Action code: WHEN CONVENIENT

Overhaul Strategy ME/ME-C and ME-B Engines

ME specific components

SL2017-644/JERA
March 2017

Concerns

Owners and operators of MAN B&W two-stroke marine diesel engines.
Type: ME/ME-C and ME-B

Summary

Recommendations on a detailed overhaul strategy, monitoring and update of the ME specific components of MAN B&W two-stroke engines are given based on approximately 10 years of service experience.

References are made to SL2015-609 and SL2017-643.

Dear Sirs

This service letter provides recommendations on a detailed overhaul strategy, monitoring and update of the ME specific components of MAN B&W two-stroke engines (ME/ME-C and ME-B) based on approximately 10 years of service experience.

The aim is to facilitate planning and implementation of available upgrades with focus on areas primarily related to 5-year dockings. The service letter also includes recommendations on overhauls and inspections to be done in service outside the 5-year docking intervals.

Yours faithfully

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Content:

Engine control system software version

Recommended software versions:
ME: 0905 or higher
ME-B: 0906 or higher

It is recommended that ME engines operating with engine control system (ECS) software versions 0510 or lower are upgraded to version 0905 or higher when it is convenient, typically during dry dock.

The upgrade primarily offers improved troubleshooting assistance provided by a main operating panel (MOP) interface assisting the crew on board.

Any ME engine can be upgraded to a higher software version in order to improve the troubleshooting assistance. However, this would be carried out as a normal payment job.

Hydraulics

Electric motors for electrically driven pumps

For information about the expected lifetime of electric motors and bearings, please consult the makers' guidelines. Electric motors are typically defined for a lifetime of 32,000 running hours (R/H).

Hydraulic pumps

Recommended overhaul intervals (SL2017-643):

- hydraulic pumps: 32,000 R/H
- proportional valves/control valves: 20,000 R/H.

Omission of regular maintenance of these pumps can result in:

- damage to pump elements, typically the bearings
- limited propulsion power
- damage to hydraulic components in the hydraulic cylinder unit (HCU) and fuel injection valve actuation (FIVA).

For further details and recommendations on engine driven hydraulic pumps, see SL2015-609.

Hydraulic cylinder unit

Fuel oil pressure booster

Recommended overhaul and replacement intervals (SL2017-643):

- overhaul of suction valve: 8,000 R/H
- replacement of suction valve: 32,000 R/H
- overhaul of complete fuel oil pressure booster: 32,000 R/H.

Generally, service experience with the fuel oil pressure booster (FOPB) has been excellent, see Fig. 1. We have yet to observe any worn-out booster elements, at least to the state where the FIVA valve and the hydraulic control loop are unable to compensate for wear in the booster cylinder and the plunger itself.

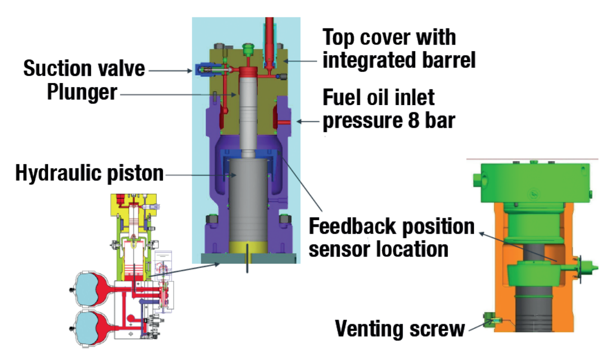


Fig. 1: Fuel oil presssure booster overview

On a limited number of engine types, we have observed minor issues with the installed suction valves which resulted in increased wear or, in some cases, damage to the suction valves. Design changes have been implemented which ensure trouble-free operation of the suction valves. It is recommended replacing the suction valve every fifth year supported by overhaul and inspection every second/

third year based on the number of running hours as previously mentioned.

Furthermore, it is recommended overhauling the FOPB completely every fifth year (32,000 R/H). This includes changing the seals on both the fuel oil side and the hydraulic oil side. During the overhaul it is also recommended checking the running surfaces of the plunger/barrel and the connection between the umbrella and the plunger. Fig. 2 shows the top cover and the umbrella mounted on the plunger.

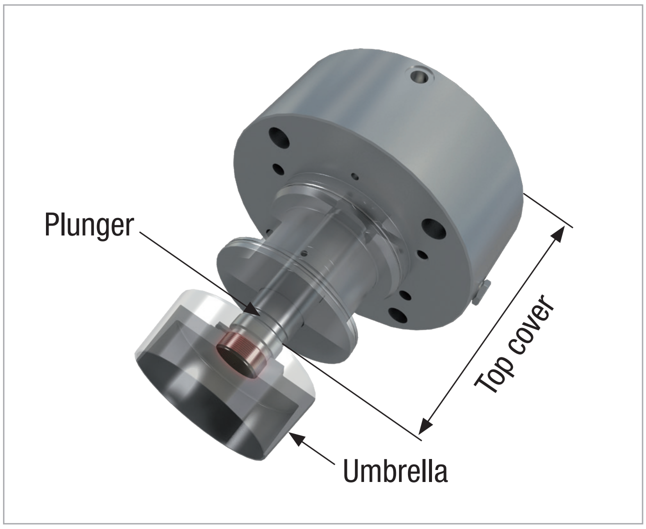


Fig. 2: Plunger and umbrella

It is recommended inspecting the high-pressure pipe with focus on the general condition of the sealing surface in order to ensure correct seating and minimise the risk of fuel oil leakages, see Fig. 3.

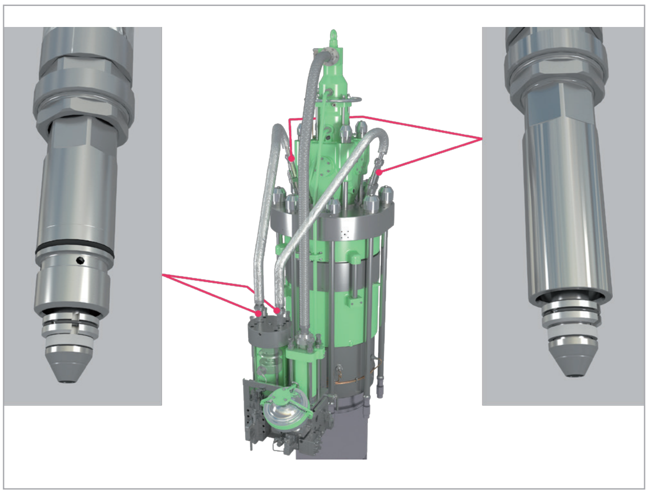


Fig. 3: Fuel oil high-pressure pipes

Exhaust valve actuator

Recommended overhaul intervals (SL2017-643):

- exhaust actuator: 32,000 R/H.

The 5-year (32,000 R/H) overhaul of the exhaust valve actuator includes an inspection of step-one and step-two pistons and the cylinder for cavitation, see Fig 4.

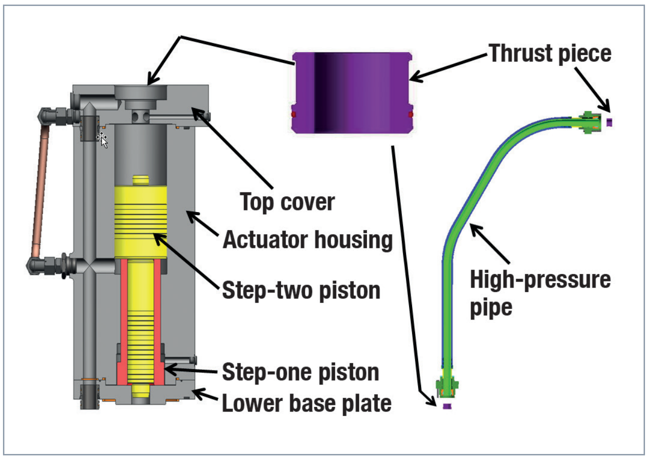


Fig. 4: Points of interest in the exhaust valve actuator and high-pressure pipe

At a number of engine types we have observed mild cavitation of the exhaust valve actuator components as seen from the photos in Figs. 5-9.

A narrow ring of surface changes can normally be found on the base plate at the outer landing surface for the step-one piston, see Fig. 5.

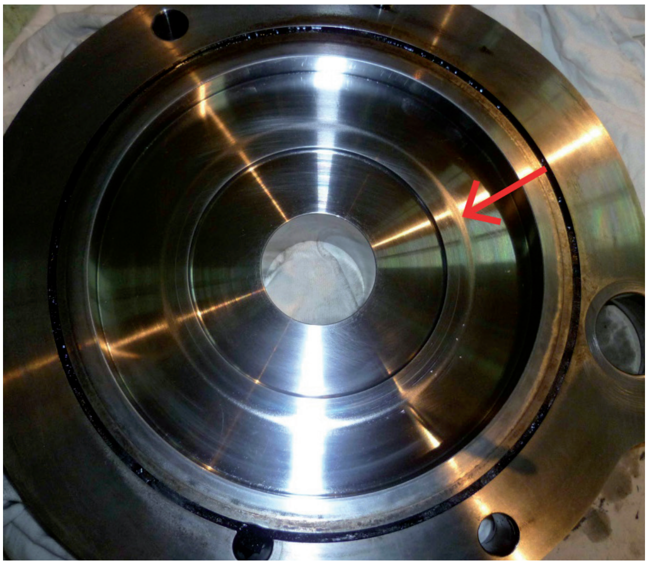


Fig. 5: Lower base plate with surface changes

In most cases cavitation can be seen near and inside the inlet holes of the top cover, see Fig. 6A. In severe cases it justifies smoothening of the surface.
Cavitation can also be seen near the grooves on the top cover, see Fig. 6B, and in severe cases slight grinding might be necessary.

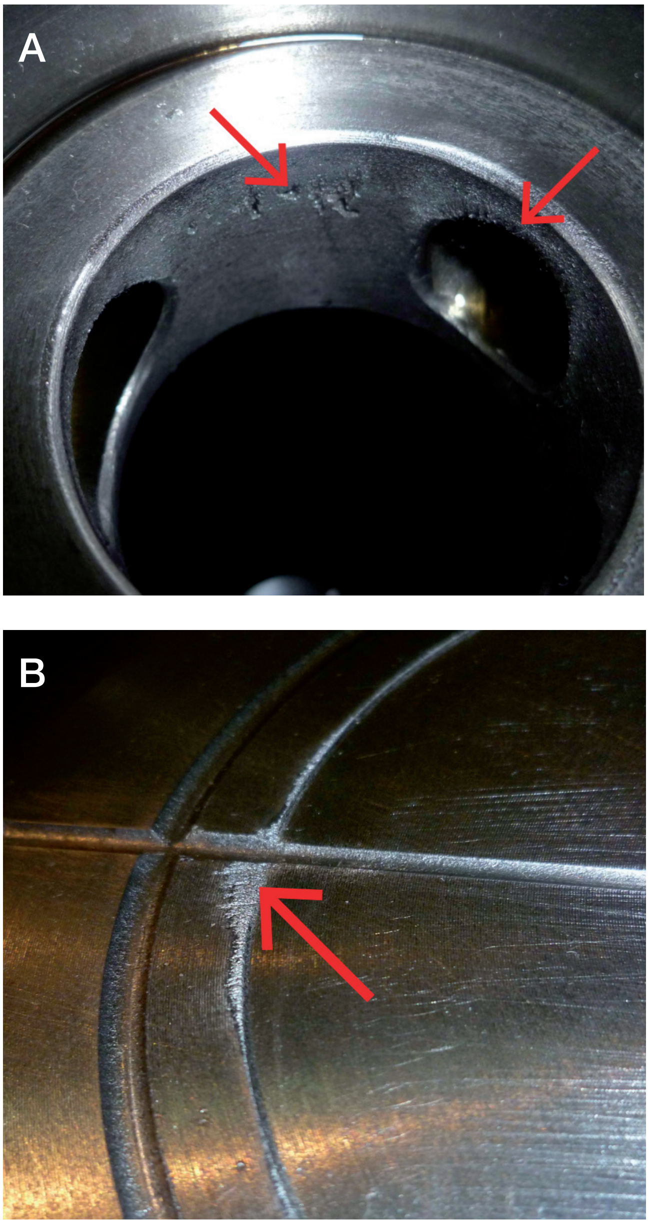


Fig.6: Cavitation near the top cover inlet holes and near the grooves

The lower thrust piece (disc) may be found with cavitation, see Fig. 7. In severe cases, where the sealing surface is affected, a new thrust piece in terms of a bushing can be mounted. Usually the upper thrust piece has no cavitation.

