KLÜBER LUBRICATION

your global specialist

Detailed information

Lubricant testing.

Focussing on mechanico-dynamical tests

Contents

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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's 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

Parameters	Test	Notes
Colour/colour code	DIN 51 411 ISO 2049	Determination of colour with colorimeter or the so-called Saybolt colour code
Density	DIN 51 757	Quotient of the mass of a substance and its volume
Flash point	DIN ISO 2592	Lowest temperature at which an oil gives off vapours that will ignite when a small flame is passed over the surface of the oil
Ash content	DIN 51 575 DIN EN 7	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
Viscosity	DIN 51 561	Measure of the inherent resistance of a fluid against flow **Dynamic viscosity:** viscosity with respect to density Unit: Pa s or N s/m^2 **Kinematic viscosity:** viscosity-density ratio Unit: mm^2/s
Demulsibility	DIN 51 589	Ability of oil to separate from water
Saponification number	DIN 51 559	Expressed in milligrams of potassium hydroxide needed to neutralize the free acids in one gram of oil and to saponify the esters contained therein
Pour point	DIN ISO 3016	The lowest temperature at which the oil sample will pour or flow under prescribed conditions
Viscosity-temperature relationship (VT)	DIN 51 563	Flow properties of a lubricating oil in relation to temperature
Viscosity Index (VI)	DIN ISO 2909	Rate of change in viscosity of an oil within a given temperature range
Evaporation loss	DIN 51 581	Determination of the oil evaporation loss at elevated temperatures
Viscosity-pressure relationship (VP)	–	Viscosity of a lubricating oil in relation to pressure
Water content		**Quality test:** When heating oil in a test tube to > 100 °C a smacking sound can be heard when the water evaporates **Quantity test:** Sample oil and xylol or hydrocarbon, e.g. SBP naphta, is heated to > 100 °C in a distillation trap; the distilled water is caught in a measuring device
Air separation ability	DIN 51 381	Determination of dispersed air in a lubricating oil

Table 1.0 b: Chemico-physical characteristics of lubricating greases

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

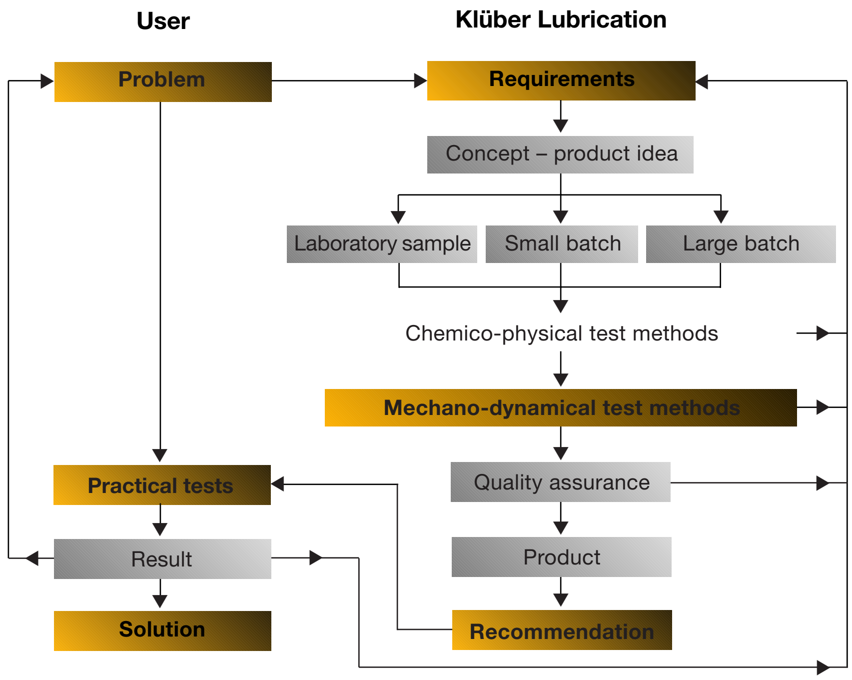


Fig. 1: Flow chart: Lubricant development

3.0
Test methods

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

Category	Type of test		Symbol
I	Operating conditions or conditions similar to actual use	Practical test (field test)	
II		Test rig	
III		Component test	
IV	Test with model system	Test with unchanged component or scaled down unit	
V		Test with specimens subjected to loads similar to actual use	
VI		Model test with simple specimens	

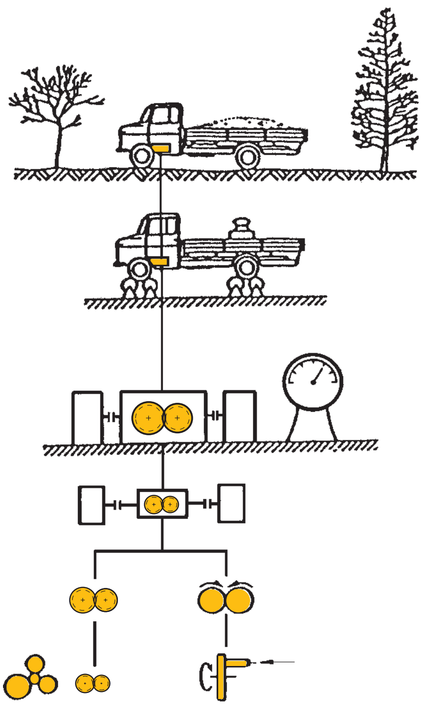


Fig. 2: Categories of mechano-dynamical tests acc. to DIN 50 322

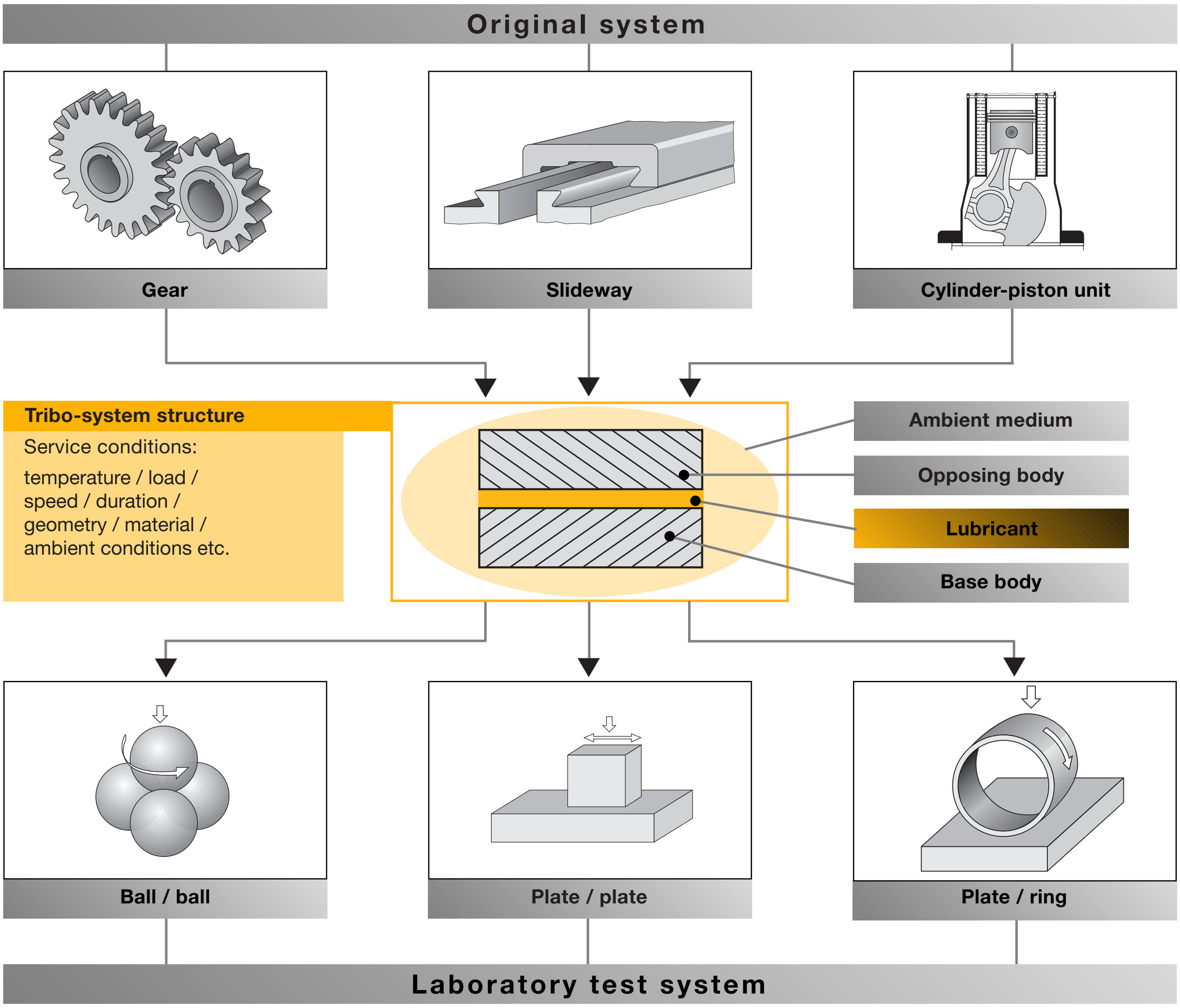


Fig. 3: Modelling of the original by analyzing the tribo-system

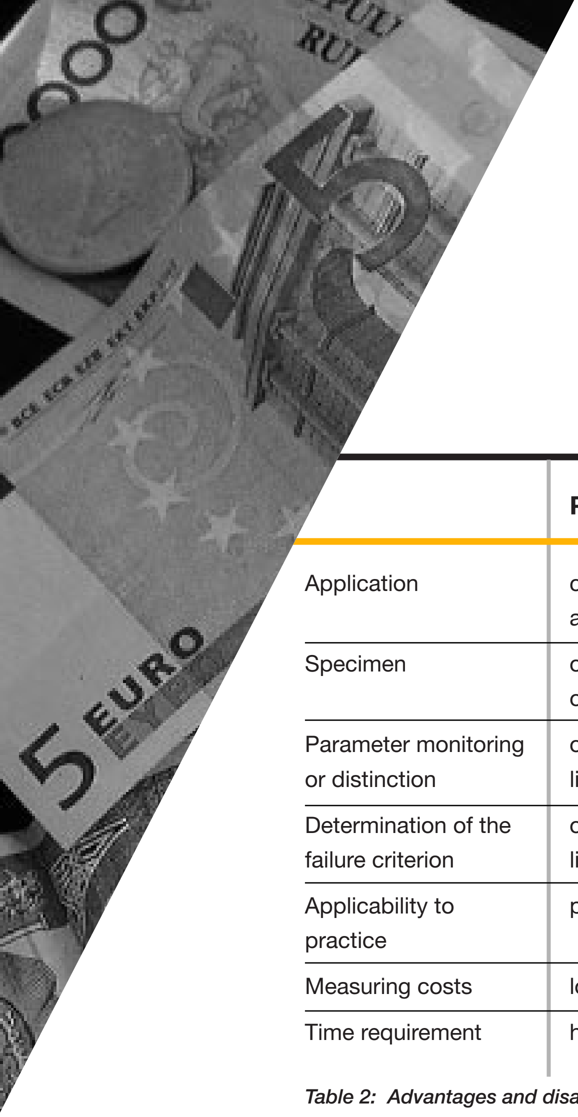
friction and wear behaviour have to be assessed (see Fig. 3).

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; adjustability 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.



	Practical test	Component test	Model test
Application	concrete application	application or development	basic analysis (phenomenon)
Specimen	original machines or devices	in most cases simple machine elements	in most cases simple contact geometry
Parameter monitoring or distinction	only possible to a limited extent	sometimes possible	possible
Determination of the failure criterion	only possible to a limited extent	sometimes possible	possible
Applicability to practice	possible	sometimes possible	only possible to a limited extent
Measuring costs	low to high	medium to high	low to medium
Time requirement	high	medium	low

Table 2: Advantages and disadvantages of test systems

4.0 Benefits and costs of tribological tests

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

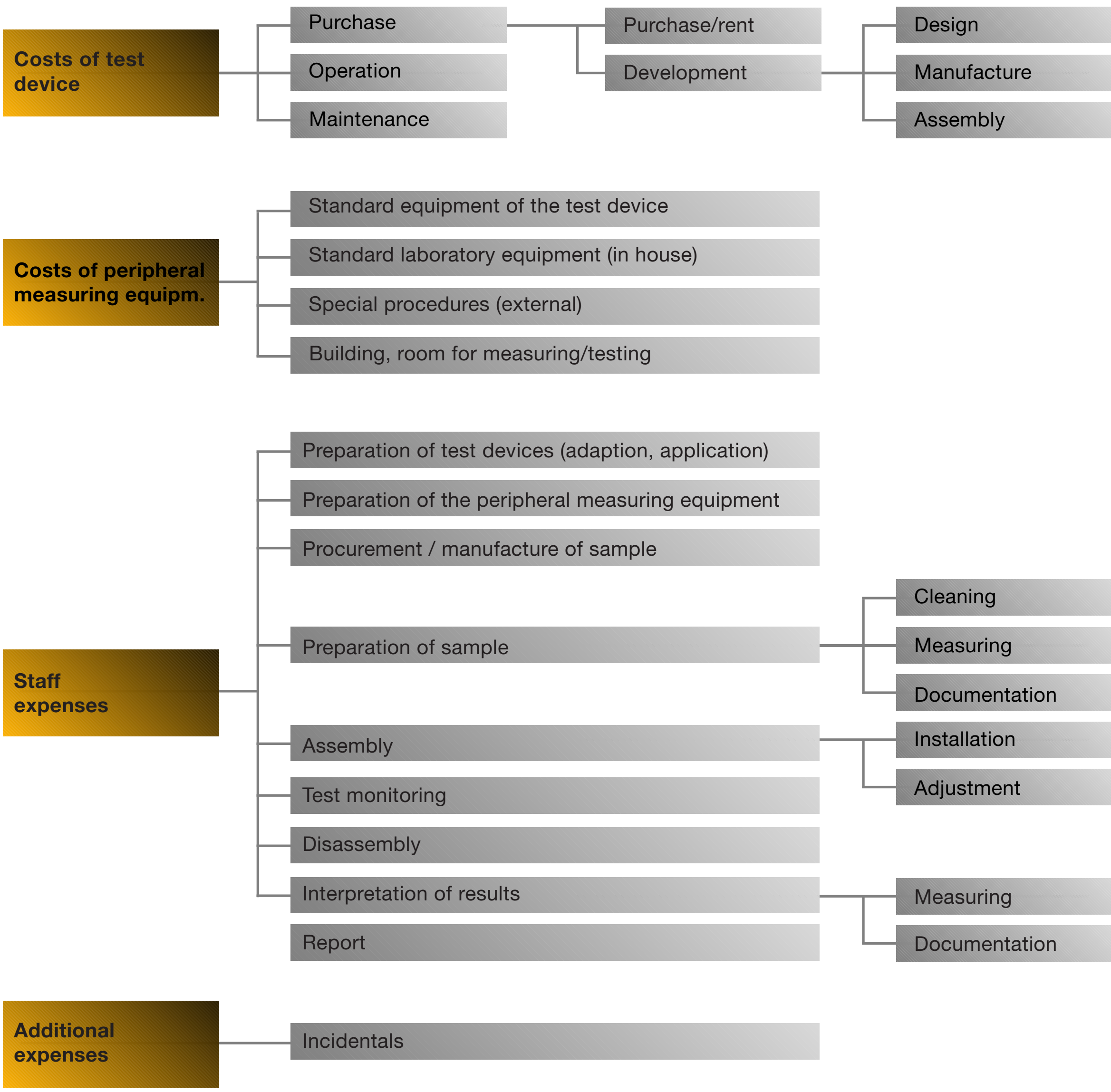
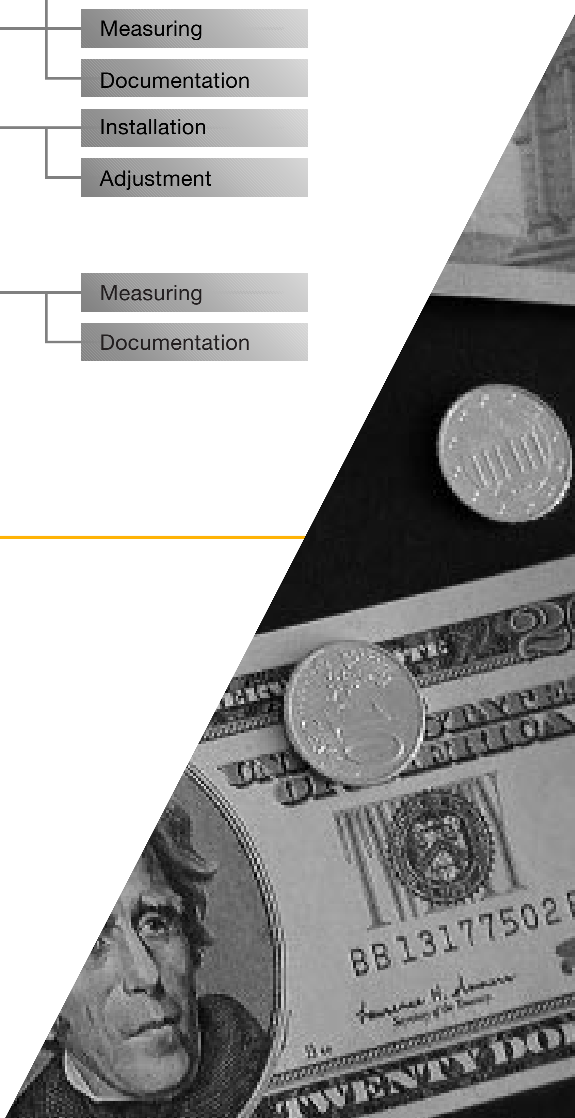


Fig. 4: Breakdown of main costs for tribological tests

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

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

Explanations to column "Application"

ST	sanitary taps	**PT**	pressing tools
PBG	plain bearings and guides	**ET**	edge tools
C	chains	**RB**	rolling bearings
G	gears		

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.

Load	Primary testing parameters	Model, component or unit testing
High temperature	Temperature: 100 to 250 °C, failure time, upper service temperature	Component
Low temperature	Starting and running torque, temperature: – 70 to 0 °C, lower service temperature	
High speeds	Speed: 1,000 to 20,000 (30,000) rpm, failure time	
Low speeds	Speed: 7.5 to 3,000 rpm, weighing of wear, steady-state temperature and frictin torque curve	
Heavy-duty	Axial load up to 80,000 N, weighing of wear, steady-state temperature and friction torque curve	
Medium duty	Axial load 1,500 to 4,500 N (FE 9), radial load up to 800 N (ROF), failure time	
Low duty	Axial load 50 to 200 N, axial load 100 N	
Oscillating motion	Oscillation angle ± 3°, wear in mg	
Stop-and-go operation exposed to media	Corrosion degree (table DIN 51 802)	
Axial load, speed	Solid-borne sound measurement acc. to noise class or level, running-in behaviour	
Axial load, speed, temperature	Friction torque, steady-state temperature, visual rating (oil separation, grease collar, etc.)	
Oscillating motion	Temperature up to 280 °C max., friction coefficient curve, wear	Model
Axial load, speed	Starting and running torque, time-related	Component
Influence of media, speed	Grease loss in % by weight, visual rating	
Temperature, churning	Temperature up to 250 °C, penetration, churning time, visual rating	Model
Load (short-term / permanent), speed, temperature	Welding load, wear scar diameter, shear stability	
Normal load, sliding speed, friction, wear	Temperature up to 150 °C, time-related friction coefficient	

No.	Test/process	Description	Application
18	Klüber high-temperature chain tester	Operating behaviour of lubricating oils	C
19	Tannert sliding indicator	Sliding friction behaviour of lubricants and material pairings	RB, PBG, C, G
20	FZG four square gear oil tester	Antiwear behaviour of fluid greases and oils	G
21	Klüber water valve tester (life test)	Service life of greases in sanitary (water) valves	ST
22	Klüber water valve tester (stick-slip)	Friction behaviour of lubricating greases in sanitary (water) valves	
23	Reichert fretting wear tester	Load-carrying capacity of lubricants and material pairings	ET
24	Brugger lubricant tester	Load-carrying capacity of lubricants and material pairings	PT
25	Press-Fit tester	Stick-slip behaviour of lubricants	PBG
26	Klüber gas cock tester	Friction and stick-slip behaviour of greases	ST
27	Brückner tester	Lubricant behaviour in vertically mounted rolling bearings	RB
28	Klüber worm gear oil tester	Wear and friction behaviour of lubricants	G
29	Klüber drive chain tester	Operating behaviour of lubricating oils	C
30	Oscillating slide plate test rig	Friction and sliding behaviour of lubricants and material pairings	RB, G, C, PBG
31	Railway switch test rig	Friction and wear behaviour of lubricants	PBG

Explanations to column "Application"

ST	sanitary taps	**PT**	pressing tools
PBG	plain bearings and guides	**ET**	edge tools
C	chains	**RB**	rolling bearings
G	gears		

