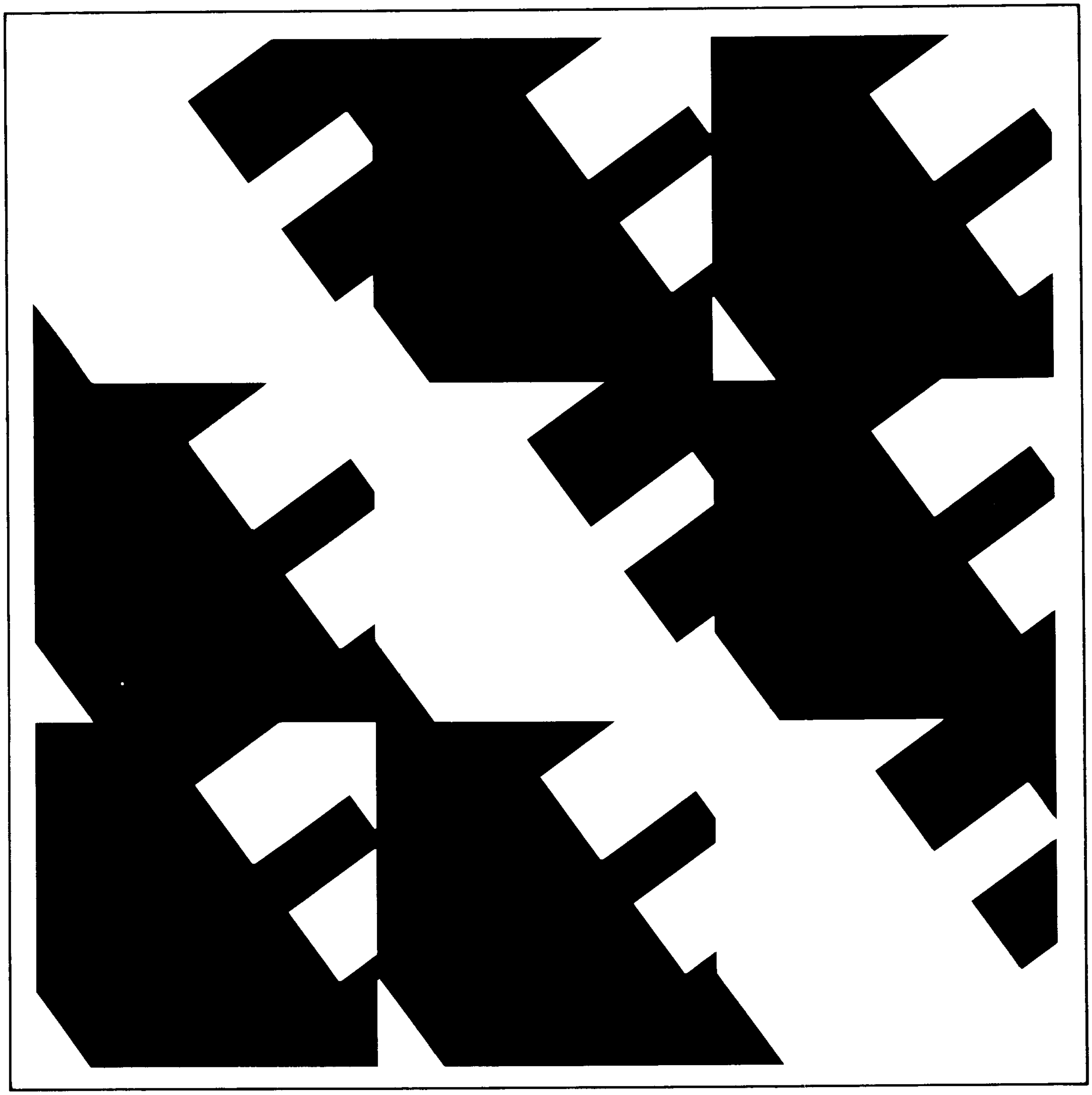
IEEE Std 85-1973
(Reaffirmed 1980)

IEEE Test Procedure for Airborne Sound Measurements on Rotating Electric Machinery



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IEEE Test Procedure for Airborne Sound Measurements on Rotating Electric Machinery

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Foreword

(This Foreword is not a part of IEEE Std 85-1973, Test Procedure for Airborne Sound Measurements on Rotating Electric Machinery.)

This document is a revision of IEEE Std 85-1965, Test Procedure for Airborne Noise Measurements on Rotating Electric Machinery.

The Institute wishes to acknowledge its indebtedness to those who have so freely given of their time and knowledge and have conducted experimental work on which many of its publications are based.

This standard was prepared by the Noise Working Group of the IEEE Rotating Machinery Committee and at the time of approval had the following membership:

Comments are invited on this publication as well as suggestions for additional material that should be included. These should be addressed to:

Secretary
IEEE Standards Committee
The Institute of Electrical and Electronics Engineers
345 East 47th Street
New York, N. Y. 10017

Approved December 12, 1972

IEEE Standards Committee

Contents

IEEE Test Procedure for Airborne Sound Measurements on Rotating Electric Machinery

1. Scope

This test procedure defines approved methods for conducting tests and reporting results to effect the uniform determination of rotating electric machine sound under steady-state conditions with an accuracy of ± 3 dB tested in these acoustical environments:

Free field

Reverberant field

Semireverberant field

This procedure assumes the presence of pure tones or the predominance of discrete frequencies in the sound spectrum

2. Definitions and Terms

2.1 Sound Pressure Level. The sound pressure level, in decibels, of a sound is equal to 20 times the logarithm to the base 10 of the ratio of the pressure of this sound to the reference pressure, 20×10^{-6} Pa (pascals)(= N/m^2) (0.0002 microbar) (see ANSI S1.8-1969, Preferred Reference Quantities for Acoustical Levels).

$$L_p = 20 \log_{10} \left(\frac{p}{p_0}\right)$$

where

L_p = sound pressure level

p_0 = reference pressure

p = measured sound pressure

2.2 *A*-Weighted Sound Level. The *A*-weighted sound level is the weighted sound pressure level, obtained by use of metering characteristics and *A*-weighting specified in ANSI S1.4-1971, Specification for Sound Level Meters.

