INTERNATIONAL STANDARD

ISO 4412-2

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Hydraulic fluid power — Test code for determination of airborne noise levels —

Part 2: Motors

Transmissions hydrauliques — Code d'essai pour la détermination du niveau de bruit aérien —

Partie 2: Moteurs

Reference number
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Contents

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 4412-2 was prepared jointly by Technical Committees ISO/TC 131, *Fluid power systems*, Sub-Committee SC 8, *Product testing and contamination control* and ISO/TC 43, *Acoustics*.

This second edition cancels and replaces the first edition (ISO 4412-2:1984), of which clauses 12 and 13 have been transferred to form a new annex A. The former annex A has become annex B, and annexes C and D have been added.

ISO 4412 consists of the following parts, under the general title *Hydraulic fluid power — Test code for determination of airborne noise levels*:

— *Part 1: Pumps*

— *Part 2: Motors*

— *Part 3: Pumps — Method using a parallelepiped microphone array*

Annexes A and B form an integral part of this part of ISO 4412. Annexes C and D are for information only.

Introduction

In hydraulic fluid power systems, power is transmitted and controlled through a liquid under pressure in an enclosed circuit. Motors are components which convert rotary fluid power to mechanical power. During the process of converting hydraulic fluid power to mechanical power, airborne noise, fluid-borne vibrations and structure-borne vibrations are radiated from the motor.

The airborne noise level of a hydraulic fluid power motor is an important consideration in component selection. The noise measurement technique must, therefore, be such as to yield accurate appraisals of these airborne noise levels. The determination of noise levels is complicated by the interactions which occur during noise measurements. The fluid-borne vibrations from the motor can be transmitted to the circuit and ultimately give rise to background airborne noise levels which could affect the determination of the motor airborne noise levels.

The procedures described in this part of ISO 4412 are intended to measure only the airborne noise radiated directly from the motor under test.

Hydraulic fluid power — Test code for determination of airborne noise levels —

Part 2:
Motors

1 Scope

This part of ISO 4412 establishes a test code describing procedures, based on ISO 2204, for the determination of the sound power levels of a hydraulic fluid power motor, under controlled conditions of installation and operation, suitable for providing a basis for comparing the noise levels of motors in terms of:

— A-weighted sound power level;

— octave band sound power levels.

From these sound power levels, if required, reference sound pressure levels may be calculated for reporting purposes in accordance with annex A.

For general purposes, the frequency range of interest includes the octave bands with centre frequencies between 125 Hz and 8 000 Hz.[1)]

Due to the inherent difficulties in the measurement of low-speed motor performance, this part of ISO 4412 is limited to motors operating at speeds exceeding 50 r/min.

Guidelines for the application of this part of ISO 4412 are given in annex C.

This part of ISO 4412 is applicable to all types of hydraulic fluid power motors operating under steady-state conditions, irrespective of size, except for any limitations imposed by the size of the test environment (see clause 5).

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 4412. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 4412 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 3448:1975, *Industrial liquid lubricants — ISO viscosity classification.*

ISO 3744:1981, *Acoustics — Determination of sound power levels of noise sources — Engineering methods for free-field conditions over a reflecting plane.*

ISO 3745:1977, *Acoustics — Determination of sound power levels of noise sources — Precision methods for anechoic and semi-anechoic rooms.*

ISO 5598:1985, *Fluid power systems and components — Vocabulary.*

ISO 6743-4:1982, *Lubricants, industrial oils and related products (class L) — Classification — Part 4: Family H (Hydraulic systems).*

IEC 50(801):1984, *International Electrotechnical Vocabulary — Chapter 801: Acoustics and electroacoustics.*

IEC 651:1979, *Sound level meters.*

1) 1 Hz = 1 s^{-1}

3 Definitions

For the purposes of this part of ISO 4412, the definitions given in ISO 5598, IEC 50 and the following definitions apply. It is accepted that the latter definitions may differ from those in other specific International Standards.

3.1 free sound field: Sound field in a homogeneous, isotropic medium free of boundaries.

NOTE 1 In practice, it is a field in which the effects of the boundaries are negligible over the frequency range of interest.

3.2 free field over a reflecting plane: Field produced by a source in the presence of one reflecting plane on which the source is located.

