Action code: WHEN CONVENIENT

Cleaning of Heavy Fuel Oil and Maximum 0.10% Sulphur Fuels

How to remove cat fines

SL2017-638/DOJA
February 2017

This SL replaces SL2005-452/KEA

Concerns

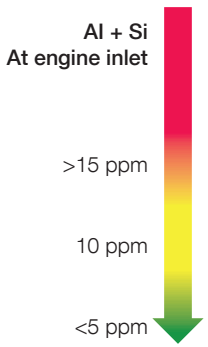
Owners and operators of MAN B&W two-stroke marine and stationary diesel engines.
For Holeby four-stroke engines, reference is made to SL2017-640/LNW.

Summary

Cat fines are small, very hard particles found in marine fuel. Cat fines can wear the engine down very fast, and they must be removed from the fuel by the fuel cleaning system on board the ship.

Recommendation:

Max. 15 ppm Al + Si at engine inlet for short periods



Cat fines (Al + Si) content entering the engine.

Dear Sirs

Abrasive particles entering the combustion chamber of two-stroke diesel engines are a cause of wear. Cat fines (catalytic fines) are small, very hard particles originating from the refining process. In case of insufficient cleaning onboard, cat fines may enter the engine with the fuel and cause wear. The latest ISO marine fuel standard specifies levels of up to maximum 60 ppm Al + Si in the fuel (ISO 8217). Such a level would cause high wear compromising reliability in the combustion chamber, and so the fuel must be cleaned on board the ship before it reaches the engine.

This Service Letter specifies the recommended maximum acceptable level of cat fines entering the engine, which is as follows:

- Always keep the level as low as possible and, max. at 15 ppm Al + Si at engine inlet for short periods.

Some guidelines on optimal operation are also given:

- Remove the cat fines from the fuel by setting a high temperature (min. 98°C) and a low flow in the fuel separators.
- Enable proper cleaning of the tanks in service by making the overflow pipe in the service tank go to the bottom of the tank, and/or by using a separate line to recirculate the fuel to the settling tank.
- To be warned when the fuel system is not operating optimally, a 10 µm abs. fine-filter should be installed in front of the engine.

More detailed information can be found in Ref. [1]. For questions or inquiries regarding the recommendations in this letter, contact our Operation Department at: leo@mandieselturbo.com

Yours faithfully

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Background: Engine Wear and Damage from Cat Fines

Abrasive particles cause wear when they enter the combustion chamber of two-stroke engines. Here, they may get trapped between sliding surfaces such as the piston ring and cylinder liner, or the piston ring and ring groove. The trapped particles either roll freely between the surfaces, or are partially embedded in one of the surfaces, see Fig. 1. Trapped hard particles will wear the sliding surfaces in a wear process known as 3-body abrasion. The more and bigger the particles are, the higher the wear will be.

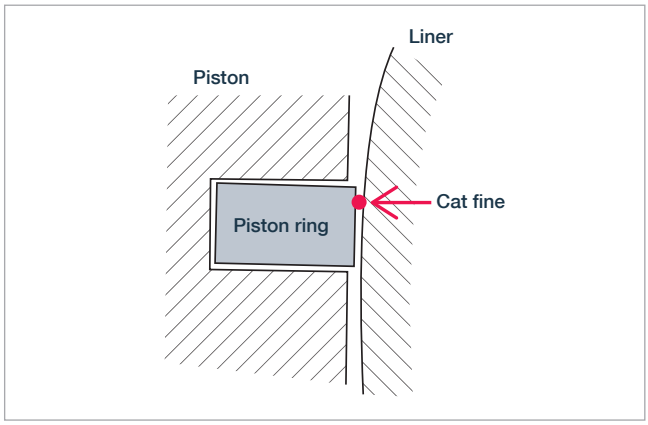

Fig. 1: Schematic illustration of cat fine particle trapped between piston ring and liner surface

