Filtration handbook

MAN Energy Solutions
Future in the making

Filtration and flushing strategy

Future in the making

Contents

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.

NOTE: The guidelines in this document are for reference only. For more detailed information regarding flushing reference is made to quality specifications from MAN Energy Solutions.

Definitions and standards

MAN Energy Solutions 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

NAS 1638 is an older american standard developed by National Aerospace Standard in 1964 to define classes of contamination in aircraft components and hydraulic fluids.

The classes refer to the maximum number of particles in 100mL in different size classes.
The concept of the code can be seen in Table 2. 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 2.

The standard officially became invalid in 2001 which is why MAN Energy Solutions specifies the international ISO 4406 standard to be used.

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 1: The ISO 4406 standard is a decisive tool defining the quantity of solid particles in the fluid in installations designed by MAN Energy Solutions

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 2

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.

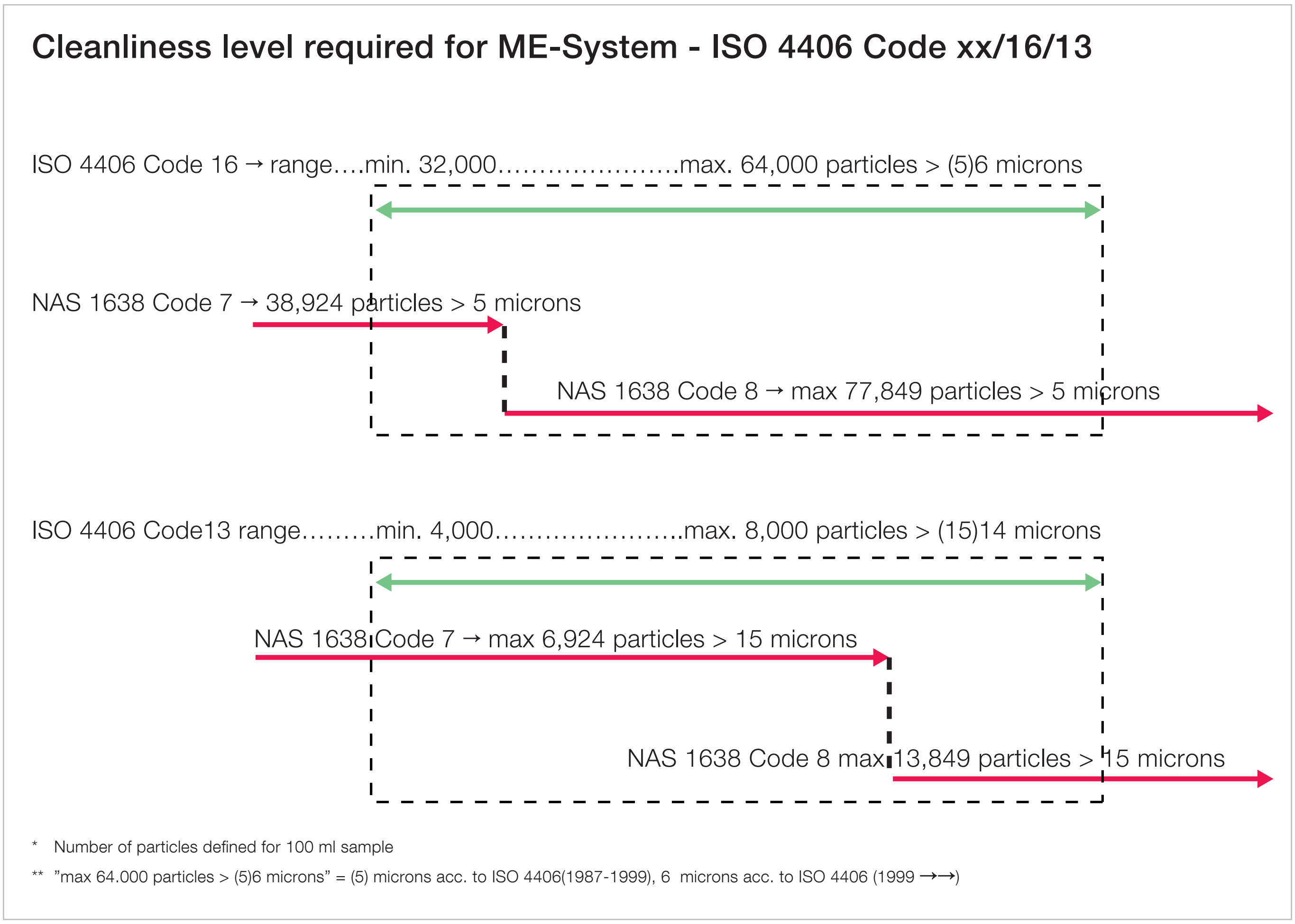


Fig. 1: ISO 4406 vs. NAS 1638 - cleanliness level required for ME/ME-C engines

Filtration ability

There are many different ways to make filter elements. Although they have same size, interface and flow capacity they can be very different in terms of their ability to clean the oil from large and small particles.

Many producers and users tend to mention “Absolute” and “Nominal” filtration rating when specifying and talking about filters.

The absolute rating of a filter refers to the diameter of the maximum particle which could pass through the filter. Typically a filtration rating in datasheets can be mentioned as absolute 3µm, 6um, 10µm, ...

However no matter how precise the filtration media is made, it is impossible to ensure that all open areas fulfil these sizes. Particles are also not perfectly shaped and might be small in one direction, but large in the other direction.

The absolute rating can also be seen as a non-realistic definition since no particle larger than the rating can pass through the filter which is not true.
The nominal rating is in this respect more realistic since it indicates the filters ability to prevent the passage of solid particles greater than the rating together with a percentage of efficiency.

No industry standard for this percentage of efficiency has been made for the nominal rating which also here makes it difficult to compare similar filters from different suppliers as they might define their filters with a different filtration efficiency.
Due to this MAN Energy Solutions prefer to use Beta Ratio when defining and talking about filtration ability of filters.

Beta Ratio (β) is a method based on laboratory multi-pass tests where a specified contaminate of known sizes is added regularly in measured quantities to the oil which is being pumped through the filter. Oil samples are taken at timed intervals at inlet and outlet of the filter. Hereafter the particles in each sample are measured and counted. Based on these results, a beta ratio is determined by dividing the number of particles of a particular size in the inlet with the number of particles of the same size in the outlet flow.

For example, if the numbers of 6 micron particles are halved in number from inlet to outlet the Beta Ratio is 2/1 = 2 which also means the filtration efficiency is 50% and 50% of the 6 micron particles are retained in the filter element.

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 XX/16/13

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. 2: Filtration requirement for ME/ME-C/ME-B

Fluid maintenance

All fluid stored in sealed containers or delivered from an oil company is recommended to be filled through a filter cartridge with a filtration ability of $\beta_6 = 200$.

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

$$\beta_6 = \frac{8{,}000{,}000 \text{ particles} > 6 \text{ microns at filter inlet}}{40{,}000 \text{ particles} > 6 \text{ microns at filter outlet}} = 200 \rightarrow \beta_6 = 200$$

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

New oil is dirty!