Load	Primary testing parameters	Model, component or unit testing
Temperature, tensile load, speed	Temperature: – 30 to 150 °C, friction and wear, runtime	Component
Normal load, temperature, low sliding speed	Temperature up to 250 °C, sliding speed 0 to 0.48 mm/s, identification of stick-slip, friction coefficient	Model
Load, speed, temperature, wear	Failure load stage, wear	Component, unit
Load cycles, open/close	Cycles achieved at 18 °C and 2.5 Nm closing torque	Component
Opening/closing torque as a function of number of cycles	Friction torque curve as a function of the turning angle at 70 °C, determination of stick-slip	
Sliding under high pressure	Specific surface pressure	
Sliding under high pressure	Specific surface pressure	
Sliding under high pressure and at low speed	Stick-slip, friction coefficient	
Opening/closing cycles under thermal load	Friction coefficient and stick-slip as a function of number of cycles	
High temperature (> 150 °C), alternating direction of rotation, vertical mounting position	Lubricant loss, visual rating	
Sliding under high pressure	Wear curve, efficiency, lubrication condition, temperatures	Unit
Tensile force, speed, temperature	Temperatures from – 20 °C to 150 °C, friction and wear behaviour	Component
Normal load, temperature, medium sliding speed	Temperature < 0 °C to 150 °C, sliding speed 1 to 150 mm/s, stick-slip, wear, friction coefficient	Model
Normal load, temperature, influence of media, sliding speed	Intermittent influence of media, friction force curve, visual rating	Component

No.	Test/process	Description	Application
32	Oscillation friction wear tester	Tribocorrosion and oscillation wear behaviour of lubricants	PBG, G, RB
33	Electrical contacts test rig	Service life of lubricants in electrical contacts	PBG
34	Trolley bearing test rig	Service life of high-temperature greases in trolley bearings	RB
35	Wire rope test rig	Service life of lubricated wire ropes	PBG
36	Grease tester FTG 2	Oil separation of greases under pressure	RB, PBG, C
37	GRW noise tester	Noise behaviour of greases in rolling bearings	RB
38	Almen-Wieland lubricant tester	High-pressure and antiwear behaviour of lubricants	PBG, RB, C, G
39	Zwick friction tester for elastomers	Determination of static and sliding friction of elastomers	PBG, G, ST
40	SKF-BeQuiet grease noise tester	Noise behaviour of rolling bearing greases	
41	Wheel bearing test	Measurement of lubricant loss	
42	GMN – KGE 4	Noise behaviour of greases	RB
43	Grease pumpability tester (central lubricating systems)	Pumpability of greases	
44	Grease depressurisation tester	Depressurisation behaviour of greases in lubricant lines	
45	Flender foam tester	Foam formation of lubricating oils	G
46	Automotive water pump test	Lubricant behaviour in complete bearing units	RB

Explanations to column "Application"

ST	sanitary taps	**PT**	pressing tools
PBG	plain bearings and guides	**ET**	edge tools
C	chains	**RB**	rolling bearings
G	gears		

Load	Primary testing parameters	Model, component or unit testing
Surface pressure, time, oscillation frequency	Degree of tribocorrosion, classification	Model
Voltage, current	Number of switching cycles, voltage drop	
Temperature, speed, oscillating direction of rotation	Temperature up to 280 °C, 20 rpm, runtime achieved	Component
Tensile force, inverted cable	Load up to 200 N, rope speed 135 mm/s, number of cycles	
Pressure, temperature	Pressure 20 bar, ambient temperature, oil separation and thickness of hardened layer	Model
Speed, axial load	Frequency band, peaks, crackling	Component
Sliding speed, radial load	Test load up to 20 kN, sliding speed 0.066 m/s, breaking load, abrasion, friction force	Model
Normal load sliding speed, temperature	Sliding speed up to 800 rpm, friction force up to 10 N, way-friction coefficient diagram	
Speed, axial load	Quantitative determination of noise peaks and frequency bands as well as of starting-up behaviour and dampening	
Temperature, speed	Temperature up to 163 °C, grease loss in g, visual rating	Component
Axial load, speed	Solid-borne sound measurement acc. to noise class or level, running-in behaviour	
Pressure, temperature, volumes, cycles	Temperature up to 350 °C, oil separation, carbon build-up, visual rating	Unit
Pressure, temperature	Time-related residual pressure at different temperatures	Component
Speed, teeth	Time-related fluid/foam volume	Model
Temperature, speed	Lubricant loss, visual rating	Component

6.0 Description of selected mechanico-dynamical tests and their significance

Contents

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.

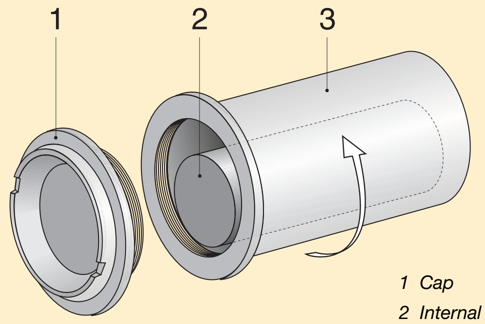


Fig. 6: Specimen for roll stability tester

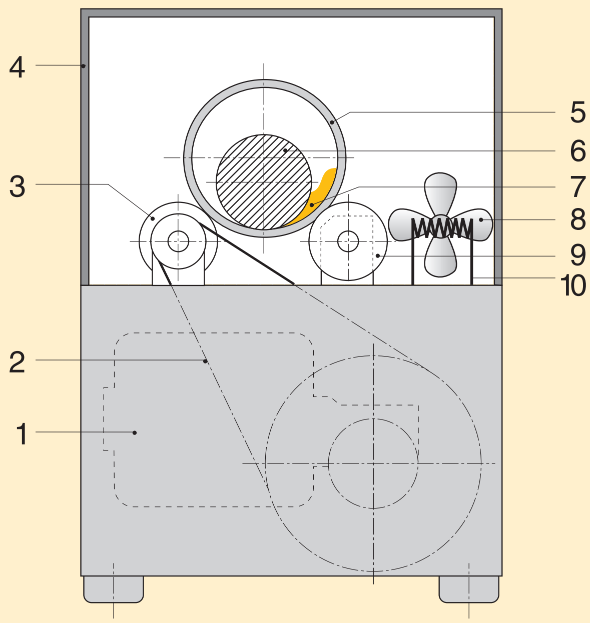
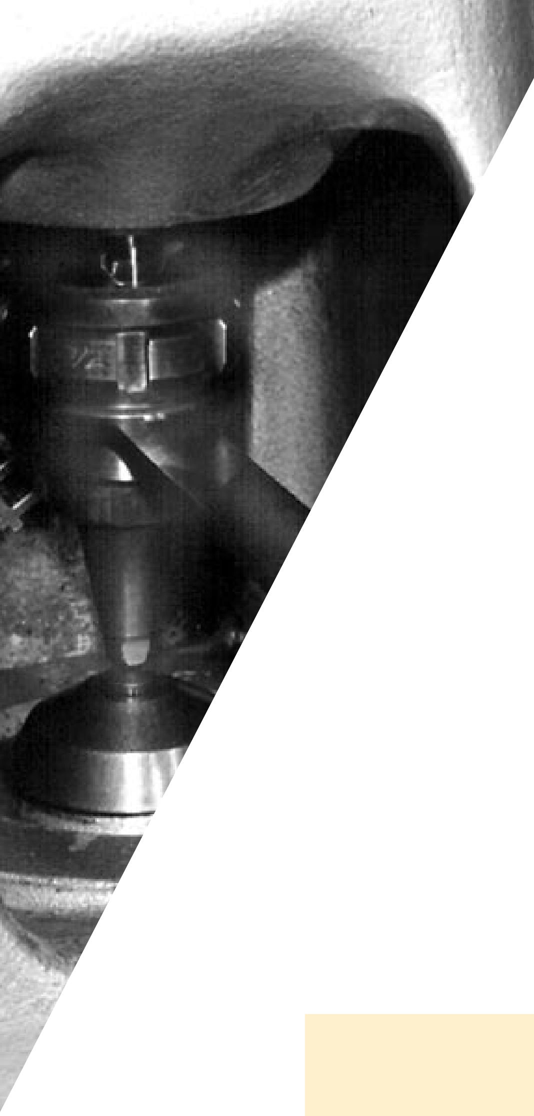


Fig. 7: Test rig drawing

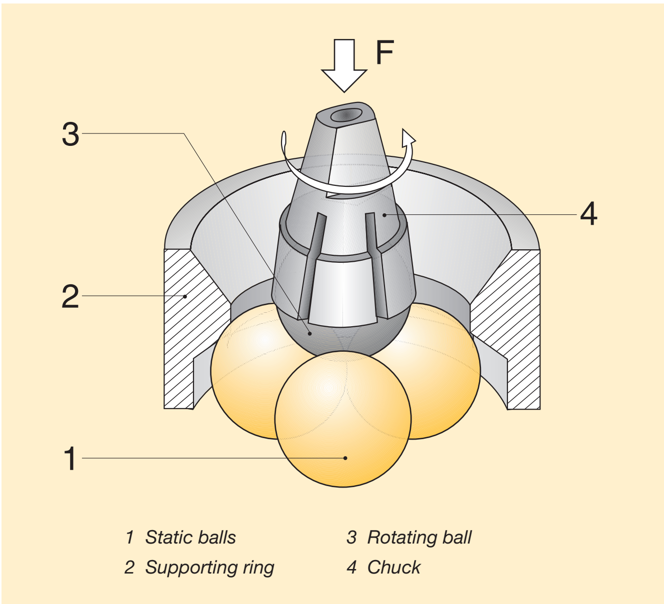


6.2
Shell four-ball wear tester

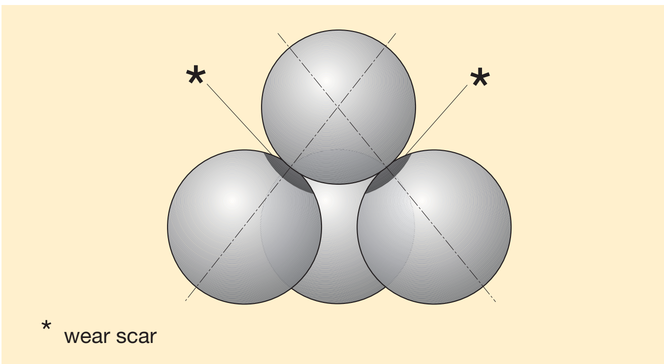
Scope
Determination of the wear indexes and the welding load of fluid and consistent lubricants; effect of antiwear and extreme-pressure additives under specific sliding friction condition

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 Cr^6)
SKF RB 12,7/310955



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

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 [1)]
- ❑ 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

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

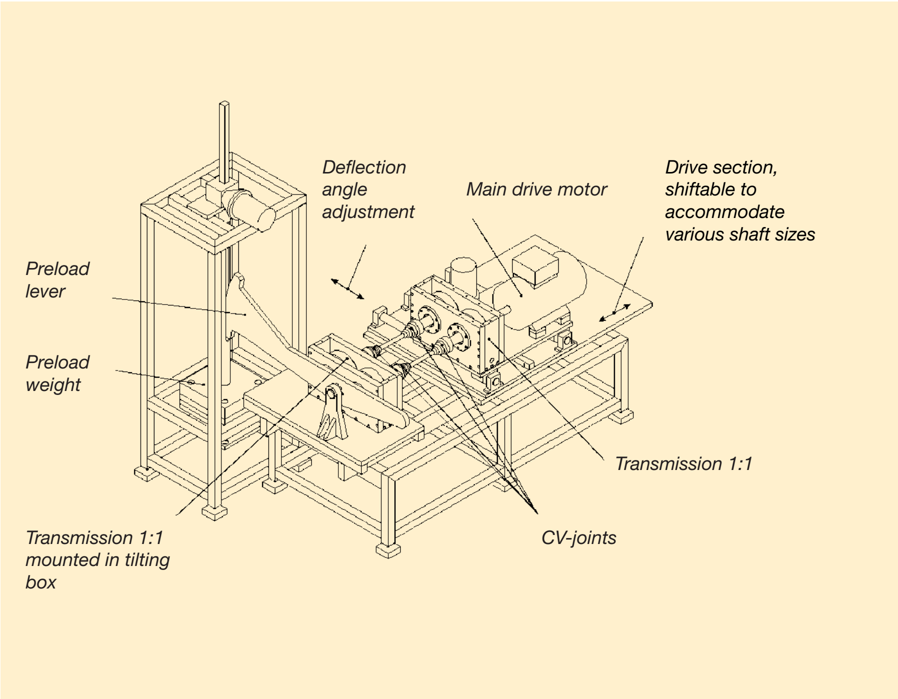
Speed:	variable, max. 1700 rpm
Load torque:	variable, max. 1200 Nm
Deflection angle:	variable*
Length of CV-jointed shaft:	350 to 1000 mm

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



CV-joint test rig

6.4
FZG* four square gear oil tester
Micropitting test acc. to Flender

Scope
Determination of micropitting resistance of gears

Standard
Flender standard

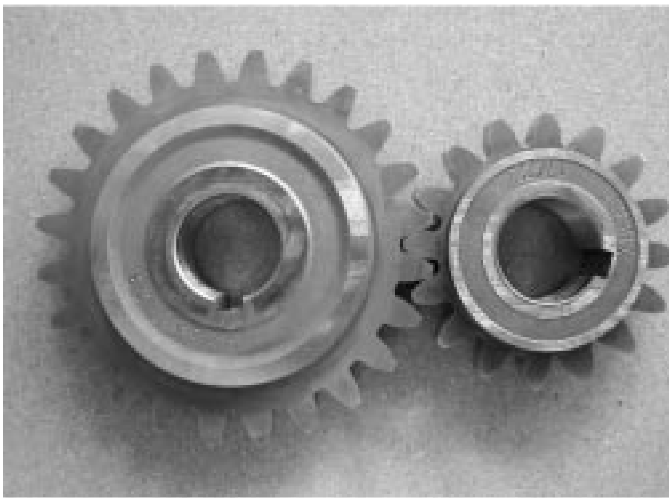
Specimen
Two gearwheels (Flender C toothing)

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 N/mm^2)
Running-in:	1 h at load stage 4
Duration of test:	100 h (short test) 300 h (long test)

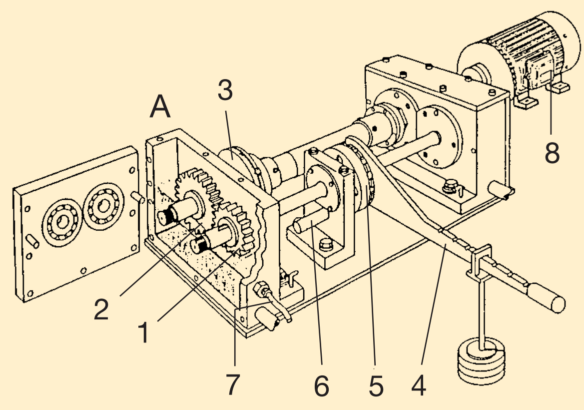
Procedure
- ❑ Clean and mount set of gears
- ❑ Fill in lubricant
- ❑ Set load at load stage 10 and start test at ambient temperature
- ❑ Run test at 90 °C (cooled)
- ❑ After 100 h short, dismount and evaluate
- ❑ In case of positive evaluation: Long test with load stage 10 for 300 h with the same oil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



Set of gears (C toothing)

Four square gear oil tester



A Test gear
B Transfer drive
1 Test pinion
2 Test wheel
3 Torsion measurement coupling
4 Load lever with weights
5 Rotating coupling
6 Locking pin
7 Temperature sensor
8 Electric motor

* 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

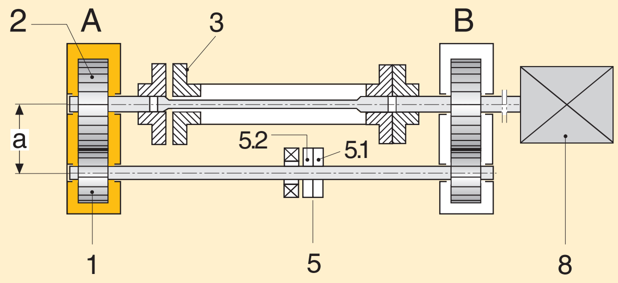
Test conditions

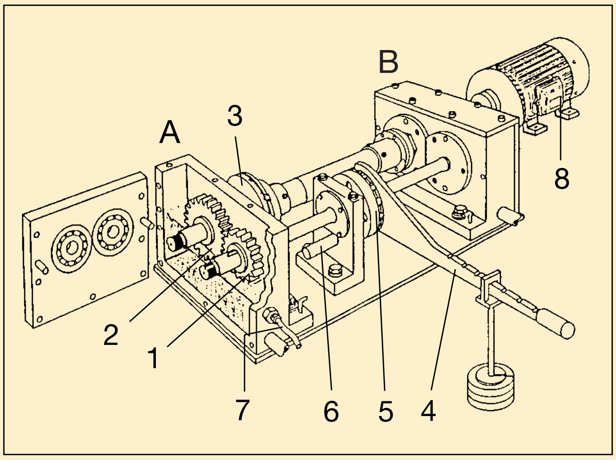
Peripheral speed:	2.76, 8.3 or 16.6 m s^{-1}
Pinion speed:	722, 2170 or 4340 rpm
Lubrication method:	splash lubrication
Oil pump temperature:	90 °C
Load:	12 load steps (99 to 15,826 N)
Duration of test:	15 min per load step

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.

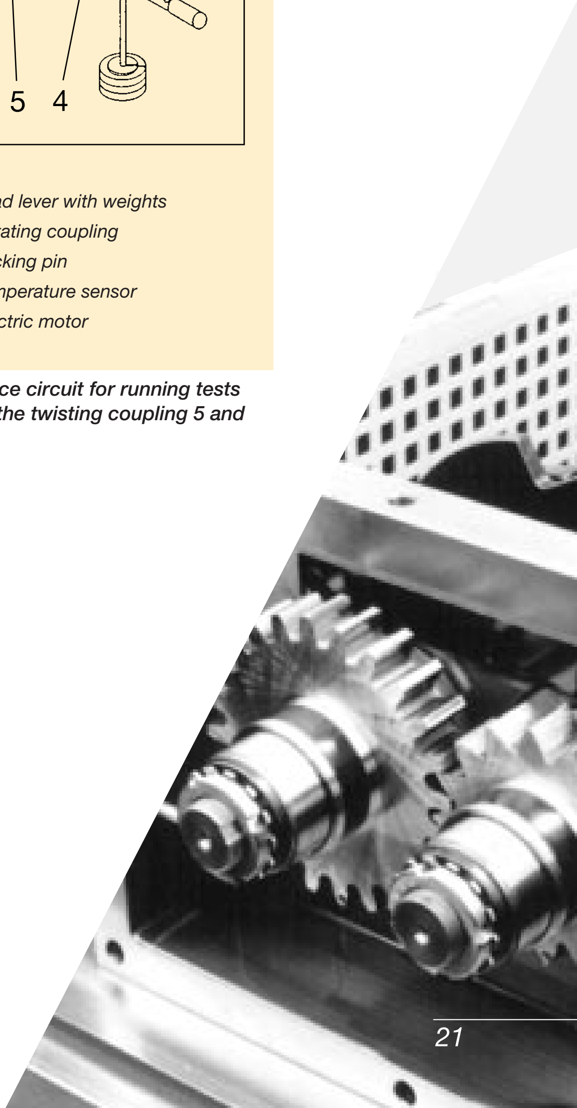
* FZG: Technical Institute for the Study of Gears and Drive Mechanisms, Technical University Munich





A Test gear
B Transfer drive
1 Test pinion
2 Test wheel
3 Torsion measurement coupling
4 Load lever with weights
5 Rotating coupling
6 Locking pin
7 Temperature sensor
8 Electric motor

Four square gear oil tester with performance circuit for running tests on gear wheels. To apply the torque open the twisting coupling 5 and distort flange 5.1 against 5.2.

