EUROVENT 8/8 - 1992

EUROVENT GUIDE FOR ACOUSTICAL TESTING AND RATING OF AIR HANDLING AND AIR CONDITIONING EQUIPMENT

EUROVENT 8/8

First Edition 1992

Published by EUROVENT/CECOMAF

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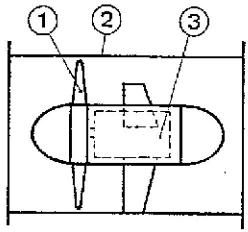
SUMMARY

1 EQUIPMENT - IDENTIFICATION

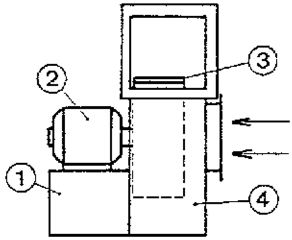
1 FANS

1.1 Axial-flow fan



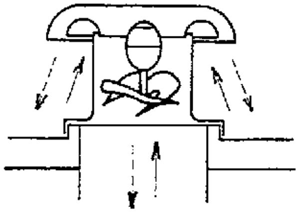
1. Impeller
2. Casing
3. Motor

1.2 Centrifugal fan

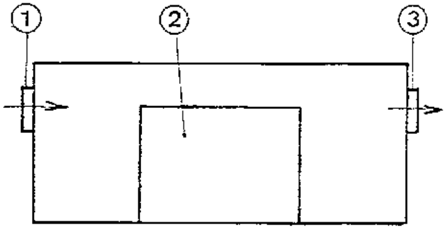


1. Motor support
2. Motor
3. Impeller
4. Casing

1.3 Powered roof ventilator



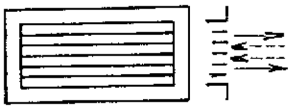
1.4 Fan for controlled exhaust ventilation systems



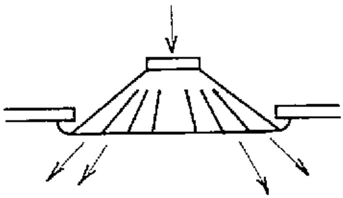
1. Air inlet
2. Fan
3. Air outlet

2 AIR TERMINAL DEVICES

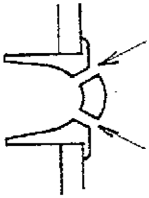
2.1 Grille



2.2 Diffuser



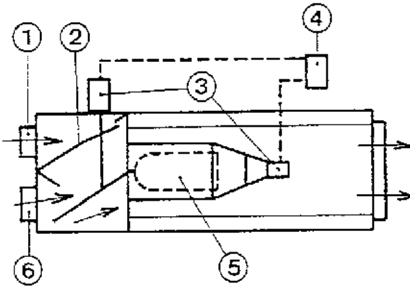
2.3 Air terminal device for controlled exhaust ventilation



3 HIGH VELOCITY EQUIPMENT

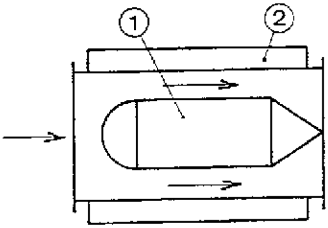
3.1 Dual duct box

1 Cold air
2 Shutters
3 Servomotor
4 Thermostat
5 Flow rate controller
6 Warm air



4 SILENCERS

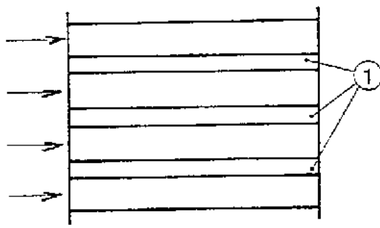
4.1 Circular



1 Core

2 Lining

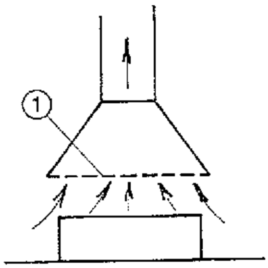
4.2 Rectangular



1 Acoustic baffles

5 COOKING HOODS

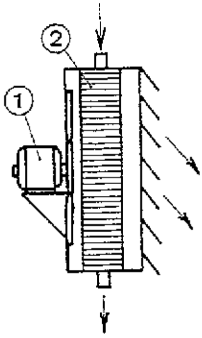
1 Screen



6 FANNED AIR HEATERS

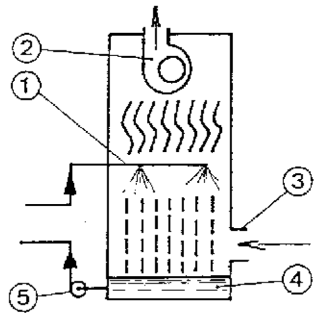
1 Heating coil

2 Fan



7 COOLING TOWERS

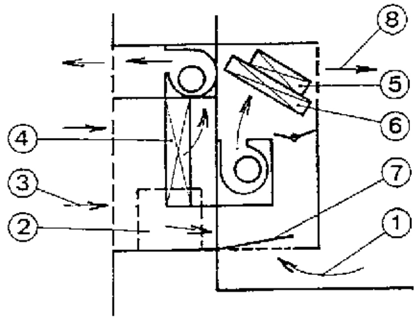
1 Spray nozzles
2 Fan
3 Air inlet
4 Collecting basin
5 Pump



8 ROOM AIR CONDITIONERS

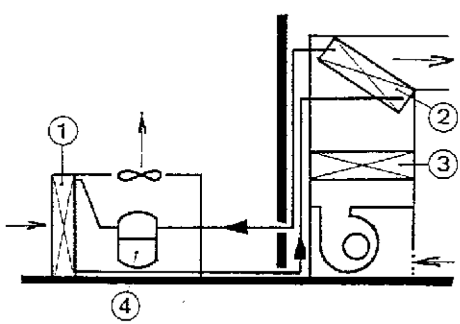
8.1 Air-cooled package room air conditioner

1 Recirculated room air
2 Compressor
3 Fresh air
4 Condenser
5 Evaporator
6 Heating coil
7 Mixing baffles
8 Conditioned supply air



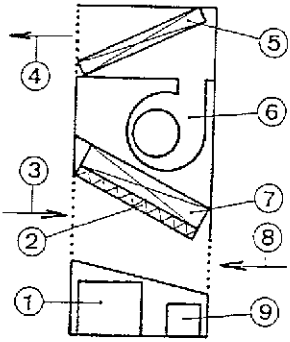
8.2 Split system - type room air conditioner

1 Condenser
2 Evaporator
3 Heating coil
4 Compressor



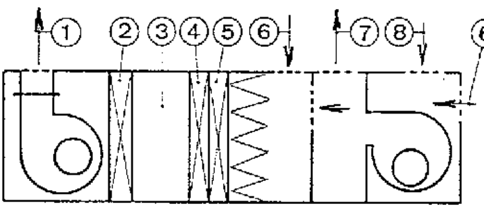
9 AUTONOMOUS AIR CONDITIONING UNITS

1 Condensing coil
2 Filter
3 Recirculated air
4 Supply air
5 Heating coil
6 Fan
7 Evaporator
8 Fresh air
9 Condenser



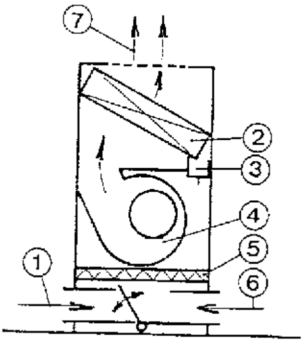
10 CENTRAL STATION AIR HANDLING UNITS

1 Conditioned supply air
2 Reheat unit
3 Washer
4 Cooling coil
5 Pre-heat unit
6 Fresh air
7 Exhaust air
8 Return air



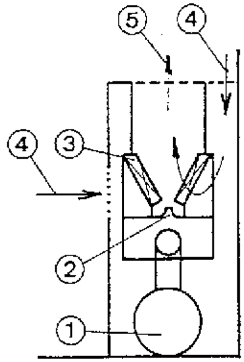
11 FAN COIL UNITS

1 Fresh air
2 Heat exchanger
3 Condensate collecting pan
4 Fan
5 Filter
6 Recirculated air
7 Conditionned supply air



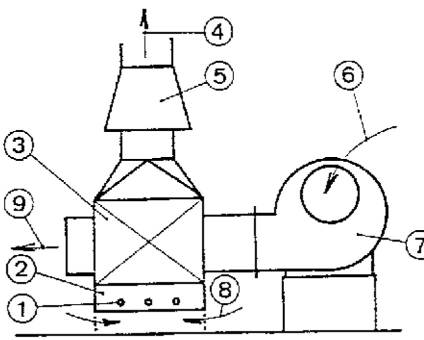
12 INDUCTION UNITS

1 Primary air
2 Nozzles
3 Heat exchanger
4 Recirculated room air
5 Conditioned supply air



13 WARM AIR GENERATORS

1 Burner
2 Combustion chamber
3 Heat exchanger
4 Combustion gases
5 Down draught diverter
6 Cold air
7 Blower
8 Combustion inlet air
9 Heated supply air



2 LIST OF METHODS

2.1 GENERAL METHODS

2.1.1 ISO METHODS

ISO 3740-1980	Acoustics - Determination of sound power levels of noise sources - Guidelines for the preparation of noise test codes.	*Acoustique - Détermination des niveaux de puissance acoustique émis par les sources de bruit - Guide pour l'utilisation des normes fondamentales et pour la préparation des codes d'essais relatifs au bruit*
ISO 3741 - 1988	Acoustics - Determination of sound power levels of noise sources - Precision methods for broad-band sources in reverberation rooms.	*Acoustique - Détermination des niveaux de puissance acoustique émis par les sources de bruit - Méthodes de laboratoire en salles réverbérantes pour les sources à large bande*
ISO 3742 - 1988	Acoustics - Determination of sound power levels of noise sources - Precision methods for discrete - frequency and narrow-band sources in reverberation rooms.	*Acoustique - Détermination des niveaux de puissance acoustique émis par les sources de bruit - Méthodes de laboratoire en salles réverbérantes pour les sources émettant des fréquences discrètes et des bruits à bandes étroites.*
ISO 3743 - 1988	Acoustics - Determination of sound power levels of noise sources - engineering methods for special reverberation test rooms.	*Acoustique - Détermination des niveaux de puissance acoustique émis par les sources de bruit - Méthodes d'expertise pour les salles d'essai réverbérantes spéciales.*
ISO 3744 - 1981	Acoustics - Determination of sound power levels of noise sources - engineering methods for free-fields conditions over a reflecting plane.	*Acoustique - Détermination des niveaux de puissance acoustique émis par les sources de bruit - Méthodes d'expertise pour les conditions de champ libre au-dessus d'un plan réfléchissant.*
ISO 3745 - 1977	Acoustics - Determination of sound power levels of noise sources - precision methods for anechoic and semi-anechoic rooms	*Acoustique - Détermination des niveaux de puissance acoustique émis par les sources de bruit - Méthodes de laboratoire pour les salles anéchoïques et semi-anéchoïques.*
ISO 3746 - 1979	Acoustics - Determination of sound power levels of noise sources - Survey method	*Acoustique - Détermination des niveaux de puissance acoustique émis par les sources de bruit - Méthode de contrôle.*
ISO 3747 - 1987	Acoustics - Determination of sound power levels of noise sources - Part 7 : Survey method using a reference sound source calibrated over a reflecting plane	*Acoustique - Détermination des niveaux de puissance acoustique émis par les sources de bruit - Méthode de contrôle faisant appel à une source sonore de référence étalonnée sur un plan réfléchissant.*
ISO 3748 (Draft)	Acoustics - Determination of sound power emitted by noise sources - Part 8 : engineering method under free-field conditions over a reflecting plane, simplified for small, omnidirectional sources.	*Acoustique - Détermination des niveaux de puissance acoustique émis par les sources de bruit - Méthode d'expertise dans les conditions de champ libre au-dessus d'un plan réfléchissant, simplifiée pour de petites sources omnidirectionnelles.*

2.1.2 EQUIVALENT STANDARDS

	ISO	FRANCE	U S A	U K	GERMANY
1 • REVERBERATION ROOM, BROAD BANDS	3741 (88)	S 31 - 022 (89)	ANSI S 1.31 (80)	4196 p.1	45635
2 • REVERBERATION ROOM, NARROW BANDS	3742 (88)	S 31 - 023 (89)	ANSI S 1.32 (80)	4196 p.2	Teil 2
3 • REVERBERATION ROOM, ENGINEERING	3743 (88)	S 31 - 024 (89)	ANSI S 1.33 (82)	4196 p.3	
4 • FREE FIELD, REFLECTING PLANE	3744 (81)	S 31 - 025 (77)	ANSI S 1.34 (80)	4196 p.4	
5 • ANECHOIC AND SEMI-ANECHOIC ROOM	3745 (77)	S 31 - 026 (78)	ANSI S 1.35 (79)	4196 p.5	
6 • SURVEY METHOD	3746 (79)	S 31 - 027 (77)	ANSI S 1.36 (79)	4196 p.6	
7 • SURVEY METHOD BY COMPARISON REF. SOURCE	3747 (87)	S 31 - 067 (86)	-	Not yet	
8 • SIMPLE ENGINEERING METHOD, SMALL SOURCES	3748	S 31 - 068	-	No BS	

2.2.1. ISO

1 • DIS 5135 *(1984)*	Air terminal devices, high/low velocity/pressure assemblies, dampers and valves in reverberation rooms.
2 • DIS 5136 *(1990)*	Determination of sound power radiated into a duct by fans - In duct method.
3 • DIS 7235 *(1991)*	Measurement procedures for ducted silencers - Insertion loss, flow noise and total pressure loss.

