ANSI/AHRI Standard 370

2015 Standard for

Sound Performance Rating of Large Air-cooled Outdoor Refrigerating and Air-conditioning Equipment

Approved by ANSI on November 6, 2015

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Note:

This standard supersedes ANSI/AHRI Standard 370-2011.

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LARGE AIR-COOLED 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 Air-cooled Outdoor Refrigerating and Air-conditioning Equipment. It establishes definitions; test requirements; rating requirements; minimum data requirements for Published Ratings; 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 air-cooled outdoor portions of factory-made commercial and industrial Large Air-cooled Outdoor Refrigerating and Air-conditioning Equipment greater than 40kW cooling capacity. This equipment is covered by AHRI Standard 340/360, *Performance Rating of Commercial and Industrial Unitary Air-conditioning* and *Heat Pump Equipment*, ANSI/AHRI Standards 365 (I-P) and 366 (SI), *Commercial and Industrial Unitary Air-conditioning Condensing Units*, ANSI/AHRI Standard 520, *Performance Rating of Positive Displacement Condensing Units,* ANSI/AHRI Standard 460, *Performance Rating of Remote Mechanical-draft Air-cooled Refrigerant Condensers*, AHRI Standards 490 (I-P) and 491 (SI), *Remote Mechanical-draft Evaporatively-cooled Refrigerant Condensers*, as well as AHRI Standards 550/590 (I-P) and 551/591 (SI), *Performance Rating of Water Chilling Packages Using the Vapor Compression Cycle*.

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 AHRI Standard 270, *Sound Rating of Outdoor Unitary Equipment* (cooling capacity ratings of less than 40 kW).

Section 3. Definitions

All terms in this document will follow the standard industry definitions in the *ASHRAE Terminology* website (https://www.ashrae.org/resources--publications/free-resources/ashrae-terminology) 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 Air-cooled 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.

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

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

3.11 *Sound Intensity Level, L_i*. Ten times the logarithm to the base ten of the ratio of the sound intensity component radiated by the source to a reference sound intensity, expressed in decibels (dB). The reference sound intensity used in this standard is 1 picowatt per square meter, pW/m^2 (internationally recognized units). The sound intensity component is the value of the intensity vector, normal to a measurement surface, directed out of a volume enclosing the sound source.

3.12 *Sound Power Level, L_w*. 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).

3.12.1 *A-weighted Sound Power Level, L_{wA}*. The logarithmic summation of A-weighted, one-third octave band levels.

3.13 *Sound Pressure Level, L_p.* 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.

3.14 *Sound Quality Indicator (SQI).* The calculated metric determined when following the procedure contained in ANSI/AHRI Standard 1140 for quantifying sound quality whereby measured sound levels are weighted to adjust for psychoacoustic sensitivity to frequency distribution and any discreet tones which may be present and then converted to a single number Sound Quality Indicator.

3.15 *Unit Under Test (UUT).* HVAC equipment for which the sound power is to be determined.

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 room, or an indoor or outdoor space that is an essentially free field over a reflecting plane.

4.1.1 Sound tests in a reverberation room shall be conducted in a reverberation room meeting the requirements of and is qualified per ANSI/AHRI Standard 220. Sound tests shall be conducted in accordance with ANSI/AHRI Standard 220 using a RSS that meets the performance requirements of and is calibrated per ANSI/AHRI Standard 250.

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 Air-cooled 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 Air-cooled Outdoor Refrigerating and Air-conditioning Equipment in Appendix C of this standard.

4.1.4 Sound tests using sound intensity shall be conducted in accordance with ANSI/AHRI Standard 230, as adapted for Large Air-cooled Outdoor Refrigerating and Air-conditioning Equipment. For this equipment, the sound component of interest as discussed in Section 7 of ANSI/AHRI Standard 230 is the entire unit. The measurement grid shall enclose the entire unit.

4.2 *Test Conditions*. 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. 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 sound measurements shall be made with the equipment operating at the AHRI standard thermal rating condition.

