevent **scavenge air** (and exhaust, in case of **loop scavenge engine**) entering the water spaces as well as the water escaping from the jackets. They are made of special rubber, **highly resistant to** heat and oil. The bores of the cylinder liners, when new, have a specially prepared surface designed to aid the **running-in** of the piston rings and the liner. It is slightly rough in order to retain the oil and to promote rapid **wear-in**. As the rings **run in**, a **glazed surface** is produced which **resists wear**.

Insert the missing terms

- The water jackets does not usually extend below the _____ . The _____ are therefore situated just above the ports and are designed to prevent _____(and exhaust, in case of _____ **scavenge engine**) entering the water spaces as well as the water escaping from the jackets. They are made of special rubber, **highly** _____ heat and oil. The bores of the cylinder liners, when new, have a specially prepared surface designed to aid the _____ of the piston rings and the liner. It is slightly rough in order to retain the oil and to promote rapid _____**.** As the rings _____, a _____ is produced which **resists** _____.

Complete the text below

- .... usually extend below the **port belt**.
- The **sealing rings** are therefore situated just above the ports and are designed .... (and exhaust, in case of **loop scavenge engine**) entering the water spaces as well as ....
- They are made of special rubber, **highly resistant to** ....
- The bores of the cylinder liners, when new, have a specially prepared surface designed to .... and the liner.
- It is slightly rough in order .... and to promote rapid **wear-in**.
- As the rings **run in**, a **glazed surface** is produced which ....

- When the piston rings are **renewed** the **glaze** on the liner bore should be broken by **honing** to provide the surface suitable for rapid **running-in**. In order to provide a harder **wearing surface**, the bore of liners ***is subjected to*** the process of nitriding.

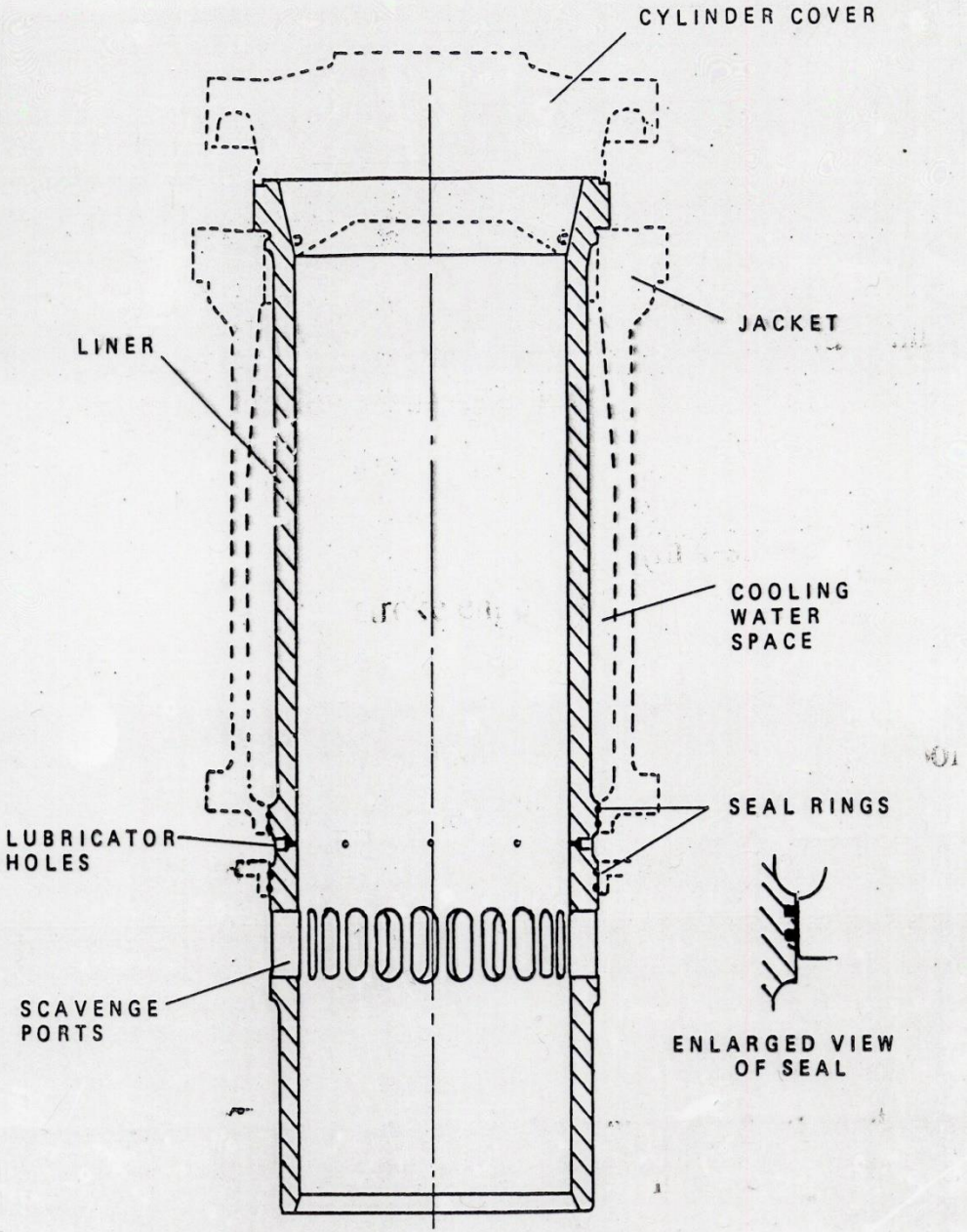
  - *hone/honing:* a tool consisting of a number of fine abrasive slips held in a machine head, rotated and reciprocated to impart a smooth finish to cylinder bores, etc.

Complete the parts of the words below

- When the piston rings are **r**..... the **g** ..... on the liner bore should be broken by **h** ..... to provide the surface suitable for rapid **r** ..... In order to provide a harder **w** ..... ***s*** ....., the bore of liners ***is s*** ..... ***to*** the process of n .....

Complete the text below

- .... the glaze on the liner bore should be broken by honing to provide the surface suitable for rapid running-in.
- .... a harder wearing surface, the bore of liners .... the process of nitriding.



Cylinder liner

PART II.

Material Properties

- in the 1960's the liners were cast in sand molds. Nowadays they are formed using centrifugal casting that involves rotating a mold at high speed whilst pouring in the molten metal.
- During the smelting process, elements are added to the grey cast iron to produce an alloy with improved mechanical properties of hardness, corrosion resistance, and machineability. The most popular alloying elements are:
  - **Manganese** – improves mechanical properties.
  - **Chromium** – adds hardness and corrosive resistance.
  - **Silicon** – reduces the formation of white cast iron, promoting instead the desired grey graphite cast iron.

Material Properties

- in the 1960's the liners were cast in sand _____. Nowadays they are formed using centrifugal _____ that involves rotating a mold at high speed whilst pouring in the molten metal.
- During the _____ process, elements are added to the grey cast iron to produce an alloy with improved mechanical properties of _____, corrosion resistance, and _____
- The most popular alloying elements are:
  - _____– improves mechanical properties.
  - _____– adds hardness and corrosive resistance.
  - **Silicon** – reduces the formation of white cast iron, promoting instead the desired grey graphite _____.

Lubrication

- Although grey cast iron has the property of self lubrication due to the graphite content, lubrication is also provided by a forced total loss system through the quills screwed into strategic points in the liner. The supply of oil is adjusted through the individual lubrication pumps located at the front of the engine at the control level. Any excess oil is removed from the liner by the piston oil scraper rings, and deposited in the scavenge air space. This oil is prevented from entering the crankcase by the piston-rod gland, and is drained into the dirty oil tank. This oil should *never* be reused or added to the heavy fuel oil.

Lubrication - grammar

- _____ grey cast iron has the property of self lubrication _____ the graphite content, lubrication is also provided by a forced total loss system _____ the quills screwed into strategic points in the liner.
- The supply of oil is adjusted _____ the individual lubrication pumps located at the front of the engine at the control level.
- Any excess oil is removed from the liner _____ the piston oil scraper rings, and deposited in the scavenge air space.
- This oil is prevented _____ entering the crankcase by the piston-rod gland, and is drained into the dirty oil tank.
- This oil should *never* _____ reused or added to the heavy fuel oil.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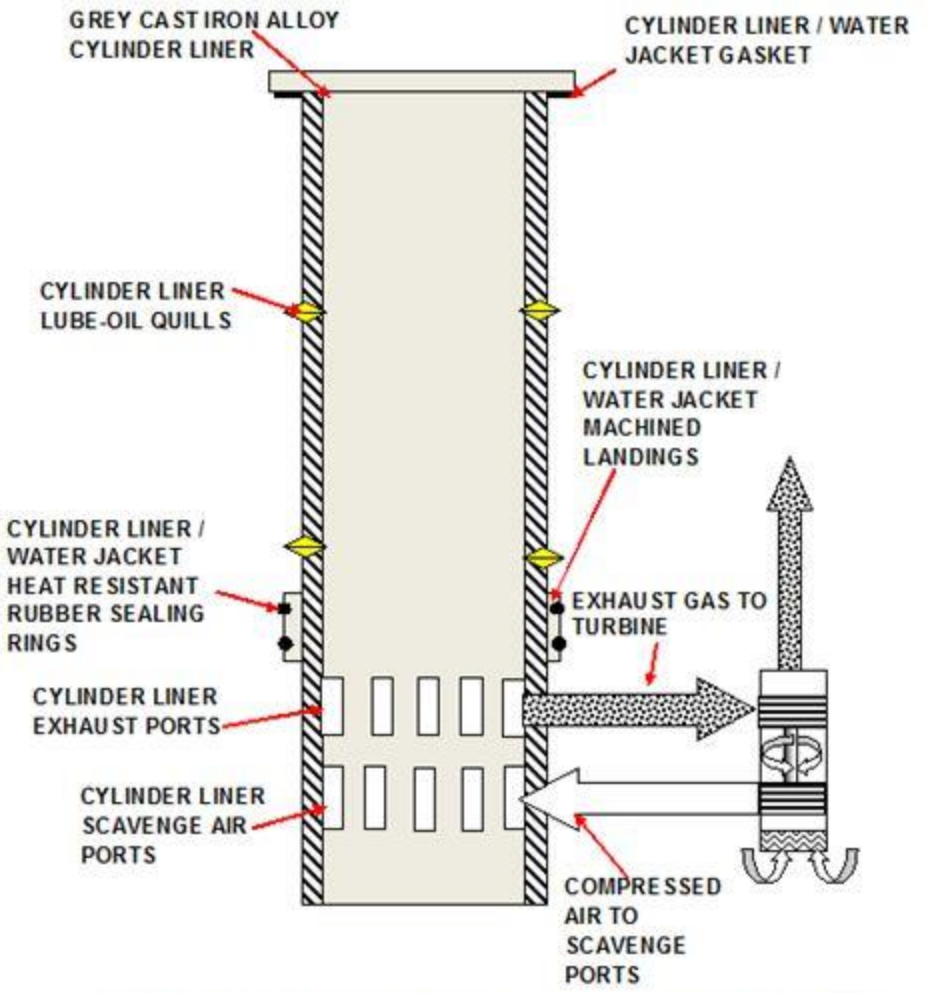
Water Sealing and Cooling

- The cylinder liner is fitted into the water jacket where water is circulated to cool the combustion section of the cylinder.
- To prevent the ingress into the liner through the ports, there are high temperature resistant rubber rings fitted to machined landings above the scavenge and exhaust ports.
- There is also a gasket placed between the top landing of the liner and the water jacket.
- Many years ago when I was a seagoing engineer, we had a problem with the rubber sealing rings allowing water to enter the liner ports. We had to replace these rings at regular intervals this necessitated the "pulling" of the liner; quite a big job involving removal of the cylinder head and piston.
- We were using a well known water resistant grease to lubricate the rubber rings before being fitted into their machined grooves. This was to prevent them twisting or "riding up" when dropping the liners into the water jackets
-

Read more:
http://www.brighthub.com/engineering/marine/articles/54062.aspx#ixzz1cORgM5d1

Operation

- Starting with the piston at Bottom Dead Centre (BDC) the scavenge air ports are exposed allowing a fresh charge of pressurized air to enter the cylinder. As the piston rises, it covers the scavenge air inlet ports and expels the previous cycle exhaust gasses through exhaust ports. The piston continues to rise inside the cylinder liner compressing the air until it reaches almost Top Dead Centre (TDC), fuel is injected, and compression combustion occurs, pushing the pistom back down the liner.
- A sketch of a marine diesel engine cylinder liner using loop system of scavenging is shown below;
-



MARINE DIESEL 2-STROKE CYLINDER LINER CYLINDER LINER WITH LOOP SCAVENGING

Drawn by Willie Scott 18/03/2011

Machining

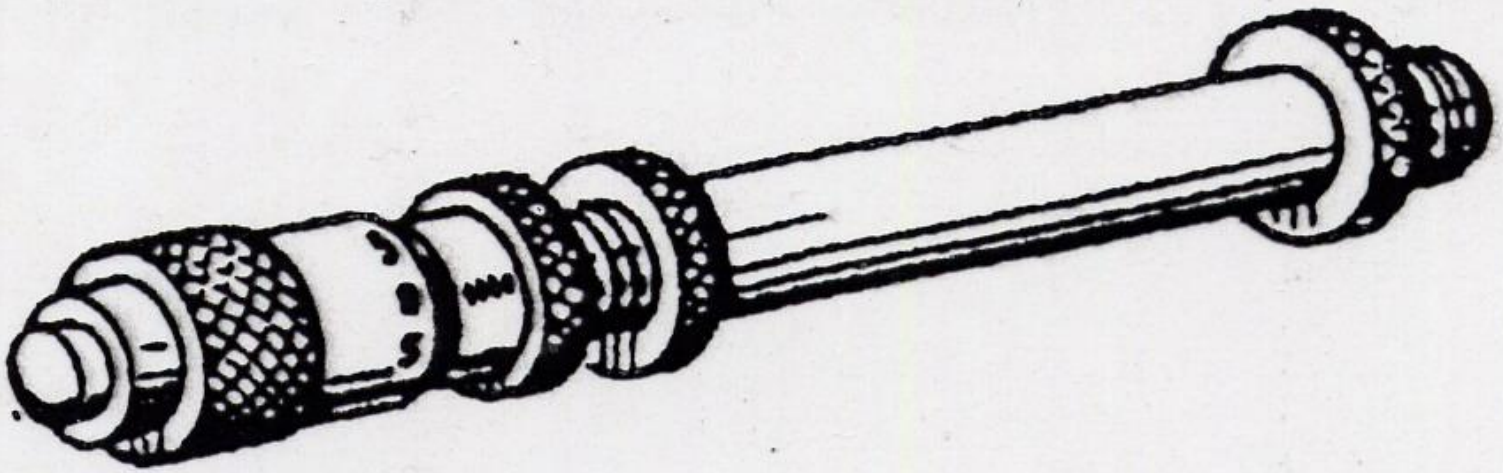
- This consists of internal machining of the bore that contrary to other engines should not have a perfect "hone like" finish. Other machining is carried out on the landings, including cutting the grooves for the rubber ring seals, cutting out of the exhaust /inlet ports and drilling and threading of the penetrations for the insertion of the lube-oil quills.
-

- **GAUGING***
- **It is made internally during cylinder overhaul after 6000 – 8000 hours.**

- 4.1 GAUGE **(micrometer & extension bar / template bar / gaugin strip).**

Gauging

- **It is made internally during cylinder overhaul after 6000 – 8000 hours.**
- 4.1 GAUGE **(micrometer & extension bar / template bar / gauging strip).**
- 4.2 READINGS **(at 6 – 8 vertical positions – total wear from original & wear since last recording)**
- 4.3 WEAR RATES*
- **High at the beginning, later almost constant ;**
  - **acceptable wear – 0.1 mm per 1000 hours;**
  - **maximum wear before renewal – app. 0.6-0.8 % of the original diametar)**



Micrometer

- **Materials of Construction**
- Given the stringent requirements of strength and anti-corrosion property and provide a good surface for the piston rings to slide along its length, Cast Iron is the most widely used material mainly because of its lubricating properties which is a result of graphite present in its micro-structure.

