INTERNATIONAL STANDARD

ISO 28520

First edition
2009-02-15

Ships and marine technology — Lubricating oil systems — Guidance for grades of cleanliness and flushing

Navires et technologie maritime — Circuits d'huile de graissage — Guide relatif aux degrés de propreté et de rinçage

Reference number
ISO 28520:2009(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 28520 was prepared by Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 3, *Piping and machinery*.

Ships and marine technology — Lubricating oil systems — Guidance for grades of cleanliness and flushing

1 Scope

This International Standard provides guidance for flushing of lubricating oil systems, and grading of the resultant cleanliness. The flushing process is twofold:

— to remove dirt from the erection and installation, and

— to demonstrate that the pipes and the system as a whole is sufficiently clean.

Crankcase and, where applicable, gearbox etc. are cleaned separately before flushing, and requirements relating to this are also specified in this International Standard. Similar considerations apply to the system tank and other components of the system.

For this International Standard, the cleaning process is considered as "washing through" when the Reynolds number, R_e, is $\leqslant$ 3 000, and "flushing" when the $R_e \geqslant$ 3 000.

NOTE If available, any original equipment manufacturer requirements for flushing take precedence over the requirements outlined in this International Standard.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 4406, *Hydraulic fluid power — Fluids — Method for coding the level of contamination by solid particles*

ISO 8501-1, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings*

ISO 28521[1], *Ships and marine technology — Hydraulic oil systems — Guidance for grades of cleanliness and flushing*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

1) To be published.

3.1
main engine
ME
prime mover used for propulsion of the vessel or to drive a ship's generator

3.2
turbocharger
TC
centrifugal blower driven by exhaust-gas turbines and used to supercharge an engine

3.3
lubricating oil
LO
petroleum product designed to reduce friction and heat between moving parts in internal combustion engines

3.4
Reynolds number
R_e
dimensionless ratio of the internal flow forces to the viscous forces within a fluid

NOTE An indicator of the flow characteristics (laminar or turbulent) of a moving fluid.

4 Recommended degrees of pipe cleaning

This clause specifies the recommended degrees of pipe cleaning during and after prefabrication for pipes or parts, possibly followed by inside surface treatment.

To ensure the best possible conditions for flushing, individual prefabricated parts should be made and cleaned, before erection on-board.

4.1 Degrees of pipe cleaning during/after prefabrication

Concerning prefabrication of pipes and parts, it is recommended that these are completely cleaned inside, which means that all welds associated with the welding of pipe sections and pipe branches should be smooth and free of slag, welding spatter, burns and porosities. Fillet welds on flanges should be smooth and finely grounded and should also be free of roundings as these can damage part of the joint faces. Concerning possible subsequent chemical acid-cleaning or mechanical blast-cleaning, the degree of cleaning should correspond to Sa 2 1/2 as specified in ISO 8501-1.

Steel sand should not be used for shot blasting, due to the risk of adhesion by magnetism or rusting; copper (Cu) slag should be used instead. Sealing surfaces are to be mechanically well protected during shot blasting.

4.2 Inside surface treatment

In order to maintain the above-mentioned degree of cleaning before erection on-board, it is recommended that the inside of the pipes be treated with an appropriate oil product.

Painting the inside with appropriate paint is sometimes prescribed by various manufacturers, and any such requirements should be followed.

5 Cleaning of system components

Shot blasting, grinding, painting and welding should not be executed in the near vicinity during cleaning operations on the items listed in 5.1 to 5.4.

5.1 Pumps, valves, filters, oil coolers, etc.

System oil requirements shall be requested from suppliers of these auxiliaries.

