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Measurement of airborne noise from hydraulic fluid power systems and components

Part 4. Method of determining sound power levels from valves controlling flow and pressure

Mesurage du bruit aérien émis par les systèmes de transmissions hydrauliques
Partie 4. Méthode de détermination des niveaux de puissance acoustique des appareils de réglage du débit et de la pression

Messung des Luftschalls von Hydraulikanlagen und -bestandteilen
Teil 4. Verfahren zur Bestimmung der Schalldruckpegel von Ventilen zur Durchfluß- und Drucksteuerung

British Standards Institution

Contents

Foreword

This British Standard has been prepared under the direction of the Mechanical Engineering Standards Committee and is one of a group of British Standards related to the measurement of noise emanating from hydraulic fluid power systems and components.

It is intended that this standard, which is based upon procedures given in ISO 2204 published by the International Organization for Standardization, will unify testing methods and enable the performance of different valves to be compared on a common basis.

It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people, for whom it has been prepared.

The standard comprises the following Parts.

Part 1 Method of test for pumps
Part 2 Method of test for motors
Part 3 Guide to the application of Part 1 and Part 2

Further Parts are planned.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

British Standard

Measurement of airborne noise from hydraulic fluid power systems and components

Part 4. Method of determining sound power levels from valves controlling flow and pressure

0. Introduction

In hydraulic fluid power systems, power is transmitted and controlled through a liquid under pressure in a closed circuit. Valves are components which control flow and pressure by providing a variable restriction to the fluid flow. During the process of restricting flow via a variable orifice, potential or pressure energy is converted into kinetic energy. If the static pressure of the fluid in the high velocity stream falls below the fluid vapour pressure, cavitation can occur which generates noise. Cavitation noise in fluid power valves is characterized by a random (and therefore broadband) disturbance with dominant energy levels from around 2 kHz up to and beyond the upper frequency limits of the human ear. This sound energy can be transmitted as fluid borne or structure borne noise, or radiated as valve casing airborne noise.

The airborne noise level of a hydraulic fluid power valve is an important consideration in component selection. It is essential that the noise measurement technique, therefore, provides accurate appraisals of these airborne noise levels. The determination of noise levels is complicated by the interactions which occur with the fluid power system during noise measurements. The fluid borne and structure borne sound energy from the valve can be transmitted via the circuit which ultimately gives rise to increased overall noise levels.

1. Scope

This British Standard describes procedures for the determination of the sound power levels of a hydraulic fluid power valve, under controlled conditions of installation and operation, suitable for providing a basis for comparing the noise levels of valves in terms of:

(a) A-weighted sound power level;

(b) octave band sound power levels.

From these sound power levels, reference sound pressure levels may be calculated for reporting purposes (see clause **11**). For general purposes, the frequency range of interest includes the octave bands with centre frequencies between 125 Hz and 8000 Hz.

This method is applicable to all types of fluid power control valves operating with oil hydraulic fluids* under steady state conditions, irrespective of size or specific function, provided that the noise level measured is dominantly cavitation noise and the physical provisions of the method can be complied with.

The procedures described are intended to measure the airborne noise level obtainable from a valve installation representing good noise control practice, including valve casing noise and the noise radiated by flexible fluid lines immediately adjacent to the valve. Other systems dependent factors are eliminated.

The measurement of valve noise due to instability is specifically excluded from the provisions of this standard. Guidance on valve stability and its detection is given in appendix A. Guidance is also given in appendix B on measuring in an anechoic chamber.

Accuracy of measurement is divided into three classes, A, B and C, which are explained in appendix C.

NOTE. The titles of the publications referred to in this standard are listed on the inside back cover.

2. Definitions

For the purposes of this British Standard, the following definitions apply.

NOTE. Other acoustical terms are given in BS 661.

2.1 free sound field. A sound field produced in a homogeneous, isotropic medium free of boundaries.

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

2.2 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.

2.3 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.

2.4 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.

2.5 special reverberant room. A room having reverberation time/frequency chararacteristics as specified in BS 4196 : Part 3.

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

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

2.7 mean sound pressure level (L_p). 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. 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.

*e.g. hydraulic fluid designations L-HH, L-HL, L-HM, L-HR, L-HV and L-HG only as classified in BS 6413 : Part 4.

2.8 sound power level (L_W). Ten times the logarithm to the base 10 of the ratio of a given power to the reference sound power in decibels (dB).

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

2.9 volume of source under test. The volume of the envelope of the whole valve and relevant adjacent flexible hose.