- Cast Iron is also porous in nature and this helps to prevent or minimize the risk of seizure of the piston during its operation and also is a remedial measure against extensive galling which takes place during piston motion.

QUESTIONS AND DISCUSSION

1. *What are cylinder liners made of ?*
2. *What is the use of the flange at the top of the liner ?*
3. *Why are the rubber rings fitted to the lower end of the liner ?*
4. *What must be done if water runs outside through leak-off hole ?*
5. *Why does the upper part of the liner bore suffer the greatest wear ?*
6. *How are cylinder liners in high output engines cooled ?*
7. *Describe the design features of the cylinder liner in loop scavenge and uniflow scavenge engines.*
8. *Why is the inner surface of the cylinder liners in new engines rough ? What is the running-in period ?*
9. *What id the meaning of the words " grinding " and " honing " ?*
10. *What is inspected when the cylinder liners are removed during periodical overhaul ?*

I. Tick off the following statements TRUE - FALSE

- For four - and two - cycle engines the cylinder liners are continuous cylindrical shapes.
- The liners usually carries a flange at the upper end which rests on a shoulder in the cylinder casting and is rigidly attached to it.
- In trunk piston engines the maximum wear occurs about mid-length of a liner because of the piston side thrust.
- The liner wear tends to be greatest at the top of the stroke adjacent to the combustion space.
- As the piston moves upwards the cylinder pressure rises and presses the ring against the liners with increasing force.
- The friction between the piston rings and the liner increases also owing to the fact that the lubricating oil film on the upper part of the cylinder, which is exposed to high temperature gas, has its lubricating properties impaired.

True or false?

- A water jacket seal is made at the lower end of the jacket by copper rings fitted within grooves machined in the liner.
- There is a relief groove between the two rings to allow, in the event of leaks, water or oil to pass outside.
- In loop scavenge engines the gas is expelled through exhaust port in the opposite side of the liner.
- Large bore engines have a system of holes bored tangentially into the cylinder wall so that the cooling water is led as close as possible to the hot inner wall of the liner.
- The liner bore has tiny porous spots which can retain lubricating oil.
- The bores of the liners, when new, must have perfectly smooth mirror-like surface.
- If new piston rings are fitted, the liner should be deglazed.

II . Correct the FALSE statements and match TRUE ones with the sentences of similar meaning from Lesson 4 writing them down in your notebook

III Compare the two sentences and give the alternative expressions for the phrases listed below:

1. to carry the flange at the upper end _____
2. to rest on a shoulder in the cylinder casting _____
3. to attach rigidly _____
4. wear tends to be the greatest _____
5. to press against with force _____
6. to be exposed to high-temperature gas _____
7. There is a relif groove to allow … _____
8. to bore a system of holes _____
9. to lead the cooling water _____
10. to have tiny porous spots _____
11. to make (a surface) mirror-like _____
12. to de-glaze _____

IV. Write a summary about cylinder liners using the expressions above.

V. Separate the words in following passage to make sensible sentences. Find the wrong words and delete them:

- Aflangeisprovidedatthetop of the linertoensure/secureittothecylinder block. Rubberringsarefittedatthelowerendofthelinertoformaseat/sealforthebottomofthewaterspace. Thereisaleak-offholebetweentheupperandlowerendringstoensure/securethatanyleakofwateroroilrunstotheoutsideofthe engine. Whenthepistonreaches/touchesthetopofitstravel, itrevolves/reversesitsdirectionof motionanditisatthispointthatthelineroffers/suffersitsgreatest wear/ware. Intwostroke enginescylinderlinershaveports/partsaboutmidday/midwayalongtheir lengthfortheadmissionofairandfortheexhaustinthecaseofloop/loosescavengeengines. Inthis/theselinersthesealingringsarearrangedabovetheport bolt/belt.

VI Some of the most common prepositions used in technical English to indicate LOCATION and DIRECTION are:

- **AT** expressing " being in, on or near a place thought of as POINT "
- **IN** expressing " being inside a place, material, class, group, etc. ". It also indicates condition, form, arrangement, etc.
- **ON** expressing (1) " supported by a surface ", (2) " fitted or attached to a surface ", (3) " forming a part of the surface ", (4) "in the contact with", "lying against"
- **TO** expressing " in the direction of ", " towards "
- **FROM** expressing (1) " out of a starting point ", (2) " showing the material used in process ": Ex. Liners are made from close grained cast iron.
- **INTO** expressing " motion or direction to a point being inside "

Fill in the blanks in the following sentences using the correct prepositions. Give reasons for using them.

- The connecting rod is a bar with a bearing _____ each end, whose purpose is to transmit the piston thrust _____ the crankshaft.
- The small end bearing is a bush having an interference fit _____ the eye bored _____ the rod.
- Doors are provided _____ the cylinder casing.
- _____ the most usual arrangement cylinder liners are enclosed _____ one cast iron casing forminfg a cylinder block.
- A casting termed the column is mounted _____ the bedplate.
- The crankshaft bearings are formed _____ the bedplate.

- The gas pressure produced _____ the cylinder is transmitted _____ the top of the cylinder block _____ the crankshft main bearings.
- Solid forged crankshafts are made_____ a single piece while _____ semi-built designs the crankpins and webs are cast _____ one piece and shrunk _____ ___ the journal.
- A distant piece is interposed between the foot and the box to permit the piston to be moved nearer_____ or farther _____ the cylinder head _____ top dead centre.
- _____ medium speed engines the piston and the connecting rod must be fitted together before being assembled _____ the cylinder.
- When the piston rings are renewed the glaze _____ the liner bore should be broken by honing.

PURPOSE

- Cylinder liners are simple cylindrical shapes flanged at the top end **to provide** location and secure them in the cylinder block.
- The lower end of the liner is fitted with rubber rings **so as to form** a seal for the bottom of the water spaces.
- The sealing rings… are designed **to prevent** scavenge air entering the water spaces.
- The bore surface of the cylinder liner is slightly rough **in order to** retain the oil and to promote rapid wear in.
- **In order to** provide a harder wearing surface, the bore of liners is subjected to the process of nitriding.
-

Expressing PURPOSE

- Istaknute rečenice ili dijelovi rečenica izražavju namjeru, namjenu, cilj ili svrhu sadržaja izrečenog u rečenici na koju se odnose. One mogu prethoditi glavnoj rečenici, kao u primjeru (5), ili slijediti iza nje , kao u primjerima (1), (2), (3), (4).

- Namjera ili cilj se najčešće uvodi sa:

- **TO + INFINITIV (1), (3)**
- **IN ORDER TO + INFINITIV (4), (5)**
- **SO AS TO + INFINITIV (2)**

I. Link the followig pairs of sentences so that they express PURPOSE. Omit all un necessary items.

E.g.

- *Studs should be evenly tightened. They must provide a satisfactory joint.*

- ***Studs should be evenly tightened <u>(in order) to provide</u> a satisfactory joint.***

Connect the sentence pairs below to express purpose

- The inner wall of the cylinder liner is porous. It should provide an oil retaining surface.
- A thin layer of lead or indium is often added to the main bearing shells. The layer gives protection against corrosion.
- Efficient scavenging is essential. It si designed to ensure sufficient supply of fresh air for combustion.
- The diesel oil supply system uses a transfer pump. It is fitted with the purpose of drawing oil from the double bottom tanks.
- The viscosity regulator controls fuel oil temperature. The device must provide oil at the correct viscosity for combustion.
- When distant pieces are fitted under the crosshead bearings they must be of exactly the same thickness. Accuracy is required with purpose of ensuring the correct alignment of the connecting rod.
- The connecting rod is usually forged from alloy steel, frequently with an " I " or " channel " section. This shape permits giving the greatest stiffness for its weight.
- Connecting rods sometimes taper slightly from the bottom to the top of the shank. The tapering is aimed at increasing the resistance to the bending stresses.

LESSON FOUR

CYLINDER LINERS

1. LINER DEFINITION

A removable component, cylindrical in shape, inserted into the engine block. It can be replaced when worn out.

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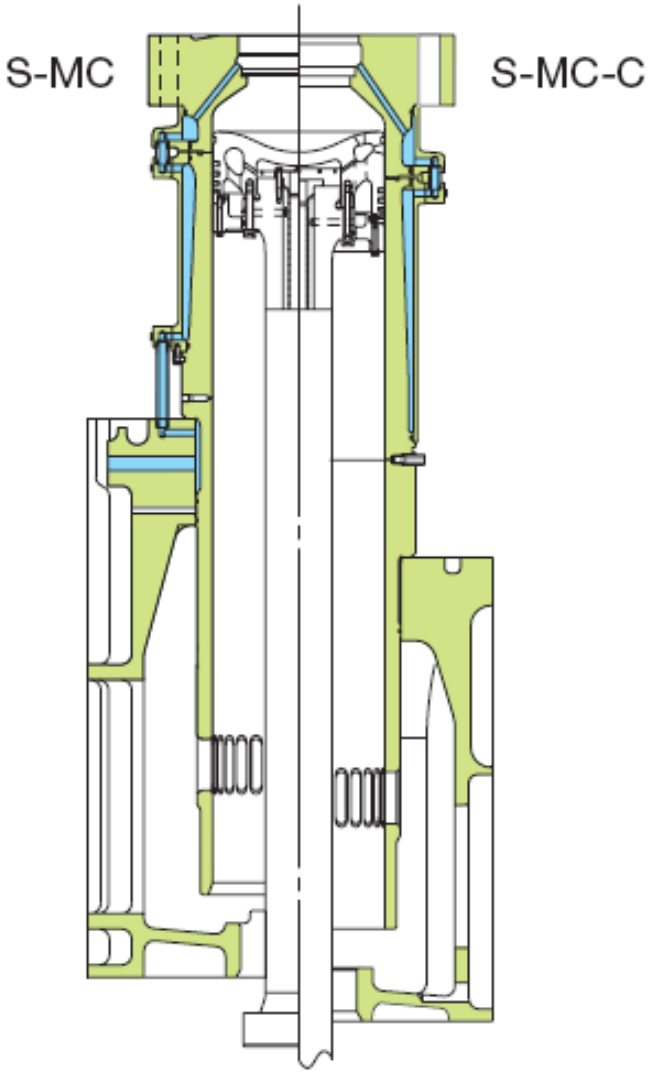
1.1 FUNCTION

It provides the surface for the piston to slide and carry out its compression task.

Cylinder Liner and Frame Configuration



Cylinder liner:

- Low position of mating surface cylinder cover/cylinder liner
- Slim cylinder liner
- Straightforward cooling jacket

Cylinder frame:

- Smaller and lighter
- Uncooled and straightforward design

1. LINER DEFINITION

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1.2 TYPES

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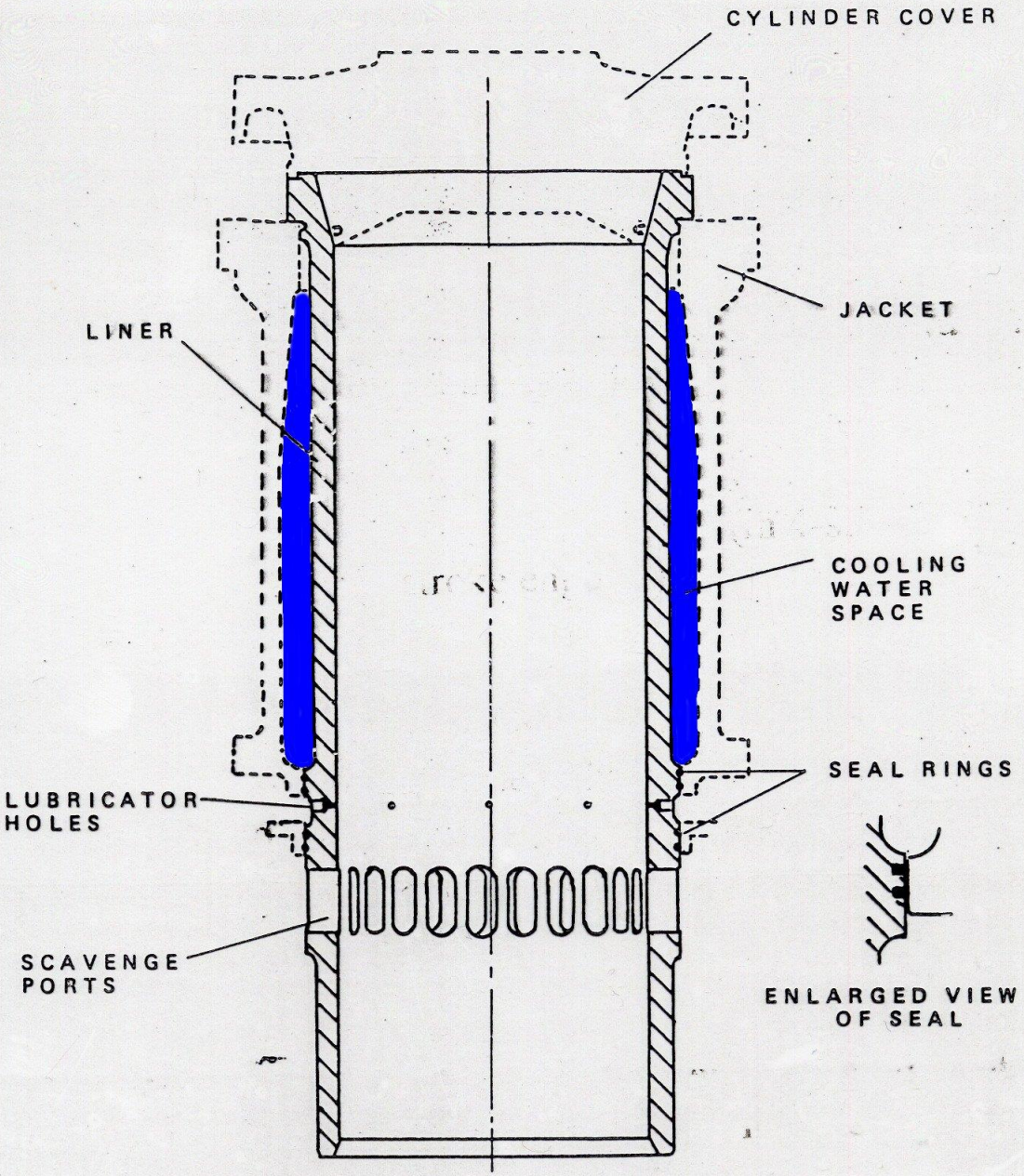
1.2 TYPES

Wet liners (the water is in direct contact with outer surface of the liner);



Cylinder liner

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1.3 MANUFACTIRING

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- **Chromium plate liners (to reduce wear rate),**

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- **Grey cast steel + vanadium & titanium**
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It can be made in one (single) piece or in two (double) piece element

1.4 CONDITIONS TO MEET

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Strenght, wear resistance & corrosion ressistance (sulphur in fuel).