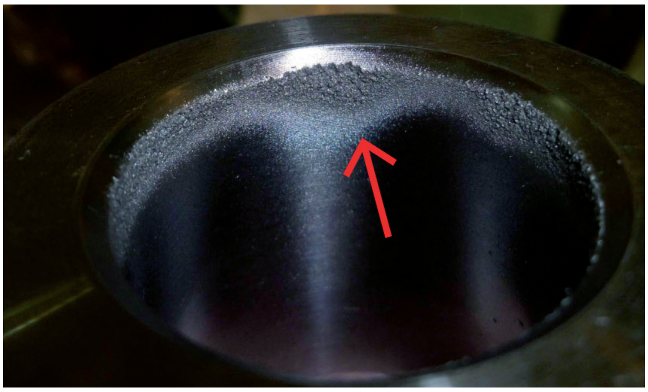


Fig. 7: Lower thrust piece with cavitation

The step-one piston may have a ring of cavitation on the inside (Fig. 8A) and at both ends (Fig. 8B). Usually, this cavitation is regarded as harmless and the piston can be used again.

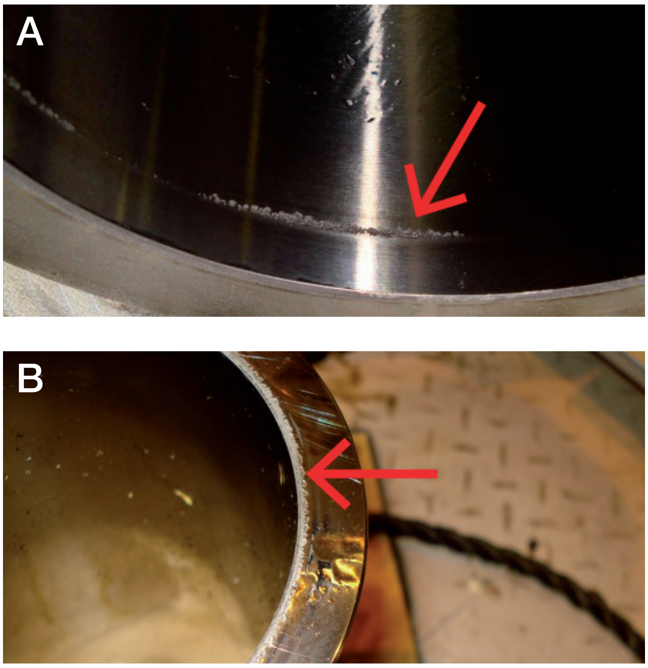


Fig. 8: Step-one piston with cavitation

The step-two piston can have two different designs with either a short or a long damper nose at the top end of the piston.

Only the long damper nose has been seen with cavitation, see Fig. 9A. This cavitation is cosmetic and the piston can be reused.

If the running surfaces of the piston and the actuator housing have slight score marks, as shown in Fig. 9B and C, these can be polished to flatten the surface. In severe cases, the piston and the housing must be replaced because the housing will have similar severe score marks.

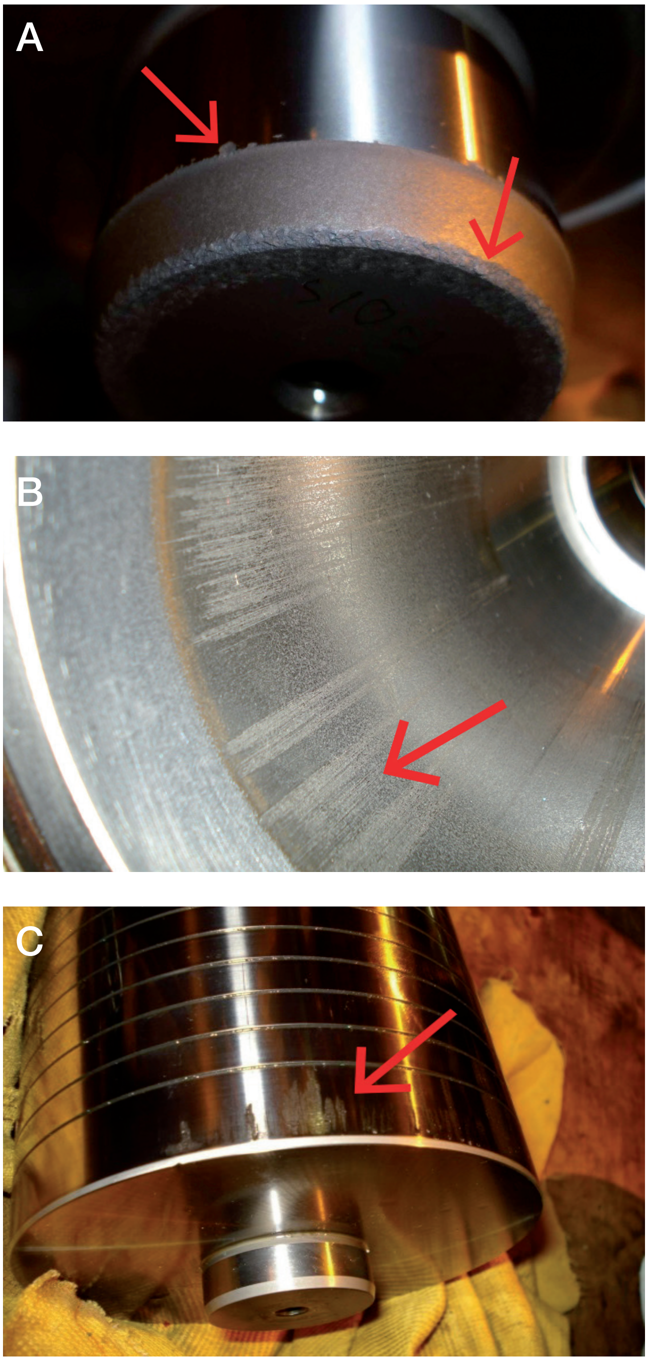


Fig. 9: Step-two piston with cavitation

In the majority of the above cases, the cavitation does not influence the performance of the actuator itself. However, the condition calls for inspection every fifth year. An inspection should also be carried out if any operational problems are encountered with the exhaust valve actuation in service.

Similar mild cavitation has been observed on the high-pressure pipe for some engine types, mostly in the uppermost bend on these pipes. The condition is not alarming, but it is recommended making a visual inspection when a normal overhaul is carried out and the high-pressure pipe is dismantled from the engine.

Non-return valve of exhaust valve actuator

Occasionally, we have observed failures of the non-return valve (NRV) at the low-pressure oil inlet side to the actuator resulting in unstable exhaust valve actuation and, in a few cases, actual damage to the actuator itself.

Currently, there are two types of NRV available, a standard and a heavy-duty type. For the standard type, we recommend replacement every second year to ensure troublefree operation. The possibility exists to upgrade to the heavy-duty type on request. The heavy-duty type is the standard on primarily large bore engines (above 700 mm bore).

For the small and medium bore engines (engines with bore diamters below 700 mm) an upgrade is possible with a kit and a minor adjustment to the original pipes.

Hydraulic control valves (FIVA/ELVA/ELFI)

Recommended overhaul intervals (SL2017-643):

- FIVA valve: 32,000 R/H

Currently, there are four major suppliers of FIVA valves in the market. These are:

1. MAN Diesel & Turbo (Parker or MOOG control valve)
2. Nabtesco (Senaco valve and Nabtesco control valve)
3. Bosch Rexroth
4. Curtiss Wright (CW).

The tool "HCU event" on the main operating panel (MOP) can be used to plot the curves shown in Fig. 10. When the unit is operating well it is recommended making a trend on each unit, manually, with the engine running. The trend can be used for later troubleshooting.

Fig. 10 shows the signals from a FIVA in working order. On the figure, activation of the fuel pump is seen as plunger position Ch. 31, while the exhaust valve is shown as exhaust valve position, Ch. 34. The setpoint activates the FIVA and hereby FIVA feedback Ch. 30. A small mechanical delay is likely to occur, whereas large deviations are mostly caused by problems with the MPC or the proportional valve for the specific unit.

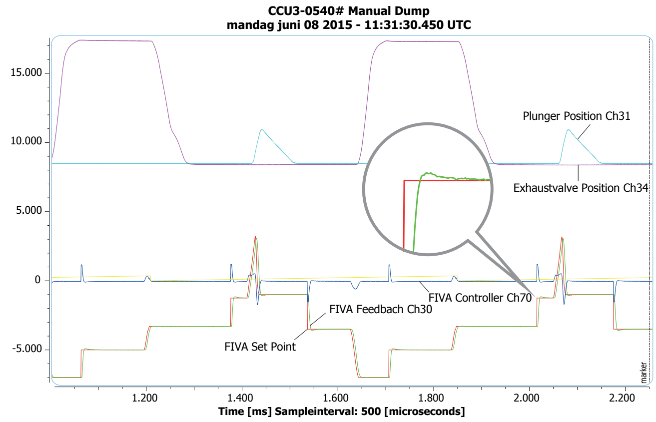


Fig. 10: Signals from a FIVA in working order

The curves in Fig. 10 are examples, the actual function must be monitored using HCU events. Note, that it is only possible in ECS version 0905 and higher. For further guidance, see the MOP description in the manual on board.

On-site overhaul and calibration can be carried out on board. The individual overhaul strategies differ and the major difference is between the Curtiss Wright (CW) and the rest of the FIVA/ELFI valves. The only possible and reliable overhaul of a CW valve is a factory recondition because calibration is not possible on board. A retrofit solution where all FIVAs will be replaced with the new MAN Diesel & Turbo FIVA can be offered.

The CW FIVAs will be serviced until December 2018 and retrofit solutions are offered. For the remaining FIVAs, an on board overhaul is offered which includes:

- exchange of O-rings
- replacement of the 4/3-way control/proportional valve
- function test of the valve after completion.

The two items below can be carried out on the basis of on board troubleshooting:

- dismantling, cleaning and visual inspection of the valve housing and the main spool
- replacement and calibration of the feedback sensor.

Accumulator

Recommended overhaul intervals (SL2017-643):

- recharging of accumulators: 2,000 R/H
- replacement of accumulator membrane: 32,000 R/H.

It is our impression that the condition and maintenance of the accumulator installed on the HCU and HPS are often overlooked. It is therefore important for us to stress that checking and maintaining the N_2 pressures are vital in ensuring trouble-free operation of HPS pumps and ELFI and FIVA valves in accordance with the intervals and pressure settings specified in the instruction manual on board.