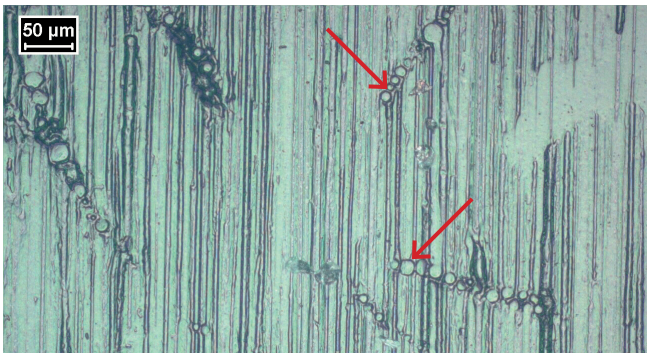

Fig. 2: Cat fines (examples at red arrows) embedded in the soft graphite lamellas on a cylinder liner surface (replica)

An example of such particle trapping can be seen in Fig. 2, where cat fines are embedded in the soft graphite lamellas in the cylinder liner surface. Cat fines are small, very hard particles which may enter the engine with the fuel. They enter the fuel during the refining process. Cat fines are found both in heavy fuel oil (HFO) and in some of the new types of fuel with less than 0.1% S (ULSFO), see also SL2014-593. They mainly consist of aluminium (Al) and silicon (Si) oxides – equal in hardness to Al_2O_3 (corundum) and SiO_2 (quartz), which are commonly used for grinding and polishing material.

The latest marine fuel standard specifies a maximum of up to 60 ppm Al + Si in the fuel (ISO 8217). This high level would cause extremely high wear in the combustion chamber. The cat fines can wear the engine fast, and it is highly recommended to use the fuel cleaning and condition system to clean the fuel to the maximum and remove the cat fines before they reach the engine.

Maximum Limit for Cat Fines in the Fuel Entering the Engine

Cases have shown that even very small amounts of cat fines can be detrimental to the engine. So all measures must be taken to reduce the risk of introducing cat fines into the engine. Consequently, we specify keeping as low a cat fine level as possible before the engine inlet. A maximum level of 15 ppm is acceptable for a short period of time, but the normal level must be kept lower, see Fig. 3.

The Al and Si content should be measured according to ISO 8217: IP 501, IP 470 or ISO 10478.

Cat fines in the fuel as bunkered are specified with between 0-80 ppm Al + Si in ISO 8217-2005 and 0-60 ppm in newer versions of ISO 8217. Tests have shown that the lower the cat fines content, the lower the wear in the combustion chamber.

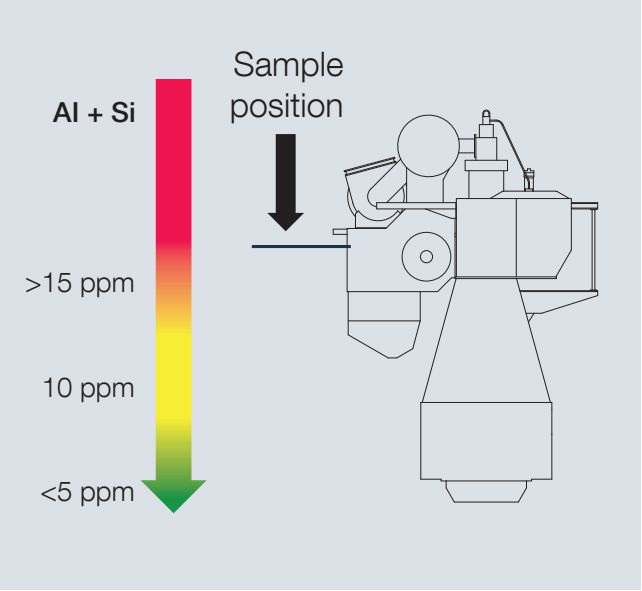

Fig. 3: Recommended maximum content of cat fines in fuel entering the engine

A low level of cat fines can be achieved by cleaning the fuel at all times to a high standard. For example, when bunkering a fuel with 80 ppm Al + Si, it should be cleaned on board to 15 ppm, and when bunkering a fuel with 30 ppm Al + Si, it should be cleaned on board to 6 ppm Al + Si, see Fig. 4.