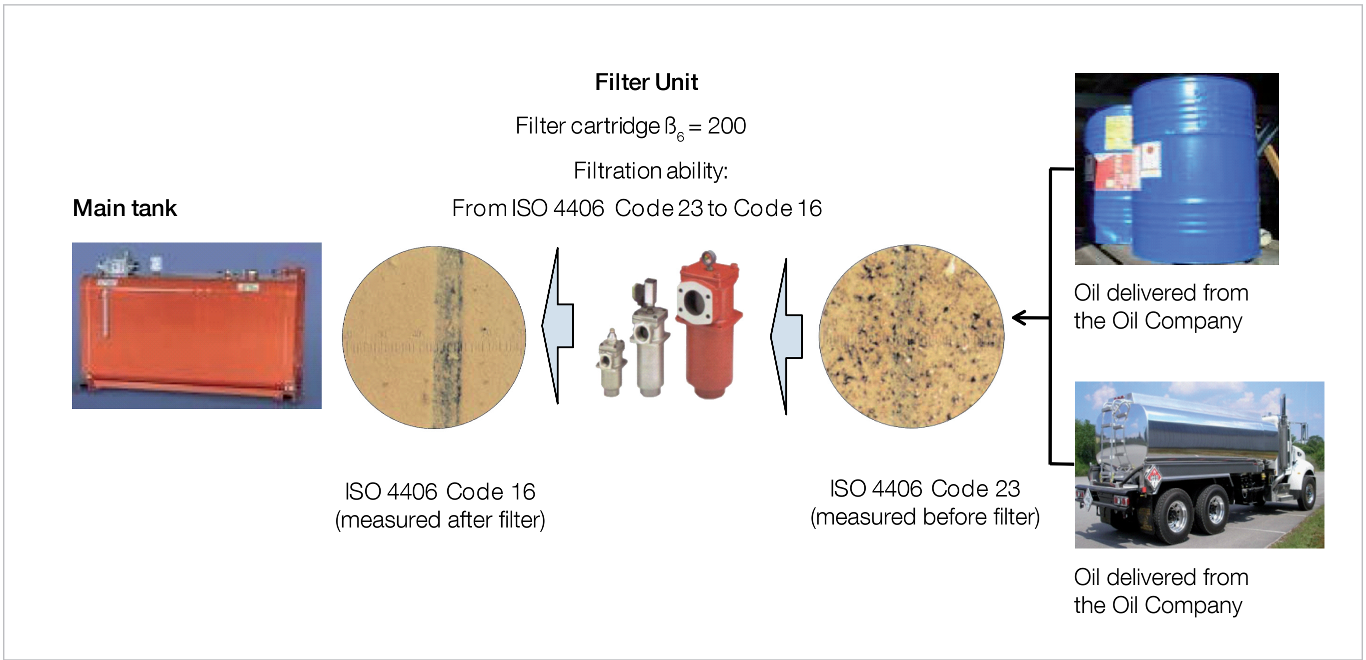


Fig. 3: Filtration ability of filter cartridge = $\beta_6 = 200$

Example of contaminants amount to be removed

Given that we assume that the particles are cubic sized.
For example 6 micron => (0.0006 x 0.0006 x 0.0006) x particle amount in specific ISO 4406 code (100 mL) x 10,000 = cm³/1,000 litres oil tank

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 3

Filling new oil to tank

Data sheets of filter elements often mention retention capacity in gram at a certain pressure drop since the test method is to weight the filter elements after testing.

In order to use this when sizing a filter element we might assume that 1 gram = 1 cm^3.

Steel and rust particles are heavier, but normally a minority compared with dust and cloth particles which are lighter.

Example: How to choose the correct filter cartridge size.

Steps to follow:

- 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 = 1.0 cm^3/m^3 (Table 3).
- Contaminants > 6 microns to be removed, i.e. 48 m^3 x 1.0 cm^3/m^3 = 48 cm^3 (from look-up in table 4: filtertype 250 and 6 µm).

Conclusion of example:

- 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

3.2.1 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

3.2.2 Filter surface area W/HC

Filter type	Filter surface area
160	2,750 cm²
250	4,400 cm²
400	6,730 cm²

Table 4

4. FILTER SPECIFICATIONS

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 5

Cleanliness requirement

The cleanliness level for the lubricating oil used for flushing the main engine must comply with ISO 4406 Code xx/19/15.

The cleanliness level for the lubricating oil used for flow cleaning the ME system must comply with ISO 4406 Code xx/16/13.

However if using a ME-filter with a filtration ability β_6=min.8 which often is installed in the redundancy part of the ME filter arrangement and known as SFF (Super Fine Filter), it is possible to clean the oil from ISO code xx/19/15 to ISO code xx/16/13 in a single pass through the filter.

This enable the opportunity to begin flushing of the ME-system when the cleanliness level measured before the ME-filter is in minimum ISO 4406 Code xx/19/15.

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.

The oil must circulate for more time during flushing since entrapped particles in the system will be loosened and affect the cleanliness.

We recommend to follow the flushing procedures from MAN Energy Solutions.

General flushing conditions

When preheating is available, MAN Energy Solutions recommends preheating 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 3,000, see also Fig. 5.

Formula for calculating the Reynolds number:

$$Re = \frac{(V \times D)}{\eta} 1,000$$

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

Example:

Reynolds number	3,000
Inner pipe diameter	300 mm (0.3 m)
Oil viscosity	112 cSt

Calculation of minimum flow velocity:

$$V = \frac{\left(\frac{Re}{1,000}\right) \times \eta}{D} = 1.12 m/s$$

Calculation of minimum pump flow:

$$Q = D^2 \frac{(\pi)}{4} \times 1.12 \times 60,000 = 4,750 \text{ L/min}$$

Use of flushing equipment

For filling and topping up, it is recommended to use a filter cartridge with a filtration ability of β_6 = 200.

For flushing, a filtration ability of minimum β_{10} = 75 is needed, however, MAN Energy Solutions recommends a filter with a minimum filtration ability of β_6 = 75.

For additional flushing filters, so-called "off-line" filters, a minimum filtration ability of β_6 = 75 is recommended, and a minimum filtration ability of β_{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 β_6 = 200 filter cartridge.

MAN Energy Solutions 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. 5 can be used for estimation of the flow velocity required to reach a Reynolds number higher than 3,000.