5.2 Engine crankcase

When engines (especially large engines) are delivered without cleaned and sealed lubricating oil systems, including the crankcase, the crankcase shall be cleaned before flushing. This can be done as follows.

a) Blank-offs are placed on each oil drain to the engine mainframe. Starting at the top of one cylinder block at a time, the inside of the crankcase is washed down with oil to remove rough particles. During this task the engine crankshaft is turned at regular intervals so that chains, chain wheels, and the crankshaft are washed down and cleaned.

b) A thin, non-drying oil, is recommended (about SAE 10 to 30 cSt), the remainder of which is compatible with the system oil, which can dissolve the rust-prevention product which the engine has been coated with when delivered. System oil (SAE 30 – 90 cSt or SAE 40 – 175 cSt) may be employed instead, provided the oil is heated to 55 °C to 60 °C. In practice, 200 l to 400 l per cylinder have proven to be sufficient, with the same quantity used for camshaft drive.

When the camshaft drive is cleaned, the thrust bearing cover is removed if possible, and the thrust bearing is washed down. Furthermore, the thrust-bearing ahead and astern thrust-pads are taken out for wiping if possible. Ensure that the flash point of the oil is not too low (danger of fire).

Some rust prevention oils can influence the foam characteristic of the system oil; this occurrence can be limited in the following way. The work can be partly done from the outside of the crank and shaft casting through various inspection covers. After an appropriate amount of time, allowing for dripping and draining, the dirty flush oil and deposited sediments shall be removed from the oil sump. The inside of the engine is then wiped with lint-free and non-frayed cloths, and an inspection is made before the actual flushing is commenced.

5.3 Gearbox

If gears are delivered with no cleaned and sealed lubrication oil systems, including pump and pipes, the gears shall be cleaned before flushing.

5.3.1 Sealed gearboxes

For sealed gearboxes, external piping, filters and pumps, see 6.3.1.

5.3.2 Non-sealed gearboxes

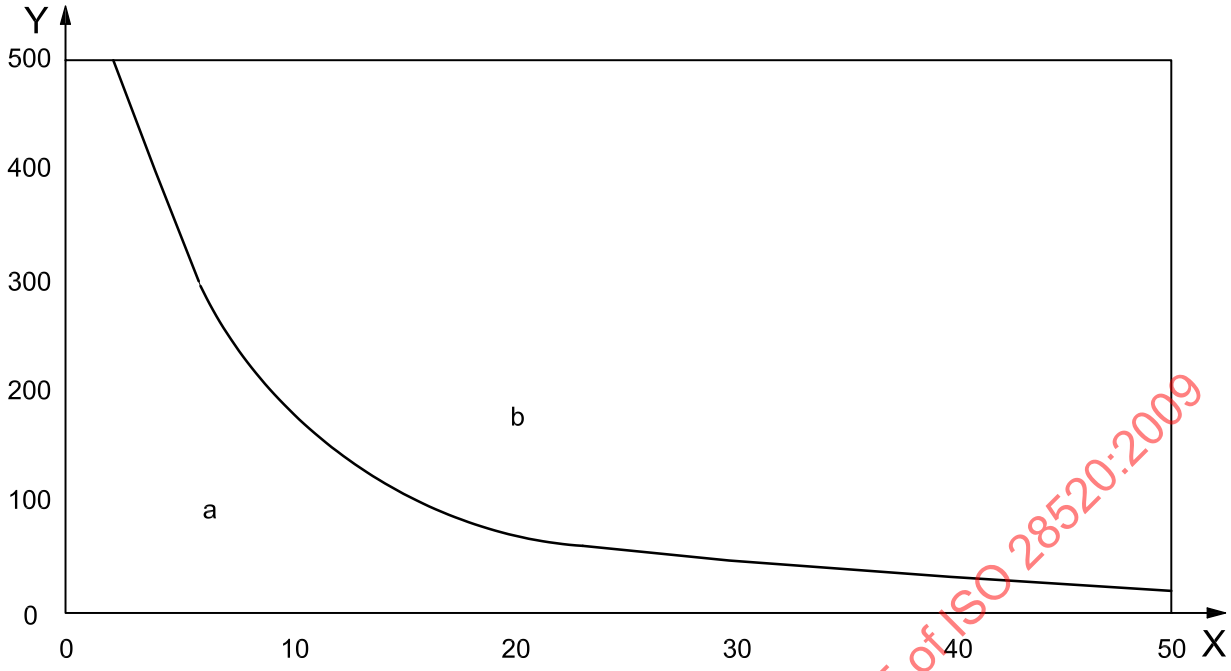
For non-sealed gearboxes (when assembling gearboxes, including external pump, piping, filters and coolers) see 6.3.2.