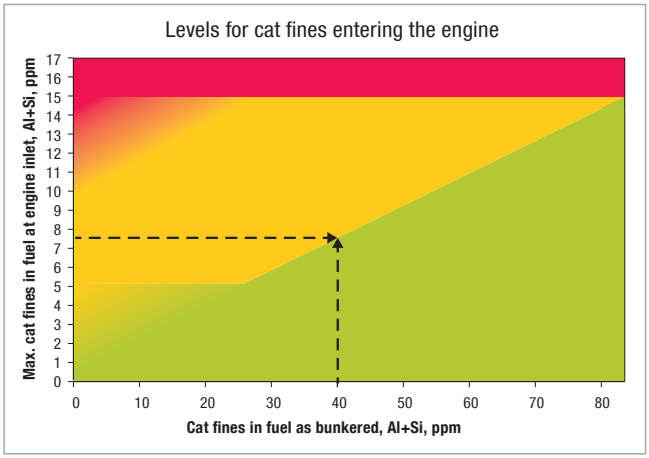

Fig. 4: Recommended levels for cat fines entering the engine based on the cat fines content in the fuel as bunkered (example with arrows illustrates that a fuel bunkered with 40 ppm Al + Si should be cleaned on board to 7-8 ppm Al + Si)

On-board monitoring

Succesful optimisation of the fuel cleaning and the cylinder condition depends on the operators following the condition closely and acting on the information obtained. It is recommended to check the fuel regularly for cat fines content, use drain oil analysis, and inspect the engine for wear of combustion chamber parts, i.e. piston rings, pistons and cylinder liners.

Fuel sampling for check of cat fines content

We recommend that you check the efficiency of the fuel cleaning system by taking a full set of fuel samples every four months. Also, check the separator efficiency when operating on a fuel with more than 25 ppm cat fines (Al + Si) in the fuel as bunkered. The sample positions are described in Table 1 and shown in Fig. 5.

Full set of samples - Every four months	**Check separator efficiency** - When the Al + Si content is above 25 ppm in the fuel bunkered
▪ At engine inlet ▪ Before separator ▪ After separator ▪ Bunker sample	▪ Before separator ▪ After separator

Table 1: Fuel sample positions

Send the samples to an established fuel analysing institute that can measure the Al + Si content according to ISO 8217. Onboard cat fines measuring equipment exist in the market, and we support the further development.

Cylinder lube drain oil

Used oil taken from the engine through the scavenge bottom drain can be used for cylinder condition evaluation, see SL2014-587. If high amounts of cat fines are fed into the engine, the drain oil will show a high iron amount due to the higher wear of the liner and piston ring, see also [1].

Fuel Cleaning System

Fuel cleaning systems on board ships are complicated and require thorough attention. It is important that they are designed and built to ensure acceptable cleaning and conditioning of the fuel. In some cases, it is seen that the fuel separator and preheater installed are too small, that the steam supply to the preheater is limited, or that the temperature control is too slow. These are all factors that reduce the ability to clean the fuel efficiently.