2.10 cavitation. The formation and collapse of fluid vapour cavities in the operating fluid caused by localized regions of low static pressure generated by high flow velocities.

3. Measurement uncertainty

Use methods of measurement which tend to result in standard deviations that are equal to or less than those given in table 1. To meet this requirement the methods given in the standards listed in table 2 shall be used.

Table 1. Standard deviation of sound power level determination

Octave band centred on frequency of	Standard deviation
Hz	dB
125	5.0
250	3.0
500	2.0
1000 to 4000	2.0
8000	3.0

NOTE 1. 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 2. The A-weighted sound power level will in most practical cases be determined with a standard deviation of approximately 2 dB.

4. Test environment

4.1 Conduct tests in environments that provide 'free-field over a reflecting plane' or 'special reverberant' conditions that meet the environmental qualification requirements described in BS 4196 : Part 3 and Part 4 (see table 2).

4.2 When more exacting environmental qualification procedures and measurement techniques are required, conduct tests in 'anechoic' or 'reverberant' environments as described in BS 4196 : Part 2 and Part 5.

5. Instrumentation

5.1 Use instrumentation to measure fluid flow, fluid pressure and fluid temperature in accordance with the recommendations for 'industrial class' accuracy of testing, i.e. class C given in appendix C.

5.2 Use instrumentation for acoustical measurements in accordance with BS 5969. This instrumentation shall be in accordance with the relevant British Standard given in table 2 for both performance and calibration.

6. Installation conditions for valve

NOTE. Figure 1 shows a typical example of a test installation comprising a valve, coiled outlet hose and a one metre radius array of ten microphones set up in an anechoic chamber.

6.1 Valve location. Locate the valve in any position consistent with the source installation and measurement surface (or microphone traverse) requirements specified in the relevant British Standard (see table 2) for the test environment used.

6.2 Valve mounting

6.2.1 Mount the valve on a vibration isolating mounting so as to minimize the noise radiated by the mounting as a result of valve case vibration.

6.2.2 Use a mount which provides minimal interference with the sound radiation from the valve and fluid lines.

6.2.3 Test line mounting valves as supplied. Test cartridge valves in a housing of minimum size consistent with achieving the flow and pressure ratings of the valve. Test gasket mounting valves on an adaptor plate, again of minimum size. When valves specifically designed for incorporation within a dedicated housing, which may form part of a large structure, are to be tested, ensure that the inlet and outlet fluid connections are effected by flexible hose and the whole structure is carried on isolating mounts.

The system employed shall be described in the test report (see clause **13**). Any external control linkages which extend beyond the volume of the source (as defined in **2.9**) shall also incorporate effective vibration isolation as close to the valve as possible.

6.3 Fluid supply

6.3.1 Install the hydraulic power pack supplying fluid flow and pressure outside the measurement environment or within an acoustic enclosure in such a manner as to control the background noise levels to the values described in clause **9**.

Table 2. Environmental qualification procedures

Method of measurement	Test environment	Relevant British Standard	Qualification procedure of relevant standard
Engineering	Free-field over a reflecting plane	BS 4196 : Part 4 : 1981	Clause **4** and appendix A
Engineering	Special reverberant	BS 4196 : Part 3 : 1981	Clause **4**
Precision	Anechoic	BS 4196 : Part 5 : 1981	Clause **4** and appendix A
Precision	Reverberant	BS 4196 : Part 2 : 1981	Appendix A

