

Cylinder Liner

Ident No.: 0742048-3

Machining of Cylinder Liner

This document is valid for existing engine types on order as of the date of this document:

Engine types:

All two-stroke engine types

Scope and Field of Application

This Production Recommendation provides guidelines for manufacturing of MAN B&W cylinder liners.

Production Recommendation

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Contents

1. References	3
2. Sequence of operations	3
2.1. Rough turning inside and outside	4
2.2. Test of liner material	5
2.3. Stress relieving heat treatment	5
2.4. Inside finish turning and liner surfaces	5
2.5. Outside finish turning	7
2.6. Semi-honing of wave cut profile surface	7
2.7. Pressure test	9
2.8. Drilling and/or milling of scavenging air ports and drilling of lubrication nozzle holes	9
2.9. Gun drilling of water cooling holes (for bore-cooled liners)	12
2.10. Grinding inside liner: Lubrication groove + Scavenge air port edges	15
2.11. Cleaning	17

Changes in this revision:

Section 2.7 is updated.

Section 2.11 is updated.

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1. References

MAN B&W Quality Specification:

No. 0743173-3; Tarkalloy-C/A, Cylinder Liners.

No. 0743614-4; Final inspection of running surface on cylinder liners, wave cut and semi honing.

No. 0743525-7; Pressure and Functional Test of Components.

MAN B&W Quality Control, Dimensional Inspection Scheme:

No. 0742619-9; Dimensional Inspection of Cylinder Liner.

2. Sequence of operations

2.1 Rough turning inside and outside.

2.2 Test of liner material.

2.3 Stress relieving by heat treatment.

2.4 Inside finish turning and wave profile cutting.

2.5 Outside finish turning.

2.6 Semi-honing of wave cut profile surface.

2.7 Pressure test.

2.8 Drilling and/or milling of scavenge air ports, and drilling of lubrication nozzle holes.

2.9 Gun drilling of water cooling holes (for bore-cooled liners).

2.10 Grinding inside liner : lubrication groove + scavenge air port edges.

Date	Designer	Checked	AC	Revision change	Revision
2018-10-24	KIM	JSC	Z3	Section 2.7 and 2.11 are updated	7

2.1. Rough turning inside and outside

A liner lathe is usually provided with an outside turning work head (chuck) and a heavy duty center rod, where the inside turning tool has firm support. This provides that rough boring and rough turning outside even can be carried out simultaneously.

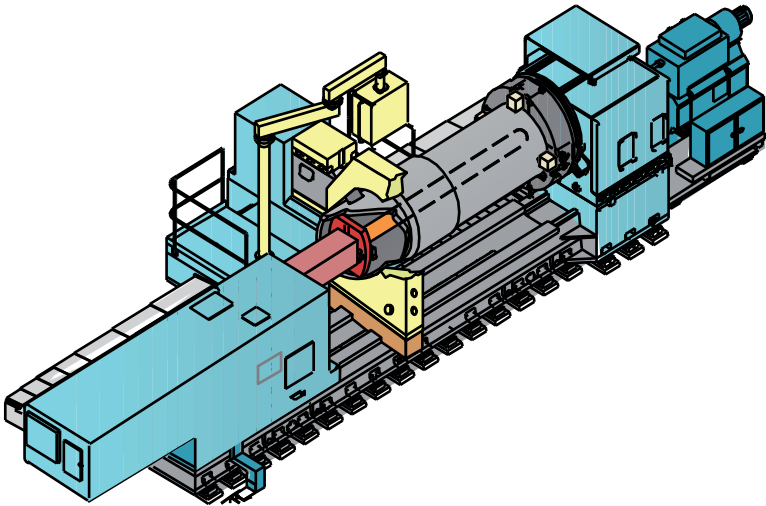


Figure 1:

Before setup of the liner in the lathe, an adjustable centering tool is inserted in the bottom end. Set up the liner in the lathe with the centering tool supported by the boring rod pivot, and the top end in the chuck.

Rough turn the diameter of top end collar including two slots for later material testing, the rest of the outside (allowance 5 mm), a face for the back stay rolls, and the bottom end face.

The liner is removed from the lathe and the centering tool is dismantled.

