

# Selection of lubricant class (liquids, solids, semi-solids and gases)

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## **SELECTION OF LUBRICANT CLASS (LIQUIDS, SOLIDS, SEMI-SOLIDS AND GASES)**

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## **SELECTION OF LUBRICANT CLASS (LIQUIDS, SOLIDS, SEMI-SOLIDS AND GASES)**

### **1. INTRODUCTION**

The majority of tribological contacts are designed to be used with the addition of a lubricant. However, in many cases the use of a separate lubricant can be avoided, for example by the use of appropriate contact materials or by using a process fluid as a lubricant. Avoiding the use of a separate lubricant can often provide a simple and effective solution and should always be considered as a first option. This Data Item provides guidance on identifying the applications in which this option is practical.

The Data Item then gives guidance on the selection of the appropriate lubricant class for those applications in which the use of an added lubricant is still required. A lubricant is defined as a substance introduced into a loaded moving contact in order to control, and usually to reduce, friction, and will normally also reduce wear. For this purpose lubricants are divided into four broad classes, namely oils (liquids), greases (semi-solids), solids and gases.

There are several possible strategies for selecting a lubricant class and the correct one to apply depends on the particular circumstances. If the mechanical aspects of the tribological system are already defined, a relatively straightforward process, albeit one requiring considerable knowledge, can be applied to select a lubricant for that system. Such an approach involves identifying the type of motion, the speed, the temperature, the load, and the environment as a necessary preliminary to selecting the lubricant. Various types of analysis, such as elastohydrodynamic lubrication analysis, can then be applied to guide the selection. A knowledge of normal lubrication practice in similar devices can also be beneficially applied.

There is, however, an earlier stage in the design process, during which decisions are made on the types of tribological device used in the machine or mechanism, and the choices made often imply that a certain class of lubricant be used. A traditional hinge, for example, typically consists of two separate metallic plates with their edges wrapped around a common pivot pin. The choice of such a device, however, virtually presupposes that oil or grease lubrication will be required or, at least, be beneficial. Alternative devices for providing a hinge motion do exist, such as non-metallic hinges and elastomeric bushes, that do not require any additional lubrication and can often provide a better solution than the conventional choice.

Accordingly, the first part of this Data Item provides a strategy for the preliminary selection of tribological devices, such as bearings and drives. The strategy is aimed at avoiding or, at least, minimising the need for additional lubrication and associated support equipment and maintenance. The second part of the Item presents further strategies applicable when additional lubrication cannot be avoided. These strategies allow the lubricant class to be chosen based on analysis of the tribological system and on knowledge of normal practice in similar or related devices.

Possible adverse environmental effects, particularly with oils, and especially those containing additives, should be borne in mind. Lubricants and lubricant additives are increasingly controlled by legislation.

## 2. PRELIMINARY SELECTION OF TRIBOLOGICAL DEVICE

This section presents a strategy for selecting tribological devices so as to minimise, if not eliminate, the need for additional lubrication and associated support equipment and maintenance. The procedure is applicable to the selection of devices such as bearings and drives that might require, or have traditionally required, a lubricating substance to be introduced. Potential lubricating substances include oils (liquids), greases (semi-solids), solids, and gases. The strategy should be applied at an early stage in the design process.

Reasons for avoiding the addition of a lubricating substance include the following.

- Reducing complexity of system
- Simplifying sealing
- Avoiding contamination of product by lubricant
- Avoiding contamination of environment by lubricant
- Eliminating fire risk associated with lubricant
- Avoiding hazardous chemical reaction with handled fluids
- Reducing maintenance and extending service intervals
- Avoiding agglomeration of abrasives

A staged consideration of various device types with increasingly demanding lubrication requirements is advocated as summarised here and in the flowchart of Figure 2.1.

Stage 1: Consider device types requiring neither additional lubricating substances nor lubrication related maintenance.

Stage 2: Consider device types that utilise, as a lubricant, some substance (usually a fluid) that is already present.

Stage 3: Consider device types requiring an additional lubricant or lubrication system, or requiring lubrication-related maintenance.

The lubrication requirements of various bearing types are given in Section 2.4\*. At each stage in the selection process, the performance of the device types with respect to load, speed, temperature and other factors, must also be considered. Approximate load, speed and temperature limits of various bearing types are given in Section 2.4. Information from other sources (see the list of References and Derivations in Section 5) and manufacturer's information should be considered where appropriate.

Each of the three stages of the selection procedure is discussed in more detail in Sections 2.1, 2.2 and 2.3 with particular reference to rotary bearing systems. The supporting data for these systems are given in Table 2.1.

\* Similar considerations apply to other tribological devices, such as drives and dynamic seals.