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

Note: Where applicable, manufacturers should account for contributions from exhaust fan(s), return fan(s), and indoor fan(s) which would be measured per ANSI/AHRI Standards 260 (I-P) and 261 (SI) and be added to ANSI/AHRI Standard 370 Sound Rating.

4.2.3 *Fan(s) Only Sound Rating (Optional).* The compression equipment shall be turned off and sound readings taken with only the outdoor fans operating. The speed of the fan shall be controlled to match within ± 3% of the speed during the rating condition.

4.2.4 *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

4.2.4.1 *Testing with Air Temperature Control*. When not simulating indoor or outdoor load, the air temperature shall be controlled to ± 1°C.

4.2.4.2 *Testing with Simulated Indoor-side Load*. When the indoor-side loading is simulated by a method not requiring air temperature control, the following tolerances apply during sound rating tests:

Evaporator pressure……± 15 kPa

4.2.4.3 *Testing with Simulated Outdoor-side Load.* When the outdoor-side loading is simulated by a method not requiring air temperature control, the following tolerances apply during sound rating tests:

Compressor discharge pressure……. ± 70 kPa

4.3 *Data to be Taken.* Sound level data taken shall be in One-third Octave Bands (50 Hz to 10,000 Hz are required) in accordance with the procedure specified for the type of test being conducted.

4.4 *Air Velocity at Measurement Positions.* Sound pressure level measurements shall not be made when the air velocity over the microphone exceeds 2.0 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. Sound Intensity Level measurements in airflow shall meet the requirements of ANSI/AHRI Standard 230 Section 6.3.

4.5 *Unit Installation*. The UUT shall be located within the reverberation room as specified in ANSI/AHRI Standard 220 when testing per Sections 4.1.2 or 4.1.3 of this standard or per ANSI/AHRI Standard 230 when testing per Section 4.1.4. Where applicable, unit supply and return ducting shall be lagged to prevent sound radiating from them (refer to ANSI/AHRI Standards 260 (I-P) and 261 (SI) for guidance in duct construction). Care must be taken to minimize the noise radiating from the connecting refrigerant piping on split systems or water piping on air-cooled chilled water systems.

Section 5. Rating Requirements

5.1 *Product Ratings.* The outdoor sound rating shall be for the complete unit operating at AHRI thermal rating condition.

5.1.1 *Required Rat*ings:
5.1.1.1 Un-weighted octave band Sound Power Levels, dB (63 Hz to 8,000 Hz)
5.1.1.2 Overall A-weighted Sound Power Level, dB (A-weighted 50 Hz to 10,000 Hz)
5.1.1.3 Thermal conditions and capacity

5.1.2 *Optional Information*:
5.1.2.1 Sound Quality Indicator (SQI) per ANSI/AHRI Standard 1140
5.1.2.2 Un-weighted one-third octave band Sound Power Levels, dB (50 Hz to 10,000 Hz)

5.2 *Application Ratings.* If these are to be published, application ratings shall include the following information:

5.2.1 *Required Ratings*:
5.2.1.1 Un-weighted octave band Sound Power Levels, dB (63 Hz to 8,000 Hz)
5.2.2.2 Overall A-weighted Sound Power Level, dB (A-weighted 50 Hz to 10,000 Hz)
5.2.2.3 Thermal conditions and capacity where applicable

5.2.2 *Optional Information*:
5.2.2.1 Sound Quality Indicator (SQI) per ANSI/AHRI Standard 1140
5.2.2.2 Un-weighted one-third octave band Sound Power Levels, dB (50 Hz to 10,000 Hz)

5.3 *Determination of Outdoor One-third Octave Band Sound Power Levels*. The unit's one-third octave band Sound Power Levels shall be determined per ANSI/AHRI Standard 220. The Unit Under Test shall be installed as specified by Section 4.5 of this standard.

5.3.1 *Octave Band Sound Power Level Calculations.* Octave band sound power level calculations shall be made per ANSI/AHRI Standard 220.

Each octave band Sound Power Level shall be rounded to the nearest decibel.

5.3.2 *A-weighted Sound Power Level.* The A-weighted Sound Power Level shall be calculated per ANSI/AHRI Standard 220.

