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Rolling bearings — Noise testing of rolling bearing greases —

Part 3: Test and evaluation method MQ

Roulements — Essais de bruit de graisse pour roulement —
Partie 3: Méthode d'essai et interpretation MQ

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Foreword

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

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

This document was prepared by Technical Committee ISO/TC 4, *Rolling bearings*.

This document is intended to be used in conjunction with ISO 21250-1.

A list of all parts in the ISO 21250 series can be found on the ISO website.

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

Introduction

The rolling bearing life theory emphasizes the use of pure and homogeneous lubricants as essential for a long bearing service life. The lubrication of rolling bearings is described in several national standards. The GfT worksheet 3[11] contains theoretical and practical knowledge of rolling bearing lubrication.

Grease lubrication is the most common type of rolling bearing lubrication. The purity grade of rolling bearing grease is influenced by thickeners, base oils, additives and solid lubricant additives as well as the manufacturing process and is reflected in the running noise. Therefore, noise testing of rolling bearing greases is recommended.

In addition, grease noise testing after this document allows the grease manufacturers to develop low-noise lubricants with highest damping properties. This document can also support the rolling bearing manufacturers and end-users in the selection of low noise grease with better damping properties.

This document covers requirements for the testing assembly and the test machine of method MQ to determine and assess the noise characteristics of rolling bearing grease jointly with ISO 21250-1, ISO 21250-2 and ISO 21250-4.

Rolling bearings — Noise testing of rolling bearing greases —

Part 3:
Test and evaluation method MQ

1 Scope

This document specifies the testing and evaluation method of rolling bearing grease noise in accordance with the method MQ.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 5593, *Rolling bearings — Vocabulary*

ISO 15242-1, *Rolling bearings — Measuring methods for vibration — Part 1: Fundamentals*

ISO 21250-1:2020, *Rolling bearings — Noise testing of rolling bearing greases — Part 1: Basic principles, testing assembly and test machine*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5593, ISO 15242-1, ISO 21250-1 and the following apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
sampling rate
sample rate
<signal processing> frequency with which a continuous signal is sampled and converted into a time-discrete signal

Note 1 to entry: The unit is hertz (Hz) or samples (readings) per second [samples per second (samples/s)].

4 Symbols, abbreviated terms and subscripts

For the application of this document, the symbols, abbreviated terms and subscripts according to ISO 21250-1:2020, Table 1 and Table 2, the symbols and abbreviated terms contained in Table 1 and subscripts contained in Table 2 apply.

Table 1 — Symbols and abbreviated terms

Symbol	Unit	Description
GD	—	Grease damping
H[a]	—	High band, H-band (1 800 Hz to 10 000 Hz)
i	—	Consecutive number
L[b]	—	Low band, L-band (50 Hz to 300 Hz)
M[a]	—	Medium band, M-band (300 Hz to 1 800 Hz)
v	$\mu m \cdot s^{-1}$	Vibration velocity
$\overline{v}_i$	$\mu m \cdot s^{-1}$	Vibration velocity, twice smoothed to the counting point *i*

[a] Can be used as subscript, too, where necessary.

[b] The L-band is used in noise and vibration analysis in the ISO 15242 series. However, this document does not consider this frequency range for grease noise testing and its analysis.

Table 2 — Subscripts

Subscript-symbol	Description
MP	Measuring point
MQ	Method MQ according to ISO 21250-3
NL[a]	Noise level, average value (of vibration velocity)
NP[a]	Noise peak
pk	Peak value
ref	Reference, ungreased bearing
rms	Root mean square
0-32	Starting interval 0 s to 32 s
0-64	Interval 0 s to 64 s
32-64	Operating interval 32 s to 64 s
SUN[a]	Start-up noise of the greased bearing

[a] Noise values with this subscript can be expressed in $\mu m \cdot s^{-1}$ or in % based on the reference value of 16,9 $\mu m \cdot s^{-1}$.