2.2.2 EUROVENT

1 • EUROVENT 8/1 *(1980)*	Acoustical measurements on machines and equipment in the free field or large rooms on a hard reflecting plane.
2 • EUROVENT 8/2 *(1992)*	Acoustical measurements of fan coil units in reverberation rooms.
3 • EUROVENT 8/3 *(1980)*	Acoustical measurements of induction units in reverberation rooms.
4 • EUROVENT 8/4 *(1982)*	Acoustical measurements of air-cooled packaged room air conditioners in reverberation rooms.
5 • EUROVENT 8/5 *(1987)*	Acoustical measurements of autonomous air conditioning units in reverberation rooms.
6 • EUROVENT 8/6 *(1986)*	Acoustical measurements of split system type room air conditioners in reverberation rooms
7 • EUROVENT 8/7 *(1992)*	Silencer test codes
8 • EUROVENT 8/9 *(1992)*	Real room acoustic test procedure (HEVAC Document)

2.2.3 FRANCE

1 · NF S 31-021	*(1982)*	On platform measurement of the noise emitted by inlet of fans ducted on outlet.
2 · NF E 71-701	*(1980)*	Controlled mechanical ventilation components Performance and acoustic testing of exhaust air terminal devices
3 · NF E 51-704	*(1986)*	Controlled mechanical ventilation components - Performance and acoustic testing of kitchen hoods.
4 · NF E 51-705	*(1989)*	Controlled mechanical ventilation components - Performance and acoustic testing of fans.
5 · NF E 51-706	*(1988)*	Controlled mechanical ventilation components Performance and acoustic testing of system used for family house ventilation.
6 · NF S 31-063	*(1985)*	Determination of sound power level of fans : in-duct method.

2.2.4 GERMANY

1 · E DIN IEC 59 C (CO) 27 *(1983)*	Test code for the determination of airborne noise by household and similar electrical appliances ; part 2 : particular requirements for forced draught convection heaters.
VDI 3734 Blatt 8 *(1981)*	Characteristic noise emission values of technical sound sources : cooker hoods.
DIN 45635	Measurement of airborne noise emitted by machines

a) Beiblatt 1 (1979)	Enveloping surface method : form for report
b) Beiblatt 2 *(1977)*	Explanatory notes
c) Teil 1 *(1984)*	Enveloping surface method
d) Teil 2 *(1977)*	Reverberation room
e) Teil 3 *(1978)*	Special reverberation room
f) Teil 8 *(1981)*	Structure borne noise
g) Teil 9 *(1977)*	Induct method
h) Teil 14 *(1980)*	Air coolers
i) Teil 18 *(1976)*	Household equipment
j) Teil 35 *(1983)*	Heat pumps
k) Teil 38 *(1984)*	Fans
l) Teil 46 *(1983)*	Cooling towers
m) Teil 56 *(1984)*	Air heaters

2.2.5 U.K.

1 • **BS 848 Part 2** *(1983)*		Fan noise testing
2 • **BS 4773 Part 2** *(1976)*		Acoustical testing and rating of air terminal devices
3 • **BS 4954 Part 2** *(1978)*		Method of acoustical testing and rating of induction units for sound power emission and terminal attenuation
4 • **BS 4857 Part 2** *(1978)*		Method of acoustical testing and rating terminal reheat units for air distribution systems
5 • **BS 4718** *(1971)*		Method of testing for silencers in air distribution systems
6 • **BS 4856**		Methods for testing and rating fan-coil unit heaters and unit coolers
Part 4	*(1978)*	Acoustics performance : without additional ducting
Part 5	*(1979)*	Acoustics performance : with ducting
7 • **BS 4485 Part 2**		Water cooling towers, method of testing and acceptance testing.

2.2.6. USA

1 • **ASHRAE 68-86** *(AMCA 330-86)*	*(1986)*	Laboratory method of testing in-duct sound power, measurement procedure for fans.
2 • **AMCA 300-85**	*(1987)*	Reverberant room method for sound testing of fans.
3 • **AMCA 301-76**	*(1976)*	Methods for calculating fan sound ratings from laboratory test data
4 • **AMCA 302-73**	*(1973)*	Application of sone ratings for non-ducted air moving devices
5 • **AMCA 303-79**	*(1979)*	Application of sound power level ratings for fans
6 • **AD - 63**	*(1963)*	Measurement of room power level ratings for fans
7 • **AHAM RAC - 2SR**	*(1971)*	Sound rating of room air conditioners
8 • **ARI 270-84**	*(1984)*	Sound rating of outdoor unitary equipment
9 • **ARI 275-84**	*(1984)*	Application of sound rated outdoor unitary equipment
10 • **ARI 350-86**	*(1986)*	Sound rating of non-ducted indoor air-conditioning equipment
11 • **ARI 575-87**	*(1987)*	Method of measuring machinery sound within equipment room
12 • **ARI 370-86**	*(1986)*	Sound rating of large outdoor equipment.

3 DESCRIPTION OF METHODS

3.1 ISO

Technical Committee 43 of the International Organization for Standardization (ISO) has the task of preparing international standards in acoustics. Up to now, about 50 standards have been published dealing with various aspects of acoustics. A very important series of general standards (3741 to 3748) concerns the determination of the sound power level of machines and equipment. These standards have been transformed into national standards in many countries (see 2.1.2).

The ISO also prepares specific standards for some equipment. In the field of air handling, only three such standards have been published as drafts They deal with fans, silencers and air terminal devices.

The general presentation of ISO standards is given in Tables 1 and 2.

TABLE 1

INTERNATIONAL STANDARDS SPECIFYING VARIOUS METHODS FOR DETERMINING THE SOUND POWER LEVELS OF MACHINES AND EQUIPMENT

International Standard N°	Classification of method	Test environment	Volume of source	Character of noise	Sound power levels obtainable	Optional information available
3741	Precision	Reverberation room meeting specified requirements	Preferably less than 1% of test room	Steady broad-band	In one-third octave or octave bands	A-weighted sound power level
3742				Steady discrete frequency or narrow bands		
3743	Engineering	Special test room		Steady broad-band narrow-band discrete frequency	A-weighted & in octave bands	Other weighted sound power levels
3744	Engineering	Outdoors or in large room	No restrictions; limited only by available test environment	Any	A-weighted and in one-third octave or octave bands	Directivity information and sound pressure level as a function of time ; other weighted sound power levels
3745	Precision	Anechoic or semi-anechoic room	Preferably less than 0.5 % of test room volume	Any		
3746	Survey	No special test environment	No restrictions : limited only by available test environment	Steady broad-band narrow-band discrete frequency	A-weighted	Sound pressure levels as a function of time : other weighted sound power levels
3747	Survey (comparison method only)	No special test environment	No restriction	Steady broad-band narrow-band discrete frequency	A-weighted	Octave power levels and sound pressure levels forparticular positions
3748	Engineering	Free field over a reflecting plane	Less than 1 m^3	Steady broad-band omnidirectional	A-weighted and in octave bands	Sound pressure levels for particular positions
DIS 5136 (possibly 3749)	Engineering	In duct	Duct diameter 0.15 to 2 m	Steady broad-band narrow-band discrete frequency	In one third octave or octave band	A-weighted sound power level

TABLE 2

PRECISION OF MEASUREMENT METHOD STANDARD DEVIATION IN dB

INTERNATIONAL STANDARD	63			125			250			500			1000			2000			4000			8000			A
	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	
3741 3742				3			2			1,5												3			-
3743				5			3			2												3			2
3744	5 for outdoors			3			2						1,5									2,5			2
3745 Anechoic room				1									0,5									1			
3745 Semi-anechoic room				1,5									1									1,5			
3746	-																								5
3747	-																								4
3748	-																								2
DIS 5136	3.5	3	2,5		2	1,6													2		2,5			4	

1 - The standard deviations given in this table reflect the cumulative effects of all causes of measurement uncertainty, such as source location, duct end reflections, duct transitions, instrument calibration, sound pressure to sound power computating and sampling errors. It does not include variations in the sound power radiated by the equipment itself caused by changes in the mounting arrangements for example. The standard deviations are those which would be expected if the measurement were repeated in many different laboratories.

2 - The 95 % confidence limits may be calculated for a normal distribution of data by multipling the quoted standard deviation by the factor 1.96.

3 - When octave band sound power levels are calculated, the uncertainty of each octave band level will not be greater than that of the largest uncertainty of the three constituent one-third octave bands.

I S O 3741

PRECISION METHODS FOR BROAD BAND SOURCES IN REVERBERATION ROOMS

This international standard specifies in detail two laboratory methods for determining the sound power radiated by a device, machine, component or sub-assembly as a function of frequency, using a reverberation test room of prescribed acoustical characteristics.

DESCRIPTION

The methods described in this standard are particularly advantageous for rating the sound power output of sources which produce steady broad band noise and for which directivity information is not required. The extent of the applicability of the standard is summarized in Table1, while the uncertainties in determining the sound power levels are given in Table 2. The volume of the source should preferably be less than 1% of the volume of the reverberation room, which should comply with the specifications outlined in Appendix A or Appendix D of the standard.

PROCEDURE

The test object is placed in the reverberation room in one or more typical operating positions. Unless a particular position is specified, the source should be placed at least 1.5 m from any wall of the room.

The sound pressure levels in the room can be measured by :

1. moving a single microphone from position to position, or
2. employing an array of fixed microphones, or
3. moving a microphone continuously over an appropriate path in the test room.

For methods (1) and (2), at least three fixed microphones or microphone positions should be used, placed at least at a distance of l /2 from each other, where λ is the wavelength corresponding to the lowest frequency of interest. The output of the microphones should be automatically scanned and/or averaged on a mean-square basis.

For method (3), the microphone should traverse, at constant speed, a path of at least 3 m in length, while the signal from the microphone is being averaged on a mean-square basis.

From the determination of the sound pressure levels in octave of third octave bands, the sound power level of the source may be calculated using either the direct method, which requires the reverberation time of the room to the know in each octave of third octave band of interest, or by the comparison method which requires the use of a reference sound source of known sound power output.

To calculate the sound power of the source by the direct method, the following equation is used :

$$L_W = L_p - 10 \log_{10} \left(\frac{T}{T_0}\right) + 10 \log_{10}\left(\frac{V}{V_0}\right) + 10 \log_{10} \left(1 + \frac{S\lambda}{8V}\right) + 10 \log_{10}\left(\frac{B}{1000}\right) - 14 \text{ dB}$$

where :

L_W = sound power level of the source under test, in dB. Reference 1 pW

L_P = mean band pressure level, in dB Reference 20 μPa

T = reverberation time of the room in seconds

T_0 = 1 sec

V = volume of the room in cubic metres

V_0 = $1 m^3$

λ = wavelength at the centre frequency of the octave or third octave band, in meters

S = total surface area of the room, in square meters

B = barometric pressure in millibars

When calculating the sound power output of the source using a reference sound source, i.e. the comparison method, it is not necessary to measure the reverberation time of the room. The sound pressure level in the room due to the operation of the reference sound source alone is measured and corrected if necessary for background noise. The sound power level of the source in each octave or third octave band of interest may be obtained from the following relationship :

$$L_W = L_p + (L_{wr} - L_{pr})$$

where :

L_W = band power level of source under test in dB. Reference 1 pW

L_p = mean band power level of source under test in dB. Reference 20 μPa

L_{wr} = band power level of reference sound source, in dB. Reference 1 pW

L_{pr} = mean band pressure level of reference sound source, in dB. Reference 20 MPa

I S O 3742

PRECISION METHODS FOR DISCRETE FREQUENCY AND NATTOW BAND SOURCES IN REVERBERATION ROOMS

This international standard specifies in detail two laboratory methods for determining, in a reverberation test room, the sound power of weak sources which radiate discrete frequencies or narrow bands of noise.