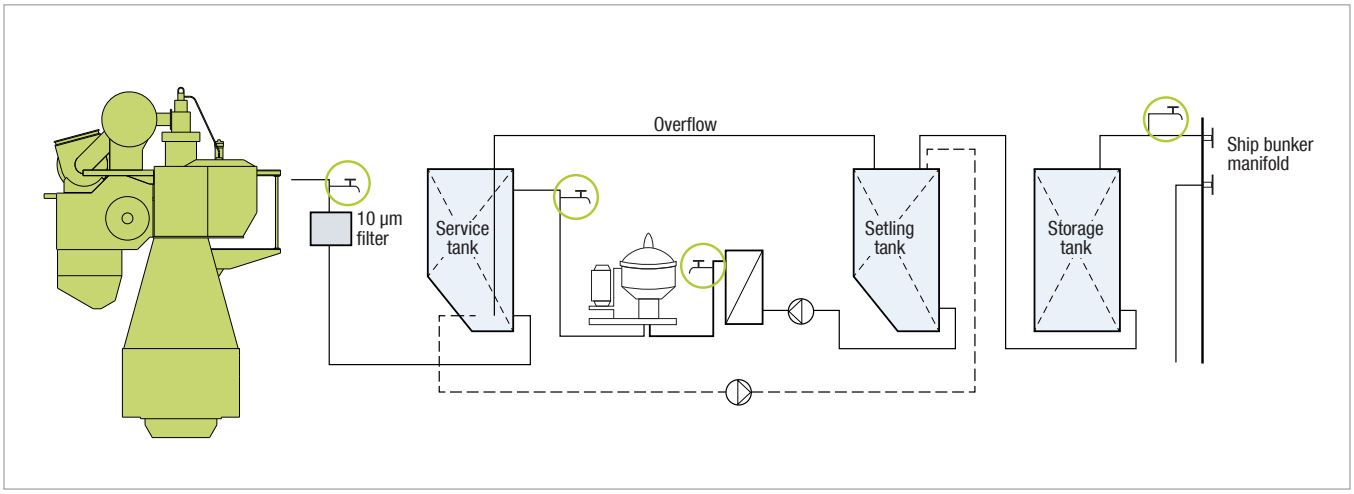

Fig. 5: Schematic fuel cleaning system diagram - note the positions of the sample valves in the green circles

We recommend consulting the MAN Diesel & Turbo project guides and operation manuals, the CIMAC recommendations [2, 3], IACS recommendations, and separator manufacturers for information and advice, see also [1].

For fuels outside ISO 8217 (e.g. with higher viscosity), special cleaning systems must be installed and operated to ensure the same good cleaning levels.

Operation of separators

The cleaning system must be designed for optimal operation at both high and low flows with stable high temperatures. Too low a temperature and too high a flow through the separators during fuel cleaning will result in insufficient removal of water, cat fines, sludge and other contaminants (Fig. 6). The recommendations for actual operation from the separator manufacturers should be followed.

Separator temperature

The separator temperature should always be kept as high as possible. The higher the temperature, the better the cleaning.

To keep the temperature correct and stable, a proportional-integral-differential controller (PID controller) should be installed on the preheater to the separator. If only a P-function controller is installed, it will most likely cause excessive temperature variations and, therefore, too low or too high a fuel oil inlet temperature to the separator. If the inlet temperature is too high, it may cause boiling of the control water in the separator.

The viscosity of the distillates, the new types of fuel with less than 0.1% S (ULSFO) and heavy fuel (HFO) are very different. Therefore, it is important to pay attention to the recommended temperature for the different fuel types during the cleaning process, see Table 2. If a thin fuel is heated too high, the viscosity of the fuel may become too low, see SL2014-593 for more details. The viscosity at engine inlet should always be kept above 2 cSt.

Fuel type		Fuel temperature in separator
Distillates		40-50°C
ULSFO	Viscosity @ 50 C	
	Up to 20 cSt	50°C
	20-40 cSt	60°C
	40-50 cSt	70°C
	50-80 cSt	80°C
	>80 cSt	98°C
HFO		98°C or higher

Table 2: Recommended fuel cleaning temperature in the separator

Separator flow

The lower the flow is through the separator, the longer the fuel stays in the separator, and the better the fuel is cleaned. Normally, a fuel separator has a layout for 100% load fuel consumption of the engine plus constant values for different margins. To be able to clean the fuel to a suitable level, the separator should be able to treat approximately the following quantity of oil: 0.23 litres/kWh in relation to CFR (certified flow rate). CFR must be given as according to CEN CWA 15375 or similar.