3.3 reverberant sound field: That portion of the sound field in a test room over which the influence of sound received directly from the source is negligible.

3.4 anechoic room: A test room having boundaries which absorb essentially all of the incident sound energy over the frequency range of interest, thereby affording free-field conditions over the measurement surface.

3.5 mean-square sound pressure: The sound pressure averaged in space and time on a mean-square basis.

NOTE 2 In practice, this is estimated by space and time averaging over a finite path length or over a number of fixed microphone positions.

3.6 mean sound pressure level: Ten times the logarithm to the base 10 of the ratio of the mean-square sound pressure to the square of the reference sound pressure, in decibels (dB).

NOTE 3 The weighting network or the width of the frequency band used should always be indicated; for example, A-weighted sound pressure level, octave band sound pressure level. The reference sound pressure is 20 µPa[2].

3.7 sound power level: Ten times the logarithm to the base 10 of the ratio of a given sound power to the reference sound power, in decibels.

NOTE 4 The weighting network or the width of the frequency band used should always be indicated. The reference sound power is 1 pW[3].

3.8 volume of source under test: Volume of the envelope of the whole motor under test.

4 Measurement uncertainty

Methods of measurement should be used which tend to result in standard deviations which are equal to or less than those specified in table 1. Methods given in ISO 3744 meet this requirement.

Table 1 — Standard deviation of sound power level determinations

Standard deviation, dB, for octave bands centred on:				
125 Hz	250 Hz	500 Hz	1 000 Hz to 4 000 Hz	8 000 Hz
5,0	3,0	2,0	2,0	3,0

The standard deviations given in table 1 include the effects of allowable variations in the positioning of the measurement points and in the selection of any prescribed measurement surface, but exclude variations in the sound power output of the source from test to test.

NOTE 5 The A-weighted sound power level will in most practical cases be determined with a standard deviation of approximately 2 dB.

5 Test environment

Tests shall be conducted in an environment which provides "free-field over a reflecting plane" or "special reverberant" conditions which meet the environmental qualification requirements described in ISO 3744:1981, clause 4 and annex A.

For more precise measurements, conduct tests in accordance with ISO 3745.

2) 1 µPa = 10^{-6} N/m^2

3) 1 pW = 10^{-12} W

6 Instrumentation

6.1 The instrumentation used to measure fluid flow, fluid pressure, motor speed and fluid temperature shall be in accordance with the recommendations for "industrial class" accuracy of testing; i.e. class C given in annex B.

6.2 The instrumentation used for acoustical measurements shall be in accordance with IEC 651. This instrumentation shall be in accordance with ISO 3744 for both performance and calibration; i.e. type 2 instruments for engineering (grade 2) measurements.

7 Installation conditions

7.1 Motor location

The motor may be located in any position consistent with the source installation and measurement surface (or microphone traverse) requirements specified in ISO 3744 for the test environment being used.

7.2 Motor mounting

7.2.1 The motor mounting shall be constructed so that it will minimize the noise radiated by the mounting as a result of motor vibrations.

7.2.2 The mounting bracket shall be constructed of high-damping material or with sound-damping and sound-insulating material applied to the bracket as required.

7.2.3 Vibration isolation techniques, if needed, shall be used even if the motor is usually securely mounted.

7.2.4 Flange mountings that are as small as practical shall be used so as to minimize interference with radiation of sound towards the shaft end of the motor.

7.3 Motor-driven load

The load system shall be located outside the test space and the load shall be driven through flexible couplings and an intermediate shaft, or the load system shall be isolated in an acoustic enclosure.

7.4 Hydraulic circuit

7.4.1 The circuit shall include all oil filters, oil coolers, reservoirs and restrictor valves as required to meet the motor hydraulic operating conditions (see clause 8).

7.4.2 The test fluid and degree of filtration shall be in accordance with the motor manufacturer's recommendations.

7.4.3 Inlet and discharge lines shall be installed with diameters in accordance with the manufacturers' recommended practice.

7.4.4 The outlet pressure gauge shall be mounted at the same height as the outlet fittings or it shall be calibrated for any height difference.

7.4.5 Pressure fluctuations and standing waves in the inlet and outlet ports shall be minimized by such measures as selected line lengths, long lengths of flexible hose, accumulators, inline silencers and in-line pulsation pumps.