2.3 Octave Band Level. The octave band level of a sound is the band level for a frequency band corresponding to a specified octave. Octave bands, and one-third octave bands, as used in this procedure refer to those of ANSI S1.6-1967, Preferred Frequencies and Band Numbers for Acoustical Measurements, centered at 125 Hz through the band centered at 8000 Hz. Bands are detailed in Table 1.

2.4 Sound Power Level. The sound power level, in decibels, is equal to 10 times the logarithm to the base 10 of the ratio of a given power to the reference power, 10^{-12} W (see ANSI S1.8-1969).

$$L_W = 10 \log_{10}\left(\frac{W}{W_0}\right)$$

where

L_W = sound power level

W = measured sound power in watts

W_0 = reference power

Table 1
Preferred Frequencies For Acoustical Measurements
(See ANSI S1.6-1967)

Octave Band Edge Frequencies	Octave Band Center Frequency	One-Third Octave Center Frequencies
90/180	125	100 125 160
180/355	250	200 250 315
355/710	500	400 500 630
710/1400	1000	800 1000 1250
1400/2800	2000	1600 2000 2500
2800/5600	4000	3150 4000 5000
5600/11200	8000	6300 8000 10 000

2.5 *A*-Weighted Sound Power Level. The *A*-weighted sound power level, in decibels, is equal to the sound power level determined by weighting each of the frequency bands according to Table 2.

2.6 Prescribed Surface. A prescribed surface is a hypothetical surface surrounding the machine on which sound measurements are made. See Figs 1 through 4.

2.7 Equivalent Radius. The measurements made along the prescribed surface should be assumed to have been made over a hemisphere of equivalent radius:

$$r_s = \left[a \frac{(b + c)}{2}\right]^{1/2}$$

The area of the equivalent hemisphere is given by

$$S = \pi a (b + c).$$

See Figs 1 through 4.

If the prescribed surface is a hemisphere, the radius r_s is the radius of the hemisphere measured from the acoustic center.

Table 2
Corrections to be
Applied to Obtain *A*-Weighting
(See ANSI S1.4-1961)

Band Center (Hz)	Octave Band Correction (dB)	One-Third Octave Band Correction (dB)
100		−19
125	−16	−16
160		−13
200		−11
250	− 9	− 9
315		− 7
400		− 5
500	− 3	− 3
630		− 2
800		− 1
1000	0	0
1250		+ 1
1600		+ 1
2000	+ 1	+ 1
2500		+ 1
3150		+ 1
4000	+ 1	+ 1
5000		+ 1
6300		0
8000	− 1	− 1
10 000		− 2

2.8 Reference Distance. A standard 1 m distance from the major machine surfaces at which mean sound level data shall be reported.

2.9 Reference Radius. The sum of the reference distance and one half the maximum linear dimension as defined in 2.12.

2.10 Background Level. Any sound at the points of measurement other than that of the machine being tested. It also includes the sound of any test support equipment.

2.11 Mean Sound Pressure Level or Mean Sound Level. This quantity is determined from the following equation:

$$L_{p(M)} = 10 \log_{10} \frac{1}{n} \left[\text{antilog}_{10} \frac{L_{p(1)}}{10} + \text{antilog}_{10} \frac{L_{p(2)}}{10} + \cdots + \text{antilog}_{10} \frac{L_{p(n)}}{10}\right]$$

where

$L_{p(M)}$ = mean sound pressure level or mean sound level

$L_{p(1)}$ = level in decibels of the first measurement

$L_{p(n)}$ = level in decibels of the *n*th measurement

n = number of measurements

All L_p values must be of the same weighting.

NOTE: When the extremes of the decibel readings at the various test positions do not differ by more than 4 dB, a simple arithmetic average of the decibel readings will give a result differing not more than 0.5 dB from the preceding equation.

2.12 Machine. A machine is any rotating electrical device of which the acoustical characteristics are to be measured.

2.12.1 *Small Machine.* A machine having a maximum linear dimension of 250 mm. This dimension is over major surfaces, excluding minor surface protuberances as well as shaft extension, and is measured either parallel to the shaft, or at right angles to it, according to which dimension gives the greater measurement.

2.12.2 *Medium Machine.* A machine having a maximum linear dimension from 250 mm to 1 m as measured in 2.12.1.

2.12.3 *Large Machine.* A machine having a maximum linear dimension in excess of 1 m as measured in 2.12.1.

3. Installation and Operation

Installation and operation shall be in accordance with the following.

3.1 Machine Mounting.

3.1.1 ***Field Installation.*** Machine vibration can cause vibration of the base, floor, or surrounding structure, in the frequency range to be measured. If such vibrations are found to exist, the errors they will contribute to the sound measurements must be recognized and their effect corrected.

