Lubricant testing.
Focussing on mechanico-dynamical tests
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Introduction</td>
<td>3</td>
</tr>
<tr>
<td>2.0</td>
<td>Purpose of mechanico-dynamical tests</td>
<td>3</td>
</tr>
<tr>
<td>3.0</td>
<td>Test methods</td>
<td>6</td>
</tr>
<tr>
<td>4.0</td>
<td>Benefits and costs of tribological tests</td>
<td>8</td>
</tr>
<tr>
<td>5.0</td>
<td>Standard Klüber tests</td>
<td>10</td>
</tr>
<tr>
<td>6.0</td>
<td>Description of selected mechanico-dynamical tests and their significance</td>
<td>16</td>
</tr>
<tr>
<td>6.1</td>
<td>Roll stability tester</td>
<td>17</td>
</tr>
<tr>
<td>6.2</td>
<td>Shell four-ball wear tester</td>
<td>18</td>
</tr>
<tr>
<td>6.3</td>
<td>CV-joint test rig</td>
<td>19</td>
</tr>
<tr>
<td>6.4</td>
<td>FZG four square gear oil tester Micropitting test acc. to Flender</td>
<td>20</td>
</tr>
<tr>
<td>6.5</td>
<td>FZG four square gear oil tester</td>
<td>21</td>
</tr>
<tr>
<td>6.6</td>
<td>Oscillation friction wear tester</td>
<td>22</td>
</tr>
<tr>
<td>6.7</td>
<td>EMCOR-machine</td>
<td>23</td>
</tr>
<tr>
<td>6.8</td>
<td>Tannert sliding indicator</td>
<td>24</td>
</tr>
<tr>
<td>6.9</td>
<td>Reichert fretting wear tester</td>
<td>25</td>
</tr>
<tr>
<td>6.10</td>
<td>Sliding friction test rig</td>
<td>26</td>
</tr>
<tr>
<td>6.11</td>
<td>Water wash-out test</td>
<td>27</td>
</tr>
<tr>
<td>6.12</td>
<td>FE 9 Rolling bearing grease tester</td>
<td>28</td>
</tr>
<tr>
<td>6.13</td>
<td>ROF rolling bearing grease tester</td>
<td>30</td>
</tr>
<tr>
<td>6.14</td>
<td>FE-8 rolling bearing lubricant tester</td>
<td>32</td>
</tr>
<tr>
<td>6.15</td>
<td>SNR – FEB 2 rolling bearing grease tester</td>
<td>33</td>
</tr>
<tr>
<td>6.16</td>
<td>Low-temperature torque tester – IP 186</td>
<td>34</td>
</tr>
<tr>
<td>6.17</td>
<td>Low-temperature torque test rig – ASTM D 1478</td>
<td>36</td>
</tr>
<tr>
<td>6.18</td>
<td>Rolling bearing torque tester</td>
<td>37</td>
</tr>
<tr>
<td>6.19</td>
<td>Brugger lubricant tester</td>
<td>38</td>
</tr>
<tr>
<td>6.20</td>
<td>Grease tester FTG 2</td>
<td>39</td>
</tr>
<tr>
<td>6.21</td>
<td>GRW noise tester</td>
<td>40</td>
</tr>
<tr>
<td>6.22</td>
<td>Almen-Wieland lubricant tester</td>
<td>41</td>
</tr>
<tr>
<td>6.23</td>
<td>HTN Spengler test rig for rolling bearing greases</td>
<td>42</td>
</tr>
<tr>
<td>6.24</td>
<td>FAG vibrational quality test rig MGG 11</td>
<td>43</td>
</tr>
<tr>
<td>6.25</td>
<td>Zwick elastomer friction tester</td>
<td>44</td>
</tr>
<tr>
<td>6.26</td>
<td>Press-Fit test</td>
<td>45</td>
</tr>
<tr>
<td>6.27</td>
<td>SKF BeQuiet grease noise test rig</td>
<td>46</td>
</tr>
<tr>
<td>6.28</td>
<td>Timken machine</td>
<td>47</td>
</tr>
<tr>
<td>7.0</td>
<td>Special component tests developed by Klüber</td>
<td>48</td>
</tr>
<tr>
<td>7.1</td>
<td>Klüber worm gear oil tester</td>
<td>49</td>
</tr>
<tr>
<td>7.2</td>
<td>Klüber high-temperature chain tester</td>
<td>50</td>
</tr>
<tr>
<td>7.3</td>
<td>Klüber drive chain tester</td>
<td>51</td>
</tr>
<tr>
<td>7.4</td>
<td>Brückner test</td>
<td>52</td>
</tr>
<tr>
<td>7.5</td>
<td>Klüber bicycle chain test rig</td>
<td>53</td>
</tr>
<tr>
<td>7.6</td>
<td>Klüber water valve tester (stick-slip)</td>
<td>54</td>
</tr>
<tr>
<td>7.7</td>
<td>Klüber water valve tester (life test)</td>
<td>55</td>
</tr>
<tr>
<td>7.8</td>
<td>Oscillating slide plate test rig</td>
<td>56</td>
</tr>
<tr>
<td>7.9</td>
<td>Railway point test rig</td>
<td>57</td>
</tr>
<tr>
<td>7.10</td>
<td>Oscillation friction wear tester</td>
<td>58</td>
</tr>
<tr>
<td>7.11</td>
<td>Test rig for electrical contacts</td>
<td>59</td>
</tr>
<tr>
<td>7.12</td>
<td>Trolley bearing test rig</td>
<td>60</td>
</tr>
<tr>
<td>7.13</td>
<td>Wire rope test rig</td>
<td>61</td>
</tr>
<tr>
<td>7.14</td>
<td>Klüber pulley test rig</td>
<td>62</td>
</tr>
<tr>
<td>7.15</td>
<td>Klüber spindle bearing test rig</td>
<td>63</td>
</tr>
<tr>
<td>7.16</td>
<td>Ball joint test rig</td>
<td>64</td>
</tr>
<tr>
<td>7.17</td>
<td>Grease depressurisation test rig</td>
<td>65</td>
</tr>
</tbody>
</table>
1.0 Introduction

The performance of lubricants is not exhaustively described by the parameters determined in tests. It takes a lubrication specialist to interpret these data and draw correct conclusions which enable him to select the most suitable lubricant. This brochure explains the role of performance parameters in the decision-making when selecting a lubricant.

Basically, there are two different types of lubricant parameters: chemico-physical and mechanico-dynamical.

Chemico-physical tests only concentrate on certain lubricant properties, whereas mechanico-dynamical tests try to simulate the effects of load, speed, media and temperature on the friction and wear behaviour of a tribo-system.

There is no such thing as a universal test rig. Especially in case of new machine designs only drawings are available and not a prototype of the original machine. When developing a lubricant the engineer often has to rely on model test rigs reflecting the original system only to a limited extent. Numerous model tests under different testing conditions are necessary to interpret the results correctly and relate them to the original system.

Chemico-physical tests generally precede mechanico-dynamical tests. Depending on the lubricant type and the requirements there are many different test procedures. Some of them are listed in table 1.0 a and 1.0 b.

2.0 Purpose of mechanico-dynamical tests

Lubricants developed by Klüber Lubrication and tested by the user have to be evaluated in terms of technical suitability and performance limits. Mechanico-dynamical lubricant tests which subject the lubricant and the pertinent material to temperature, load, relative movement and media are an important link between Klüber Lubrication and the user and help to develop optimum lubricant formulations and solutions to lubrication problems (see Fig. 1).

Mechanico-dynamical tests offer the following advantages:

- Simplified representation of the lubrication problem by suitable test methods and conditions.
- Verification of the product idea, concept and principles.
- Optimization of the lubricant formulation and manufacturing process; impact of operating and testing parameters on friction and wear behaviour.
- Technical documentation and confirmation of the lubricant recommendation.
- Limitation of time-consuming and cost-intensive practical tests to a few, promising lubricant types.
- Shortening of the development time and financial savings.

The results of mechanico-dynamical test prove the technological advantages offered by special lubricants. The interpretation of test results serves different purposes:

- They help the chemical engineer to determine whether the lubricant meets the requirements.
- They allow the test engineer and designer to draw conclusions as to the lubricants’ application and performance limits.
- They permit the production department to verify the quality standards and prove quality assurance.
- They make it possible for consulting and sales engineers to provide competent and well-founded recommendations.
- For the user it is possible to directly compare standard test results or relate results obtained on non-standard equipment and assess their applicability in practice.
### Table 1.0 a: Chemico-physical characteristics of lubricating oils

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Test</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour/colour code</td>
<td>DIN 51 411</td>
<td>Determination of colour with colorimeter or the so-called Saybolt colour code</td>
</tr>
<tr>
<td></td>
<td>ISO 2049</td>
<td></td>
</tr>
<tr>
<td>Density</td>
<td>DIN 51 757</td>
<td>Quotient of the mass of a substance and its volume</td>
</tr>
<tr>
<td>Flash point</td>
<td>DIN ISO 2592</td>
<td>Lowest temperature at which an oil gives off vapours that will ignite when a small flame is passed over the surface of the oil</td>
</tr>
<tr>
<td>Ash content</td>
<td>DIN 51 575</td>
<td>Residue (oxide or sulphate ash) remaining after the combustion of an organic compound; the sulphate ash content is determined only for metallic-organic additives or for used oils</td>
</tr>
<tr>
<td></td>
<td>DIN EN 7</td>
<td></td>
</tr>
<tr>
<td>Viscosity</td>
<td>DIN 51 561</td>
<td>Measure of the inherent resistance of a fluid against flow</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Dynamic viscosity:</strong> viscosity with respect to density</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit: Pa s or N s/m²</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Kinematic viscosity:</strong> viscosity-density ratio</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit: mm²/s</td>
</tr>
<tr>
<td>Demulsibility</td>
<td>DIN 51 589</td>
<td>Ability of oil to separate from water</td>
</tr>
<tr>
<td>Saponification number</td>
<td>DIN 51 559</td>
<td>Expressed in milligrams of potassium hydroxide needed to neutralize the free acids in one gram of oil and to saponify the esters contained therein</td>
</tr>
<tr>
<td>Pour point</td>
<td>DIN ISO 3016</td>
<td>The lowest temperature at which the oil sample will pour or flow under prescribed conditions</td>
</tr>
<tr>
<td>Viscosity-temperature</td>
<td>DIN 51 563</td>
<td>Flow properties of a lubricating oil in relation to temperature</td>
</tr>
<tr>
<td>relationship (VT)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Viscosity Index (VI)</td>
<td>DIN ISO 2909</td>
<td>Rate of change in viscosity of an oil within a given temperature range</td>
</tr>
<tr>
<td>Evaporation loss</td>
<td>DIN 51 581</td>
<td>Determination of the oil evaporation loss at elevated temperatures</td>
</tr>
<tr>
<td>Viscosity-pressure relationship (VP)</td>
<td>–</td>
<td>Viscosity of a lubricating oil in relation to pressure</td>
</tr>
<tr>
<td>Water content</td>
<td></td>
<td><strong>Quality test:</strong> When heating oil in a test tube to &gt; 100 °C a smacking sound can be heard when the water evaporates</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Quantity test:</strong> Sample oil and xylol or hydrocarbon, e.g. SBP naphta, is heated to &gt; 100 °C in a distillation trap; the distilled water is caught in a measuring device</td>
</tr>
<tr>
<td>Air separation ability</td>
<td>DIN 51 381</td>
<td>Determination of dispersed air in a lubricating oil</td>
</tr>
</tbody>
</table>
### Table 1.0 b: Chemico-physical characteristics of lubricating greases