DESCRIPTION

The measurement procedures specified in ISO 3741 apply to sources which emit steady broad band noise ISO 3742 gives additional precautions which must be adhered to when discrete frequencies or narrow bands of noise are present in the noise spectrum of the source.

When dealing with such a source a greater number of source locations and microphone positions (or a greater path length for a moving microphone) is required than that stated in ISO 3741 in order to obtain the level of accuracy given in Table 2.

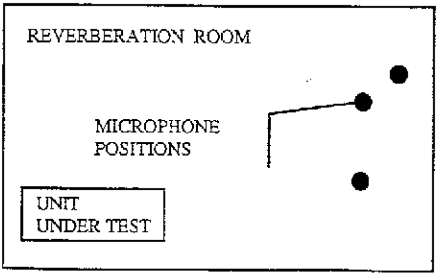
These elaborations are necessary in order to obtain a good estimate of the mean sound pressure level throughout the room and also to overcome the influence of the normal modes of the room and the position of the source within the room on the sound power radiated by the source. The required number of source locations and positions depends upon the desired accuracy, the spectrum of the radiated noise and the properties of the room. These numbers can usually be reduced if rotating diffusers are used in the room during the measurements. Guidelines for the design of suitable diffusers are given in the appendix of the standard.

PROCEDURE

As for ISO 3741, the volume of the source should not be more than 1 % of the total volume of the test room. The presence of a discrete frequency component in the noise spectrum of the source can usually be detected simply by listening. However, discrete frequency components may be present even though they are inaudible.

When such components are present they produce variations in the spatial distribution of sound pressure levels around the source. An estimate of standard deviation in these variations should be determined using an array of six microphones. From this estimated value, the minimum number of microphone positions (or appropriate path length) and the recommended number of source locations can be determined by following the procedures of the Standard.

Sound pressure levels in the octave or third octave bands of interest can then be measured according to the procedures of ISO 3741. The sound power level emitted by the source can then be calculated by the direct or comparative method as described in ISO 3741.



I S O 3743

ENGINEERING METHODS FOR SPECIAL REVERBERATION TEST ROOMS

This international standard specifies relatively simple engineering methods for determining the approximate sound power levels of small noise sources. The measurements are carried out with the source placed in a specially designed room having a prescribed reverberation time over the frequency range of interest. The results of the measurements are given in terms of the A-weighted and/or octave band power levels of the source.

DESCRIPTION

The methods for determining sound levels described in this standard are particularly suitable if costs and labour must be kept to a minimum and great precision is not required.

The field of application of this standard and the uncertainty of the measurements are given in Tables 1 and 2. The properties of the test room are chosen so that the room's influence on the sound power output of the source is reasonably small.

Guidelines for the design of a suitable test room are given in appendix A of the standard. The reverberation time of the test room should fall within the two limiting curves defined in the standard. For methods of measuring the reverberation time of the room, reference should be made to ISO/R 354. The size of the room determines the maximum size of the source and lower limit frequency for which the methods are applicable. The minimum permitted volume of the test room is 70 m^3, while the source should not be greater than 1% of the total room volume.

PROCEDURE

Before the test room is used for sound power determinations, its suitability should be evaluated by determining the differences between the known sound power levels of a reference sound source and the sound power levels in each octave band of interests, as found by employing the test method in the test room. The difference should not be greater than those quoted in the table given in the standard.

The source to be tested should be placed in the test room in one or more locations typical of normal use. If such a location cannot be stipulated, then the source should be placed on the floor a least 1m from any wall. The minimum number of microphone positions and source locations necessary to obtain the specified precision in the measurements depends upon the properties of the source and the test room, and may be determined from the following procedure. The standard deviation of the sound pressure levels measured at six different microphone positions for each octave band and for A-weighting is calculated.

By entering this value in the table given in the standard, one obtains the number of microphone positions and source locations to be used.

The sound pressure levels in the test room are determined using the procedure and instrumentation described in ISO 3741.

To calculate the approximate band power levels or A-weighted sound power level of the source by the direct method, the following equation should be used :

$$L_W = L_{pm} - 10 \log_{10} \left(\frac{T_N}{T_0}\right) + 10 \log_{10} \left(\frac{V}{V_0}\right) - 13 \qquad \text{Eqn. 1}$$

where :

L_{pm}	=	mean octave band level or mean A-weighted level in dB
L_W	=	band power level or A-weighted sound power level of the source under test, in dB. Reference 1 pW.
L_N	=	nominal reverberation time of the test room as explained in the standard
L_0	=	1 sec
V	=	volume of the test room in cubic metres
V_0	=	1 m^3

The constant which appears in the above equation is 13 instead of 14, the figure which appears in other ISO documents. This constant and the variation in the reverberation time with frequency roughly compensate for the increase in sound energy density near the surfaces of the test room and near the souce.

For determining the band power by the comparison method, a reference sound source shown in ISO 3741 should be used. The number of microphone positions and source locations should be determined from standard deviation measurements, as for the direct method. The sound power can then be evaluated as described in ISO 3741.

I S O 3744

ENGINEERING METHODS FOR FREE FIELD CONDITIONS OVER A REFLECTING PLANE

The international standard specifies engineering methods for measuring the sound pressure levels over a given surface which envelops the noise source under investigation. The sound power level of the source is calculated from these measurements.

DESCRIPTION

The method for determining sound power levels described in this standard is particularly useful for measurements on relatively large test objects. The greatest permissible linear dimension of the source is 15 m. The procedures are applicable to any type of noise with the exception of isolated bursts of sound energy or a pulse train with a repetition rate of less than 10 per second.
The accuracy to be expected from the methods is given in Table 2.

The method outlined in this standard may be used in laboratory rooms which provide a free field over a reflecting plane or in field situations where the acoustical characteristics comply with the requirements of this standard. A room in which the contributions of the reverberant field to the sound pressure levels over the measurement surface are small compared with those of the direct field of the source may also be used. If the test room does not meet the requirements of this standard, measurements should be performed in accordance with ISO 3746.

PROCEDURE

The source is placed on a hard reflecting surface and the minimum distance, R_{min} from the source within which satisfactory environmental conditions exist is determined according to the procedures described in the standard. The value of R_{min} is important in the selection of the appropriate measurement surface.

The magnitude of the environmental correction factor should be determined according to one of the four prescribed methods. These methods are used to check that free field conditions exist and to qualify a given measurement surface for a particular sound source under test. The free field qualification is satisfied if the ratio of the sound absorption, A, of the room to the area, S, of the measurement surface, is sufficiently large.

In general, ratios of $A/S > 10$ require no corrections. For ratios of A/S of between 10 and 6 the environmental correction is usually smaller than 2 dB. For ratios of $A/S < 5$, measurements should be performed according to ISO 3746.

The three possible measurement surfaces are a hemisphere, a rectangular parallelepiped and a surface which follows the general shape of the source i.e. a conformal surface. When conditions permit, the use of a hemispheric surface is preferable. When measurements need to be made close to the machine, the conformal surface gives the most accurate result, although more effort is required to position the microphones than for the other two surfaces.

For the three surfaces mentioned i.e., hemispheric rectangular parallelepiped, and oncformal, the minimum number of microphone positions required are 9, 10 and 8 respectively.

To calculate the sound power of the souce from the measured sound pressure level over the measurement surface. The surface sound pressure level is first determined for A-weighting and for each octave band of interest from the following equation:

$$\overline{L_p} = 10 \log_{10} \frac{1}{N} \left| \sum_{i=i}^{N} 10^{0,1 L_{pi}} \right| - K$$

where :

$\overline{L_p}$ = surface sound pressure level, en dB, reference 20 µPa

L_{pi} = A-weighted or band pressure levels resulting from the i^{th} measurement in dB, reference 20 µPa

N = Total number of measurements

K = correction factor relating to environment described in the qualification procedures of Appendix A.

The sound power output of the source can then be calculated from the equation :

$$L_W = \overline{L_p} + 10 \log_{10} \left(\frac{S}{S_0}\right)$$

where

L_W = A-weighted or band power level of the source in dB, reference 1 pW

$\overline{L_p}$ = mean sound pressure level as determined from Eqn.1, in dB, reference 20 µPa

S = area of the measurement surface

S_0 = 1 m3

I S O 3745

PRECISION METHODS FOR ANECHOIC AND SEMI-ANECHOIC ROOMS

This international standard specifies in detail two laboratory methods for determining the sound power radiated by a source using a laboratory anechoic room having prescribed acousticl characteristics.

DESCRIPTION

The method for determining sound power levels described in this standard are based on two premises:

(1) When a source is radiating in a completely free field (e.g. anechoic room) or in a free field above a reflecting plane (e.g. semi-anechoic room), then the reverberant field produced is negligible; and

(2) The total radiated power is obtained from the mean sound pressure levels averaged in time and space over a hypothetical sphere or hemisphere surrounding the source from the sound pressure level measurements thus, the weighted sound power level of the source as well as the sound power level of the source in octave or third octave bands may be calculated.

The methods apply primarily to small sources whose volumes are preferably less than 0.5% of the volume ofthe test room. This limitation is necessary to ensure that the hypothetical sphere or hemisphere can be situated in the far radiation field of the source.

The character of the noise emitted by the source should be relatively steady for a least 30 s. All types of noise may be accommodated with the exception of isolated bursts of sound or a pulse train with a repetition rate of less than 10 per second.

The accuracy to be expected from these methods is given in Table 2.

The preferred environment for measurements which gives the least uncertainty is an anechoic room.

However, reasonable accuracy can be obtained i a semi-anechoic room providing the precautions specified in this standard are observed.

If a semi-anechoic room is used for the tests, then the reflecting plane on which the source is mounted should extend at least to the measurement surface. The sound absorption coefficient of the reflecting plane should not exceed 0.06. Procedures for determining whether or not an anechoic room (or a semi-anechoic room) is suitable as a test environment are given in appendix A of the standard.

PROCEDURE

Whenever practicable, the source should be mounted in the test room in a typical operating position. Sources which are normally supported by or associated with a hard surface should be mounted in a free field above a reflecting plane. The mounting base should be prevented from vibrating and radiating an excessive amount of noise by the use of resilient layers.

For a free field, the measurement surface is a hypothetical sphere preferably centred on the acoustic centre of the source. If, as is often the case, the acoustic centre is unknown then the geometric centre is chosen. The radius of the sphere should be at least twice the major dimension of the source and not less than 1 m.

For a free field above a reflecting plane, the surface is a hypothetical hemisphere centred on the projection on the floor of a chosen centre (preferably the acoustic centre). The radius of the hemisphere should be at least twice the major source dimension or four times the average distance of the source from the reflecting plane, whichever is the larger, and not less than 1 m.

The sound pressure levels can be measured over the hypothetical surface by positioning the microphones as described in the standard according to any of the following methods.

1) moving a single microphone from position to position or employing an array of fixed microphones and sampling their outputs sequentially.

2) moving a microphone along multiple parallel circular paths regularly spaced on the test sphere (or hemisphere).

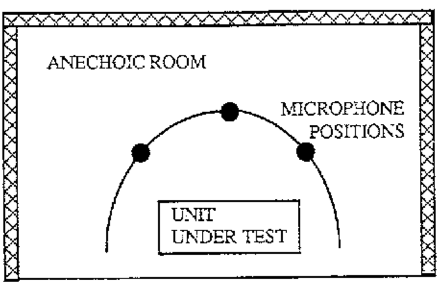
3) moving a microphone along multiple meridional arcs regularly spaced on the test sphere (or hemisphere).

From the measured sound pressure levels over the test surface, a mean surface sound pressure level is calculated. The sound power output of the source can then be determined from the following equation :

$$L_W = \overline{L_p} + 10 \log_{10} \left(\frac{S}{S_0} \right) + C$$

where :

- L_W = A-weighted or band power level of the source in dB, reference 1 pW
- L_p = surface sound pressure level over the test sphere, in dB, reference 20 µPa
- S = $4 \pi r^2$ the area of the test sphere of radius r or $2 \pi r^2$ if a hemisphere over a reflecting plane is used
- S_0 = 1 m^2
- C = correction term, in dB, for the influence of temperature and pressure.