The liner is set up in the lathe reversed, with the bottom end in the chuck. The outside face is supported by back stay with two or more supporting rolls. The boring operation is done using the boring rod tool, which (depending on design) is provided with two to eight cutting tools for roughing in one pass.

Allowance 5 mm.

Simultaneously, the semi-finish outside turning can be performed. Allowance 3 mm, except for non-critical dimensions, which are turned finished in accordance with the drawing.

The dead head, including material testing ring, is slotted off. To prevent damages to the lathe bed, a wooden “cradle” can be put under the dead head. Test of liner material.

Date	Designer	Checked	AC	Revision change	Revision
2018-10-24	KIM	JSC	Z3	Section 2.7 and 2.11 are updated	7

2.2. Test of liner material

Test pieces are cut out from the ring on the dead head, as close to the slotted-off end as possible. The ring is created by turning a slot when the liner is in the lathe, so a ring is formed near the top end, see previous section.

For details regarding tests, please see MAN B&W Quality Specification No. 0743173-3; *Quality Specification for Cylinder Liners*.

2.3. Stress relieving heat treatment

Please see MAN B&W Quality Specification No. 0743173-3; *Quality Specification for Cylinder Liners*.

2.4. Inside finish turning and liner surfaces

Finish turning inside, including groove for PC-ring (if applied). Please observe the dimensions of the undercut radius in the corner of the circular and plane face of the PC-ring groove.

The boring rod is now equipped with 2 to 6 cutting tools, depending of design, to make it possible to machine down to an allowance of 0.15 to 0.30 mm for wave cut finish turning.

The liner surface created by special tool, see figure 2, followed by semi honing, provides optimal lubrication condition for liner and piston rings.

Wave cut turning is carried out by means of a single tool with special ground radius insert.

Table 1:

Liner type	Radius of insert
Liner 26	20
Liners 35 - 40 - 42	45
Liner 46	56
Liner 50	63
Liner 60	84
Liners 65 - 70	100
Liner 80	136
Liners 90 - 98	178

Date	Designer	Checked	AC	Revision change	Revision
2018-10-24	KIM	JSC	Z3	Section 2.7 and 2.11 are updated	7

The wave cut depth and pitch is stated on the drawing.
The wave cut depth and pattern must be uniform throughout the liner.



Figure 2: The turning tools (Sandvic Coromant) or similar.



Figure 3: The turning process.

Cutting data:

- N 5-6 R/min
- Vc 15 M/min

However, most flaws from the wave cutting will not show before the liner is finished after honing.

Date	Designer	Checked	AC	Revision change	Revision
2018-10-24	KIM	JSC	Z3	Section 2.7 and 2.11 are updated	7

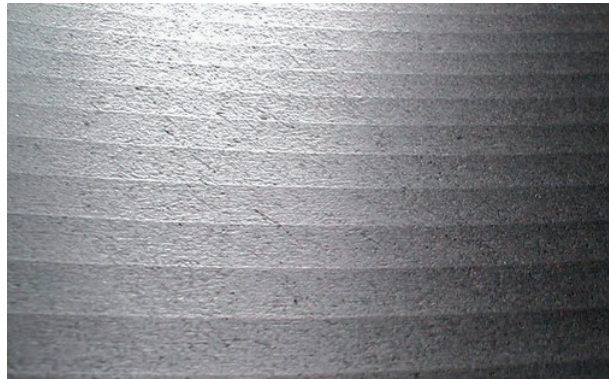


Figure 4: Good and even wave cut.

2.5. Outside finish turning

The liner is setup in the lathe with centering tools in both ends to align the bore centre to the inside circumference.

Machine according to drawing.

Note! Beware of all radius to be with smooth transitions - no step is allowed between a radius and a straight face.

2.6. Semi-honing of wave cut profile surface

Semi-honing (meaning: "a 50% honed surface") of the wave cut is necessary to create an optimal running surface for the piston rings.



Figure 5: Honing machine.

Date	Designer	Checked	AC	Revision change	Revision
2018-10-24	KIM	JSC	Z3	Section 2.7 and 2.11 are updated	7

The honing head is equipped with three to eight honing stones. A shaft with universal joints is used to connect the traversing mechanism to the honing head and the joints are to eliminate misalignment in the setup to be transferred onto the honed surface. The honing head moves up and down when rotating, and creates a crisscross pattern on the liner bore wave cut surface.