7.4.6 A stable load valve shall be used in the outlet line if back pressure is regulated.

NOTE 6 Unstable load valves in the lines can generate and transmit noise through the fluid and piping which can emerge as airborne sound at the motor.

7.4.7 Any control valves shall be positioned far from the motor, preferably outside the test room, to minimize the interaction.

7.4.8 All fluid lines and valves in the test space shall be wrapped with sound-isolating materials, if required (see 10.1). Material having a sound-transmission loss of at least 10 dB at 125 Hz, and a greater loss at higher frequencies, shall be used.

8 Operating conditions

8.1 Determine the sound power levels of the motor for any desired set of operating conditions (see 11.3.7).

8.2 These test conditions shall be maintained throughout the test within the limits given in table 2.

Table 2 — Allowable variations of mean indicated values of controlled parameters

Test parameter	Allowable variation
Pressure	±2 %
Speed	±2 %
Temperature	±2 °C
Torque	±2 %

8.3 The motor shall be tested in the "as-delivered" condition with any ancillary equipment operating normally during the test, so as to include their noise contributions to the airborne noise level of the motor.

9 Location and number of sound measurement points

The location and number of measurement points shall be as required by ISO 3744 for the method of measurement selected for the motor noise test.

10 Test procedure

10.1 Background noise measurements

10.1.1 Measure the background noise of interest that is present during the motor noise test which does not emanate from the motor itself.

Over the frequency range of interest, the band sound pressure levels of this background noise shall be at least 6 dB below the motor band sound pressure levels at each measurement point.

10.1.2 Correct for this background noise, if evidenced by these measurements, by applying the corrections for this purpose given in ISO 3744.

10.1.3 When measurement of band levels of background noise is not practical, the A-weighted background sound level of each measurement point shall be at least 6 dB below the motor A-weighted sound level.

Correct these A-weighted measurements for background noise.

NOTES

7 Easing the requirements for background noise levels can lead to an overestimate of the motor band sound pressure levels.

8 The A-weighted background sound level at each measurement point may be checked by covering the motor with sound-insulating materials capable of a transmission loss of at least 10 dB over the frequency range which is "determining" the A-weighted sound level of the motor.

10.1.4 If the background level is found to be too high, check for further noise control of the motor mounting, driven load or hydraulic circuit, as indicated.

10.1.5 Ensure that the orientation of the microphone and the period of observation are as specified in ISO 3744.

10.2 Motor measurements

10.2.1 Measurement sequence

Prior to commencement of a series of tests, operate the motor for a sufficient time to purge air from the system and to stabilize all variables, including fluid condition, to within the limits specified in table 2.

Measure the following for each test:

a) motor speed;

b) output torque;

c) fluid temperature and pressure at motor inlet and fluid pressure at discharge fittings or at the test point provided by the motor manufacturer;

d) band sound pressure levels at each measurement point over the frequency range of interest;

e) A-weighted sound pressure level at each measurement point.

10.2.2 New or rebuilt motors

10.2.2.1 Repeat the initial motor measurement test of the series at the end of a test series or after 1 h of testing.

10.2.2.2 If the A-weighted sound level at any selected measurement point does not duplicate that of the first test within 2 dB (A), the whole test series shall be invalidated.

11 Information to be recorded

11.1 Specifications

The information given in 11.2 and 11.3 shall be compiled and recorded for all measurements made according to the requirements of this part of ISO 4412.

11.2 General information

a) name and address of the motor manufacturer and, if applicable, the user;

b) reference number(s) for identification of the motor;

c) name and address of persons or organization responsible for the acoustic tests on the motor;

d) date and place of acoustic tests;

e) statement that the sound power levels of the motor have been obtained in full conformance with this part of ISO 4412 and ISO 3744 for the determination of sound power levels of noise sources (see also clause 13).

11.3 Motor under test

11.3.1 Description of motor

a) type of motor (e.g. gear or piston), including ancillary equipment;

b) type of displacement (e.g. fixed or variable);

c) motor overall linear dimensions (with sketch if necessary);

d) motor maximum displacement;

e) type of displacement controller and setting.