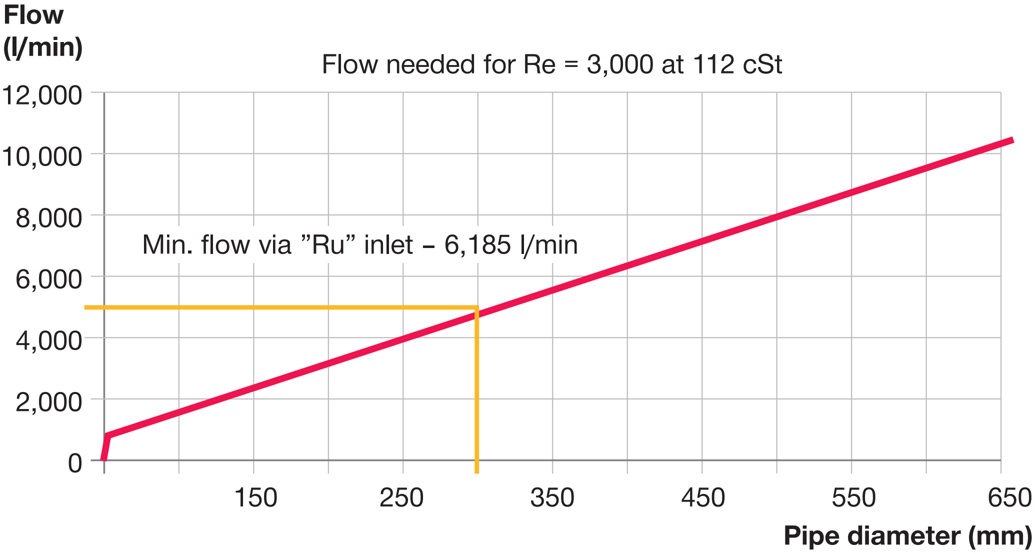


Fig. 5: Flow/flow velocity nomogram

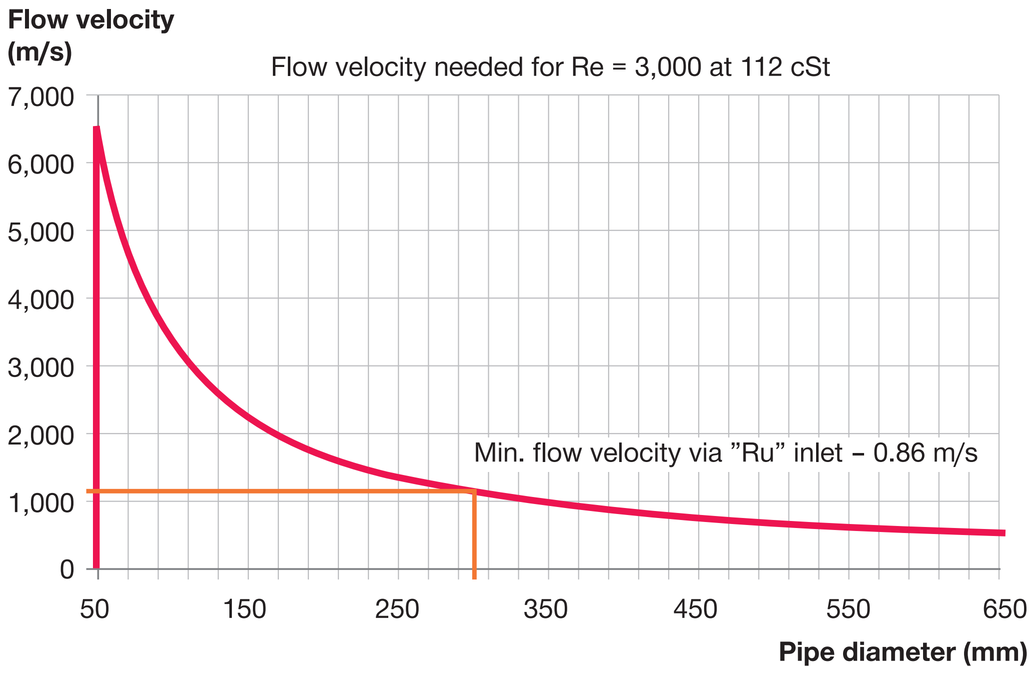


Fig. 6: Flow/flow velocity nomogram

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

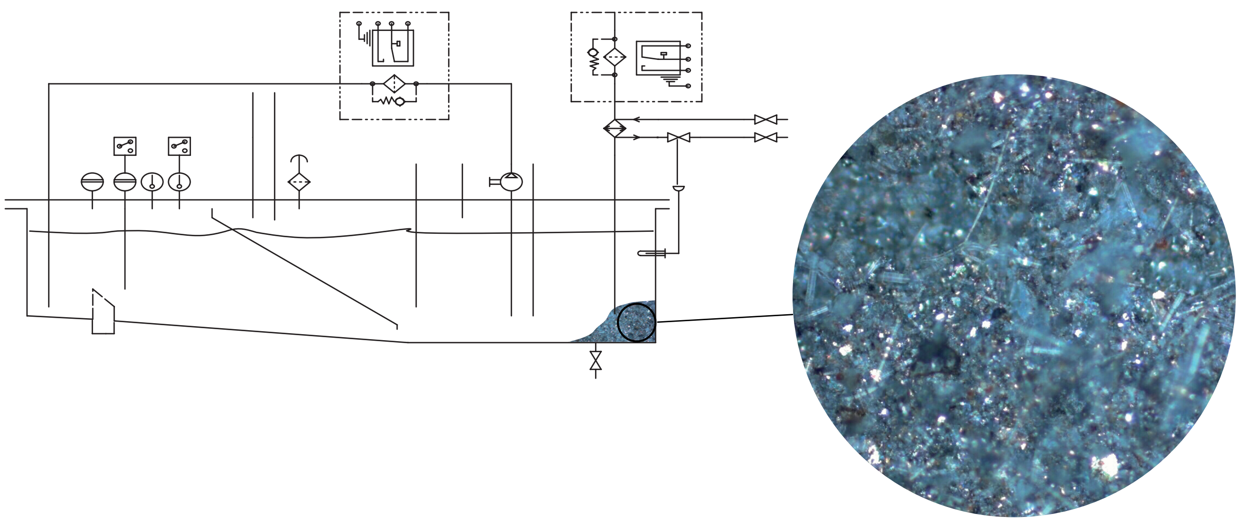
Hydraulic pipes should only be welded if absolutely necessary. If so, each welding point must be placed so that mechanical removal of any welding slag is possible.

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. 7: Empty hydraulic oil tank

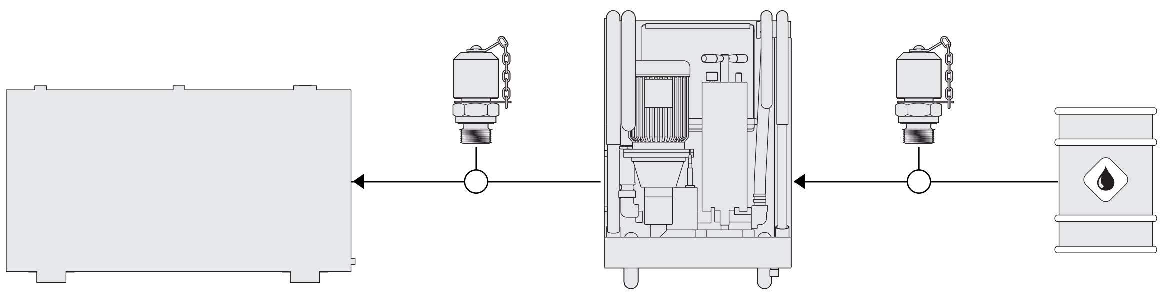
MAN Energy Solutions advice to use a filter for filling of the oil tank (on the test bed, at shipyard, on board)

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

- filter cartridge with a beta rating of β_6 = 200

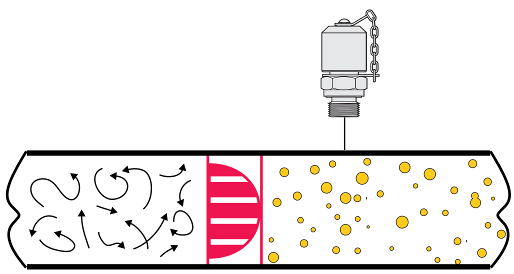
For flushing of the system, please follow, MAN Energy Solutions Quality Specifications.

Filter position as close as possible to storage/main tank



Main tank

Filling unit
Filter cartridge filtration ability: ß6 = 200:
From ISO 4406 Code 23 to 16 after one pass.



Sample point assembly (minimess):
Always vertical position and connected to upper part of pipe

Fig. 8: Hydraulic oil tank filled

Flushing procedure for ME installations when using the conventional ME-filter (redunancy filter).

For newer installations where an alternative ME-filter solution like Boll & Kirch 6.49 or similar is also used. Here the main filter is β_6 = min.8 and the mentioned oil filtration can be done directly without changes at the filter.

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 β_6 = 8 to the ME redundancy filter and then directing the main lube oil flow through this filter.

The described configuration is recommended to 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.

