SOUND RATING OF LARGE OUTDOOR REFRIGERATING AND AIR-CONDITIONING EQUIPMENT

Section 1. Purpose

1.1 *Purpose.* The purpose of this standard is to establish methods for determining the sound ratings of the outdoor portions of factory-made commercial and industrial Large Outdoor Refrigerating and Air-Conditioning Equipment. It establishes definitions; test requirements; rating requirements; minimum data requirements for Published Ratings; marking and nameplate data; and conformance conditions.

1.1.1 *Intent.* This standard is intended for the guidance of the industry, including manufacturers, engineers, installers, contractors and users.

1.1.2 *Review and Amendment.* This standard is subject to review and amendment as technology advances.

Section 2. Scope

2.1 *Scope.* This standard applies to the outdoor portions of factory-made commercial and industrial Large Outdoor Refrigerating and Air-Conditioning Equipment, including heat pumps, used for refrigerating or air-conditioning of spaces, as defined in Section 3 of this standard.

2.2 *Exclusions.* This standard does not apply to the outdoor portions of unitary air-conditioning or heat pump equipment which fall within the scope of ARI Standard 270 (cooling capacity ratings of less than 135,000 Btu/h [40 kW]) nor does it apply to air or evaporatively cooled condensers that fall within the scope of ARI Standards 460 and 490.

Section 3. Definitions

All terms in this document shall follow the standard industry definitions established in the current edition of *ASHRAE Terminology of Heating, Ventilation, Air-Conditioning and Refrigeration*, unless otherwise defined in this section.

3.1 *Comparison Method.* A method of determining Sound Power Level of the equipment under test in a reverberation room by comparing the average Sound Pressure Level of that equipment to the average Sound Pressure Level of a Reference Sound Source of known Sound Power Level output. The difference in Sound Power Level is equal to the difference in Sound Pressure Level when conditions in the room are the same for both sets of measurements.

3.2 *Hertz (Hz).* A unit of frequency equal to one cycle per second.

3.3 *Large Outdoor Refrigerating and Air-Conditioning Equipment.* Equipment that consists of one or more assemblies, including an outdoor coil and outdoor fan, and which may include a compressor. Remote, mechanical-draft, air-cooled and evaporative refrigerant condensers are not included.

3.4 *Octave Band.* A band of sound covering a range of frequencies such that the highest is twice the lowest. The Octave Bands used in this standard are those defined in ANSI Standard S1.11.

3.5 *One-Third Octave Band.* A band of sound covering a range of frequencies such that the highest frequency is the cube root of two times the lowest. The One-Third Octave Bands used in this standard are those defined in ANSI Standard S1.11.

3.6 *Published Rating.* A statement of the assigned values of those performance characteristics, under stated rating conditions, by which a unit may be chosen to fit its application. These values apply to all units of like nominal size and type (identification) produced by the same manufacturer. As used herein, the term Published Rating includes the rating of all performance characteristics shown on the unit or published in specifications, advertising or other literature controlled by the manufacturer, at stated rating conditions.

3.6.1 *Application Rating.* A rating based on tests performed at Application Rating Conditions (other than Standard Rating Conditions).

3.6.2 *Standard Rating.* A rating based on tests performed at Standard Rating Conditions.

3.7 *Rating Conditions.* Any set of operating conditions under which a single level of performance results, and which cause only that level of performance to occur.

3.7.1 *Standard Rating Conditions.* Rating Conditions used as the basis of comparison for performance characteristics.

3.8 *Reference Sound Source (RSS).* A portable, aerodynamic sound source that produces a known stable broad band sound power output.

3.9 *"Shall" or "Should".* "Shall" or "should" shall be interpreted as follows:

3.9.1 *Shall.* Where "shall" or "shall not" is used for a provision specified, that provision is mandatory if compliance with the standard is claimed.

3.9.2 *Should.* "Should" is used to indicate provisions which are not mandatory but which are desirable as good practice.

3.10 *Sound Power Level, L_w.* This is ten times the logarithm to the base ten of the ratio of the sound power radiated by the source to a reference sound power, expressed in decibels, dB. The reference sound power used in this standard is 1 picowatt (pW).

3.10.1 *A-Weighted Sound Power Level, L_{wa}.* The logarithmic summation of A-Weighted One-Third Octave Band levels.

3.11 *Sound Pressure Level, L_p.* This is twenty times the logarithm to the base ten of the ratio of a given sound pressure to a reference sound pressure of 20 μPa, expressed in decibels, dB.

3.12 *Tone.* For the purposes of this standard, a tone is considered to exist within a One-Third Octave Band when the sound level in that band exceeds the average of the levels of the two adjacent bands by 9 dB or more.

3.13 *Tone Adjustment.* An adjustment made to the One-Third Octave Band data to account for the subjective response to the presence of tones.

Section 4. Test Requirements

4.1 *Test Requirements.* All standard Sound Power Level ratings shall be determined by tests conducted in a qualified reverberation room, anechoic or hemianechoic room, or an indoor or outdoor space that is an essentially free field over a reflecting plane.

4.1.1 Sound tests conducted in a reverberation room shall use the Comparison Method in accordance with ISO 3741 using a Reference Sound Source calibrated in a hemi-anechoic environment in accordance with ARI Standard 250.

a. The room shall be qualified for measuring sound containing pure tone components in accordance with ISO 3741, Annex A
b. Qualification to the 63 Hz Octave Band shall be in accordance with ARI Standard 280
c. The volume of the equipment to be tested shall not exceed 5% of the volume of the room
d. The instrumentation and instrumentation systems employed in reverberation room testing shall meet or exceed the requirements of ISO 3741.

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4.1.2 Sound tests in a hemi-anechoic room which affords a free field condition above the measurement space or above a reflecting plane shall be conducted in accordance ISO 3745, as adapted for Large Outdoor Refrigerating and Air-Conditioning Equipment in Appendix C of this standard.

4.1.3 Sound tests in indoor or outdoor spaces that qualify as an essentially free field over a reflecting plane shall be conducted in accordance with ISO 3744, as adapted for Large Outdoor Refrigerating and Air-Conditioning Equipment in Appendix C of this standard.

4.2 *Methods of Test.* Sound tests shall be conducted as prescribed below:

4.2.1 *Standard Sound Ratings.* Standard sound ratings shall be based on sound tests conducted with the unit operating at rated voltage, V, phase and frequency, Hz, as specified on the unit nameplate and measured at the service connection. The tests shall consist of two phases:

a. In the first phase, the sound measurements shall be made with the equipment operating at the ARI standard thermal rating condition
b. In the second phase, the compression equipment shall be turned off and sound readings taken with only the fans operating. During this phase, the temperature of the ambient air entering the unit shall be within ± 2.0 °F [1.1 °C] of the temperature measured during compressor operation.

4.2.2 *Application Sound Ratings.* Application Sound Ratings for conditions other than the ARI standard thermal rating condition shall be based on sound tests conducted with the equipment operating at those conditions.

4.2.3 *Test Condition Tolerances.* During sound rating tests, the equipment operating conditions shall not deviate from the specified operating conditions by more than the following tolerances:

Air Temperature .....± 2.0°F [± 1.1°C]

When the indoor-side loading is simulated by a method not requiring air, the following tolerances apply:

Suction gas temperature at compressor.....± 5.0°F [± 2.8°C]
Evaporator pressure.....± 2.0 psi [±14 kPa]

The suction gas superheat must be at least 10°F [5.6°C] in the equivalent Standard Rating test specified in the ARI Standard for the equipment being tested.

4.3 *Data to be Taken.* Sound data shall be measured and recorded in One-Third Octave Bands (50 to 10,000 Hz) in accordance with the procedure specified above for the type of test being conducted.

4.4 *Air Velocity at Measurement Positions.* Sound measurements shall not be made when the air velocity over the microphone exceeds 1,056 ft/min [5.4 m/s]. A foam windscreen shall be installed on the microphone which shall not affect the microphone response by more than ± 1 dB for frequencies of 20 to 4,000 Hz or ± 1.5 dB for frequencies above 4,000 Hz.

Section 5. Rating Requirements

5.1 *Introduction.* The sound rating shall include two sets of Sound Power Levels, one for the complete unit and one for the unit operating with "fans only." Each set shall be comprised of: Octave Band Sound Power Levels (L_w); an A-Weighted Sound Power Level (L_{WA}); a Tone Adjusted A-Weighted Sound Power Level (L_{WAT}); and optionally, One-Third Octave Band Sound Power Levels.