Since the engine is rarely running at 100% load, there is a large potential for increasing the separation efficiency by applying automatic flow control in relation to the actual fuel consumption. Furthermore, when the cat fines content in the fuel as bunkered is higher than 25 ppm Al + Si, we recommend operating two separators in parallel to reduce the flow and increase the fuel cleaning efficiency. If flow reduction is not possible, we recommend to operate the separators in series.

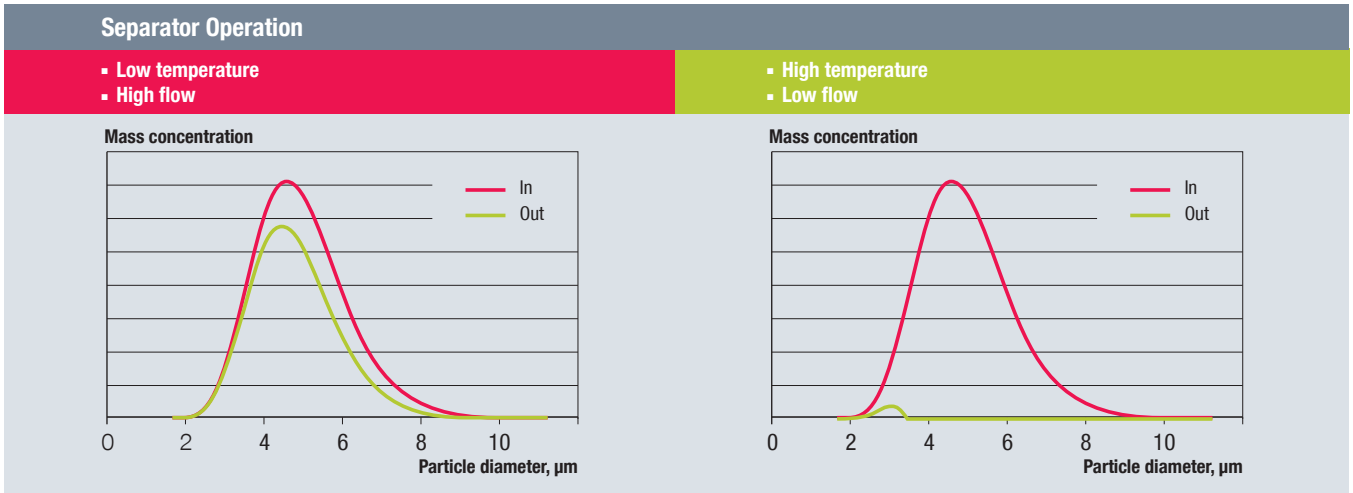

Fig. 6: Separator operations at different parameters – note the increased cleaning at high temperature and low flow

Proper maintenance

Proper maintenance of the separators is important, and it must be carried out in accordance with the recommendations from the separator manufacturers. For easy cleaning, the CIP (cleaning in place) systems can be used. If the bowl is not cleaned in time, the amount of deposits on the bowl discs will grow to an excessive level that will reduce the free channel height, increase the flow velocity and, thereby, reduce the separation performance.

Tank cleaning

Cleaning of the settling and service tanks in service must be possible. In calm weather, the cat fines will settle in the bottom of the tanks, but in high sea they can be hurled up and transferred further on in the system in high concentrations.

From the settling tank, the high concentration of cat fines may be led to the separators, which are unable to remove them to a satisfactory level. This means that the service tank will be contaminated with high amounts of cat fines, which will be led to the engine where they will cause increased wear.

Even normal good cleaning of the fuel will lead to a concentration of cat fines in the bottom of the service tank if the system is not designed and operated with measures for continuous cleaning of the service tanks.