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Test</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texture</td>
<td>–</td>
<td>Cohesion properties</td>
</tr>
<tr>
<td>Density</td>
<td>DIN 51 757</td>
<td>Quotient of a mass of a substance and its volume; facilitates identification</td>
</tr>
<tr>
<td>Base oil viscosity</td>
<td>DIN 51 561</td>
<td>Indicates the load-carrying capacity and the friction and physical wear behaviour as well as the flow characteristics</td>
</tr>
<tr>
<td>Drop point</td>
<td>DIN ISO 2176</td>
<td>Determines the temperature at which the grease drips off the testing unit in a non-decomposed condition</td>
</tr>
<tr>
<td>Penetration</td>
<td>DIN ISO 2137</td>
<td>Determines the consistency of a lubricating grease. The penetration depth of a metal cone into a grease-filled cup is measured in tenths of mm. The ranges are classified in NLGI grades</td>
</tr>
<tr>
<td>Apparent viscosity</td>
<td>DIN 53 018, part 1</td>
<td>Determination of the internal resistance of a grease to shearing on the basis of its Newtonian flow behaviour</td>
</tr>
<tr>
<td>Flow pressure</td>
<td>DIN 51 805</td>
<td>Temperature-dependent pressure needed to force a grease out of a nozzle. Indicates the lower service temperature</td>
</tr>
<tr>
<td>Corrosivity on copper/steel</td>
<td>DIN 51 811</td>
<td>Corrosion protection or effect of the lubricant on non-ferrous metal alloys or steels</td>
</tr>
<tr>
<td>Oxidation resistance</td>
<td>DIN 51 808</td>
<td>Resistance of the grease to absorb oxygen measured by the drop in pressure; indicates grease ageing</td>
</tr>
<tr>
<td>Water resistance</td>
<td>DIN 51 807, part 1</td>
<td>Statistic test to check the emulsification of the grease</td>
</tr>
<tr>
<td>Oil separation</td>
<td>DIN 51 817</td>
<td>Determination of oil bleeding in percent by weight</td>
</tr>
</tbody>
</table>

### Fig. 1: Flow chart: Lubricant development

- **User** → **Problem** → **Requirements** → **Concept – product idea** → **Laboratory sample** → **Small batch** → **Large batch** → **Chemico-physical test methods** → **Mechano-dynamical test methods** → **Practical tests** → **Result** → **Solution** → **Quality assurance** → **Product** → **Recommendation**
DIN 50 322 provides a basis for lubricant analysis. This standard makes a distinction between six different test categories. Fig. 2 shows the testing categories by means of the example “wear test of a manual gear mechanism in a commercial vehicle”.

I  **Practical test**
The complete original unit is tested under conditions identical to actual use.

II  **Bench test**
The original unit operates in the laboratory under reproducible test conditions similar to actual use.

III  **Component/sub-component test**
Components taken from the original unit are operated in the laboratory and subjected to defined conditions similar to actual use.

IV  **Model test with scaled components/sub-components**
Scaled down components are tested in the laboratory under defined conditions in accordance with the modified size.

V  **Model test with simplified components**
Test specimens similar to the component are subjected to conditions similar to actual use.

VI  **Model test with most simple test specimens**
Test specimens of simple geometry are tested in the laboratory under simplified and variable conditions.

Since practical tests and test rigs are very complex and expensive, alternative testing systems are used in most cases. The original unit has to be reduced to a tribological system and the load/stress factors influencing the

<table>
<thead>
<tr>
<th>Category</th>
<th>Type of test</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Practical test (field test)</td>
<td><img src="image" alt="Practical test" /></td>
</tr>
<tr>
<td>II</td>
<td>Test rig</td>
<td><img src="image" alt="Test rig" /></td>
</tr>
<tr>
<td>III</td>
<td>Component test</td>
<td><img src="image" alt="Component test" /></td>
</tr>
<tr>
<td>IV</td>
<td>Test with unchanged component or scaled down unit</td>
<td><img src="image" alt="Model test" /></td>
</tr>
<tr>
<td>V</td>
<td>Test with specimens subjected to loads similar to actual use</td>
<td><img src="image" alt="Test with specimens" /></td>
</tr>
<tr>
<td>VI</td>
<td>Model test with simple specimens</td>
<td><img src="image" alt="Model test" /></td>
</tr>
</tbody>
</table>

Fig. 2: Categories of mechano-dynamical tests acc. to DIN 50 322
friction and wear behaviour have to be assessed (see Fig. 3).

Test rig design, specimens and the measuring methods are much more sophisticated in case of component test rigs but the results are accepted on a much wider basis than with model test rigs. In most cases, a manufacturer of special lubricants can only carry out component tests or use model systems.

Model test rigs offer several advantages: specimens of simple geometry (materials and working surfaces can easily be modified); shorter test duration and better reproducibility of the results due to the reduced number of possible influencing factors; adjust-

ability of the test parameters in a wide range; lower test costs.

Component tests rigs, however, are very expensive and the tests time-consuming and expensive. The results determined with model test rigs allow better interpretation as far as the effects of the test parameters are concerned, whereas the test results obtained from component test rigs give solid information about the applicability to practical use.

Simple test principles require specimens which can be easily obtained or manufactured. Commercial basic elements, such as rolling bearing rings, balls, cylinders, discs, blocks, plates etc. have proven successful.
The purchasing costs of test machines mainly depend on the design, the adjustable range of forces to be applied, torques, temperatures, number of revolutions, speeds and the measuring technique, including data acquisition.

The average price of model test rigs is between 5,000 € and 75,000 €, of component test rigs between 15,000 € and 250,000 € or more if the load/stress factors, i.e. dynamic changes in loads, are tested. Additional costs are incurred for the operation and maintenance of the test machine, for the necessary peripheral testing and measuring equipment and, last but not least, for the staff. A breakdown of these costs is given in Fig. 4. A model test including the interpretation of results costs between 50 € and 500 € depending on the device, a component test several 1,000 €. Mechano-dynamical tests are worth the effort and the financial expenditure because damage due to an inadequate lubricant recommendation or application are many times higher (machine damage, repair, standstill and subsequent costs), all the more since a lot of machines are interconnected.

Lubricants tailored to the specific application and pertinent quality

Table 2: Advantages and disadvantages of test systems

<table>
<thead>
<tr>
<th>Practical test</th>
<th>Component test</th>
<th>Model test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>application or development</td>
<td>basic analysis (phenomenon)</td>
</tr>
<tr>
<td>Specimen</td>
<td>original machines or devices</td>
<td>in most cases simple machine elements</td>
</tr>
<tr>
<td>Parameter monitoring or distinction</td>
<td>only possible to a limited extent</td>
<td>sometimes possible</td>
</tr>
<tr>
<td>Determination of the failure criterion</td>
<td>only possible to a limited extent</td>
<td>sometimes possible</td>
</tr>
<tr>
<td>Applicability to practice</td>
<td>possible</td>
<td>only possible to a limited extent</td>
</tr>
<tr>
<td>Measuring costs</td>
<td>low to high</td>
<td>medium to high</td>
</tr>
<tr>
<td>Time requirement</td>
<td>high</td>
<td>low</td>
</tr>
</tbody>
</table>

4.0 Benefits and costs of tribological tests
Fig. 4: Breakdown of main costs for tribological tests

Standards are rather expensive but ensure a long and trouble-free operation of the machine and thus a quick return on investment.

Klüber quality is not left to chance. In-house or external tribological tests are an integral part of raw material inspections, as well as performance and quality ratings of lubricants. Recently Klüber made huge investments in mechano-dynamical testing and is constantly extending its test machinery to ensure the quality of our products and satisfy our customers.
## 5.0 Standard Klüber tests

<table>
<thead>
<tr>
<th>No.</th>
<th>Test/process</th>
<th>Description</th>
<th>Application</th>
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<tbody>
<tr>
<td>1</td>
<td>FE 9 rolling bearing grease tester</td>
<td>Service life of greases</td>
<td>RB</td>
</tr>
<tr>
<td>2</td>
<td>Low-temperature torque tester IP 186, – ASTM 1478</td>
<td>Low-temperature torque of grease-lubricated rolling bearings</td>
<td>RB, G</td>
</tr>
<tr>
<td>3</td>
<td>ROF rolling bearing grease tester</td>
<td>Service life of greases</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>FE 8 rolling bearing wear and friction tester</td>
<td>Antiwear behaviour of greases</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>FE 8 rolling bearing lubricant tester</td>
<td>Antiwear behaviour of greases</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>FE 9 rolling bearing grease tester ROF rolling bearing grease tester</td>
<td>Service life of greases</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>ROF rolling bearing grease tester</td>
<td>Service life of greases</td>
<td>RB</td>
</tr>
<tr>
<td>8</td>
<td>SNR – FEB 2 rolling bearing tester</td>
<td>Antiwear behaviour of greases</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>EMCOR machine</td>
<td>Antiwear behaviour of greases</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Vibrational quality tester MGG 11, SKF–MVH 90 B</td>
<td>Noise behaviour of greases</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>FAG rolling bearing tester “KSM” for rolling bearing greases</td>
<td>Lubricant behaviour in the rolling bearing</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Oscillation friction and wear tester</td>
<td>Operating value of lubricants</td>
<td>RB, G, C, ST</td>
</tr>
<tr>
<td>13</td>
<td>Rolling bearing torque testing machine</td>
<td>Starting and friction torque of greases</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Water wash-out test</td>
<td>Water resistance of greases</td>
<td>RB</td>
</tr>
<tr>
<td>15</td>
<td>Roll stability tester</td>
<td>Churning resistance of greases</td>
<td>RB, G</td>
</tr>
<tr>
<td>16</td>
<td>Shell four ball wear tester</td>
<td>Antiwear behaviour of lubricants</td>
<td>RB, G, C</td>
</tr>
<tr>
<td>17</td>
<td>Sliding friction tester</td>
<td>Sliding friction behaviour of lubricants, ball-on-disk, pin-on-disk</td>
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</table>

**Explanations to column “Application”**

<table>
<thead>
<tr>
<th>ST</th>
<th>sanitary taps</th>
</tr>
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<tbody>
<tr>
<td>PBG</td>
<td>plain bearings and guides</td>
</tr>
<tr>
<td>C</td>
<td>chains</td>
</tr>
<tr>
<td>G</td>
<td>gears</td>
</tr>
<tr>
<td>PT</td>
<td>pressing tools</td>
</tr>
<tr>
<td>ET</td>
<td>edge tools</td>
</tr>
<tr>
<td>RB</td>
<td>rolling bearings</td>
</tr>
</tbody>
</table>
Table 3 shows the most common tests and tests methods. Besides a brief description of the test, the focal test parameters and the load types are listed. The main application of the test and the category of the test system are also listed.