The A-weighted Sound Power Level shall be rounded to the nearest decibel.

5.4 *Sound Quality Indicator Calculation (Optional).* If the Sound Quality Indicator of the outdoor unit is to be determined, the procedures in ANSI/AHRI Standard 1140 shall be used (see ANSI/AHRI Standard 1140 for example calculation). The SQI can be used for both full unit operation and fan(s) only operation.

5.5 *Rating Tolerances.* Any equipment tested in accordance with this standard shall have un-weighted octave band Sound Power Levels (L_w) and an overall A-weighted Sound Power Level (L_{wA}), not higher than their Published Ratings. An optional Sound Quality Indicator (SQI) or optional one-third octave band Sound Power Levels can be determined, none of which shall be higher than its Published Rating. (Refer to Appendix C.)

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

Section 6. Minimum Data Requirements for Published Ratings

6.1 *Published Ratings*. Published sound power ratings shall be for the unit with all components running that are necessary to produce the AHRI standard thermal rating. Additionally, sound power data may be published for the unit operating with only the fan(s) running or at application rating points. Variable speed equipment shall be operated at constant speed for the

duration of the test. For equipment with variable capacity compressors, the compressors shall be operated at rated and constant capacity for the duration of the test.

6.1.1 Required:

6.1.1.1 The octave band un-weighted Sound Power Levels to the nearest decibel from 63 Hz to 8,000 Hz

6.1.1.2 The overall A-weighted Sound Power Level to the nearest decibel covering the range of 50 Hz to 10,000 Hz

6.1.1.3 Sound measurement type; reverberant room, hemi-anechoic room, free-field over a reflecting plane or sound intensity

6.1.1.4 Thermal conditions, capacity, fan(s) and compressor(s) speed

6.1.1.5 Statement of options tested with the equipment. These options may include economizers, exhaust fans, high static drives and return fans.

6.1.2 Optional:

6.1.2.1 The Sound Quality Indicator (SQI)
6.1.2.2
6.1.2.3 The one-third octave band un-weighted Sound Power Levels

6.2 *Minimum Data Requirements for Published Ratings.* As a minimum, Published Ratings shall include all Standard Ratings. All claims to ratings within the scope of this standard shall include the statement "Rated in accordance with ANSI/AHRI Standard 370." All claims to ratings outside the scope of this standard shall include the statement "Outside the scope of ANSI/AHRI Standard 370." Wherever Application Ratings are published or printed, they shall include a statement of the conditions at which the ratings apply.

Section 7. Conformance Conditions

7.1 *Conformance.* While conformance with this standard is voluntary, conformance shall not be claimed or implied for products or equipment within the standard's *Purpose* (Section 1) and *Scope* (Section 2) unless such claims meet all of the requirements of the standard and all of the testing and rating requirements are measured and reported in complete compliance with the standard. Any product that has not met all the requirements of the standard cannot reference, state, or acknowledge the standard in any written, oral, or electronic communication.

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/AHRI Standard 270-2015, *Sound Rating of Outdoor Unitary Equipment*, 2008, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.2 ANSI Standard S1.11-2004, *Specification for Octave-Band and Fractional Octave-Band Analog and Digital Filters*, 2004, American National Standards Institute, 25 West 43rd Street, 4th Fl., New York, NY 10036, U.S.A.