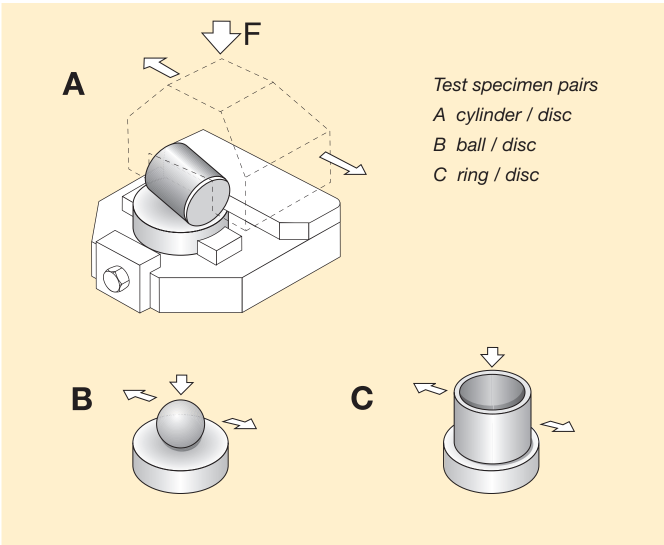


6.6 Oscillation friction wear tester

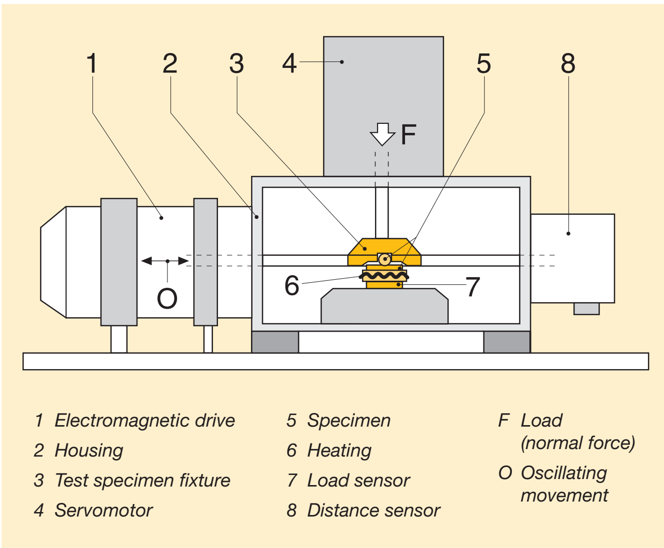
Scope
Determination of the fretting and tribo-corrosion of lubricants, coatings and plastics subject to constant load and oscillating sliding movements

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

ASTM D 5706
ASTM D 5707
ASTM D 6425



Test specimen pairs and test principle



Test rig design

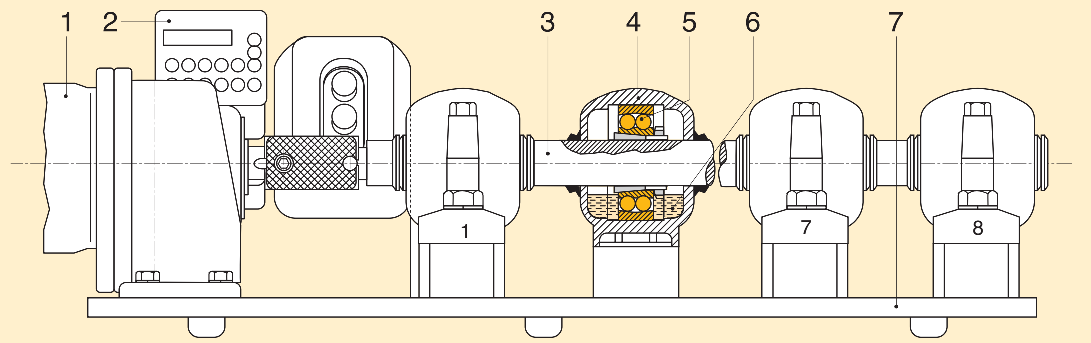
Specimen
Disc, lapped or ground
d = 24 mm, h = 7.85 mm
Cylinder, d = 15 mm, h = 22 mm
Ball, d = 10 mm
Cylinder, d = 10 mm, h = 10 mm,
Hardness of the specimen 63 HRC
with standard material 100 Cr 6

Test conditions		Standard
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

6.7
EMCOR-machine
(SKF-EMCOR method)



1 Electric motor
2 Automatic timer
3 Shaft with nylon lining
4 Pedestal plain bearings, 8 units
5 Test bearings, 8 units
6 Test medium
7 Support

EMCOR machine

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

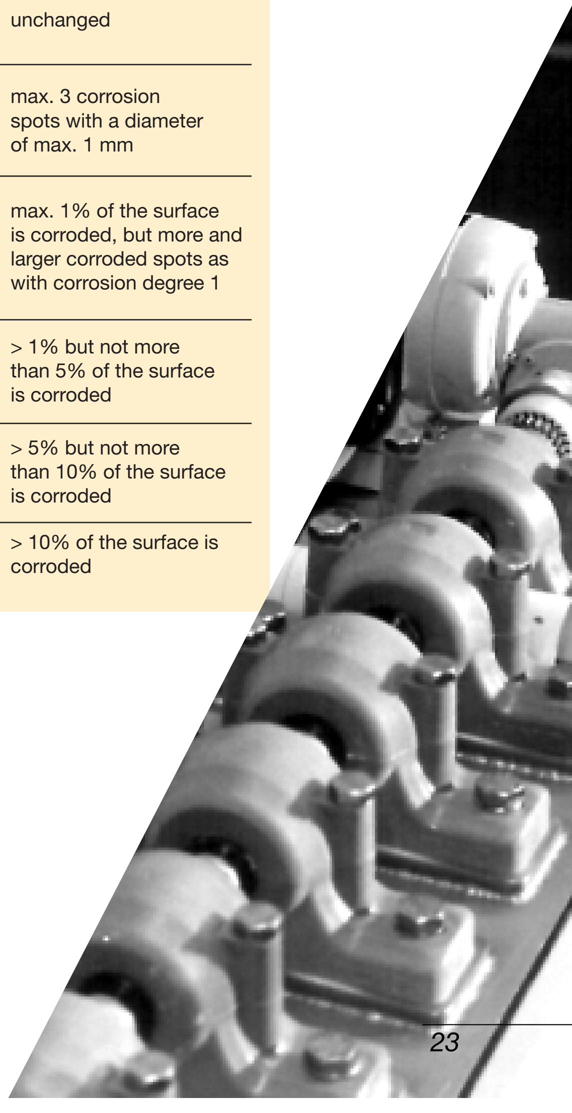
Test conditions
Duration of test: 168 h with alternating running and stop periods
Speed: 80 rpm
Test medium: distilled water or other aqueous media
Grease volume: 11 cm^3 per bearing

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 degree	Meaning	Description
0	no corrosion	unchanged
1	traces of corrosion	max. 3 corrosion spots with a diameter of max. 1 mm
2	slight corrosion	max. 1% of the surface is corroded, but more and larger corroded spots as with corrosion degree 1
3	moderate corrosion	> 1% but not more than 5% of the surface is corroded
4	strong corrosion	> 5% but not more than 10% of the surface is corroded
5	very strong corrosion	> 10% of the surface is corroded

Corrosion degrees

Result
Corrosion rating on the outer bearing races

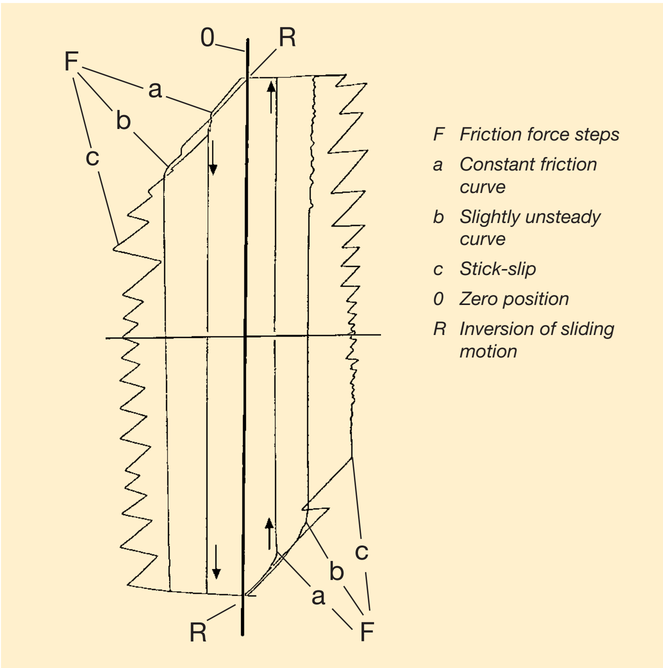


6.8
Tannert sliding indicator

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



Friction force curves with slow, reversing sliding movement

Sliding elements:

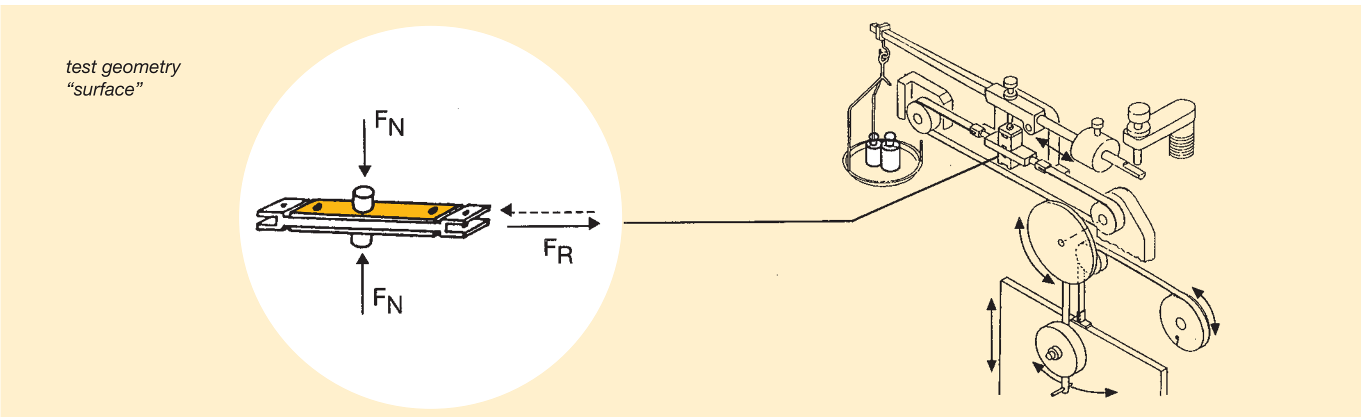
Block	29.8 x 24.9 x 15 mm (surface contact)
Cylinder	Ø 13 x 13 mm (surface contact)
Cylinder	Ø 10 x 10 mm (linear contact)

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



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

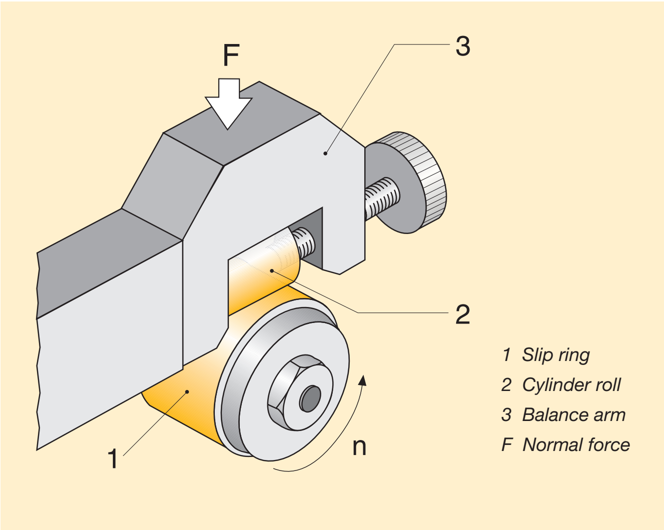
Cylindrical roller	Ø 12 mm, h = 18 mm
Needle bearing inner ring	Ø 30 x Ø 35 x 16 mm

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



Testing principle

6.10

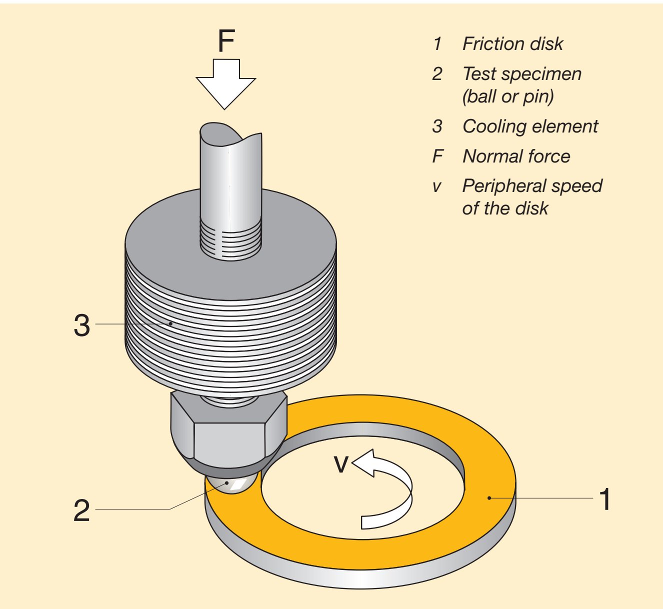
Sliding friction test rig

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 mm, SKF 310955
or
Plastic pin, d = 12.0 mm
Bearing, INA-WS 81111



Testing principle

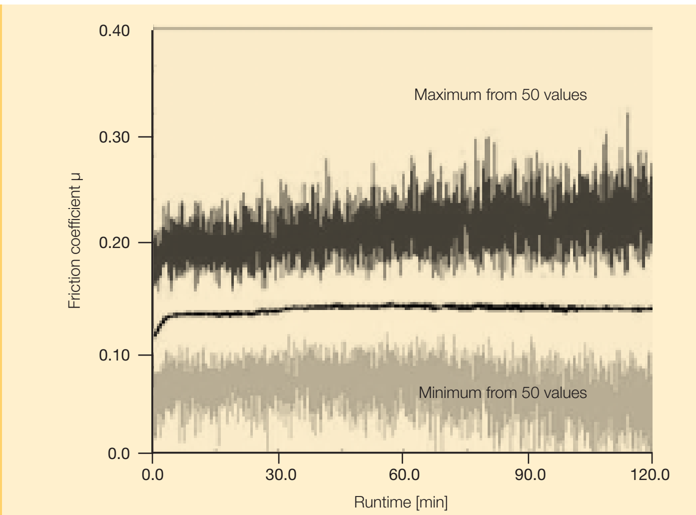
Test conditions

Duration of test:	1 min to 8 h
Speed:	up to 1200 rpm (V_{max} = 4.2 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 μ 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)

Test conditions:	
Scan rate [scans/s]:	*25*
Nominal test duration [min]:	*120*
Actual test duration [min]:	*120*
Load [N]:	*10*
Speed [rpm]:	*48*
Temperature [°C]:	*20*
Initial friction coefficient μ:	
Maximum value:*	*0.43*
Medium value:*	*0.09*
Minimum value:*	*0.00*
Final friction coefficient μ:	
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*



Example of documentation on PC

6.11
Water wash-out test

Scope
Behaviour of a lubricant under dynamic conditions at different temperatures

Standards
DIN 51 807; ASTM D 1264

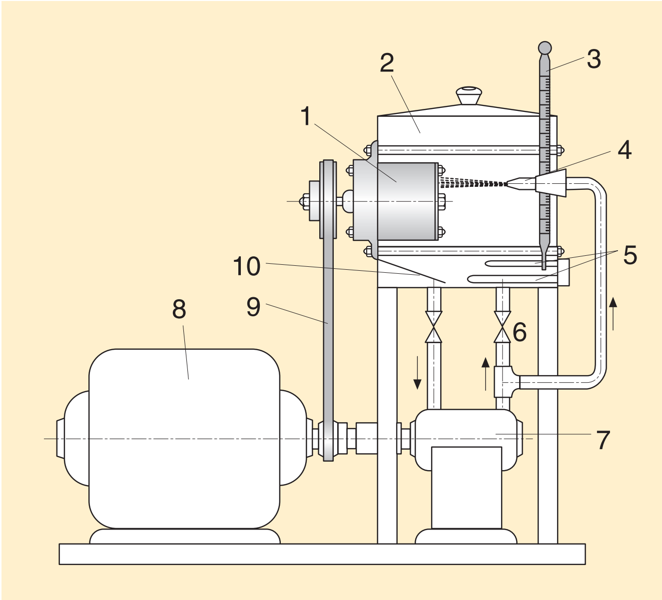
Specimen
Deep groove ball bearing 6204, open

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 cm^3/s

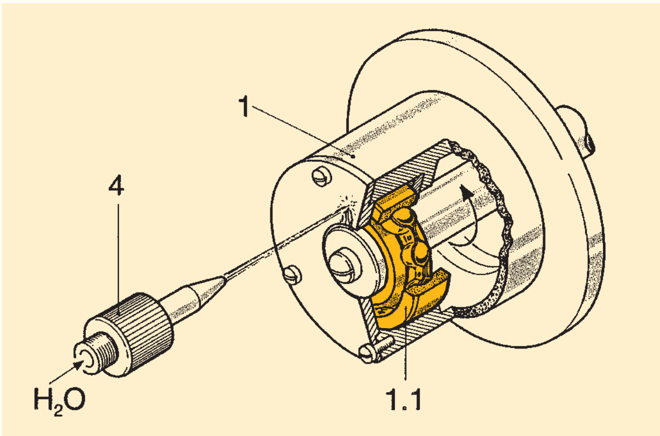
Procedure
- ❑ Weigh the test bearing and the housing cover
- ❑ Lubricate the test bearing with 4 ± 0.05 g of grease
- ❑ Mount the test bearing in the bearing housing and fix the cover
- ❑ Run the test for 60 min directing a defined water jet onto the capped specimen
- ❑ Disassemble the test bearing
- ❑ 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



1 Bearing housing
1.1 Test bearing
2 Water tank
3 Thermometer
4 Nozzle
5 Heating
6 Valve
7 Pump
8 Motor
9 V-belt
10 Cooling pipe

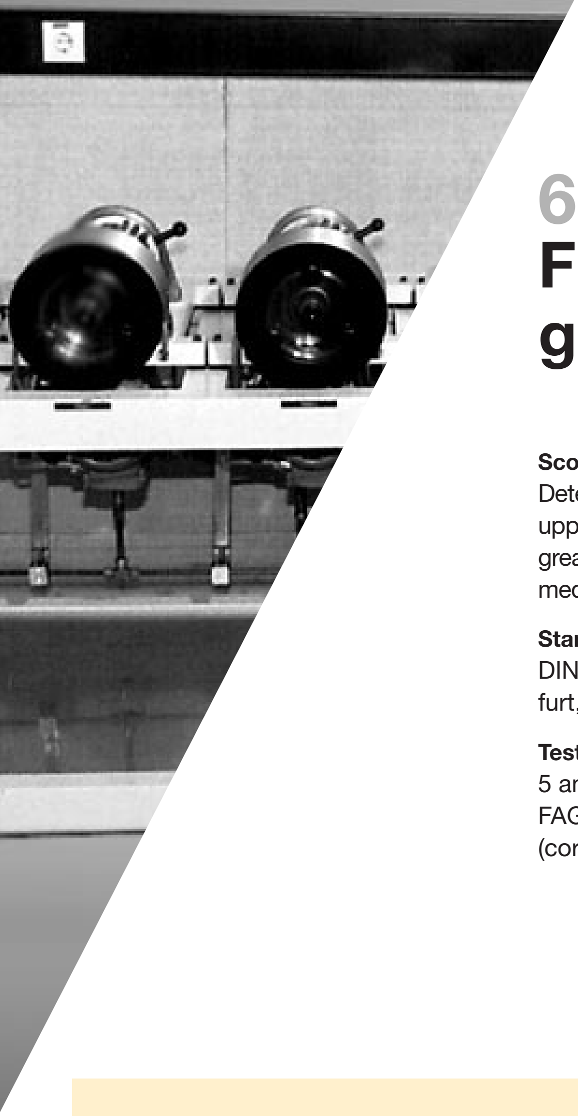
Drawing of the test rig



Principle of the test

Rating level	Loss in weight, %	Change
1	< 10	low
2	> 10 but < 30	moderate
3	> 30	high

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

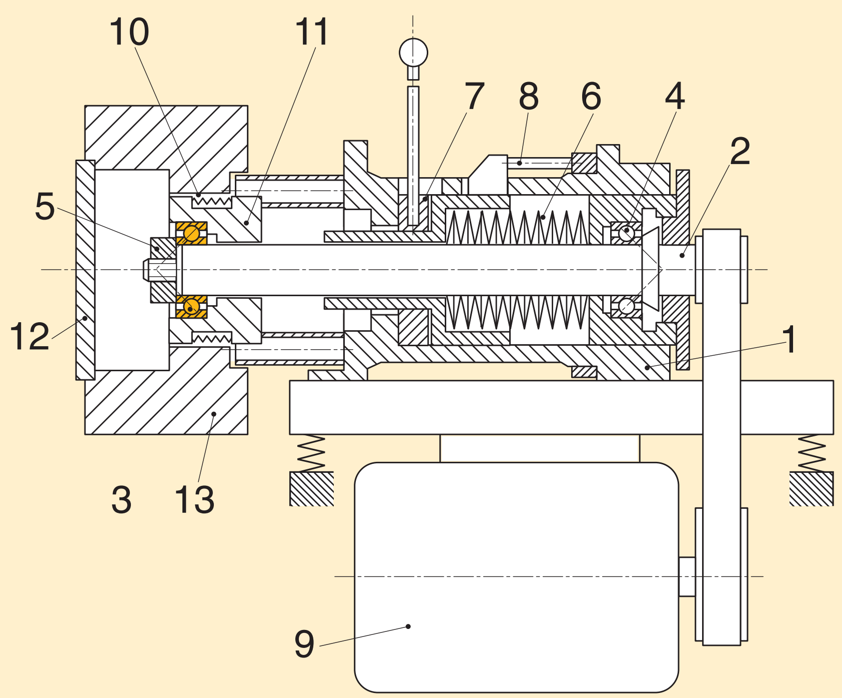
Axial load:	1500, 3000, 4500 N, DIN 51 821: 1500 N
Speed:	3000, 6000 rpm, DIN 51 821: 6000 rpm
Temperature:	max. 240 °C, DIN 51 821: 120 to 200 °C acc. to DIN 51 821 in steps of 20 °C
Grease quantity per bearing:	* 2 cm^3 ** 10 cm^3

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_{50} or F_{10} 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 β