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1.5 LIMITATIONS

1.4 CONDITIONS TO MEET

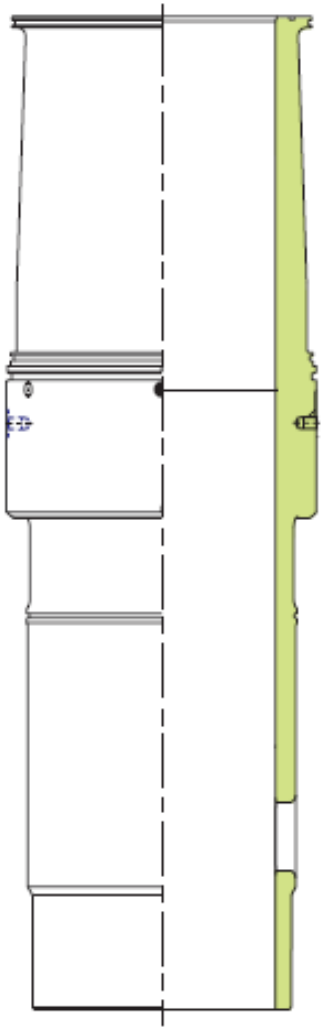
Strength, wear resistance & corrosion ressistance (sulphur in fuel).

1.5 LIMITATIONS

Thickness (0,085D – 0,1D) because of:

cooling and thermal stresses.

Slim Cylinder Liner



- For S46MC-C, S50MC-C and S60MC-C
- Only one cooling jacket required
- Single level cylinder lubrication

1.4 CONDITIONS TO MEET

Strength, wear resistance & corrosion ressistance (sulphur in fuel).

1.5 LIMITATIONS

Thickness (0,085D – 0,1D) because of:

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1.6 CONNECTIONS AND ARRANGEMENTS*

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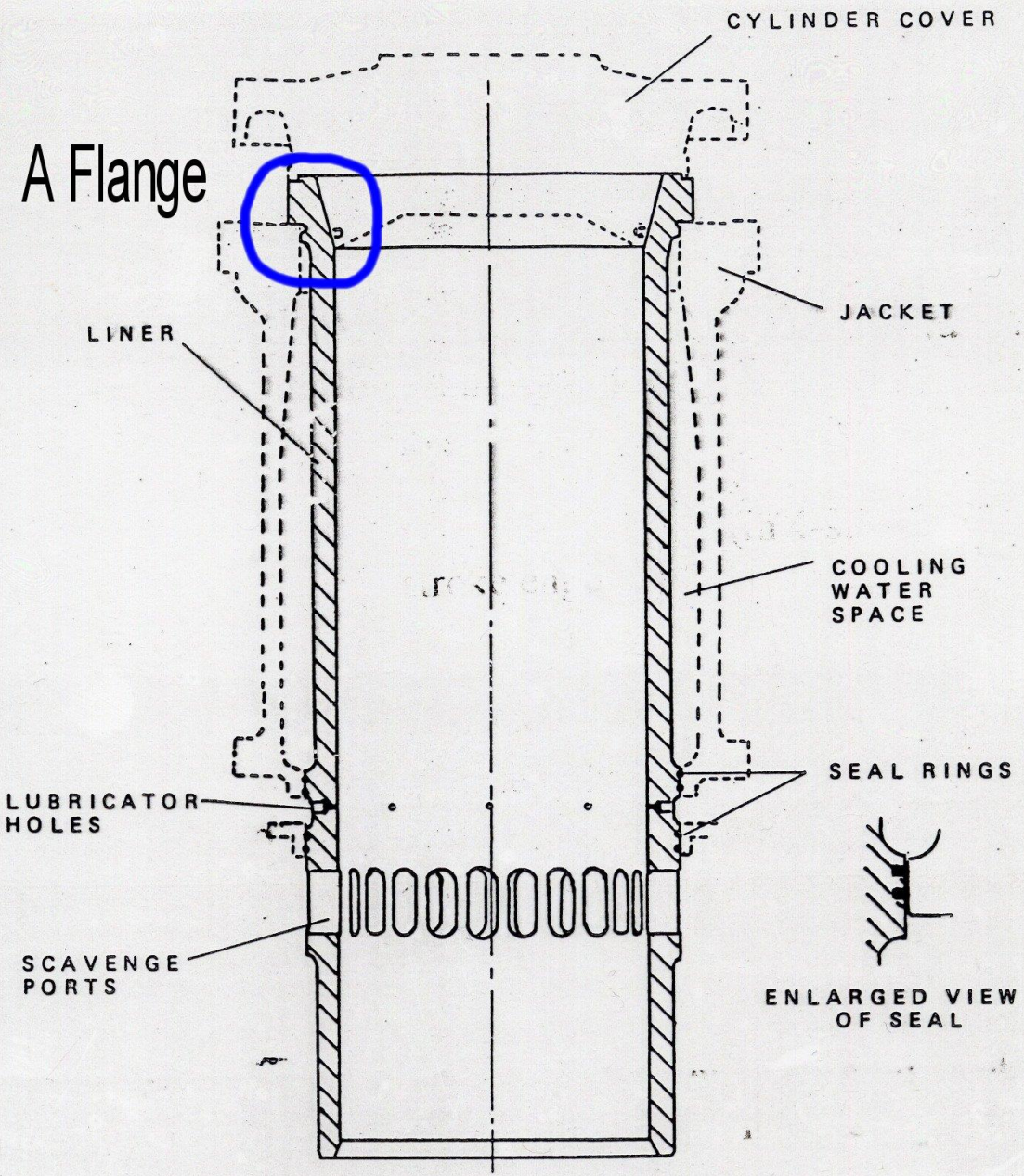
1.6 CONNECTIONS AND ARRANGEMENTS*

1.6.1 Connections

- **At the top – flange (for securing in the cylinder block or to the water jacket).**

A Flange



Cylinder liner

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- **At the top – flange (for securing in the cylinder block or to the water jacket).**

1.6.2 Arrangements

- **Below the top flange – joint ring (copper or heat ressistant rubber);**

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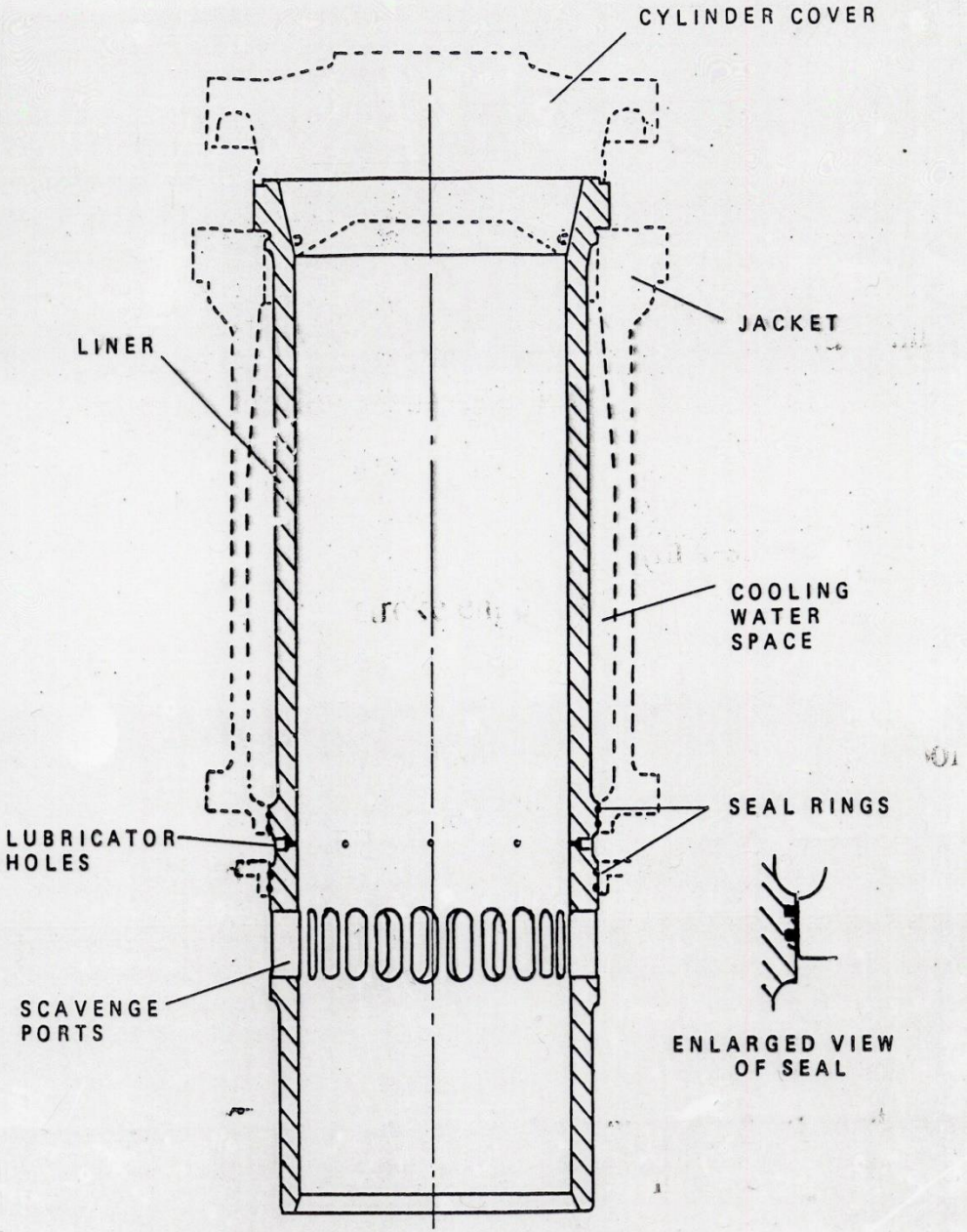
- **Lower end of the liner – rubber ring seal for the bottom of water space.**



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- **Below the top flange – joint ring (copper or heat ressistant rubber);**
- **Lower end of the liner – rubber ring seal for the bottom of water space.**
- **Between the upper & lower rings – leek-off hole (a drain for oil & water out of the engine).**

1.7 DESIGN

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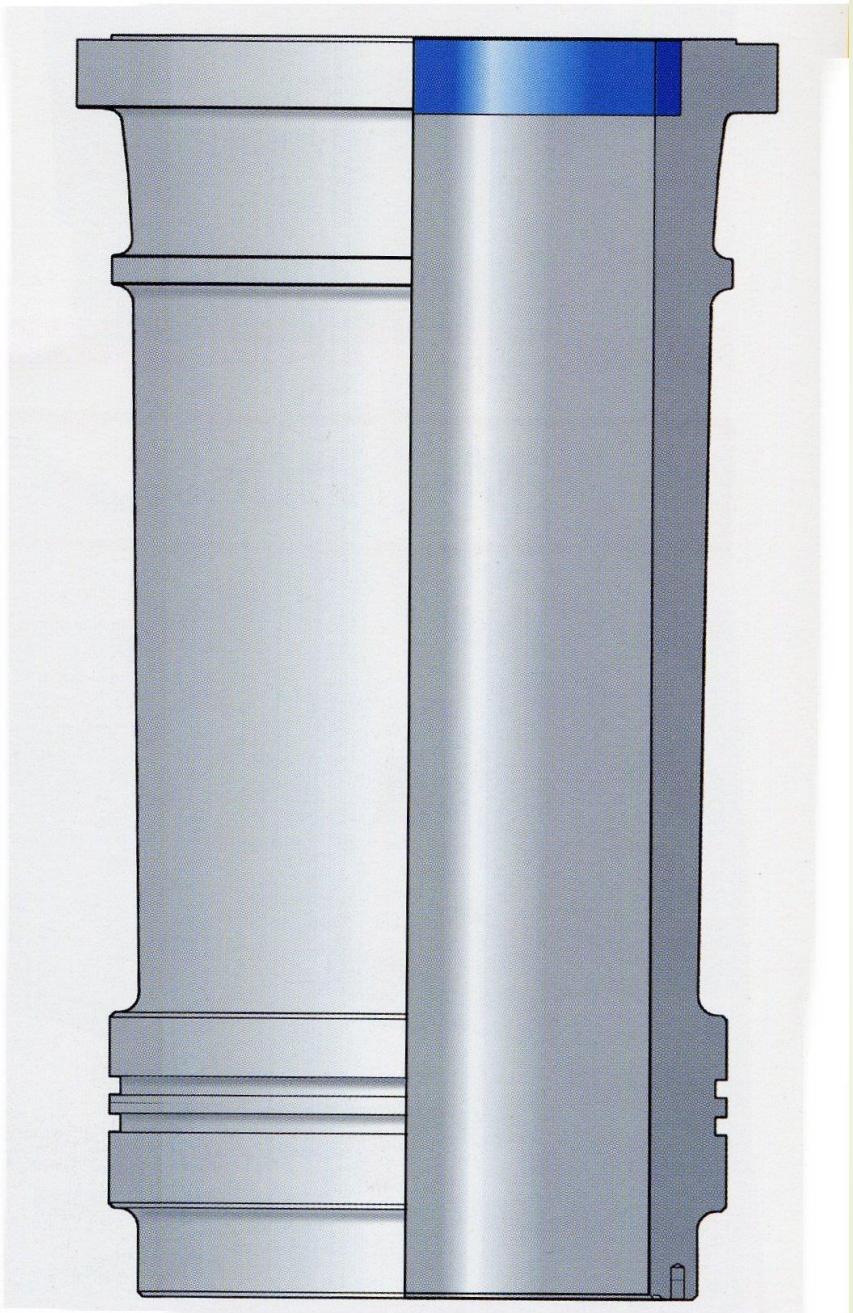
- **Uninterrupted or continuous liner (in 4-stroke enginers);**