5 Calculation method

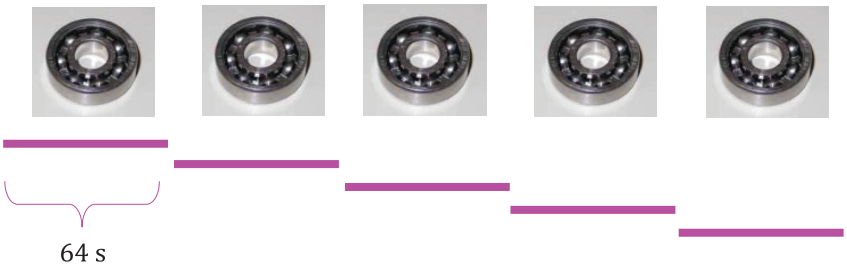
The formulae for calculation of grease damping and peak values are shown in ISO 21250-1:2020, Table 4 and Table 5, respectively.

A sampling rate of 8 readings per second shall be used, i.e. within 32 s, 256 points are required.

6 Test method MQ

6.1 General information

The procedure of MQ requires test bearings to be greased manually. The dosed/balanced quantities of grease shall be introduced in to the bearings by means of a manual grease dosing unit (feeder) or a spatula. There are five pre-greased bearings to be measured for a period of 64 s (each one with a run-in time), as shown in Figure 1.



NOTE Five doses of grease × 64 s = 320 s (including run-in-time) measurement: 4 096 measuring points (MP) at 32,768 kHz ≙ 0,125 s, thus 512 MP/grease dose and in total 2 560 MP.

Figure 1 — Duration of measurement— Process MQ

The process for the manual pre-greasing is represented in B.2.

6.2 Measuring principle

For the application of this document, the measuring principle, test bearings and amount of grease, test load, spindle speed, signal recording and display of measuring results according to ISO 21250-1:2020, Clause 7, applies. The peak detection algorithm for processing of the input signal is shown in ISO 21250-1:2020, Table 5).

An example of a test machine, the test set-up, electronic system and test reports is given in Annex A.

6.3 Testing procedure

6.3.1 Reference measurement of preserved, ungreased bearings

The testing procedure shall include the following steps:

1) The noise tester shall be turned on and warmed up until a spindle temperature of 30 °C is reached on the housing.

2) The MQ-test programme shall be started.

3) For five prepared (cleaned and newly preserved) test bearings (according to B.1), the reference state shall be measured. The noise levels and noise peaks shall be in accordance with the allowed values (see Table 3) for the test to proceed.

4) Mark an arrow on the outer ring side face of the test bearing with a permanent marker.

5) The test bearing shall be pushed on to the mandrel in such a way that the marking (arrow head) on the outer ring points exactly to the sensor.

6) Apply the axial test load according to Table 3 on the test bearing.

7) Lower the sensor and start to rotate the spindle.

8) After this, start the measurement procedure.

9) After the measurement shut off the noise tester, loosen the loading device and withdraw the test bearing from the mandrel.

10) Repeat steps 4) through 9) with the other four test bearings. The test bearings shall be sorted according to order of testing (place 1 to 5).

11) Bearings that are worse than the allowed values (Table 3) shall be rejected. The measurement shall then be repeated with an additional bearing, until five appropriate reference bearings are found.

Table 3 — Basic designation of the test bearings, axial loads, permissible noise level v_{NL} and permissible noise peaks v_{NP}

Basic bearing designation	Axial load N	Axial load tolerance %	Noise level µm · s^{-1}		Noise peak µm · s^{-1}	
			$v_{NL, M\ 0\text{-}64}$	$v_{NL, H\ 0\text{-}64}$	$v_{NP, M\ 0\text{-}64}$	$v_{NP, H\ 0\text{-}64}$
608	30	±10	≤8	≤12	≤2	≤3
6202	60	±10	≤14	≤16	≤3,5	≤4

6.3.2 Comparison measurement of greased bearings

Five appropriate test bearings shall be greased in the order of their reference measurements (in accordance with B.2). Their measurement shall be carried out immediately afterwards in the same sequence and as follows:

1) The test bearing shall be pushed on to the mandrel in such a way that the marking (arrow head) on the outer ring points exactly to the sensor.
2) Apply the axial load according to Table 3 on the test bearing.
3) Lower the sensor and start to rotate the spindle.
4) After this, start the measurement procedure.
5) After the measurement shut off the noise tester, loosen the loading device and withdraw the test bearing from the mandrel.