<table>
<thead>
<tr>
<th>Load</th>
<th>Primary testing parameters</th>
<th>Model, component or unit testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>High temperature</td>
<td>Temperature: 100 to 250 °C, failure time, upper service temperature</td>
<td></td>
</tr>
<tr>
<td>Low temperature</td>
<td>Starting and running torque, temperature: – 70 to 0 °C, lower service temperature</td>
<td></td>
</tr>
<tr>
<td>High speeds</td>
<td>Speed: 1,000 to 20,000 (30,000) rpm, failure time</td>
<td></td>
</tr>
<tr>
<td>Low speeds</td>
<td>Speed: 7.5 to 3,000 rpm, weighing of wear, steady-state temperature and friction torque curve</td>
<td></td>
</tr>
<tr>
<td>Heavy-duty</td>
<td>Axial load up to 80,000 N, weighing of wear, steady-state temperature and friction torque curve</td>
<td>Component</td>
</tr>
<tr>
<td>Medium duty</td>
<td>Axial load 1,500 to 4,500 N (FE 9), radial load up to 800 N (ROF), failure time</td>
<td></td>
</tr>
<tr>
<td>Low duty</td>
<td>Axial load 50 to 200 N, axial load 100 N</td>
<td></td>
</tr>
<tr>
<td>Oscillating motion</td>
<td>Oscillation angle ± 3°, wear in mg</td>
<td></td>
</tr>
<tr>
<td>Stop-and-go operation exposed to media</td>
<td>Corrosion degree (table DIN 51 802)</td>
<td></td>
</tr>
<tr>
<td>Axial load, speed</td>
<td>Solid-borne sound measurement acc. to noise class or level, running-in behaviour</td>
<td></td>
</tr>
<tr>
<td>Axial load, speed, temperature</td>
<td>Friction torque, steady-state temperature, visual rating (oil separation, grease collar, etc.)</td>
<td></td>
</tr>
<tr>
<td>Oscillating motion</td>
<td>Temperature up to 280 °C max., friction coefficient curve, wear</td>
<td>Model</td>
</tr>
<tr>
<td>Axial load, speed</td>
<td>Starting and running torque, time-related</td>
<td>Component</td>
</tr>
<tr>
<td>Influence of media, speed</td>
<td>Grease loss in % by weight, visual rating</td>
<td></td>
</tr>
<tr>
<td>Temperature, churning</td>
<td>Temperature up to 250 °C, penetration, churning time, visual rating</td>
<td></td>
</tr>
<tr>
<td>Load (short-term / permanent), speed, temperature</td>
<td>Welding load, wear scar diameter, shear stability</td>
<td>Model</td>
</tr>
<tr>
<td>Normal load, sliding speed, friction, wear</td>
<td>Temperature up to 150 °C, time-related friction coefficient</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Test/process</td>
<td>Description</td>
</tr>
<tr>
<td>-----</td>
<td>--------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>18</td>
<td>Klüber high-temperature chain tester</td>
<td>Operating behaviour of lubricating oils</td>
</tr>
<tr>
<td>19</td>
<td>Tannert sliding indicator</td>
<td>Sliding friction behaviour of lubricants and material pairings</td>
</tr>
<tr>
<td>20</td>
<td>FZG four square gear oil tester</td>
<td>Antiwear behaviour of fluid greases and oils</td>
</tr>
<tr>
<td>21</td>
<td>Klüber water valve tester (life test)</td>
<td>Service life of greases in sanitary (water) valves</td>
</tr>
<tr>
<td>22</td>
<td>Klüber water valve tester (stick-slip)</td>
<td>Friction behaviour of lubricating greases in sanitary (water) valves</td>
</tr>
<tr>
<td>23</td>
<td>Reichert fretting wear tester</td>
<td>Load-carrying capacity of lubricants and material pairings</td>
</tr>
<tr>
<td>24</td>
<td>Brugger lubricant tester</td>
<td>Load-carrying capacity of lubricants and material pairings</td>
</tr>
<tr>
<td>25</td>
<td>Press-Fit tester</td>
<td>Stick-slip behaviour of lubricants</td>
</tr>
<tr>
<td>26</td>
<td>Klüber gas cock tester</td>
<td>Friction and stick-slip behaviour of greases</td>
</tr>
<tr>
<td>27</td>
<td>Brückner tester</td>
<td>Lubricant behaviour in vertically mounted rolling bearings</td>
</tr>
<tr>
<td>28</td>
<td>Klüber worm gear oil tester</td>
<td>Wear and friction behaviour of lubricants</td>
</tr>
<tr>
<td>29</td>
<td>Klüber drive chain tester</td>
<td>Operating behaviour of lubricating oils</td>
</tr>
<tr>
<td>30</td>
<td>Oscillating slide plate test rig</td>
<td>Friction and sliding behaviour of lubricants and material pairings</td>
</tr>
<tr>
<td>31</td>
<td>Railway switch test rig</td>
<td>Friction and wear behaviour of lubricants</td>
</tr>
</tbody>
</table>

**Explanations to column “Application”**

<table>
<thead>
<tr>
<th>ST</th>
<th>PT</th>
<th>PBG</th>
<th>ET</th>
<th>RB</th>
</tr>
</thead>
<tbody>
<tr>
<td>sanitary taps</td>
<td>pressing tools</td>
<td>plain bearings and guides</td>
<td>edge tools</td>
<td>rolling bearings</td>
</tr>
<tr>
<td>Load</td>
<td>Primary testing parameters</td>
<td>Model, component or unit testing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>-----------------------------</td>
<td>----------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature, tensile load, speed</td>
<td>Temperature: – 30 to 150 °C, friction and wear, runtime</td>
<td>Component</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal load, temperature, low sliding speed</td>
<td>Temperature up to 250 °C, sliding speed 0 to 0.48 mm/s, identification of stick-slip, friction coefficient</td>
<td>Model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load, speed, temperature, wear</td>
<td>Failure load stage, wear</td>
<td>Component, unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load cycles, open/close</td>
<td>Cycles achieved at 18 °C and 2.5 Nm closing torque</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opening/closing torque as a function of number of cycles</td>
<td>Friction torque curve as a function of the turning angle at 70 °C, determination of stick-slip</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sliding under high pressure</td>
<td>Specific surface pressure</td>
<td>Component</td>
<td></td>
<td></td>
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<tr>
<td>Sliding under high pressure</td>
<td>Specific surface pressure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sliding under high pressure and at low speed</td>
<td>Stick-slip, friction coefficient</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opening/closing cycles under thermal load</td>
<td>Friction coefficient and stick-slip as a function of number of cycles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High temperature (&gt; 150 °C), alternating direction of rotation, vertical mounting position</td>
<td>Lubricant loss, visual rating</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sliding under high pressure</td>
<td>Wear curve, efficiency, lubrication condition, temperatures</td>
<td>Unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tensile force, speed, temperature</td>
<td>Temperatures from – 20 °C to 150 °C, friction and wear behaviour</td>
<td>Component</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal load, temperature, medium sliding speed</td>
<td>Temperature &lt; 0 °C to 150 °C, sliding speed 1 to 150 mm/s, stick-slip, wear, friction coefficient</td>
<td>Model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal load, temperature, influence of media, sliding speed</td>
<td>Intermittent influence of media, friction force curve, visual rating</td>
<td>Component</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Test/process</td>
<td>Description</td>
<td>Application</td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>--------------</td>
<td>-------------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Oscillation friction wear tester</td>
<td>Tribocorrosion and oscillation wear behaviour of lubricants</td>
<td>PBG, G, RB</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Electrical contacts test rig</td>
<td>Service life of lubricants in electrical contacts</td>
<td>PBG</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Trolley bearing test rig</td>
<td>Service life of high-temperature greases in trolley bearings</td>
<td>RB</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>Wire rope test rig</td>
<td>Service life of lubricated wire ropes</td>
<td>PBG</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Grease tester FTG 2</td>
<td>Oil separation of greases under pressure</td>
<td>RB, PBG, C</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>GRW noise tester</td>
<td>Noise behaviour of greases in rolling bearings</td>
<td>RB</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>Almen-Wieland lubricant tester</td>
<td>High-pressure and antiwear behaviour of lubricants</td>
<td>PBG, RB, C, G</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>Zwick friction tester for elastomers</td>
<td>Determination of static and sliding friction of elastomers</td>
<td>PBG, G, ST</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>SKF-BeQuiet grease noise tester</td>
<td>Noise behaviour of rolling bearing greases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>Wheel bearing test</td>
<td>Measurement of lubricant loss</td>
<td></td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>GMN – KGE 4</td>
<td>Noise behaviour of greases</td>
<td>RB</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Grease pumphability tester (central lubricating systems)</td>
<td>Pumpability of greases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>Grease depressurisation tester</td>
<td>Depressurisation behaviour of greases in lubricant lines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>Flender foam tester</td>
<td>Foam formation of lubricating oils</td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>Automotive water pump test</td>
<td>Lubricant behaviour in complete bearing units</td>
<td>RB</td>
<td></td>
</tr>
</tbody>
</table>

**Explanations to column “Application”**

- **ST**: sanitary taps
- **PBG**: plain bearings and guides
- **C**: chains
- **G**: gears
- **PT**: pressing tools
- **ET**: edge tools
- **RB**: rolling bearings
<table>
<thead>
<tr>
<th>Load</th>
<th>Primary testing parameters</th>
<th>Model, component or unit testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface pressure, time, oscillation frequency</td>
<td>Degree of tribocorrosion, classification</td>
<td>Model</td>
</tr>
<tr>
<td>Voltage, current</td>
<td>Number of switching cycles, voltage drop</td>
<td></td>
</tr>
<tr>
<td>Temperature, speed, oscillating direction of rotation</td>
<td>Temperature up to 280 °C, 20 rpm, runtime achieved</td>
<td>Component</td>
</tr>
<tr>
<td>Tensile force, inverted cable</td>
<td>Load up to 200 N, rope speed 135 mm/s, number of cycles</td>
<td></td>
</tr>
<tr>
<td>Pressure, temperature</td>
<td>Pressure 20 bar, ambient temperature, oil separation and thickness of hardened layer</td>
<td>Model</td>
</tr>
<tr>
<td>Speed, axial load</td>
<td>Frequency band, peaks, crackling</td>
<td>Component</td>
</tr>
<tr>
<td>Sliding speed, radial load</td>
<td>Test load up to 20 kN, sliding speed 0.066 m/s, breaking load, abrasion, friction force</td>
<td>Model</td>
</tr>
<tr>
<td>Normal load sliding speed, temperature</td>
<td>Sliding speed up to 800 rpm, friction force up to 10 N, way-friction coefficient diagram</td>
<td></td>
</tr>
<tr>
<td>Speed, axial load</td>
<td>Quantitative determination of noise peaks and frequency bands as well as of starting-up behaviour and dampening</td>
<td></td>
</tr>
<tr>
<td>Temperature, speed</td>
<td>Temperature up to 163 °C, grease loss in g, visual rating</td>
<td>Component</td>
</tr>
<tr>
<td>Axial load, speed</td>
<td>Solid-borne sound measurement acc. to noise class or level, running-in behaviour</td>
<td></td>
</tr>
<tr>
<td>Pressure, temperature, volumes, cycles</td>
<td>Temperature up to 350 °C, oil separation, carbon build-up, visual rating</td>
<td>Unit</td>
</tr>
<tr>
<td>Pressure, temperature</td>
<td>Time-related residual pressure at different temperatures</td>
<td>Component</td>
</tr>
<tr>
<td>Speed, teeth</td>
<td>Time-related fluid/foam volume</td>
<td>Model</td>
</tr>
<tr>
<td>Temperature, speed</td>
<td>Lubricant loss, visual rating</td>
<td>Component</td>
</tr>
</tbody>
</table>
6.0 Description of selected mechanico-dynamical tests and their significance