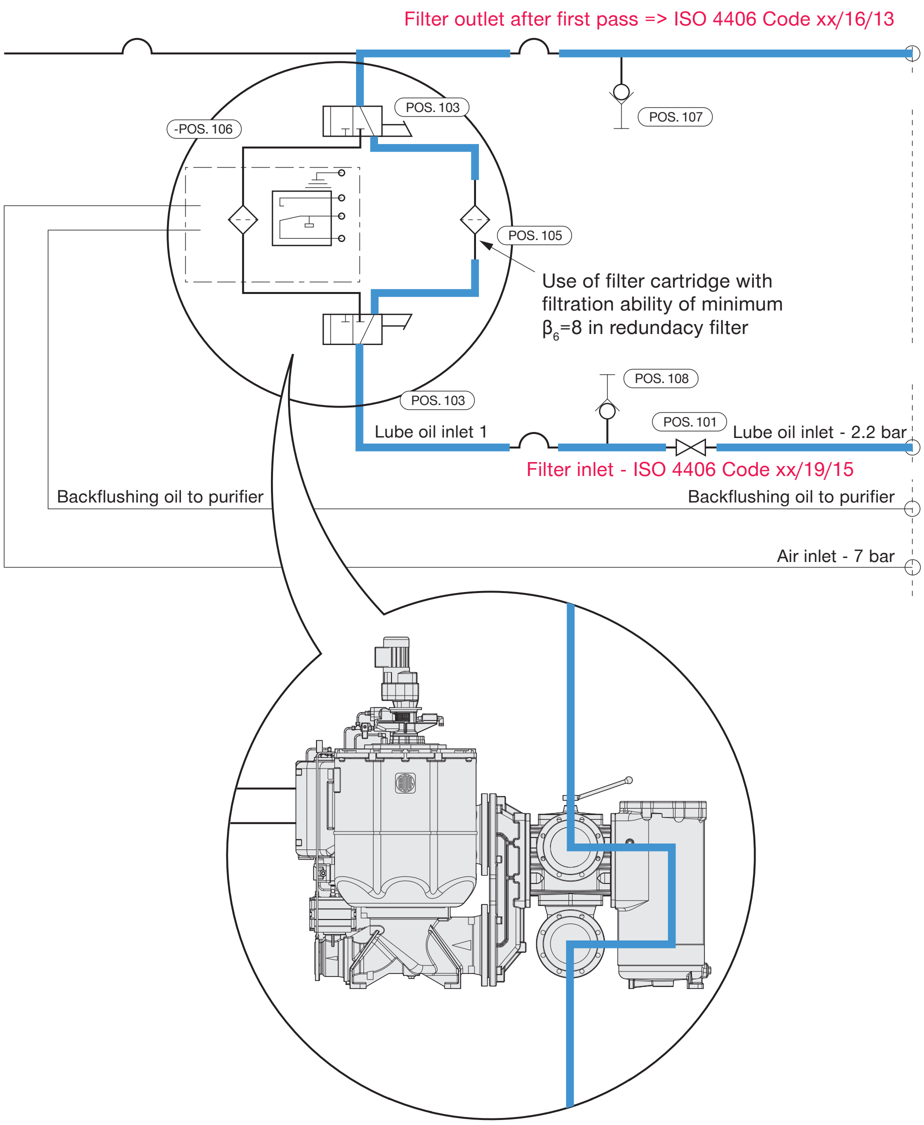


Fig. 12: Flushing through ME redundancy filter fitted with a high-filtration ability filter cartridge

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 β_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.

The cleaning efficiency of the system and the release of particles from the system increase when using a new oil and when partly refilling the system with new oil.

Therefore, you will see that the number of particles caught in the filter system increases in the period after, no matter if you added filtered new oil or not.

The cleaning additives in a new oil simply just works better than in an old oil.

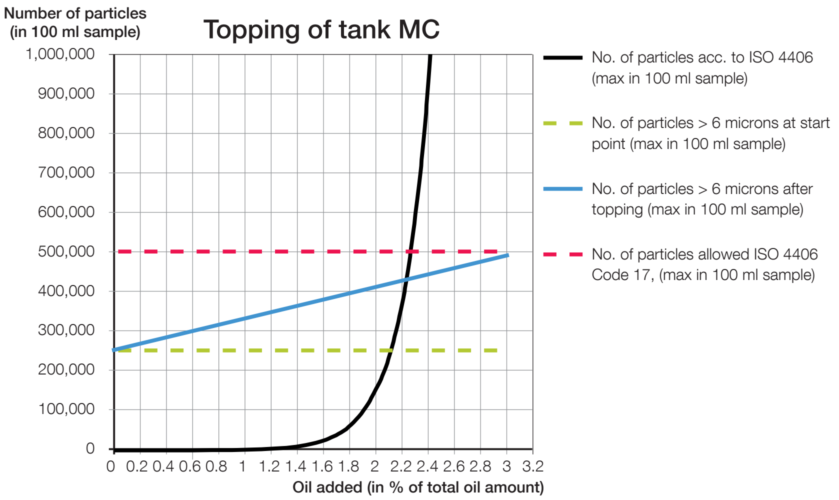


Fig. 13: Installations in service, max. 3% of tank capacity per day

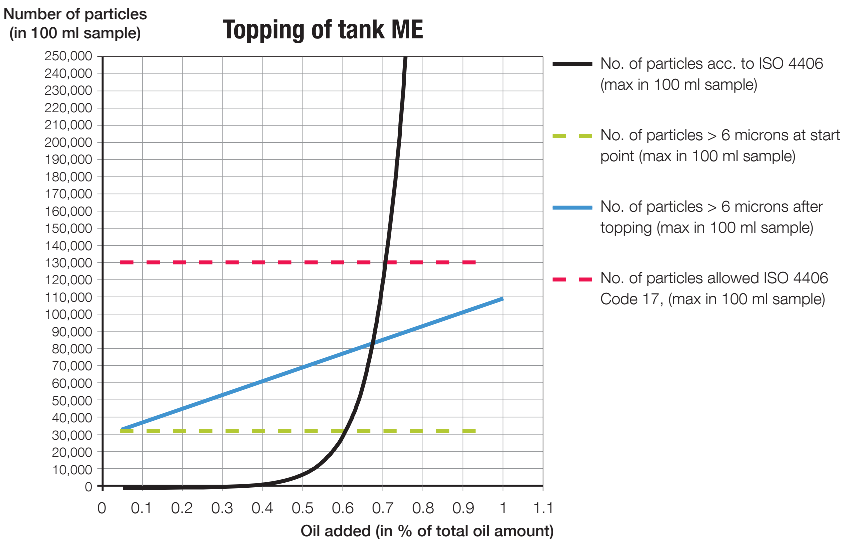


Fig. 14: Installations in service, max. 1% of tank capacity per day

Temporary filters

A temporary filter 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.

The reason is to install an extra protection of all control valves which demands high oil cleanliness since the first hours of engine running will release particles that the flushing did not catch as illustrated at fig. 16.

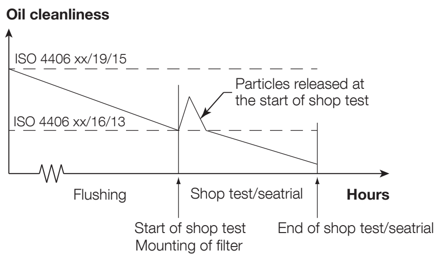


Fig. 16:

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

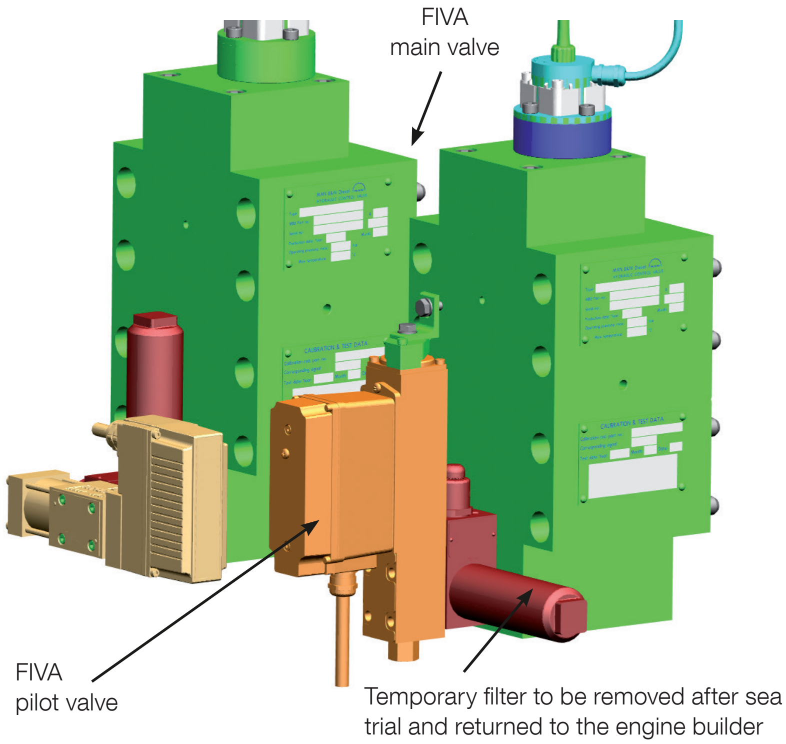


Fig. 15: FIVA unit with temporary filter

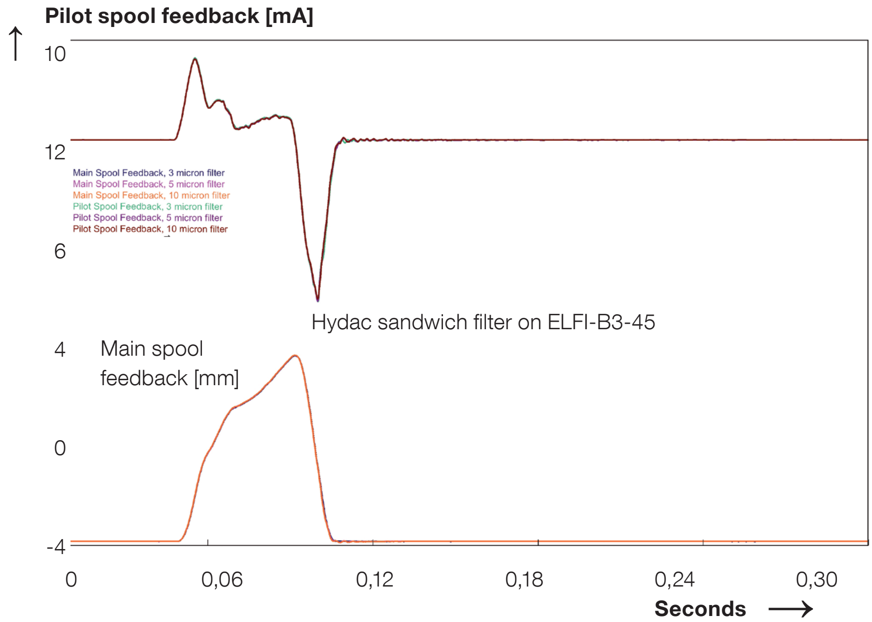


Fig. 17: The Hydac sandwich filter has been tested successfully without any performance change on ELFI-B3-45 at the MAN Energy Solutions research centre in Copenhagen