3.1.2 ***Test Mounting.*** A machine which is under test should be vibration-isolated from the test floor using resilient mounts resulting in a natural frequency of oscillation in the vertical direction, in hertz, which numerically is smaller than the shaft speed in revolutions per minute divided by 240 for speeds of 750 r/min or over, and smaller than the shaft speed in revolutions per minute divided by 120 for speeds less than 750 r/min. The deflection of the resilient mount to produce a desired natural frequency is:

$$d = k/f_n^{\,2}$$

where

d = deflection
f_n = natural frequency in hertz
k = 247 to give d in millimeters
k = 9.73 to give d in inches

When isolators are used in compression, they shall be compressed less than one half their undeflected thickness. For large machines, where it is impractical to provide resilient mounts, care should be taken to eliminate sound from any surfaces external to the machine and excited by forces transmitted from the machine.

3.1.3 ***Multiunit Machines.*** Two or more machines, mounted on a common self-supporting base, for tests in other than field installation, shall be tested with the base vibration isolated from the test floor as described in 3.1.2.

3.2 Operating Condition. Unless otherwise specified, sound tests shall be taken as described in 3.2.1. Prior to sound measurement, the machine shall be run long enough for the sound to stabilize.

3.2.1 *No-Load Test.* The machine should be tested, running at no-load speed, and energized at rated voltage from an appropriate power supply. An ac motor shall be sound tested at each of the speeds indicated on the nameplate. A synchronous machine shall be operated as a motor; if it is provided with adjustable field excitation, the latter shall be adjusted to give minimum armature current. A dc shunt or compound machine shall be operated with rated armature voltage at rated speed.

3.2.2 ***Full-Load Test.*** When full-load testing is required, agreement should be reached between user and tester regarding the following:

(1) Mounting
(2) Method of loading
(3) Background noise
(4) Accuracy of measurements
(5) Power input requirements
(6) Interpretation of data

4. Measuring Instruments

4.1 Sound Level Meter. Sound level meters shall comply with ANSI S1.4-1971, Class II or better.

4.2 Band Filter Networks. The filtered octave band and one-third octave band frequencies shall be those tabulated in ANSI S1.4-1971, and the networks shall meet the requirements for Class II or Class III filters of ANSI S1.11-1966, Specification for Octave, Half-Octave, and Third-Octave Band Filter Sets.

4.3 Level Recorder. A permanent record may be obtained by a device responding to the mean square value of the input signal over a time period much greater than the minimum rate of signal fluctuation. A true rms (root mean square) level recorder with an electrical response within ± 0.5 dB of the mean, throughout the frequency range of interest, shall be used. Alternate procedures, such as analog or digital squaring and integration of the signal, shall comply with the above.

4.4 Sound Measuring Systems.

4.4.1 ***Microphone.*** The transducer converting the fluctuations in sound pressure to an electrical analog shall have an effective diameter of 25 mm or less. A microphone, conforming to ANSI S1.12-1967, Specifications for Laboratory Standard Microphones, shall be used.

4.4.2 ***Interconnecting Cable.*** The microphone cable system shall not introduce cable noise interfering with the signal when flexed, moved, or subjected to environmental conditions encountered during testing.

4.4.3 *Microphone Signal Amplifier.* The electrical characteristics shall satisfy the electrical requirements of ANSI S1.4-1971, Class II or better.

4.4.4 *Frequency Analyzer.* The frequency/electrical requirements of 4.2 shall be satisfied.

4.5 Calibration. Individual components should be calibrated at least annually by a recognized competent laboratory using the manufacturer's recommended technique of calibration, and a record of same maintained on file.

4.6 System Check Out. The complete sound measuring system, or sound level meter, band filters, and level recorders, shall be checked immediately prior to and after each test, recording any variations and correction factors so determined. A stable acoustical calibrator of known response characteristics shall be applied to the microphone of the sound level meter or sound measuring system and the output recorded. If the before and after calibration differ by more than 1 dB, the test shall be repeated. If the calibration continues to vary on repeated tests, the equipment shall be calibrated as described in 4.5.

4.7 Electrical Characteristic Measurement Instrumentation. For the unit on test, all instruments (voltmeters, ammeters, frequency meters, rpm counters, etc) necessary for determining conformance to operational requirements of voltage, amperage, speed, etc, shall be calibrated as described in 4.5, to provide an overall accuracy of ± 1 percent in the range of interest.

5. Test Environment

5.1 Free Field Over a Reflecting Plane. Free-field conditions exist if sound reflections from walls or other objects have no significant influence on the measurements.

5.1.1 *Free-Field Conditions in a Test Room.* To realize free-field conditions above a reflecting plane in an enclosure, a test room having the following requirements is necessary:

(1) Adequate volume

(2) High degree of sound absorption over the frequency range of interest on all surfaces but one (the floor)

(3) Absence of acoustically reflecting surfaces and obstructions other than those associated with the machinery under test

The room shall be large enough so that the test points are located no less than $\lambda/4$ from the absorbent surfaces of the test room, where λ is the wavelength of the center frequency of the lowest frequency band of interest. For 125 Hz, $\lambda = 2.6$ m.

5.1.2 *Other Free-Field Situations.* It may be desirable to make noise measurements in factory areas or out-of-doors in areas not considered specially constructed test rooms. The following requirements serve as a guide:

(1) A smooth reflecting plane extending continuously from the sound source to beyond the farthest microphone position with an average sound-absorption coefficient not in excess of 0.1.

(2) Absence of acoustically reflecting surfaces and obstructions other than the reflecting plane and machine under tests. As a guide, no obstruction should be closer than $\lambda/2$ from the source or within $\lambda/4$ of the microphone position. (λ is the wavelength of the center frequency of the lowest frequency band of interest.)

The suitability of an area for free-field measurements can be established using the test described in 5.4. It is sufficient to establish suitability only once or until the environment has been altered.