A1.3 ANSI/AHRI Standard 220-2014, *Reverberation Room Qualification and Testing Procedures for Determining Sound Power of HVAC Equipment*, 2014, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.4 ANSI/AHRI Standard 230-2013, *Sound Intensity Testing Procedures for Determining Sound Power of HVAC Equipment*, 2013, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.5 ANSI/AHRI Standard 250-2013, Performance and Calibration of Reference Sound Sources, 2013, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.6 ANSI/AHRI Standard 260 (I-P)-2012, *Sound Rating of Ducted Air Moving and Conditioning Equipment*, 2012, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.7 ANSI/AHRI Standard 261 (SI)-2012, *Sound Rating of Ducted Air Moving and Conditioning Equipment*, 2012, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.8 ANSI/AHRI Standard 340/360-2007 with Addendum 2, *Performance Rating of Commercial and Industrial Unitary Air-Conditioning* and *Heat Pump Equipment*, 2007, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.8 ANSI/AHRI Standard 365 (I-P)-2009, *Commercial and Industrial Unitary Air-Conditioning Condensing Units*, 2009, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.10 ANSI/AHRI Standard 366 (SI)-2009, *Commercial and Industrial Unitary Air-Conditioning Condensing Units*, 2009, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.11 ANSI/AHRI Standard 460-2005, *Performance Rating of Remote Mechanical-Draft Air-Cooled Refrigerant Condensers*, 2005, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.12 ANSI/AHRI Standard 490 (I-P)-2011, *Remote Mechanical-Draft Evaporatively-Cooled Refrigerant Condensers*, 2003, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.13 ANSI/AHRI Standard 491 (SI)-2011, *Remote Mechanical-Draft Evaporatively-Cooled Refrigerant Condensers*, 2003, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.14 ANSI/AHRI Standard 520-2004, *Performance Rating of Positive Displacement Condensing Units*, 2004, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.15 ANSI/AHRI Standard 550/590 (I-P)-2011 with Addendum 3, *Performance Rating of Water Chilling Packages Using the Vapor Compression Cycle*, 2011, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.16 ABSI/AHRI Standard 551/591 (SI)-2011 with Addendum 3, *Performance Rating of Water Chilling Packages Using the Vapor Compression Cycle*, 2011, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.17 ANSI/AHRI Standard 1140-2012, *Sound Quality Evaluation Procedures for Air-Conditioning and Refrigeration Equipment*, 2012, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.18 *ASHRAE Terminology*, https://www.ashrae.org/resources--publications/free-resources/ashrae-terminology, 2014, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.19 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*, 2009, International Organization for Standardization, Case Postale 56, CH-1211, Geneva 21 Switzerland.

A1.20 ISO 3745, Acoustics -- *Determination of sound power levels of noise sources using sound pressure -- Precision methods for anechoic and hemi-anechoic rooms*, 2003, International Organization for Standardization, Case Postale 56, CH-1211, Geneva 21 Switzerland.

APPENDIX B. REFERENCES – INFORMATIVE

B1 Listed here are standards, handbooks, and other publications which may provide useful information and background but are not considered essential. References in this appendix are not considered part of the standard.

None.

APPENDIX C. EXPECTED SIZE OF MEASUREMENT ERRORS – INFORMATIVE

Table C1. Maximum Standard Deviations of Sound Power Level Reproducibility Determined in Accordance with this Standard

One-third Octave Band Center Frequency, Hz	One-third Octave Band Maximum Standard Deviation of Reproducibility, σ_{R0}, dB
50 - 80	4.0
100 - 160	3.0
200 - 315	2.0
400 - 5,000	1.5
6,300 - 10,000	3.0
Octave Band Center Frequency, Hz	Octave Band Maximum Standard Deviation of Reproducibility, σ_{R0}, dB
63	3.5
125	2.5
250	1.5
500 - 4,000	1.0
8,000	2.0
A-weighted 50-10,000 Hz	A-weighted Maximum Standard Deviation of Reproducibility, σ_{R0}, dB
A-weighted	0.5[1]

Note: 1. Applicable to a source which emits noise with a relatively "flat" spectrum in the frequency range 50 Hz to 10,000 Hz.

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

Section D1. Purpose

D1.1 *Purpose*. The purpose of this appendix is to provide a procedure for determining the Sound Power Levels (L_w) 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 D2. Test Method

D2.1 *Instrumentation.* The instrumentation and instrumentation systems employed shall meet the requirements of ANSI/AHRI Standard 220 except that the measurement microphone(s) shall be free field type.

D2.2 *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.

D2.2.1 The reflecting plane shall extend at least 3.5 m beyond the measurement surface. This distance is approximately equal to half a wavelength ($\lambda/2$) at 50 Hz (the lowest frequency of interest).

D2.2.2 The site shall meet the qualification requirements of ISO 3744 or ISO 3745 as applicable.