1 Housing of the test unit
2 Shaft
3 Test bearing
4 Auxiliary bearing
5 Shaft nut
6 Spring washer
7 Tensioning device
8 Stop
9 Electric motor
10 Electric resistance heating
11 Test head
12 Housing cap
13 Heat insulating cover

Test unit, cross section

Test DIN 51 821 – 02 – A / 1500 / 6000 – 160

F_{10} = 110 h
F_{50} = 200 h

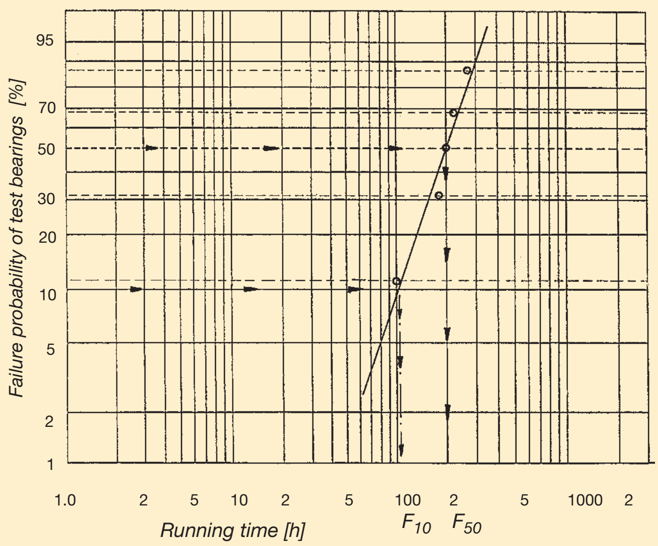
* in rolling bearing catalogues also called L_{10} and L_{50}

Explanation:
With the test parameters of the assembly A

Axial test load F_A = 1500 N
Test speed n = 6000 rpm
Test temperature θ = 160 °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

FE 9 grease service life

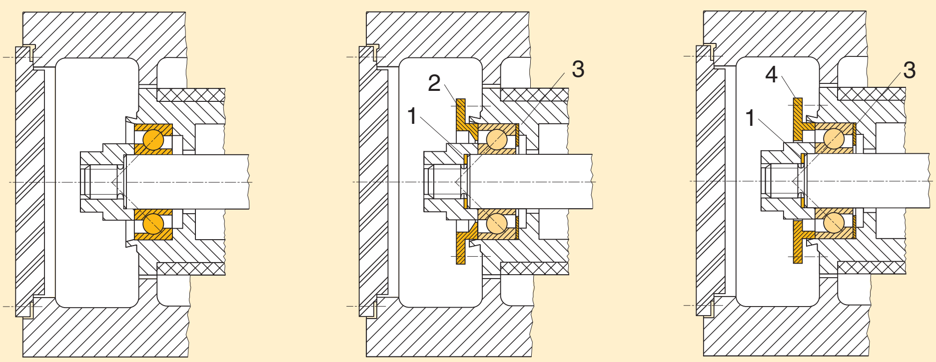


Run No.: 824
Grease: M 98/89, Test grease B
Batch: # 654321
Filling quantity [cm³]: 2
Speed n [rpm]: 6000
Axial load F_A [N]: 1500
Temperature ϑ_{AR} [°C]: 160
Assembly: A
Test evaluation:
F_{10} = 110 h
F_{50} = 200 h
β = 3.15 (gradient)

Bearing No.	Running time [h]:
1	100
2	190
3	200
4	222
5	380

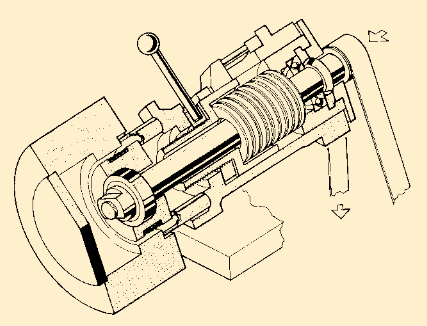
Example WEIBULL diagram acc. to DIN 51 821, pt. 2

Assembly A ***Assembly B*** ***Assembly C***

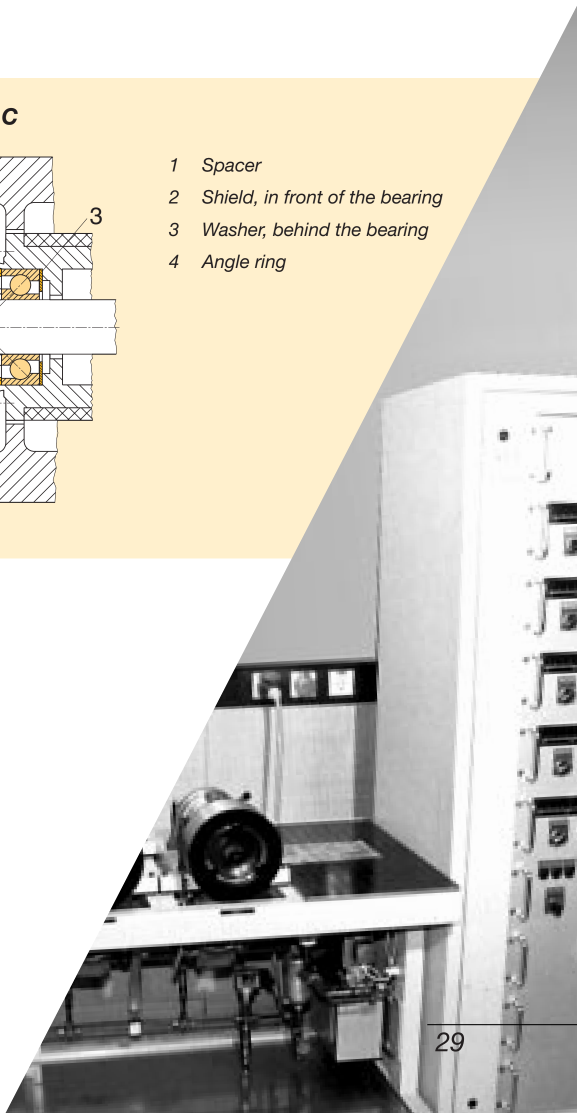


1 Spacer
2 Shield, in front of the bearing
3 Washer, behind the bearing
4 Angle ring

Various assemblies of the test bearings



Test unit, perspective view



6.13
ROF rolling bearing grease tester

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

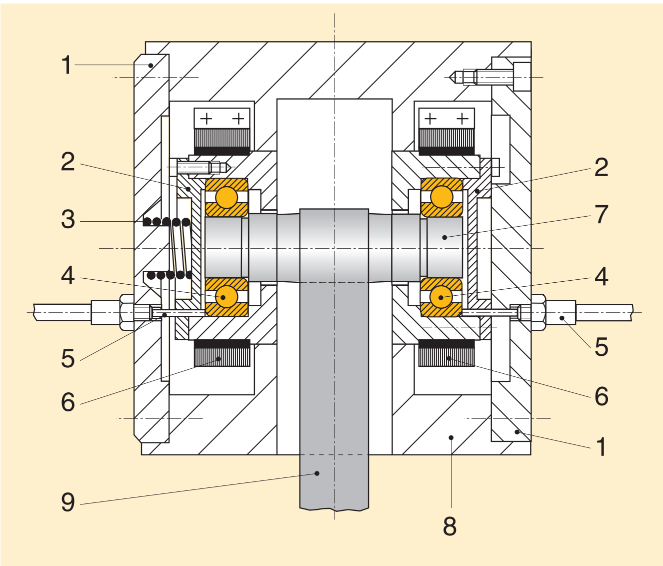
Test conditions

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 L_{10} and L_{50} values are determined by means of the WEIBULL diagram

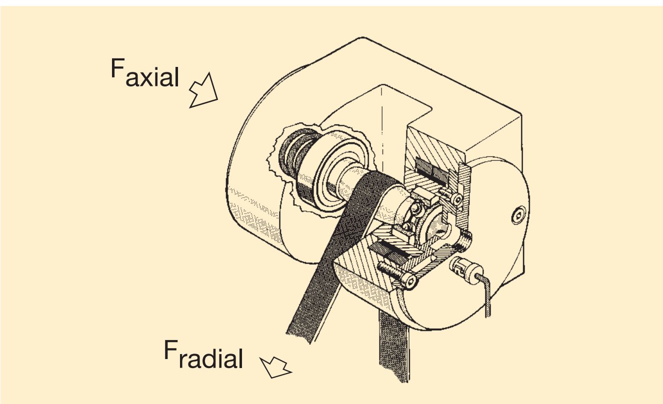
Test result
Running times L_{10}, L_{50} with 90% confidence range. Failure time β

1 Housing cover
2 Bearing cap
3 Pressure spring (applies the axial load)
4 Test bearing
5 Temperature sensor
6 Heating, controlled
7 Spindle
8 Housing
9 Belt, tensioned by motor weight and additional weights (radial loads)



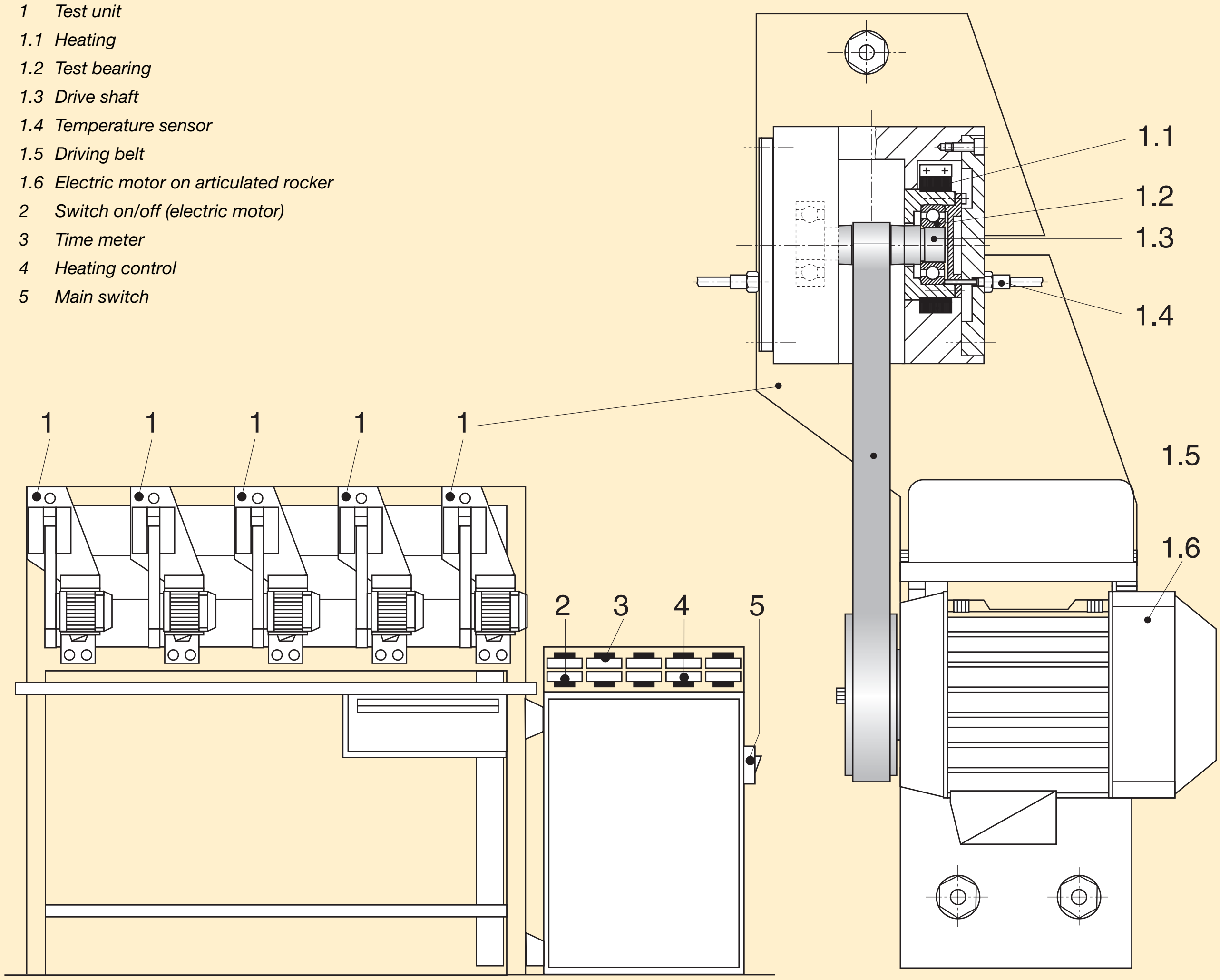
Test head, cross section

* optional 100 N, 150 N, 200 N … up to 800 N per bearing



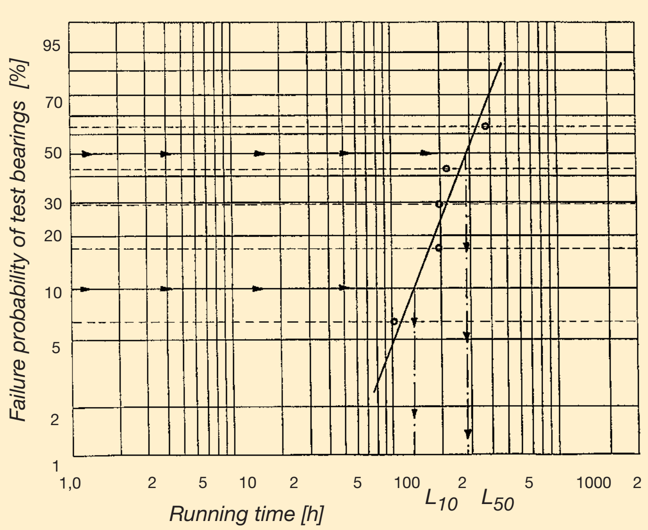
Test head, perspective view

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

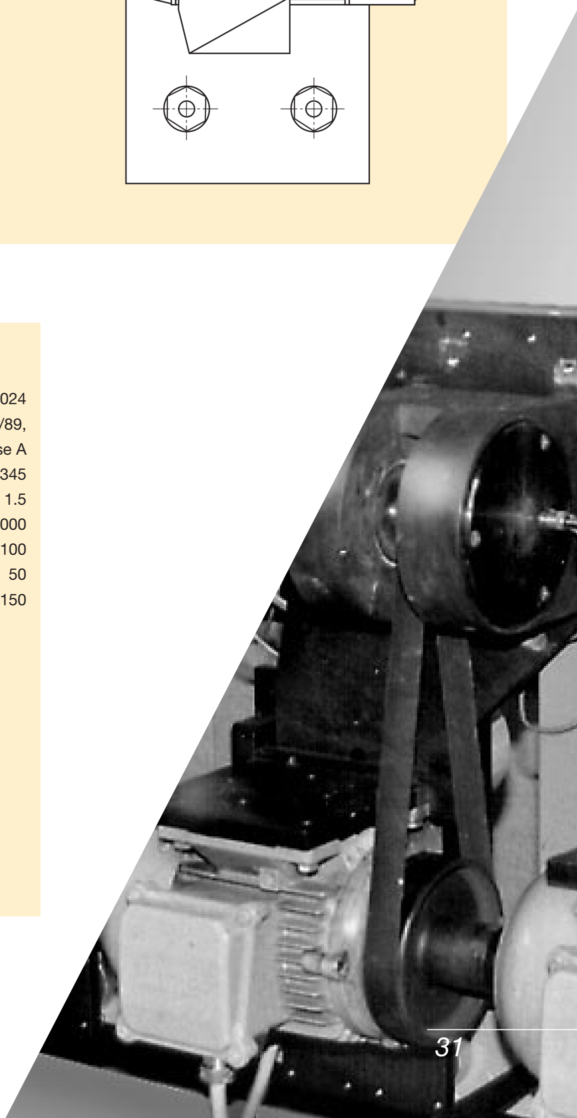
ROF grease service life



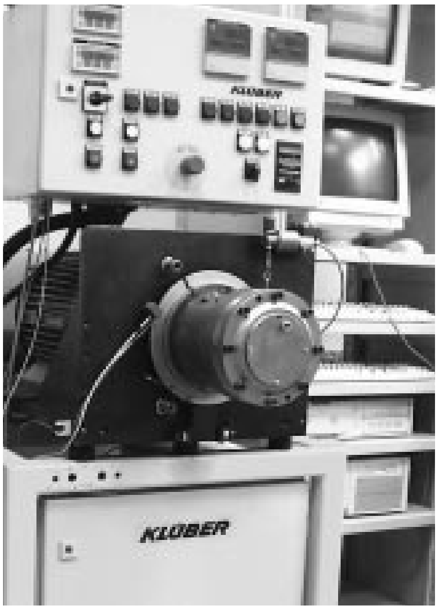
Run No.: 1024
Grease: M 97/89, Test grease A
Batch: # 612345
Filling quantity [cm³]: 1.5
Speed n [min⁻¹]: 10,000
Axial load F_A [N]: 100
Radial load F_R [N]: 50
Temperature ϑ_{AR} [°C]: 150
Test evaluation:
L_{10} = 130 h
L_{50} = 280 h
β = 2.45 (gradient)

Bearing No.	Running time [h]:
1	103
2	194
3	199
4	216
5	390

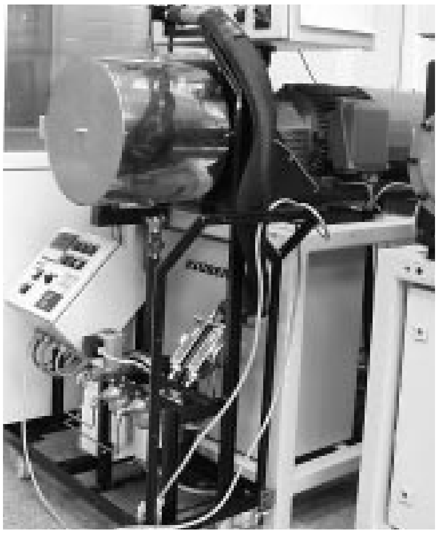
WEIBULL diagram



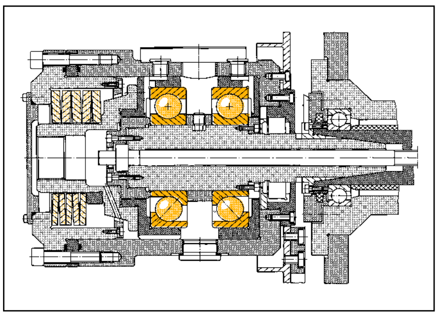
6.14
FE-8 rolling bearing lubricant tester



Test setup for greases



Test setup for oils, with thermal protection cover



FE 8 test head

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

6.15
SNR – FEB 2 rolling bearing grease tester

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

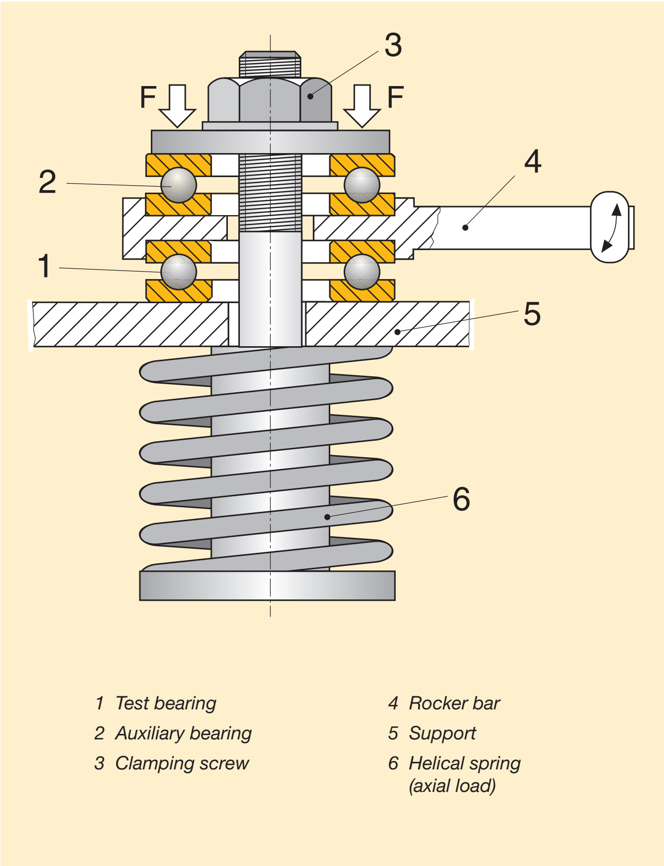
Specimen
2 thrust ball bearings BP 10071
d = 35.2 mm, D = 55.5 mm, H = 16 mm
2 thrust ball bearings FAG 51206
d = 30 mm, D = 52 mm, H = 16 mm
2 cylindrical roller thrust bearings SKF WS 81206
d = 30 mm, D = 52 mm, H = 16 mm