11.3.2 Acoustic environment for tests

a) internal dimensions of the test room and the type of acoustic field for the measurements (e.g. free field over a reflecting plane);

b) the acoustical treatment of the test room;

c) the date of measurement;

d) ambient air temperature (in degrees Celsius), relative humidity (in percentage) and barometric pressure (in pascals[4]);

e) results of acoustical qualification of test environments as required by clause 5.

11.3.3 Reference sound source (when applicable)

a) manufacturer, type and serial number;

b) sound power level calibration data, including name of calibrating laboratory and date of calibration.

11.3.4 Mounting and installation conditions of motor

a) description of motor mounting conditions;

b) nature and characteristics of the hydraulic circuit and details of any acoustic insulation treatment;

c) nature and description of other machines being used which could have an influence on the measured sound pressure levels of the motor.

11.3.5 Location of motor in test environment

11.3.5.1 Include a sketch showing the location of the motor in relation to walls, floor and ceiling of the test room.

11.3.5.2 Show on this sketch the location of other reflecting or absorbing screens and noise sources which can influence measurements.

11.3.6 Instrumentation

a) details of equipment used to monitor motor operating conditions (see 11.3.7), including type, serial number and manufacturer;

b) details of equipment used for acoustic measurements including name, type, serial number and manufacturer;

c) bandwidth of frequency analyser;

d) overall frequency response of instrumentation system and date and method of calibration;

e) method of calibration of microphones and date and place of calibration.

11.3.7 Motor operating conditions

Include the following details for each test:

a) full description of fluid, including classification in accordance with ISO 6743-4;

b) fluid viscosity classification in accordance with ISO 3448, in centistokes or in square millimetres per second[5];

c) shaft speed, in revolutions per minute;

d) output torque, in newton metres;

e) inlet pressure, in megapascals (bars[6]);

f) outlet pressure, in megapascals (bars);

g) temperature of fluid at motor inlet, in degrees Celsius.

11.3.8 Acoustical data

Include all data as required by ISO 3744.

4) 1 Pa = 10^{-5} bar

5) 1 cSt = 1 mm^2/s

6) 1 bar = 10^5 N/m^2 = 10^5 Pa = 0,1 MPa

12 Test report

The test report shall contain the following information:

a) the A-weighted sound power level and octave band sound power levels for each frequency band of interest for each set of operating conditions;

b) a statement that the sound power levels have been obtained in full conformance with the procedures of this part of ISO 4412 and specific paragraphs of ISO 3744 for the determination of sound power levels of noise sources.

13 Identification statement (Reference to this part of ISO 4412)

Use the following statement in test reports, catalogues and sales literature when electing to comply with this part of ISO 4412:

"Airborne noise levels determined in accordance with ISO 4412-2, *Hydraulic fluid power — Test code for determination of airborne noise levels — Part 2: Motors*".

Annex A
(normative)

Calculation of sound levels

A.1 Calculation of motor mean sound pressure levels and sound power levels

A.1.1 Refer to ISO 3744 for information regarding corrections to be applied and the method of calculating the mean levels and the motor sound power levels.

A.1.2 Correct the measured band sound pressure levels (and A-weighted sound levels, where appropriate) at each measurement position for the measured background noise (background noise corrections).

A.1.3 Use these corrected levels to calculate the motor mean band sound levels and mean A-weighted sound level.

A.1.4 Calculate the motor sound power level from these mean sound pressure levels, taking into account any correction for unwanted environmental reflections (environmental correction factor).

A.2 Calculation of mean sound pressure level at a reference distance

The mean sound pressure level at a distance r, in metres, from the equivalent point source radiating into a free field over a reflecting plane (hemispherical radiation) from the calculated motor sound power level is evaluated as follows:

$$\overline{L_p} = L_W - 10\log[2\pi r^2/S_0]$$

where

$\overline{L_p}$ is the mean sound pressure level, A-weighted or in bands, in decibels (reference: 20 µPa);

L_W is the A-weighted or band power level of the motor under test, in decibels (reference: 1 pW);

$2\pi r^2$ is the area of the hemisphere, in square metres, of radius r;

S_0 = 1 m².

For calculation purposes, choose a reference distance of r = 1 m, in which case the numerical value of $\overline{L_p}$ is obtained by subtracting 8 dB from the numerical value of the calculated sound power level, L_W.