5.2 Reverberant Field. A reverberant field is one in which the sound intensity is predominantly due to reflected sound energy. Calculation of the sound power level of a machine from measurements of sound pressure levels is based on the premise that, in a reverberant field, the measured sound pressure level is independent of the microphone position with respect to the sound source, and depends only on the degree of diffusion and the emitted sound. It is recommended that the proportion of the test room be kept within the limits of 1: (1.17 to 1.45): (1.47 to 2.1). The room volume shall be at least 180 m^3 to permit measurements in octave bands down to the one centered on 125 Hz. The test room shall be sized so that no portion of the machine is closer than 1 m to the ceiling or any wall. Space should also be provided for the proper location of measuring points. (See 7.2.2.) The suitability of an area for reverberant field measurements can be established using the test described in 5.4.

5.3 Semireverberant Field. Measurements may be made in rooms where the resulting sound field is, in general, neither a free field nor a reverberant field. That is, the sound field near the source usually attenuates less with distance than it would in a free field, and it may not reach a uniform level over any usable portion of the room as it would in a reverberant field. The room shall be large enough to permit measurement points on the prescribed surface without being closer than 1 m to the ceiling, to any wall, or to any other reflecting surface.

5.4 Test to Determine Type of Environment. To determine the field condition, a small broad-band noise source shall be placed in the room at the position subsequently to be occupied by the geometric center of the largest machine to be tested. Octave band sound pressure level measurements shall be made at not less than five dispersed points at a radius of 2 m from the acoustic center of the source. For these measurements the microphone shall not be closer than 1 m or $\lambda/4$, whichever is larger, to any wall or ceiling. Determine the band mean pressure level.

Additional octave band sound pressure level measurements shall be made for a similar number of points chosen at a radius of 1 m from the source, on the same radial lines. Determine the band mean pressure level. The difference of the two band mean pressure levels shall determine the type of environment according to the following:

Field Condition	Difference in Decibels
Reverberant	1 maximum
Semireverberant	over 1 through 5
Free	over 5

5.5 Background Level. The background sound pressure levels, existing at typical microphone locations, shall be determined in all frequency bands of interest. If the increase in the sound pressure level in any given frequency band, with the test machine operating, is 10 dB or more than the background levels, then preferred conditions exist and the sound is essentially that produced by the test machine. If the difference, to the nearest integer, between background and test sound pressure levels is between 3 and 9 dB, the sound pressure level due to the test machine alone may be approximated by applying the corrections as follows:

Difference in Decibel Level	Decibels to be Subtracted from Measured Level
3	3
4 through 5	2
6 through 9	1

When corrections of 3 dB are applied, the corrected levels shall be reported in brackets. When the increase is less than 3 dB, measurements, in general, cease to have any significance because the sound pressure level of the test machine is less than background levels. In such cases, the noise should be reported as "at least 3 dB below total measured sound."

6. Quantities to Be Reported

This test code does not provide data as defined in 6.2 unless it is specified by the user of the code.

6.1 Standard.

(1) A-weighted sound power level

(2) A-weighted mean sound level at the reference distance of 1 m for conditions of a free field over a reflecting plane

6.2 Additional (to be Specifically Requested).

(1) Sound power level in octave bands or one-third octave bands

(2) Sound pressure levels in octave bands or one-third octave bands at the reference distance of 1 m for conditions of a free field over a reflecting plane

7. Methods of Measurement

7.1 Free Field Over a Reflecting Plane. Section 5.1 defines the requirements for this environment. To establish if the requirements exist, the test described in 5.4 shall be used.

7.1.1 ***Location of Measurement Points.*** For all machines, measurements shall be made at points located on the prescribed surface. The number of measurement locations and the size

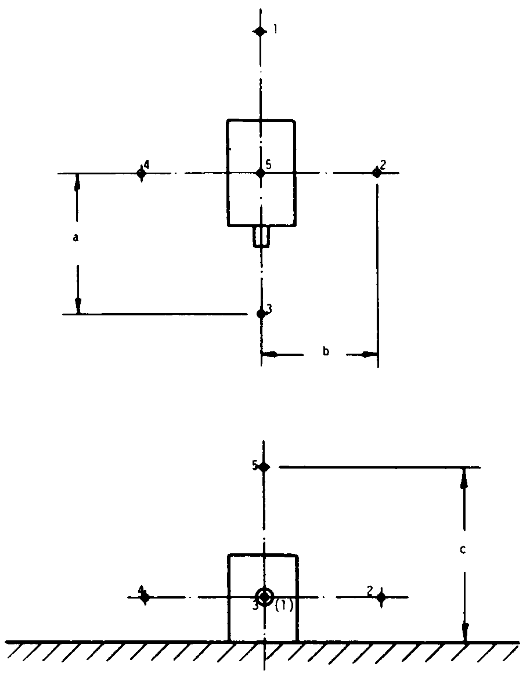

Fig 1 (A)
Prescribed Points, Small Machines
(all points of measurement (1 through 5) shall be located at a distance of 0.3 m or greater from the major machine surfaces)