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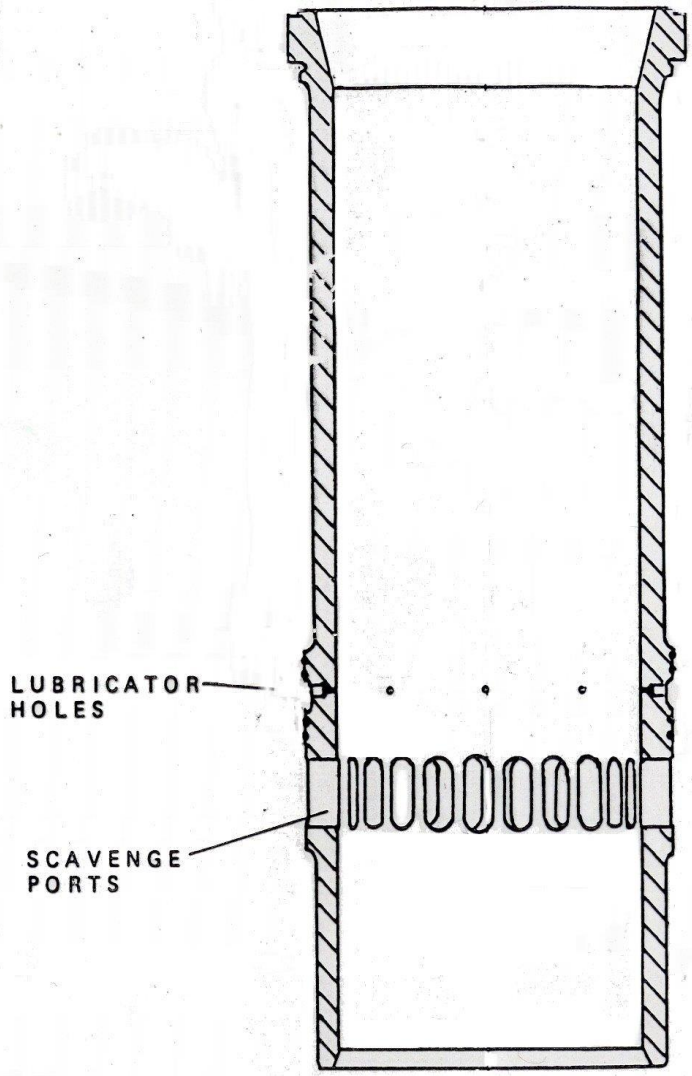
- **Uninterrupted or continuous liner (in 4-stroke enginers);**
- **Ported liner (2-stroke engines)**



Cylinder liner

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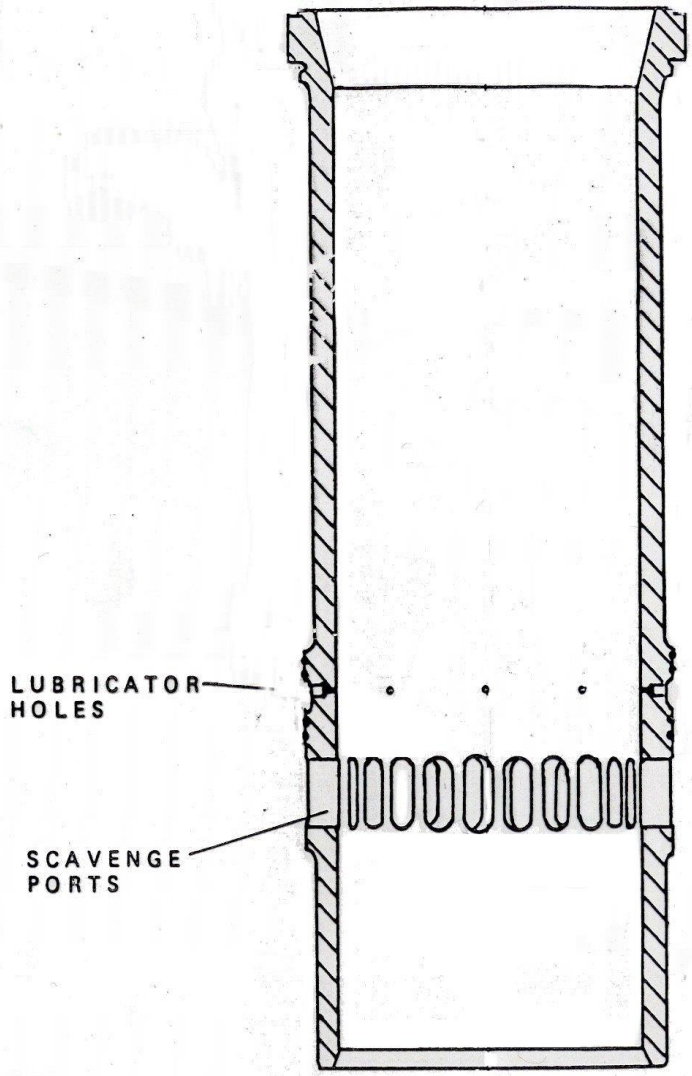
- **Traditional two stroke loop scavange engines have ports midway along their lenght;**



Cylinder liner

1.7 DESIGN

- **Uninterrupted or continuous liner (in 4-stroke enginers);**
- **Ported liner (2-stroke engines)**

1.8 SCAVENGING

- **Traditional two stroke loop scavange engines have ports midway along their lenght;**
- **Modern two stroke engines are provided with uniflow scavenging system.**

2. COOLING*

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2.1 PURPOSE

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2.2 IN WET LINERS

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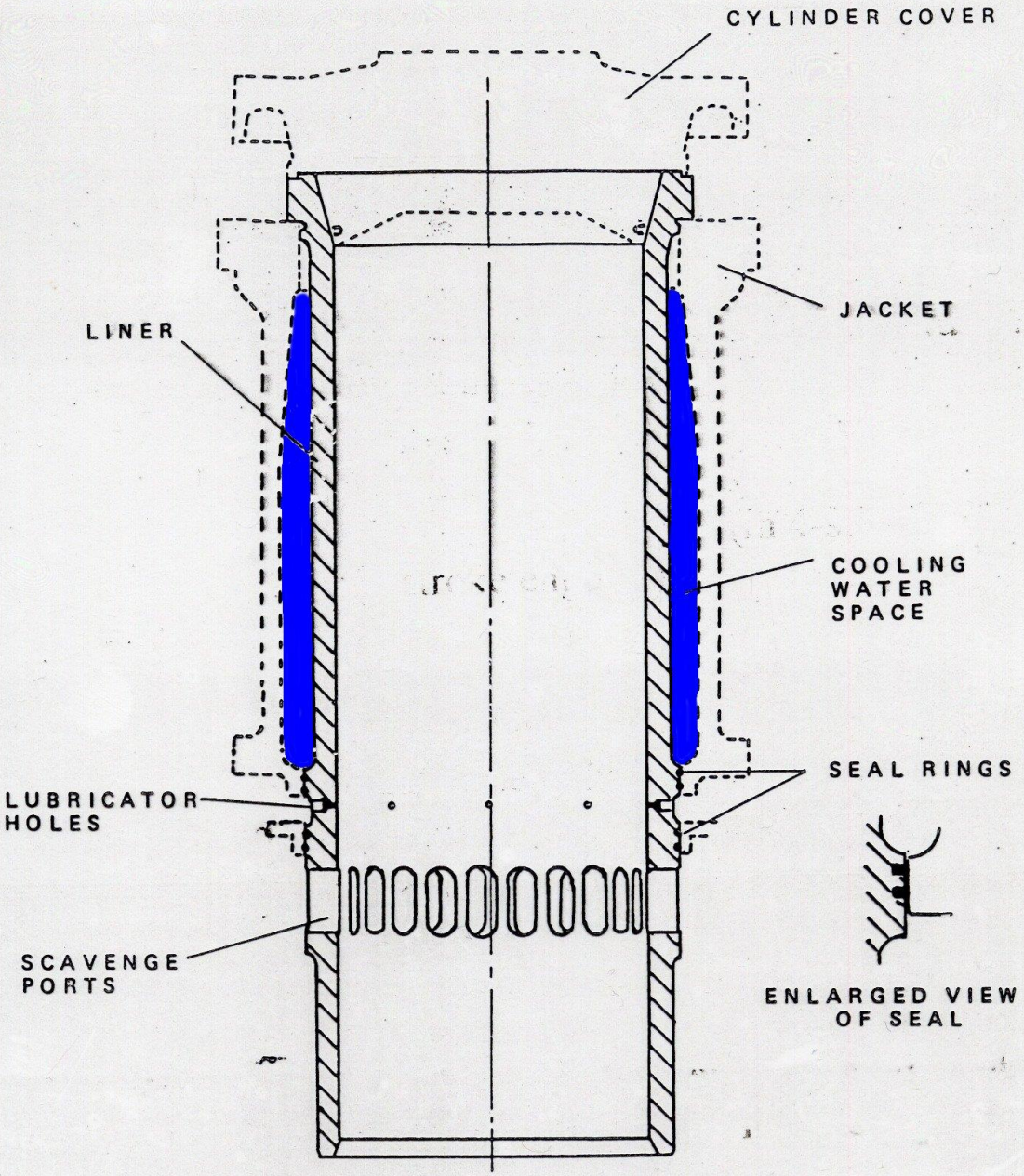
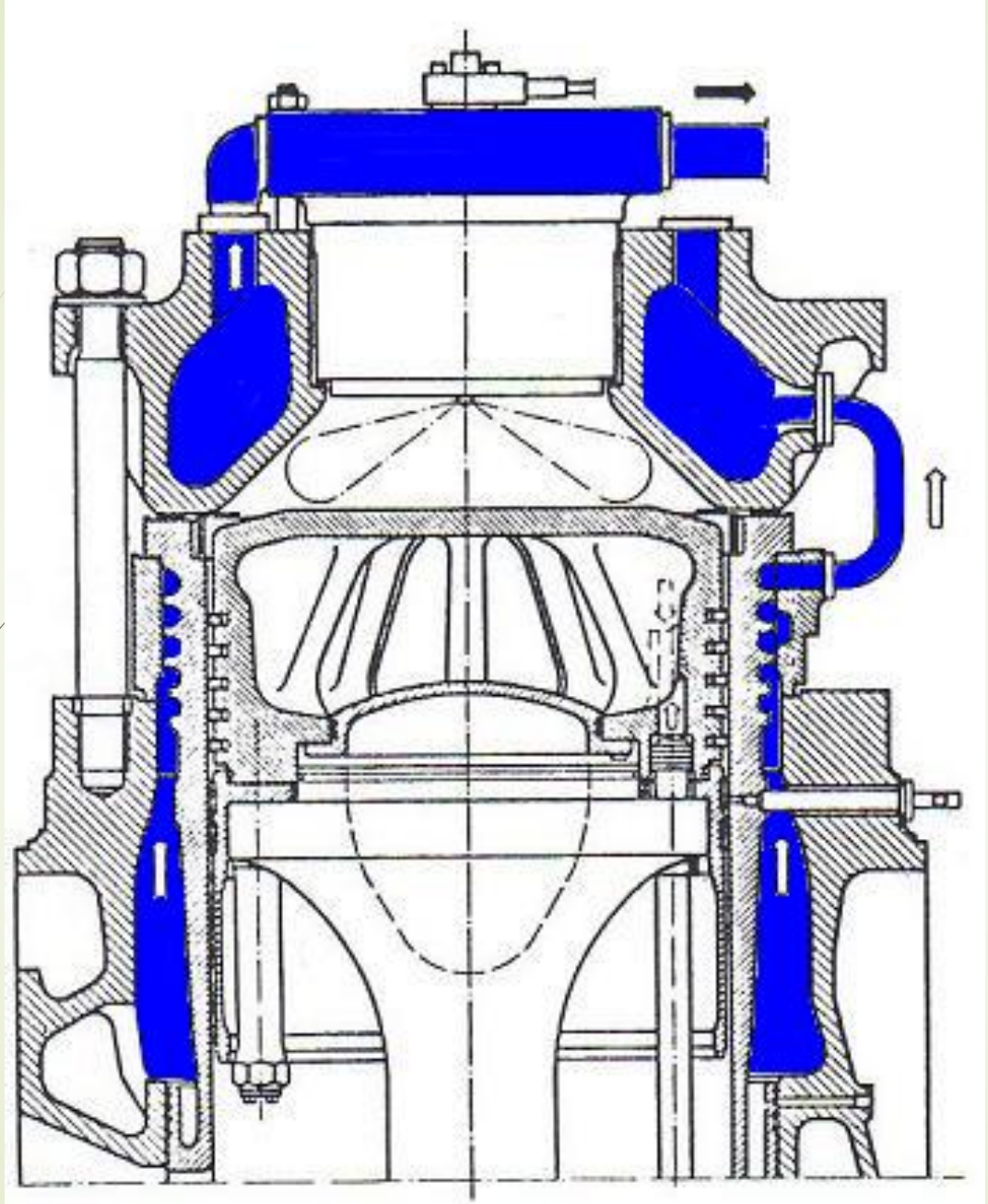
2.2 IN WET LINERS

By circulation of chemically treated fresh water (to reduce corrosion and prevent scale formation) in the upper ends of liners.



Cylinder liner



Forbrenningsrom

2. COOLING*

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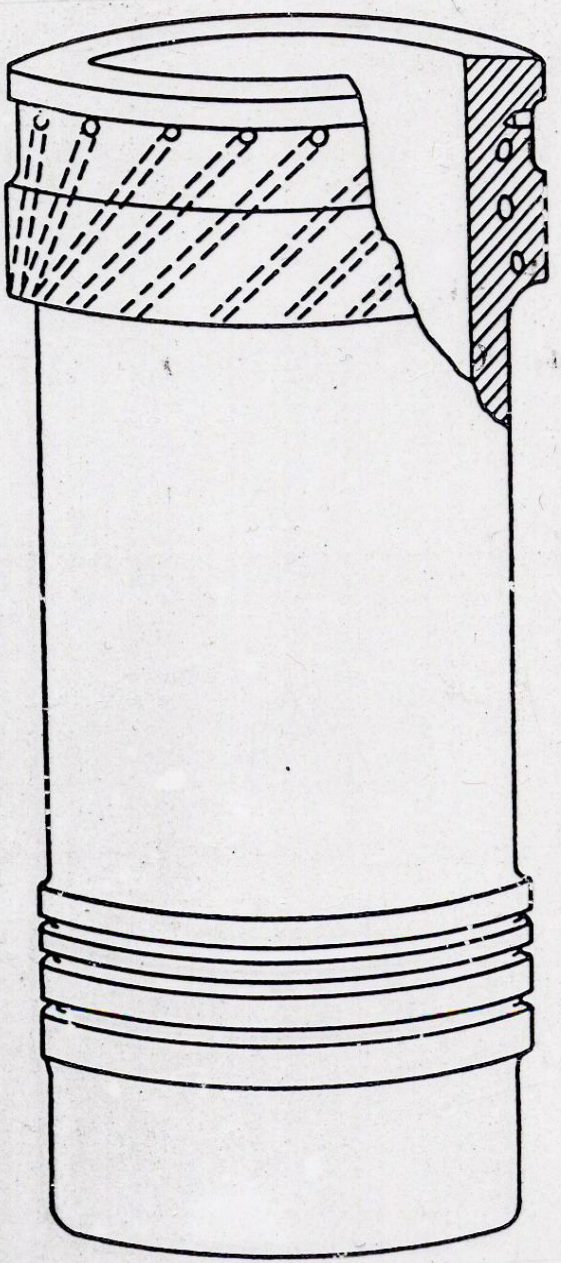
- **Limit thermal expansion thereby maintaining the piston clearance.**

2.2 IN WET LINERS

By circulation of chemically treated fresh water (to reduce corrosion and prevent scale formation) in the upper ends of liners.