5.2 *Determination of Sound Power Levels.* All Sound Power Levels, including Octave Band, A-Weighted, and Tone Adjusted A-Weighted, shall be computed from the non-rounded, measured One-Third Octave Band data.

5.2.1 *Octave Band Sound Power Levels.* Octave Band Sound Power Levels shall be determined from the One-Third Octave Band Sound Power Levels by logarithmically summing the three One-Third Octave Bands comprising each Octave Band (Equation 1). The resulting sound power values shall be expressed in dB re 1 pW for each band, to the nearest 1.0 dB.

$$L_W = 10 \log_{10}\left(\sum_{n=1}^{3} 10^{0.10 \cdot L_{W(n)}}\right) \qquad 1$$

where:

L_W = Octave Band Sound Power Level, dB
$L_{W(n)}$ = Sound Power Level, dB, in each of the One-Third Octave Bands comprising the Octave Band

5.2.2 *A-Weighted Sound Power Level.* The A-Weighted Sound Power Level shall be calculated from the One-Third Octave Band spectrum by arithmetically applying the A-Weighting Adjustments given in Table 1 to each One-Third Octave Band value and summing the 50 through 10,000 Hz bands using Equation 2.

Table 1. A-Weighting Adjustments

Frequency (Hz)	Adjustments (dB)
50	-30.2
63	-26.3
80	-22.5
100	-19.1
125	-16.1
160	-13.4
200	-10.9
250	-8.6
315	-6.6
400	-4.8
500	-3.2
630	-1.9
800	-0.8
1000	0
1250	+0.6
1600	+1.0
2000	+1.2
2500	+1.3
3150	+1.2
4000	+1.0
5000	+0.5
6300	-0.1
8000	-1.1
10000	-2.5

The resulting A-Weighted Sound Power Level shall be expressed in dB re 1 pW, to the nearest decibel.

$$L_{WA} = 10 \log_{10}\left(\sum_{n=1}^{N} 10^{0.10 \cdot L_{WA(n)}}\right) \qquad 2$$

where:

L_{WA} = A-Weighted Sound Power Level, dB

$L_{WA(n)}$ = Sound Power Level, dB, in the n^{th} One-Third Octave Band, adjusted for A-Weighting

N = Total number of bands summed

See Appendix E for an example calculation of A-Weighted Sound Power Level.

5.2.3 *Tone Adjusted, A-Weighted Sound Power Level.* The Tone Adjusted, A-Weighted Sound Power Level shall be determined from the One-Third Octave Band Sound Power spectrum as follows:

5.2.3.1 For each One-Third Octave Band value, determine the Projection (P) by computing the mathematical average of the two adjacent One-Third Octave Bands and subtracting that value from the One-Third Octave Band being considered.

5.2.3.2 Whenever the value of P for the One-Third Octave Band being considered equals or exceeds 2 dB, calculate a Tone Adjusted Sound Power Level (L'_W) for that One-Third Octave Band using Equation 3:

$$L'_W = L_W - P + 10\log_{10}\left(10^{(D+B)}+1\right) \qquad 3$$

where:

B = $76.2794 - 75.7439\,Y + 29.9803\,Y^2 - 6.13769\,Y^3 + 0.691827\,Y^4 - 0.0408822\,Y^5 + 0.000991561\,Y^6$

D = $\log_{10}(10^{(P/10)} - 1)$

F = Band center frequency, Hz, where $125\ \text{Hz} \le F \le 8{,}000\ \text{Hz}$

L'_W = Tone Adjusted Sound Power Level for the band, dB

L_W = Original Sound Power Level for the band, dB

P = Projection above the average of the two adjacent bands, dB

Y = $\ln F$

Note: Appendix D lists Tone Adjustment values over a range of frequencies and projections. It illustrates the magnitude of the adjustments and provides a means to verify software incorporating Equation 3.

5.2.3.3 Apply the A-Weighting Adjustment from Table 1 arithmetically to each One-Third Octave Band (as adjusted for Tone, if necessary, per 5.2.3.2) comprising the spectrum and sum the 50 through 10,000 Hz bands using Equation 4. The resulting Tone Adjusted, A-Weighted Sound Power Level shall be expressed in dB re 1 pW, to the nearest decibel.

$$L_{WAT} = 10\log_{10}\left(\sum_{n=1}^{N} 10^{0.10\cdot L_{WAT(n)}}\right) \qquad 4$$

where:

L_{WAT} = Tone Adjusted, A-Weighted Sound Power Level , dB

$L_{WAT(n)}$ = Sound Power Level for the n^{th} One-Third Octave Band, adjusted for A-Weighting and Tone

N = Total number of bands summed

See Appendix F for an example calculation of Tone Adjusted, A-Weighted Sound Power Level.

5.3 *Rating Tolerances.* Any Large, Outdoor Refrigerating and Air-Conditioning Equipment tested in accordance with this standard shall have Octave Band Sound Power Levels (L_W); an A-Weighted Sound Power Level (L_{WA}); and a Tone Adjusted A-Weighted Sound Power Level (L_{WAT}) for the complete unit not higher than its Published Rating.

Section 6. Minimum Data Requirements for Published Ratings

6.1 *Published Ratings.* As a minimum, Published Ratings (expressed to the nearest decibel) shall include two sets of Sound Power Levels. The first set shall be for the unit with all components running as are necessary to produce the ARI standard thermal rating. The second set shall be for the unit operating with only the fans running. Both sets shall include items a, b, and c while item d may be included at the manufacturer's option:

a. The Octave Band Sound Power Levels

b. The A-Weighted Sound Power Level

c. The Tone Adjusted, A-Weighted Sound Power Level

d. Optionally, the One-Third Octave Band Sound Power Levels may be published

6.2 *Standard Sound Rating.* When ARI standard thermal rating conditions have been established for the equipment, a standard sound rating shall be published for the unit operating at those conditions, accompanied by the same data for the unit operating with "fans only."

All claims to sound ratings within the scope of this standard shall include the statement "Rated in accordance with ARI Standard 370." All claims to ratings outside the scope of this standard shall include the statement "Outside the scope of ARI Standard 370". Wherever Application Sound Ratings are published or printed, they shall include a statement of the standard thermal rating conditions at which the ratings apply and be accompanied by the Standard Sound Rating.

Section 7. Marking and Nameplate Data

7.1 *Marking and Nameplate Data.* As a minimum, the nameplate shall display the manufacturer's name, model designation, and electrical characteristics.

Nameplate voltages for 60 Hertz systems shall include one or more of the equipment nameplate voltage ratings shown in Table 1 of ARI Standard 110. Nameplate voltages for 50 Hertz systems shall include one or more of the utilization voltages shown in Table 1 of IEC Standard Publication 60038.

Section 8. Conformance Conditions

8.1 *Conformance.* While conformance with this standard is voluntary, conformance shall not be claimed or implied for products or equipment within its *Purpose* (Section 1) and *Scope* (Section 2) unless such claims meet all of the requirements of the standard.

APPENDIX A. REFERENCES - NORMATIVE

A1 Listed here are all standards, handbooks, and other publications essential to the formation and implementation of the standard. All references in this appendix are considered as part of this standard.

A1.1 ANSI Standard S1.11 1986 (R1993), *Octave-Band and Fractional Octave-Band Analog and Digital Filters,* American National Standards Institute, 25 West 43rd Street, 4th Fl., New York, NY 10036, U.S.A.

A1.2 ARI Standard 110-2001, *Air-Conditioning and Refrigerating Equipment Nameplate Voltages,* 1997, Air-Conditioning and Refrigeration Institute, 4301 North Fairfax Drive, Suite 425, Arlington, VA 22203, U.S.A.

A1.3 ARI Standard 250-2001, *Reference Sound Source,* 2001, Air-Conditioning and Refrigeration Institute, 4301 North Fairfax Drive, Suite 425, Arlington, VA 22203, U.S.A.

A1.4 ARI Standard 270-95, *Sound Rating of Outdoor Unitary Equipment,* 1995, Air-Conditioning and Refrigeration Institute, 4301 North Fairfax Drive, Suite 425, Arlington, VA 22203, U.S.A.

A1.5 ARI Standard 280-95, *Sound Power Rating of Refrigerating and Air-Conditioning Equipment at Low Frequencies - Below 100 Hz,* 1995, Air-Conditioning and Refrigeration Institute, 4301 North Fairfax Drive, Suite 425, Arlington, VA 22203, U.S.A.