Safety screen at Multiway Valves

I 2019 we introduced Multiway Valves like FIVA, ELFI, ELVA and PEVA with a safety screen in the oil line for the controlling proportional valve.

The safety screen is a small filter strainer with a mesh size of 100 µm which intend to minimize the risk of larger particle to enter and disturb the function the controlling proportional valve.

After a service test of almost 6,000 running hours the safety screen was inspected and large particles were found which could have resulted in a malfunction of the valve.

All Multiway Valves equipped with a safety screen will need to have the filter strainer inspected and cleaned every 6,000 running hours or approximately once a year.

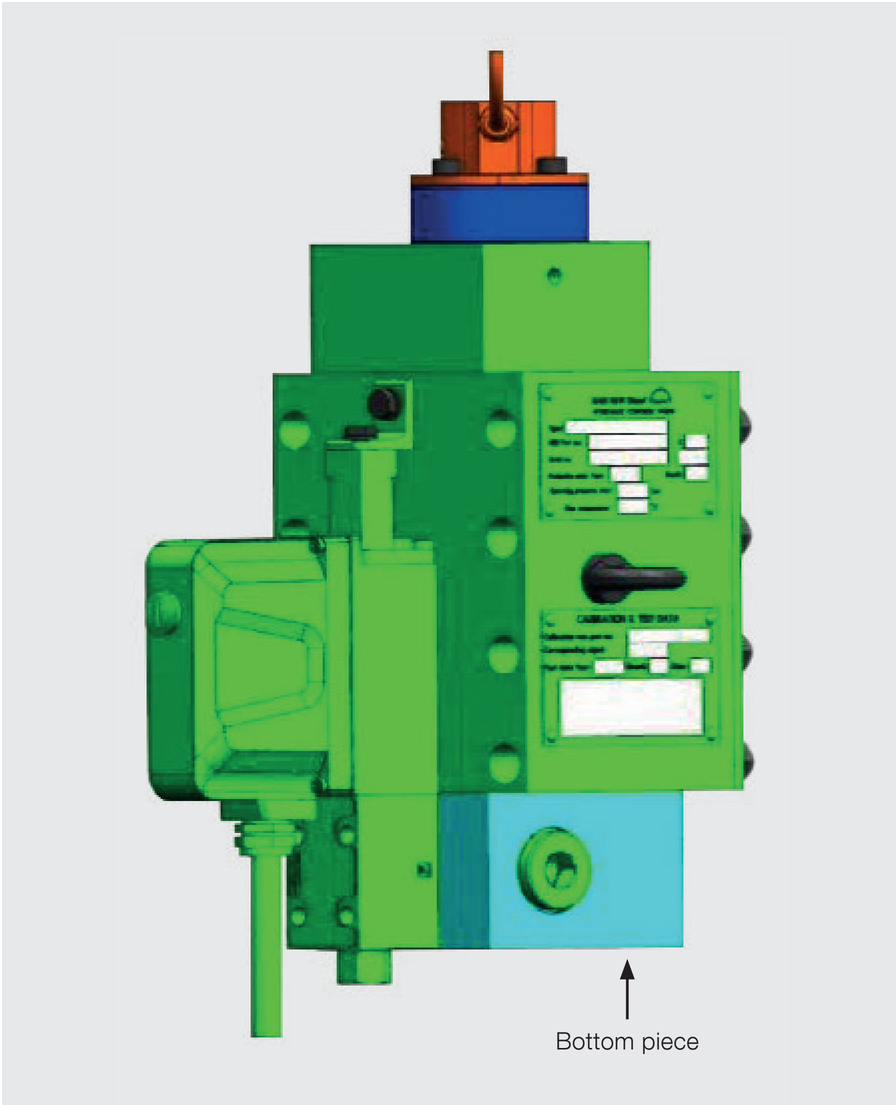


Fig. 18: FIVA with new bottom piece for permanent filter

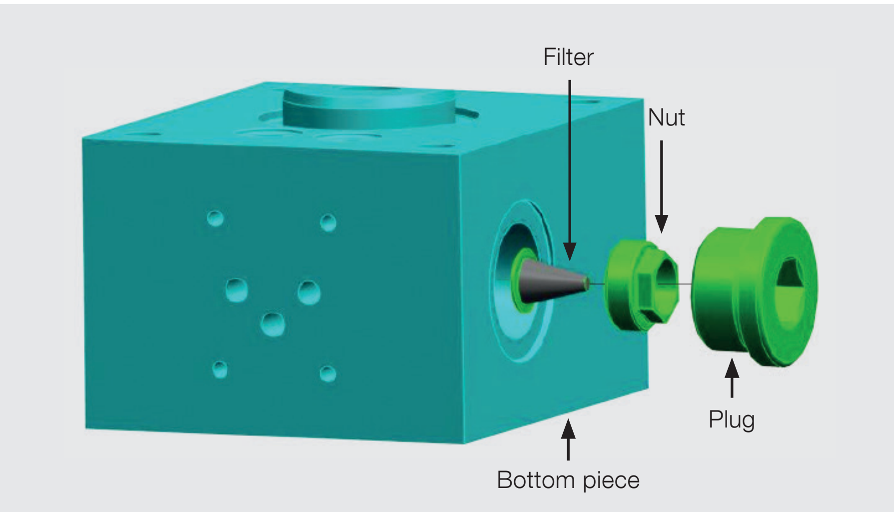


Fig. 19: New bottom piece showing filter placement and assembly order.

Fig. 20: Filter with large particles

How to define contamination level

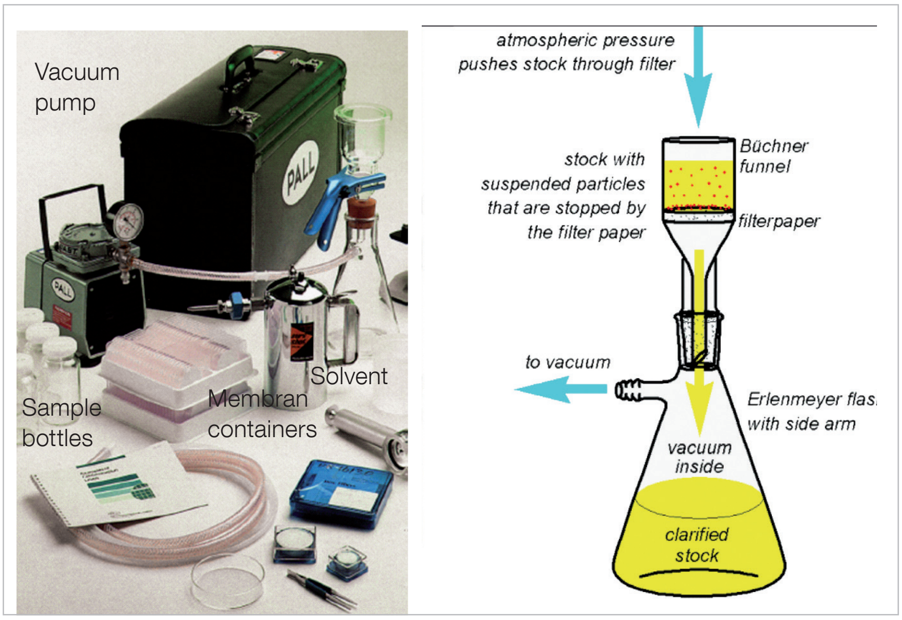


Fig.21: How to collect contaminants for examination

Fig. 22: Magnifier and comparator book

Cleanliness of hydraulic oil is normally examined by the laser method. However, this is not a suitable method for system oil, as system oil is black containing soot, small water-droplets, air-bubbles etc. which the laser method (ISO 11500) counts as particles, but which do not harm the engine components. The microscope method removes the soot etc. and do merely look at actual particles. MAN Energy Solutions therefore recommends to use the microscope method (ISO 4407).