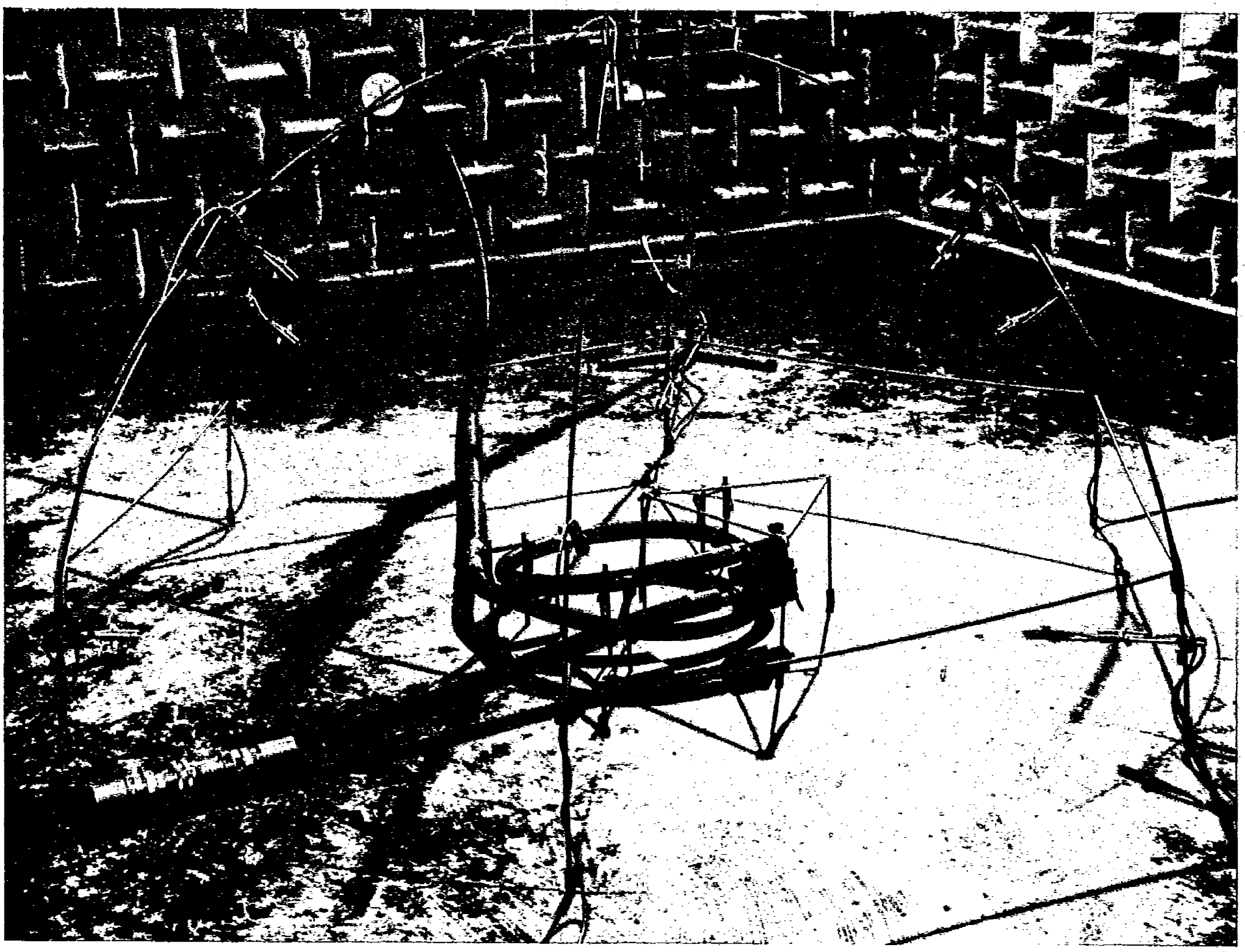


Figure 1. Example of test installation in an anechoic chamber

Photograph by courtesy of British Hydraulic Research Association

6.3.2 Reduce the fluid borne noise in the high pressure supply line to a level which allows the resulting background airborne noise described in clause **9** by using 'quiet' pumps, and if necessary pressure ripple attenuators, to a level which is in accordance with clause **9**. Use at least 15 m of hose between the pump or silencer and the valve inlet to ensure attenuation of high frequency structure borne and fluid borne noise.

6.4 Hydraulic circuit

6.4.1 Include in the circuit all oil filters, oil coolers, reservoirs, pumps and restrictor valves as required to meet the valve hydraulic operating conditions (see clause **7**).

6.4.2 Use test fluid and filtration in accordance with the manufacturer's instructions. Use flexible hose for all fluid lines within the measurement environment.

6.4.3 Install hose inlet and outlet sizes which provide a maximum velocity of flow below 5 m/s at full rated valve capacity. Connect the hose to the valve ports with the minimum of rigid fittings (see **6.4.6**).

6.4.4 Use only wire braided or multi-spiral synthetic rubber lined hoses. For any hydraulic servo connections or leakage lines use as small bore hose as is practicable.

6.4.5 Do not enclose the fluid lines in acoustic material as their noise contribution close to the valve is included in the test measurement.

NOTE. Very little noise is radiated by the inlet line, provided adequate suppression of flow source ripple is achieved. The noise radiated by the return line rapidly decays with distance from the valve due to the high frequency attenuation properties of flexible hose.