A1.6 ARI Standard 460-2000, *Remote Mechanical-Draft Air-Cooled Refrigerant Condensers,* 2000, Air-Conditioning and Refrigeration Institute, 4301 North Fairfax Drive, Suite 425, Arlington, VA 22203, U.S.A.

A1.7 ARI Standard 490-98, *Remote Mechanical-Draft Evaporative Refrigerant Condensers,* 1998, Air-Conditioning and Refrigeration Institute, 4301 North Fairfax Drive, Suite 425, Arlington, VA 22203, U.S.A.

A1.8 *ASHRAE Terminology of Heating, Ventilating, Air-Conditioning and Refrigeration,* Second Edition, 1991, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E. Atlanta, GA 30329. U.S.A.

A1.9 IEC Standard Publication 60038, *IEC Standard Voltages,* International Electrotechnical Commissions, 1983, 3, rue de Varembe, P.O. Box 131, 1211 Geneva 20, Switzerland.

A1.10 *ISO 3741, Acoustics - Determination of Sound Power Levels of Noise Sources - Precision Methods for Broad-Band Sources in Reverberation Rooms,* 1988, International Organization for Standardization, 1, rue de Varembe, Case Postale 56 CH-1211 Geneva 20, Switzerland.

A1.11 *ISO 3744, Acoustics - Determination of Sound Power Levels of Noise Sources Using Sound Pressure - Engineering Method in an Essentially Free Field Over a Reflecting Plane,* 1994, International Organization for Standardization, 1, rue de Varembe, Case Postale 56 CH-1211 Geneva 20, Switzerland.

A1.12 *ISO 3745, Acoustics - Determination of Sound Power Levels of Noise Sources - Precision Methods for Anechoic and Semi-Anechoic Rooms,* 1977, International Organization for Standardization, 1, rue de Varembe, Case Postale 56 CH-1211 Geneva 20, Switzerland.

APPENDIX B. REFERENCES - INFORMATIVE

None.

APPENDIX C. DETERMINING SOUND POWER LEVELS USING SOUND PRESSURE MEASUREMENTS MADE IN A FREE FIELD OVER A REFLECTING PLANE - NORMATIVE

Section C1. Purpose

C1.1 *Purpose.* The purpose of this appendix is to provide a procedure for determining the Sound Power Levels (L_W) of equipment by measuring sound pressure in an essentially free field over a reflecting plane, as adapted from ISO 3744 or in a free field condition above a reflecting plane in a hemi-anechoic room as adapted from ISO 3745.

Section C2. Scope

C2.1 *Scope.* This procedure applies to Large Outdoor Refrigerating and Air-Conditioning Equipment.

Section C3. Definitions

C3.1 *Definitions.* The definitions of terms used in this appendix are the same as those set forth in Section 3 of this standard.

Section C4. Test Method

C4.1 *Instrumentation.* The instrumentation and instrumentation systems employed shall meet the requirements of ISO 3744 or ISO 3745.

C4.2 *Test Environment.* The test site shall be a flat, indoor or outdoor area free of reflecting objects other than the reflecting plane, such that the source radiates into a free field over a reflecting plane.

C4.2.1 The reflecting plane shall extend at least half a wavelength ($\lambda/2$) (for the lowest frequency of interest) beyond the projection of the measurement surface (Section C4.3.1) on the reflecting plane.

Note: For 50 Hz, this is about 6.7m.

C4.2.2 The site shall meet the qualification requirements of ISO 3744.

C4.2.3 The need for [illegible] environmental correction (K_2) [illegible] purposes of the test [illegible] ordinarily [illegible] the purposes of this document, the value of K_2 shall be limited to:

$-2.0\ dB \le K_2 \le +2.0\ dB$

C4.3 *Microphone Measurement Points.* The points of sound pressure measurement shall be determined relative to a reference parallelepiped, the smallest imaginary rectangular parallelepiped, terminating on the reflecting plane, that will just enclose the machine. In determining the size of the reference parallelepiped, minor projections from the machine which are unlikely to be major radiators of sound energy may be disregarded.

C4.3.1 The measurement parallelepiped on which the microphones are positioned is an hypothetical surface of area, S, m^2, enveloping the machine whose sides and top are parallel to the sides and top of the reference parallelepiped and are spaced at a distance of [1.0 m] outward from the reference parallelepiped.

C4.3.2 The area of the measurement surface (S) is given by Equation C1 below:

$$S = \pi (L/2)((W/2)+H) \qquad C1$$

where:

L = Length of the measurement parallelepiped, m
W = Width of the measurement parallelepiped, m
H = Height of the measurement parallelepiped, m

such that $L \ge W$ (Figures C1 and C2).

Note: Equation C1 calculates an equivalent hemisphere area which is done to give equivalency between the survey method and reverberation room method.

C4.3.3 The key measurement stations shall be located at the mid-point of each of the four sides of the measurement parallelepiped (Figure C1).

a. Additional intermediate measurement stations shall be added extending outward at 1 m intervals (d) from the key stations towards the corners of the measurement parallelepiped. The distance (f) between

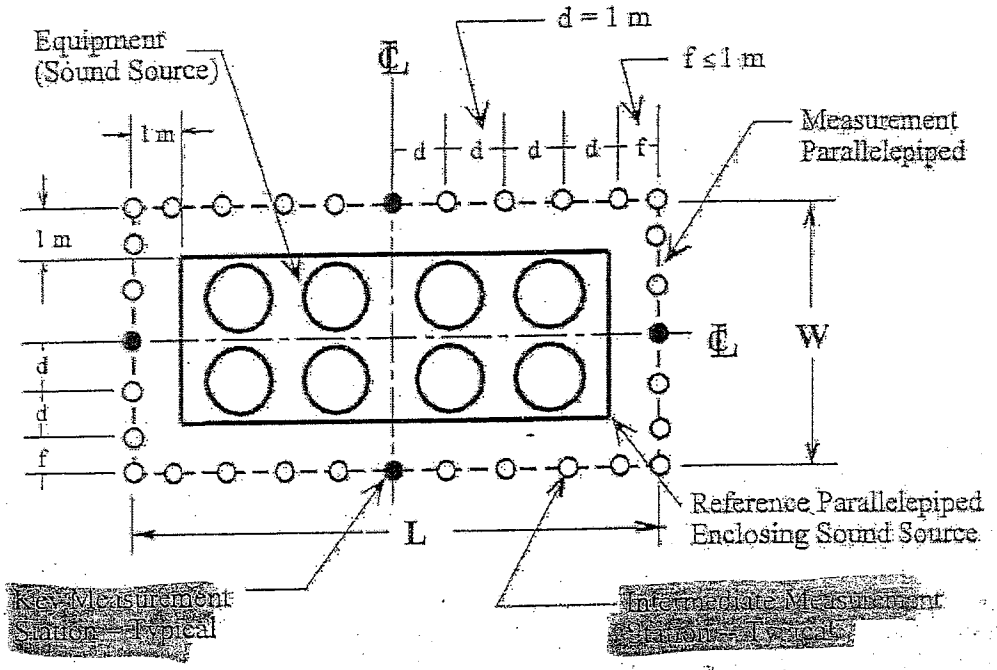

Figure C1. Plan View of Measurement Parallelepiped

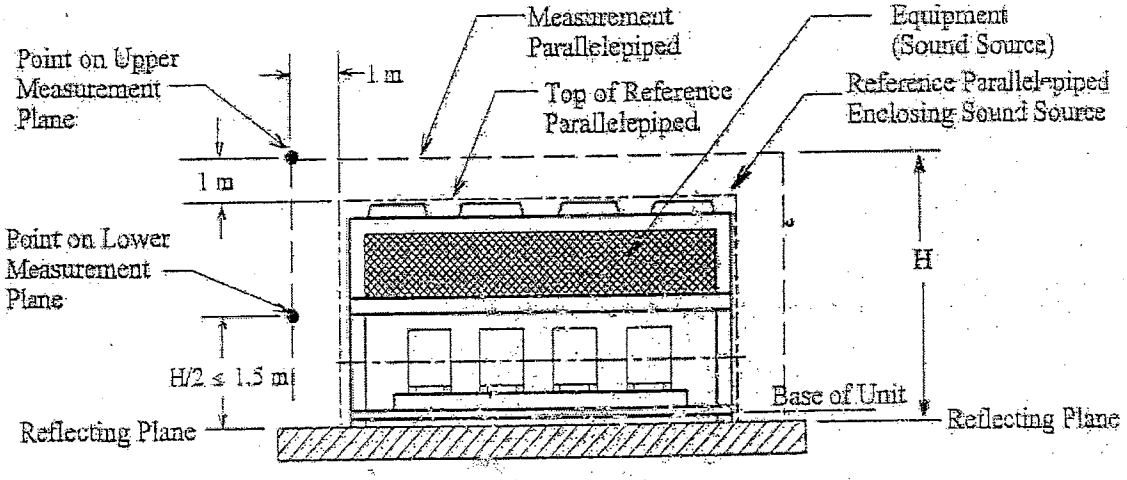

Figure C2. Elevation of Measurement Parallelepiped

the last intermediate and the corner stations may be less than, but shall be no greater

than 1 m. (Figure C1).

second shall be at a level midway between the upper plane and the reflecting plane or 1.5 m above the reflecting plane, whichever is less (Figure C2).

