International Standard 4412/2

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Hydraulic fluid power — Test code for the determination of airborne noise levels — Part 2: Motors

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 4412/2 was developed by Technical Committee ISO/TC 131, *Fluid power systems*, and was circulated to the member bodies in December 1981.

It has been approved by the member bodies of the following countries:

Austria	Hungary	Romania
Belgium	India	Spain
Canada	Italy	Sweden
Czechoslovakia	*Japan*	United Kingdom
Egypt, Arab Rep. of	Netherlands	USA
Finland	Norway	USSR
Germany, F.R.	Poland	

The member bodies of the following countries expressed disapproval of the document on technical grounds:

Australia
France

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Hydraulic fluid power — Test code for the determination of airborne noise levels — Part 2: Motors

0 Introduction

In hydraulic fluid power systems, power is transmitted and controlled through a liquid under pressure within an enclosed circuit. Motors are components which convert fluid power to mechanical power. During the process of converting hydraulic fluid power into mechanical power, airborne noise, fluid-borne vibration 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 shall, 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.

1 Scope

This part of ISO 4412 specifies 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, reference sound pressure levels may be calculated for reporting purposes (see clause 13).

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.

2 Field of application

The test code specified in 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 6).

3 References

ISO 2204, *Acoustics — Guide to International Standards on the measurement of airborne acoustical noise and evaluation of its effects on human beings.*

ISO 3740, *Acoustics — Determination of sound power levels of noise sources — Guidelines for the use of basic standards and for the preparation of noise test codes.*

ISO 3742, *Acoustics — Determination of sound power levels of noise sources — Precision methods for discrete-frequency and narrow-band sources in reverberation rooms.*

ISO 3743, *Acoustics — Determination of sound power levels of noise sources — Engineering methods for special reverberation test rooms.*

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

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

ISO 5598, *Hydraulic and pneumatic fluid power — Vocabulary.* [2)]

IEC Publication 50 (08), *International Electrotechnical Vocabulary (2nd edition) — Group 08: Electro-acoustics.*

IEC Publication 651, *Sound level meters.*

4 Definitions

For the purpose of this part of ISO 4412, the following definitions apply. It is accepted that these definitions may differ from those in other specific International Standards. For definitions of other terms used, see ISO 5598 and IEC Publication 50.

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

2) At present at the stage of draft.

4.1 free sound field: Sound field in a homogeneous, isotropic medium free of boundaries. In practice, it is a field in which the effects of the boundaries are negligible over the frequency range of interest.

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

4.3 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.

4.4 anechoic room: 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.

4.5 special reverberant room: Room having reverberation time/frequency characteristics as specified in ISO 3743.

4.6 mean-square sound pressure: The sound pressure averaged in space and time on a mean-square basis. In practice, this is estimated by space and time averaging over a finite path length or over a number of fixed microphone positions.

4.7 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. 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[1] (unit: decibel).

4.8 sound power level: Ten times the logarithm to the base 10 of the ratio of a given sound power to the reference sound power. The weighting network or the width of the frequency band used should always be indicated. The reference sound power is 1 pW[2] (unit: decibel).

4.9 volume of source under test: The volume of the noise source is the volume of the envelope of the whole motor under test.

5 Measurement uncertainty

Use methods of measurement which tend to result in standard deviations which are equal to or less than those specified in table 1. (The International Standards indicated in table 2 will meet this requirement.)

Table 1 — Standard deviation of sound power level determinations

Standard deviation (dB) for octave band centred (Hz)					
Hz	125	250	500	1 000 to 4 000	8 000
dB	5,0	3,0	2,0	2,0	3,0

1) 1 μPa = 10^{-6} N/m^2

2) 1 pW = 10^{-12} W

The standard deviations of table 1 include the effects of acceptable 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 — The A-weighted sound power level will in most practical cases be determined with a standard deviation of approximately 2 dB.

6 Test environment

6.1 Conduct tests in environments which provide "free-field over a reflecting plane" or "special reverberant" conditions which meet the environmental qualification requirements described in ISO 3743 and ISO 3744 (see table 2).

6.2 Conduct tests in "anechoic" or "reverberant" environments when more exacting environmental qualification procedures and measurement techniques, as specified in ISO 3745 and ISO 3742 (see table 2), are required.