7 Evaluation of results

7.1 General information

For the use of measuring electronics equipment conforming to this document, the following applies:

1) The machine should have an automated test procedure.
2) The result shall be saved in a printable version and/or be printed on paper.

7.2 Description of results

7.2.1 Preserved bearings

For preserved bearings, the evaluation program indicates, in addition to the noise peaks from 0 s to 32 s, also the noise peaks from 32 s to 64 s and the noise level from 32 s to 64 s of all bearings in the M- and H-bands as well as start-up noise and maximum values.

7.2.2 Greased bearings

For greased bearings, the graphs shall be printed. In addition to the assessment parameters, which are the noise peaks from 0 s to 32 s, the noise peaks from 32 s to 64 s, the damping factors, the start-up noise values of all bearings in the M- and H-bands and the mean values, as well as the classifications to the grease noise class, also the maximum value shall be printed.

7.3 Grease noise classes — Rating scale

The calculation methods for the noise peak values $\nu_{NP,\ M\ 0\text{-}32}$, $\nu_{NP,\ H\ 0\text{-}32}$ and $\nu_{NP,\ M\ 32\text{-}64}$, $\nu_{NP,\ H\ 32\text{-}64}$ are given in ISO 21250-1:2020, Table 5, Formulae (7) to (10) . The calculation methods for the damping factors $GD_{M\ MQ}$ and $GD_{H\ MQ}$ are given in ISO 21250-1:2020, Table 4, Formulae (5) and (6). The assessment shall be carried out in accordance with Table 4.

Table 4 — Grease noise classes — rating scale

Grease noise class	Noise peak values %[a]				Damping factor —[b]	
	$\nu_{NP,\ M\ 0\text{-}32}$	$\nu_{NP,\ H\ 0\text{-}32}$	$\nu_{NP,\ M\ 32\text{-}64}$	$\nu_{NP,\ H\ 32\text{-}64}$	$GD_{M,\ MQ}$	$GD_{H,\ MQ}$
I	≤8,3	≤8,6	≤5,7	≤5,8	≥0,95	≥1,20
II	>8,3	>8,6	$5,7 < \nu_{NP,\ M\ 32\text{-}64} \leq 10,0$	$5,8 < \nu_{NP,\ H\ 32\text{-}64} \leq 10,5$	$0,70 \leq GD_{M,\ MQ} < 0,95$	$0,80 \leq GD_{H,\ MQ} < 1,20$
III	>8,3	>8,6	$10,0 < \nu_{NP,\ M\ 32\text{-}64} \leq 13,9$	$10,5 < \nu_{NP,\ H\ 32\text{-}64} \leq 15,0$	$0,50 \leq GD_{M,\ MQ} < 0,70$	$0,50 \leq GD_{H,\ MQ} < 0,80$
IV	>8,3	>8,6	$13,9 < \nu_{NP,\ M\ 32\text{-}64} \leq 18,0$	$15,0 < \nu_{NP,\ H\ 32\text{-}64} \leq 19,7$	$0,40 \leq GD_{M,\ MQ} < 0,50$	$0,40 \leq GD_{H,\ MQ} < 0,50$
>IV	>8,3	>8,6	>18,0	>19,7	<0,40	<0,40

[a] Based on the reference value 16,9 $\mu m \cdot s^{-1}$.

[b] Dimensionless.

For each individual test bearing, the grease noise class is emitted. This is calculated from the worst value of each of noise peak values and damping factors and the mapping of these in both the middle and high frequency ranges.

The total noise class corresponds to the arithmetic mean, from the mapping of the five test bearing results. The result of the grease noise class is rounded to a whole number (e.g. "I+I+II+II+I = VII/5 = 1,4" results in "I"; "I+II+II+II+I = VIII/5 = 1,6" results in “II“). The noise class shall be indicated in Roman numerals.