C4.4 *Data to be Taken.* The Sound Pressure Level shall be measured and recorded in each of the One-Third Octave Bands ranging from 50 Hz to 10,000 Hz at each measurement position.

C4.4.1 A full set of measurements shall be taken with the equipment operating in each of the two modes specified in Section 4.2.1 of this standard.

C4.4.2 An additional measurement run shall be made to determine the background noise level at each measurement position.

Section C5. Calculation of Results

C5.1 *Correction for Background Noise.* Each of the measured Sound Pressure Levels ($L_{p(m)}$) shall be compared to the measured background noise ($L_{p(b)}$) at the same position and frequency such that:

$$\Delta L = L_{P(m)} - L_{P(b)} \qquad \text{C2}$$

where:

ΔL = Difference in Sound Pressure Levels between the measured Sound Pressure Level of the unit and the background noise, dB

$L_{P(b)}$ = Sound Pressure Level of the background noise at the measurement point, dB

$L_{P(m)}$ = Sound Pressure Level of the measured noise signal, dB

Then:

a. If $\Delta L > 10.0$, no adjustment is required

b. If $6.0 \leq \Delta L \leq 10.0$, the measured value $L_{P(m)}$, shall be adjusted by adding the value K_1, where:

$$K_1 = -10\log\left(1 - 10^{-0.10\,\Delta L}\right) \qquad \text{C3}$$

c. If $\Delta L < 6.0$, the actual value for the unit is indeterminate. The measured value shall be used in the analysis, however, recognizing it has a significant background noise component.

C5.2 *Calculation of Surface Sound Pressure Level.* For each One-Third Octave Band, correct the measured value for background noise and calculate the average Sound Pressure Level over the measurement surface (L_P) using the following equation:

$$\overline{L}_P = 10\log_{10}\left(\frac{1}{M}\sum_{m=1}^{M} 10^{0.10\cdot L_{P(m)}}\right) \qquad \text{C4}$$

where:

$\overline{L}_P$ = Sound Pressure Level for each One-Third Octave Band, averaged over the measurement surface, in dB, re 20 µPa

$L_{P(m)}$ = Sound Pressure Level of the m^{th} measurement, in dB, re 20 µPa

M = The total number of measurement positions

Then, the surface Sound Pressure Level, $\overline{L}_{Pf}$ shall be adjusted by adding the value of the environmental correction, K_2 to account for departures of the test environment from the ideal condition, such that:

$$\overline{L}_{Pf} = \overline{L}_P - K_2 \qquad \text{C5}$$

where:

$\overline{L}_{Pf}$ = Surface Sound Pressure Level in dB, re 20 µPa

K_2 = Mean value of environmental correction over the measurement surface in decibels, as determined from Annex A of ISO 3744

C5.3 *Calculation of Sound Power Level.* The Sound Power Level ($L_{W(n)}$) characterizing the noise emitted by the source for each One-Third Octave Band shall be calculated as:

$$L_{W(n)} = \overline{L}_{Pf} + 10\log\left(\frac{S}{S_0}\right) \qquad \text{C6}$$

where:

$L_{W(n)}$ = Sound Power Level in the n^{th} One-Third Octave Band, dB

S = Area of the measurement surface over which the measurements were averaged, m^2

S_0 = Reference surface area = 1 m^2

The resulting values for Sound Power Level, $L_{W(n)}$ by One-Third Octave Band shall be used to determine the equipment sound rating levels as described in Section 5 of this standard.

APPENDIX D. TONE ADJUSTMENTS AT ONE-THIRD OCTAVE BAND FREQUENCIES FOR SPECIFIC VALUES OF PROJECTION (P) – INFORMATIVE

D1 Listed in this table are Tone Adjustments at One-Third Octave Band frequencies for specific values of projection (P), rounded to the nearest 0.1 dB. These data are provided as a means for users of this standard to validate their methodology for calculating Tone Adjusted, A-Weighted Sound Power Levels in accordance with Section 5.2.3 of this standard.

Table D1. One-Third Octave Band Adjustments for Tone Response

One-Third Octave Band Frequency	Projection of One-Third Octave Band above the arithmetic average of the two adjacent bands.												
	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0
50	†	†	†	†	†	†	†	†	†	†	†	†	†
63	†	†	†	†	†	†	†	†	†	†	†	†	†
80	†	†	†	†	†	†	†	†	†	†	†	†	†
100	†	†	†	†	†	†	†	†	†	†	†	†	†
125	†	†	†	†	†	†	†	†	†	†	†	†	†
160	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
200	0.5	0.5	0.6	0.7	0.7	0.8	0.8	0.9	0.9	0.9	1.0	1.0	1.0
250	0.8	1.0	1.1	1.2	1.3	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.7
315	1.2	1.4	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.2	2.3	2.3	2.4
400	1.5	1.8	2.0	2.1	2.3	2.4	2.5	2.6	2.7	2.8	2.8	2.9	3.0
500	1.8	2.1	2.3	2.5	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.3	3.4
630	2.1	2.4	2.6	2.8	3.0	3.2	3.3	3.4	3.5	3.6	3.7	3.7	3.8
800	2.3	2.6	2.9	3.1	3.3	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.1
1000	2.5	2.8	3.1	3.4	3.6	3.7	3.9	4.0	4.1	4.2	4.3	4.4	4.4
1250	2.7	3.0	3.3	3.6	3.8	4.0	4.1	4.3	4.4	4.5	4.6	4.6	4.7
1600	2.9	3.2	3.6	3.8	4.0	4.2	4.4	4.5	4.6	4.7	4.8	4.9	5.0
2000	3.0	3.4	3.7	4.0	4.2	4.4	4.6	4.7	4.8	4.9	5.0	5.1	5.2
2500	3.1	3.5	3.9	4.1	4.4	4.5	4.7	4.9	5.0	5.1	5.2	5.3	5.3
3150	3.2	3.6	4.0	4.2	4.5	4.7	4.8	5.0	5.1	5.2	5.3	5.4	5.4
4000	3.3	3.7	4.0	4.3	4.5	4.7	4.9	5.0	5.2	5.3	5.4	5.4	5.5
5000	3.3	3.7	4.0	4.3	4.5	4.7	4.9	5.0	5.1	5.3	5.4	5.4	5.5
6300	3.2	3.6	4.0	4.2	4.5	4.7	4.8	5.0	5.1	5.2	5.3	5.4	5.5
8000	3.2	3.6	3.9	4.2	4.4	4.6	4.8	4.9	5.0	5.1	5.2	5.3	5.4
10000	†	†	†	†	†	†	†	†	†	†	†	†	†

† Tone Adjustments are not applicable to frequencies below 160 Hz or above 8000 Hz.