Contents

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1</td>
<td>Roll stability tester</td>
<td>17</td>
</tr>
<tr>
<td>6.2</td>
<td>Shell four-ball wear tester</td>
<td>18</td>
</tr>
<tr>
<td>6.3</td>
<td>CV-joint test rig</td>
<td>19</td>
</tr>
<tr>
<td>6.4</td>
<td>FZG four square gear oil tester</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Micropitting test acc. to Flender</td>
<td></td>
</tr>
<tr>
<td>6.5</td>
<td>FZG four square gear oil tester</td>
<td>21</td>
</tr>
<tr>
<td>6.6</td>
<td>Oscillation friction wear tester</td>
<td>22</td>
</tr>
<tr>
<td>6.7</td>
<td>EMCOR-machine</td>
<td>23</td>
</tr>
<tr>
<td>6.8</td>
<td>Tannert sliding indicator</td>
<td>24</td>
</tr>
<tr>
<td>6.9</td>
<td>Reichert fretting wear tester</td>
<td>25</td>
</tr>
<tr>
<td>6.10</td>
<td>Sliding friction test rig</td>
<td>26</td>
</tr>
<tr>
<td>6.11</td>
<td>Water wash-out test</td>
<td>27</td>
</tr>
<tr>
<td>6.12</td>
<td>FE 9 Rolling bearing grease tester</td>
<td>28</td>
</tr>
<tr>
<td>6.13</td>
<td>ROF rolling bearing grease tester</td>
<td>30</td>
</tr>
<tr>
<td>6.14</td>
<td>FE 8 rolling bearing lubricant tester</td>
<td>32</td>
</tr>
<tr>
<td>6.15</td>
<td>SNR – FEB 2 rolling bearing grease tester</td>
<td>33</td>
</tr>
<tr>
<td>6.16</td>
<td>Low-temperature torque tester – IP 186</td>
<td>34</td>
</tr>
<tr>
<td>6.17</td>
<td>Low-temperature torque test rig – ASTM D 1478</td>
<td>36</td>
</tr>
<tr>
<td>6.18</td>
<td>Rolling bearing torque tester</td>
<td>37</td>
</tr>
<tr>
<td>6.19</td>
<td>Brugger lubricant tester</td>
<td>38</td>
</tr>
<tr>
<td>6.20</td>
<td>Grease tester FTG 2</td>
<td>39</td>
</tr>
<tr>
<td>6.21</td>
<td>GRW noise tester</td>
<td>40</td>
</tr>
<tr>
<td>6.22</td>
<td>Almen-Wieland lubricant tester</td>
<td>41</td>
</tr>
<tr>
<td>6.23</td>
<td>HTN Spengler test rig for rolling bearing greases</td>
<td>42</td>
</tr>
<tr>
<td>6.24</td>
<td>FAG vibrational quality test rig MGG 11</td>
<td>43</td>
</tr>
<tr>
<td>6.25</td>
<td>Zwick elastomer friction tester</td>
<td>44</td>
</tr>
<tr>
<td>6.26</td>
<td>Press-Fit test</td>
<td>45</td>
</tr>
<tr>
<td>6.27</td>
<td>SKF BeQuiet grease noise test rig</td>
<td>46</td>
</tr>
<tr>
<td>6.28</td>
<td>Timken machine</td>
<td>47</td>
</tr>
</tbody>
</table>
6.1 Roll stability tester

Scope
Determination of the mechanical stability of lubricating greases; determination of the oil separation; change in consistency

Standard
ASTM D 1831, Klüber testing conditions

Specimen
Hollow cylinder with screw cap and internal rotating cylinder

Test conditions
Duration of test: 2 h, 50 h, 100 h
Grease quantity: 55 cm³ or 50 g for greases with a density of 0.9 g/cm³
Speed: 165 rpm
Temperature: ambient temperature up to 70 °C, 100 °C, 130 °C, 150 °C

Procedure
❑ Take lubricant sample
❑ Determine the worked penetration in acc. with DIN 51 804, pt. 2
❑ Distribute the grease on the inside wall of the cylinder
❑ Insert the roll weight (internal cylinder) in the cylinder and tighten the cap
❑ Mount the cylinder in position
❑ Set the preheating time, working time and the test temperature
❑ Start the machine after preheating
❑ After the test carry out a visual evaluation of the grease and determine the worked penetration again

Result
❑ Documentation of the change in worked penetration, test temperature and duration.
6.2
Shell four-ball wear tester

Scope
Determination of the wear indexes and the welding load of fluid and consistent lubricants; effect of antiwear and extreme-pressure additives under specific sliding friction condition

Standards
DIN 51 350 part 1 through 5
ASTM D 2266
ASTM D 2596
ASTM D 2783
ASTM 4172

Specimen
4 steel balls 1/2″ (100 Cr6)
SKF RB 12,7/310955

Test conditions
Duration of test: 60 s for welding load*
Speed: 1450 rpm (acc. to DIN) or 1490 rpm, 1200 rpm (acc. to ASTM)
Load: 57 load stages from 150 to 12,000 N

Procedure
- Mount a supporting ring with three balls in the ball pot
- Cover the three balls with grease
- Install the ball pot assembly in the test apparatus and mount the fourth ball in the upper spindle chuck
- Set the load, speed and time, start the machine
- After the test, disassemble the ball pot and dismount the balls

Result
- Determination of the nonseizure load and seizure load
- Determination of the scar diameters in case of nonseizure loads

1) Seizure load is the load at which welding of the four balls occurs
Nonseizure load is the load at which welding of the four balls does not occur prior to achieving the seizure load stage

2) AW = antiwear
EP = extreme pressure

* 60 min determination of permanent wear

Four-ball test assembly

Measurement of the wear scar diameter: determination of the average wear scar diameter in the sliding direction and perpendicular to the sliding direction
6.3 CV-joint test rig

Scope
Determination of grease life in CV joints

Standard
Klüber specifications

Specimen
4 CV joints with different geometry

Test conditions
- Speed: variable, max. 1700 rpm
- Load torque: variable, max. 1200 Nm
- Deflection angle: variable*
- Length of CV-jointed shaft: 350 to 1000 mm
The joints can be cooled or heated up by an air flow.

Procedure
- Clean and grease joints
- Mount CV joints to test rig
- Set testing parameters
- Start test
- Document temperature
- The runtime of each individual joint is recorded in number of revolutions
- When the limit temperature is exceeded, the test is terminated
- Dismount specimen; clean and measure wear marks

Result
Statistic evaluation of runtime values.

* The maximum value depends on the length of the shaft
6.4 FZG* four square gear oil tester
Micropitting test acc. to Flender

Scope
Determination of micropitting resistance of gears

Standard
Flender standard

Specimen
Two gearwheels (Flender C toothing)

Test conditions
Peripheral speed: 8.3 m s⁻¹
Pinion speed: 2170 rpm
Lubrication method: splash lubrication
Oil sump temperature: max 90 °C (with cooling)
Load: load stage 10
\( P_c = 1547 \, \text{N/mm}^2 \)
Running-in: 1 h at load stage 4
Duration of test: 100 h (short test) 300 h (long test)

Procedure
- Clean and mount set of gears
- Fill in lubricant
- Set load at load stage 10 and start test at ambient temperature
- Run test at 90 °C (cooled)
- After 100 h short, dismount and evaluate
- In case of positive evaluation: Long test with load stage 10 for 300 h with the same oil and flank

Result
The percentage of tooth flank surface affected by micropitting, and profile deformation compared with new gears are determined on three teeth.
Then the oil is rated in load-carrying capacity classes I (very high capacity) to VI (very low capacity).

* FZG: Technical Institute for the Study of Gears and Drive Mechanisms, Technical University Munich
6.5

FZG* four square gear oil tester

Scope
Determination of the limit stress capacity of lubricants, especially for gears

Standard
DIN 51 354 parts 1 and 2

Specimen
Two gear wheels

Test conditions
Peripheral speed: 2.76, 8.3 or 16.6 m s⁻¹
Pinion speed: 722, 2170 or 4340 rpm
Lubrication method: splash lubrication
Oil pump temperature: 90 °C
Load: 12 load steps (99 to 15,826 N)
Duration of test: 15 min per load step

Procedure
- Mount the test gear pair
- Start the test with load stage 1
- As from load stage 4 check the tooth flanks of the pinion usually and describe their condition
- Determine the scuffing load stage or terminate the test at scuffing load stage 12

Result
Determination of the scuffing load stage and the specific wear in mg/kWh.

* FZG: Technical Institute for the Study of Gears and Drive Mechanisms, Technical University Munich

![Diagram of FZG four square gear oil tester with performance circuit](image-url)
6.6 Oscillation friction wear tester

Scope
Determination of the fretting and tribocorrosion of lubricants, coatings and plastics subject to constant load and oscillating sliding movements

Standard
DIN 65 593 E
DIN 51 834 / Klüber test conditions

ASTM D 5706
ASTM D 5707
ASTM D 6425

Specimen
Disc, lapped or ground
d = 24 mm, h = 7.85 mm
Cylinder, d = 15 mm, h = 22 mm
Ball, d = 10 mm
Cylinder, d = 10 mm, h = 10 mm,
Hardness of the specimen 63 HRC
with standard material 100 Cr 6

Test conditions
Load: 1 to 2000 N 300 N
Sliding distance: 1 to 4 mm 1 mm
Frequency: 1 to 500 Hz 50 Hz
Temperature: – 40 to +900 °C 50 °C
Duration of test: 120 min or 24 h 120 min
Contact geometry: linear (cylinder),
surface (ring),
point (ball)

Procedure
❑ Clean the test specimens and insert them into the appropriate fixtures
❑ Apply lubricant and install fixtures in the test rig
❑ Set test parameters, wait until heated and start the test unit
❑ Document the friction coefficient curve by means of printer
❑ Disassemble the test specimens and measure the wear marks

Result
Evaluation of friction coefficients and wear on specimen over time

Test specimen pairs and test principle

Test rig design
Scope
Determination of the anti-corrosion properties of lubricating greases

Standard
DIN 51 802, IP 220, ISO 11 007

Specimen
Self-aligning ball bearings: 1306 K / 236725
Special type with steel cage

Test conditions
Duration of test: 168 h with alternating running and stop periods
Speed: 80 rpm
Test medium: distilled water or other aqueous media
Grease volume: 11 cm³ per bearing

Procedure
❑ Dismount and clean the test bearings
❑ Visually examine the outer bearing races for corrosion
❑ Grease the test bearings and mount them on the drive shafts of the test units
❑ Run the test
❑ Disassemble and clean the test bearings
❑ Examine outer bearing races visually without optical aids