Table 2 — Environmental qualification procedures

Method of measurement	Test environment	Relevant International Standard	Qualification procedure of relevant International Standard
Engineering (grade 2)	Free-field over a reflecting plane	ISO 3744	Clause 4 and annex
Engineering (grade 2)	Special reverberant	ISO 3743	Clause 4
Precision (grade 1)	Anechoic	ISO 3745	Clause 4 and annex
Precision (grade 1)	Reverberant	ISO 3742	Annex

7 Instrumentation

7.1 Use instrumentation to measure fluid flow, fluid pressure, motor speed and fluid temperature in accordance with the recommendations for "industrial class" accuracy of testing, i.e. class C given in the annex.

7.2 Use instrumentation for acoustical measurements in accordance with IEC Publication 651. This instrumentation shall be used in accordance with the relevant International Standard specified in table 2 for both performance and calibration.

8 Installation conditions for motor

8.1 Motor location

Locate the motor in any position consistent with the source installation and measurement surface (or microphone traverse) requirements specified in the relevant International Standard (see table 2) for the test environment being used.

8.2 Motor mounting

8.2.1 Construct the motor mounting so that it will minimize the sound radiated by the mounting as a result of motor vibrations.

8.2.2 Construct mounting bracket of high damping material or with sound damping and sound insulating material applied to the bracket as required.

8.2.3 Employ vibration isolation techniques, if needed, even if the motor is usually securely mounted.

8.2.4 Use flange mountings that are as small as practical to minimize interference with radiation of sound towards the shaft end of the motor.

8.3 Motor driven load

Locate the driven system outside the test space and drive the load through flexible couplings and an intermediate shaft or isolate the load system in an acoustic enclosure.

8.4 Hydraulic circuit

8.4.1 Include in the circuit all oil filters, oil coolers, reservoirs and restrictor valves as required to meet the motor hydraulic operating conditions (see clause 9).

8.4.2 Use test fluid and filtration in accordance with the manufacturer's recommendation.

8.4.3 Install inlet and discharge line diameters in accordance with the manufacturer's recommended practice.

8.4.4 Mount the outlet pressure gauge at the same height as the outlet fitting or calibrate for any height difference.

8.4.5 Minimize pressure fluctuations and standing waves in the inlet and outlet ports by such measures as selected line lengths, long lengths of flexible hose, accumulators, inline silencers, low pulsation pumps.

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

NOTE — 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.

8.4.7 Position any control valves far from the motor, preferably outside the test room, to minimize the interaction.

8.4.8 Wrap all fluid lines and valves in the test space with acoustical materials, if required (see 11.1). Use material having a sound transmission loss of at least 10 dB at 125 Hz, and greater loss at higher frequencies.

9 Operating conditions

9.1 Determine the sound power levels of motors for any desired set of operating conditions (see 14.2.7).

9.2 Maintain these test conditions during the test within the limits specified in table 3.

Table 3 — Acceptable variations in test conditions

Test parameter	Acceptable variation (±)
Pressure	2 %
Speed	2 %
Temperature	2 °C

9.3 Test the motor 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.

10 Location and number of sound measurement points

The location and number of measurement points are to be as required by the relevant International Standard (see table 2) for the particular environment and method of measurement selected for the motor noise test.

11 Test procedure

11.1 Background noise measurements

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

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

11.1.2 Correct for this background noise, if evidenced by measurement, by applying the corrections for this purpose given in the relevant International Standard (see table 2).

11.1.3 When measuring band levels of background noise is not practical, ensure that the A-weighted background sound level of each measurement point is at least 6 dB below the motor A-weighted sound level.

11.1.3.1 Correct these A-weighted measurements for background noise.

NOTES

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

2 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.

11.1.4 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.

11.1.5 Ensure that the orientation of the microphone and the period of observation are as specified in the relevant International Standard (see table 2).

11.2 Motor measurements

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 3.

Measure the following for each test:

a) motor speed;

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

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

d) A-weighted sound level at each measurement point, if required by the relevant International Standard (see table 2).

11.2.1 New or rebuilt motor

11.2.1.1 Repeat the initial motor measurement test of the series at the end of a test series or after one hour of testing.

11.2.1.2 Invalidate the whole test series if the A-weighted sound level at any selected measurement point does not duplicate that of the first test within 2 dB (A).