Incorrect N_2 pressure may result in incorrect injection timing and exhaust valve opening or hydraulic pressure fluctuations in the HPS. This will initiate alarms and, in more severe cases, slowdown of the engine itself.

Examples showing typical damage to the diaphragm in the accumulator are shown in Fig. 11.

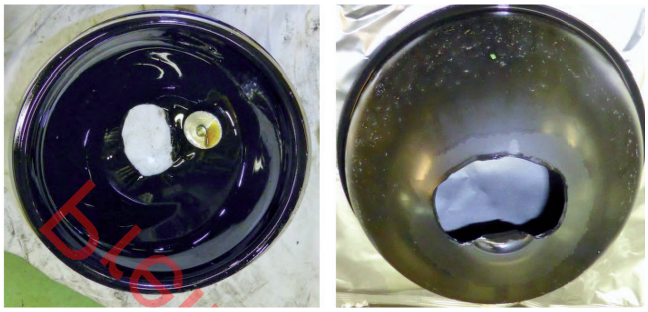


Fig. 11: Typical damage to the diaphragm

System and hydraulic oil cleanliness

The following recommendations apply with regard to system and hydraulic oil:

1. After the 6 μm filter, the oil cleanliness must comply with ISO 4406 xx/16/13 and be monitored at a regular basis.
2. The risk of air in the system oil must be eliminated.
3. As part of a condition-based monitoring system, the pump build-up pressure time should be monitored.
4. We recommend installing a water-in-oil monitoring system.

For further details, please check the relevant information mentioned in the enclosed *Filtration Handbook, Filtration and flushing strategy* issued by MAN Diesel & Turbo.

The typical standard oil analysis, which is used today on merchant marine vessels is missing vital tests.

The operation manual for ME engines recommends testing the oil cleanliness regularly, including a particle count in accordance with ISO 4406.

Hydraulic oil cleanliness is vital for the correct functioning of hydraulic control valves and hydraulic pumps installed on two-stroke engines. Furthermore, clean oil will ensure an optimum lifetime of the involved hydraulic components.

Since this issue is often neglected, and since further tests will facilitate monitoring of both the function and correct use of oil purification systems on board, we strongly recommend introducing or implementing the following extra tests as part of any regular oil sample analysis, see also Fig. 12.

Before the engine or the hydraulic filter:
The oil cleanliness should be in accordance with ISO 4406, acceptance criteria xx/19/15.

After the engine or the hydraulic filter:
The oil cleanliness should be in accordance with ISO 4406, acceptance criteria xx/16/13.

Cleanliness of hydraulic oil is normally examined by the laser method. However, this is not a suitable method for the system oil, as the system oil is black containing harmless soot, small water-droplets, air-bubbles, etc., which the laser method counts as particles. With the microscope method, the soot, etc., is removed and merely the number of actual particles are counted. MAN Diesel & Turbo therefore recommends using the microscope method (ISO 4407).

The results obtained could moreover be used to trend and monitor the efficiency of the purifiers and related equipment on board.

We recommend implementing a check for asphaltene on a regular basis (intervals of approximately six months), to monitor the performance of the FOPB umbrella and the seals.

Any elevated level of asphaltene (from fuel oil) in the system oil may result in higher and, at times, faster developing/increasing burn rates on the piston crown top due to the decreased level of cooling. The oil is considered uncontaminated if the asphaltene concentration in a sample is below 0.10% volume.

Superfine filter

In order to optimise the cleanliness of the hydraulic oil, a superfine filter (SFF) has been developed. The SFF significantly reduces the risk of damage to the FIVA and HPS control valves. The installation is a simple plug and play solution and is suitable for all ME/ME-C and ME-B engines with a specific filter type. Please check with MAN Diesel &

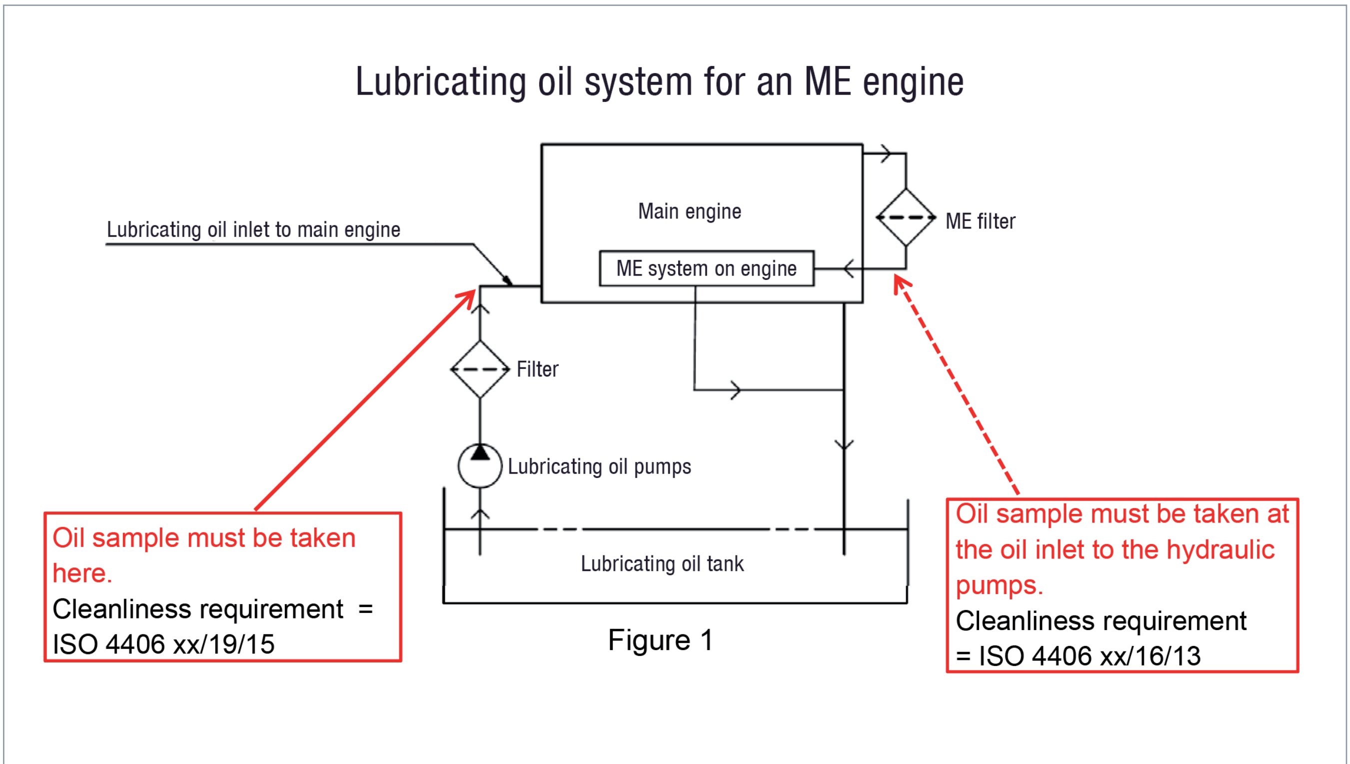


Fig. 12 - Fig. 1 from: Cleanliness requirements for lubrication oil, newsletter issued by MAN Diesel & Turbo (Issue 4, March 2010, LEP)

Turbo which filter should be used for your specific engine(s).

The SFF should as a minimum be used once every month for eight hours with the engine running. We also recommend using it for two hours with the engine running after the hydraulic oil main tank has been topped up.

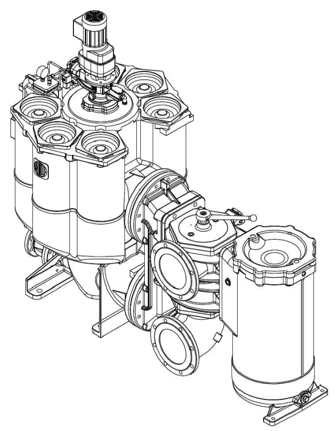


Fig. 13: Hydraulic auto-filter

If you have any questions regarding this service letter, please contact MAN Diesel & Turbo at: dt-cph@mandieselturbo.com.

Filtration Handbook

Filtration and flushing strategy

Engineering the Future – since 1758.

MAN Diesel & Turbo

Content

Filtration Handbook

Filtration and flushing strategy

Introduction

The exacting tolerances in today's hydraulic systems require tight control of the system contamination.

Experience has shown that impurities found in the system originate from the installation and from new oil.

If not removed, particles will cause damage to valves, pumps and bearings and, eventually, lead to malfunction of the system and increased wear on the hydraulic components.

To avoid the above and reduce flushing time to a minimum, the whole system must be absolutely clean before filling up with oil and starting up the engine.

Purpose of this Paper

It is vital that hydraulic system installations are carried out in accordance with the best practices, as described in this paper.

This will prevent difficulties during start-up of the equipment and reduce the risk of suffering damage to the system.

By following the guidelines given in this paper, a quicker and more efficient flushing process is achieved.

Definitions and Standards

MAN Diesel & Turbo specifies the international ISO 4406 standard to be used when defining the quantity of solid particles in the fluid used in a given hydraulic power system.

ISO 4406

The scale numbers are allocated according to the number of particles per 100 ml of the fluid sample. A step ratio of generally two, as given between the upper and lower limits for the number of particles per 100 ml, has been adopted to keep the number of scale numbers within a reasonable limit and to ensure that each step is meaningful, see Table I.

NAS 1638

The concept of the code can be seen in Table II. It is based on a fixed particle size distribution of the contaminants over a size range of >5 to >100 microns. From this basic distribution, a series of classes covering clean or dirty levels has been defined. The interval between each class is double the contamination level, see Table II.

ISO 4406 chart

	Number of particles per 100 ml	
Range number	**More than**	**Up to and including**
24	8,000,000	16,000,000
23	4,000,000	8,000,000
22	2,000,000	4,000,000
21	1,000,000	2,000,000
20	500,000	1,000,000
19	250,000	500,000
18	130,000	250,000
17	64,000	130,000
16	32,000	64,000
15	16,000	32,000
14	8,000	16,000
13	4,000	8,000
12	2,000	4,000
11	1,000	2,000
10	500	1,000
9	250	500
8	130	250
7	64	130
6	32	64

Table I: The ISO 4406 standard is a decisive tool defining the quantity of solid particles in the fluid in MAN Diesel & Turbo installations

Class	Maximum particles/100 ml in specified size rang (μm)				
	5-15	**15-25**	**25-50**	**50-100**	**>100**
0	125	22	4	1	0
0	250	44	8	2	0
1	500	89	16	3	1
2	1,000	178	32	6	1
3	2,000	356	63	11	2
4	4,000	712	126	22	4
5	8,000	1,425	253	45	8
6	16,000	2,850	506	90	16
7	32,000	5,700	1,012	180	32
8	64,000	11,400	2,025	360	64
9	128,000	22,800	4,050	720	128
10	256,000	45,600	8,100	1,440	256
11	512,000	91,200	16,200	2,880	512
12	102,400	182,400	32,400	5,760	1,024

Table II

Cleanliness requirement – ISO 4406 versus NAS 1638

The recommended standard for definition of oil cleanliness level is ISO 4406.

If NAS 1638 is used, the number of particles in a 100 ml sample larger than 6 and/or 14 microns must be within the range specified by the ISO 4406 code.

