LUBRICANTS

Lubricant applications at Deutsche Bahn AG

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Lubricants are used in the entire railway area and the significance of lubricants for railway operations is similar to that of the rails. Or, in other words, there can be nearly no operation without lubricants.

When lubricants are used according to special requirements, it is possible to achieve considerable cost savings.

Professor Just (Chairman of the International Tribological Council), for example, demonstrated in the 'Just Report' of 1966 that tribological measures – including enhanced lubrication technology – could lead to savings of more than £900 million a year for the British economy. This order of magnitude is most likely still valid today.

Using the wrong or non-compliant lubricants can cause great damage to the railway enterprise.

A few examples of this damage are: high wheel flange wear from using the wrong wheel flange greases; overheated axle boxes from unsuitable greases for axle roller bearings; extreme buffer disc wear from poor lubrication; malfunctions of

Bahn AG (DB AG) to operate a lubricant management system.

It is for this reason that DB AG has a Technical Division for Tribology. This Division's main tasks include not only the testing and railway acceptance of lubricants but also type management and setting up the technical conditions for the most cost effective and reliable supply of lubricants to DB AG. Close collaboration with the Technical Purchasing Division for Lubricants is essential in achieving this.

Procurement

Figure 1 provides an overview of the lubricants purchased by DB AG. The annual purchasing volume of lubricants at DB AG is currently approximately €7 million. Wherever possible, DB AG uses general standards for procurement – e.g. DIN EN 590 for fuels and DIN 51524 T 2 and T 3 for hydraulic oils.

In railway operations, however, which are characterised by very long application periods under varying operating conditions, it is often found that the procurement of lubricants in accordance with an ISO, EN or DIN standard is generally only a compromise with regard to actual requirements – or is not even possible at all. Procurement pursuant to our own technical specifications on the other hand is more likely to take account of the real conditions – as is the case for switch and wheel flange greases, for example. It is for this reason that railway standards have been prepared particularly for lubricants for railway applications by the

Technical Division for Tribology together with the departments using them in practice. These railway standards serve as the basis for procurement.

For various reasons – in particular because of the procurement of new vehicles – there are

![Figure 1: Purchase of lubricants in tons for 2003](image-url)
currently too many different lubricants (more than 250 types) in use at DB AG. This makes maintenance work distinctly more difficult and can lead to mistakes and thus considerable damage.

One of the objectives of the joint work performed by the Lubricants Purchasing Division and the Technical Division for Tribology is to reduce the number of types and application of special lubricants wherever this is technically possible, in order to simplify the upkeep and maintenance process for the vehicles.

A further focal point of their joint work is to ensure that DB AG is supplied with lubricants by the most favourably priced product will receive the major order volume.

As it is practically not possible to promote competition when purchasing is decentral (because consumers generally always order the least expensive product), a central call-off office has been set up in the Lubricants Purchasing Division. This office makes sure that competition is promoted by optimum distribution of the purchase amounts among the suppliers.

**Quality control**

In order to be able to carry out low-fault railway operations, a high degree of functional reliability of the individual components is required. Consideration must also be given here to the fact that train running has special features – particularly because it is track-bound - compared with road traffic and so does not leave many alternatives in the event of damage.

The functional reliability of the vehicles is affected by the functional reliability of the lubricants. Since operational safety and reliability are a top priority at DB AG, the Technical Division for Tribology carries out a batch-by-batch inspection of those lubricants used for lubricating safety-critical components and of those of decisive significance for functional reliability. In other words, the lubricants may only be supplied to the
DB AG consumers when the agreed quality criteria have been complied with.

Laboratories accredited for lubricant investigations, physical-chemical, tribological laboratories and laboratories for testing with original components are assigned to the above-mentioned Technical Division.

In comparison to testing in advance and quite apart from the financial losses caused by damage or malfunctions, the removal of non-compliant lubricants - e.g. from axle roller bearings or wheel flange lubricating devices would be much more time and cost intensive. Figure 2 illustrates to what degree this procedure is justified.

Although the firms are aware that certain parameters of the lubricants are tested (stipulation in the framework agreements), cases of non-compliance occur again and again and can occasionally even lead to bottlenecks in supply - especially for products for railway applications. The situation is particularly critical when there is only one supplier for a certain type of lubricant.

The supplier assessments carried out regularly by the Technical Purchasing Division for Lubricants, the Quality Inspection Service and the Technical Division for Tribology are a further measure towards quality control.

**Lubricant clearance for DB AG**

Owing to the high demands placed on reliability, clearance is required for many lubricants. In the same way as new vehicles or their components have to be tested thoroughly as prototypes in everyday operations before they are procured for DB AG, the lubricants have to be tested thoroughly for their 'railway suitability' before their general application. Whenever lubricants have been employed without adequate testing, there have generally been problems.