5.3.3 Choice of cleanliness level

The most impurity-sensitive components in a gearbox are, typically, ball- and roller-bearings. Information concerning required bearing-cleanliness may be obtained from the bearing supplier, but shall in all cases be stated by the gearbox supplier.

To a wide extent, the demand for life cycle and bearing load conditions shall guide the choice of cleanliness level.

Bearing manufacturers have developed a bearing-lifetime theory, which among other items includes the influence of impurities on service lifetime based on system lubrication oil. Figures 1 and 2 show the relationship between size and hardness of impurities, how harmful they are to bearing life, and how important it is to focus on cleanliness.



Key

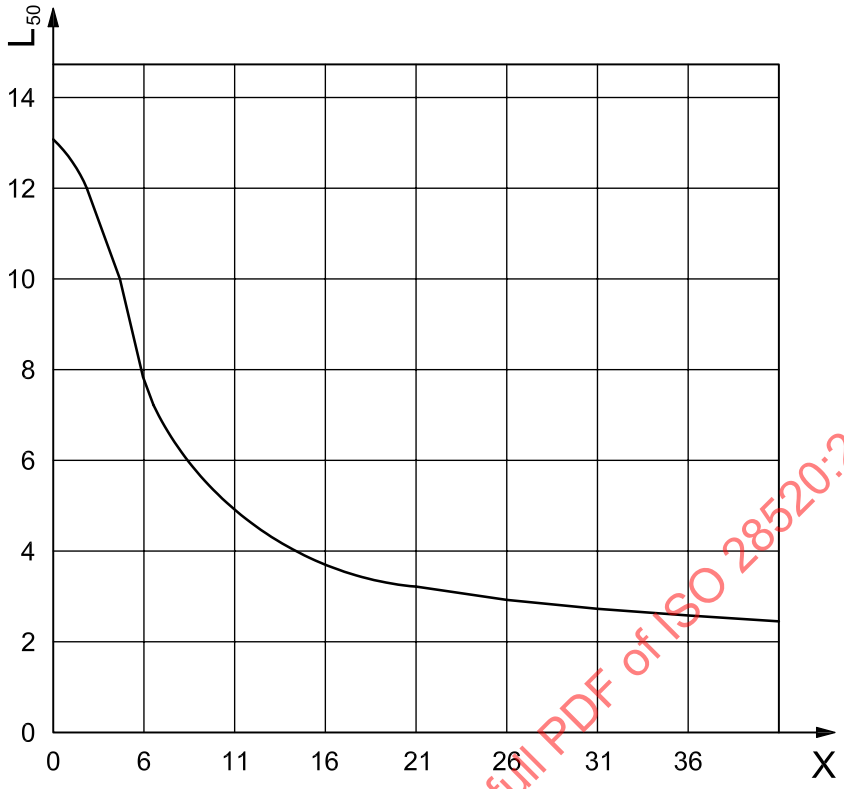
X grain hardness, expressed in Vickers hardness (HV)
Y grain size, expressed in micrometres

[a] Harmless.

[b] Harmful.

NOTE In the calculation of these results the following parameters are used: friction coefficient, μ, 0,1; oil film thickness 0,4 ∝m; hardness of outer track and roller 800 HV.

Figure 1 — Attrition particle's damaging effects with relation to their size and hardness



Key

L_{50} bearing lifetime, expressed in million revolutions
X absolute filter fineness, expressed in micrometres

Figure 2 — Bearing lifetime (L_{50}) as a function of filter fineness

Table 1 indicates proposals for the degree of cleanliness for the various gear types.

Gear type, in this context, is a specification that combines and includes such characteristics as speed, load variation and lifetime frequent start-stop.

