Methods for

Testing and rating terminal reheat units for air distribution systems —

Part 2: Acoustic testing and rating

UDC 628.8:697.978:697.356:620.111.3

Cooperating organizations

The Refrigeration, Heating and Air Conditioning Standards Committee, under whose direction this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

Association of Consulting Engineers
Association of Manufacturers of Domestic Electrical Appliances
Boiler and Radiator Manufacturers Association Limited*
British Combustion Equipment Manufacturers Association
British Gas Corporation
British Refrigeration and Air Conditioning Association*
Building Services Research and Information Association*
Chartered Institution of Building Services*
Department of the Environment (PSA)
Department of Health and Social Security*
Electricity Supply Industry in England and Wales
Engineering Equipment Users Association
Heating and Ventilating Contractors' Association*
Hevac Association*
Institute of Fuel
Institute of Refrigeration*
Institution of Gas Engineers
Lloyds Register of Shipping
Manufacturers Association of Radiators and Convectors Ltd*
Ministry of Defence*
National Coal Board
Society of British Gas Industries
Water-tube Boilermakers' Association

The organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

Department of the Environment — Building Research Establishment
Institute of Domestic Heating Engineers
Portsmouth Polytechnic

This British Standard, having been prepared under the direction of the Refrigeration, Heating and Air Conditioning Standards Committee, was published under the authority of the Executive Board on 31 August 1978

The following BSI references relate to the work on this standard:
Committee reference RHE/6
Draft for comment 76/71260 DC

ISBN 0 580 10277 7

Amendments issued since publication

Amd. No.	Date of issue	Comments

Contents

Foreword

This Part of this British Standard has been prepared under the direction of the Refrigeration, Heating and Air Conditioning Standards Committee in response to requests from industry.

The committee acknowledge their debt to the Building Services Research and Information Association for the Association's work in formulating the methods of testing that appear in this standard. It is intended to review this standard when a series of ISO standards dealing with acoustic testing has been completed and published as British Standards.

Where reference is made to British Standards for which no metric version is available, the appropriate British Standard in imperial units should be used in conjunction with BS 350. Attention is also drawn to BS 3763 and PD 5686.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 20, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

1 Scope

This Part of this British Standard deals with methods of acoustic testing and rating of terminal reheat units, defined in Part 1 of the standard, for:

a) static terminal attenuation;

b) sound generation, upstream and downstream of the unit;

c) radiation of sound from the casing.

2 References

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

3 Definitions

For the purposes of this British Standard the definitions of acoustic terms given in BS 661 apply; other definitions given in BS 4857-1, together with the following, also apply.

3.1
dummy load

a flow restrictor or similar device having the same pressure/flow characteristic as the unit under test

3.2
insertion loss

the insertion loss of a terminal reheat unit is the attenuation it gives to noise propagated from the system through the supply duct. It is defined here as the difference between the sound power radiated from, the open end of the supply duct, and that radiated when the unit is connected to this supply duct. The test is conducted without air flow to determine the static insertion loss

3.3
noise radiated in direction of inlet

the rate at which sound energy enters a uniform airway connected to the unit inlet

3.4
noise radiated in direction of outlet

the rate at which sound energy enters a uniform airway connected to the unit outlet

3.5
steady state conditions

steady state conditions are considered to exist for test purposes if the air volume flow rate does not vary by more than ± 2 % from a mean value during the test

3.6
terminal attenuation

terminal attenuation is the difference between the sound power level in the supply inlet duct and the sound power level in the outlet duct. Terminal attenuation can be calculated from the insertion loss by adding the outlet duct and reflection and subtracting the inlet duct end reflection

4 Nomenclature

Symbol	Quantity	Unit
P	Sound pressure	Pa
P_O	Reference sound pressure (= 2×10^{-5} Pa)	Pa
L_p	Sound pressure level	
	$= 20 \log_{10} \dfrac{P}{P_O}$	dB
W	Sound power	W

W_O	Reference sound power (= 10^{-12} W)	W
L_W	Sound power level	
	$= 10 \log_{10} \frac{W}{W_O}$	dB
A	Octave band terminal attenuation	dB
T	Reverberation time of the test room	s
α	Random incident absorption coefficient	—
V	Volume of the test room	m^3
S	Surface area of the test room	m^2
λ	Wavelength of sound	m
X_r	End reflection	dB

NOTE In the text, mean values are indicated by a bar over the symbol.

5 General test requirements

5.1 The tests shall be carried out in accordance with the conditions and methods specified in section 2, unless otherwise specified in section 1.

5.2 Multiple outlet boxes shall be tested with a single outlet duct fitted. This single duct shall have an outlet area equal to the sum of the areas of the multiple outlets.

5.3 Units designed for use in a specific situation shall be tested under conditions simulating this situation.

6 Instrumentation

Instrumentation shall comply with the provisions of section 2 and of BS 4857-1.

7 Test methods

7.1 Terminal attenuation

7.1.1 The unit shall be connected to a system similar to that shown in Figure 1. The minimum dimension of the chamber shown shall be three and a half times the air supply duct diameter (or mean of sides if rectangular).

7.1.2 A suitable random noise source is either:

a) a loud-speaker connected to a random noise generator;

b) the reference sound source described in section 2.

Where a tape recording is used for the noise source, precautions shall be taken to ensure that the output remains constant throughout the duration of the test. A closed loop tape is recommended to minimize the effects of tape sensitivity variations and the loop should pass the play-back head at least three times during each frequency band measurement. The tape should be of the type recommended for closed loop working, i.e. with a permanently lubricated surface.

7.1.3 Background noise levels shall be measured with the sound source operating during both unit-in and unit-out tests. These levels should be more than 6 dB below the measured mean sound pressure levels (see also clause **19**).

If the background noise level is less than 6 dB below the mean sound pressure level measured during the unit-in test then this will reduce the measured insertion loss. Where this occurs the results shall be reported with a note to this effect.

A correction for the intrusion of background noise affecting the measurements of sound pressure level with the equipment operating shall be applied for the condition indicated in Table 1.

NOTE For measurement of noise of quiet equipments, see Appendix A.