12 Calculation of motor mean sound pressure levels and sound power levels

12.1 Refer to the relevant International Standard (see table 2) to find information regarding corrections to be applied and the method of calculating the mean levels and pump sound power levels.

12.2 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).

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

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

13 Calculation of mean sound pressure level at a reference distance

The calculation of 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 defined in ISO 3740 as:

$$\bar{L}_p = L_W - 10 \log [2 \pi r^2 / S_0]$$

where

$\bar{L}_p$ is the mean sound pressure level, A-weighted or in bands. Reference: 20 µPa;

L_W is the A-weighted or band power level of motor under test. Reference: 1 pW;

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

$S_0 = 1 \text{ m}^2$.

NOTE — For reporting purposes, choose a reference distance of r = 1 m in which case the numerical value of $\bar{L}_p$ is obtained by subtracting 8 dB from the numerical value of the calculated sound power level L_W.

14 Information to be recorded

Compile and record the following information for all measurements made according to the requirements of this part of ISO 4412:

14.1 General information

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

b) reference number(s) for identification of 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 the relevant International Standard for the determination of sound power levels of noise sources as selected from table 2 (see clause 16).

14.2 Motor under test

14.2.1 Description of motor

a) type of motor including ancillary equipment (for example gear or piston);

b) type of displacement (for example fixed or variable);

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

d) motor maximum displacement;

e) type of displacement controller and setting.

14.2.2 Acoustic environment for tests

a) the test room internal dimensions and the type of acoustic field for the measurements (for example anechoic, free-field over a reflecting plane, reverberant or special reverberant);

b) the test room acoustic treatment;

c) the test room reverberation times (when applicable) and date of measurement;

d) ambient air temperature (in degrees Celsius), relative humidity (percentage) and barometric pressure (in millibars);

e) results of acoustical qualification of test environment as required by the relevant International Standard (see table 2).

14.2.3 Reference sound source (when applicable)

a) manufacturer, type and serial number;

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

14.2.4 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.

14.2.5 Location of motor in test environment

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

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

14.2.6 Instrumentation

a) details of equipment used to monitor motor operating conditions (see 14.2.7), including type, serial number and manufacturer;

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

c) band width 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.

14.2.7 Motor operating conditions

Include the following details for each test:

a) full description of fluid;

b) fluid viscosity, in centistokes or square millimetres per second;

c) shaft speed, in revolutions per minute;

d) inlet pressure, in bar[1];

e) outlet pressure, in bar;

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

14.2.8 Acoustical data

Include all data as required by the relevant International Standard (see table 2).

15 Test report

Provide the following information in the test report:

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 the relevant International Standard for the determination of sound power levels of noise sources as selected from table 2.

16 Identification statement (Reference to this International Standard)

Use the following statement in test reports, catalogues, and sales literature when electing to comply with this International Standard:

"Test code for the determination of airborne noise levels conforms to ISO 4412/2, *Hydraulic fluid power — Test code for the determination of airborne noise levels — Part 2: Motors.*"

1) 1Pa = 1 N/m^2; 1 bar = 10^5 Pa

Annex

Errors and classes of measurement[1)]

A.1 Classes of measurement

Depending on the accuracy required, carry out the tests to one of three classes of measurement, A, B or C. The classes of measurement should be agreed between the parties concerned. The use of class A and B is restricted to special cases when there is a need to have the performance more precisely defined. Attention is drawn to the fact that classes A and B tests require more accurate apparatus and methods, which may increase the costs of such tests.

A.2 Errors

Use any device or method which by calibration or comparison with International Standards has been demonstrated to be capable of measuring with systematic errors not exceeding the limits in table 4.

Table 4 — Acceptable systematic errors of measuring instruments as determined during calibration

Class of measurement	Units	A	B	C
Input signal	%	± 0,5	± 1,5	± 2,5
Flow	%	± 0,5	± 1,5	± 2,5
Pressure	%	± 0,5	± 1,5	± 2,5
Temperature	°C	± 0,5	± 1,0	± 2,0

NOTE — The percentage limits given in table 4 are of the value of the quantity being measured and not of the maximum values of the test or the maximum reading of the instrument.

1) The contents of this annex are under review and may be subject to amendment in the future.