APPENDIX E. EXAMPLE CALCULATION OF A-WEIGHTED SOUND POWER LEVEL - INFORMATIVE

Table E1. Example Calculation of A-Weighted Sound Power Level

One-Third Octave Band Center Frequency (Hz)	Equipment Sound Power Level (dB re 1 pW)	A-Weighting Adjustment, dB (from Table 1)	A-Weighted Sound Power Level (dB re 1 pW)	$10^{0.10 \cdot L_{WA(n)}}$
50	92.3	-30.2	62.1	1,621,810
63*	94.0	-26.3	67.7	5,888,437
80	97.0	-22.5	74.5	28,183,829
100	98.7	-19.1	79.6	91,201,084
125*	104.2	-16.1	88.1	645,654,229
160	102.6	-13.4	89.2	831,763,771
200	101.0	-10.9	90.1	1,023,292,992
250*	99.5	-8.6	90.9	1,230,268,771
315	97.5	-6.6	90.9	1,230,268,771
400	97.4	-4.8	92.6	1,819,700,859
500*	100.2	-3.2	97.0	5,011,872,336
630	97.9	-1.9	96.0	3,981,071,706
800	95.6	-0.8	94.8	3,019,951,720
1,000*	92.4	0	92.4	1,737,800,829
1,250	90.0	+0.6	90.6	1,148,153,621
1,600	91.1	+1.0	92.1	1,621,810,097
2,000*	86.1	+1.2	87.3	537,031,796
2,500	87.1	+1.3	88.4	691,830,971
3,150	83.0	+1.2	84.2	263,026,799
4,000*	81.0	+1.0	82.0	158,489,319
5,000	78.2	+0.5	78.7	74,131,024
6,300	77.6	-0.1	77.5	56,234,133
8,000*	77.5	-1.1	76.4	43,651,583
10,000	68.4	-2.5	65.9	3,890,451

* Indicates center frequencies as specified in ANSI S1.11

$$\sum_{n=1}^{24} 10^{0.10 \cdot L_{WA(n)}} = 25{,}256{,}790{,}939$$

Then, using Equation 2, $L_{WA} = 10\,[\log_{10}(25{,}256{,}790{,}939)] = 104.02$ or 104 dB

APPENDIX F. EXAMPLE CALCULATION OF TONE ADJUSTED, A-WEIGHTED SOUND POWER LEVELS – INFORMATIVE

Table F1. Example Calculation of Tone Adjusted, A-Weighted Sound Power Level

One-Third Octave Band Center Frequency (Hz)	Equipment Sound Power Level (dB re 1 pW)	Tone Adjustment (from Equation 3)	A-Weighting Adjustment (from Table 1)	Tone Adjusted, A-Weighted Sound Power Level (dB re 1 pW)	$10^{0.10 \cdot L_{WAT(n)}}$
50	92.3	--	-30.2	62.1	1,621,810
63*	94.0	--	-26.3	67.7	5,888,437
80	97.0	--	-22.5	74.5	28,183,829
100	98.7	--	-19.1	79.6	91,201,084
125*	104.2	-0.1	-16.1	88.0	630,957,344
160	102.6	--	-13.4	89.2	831,763,771
200	101.0	--	-10.9	90.1	1,023,292,992
250*	99.5	--	-8.6	90.9	1,230,268,771
315	97.5	--	-6.6	90.9	1,230,268,771
400	97.4	--	-4.8	92.6	1,819,700,859
500*	100.2	+2.1	-3.2	99.1	8,128,305,162
630	97.9	--	-1.9	96.0	3,981,071,706
800	95.6	--	-0.8	94.8	3,019,951,720
1,000*	92.4	--	0	92.4	1,737,800,829
1,250	90.0	--	+0.6	90.6	1,148,153,621
1,600	91.1	+3.6	+1.0	95.7	3,715,352,291
2,000*	86.1	--	+1.2	87.3	537,031,796
2,500	87.1	+3.5	+1.3	91.9	1,548,816,619
3,150	83.0	--	+1.2	84.2	263,026,799
4,000*	81.0	--	+1.0	82.0	158,489,319
5,000	78.2	--	+0.5	78.7	74,131,024
6,300	77.6	--	-0.1	77.5	56,234,133
8,000*	77.5	+4.6	-1.1	81.0	125,892,541
10,000	68.4	--	-2.5	65.9	3,890,451

* Indicates center frequencies as specified in ANSI S1.11

$$\sum_{n=1}^{24} 10^{0.10 \cdot L_{WAT(n)}} = 31,391,295,680$$

Then, using Equation 4, $L_{WAT} = 10\ [\log_{10}(31,391,295,680)] = 104.97$ or 105 dB

1994 STANDARD for

METHOD OF MEASURING MACHINERY SOUND WITHIN AN EQUIPMENT SPACE

AIR-CONDITIONING & REFRIGERATION INSTITUTE

Standard 575

4301 NORTH FAIRFAX DRIVE • ARLINGTON, VIRGINIA 22203

IMPORTANT

SAFETY RECOMMENDATIONS

It is strongly recommended that the product be designed, constructed, assembled and installed in accordance with nationally recognized safety requirements appropriate for products covered by this standard.

ARI, as a manufacturers' trade association, uses its best efforts to develop standards employing state-of-the-art and accepted industry practices. However, ARI does not certify or guarantee safety of any products, components or systems designed, tested, rated, installed or operated in accordance with these standards or that any tests conducted under its standards will be non-hazardous or free from risk.

FOREWORD

This document establishes a uniform method of measuring the sound levels produced by air-conditioning and refrigerating machinery installed in mechanical equipment spaces. However, it should be emphasized that this standard was developed for use where the test conditions usually cannot be controlled, e.g., ambient temperature; equipment loading; physical attributes of the space; background sound sources, etc. Since the results obtained may vary substantially, a tolerance on these results cannot be specified.

Uniform practices in making sound level measurements are necessary for effective communication between the owner, the architect, the acoustician, the consulting engineer, the contractor and the equipment manufacturer.

Specification for sound levels produced by machinery may be written, both for the purpose of supplying information in order to evaluate compliance with noise exposure limits and for the purpose of providing information for adequate building design to meet the acoustical design goals of adjacent occupied spaces. In view of the geometrical and acoustical properties of large equipment, both purposes can best be served by sound data expressed in terms of sound pressure level measured close to the equipment. Sound pressure measurements close to the equipment are least affected by the environment in which the machines are installed.

This standard is based upon the procedures established in American National Standard S1.13-1971 (R1986).

Note:

This standard supersedes ARI Standard 575-87.

Price $15.00 (M) $30.00 (NM)
Printed in U.S.A.

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FIGURES

APPENDICES

METHOD OF MEASURING MACHINERY SOUND WITHIN AN EQUIPMENT SPACE

Section 1. Purpose

1.1 *Purpose.* The purpose of this standard is to establish a uniform method of measuring and recording the sound pressure level of machinery installed in a mechanical equipment space. It is not the intent of this standard to be used for the sound rating of equipment.

Section 2. Scope

2.1 *Scope.* This standard applies to water chilling systems, pumps and similar operating machines and parts thereof, which for reasons of size or operating characteristics are more practically evaluated in situ.

Section 3. Definitions

3.1 *"A" -Weighted Sound Pressure Level.* The measured value obtained with a sound level meter using its "A" weighting network.

3.2 *Octave Band.* An octave band is a band of sound covering a range of frequencies such that the highest is twice the lowest. The octave bands used in this standard are those defined in American National Standard Institute Standard S1.11-1986.

3.3 *Operating Conditions.* Operating conditions are those conditions specified for the particular installation. In general, they are those parameters listed in the job specification sheets for the particular equipment. Examples of parameters to be recorded are found on data sheets in Appendix A.

3.4 *"Shall," "Should," "Recommended" or "It Is Recommended."* "Shall," "should," "recommended" or "it is recommended" shall be interpreted as follows:

3.4.1 *Shall.* Where "shall" or "shall not" is used for a provision specified, that provision is mandatory if compliance with the standard is claimed.

3.4.2 *Should, Recommended or It Is Recommended.* "Should," "recommended" or "it is recommended" is used to indicate provisions which are not mandatory but which are desirable as good practice.

3.5 *Sound Pressure Level.* The sound pressure level (L_p), in decibels (dB), of a sound is 20 times the logarithm to the base 10 of the ratio of a given pressure to a reference pressure. The reference pressure (P_o) used in this standard is 20 micropascals.

$$L_p = 20 \log_{10} (p/P_o)$$

where p is the measured RMS (root mean square) sound pressure, in Pa.

3.6 *Uncertain and Valid Measurements.*

3.6.1 An uncertain measurement is at a point where sound energy of other sources causes the observed value to be above its true value.

3.6.2 A valid measurement is at a point where other equipment or adjacent surfaces do not significantly affect the value observed.

Section 4. Instruments

4.1 *Sound Level Meter.* A meter meeting the requirements of the Type 1 meter described in American National Standards Institute Standard S1.4-1983 is to be used.

4.2 *Frequency Analyzer.* An octave or third-octave band filter set meeting the requirements for Class II or III filters respectively, of American National Standards Institute Standard S1.11-1986 is to be used.

4.3 *Calibration.* During each series of measurements, an acoustical calibrator with an accuracy of ±0.5 dB shall be applied to the microphone for checking the calibration of the entire measuring system at one or more frequencies over the frequency range of interest. The calibrator shall be checked at the manufacturer's recommended intervals or at least once every year to verify that its output has not changed. In addition, an electrical calibration of the instrumentation system over the entire frequency range of interest shall be performed periodically as recommended by the manufacturer, but at intervals of not more than two years.

