
**Plain bearings with liquid
lubrication — Lubricant supply
arrangements and monitoring**

*Paliers lisses à lubrification fluide — Equipements de graissage et de
surveillance*

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 123, *Plain bearings*, Subcommittee SC 3, *Dimensions, tolerances and construction*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document is based on German standard DIN 31692-1:1996.

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Plain bearings with liquid lubrication — Lubricant supply arrangements and monitoring

1 Scope

This document provides requirements and guidance on lubricant supply arrangements and monitoring for liquid-lubricated bearings (plain bearing assemblies) such as those specified in ISO 11687 (all parts).

This document is intended to assist the design of oil-based lubrication systems for hydrodynamic plain bearings mainly to be used in large-scale rotating machinery for power generation, industry and transportation.

This document focuses on the most important requirements and characteristics of lubricant supply arrangements and monitoring for plain bearings. Additional standards such as ISO 10438-1, ISO 10438-2 and ISO 10438-3 would be needed to design complete low-pressure or high-pressure lubrication systems, along with their corresponding components.

Wherever this document specifies a particular form of solution, whether design or operation, different solutions can be selected provided they are justified by engineering assessment or reference to similar systems already in operation.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

4 Lubrication arrangements

4.1 Self-contained bearings

The low-pressure lubrication of self-contained bearings is ensured by an internal oil reservoir and a supply mechanism, driven by the main shaft rotation. Typical self-contained bearing lubrication supply mechanisms include ring lubrication and viscosity pump lubrication. The lubrication does not require external energy or equipment. The lubricant does not leave the bearing internal reservoir.

4.2 Circulated lubrication (forced lubrication)

4.2.1 General

The oil supply of forced-lubricated bearings consists of a closed circulation system. The oil supply in these cases is provided by pumping the lubricant through the bearings. In the supply system, the oil is pumped out of the reservoir, filtered, cooled and controlled at the desired flow rate or pressure before being fed to the machine bearings. For this purpose, a complete oil supply system consists of a reservoir,

pumping, filtering, cooling and controlling units. After lubricating the bearings, the oil returns to the reservoir. Some lube oil units are operated independently of the machine being supplied. Others have the main lube oil pump being driven by the shaft of the machine.

4.2.2 Oil feed and oil return

To minimize the possibility of vibrations or thermally induced tensile or compressive stresses occurring in the bearing housing, flexible compensators or connections shall be provided in the oil supply and drain piping systems if applicable.

For electrically insulated plain bearings, it is necessary to consider whether oil supply and drain pipes connected to the bearing also need insulating to prevent short circuit of the bearing insulation.

To restrict the pressure losses in the piping system to an economically justifiable amount, the oil mean flow velocity should not exceed 2 m/s in the supply lines according to experience.

The design of the return fluid flow path from the bearing to the oil reservoir shall be determined by the technical requirements of the bearing housing and the design requirements of the overall system installation.

When the return flow is driven by gravity, oil return lines shall have a slope of at least 5 %. According to ISO 10438-1, oil drains shall be sized to run no more than half full when flowing at normal drain operating temperature at maximum flow conditions and shall be arranged to ensure good drainage (recognizing the possibility of foaming conditions). Junctions and changes in the direction of pipes shall be designed so as not to impair lubricant flow. Sharp bends and down or up loops shall be avoided. Junctions in return pipes shall be located in the direction of flow. In order to prevent foaming, vertical slopes exceeding 1 m in length shall be avoided. No devices significantly impeding the flow in the return line, such as filters, etc. shall be installed.

Where more than one device (bearings, and possibly other consumers) is to be supplied with lubrication oil, the design of the oil supply and circulation system should mitigate against the potential harmful interactions in the return lines and oil reservoir caused by differential air pressure conditions.