Honing must be done in vertical position.

Stones with grain size 40 to 60 can be used for rough honing, and finish honing is carried out with grain size 60 to 100.

Finished honed liner surface roughness: Ra 0.4 - 1.6.

The honing width (width of the removed material on top of the wave cut) is stated on the liner drawing, either as a formula or a specific dimension with a given tolerance.

The honing pattern must be uniform throughout the whole liner, within tolerances and have a uniform depth of the wave profile.

If the scavenge air ports are machined before semi-honing, a full length honing stroke is only possible by using long and rigid stones which are sufficiently supported by the stone base to avoid torsion of the stones (the base is a slotted steel bar which holds the stone in position).

We recommend the stones to be two to three times the length of the scavenging air port height. If such long stones are not available, honing must then take place above, under, and on the port area, in three single operations. There must be no transitions steps between the honed areas after honing.

For inspection and measurement of surface and wave cut, see MAN Quality Specification No. 0743614-4; *Final Inspection of running surface on Cylinder Liners, Wave Cut and Semi Honing*.

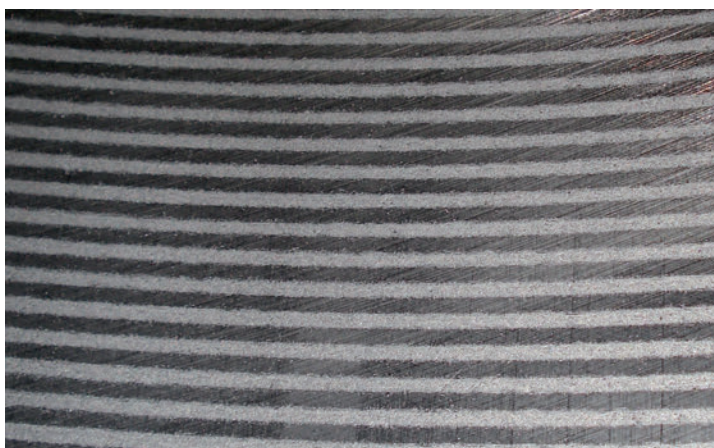


Figure 6: Example of a good honing.

Date	Designer	Checked	AC	Revision change	Revision
2018-10-24	KIM	JSC	Z3	Section 2.7 and 2.11 are updated	7

2.7. Pressure test

The cylinder liners are to be water pressure tested, in accordance with the rules of the Classification Societies, in the whole water cooled length. Testing with inside or outside pressure is optional. Test pressure and time to be according to MAN B&W Quality Specification No. 0743525-7; *Pressure and functional Test of Components*.

Judgment is carried out while liner is still under pressure:

- If “dark spots” or drops of water are observed, wipe off with a clean rag.
- If the formation of drops or “sweating” continues in the water-cooled length, i.e. from contact surface for cylinder cover to the lowermost edge of the lowest O-ring groove, the liner is not acceptable.

2.8. Drilling and/or milling of scavenging air ports and drilling of lubrication nozzle holes

The MAN B&W drawing standard is scavenge air ports machined by milling using a jig on a CNC milling machine with indexing table.

A milled port hole provides maximum intake of air for engine combustion. However, it is possible to machine the scavenging air ports solely by drilling instead of drilling/ milling by using short carbide tipped drills.

This procedure is in general more time consuming than milling, but is an option for makers without facility for milling. It requires an approved List of Difference (LOD) from MAN B&W, because it is not our standard, and the decreased air intake area can affect emission values, and thus has to be approved by MAN B&W.



Figure 7: Drilling of scavenge air ports.

Date	Designer	Checked	AC	Revision change	Revision
2018-10-24	KIM	JSC	Z3	Section 2.7 and 2.11 are updated	7

To make way for the milling tool, a short carbide tipped tool is used to penetrate each port hole of the liner. This tool must have a diameter, so the milling tool can cut through the hole, as the milling tool normally cannot penetrate the liner.

