International Standard 4412/1

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Hydraulic fluid power — Test code for the determination of airborne noise levels — Part 1 : Pumps

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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 4412/1 was developed by Technical Committee ISO/TC 131, *Fluid power systems and components*, and was circulated to the member bodies in September 1976.

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

Australia	India	Spain
Austria	Italy	Sweden
Belgium	Korea, Rep. of	Turkey
Brazil	Mexico	United Kingdom
Bulgaria	Netherlands	USA
Chile	Philippines	USSR
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The member body of the following country expressed disapproval of the document on technical grounds :

France

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Hydraulic fluid power — Test code for the determination of airborne noise levels — Part 1 : Pumps

0 Introduction

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

The airborne noise level of a hydraulic fluid power pump 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 and structure-borne vibrations from the pump can be transmitted to the circuit and ultimately give rise to background airborne noise levels which could affect the determination of the pump airborne noise levels.

The procedures described in this International Standard are intended to measure only the airborne noise radiated directly from the pump under test.

1 Scope

This International Standard establishes a test code describing procedures based on ISO 2204 for the determination of the sound power levels of a hydraulic fluid power pump, under controlled conditions of installation and operation, suitable for providing a basis for comparing the noise levels of pumps 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 and 8 000 Hz.[1)]

2 Field of application

The test code specified by this International Standard is applicable to all types of hydraulic fluid power pumps 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 the measurement of airborne acoustical noise and evaluation of its effects on man.*

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.*[2)]

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

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

IEC Publication 179, *Precision sound level meters.*

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

2) At present at the stage of draft

4 Definitions

For the purposes of this International Standard, 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 IEC Publication 50.

4.1 free sound field : A 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 : A 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 : 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.

4.5 special reverberant room : A 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 (Unit : decibel (dB)).[1)]

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 (Unit : decibel (dB)).[2)]

4.9 volume of source under test : The volume of the noise source is the volume of the envelope of the whole pump 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 meet this requirement.

Table 1 — Standard deviation of sound power level determinations

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

The standard deviations of 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 — 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 3742 and ISO 3745 (see table 2), are required.

Table 2 — Environmental qualification procedures

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

1) 1 μPa = 10^{-6} N/m^2

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

7 Instrumentation

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

7.2 Use instrumentation for acoustical measurements in accordance with IEC Publication no. 179. This instrumentation shall be in accordance with the relevant International Standard specified in table 2 for both performance and calibration.

8 Installation conditions of pump

8.1 Pump location

Locate the pump 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 Pump mounting

8.2.1 Construct the pump mounting so that it will minimize the noise radiated by the mounting as a result of pump 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 pump 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 pump.

8.3 Pump drive

Locate the drive motor outside the test space and drive the pump through flexible couplings and an intermediate shaft or isolate the motor 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 pump hydraulic operating conditions (see clause 9).

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

8.4.3 Install inlet and discharge line diameters in accordance with the manufacturers' recommended practice. Exercise extra care when assembling inlet lines to prevent air leaking into the circuit.

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

8.4.5 Select the lengths of pipe between the pump and the load valve which minimize setting up standing waves in the discharge line which can increase the sound radiated from the pump.

NOTE — It has been found that a long length of hydraulic hose can minimize standing wave effects.

8.4.6 Use a stable load valve.

NOTE — Unstable load valves in the discharge line can generate and transmit noise through the fluid and piping which can emerge as airborne sound at the pump.

8.4.7 Position the load valve far from the pump, preferably outside the test room, to minimize the interaction. Locate the load valve close to the pump only when adequate control of its acoustic performance can be provided.

8.4.8 Wrap all fluid lines and load 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 pumps 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 — Allowable variations in test conditions

Test parameter	Allowable variation (±)
Flow	2 %
Pressure	2 %
Speed	1 %
Temperature	2 °C

9.3 Test the pump in the "as delivered" condition with any ancillary pumps and valves operating normally during the test, so as to include their noise contributions to the airborne noise level of the pump.

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 stated in table 2 for the particular environment and method of measurement selected for the pump noise test.

11 Test procedure

11.1 Background noise measurements

11.1.1 Measure the background noise of interest that is present during the pump noise test which does not emanate from the pump 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 pump 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 in table 2.

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

11.1.3.1 In this case correct these A-weighted measurements for background noise. Easing the requirements for background noise levels can lead to an overestimate of the pump band sound pressure levels.

NOTE — The A-weighted background sound level at each measurement point may be checked by covering the pump 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 pump.

11.1.4 If the background level is found to be too high, check for further noise control of the pump mounting, drive 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 Pump measurements

Prior to commencement of a series of tests, operate the pump 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) pump speed and flow rate;

b) fluid temperature and pressure at pump inlet and fluid pressure at discharge fittings or at the test point provided by the pump 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.

11.2.1 New or rebuilt pumps

11.2.1.1 Repeat the initial pump 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 pump mean sound pressure levels and sound power levels

12.1 Refer to the relevant International Standard as shown in 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-weighed 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 pump mean band sound levels and mean A-weighted sound level.

12.4 Calculate the pump 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 (m) from the equivalent point source radiating into a free-field over a reflecting plane (hemispherical radiation) from the calculated pump sound power level is defined in ISO 3740 as :

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

where

$\overline{L_p}$ is the mean sound pressure level, A-weighted or in bands.

Reference : 20 µPa;

L_W is the A-weighted or band power level of pump under test.

Reference : 1 pW;

$2 \pi r^2$ is the area of hemisphere (m^2) of radius r;

$S_0 = 1$ (m^2).

NOTE — For reporting 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.

14 Information to be recorded

Compile and record the following information for all measurements made according to the requirements of this International Standard :

14.1 General information

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

b) reference number(s) for identification of pump;

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

d) date and place of acoustic tests;

e) statement that the sound power levels of the pump have been obtained in full conformance with this International Standard and the relevant International Standard for the determination of sound power levels of noise sources as selected from table 2. (See also, clause 16.)

14.2 Pump under test

14.2.1 Description of pump

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

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

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

d) pump 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 in table 2.

14.2.3 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 calibrations.

14.2.4 Mounting and installation conditions of pump

a) description of pump 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 pump.

14.2.5 Location of pump in test environment

Include a sketch showing the location of the pump in relation to walls, floor and ceiling of test room. Also, show 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 pump 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) 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.

14.2.7 Pump operating conditions

Include the following details for each test :

a) full description of fluid;

b) fluid viscosity (m^2/s);

c) shaft speed (rev/min);

d) inlet pressure (bar)[1];

e) outlet pressure (bar)[1];

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

f) pump delivery (flow) either measured or calculated (l/min);

g) temperature of fluid at pump inlet (°C).

14.2.8 Acoustical data

Include all data as required by the relevant International Standard listed in 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 International Standard 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 4412/1, *Hydraulic fluid power — Test code for the determination of airborne noise levels — Part 1 : Pumps.*"

Annex

Errors and classes of measurement[1)]

A.1 Classes of measurement

Depending on the accuracy required, the tests may be carried out to one of three classes of measurement, A, B or C. The classes of measurement shall 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 class A and B tests require more accurate apparatus and methods, which may increase the costs of such tests.

A.2 Errors

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 may be used.

Table 4 — Permissible 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.