D2.2.3 The need for and the value of the environmental correction (K_2) to account for departures of the test environment from the ideal condition shall be determined using the procedure described in Appendix E. For the purposes of this document, the value of K_2 shall be limited to: -2.0 dB ≤ K_2 ≤ + 2.0 dB. The environmental correction (K_2) shall be determined by test only using a vertical shafted RSS that meets the requirements of and is calibrated per ANSI/AHRI Standard 250.

D2.3 *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, which 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.

D2.3.1 The measurement parallelepiped on which the microphones are positioned is a 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.

D2.3.2 The area of the measurement surface (*S*) is given by Equation D1 below:

$$S = \pi \cdot (L/2) \cdot (W/2+H) \qquad D1$$

Where:

H = Height of the measurement parallelepiped, m
L = Length of the measurement parallelepiped, m
S = Measurement surface area, m^2
W = Width of the measurement parallelepiped, m
Such that $L \geq W$ (Figures D1 and D2).

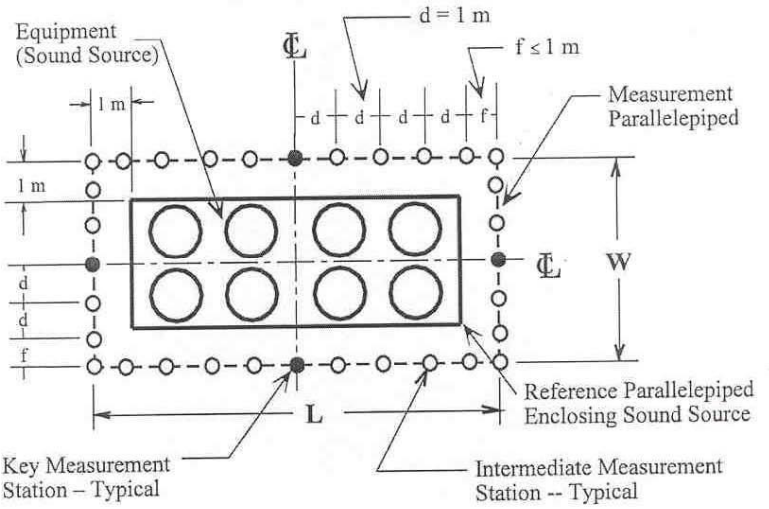

Figure D1. Plan View of Measurement Parallelepiped

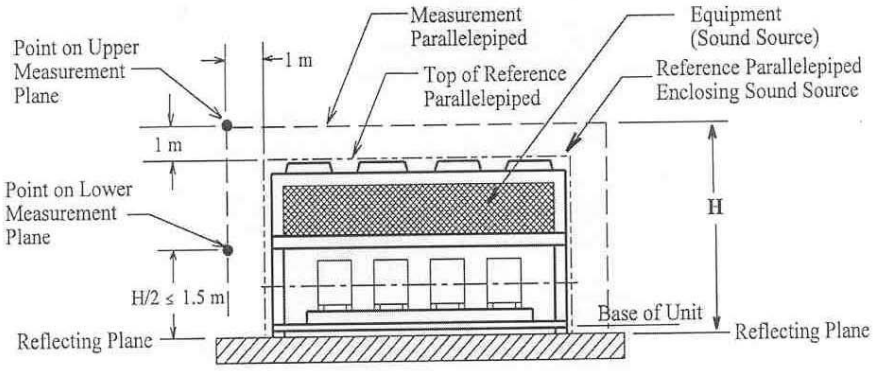

Figure D2. Elevation of Measurement Parallelepiped

Note: Equation D1 calculates an equivalent hemisphere area which is based on empirical data to give equivalency between the survey method and reverberation room method.

D2.3.3 The key measurement stations shall be located at the mid-point of each of the four sides of the measurement parallelepiped (Figure D1).

D2.3.3.1 Additional intermediate measurement stations shall be added extending outward at 1.0 m intervals from the key stations towards the corners of the measured parallelepiped. The distance between the last immediate and the corner stations may be less than, but shall be no greater than 1.0 m (Figure D1).