The hole is drilled in the downward end of the port, if the liner stands in vertical position, please see left side of photo below. The port walls does not need to have a fine surface, roughness value: Ra12.5 (and without any sharp edges).

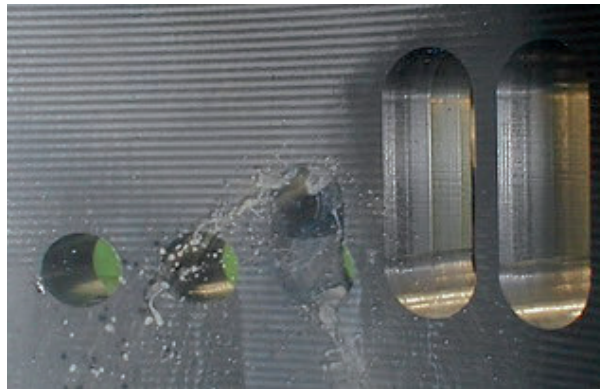


Figure 8: Milling of scavenge air ports.

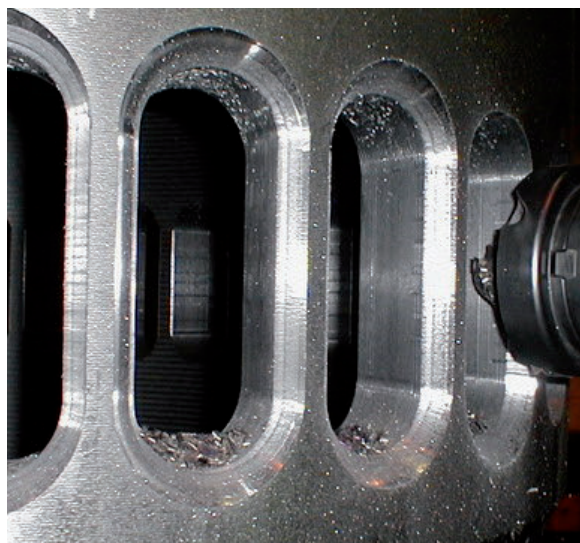


Figure 9: 3. Operation: Chamfering - Special milling cutter. (for shape of actual cutter - see liner drawing).

This cutter normally makes the outside port edges in one single pass from bottom to top with low revolutions.

Date	Designer	Checked	AC	Revision change	Revision
2018-10-24	KIM	JSC	Z3	Section 2.7 and 2.11 are updated	7

For K98 liners, a special cutter similar to the one for 70 and 80 liners are used to machine the port edge by linear and circular interpolation using CNC control.
The speed and feed can be increased substantially by using the interpolation method.

Lifting is to be done by clamp a special “belt” type lifting tool on the outside diameter of the liner. If the scavenging air port edges has been ground, it is possible to use a fibre sling through the ports for lifting.

Note! Do NOT attempt to lift the liner by use of a steel bar put through two opposite port holes, as it can squeeze out material at the edges of the liner port, and thus making severe damages to the piston ring allocate layer during running-in of the engine.

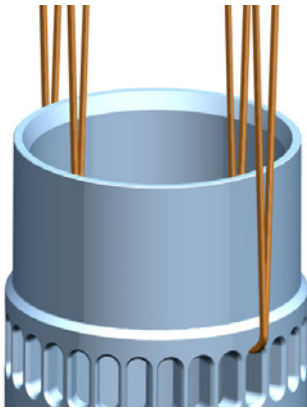


Figure 10:

The holes for oil lubricators are drilled on a conventional vertical drilling machine with drill jig, or can be carried out in conjunction with the scavenge air port machining on a CNC milling machine.