Table 1 — Level of cleanliness for the various types of gear

Type of gear	Level of cleanliness after approved flushing	Level of cleanliness after commissioning trial	Max. allowable contamination during service	Typical service oil filter
	ISO 4406	ISO 4406	ISO 4406	$\beta_x > 75$
1	16/14/11	17/15/12	18/16/13	3-5 µm
2	17/15/12	18/16/13	19/17/14	5-10 µm
3	18/16/13	19/17/14	20/18/15	5-10 µm
4	21/19/16	22/20/17	23/21/19	20-50 µm

The classification of type of gear (number) is explained as follows.

1) Demand for long service life, high operational reliability, high gear load, rpm (> 3 000), frequent start-stop, such as on ferries with gas turbines on short crossings, and high loaded gear with multiple power take-off (PTO).

2) Medium loaded gear, rare demand for maximum load, gearing where secondary PTO is running idle, such as on big trawlers, gear on ferries where two main engines are coupled to a joint common gear box, integrated gear and controllable pitch propeller (CPP) control systems.

3) Same as 2), but with separated gear and CPP control system separated with individual oil supplies.

4) Gear with low rpm/load and low service time.

5.3.4 Instruction manual

The instruction manual shall contain requirements for and descriptions of programmed maintenance, which will ensure that the earlier-stated levels of cleanliness can be maintained.

5.4 Tanks

The system tanks shall be internally cleaned for spatter and oxide scales, brushed, vacuum cleaned, and possibly coated according to special prescriptions.

Internal tank-surfaces should be washed down before flushing, according to the same principles stated in 5.2. It is assumed that storage tanks are clean.

5.5 Special comments

Pipe and components between the filter and bearings shall be cleaned meticulously for spatter, oxide scales, etc. and the components supplied by the manufacturers and sub-contractors shall be checked for cleanliness. This applies especially to oil coolers (see Figure 5), if they are placed between filters and the engine.

During system filling with flush-oil from the storage tank, the system LO separator or filter shall be operable in order to obtain an initial flush-oil start-off cleanliness level of ISO 19/17/14 or better (see ISO 4406).

6 Flushing

The aim of the flushing process can be summed up as follows:

6.1 Flushing practice (2-stroke engine)

Flushing is divided into

a) the flushing of external piping systems (mainly shipyard fabricated piping), and

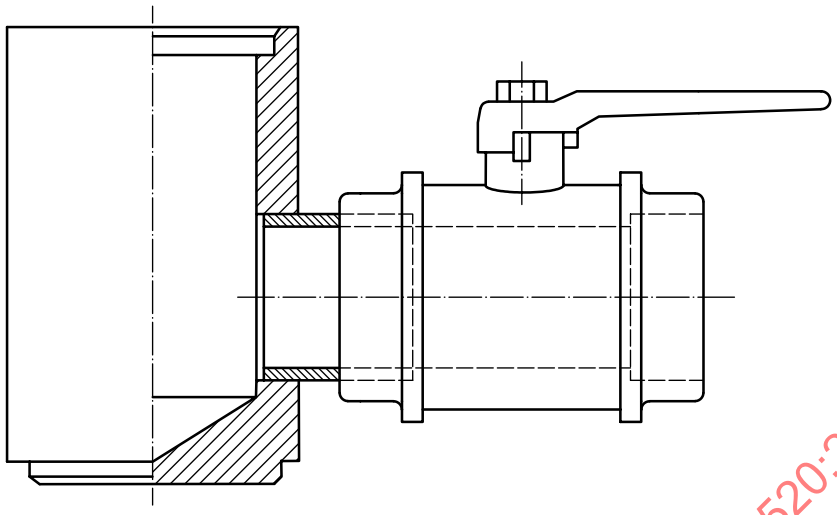
b) the flushing of internal surfaces and piping (mainly engine builder fabricated piping).

6.1.1 First flushing sequence

6.1.1.1 General

The first flushing sequence concerns, in principle, all system piping fabricated at the shipyard/ plant's pipe shops.

The oil supply for main bearings and crossheads is attained by specially designed orifice pieces which, during flushing, cause the oil to sprinkle over the inside of the engine (see Figure 3).



NOTE Adapter piece at the end of the telescope pipe to be removed and orifice piece to be attached.