D2.3.3.2 Measurements shall be taken at two elevations at each station. The uppermost shall be in a horizontal plane 1.0 m above the top of the reference parallelepiped. The height (H) of the uppermost microphone shall not exceed 6.0 m. The second shall be at a level 1.5 m above the reflecting plane (Figure D2). If the height of the reference parallelepiped is 3.0 m or less, then measurements are only required at a height of 1.5 m.

D2.3.3.3 The surface Sound Pressure Level, 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.

D2.4 *Data to be Taken.* The Sound Pressure Level shall be measured and recorded in each of the One-third Octave Bands from 50 Hz to 10,000 Hz at each measurement position.

D2.4.1 A full set of measurements shall be taken with the equipment operating in the mode specified in Section 4.2.1 of this standard.

D2.4.2 An additional measurement run shall be made to determine the background noise level at each measurement position.

Section D3. Calculation of Results

D3.1 *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 and the correction for each microphone position and frequency shall be determined per ANSI/AHRI Standard 220.

D3.2 *Calculation of Surface Sound Pressure Level.* For each One-third Octave Band, once the measured value has been corrected for background noise, calculate the average Sound Pressure Level over the measurement surface ($\overline{L}_P$) adjusted for the environmental effects ($\overline{L}_{Pf}$) using Equations D2 and D3.

$$\overline{L}_P = 10 \cdot \log_{10}\left(\frac{1}{M}\sum_{m=1}^{M} 10^{0.10 \cdot L_{P(m)}}\right) \quad \text{D2}$$

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 mth measurement, in dB, re: 20 μPa
M = The total number of measurement positions

$$\overline{L}_{Pf} = \overline{L}_P - K_2 \quad \text{D3}$$

Where:

K_2 = Mean value of environmental correction over the measurement surface in decibels, as determined from Appendix E
$\overline{L}_{Pf}$ = Surface Sound Pressure Level in dB, re: 20 μPa

E3.3 *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 using Equation D4.

$$L_{W(n)} = \overline{L}_{Pf} + 10 \cdot \log\left(\frac{S}{S_0}\right) \quad \text{D4}$$

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 = 1.0 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 E. DETERMINATION OF K_2 – NORMATIVE

Section E1. Purpose

E1.1 *Purpose.* The purpose of this appendix is to provide a procedure for determining a correction factor, K_2, which quantifies the behavior of a test environment that deviates slightly from a free-field over a reflecting plane or a hemi-anechoic test room. This factor is used to mitigate the effects that the reverberant build-up of acoustic energy in the space will have on the calculation of sound power. The method detailed in this appendix compares a series of reference sound source sound pressure level measurements made in a known environment (controlled measurement space) with a series of identical sound pressure level measurements made in the test space (where actual chiller sound measurements will be made) to calculate the correction factor.

Section E2. Test Method

E2.1 *Instrumentation.* The instrumentation and instrumentation systems employed shall meet the requirements of ANSI/AHRI Standard 220 except that the measurement microphone(s) shall be a 12 mm diameter free field microphone with a windscreen. For all measurements, the microphone shall be oriented to point directly at the RSS.

E2.2 *Test Environments.* The test site for the controlled measurement shall be a flat, indoor or outdoor area free of reflecting objects other than the reflecting plane on which the test unit sits, such that the source radiates into a free field over a reflecting plane. The controlled measurement site shall meet the requirements of Section E2.2.

Note: As examples, an outdoor space on a hard reflective surface with no walls (or obstructions) within 15 meters of the parallelepiped surface should qualify as a free field or a hemi-anechoic room qualified in accordance with ISO 3745 would meet the requirements for the test environment for the control series of measurements.

E2.3 *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, which will just enclose the machine to be tested. 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.

E2.3.1 The measurement parallelepiped on which the microphones are positioned is a hypothetical surface 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.

E2.3.2 The key measurement stations shall be located at the mid-point of each of the four sides of the measurement parallelepiped (Figure D1).

E2.3.3 Additional intermediate measurement stations shall be added extending outward at 1 m intervals (d) from the key stations towards the corners of the measured parallelepiped. The distance (f) between the last intermediate stations may be less than, but shall be no greater than 1 m (Figure D1).