The start-up noise for each individual test bearing is displayed. The start-up noise with a slash appended is the starting value, expressed in Arabic numerals. The larger of the two averages ($\nu_{SUN\ H}$, $\nu_{SUN\ M}$) is printed, which is indicated in two decimal places, and rounded down to the integer number (e.g. 2,00 to 2,99 will be rounded down to 2). See also example in Annex D.

7.4 Accuracy of results

When two results are achieved under repeatable conditions, both results can be considered to be accepted provided that both pairs of values for the noise class and the pairs of values for the starting value do not deviate by more than one number in value.

In case of non-equal classes of noise, the result of the better class of noise and, at same noise classes and different starting values, the result with the better starting value shall be indicated.

Examples of results are shown in Table 5.

Table 5 — Accuracy of the measurement results

Result pairs, repeated	Accepted	Indication of result
I/2, III/2	No	—
II/1, II/3	No	—
II/2, III/2	Yes	II/2
III/1, III/2	Yes	III/1
II/2, III/1	Yes	II/2

7.5 Permissible results in specifications

Table 6 shows typical noise requirements with permissible results.

Table 6 — Permissible results in specifications

Requirement for noise class	Permissible results
I/1	I/1
≤I/2	I/1, I/2
≤II/1	I/1, I/2, II/1
≤II/2	I/1, I/2, I/3, II/1, II/2
≤III/1	I/1, I/2, I/3, II/1, II/2, III/1
≤III/2	I/1, I/2, I/3, II/1, II/2, II/3, III/1, III/2
≤IV/1	I/1, I/2, I/3, I/4, II/1, II/2, II/3, III/1, III/2, IV/1

7.6 Plausibility of results

After the measurement, the graphs and single values shall be checked for plausibility (in accordance with Annex C).

In general, it is recommended to repeat the measurement (in accordance with C.1). The measurement with the better results can be taken.

A bearing with strikingly different noise diagram (in accordance with C.2) shall be eliminated and be replaced by another one, i.e. an additional bearing shall be investigated.

In case of appearance of unusual peaks of the same shape (mostly with different amplitude) in a bearing at exactly the same point in time in both frequency bands, these can be hidden in the evaluation by the program. These time windows shall be presented in the diagram but shall not be taken into account when evaluating.

Both provisions should be limited to exceptions. In a series of measurement of five bearings, a maximum of five adjustments can be made. Any correction shall cover a time frame of 3 s maximum.

These effects are usually caused by inadequate bearing preparation.

Annex A
(informative)

Test machine, test setup, electronic system and test reports: examples

A.1 Test machine

The test machine shall have the following main components:

— a high-quality spindle with a speed of 1 800 min^{-1} ($^{+1\,\%}_{-2\,\%}$ speed deviation) and a rotation of the inner ring in one direction;

NOTE The lower speed limit is considered to be 1 764 min^{-1} and the upper speed limit 1 818 min^{-1}.

— a pneumatic loading device for loading of the bearing;

— electronics with evaluation software;

— a special interface to the fully automated measurements, storage of collected readings and interpretation of results.

The test machine is usually a semi-automatic machine for use in laboratories and consists of the following units, for example (see Figure A.1):

— personal computer (PC);

— input and output devices;

— storage space for tools;

— calibration device;

— printer;

— electronics;

— pneumatic and test mechanics.

It may contain the following additional components:

— a special adapter for mounting the test bearing including inlet for the grease, as well as inlet for compressed air to blow out the grease;

— a grease dispensing unit, preferably from a linear actuator, which is driven by a variable speed electric motor and moves the piston in the syringe with the grease sample.

The testing procedure shall be automated, to eliminate subjective operator influences and the risk of possible contamination, which negatively influence the result. It is on a controlled dosage of grease and peak measurement in combination with a test bearing that has a very good noise level quality.

The testing procedure shall preferably be monitored by software, which stores all vibration peaks and evaluates the result in accordance with Clause 5.

Alternative components, procedures and monitoring employed shall be reported with the results.