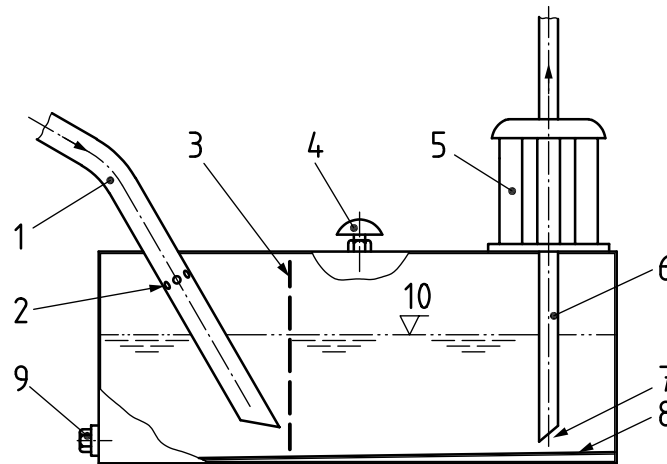
4.2.3 Oil reservoirs

The basic design requirements for oil reservoirs are given by ISO 4413 in conjunction with ISO 10438-1. Based on experience and with respect to air release and oil aging, the capacity of oil reservoirs should be approximately eight times the quantity delivered per minute. The factor eight may be reduced to three depending on the ratio of exposed surface area to volume in the oil reservoir, lubricant properties (air release additives), operating conditions, duty cycle and oil change interval. Small oil reservoirs in particular should have an internal weir or baffle plate between return and suction pipe to settle the returning oil and to permit entrained air in the oil to escape.

Oil reservoirs shall be suitably vented to allow entrained air to escape. In the – recommended – case of return pipes discharging below the reservoir oil level, vent holes shall be provided above the oil level so that the air in the reservoir is able to communicate with the air in the bearing housing via the partly filled return pipe. Oil reservoirs shall be equipped with an oil level indicator.

The suction port of the outlet line shall be chamfered to reduce the inlet flow resistance and shall be situated low relative to the fluid level in order to minimize the foam content of the fluid drawn into the outlet line. In addition, the suction port shall be positioned a sufficient distance away from the bottom of the reservoir to prevent any deposits entering the device.

The bottom of the oil reservoir shall have a slope towards the oil drain. The sloping floor of the reservoir acts to drive liquid contaminant (specifically, water) in the direction of the drain port, where it can be detected by sampling or removed.

**Key**

- 1 return pipe
- 2 vent holes located around the return pipe circumference
- 3 baffle plate
- 4 vent
- 5 pump
- 6 outlet line
- 7 chamfered suction port
- 8 sloping floor
- 9 drain port
- 10 oil level indicator

Figure 1 — Oil reservoir (schematic)**4.3 Hydrostatic lubrication**

In both self-contained and circulating oil (forced lubricated) bearings, hydrostatic shaft lift (“jacking”) using a high-pressure oil supply can be used to reduce friction and excessive bearing wear during machine start up, shutdown and periods of prolonged operation at low shaft speed. In addition, in many cases, hydrostatic jacking is specified to enable shaft rotation for maintenance purposes.

The lubricant flow rate depends on the bearing design and operating conditions. After switching on the high-pressure oil supply, the jacking pressure usually rises and peaks before falling back to a steady-state value once lift has been achieved. The required jacking pressure and flow rate should be defined by the bearing supplier (designer).

A low loss non-return valve should be installed in each high-pressure jacking supply line to prevent back flow from the bearing during normal operation.

5 Lubricants**5.1 Suitable lubricants for plain bearings**

Hydrodynamic plain bearings can be operated with lubricants of different chemical bases. For the provisions given hereafter, lubrication using oils from a petroleum base (mineral oil) is assumed. Synthetic lubricants can also be used. The bearing manufacturer shall be asked for acceptable classes of lubricants (ISO 6743-99).

Many branded lubricants containing additives for defoaming, demulsification of water and antioxidants to extend the service life are suitable for use in hydrodynamic plain bearings. To avoid undesirable chemical interactions, the bearing manufacturer shall be asked for compatibility of the bearing materials with the selected lubricant. Moreover, the chemical compatibility of all components of the whole lubrication system with the lubricant shall be examined.

Lubricant viscosity grade (ISO 3448) is typically between ISO VG 15 and ISO VG 150, at a viscosity index (ISO 2909) of about 100 (common hydraulic oil) or above (multigrade oils).

Special consideration shall be taken for lubricants that are circulated at low temperatures or with viscosities outside this range.