A generally acknowledged best practice is to:

- use fuel tanks with sloped bottom – to concentrate the drain
- drain the settling tank and service tank at regular intervals
- enable cleaning of the tanks in service by recirculating the fuel back to the centrifuges, either by having the overflow pipe in the service tank leading all the way to the bottom of the tank and led to the top of the settling tank, and/or by means of a separate line and a recirculating pump, see Fig. 7 and also Ref. [1]
- clean all fuel content in the service tank before use if the tank has not been in use for some time (e.g. 1-2 weeks).

If the above-described equipment for tank cleaning is not installed, suitable procedures must be made to otherwise avoid feeding sludge and fuel with a high content of cat fines to the engine.

Operation in heavy weather

As described above, the cat fines will concentrate in the bottom of the tanks during normal operation in calm weather. To reduce the risk of feeding cat fines to the engine in rough weather, the following can be applied:

- use the standby separator simultaneously with the separator already in service and decrease the flow – to increase cleaning efficiency
- use a high-suction line – to better protect against cat fines settled in the bottom of the tank, see Fig. 7.

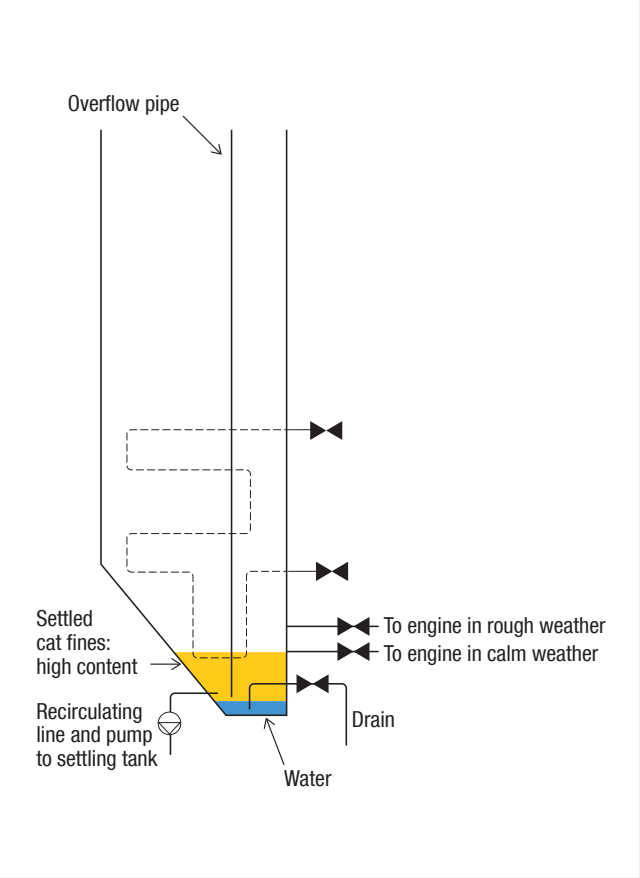

Fig. 7: Schematic drawing of fuel service tank - note that the overflow pipe goes to the bottom of the tank

Fuel fine filter in front of engine

Removal of cat fines from the fuel has to be done in fuel separators because of the substantial amount of dirt and cat fines present in the fuel.

However, as described above, a number of factors may impact the separation efficiency. Therefore, to protect the engine, we specify a 10-µm fine filter before the engine as standard. The filter should be a max. 10-µm (absolute) full-flow automatic back-flushing filter positioned in the high-temperature fuel recirculation system, see Fig. 8. Alternatively it can be positioned in the supply system.

Such a filter is by no means sufficient to remove all the cat fines from the fuel, but it will act as an indicator for insufficient operation of the separators. For example, an increased number of cleaning cycles for the filter indicates that the operation of the separators must be optimised.

In summary, we have seen increased reliability and low wear rates when:

1. 10 µm filter is installed in front of the engine
2. filter cleaning cycles are logged on a daily basis
3. action is taken to improve the fuel cleaning if the cleaning cycle number increases to higher than normal.