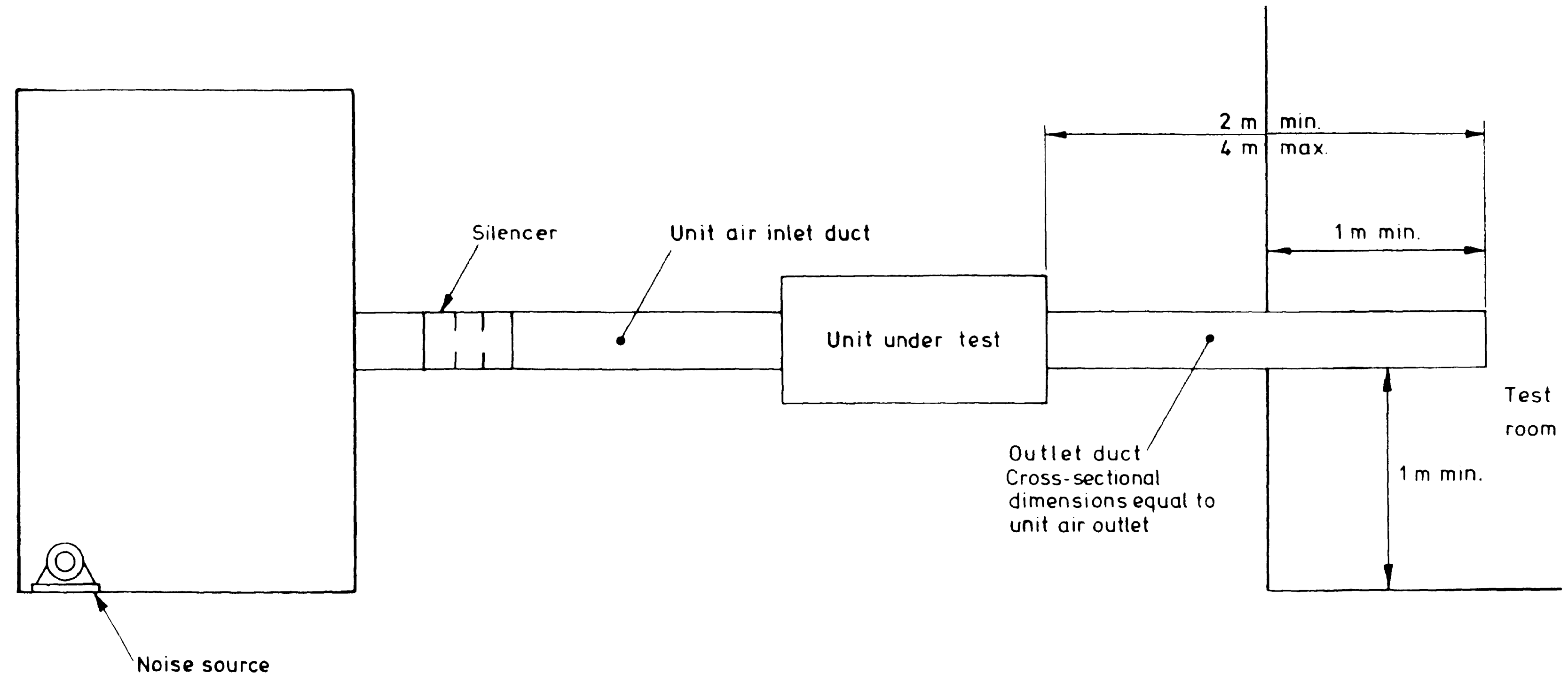

Figure 1 — Arrangement of equipment for insertion loss test

Table 1 — Correction conditions for background noise

Increase in room sound pressure level produced by equipment operation	Correction
dB	
0 to 5[a]	No correction permitted but results may be reported as affected by background noise
6 to 8	Subtract 1 dB from measured $\overline{L_P}$
Above 8	No correction

[a] The presence of a discrete frequency component in any one-third octave band means that any measurements in this band are of doubtful value. Measurements may be made in either one-third or one octave bands not containing the discrete frequency, and these will have the usual accuracy.

7.1.4 The test shall be carried out as follows.

a) With the unit installed as shown in Figure 1 and the noise source operating, measure the mean sound pressure level, in octave bands, in the test room, $\overline{L_{Pi}}$.

b) Remove the unit and substitute a length of straight duct as shown in Figure 2.

a) Repeat test a) maintaining the output of the noise source constant. This gives $\overline{L_{Po}}$.

7.1.5 The terminal attenuation *A* shall be calculated from the following equation.

$$A = \overline{L_{Po}} - \overline{L_{Pi}} + X_{ro} - X_{ri}$$

where

$\overline{L_{Pi}}$ is the measured mean sound pressure level for the unit-in test (in dB)

$\overline{L_{Po}}$ is the measure of mean sound pressure level for the unit-out test (in dB)

X_{ri} is the end reflection obtained from Figure 3 for the terminal duct dimension for the unit-in test (in dB)

X_{ro} is the end reflection obtained from Figure 3 for the terminal duct dimension for the unit-out test (in dB)

7.1.6 Noise from the source which may reach the microphone measuring stations without passing through the unit under test (flanking transmission) will appear to reduce the terminal attenuation of the unit. The following procedure shall be carried out to determine whether this is occurring.

a) Measure the octave band sound pressure level in the same way as for the unit-in test with the sound source operating.

b) Block the inlet duct with a high transmission loss barrier immediately upstream of the unit and repeat test a).

If the octave band sound pressure level measured under b) is at least 10 dB below that measured under a) in each band of concern, the terminal attenuation measurements made on the unit will not be affected by such flanking transmission.

7.2 Generated noise

7.2.1 *General*. The tests described in this clause are for the determination of air flow generated noise radiated through both the inlet and outlet connections.