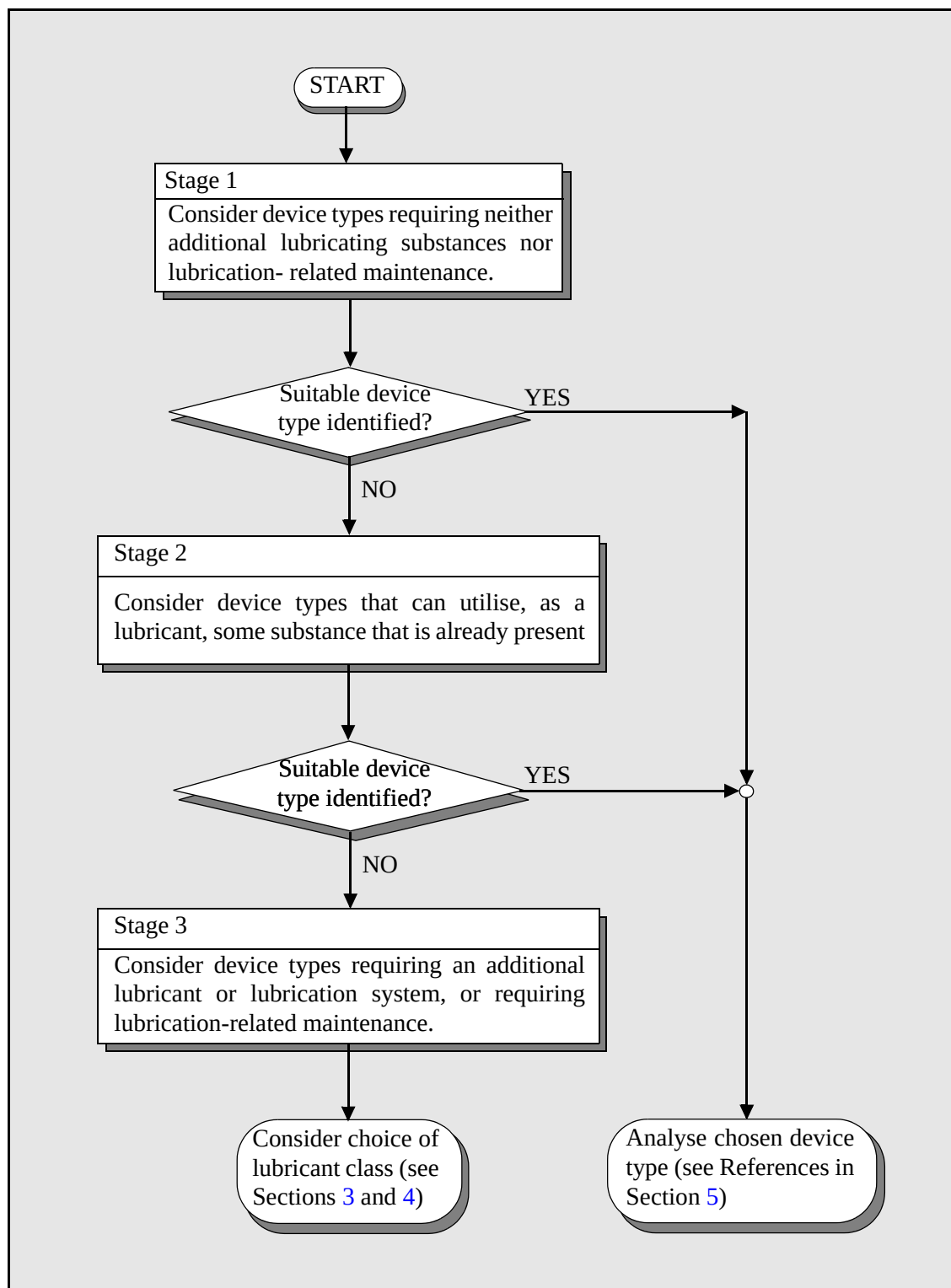


**FIGURE 2.1 Flowchart for Preliminary Selection of Tribological Device**

## 2.1 Stage 1: Avoiding Addition of Lubricant Altogether

The first stage of the procedure consists of selecting or designing the bearing, or other tribological devices, so that it does not require the application of an additional lubricating substance, or require any lubrication-related maintenance.

For a rotary bearing, the options are (in no particular order) as follows.

- Dry rubbing bearing
- Oil impregnated porous metal bearing
- “Plastics” rolling bearing
- “Sealed-for-life” rolling bearing
- Magnetic bearing<sup>\*</sup>

The compatibility of the device with its local environment should be considered. In particular, the effectiveness of the seals in “sealed-for-life” rolling bearings to prevent both the escape of fluid from the device and the ingress of fluids and solids from the local environment should be checked.

An example of a machine where bearings run with no added lubricant is a centrifugal compressor handling hydrocarbon gases. Magnetic bearings, for example, can be a viable option for such machines if incorporated at the design stage, particularly in those machines using dry gas seals. Such a solution can also be profitable in the handling of flammable or hazardous fluids, such as oxidising materials.

## 2.2 Stage 2: Making use of Existing Substance

Unless the local environment is a vacuum, there will always be some fluid present, be it a process fluid, a lubricant intended for some other components, or simply air. If the fluid present is a liquid that can act as a lubricant, further rotary bearing system options become available as follows.

- Rubbing bearing (liquid lubricated)
- Rolling bearing (liquid lubricated)
- Hydrodynamic bearing

If the fluid present is a gas or air, the following rotary bearing option can be considered.

- Aerodynamic bearing

Examples of situations where a fluid that is present might be used as the lubricant include the following.