More effective cooling may be obtained by bore-cooled liners, i.e. through additional drillings for cooling water made



Cylinder liner with drilled passages for cooling

3. LUBRICATION*

3.1 PURPOSE

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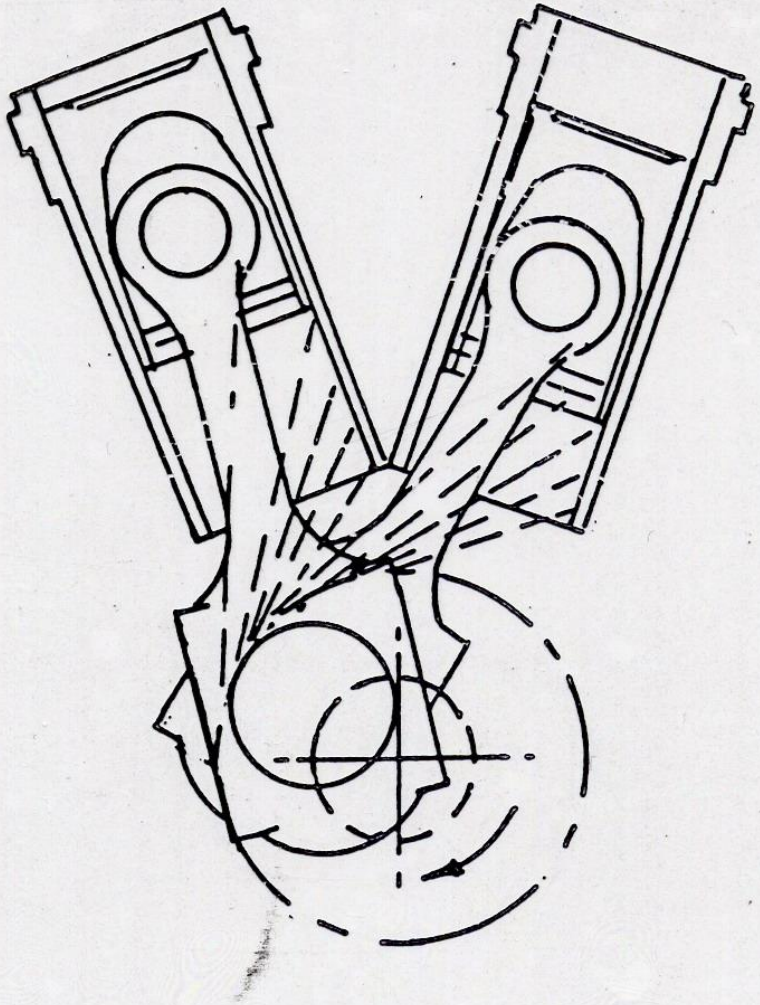
In trunk piston engines – by oil splashing from the crankcase.



Splash lubrication

3. LUBRICATION*

3.1 PURPOSE

To reduce piston ring friction & wear;

Oil film acts as gas seal to (prevent blow by) & corrosion inibitor;

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In large crosshead-type engines – sepatate cylinder lubrication system fitted

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3.3 OIL INJECTION

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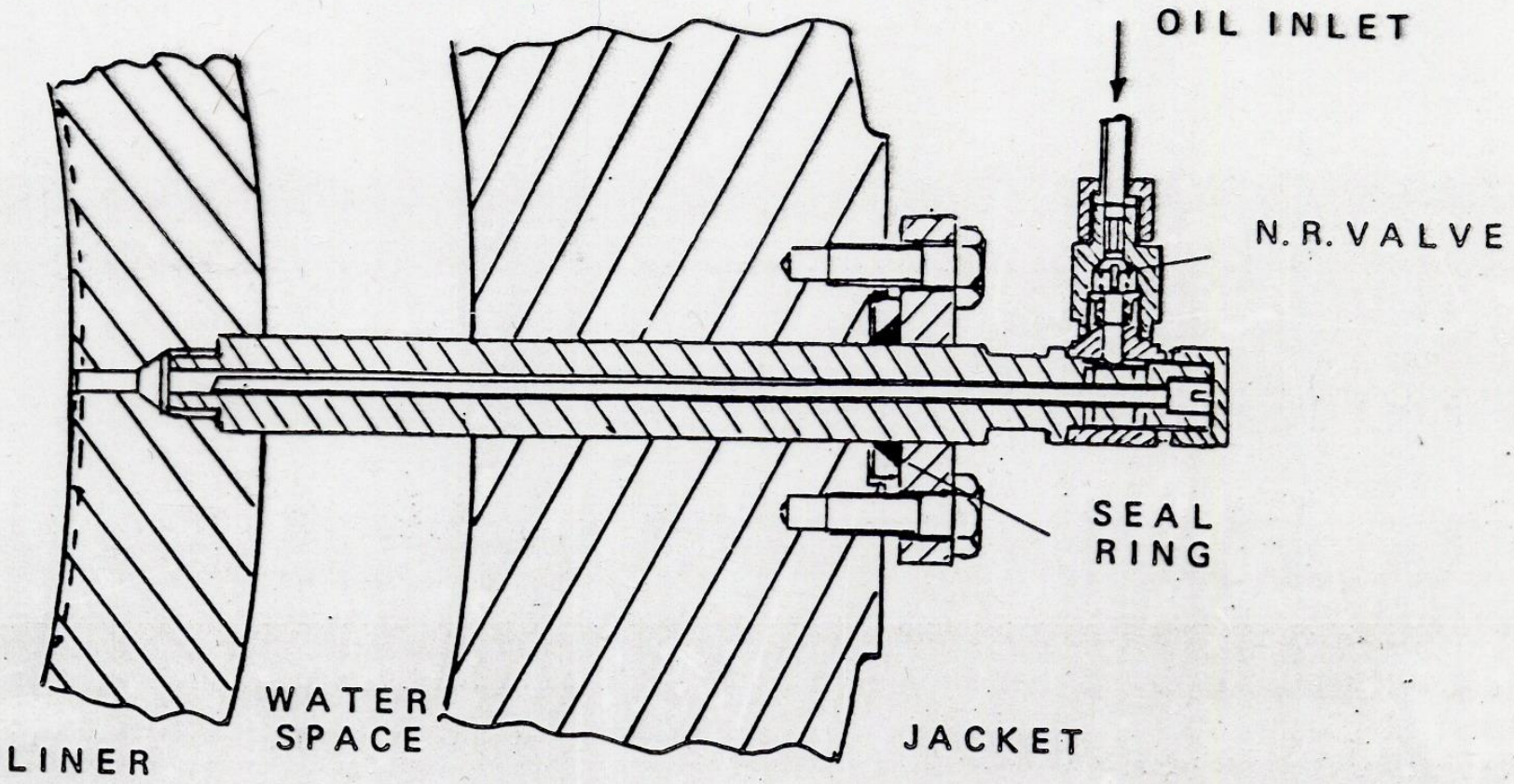
3.3 OIL INJECTION

Through lubricator quills – timed to inject oil between the piston rings as they pass.



Cylinder liner lubricator quill

4. GAUGING*

It is made internally during cylinder overhaul after 6000 – 8000 hours.

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It is made internally during cylinder overhaul after 6000 – 8000 hours.

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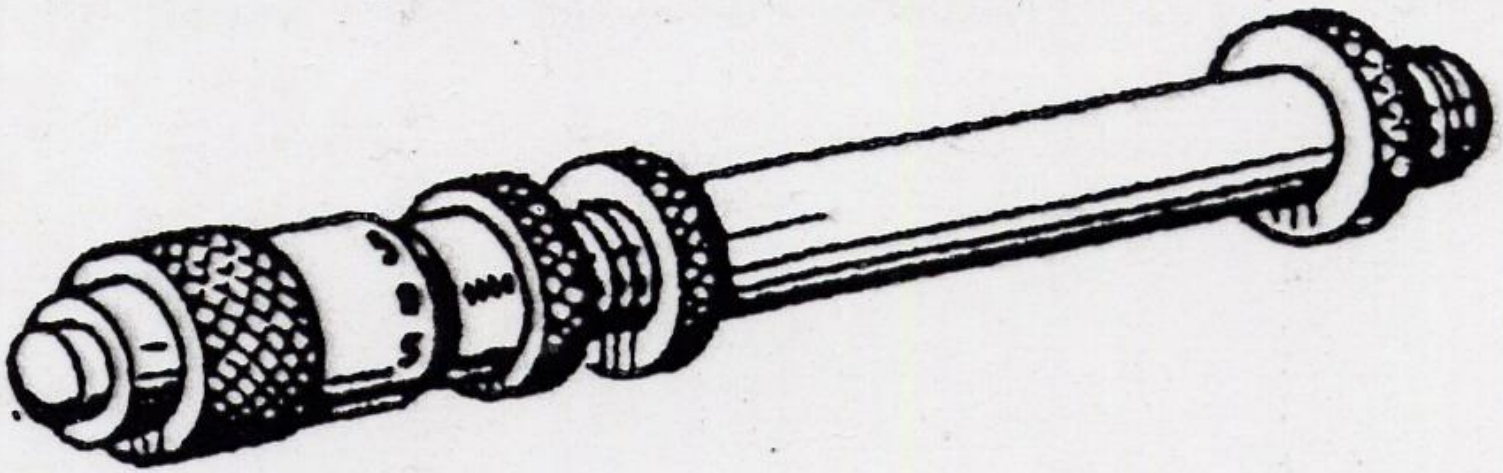
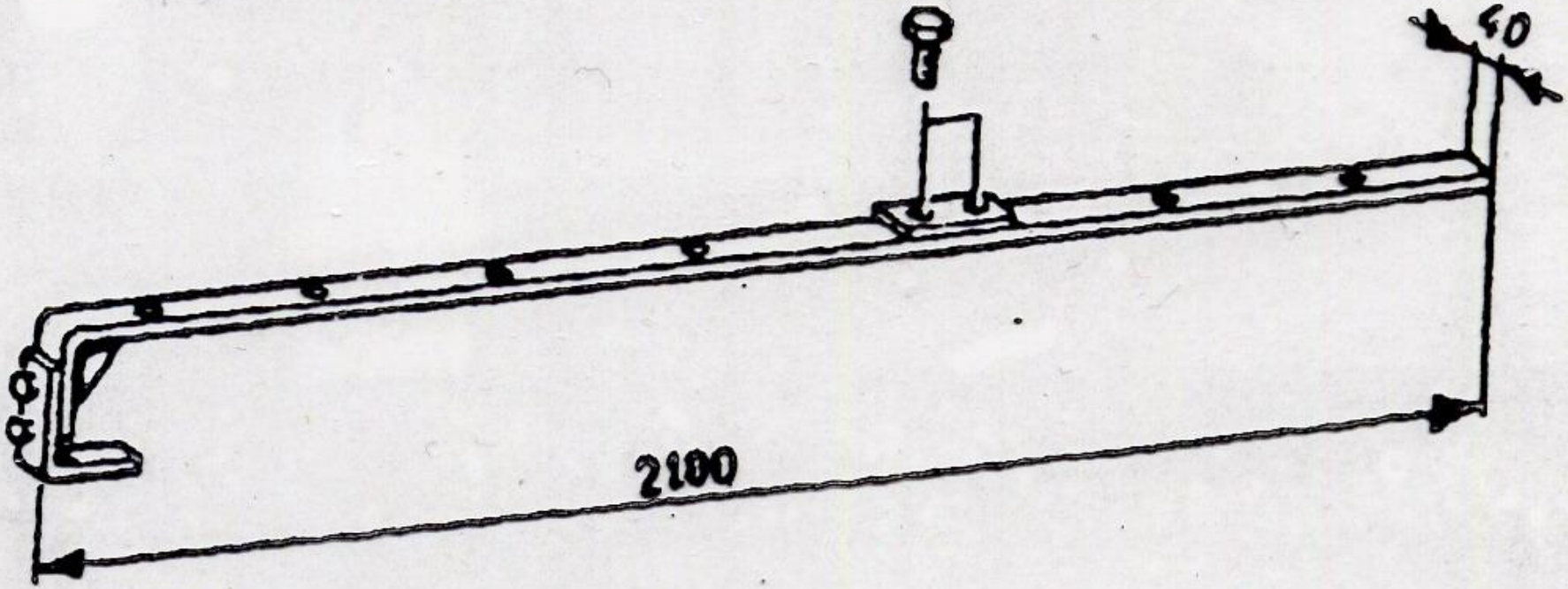


Micrometer



Template bar

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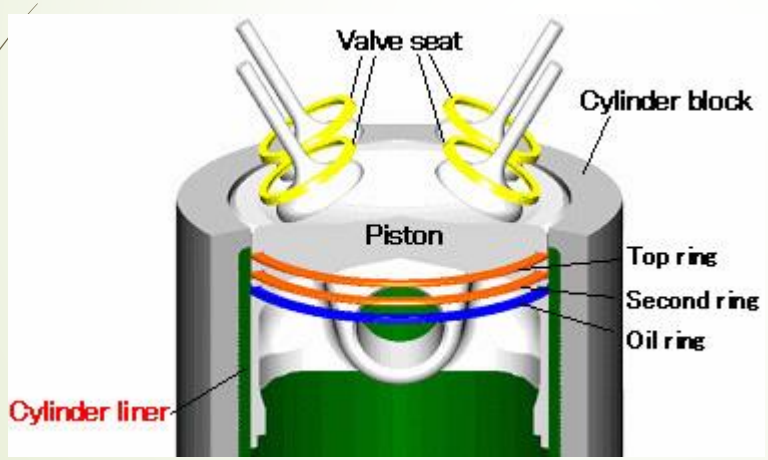
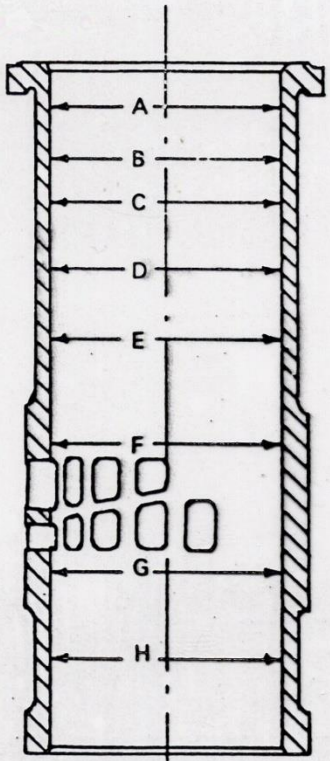
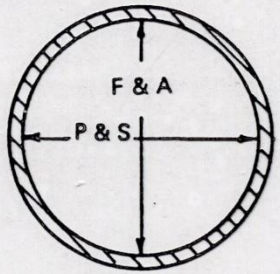
4.2 READINGS **(at 6 – 8 vertical positions – total wear from original & wear since last recording)**