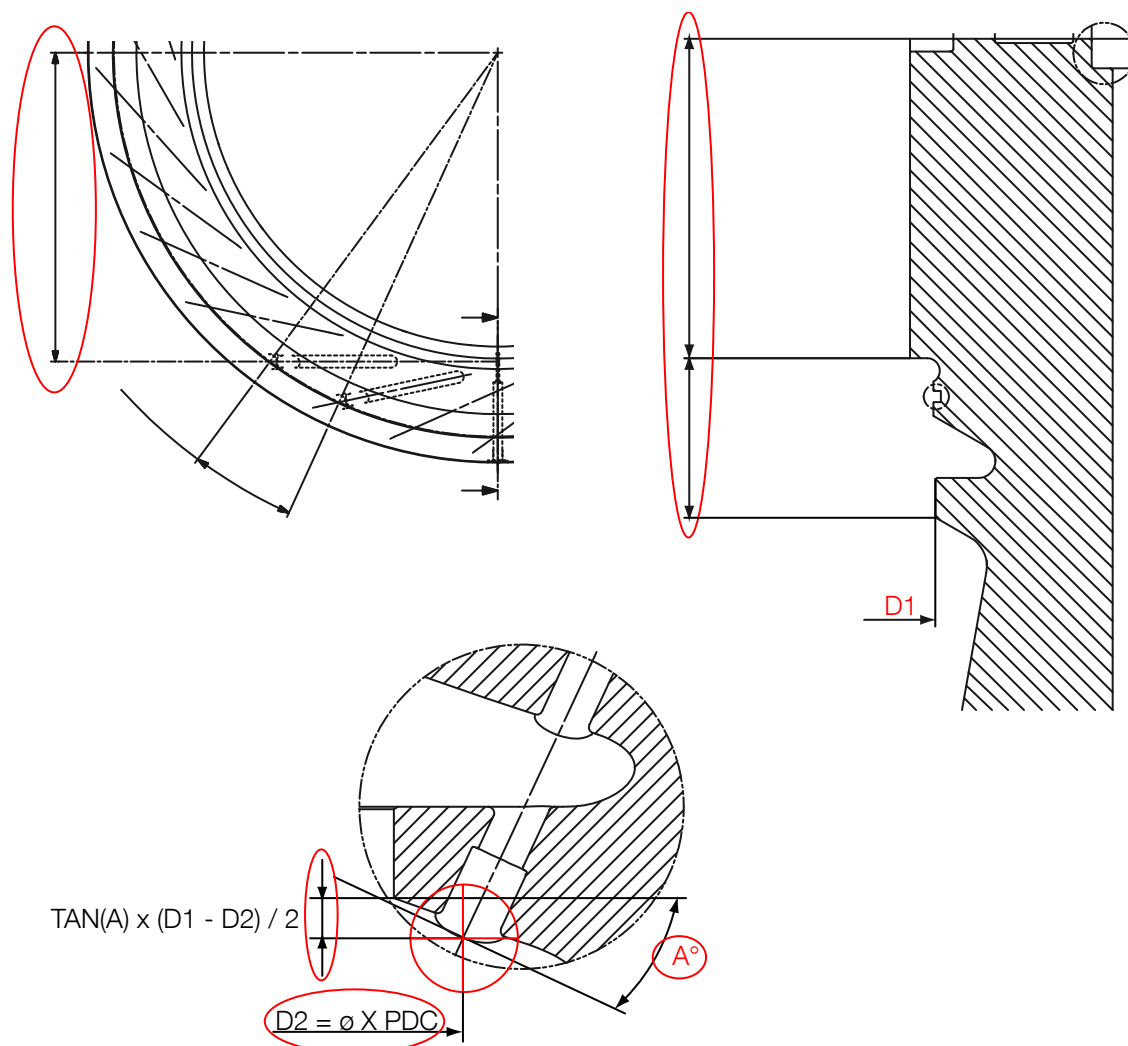
Note! For lubricator nozzles, three things are crucial - the distance of hole bottom to liner axial center, the seat angle, and the surface roughness of hole bottom seat.

Date	Designer	Checked	AC	Revision change	Revision
2018-10-24	KIM	JSC	Z3	Section 2.7 and 2.11 are updated	7

2.9. Gun drilling of water cooling holes (for bore-cooled liners)

Water cooling holes are normally drilled in special automatic machines facilitating automatic change of position of holes, and the use of carbide gun-drills with high pressure internal cooling supplied through the tool tip.

It is important before drilling / milling to calculate the exact coordinates and angle for the drilling.



It is also important that the drilling is performed correctly according to the rules of deep holes drilling.