Figure 3 — Orifice piece for crosshead bearing

Lubricating oil spray nozzle piping for ME chain, thrust bearing and torsion vibration damper are to be blanked off. Lubricating oil piping for turbochargers is to be flushed with the TC bypassed.

The following shall be observed:

a) All valves etc. shall be fully open and the crankcase well ventilated. ME cylinder cooling water shall be operable and able to maintain a constant temperature of 50 °C in order to prevent surface condensation.

b) It is advisable to have an “off-line” flushing unit to operate in parallel on the circulations tank, if the flushing pump capacity chosen is capable of circulating the total flush oil charge once every hour.

c) It is recommended to have installed LO separators run in a recirculation mode from the oil tank during flushing. Furthermore, a “pipe vibrator” unit is to be operated in order to hammer and vibrate loose small particles from bends and pipe branches.

d) When running with LO separators and flushing unit simultaneously, it is of great importance to keep flushing oil at 50 °C to 60 °C. This temperature range is obtained by either installing heating coils in the circulation tank, or by circulating hot water (cooling system) through separator preheaters.

   When running full-flow flushing systems, for instance on the camshaft LO system, one full-flow filter may be used if filter capacity corresponds to pump unit's total capacity. In this situation, an “off-line” flushing unit should also be used, as previously described in b).

   The permanent filter in the lubricating oil pipe system may be used for cleaning impurities from flushing oil. However, a satisfactory level of cleaning according to engine builder's specifications may not be expected within a reasonable span of time when using these filters alone. In some instances, where the overall flow resistance does allow it, a fine mesh insert with less permeability may be inserted in the permanent bypass filter (see Figure 5).

   When deciding size and flow capacity for the temporary full-flow filter insert (Figure 6), attention shall be paid to the overall system permeability. When using an offline flush unit, it is recommended to use a 10 µm filter at the first session and a 6 µm filter at the second and final session.

   In full-flow flushing systems, it is advisable to run the system with a 6 µm or 3 µm filter insert in the full-flow filter. The type of full-flow filter insert is to be based on the demand of system permeability and

cleanliness. When deciding size and figure of merit for filter insert, ISO 28521:—[2], 11.2, shall be observed.

e) Suitable system oil is normally chosen for flushing. When the lubricating oil system or other conditions do not permit heating of the lubricating oil, it will be suitable to employ a rinsing oil which is reconcilable with and of a lower viscosity [e.g. about 70 cSt[3] at 40 °C] than the system oil [see item f)]. For flushing purposes, it shall be noted that the system is only to be filled with so much oil as is needed for air-free circulation.

f) The flush oil shall be heated to at least the normal running temperature of the engine (or to a temperature 10 °C to 20 °C higher than this, but not exceeding 90 °C to avoid danger of oxidation). The heating can be achieved as described above. High temperatures are conducive to removal of dirt from the erection and assembling and lower the viscosity, which is beneficial to efficient separation [see item c)] and to the achievement of turbulent flow (see 6.1.1.2).

g) Before commencing the first flushing session, all branch piping and crosshead bearings shall be blanked off, as shown in Figure 5.

h) During the first and second session of flushing, the degree of pollution of the permanent and temporary built-in system filters shall be constantly observed on the indicators or by visual control of the filter insert.

Oil samples shall be taken and investigated by microscopy at the yard/plant.

Oil samples shall also be taken at intervals, to gain experience of the flushing progress and duration. When the pre-set level of impurity is reached, classified oil samples shall be taken.

If no pre-set level of impurity is mentioned, the flushing process may be stopped at a level where the impurity levels for both the main LO system and camshaft LO system do not exceed Code 18/16/13, as defined in ISO 4406, for a chosen period of time.