6.4.6 Fit a rigid elbow directly to the outlet port of the valve before connecting to the return hose.

6.4.7 When measuring in an anechoic chamber, coil the outlet hose around the valve to its manufacturer's specified minimum bend radius for a peripheral length of at least 1 m. Contain the valve body and a length of 1 m at the beginning of the return hose within the source volume described in BS 4196 : Part 4. Suspend the hoses on flexible supports which do not radiate significant noise or interfere with the noise radiation. Where the hoses cross over separate them by an air gap.

NOTE. Refer to appendix B for guidance.

6.4.8 Use a length of at least 15 m of return line hose before connecting it to the back-pressure control valve or reservoir.

6.4.9 Monitor fluid pressure at the valve inlet and outlet fittings using gauges or transducers which comply with **5.1** and are mounted outside the noise measuring environment. Use a small diameter (1 mm or less) pressure tapping which fits flush with the walls of the fittings. Mount the return line gauge or transducer at the same height as the tapping point (or calibrate for any height difference) and purge the gauge line of air. Employ as small a diameter flexible hose as practicable for the gauge lines.

6.4.10 Ensure that any valve controlling back-pressure is stable in operation.

NOTE. Valve back-pressure has a profound effect on cavitation noise levels, so particular care should be taken with the control and measurement of return line conditions.

7. Operating conditions

7.1 Determine the sound power level of the valve for any desired set of operating conditions (see **12.8**).

To allow direct comparison between competitive components use a fluid with a viscosity of class VG32* at the flow and pressure settings listed in tables 3 and 4 and at a fluid inlet temperature of 50 °C.

NOTE. Normally three such settings of each parameter, which fall within the valve's normal operating range, are adequate.

Table 3. Flow settings

Flow rate	
mL/s	L/s
1.6	1.0
4.0	2.5
10.0	6.3
25	16
63	40
160	100
400	

Table 4. Pressure settings†

Pressure (gauge)
bar‡
2.5
6.3
10
16
25
40
63
100
160
250
400
630
1000
1600
2500

7.2 Maintain these test conditions during the test within the limits given in table 5.

Table 5. Limit of variations in test conditions

Test parameter	Allowable variable
Flow	± 2 %
Pressure	± 2 %
Temperature	± 2 °C

7.3 Test the valve in the 'as delivered' condition with any ancillary services, such as pilot pressures and flows, that would be required in normal operation so as to include their noise contributions to the airborne noise from the valve body and connecting base. Also include in the noise measurement manual controls which are normally integral with the valve. If the valve is locked to give the required operating conditions ensure that the locking device does not affect the noise levels or interfere with the sound radiation patterns.

8. Location and number of sound measurement points

The location and number of measurement points shall be as described in the relevant British Standard given in table 2 for the particular environment and method of measurement selected for the valve noise test.

9. Test procedure

9.1 Background noise measurements

9.1.1 Measure the background noise over the frequency range of interest that is present during the valve noise test which does not emanate from the valve and flexible fluid lines within the measurement volume.

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

9.1.2 Correct for this background noise, if evidenced by measurement, by applying the corrections for this purpose given in the relevant British Standard referred to in table 2.

9.1.3 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 valve A-weighted sound level. Correct these A-weighted measurements for background noise.

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

NOTE 2. The A-weight background sound level at each measurement point may be checked by covering the valve, and all hose within the volume source defined in **2.9**, with sound insulating materials capable of a transmission loss of at least 10 dB over the frequency range of interest.

9.1.4 If the background level is found to be too high, check for further noise control of the power pack, back-pressure control or hydraulic circuit.

9.1.5 Ensure that the orientation of the microphone and the period of observation are as described in the relevant British Standard (see table 2).

9.2 Valve instability checks. At each set test point check the valve for indications of operational instability. If there is evidence of such instability (see appendix B) discontinue the test and provide details in the test report (see clause **13**).

9.3 Valve measurements

9.3.1 *General.* Prior to commencement of a series of tests, operate the valve for a sufficient time to purge air from the system and to stabilize all variables, including fluid condition, to within the limits given in table 5. Operate also any air bleed points fitted to the valve.

Measure the following for each test:

(a) flow rate;

(b) fluid temperature and pressure at valve inlet and fluid pressure at discharge fittings;

*See BS 4231.
†The range of pressures have been selected from ISO 2944.
‡1 bar = 10^5 N/m² = 10^5 Pa.

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

(d) A-weighted sound pressure level at each measurement point, if required by the relevant British Standard.

9.3.2 *New or rebuilt valves*

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

9.3.2.2 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.