The results show, that for used oil samples the microscope method measures 4-6 cleanliness classes below the laser method.

MAN Energy Solutions recommend on regular basis, when lube oil samples are send ashore for analyse, that a particle counting are also performed on the ME Hydraulic System oil according ISO 4407 which is particle counting by microscope 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. In the P2 line of the ME system. Minimess sample points at the ME-filter inlet and outlet are also recommendable.

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.

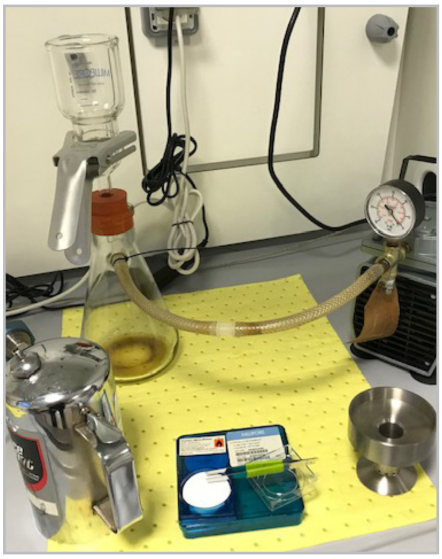
Using a vacuum pump, a representative sample of hydraulic fluid, usually 100 ml, is drawn from the 70ºC preheated system through a 47 mm diameter laboratory membrane filter disc with a filter mesh size of 1.2 microns.

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.

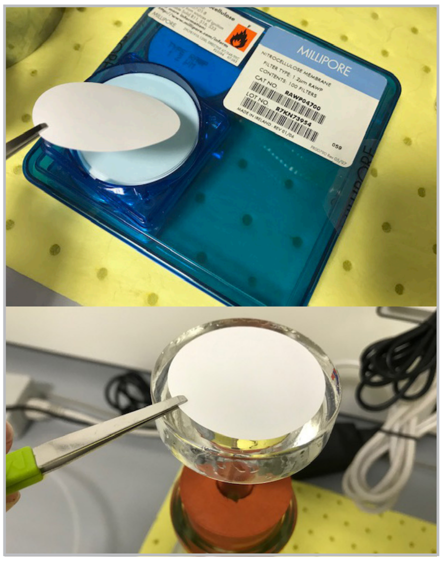
Analyse the membrane filter disc under microscope and compare a view on a prepared filter diaphragm with the ”comparator” picture with the same magnification. Use of a comparator book for this analysis is recommended.

Oil analysis procedure

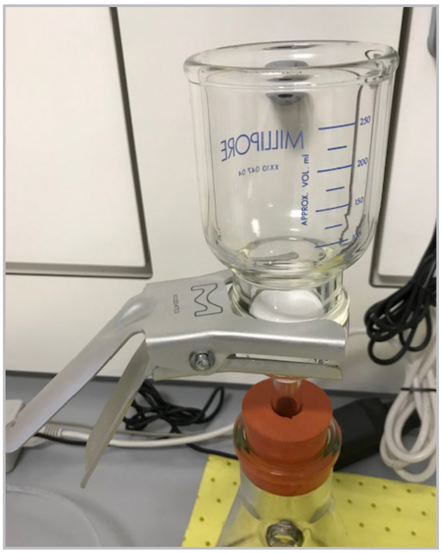
1. Heat oil samples in an oven to around 70°C. This will usual take one hour. The heating of the oil samples are important in order to be able to draw the oil though the filter discs



2. Prepare the test equipment



3. Take one 1,2 micron filter disc by forceps and place it at the top of the funnel

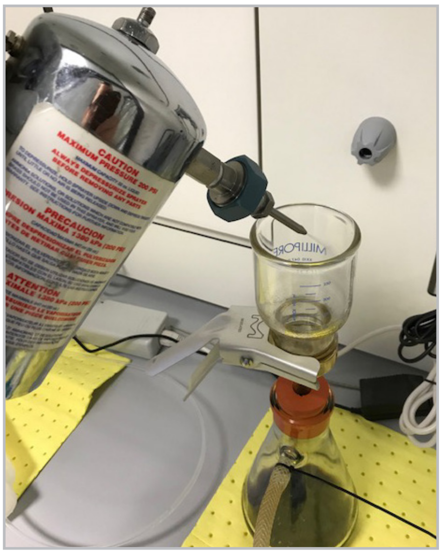


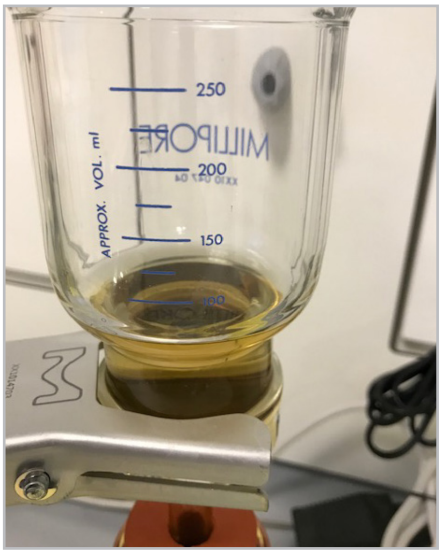
4. Clamp the measuring glass on the top

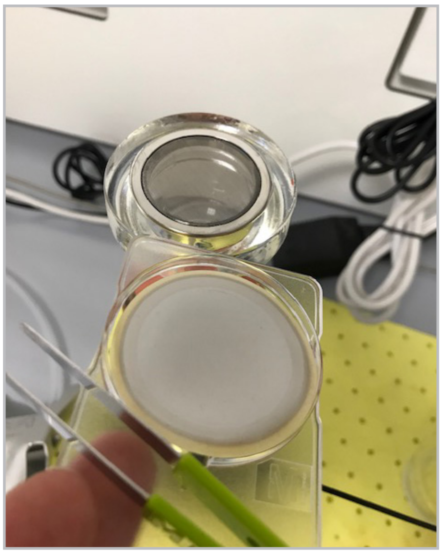
5. Take a well heated oil sample and shake it thoroughly for half a minute. Remove the screw cap and fil the measuring glass to the 100 mL mark.

6. Start the vacuum pump and the oil will be drawn through the filter disc to the bottle below.

Stop the vacuum pump when the oil is through.







7. Spray solvent / benzine onto the sides of the measuring glass and wait a minute so the solvent can dissolve the black soot particles

8. Start the vacuum pump and the solvent / benzine will be drawn through the filter disc. Stop the vaccum pump afterwards and remove the clamp together with the measuring glass.

9. Place by forceps the filter disc into the suitable container.

   Now the filter disc is ready to examinate under microscope.

Normally the filter disc would visually look fairly clean since our eyes cannot see particles smaller than 40 µm. However sometimes it is possible to determine if the cleanliness is not okay or not before analyse under microscope.

Fig. 23: Example of too dirty filter disc

Air amount in oil

Another important factor together with keeping the oil clean is to ensure a low amount of air in the oil.

A high content of air in the oil will decrease the efficiency of the hydraulic system as well as increase cavitation and wear at the hydraulic components.

It is the responsibility of the ship designer to ensure that the amount of air in the oil (x_{air}) put into the engine by the main lube oil pumps, does not exceed a maximum 1.5%.

This is to be confirmed on sea trial with the engine running in 100% load. An oil sample is to be made from the main low pressure supply line on the main engine downstream after the de-aerating nozzle shown in the main lubricating oil system diagram.

Such an oil sample must be made by using a bottle similar to the ones shown in fig. 24.