I S O 3746

SURVEY METHOD

This international standard specifies a survey method for determining the A-weighted sound power level of a device or machine. The sound power level of the source is calculatd from the measured values of the weighted sound pressure levels at prescribed microphone positions.

DESCRIPTION

The methods specified in this standard are particularly useful for rating the sound power output of a source that produces a steady noise and which cannot be moved to a special test environment and to which the methods specified in ISO 3741, 3742, 3743, 3744 and 3745 cannot or should not be applied as they are impracticable under the circumstances.

The volume of the source is not restricted by the Standard. However, if the measurements are made indoors then the volume of the test room must be sufficiently larger than the volume of the source for the microphones to be located at the specified positions around the source. The noise emitted by the source may be of any character with the exception of single impulses or pulse trains with a repetition rate of less than 5 per second.

The accuracy to be expected from these methods is given in Table 2.

The ideal test environment would be free from reflecting objects so that the source could radiate into a free field over a reflecting plane. Suitable test environments are :

1) a flat outdoor area

2) a room complying with the qualifications specified in the Appendix of the standard

The A-weighted sound pressure level due to the background noise should be at least dB below that produced with the source operating.

PROCEDURE

The qualification procedure of the test room is based on the premise that the ratio $A/S \geq 1$ where A is the sound absorption area of the room and S is the area of the measurement surface. The methods of determining the absorption area A of the test room are described in the Appendix of the Standard.

To facilitate the location of the microphone positions, an imaginary reference surface in the form of a rectangular parallelepiped is defined which only encloses the source. The measurement surface over which the microphones are positioned can be either a hemisphere or a rectangular parallelepiped. The radius of the hemisphere should be twice the largest dimension of the reference surface. When the measurement surface is a rectangular parallelepiped, the distance between this surface and the reference surface should normally be 1 m. The hemisphere is preferred for small cubical sources whereas the rectangular parallepiped is more suitable when measurements must be performed close to the test source. The minimum number of microphone positions for the hemisphere and the rectangular parallelepiped are 5 and 6, respectively. If the range of the measured levels in dB exceeds 1.5 times the number of microphone positions, then additional positions as prescribed in the standard should be used.

From the measured values of the A-weighted sound pressure level over the measurement surface, a mean sound pressure level can be calculated from the relation :

$$L_{p(A)} = 10 \log 10 \frac{1}{N} \left| \sum_{i=i}^{N} 10^{0,1 \ L_{pi}} \right| - K$$

where :

$L_{p(A)}$ = mean A-weighted sound pressure level, in dB, reference 20 µPa

L_{pi} = A-weighted sound pressure level resulting from the i^{th} measurement in dB, reference 20 µPa

N = total number of measurements

K = environmental correction to account for the influence of reflected sound, in dB

Procedures for calculating K are given in the appendix of the standard. The maximum allowable value of K is 7 dB.

The A-weighted sound power output of the source can then be calculated from :

$$L_{w(A)} = L_{p(A)} + 10 \log_{10} \left(\frac{S}{S_o}\right)$$

where :

S = area of the measurement surface

S_o = reference area of 1 m^2

I S O 3747

SURVEY METHOD USING A REFERENCE SOUND SOURCE

This international standard specifies a survey method for determining the A-weighted sound power level of a device or machine. The sound power level of the source is calculated from the measured values of the A-weighted sound pressure levels produced at specified measurement points by the souce under test and by a reference sound source.

DESCRIPTION

This international standard applies to sources which radiate broad-band noise, narrow band noise and discrete tones. It is primarily applicable to sources that produce a steady noise. The specified procedures are not applicable to isolated bursty of sound energy or burst trains with repetition rates of less than 5 per second.

The largest dimension of the noise souce should be less than 15 m; otherwise the uncertainties given in Table 2 may be exceeded.

There are no restrictions on acoustical and geometrical properties of test sites. If possible, the volume of the test room should exceed 30 m^3.

PROCEDURE

The sound power level of the souce under test is calculatd from the measured values of the sound pressure level by using environmental corrections. These environmental corrections are calculatd from the differences between the values obtained with a reference sound source and those given by its calibration.

Different microphone arrays and positions for the reference sound source are given for different acoustical situations, depending upon the size of the source under test as well as the size, number and orientation of the reflecting planes which are situated in the proximity of the source being tested.

The positions of the reference sound source also depend upon whether it is possible to place the reference source on the topmost outer surface of the souce under testing.

The mean A-weighted sound pressure L_{pA} is calculated from the measured values L_{PAI} :

$$L_{p(A)} = 10 \log \left[\frac{1}{N} \sum_{i=1}^{N} 10^{0,1 L_{PAi}} \right]$$

The mean A-weighted eenvironmentally-corrected sound pressure level L_{PAf} is calculated using the equation:

$$\overline{L_{PAf}} = \overline{L_{PA}} - K$$

where K is the environmental correction calculated from the measured value of the sound pressure level produced by the reference source and the value determined from its calibration curve.

The A-weighted sound power of the equipment under test L_{WA} is calculated from the equation :

$$L_{WA} = \overline{L_{PAF}} + 10 \log \frac{S}{S_o}$$

where :

S = area of the measurement surface

S_o = reference area of 1 m^2

I S O 3748

ENGINEERING METHOD UNDER FREE-FIELD CONDITIONS OVER A REFLECTING PLANE, SIMPLIFIED FOR SMALL OMNIDIRECTIONAL SOURCES

This international standard specifies a simplified engineering method for determining the A-weighted sound power level of a small omnidirectional source.

DESCRIPTION

This international standard applies primarily to sources which radiate steady broad-band noise, but it may be applied to other souces, except for those which produce isolated bursts of sound energy or burst trains with repetition rates of less than 5 per second. The source must be omnidirectional.

The volume of the source should not exceed 1.0 m^3. For sources radiating narrow-band noise or pure tones, the uncertainties given in Table 2 may be exceeded. The test will be free from a reflecting object so that the source may radiate into a free field over a reflecting plane. The absorption factor of the reflecting plane should not exceed 0.06 for all frequencies considered.

PROCEDURE

The mean A-weighted sound pressure level $\overline{L_{PA}}$ is calculated from 5 sound pressure levels measured at specified positions :

$$\overline{L_{pA}} = 10 \log \frac{1}{5} \sum_{i=1}^{5} 10^{0,1 L_{PAi}}$$

The A-weighted sound power level L_{WA} is calculated from the equation :

$$\overline{L_{WA}} = (\overline{L_{PA}} - 1) + 10 \log \frac{S}{S_0}$$

where

S = area of the measurement surface

S_0 = reference area of 1 m2

In this equation, 1 dB is subtracted from L_{PA} because the measurements are not carried out at four angular positions as in standard 3744. For this reason, the calculated mean value L_{PA} is too high, as five measuring points are nearest to the source.

I S O DIS 5135 - 1984

DETERMINATION OF SOUND POWER LEVELS OF NOISE FROM AIR TERMINAL DEVICES, HIGH/LOW VELOCITY/PRESSURE ASSEMBLIES, DAMPERS AND VALUES BY MEASUREMENT IN A REVERBERATION ROOM

This standard establishes general rules for the acoustical testing of air terminal devices, high and low pressure assemblies, dampers and valves in a reverberation room. The method is based essentially on ISO standards 3741 and 3742. The specifications are given concerning the location of equipment in the test room and the operational conditions. Mounting details for equipment are presented in a few sketches. In general a minimal distance from an adjacent wall is prescribed. The method of rating which allows a certain range for extrapolation of the results is also presented.

I S O DIS 5136 - 1990

DETERMINATION OF SOUND POWER RADIATED INTO A DUCT BY FANS : IN-DUCT METHOD

This international standard specifies a method for the determination of the sound power radiated into a duct by fans. It also applies to other aerodynamic sources.

DESCRIPTION

The sound power radiated into a duct by a fan depends to some extent on the type of duct, characterized by its acoustical impedance. For a measurement method, the duct has to be well prescribed. In this standard, the duct is of a circular cross-section and terminated anechoically by use of an anechoic termination. To suppress the turbulent pressure fluctuations at the microphone, the use of a long cylindrical windscreen ("sampling tube") is prescribed. The extent of the applicability of the standard is summarized in Table 1, while the uncertainties in determining the sound power levels are given in Table 2.

PROCEDURE

The standard may only be used for fans connected to ducts on at least one side. The prescriptions are given for testing on the inlet or the outlet side. The test duct diameter range is limited from 0.15 m to 2.0 m. The velocity within the duct must not exceed 30 m/s with a swirl angle of less than 10 degrees.

The microphone with the sampling tube is mounted on the test duct in the prescribed measuring plane and at three prescribed positions. From the measured third octave band sound pressure levels Lp1, Lp2 and Lp3, the average sound pressure level Lp is calculated using the formula :

$$L_p = 10 \log \frac{1}{3} \sum_{i=1}^{3} 10^{0,1 L_{Ppi}} - C$$

where C is the correction given by :

$$C = C_1 + C_2 + C_3 + C_4$$

C_1 is the free field microphone response correction

C_2 is the frequency response correction of the sampling tube

C_3 is the flow velocity correction

C_4 is the modal correction.

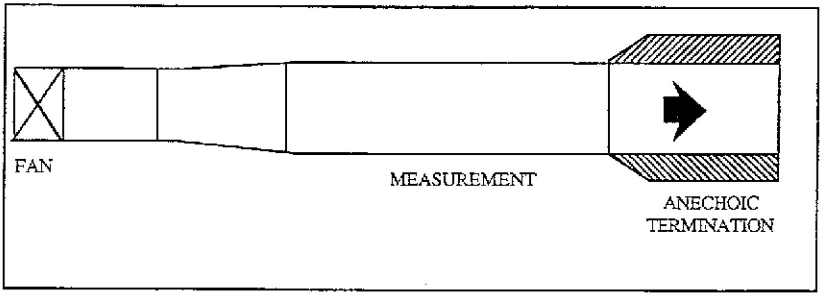
The sound power level Lw of the sound radiated into the test duct for each frequency band is obtained by using the plane wave formula :

$$Lw = Lp + 10 \log \frac{S}{S_o}$$

where :

S is the cross sectional area of the duct in m^2

$S_o = 1 \ m^2$



In duct method for test on outlet side.

I S O DIS 7235 - 1991

MEASUREMENT PROCEDURE FOR DUCTED SILENCERS - INSERTION LOSS FLOW NOISE AND TOTAL PRESSURE LOSS

This international standard defines basic requirements for determining:

- The insertion loss of silencers with and without air flow
- The sound power level of the flow noise generated by silencers

The total pressure loss of silencers with air flow.

DESCRIPTION

This standard contains two methods to determine the insertion loss of ducted silencers : the direct method and the substitution method.

With the direct method,the sound pressure level is measured in the test duct in front of and after the silencer. As the silencer normally reflects part of the incident sound wave, standing waves are set up in the test duct in spite of the presence of anechoic terminations; nevertheless, the applied procedure permits minimizing these standing waves.

With the substitution method,the sound pressure level of the transmitted wave is first determined with the silencer installed between the test ducts and then when it is replaced by the substitution duct (a hardwall duct element). The sound pressure level of the transmitted wave can be measured either in the test duct after the silencer or in a reverberation room connected to this duct via a qualified transmission element.

PROCEDURE

The standard may be used for silencers which are usually connected to ducts. The prescriptions are given for the test duct with anechoic termination or with a transmission element to a reverberation room. When the microphone is placed in the duct, the windscreens must be used to suppress the flow-induced noise. The sampling tube according to ISO 5136 is not considered suitable because of its high directivity.

When applying the direct method,the insertion loss of silencer is given by :

$$D = Lps - Lpr + 10 \log \frac{Ss}{Sr}$$

where :

Ss is the cross sectional area of the source side of the test duct
Sr is the cross sectional area of the receiving side of the test duct
Lps is the spatial average of the sound pressure level on the source side
Lpr is the spatial average of the sound pressure level on the receiving side.

When applying the substitution method,the insertion loss of silencer is given by :

$$D = Lp1 - Lp2$$

where :

Lp1 is the spatial average of the sound pressure level with the substitution duct
Lp2 is the spatial average of the sound pressure level with the silencer.