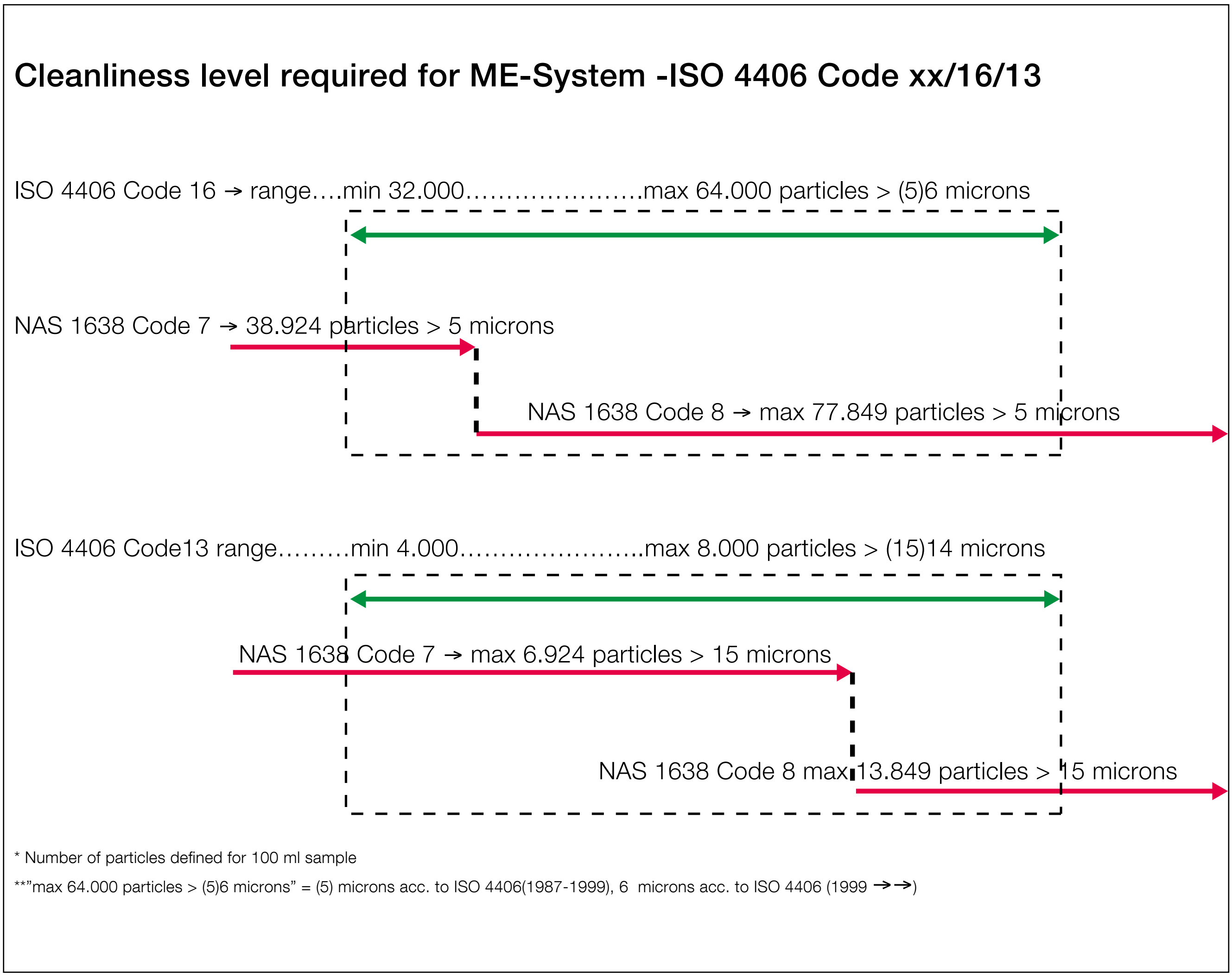


Fig. 1: ISO 4406 vs. NAS 1638 - cleanliness level required for ME/ME-C engines

Fluid Maintenance

All fluid stored in sealed containers or delivered from an oil company must be filled through a filter cartridge with a filtration ability of $ß_6$ (beta) = 200.

Beta ratio: example of filtration ability, valid for particles > 6 microns

$$ß_6 = \frac{\text{8,000,000 particles > 6 microns at filter inlet}}{\text{40,000 particles > 6 microns at filter outlet}} = 200 \rightarrow ß_6 = 200$$

From ISO 4406 Code 23 to ISO 4406 Code 16 after first pass

New oil is dirty!

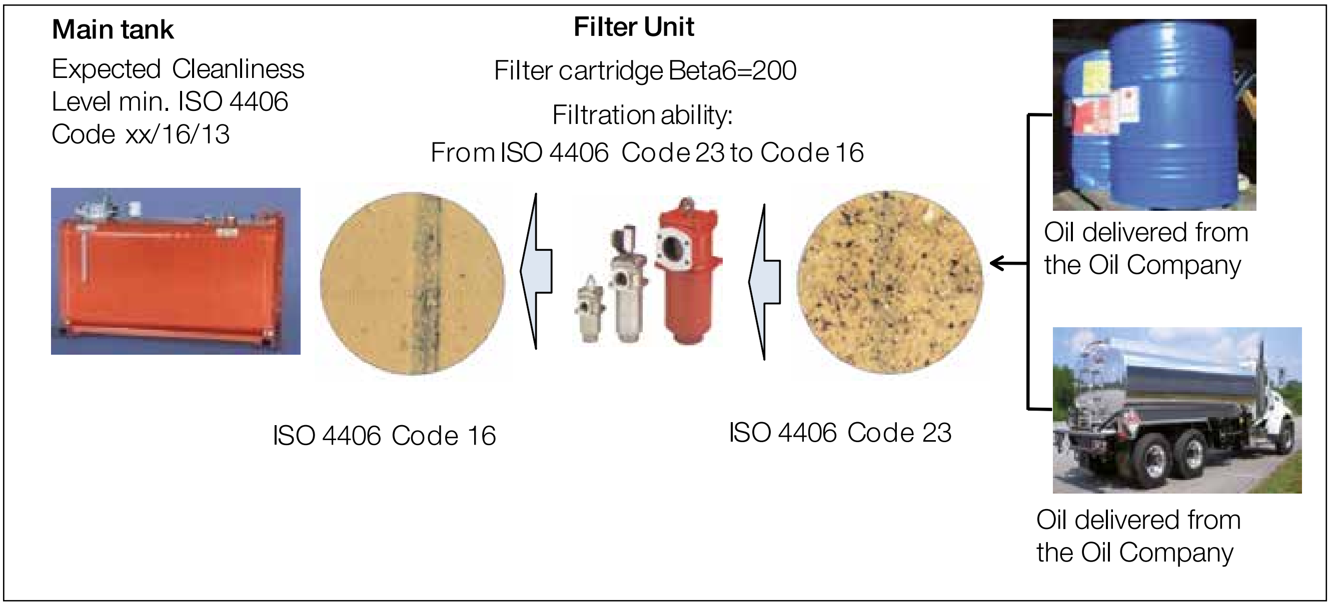


Fig. 3: Filtration ability of filter cartridge: $ß_6$ = 200

Example of contaminants amount to be removed

The table below can be used to define the filter-cartridge dirt and contaminants capacity

ISO 4406 Code xx → Code xx	Max. contaminants amount to be removed in cm³/1000 litres oil tank
Code 23 to Code 16 for particles > 6 microns (new oil at delivery date)	17.1
From Code 19 to Code 16 for particles > 6 microns	1.0
From Code 16 to Code 13 for particles > 14 microns	6.6

Table III

Filling New Oil to Tank

Example: How to choose the correct filter cartridge size.

Tasks:

- Oil amount of 48,000 litres must be moved to hydraulic tank.
- Pump equipment (flow): 200 l/min. → 12 m^3/h
- To be cleaned from ISO 4406 Code 19 to ISO 4406 Code 16 for particles > 6 microns.
- Contaminants > 6 microns to be removed, i.e. 48 m^3 x 1.0 cm^3 = 48 cm^3

Equipment needed:

- Filter element: 0250 DN 6 BN/HC /-V
- Filtration time: 48.000/200 = 240 min → 4 hours.
- Final cleanliness level: ISO 4406 Code 16 (for particles > 6 microns).

0250 DN 010 BN/HC /-V

Size
0160, 0250, 0400

Type
DN

Filtration rating µm
BN/HC: 3, 6, 10, 25
W/HC: 25, 50, 100, 200 (on request)

Filter material
BN/HC
W/HC

Supplementary details
V = FPM seals, filter suitable for rapidly biodegradable oils and phosphate esters (HFD-R)

Fig. 4: Data for filter element

Element specifications

Filter type	ISOMTD contamination retention capacity in g at Δp = 5 bar for BN/HC elements			
	3 µm	6µm	10µm	25µm
160	27.5	29.3	33.1	36.7
250	46.0	49.0	55.2	61.3
400	76.2	81.3	91.4	101.5

Filter surface area W/HC

Filter type	Filter surface area
160	2750 cm^2
250	4400 cm^2
400	6730 cm^2

Table IV:

Filter type	Port	Element size	Weight [kg] with element
160	G 1 ¼	0160 DN...	10.3
250	G 1 ½	0250 DN...	11.6
400	DN 38 *	0400 DN...	13.0

* Flange SAE 1 1/2"; 3000 psi

Table V:

How to define a filter?

The following parameters are decisive for a filter definition:

- oil flow
- system pressure
- pressure drop
- operating viscosity
- filtration ability.

Minimum requirement of cleanliness level – ME Hydraulic System

ISO 4406, Code 4/6/14

Particle > 14 microns

Particle > 6 microns

Particle > 4 microns

This corresponds to a quantity interval of:

Number of particles > 4 microns, cleanliness code omitted

Number of particles > 6 microns from 32,000 to 64,000 in 100 ml sample.

Number of particles > 14 microns from 4,000 to 8,000 in 100 ml sample.

ISO 4406 chart

Range number	Number of particles per 100 ml	
	More than	Up to and including
24	8,000,000	16,000,000
23	4,000,000	8,000,000
22	2,000,000	4,000,000
21	1,000,000	2,000,000
20	500,000	1,000,000
19	250,000	500,000
18	130,000	250,000
17	64,000	130,000
16	32,000	64,000
15	16,000	32,000
14	8,000	16,000
13	4,000	8,000
12	2,000	4,000
11	1,000	2,000
10	500	1,000
9	250	500
8	130	250
7	64	130
6	32	64

Fig. 5: Filtration requirement for ME/ME-C/ME-B

Cleanliness Requirement

The cleanliness level of oil used for flushing must, as a minimum, be according to ISO 4406 Code xx/16/13.

When the oil cleanliness level in the tank is according to the above, flushing of the main engine and ME-system can be performed in parallel.

General Flushing Conditions

Preheat the oil to a temperature of 60-65 degrees Celsius.

To ensure a sufficiently turbulent flow in the system, the oil flow velocity must, as a minimum, reach a Reynolds number higher than 3000, see also Fig. 6..

Formula for calculating the Reynolds number:

$$Re = \frac{(V \times D)}{\surd} 1000$$

Re – Reynolds number
$\surd$ – kinematic viscosity (cSt)
V – flow velocity (m/s)
D – inner pipe diameter (mm)

Example:

Reynolds number	3000
Inner pipe diameter	300 mm (0.3 m)
Oil viscosity	112 cSt

Calculation of minimum flow velocity:

$$V = \frac{(\frac{Re}{1000}) \times \surd}{D} = 1.12 m/s$$

Calculation of minimum pump flow:

$$Q = D^2 \frac{(PI)}{4} \times 1.12 \times 3600 = 285 \frac{m^3}{h}$$

Use of Flushing Equipment

For filling and topping up, always use a filter cartridge with a filtration ability of $ß_6$ = 200.

For flushing, a filtration ability of minimum $ß_{10}$ = 75 is needed, however, MAN Diesel & Turbo recommends a filter with a minimum filtration ability of $ß_6$ = 75.