E2.3.4 The exact measurement parallelepiped shall be used for both the measurements conducted in the control space and in the test area.

E2.3.5 Measurements shall be taken at two elevations at each station. The uppermost shall be in a horizontal plane 1.0 m above the top of the reference parallelepiped. The 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 D2).

E2.4 *Reference Sound Source Positions.* The required number of reference sound source positions is a function of the length of the measurement parallelepiped and shall be determined using Figure D1 and Table E1.

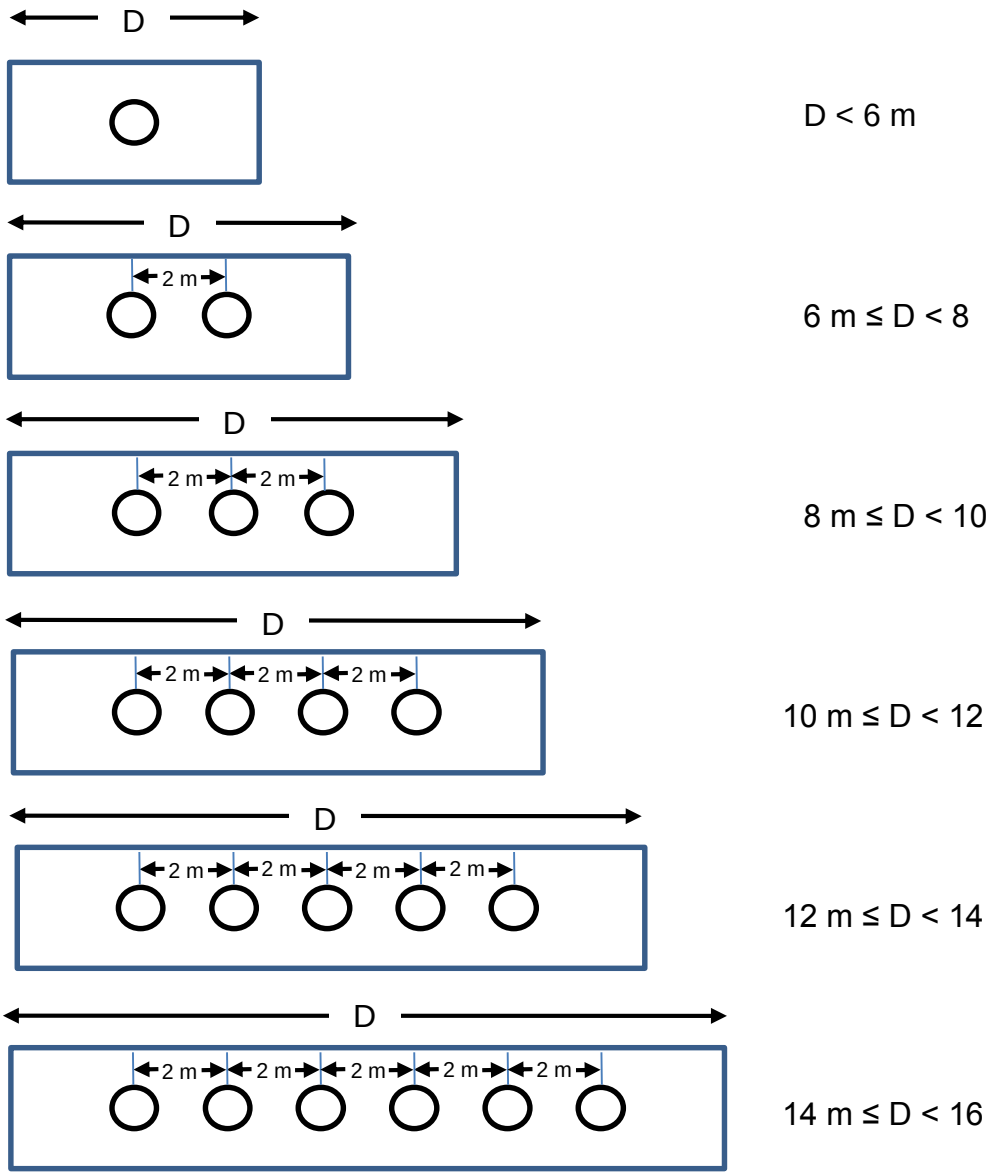

Figure E1. Schematic of RSS Locations Required for Determination of K_2

Table E1. Required Number of RSS Positions Based on Parallelepiped Length	
Measurement Parallelepiped Length, D(m)	Number of RSS positions
D < 6	1
6 ≤ D < 8	2
8 ≤ D < 10	3
10 ≤ D < 12	4
12 ≤ D < 14	5
14 ≤ D < 16	6

E2.5 *Test Procedure – Qualified Room or Free-field Area (Control).* In the qualified test area, the Sound Pressure Level shall be measured and recorded in each of the One-third Octave Bands from 50 Hz to 10,000 Hz at each measurement position using the following steps:

E2.5.1 Place the RSS at one of the source locations as indicated in Figure E1.

E2.5.2 Position a microphone in a consistent location and orientation relative to each position of the RSS at least 2 meters but not greater than 3 meters from the RSS. This measurement is used to monitor the stability of the RSS. Data at this fixed microphone shall be taken simultaneously with the measurements of the parallelepiped position data. The sound pressure level measured at this fixed location shall not vary by more than 0.5 dB over the duration of the test in any of the One-third Octave Bands from 50 Hz to 10,000 Hz in order for the measurement to be considered valid.

E2.5.3 Acquire one-third octave band sound pressure level data at each of the measurement positions on the parallelepiped with the RSS not in operation.

E2.5.4 Acquire one-third octave band sound pressure level data at each of the measurement positions on the parallelepiped with the RSS operating.

E2.5.4.1 If multiple RSS positions are required per Section E2.4, relocate the RSS to the additional position(s) and repeat the step in Section E.5.4.