DB clearance is required for the following products:

- Lubricants for safety-critical components (e.g. greases for axle roller bearings)
- Lubricants according to DIN or international standards with additional DB AG requirements (e.g. oils for hydrodynamic transmissions)
- Rapidly biodegradable lubricants

All other lubricants procured pursuant to DIN or international standards are employed without railway acceptance.

Laboratory and field tests are required for DB clearance and the two examples below deal with some of the aspects involved.

**Figure 4:** Typical pattern of the actuating force during testing with the WESP

Switch greases demonstrate very well what can happen when lubricants are employed without suitability testing.

**Example 1:** In the initial euphoria surrounding the application of rapidly biodegradable switch greases, a station used grease with rape oil or with unsaturated ester as the base oil. During intense exposure to the sun, the base fluid polymerised owing to the double bonds contained from the influence of the UV rays. This led to extremely stiff working of the switches.

In order to avoid switch malfunctions like this in the future, a test to determine the UV stability was included in the inspection of switch greases. In this test, the switch greases must withstand 100 hours of exposure to UV light without formation of skin or any other changes such as conglutination. Following this, the greases
are tested on the WESP switch grease test rig (see Figure 3).

Figure 4 shows a typical pattern of the actuating force during measurement with the WESP. The performed predominantly in the laboratory. Field testing on the entire DB AG rail network does not often provide much meaningful information, here owing to the disturbing influence of other railway

![Graph showing influence of exposure to UV-light](image)

**Figure 6: Influence of exposure to UV-light**
(Measurements of actuating force with the WESP at -5°C)

- Before exposure to UV
- After 100 h of UV exposure

![Test rig to determine the adhesive strength](image)

**Figure 7: Test rig to determine the adhesive strength**

**Evaluation:**

- a) good adhesion
- b) poor adhesion

![Axial forces](image)

A large increase in the actuating force at low temperatures is evident and this corresponds well with the results from field testing (see Figure 5).

Figure 5 shows how great the change in these actuating forces can be when UV stability is inadequate. The effect is particularly noticeable at high and low temperatures. During testing on the WESP, this can even cause the drive rod (12 mm diameter) to bend.

**Example 2:** Wheel flange greases represent one of the very few examples for which testing can be vehicles or while testing can only be carried out in restricted areas.

One of the properties to be tested first in the laboratory is the adhesive strength of the grease. This test is performed by means of a mass-reduced original ICE wheel (see Figure 7).

If the adhesive strength is adequate, the wear is determined by means of a two-disc test rig (see Figure 8).

Corresponding field test results with regard to the wear protection of the grease with solid
lubricants and of the grease without solid lubricants that were obtained in a selected area can be seen in Figure 9.

As in most cases it is not possible to simulate the great diversity of real life influences to the full extent with laboratory tests, field testing is essential for many lubricant applications. The necessary reevaluation intervals, for example, can generally only be determined with certainty under real life conditions.

However, laboratory tests are necessary in advance in order to prevent damage during field testing. In some cases, it is possible to dispense with laboratory tests by using the experience made by other railway companies.

Lubricants used
Owing to the great variety of types within the general range of lubricants employed at DB AG, only the most important lubricants used for major components will be discussed.

As can be seen from Table 1, ‘engine oils’ make up the biggest amount by far and 95% are SAE 15W-40 multigrade engine oils. At present, an oil of the API Specification CF-4 is used for the majority of engines. In addition, three engine oils of the API Specification CH-4 are currently being tested with regard to their suitability for application in railway engines and to determine the necessary intervals for oil changes. This means that predominantly the API Specification CH-4 will be employed at DB AG as from 2005. The remaining 5% of the engine oils are mainly SAE 30 monograde engine oils, which are used in piston compressors and some older engines.

‘Transmission oils’ are in second place and, of these, more than 60% are oils for hydrodynamic transmissions (ISO VG 32). The other transmission oils, which are mainly used for lubricating axle transmissions, comprise monograde oils from ISO VG 100 (CLP 100) to ISO VG 680 and multigrade oils. The latter are mainly in the SAE viscosity class 80W-90 or 85W-90 and the API Specification GL-5. However, SAE 80W-140, API GL-5, SAE 85W-90, API GL-4 as well as SAE 80W and API GL-4 oils are used for axle transmissions.

The third group comprises ‘hydraulic oils’, covering the range from ISO VG 5 to ISO VG 68. Mainly ISO VG 32 and 46 hydraulic oils (HLP or HVLP) are used. These are generally mineral oils but a small number are also synthetic esters.

The ‘other oils’ column covers almost the entire range of lubricants offered by the mineral oil industry from non-additive axle oils (e.g. L-AN 350) to cooling lubricants.
LUBRICANTS

In the case of the 'greases', the antifriction bearing greases deserve special mention and of those, the axle roller bearing greases.