For additional flushing filters, so-called “off-line” filters, a minimum filtration ability of $ß_6$ = 75 is recomended, and a minimum filtration ability of $ß_{10}$ = 75 is needed.

Use of ME-filter for flushing is recommended. Backflushing oil must be returned to a separate backflushing tank and then back to the main tank via a $ß_6$ = 200 filter cartridge.

MAN Diesel & Turbo recommends use of a purifier during flushing. A portable vibrator or hammer can be used on the outside of the lube oil pipes to loosen impurities in the piping system.

It is also recommended to circulate oil through the system at maximum pump capacity, but not higher than the maximum capacity of the filters.

The nomograms shown in Fig. 6 can be used for estimation of the flow velocity required to reach a Reynolds number higher than 3000.

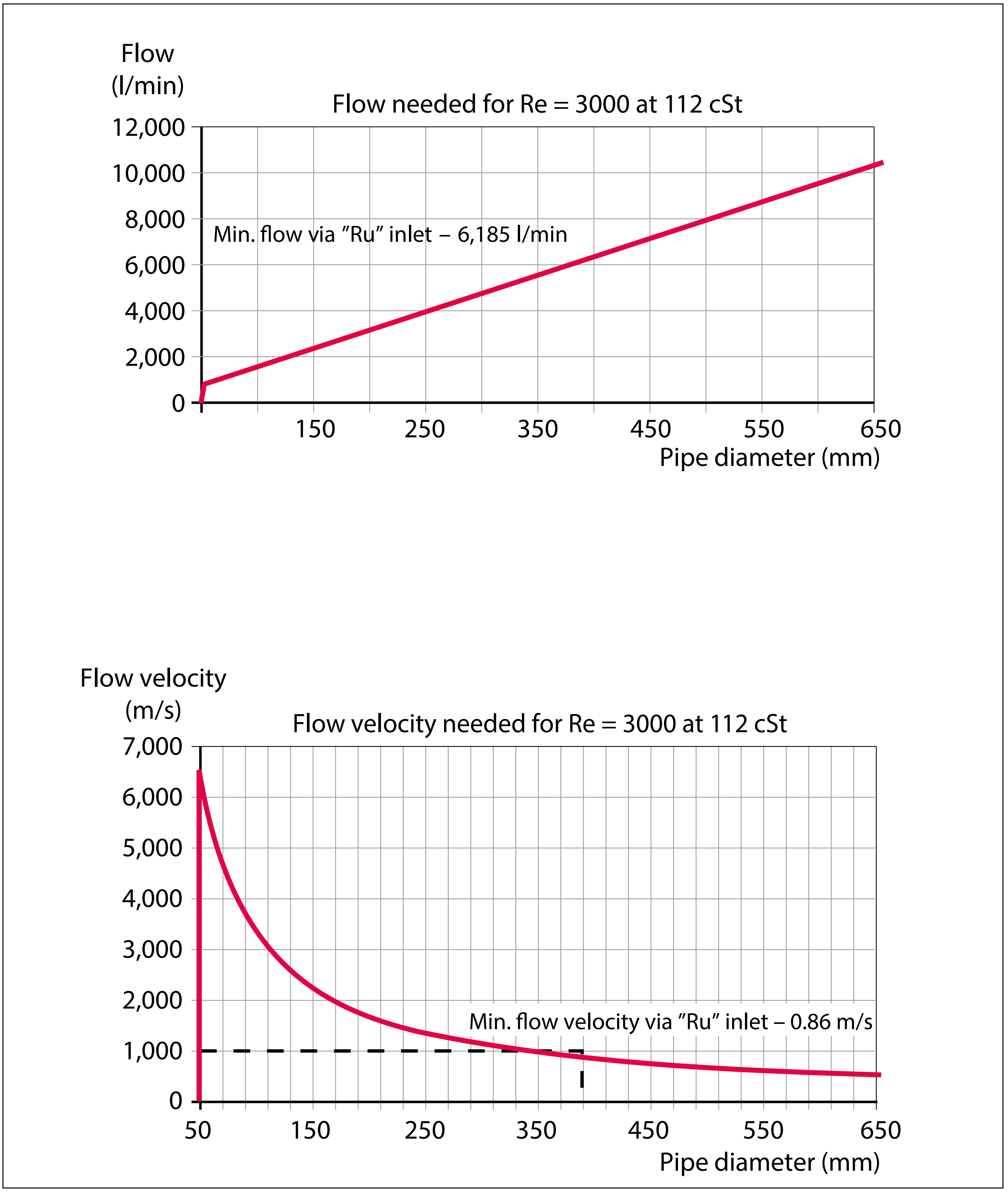


Fig. 6: Flow/flow velocity nomograms

Treatment of Tank

Each single surface of the tank, horizontal and vertical, must be cleaned as described below:

- any slag (and other impurities) after welding must be removed mechanically
- clean all visible impurities
- treat scale on the surface with a de-scaling agent
- if rust is found, treat the surface with de-rust agent
- use a vacuum cleaner to remove small particles from the surface and corners
- wash the surface with grease-dissolving liquid.

Cleaned areas must be protected with anti-rust agent immediately after they have been cleaned, so as to provide protection until the system is filled up. The agent must be of a type that can be mixed with lubricating oil.

Cleaning of the oil tank

New or repaired components are often the carriers of contamination. Before final assembly, this built-in contamination must be removed from the blocks, pipes, oil tank and any other components prepared for use in the system.

Treatment of Pipes and Additional Installations

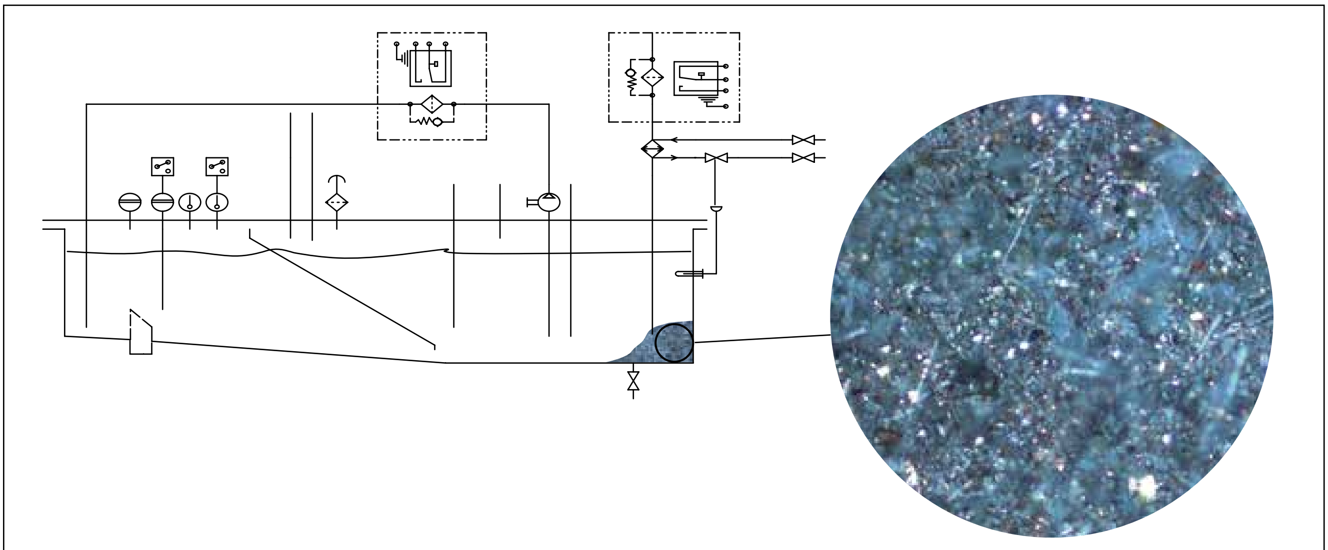
Hydraulic pipes should only be welded if absolutely necessary. If so, each welding point must be placed so that mechanical removal of any welding slag is possible.

All pipe dimensions larger than ø25 mm (externally) should be fitted with flanges if possible. The flanges and pipes must always follow the requirements of the class.

All cut surfaces must be ground, and the inner surface must be smooth. Any slag (and other impurities) must be removed mechanically. Clean all visible impurities. Scale on the inner surface must be treated with a de-scaling agent. If rust is found, the inner surface must be treated with de-rust agent. Use compressed air to remove small particles from the surface. Degrease all pipes using grease-dissolving liquid.
Pipes that have been treated with acid are to be neutralised or washed in a combination of cleaning/neutralising agents.

Cleaned areas must be protected with an anti-rust agent immediately after being cleaned, so as to provide protection until the system is filled up. The agent must be of a type that can be mixed with lubricating oil.

When a pipe is treated with an internal protection agent, open connections must be blanked off (remember to remove all temporary gaskets and plugs, before assembly).



Contermination found in 'clean' oil tank

Fig. 2: Empty hydraulic oil tank

Step I
Filling of the oil tank (on the test bed, at shipyard, on board)

Use a filter unit for filling and simultaneous cleaning (filtration during filling):

- filter cartridge with a beta rating of $\beta_6 = 200$
- filter rating in accordance with Multi Pass Test ISO 16889 defined for an operating viscosity of 100 cSt and a pressure drop of dP = 0.15 bar.

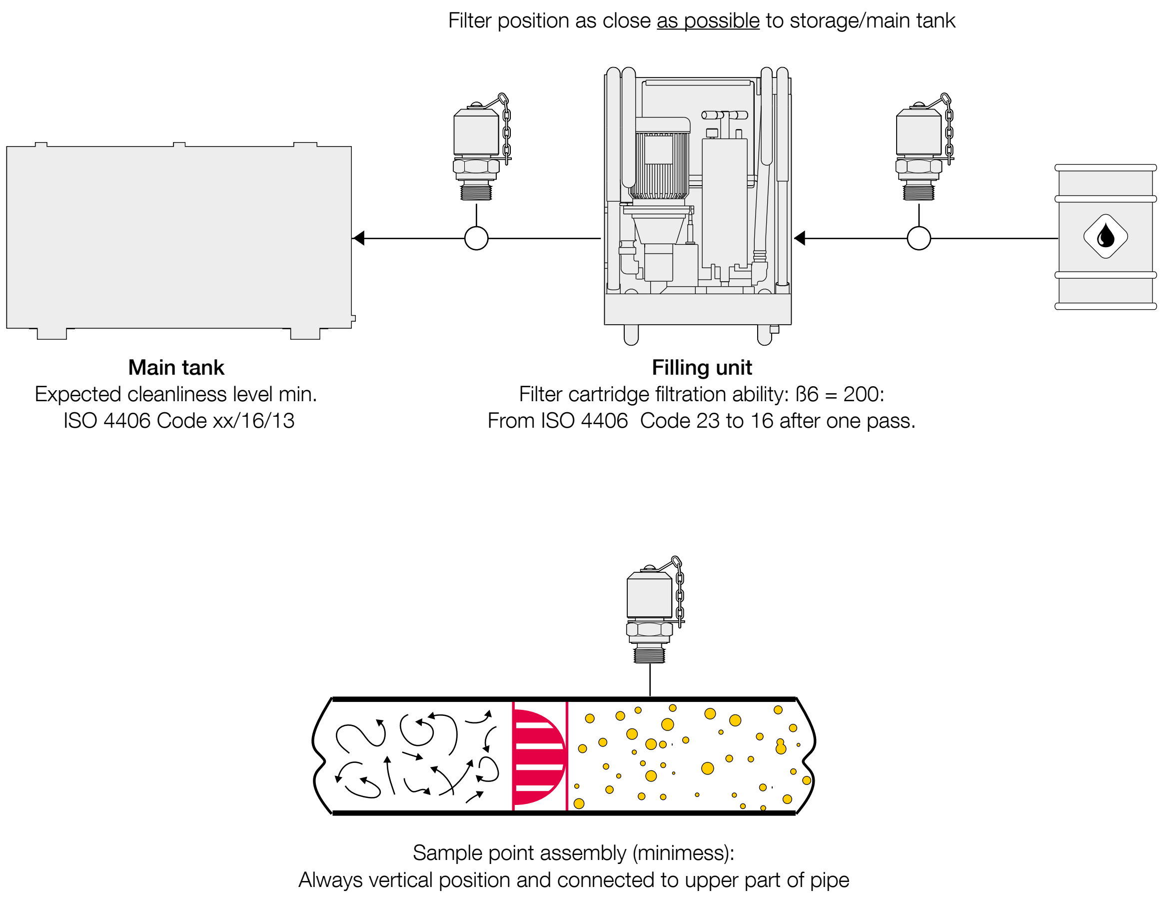


Fig. 7: Hydraulic oil tank filled

Step II
Oil cleanliness improvement in the existing tank
Flush pipes and additional installations, and use additional filter $ß_6$ = 200 to minimise flushing time.