Date	Designer	Checked	AC	Revision change	Revision
2018-10-24	KIM	JSC	Z3	Section 2.7 and 2.11 are updated	7

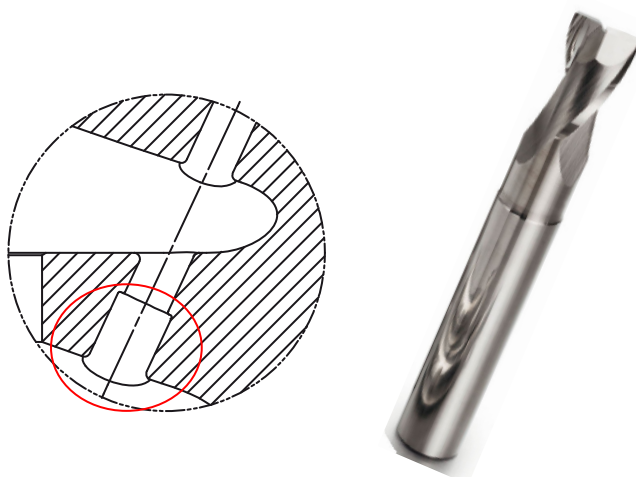
Machining sequences:

1. Drilling sequences:

Drilling/milling a spot face (hole for Spring Pin).

The hole has to be drilled / milled with an HM end mill with corner radius.

Sandvik CoroMill PLURA or similar is a suitable mill for this operation



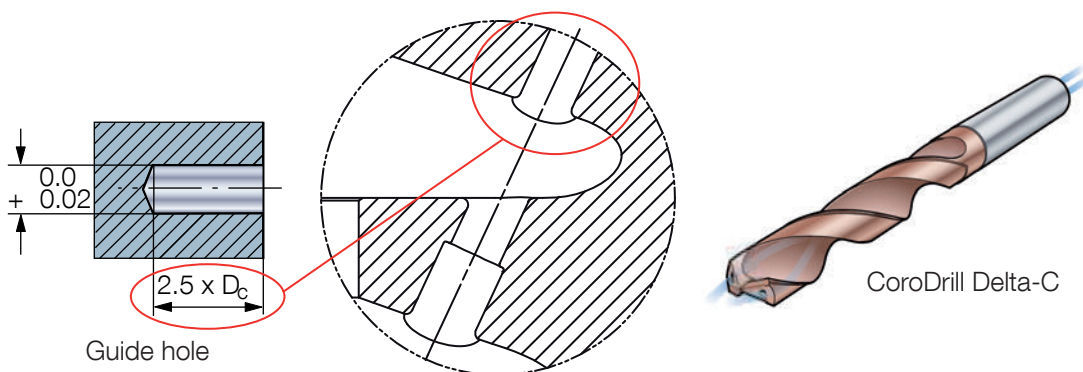
2. Drilling a guide hole:

Guide hole is required in order to properly drill with a gun drill.

The guide hole is drilled out with a short solid carbide drill.

Sandvik CoroDrill Delta-C or similar is a suitable drill for this operation.

The guide hole should be drilled to tolerance 0.0 to + 0.02 mm larger than gun-drill diameter.



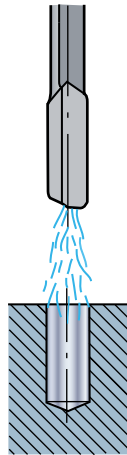
3. Deep hole drilling:

The deep hole drilling is carried out with a Gun-drill from Sandvik Coromant or Similar.

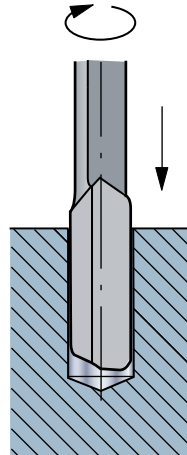
The sequence is as follows:

Date	Designer	Checked	AC	Revision change	Revision
2018-10-24	KIM	JSC	Z3	Section 2.7 and 2.11 are updated	7

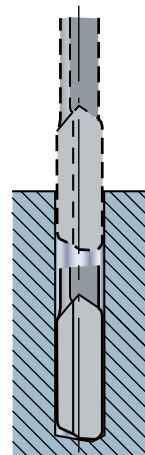
A. Feeding gun drill into guide hole



B. Start drilling



C. After the hole has been drilled



Caution:

Outside of the hole, the gun drill must not be rotating

Feed to insert the drill into the guide hole while supplying cutting fluid

Start cutting rotation
Start cutting feed

Rapid return
Stop at the guide hole position

Stop cutting rotation and coolant supply

Pull out the gun-drill from the workpiece

Gun drilling to bottom, subtracted the length of hole bottom radius.