First the initial oil volume must be noted, see fig. 24 (A). The oil sample volume is to be evaluated after 24h in order to assume no air content in the final oil volume, see fig. 24 (B).

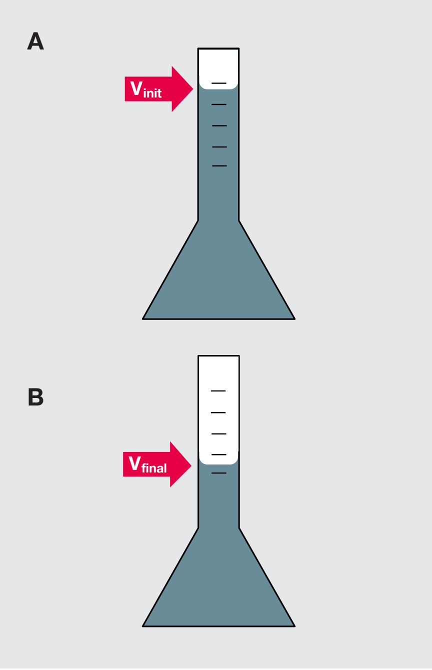


Fig. 24: Design proposal

Recommendations for design of lubricating oil sump tank

A way to keep the air content low is to ensure that the oil level in the tank never is under minimum level.

Because if the oil circulating rate is too high the oil will not have sufficient time for deaeration.

1. Considerations about Design of Lubricating Oil Sump Tank

The lubricating oil sump tank for the two-stroke marine diesel engines has several functions which are shortly listed here, as a basis for the recommendations that will be given later on:

- To settle the solid particles that will be separated by the centrifuges
- To de-aerate and degas the lubricating oil
- To act as a storage tank of the total volume of lubricating oil
- To contain the necessary oil volume in order to avoid a too high circulating rate
- To avoid that air be sucked by the lubricating oil pumps

The tank is located under the crankcase oil pan, in order to facilitate the oil flow from the crankcase outlets. It has to be designed with a symmetrical cross section to avoid bedplate distortions.

Usually, there is a cofferdam under the lubricating oil sump tank.

If the ship is not equipped with a cofferdam below the lubricating oil

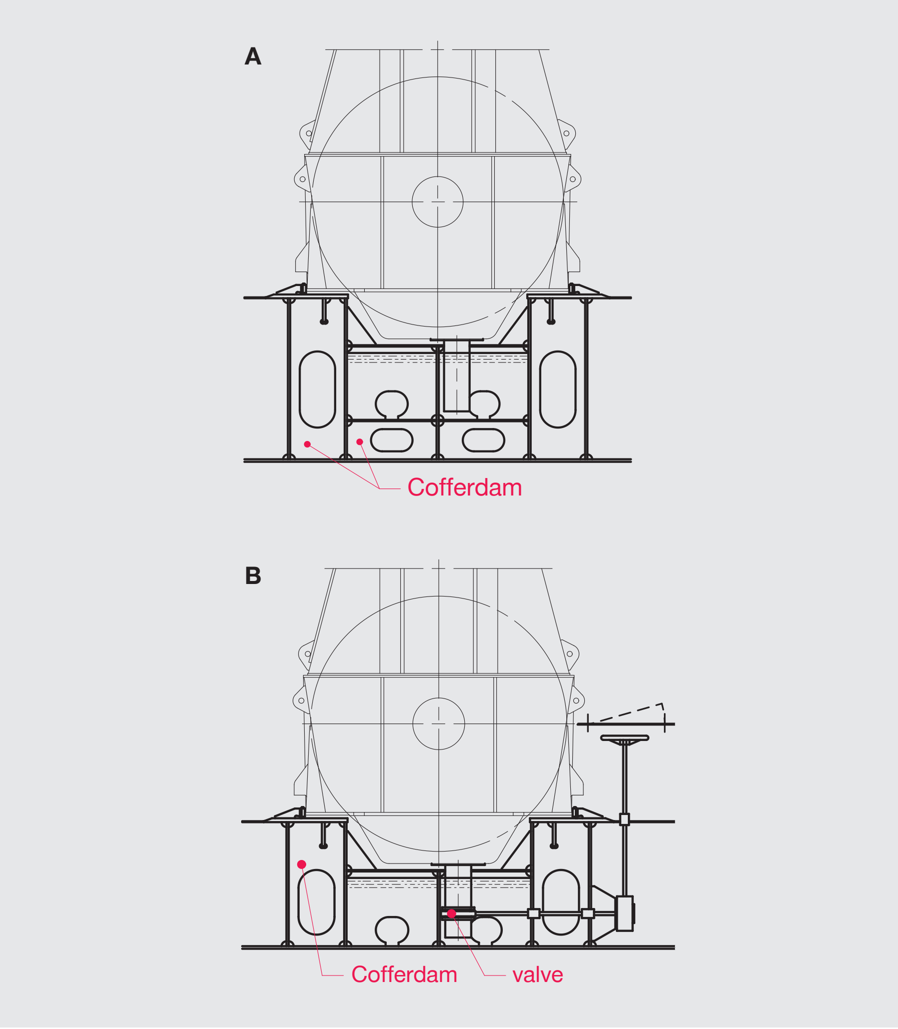


Fig. 25: A: Cofferdam below oil tank. B: No cofferdam below oil tank and valve in oil outlet

bottom tank, the lubricating oil outlet from the engine can be equipped with valves in the outlet, if required by the classification society. This can also be arranged with emergency suction from the engine oil pan.

2. Lubricating Oil Volume and Circulating Rate

The lubricating oil sump tank has to be dimensioned in accordance with the main lubricating oil pump capacity and the recommended circulating rate, which should be between 15 and 18 times per hour.

In some cases, when space is limited, it might be necessary to reduce the tank size to a minimum. However, it will not – under any circumstances – be advisable to increase the circulating rate to more than 20 times per hour.

In other cases, especially for engines with a large numbers of cylinders the tank size might be too big using the length extension of the engine as tank boundaries. For those engines the lub. oil bottom tank can be designed as below fig. 26.

Example:
Pump capacity: 280 m³/h
No. of oil circulations per hour: 15 l/h

That means that the total oil volume should be between:

- Recommended maximum oil volume (in circulation): 280/15=18.7 m³
- Recommended minimum oil volume (in circulation): 280/18=15.6 m³

It is good practice to design the tank volume with a capacity of approx. 5% to 10% more than the initial oil filling volume with pumps stopped.

When taking the above into consideration, the normally acceptable range of tank volume will be between:

Maximum tank volume:
18.7×1.10=20.6 m³

Minimum tank volume:
15.6×1.05=16.4 m³

Therefore, the tank volume is to be increased corresponding to the volume of the oil from the system outside the engine – if such a system is present.