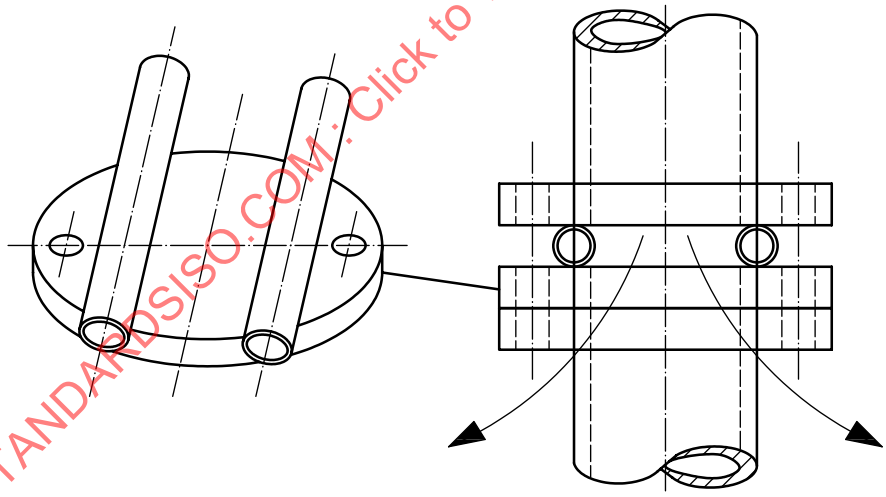
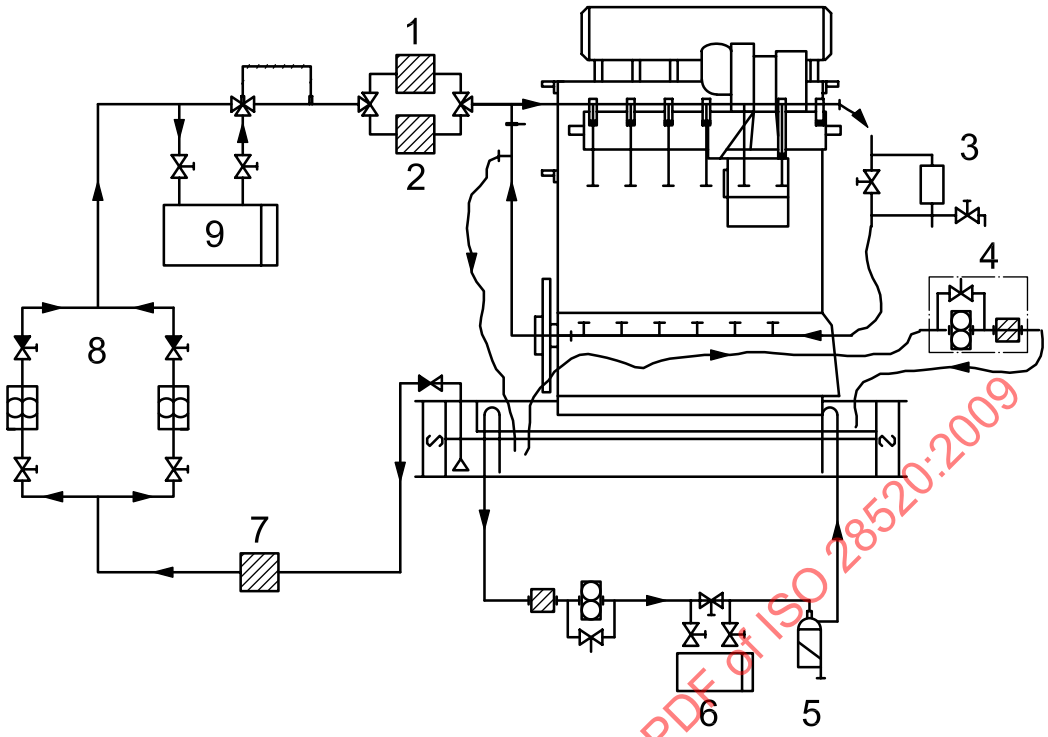


Figure 4 — Orifice for main bearing

2) To be published.