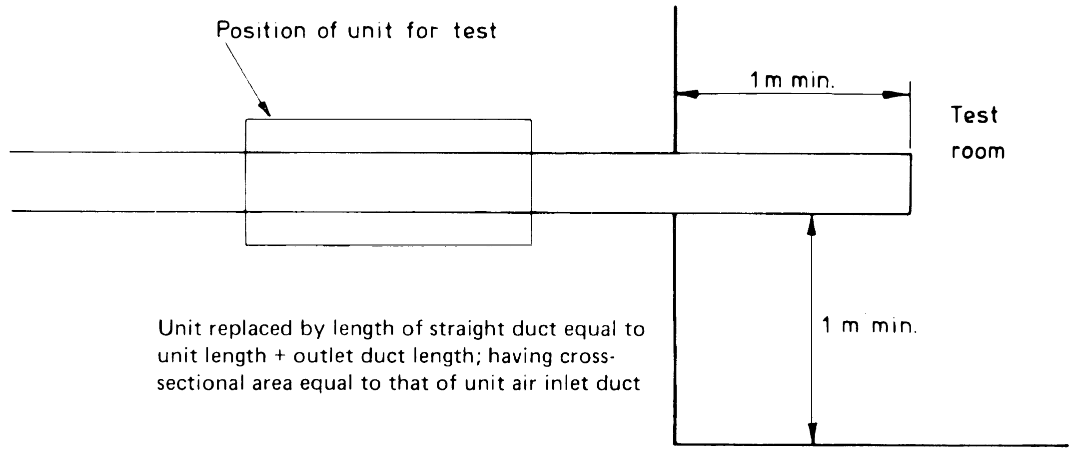

Figure 2 — Typical arrangement for unit-out test

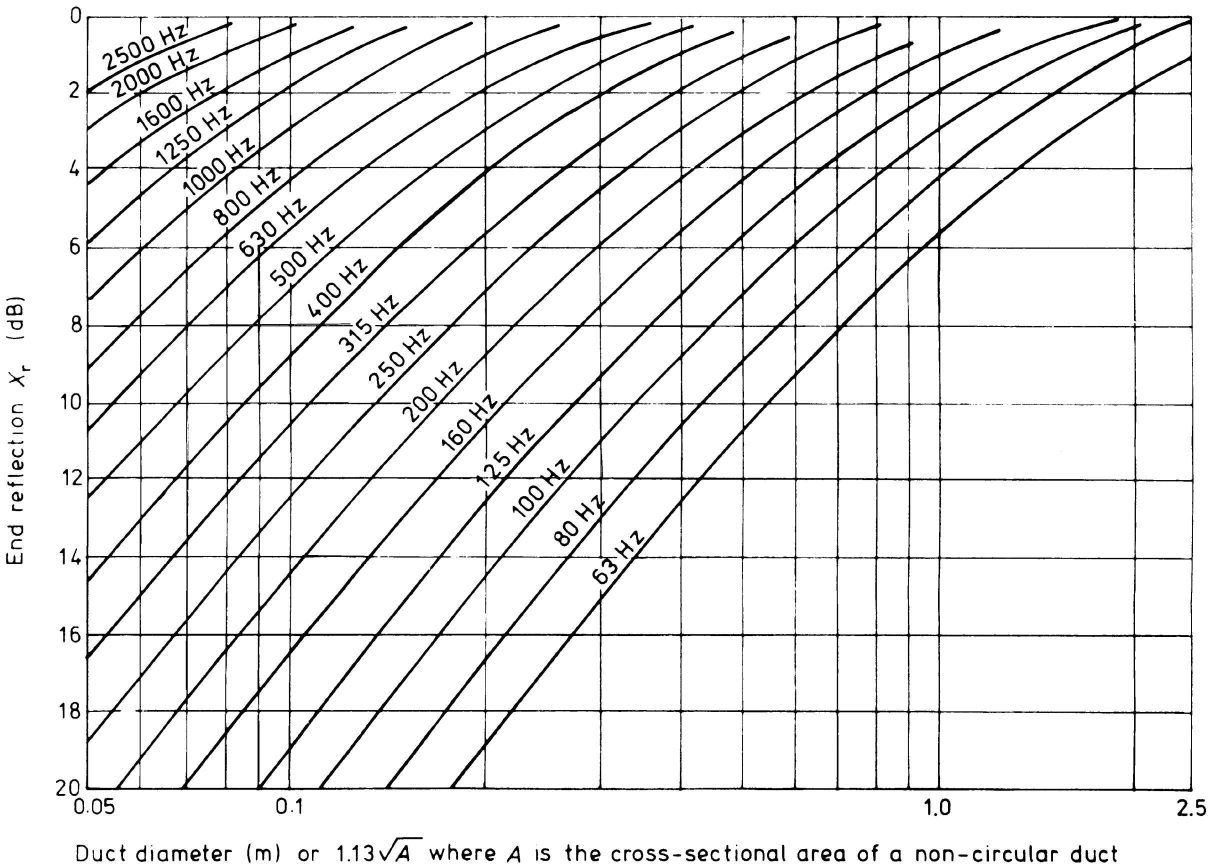

Figure 3 — End reflection correction

The noise radiated through the inlet connection is measured with the fan connected to the outlet duct. The unit shall be capable of withstanding the negative pressures resulting from this arrangement.

The background noise level shall be measured with the unit removed and replaced by plain ductwork and a dummy load connected to the fan inlet (or outlet if the test is for noise radiated upstream of the unit). All air control dampers shall be in the position required for the test and the dummy load adjusted such that the air flow rate is within 5 % of that required for the test. No correction shall be made for background noise. If the background level is less than 6 dB below the noise generated by the unit then the test results may be reported as affected by background noise.

7.2.2 *Noise radiated in direction of outlet.* The unit shall be connected to an air supply system similar to that shown in Figure 4. The outlet duct from the unit shall be not less than 2 m long and shall be positioned in the test room such that the discharge end is at least 1 m from the room surfaces. The test shall be carried out under steady state conditions, such conditions being satisfied if the air volume flow rate does not vary by more than ± 2 % of the mean value during the test.

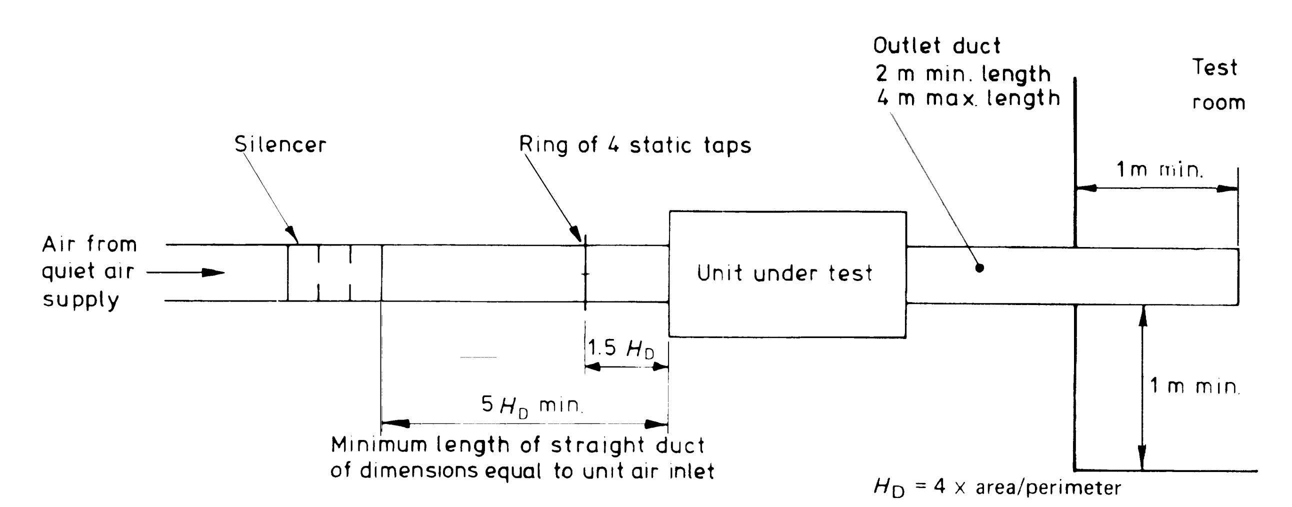

Figure 4 — Arrangement of equipment for generated noise test; noise radiated, in direction of outlet

The outlet generated sound power level L_{wc} of the unit shall be calculated from the following equation:

$$L_{wc} = L_w + X_r$$

where

L_w is the sound power level as determined from the measured mean sound pressure level in the test room (in dB)

X_r is the end reflection taken from Figure 3 (in dB)

7.2.3 *Noise radiated through inlet connection.* The unit shall be connected to an air supply system similar to that shown in Figure 5.

It is necessary to employ a flared entry to the inlet duct to prevent significant air flow noise being generated at this position. The end reflection correction (see Figure 3) for such an entry is calculated as the arithmetic average of the values previously used for the duct itself and for the maximum opening of the flared entry.

The inlet static pressure shall be the differential pressure indicated in Figure 5.

The test shall be carried out and the results calculated as described in **7.2.2**.

7.3 Casing noise radiation

7.3.1 For this test the unit shall be connected to an air supply system similar to that shown in Figure 6. All ductwork and connections shall be such that the radiation from them is at a much lower level than the radiation from the unit casing. This may be achieved by either:

a) using very heavy duct materials, or

b) using an efficient acoustic lagging for the ductwork, if it is similar in thickness to the unit casing.

This test arrangement may result in a large portion of the test room being rendered unusable for measurements; if so, the absorption properties of the room will also have been modified. It is, therefore, essential that the room absorption properties be measured before the test, either by a new measurement of the reverberation times or by means of the reference sound source.

7.3.2 The test shall be carried out under steady state conditions (see **3.5**) and these shall be established before commencing the test.

7.3.3 Background noise may be measured by removing the unit and replacing it with ducts (similar to the inlet and outlet ducts), and with a dummy load (equivalent to that provided by the unit) applied to the fan inlet. No correction for background noise is to be applied, but if this noise is less than 6 dB below the test sound pressure levels then the results may be reported as affected by background noise.

7.3.4 The test measurements shall be carried out in one-third octave bands, using one of the methods described in section 2.

8 Rating tests

8.1 General. The tests specified in **8.2** and **8.3** shall be carried out on each unit in the range. The results may not be interpolated or extrapolated to any conditions or component settings other than those existing at the time of the test.

8.2 Minimum static pressure. Tests shall be carried out with the flow controllers either removed or held in the fully open position by means that do not obstruct the internal air passages (e.g. thin wire).

8.3 Air flow generated noise and casing radiation. Tests shall be carried out over a range of flow rates and static pressures as set out below:

a) at air flow rates corresponding to the maximum, minimum and mean settings of the flow rate controller;

b) at inlet static pressures equal to the maximum recommended value.