Key

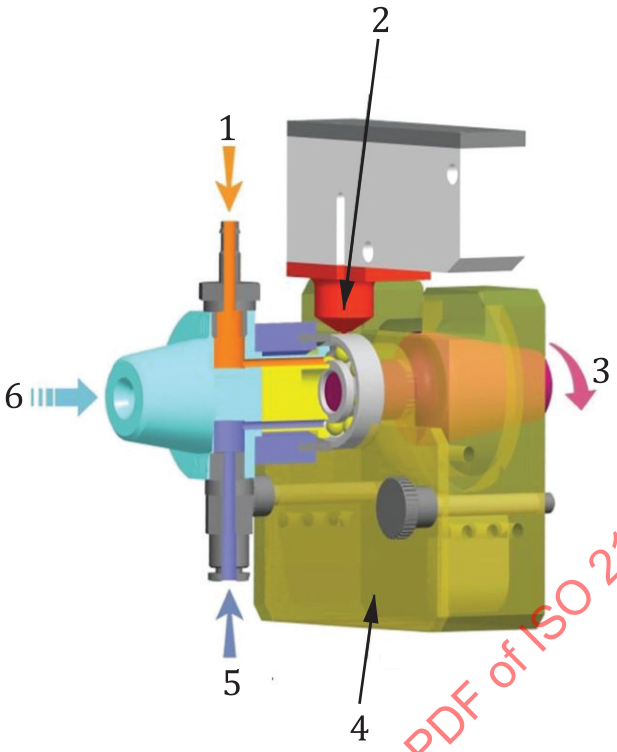
1 screen
2 electronic control cabinet
3 keyboard
4 cabinet for tools, printer and calibration device
5 test mechanics
6 grease dosing unit
7 control panel
8 cabinet for electrical, mechanical and pneumatic unit

Figure A.1 — Example of a test machine

A.2 Test setup

The test bearing shall be pushed onto a mandrel firmly connected with the spindle. The axial load shall be applied via an adapter onto the outer ring.

The adapter can contain an intake for the grease as well as an inlet for compressed air to blow out the grease. An example is contained in Figure A.2.



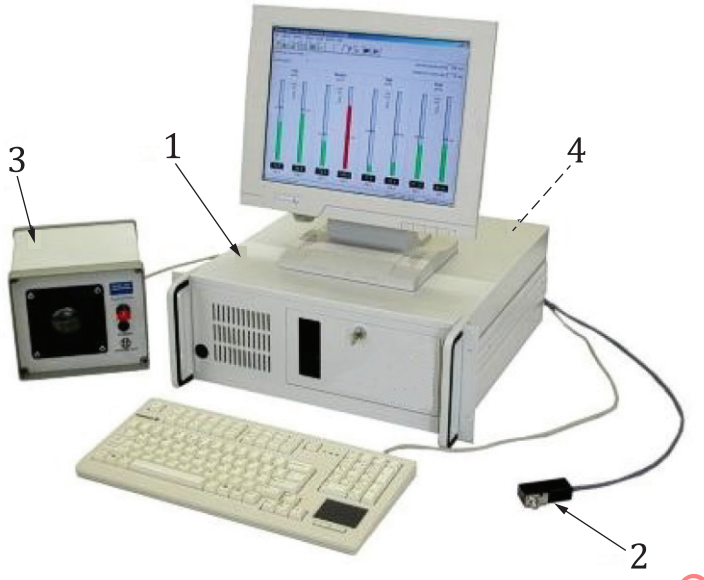
Key

1 grease
2 sensor
3 spindle
4 grease container
5 compressed air
6 axial load

Figure A.2 — Example of the test mechanism

A.3 Electronic system

The measuring electronic system for example consists of the components described in Figure A.3.