10. Calculation of valve mean sound pressure levels and sound power levels

10.1 Refer to the relevant British Standard as given in table 2 to find information regarding corrections to be applied and the method of calculating the mean levels and valve sound power levels.

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

10.3 Use these corrected pressure levels to calculate the valve mean band sound pressure levels and mean A-weighted sound pressure level.

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

11. Calculation of mean sound pressure level at a reference distance

The calculation of the mean sound pressure level, $\overline{L_p}$ (in dB), at a distance r (in m) from the equivalent point source radiating into a free-field over a reflecting plane (hemispherical radiation) from the calculated valve sound power level is defined in BS 4196 : Part 0 as:

$$\overline{L_p} = L_w - 10 \log (2\pi r^2 / S_o)$$

where

L_w is the A-weighted or band power level of valve under test (in dB);

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

S_o $= 1\ m^2$.

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.

12. Information to be recorded

12.1 General information

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

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

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

(d) date and place of acoustic tests;

(e) class of accuracy used;

(f) statement that the sound power levels of the valve have been obtained in full conformance with this British Standard, I.e. BS 5944 : Part 4 and the relevant British Standard for the determination of sound power levels of noise sources as selected from table 2. (See also clause **14**.)

12.2 Description of valve

(a) type of valve (poppet, spool, sleeve, etc);

(b) function of valve (pressure control, relief, flow control, direction, etc);

(c) valve overall linear dimensions, including port sizes;

(d) valve maximum inlet pressure, outlet pressure and flow rates;

(e) type of actuator or setting control.

12.3 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 °C), relative humidity (in %) and barometric pressure (in mbar);

(e) results of acoustical qualification of test environment as required by the relevant British Standard given in table 2.

12.4 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.

12.5 Mounting and installation conditions of valve

(a) description of valve 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 valve;

(d) state outlet hose size and construction.

12.6 Location of valve in test environment. A sketch showing the location of the valve and outlet hose in relation to walls, floor and ceiling of test room, and also showing the location of other reflecting or absorbing screens and noise sources which can influence measurements.

12.7 Instrumentation

(a) details of equipment used to monitor valve operating conditions (see **12.8**), 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.

12.8 Valve operating conditions. For each test:

(a) full description of fluid, including classification in accordance with BS 6413 : Part 4;

(b) fluid viscosity classification in accordance with BS 4231 (in mm^2/s*);

(c) water content of fluid (even in normally 'dry' fluids) as determined by the method described in BS 4385 (in %)†;

(d) flow rate (L/min);

(e) inlet pressure (in bar);

(f) outlet pressure (in bar);

(g) valve setting, if applicable;

(h) temperature of fluid at valve inlet (in °C).

12.9 Acoustical data. All data as required by the relevant British Standard listed in table 2.

13. Test report

The test report shall contain the following information:

(a) description of the test installation (see **6.2.3**);

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

(c) whether operational instability was detected and the test consequently discontinued (see **9.2**);

(d) a statement that the sound power levels have been obtained in full conformance with the procedures of this British Standard and specific paragraphs of the relevant British Standard for the determination of sound power levels of noise sources as selected from table 2 (see clause **14**).

14. Identification statement

Use the following statement in test reports, catalogues and sales literature when complying with the requirements of this British Standard.

'Airborne noise levels determined in accordance with BS 5944 : Part 4.'

Appendix A

Guidance on valve instability and its detection

If a valve is unstable in operation it will normally emit enhanced noise levels resulting in an overestimation of the measured sound power. For this reason, the measurement of the valve noise due to instability is excluded from this standard (as stated in clause 1).

Grossly unstable valves will be self evident. The hydraulic system will be subjected to uncontrolled pressure variations and shocks generated by the valve. Also sudden changes in noise level indicate the onset of instability.

Less violent forms of instability can be detected by observing a microphone sound trace on an oscilloscope. (The suggested time base setting is 1 m/s per centimetre of trace.)

Valve instability may also be characterized by the presence of a dominant periodic disturbance in the valve noise frequency spectrum. This instability usually results in relatively low frequency fluid borne noise which is not sufficiently attenuated within a length of 1 m at the beginning of the valve outlet hose. Cavitation noise is manifested by a random high frequency trace.

Valve instability can be highly dependent upon interaction with the hydraulic test circuit; it is essential therefore that the circuit be designed accordingly.

NOTE. Periodic noise may also be present if the background airborne or fluid-borne noise from the hydraulic power pack is not sufficiently suppressed (see **6.3.2** and **9.1.1**).