- Handling of heat transfer, refrigerant and toxic fluids: magnetically-driven pumps can be used in which the impeller and impeller bearings run in the process fluid thus avoiding the need for seals around the impeller shaft.

<sup>\*</sup> Although magnetic bearings do not require any lubrication-related maintenance, the cost of maintaining the power supply and control system should be considered.

- Water and seawater pumps: boiler feed pumps can use water-lubricated silicon carbide bearings while water slurry pumps can use rubber bearings.
- Handling of volatile solvents: volatile solvents are difficult to seal.

### 2.3 Stage 3: Introducing Lubricating Substance

If none of the options considered so far is satisfactory, consideration should be given to introducing an oil (liquid), a grease (semi-solid), a solid, or a high-pressure gas as a lubricant. Ideally, the lubricant should be introduced in such a way that no external devices are required. The options include the following.

- A drop of oil
- A smear of grease
- A coating of solid lubricant
- Self-contained lubrication system (*e.g.* ring oiler or splash)

All of these potential lubrication options may not be satisfactory if one, or a combination, of the following conditions apply.

- Speed or load is too high
- Ambient temperature is too high
- Wear debris accumulates
- The environment will be contaminated
- The life is too short

With oil or grease lubrication, more involved lubrication systems can be considered as follows (listed in order of increasing complexity).

- Total loss wick or drip system
- Replenishable oil- or grease-filled system
- Recirculating, passive (*e.g.* splash or dip) systems
- Total loss, centralised system\*
- Recirculating, active (pumped) systems

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\* Not all oil mist systems are total loss.

If there is a requirement for low friction support of a load from zero speed or accurate and controllable location, the following bearing options should be considered.

- Hydrostatic bearing
- Aerostatic bearing

These bearing system options require the adoption or availability of a high pressure oil or gas supply.

Very approximate load/speed limits for various rotary bearings are shown in Figure 2.2. The figure is not intended for design purposes but merely shows the interaction between load and speed for guidance only. In practice, bearings should only ever be required to operate near the limits shown in exceptional circumstances (*e.g.* overloads) and with very careful design and installation.

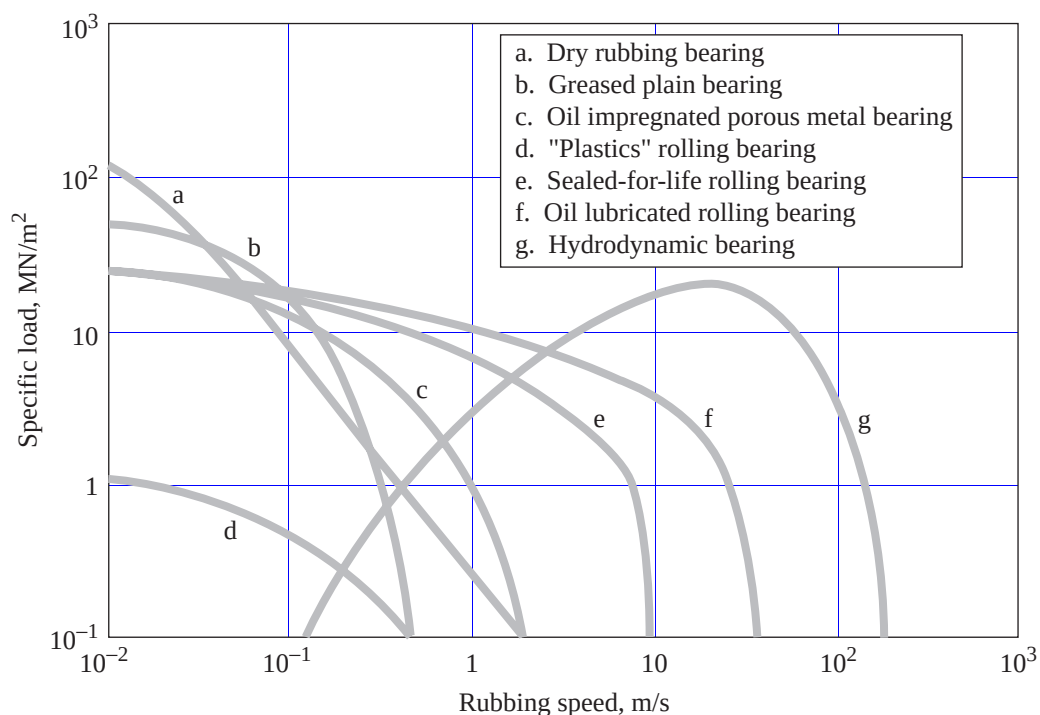


**FIGURE 2.2 Approximate Load/speed Limits for Various Rotary Bearings**

Note that hydrostatic bearings (see References 7 and 8) and aerostatic bearings (see Reference 29) are often considered to be applicable over the whole range of load and speed and have not been included on Figure 2.2.

## 2.4 Lubrication Requirements and Operating Limits

This section presents tables summarising the lubrication requirements and extreme operating limits of various bearing system types. Data are provided for rotary bearings, oscillatory bearings and linear bearings. The tables are intended to provide supporting data for the preliminary selection of a tribological device.