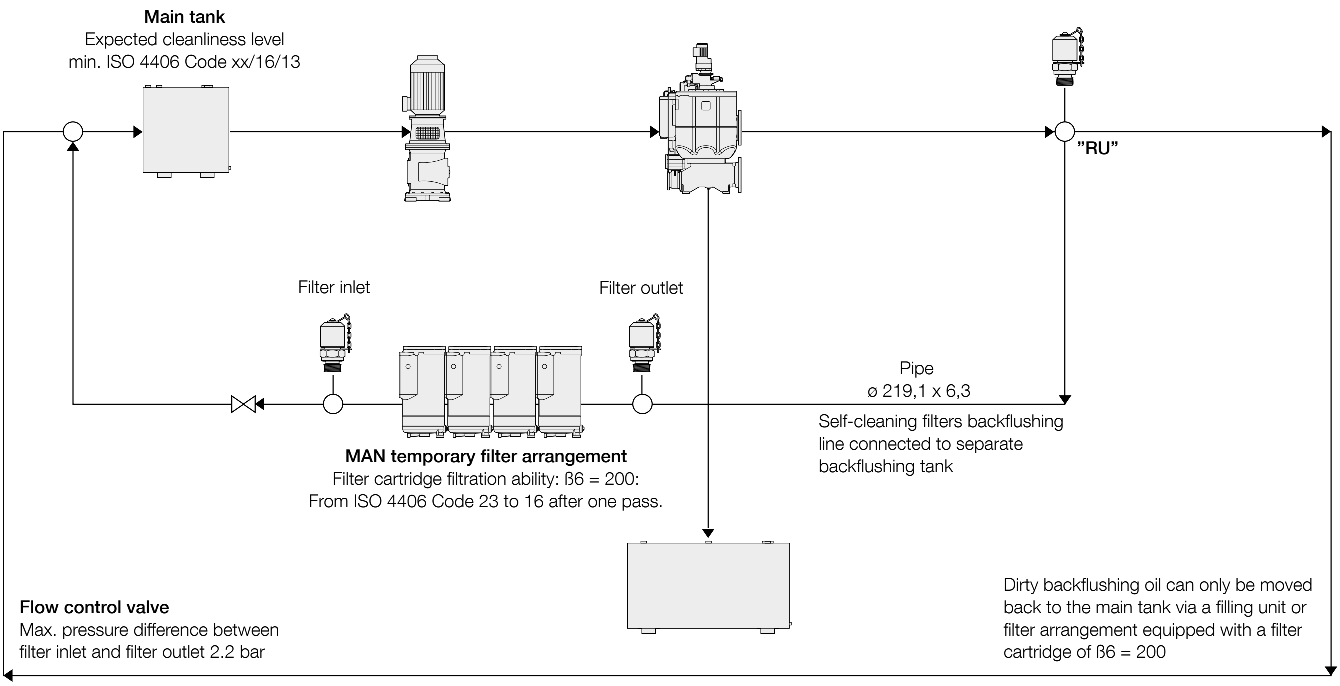


Fig. 8: Cleanliness improvement in the existing oil tank, flushing of pipes and additional installations (test bed, shipyard, on board)

Step III
Flushing of shipyard installations (piping)

MAN Diesel & Turbo recommends use of an additional filter for parallel filtration to reduce flushing time. A separate backflushing tank is also needed.

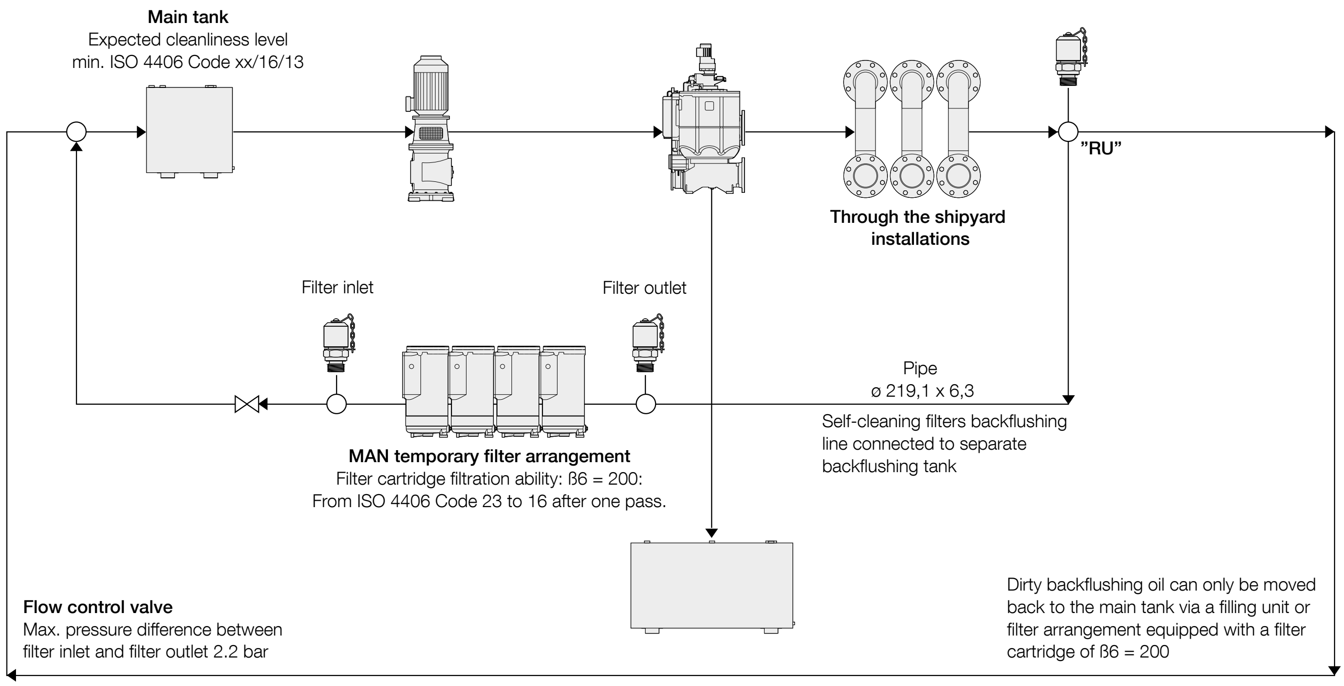


Fig. 9: Preventing hydraulic failures, flushing on the test bed and at the shipyard

Step IV
Engine flushing

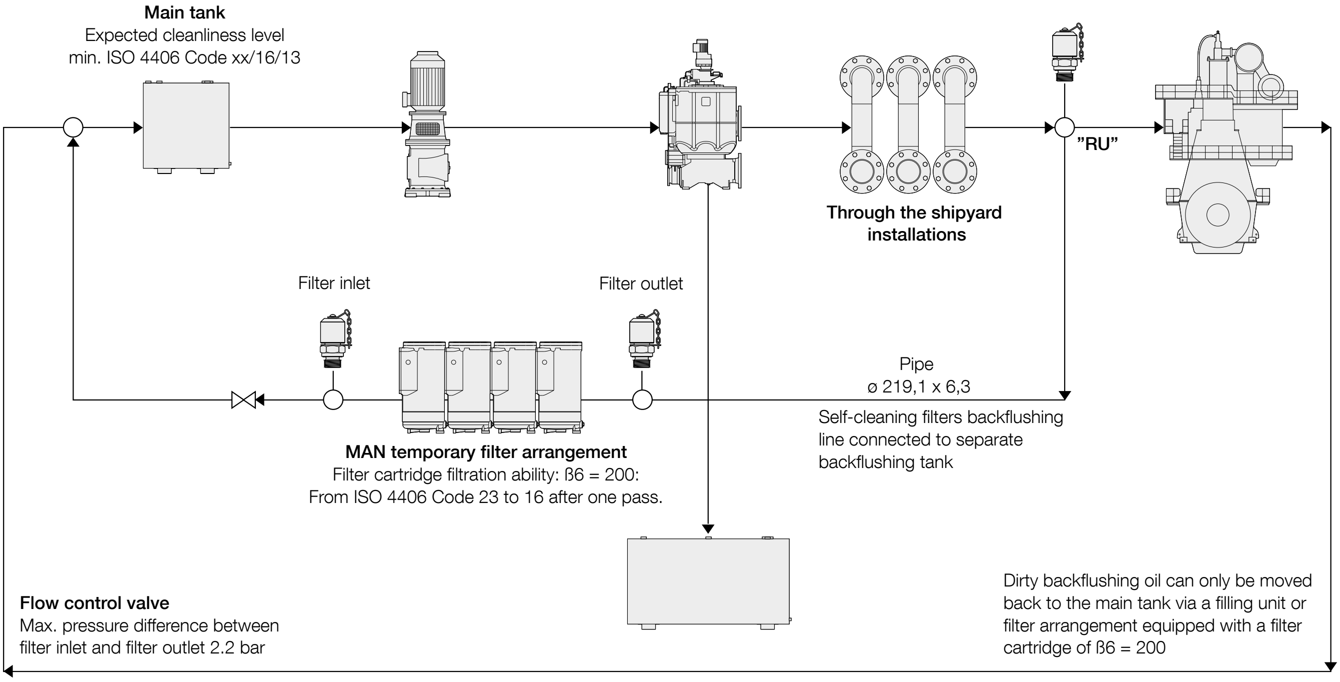


Fig. 10: Flushing of engine on the test bed and at the shipyard

New improved flushing procedure for ME installations

The time required to clean the ME system to ISO 4406 Code xx/16/13 cleanliness level, can be greatly reduced by fitting a filter cartridge with a filtration ability of minimum B6 = 16 and B14 = 100 to the ME redundancy filter and then directing the main lube oil flow through this filter.

The above-described configuration must be applied on all new installations on the test bed, during quay trial and sea trial, and for the following 14 days after that.

After this period, the ME lube oil flow can be switched back to run through the main filter (Pos. 106) for normal engine service running.

This solution is time saving for the crew and has no negative effects on the service life of the redundancy filter.