Corrosion degrees

<table>
<thead>
<tr>
<th>Corrosion degree</th>
<th>Meaning</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>no corrosion</td>
<td>unchanged</td>
</tr>
<tr>
<td>1</td>
<td>traces of corrosion</td>
<td>max. 3 corrosion spots with a diameter of max. 1 mm</td>
</tr>
<tr>
<td>2</td>
<td>slight corrosion</td>
<td>max. 1% of the surface is corroded, but more and larger corroded spots as with corrosion degree 1</td>
</tr>
<tr>
<td>3</td>
<td>moderate corrosion</td>
<td>&gt; 1% but not more than 5% of the surface is corroded</td>
</tr>
<tr>
<td>4</td>
<td>strong corrosion</td>
<td>&gt; 5% but not more than 10% of the surface is corroded</td>
</tr>
<tr>
<td>5</td>
<td>very strong corrosion</td>
<td>&gt; 10% of the surface is corroded</td>
</tr>
</tbody>
</table>

Result
Corrosion rating on the outer bearing races
6.8 Tannert sliding indicator

Scope
Sliding and stick-slip behaviour of lubricants and materials subject to low sliding speeds

Standard
Klüber test conditions

Specimen
Two sliding elements and a sliding tongue (79.5 x 20 x 3 to 5 mm), various material pairings possible

Sliding elements:
- Block 29.8 x 24.9 x 15 mm (surface contact)
- Cylinder Ø 13 x 13 mm (surface contact)
- Cylinder Ø 10 x 10 mm (linear contact)

Test conditions
- Sliding speed: max. 0.243 or 0.486 mm s⁻¹
- Sliding distance: 20 mm
- Temperature: ambient temperature to 150 °C
- Load: variable from 50 to 1200 N
- Geometry: line and/or surface
- Given parameters: number of runs, time [h]

Procedure
- Apply the test lubricant to the sliding elements and tongue
- Fix the sliding elements in the sliding table
- Set the specified load and heating
- Start the test unit
- Record the friction force curve graphically over the friction distance depending on the load steps

Result
Determination of the friction coefficient and identification of stick-slip

Friction force curves with slow, reversing sliding movement

Test rig design
6.9 Reichert fretting wear tester

**Scope**
Load-carrying capacity of lubricants in the mixed friction regime

**Standard**
Klüber test conditions
VKIS work sheet

**Specimen**
Cylindrical roller Ø 12 mm, h = 18 mm
Needle bearing inner ring Ø 30 x Ø 35 x 16 mm

**Test conditions**
Load: 300 N, constant
Rotational speed: 980 rpm, constant
Sliding speed: 1.8 ms⁻¹
Friction distance: 100 m per test run

**Procedure**
- Mount specimens to tester
- Start reference run with neutral oil or deionised water
- Drain reference fluid, clean specimens
- Check wear marks on cylindrical roller
- Remount cylinder roller with standard surface depth in contact with bearing inner ring
- Apply lubricant to be tested
- Perform three test runs
- Measure wear marks (abrasion on cylindrical roller, mean value)
- Determine elliptical surface and specific surface pressure using the appropriate tables

**Result**
Specific surface pressure calculated by means of the resulting wear
### 6.10 Sliding friction test rig

**Principle:** ball – disk

**Scope**
Determination of the friction force curve and wear behaviour with various material pairings and lubricants

**Standard**
Klüber specifications test conditions

**Specimen**
- Ball, \( d = 12.7 \text{ mm}, \) SKF 310955
- Plastic pin, \( d = 12.0 \text{ mm} \)
- Bearing, INA-WS 81111

**Test conditions**
- Duration of test: 1 min to 8 h
- Speed: up to 1200 rpm \((V_{\text{max}} = 4.2 \text{ m s}^{-1})\)
- Temperature: ambient temp. to 150 °C
- Load: 10 to 100 N, vertical

**Procedure**
- Prepare and position the specimens
- Connect the measuring amplifier
- Digital data recording
- Apply the lubricant to be tested
- Set the test parameters
- Carry out the test run
- Disassemble the specimen and measure the wear

**Result**
- Friction coefficient \( \mu \) at start-up, at the end and during the test
- Wear scar diameter of the ball or wear volume of the pin
- Friction oscillations (if any)

---

**Example of documentation on PC**

<table>
<thead>
<tr>
<th>Test conditions:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Scan rate [scans/s]:</td>
<td>25</td>
</tr>
<tr>
<td>Nominal test duration [min]:</td>
<td>120</td>
</tr>
<tr>
<td>Actual test duration [min]:</td>
<td>120</td>
</tr>
<tr>
<td>Load [N]:</td>
<td>10</td>
</tr>
<tr>
<td>Speed [rpm]:</td>
<td>48</td>
</tr>
<tr>
<td>Temperature [°C]:</td>
<td>20</td>
</tr>
</tbody>
</table>

**Initial friction coefficient \( \mu \):**
- Maximum value*: 0.43
- Medium value*: 0.09
- Minimum value*: 0.00

**Final friction coefficient \( \mu \):**
- Maximum value*: 0.43
- Medium value*: 0.09
- Minimum value*: 0.00

*from 50 registered values

**Mean value of all medium values:** 0.13

**Variance:** 0.0001
6.11 Water wash-out test

**Scope**
Behaviour of a lubricant under dynamic conditions at different temperatures

**Standards**
DIN 51 807; ASTM D 1264

**Specimen**
Deep groove ball bearing 6204, open

**Test conditions**
Duration of test: 1 h  
Speed: 600 rpm  
Temperature: 40 °C; 80 °C acc. to DIN  
            38 °C; 79 °C to ASTM  
Water flow: 5 ± 0.5 cm³/s

**Procedure**
- Weigh the test bearing and the housing cover
- Lubricate the test bearing with 4 ± 0.05 g of grease
- Mount the test bearing in the bearing housing and fix the cover
- Run the test for 60 min directing a defined water jet onto the capped specimen
- Disassemble the test bearing
- Dry the test bearing and housing cover for 16 h at 95 °C in the drying cabinet or for 15 h at 77 °C in the drying cabinet (ASTM), then weigh

**Test result**
Determination of the loss in weight of lubricating grease in percent. Visual rating

<table>
<thead>
<tr>
<th>Rating level</th>
<th>Loss in weight, %</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&lt; 10</td>
<td>low</td>
</tr>
<tr>
<td>2</td>
<td>&gt; 10 but &lt; 30</td>
<td>moderate</td>
</tr>
<tr>
<td>3</td>
<td>&gt; 30</td>
<td>high</td>
</tr>
</tbody>
</table>

Water wash-out test, rating
6.12

FE 9 Rolling bearing grease tester

Scope
Determination of the service life and the upper service temperature of lubricating greases in rolling bearings subject to medium speeds and medium axial loads

Standard
DIN 51 821, DIN 51 825 FAG Schweinfurt, Germany / Klüber test conditions

Test specimen
5 angular contact ball bearings
FAG-special type 529689 S 2 (corr. to 7206 B open, with steel cage)

Test conditions
Axial load: 1500, 3000, 4500 N, DIN 51 821: 1500 N
Speed: 3000, 6000 rpm, DIN 51 821: 6000 rpm
Temperature: max. 240 °C, DIN 51 821: 120 to 200 °C acc. to DIN 51 821 in steps of 20 °C

Grease quantity per bearing: * 2 cm³
** 10 cm³

Various assemblies
* A: Test bearing without washer, open
* B: Bearing shielded on both sides with external washers
** C: As B; plus additional grease reservoir on one washer

Test procedure
- Disassemble, clean, mount and lubricate the test bearings
- Fix the 5 test bearings in the test units
- Set the test parameters
- Carry out the test run
- Record the running time of the test bearings, expressed in h

The 5 running time values are evaluated statistically and shown in the WEIBULL diagram. This diagram indicates the $F_{10}$ or $F_{50}$ running times (h), i.e. where 50% or 10% of the bearings will probably fail due to the selected test parameters and the lubricant.

Test result
Running times $F_{10}$, $F_{50}$ with 90% confidence range, failure time $\beta$
Test DIN 51 821 – 02 – A / 1500 / 6000 – 160

\[ F_{10} = 110 \text{ h} \]
\[ F_{50} = 200 \text{ h} \]

* in rolling bearing catalogues also called L10 and L50

**Explanation:**
With the test parameters of the assembly A

Axial test load \( F_A = 1500 \text{ N} \)
Test speed \( n = 6000 \text{ rpm} \)
Test temperature \( \theta = 160 \text{ °C} \)

- 10% of the test bearings achieve a lifetime of 110 h
- 50% of the test bearings a lifetime of more than 200 h
- A longer service life is possible by relubricating in-time

![Example WEIBULL diagram acc. to DIN 51 821, pt. 2](image)
**Scope**
Determination of the service life and the upper service temperature of lubricating greases in rolling bearings subject to high speeds and low axial and radial loads

**Standard**
SKF-ERC, Nieuwegein, Netherlands
Klüber test conditions

**Test specimen**
10 deep groove ball bearings
6204 - 2Z - C3 / VM 104
up to 180 °C
(shielded on both sides)

10 deep groove ball bearings
6204 - 2Z - C3 - **S2** / VM 104
180 to 240 °C

**Test conditions**
- Axial load: 100 N (standard)
- Radial load: 50 N (standard) *per bearing*
- Speed: 10,000 (standard) variable up to 30,000 rpm
- Temperature: Room temperature up to 240 °C
- Grease quantity per bearing: 1.5 cm³ = 35% fill

**Test procedure**
- Clean, dry and lubricate the test bearings
- Fix the test bearings in the test units
- Set the test parameters
- Carry out the test run
- Record the running time
- Similar to the FAG-FE 9 rolling bearing grease tester the L₁₀ and L₅₀ values are determined by means of the WEIBULL diagram

**Test result**
Running times L₁₀, L₅₀ with 90% confidence range. Failure time β

* optional 100 N, 150 N, 200 N ... up to 800 N per bearing
1 Test unit
1.1 Heating
1.2 Test bearing
1.3 Drive shaft
1.4 Temperature sensor
1.5 Driving belt
1.6 Electric motor on articulated rocker
2 Switch on/off (electric motor)
3 Time meter
4 Heating control
5 Main switch

---

**Drawings of test rigs**

---

**ROF grease service life**

- Run No.: 1024
- Grease: M 97/89, Test grease A
- Batch: # 612345
- Filling quantity (cm³): 1.5
- Speed n (min⁻¹): 10,000
- Axial load F_A [N]: 100
- Radial load F_R [N]: 50
- Temperature θ_AR [°C]: 150

Test evaluation:
- L₁₀ = 130 h
- L₅₀ = 280 h
- β = 2.45 (gradient)

<table>
<thead>
<tr>
<th>Bearing Running time [h]</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
</tr>
</tbody>
</table>

---

**WEIBULL diagram**
6.14
FE-8 rolling bearing lubricant tester

Scope
Determination of the service value of lubricants for rolling bearings under realistic operating conditions

Standard
DIN 51819 FAG, Schweinfurt, Germany

Specimen
2 angular contact ball bearings 536050 (corr. to 7312 B) or
2 tapered roller bearings 536048 (corr. to 31312 A) or
2 cylinder roller thrust bearings 81212 or
4 spherical roller bearings 21312

Test conditions
Duration of test: 500 to 1500 h for grease;
80 h for oil
Load: 5 to 100 kN, variable
Speed: 7.5 to 6000 rpm in steps
Temperature: ambient temperature to 150 °C

Test procedure
- Clean, weigh and lubricate the test bearings
- Assemble the test head
- Mount the test head in the test machine
- Connect measurement devices
- Set the temperature and speed and start the test
- Monitor the test by PC and record the test data
- Disassemble and weigh the test bearings, evaluate the PC records

Test results
Friction torque and temperature curve in the bearing. Determination of the wear on rolling bearing components
Scope
Anti-wear behaviour of lubricating greases in rolling bearings subject to minor oscillating rolling and sliding movements and constant load. The term “False Brinell Test” is used because the wear pattern is similar to the result of the Brinell hardness test.