3.2 *E U R O V E N T*

The EUROVENT Acoustic group was formed in 1977 with the task of establishing codes for acoustics testing of air handling equipment on the basis of available standards. Up to now, this group has begun work on eleven different documents, some of which are still in the draft stage.

The first document 8/0, Acoustics Terminology, includes 109 terms used in the field of acoustics and their definitions in English, French and German. Whenever possible, the definitions were taken from standards existing in the UK, France and Germany.

The next seven documents, from 8/1 to 8/7, concern testing of various types of air handling equipment. There is a separate document for much of the equipment: large machines, fan coil units, induction units, room air conditioners, autonomous air conditioners, split systems and silencers.

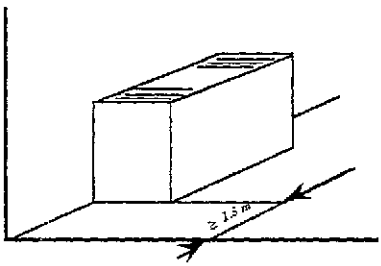
The test method is always based on an ISO standard (generally ISO 3741, 3742 and 3744).

The present document has been designated 8/8.

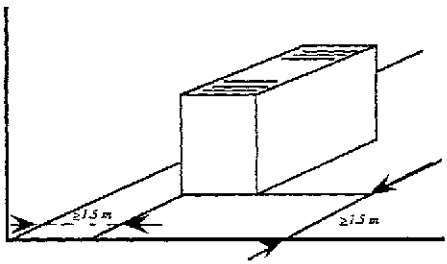
The Document 8/9 describes a simplified method which can be used for small equipment as a means of comparison between products.

ACOUSTICAL MEASUREMENTS OF COIL UNITS IN REVERBERATION ROOMS

This document is based essentially on ISO standard 3741 and 3742 enabling determination of the sounds of sources emitting discrete-frequency noise. Specifications are given concerning the location of equipment in the test room and the means of fixation on the floor or on the wall, if required.



Equipment location for floor mounted units



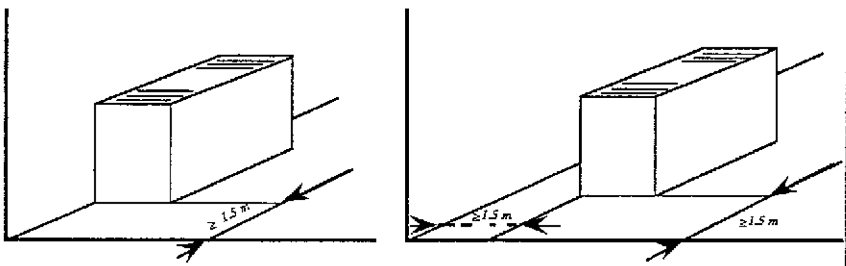
Equipment location for ceiling mounted units

Acoustical measurements of fan coil units are normally carried out at zero heat load. The fan impeller speed is measured and considered as a parameter determining the operating point.

EUROVENT 8/3 (1980)

ACOUSTICAL MEASUREMENTS OF INDUCTION UNITS IN REVERBERATION ROOMS

This document is based essentially on ISO standard 3741 and 3742 allowing the determination of the sound power of sources emitting discrete-frequency noise. The specifications are given concerning the location of equipment in the test room and the means of fixation on the floor or on the wall if required.

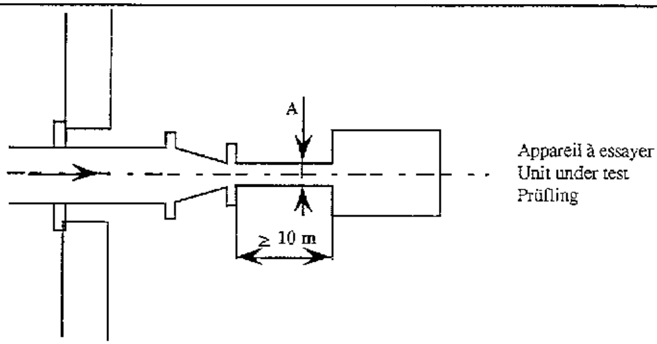


Equipment location for floor mounted units

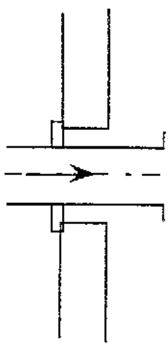
Equipment location for ceiling mounted units

Acoustical measurements of induction units are normally carried out at zero heat load. The pressure measured in the supply duct at two diameters upstrem of the inlet to the unit by means of wall pressure tapping is considered as a parameter determining the operating point.

The determination of the background noise is complicated by the presence of auxiliary equipment supplying primary air. The background noise is measured with the induction and its 10 D of supply duct disconnected from the supply system within the reverberation room.



a) Essai
Test
Prüfung



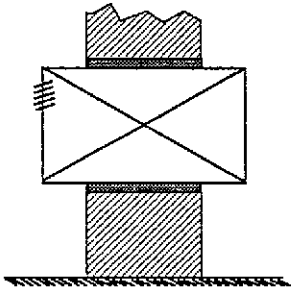
b) Détermination du bruit de fonds
Background noise test
Bestimaug des Kintergrundgeräusches

ACOUSTICAL MEASUREMENTS OF AIR-COOLED PACKAGED ROOM AIR CONDITIONERS IN REVERBERATION ROOMS

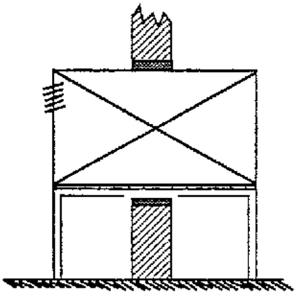
For these room air conditioners, the acoustical characteristics to be determined by the tests are :

- sound power radiated directly to the room,
- sound power radiated to the outdoors,
- attenuation of noise from outdoors (sound insulation).

The determination of the sound power is based essentially on ISO standards 3741 and 3742 enabling this determination for sources emitting discrete frequency noise. The unit is installed in the wall of the reverberation room and specifications are given for its installation.



Example of the installation of a window air conditioner on a "heavy" partition



Example of the installation of a window air conditioner with supports.

The room air conditioner must be tested with its compressor operating; consequently, the temperature and humidity must be maintained on both sides of the unit in order to keep the unit working at its normal operating range.

The measurement of sound insulation is performed with a broad-band noise source installed in the room on the outside of the equipment. The mean sound pressure levels are measured in both rooms and standard insulation is defined by the expression :

$$D_n = Lp_1 - Lp_2 + 10 \log \frac{Tr}{To}$$

where Tr is the receiving room verberation time and To is the reference time equal to 0.5 s.

EUROVENT 8/5 (1987)

ACOUSTICAL MEASUREMENTS OF AUTONOMOUS AIR CONDITIONING UNITS IN REVERBERATION ROOMS

Based essentially on ISO standards 3741 and 3742, this document recommends a test method for use with units of up to 25 kW cooling power. For larger units in which thermal compensation becomes a problem, the use of the free field test method, as given in EUROVENT document 8/1, is recommended.

For units without ducting the total sound power level generated by air supply terminal devices and casing are determined together by testing the unit in a reverberation room.

For units with a ducted outlet, the sound power level radiated by the casing is determined separately from the sound power level radiated into the outlet duct (see figure).

The autonomous air-conditioning unit must be tested with its compressor operating. The air temperature must be maintained between 20° and 30°C. There is no need for humidity control.

a) For units with a ducted outlet, the sound power level radiated by the casing only shall be determined by testing the unit in a reverberation room with the ductwork arranged as shown in Figures 2a and 2b.

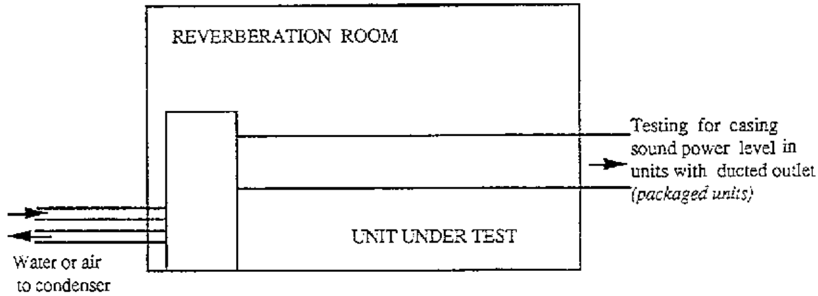


FIGURE 2a

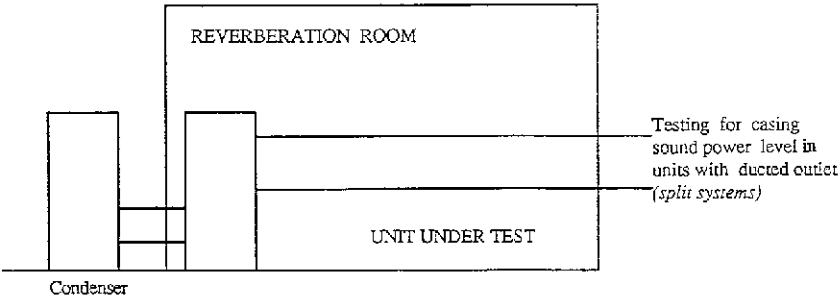


FIGURE 2b

b) In units with a ducted outlet, the sound power level radiated into the outlet duct shall be determined by testing the unit located outside a reverberation room with the ductwork extending into the room, as shown in Figures 3a and 3b.

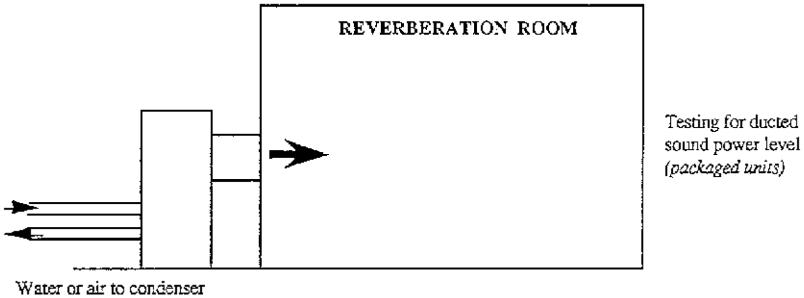


FIGURE 3a

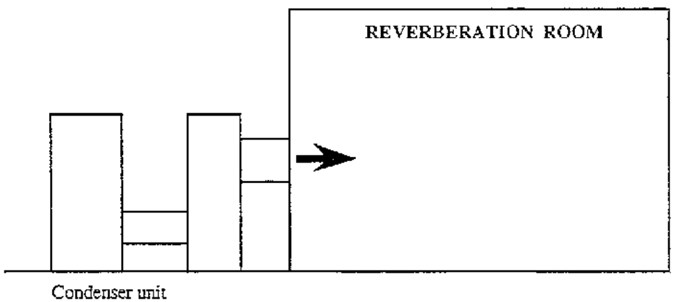


FIGURE 3b

EUROVENT 8/6 (1986)

ACOUSTICAL MEASUREMENTS OF SPLIT SYSTEM TYPE ROOM AIR CONDITIONERS IN REVERBERATION ROOMS

Based essentially on ISO standards 3741 and 3742, this document recommends a test method to use for split system type air conditioners.

The unit must be tested with the compressor operating. The temperature and humidity must be maintained to keep the unit working within its normal operating range.

When testing the indoor section of the air conditioner, the unit shall be placed in the reverberation room near the wall. When testing the outdoor section containing the compressor, its separation from the wall shall be not less than 1.5 m.

3.3 F R A N C E

French standards are issued by AFNOR. In the AFNOR catalogue, the acoustics standards can be found under the designation S 30 - Generalities (19 different standards) and S 31 - Measurements (88 different standards). Recently, some acoustical test methods were incorporated into more general standards concerning performance testing, and may have different designations.

Only six standards apply to air handling equipment :

a •	**NF S 31-021**	*(1982)*	Fans
b •	**NF E 51-701**	*(1980)*	ATD
c •	**NF E 51-704**	*(1986)*	Kitchen hoods
d •	**NF S 31-063**	*(1985)*	Fans in duct
e •	**NF E 51-705**	*(1989)*	Fans in chamber
f •	**NF E 51-706**	*(1988)*	House ventilation

NF S 31-021 (1982)

ON-PLATFORM MEASUREMENT OF THE NOISE EMITTED BY INLET OF FANS DUCTED ON OUTLET

This standard specifies a method for the determination of sound power emission from ducted fans. Instructions are given for the determination of :

a) sound power radiating from the inlet

b) sound power radiating from the casing

DESCRIPTION

The method uses the general prescriptions for ISO 3744 and equivalent French standard S31-025.