E2.6 *Test Procedure –Sound Test Area.* The Sound Pressure Level shall be measured and recorded in each of the One-third Octave Bands from 50 Hz to 10,000 Hz at each measurement position in the test area using the method outlined in Sections E2.5.1 through E2.5.4.1.

Section E3. Calculation of Results

E3.1 *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 and the correction for each microphone position and frequency shall be determined per ANSI/AHRI Standard 220 for both sets of data acquired in Sections E2.5 and E2.6.

E3.2 *Calculation of Surface Sound Pressure Level – Control Area.* For each One-third Octave Band, once the measured values from Section E2.5 have been corrected for background noise, calculate the average Sound Pressure Level over the control area measurement surface ($\overline{L}_{P_{CONTROL}}$) using Equation E1.

$$\overline{L}_{P_{CONTROL}} = 10 \cdot \log_{10}\left(\frac{1}{M} \sum_{m=1}^{M} 10^{0.10 \cdot L_{P(m)}} \right) \qquad \text{E1}$$

Where:

$\overline{L}_{P\ CONTROL}$ = Sound Pressure Level for each One-third Octave Band, averaged over the control 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 measurements made including all RSS locations

E3.3 *Calculation of Surface Sound Pressure Level – Test Area.* For each One-third Octave Band, once the measured values from Section E2.6 have been corrected for background noise, calculate the average Sound Pressure Level over the test area measurement surface ($\overline{L}_{P_{TEST}}$) using Equation E2.

$$\overline{L}_{P_{TEST}} = 10 \cdot \log_{10}\left(\frac{1}{M} \sum_{m=1}^{M} 10^{0.10 \cdot L_{P(m)}} \right) \qquad \text{E2}$$

Where:

$\overline{L}_{P\ TEST}$ = Sound Pressure Level for each One-third Octave Band, averaged over the test 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 measurements made including all RSS locations

E3.4 *Calculation of K_2.* For each One-third Octave Band, the environmental correction, K_2 can be calculated by subtracting the average sound pressure level for the control area from the test area using Equation E3.

$$K_2 = \overline{L}_{P_{TEST}} - \overline{L}_{P_{CONTROL}} \quad \text{E3}$$