Test conditions

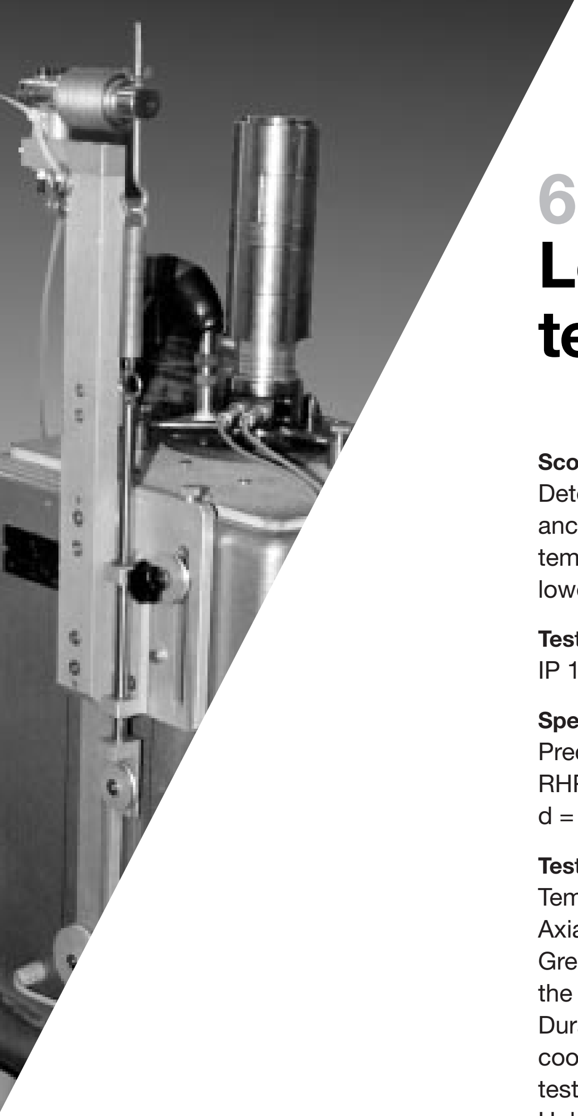
Axial load:	8000 N (Hertzian pressure 2100 N/mm²)
Duration of test:	5 or 50 h
Frequency:	24 Hz
Oscillation angle:	± 3°
Temperature of lower bearing ring:	– 20 °C or + 25°C

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



SNR - FEB 2, testing principle



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

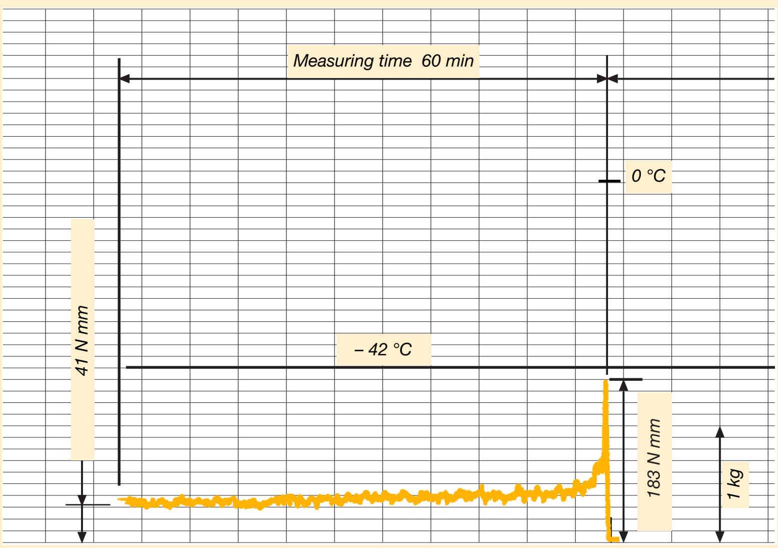
Test standard
IP 186

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



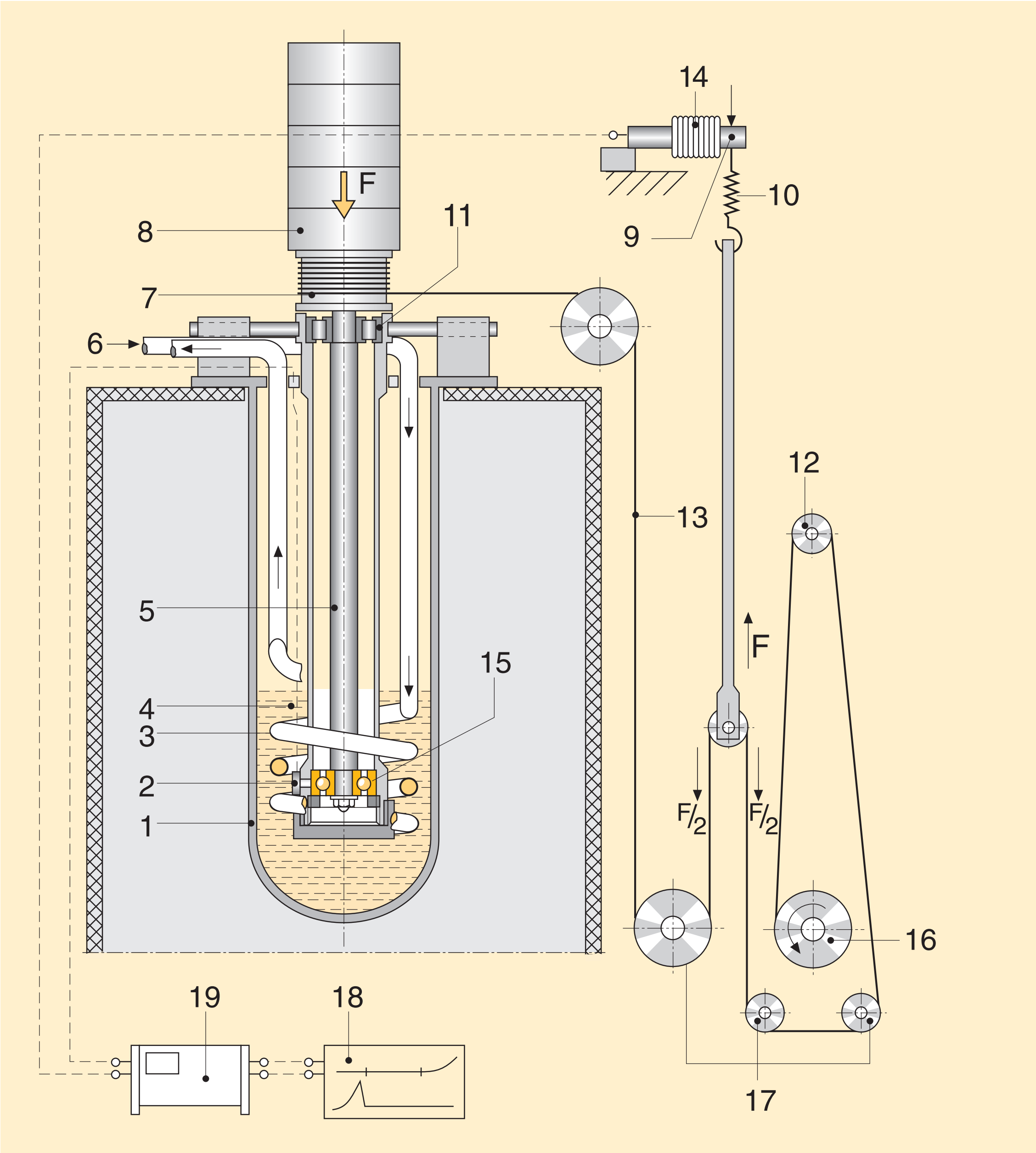
Evaluation of the recordings
Bowden cable

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

Evaluation



1 Insulating receptacle
2 Temperature sensor
3 Cooling spiral
4 Cooling bath
5 Test spindle
6 Cooling by means of cryostat
7 Drive cable drum
8 Axial loads
9 Weighing cells
10 Dampening spring
11 Auxiliary bearing
12 Tensioning roll
13 Bowden cable
14 Force-measuring roll
15 Test bearing
16 Motor with cable drum
17 Return roller
18 Plotter
19 Measurement amplifier

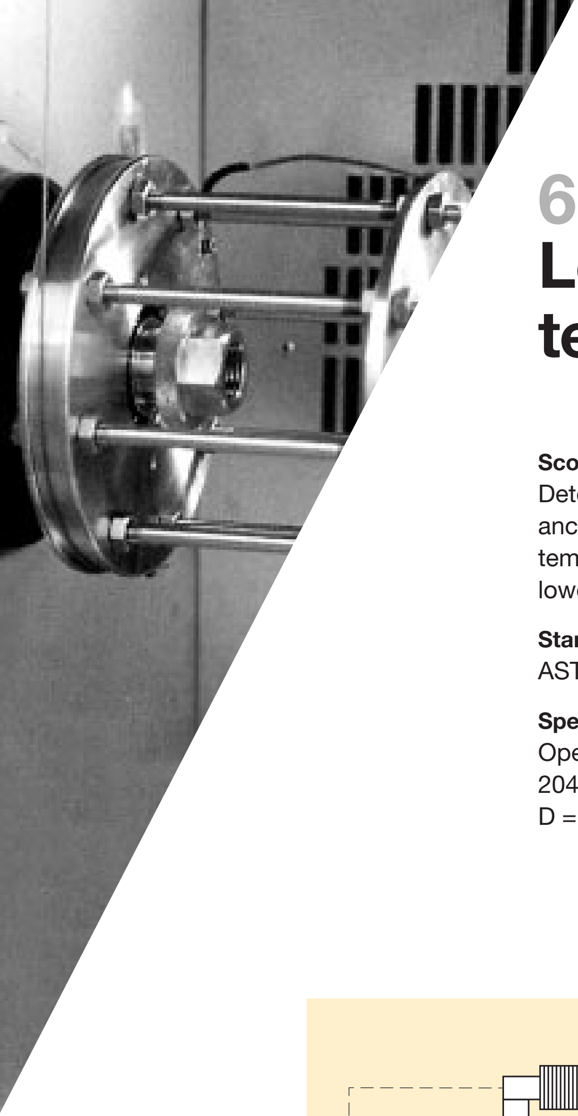
Low-temperature torque tester, principle

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

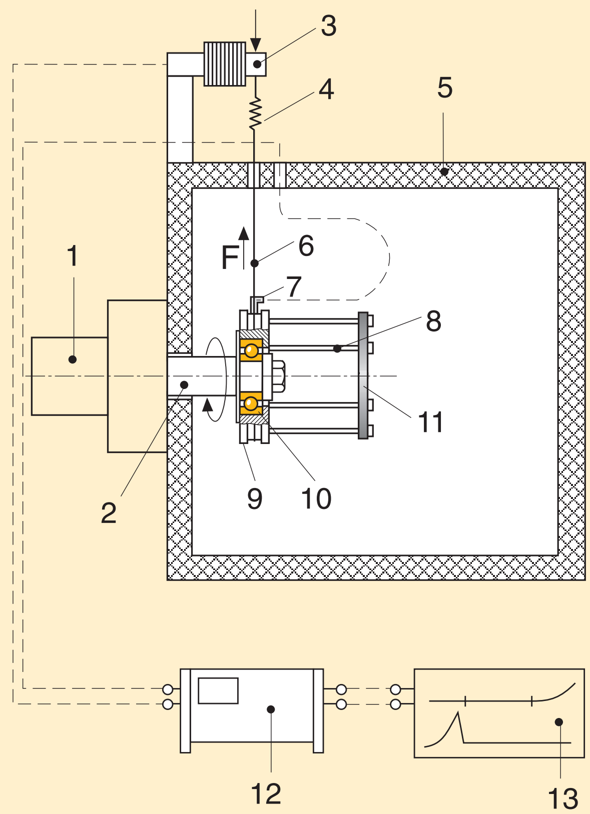


6.17
Low-temperature torque test rig – ASTM D 1478

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



1 Gear motor
2 Drive shaft
3 Weighing cell
4 Dampening spring
5 Low-temperature chamber
6 Bowden cable
7 Temperature probe
8 Rods
9 Cable disc
10 Test bearing
11 Load disc
12 Data recording
13 Plotter

Low-temperature torque tester, principle

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

6.18
Rolling bearing torque tester

Scope
Starting and running torques of lubricants in rolling bearings

Standard
Klüber test conditions

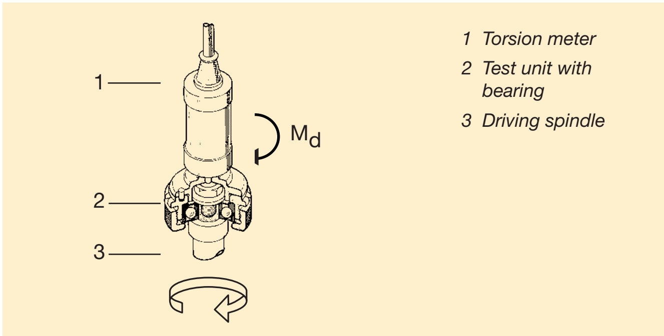
Specimen
Deep groove ball bearings
6202 2 ZY HG

Test conditions

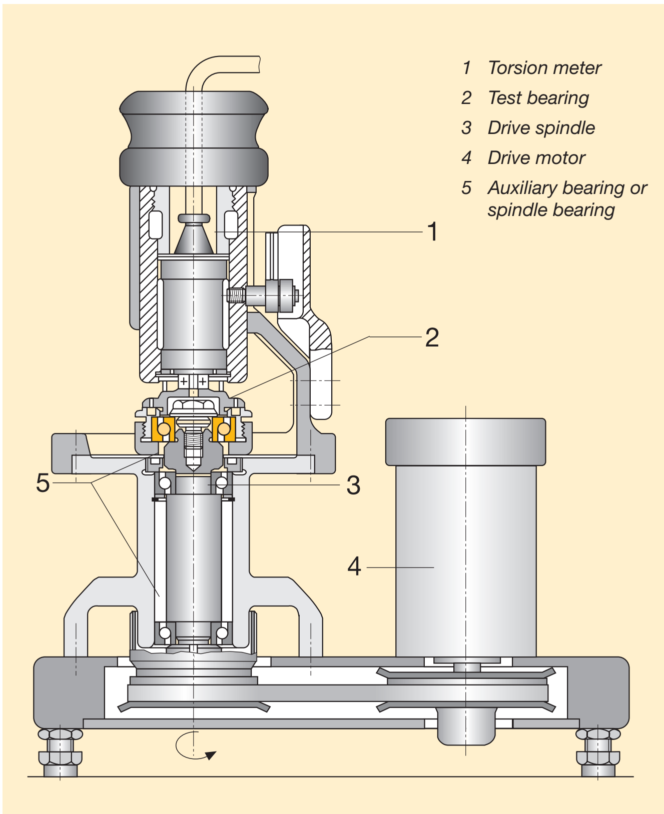
Duration of test:	1 h, variable, standard per test run	
Speed:	3500 rpm, variable, standard	
Axial load:	10 N, constant	
Lubricant fill in the bearing:	grease:	30 % of the empty space
	oil:	20 μl per ball

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

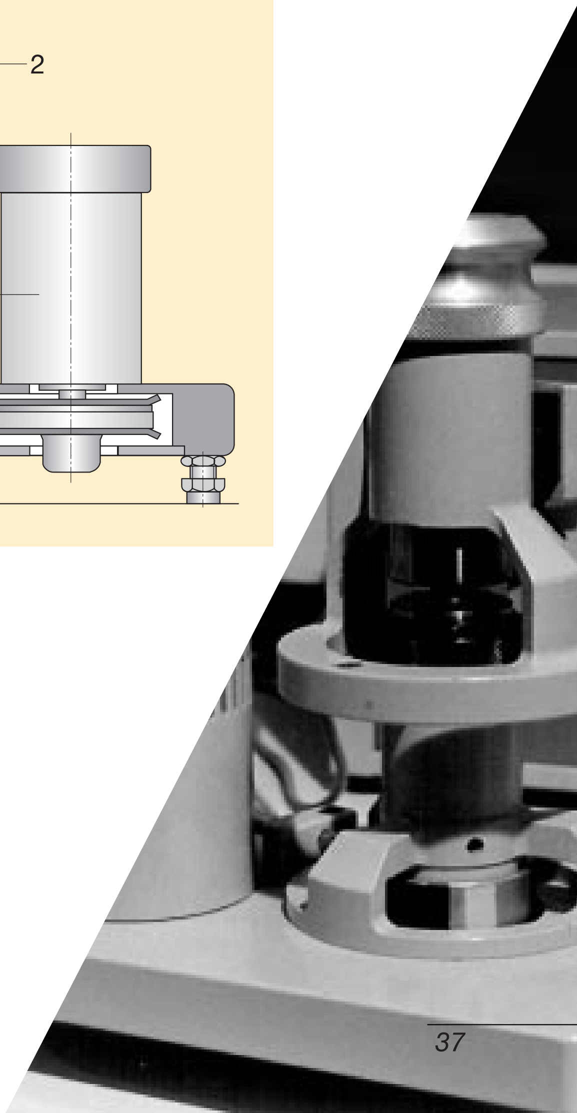
Result
Determination of the starting and restarting torque and recording of the friction behaviour



Test principle



Test unit

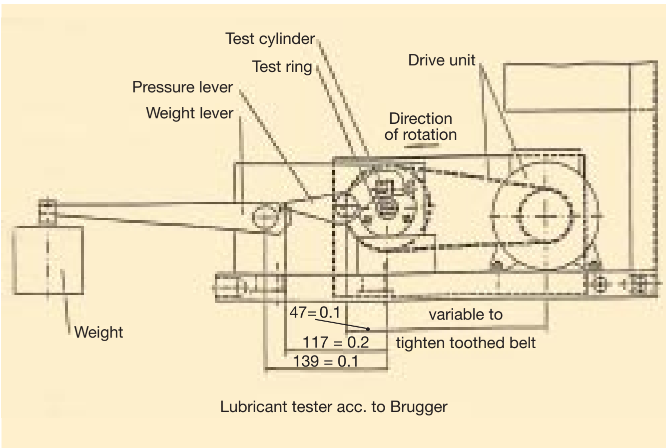


6.19
Brugger lubricant tester

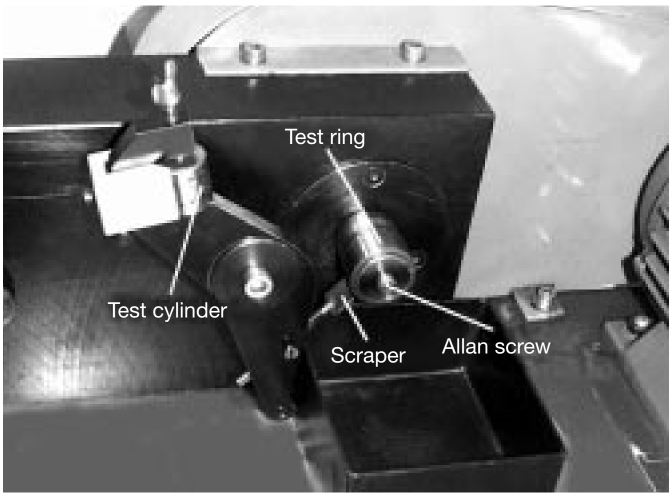
Scope
Determination of load-bearing capacity in boundary and mixed friction regime

Standard
DIN 51347 parts 1 and 2

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



Test setup



Specimen in place

Test conditions

Duration of test:	Drip-off time of oils 60 s Runtime 30 s
Speed:	940 rpm $\hat{=}$ 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/mm^2.