Section 5. Sound Measurements and

Calculation Procedures

5.1 *Measurements.*

5.1.1 *Measurement Points.* The points where measurements are to be taken are determined relative to a reference parallelopiped, which is the smallest imaginary rectangular parallelopiped that will enclose the machine (see Figure 1). Minor projections from the machine are disregarded in determining the size of the reference parallelopiped.

The measurement points shall be positioned on the surface of a measurement parallelopiped whose planes are 1 meter out from the vertical sides of the reference parallelopiped. Key measurement points are located at the center of each vertical plane of the measurement parallelopiped. The remaining measurement points are at 1 meter intervals on the measurement planes starting from the key points. All measurement points are at a height of 1.5 meters from the floor. If the shortest distance between two measurement points at a corner of the measurement parallelopiped is less than 1 meter, the point nearest to the corner shall be eliminated. The total number of points on the measurement parallelopiped is N.

5.1.2 *Operation of Sound Level Meter.* The sound level meter shall be used in the slow response position. The instrument manufacturer's recommendations shall be followed in using the meter and in determining the correct microphone orientation for the flattest frequency response.

5.1.3 *Data to be Taken.* "A" weighted sound pressure level measurements shall be taken at all measurement points. Octave band measurements (63 through 8000 Hz octave bands) shall be made at the four key measurement points.

A full set of measurements shall be taken with the test unit operating. A second full set of data shall be obtained with the test unit off and all other equipment in the area operating as before to establish the background sound levels.

5.1.4 *Valid Measurement Points.* A valid measurement point cannot be closer than 1 meter to a wall or other plane surface larger than 1 square meter. A measurement shall not be recorded at any measurement point that does not meet this criterion. The number of invalid measurement points is N_I.

5.1.5 *Pure Tones.* When pure tones are generated by the operating machine, interference patterns may affect the measured values. If the "A" weighted sound pressure level or any octave band sound pressure level varies 6 dB or more within an area of 0.5 meter radius of the measuring point and on the surface of the measurement parallelopiped, the highest and lowest values observed within this area shall be recorded. If variations are less than 6 dB the value obtained at the specified measurement point shall be recorded.

5.2 *Calculation Procedures.*

5.2.1 *Uncertain Measurements Due to Background Noise.* Any "A"-weighted or octave band sound pressure level taken with test unit operating must be at least 6 dB above the corresponding level with the test unit off and other equipment operating. Any level which does not meet this criterion shall be marked uncertain by the use of an asterisk (*). The number of uncertain measurement points is N_U.

5.2.2 *Pure Tones.* Where the highest and lowest values were recorded for a measurement point as specified in 5.1.5 the value used in the calculations for this point shall be the highest value minus 3 dB.

5.2.3 *Representative "A"-Weighted Sound Pressure Level.* If half or more of the measurement points remain (that is, if $N - N_U - N_I \geq N/2$) after applying the limitations of 5.1.4 and 5.2.1, the representative "A"-Weighted Sound Pressure Level (A_R) shall be calculated using Equation 1. However, if less than half remain, the Representative High Limit Sound Pressure level shall be calculated per 5.2.5.

5.2.4 *Representative Octave Band Sound Pressure Levels.* If two or more key measuring points remain after applying the limitations of 5.1.4 and 5.2.1, the Representative Octave Band Sound Pressure Levels (OB_R) shall be calculated using Equation 1. However, if less than two remain the Representative High Limit Octave Band Sound Pressure Level shall be calculated per 5.2.6.

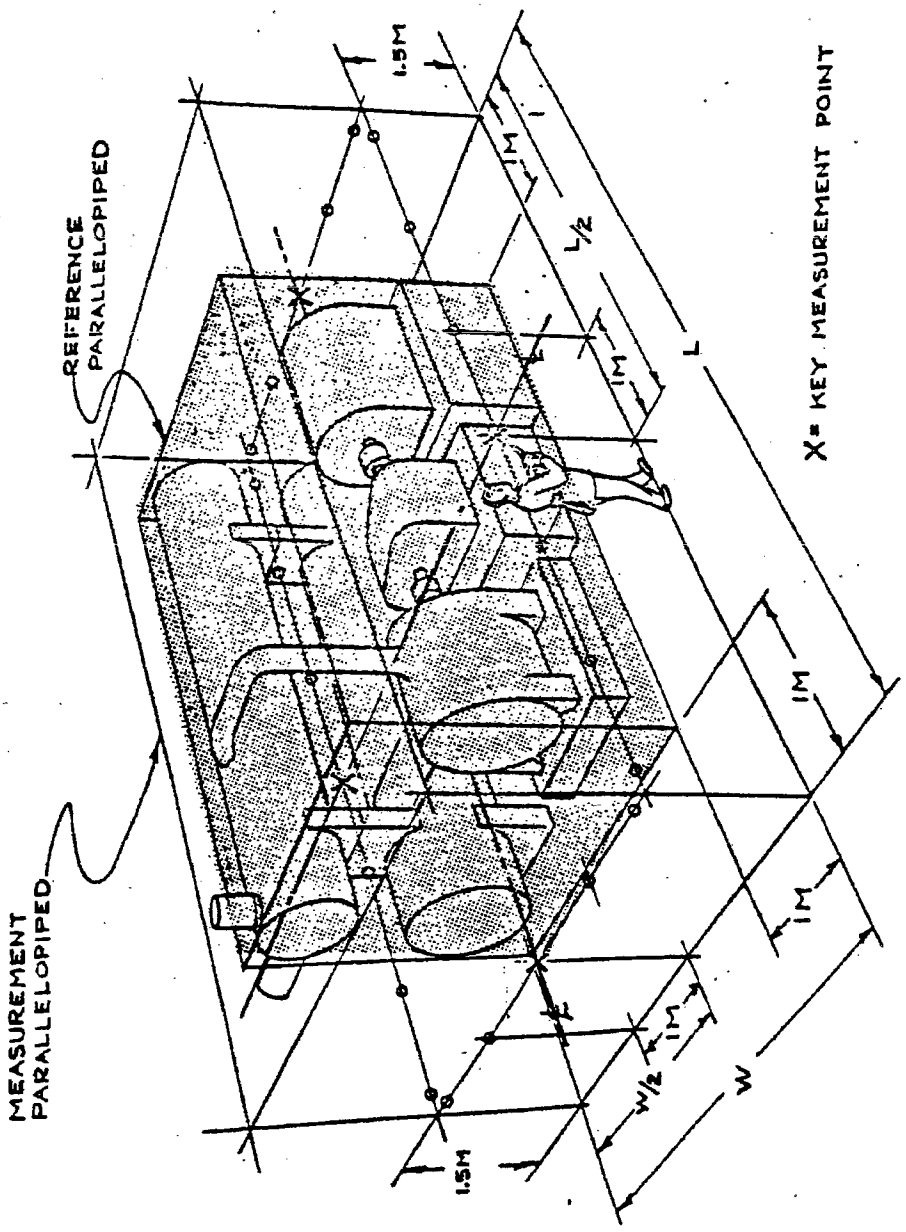


Figure 1. Test Unit Measurement Points

5.2.5 *Representative High Limit "A"-Weighted Sound Pressure Levels.* If half or more of the measurement points can be obtained by adding the uncertain to the valid measurement points (that is, if $N - N_1 \geq N/2$), then a Representative High Limit "A"-Weighted Sound Pressure Level (A_H) can be calculated using Equation 1 with $N_U = 0$. If this criteria cannot be met neither a Representative or Representative High Limit "A"-Weighted Sound Pressure Level can be obtained.

5.2.6 *Representative High Limit Octave Band Level.* If two or more key measurement points can be obtained by adding the uncertain points to the valid measurement points a Representative High Limit Octave Band Sound Pressure Level (OB_H) can be calculated using Equation 1. If this criteria cannot be met neither Representative nor Representative High Limit Octave Band Sound Pressure Levels can be obtained.

5.2.7 *Sound Pressure Level Averaging Equation.*

$$L = 10 \log_{10} \left[\sum_{i=1}^{n} 10^{L_i / 10} \right] - 10 \log_{10} n \qquad (1)$$

Where: L = Representative or High Limit Sound Pressure Level Logarithmic average rounded off to the nearest 0.5 dB)

L_n = Sound pressure level at the measured points

n = Number of points to be averaged = $(N - N_U - N_1)$

Section 6. Machinery Sound Specifications and Data Presentation

6.1 *Sound Level Specifications.* Information required for specifying machinery sound levels should include the following:

a. Machine description.

b. Desired Representative "A"-Weighted Sound Pressure Level (A_R).

c. If desired, optional Representative Octave Band Sound Pressure Level (OB_R).

d. Operating conditions at which (A_R) and (OB_R) are specified (see Section 7).