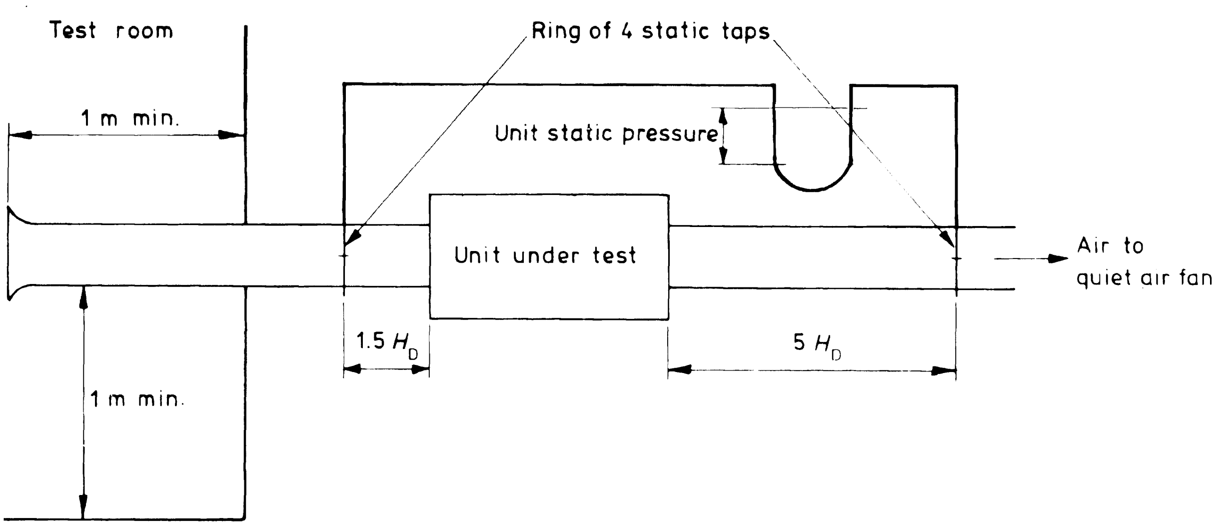

Figure 5 — Arrangement of equipment for generated noise test; noise radiated, in direction of inlet

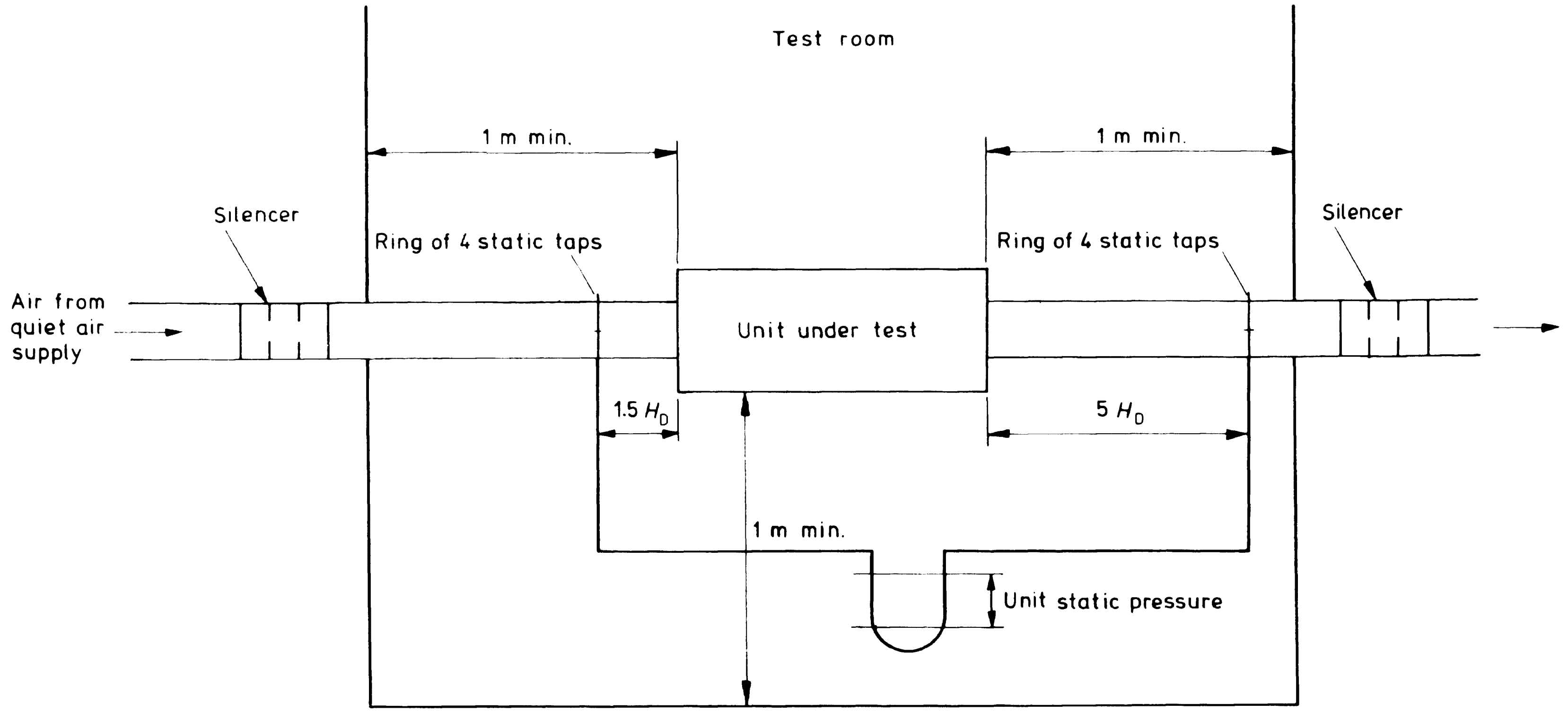

Figure 6 — Arrangement of equipment for casing radiation test

9 Reporting of test results

The test results shall include at least the following items.

a) A description of the unit being tested, its installation and mode of use.

b) A statement that the test was conducted in full accordance with this standard.

c) The quantity measured, including non-acoustic performance measurements.

d) The background noise level.

e) The computed sound power level.

f) A statement as to whether there were discrete frequency components in the spectrum. If such discrete frequency components have been identified, the one-third octave bands in which they occur shall be included in this report.

g) The static insertion loss.

h) The upstream sound power level generation.

i) The downstream sound power level generation.

j) The casing sound power level radiation.

Section 2. Test methods

10 General

10.1 This section describes in detail two laboratory methods for determining the mean sound power radiated by a device, machine, component or sub-assembly in successive frequency bands using a reverberant test room having prescribed acoustic characteristics. While other methods could be used to measure the noise emitted, the methods here described are particularly advantageous for rating the sound output of sources which produce steady noise and for which directivity information is not required. If the noise level of the source varies, or if directional effects are present, one of the other methods described in BS 4196 or summarized in ISO/R 495 or ISO/R 1680 or ISO 2204 should be selected.

The computation of sound power level from sound pressure level measurements is based on the premise that the mean sound pressure level averaged in space and time, $\overline{L_{\mathrm{P}}}$, is:

a) directly proportional to the sound power output of the source;

b) inversely proportional to the equivalent absorption area in the room; and

c) a function of air density and velocity of sound in air.

The procedure permits firstly, the rating of apparatus according to its sound power output within the reverberant field; and secondly, the prediction of sound pressure levels produced by a device in a given situation.