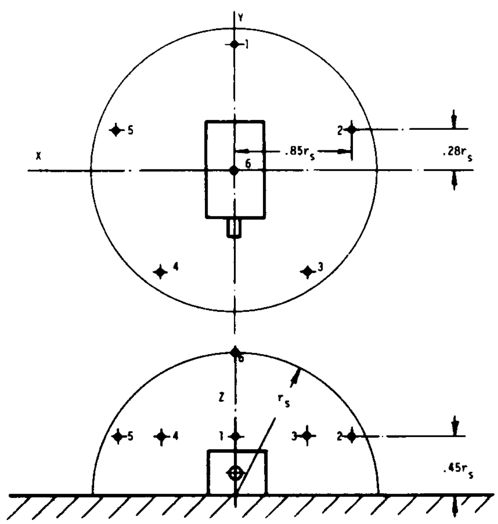

Fig 1(B)
Six-Point Hemisphere, Small Machines

Point Number	Coordinates of Measuring Point (X, Y, Z)
1	$(0, 0.89, 0.45)r_s$
2	$(0.85, 0.28, 0.45)r_s$
3	$(0.53, -0.72, 0.45)r_s$
4	$(-0.53, -0.72, 0.45)r_s$
5	$(-0.85, 0.28, 0.45)r_s$
6	$(0, 0, 1.0)r_s$

and shape of the prescribed surface are determined by the size of the machine to be tested. If measurements at these points indicate levels which exceed adjacent levels by more than 5 dB, additional points should be added midway between the measuring points already in use. The various categories of machine sizes are defined in 2.12.

7.1.1.1 *Small Machines.* For small machines the preferred microphone positions shall be in accordance with Fig 1 (A). Although not preferred, this procedure recognizes the hemispherical point array concept, and if it is used, the radius of the hemisphere shall be 0.5 m or greater. The center of the hemisphere shall be in the reflecting plane immediately below the geometric center of the machine. The standard measurement points shall be the six points shown in Fig 1 (B).

7.1.1.2 *Medium Machines.* For medium machines, the preferred microphone positions shall be in accordance with Fig 2 (A). Although not preferred this procedure recognizes the hemispherical point array concept, and if it is used, the radius of the hemisphere shall be 1.0 m or greater plus one half the major machine dimension. The center of the hemisphere shall be in the reflecting plane immediately below the geometric center of the machine. The measurement points shall be the twelve points shown in Fig 2 (B).

7.1.1.3 *Large Machines.* For large machines, the microphone positions shall be located on rectilinear paths 1 m or greater from the major machine surfaces. The paths shall be described by two planes passing through the machine as shown in Figs 3 and 4.

7.1.2 ***Test Procedure.*** Two sets of sound pressure levels shall be obtained at each frequency band as follows:

(1) Background level

(2) With the machine being tested in operation

The microphone locations shall be the same for both sets of readings. Where multiple tests

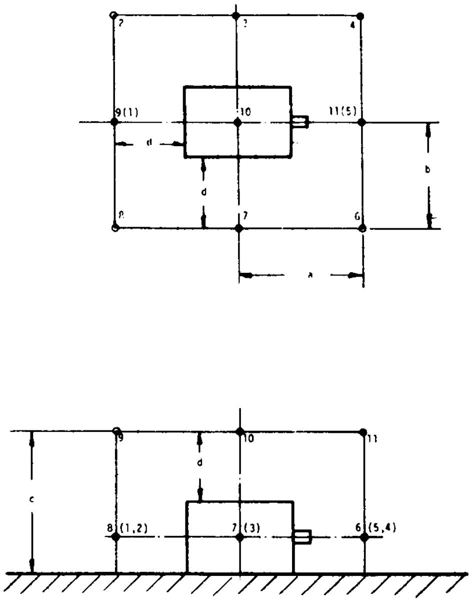

Fig 2 (A)
Prescribed Points, Medium Machines
(all points of measurement shall be located on the rectilinear planes prescribed where d = 1 m or greater)

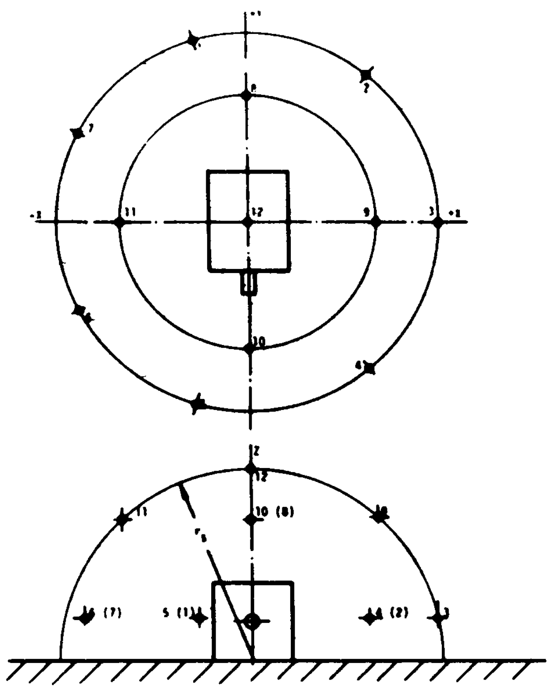

Fig 2 (B)
Twelve-Point Hemisphere, Medium Machines

Point Number	Coordinates of Measuring Point (X, Y, Z)
1	$(-0.21,\ 0.93,\ 0.29)r_s$
2	$(\ 0.60,\ 0.75,\ 0.29)r_s$
3	$(\ 0.96,\ 0,\ 0.29)r_s$
4	$(\ 0.60,\ -0.75,\ 0.29)r_s$
5	$(-0.21,\ -0.93,\ 0.29)r_s$
6	$(-0.86,\ -0.42,\ 0.29)r_s$
7	$(-0.86,\ 0.42,\ 0.29)r_s$
8	$(\ 0,\ 0.66,\ 0.75)r_s$
9	$(\ 0.66,\ 0,\ 0.75)r_s$
10	$(\ 0,\ -0.66,\ 0.75)r_s$
11	$(-0.66,\ 0,\ 0.75)r_s$
12	$(\ 0,\ 0,\ 1)r_s$

of machines are being made, measurements of the background levels shall be at least at the beginning and end of each major test series.