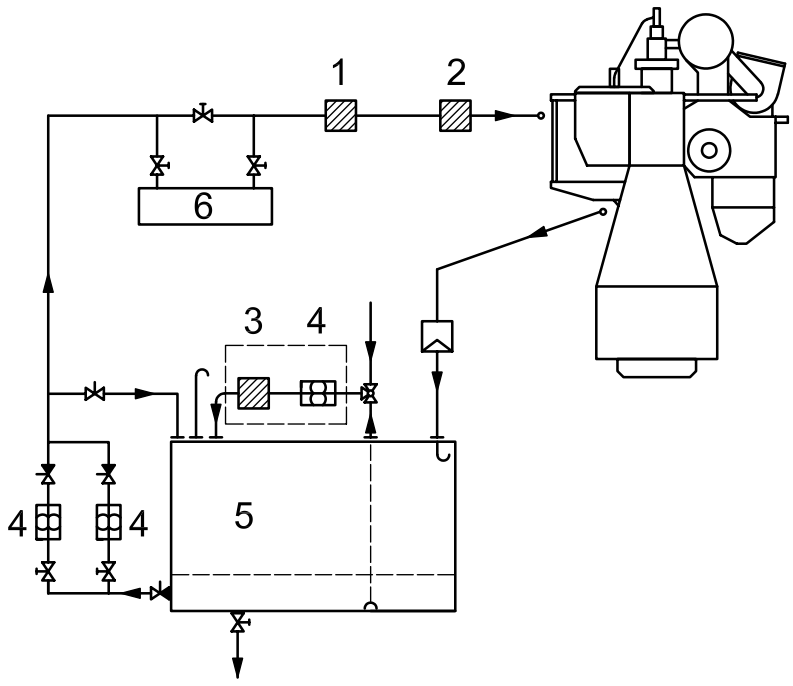
3) 1 cSt = 1×10^{-6} m^2/s.



Key

1 auto filter
2 bypass filter
3 flushing-bag retainer
4 flush unit
5 separator
6 preheater
7 suction filter
8 LO pumps
9 LO cooler

Figure 5 — Flushing system with bypass filter



Key

1 full-flow filter
2 permanent filter
3 final filter
4 pump
5 circulation tank
6 oil cooler

Figure 6 — Flushing system with permanent filter

6.1.1.2 Flow velocities

Flushing is best promoted when the velocity of flow is relatively high and/or the viscosity relatively low, so that a turbulent flow is created in the piping system during flushing. Turbulent flow appears if the Reynolds number, Re, exceeds 2 300 (3 000).

For $Re > 2\ 300$, a once "disturbed" flow stays turbulent. For $Re > 3\ 000$, the flow will always be turbulent.

The Reynolds number is calculated using the following equation

$$Re = w \times d \times 1\ 000/v$$

where

w is the average flow velocity (m/s),

d is the inside pipe diameter (mm), and

v is the kinematic viscosity [4] (cSt).

EXAMPLE 1 For a pipe with $w = 2{,}5$ m/s, $d = 0{,}2$ m and $v = 80$ cSt, $Re = 6\ 250$ (turbulent).

EXAMPLE 2 For a pipe with $w = 1{,}8$ m/s, $d = 0{,}1$ m and $v = 85$ cSt, $Re = 2\ 118$ (laminar).

The flow velocity cannot be raised to exceed the system's calculated maximum velocity if the system's own pumps are only engaged alternately. Two parallel-shunted positive pumps (engaging the auxiliary pump as well) may, however, almost double the velocity. All pumps that are part of the system shall, together or alternately, participate in the flushing. When the flushing is planned, it shall be ascertained that the filters can handle the increased amount of oil.

6.1.2 Second flushing session

Orifice blanks and hoses are to be disconnected and removed, and the piping system shall hereafter be reestablished. The system is once again at the stage shown in Figure 5.

Lubricating oil piping to main and crosshead bearings is to be furnished with a retainer (see Figure 7) for the "flushing unit bag", as indicated in Figure 5. It is important that hoses, retainers and flushing bags are an integral part of the second flushing session.

During the entire second flushing session, turbulent liquid flow conditions shall be maintained (see 6.1.1.2).

4) The SI unit of kinematic viscosity is the metre squared per second, although for this application the centistoke is commonly used, where 1 cSt = 1×10^{-6} m^2/s.