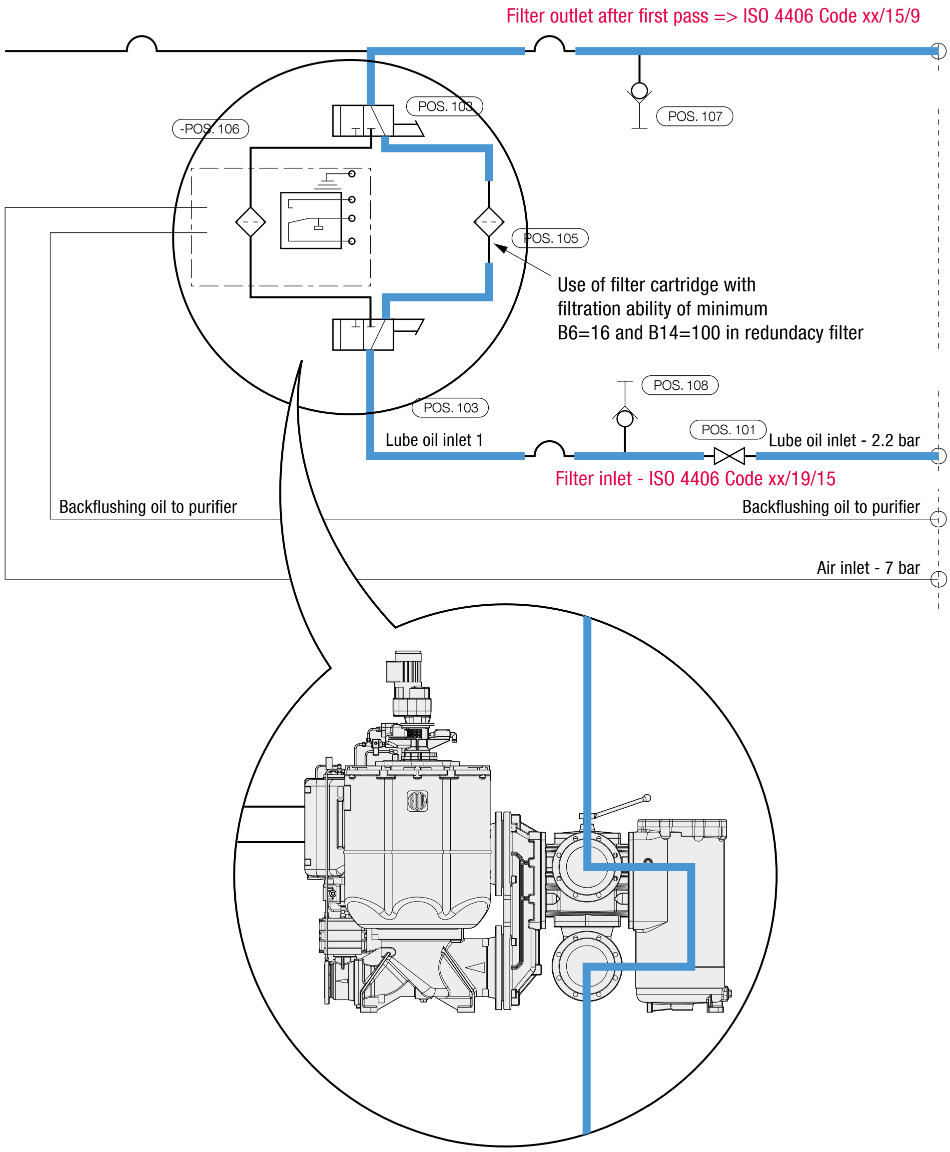


Fig. X: Flushing through ME redundancy filter fitted with a high-filtration ability filter cartridge

Topping-up of Main Tank

Valid on test bed and for installations in service

All fluid delivered from an oil company must be filled through a filter cartridge with filtration ability of B_6 (beta) = 200.

As mentioned, this is not only important to prevent difficulties during start-up, but also when topping up the main tank for installations in service.

Unlimited topping-up of the main tank without the above filter will result in increased wear of valves, pumps and bearings and, eventually, will lead to malfunction of the systems.

For installations without the necessary filling equipment, the rules described in the following must be observed.

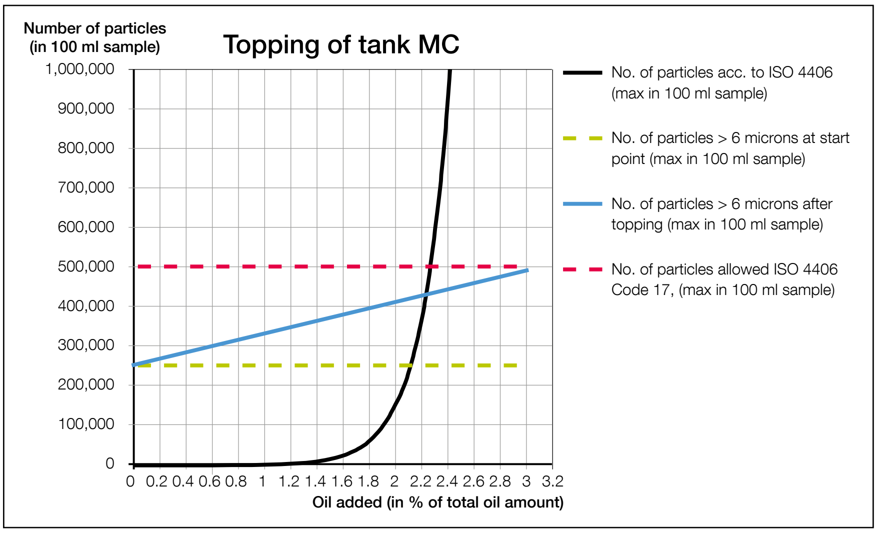


Fig. 11: Installations in service, max. 3% of tank capacity per day

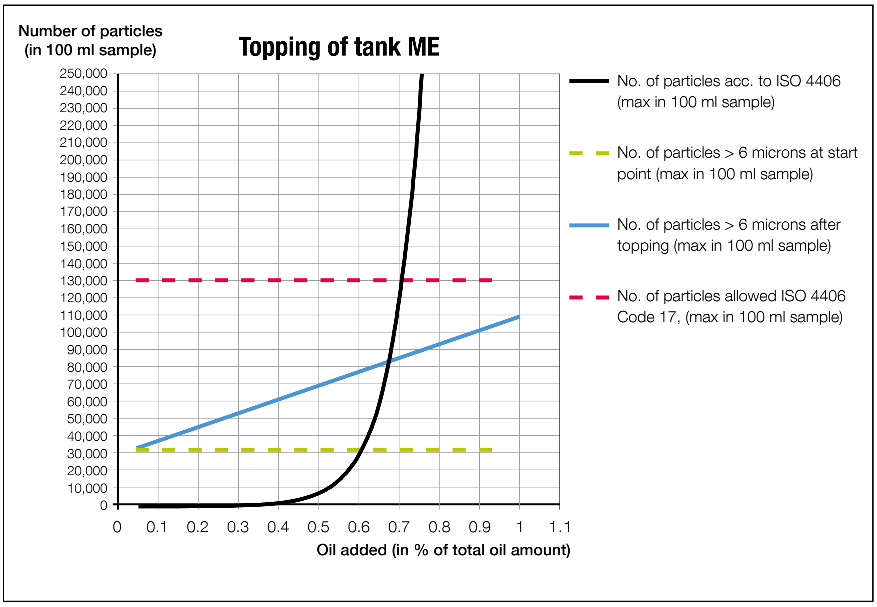


Fig. 12: Installations in service, max. 1% of tank capacity per day

Temporary Filters

A temporary filter with a mesh size of 3 microns can be used between the FIVA main valve and the FIVA pilot valve, and also the HPS pump and the pilot valve for pump control. However, the filters must be removed after sea trial.

When using these filters, the cleanliness level of the ME system oil can be according to ISO 4406 Code xx/17/14.

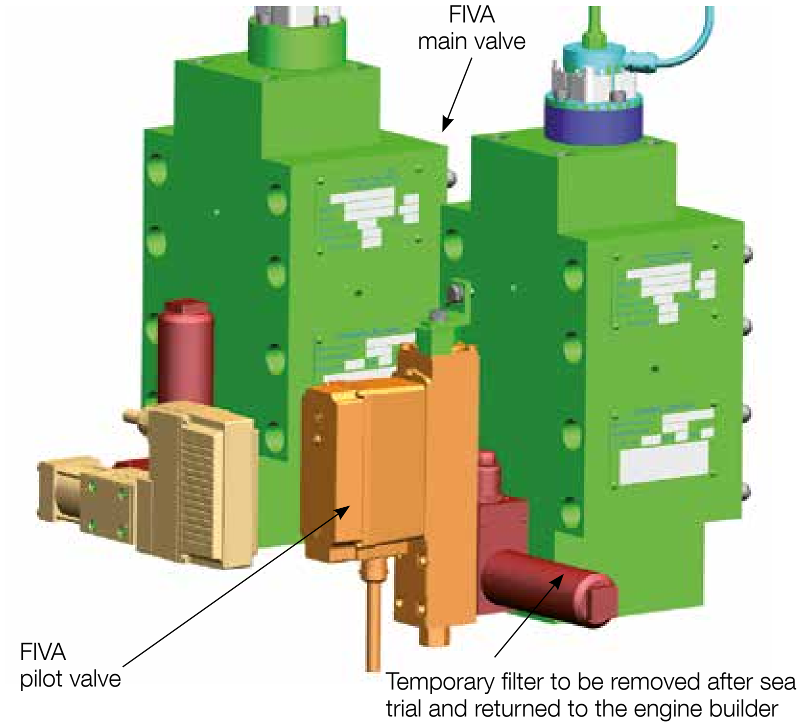


Fig. 13: FIVA unit with temporary filter

In 2010, the same type of Hydac sandwich filter (3 microns) was installed for testing in service for two months on ELFI B3-45. The test result was positive with no performance change recorded.

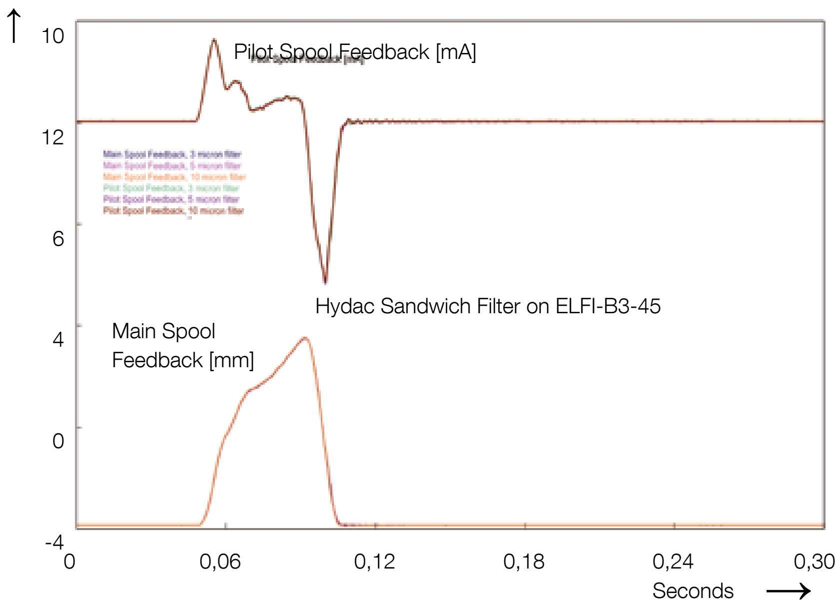


Fig. 14: The Hydac sandwich filter has been tested successfully without any performance change on ELFI-B3-45 at the MAN Diesel & Turbo research centre in Copenhagen

How to define contamination level

Quick method

A filter diaphragm with all contaminants from a 100 ml sample must be prepared. The recommended sample point position is diagram Pos. 340 or Pos. 425.