PROCEDURE

The fan is installed in such a manner that its outlet duct is connected to the reduced chamber installation required by French standards NF X 10-200 for performance testing. The sound pressure is measured in free field conditions over a reflecting plane. The environmental correction factor should be determined according to one of the methods described in international standards ISO 3744.

RATING

Tests results are to be reported for all operating points. To calculate the total sound power level L_{W2} for an angular velocity ω_2 from the total sound power level L_{W1} for an angular velocity ω_1, the following correlation may be used:

$$L_{W2} - L_{W1} \simeq 50 \log \frac{\omega_2}{\omega_1}$$

This correlation may not be used for octave band sound power levels. For a range or geometrically similar fans, the following correlation relating total sound power level L_W, angular velocity and rotor radius R is given :

$$(L_W)\ \omega_2\ R_2 - (L_W)\ \omega_1\ R_1 \simeq 50 \log \frac{\omega_2}{\omega_1} + 70 \log \frac{R_2}{R_1}$$

NF E 51-701 (1980)

CONTROLLED MECHANICAL VENTILATION COMPONENTS-PERFORMANCE AND ACOUSTICAL TESTING OF EXHAUST AIR TERMINAL DEVICES

SCOPE

Testing for the determination of two acoustical characteristics of exhaust air terminal devices :

a) noise generated by the device

b) attenuation of noise generated by the device

GENERATED METHOD

Testing in a reverberation room.

INSTALLATION OF UNIT AND TESTING

For testing of generated noise, the device is installed in a wall of the reverberation room and connected to the set-up needed for performance testing. The sound power level radiated by the device is calculated from the sound pressure level measured in the room.

For testing of sound attenuation, two devices connected to the same duct are installed in a manner similar to that generally used, each in a separate reverberation room.

Two reverberation rooms are used; the sound produced in the first is received in the second. Attenuation is expressed by:

$$\delta = L_{p1} - L_{p2} - 10 \log \frac{A2}{4}$$

where L_{p1} and L_{p2} are mean values of sound pressure level in the rooms and A_2 the equivalent absorption of the reception room.

NF E 51-704 (1986)

CONTROLLED MECHANICAL VENTILATION COMPONENTS - PERFORMANCE AND ACOUSTICAL TESTING OF KITCHEN HOODS

The acoustical characteristics of cooking hoods are determined in an identical manner as for extract air terminal devices as described in NF E 51-701.

S 31-063 (1985)

DETERMINATION OF SOUND POWER RADIATING INTO A DUCT BY FANS - IN DUCT METHOD

This standard describes a method for determination of sound power radiating into a duct by fans. It is in total agreement with international standard DIS 5136.2 except for some editorial changes.

3.4 *G E R M A N Y*

German standards are issued by DIN 45635 which applies to all measurements of airborne noise emitted by machines. The various sections of this standard give instructions for application of different methods:

a •	**Part 1**	- enveloping surface method
b •	**Part 2**	- reverberation rom method
c •	**Part 3**	- special reverberation room method
d •	**Part 8**	- method by measurement of structure-borne noise
e •	**Part 9** -	- in-duct method

Additional section parts of the standard give instructions for testing and rating specific equipment (see 2.2.4).

DIN 45635 Teil 14 (July 1980)

TESTING OF AIR-COOLED HEAT EXCHANGERS

This part of the general standard prescribes the conditions of testing air-cooled heat exchangers. The enveloping surface method on a reflecting plane must be applied. Specifications are given for the determination of measurement surface and microphone positions.

V D I 3734 Blatt (February 1981)

CHARACTERISTIC NOISE EMISSION VALUE OF AIR COOLERS

The purpose of this document is to provide a procedure for rating the sound performance of air coolers. These units must be tested according to test standard DIN 45635 Teil 14. Five classes of air coolers are defined as a function of their construction and the emitted sound power given in L_W (A).

3.5 *UNITED KINGDOM*

British standards are issued by BSI. In the BSI catalogue, the acoustic standards do not have any particular designation. Eight standards apply to air handling equipment:

a•	**BS 848**	(1985)	Part 2	- Fans
b•	**BS 4773**	(1976)	Part 2	- Air terminal devices
c•	**BS 4856**	(1978)	Part 4	- Fan coil units without ducting
d•	**BS 4856**	(1979)	Part 5	- Fan coil units with ducting
e•	**BS 4857**	(1978)	Part 2	- Terminal reheat units
f•	**BS 4954**	(1978)	Part 2	- Induction units
g•	**BS 4485**	(1969)	Part 2	-Cooling towers
h•	**BS 4718**	(1971)	/	-Silencers

BS 848 - Part 2 (1985)

FANS FOR GENERAL PURPOSES AND METHODS OF NOISE TESTING

This standard recognizes that the sound power radiated by a fan, like its performance characteristics, is influenced by the presence of ducting on the inlet or outlet side. The following four installation types are defined:

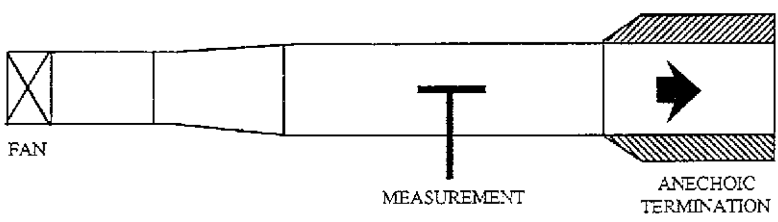
TYPE A	:	free inlet, free outlet
TYPE B	:	free inlet, ducted outlet
TYPE C	:	ducted inlet, free outlet
TYPE D	:	ducted inlet, ducted outlet

The inlet (or outlet) fan sound power found in each of the four standardized conditions may be different, while the fan inlet sound power and fan outlet sound power may also be found to be different for any given installation type. It is therefore possible that up to eight different sound power levels may be determined to characterize the statement of fan noise performance.

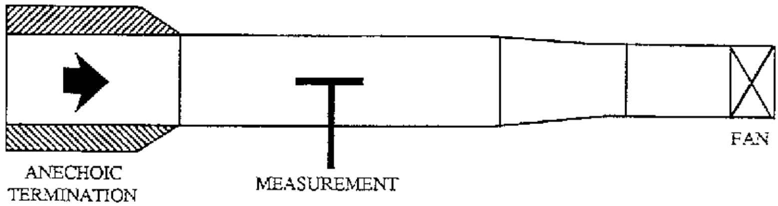
The following four test methods are described:

- in-duct method
- reverberant field method
- free field method
- semi-reverberant method

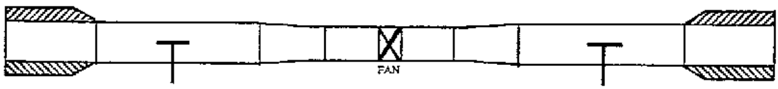
a) The in-duct method, based on ISO/DIS 5136, will be used to determine the sound power radiated into an anechoically terminated duct on the inlet and the outlet side of the fan; it is therefore applied for testing with type B, C and D installations.



In-duct method for type B installation

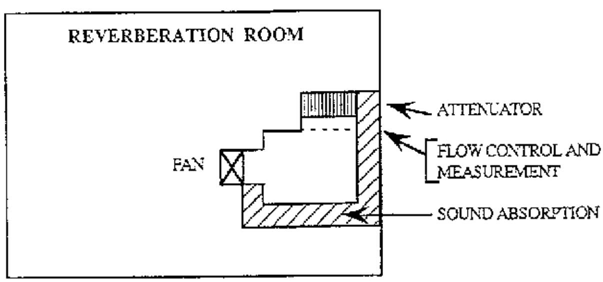


In-duct method for type C installation

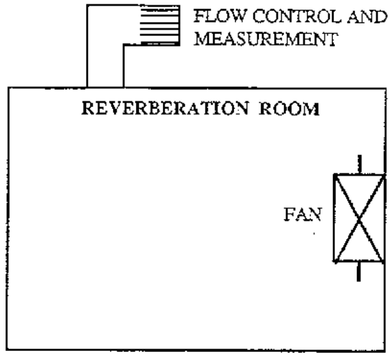


In-duct method for type D installation

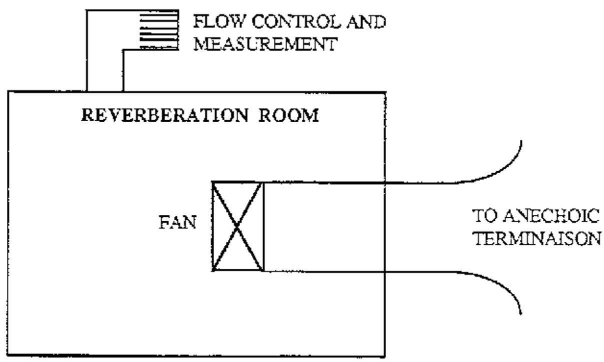
b) The reverberant field method based on general BSI and ISO standards may be used to determine the sound power radiated by the free inlet in type A and B installations and by the free outlet in type A and C installations. The air circuit may be inside or outside the walls of the reverberant room.



Test room with the whole air circuit within the walls.



Test room with type A installation



Test room with type B and C installations

Test room with type B and C installations

c) Free field and semi-reverberant methods may be used for the determination of open inlet and open outlet sound power level of fans for type A, B and C installatons, and also for fans too small for testing by the in-duct method. The standards gives prescriptions for:

- an anechoic chamber with a spherical free field,
- an anechoic chamber with a hemispherical free field over a reflecting plane,
- a flat outdoor area,
- a large room.

The influence of non-ideal free-field conditions (semi-reverberant field) is allowed for by the addition of an environmental correction K.

Uncertainty in determination of the sound power levels

1/3 Octave band Center frequency	METHOD OF TEST		
	In-duct	Reverberant field	Free field
	STANDARD DEVIATION		
50	3.5	Not defined	
63	3.0	for 50.63 and 80 nz	
80	2.5		
100	2.5	3.0	3.0
125	2.0	3.0	3.0
160	1.6	3.0	3.0
200	1.6	2.0	3.0
250 - 315	1.6	2.0	3.0
400 - 630	1.6	1.5	2.0
800 - 2500	1.6	1.5	1.5
3150 - 4000	2.0	1.5	1.5
5000	2.5	1.5	1.5
6300 - 8000	2.5	3.0	3.0
10000	4.0	3.0	3.0

GENERALIZED METHOD FOR SOUND POWER LEVEL PREDICTION

The method is given only as a guide without an estimation of the uncertainties. It relates only to the aerodynamic source of the noise and applies to fans having geometric similarity and at the same relative opening point, i.e. equality of the ratio :

$$\frac{\text{Flow rate}}{(\text{rational speed}) \times (\text{impeller diameter})^3}$$

and with the same type of installation

Inlet and outlet noise should be separately analysed and predicted.
Generalized sound power level

$$Lg = L_W - 10 \; (5 - A) \; \log n - 10 \; (8 - 2A) \; \log D_r - 10 \log BW$$

where :

L_W = band sound power level dB

n = rotational speed, rev/s

D_r = impeller diameter, m

BW = band with Hz

A = experimental index, to be established by testing; otherwise take 0.4 for axial fans and 0.5 for centrifugal fans plotted against :

$$x = \log \frac{fc}{n}$$

fc = band centre frequency, Hz for each third octave band

BS 4773 - PART 2 (1976)

METHODS FOR TESTING AND RATING AIR TERMINAL DEVICES FOR AIR DISTRIBUTION SYSTEMS ACOUSTICAL TESTING

SCOPE

Testing and rating for sound power emission from air terminal devices

GENERAL METHOD

Testing in a reverberation room

FREQUENCY RANGE OF INTEREST

For general purposes, octave bands with centre frequencies between 125 Hz and 8000 Hz.

INSTALLATION OF UNIT AND TESTING

The air terminal device is installed in the test room in the position representative of its normal usage (against or away from a wall, floor or ceiling). A quiet air supply system is used. The background noise is measured with the air terminal device removed.

RATING

Tests are carried out for a minimum of four air flow rates. For each octave band the sound power L_W is plotted against log q_V where q_V is the air flow rate and a straight line is drawn through the points. This line may be extended down to 0.5 times the minimum value of q_V and up to twice the maximum measured value of q_V. For a range of geometrically similar air terminal devices, the tests must be carried out for a minimum of three sizes. The method of selecting the sizes is described in the standard.