When the standard information of 6.1 is the only requirement, this test procedure permits sound level measurements. For these measurements, the sound level meter of 4.1 shall be used.

When the octave band analyzer is used in conjunction with the sound level meter, the flat response of the sound level meter shall be used.

7.1.3 ***Measurement Corrections.*** The data obtained at each measurement point shall be corrected for the effect of background noise as shown in 5.5.

7.1.4 ***Calculation of the Mean Level.*** The corrected data shall be averaged as outlined in 2.11.

7.1.5 ***Calculation of A-Weighted Mean Sound Level Using Octave Band Mean Sound Pressure Levels.*** Apply the weighting correction as shown in Table 2 to the results of 7.1.4. Sum the weighted octave band sound pressure levels, using the following equation:

$$L_{p(M)}\ (A\text{-weighted}) = 10 \log_{10} \times \left[\operatorname{antilog}_{10} \frac{L_{p(1)}}{10} + \operatorname{antilog}_{10} \frac{L_{p(2)}}{10} + \cdots + \operatorname{antilog}_{10} \frac{L_{p(7)}}{10}\right]$$

where

$L_{p(M)}$ (A-weighted) = mean sound level (A-weighted)

$L_{p(1)}$ = first-octave band weighted sound level

$L_{p(7)}$ = seventh-octave band weighted sound level

7.1.6 *Calculation of the A-Weighted Mean Sound Level at a Reference Distance for the Condition of a Free Field Over a Reflecting Plane [as Required in 6.1 (2)].* Using the mean sound pressure level determined in 7.1.5, adjust for the reference distance using the following equation:

$$L_{p(d)} = L_{p(M)} + 20 \log_{10} \frac{r_s}{r_d}$$

where

$L_{p(d)}$ = A-weighted mean sound level at the reference distance

$L_{p(M)}$ = mean sound level determined by 7.1.5

r_s = equivalent radius; see 2.7

r_d = reference radius; see 2.9

7.1.7 *Calculation of the A-Weighted Sound Power Level [as Required in 6.1 (1) or as Required in 6.2 (1)].* The sound power levels produced by a machine shall be calculated from mean sound pressure levels (or the A-weighted mean sound level) by using the following equation:

$$L_W = L_{p(M)} + 10 \log_{10} \frac{2\pi r_s^2}{S_0}$$

where

r_s = equivalent radius; see 2.7

S_0 = 1.0 m^2

$L_{p(M)}$ = mean sound pressure level for each octave band as determined by 7.1.4, or

= A-weighted mean sound level as determined by 7.1.5

7.1.8 *Calculation of Octave Band Sound Pressure Level at the Reference Distance for the Condition of a Free Field Over a Reflecting Plane [as Required in 6.2 (2)].* Using the mean octave band sound pressure levels determined in 7.1.4, adjust for the reference distance using the following equation:

$$L_{p(d)} = L_{p(M)} + 20 \log_{10} \frac{r_s}{r_d}$$

where

$L_{p(d)}$ = octave band mean sound pressure level at the reference distance

$L_{p(M)}$ = mean octave band sound pressure level determined in 7.1.4

r_s = equivalent radius; see 2.7

r_d = reference radius; see 2.9

7.2 Reverberant Field. Section 5.2 defines the requirements for this environment. To establish if the requirements exist, the test described in 5.4 shall be used.

7.2.1 *Reference Sound Source.* A reference sound source, calibrated as to its free-field sound power level output in appropriate frequency bands, shall be used to establish a sound field in the test room. The reference sound source shall have the following characteristics.

The sound shall be broad band in character without pure tone components, in other words, the sound pressure level in any 2-percent frequency band shall be below the corresponding octave band level by at least 10 dB.

The sound power level in each frequency band shall remain constant within 1 dB.

The reference sound source shall be suitably mounted to prevent transmission, in the frequency range of interest, of noise and vibration to the structure on which it rests. The directivity index of the source, in any third-octave band, shall not exceed 3 dB relative to uniform hemispherical radiation.

7.2.2 *Location of Measurement Points.* Measurements shall be made at a distance from the machine surface of at least one maximum linear dimension of the machine or $2/3\,(V)^{1/3}$ whichever is greater, where V is the volume of the test room.

Space averaged levels shall be computed from measurements made at not less than five measuring points or from readings obtained by moving the microphone over at least one zone of linear dimension not less than 1.5 m.

7.2.3 *Test Procedure.* Three sets of readings of sound pressure level shall be obtained at each frequency band as follows:

(1) Background level

(2) With a reference sound source in operation in the location to be used by the machine under test

(3) With the machine being tested in operation

The microphone locations shall be the same for all sets of readings. Where multiple tests of machines are being made, measurements of the background and reference sound source levels shall be at least at the beginning and end of each major test series.