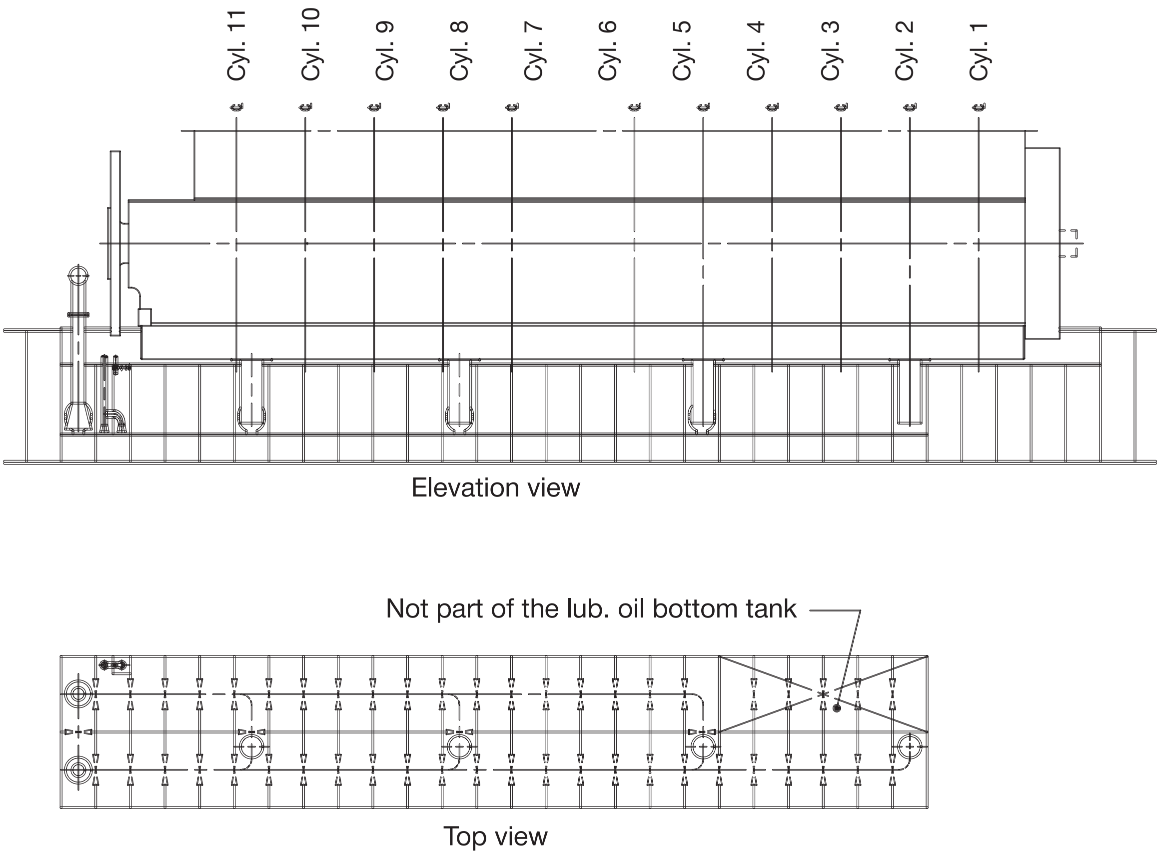


Fig. 26: Design proposal

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
If the ME-system is dismantled before being sent to the shipyard, flushing of the system must be performed on board.

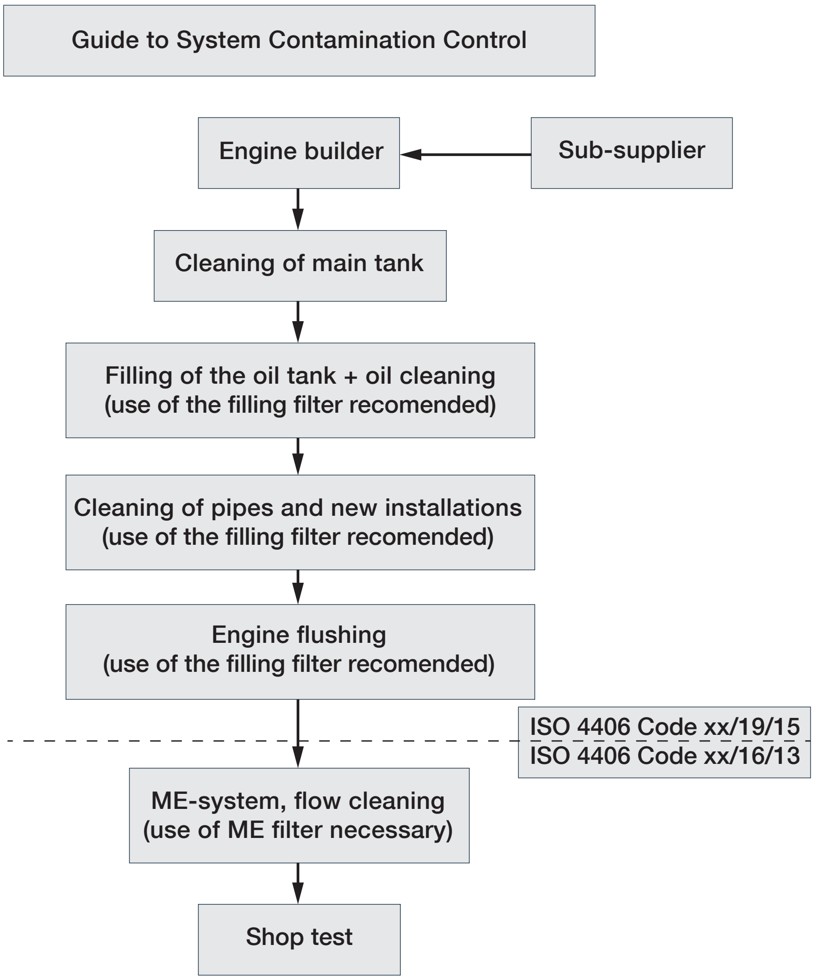


Fig. 27: Flushing at the shipyard

Even when delivered finish-assembled, flushing of the main engine must be performed at the shipyard. The ME-system can be omitted if the main engine is delivered without opening of the ME-system.

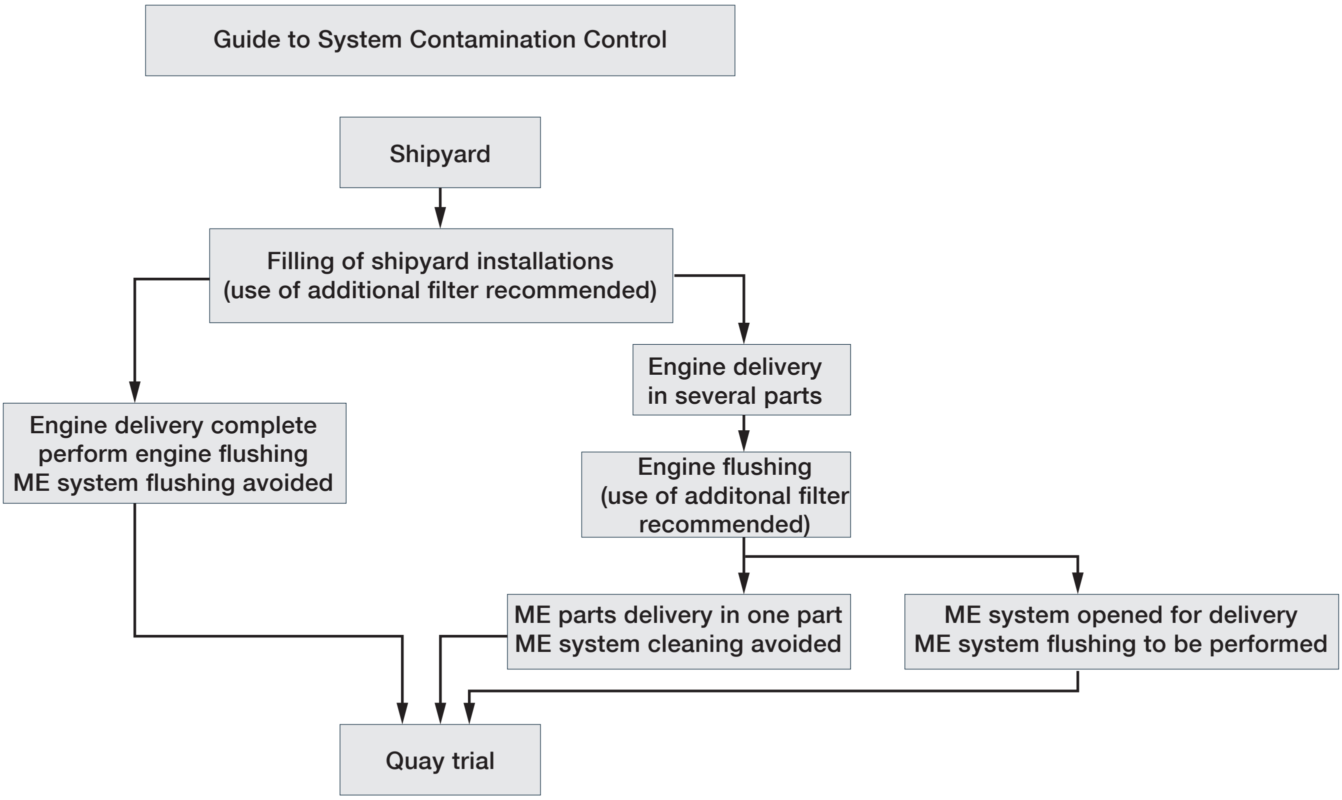


Fig. 28: Flushing of shipyard installations only

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 Energy Solutions 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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