6.2 *Data Presentation.* When a sound test is conducted in accordance with this standard, a report shall be supplied and it shall include the information in 6.2.1; 6.2.2 and 6.2.3. In addition, the data defined in 6.2.4 should be provided when specified by the user.

6.2.1 Statement that the test was conducted in accordance with ARI Standard 575.

6.2.2 Description of the machine, the operating conditions and a sketch showing the test layout and microphone locations (see Appendix B for Form and sample calculation).

6.2.3 Representative "A"-Weighted Sound Pressure Level (A_R) or *Representative High Limit Sound Pressure Level (A_H)* as calculated per 5.2. A_H will be reported only if the data for computing A_R cannot be obtained. If the latter course is followed, the reasons that the A_R cannot be obtained shall be submitted to the user.

6.2.4 Representative Octave Band Sound Pressure Levels at (OB_R) or Representative High Limit Octave Band Sound Pressure Levels (OB_H), in the 63 Hz through 8000 Hz bands, inclusive, as calculated high limit. OB_H levels, calculated per 5.2, shall only be reported in the case that OB_R levels cannot be obtained. If the latter course is followed, the reasons that the lower value OB_R cannot be obtained shall be submitted to the user.

Section 7. System Operating Conditions

7.1 *Operating Conditions for Test.* Sound tests shall be made with the machine operating at design operating conditions. If this operating point cannot be obtained, the sound test may be made at some other steady state condition mutually agreed upon by the parties concerned. This condition shall clearly be described in the test report. See Appendix A for examples of typical report forms.

Section 8. Voluntary Conformance

8.1 *Conformance.* While conformance with this standard is voluntary, conformance shall not be claimed or implied for products or equipment within its *Purpose* (Section 1) and *Scope* (Section 2) unless such claims meet all of the requirements of the standard.

APPENDIX A

Operating Conditions

The following data forms shown in this appendix are intended as a guide to ensure that adequate data are recorded. Because of the wide range of machinery which can be expected to be installed in building machinery spaces, a universal data form is not practical. If the attached forms are not adequate, one should be tailored to meet individual requirements.

CENTRIFUGAL CHILLER OPERATIONAL DATA RECORDING FORM PER ARI STANDARD 575

MACHINE SPECIFICATIONS:

Model: _____ Manufacturer: _____ Serial: _____

Rated Compressor Speed: _____ Capacity: _____

Rated Load Amperage: _____ Volts: _____

Type of Driver: _____ Refrigerant: _____

Auxiliaries, such as Gears: _____

Comments: _____

_____

TEST CONDITIONS:

Suction Temperature/Pressure	_____ °F [°C]/	_____ psig [kPa]
Chilled Water Temperature In/Out	_____ °F [°C]/	_____ °F [°C]
Chilled Water Pressure In/Out	_____ psig [kPa]/	_____ psig [kPa]
Discharge Temperature/Pressure	_____ °F [°C]/	_____ psig [kPa]
Condenser Water Temperature In/Out	_____ °F [°C]/	_____ °F [°C]
Condenser Water Pressure In/Out	_____ psig [kPa]/	_____ psig [kPa]
Interstage(s) Temperature/Pressure	_____ °F [°C]/	_____ psig [kPa]
	_____ °F [°C]/	_____ psig [kPa]
Compressor Speed	_____ rpm	
Compressor Capacity Control Position	_____	
Driver Speed	_____ rpm	
Electric Motor	_____ amps	_____ volts
Steam Turbine Pressures:		
Before Control Valve	_____ psig [kPa]	
Steam Chest	_____ psig [kPa]	
Condenser	_____ psig [kPa]	

RECIPROCATING CHILLER OPERATIONAL DATA RECORDING FORM PER ARI STANDARD 575

MACHINE SPECIFICATIONS:

Model:_____ Manufacturer:_____ Serial:_____

Rated Compressor Speed:_____ Capacity:_____

Rated Load Amperage:_____ Volts:_____

Type of Driver:_____ Refrigerant:_____

Auxiliaries, such as Gears:_____

Comments:_____

_____

TEST CONDITIONS:

Suction Temperature/Pressure	_____°F [°C]/	_____ psig [kPa]
Chilled Water Temperature In/Out	_____°F [°C]/	_____ °F [°C]
Chilled Water Pressure In/Out	_____psig [kPa]/	_____ psig [kPa]
Discharge Temperature/Pressure	_____°F [°C]/	_____ psig [kPa]
Condenser Water Temperature In/Out	_____°F [°C]/	_____°F [°C]
Condenser Water Pressure In/Out	_____psig [kPa]/	_____ psig [kPa]
Number of Compressors	_____	
Number of Compressors Running	_____	
Compressor Speed	_____rpm	
Electric Motor—Compressor 1	_____amps	_____ volts
2	_____amps	_____ volts
3	_____amps	_____ volts
4	_____amps	_____ volts

ABSORPTION CHILLER OPERATIONAL DATA RECORDING FORM PER ARI STANDARD 575

MACHINE SPECIFICATIONS:

Model:_____ Manufacturer:_____ Serial:_____

Capacity:_____ Pump Speed:_____

Heat Source: Steam: _____ Hot Water:_____

Rated Steam Pressure:_____ Rated Hot Water Temperature:_____

Type and Location of Steam (Hot Water) Control Valve: _____

Comments:_____

TEST CONDITIONS:

Chilled Water Temperature In/Out	_____°F [°C]/	_____ °F [°C]
Chilled Water Pressure In/Out	_____psig [kPa]/	_____ psig [kPa]
Condenser Water Temperature—Absorber In/Out	_____°F [°C]/	_____°F [°C]
Condenser Water Pressure—Absorber In/Out	_____psig [kPa]/	_____ psig [kPa]
Condenser Water Temperature—Condenser In/Out	_____°F [°C]/	_____°F [°C]
Condenser Water Pressure—Condenser In/Out	_____psig [kPa]/	_____ psig [kPa]
Capacity Control Valve Position	_____	
Steam (Hot Water) Pressure at Control Valve Upstream/Downstream	_____psig [kPa]/	_____psig [kPa]
Steam (Hot Water) Temperature at Control Valve Upstream/Downstream	_____°F [°C]/	_____°F [°C]

PUMP OPERATIONAL DATA RECORDING FORM PER ARI STANDARD 575

MACHINE SPECIFICATIONS:

Model:_____ Manufacturer:_____ Serial:_____

Rated Pump Speed:_____ Capacity:_____

Rated Load Amperage:_____ Voltage:_____

Type of Driver:_____ Type of Pump:_____

Auxiliaries, such as Gears:_____

Comments:_____

TEST CONDITIONS:

Fluid Being Pumped	_____
Suction Temperature/Pressure	_____ °F [°C]/ _____ psig [kPa]
Discharge Temperature/Pressure	_____ °F [°C]/ _____ psig [kPa]
Pump Speed	_____ rpm
Driver Speed	_____ rpm
Electric Motor	_____ amps _____ volts

APPENDIX B. SOUND LEVEL RECORDING FORMAT PER ARI STANDARD 575

Unit Type _____

Model Number _____

Serial Number _____

Measurement Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
db(A) Test Unit ON																										
db(A) Test Unit Off																										

A-Weighted Sound Pressure Level dbA AR _____ or AH _____

Hz	Octave Band Sound Pressure Levels at Key Measurement Points								
	Key Location ( )		Key Location ( )		Key Location ( )		Key Location ( )		
	Test Unit ON	Test Unit Off	Test Unit ON	Test Unit OFF	Test Unit ON	Test Unit OFF	Test Unit ON	Test Unit OFF	Average Octave Band Level
63									
125									
250									
500									
1000									
2000									
4000									
8000									

*Indicates uncertain measurements (See 5.2.1 of standard)

Sketch Showing Microphone Locations, Orientation of Test Unit, Key Measurement Points, and Surroundings