Two methods of correlating mean sound power level, size of the air terminal device and air flow rate are given.

a• For each octave band plot L_W-50 log A where A is the free area of the air terminal device against log q_V. If 80% of the test data lie between + 3dB of the best fit line drawn through the test points, these graphs may be used for extrapolation and interpolation.

b• If the above condition is not satisfied, calculate:

$$L_{WO} = L_W - 50 \log q_V + 40 \log A - Ks$$

where the correction Ks is given as follow :

Hz	125	250	500	1000	2000	4000	8000
Ks	0	3	6	9	12	15	18

For each octave band plot Lwo against $\frac{fcA}{q_V}$

If the above condition is now satisfied, these graphs may be used for extrapolation of interpolation.

BS 4856 - PART 4 (1978)

METHODS FOR TESTING AND RATING FAN COIL UNITS, UNIT HEATERS AND UNIT COOLERS - ACOUSTICAL PERFORMANCE WITHOUT ADDITIONAL DUCTING

SCOPE

Testing and rating fan-coil units, unit heaters and unit coolers when used without ducting. Instructions are given for calculation and for the presentation of test results for sound power radiated from the unit.

GENERAL METHOD

Testing in a reverberation room

FREQUENCY RANGE OF INTEREST

For general purposes octave bands with centre frequencies between 125 Hz and 8000 Hz.

INSTALLATION OF UNIT AND TESTING

The unit is installed in the reverberation room in the position representative of its normal usage.

BS 4856 - PART 5 (1979)

METHODS FOR TESTING AND RATING FAN COIL UNITS, UNIT HEATERS AND UNIT COOLERS - ACOUSTICAL PERFORMANCE WITH DUCTING

SCOPE

Testing and rating fan coil units, unit heaters and unit coolers when used without ducting. Instructions are given for calculation and for the presentation of test results comprising :

a) sound power from the outlet

b) sound power radiated from the inlet

c) sound power radiated from the casing

GENERAL METHOD

Testing in a reverberation room

FREQUENCY RANGE OF INTEREST

For general purposes, octave bands with centre frequencies between 125 Hz and 8000 Hz.

INSTALLATION OF UNIT AND TESTING

a • For testing for sound power radiated from the outlet, the unit is installed outside the test room according to Figure 1.

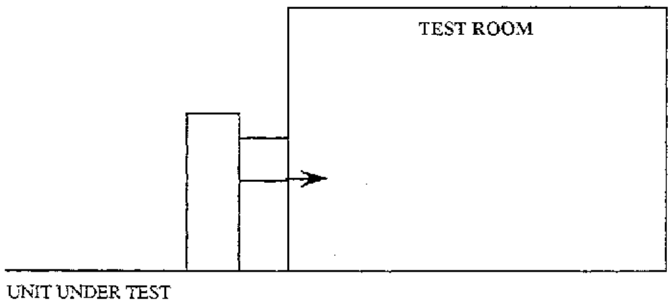


FIGURE 1

b) For units with free inlet and ducted outlet supplying air to outside space, the test for sound power radiating from the inlet and casing is carried out according to Figure 2.

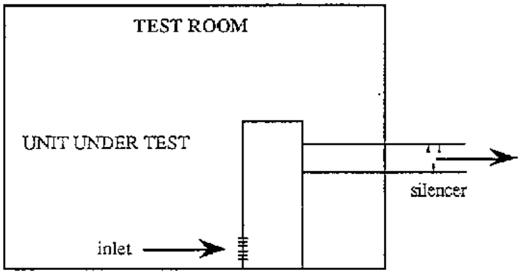


FIGURE 2

c) For units with ducted inlet, the sound power radiating from the inlet is measured with the unit installed outside the reverberation room according to FIgure 3.

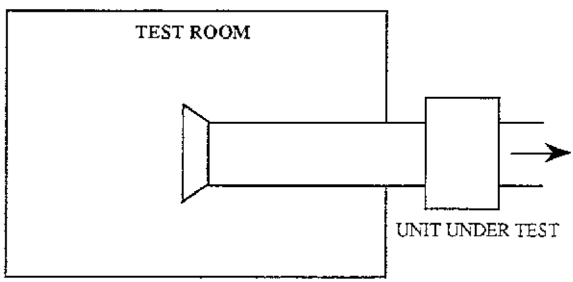


FIGURE 3

The end reflection correction (Fig.2) is applied to the sound power level obtained from the mean sound pressure level in the reverberation room.

d) For units with ducted inlet and ducted outlet, the sound power radiating from the casing is measured according to Figure 4.

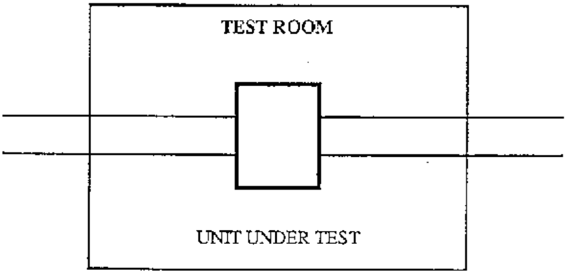


FIGURE 4

RATING

The acoustical rating for a range of geometrically similar units can be determined from test results provided that the tests have been made on at least three sizes of units evenly spread throughout the range.

BS 4857 - PART 2 (1978)

METHODS FOR TESTING AND RATING TERMINAL REHEAT UNITS FOR AIR DISTRIBUTION SYSTEMS - ACOUSTICAL TESTING AND RATING

SCOPE

Testing and rating of terminal reheat units. Instructions are given for testing, calculation and presentation of results comprising :

a • static terminal attenuation

b • sound generation upstream and downstream of the unit

c • sound power radiating from the casing

GENERAL METHOD

Testing in a reverberation room

FREQUENCY RANGE OF INTEREST

For general purposes, octave bands with centre frequencies between 125 Hz and 8000 Hz.

INSTALLATION OF UNIT AND TESTING

a • For testing for static terminal attenuation the unit is installed according to Figure 5.

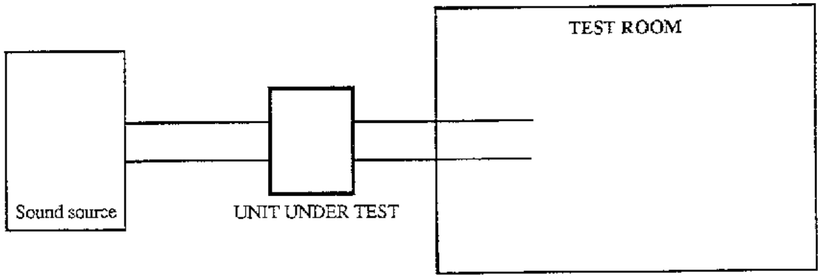


FIGURE 5

The test is carried out without air flow. The mean sound pressure level in the reverberation room is measured :

- with the unit installed according to Fig. 5
- with a straight duct having a cross-sectional area equal to that of unit air inlet duct and a length equal to unit length+outlet duct length installed in place of the unit under testing.

The terminal attenuation is calculated from the difference between these mean sound pressure levels (including each end reflection correction calculated from Figure 6).

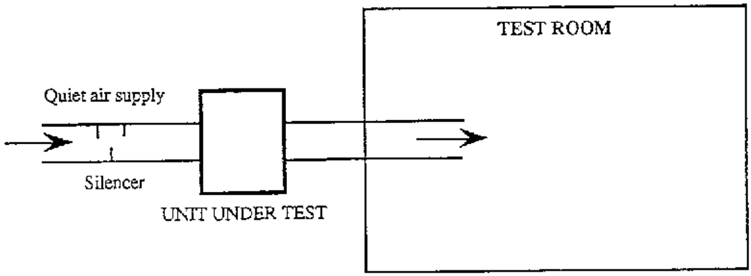


FIGURE 6

The end reflection correction (Figure 2) is applied to the sound power level obtained from the mean sound pressure level in the reverberation room.

c• For testing for noise generated by the unit and radiating in the direction of the inlet, the quiet air exhaust system is connected to the unit placed outside the test room, with the inlet duct terminating in the test room according to Figure 7.

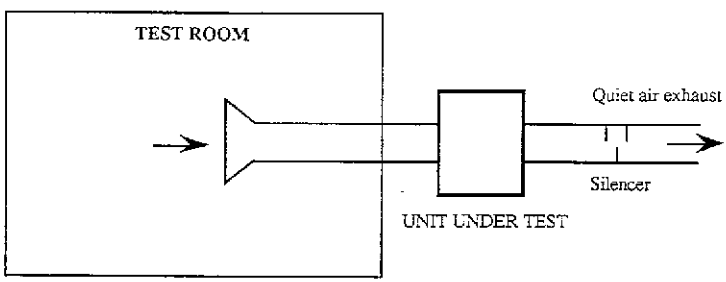


FIGURE 7

The entry to the inlet duct is flared to prevent significant air flow noise generated at this position.

The end reflection correction (Figure 2) is applied to the sound power level obtained from the mean sound pressure level in the reverberation room.

d• For testing for casing noise generation, the unit is placed in the reverberation room according to Figure 8. The quiet air supply is connected to the inlet duct.

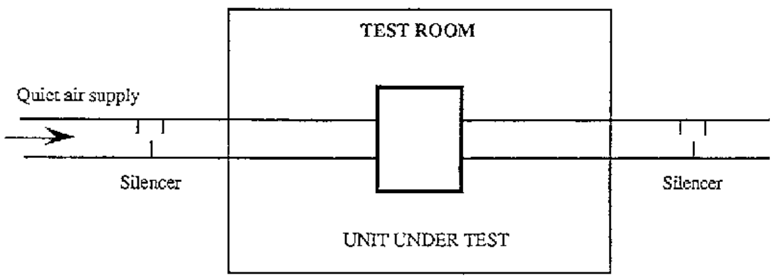


FIGURE 8

RATING

For each unit, tests must be carried out for three air flow rates and for maximum inlet static pressure. Results may not be extrapolated or interpolated to any conditions or component settings other than those existing at the time of the test.

BS 4954 - PART 2 (1978)

METHODS FOR TESTING AND RATING INDUCTION UNITS FOR AIR DISTRIBUTION SYSTEMS - ACOUSTICAL TESTING AND RATING

SCOPE

Testing and rating of induction units. Instructions are given for testing, calculation and presentation of results, comprising:

a • generated sound power

b • terminal attenuation

GENERAL METHOD

Testing in a reverberation room

FREQUENCY RANGE OF INTEREST

For general purposes,octave bands with centre frequencies between 125 Hz and 8000 Hz.

INSTALLATION OF UNIT AND TESTING

a • For testing for generated sound power, the unit is placed in the reverberation room with the inlet connected to a quiet air supply according to Figure 9. The background noise level is measured with the unit removed and with a dummy load equivalent to that imposed by the unit, connected to the fan outlet.

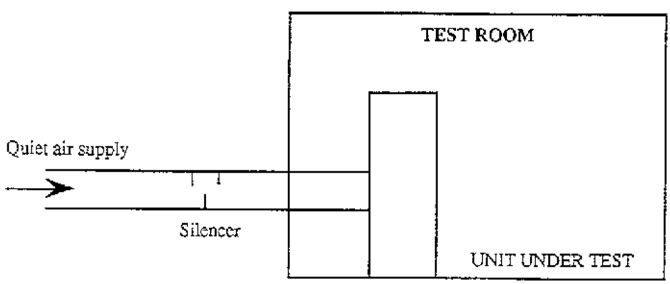


FIGURE 9

Data on modular units may be extrapolated for lengths of unit other than that of the test unit provided that the correlation given above is satisfactory. The equation to use is :

$$L_W = L_{WO} \div 57 \log \frac{qv\, lt}{l} + 10 \log \frac{lt}{l}$$

The length of the unit tested 1 is the length for which data are required. For testing terminal attenuation, the unit is placed in the test room according to Figure 10.

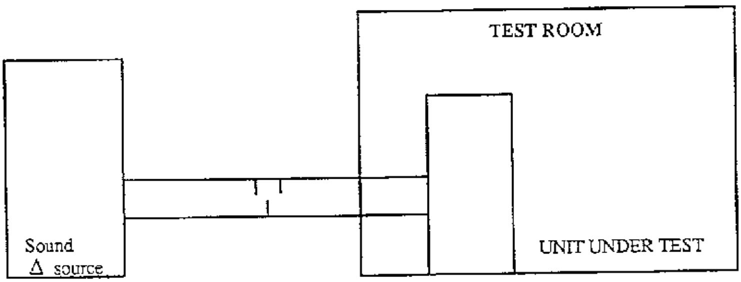


FIGURE 10

The test is carried out:

- with the unit installed
- with the unit removed

The difference in sound powers obtained from measurement in the reverberation rooms is considered as insertion loss. To obtain terminal attenuation, the end reflection.