DB AG currently still uses different greases for lubricating the axle roller bearings on the ICE family, locomotives, passenger coaches and freight wagons. These are mineral-oil-based Li-12 hydroxy stearate soap greases – of consistency class 2.5 for the ICE, of consistency class 3 for locomotives, and of consistency class 2 for passenger and freight stock. These are, however, not of the same type of grease only in different consistency classes – they are different greases from different manufacturers. Although DB AG has been making attempts for a long time, together with the antifriction bearing industry, to obtain a standard, state-of-the-art grease for the lubrication of all railway vehicle axle bearings, the mineral oil industry has still not been able to offer DB AG an antifriction bearing grease that will fulfil the high demands of UIC Leaflet 814 and EN 12081 at a reasonable price.

The 'other greases' column contains not only the switch and wheel flange greases (major part of the volume), the lubricants for buffing and draw gear and the greases for brake components, but also a large number of special-purpose lubricants which cannot be dealt with in further detail here.

As for switch greases, since 1995, it has been the general policy of DB AG to use rapidly biodegradable greases – softer than consistency class 000. With regard to the wheel flange greases (consistency class 00 to 000), a mineral-oil-based grease (partly because of older installations) is used in addition to rapidly biodegradable greases.

The cushioning devices of the side buffers are lubricated with a mineral-oil-based calcium soap grease and the brake cylinders with a mineral-oil-based Li soap grease.

In general, DB AG attempts to use rapidly biodegradable lubricants – e.g. for screw couplings and buffer discs – wherever the lubricants come into
contact with the environment and wherever it is technically possible.

**Potentials of savings**

As already mentioned in the introduction, considerable costs can be saved by tribological measures.

Merely by extending the intervals for engine oil changes by using high-grade engine oils, it is possible to reduce the engine oil consumption by approximately 1/3 and thus to lower costs. This, of course, presupposes that the engine oils are of a better quality in order to ensure wear prevention over a longer period of time. According to calculations, some €500,000 in lubricant costs per year can be saved by extending the intervals for engine oil changes.

In consultation with the engine manufacturer, it has already been possible to extend the interval for oil changes from 1,000 to 2,000 engine hours for two types of engine on the Class 218 locomotives. The expected savings here alone are €115,000 a year.

Further extensions of the intervals for engine oil changes are currently being examined in an operational test together with the type-support department and the vehicle keepers. Savings of approximately €280,000 a year are expected here as well.

Another example is the standardisation of the lubricants for axle bearings and extension of the changing intervals at the same time. The anticipated savings here are approximately €50,000 a year.

Further savings possibilities are the improvement of the competitive situation, the extension of the application of lubricants already available, the employment of higher-grade lubricants with longer periods of use, and the technically justified reduction of the employment of special-purpose lubricants.

In addition, the ordering activities are concentrated in the central call-off office, which also produces a rationalisation effect (up to approximately €300,000 a year).

The figures given above – except for the last-mentioned €300,000 a year – are purely the costs for lubricants. The actual savings – from removing certain intervals for lubricant changes, from improving the cleanliness of the engines, from increasing the functional reliability of the vehicles by demand-responsive lubrication, from extending the period of use of the components and thus lowering the LCC – are a great deal higher by far.

**Outlook**

Since reorganisation in mid-2000, there has been intense collaboration between the Technical Division for Tribology and the Technical Purchasing Division for Lubricants in order to provide a reliable and cost-effective supply of lubricants for DB AG.

Although a great deal has already been achieved, there are still many tasks to be dealt with for the future. It is, for example, planned to gain at least three suppliers for each type of lubricant and to cut the present number of types of lubricant by 30%, while employing higher-grade multigrade lubricants and reducing the employment of special-purpose lubricants.

Apart from the effects already detailed, this will lead to a concentration of the quantities and simplification of stock-keeping.

These measures are intended to bring about an improvement in the reliability of supplies and to lead to a distinct reduction in costs for the maintenance of railway vehicles and technical installations. This can however only be achieved in joint action with the involvement of the working group Lubricant Applications DB AG. This working group, in which representatives from the technology and corporate divisions (users) of DB AG work together, was set up by the Technical Division for Tribology and the Technical Purchasing Division for Lubricants.

**Literature**


Wolfgang Wohlgemuth's professional career includes: Scientific Assistant for lubricants in the Central Testing and Development Facility of the Ministry of Transport in Brandenburg-Kleinschütz (1987-1982) and between 1983 and 1994 he was Scientific Head of the Working Group Service Fluids, specialist area Lubricants/Lubrication Technology and Chemical Water Service in the same facility (1988 renamed Scientific-Technical Centre of the Deutsche Reichsbahn, as from 1991 Central Office for Environmental Protection and Material Testing) (since 1991 he has been Head of the Specialist Group 'Tribology Tribotechnology' in the Research and Testing Central Division of Deutsche Bahn, München-Fünfhaus, 1997 renamed Research and Technology Centre, at from 2002 DB Systemtechnik München-Fünfhaus from 1994 to date.