Standard
SNR Roulements, Annecy/France
Klüber test conditions

Specimen
2 thrust ball bearings BP 10071
d = 35.2 mm, D = 55.5 mm, H = 16 mm
2 thrust ball bearings FAG 51206
d = 30 mm, D = 52 mm, H = 16 mm
2 cylindrical roller thrust bearings
SKF WS 81206
d = 30 mm, D = 52 mm, H = 16 mm

Test conditions
Axial load: 8000 N
(Hertzian pressure 2100 N/mm²)
Duration of test: 5 or 50 h
Frequency: 24 Hz
Oscillation angle: ± 3°
Temperature of lower bearing ring: – 20 °C or + 25°C

Test procedure
❑ Clean, weigh and lubricate the test bearings
❑ Mount the bearings in the test rig
❑ Set the test parameters and start the test
❑ Disassemble, clean and weigh the shaft and housing disks of the bearings after end of test
❑ Document the weight losses, the appearance of the bearing elements and evaluate the lubricating grease

Result
Weight loss [mg] of the bearing rings.
Depth of grooves
6.16
Low-temperature torque tester – IP 186

Scope
Determination of the rotational resistance of rolling bearing greases at low temperatures and determination of the lower service temperature

Test standard
IP 186

Specimen
Precision separable ball bearings
RHP 7204 TU EP 9
d = 20 mm, D = 47 mm, B = 14 mm

Test conditions
Temperature: up to – 73 °C
Axial load: 4.5 kg
Grease quantity in the bearing: 2.5 cm³
Duration of cooling down to test temperature: 1 to 1.5 h
Holding time of test temperature: 2 h
Final running time of the traction rope drive: 60 min = 60 revolutions

Procedure
❑ Mount the greased test bearing in a vertical spindle surrounded by a cooling jacket and submit it to axial load. Rotate the bearing in order to distribute the grease evenly
❑ Cool the test spindle in the cooling bath to test temperature
❑ Upon termination of the static period at a constant temperature move the test bearing via a Bowden control at constant speed
❑ Measure and record the Bowden cable force and the temperature of the rolling bearing outer ring during the cooling, static and running time
❑ Convert the force to torque

Evaluation of the recordings
Bowden cable
Starting torque: 183 N mm
Running torque: 41 N mm
Test temperature: – 42 °C, constant
Tested lubricant: CENTOPLEX 1 DL

For comparison:
To determine the lower service temperature of rolling bearing greases the following non-standard torque limit values are accepted:

- Starting torque < 1 000 N mm
- Running torque < 100 N mm
Result

- Driving torque required to loosen the test bearing during start-up of the Bowden cable (starting torque)
- Driving torque required to rotate the test bearing by the end of the test (running torque)

The following parameters are recorded:

- Cooling speed of the test bearing
- Constancy of the test temperature during the test time and the measurement
6.17
Low-temperature torque test rig – ASTM D 1478

Scope
Determination of the rotational resistance of rolling bearing greases at low temperatures and determination of the lower service temperature

Standard
ASTM D 1478

Specimen
Open deep groove ball bearing size 204 20 BC 0210 – AFBMA Code
D = 47 mm, d = 19 mm, B = 14 mm

Test conditions
Test temperature: to – 54 °C
Radial load (incl. tilts): 454 g (total mass from part 8, 9, 11)
Bearing grease fill: level fill to bearing ring, no air inclusions
Cooling time to test temperature: 1 to 1.5 h
Test temperature hold for: 2 h
Running time of the Bowden cable drive: 60 min = 60 revolutions
Friction torque measuring range: 0 to aprox. 3000 Nmm

Procedure
❑ Mount the fully filled test bearing in a pulley with screwed on load disc connected via rods. This disc generates a skewed load on the bearing between the outer and inner ring in addition to the radial load
❑ Cool the bearing down to the required temperature and hold it
❑ Rotate the bearing inner ring (by motor) at constant speed
❑ Measure and record the Bowden cable force and the temperature of the bearing outer ring during the cooling, rest and running time
❑ Convert the force to friction torque

Result
See IP 186 (see pages 34/35)
– starting torque
– running torque resulting in the lower service temperature of rolling bearing greases

Low-temperature torque tester, principle
6.18
Rolling bearing torque tester

Scope
Starting and running torques of lubricants in rolling bearings

Standard
Klüber test conditions

Specimen
Deep groove ball bearings 6202 2 ZY HG

Test conditions
Duration of test: 1 h, variable, standard per test run
Speed: 3500 rpm, variable, standard
Axial load: 10 N, constant
Lubricant fill in the bearing: grease: 30 % of the empty space, oil: 20 µl per ball

Procedure
☐ Clean the bearing in an ultrasonic bath
☐ Fill the bearing with grease or oil and mount it in the test rig
☐ Run the test for 60 min; record the friction torque during the whole running time
☐ Repeat the test twice
☐ 1 h after third test run: determine torque for new start

Result
Determination of the starting and restarting torque and recording of the friction behaviour
Scope
Determination of load-bearing capacity in boundary and mixed friction regime

Standard
DIN 51347 parts 1 and 2

Specimen
Test ring, outer diameter 25 mm, and test cylinder, 18 mm x 18 mm

Test conditions
Duration of test: Drip-off time of oils 60 s
Runtime 30 s
Speed: 940 rpm ≈ 1.23 ms⁻¹
Radial load: 400 N
Grease film thickness: 1 mm (scraper)
Test media: Greases, pastes, oils, cutting fluids, coolants

Procedure
- Prepare a defined lateral surface on the test ring using a grinding file (silicon-carbide)
- Clean specimen
- Mount specimen and apply lubricant to test ring
- Wait for 30 s
- Apply load by lowering lever arm with weight
- Wait for 30 s
- Start test
- Upon completion of the test (30 s), remove load
- Repeat test twice as described
- Dismount test cylinder upon completion of third test
- Measure the three wear marks on the test cylinder

Result
Load-bearing capacity B calculated in N/mm².

Test setup

Specimen in place

Lubricant tester acc. to Brugger
6.20

**Grease tester FTG 2**

acc. to Vogel / Marawe

**Scope**
Determination of oil separation in greases subject to pressure, hardening of thickener

**Standard**
Test description by Messrs. Vogel

**Specimen**
Filtering paper

**Test conditions**
- Duration of test: 24 h
- Grease volume: 2.5 cm³
- Load acting on grease: 20 bar
- Temperature: 23 °C ± 2 K

**Procedure**
- Acclimatise tester and specimen in heating cabinet
- Fill test cylinder
- Place filtering paper on compression plate
- Close test cylinder
- Apply compression load
- Read measured distance after 3 s (in heating cabinet)
- Remove load and read measured distance after 24 h
- Open seat valve and drain grease that is still viscous
- Measure thickness of hardened grease
- Remove hardened grease
- Evaluate test results and generate test log

**Result**
Oil separation and thickness of hardened grease

---

**Test setup**

---

**Test procedure**

---
6.21  
GRW noise tester

Scope  
Determination of running noise characteristics of a grease used in rolling bearings in high and low bands as well as peaks; acoustic evaluation (loudspeaker)

Standard  
Test description by GRW

Specimen  
Uncapped deep groove ball bearings with the following inner diameters: 4 mm, 5 mm, 6 mm, 8 mm, 12 mm, 15 mm

Test conditions  
Duration of test: 45 s/bearing in standard test  
Pickup: acceleration sensor  
Speed: 3000 rpm  
Axial load: approx. 10 N (manual)  
Test conducted with: 5 to 10 test bearings  
Grease quantity: approx. 20 mg at 684 frequency response: high frequency band 1.6 to 5 kHz, low frequency band 500 Hz to 1.6 kHz  
Displays: high frequency band, low frequency band, peaks in dB

Acoustic evaluation via loudspeaker

Procedure  
❑ Switch on spindle, amplifier and computer  
❑ Mount prepared test bearing No.1 to spindle, apply axial load, start data recording. Verify reference values of oiled bearings.  
❑ Fill grease injector with grease to be tested  
❑ Grease one side of bearing No.1 using the metering device (weigh grease accurately)  
❑ Mount bearing No.1 to the spindle, apply axial load, record high and low frequencies and peaks by means of data recording system, start plotter and checked data for “greased” bearings (compare measured values with nominal values)  
❑ Conduct same test with bearings No.2 to 10  
❑ Evaluation on PC

Result  
In dB, (frequency bands and peaks), cracking (acoustic evaluation).  
Exemplary result 45-38-48 o.k.  
– cracking 1–5  
1–3 o.k.  
4–5 not o.k.
Scope
Extreme-pressure and wear behaviour of lubricating oils, dispersions, greases and pastes

Standard
Wieland test description

Specimen
1 steel shaft Ø 6.3 mm
2 steel half bearings Ø 6.5 mm

Test conditions
Sliding speed: 0.066 ms⁻¹
Test load: 0 to 20 kN
Temperature: ambient temperature
Type of friction: sliding friction

Procedure
❑ Clean and mount specimen
❑ Apply lubricant; use spatula for greases (half bearings); for oil lubrication fill pan
❑ Set revolutions counter to zero
❑ Start test run
❑ Increase pressure every 100 revolutions (30 s) until maximum load (20 kN) is reached or the shaft ruptures or excessive wear occurs (friction coefficient no longer indicated)
❑ Record friction coefficient indicated for each load stage (tilting motor with indicator scale)

Result
Rupture load, abrasion and friction force
Scope
Evaluation of rolling bearing greases under real-life thermal and dynamic conditions

Test principle
Short-time tests of lubricant behaviour in rolling bearings under high dynamic and thermal stress. The lubricant is evaluated at high speeds, varying temperatures and under axial load. The result is evaluated visually, but both bearing temperatures and the frictional torque are also recorded continuously.