More Information

More detailed information on cat fines, cat fines removal and wear in the engine caused by cat fines can be found in the separate MAN Diesel & Turbo paper: “Cat fines – Impact on engine wear & How to reduce the wear!”.

References

[1] MAN Diesel & Turbo paper: “Cat fines – Impact on engine wear & How to reduce the wear!”.
[2] CIMAC rec. 25: Recommendations concerning the design of heavy fuel treatment plant for diesel engines.
[3] CIMAC Guideline: Filter treatment of residual fuel oil.

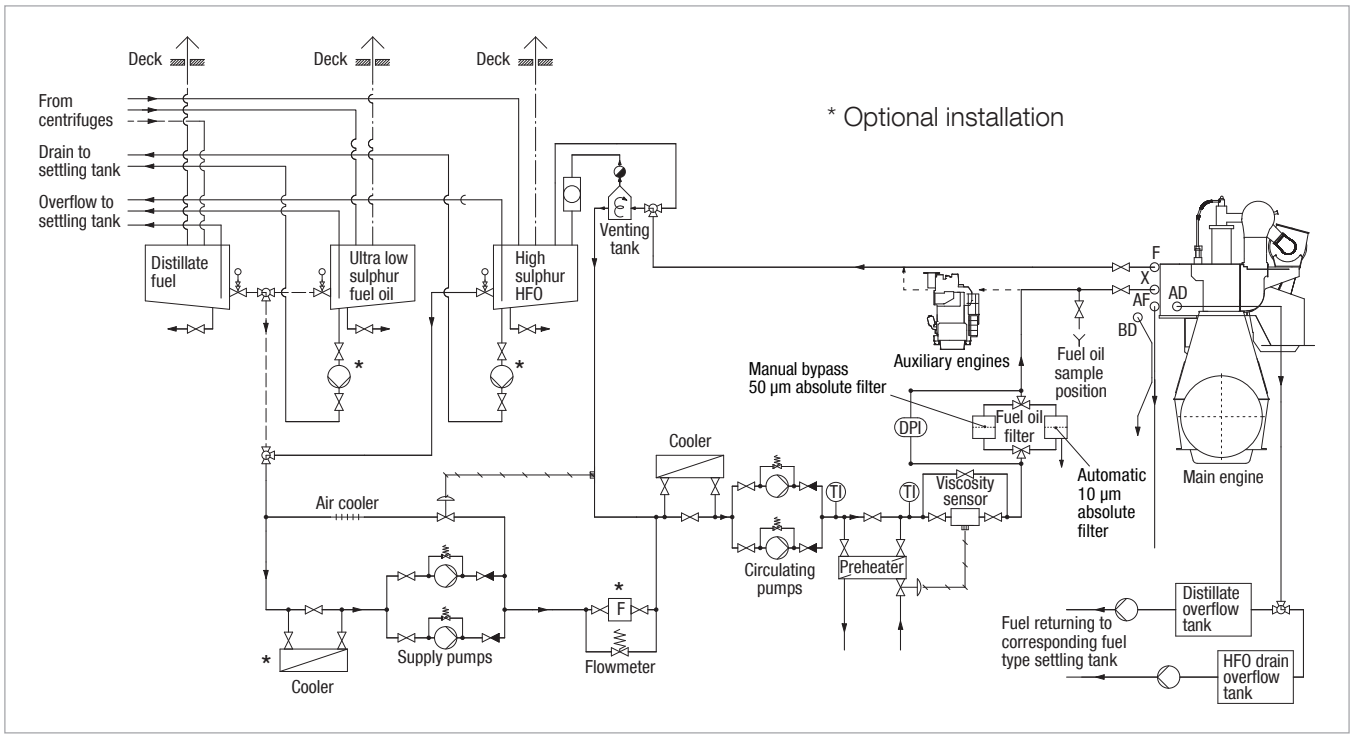

Fig. 8: Schematic of fuel circulating system with a max. 10 µm filter in front of the engine