The sound pressure level readings shall be made without observers or operators in the

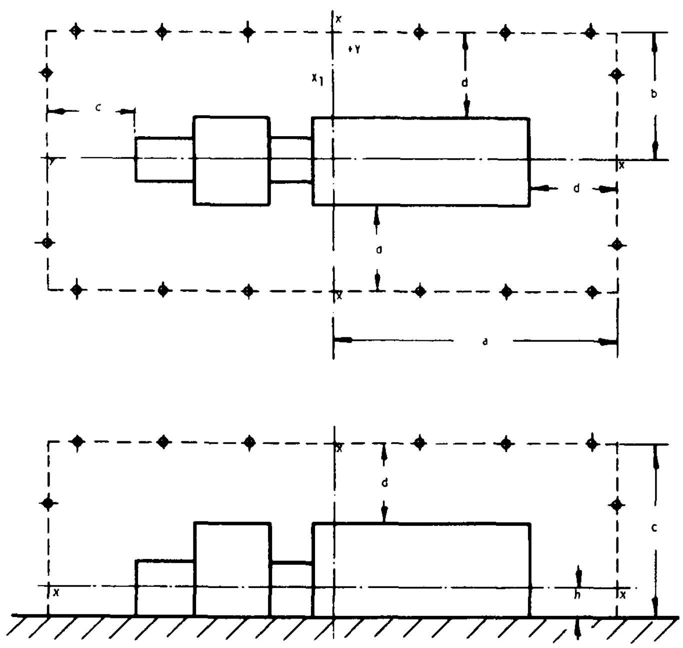

Fig 3
Prescribed Points, Large Horizontal Machines

h = shaft height or 0.3 m, whichever is greater
X = key measuring points
O = measuring points marked off at intervals of 1 m ±0.25 m from key points
d = 1 m or greater from major machine surfaces

test room.

When the octave band analyzer is used in conjunction with the sound level meter, the flat response of the sound level meter shall be used.

7.2.4 *Measurement Corrections.* The data obtained at each measurement point shall be corrected for the effect of background level as shown in 5.5.

7.2.5 *Calculation of Mean Level.* The corrected data shall be averaged as outlined in 2.11.

7.2.6 ***Calculation of the Sound Power Level in Octave Bands [as Required in 6.2 (1)].*** **The octave band sound power level can be obtained from the octave band mean pressure levels by taking into account the influence of the test room. The octave band sound power levels of the machine on test can be determined from the equation:**

$$L_W = (L_{W(r)} - L_{p(Mr)}) + L_{p(M)}$$

where

L_W = octave band power level of the machine on test

$L_{W(r)}$ = octave band power level of the reference source from the calibration

$L_{p(M)}$ = octave band mean sound pressure level of the machine on test

$L_{p(Mr)}$ = octave band mean sound pressure level of the reference source

7.2.7 ***Calculation of the Mean Sound Pressure Levels in Octave Bands at the Reference Distance for the Conditions of a Free Field Over a Reflecting Plane [as Required by 6.2 (2)].*** **The following equation shall be used for each octave:**

$$L_{p(d)} = L_W - 10 \log_{10} \frac{2\pi r_d^2}{S_0}$$

where

$L_{p(d)}$ = octave band mean pressure level at reference distance

L_W = octave band power level from 7.2.6

S_0 = 1.0 m²

r_d = reference radius; see 2.9

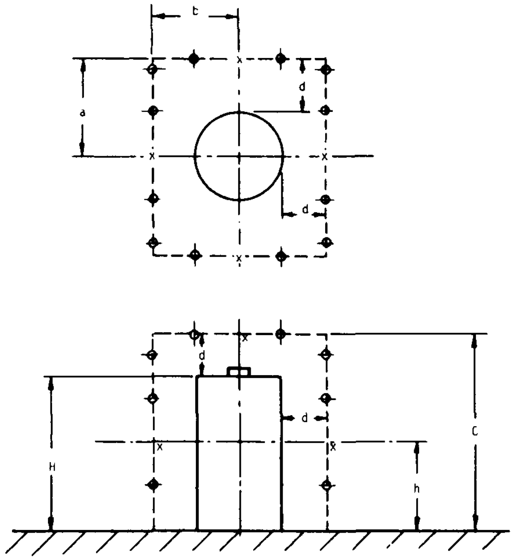

Fig 4
Prescribed Points, Large Vertical Machines

d = 1 m or greater from major machine surfaces
h = $H/2$ but not less than 0.3 m
X = key measuring points
O = other measuring points marked off at intervals of 1 m from key points, but always greater than 0.3 m from floor

7.2.8 ***Calculation of the A-Weighted Mean Sound Level at a Reference Distance for the Condition of a Free Field Over a Reflecting Plane [as Required in 6.1 (2)].*** **Using the octave band mean sound pressure levels determined in 7.2.7,**

(1) Apply the weighting corrections as shown in Table 2

(2) Sum these octave band weighted sound levels, using the following equation:

$$L_{p(M)} = 10 \log_{10} \left[\text{antilog}_{10} \frac{L_{p(1)}}{10} + \text{antilog}_{10} \frac{L_{p(2)}}{10} + \cdots + \text{antilog}_{10} \frac{L_{p(7)}}{10} \right]$$

where

$L_{p(M)}$ (A-weighted) = mean sound level (A-weighted)

$L_{p(1)}$ = first-octave band weighted sound level

$L_{p(7)}$ = seventh-octave band weighted sound level

7.2.9 ***Calculation of A-Weighted Sound Power Level [as Required in 6.1 (1)].*** **Apply the method outlined in 7.2.8 using the octave band sound power levels L_W determined in 7.2.6 in place of sound pressure levels L_p.**

7.3 Semireverberant Field. Section 5.3 gives the considerations for this environment. To establish if the requirements exist, the test described in 5.4 shall be used.

7.3.1 *Reference Sound Source.* See 7.2.1.

7.3.2 *Location of Measurement Points.* Follow the procedure outlined in 7.1.1.

7.3.3 *Test Procedure.* Three sets of readings of sound pressure level shall be obtained at each frequency band as follows:

(1) Background level

(2) With a reference sound source in operation in the location to be used by the machine under test

(3) With the machine being tested in operation at test conditions

The microphone locations shall be the same for all sets of readings. Where multiple tests of machines are being made, measurements of the background and reference sound source levels shall be at least at the beginning and end of each major test series. The sound pressure level readings shall be made without observers or operators in the immediate test area.