Key

1 industrial PC; with adequate performance; data acquisition card: 20 bit AD-converter, signal processor, antialiasing-filter;

2 (two) sensor connections

3 loudspeaker

4 inputs and outputs for machine control (rear side)

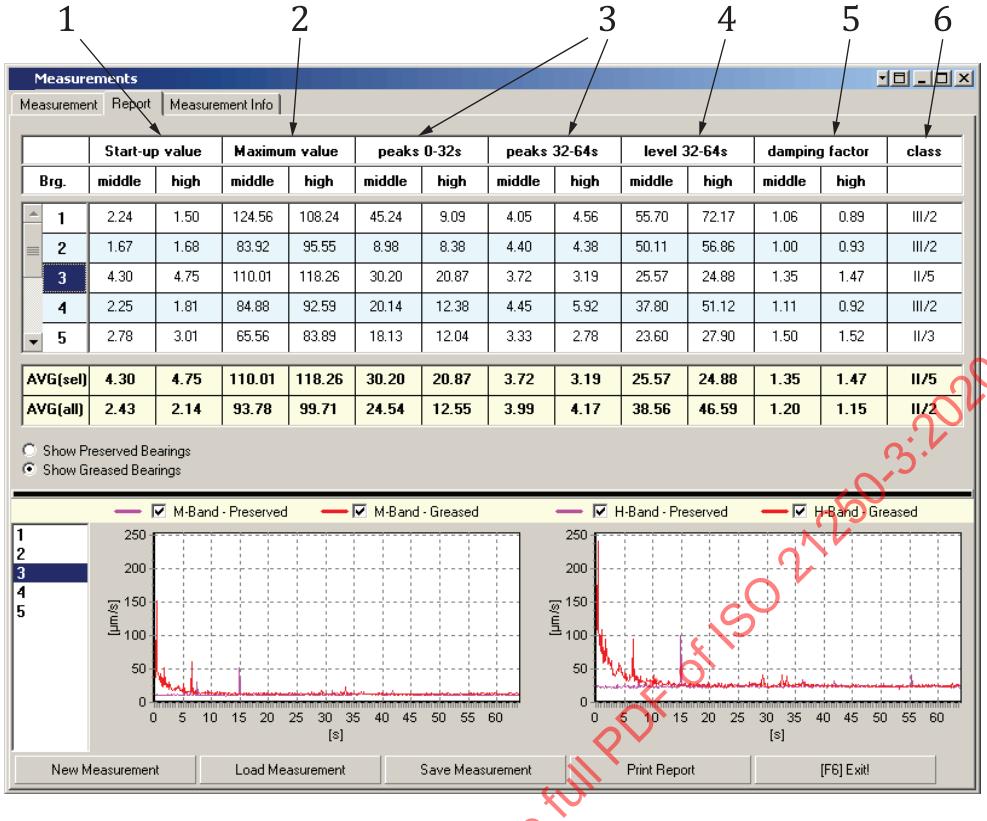
Figure A.3 — Example of measuring electronics

Practical hints for calibration are given in ISO 21250-2:2020, Annex C.

A.4 Test reports

The output of the results shall be in the form of lists and graphs according to Figure A.4 and Figure A.5.

NOTE Compliance with this informative Annex will support achievement of valid results.



Key

1 starting value expressed as the ratio of the smoothened maximum value in the starting range related to the noise level from 32 s to 64 s

2 smoothened maximum value in the starting range: each measurement point is the mean value over the period of ± 1 s (equals ± 8 measuring points), averaged to a new value