Sample bottles should be clean to reduce the interference of contaminants from the bottles. Use the bottles cleaned and validated in accordance with ISO 3722 and BS 5540.

Using a vacuum pump, a representative sample of hydraulic fluid, usually 100 ml, is drawn from the 70ºC preheated system through a 47 mm diameter laboratory membrane filter disc with a filter mesh size of 1.2 microns.

All contaminants larger than 1.2 micron are collected on the surface of the filter disc. Residual sample fluid is washed from the filter disc using a suitable solvent filtered through a 1.2 micron filter mesh, and the membrane filter disc is transferred to a suitable protected container.

Compare a view on a prepared filter diaphragm with the "comparator" picture with the same magnification. Use of a comparator book for this analysis is recommended.

The method described is a decisive tool for onsite system fluid analysis. This method cannot determine the exact particle count, but allows you to estimate the cleanliness level.

For documentation, particle counting can be ordered from a local laboratory.

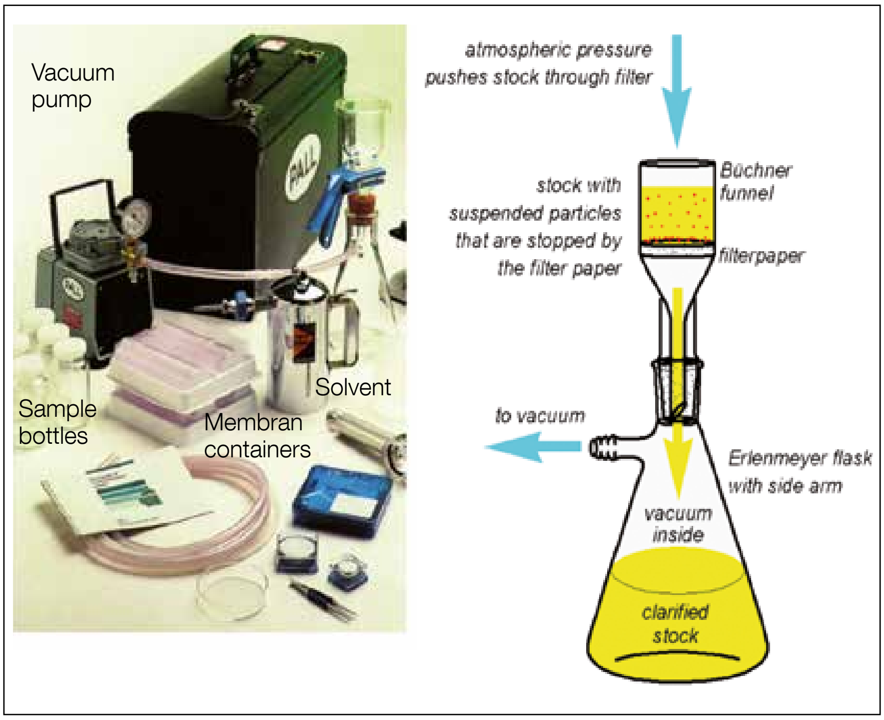


Fig.15: How to collect contaminants for examination

Fig. 16: Filtration on ME/ME-C/ME-B engines

Guide to Contamination Control

When the engine is delivered in several parts, flushing of the engine at the shipyard is needed.

Dismantling of ME parts before sending to yard

During dismantling of the ME-system, open connections must be hermetically sealed using rubber seals and blind flanges. In this way, flushing of ME parts at the yard can be avoided.

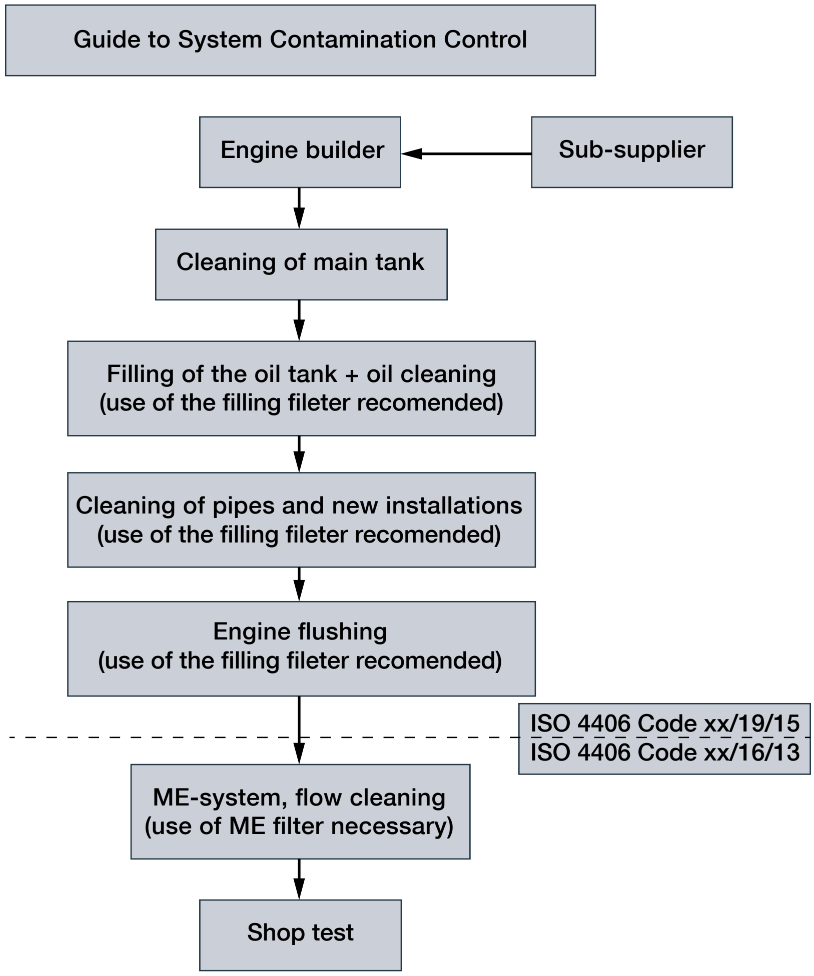


Fig. 17: Flushing at the shipyard

When the engine is delivered finish-assembled, flushing of the engine at the shipyard can be avoided. However, flushing of shipyard installations is always required.

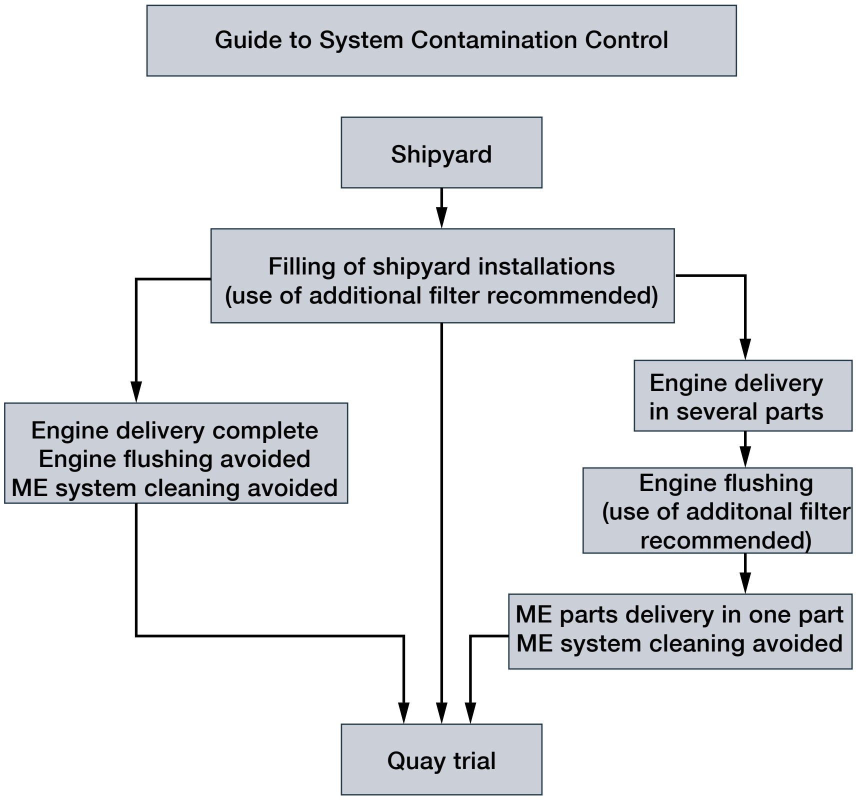


Fig. 18: Flushing of shipyard installations only

Filtration Ability of ME filter

Filtration ability for particles > 6 microns

Metal fibre fleece can remove min. 55% of particles larger than 6 microns for every pass through the filter.

Filtration ability for particles > 14 microns

Metal fibre fleece can remove min 95% of particles larger than 14 microns for every pass through the filter.

Example: ISO 4406 Code xx/xx/19, max 500,000 particles > 14 microns → (500,000 – (500,000 x 0.95)) = 25,000 → ISO Code 15.

The oil cleanliness level for particles > 14 microns will be improved from ISO 4406 Code 19 to Code 15 after first pass through the ME filter.

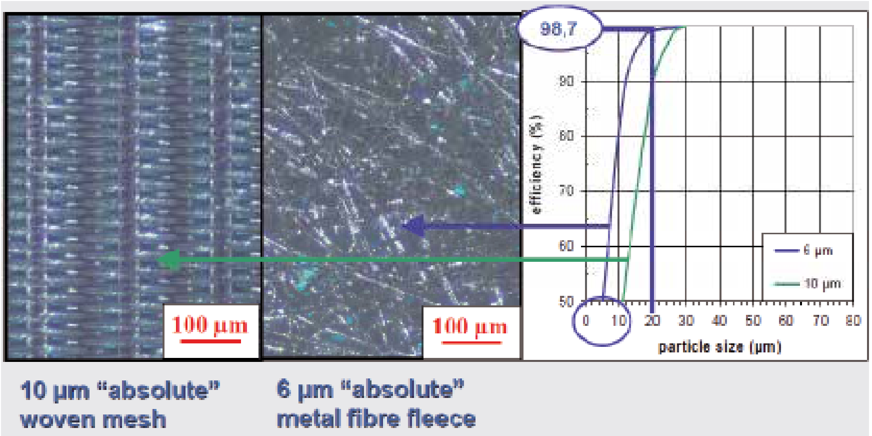


Fig. 19: Filtration ability of ME filter

ISO 4406 Chart

	Number of particles per 100 ml	
Range number	More than	Up to and including
24	8,000,000	16,000,000
23	4,000,000	8,000,000
22	2,000,000	4,000,000
21	1,000,000	2,000,000
20	500,000	1,000,000
19	250,000	500,000
18	130,000	250,000
17	64,000	130,000
16	32,000	6,4000
15	1,6000	32,000
14	8,000	16,000
13	4,000	8,000
12	2,000	4,000
11	1,000	2,000
10	500	1,000
9	250	500
8	130	250
7	64	130
6	32	64

Table VI

Summary

The starting point for every filtration and flushing strategy is that all new oil is dirty. The proper cleaning and flushing of hydraulic systems is therefore vital to ensure reliable and longterm operation without unexpected downtime of the system for maintenance and repair.

MAN Diesel & Turbo recommends following the standards and guidelines described in this paper, so as to achieve the best possible system condition on low speed MAN B&W two-stroke diesel engines.

This includes application of the ISO 4406 standard and use of the proper filter cartridges for filtration and the proper filters for flushing. Furthermore, it is important to monitor the cleanliness level of the oil by means of onsite fluid analyses, in order to be able to control the level of contamination.

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