10.2 This standard is in accordance with the current practice of the specification of sound power level in octave bands thus providing a basis for comparing the acoustic performance of items of similar equipment.

Measured sound pressure levels after installation will depend upon the equipment and its operating conditions, the size and acoustic properties of the room, the manner in which the equipment is installed and the number and disposition of discrete units of such equipment within the room. The methods of predicting room sound pressure level from the octave band sound power levels of items of equipment are well documented[1)] and are not repeated here. Certain methods to be adopted for the assessment of noise generated by very quiet equipment are included in Appendix A. The section is concerned with the general requirements for the objective measurement and determination of the sound generated by equipment used in heating and air conditioning systems. It covers the diffuse field method of test using a reverberant test room and follows the guidelines set out in BS 4196 for this method of test.

[1)] The CIBS Guide. Chartered Institution of Building Services, London.
The ASHRAE Guide. American Society of Heating, Refrigerating and Air Conditioning Engineers, New York.

10.3 This section covers test facilities and methods of measurement for broad band sound in octave bands with centre frequencies in the range 125 Hz to 8 000 Hz. The methods may be less accurate when applied to lower frequency bands because of the difficulty in producing low frequency diffuse sound fields in the test room and also because the room can influence the low frequency sound power output of the equipment.

The section covers equipment:

a) operating under steady state conditions;

b) for which the rating in terms of sound power level and not of directivity are of prime importance;

c) used in, or communicating with, a treated space.

The section does not cover:

d) items too large for test by the reverberant room method. Such equipment shall be tested by one of the alternative methods of test outlined in BS 4196;

e) fans. These are covered by BS 848-2.

10.4 The acoustic performance specification includes:

a) a sound power level spectrum expressed in frequency bands of one octave width;

b) the identification of any significant discrete tones or narrow band noise levels (i.e. frequency bands less than one-third octave band width). While the facilities and method of test described do not permit an accurate assessment of significant tonal qualities in the equipment sound spectrum, this will influence the subjective assessment of the noise produced. The identification of the presence of these tones is an important feature of this standard.

NOTE If directivity measurements are required a free field method of test, as outlined in BS 4196, should be used.

When significant discrete frequencies or narrow bands of noise are present in the spectrum of a source, the mean-square sound pressure tends to be highly dependent on the positions of the source and the microphone within the room. Hence, the average value over a limited microphone path or array may differ significantly from the value averaged over all points in the room.

11 Application

11.1 Types of noise. This section applies to sources which produce steady broad-band noise without significant discrete frequency components. A procedure for checking the latter is given in clause **16**.

11.2 Size of source. This section applies only to relatively small sound sources, i.e., sources with volumes normally not greater than 2.5 % of the volume of the reverberation room used for the test (see **17.1**).

11.3 Use of data. The data obtained from the tests specified may be used for the following purposes.

a) The specification of the acoustic performance of the equipment.

b) Verification that the acoustic performance complies with the requirements of a specification.

c) Comparison between the acoustic performance of different items of equipment.

d) The calculation of the sound pressure level at a distance from the equipment within a reverberant field.

12 Precision

The calibration and measurement procedures are designed to determine the sound power levels of sources of broad band sound within the ranges of accuracy shown in Table 2.

The ranges shown in Table 2 assume that the measurements have been taken with care, and that tests have been carried out in accordance with this standard, but take into account the cumulative effect of all causes of uncertainty, such as the accuracy of calibration of the reference sound source (see **18.3.1**), the accuracy of the sound measuring equipment and the degree of imprecision inherent in the sampling of the sound field.

Table 2 — Range of accuracy in determining sound power levels of broad band sources in reverberation rooms

Octave band centre frequencies	Range of accuracy	One-third octave band centre frequencies	Range of accuracy
Hz	dB	Hz	dB
125	± 4	100 to 160	± 6
250	± 3	200 to 315	± 4
500, 1 000, 2 000 and 4 000	± 2	400 to 5 000	± 3
8 000	± 4	6 300 to 10 000	± 6

13 Instrumentation

13.1 Acoustic instrumentation

13.1.1 *General*. The instrumentation shall be designed to permit the determination of values of octave band and one-third octave band sound pressure levels over the range of frequencies specified in Table 3. Tolerances of the several sections of the measuring chain shall not exceed the tolerances that are stipulated in the relevant clauses of BS 4197. The filters shall comply with the requirements of BS 2475.

13.1.2 *Calibration*. The calibration of the measuring equipment at the time of each series of noise measurements shall comply in all respects with the requirements of BS 4197.

NOTE 1 It is recommended that maintenance of the calibration should be carried out by

a) periodic determination of the frequency response of the microphone, combined with verification of the response of the electrical system using an insert voltage technique;

b) checking the response of the overall electro-acoustical system at appropriate intervals, e.g. immediately before and immediately after each set of noise measurements, using an acoustic calibrator generating a known sound pressure level at a known frequency in the range 250 Hz to 1 000 Hz. The output of the calibrator should be accurate to within ± 0.5 dB and it is desirable that the frequency chosen corresponds to a preferred octave band centre frequency.

NOTE 2 If the response of the system, checked as in note 1 b), is not in accordance with that expected, the measuring equipment may be adjusted. In case of large deviations, or where the full adjustment cannot be made, the fault in the equipment should be traced and rectified and the equipment recalibrated as necessary.

13.2 Windshields. When a moving air stream is likely to affect the measurements, the microphone shall be fitted with a suitable windshield and the appropriate correction be applied for the direct method of test.

In the case of the substitution method of test **18.3** a wind-shield correction is unnecessary when the same windshield is used for all tests.

13.3 Other instrumentation. Other measurements associated with the determination of the performance of the unit during the course of an acoustical test shall be in accordance with those stipulated in section 1.

14 Installation

The installation requirements for equipment being tested are described in section 1.

14.1 Associated test ducting. Ducting forming part of the test installations shall be made airtight. It is recommended that sheet metal (steel or aluminium) ducting should have a minimum thickness of 1.5 mm for square and rectangular sections and 1.2 mm for circular ducts. In addition, square and rectangular sheet metal ducts should be adequately stiffened to limit panel vibrations.

14.2 Mounting. The mounting of the equipment under test and any associated ducting should be such that any existing vibrations from the equipment are isolated from the room structure.

15 Quantities to be measured

The acoustic quantities to be measured are the sound pressure levels in frequency bands. One-third octave bands are necessary to establish whether discrete frequency components are present in the noise. Octave bands may be used where it has been established that there are no discrete frequency components, or where, for a particular category of equipment, it may be assumed that no discrete frequency components are present.

The required bandwidths for the performance specification are set out in Table 3.

Table 3 — Bandwidths

Centre frequency	
Octave band	**One-third octave band**
Hz	Hz
	100
125	125
	160
	200
250	250
	315
	400
500	500
	630
	800
1 000	1 000
	1 250
	1 600
2 000	2 000
	2 500
	3 150
4 000	4 000
	5 000
	6 300
8 000	8 000
	10 000

Measurements at lower frequencies than those stated above may require special techniques, and are outside the scope of this standard.

16 Discrete frequency components

The presence of significant discrete frequency components in the sound spectrum shall be determined from a test using one-third octave filters and shall be carried out in accordance with clause **17**. A discrete frequency component shall be assessed as being significant and present in a one-third octave band if the sound power level in that one-third octave band exceeds the arithmetic average of the sound power levels in the two adjacent bands by at least the amount in Table 4.