5.2 Oil cleanliness

Due care shall be taken regarding the cleanliness of the lubricant. Depending on the bearing design and application, the requirements for lubricant cleanliness can be different. ISO 4406 should be used to specify the required cleanliness level (in terms of the maximum contamination) of each system element: bearing, pump, etc. A helpful method for determining the required cleanliness level of lubrication systems is given by ISO 12669. As a rule of thumb, for plain bearings, the maximum admissible level of contamination by solid particles is 17/15/12 (ISO 4406). In cases where the oil supply system is serving different machines, the particular demands on cleanliness shall be considered for each machine element with the specifications for the oil supply system (filtration concept).

Contamination of sensitive components with particles shall be minimized by means of oil filtration. The location of the particulate filter in the lubrication system should be chosen with consideration to factors including the sensitivity of the most critical system components (which can include the pump), the location(s) where particles are most likely to enter the system or be generated by a system component, the possible influence of the pressure drop across the filter (in the blocked condition) and the accessibility of the filter for maintenance.

The lubrication system should detect the onset of a progressive or sudden blockage of the filter element. There should be a predetermined system response to such an event, which may comprise (a) a warning signal to operators and/or (b) a shutdown of the machinery.

In the event that operation of the lubrication system cannot be interrupted for filter element replacement, a duplex filter should be selected.

Additional valuable indications concerning selection, installation, operation and maintenance of the filter are given in ISO 10438-3.

In cases of high ambient humidity, moisture can condense on system component surfaces and lead to damage by corrosion. In an attempt to minimize the risk of such corrosion occurring, some lubricant standards limit the moisture content [mg/kg] or the water separation ability [s] of lubricant (see ISO 8068 for example).

Oil circulating pipelines shall be cleaned from debris and particles before they are connected to the bearing.

At the site, prior to placing the machinery in service, the entire lubrication system shall be flushed to ensure the required cleanliness.

6 Lubricant heating

Where plain bearings or the lubrication units are provided with a heater, according to experience, the capacity per 1 cm² heating area should not exceed 1,5 W in order to prevent local overheating (cracking) and deterioration of the lubricating oil. In cases where heating equipment is integrated into the bearing housing, the bearing manufacturer is responsible for the design of the components needed (if applicable, including thermostatic control and safety shutdown, see ISO 10438-3). Otherwise, the supplier of the oil feed system shall be asked for appropriate selection of the heating equipment.

7 Monitoring

7.1 Requirements for design or selection of the lubrication monitoring system

For self-contained bearings, a means of monitoring the oil level on a regular basis shall be provided. This is particularly beneficial for bearings with integrated water coolers, where early indication of an internal water leakage problem can be provided. In addition, self-contained bearings should be provided with a sight glass for monitoring the proper function of the integrated lubrication system as necessary.

For forced lubricated bearings, the oil inlet temperature together with the flow rate are the most relevant parameters for the adjustment (commissioning) and control of forced lubrication systems. These values shall be monitored and connected to the plant's control and alarm system. However, measuring the oil supply temperature does not substitute monitoring of the individual bearing temperature, which is always indispensable.

Sometimes, for commercial reasons, the control of lubricant flow rate is replaced by a more simple oil pressure measurement. In these cases, the adjustment of individual flow rates shall be verified for the lubrication oil at nominal service temperature. Again, the oil supply pressure shall be connected to the plant's control board and alarm system.

Where bearings include hydrostatic jacking, a means of monitoring the specified high-pressure flow rate delivered to the bearing shall be provided. In addition, at least for functional testing of the hydrostatic jacking at commissioning, a supply pressure measuring device should be installed at the bearing inlet.

7.2 Requirements for through-life operation of the overall bearing and lubrication system

During operation, aging of the lubricant occurs for many reasons such as oxidation, local overheating (cracking), contamination (chemical substances, particles), additive depletion, non-reversible shear thinning (destruction of long-chain molecules leading to viscosity reduction) and biological attack.

Depending on the relevant service conditions, the lubricant in self-contained bearing systems should be changed every 4 000 to 8 000 service hours or once a year where machinery is not subject to continuous operation (e.g. emergency power supplies).

For forced lubrication systems, the normal service life for lubricants is in the range of 20 000 service hours, depending on the specific service conditions.

Starting from a baseline measurement at initial fill of the lube system, regular periodic analysis of the lubricant quality is important to enable changes over time to be identified. This method provides reliable information upon which to base suitable lubricant replacement intervals and can help in saving valuable resources and money. Therefore, it shall be preferred.