4. Gun drilling of hole bottom radius:

The finish drilling is carried out with a radius gun-drill from Sandvik Coromant or similar.
The sequence is the same as point 3.

Note!

The cooling water holes will later be fitted with special tubes.

Please observe correct centering of the milled tube collar hole/cooling hole, and furthermore observe the requirement of a R0.8 radius for the tube seating at the entrance face of the deep hole, as this radius has the important function of avoiding the tube collar to crack in service.

Date	Designer	Checked	AC	Revision change	Revision
2018-10-24	KIM	JSC	Z3	Section 2.7 and 2.11 are updated	7

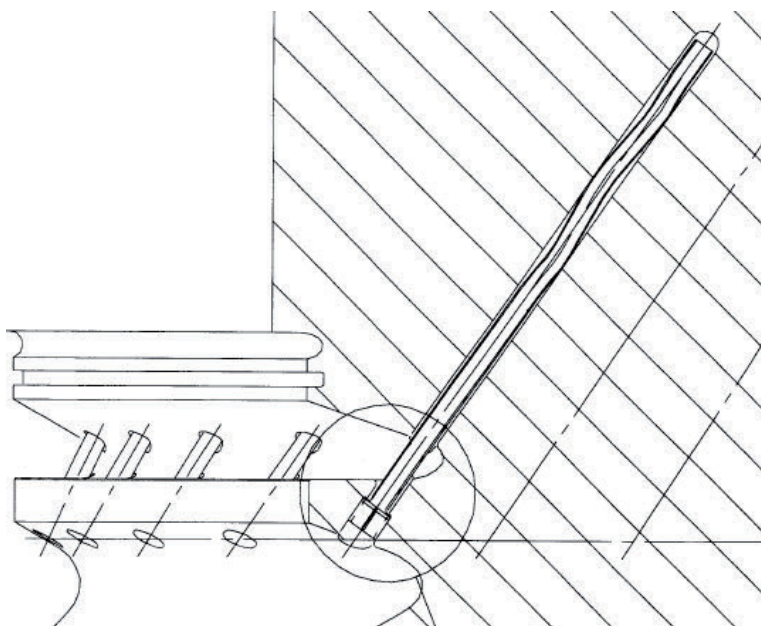


Figure 11: Tube in cooling hole.

2.10. Grinding inside liner: Lubrication groove + Scavenge air port edges

If the liner has lubrication grooves, it is usually ground by hand grinding, using an angle grinding machine.

We recommend to make a template to check the shape frequently during the work, see figure 12.

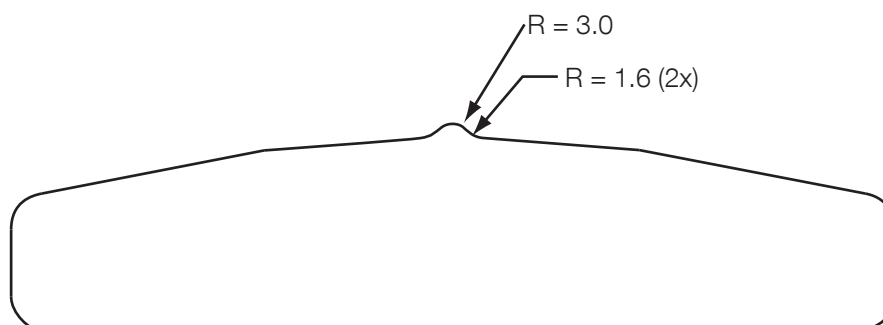


Figure 12: Steel Plate groove template.

For machining of the zig-zag groove, it is possible to use a CNC milling machine with angle head extension in combination with a vertical roundtable and backstay rolls for support of the liner.

A special ground carbide milling cutter of same shape of the groove can machine the groove to specified dimensions. However, a little handwork is still required to smoothen the edges of the groove.