Table 4 — Significant discrete frequencies

One-third octave band centre frequency, Hz	100	125	160	200	250	315 to 10 000
Difference, dB	6	5	4	3	3	2

It is often possible to identify the existence of a discrete frequency component by subjective appraisal in the test room if the listening position is varied.

The presence of a discrete frequency component in any one-third octave band means that any measurements in this band are of doubtful value. Measurements may be made in other one-third or one octave bands not containing the discrete frequency and these will have the usual accuracy.

17 Method of measurement

17.1 General. The method of measurement of sound power level shall be the diffuse field method as described in BS 4196. The method requires the measurement of the sound pressure level in a reverberant room.

17.2 Suitability of the room. The room in which the noise measurements are made shall be a large enclosure in which the sound field generated by a broad band noise source shall be substantially diffuse. A test room with a volume of 180 m^3 and hard reflecting surfaces (walls, floor and ceiling) will probably be found to be satisfactory for items of equipment with a maximum size dimension of about 2 m. For a rectangular shaped room, ratios between the dimensions of the room surfaces of 1 : 1, 1 : 2, 1 : 3, 1 : 4, etc. should be avoided.

Rooms with a volume less than 180 m^3 may not meet satisfactorily the requirements for precision of measurements in the lowest frequency bands nor provide the space necessary for a microphone survey unless the item of equipment is relatively small.

17.3 Measurement procedure

17.3.1 *General.* Two methods for the determination of the mean sound pressure level in the test room are specified.

These are:

Method 1. The measurement of the sound pressure level at a sufficient number of discrete stations to determine the mean sound pressure level.

Method 2. A traversing microphone covering a path length sufficiently long to determine the mean sound pressure level.

During the full tests to measure the acoustic performance of an item of equipment, that include either the measurement of room reverberation time or the measurement of reference sound source pressure level (see clause **18**), the maximum permitted variations in the ambient air temperature and relative humidity in the test room shall be ± 5 °C and ± 5 % r.h. respectively.

17.3.2 ***Measurement procedure, method 1 (discrete measuring stations)***

17.3.2.1 *Number of microphone stations.* Measurements of sound pressure level shall be taken at a number of microphone stations in the test room. The number of stations required for the complete survey shall be determined by the range of the measurements[2)] obtained during the test and shall be as set out in Table 5.

Table 5 — Number of microphone stations

Range of measurements	Band centre frequency	
	125 Hz octave 100 Hz to 160 Hz one-third octave	250 Hz to 8 000 Hz octave 200 Hz to 10 000 Hz one-third octave
dB		
up to 2	6	5
3	6	6
4	6	8
5	8	10
6	9	12
7	11	Range too large
8	13	Range too large
Greater than 9	Range too large	Range too large

When determining the number of microphone stations required for measurements, all observations shall be taken into account and the number of stations increased until the relationship between the range of measurements and the number of stations complies with Table 5. If the range of measurements exceeds those given, the room is not suitable for a diffuse field test.

[2)] The range of measurement is the maximum reading (dB) minus the minimum reading (dB), in each frequency band.

NOTE It may be possible to reduce the range of measurements by modifying the absorption characteristics of the test room. For broad-band noise this may be done by introducing large reflecting surfaces. Where a significant discrete tone is present at the lower frequencies the introduction of some limited low frequency wall absorption may be necessary.

17.3.2.2 *Position of microphone stations.* The microphone stations shall be positioned so that they are:

a) not less than 3 m from the noise source;

NOTE This distance shall be assessed as the minimum distance to the surface of an item of equipment or, where a terminal duct is used, from the centre of the outlet opening.

b) not less than 1 m from any surface of the test room or the test installation,

c) at least 1 m from any other microphone station.

17.3.2.3 *Determination of mean sound pressure level*

The mean band sound pressure level shall be calculated from the observations at each of the microphone stations by averaging according to the following equation:

$$\overline{L}_p = 10 \log_{10}\left(\frac{1}{n}\left(\text{antilog}\,\frac{L_1}{10} + \text{antilog}\,\frac{L_2}{10} + \ldots\ \text{antilog}\,\frac{L_n}{10}\right)\right)$$

where

$\overline{L}_P$ is the mean band sound pressure level (in dB)

L_1 is the band sound pressure level at station 1 (in dB)

L_2 is the band sound pressure level at station 2 (in dB)

L_n is the band sound pressure level at station n (in dB)

n is the number of microphone stations.

NOTE When the range of measurements for a particular frequency band does not exceed 4 dB, an arithmetical average will give a sufficiently accurate value for $\overline{L}_P$ in that band.

17.3.3 ***Measurement procedure, method 2 (traversing method)***

17.3.3.1 *Suitability of the test room.* The suitability of the test room for the determination of mean sound pressure level by a traversing microphone shall be established by a room qualification test. The suitability of the room shall be re-established with the test installation in place if the latter makes any significant change to the acoustic characteristics of the room.

17.3.3.2 *Room qualification test.* The procedure for this test shall be as follows.

a) Place a reference sound source (see **17.3.2**) on the floor of the room but not closer than 1.5 m to any wall and avoiding the centreline axes.

b) With the reference sound source operating measure the sound pressure level at 12 stations in the room. The positions of these microphone stations shall comply with the requirements of **17.3.2**.

c) Calculate the standard deviation of these measurements in each frequency band using the following formula:

$$\sigma = \left(\frac{\Sigma L_p^2 - \dfrac{(\Sigma L_p)^2}{12}}{11}\right)^{1/2}$$

where

σ is the standard deviation of measurements (in dB)

ΣL_p^2 is $(L_1^2 + L_2^2 + \ldots + \ldots + L_{12}^2)$

$(\Sigma L_p)^2$ is $(L_1 + L_2 + \ldots + \ldots + L_{12})^2$

L_1 is the band sound pressure level at station 1 (in dB)

L_2 is the band sound pressure level at station 2 (in dB)

L_{12} is the band sound pressure level at station 12 (in dB)

The standard deviations calculated by this method shall not exceed the values given in Table 6.

Table 6 — Standard deviations

Band centre frequency		Maximum allowable standard deviation
Octave band	One-third octave band	
Hz	Hz	dB
125	100 to 160	2
250 to 2 000	200 to 10 000	1

If this requirement is not met then the room should be modified to increase its reverberation time or a larger room should be used.

17.3.3.3 *Microphone traverse path.* The microphone shall be traversed at approximately constant speed along a path which may be either a line or a circle. The minimum requirements for the traverse path are set out in Table 7.

Table 7 — Minimum requirements for traverse path

Traverse path details	Band centre frequency	
	125 Hz octave 100 Hz to 160 Hz one-third octave	250 Hz to 8 000 Hz octave 200 Hz to 10 000 Hz one-third octave
Length for line traverse path (m)	6	4
	Number of separate circular traverses	
Circle diameter traverse path 1 m	3	2
Circle diameter traverse path 1.25 m	2	2
Circle diameter traverse path 1.5 m	2	1
Circle diameter traverse path 2 m	1	1

All points on the traverse paths shall be at least 3 m from the noise source and 1 m from any room surface or part of the test installation. The traverse path shall not be parallel to any room surface.

Where more than one traverse line or circle is required to meet the requirements set out in Table 7, the minimum spacing between adjacent traverses shall be at least 1 m.

17.3.3.4 *Mean sound pressure level.* The mean sound pressure level shall be the average of the readings taken by the sound measuring equipment during the microphone traverse. The period of traversing shall be sufficient for an accurate mean value to be assessed.

18 Determination of sound power level

18.1 General. The sound power level may be determined from the mean sound pressure level in the test room by one of the following methods.

a) *Direct method.* This determines the absorption characteristics of the test room from the measurement of the reverberation time.

b) *Substitution method.* This compares the mean sound pressure levels generated by the equipment under test with those produced by a reference sound source of known sound power level.