When the octave band analyzer is used in conjunction with the sound level meter, the flat response of the sound level meter shall be used.

7.3.4 *Measurement Corrections.* The data obtained at each measurement point shall be corrected for the effect of background level as shown in 5.5.

7.3.5 *Calculation of the Mean Level.* The corrected data shall be averaged as outlined in 2.11.

7.3.6 ***Calculation of the Sound Power Level in Octave Bands [as Required in 6.2 (1)].*** **The octave band sound power levels can be obtained from the octave band mean pressure levels by taking into account the influence of the test room. The octave band sound power levels of the machine on test can be determined from the following equation:**

$$L_W = (L_{W(r)} - L_{p(Mr)}) + L_{p(M)}$$

where

L_W = octave band power level of the machine on test

$L_{W(r)}$ = octave band power level of the reference source from the calibration

$L_{p(M)}$ = octave band mean sound pressure level of the machine on test

$L_{p(Mr)}$ = octave band mean sound pressure level of the reference source

7.3.7 ***Calculation of the Mean Sound Pressure Levels in Octave Bands at the Reference Distance for Conditions of a Free Field Over a Reflecting Plane [as Required by 6.2 (2)].*** **The following equation shall be used for each octave:**

$$L_{p(d)} = L_W - 10 \log_{10} \frac{2\pi r_d^2}{S_0}$$

where

$L_{p(d)}$ = octave band mean pressure level at reference distance

L_W = octave band power level from 7.3.6

S_0 = 1.0 m²

r_d = reference radius; see 2.9

7.3.8 ***Calculation of the A-Weighted Mean Sound Level at the Reference Distance for the Condition of a Free Field Over a Reflecting Plane [as Required in 6.1 (2)].*** Using the levels determined in 7.3.7,

(1) Apply the weighting corrections as shown in Table 2

(2) Sum these octave band weighted sound pressure levels, using the following equation:

$$L_{p(M)} = 10 \log_{10} \left[\text{antilog}_{10} \frac{L_{p(1)}}{10} + \text{antilog}_{10} \frac{L_{p(2)}}{10} + \cdots + \text{antilog}_{10} \frac{L_{p(7)}}{10} \right]$$

where

$L_{p(M)}$ (A-weighted) = mean sound level (A-weighted)

$L_{p(1)}$ = first-octave band sound pressure level

$L_{p(7)}$ = seventh-octave band weighted sound pressure level

7.3.9 ***Calculation of A-Weighted Sound Power Level [as Required in 6.1 (1)].*** **Using the octave band sound power levels determined in 7.3.6, apply the procedures of 7.3.8.**

8. Test Report

The test report shall contain the following information:

(1) Reference to the test code

(2) Description of the machine and conditions of installation and operation, Section 3

(3) Description of the test environment and location of the tested machine

(4) Make, model, and serial number of instruments used in obtaining data

(5) Quantities to be reported as described in Section 6

IEEE Standards on Rotating Machinery

IEEE Std	Title
43-1974	Recommended Practice for Testing Insulation Resistance of Rotating Machinery
56-1977	Guide for Insulation Maintenance for Large AC Rotating Machinery (10 000 kVA and Larger)
58-1977	Induction Motor Letter Symbols
66-1969	Short Circuit Characteristics of DC Machinery
67-1972	Guide for Operation and Maintenance of Turbine Generators (ANSI C50.30-1972)
85-1973	Airborne Sound Measurements on Rotating Electric Machinery
86-1975	Definitions of Basic Per-Unit Quantities for AC Rotating Machines
95-1977	Insulation Testing of Large AC Rotating Machinery with High Direct Voltage
112A-1964	Test Procedure for Polyphase Induction Motors and Generators
113-1973	Test Code for Direct-Current Machines
114-1969	Single Phase Induction Motor Tests (ANSI C50.21-1972)
115-1965	Test Procedure for Synchronous Machines
116-1975	Test Code for Carbon Brushes
117-1974	Standard Test Procedure for Evaluation of Systems of Insulating Materials
121-1959	Guide for Measurement of Rotary Speed
251-1963	(Reaff 1972) Test Procedures for DC Tachometer Generators
252-1977	Test Procedures for Polyphase Induction Motors with Liquid in the Magnetic Gap
275-1966	(Reaff 1972) Test Procedure for Evaluation of Systems of Insulating Materials for AC Electric Machinery Employing Form-Wound Preinsulated Stator Coils
286-1975	Recommended Practice for Measurement of Power-Factor Tip-Up of Rotating Machinery Stator Coil Insulation
288-1969	Guide for Induction Motor Protection (ANSI C37.92-1972)
290-1977	Recommended Test Procedure for Electric Couplings
303-1969	Auxiliary Devices for Motors in Class 1 — Groups, A, B, C, and D, Division 2 Locations
304-1977	Test Procedure for Evaluation and Classification of Insulation Systems for DC Machines
329-1971	Synchronous Motor Protection Guide (ANSI C37.94-1972)
421-1972	Criteria and Definitions for Excitation Control Systems for Synchronous Machines
429-1972	Evaluation of Sealed Insulation Systems for AC Electric Machinery Employing Form-Wound Stator Coils (ANSI C50.26-1972)
433-1974	Recommended Practice for Insulation Testing of Large AC Rotating Machinery with High Voltage at Very Low Frequency
434-1973	Guide for Functional Evaluation of Insulation Systems for Large High-Voltage Machines
492-1974	Guide for Operation and Maintenance of Hydro-Generators