3 noise peaks of 0 s to 32 s and 32 s to 64 s

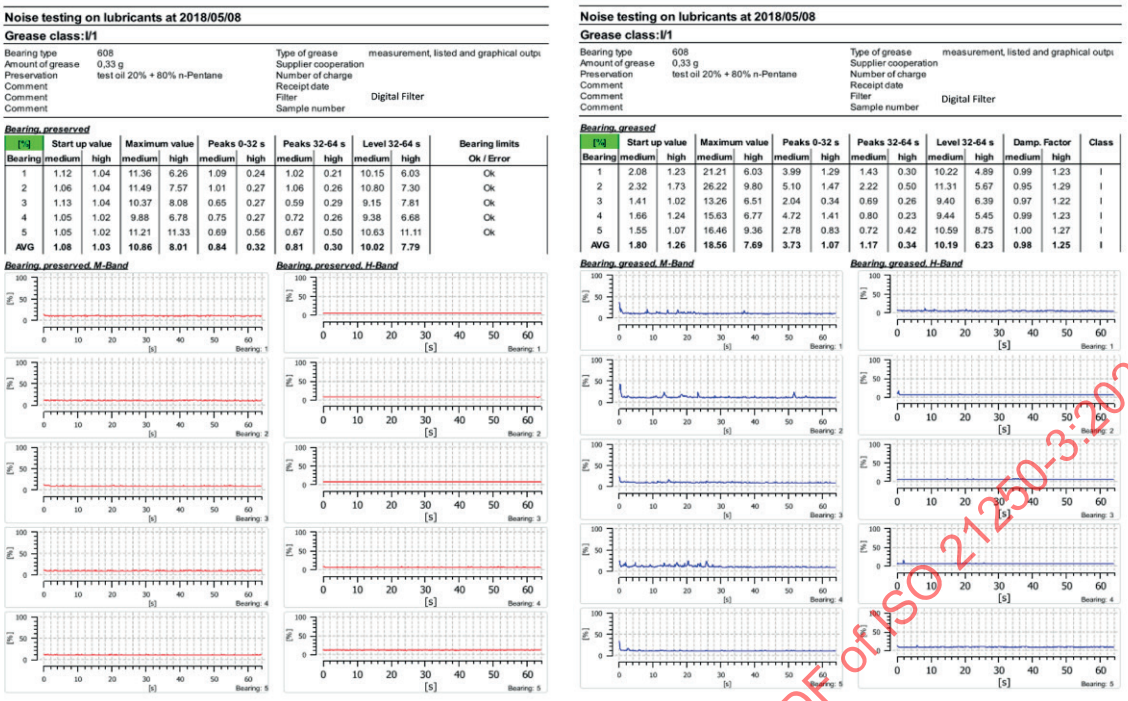
4 twice smoothened original curve: the value is a measure that takes into account the number and intensity of noise peaks

5 ratio of the noise level from 32 s to 64 s of preserved state to the noise level from 32 s to 64 s of greased one

6 II = noise class (rounded average of individual bearings)

2 = starting value (the worse of the two rounded average values)

Figure A.4 — Example 1 — Listed output and graphical output



[%]	Start up value		Maximum value		Peaks 0-32 s		Peaks 32-64 s		Level 32-64 s		Bearing limits
Bearing	medium	high	medium	high	medium	high	medium	high	medium	high	Ok / Error
1	1.12	1.04	11.36	6.26	1.09	0.24	1.02	0.21	10.15	6.03	Ok
2	1.06	1.04	11.49	7.57	1.01	0.27	1.06	0.26	10.80	7.30	Ok
3	1.13	1.04	10.37	8.08	0.65	0.27	0.59	0.29	9.15	7.81	Ok
4	1.05	1.02	9.88	6.78	0.75	0.27	0.72	0.26	9.38	6.68	Ok
5	1.05	1.02	11.21	11.33	0.69	0.56	0.67	0.50	10.63	11.11	Ok
AVG	1.08	1.03	10.86	8.01	0.84	0.32	0.81	0.30	10.02	7.79	

[%]	Start up value		Maximum value		Peaks 0-32 s		Peaks 32-64 s		Level 32-64 s		Damp. Factor		Class
Bearing	medium	high	medium	high	medium	high	medium	high	medium	high	medium	high	
1	2.08	1.23	21.21	6.03	3.99	1.29	1.43	0.30	10.22	4.89	0.99	1.23	I
2	2.32	1.73	26.22	9.80	5.10	1.47	2.22	0.50	11.31	5.67	0.95	1.29	I
3	1.41	1.02	13.26	6.51	2.04	0.34	0.69	0.26	9.40	6.39	0.97	1.22	I
4	1.66	1.24	15.63	6.77	4.72	1.41	0.80	0.23	9.44	5.45	0.99	1.23	I
5	1.55	1.07	16.46	9.36	2.78	0.83	0.72	0.42	10.59	8.75	1.00	1.27	I
AVG	1.80	1.26	18.56	7.69	3.73	1.07	1.17	0.34	10.19	6.23	0.98	1.25	I

Figure A.5 — Example 2 — Listed output and graphical output

Annex B
(normative)

Preparation of test bearings and greasing

B.1 Preparation of test bearings

WARNING — During all work with solvents or dispersion, the bearing shall only be handled with grippers and shall not be touched by hand. The use of industrial cleaning equipment yields invalid results and is not permitted.