18.2 Determination of sound power level by direct method. The reverberation time of the test room including the equipment under test shall be determined for each frequency band required.

NOTE It is recommended that the procedure outlined in BS 3638 should be used to measure the reverberation time.

The band sound power level of the equipment shall be determined from the following equation:

$$L_W = \overline{L_p} - 10 \log_{10} T + 10 \log_{10} V - 14 \text{ dB} + 10 \log_{10} \frac{k}{1-\alpha}$$

NOTE The corresponding equation in BS 4196 does not contain the last term. The term will be found to be small in large rooms with long reverberation times.

where

L_w	is the equipment band sound power level (in dB)
$\overline{L_p}$	is the mean equipment band sound pressure level (in dB)
T	is the band reverberation time of the test room (in s)
V	is the volume of the test room (in m^3)
k	is $1 + \frac{S\lambda}{8V}$
α	is $\frac{0.163V}{TS}$
S	is the surface area of the test room (in m^2)
λ	is the wavelength of sound at band centre frequency (in m)

18.3 Determination of sound power level by substitution method. The following procedure shall be adopted.

18.3.1 *Reference sound source.* The spectrum of the reference sound source shall be substantially uniform over the frequency range 88 Hz to 11 300 Hz and free from significant discrete frequencies.

An open centrifugal fan impeller running at constant speed, as shown in Figure 7, would meet this requirement. The reference sound source shall have been previously calibrated by a hemispherical free-field test (as described in Appendix B of BS 4196:1967) using a minimum of 20 microphone stations. The tolerance on the accuracy of the calibration of the sound power level of the reference sound source shall not exceed ± 1 dB for all frequency bands of concern. In use, the rotational speed of the reference sound source shall not vary by more than ± 1 % from its calibration speed.

18.3.2 *Location of reference sound source.* The position of the reference sound source in the test room shall satisfy the following conditions.

a) Its position relative to the floor shall correspond to that employed during its calibration.

b) It shall be at least 1.5 m from all room surfaces other than the floor.

c) It shall be at least 1.5 m from the equipment under test.

d) It shall not be placed on the centreline axes of the floor.

18.3.3 *Calculation of sound power levels.* The band sound power level (in dB) of the equipment shall be determined from the following equation:

$$L'_W = L'_{Wr} + \overline{L_P} - \overline{L_{Pr}}$$

where

L'_w	is the equipment band sound power level (in dB)
$\overline{L_p}$	is the equipment mean band sound pressure level (in dB)
$\overline{L_{pr}}$	is the mean band sound pressure level with reference sound source, operating (in dB)
L'_{wr}	is the band sound power level of reference sound source (in dB)

19 Background noise

Background pressure levels shall be measured at one of the microphone stations or from the microphone traverse path used during tests with the equipment operating. A correction for the intrusion of background noise affecting the measurements of sound pressure level with the equipment operating shall be applied only where permitted in **7.1.3** and then only for the condition indicated in Table 1.

To comply with these requirements a "quiet" air supply to the reverberation room is necessary. Details of one method by which this may be achieved are given in Appendix B.

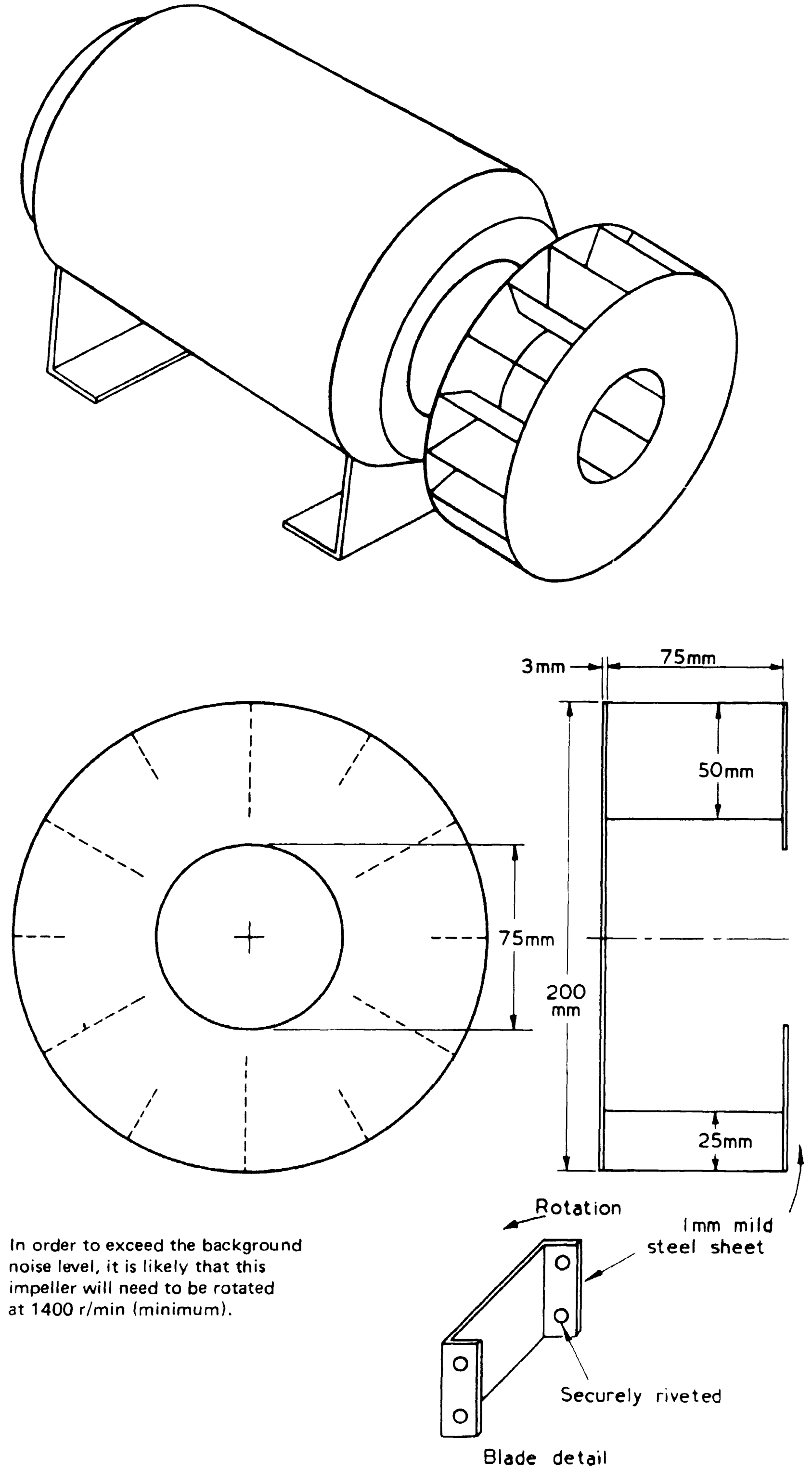

Figure 7 — Example of typical reference sound source

Appendix A Method of testing and rating quiet equipment

Some of the items of equipment which are covered by this standard produce insufficient acoustic energy for accurate measurements to be made when they are operated at air flow rates in their normal range of use.

In these cases, it may be permissible to increase the air flow rates beyond the normal range of the equipment and to plot the sound power level in each octave band as the ordinate on a linear scale and the operating condition parameter (which would normally be the air flow rate) as the abscissa on a logarithmic scale.

Providing these lines are straight, they may be extrapolated downwards to provide estimates of the performance of the equipment within its normal operating range.