Date	Designer	Checked	AC	Revision change	Revision
2018-10-24	KIM	JSC	Z3	Section 2.7 and 2.11 are updated	7



Figure 13: Conventional zig-zag groove.



Figure 14: Lubricator deep straight groove (in combination with a zig-zag groove).

The scavenge air ports are ground inside with an angle of 10° in top and bottom, and rounded slightly at the side edges, always following the contour.

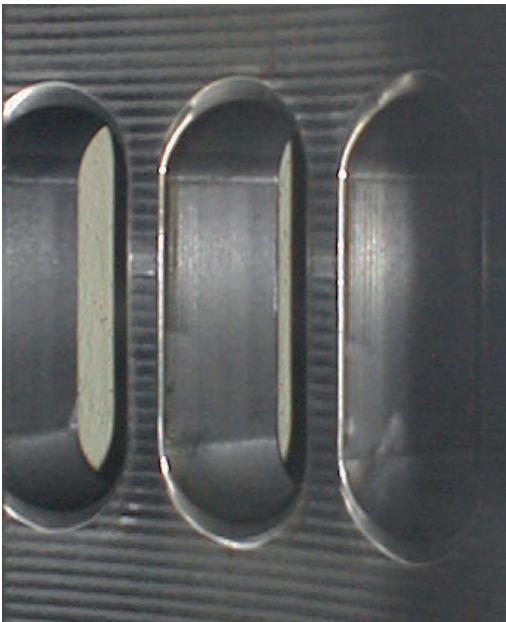


Figure 15: Correct grinding of milled ports

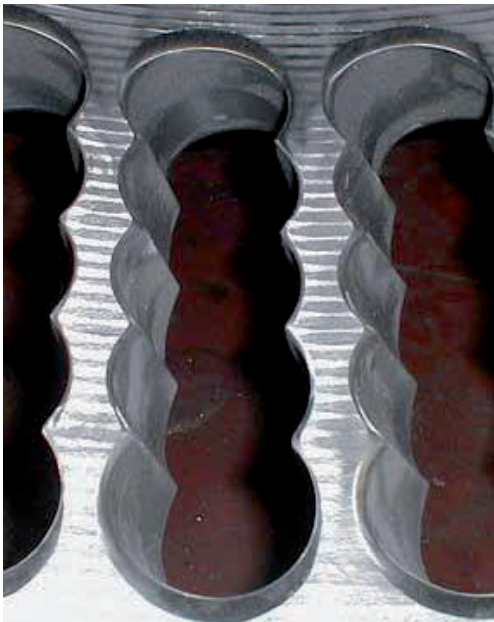


Figure 16: Correct grinding of drilled ports

Date	Designer	Checked	AC	Revision change	Revision
2018-10-24	KIM	JSC	Z3	Section 2.7 and 2.11 are updated	7

For best result of the grinding work, place the liner in horizontal position on rolls, so the liner can be rotated. The height of the work place has to be, so the worker is in a good working position. It is necessary to avoid fatigue of the body, which can lead to inaccuracy of the grinding work.

Note! Large liners (80 size and above) can be ground in vertical position with the liner standing on a steady ring of wood or steel, diameter of hole 800 mm.

This provides the worker to grind inside the liner when placed in a good working position (sitting or standing). Thus, it is unnecessary to facilitate rotation of the liner; only a turnover is required when the opposite end of the liner is ground.

Inside a liner the light is not sufficient.

The illumination of the work area must be well to make good workmanship. For that reason the light should always be close to the worker, and with most high power lamps the lamp heat can get very unpleasant.

We can recommend low-energy lights, which emits far less heat than conventional light sources (and saves power too).

Removal of grinding dust and steel dust is essential to have a clear view of the work area, and of course for the worker's health.

We recommend to use local point suction ventilation equipment, such as a suction hose placed near the work area.

Eye protection goggles and hearing aids (or ear plugs) are highly recommended.

2.11. Cleaning

The cylinder liner must be cleaned according to MAN B&W Quality Specification No. 0743173-3; *Tarkalloy-C/A, Cylinder Liners*.

Date	Designer	Checked	AC	Revision change	Revision
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