Tested By: _____ Reported By: _____ Date: _____

SOUND RECORDING FORMAT PER ARI STANDARD 575

Unit Type _____
Model Number _____
Serial Number _____

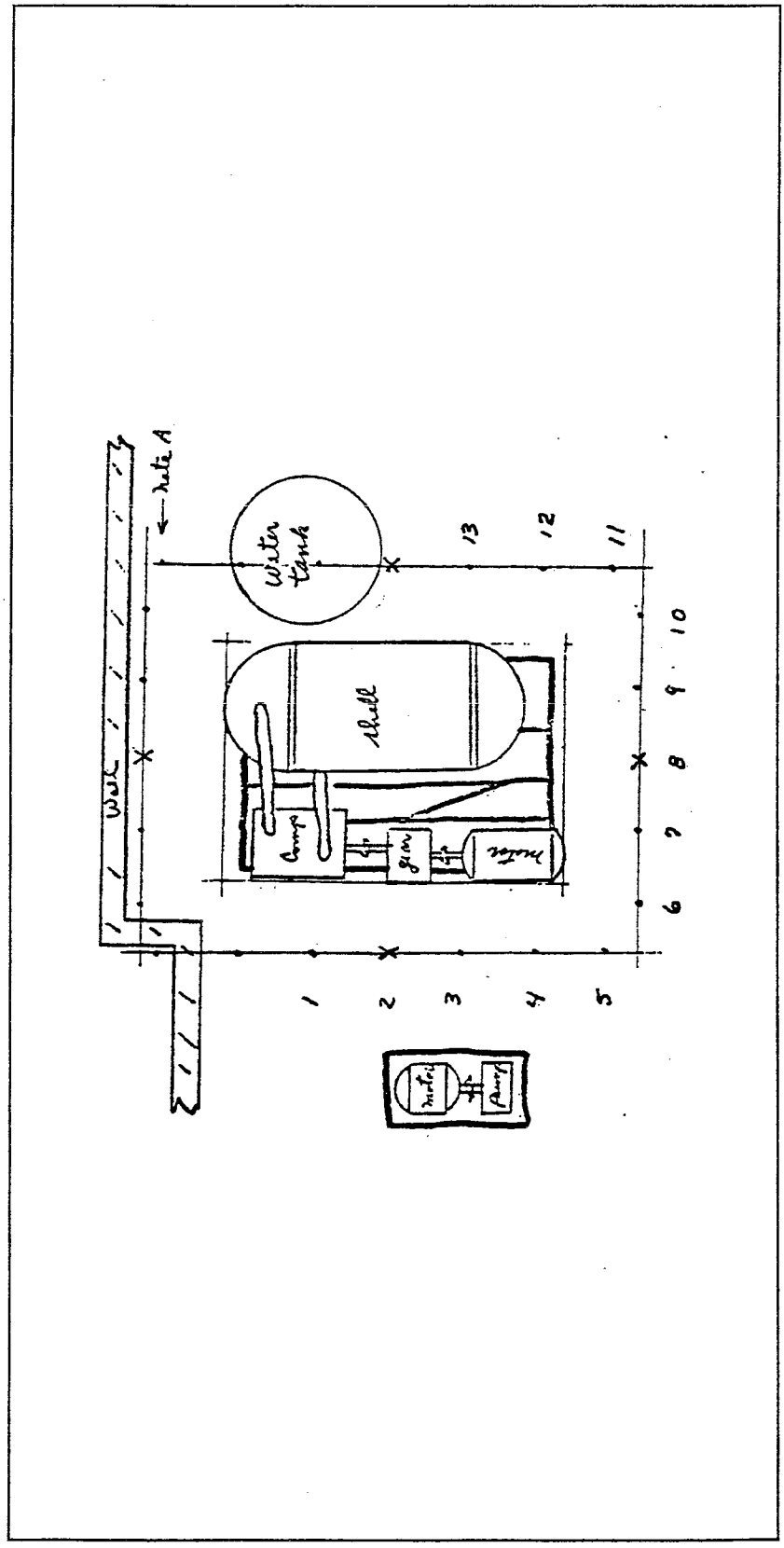
Measurement Position		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Db(A)	Test Unit ON	89	88	87	89	91	90	90	90	90	88	87	87	87													
dB(B)	Test Unit OFF	80	84 70	82 70	81 68	80	81	80	78	79	80	80	80	80													

Notes B & D

A-Weighted Sound Pressure Level dBA AR_____ or AH_____

Hz	Octave Band Sound Pressure Levels at Key Measurement Points								Note C Average Octave Band Level
	Key Location (2)		Key Location (8)		Key Location ( )		Key Location ( )		
	Test Unit ON	Test Unit OFF	Test Unit ON—Note C	Test Unit OFF	Test Unit ON	Test Unit OFF	Test Unit ON	Test Unit OFF	
63	77*	75	81*	76					OB_H 79.5*
125	83	70	84	70					OB_R 83.5
250	85	72	87	71					OB_R 865
500	86	74	88	71		NO MEASUREMENTS CAN BE MADE AT THESE LOCATIONS Note A			OB_R 87
1000	85	73	86	74					OB_R 85.5
2000	80 - 87	72	77*	72					OB_H 81.5*
4000	70 - 84*	68 - 82	60 - 82*	60 - 81					OB_H 80*
8000	73	55	73	56					OB_R 73

*Indicates uncertain measurements (see 5.2.1 of standard)
Note B
Notes B & C



Sketch Showing Microphone Locations, Orientation of Test Unit
Key Measurement Points and Surroundings

Tested By: [redacted]

Reported By: [redacted]

Date: 1-16-94

SAMPLE CALCULATIONS

Sample calculation for a water chiller where the measurement procedure is complicated by

1) the close proximity of a wall,
2) the close proximity of a water tank,
3) a pure tone generated in the gear box at 2,000 Hz,
4) a pure tone generated by an adjacent pump at 4,000 Hz,
5) high background level in the 63 Hz band.

To obtain the Representative "A" Weighted Sound Pressure Level

(Note D)

$$A_R = 10 \log_{10} \left[antilog_{10} \frac{89}{10} + antilog_{10} \frac{88}{10} + antilog_{10} \frac{87}{10} + antilog_{10} \frac{89}{10} + antilog_{10} \frac{91}{10} + antilog_{10} \frac{90}{10} \right]$$

$$\left[+ antilog_{10} \frac{90}{10} + antilog_{10} \frac{90}{10} + antilog_{10} \frac{90}{10} + antilog_{10} \frac{88}{10} + antilog_{10} \frac{87}{10} + antilog_{10} \frac{88}{10} + antilog_{10} \frac{87}{10} \right]$$

$$- 10 \log_{10} 13$$

$A_R = 100.1 - 11.1$

$= 89.0$ dB (Note E)

To obtain the Representative Octave Band Sound Pressure at 1 Meter

For the 63 Hz Band:

(Note C)

$$OB_H = 10 \log_{10} \left(antilog_{10} \frac{77*}{10} + antilog_{10} \frac{81*}{10} \right) - 10 \log_{10} 2$$

$OB_H = 79.4$ dB; use 79.5 dB

For the 125 Hz Band:

$$OB_R = 10 \log_{10} \left(antilog_{10} \frac{83}{10} + antilog_{10} \frac{84}{10} \right) - 10 \log_{10} 2$$

$OB_R = 83.4$ dB; use 83.5 dB

For the 2000 Hz Band:

(Note B)

$$OB_H = 10 \log_{10} \left(antilog_{10} \frac{87 - 3}{10} + antilog_{10} \frac{77*}{10} \right) - 10 \log_{10} 2$$

$OB_H = 81.7$ dB; use 81.5 dB

NOTE A: No measurements can be taken at these points because they are less than 1 meter from large surfaces (see 5.1.4).

NOTE B: Two values are recorded because of the pure tones present (see 5.1.5). The value used in the calculations shall be 3 dB below the highest value (see 5.2.2).

NOTE C: A valid measurement must be 6 dB above the ambient (see 5.2.1). Final results using these values less than 6 dB above background result in Representative High Limit Values.

NOTE D: The level of the ambient here is 84 - 3 = 81 dB. This is 7 dB below the measured value and is an acceptable measurement.

NOTE E: Thirteen valid measurements exist out of a possible 24 measurements. This is greater than half, and a value of A_R can be obtained. See the last statement of 5.2.3.

APPENDIX C. REFERENCES

Listed here are all standards, handbooks, and other publications essential to the formation and implementation of the standard. All references in this appendix are considered as part of this standard.

ASHRAE Terminology of Heating, Ventilation, Air-Conditioning and Refrigeration, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1991.

ANSI Standard S1.11-1986, Specifications for Octave, Half-Octave, and Third-Octave Band Filter Sets, American National Standards Institute.