Under no circumstances is upward extrapolation permitted.

An example of this technique applied to octave bands 4, 5, 6 and 7 of a slot diffuser is given in Figure 8.

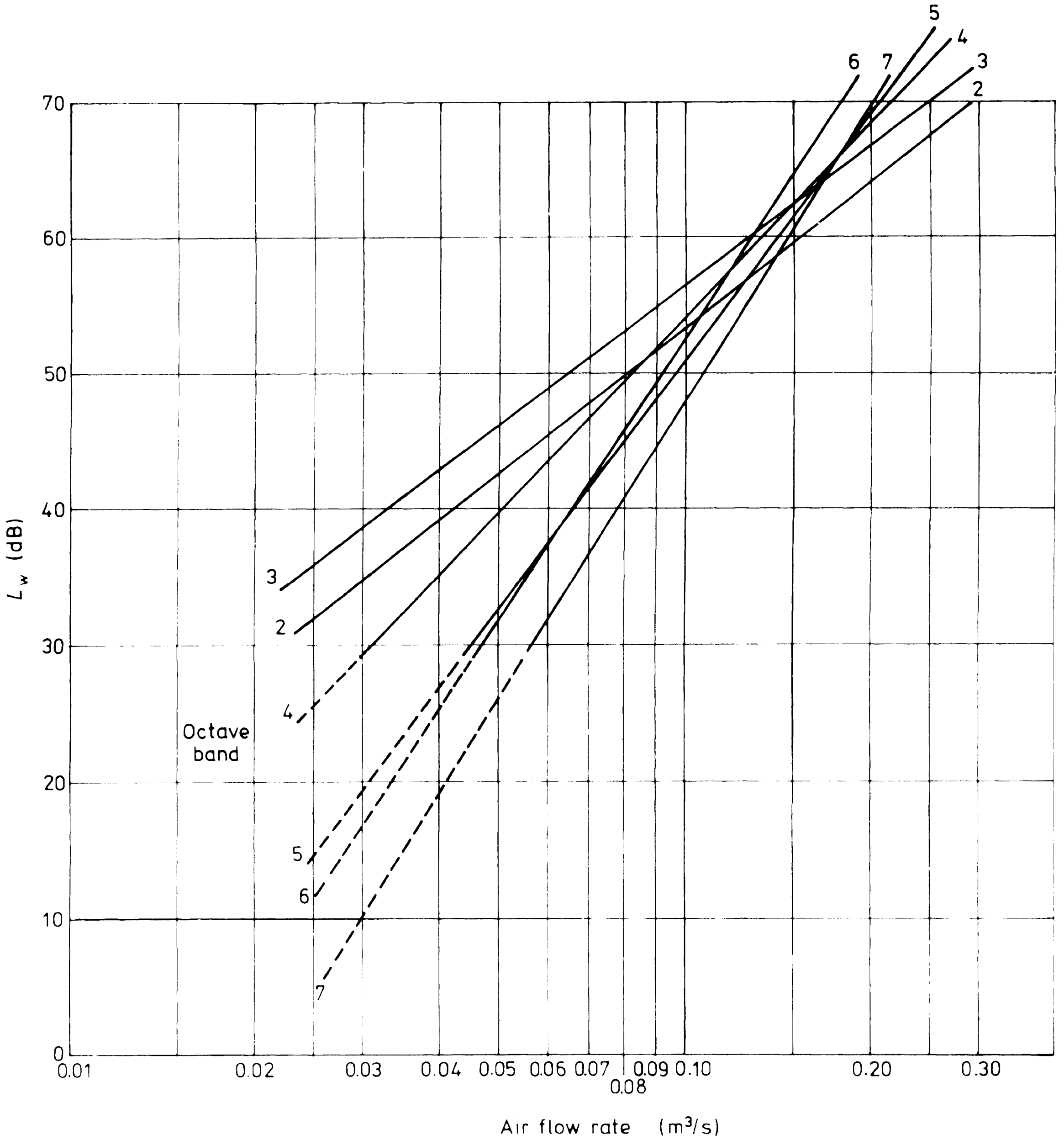

Figure 8 — Extrapolation of L_w data on octave bands 4, 5, 6 and 7 below minimum measurable value of 30 dB

Appendix B Quiet air supply for acoustic testing and rating

The following recommendations will assist in keeping the air system noise to a minimum.

All the equipment, including fan(s) and control damper(s) should be placed within an isolated plant room, generally in accordance with Figure 9.

NOTE The noise generated by venturi tube flow meters to BS 1042 is less than that from orifice plates or nozzles at comparable throat velocities.

A procedure follows for checking that the intrusion of noise from the air system is minimal. This check should be made when the equipment being tested produces a sound pressure level in the test room below the NR30[3] spectrum.

a) Measure the mean octave band sound pressure level in the test room with the entry duct of the air system blanked off and sealed, with the fan running.

b) Measure the mean octave band sound pressure levels with the required air flow rate being delivered or extracted by the system but without the equipment under test in position. These octave band sound pressure levels should be not more than 2 dB above the levels obtained from a). If the difference is more than 2 dB then ductborne noise may interfere with the test results.

c) If the criteria in b) are not met, insert a silencer with an insertion loss of at least 5 dB in all bands into the air system near the duct entry. Repeat test b). If the mean octave band sound pressure levels are more than 2 dB above the levels obtained from a), extraneous noise reaching the room other than by the duct may interfere with the test results.

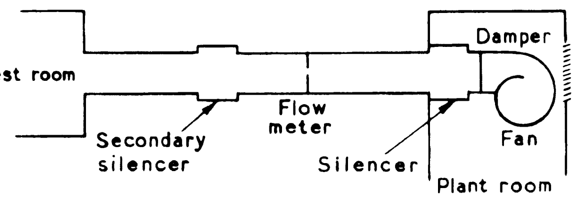

Figure 9 — Equipment for quiet air supply

[3] See Appendix Y to ISO/R 1996.

blank

Publications referred to

BS 350, *Conversion factors and tables*[4].
BS 661, *Glossary of acoustical terms.*
BS 848, *Methods of testing fans for general purposes, including mine fans.*
BS 848-2, *Fan noise testing.*
BS 1042, *Methods for the measurement of fluid flow in pipes.*
BS 2475, *Octave and one-third octave band-pass filters.*
BS 3638, *Method for the measurement of sound absorption coefficients (ISO) in a reverberation room.*
BS 3763, *The International System of units (SI)*[4].
BS 4196, *Guide to the selection of methods of measuring noise emitted by machinery.*
BS 4197, *A precision sound level meter.*
BS 4857, *Methods for testing and rating terminal reheat units for air distribution systems.*
BS 4857-1, *Thermal and aerodynamic performance.*
PD 5686, *The use of SI Units*[4].
ISO/R 495, *General requirements for the preparation of test codes for measuring the noise emitted by machines.*
ISO/R 1680, *Test code for the measurement of the airborne noise emitted by rotating electrical machinery.*
ISO/R 1996, *Acoustics — Assessment of noise with respect to community response.*
ISO 2204, *Acoustics — Guide to the measurement of airborne acoustical noise and evaluation of its effects on man.*

[4] Referred to in the foreword only.

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover.
Tel: 020 8996 9000. Fax: 020 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: 020 8996 9001. Fax: 020 8996 7001.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre.
Tel: 020 8996 7111. Fax: 020 8996 7048.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration.
Tel: 020 8996 7002. Fax: 020 8996 7001.

Copyright

BSI
389 Chiswick High Road
London
W4 4AL