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

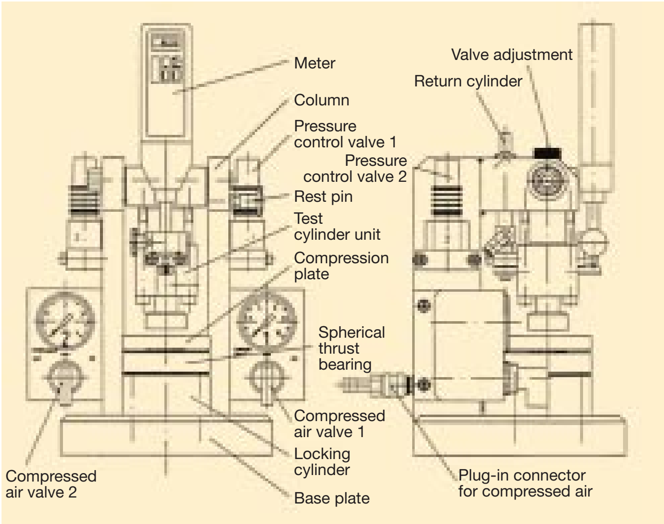
Specimen
Filtering paper

Test conditions

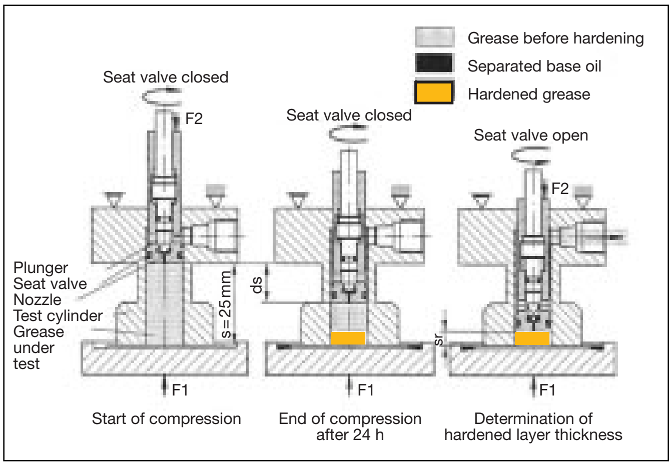
Duration of test:	24 h
Grease volume:	2.5 cm^3
Load acting on grease:	20 bar
Temperature:	23 °C ± 2 K

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

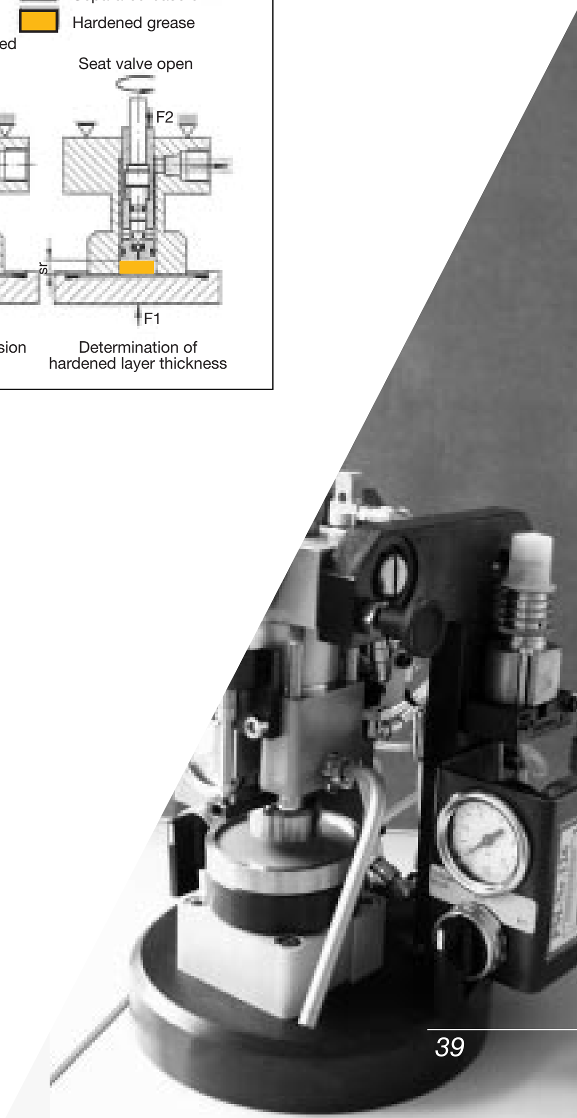
Result
Oil separation and thickness of hardened grease



Test setup



Test procedure



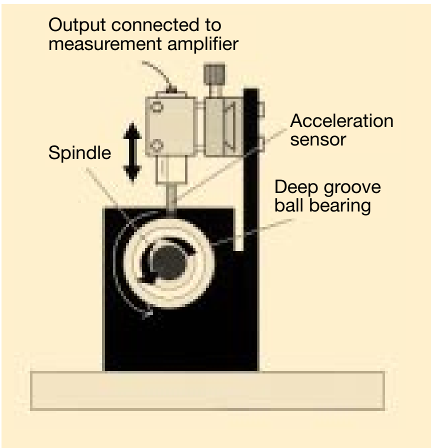
6.21 GRW noise tester

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

Spindle/bearing



Test setup

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_R

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_R (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.

6.22
Almen-Wieland lubricant tester

Scope
Extreme-pressure and wear behaviour of lubricating oils, dispersions, greases and pastes

Standard
Wieland test description

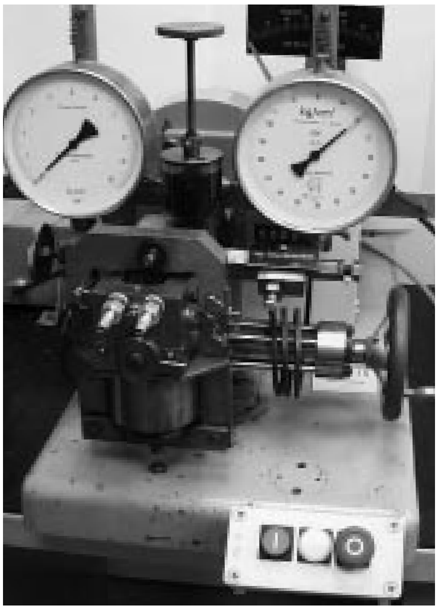
Specimen
1 steel shaft Ø 6.3 mm
2 steel half bearings Ø 6.5 mm

Test conditions

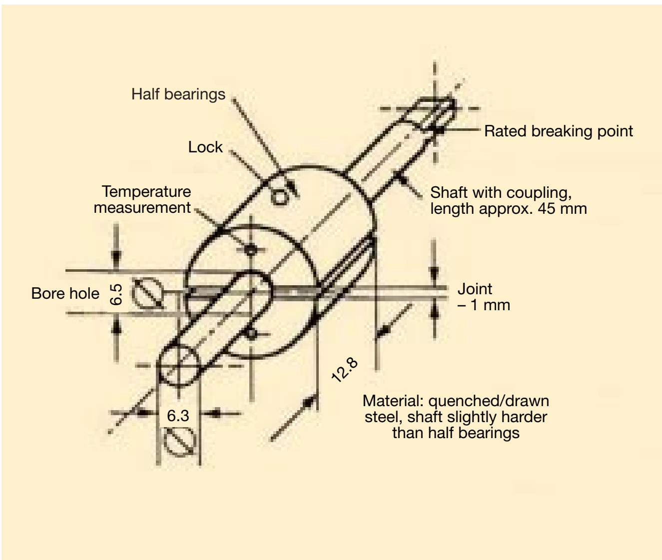
Sliding speed:	0.066 ms^{-1}
Test load:	0 to 20 kN
Temperature:	ambient temperature
Type of friction:	sliding friction

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



Total view

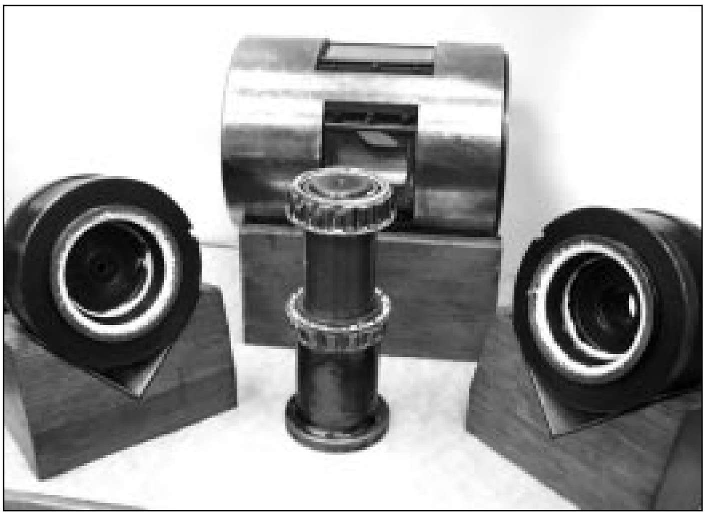


Specimen

6.23
HTN Spengler test rig for rolling bearing greases

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.



Shaft with disassembled test bearings, bushings and inspection glass

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

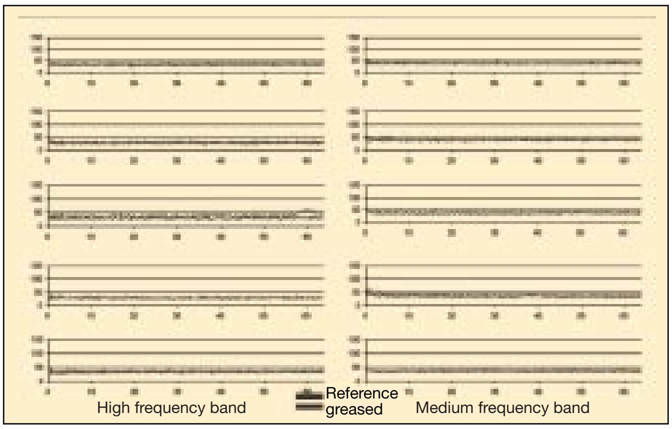
Time is variable for long-time test runs

Temperature:	ambient to 180 °C
Axial load:	500 to 1500 N
Speed:	1500 to 10,000 rpm

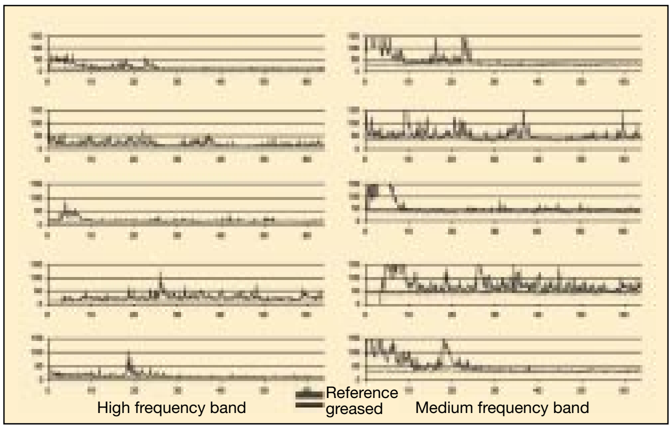
Procedure
- ❑ Start measurement program for reference run with oiled test bearings
- ❑ Grease and mount test bearings
- ❑ Set test parameters
- ❑ 120 min steady-state run without heating; then approx. 60 min with heating; 120 min under temperature; record frictional torque and temperature curves; visual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



Smooth test run



Test run with vibrations

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

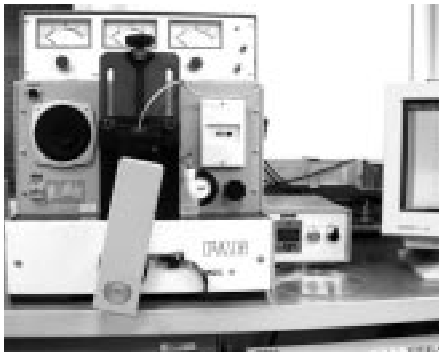
Test conditions

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^{-1}, analog display in %)

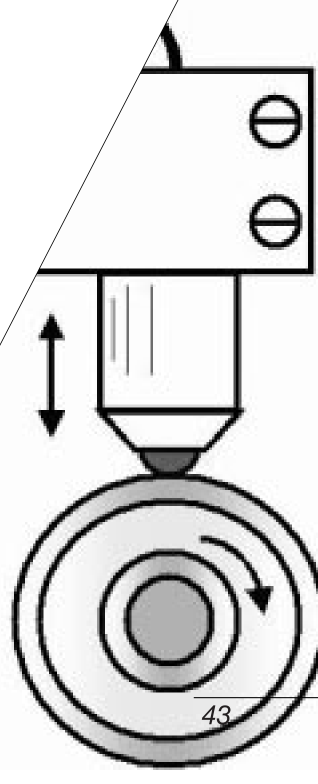
Acoustic evaluation via loudspeaker

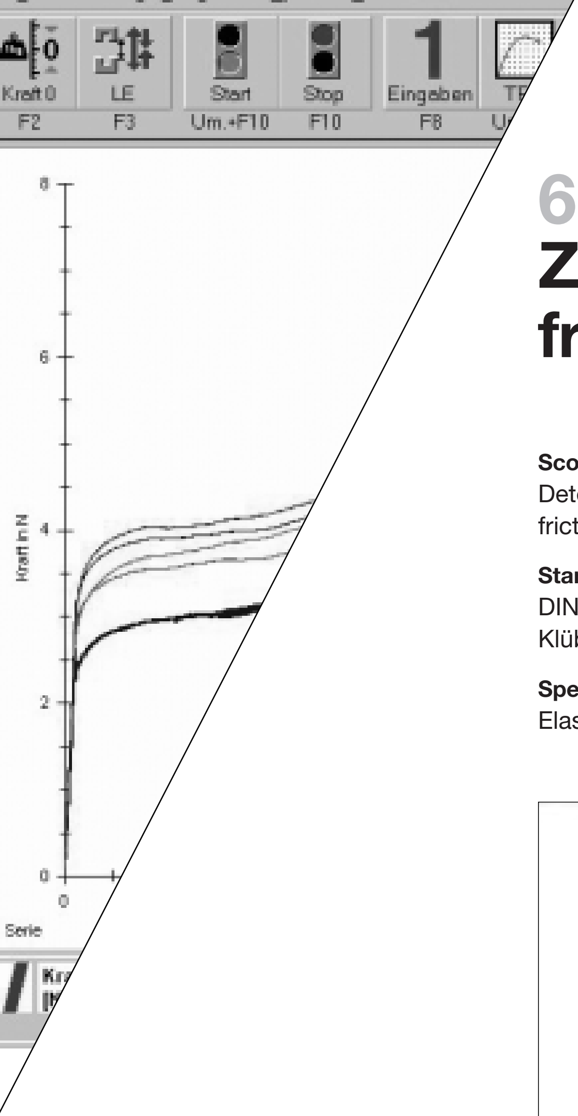
Procedure
- ❑ Start measurement program for reference run with oiled test bearings
- ❑ Mount prepared test bearings to spindle, apply axial load and verify reference conditions one by one
- ❑ Fill external metering device with grease to be tested; avoid bubbles
- ❑ Lubricate bearings 1 to 5, mount them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



Total view





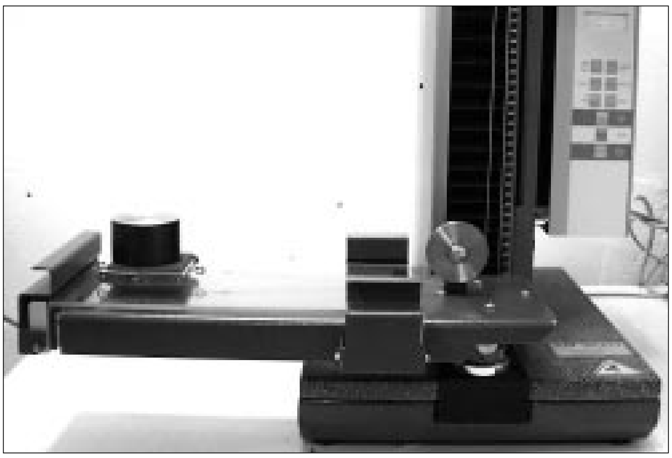
6.25
Zwick elastomer friction tester

Scope
Determination of static and sliding friction of elastomers

Standard
DIN 53 375
Klüber test conditions

Specimen
Elastomers


Total view


Test setup

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

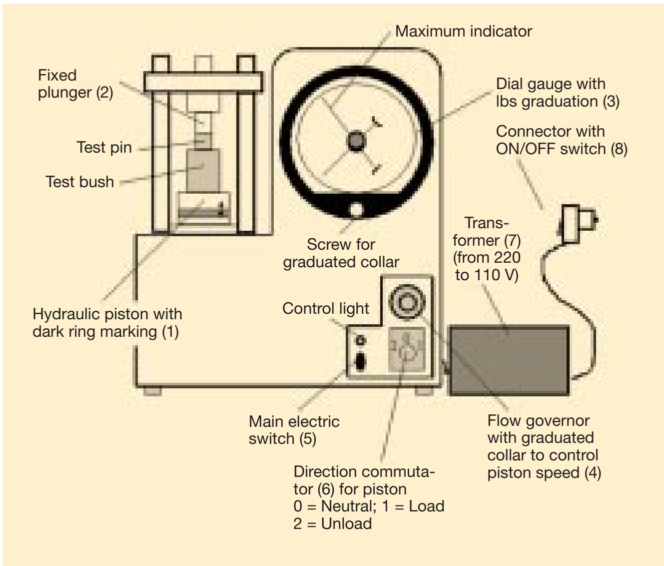
Duration of test:	approx. 30 min
Sliding speed:	15 mm · min variable
Contact geometry:	surface

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

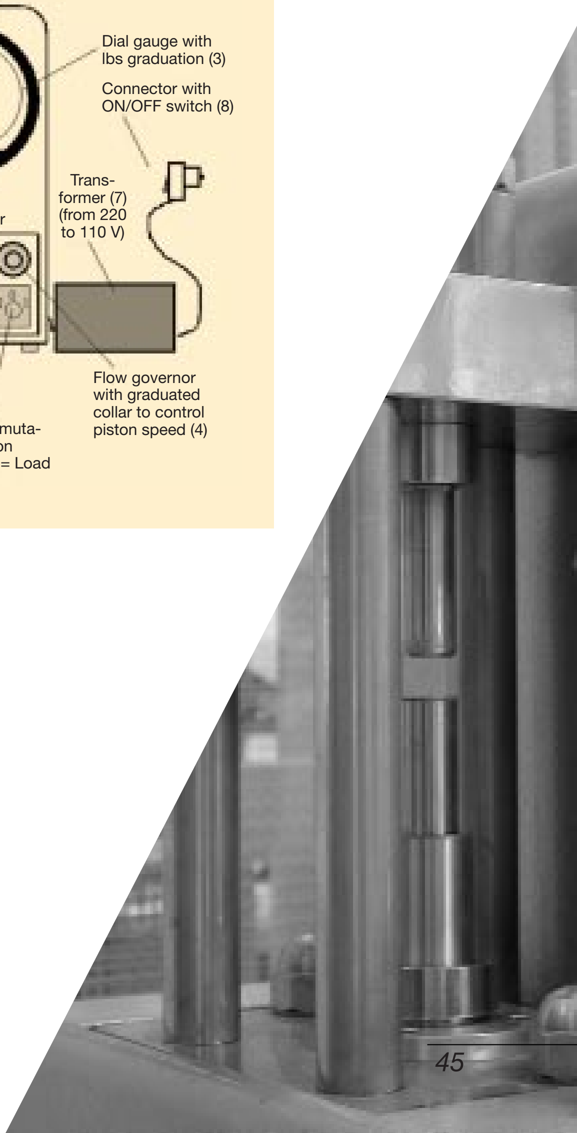
Result
Sliding friction coefficient (optional: static friction coefficient during pressing-out, joint pressure) and load when stick-slip occurs

Measurement of bushing

Total view



Test setup



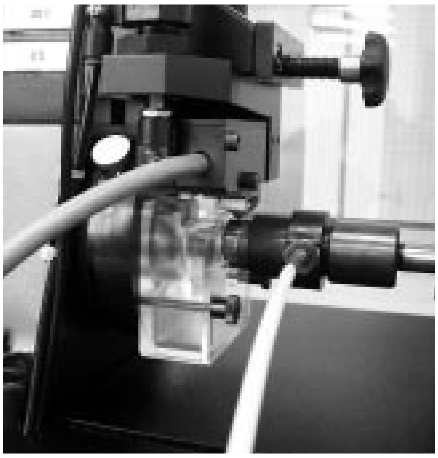
6.27
SKF BeQuiet grease noise test rig

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

Total view



Spindle/bearing/pressure unit

Mechanical unit

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

Total view

Details of the test setup

7.0 Special component tests developed by Klüber

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

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

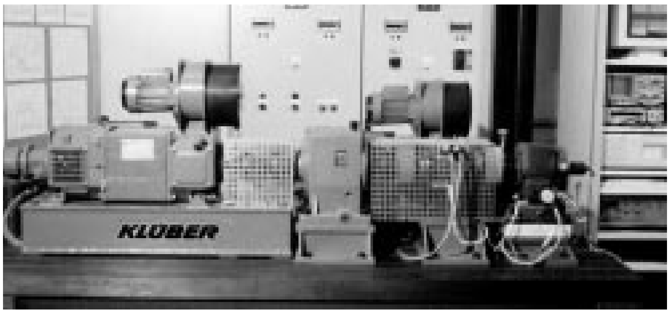
Transmission ratio:	1 : 39 (standard)
Center distance:	63 mm

Test conditions

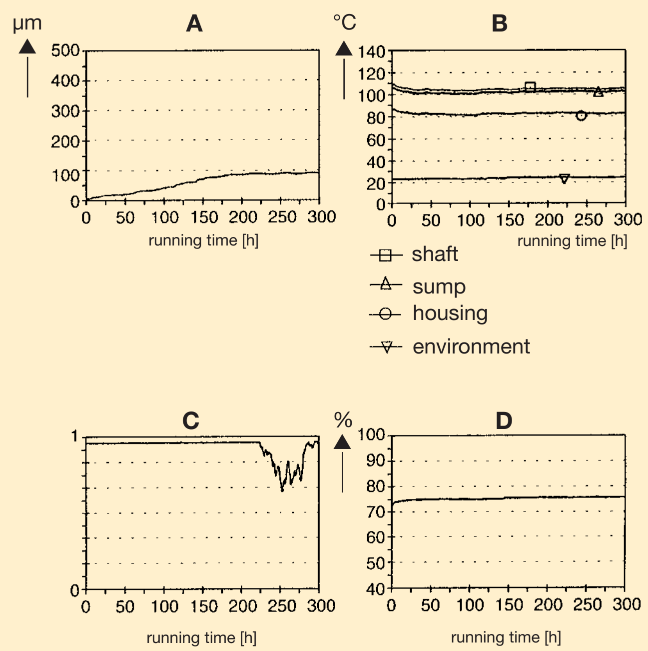
Drive speed:	variable, up to 1200 rpm, 350 rpm as standard
Driven torque:	variable, up to 500 Nm, 300 Nm as standard
Running-in time:	50 h
Duration of test:	300 h
Oil quantity:	600 ml (immersion lubrication)
Housing temperature:	max. 100 °C

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.