Standard
Klüber test conditions

Specimen
Tapered roller bearing 30206 A, special design by FAG
Angular contact ball bearing 7206 B, special design FAG 529689
Various spindle bearings

Test conditions
Grease quantity: depending on bearing type
Duration of test: 2 h under steady-state conditions
2 h under temperature
2 h heating up
Time is variable for long-time test runs
Temperature: ambient to 180 °C
Axial load: 500 to 1500 N
Speed: 1500 to 10,000 rpm

Procedure
❑ Start measurement program for reference run with oiled test bearings
❑ Grease and mount test bearings
❑ Set test parameters
❑ 120 min steady-state run without heating; then approx. 60 min with heating; 120 min under temperature; record frictional torque and temperature curves; visual inspection
❑ Dismount bearings and evaluate test result

Result
Frictional torque and temperature curve; evaluation of adhesion and lubricant behaviour during the test run (oil/grease loss, oil mist, wetting of cage and rolling elements, air emulsion, participation in circulation), grease collar formation (lubricant reservoir, sealing effect, etc.); the test serves for making a preliminary selection prior to rolling bearing life tests (e.g. ROF or FE 9).
6.24
FAG vibrational quality test rig MGG 11

Scope
Determination of noise level, starting-up behaviour and noise dampening of a lubricating grease

Standard
FAG directive QV 3.102 FB
Klüber test conditions

Specimen
Deep groove ball bearings 608

Test conditions
Duration of test: 2 x 64 s per bearing
Pickup: Speed sensor
Speed: 1800 rpm
Axial load: 20 N (pneumatic)
Test with: 5 test bearings (standard)
Grease quantity: approx. 0.33 g / bearings
Frequency response: low frequency band 50 to 300 Hz
medium frequency band 300 to 1800 Hz
high frequency band 1800 to 10,000 Hz
Display: 3 frequency bands (ms⁻¹ rad⁻², analog display in %)
Acoustic evaluation via loudspeaker

Procedure
- Start measurement program for reference run with oiled test bearings
- Mount prepared test bearings to spindle, apply axial load and verify reference conditions one by one
- Fill external metering device with grease to be tested; avoid bubbles
- Lubricate bearings 1 to 5, mount them to spindle, record measurement results
- Start evaluation program
- Print out test results

Result
Noise classes I to IV and starting-up values 1 to 9.
Result examples:
II/1: grease in good condition
III/2: grease in poor condition
6.25
Zwick elastomer friction tester

Scope
Determination of static and sliding friction of elastomers

Standard
DIN 53 375
Klüber test conditions

Specimen
Elastomers

Test conditions
Duration of test: standard approx. 1 h
Sliding speed: 0.1 to 800 mm/min
Friction force: max. 10 N

Procedure
- Fix test plate carrying defined material/surface
- Affix elastomers to be tested underneath carriage
- Apply weight load to carriage
- Start test program
- Repeat measurement five times
- Record and print out result

Result
- Static friction coefficient
- Sliding friction coefficient
- Distance / friction-coefficient diagram
6.26

Press-Fit test

Scope
Determination of sliding friction and static friction coefficients of lubricants operating under high loads (in the mixed and boundary friction regimes) and detection of stick-slip, groove formation or fretting.

Standard
Ford specification

Specimen
Pin (length 50 mm) with a diameter of 19.075 mm
Thick-walled bushing of same surface quality (inner diameter 19.050 mm) and 44 mm length

Test conditions
Duration of test: approx. 30 min
Sliding speed: 15 mm · min variable
Contact geometry: surface

Procedure
❑ Clean specimen
❑ Measure and mark biggest outer diameter of bushing
❑ Apply lubricant to the operating surfaces of both specimens
❑ Insert specimens into press
❑ Set press dynamometer to zero
❑ Press pin into bushing
❑ If the setup start to vibrate, or when the ram reaches the ring mark, stop pressing and remove ram
❑ Remove specimens and let cool to ambient temperature
❑ Calculate sliding friction coefficient from the increase in outer bushing diameter, using the pressure force and the correction factor from the table

Result
Sliding friction coefficient (optional: static friction coefficient during pressing-out, joint pressure) and load when stick-slip occurs

Test setup

Measurement of bushing

Total view
6.27

SKF BeQuiet
grease noise test rig

Scope
Quantitative determination of grease noise characteristics in a rolling bearing by measuring noise peaks and frequency bands (optional).

Standard
SKF test description

Specimen
Deep groove ball bearing 608/QE4

Test conditions
Duration of test: approx. 40 min, standard test
Pickup: speed sensor
Speed: 1800 rpm
Axial load: 30 N (pneumatic)
Test with: 1 bearing (standard)
Grease quantity: automatic time-related metering, approx. 150 mg

Frequency response:
- Low frequency band: 50 to 300 Hz
- Medium frequency band: 300 to 1800 Hz
- High frequency band: 1800 to 10,000 Hz
Peak filter:
- Pre 300 to 10,000 Hz
- Post 25 to 400 Hz
Display: µm/s; peak
Acoustic monitoring via loudspeaker

Procedure
- Lubricate new test bearing with two drops of anticorrosion oil
- Start test program, mount test bearing
- Fill grease injector without causing bubbles, insert into metering unit and connect to grease line
- Apply axial load
- Lower pickup and start spindle
- Perform reference test run; if okay, start automatic test run (with grease)
- Upon completion of the test, start evaluation program and output data

Result
Bequiet classes 1 to 4 in %; Grease noise classes GN4 (very good) to GNx (very poor).
Option: starting-up behaviour and dampening
6.28
Timken machine

**Scope**
Determination of wear data and extreme-pressure characteristics of fluid and consistent lubricants

**Standard**
DIN 51 434 parts 1 to 3  
ASTM D 2782  
ASTM D 2509

**Specimen**
Test ring, outer diameter 49.22 mm and test block, 12.32 mm x 12.32 mm x 19.1 mm

**Test conditions**
- Speed: 800 rpm  
- Duration of test: 10 min  
- Load: max. 100 lbs

**Procedure**
- Fill lubricant to be tested into receptacle  
- Switch on heating to preheat lubricant  
- Clean and weigh specimens  
- Assemble test setup mounting specimens and lever arm  
- Apply test load and switch on spindle  
- Inspect specimens after ten minutes for fretting marks  
- The maximum load without fretting marks is the OK load  
- Determine wear (in mg) by weighing the specimens

**Result**
OK load and wear
The many tests described in section 5 produce a tremendous amount of data whose interpretation and translation to the original system is quite difficult – even for an expert. This is why Klüber Lubrication concentrates on testing specific characteristics in special component tests which are closer to actual use and provide a quicker solution.

These components are tested under reproducible conditions using sophisticated testing and measuring equipment. From the results conclusions may be drawn as to the lubricant’s behaviour in terms of friction and wear and respective R&D or consulting activities.

## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1</td>
<td>Klüber worm gear oil tester</td>
<td>49</td>
</tr>
<tr>
<td>7.2</td>
<td>Klüber high-temperature chain tester</td>
<td>50</td>
</tr>
<tr>
<td>7.3</td>
<td>Klüber drive chain tester</td>
<td>51</td>
</tr>
<tr>
<td>7.4</td>
<td>Brückner test</td>
<td>52</td>
</tr>
<tr>
<td>7.5</td>
<td>Klüber bicycle chain test rig</td>
<td>53</td>
</tr>
<tr>
<td>7.6</td>
<td>Klüber water valve tester (stick-slip)</td>
<td>54</td>
</tr>
<tr>
<td>7.7</td>
<td>Klüber water valve tester (life-test)</td>
<td>55</td>
</tr>
<tr>
<td>7.8</td>
<td>Oscillating slide plate test rig</td>
<td>56</td>
</tr>
<tr>
<td>7.9</td>
<td>Railway point test rig</td>
<td>57</td>
</tr>
<tr>
<td>7.10</td>
<td>Oscillation friction wear tester</td>
<td>58</td>
</tr>
<tr>
<td>7.11</td>
<td>Test rig for electrical contacts</td>
<td>59</td>
</tr>
<tr>
<td>7.12</td>
<td>Trolley bearing test rig</td>
<td>60</td>
</tr>
<tr>
<td>7.13</td>
<td>Wire rope test rig</td>
<td>61</td>
</tr>
<tr>
<td>7.14</td>
<td>Klüber pulley test rig</td>
<td>62</td>
</tr>
<tr>
<td>7.15</td>
<td>Klüber spindle bearing test rig</td>
<td>63</td>
</tr>
<tr>
<td>7.16</td>
<td>Ball joint test rig</td>
<td>64</td>
</tr>
<tr>
<td>7.17</td>
<td>Grease depressurisation test rig</td>
<td>65</td>
</tr>
</tbody>
</table>
7.1 Klüber worm gear oil tester

Scope
Evaluation of the worm gear lubricating fluid under conditions similar to actual use

Standard
Klüber test conditions

Specimen
High-performance worm gear with wheel set (worm wheel and worm shaft) of varying tooth geometry

Transmission ratio: 1 : 39 (standard)
Center distance: 63 mm

Test conditions
Drive speed: variable, up to 1200 rpm, 350 rpm as standard
Driven torque: variable, up to 500 Nm, 300 Nm as standard
Running-in time: 50 h
Duration of test: 300 h
Oil quantity: 600 ml (immersion lubrication)
Housing temperature: max. 100 °C

Procedure
❑ Clean the gear components
❑ Install the gear in the test unit and connect it to the measuring sensor system
❑ Fill in the lubricant and heat to the required oil temperature
❑ Set the test conditions
❑ Run the test and record the measuring values by means of a computer

Result
Determine the wear of the worm wheel by weighing the wheel before and after the test.
By means of the continuously recorded measuring values conclusions may be drawn as to the efficiency, the lubricating condition (mixed and fluid friction) between the worm wheel and the shaft, wear of the worm wheel flank and temperature curve.
7.2 Klüber high-temperature chain tester

Scope
This test rig allows an evaluation of high-temperature chain oils under reproducible conditions similar to actual use. Since the thermal and not the mechanical load is the critical parameter, this test mainly determines the effect of temperature on the chain oil behaviour.

Standard
Klüber specification

Specimen
Roller chain DIN 8187–16 B – 1 x 37 E
Chain wheel disc DIN 8187, 50–16 B

Test conditions
Temperature: 200 to 220 °C, max. 300 °C
Speed: min. 0.5 m · min⁻¹; max. 4.8 m · min⁻¹
Load: weight of approx. 2.6 kg
Duration of test: variable up to 999 h

Procedure
Four enclosed chains run in a hot cabinet individually driven by speed-variable gear motors located outside the cabinet. The chains are suspended from the upper driven chain blades and are exposed to a load or tension high enough to ensure correct chain circulation. This load is provided by the lower chain blades equipped with weights suspended freely from the chains.

Result
If paint-like residues form in the lubrication gaps at higher temperatures the necessary starting torque of the respective chain rises. When exceeding a certain limit value set at the current monitor of the gear motors prior to the test the “over-loaded” driven section is automatically switched off. The service hours and the number of chain cycles achieved until switch-off are recorded. These values are used to evaluate the performance of chain lubricants. The main parameters are the wetting of the active surfaces, especially of the chain pins and bushes, formation of residues, method of dissolving the residues by means of fresh oil.
7.3 Klüber drive chain tester

Scope
Behaviour of chain lubricants under actual service conditions and influencing factors

Standard
Klüber test conditions

Specimen
Roller chain 1/2"
DIN 8187 – 08 B – 1 x 82 E

Test conditions

- **Speed:** 0.1 to 8 ms\(^{-1}\)
  - standard: 1.6 / 2.4 / 4.8 ms\(^{-1}\)
- **Strand force:** 200 N to 3500 N
  - standard: 1500 N / 1000 N / 200 N / 500 N / 800 N
- **Ambient temperature:** – 40 to 150 °C
  - standard: room temperature
- **Duration of test:** up to 1000 h
  - standard: 150 h

Procedure

- Apply lubricant on two test chains
- Mount the chains in the test rig
- Set the test parameters
- Record and document the service parameters and tribological data

Result

A
Wear and friction values by continuously recording the
- Chain length
- Electric power consumption and change of the drive motor (friction)
- Drive torque (non-standard)
- Temperature of the circulating test chains
- Speed, load and strand force (load parameters)

B
- Running time until reaching the defined chain elongation, e.g. 0.1%
Scope
Determination of grease loss in deep groove ball bearings (vertical position of shaft and rotating outer ring) exposed to dynamic and thermal load

Standard
Klüber test conditions

Specimen
Deep groove ball bearing
INA special bearing LR 202 KAH 02
Dimensions: Ø 40 x Ø 15 x 11 mm with shields

Test conditions
To test one lubricant type 5 test bearings are mounted on a shaft and installed vertically in a heating cabinet. The inner rings are fastened; the outer rings rotate. The test parameters are variable.