Alternatively, narrow band analysis techniques may be used to detect instability, if they are available.

Appendix B

Guidance on measuring in an anechoic chamber

This method for measuring the level of airborne noise from valves depends on the high frequency attenuation properties of hydraulic hose. Cavitation noise is generated in the outlet side of the valve restriction. Very little liquid-borne noise passes back through the restriction into the high pressure supply line. Therefore there are only three sound transmission paths away from the valve in addition to direct casing airborne noise radiation:

(a) structure-borne noise along the inlet line hose wall;

(b) structure-borne noise along the outlet line hose wall;

(c) liquid-borne noise along the outlet line.

The hoses described in this method have been shown to rapidly attenuate structure-borne noise above 2 kHz within 100 mm of length. The noise contribution from the inlet hose can safely be ignored. Liquid-borne noise is also rapidly attenuated, but at a reduced rate, needing about 600 mm of hose to reduce noise radiation sufficiently.

When using an anechoic chamber BS 4196 : Part 4 specifies the reference volume which has to contain all significant sound radiating surfaces of the device to be measured.

The reference volume takes the form of a rectilinear box with its lower side on the reflecting plane and the top corners lying on the surface of a hypothetical hemisphere of radius $r/2$ (where r is the microphone radius) centred on the array axes. This arrangement is shown in figure 2.

The method therefore requires the valve body and a length of at least 1 m of the return line hose to be contained

*1 mm^2/s = 1 cSt.

†If it is necessary to determine lower concentrations than those obtainable by the method described in BS 4385 an alternative method is described in BS 2611.

within this reference volume. The valve body does not have to be centrally mounted but may be displaced to one side as shown in figure 3. An elbow is fitted to the outlet line to facilitate this requirement. It also ensures that collapse of the cavitation plume occurs within a 'rigid' containment rather than within the outlet hose, which can occur with some valve designs.

Particular emphasis should be placed on the measurement of return line pressure as this has a profound effect on cavitation intensity.

It has also been found that if normal mineral oil based hydraulic fluid is used in an exceptionally dry state, cavitation intensity is affected. Cavitation intensity is also affected where water tolerant oils contain a high proportion of water. It is necessary therefore to determine the water content of the fluid.

As dissolved air can also affect cavitation it is recommended that the test rig is run for some time before taking test data to allow the valve cavitation to draw out dissolved air. This will be indicated by the noise level stabilizing.