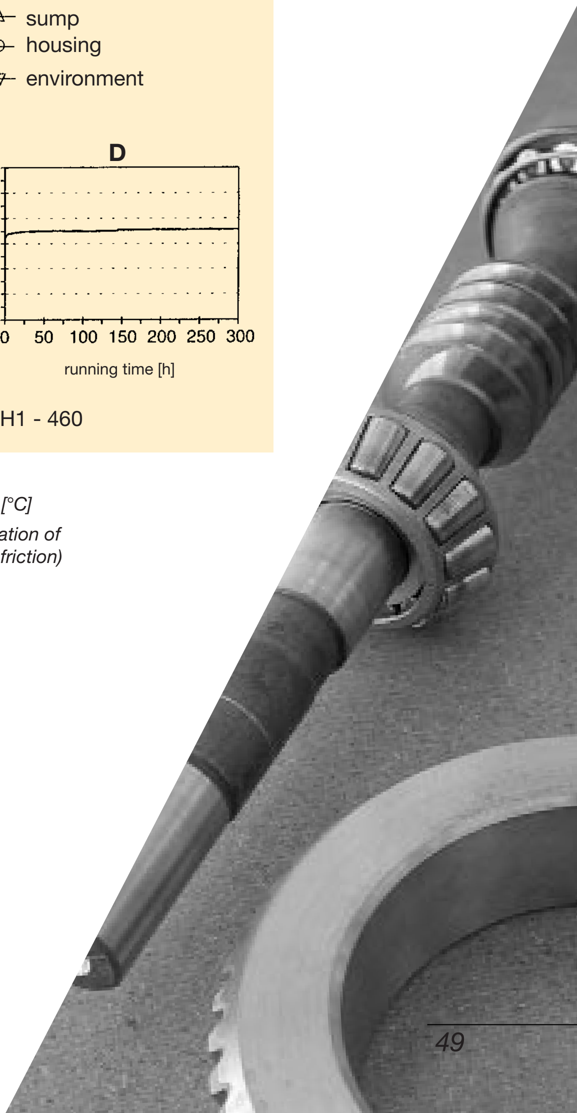
Klüber worm gear oil test rig

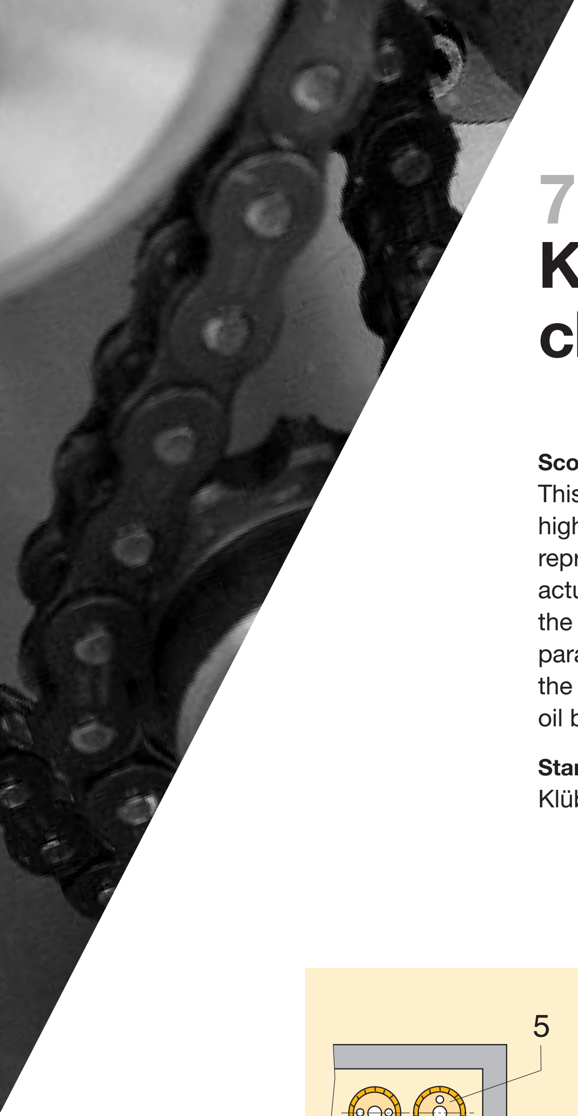


Test oil: Klüberoil 4 UH1 - 460

Test records

A	*Abrasion [µm]*
B	*Temperatures [°C]*
C	*Contact (indication of mixed or fluid friction)*
D	*Efficiency [%]*

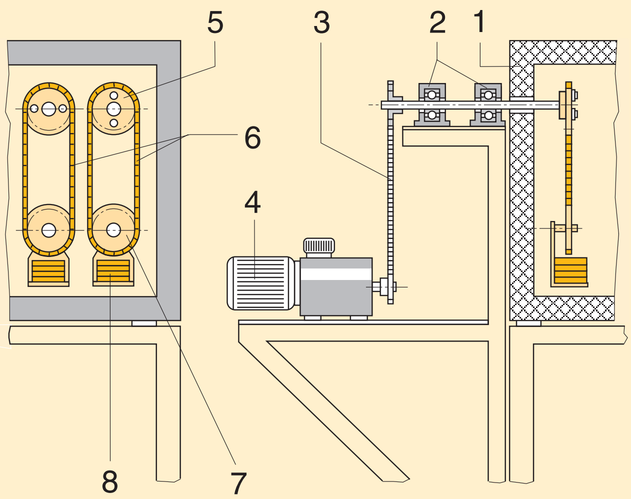




7.2
Klüber high-temperature chain tester

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



1 Heating cabinet
2 Plain pedestal bearing
3 Drive chain
4 Variable speed gear motor
5 Upper chain wheel
6 4 test chains
7 Lower chain wheel
8 Weight

Test rig drawing

Paint-like residues on a test chain caused by high temperature

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 "overloaded" 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

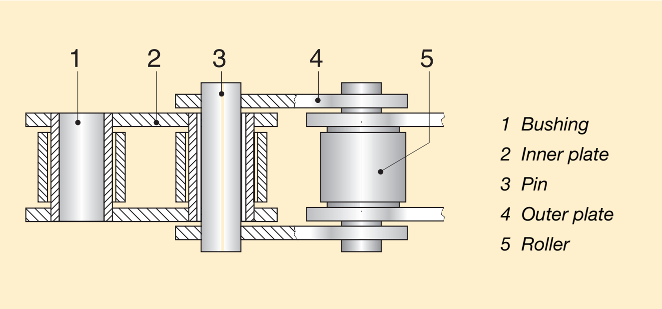
Standard
Klüber test conditions

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

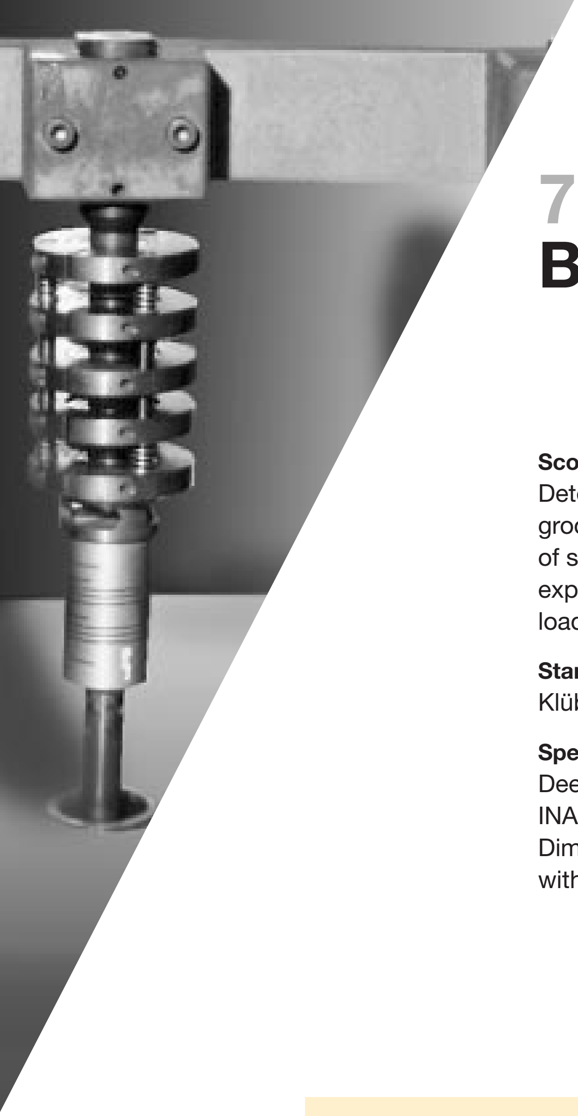
Procedure
- ❑ Apply lubricant on two test chains
- ❑ Mount the chains in the test rig
- ❑ Set the test parameters
- ❑ Record and document the service parameters and tribological data



Single roller chain DIN 8187

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%

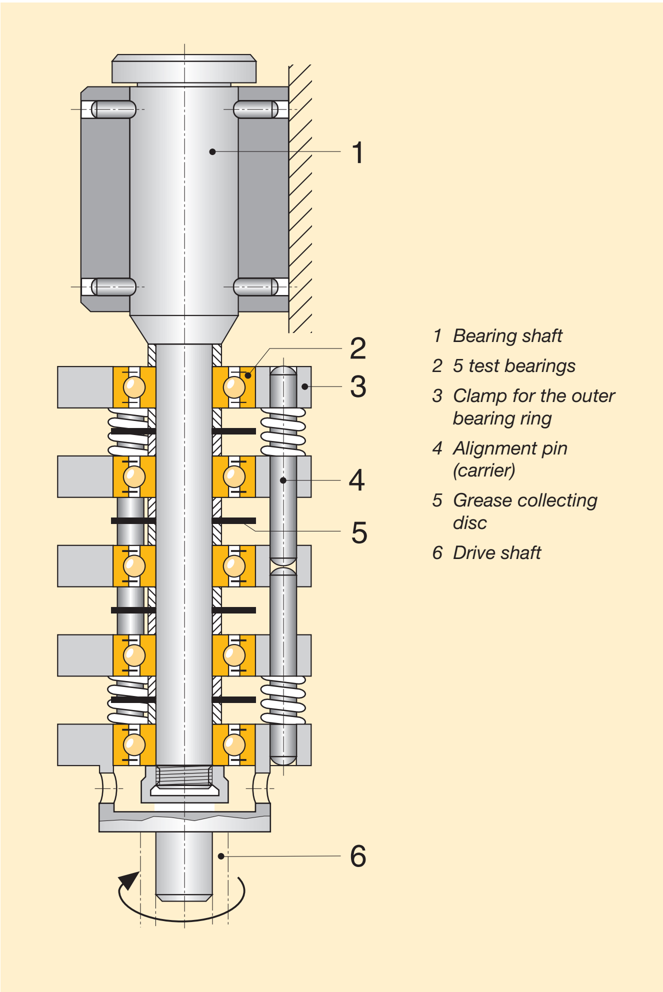


7.4
Brückner test

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 setup

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):

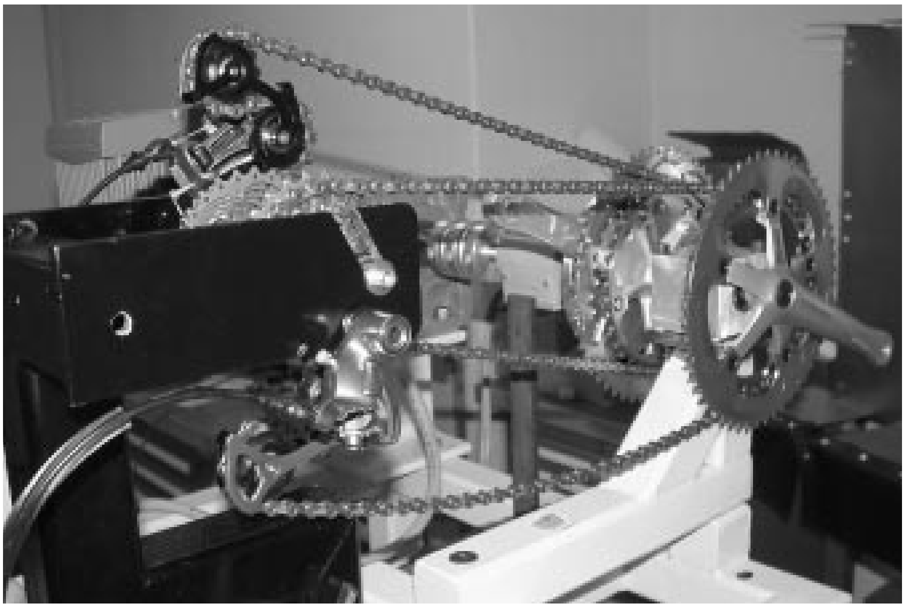
uphill	900 N
time trial	400 N

Test duration:

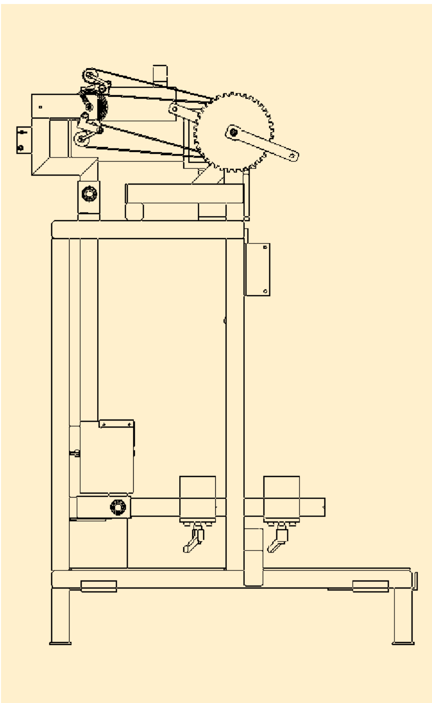
uphill	4 h
time trial	4 h

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

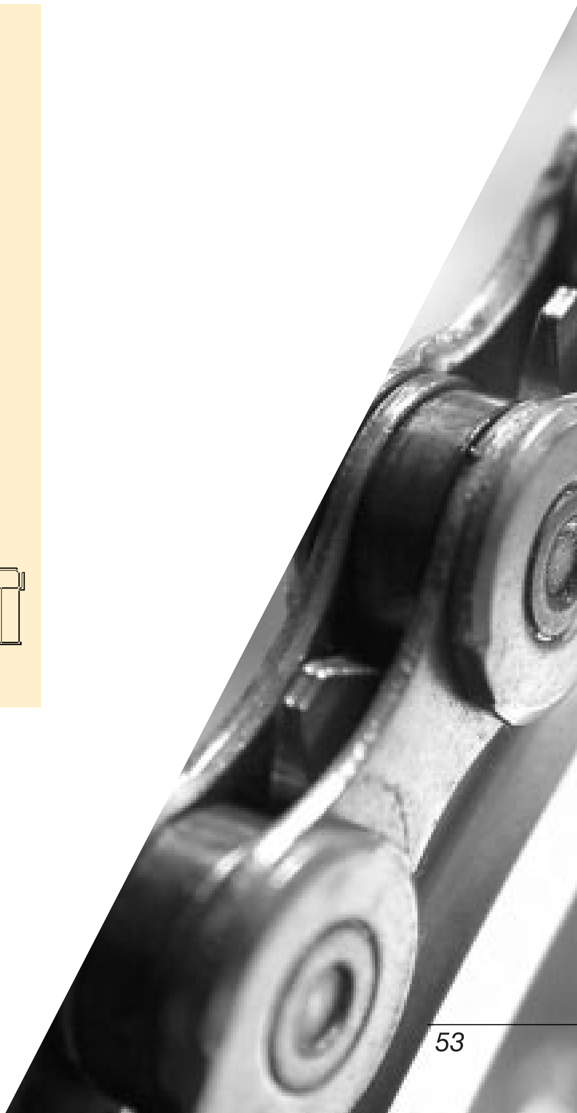
Result
- ❑ Determination of chain efficiency over the whole test duration



Klüber bicycle chain test rig



Test set up



7.6
Klüber water valve tester
(stick-slip)

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

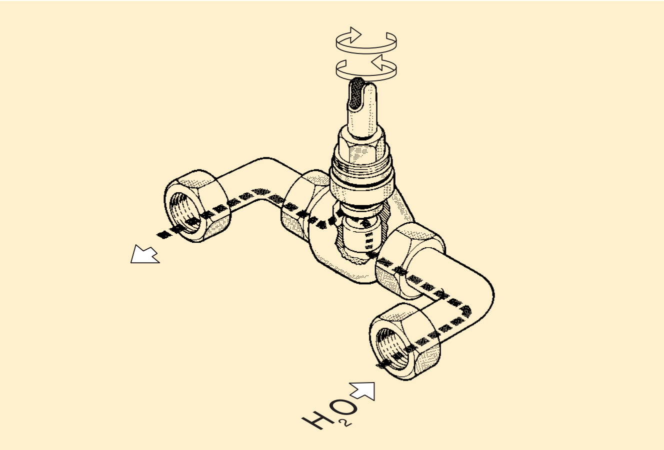
Standard
in acc. with DIN EN 200,
GROHE in-house standard
GSO - 412 - 1

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



Testing principle

Characteristic	Evaluation
0 = uniform sliding	good
1 = slight stick-slip	satisfactory
2 = perceptible stick-slip	still satisfactory
3 = pronounced stick-slip	not acceptable
4 = extreme stick-slip	not acceptable

Evaluation of the operational smoothness

7.7
Klüber water valve tester
(life test)

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

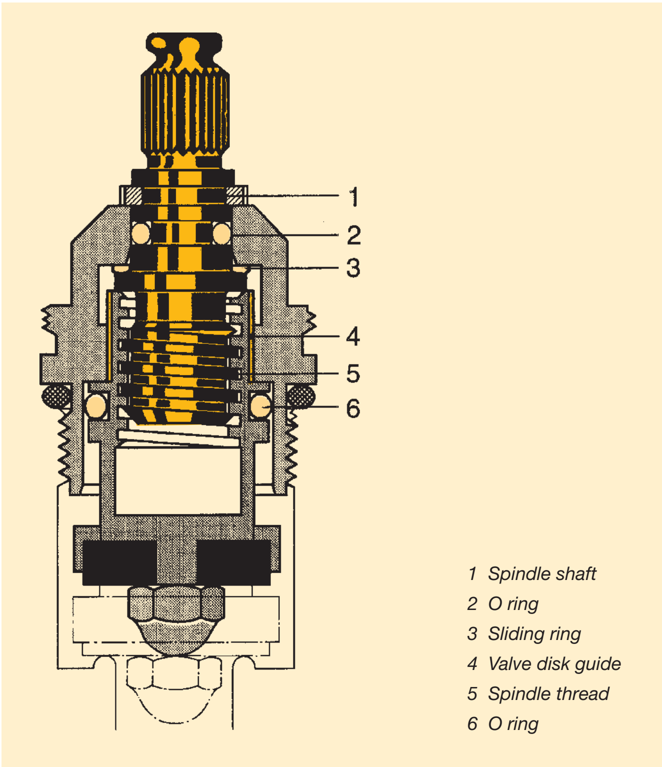
Specimen
Upper parts of valves with a nominal width of 1/2"

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



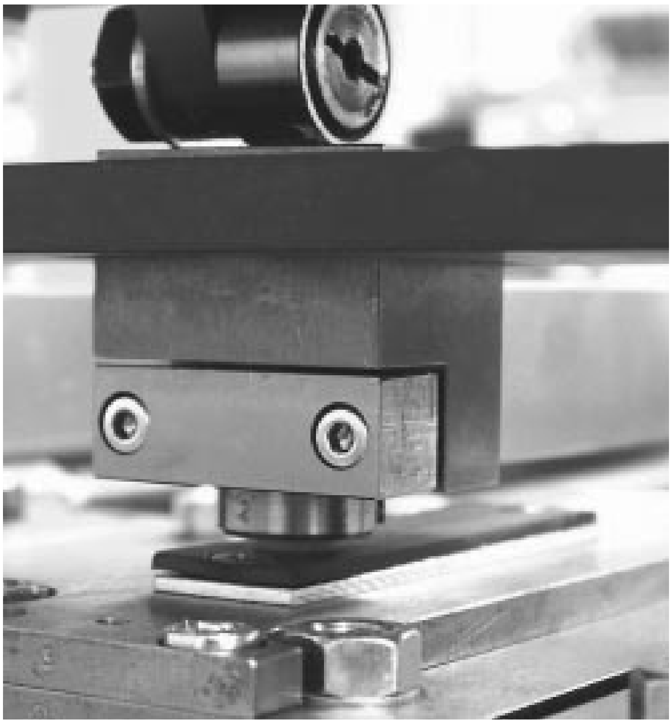
Upper part of spindle; the positioned elements are lubricated

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

Total view



Detail of specimen

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 mm
Sliding speed: v = 50 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