Cylinder liner gauging points

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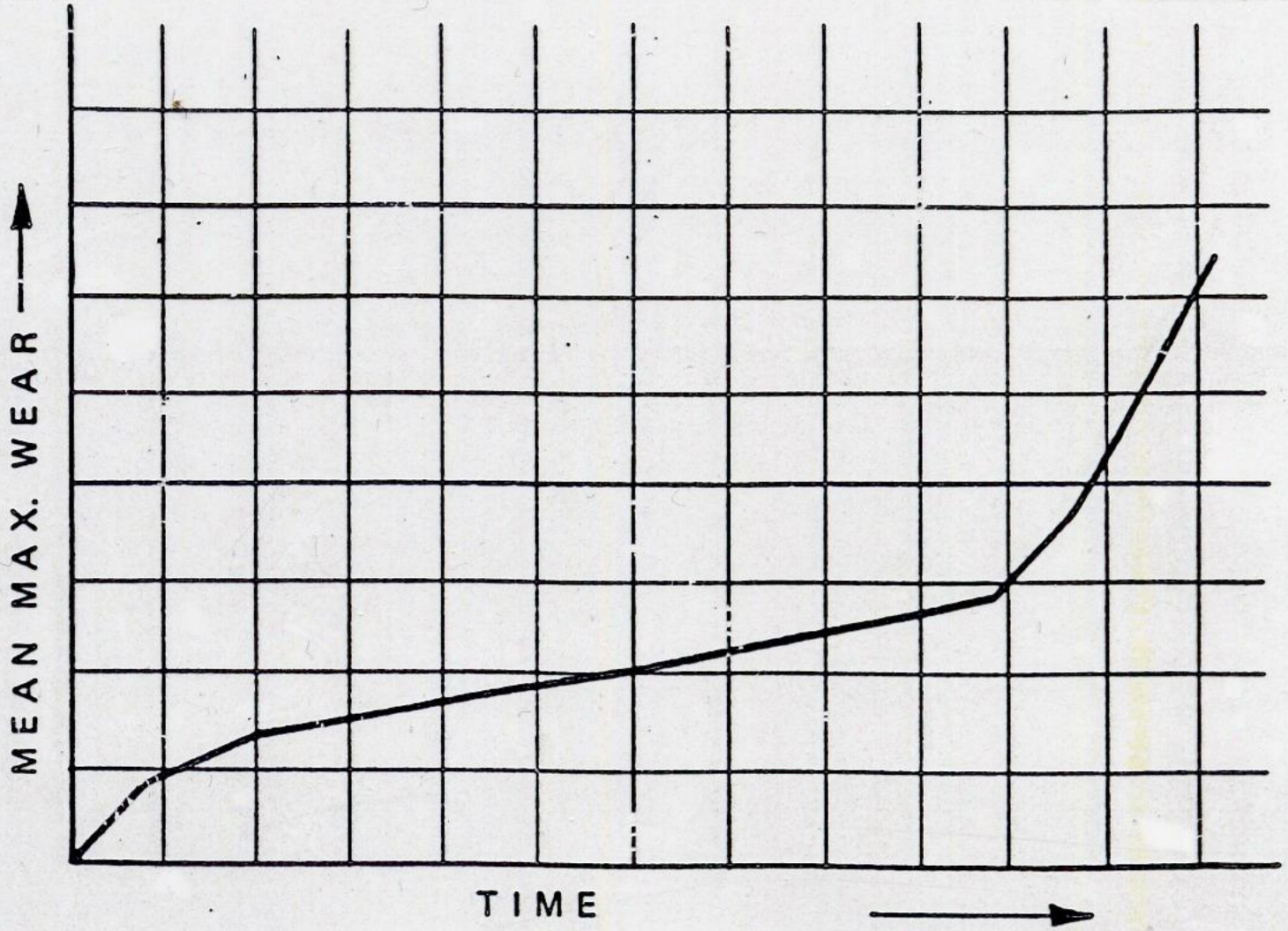
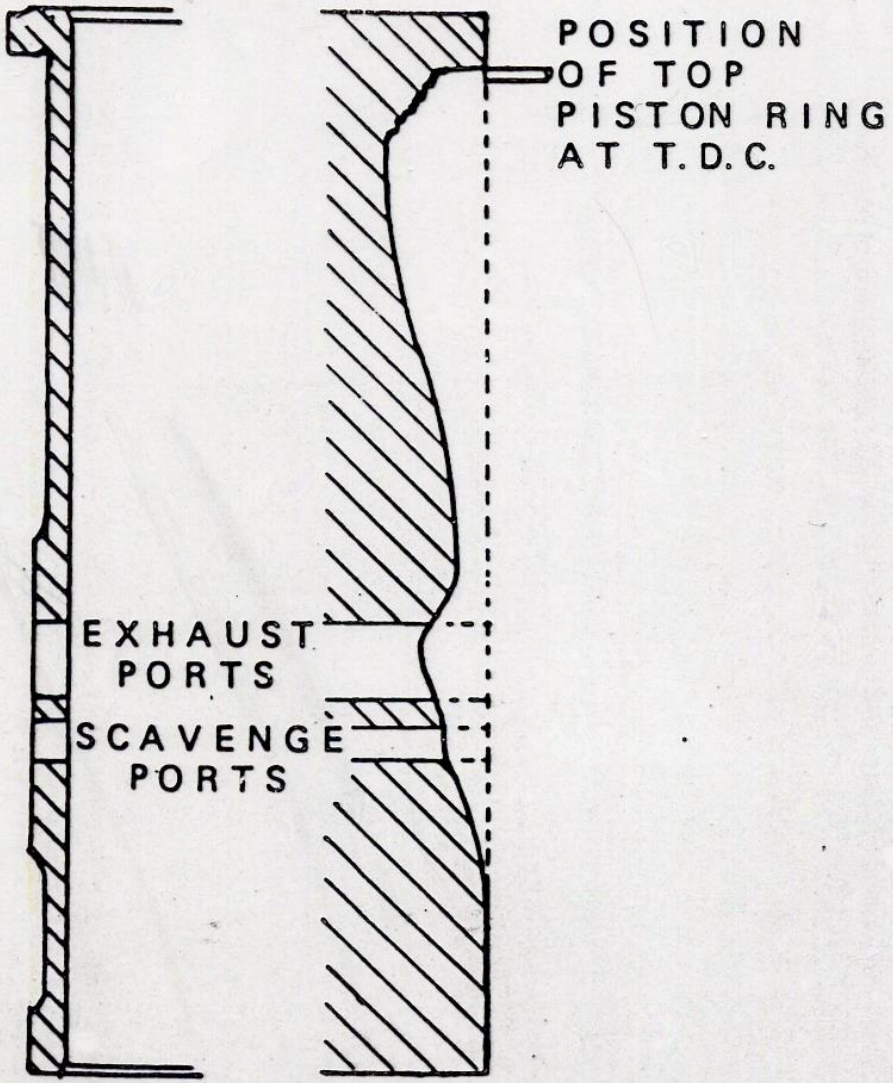
- **maximum wear before renewal – app. 0.6-0.8 % of the original diametar)**



Cylinder liner wear rate

5. WEAR CAUSES & RESULTS / REMEDIES



Liner wear pattern

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- **contanination of air and fuel.**

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- engines burning heavy fuel & high sulphur content fuel – to be neutralised by alkaline type cylinder oil;

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5.3 ABRASION (hard particles)

Products of mechanical wear, corrosion & combustion – cylinders to be regularly cleaned and inspected.

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At the top of the piston travel & at port bars

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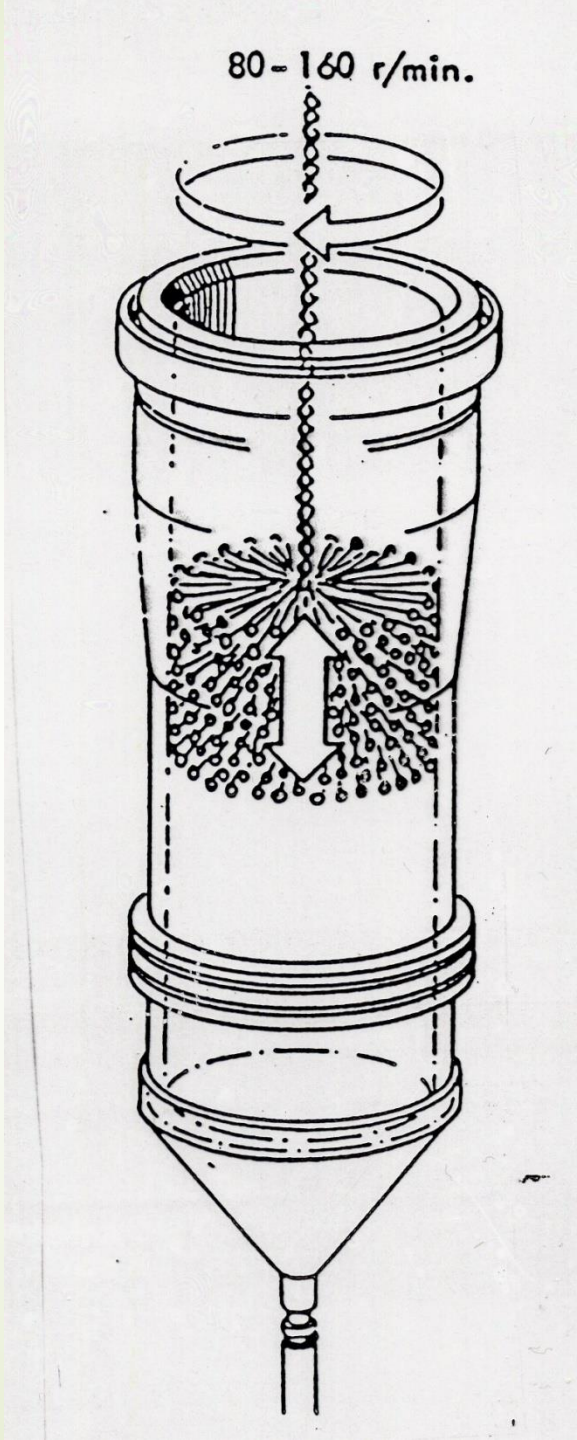
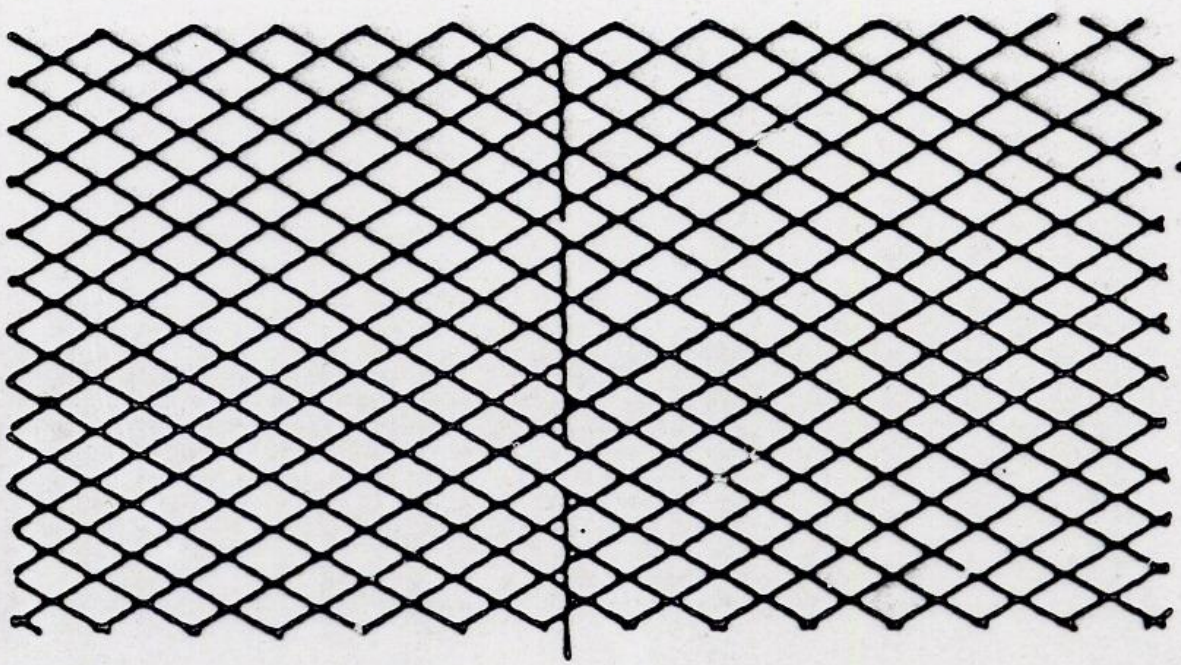
- **New liners require honing (braking the liner glze).**


80 - 160 r/min.




appr. 30°

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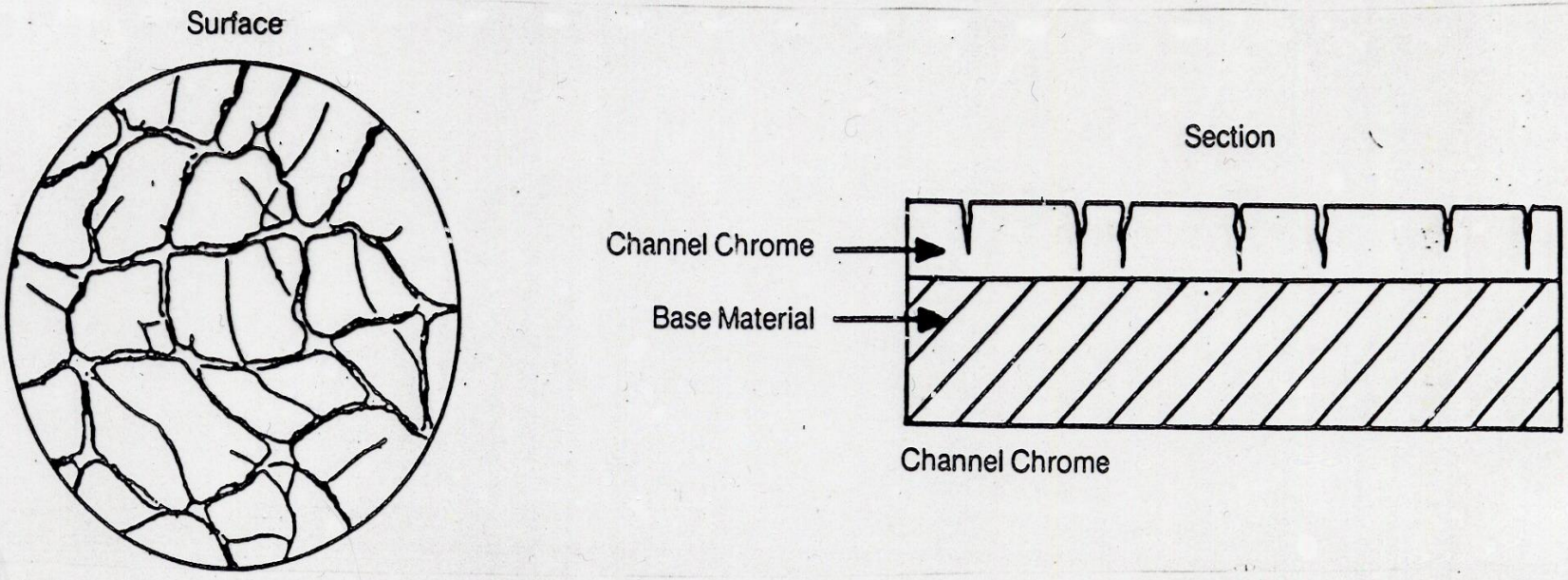
- **Hard wearing surfaces are obtained by liner bore nitrading.**



Electro deposited surface preparation (large bore two-stroke crosshead e.)