- Duration of test: 200 h as standard
- Test temperature: room temperature up to 300 °C
- Speed: 1800 to 3600 rpm as standard

Procedure
- Number the test bearings
- Clean the bearings and shields in an ultrasonic bath
- Fill the bearings with grease and mount the shields
- Weigh the bearings
- Mount and tighten the bearings on the shaft
- Mount the shaft with test bearings in the heating cabinet
- Set the test parameters (temperature, speed, duration of test)
- Start the test

Result
The grease loss in the 5 test bearings is measured, the average grease loss per bearing calculated in percent
7.5 Klüber bicycle chain test rig

Scope
Determination of the efficiency of bicycle chains

Standard
Klüber test conditions

Specimen
2 high-performance racing bicycle chains per test

Test conditions
- Speed:
  - uphill 60 rpm
  - time trial 100 rpm
- Chain transmission:
  - uphill 39/21
  - time trial 53/13
- Simulated performance:
  - uphill 450 W
  - time trial 450 W
- Chain tension (per chain):
  - uphill 900 N
  - time trial 400 N
- Test duration:
  - uphill 4 h
  - time trial 4 h

Procedure
- Clean chains and sprockets
- Lubricate and mount chains
- Run-in for 5 minutes at low load
- Run test for 4 hours under test conditions for uphill and time trials
- Record and evaluate data

Result
- Determination of chain efficiency over the whole test duration
Scope
Operating torque and smoothness when opening the upper water valve part. The friction curve, stick-slip and breakaway torque of the upper water valve parts are measured and evaluated.

Standard
in acc. with DIN EN 200,
GROHE in-house standard
GSO - 412 - 1

Specimen
Valve upper parts with a nominal width of 1/2"

Test conditions
Water temperature: 70 °C
Closing torque: 2.5 Nm
Static pressure: 6 bar
Flow pressure: 5 bar

Result
The closing and opening torques are recorded graphically with reference to the opening angle. To evaluate the operational smoothness the upper valve part is actuated under the above conditions and rated in acc. with the table shown.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 = uniform sliding</td>
<td>good</td>
</tr>
<tr>
<td>1 = slight stick-slip</td>
<td>satisfactory</td>
</tr>
<tr>
<td>2 = perceptible stick-slip</td>
<td>still satisfactory</td>
</tr>
<tr>
<td>3 = pronounced stick-slip</td>
<td>not acceptable</td>
</tr>
<tr>
<td>4 = extreme stick-slip</td>
<td>not acceptable</td>
</tr>
</tbody>
</table>

Evaluation of the operational smoothness
Scope
Endurance characteristics of greases in water valve upper parts under conditions similar to actual use

Standard
in acc. with DIN EN 200,
GROHE in-house standard
GSO - 412 - 1

Specimen
Upper parts of valves with a nominal width of 1/2"

Test conditions
Duration of test: 500,000 opening/closing cycles
Water
temperature: 18 °C or 70 °C
Closing torque: 2.5 Nm
Static pressure: 5 bar
Flow pressure: 3 bar

Procedure
- Apply the lubricant to be tested to the upper valve part
- Mount the upper parts in the test unit
- Connect the operating mechanisms to the spindles of the upper parts
- Set the test parameters
- Start the test
- Check at certain intervals

Result
Number of opening/closing cycles obtained without stick-slip
7.8 Oscillating slide plate test rig

Scope
Determination of friction and wear behaviour of material pairings in oscillating sliding contact

Standard
Klüber testing conditions

Specimen
Sliding tongues made of metal, 80 x 20 x 4 mm, or with plastic 2 times 80 x 20 x 2 mm, opposing body for linear, point-to-point and surface contact; e.g. balls or cylinder
Material: depending on requirements

Test conditions
Sliding speed: 1 to 150 mm/s
standard 50 mm/s
Load: 50 to 500 N
standard 200 N
Temperature: variable
Geometry: linear, point-to-point, surface
Testing positions: 5
Stroke length: max. 50 mm,
standard 50 mm

Procedure
❑ Reference run of linear drive unit
❑ Set test parameters (PC)
❑ Prepare and mount specimens
❑ Set test force
❑ Set up measurement recording unit (PC)
❑ Perform test (starting linear drive and measurement recording)
❑ Terminate test
❑ Evaluate results (PC)

Result
Determination of friction coefficient, detection of stick-slip, determination of wear depth
7.9
Railway point test rig

**Scope**
Determination of the friction and wear behaviour of lubricants on railway point switch plates

**Standard**
Klüber testing conditions

**Specimen**
Switch plate 420 x 170 mm
Piece of rail, length 200 mm

**Test conditions (variable)**
Duration of test: 30 h
Distance: \( s = 105 \text{ mm} \)
Sliding speed: \( v = 50 \text{ mms}^{-1} \)
Temperature and media

**Procedure**
- Clean specimens (switch plate and piece of rail)
- Apply lubricant onto switch plate
- Mount piece of rail plus additional weight load
- Set testing parameters (PC) and start test

**Result**
Friction curve covering the whole test duration (PC), visual evaluation of wear surfaces
7.10
Oscillation friction wear tester

Scope
Lubricant behaviour under oscillation motion; determination of tribocorrosion

Standard
Klüber test conditions

Specimen
Needle bearing inner ring 25 x 30 x 30 (test ring)
Strip of spring steel, hardened, blue, width 8 mm

Test conditions
Frequency: 50 Hz
Amplitude: ± 1 mm
Load: 150 N/cm² (projected surface pressure)
Duration of test: 3 h

Procedure
❑ Cut steel strip to length
❑ Clean steel strip and test ring
❑ Grease test ring and mount to shaft
❑ Insert and fix steel strip
❑ Start test

Result
Visual determination of the degree of tribocorrosion on steel strip and test ring (0 to 4)
7.11 Test rig for electrical contacts

Scope
Service life of electrical contacts in cars

Standard
Klüber test conditions

Specimen
– Model switch with slide contact
– Original component, e.g. steering columns shift

Test conditions
Assembly: 5 test units with 2 switch contacts each
Duration of test: variable; e.g. 50,000 cycles
Type of test: – control current
– load current
Voltage: 13 V
Current: 100 mA to 56 A max.
Travel speed: 10 to 100 mm/s

Procedure
❑ Switches
– clean
– lubricate
– insert
❑ Start test

Results
❑ Number of switching cycles achieved without exceeding the limit values of transition resistance
❑ Online representation of transition resistance
Scope
Service life of high-temperature greases in trolley bearings for the automotive industry

Standard
Klüber test conditions

Specimen
4” ‘trolley’ rollers (max. five)

Test conditions
Speed: 20 rpm (alternating direction of rotation)
Duration of test: until bearing failure
Temperature: up to 280 °C (250 °C as standard)

Procedure
- Open and clean new bearings
- Grease bearings with lubricant to be tested and close them
- Weigh greased bearings
- Mount bearings in the test chamber
- Close test chamber
- Start heating and drive motor
- Dismount bearings after 1000 hours of testing
- Let bearings cool and then weigh them
- Remount weighed bearings in test chamber
- Restart test, let bearings run until failure/stoppage

Result
Attained runtime in hours, evaluation of lubricant and bearing condition
Scope
Service life of impregnated wire ropes

Standard
Klüber test conditions

Specimen
Wire rope of approx. 5 m length, Ø 1.5 mm
18 pulleys, ø 32 mm

Test conditions
Duration of test: until rupture of rope
Test with: 6 test units
Stroke: 200 mm (variable)
Load: 190 mm stroke with 120 N
10 mm stroke with 200 N
Speeds: (variable)
acceleration to 125 mms⁻¹ in 0.3 s
linear motion at 125 mms⁻¹, slowdown to 0 mms⁻¹ in 0.2 s
Hold time: 0.5 s

Procedure
❑ Cut wire rope to six lengths and affix end sleeves
❑ Lubricate bearings of new pulleys with special grease
❑ Mount pulleys (three pulleys for each rope)
❑ Impregnate ropes with lubricant under vacuum
❑ Mount ropes
❑ Start test rig (with stroke counters set to zero)

Result
Number of double-strokes per rope until rupture
### Scope
Service life of grease-lubricated rolling bearings with rotating outer ring under radial and thermal load

### Standard
Klüber specification

### Specimen
Five deep groove ball bearings 6203 – Cr

### Test conditions
- Radial load: 550 N
- Speed: 13,800 rpm
- Speed factor: 393,300 mm · min⁻¹
- Temperature (inner ring): 120 °C, 140 °C, 160 °C

### Procedure
- Clean, dry and grease test bearings
- Mount bearings in test units
- Set test parameters
- Start test runs
- Record runtime

### Result
Similar to the FAG-FE9 test, the L10 and L50 values are determined applying the WEIBULL diagram

---

**Test setup**

1. Pulley
2. Tension roller
3. Flat belt
4. Steel table
5. Drive pulley
Scope
Service life of grease-lubricated high-speed spindle bearings

Standard
Klüber specification

Specimen
Ten spindle bearings 7010

Test conditions
Axial load: 100 N
Speed: max. 38,500 rpm
Speed factor: max. 2.5 \cdot 10^6 \text{ mm \cdot min}^{-1}

Procedure
- Clean, dry and grease test bearings
- Mount bearings in test units
- Set test parameters
- Perform running-in program
- Start test runs
- Record runtime

Result
Similar to the FAG-FE9 test, the L10 and L50 values are determined applying the WEIBULL diagram

Test setup

- 1 Drive pulley
- 2 Tension roller
- 3 Flat belt
- 4 Steel table
- 5 Spindle unit
7.16
Ball joint test rig

Scope
Friction torques and stick-slip behaviour of lubricants in ball joints

Standard
Klüber test conditions

Specimen
Stabiliser joint
Supporting joint

Test conditions
Rotating speed
(continuous adjustment): 2 to 100°/sec
Axial load in three steps: 0.2 kN; 1 kN; 2 kN
90° angle of rotation

Procedure
❑ Grease ball joint
❑ Mount ball joint to device
❑ Rotate joint by 90° five times
❑ Evaluate measurement results on PC

Result
Breakaway and frictional torque determined through recorded measurement result, detection of stick-slip

Results diagram

Mounting device

1  Base plate
2  POM cage
3  Disk spring
4  Ball joint
5  Tension plate
7.17
Grease depressurisation test rig

Scope
Depressurisation behaviour of greases in centralised lubricating systems

Standard
DIN 51 816, part 2 (February 1978)

Specimen
-

Test conditions
Temperature: – 10 to 40 °C
Pressure: max. 50 bar

Procedure
❑ Feed grease into line
❑ Heat up line to specified temperature
❑ Apply pressure
❑ Open stop valve
❑ Determine pressure drop using a pressure gauge

Result
Pressure drop as a function of time and temperature. For comparison, the pressure drop values after 3 min and after 10 min are normally used.

Test setup

Depressurisation behaviour of lubricating greases (example greases A and B)
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