Total view

Wear pattern on switch plate

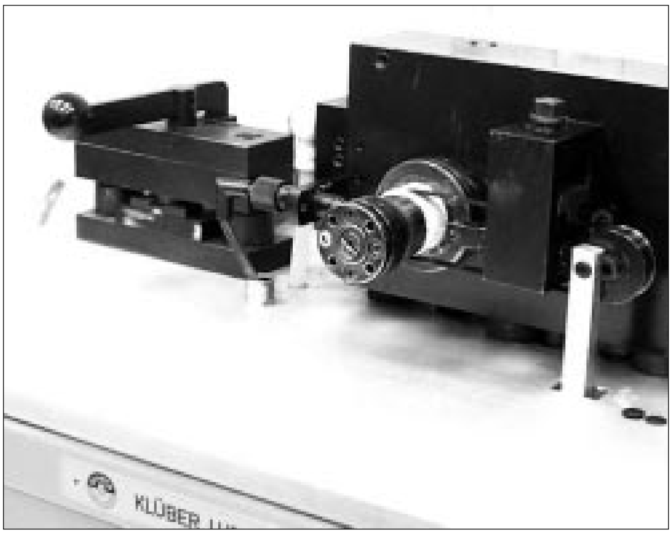
7.10 Oscillation friction wear tester

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

Total view



Test setup

Test conditions

Frequency:	50 Hz
Amplitude:	± 1 mm
Load:	150 N/cm^2 (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

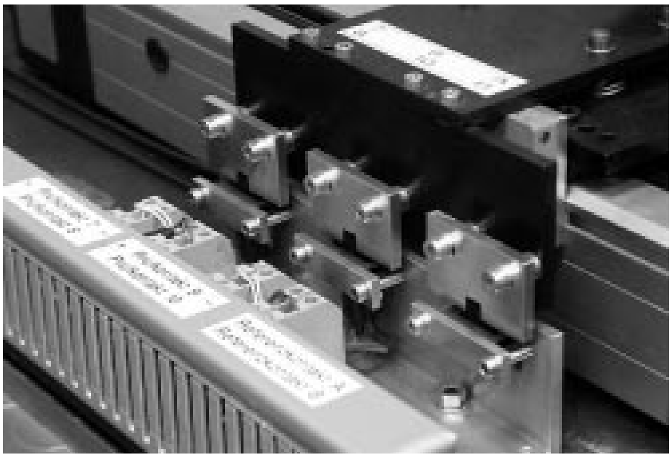
Test conditions

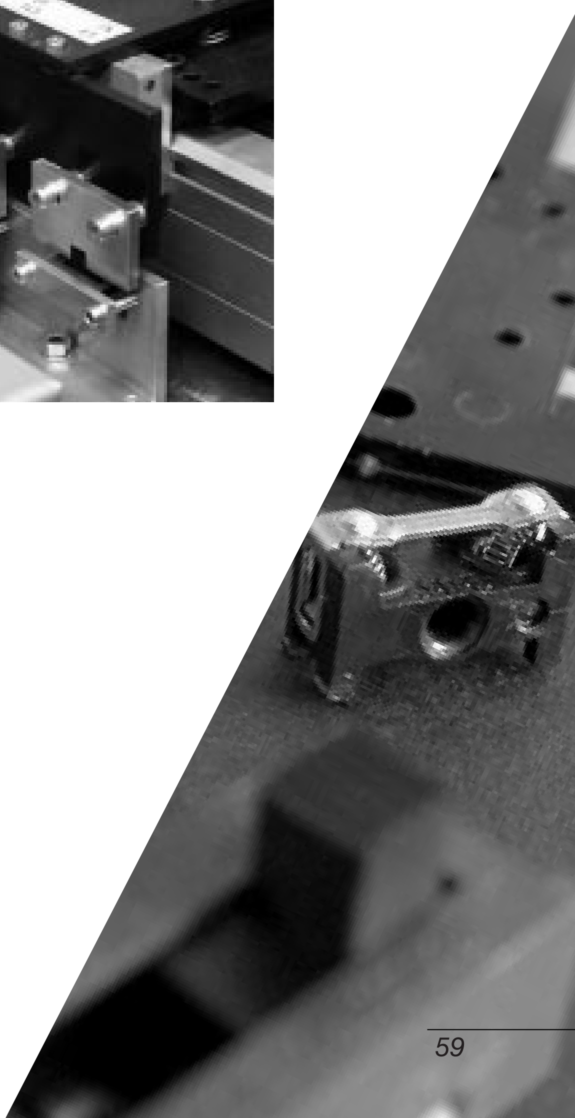
Assembly:	5 test units with 2 switch contacts each
Duration of test:	variable; e.g. 50,000 cycles
Type of test:	– control current – load current
Voltage:	13 V
Current:	100 mA to 56 A max.
Travel speed:	10 to 100 mm/s

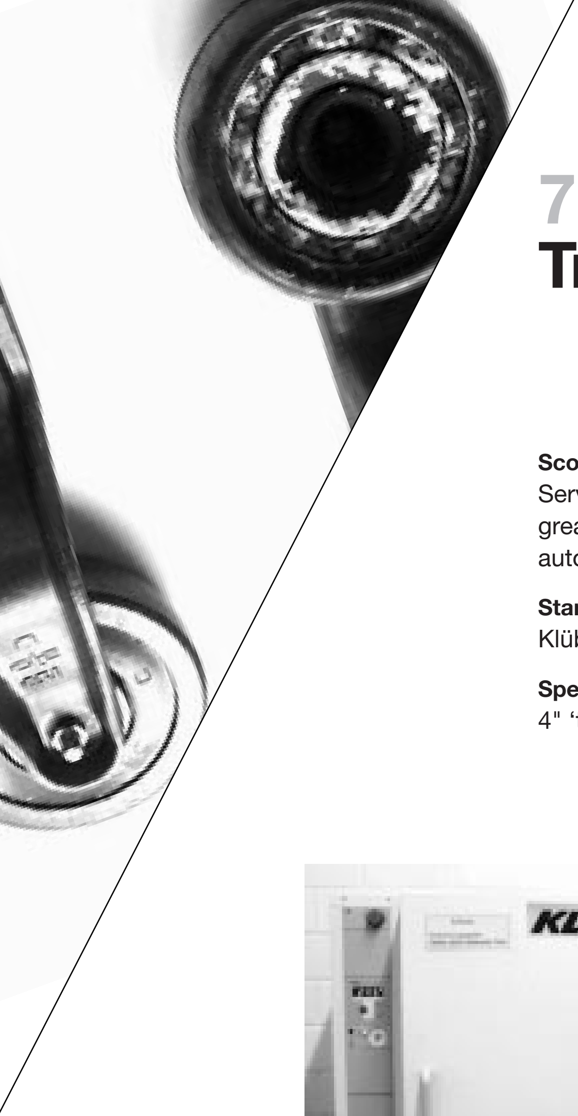
Procedure
❑ Switches
  – clean
  – lubricate
  – insert
❑ Start test

Results
❑ Number of switching cycles achieved without exceeding the limit values of transition resistance
❑ Online representation of transition resistance

Total view


Switch carrier board





7.12
Trolley bearing test rig

Scope
Service life of high-temperature greases in trolley bearings for the automotive industry

Standard
Klüber test conditions

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

Total view


Test chamber

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

7.13
Wire rope test rig

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

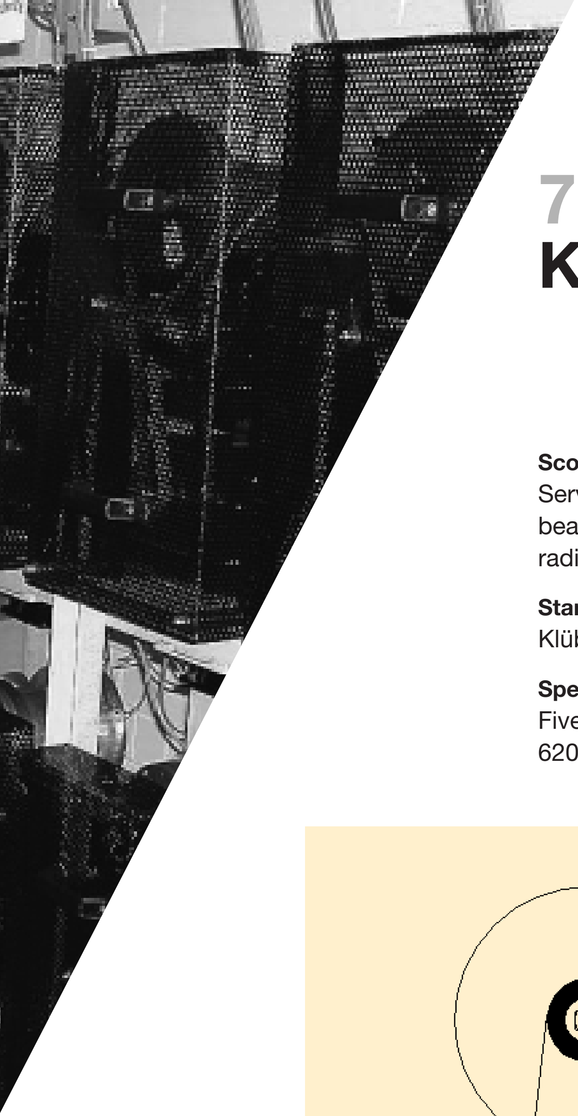
Duration of test:	until rupture of rope
Test with:	6 test units
Stroke:	200 mm (variable)
Load:	190 mm stroke with 120 N 10 mm stroke with 200 N
Speeds:	(variable) acceleration to 125 mms^{-1} in 0.3 s linear motion at 125 mms^{-1}, slow-down to 0 mms^{-1} in 0.2 s
Hold time:	0.5 s

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

Rope pulleys

Total view



7.14
Klüber pulley test rig

Scope
Service life of grease-lubricated rolling bearings with rotating outer ring under radial and thermal load

Standard
Klüber specification

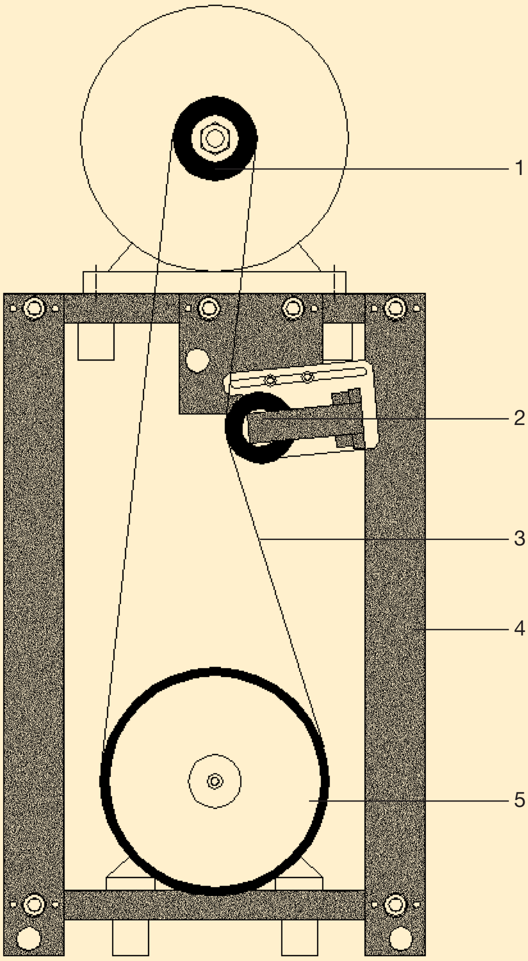
Specimen
Five deep groove ball bearings 6203 – Cr

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



1 Pulley
2 Tension roller
3 Flat belt
4 Steel table
5 Drive pulley

Test setup

7.15
Klüber spindle bearing test rig

Scope
Service life of grease-lubricated high-speed spindle bearings

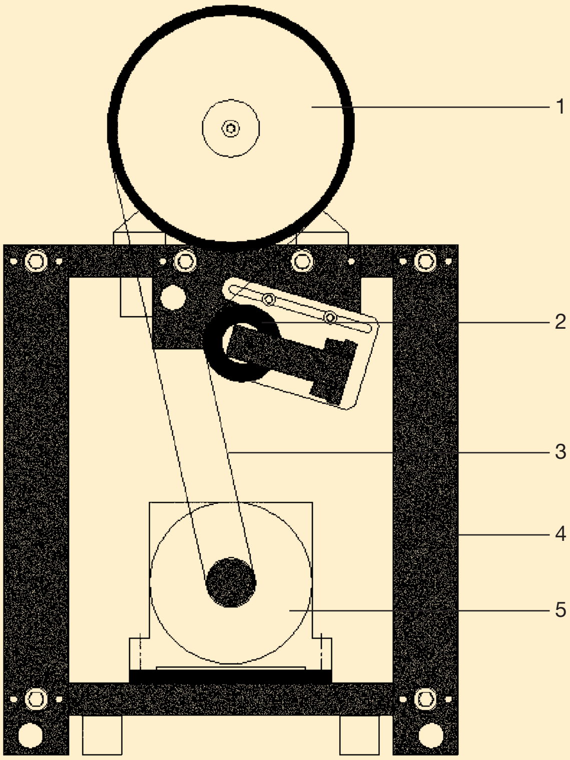
Standard
Klüber specification

Specimen
Ten spindle bearings 7010

Test conditions
Axial load: 100 N
Speed: max. 38,500 rpm
Speed factor: max. $2.5 \cdot 10^6$ mm · 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



1 Drive pulley
2 Tension roller
3 Flat belt
4 Steel table
5 Spindle unit

Test setup

7.16
Ball joint test rig

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

Standard
Klüber test conditions

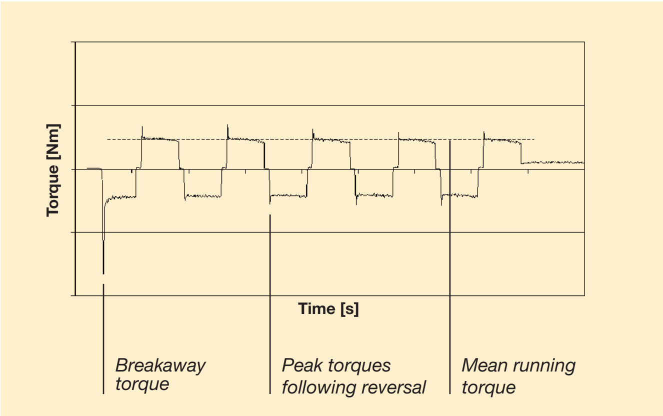
Specimen
Stabiliser joint
Supporting joint

Test conditions

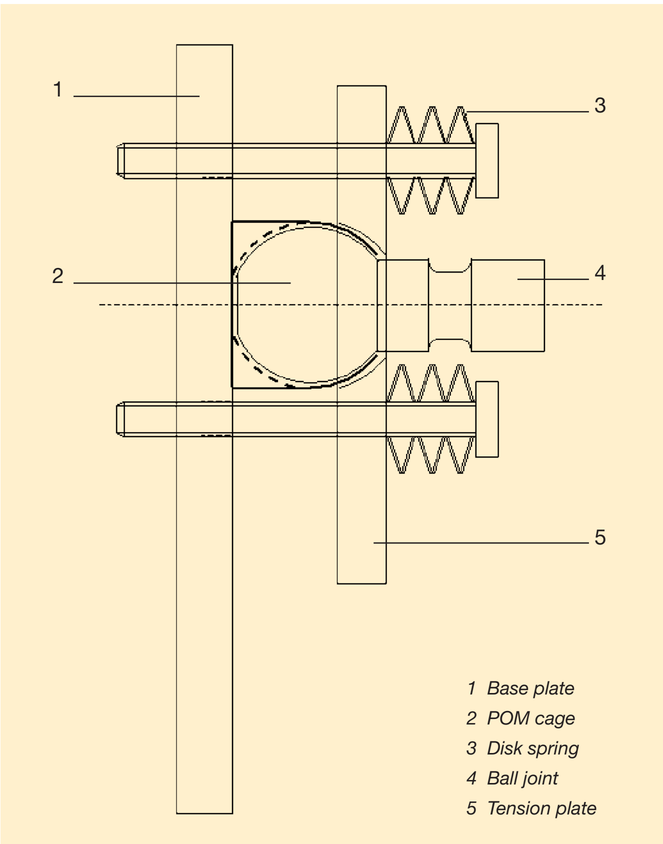
Rotating speed (continuous adjustment):	2 to 100°/sec
Axial load in three steps:	0.2 kN; 1 kN; 2 kN
90° angle of rotation	

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

7.17
Grease depressurisation test rig

Scope
Depressurisation behaviour of greases in centralised lubricating systems

Standard
DIN 51 816, part 2 (February 1978)

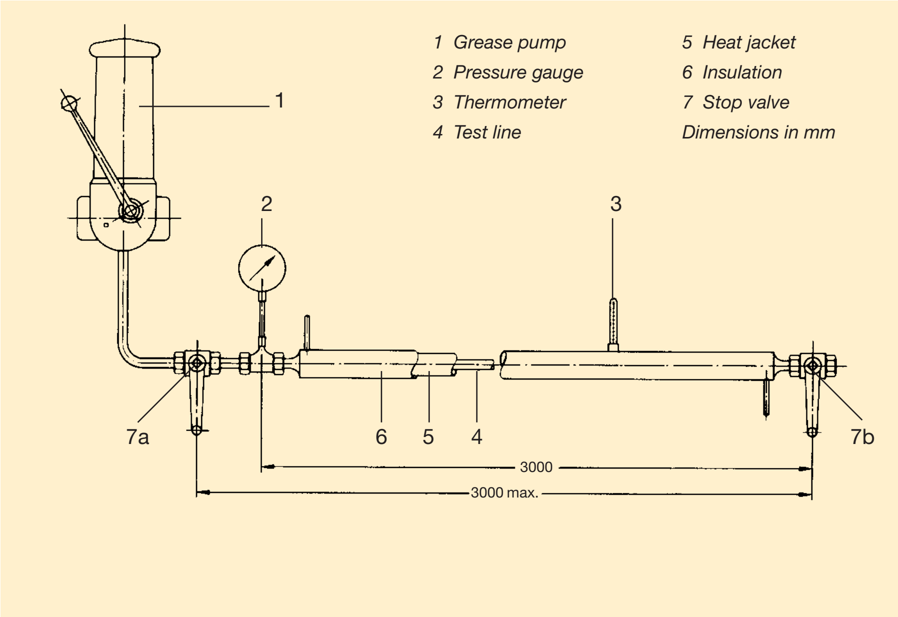
Specimen
–

Test conditions

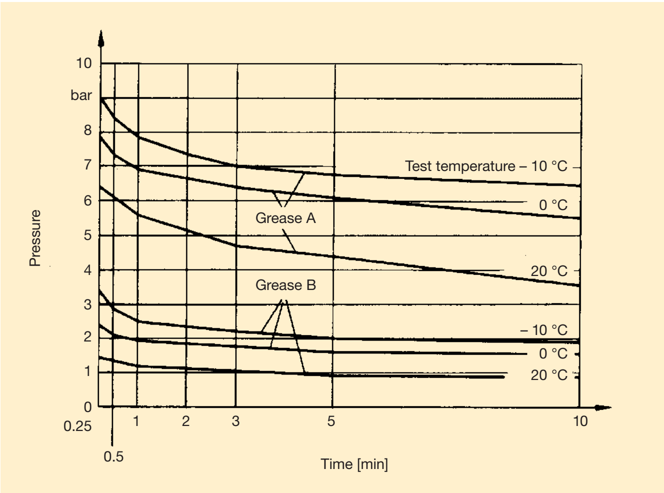
Temperature:	– 10 to 40 °C
Pressure:	max. 50 bar

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

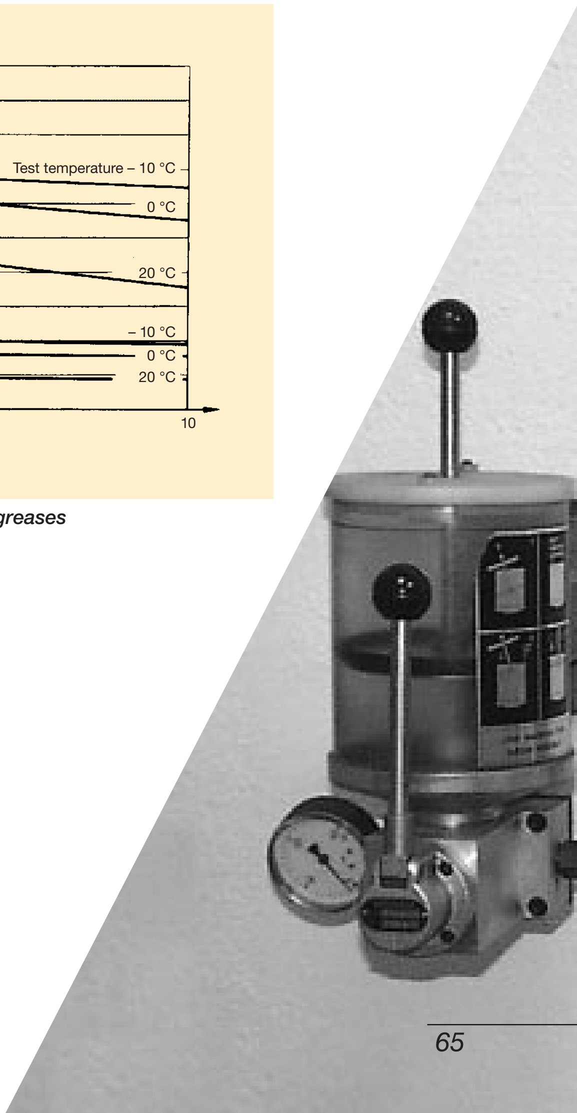
Result
Pressure drop as a function of time and temperature. For comparison, the pressure drop values after 3 min and after 10 min are normally used.



Test setup



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



Notes

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