The Cylinder Liner

(Diesel Engines)

Source: MAN B&W

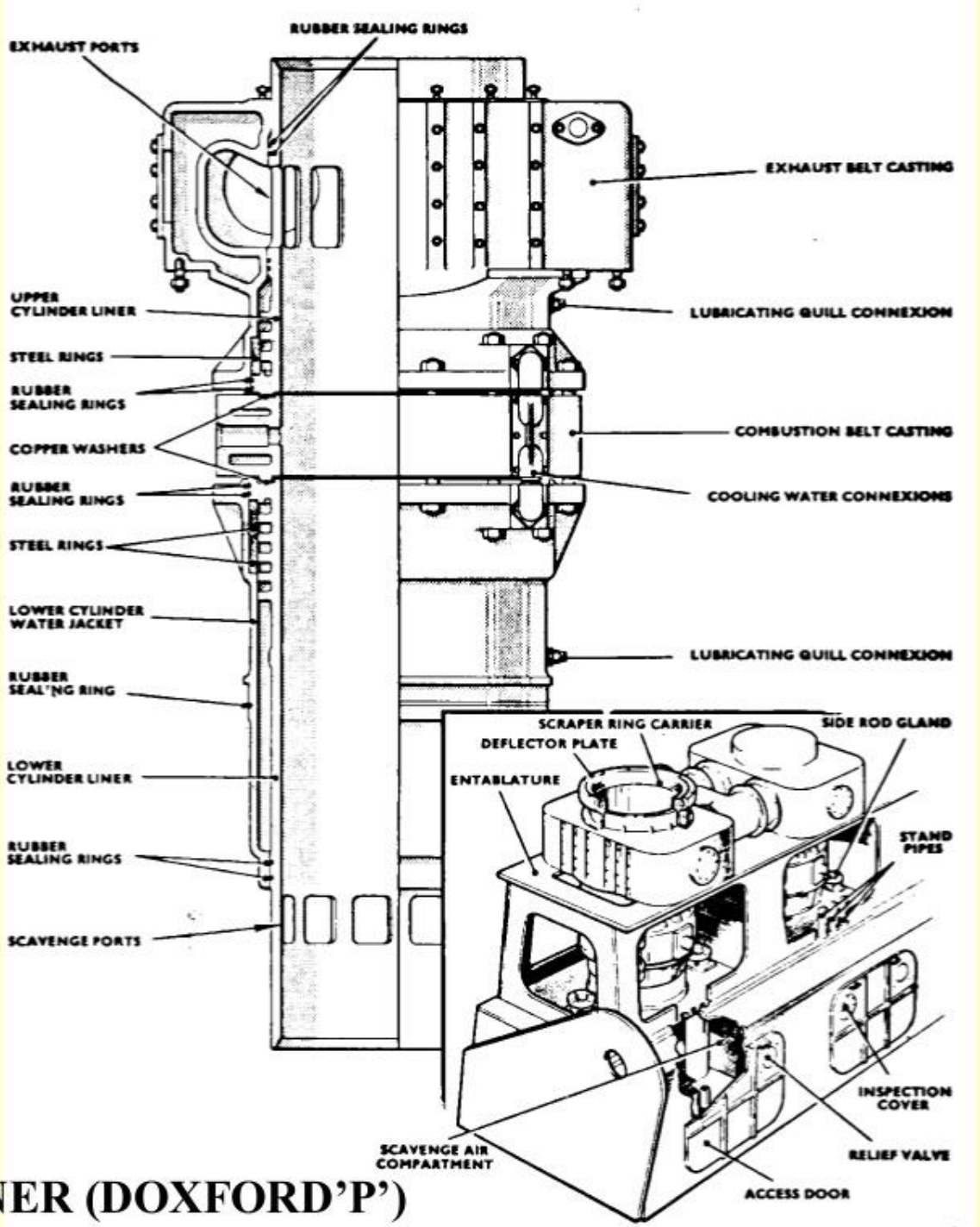
Cylinder Liner

- The function of cylinder liner is to form part of the combustion chamber which is compression and combustion of fuel/air mixture take place
- The cylinder liner forms the cylindrical space in which the piston reciprocates. The reasons for manufacturing the liner separately from the cylinder block (jacket) in which it is located are as follows;

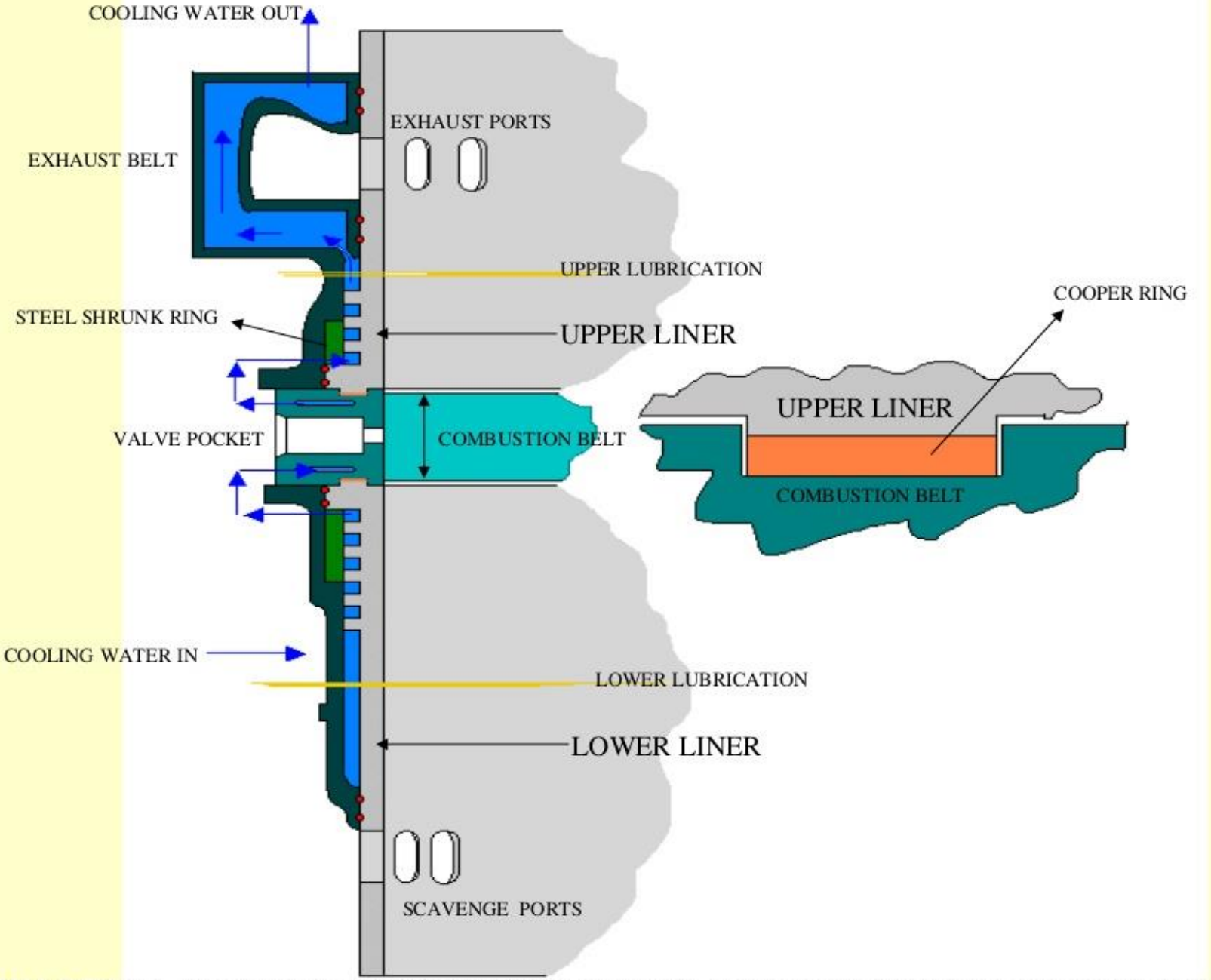
•The liner can be manufactured using a superior material to the cylinder block. While the cylinder block is made from a grey cast iron, the liner is manufactured from a cast iron alloyed with chromium, vanadium and molybdenum. (cast iron contains graphite, a lubricant. The alloying elements help resist corrosion and improve the wear resistance at high temperatures.)
•The cylinder liner will wear with use, and therefore may have to be replaced. The cylinder jacket lasts the life of the engine.
•At working temperature, the liner is a lot hotter than the jacket. The liner will expand more and is free to expand diametrically and lengthwise. If they were cast as one piece, then unacceptable thermal stresses would be set up, causing fracture of the material.
•Less risk of defects. The more complex the casting, the more difficult to produce a homogenous casting with low residual stresses.

Cylinder Liner - Types

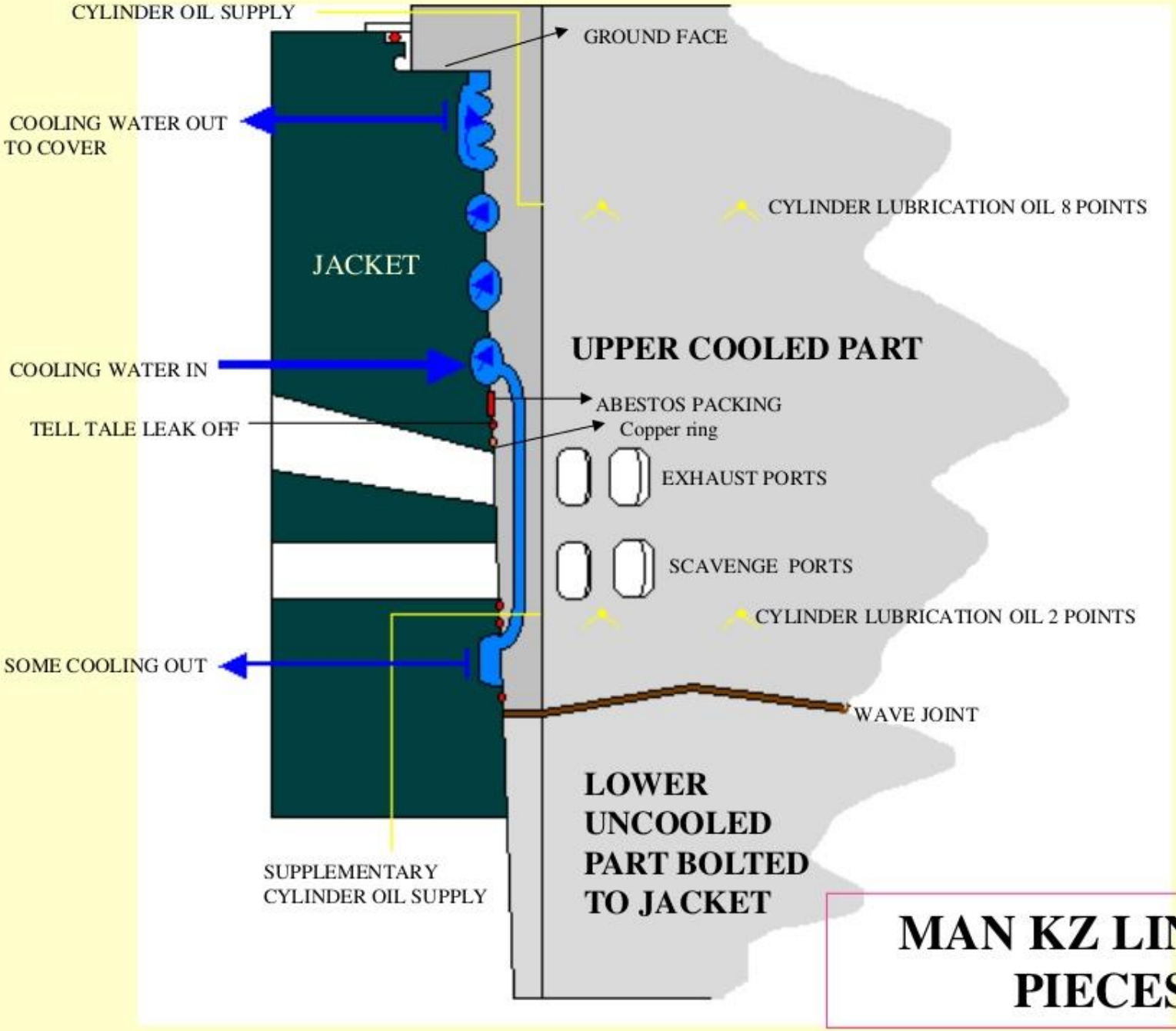
- Wet liners – usually used in medium and slow speed engines and normally cooling by water
- Dry liner – used for small engine like life boat engine etc which is the engine block built with fins and the cooling agent will be an air



3 –PIECES LINER (DOXFORD'P')