1) For the selection of test bearings, it is recommended to select new deep groove ball bearings 608 on basis of their noise levels and noise peaks. The noise level and noise peaks shall be in accordance with the permissible values given in Table 3.

   NOTE Currently, the grease noise test according to the procedure of MQ for deep groove ball bearings 6202 is still under development/testing.

2) The selected ball bearings shall be put in a cleaning tank (maximum of 3 layers one above the other). Filtered solvent shall then be poured over and, as a first step, cleaning shall be carried out with a bristle brush.

3) Contaminated solvent is to be drained.

4) Pour fresh solvent to completely wash over the bearing, cover cleaning tank and let it rest for at least 8 h (e.g. overnight).

5) The contaminated solvent shall be drained.

6) Pour fresh filtered solvent over the bearing, cover the cleaning tank and swivel (back and forth) with a gripper in the cleaning tank.

7) Steps 5) and 6) shall be repeated twice.

8) The solvent shall be drained. The bearings shall be sprayed individually with fresh filtered solvent from the squirt bottle.

9) Bearings shall be laid in a cleaning tank. Filtered ethanol shall be poured over until they are fully immersed. A gripper shall then be used to agitate and flush them back and forth in an axial direction.

10) Ethanol shall be drained.

11) Steps 9) and 10) shall be repeated twice.

12) The bearings shall be individually picked and sprayed with ethanol and then dried for 20 min at 100 °C. The bearings shall also be cooled down in a desiccator under venting (about 15 min). The dry bearings shall then be processed immediately according to step 13).

13) The preservative coating (8 µm up to 12 µm thickness) shall be applied by dipping in a dispersion, consisting of 20 % volume test oil and 80 % volume n-pentane. Then the dispersant shall be removed in a desiccator for 2 h by help of vacuum. The bearings shall be laid on clean wire or plastic mesh. The test bearing can be stored at room temperature and protected from dust (e.g. in a desiccator) for 2 weeks before testing.

As a test oil, a pure poly-alpha-olefin oil with a viscosity of ν_{40} = 11 $mm^2 \cdot s^{-1}$ shall be used.

B.2 Greasing

Greasing shall be performed as follows:

1) The test bearing shall be greased with a hand-held grease dispensing device on the side face opposite to the marking side (side of the test unit). The first two turns of the newly injected grease shall be discarded. The amount of grease shall be approximately 0,37 cm^3 (55 % to 60 % of the free volume in the bearing, for greases with a density 0,9 $g \cdot cm^{-3}$ equal to 0,33 g ± 0,02 g). The grease shall not protrude over the bearing side faces and shall pass between all cage pockets around the raceway of the outer ring to the marking side. Any protruding grease shall be planed into the bearing.

   Alternatively, also a semi-automatic grease dispenser — with a locking device for reaching the target grease quantity — can be used. Here, the first two dosages shall not be used.

2) Before any change of grease, the grease from the head and cylinder of the grease dispensing device shall first be removed coarsely with the help of a grease spatula and a brush with solvent. Then the head and cylinder of the grease dispensing device shall be cleaned for 3 min with solvent in an ultrasonic bath and afterwards blown dry with compressed air.

3) In case of greases with fluorinated oil, silicone oil, poly-phenyl ether or polyglycol, the test bearings shall be numbered by a permanent metal marker in the order of measurement and shall be washed. Next, they shall be preserved (1 µm to 2 µm petroleum). The application shall be done by a dispersion with 3 % pure petroleum and 97 % n-pentane by volume. If necessary, a compatible grease dispersion may also be applied as preservation or dry lubricant.