RATING

Tests are to be carried out at a minimum of three air flow rates for each nozzle arrangement.

To correlate test data, two equations have generally been found to be satisfactory.

a• At a given damper setting, calculate L_{WO} in a given octave band from $L_{WO} = L_W$ - 57 log q_V, where q_V is the air flow rate. Plot L_{WO} against f_c/q_V, where f_c is the octave band centre frequency. If 90% of the results lie within + 2dB of a mean line, then this line may be used to predict the unit sound power output within the test flow range and at any air flow rate lower than the minimum test flow rate.

BS 4485 - PART 2 (1969)

WATER COOLING TOWERS. METHOD OF TESTING AND ACCEPTANCE TESTING

This standard describes a method for measuring and rating of cooling tower noise. The general procedure is given in BS 4142, which describes a method for rating industrial noise affecting mixed residential and industrial areas (equivalent ISO standard 1969).

The sound pressure level given in dBA is measured at the position agreed upon by the participants concerned. Some recommendations are provided concerning the fan power level calculated from the fan drive power. A method of estimating the water noise component from known values of similar towers is also given.

BS 4718 - (1971)

TEST METHODS FOR SILENCERS FOR AIR DISTRIBUTION SYSTEMS

This standard describes a method for measuring the performance of unit silencers and silencing elements for ducted ventilating and air conditioning systems; aspects considered are attenuation of broad band airborne sound (insertion loss) and generation of aerodynamic noise (generated noise level) by air flow through the silencer. The insertion loss is measured without airflow. The standard does not apply to silencers providing selective attenuation over narrow frequency bands, or to silencers designed for direct coupling to a fan or for sound insulation of partitions with ventilated openings.

3.6 U.S.A.

American national standards are issued by ANSI. In the ANSI catalogue, the acoustical standards (38 in all) can be found under the designation S1 (Acoustics) or S3 (Biacoustics). However, different trade or industrial organizations sponsor standards, methods or codes for air handling equipment.

In 1962 ASHRAE published the standard 36-62 "Methods of testing for sound rating heating, refrigerating and air-conditioning equipment." This standard was applied to all equipment radiating sound directly to a room or to the outdoors. It was revised in 1972, but was withdrawn in 1976 because there was no longer any need for a separate ASHRAE standard after the publication of ANSI S1.21. Another ASHRAE standard for in-duct sound power measurements for fans was published in 1978.

The standards for testing and rating fans are issued by AMCA, and those for air terminal devices by ADC. Organizations such as ARI and AHAM issue the rating standards, while testing is normally carried out according to ASHRAE or AMCA standards.

Eleven standards apply to air handling equipment.

a •	ASHRAE 68-86	In-duct method
b •	AMCA 300-85	Fan testing
c •	AMCA 301-76	Fan rating
d •	AMCA 302-73	Application of loudness
e •	AMCA 303-79	Application of fan rating
f •	AD - 63	Air terminal devices
g •	AHAM RAC - 25 R	Room air conditioners
h •	ARI 270-84	Outdoor equipment
i •	ARI 275-84	Application of outdoor equipment
j •	ARI 350-86	Indoor equipment
k •	ARI 575-87	Measurement within equipment rooms
L •	ARI 370-86	Large equipment

ASHRAE 68-78 (1986)

LABORATORY METHOD OF TESTING INDUCT SOUND POWER; MEASUREMENT PROCEDURE FOR FANS

This standard was published before international standard 5136 dealing with the same method. Consequently, there are some important differences between the two documents. For instance, the ASHRAE standard prescribes six circumferential positions for the microphone in the testing plane (instead of only three for ISO 5136.2). The relative radial position is also slightly different. The ASHRAE standard uses a unique correction for the frequency response (normal incidence response) of the microphone sampling tube combination to be provided by the manufacturer. The corrections given by ISO are more precise and detailed.

The ASHRAE standard will probably be updated in accordance with the ISO standard.

AMCA 300-67 (1987)

REVERBERANT ROOM METHOD FOR SOUND TESTING OF FANS

This standard describes the methods for determination of fan sound power.

DESCRIPTION

The code is intended to apply to industrial fans (centrifugal, axial-flow propeller, wall or power roof), central station air-handling units and steam and hot water unit heaters. The prescribed method is testing in a reverberant or semi-reverberant room according to equivalent general standards.

PROCEDURE

Four test set-ups are specified:

a.• A duct of unspecified length is connected to one side of the fan.

b • A chamber treated acoustically is connected to one side of the fan.

c • The fan is tested without any ducting.

d • The fan with or without duct is mounted on a wall for separate determination of inlet or outlet sound power.

AMCA 301-76 - (1976)

METHOD FOR CALCULATING FAN SOUND RATINGS FROM LABORATORY TEST DATA

This standard prescribes two methods for rating air moving devices. The equipment must be tested in a reverberation room in accordance with AMCA Standard 300-67.

CALCULATION PROCEDURE

Two methods are given for calculation of sound power level ratings of ducted fans :

a. • Specific sound power level spectrum

$$K_W = L_W - 10 \log q_V - 20 \log \Delta p$$

(L_W is the octave sound power level, q_V the flow rate at Δ_p fan pressure) is plotted against.

$$X = 10 \log \frac{fc}{N} + 20$$

(fc is the band centre frequency and N the speed of rotation)

b • Generalized sound power level

$$L_g = L_W - 40 \log \frac{N}{1000} - 70 \log \frac{D}{20} - 10 \log BW$$

(Lw is the octave sound power level, N the speed of rotation, D the impeller diameter and BW the band width) is plotted against

$$X = 10 \log \frac{fc}{N} + 20$$

The method of calculation of loudness in sones is given for non-ducted fans.

AMCA 302-73 - (1973)

APPLICATION OF SONE RATINGS FOR NON-DUCTED AIR MOVING DEVICES WITH ROOM SONE-dBA CORRELATION

This document gives some examples of application of sound ratings in sones. Suggested limits for room loudness in sones are given for various buildings (offices, auditoriums, hospitals, restaurants, etc...). The charts and formulae permit an estimation of loudness of fans as installed taking in to consideration the room size and acoustical qualities. The correlation between A-level and loudness is given for a normal fan spectrum with an estimated error of less than +2dBA.

AMCA 303-79 - (1979)

APPLICATION OF SOUND POWER LEVEL RATINGS FOR FANS

This document provides simple explanations for the application of sound power level ratings in order to establish sound pressure levels in a specified space.

AHAM RAC-2 SR - (1971)

ROOM AIR CONDITIONER SOUND RATING STANDARD

This document explains the procedure for rating the sound performance of room air conditioners under specific test conditions in the laboratory. The room air conditioners must be tested in a reverberation room in accordance with ASHRAE standard 36 A - 63 (now ANSI S 1.31-80).

RATING PROCEDURE

One-third band sound power level test data are adjusted for discrete frequency response and then converted into rating indices. Room side and outdoor side are calculated separately. The AHAM sound ratings is determined from the rating indices by a specified procedure. For the room side, ratings can be given in numbers (11 to 28) or in letters (A to T).

ARI 270-84 - (1984)

STANDARD FOR SOUND RATING OF OUTDOOR UNITARY EQUIPMENT

The purpose of this document is to give a procedure for rating the sound power emission of factory-made air conditioning and heat pump equipment. The equipment must be tested in a reverberation room in accordance with the American national standard ANSI S 1.32-1980.

One-third octave band sound power level test data are adjusted for discrete frequency response and then converted to A-weighted levels. The ARI noise rating is given in Bels according to equation:

$$N\,R_{ARI} = 10 \log \left[\sum_{n=1}^{N} \frac{L_{Wcn}}{10} \right]$$

STANDARD RATING CONDITIONS

ARI standard noise ratings are given for standard operating conditions specified in ARI standards 210 and 240.

Air temperatures entering indoor side:

- 26.7°C dry bulb, 19.4°C wet bulb

Air temperatures entering outdoor side

- 35.0°C dry bulb, 23.9°C wet bulb

ARI 275-84

STANDARD FOR APPLICATION OF SOUND RATED OUTDOOR UNITARY EQUIPMENT

PURPOSE AND SCOPE

Method of estimating A-weighted **sound pressure level resulting** from the operation of outdoor equipment (unitary air-conditioning equipment and heat pumps) in various locations, and recommendation for application.

METHOD OF RATING

Rating in accordance with ARI Standard 270.

PROCEDURE

The standard established a method for estimating the A-weighted sound pressure level in various locations taking into consideration the effect of walls and other reflective surfaces adjacent to the equipment, the sound reduction benefit of any solid barrier and the path of sound from the unit to the point of evaluation.

ARI 350-86

STANDARD FOR SOUND RATING OF NON-DUCTED INDOOR AIR-CONDITIONING EQUIPMENT

PURPOSE AND SCOPE

Sound rating of indoor portion of non-ducted air-conditioning equipment (unitary air conditioners, heat pumps, fan-coil units).

METHOD OF TESTING

Testing in a reverberation room in accordance with American national standard ANSI S 1.32-1980.

RATING PROCEDURE

One-third octave band sound power level test data are adjusted for discrete frequency, response and then converted to A-weighted level. The ARI noise rating is given in bels according to equation:

$$N\,R_{ARI} = 10 \log \left[\sum_{n=1}^{N} 10^{\frac{L_{Wcn}}{10}} \right]$$

where LW_{cn} is the corrected and A-weighted sound power level in the n^{th} band and N is the total number of bands used in calculation (=21).

Octave band sound power levels are determined from the unweighted third-octave band data and given in decibels.

ARI 575-87

STANDARD FOR METHOD OF MEASURING MACHINERY SOUND WITHIN EQUIPMENT ROOMS

PURPOSE

To establish a uniform method of measuring, recording and specifying the sound pressure level of machinery installed in mechanical equipment spaces.

SCOPE

Air conditioning equipment (water chilling systems, pumps and similar machines) which, for reasons of size or operating problems, cannot adequately practically be evaluated by testing in a reverberation room according to ANSI standard S 1.31.

TEST PROCEDURE

The points of measurements are determined relative to the reference parallelepiped (smallest parallelepiped enclosing the machine). Octave band sound pressure levels are measured at the four indicated key points and A-weighted levels at a series of supplementary points.

Procedures are given for background noise and for pure tone correction.

4 TABLE OF APPLICABLE METHODS

	EQUIPMENT	I S O	U S A	U K	FRANCE	GERMANY	EUROVENT
1	FANS IN GENERAL	DIS 5136 (1990)	AMCA 300-85 (1985)	BS 848 Part 2 (1985)	S 31-021 (1982) S1-063 (1985)	DIN 45635 T 38 (1980)	
2	FANS FOR CONTROLLED EXHAUST VENTILATION						
3	AIR TERMINAL DEVICES, DAMPERS AND VALVES, HIGH VELOCITY PRESSURE EQUIPMENT	DIS 5135 (1984)		BS 4773 p. 2 (1976) BS 4857 p.2 (1978)			
4	AIR TERMINAL DEVICES FOR CONTROLLED EXHAUST VENTILATION				E 51-701 (1980)		
5	SOUND ATTENUATORS (SILENCER)	DP 7235 (1991)		BS 4718 (1971)		VDI RICHTLINIEN 2567 (1971)	
6	COOKING HOODS				E 51-704 (1986)		
7	FANNED AIR HEATERS						
8	FANNED AIR-COOLED HEAT EXCHANGERS					DIN 45635 T 14 (1980) VDI 3734 BL1 (1981)	8/1
9	COOLING TOWERS			BS 4485 Part 2 (1969)		DIN 45635 T 46 (Draft)	8/1
10	AIR COOLED PACKAGED ROOM AIR-CONDITIONERS						8/4
11	ROOM AIR-CONDITIONERS • PACKAGED WATER COOLED • SPLIT SYSTEMS					DIN 45635 T 35 (1977) Draft	
12	AUTONOMOUS AIR CONDITIONING UNITS						8/5
13	CENTRAL STATION HANDLING UNITS						
14	FAN COIL UNITS			BS 4856 Part 4 (1978) Part 5 (1979)			8/2
15	INDUCTION UNITS			BS 4954 Part 2 (1978)			8/3

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