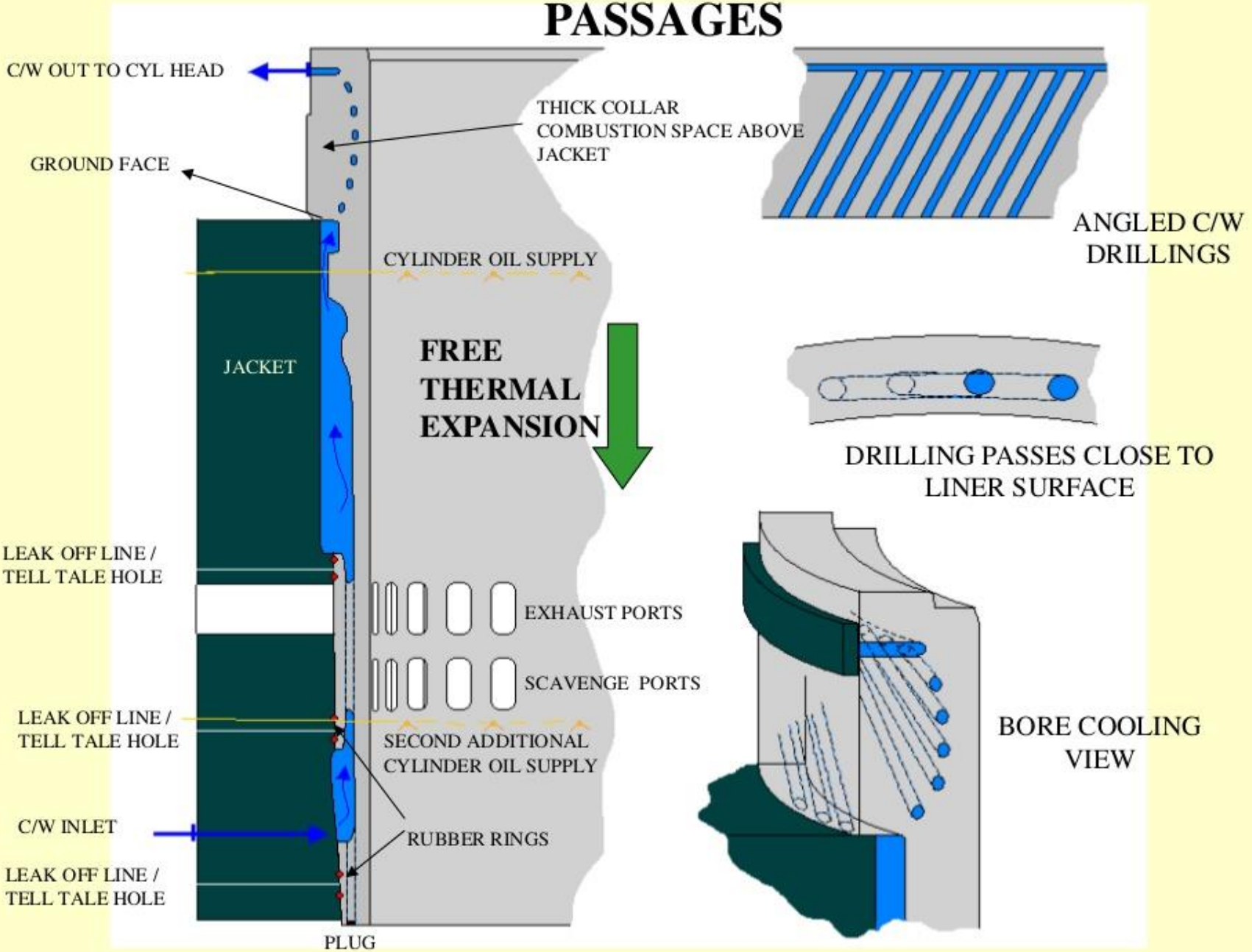


TRIPARTITE (3 PARTS) CYLINDER LINER AND JACKET (DOXFORD ‘P’TYPE



MAN KZ LINER (2 PIECES)

RND SULZER (ONE PIECE) HYPERBOLIC COOLING PASSAGES

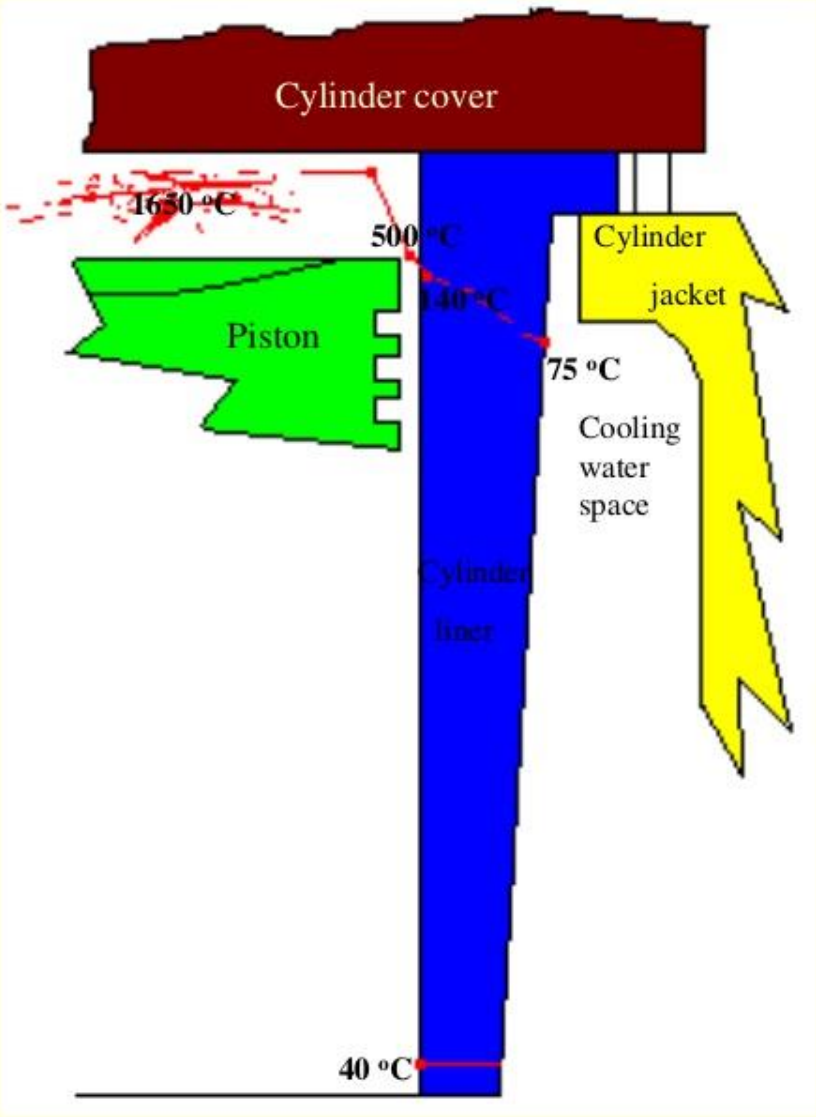


Liner-Stresses

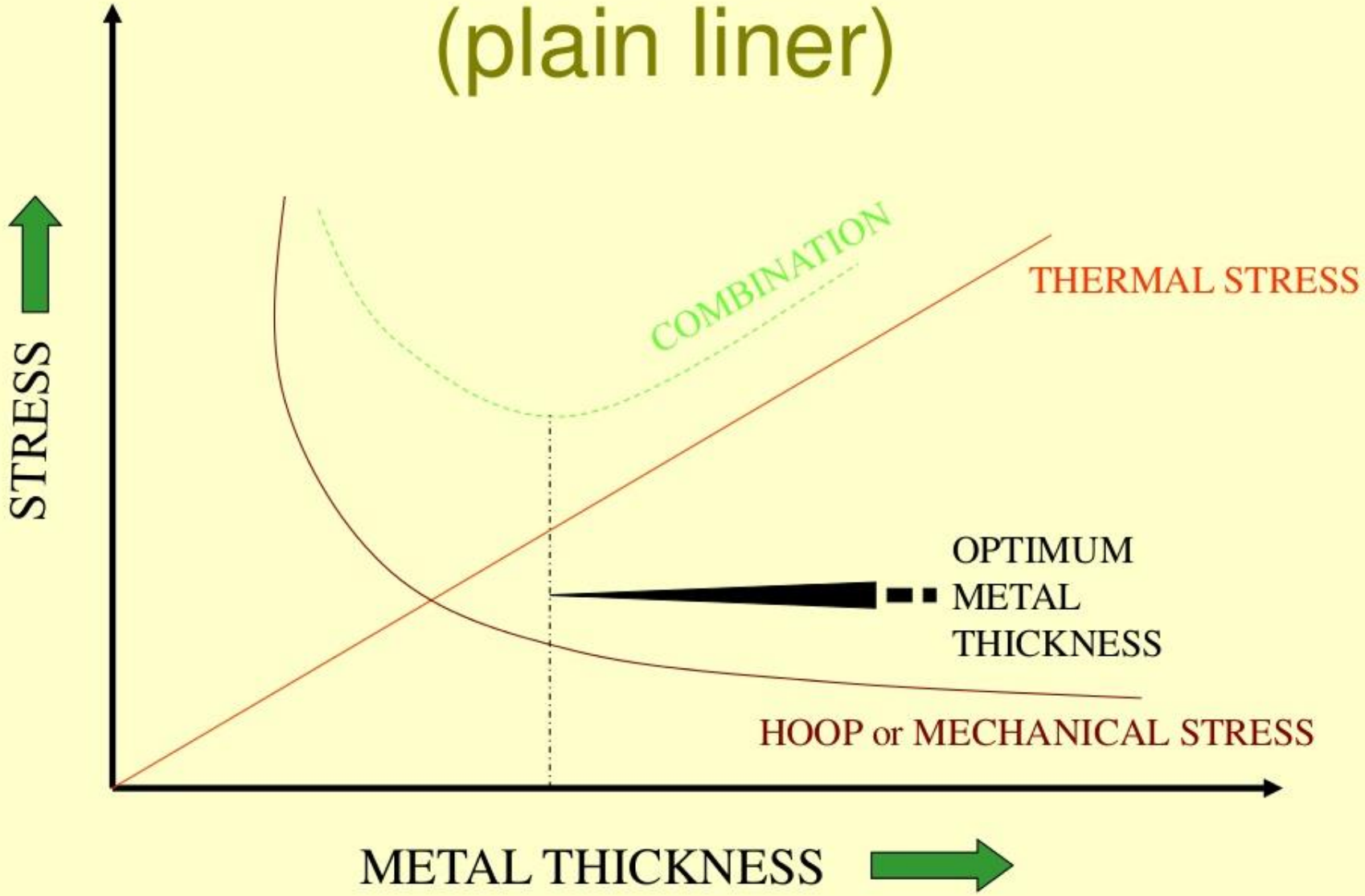
- Thicker liner will increase temperature gradient hence thermal stress but on the other hand, thicker liner have good resistance to mechanical stress. Thus, liner design becomes complex ,
- Also, inner liner surface temperature should be sufficiently low to retain oil film and high enough to avoid acid-dew (sulphur)

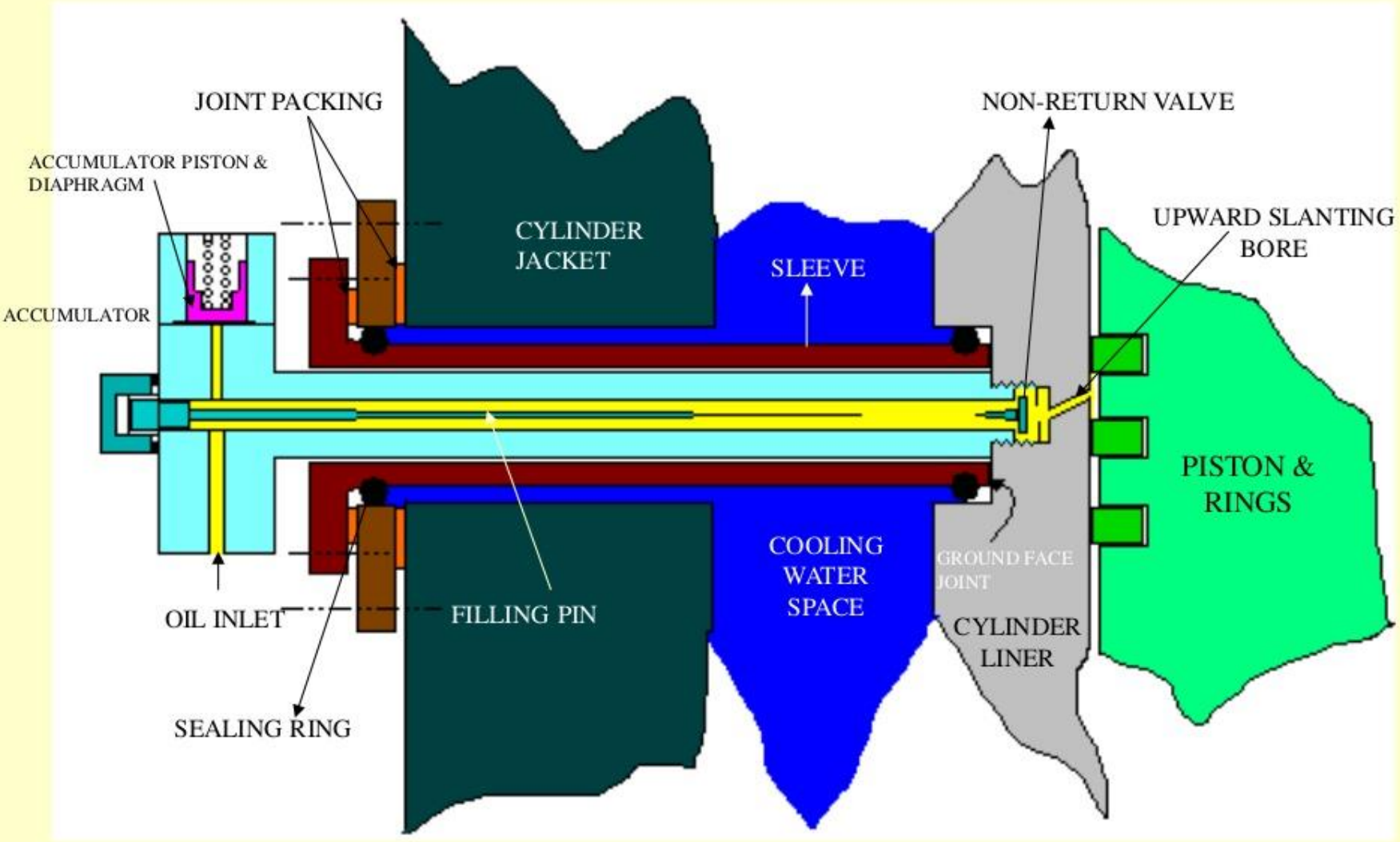
Estimated temperature in liner

- Next to liner wall 500°C
- On liner wall 140°C due to oil film, carbon deposits and stagnant
- Outer liner wall 75°C due to thickness of liner wall and cooling water
- Lower part 40°C due to expansion



Combination of stresses (plain liner)





NEW TYPE SULZER RND-M LUBRICATOR QUILL