Appendix C

Errors and classes of measurement

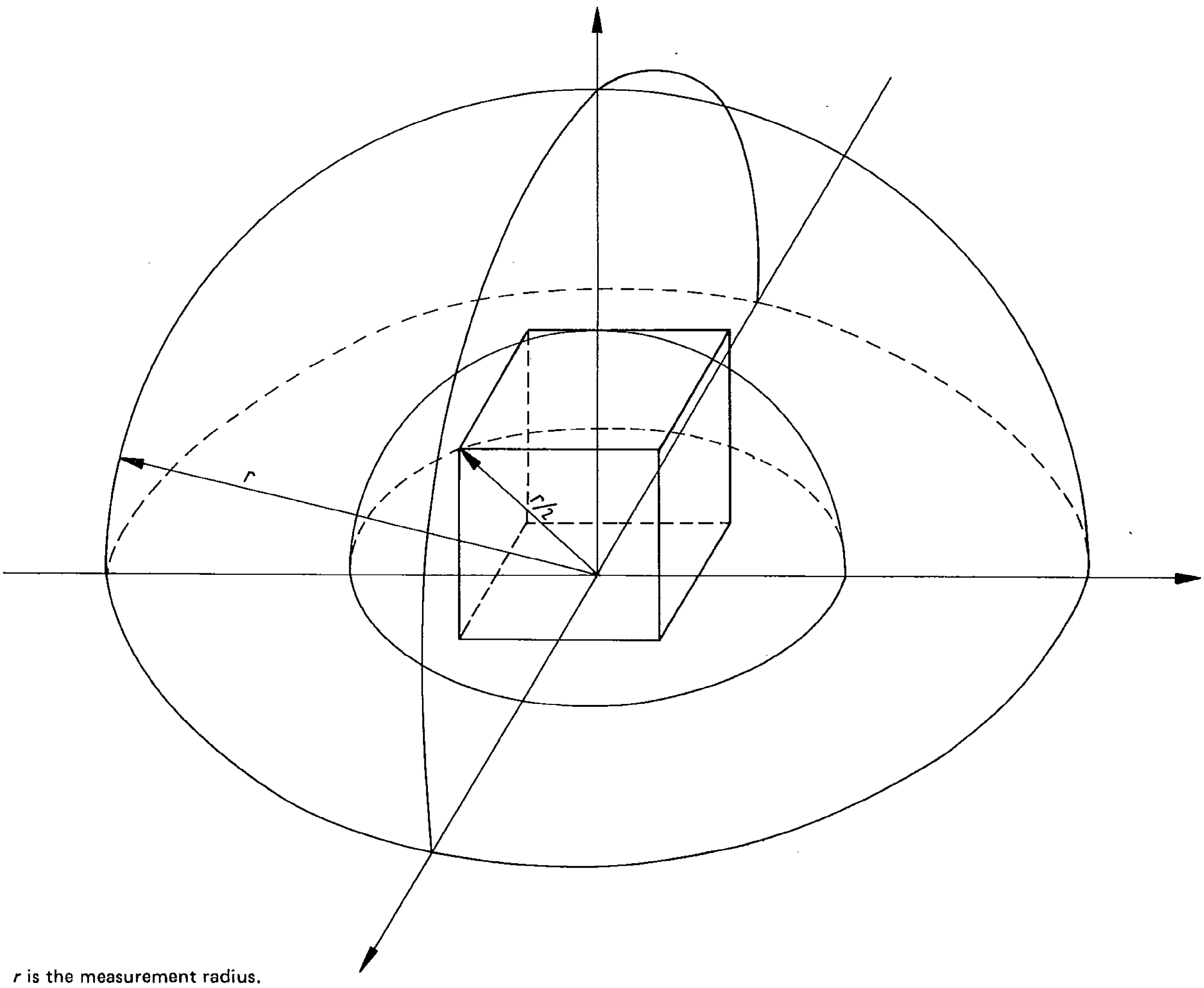
C.1 Classes of measurement. Depending on the accuracy required, carry out the tests to one of three classes of measurement, A, B or C, as agreed between the parties concerned (see **12.1**(e)). Classes A and B are intended for special cases where there is a need to have the performance more precisely defined. Attention is drawn to the fact that class A and B tests require more accurate apparatus and methods, which increase the costs of such tests.

C.2 Errors. Use any device or method that by calibration or comparison with British Standards has been demonstrated to be capable of measuring with systematic errors not exceeding the limits in table 6.

Table 6. Permissible systematic errors of measuring instruments as determined during calibration

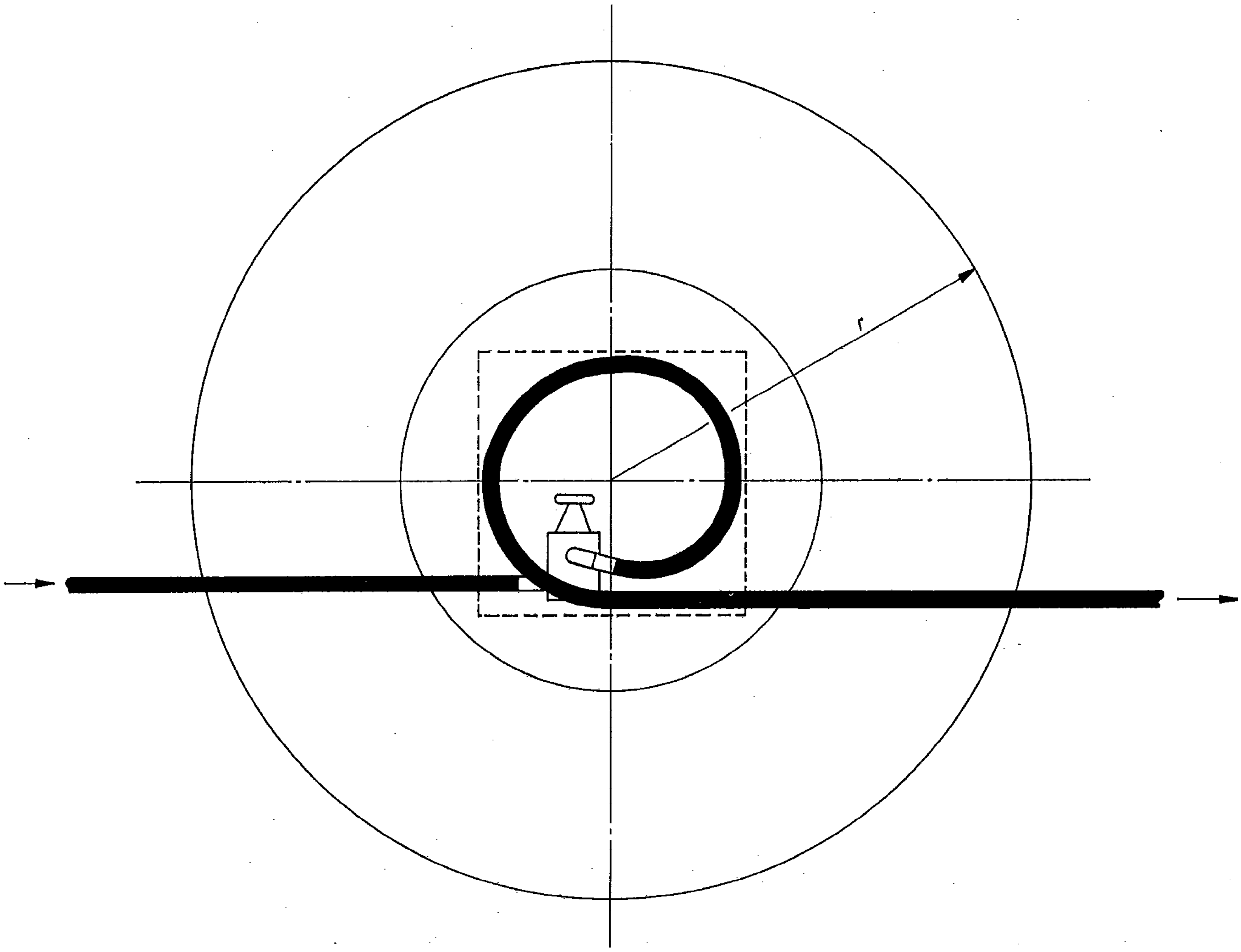
Class of measurement	Units	A	B	C
Flow	%	± 0.5	± 1.5	± 2.5
Pressure	%	± 0.5	± 1.5	± 2.5
Temperature	°C	± 0.5	± 1.0	± 2.0

NOTE. The percentage limits given in table 6 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.



r is the measurement radius.

Figure 2. Relationship between the reference box and hemispherical measurement surface



r is the measurement radius.

Figure 3. Coiling of return hose

Publications referred to

BS 661 Glossary of acoustical terms
BS 2511 Methods for the determination of water (Karl Fischer method)
BS 4196 Sound power levels of noise sources
Part 0 Guide for the use of basic standards and for the preparation of noise test codes
Part 2 Precision methods for determination of sound power levels for discrete-frequency and narrow-band sources in reverberation rooms
Part 3 Engineering methods for determination of sound power levels for sources in special reverberation test rooms
Part 4 Engineering methods for determination of sound power levels for sources in free-field conditions over a reflecting plane
Part 5 Precision methods for determination of sound power levels for sources in anechoic and semi-anechoic rooms
BS 4231 Classification for viscosity grades of industrial liquid lubricants
BS 4385 Method for determination of water in petroleum products and bituminous materials (distillation method)
BS 5944* Measurement of airborne noise from hydraulic fluid power systems and components
Part 1 Method of test for pumps
Part 2 Method of test for motors
Part 3 Guide to the application of Part 1 and Part 2
BS 5969 Specification for sound level meters
BS 6413 Lubricants, industrial oils and related products (class L)
Part 4 Classification for family H (hydraulic systems)
ISO 2204* Acoustics — Guide to international standards on the measurement of airborne acoustical noise and evaluation of its effects on human beings
ISO 2944 Fluid power systems and components — Nominal pressures

*Referred to in the foreword only.

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Committee reference MEE/186 Draft for comment 83/72219 DC

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Mechanical Engineering Standards Committee (MEE/–) to Technical Committee MEE/186 upon which the following bodies were represented:

Association of British Mining Equipment Companies
Association of Hydraulic Equipment Manufacturers
British Compressed Air Society
British Hydromechanics Research Association
British Steel Corporation
British Telecommunications
Department of Trade and Industry (National Engineering Laboratory)
Electricity Supply Industry in England and Wales
Engineering Equipment and Materials Users' Association
Federation of Manufacturers of Construction Equipment and Cranes
Health and Safety Executive
Institution of Mechanical Engineers
Machine Tool Industry Research Association
Ministry of Defence
National Coal Board

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

Bath University
Institution of Production Engineers

Amendments issued since publication

Amd. No.	Date of issue	Text affected