Note: This standard has been withdrawn because the terms and values produced by using it have not been widely accepted and are no longer supported by the member companies.

AHRI Standard 1140

Withdrawn from publication July 23, 2021

Standard for 2012

Sound Quality Evaluation Procedures for Air-Conditioning and Refrigeration Equipment

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Note:

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Withdrawn from publication July 23, 2021.
AHRI administratively withdrew support of ANS. (Was ANSI/AHRI Standard 1140-2012.)

This standard supersedes AHRI Standard 1140-2006.

Foreword:

Sound quality is subjective and its acceptability depends upon many factors including, but not limited to, the type of equipment being evaluated, the intended application for the equipment, ambient background sound where the equipment is to be applied and the listening audience. A variety of procedures are described and recommendations made to help the user select the most appropriate method for a given situation. However, it will be the responsibility of the user to insure that the chosen procedure does indeed provide a reasonable Sound Quality Indicator for the equipment being evaluated.

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SOUND QUALITY EVALUATION PROCEDURES FOR AIR-CONDITIONING AND REFRIGERATION EQUIPMENT

Section 1. Purpose

1.1 *Purpose*. The purpose of this standard is to establish sound quality evaluation procedures for air-conditioning and refrigeration equipment and to provide definitions; test requirements; sound quality evaluation procedures; 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 factory-made, residential and commercial air-conditioning as well as transport refrigeration equipment.

Section 3. Definitions

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

3.1 *Center Frequency.* The arithmetic center of a constant bandwidth filter or the geometric center (midpoint on a logarithmic scale) of a constant bandwidth filter. Each Octave Band or One-third Octave Band is named for the Center Frequency (geometric mean) of the band.

3.2 *Loudness.* Numerical designation of the strength of a sound which is proportional to its subjective magnitude as estimated by typical observers.

3.2.1 *Phon.* The Loudness level of a sound. It is numerically equal to the Sound Pressure Level of a 1 kHz free progressive wave which is judged by listeners with full hearing capability to be as loud as the unknown sound.

3.2.2 *Sone*. A linear unit of Loudness. The ratio of Loudness of a sound to that of a 1 kHz tone 40 dB above the threshold of hearing. One Sone is the Loudness of a sound whose Loudness level is 40 Phons.

3.3 *Octave Band (Hz)*. 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.

3.4 *One-third Octave Band (Hz)*. 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.

3.5 *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. 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.

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

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

3.6 *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.

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

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

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

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

3.8 *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.

3.8.1 *A-weighted Sound Power Level, L_{WA}*. The logarithmic summation of A-weighted, one-third octave band Sound Power Levels.

3.9 *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.

3.9.1 *A-weighted Sound Pressure Level, L_{PA}*. The logarithmic summation of A-weighted, one-third octave band Sound Pressure Levels.

3.10 *Sound Quality Indicator (SQI).* The calculated metric determined when following AHRI's procedure for quantifying sound quality (Appendix C) 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.

Section 4. Test Requirements

4.1 *Test Requirements*. When available, data obtained following standard AHRI/ISO sound rating procedures for the product under test shall be used for the sound quality evaluation. In some cases, it may be necessary to obtain data for the sound quality evaluation in test environments other than those required by the sound rating standard for the product of interest. In these instances, the product under test shall be operating such that it meets the AHRI thermal test and rating point for the condition being evaluated. The test environment and test method shall be clearly described.

Section 5. Sound Quality Evaluation Procedures

5.1 *AHRI Calculation Procedure*. The AHRI calculation procedure is derived from the work of R.J. Wells and W.E. Blazier, *A Procedure for Computing The Subjective Reaction To Complex Noise From Sound Power Data*, and is the preferred method of assessing the quality of sound for products within the scope of this standard. This method utilizes one-third octave band sound power data obtained in conformance with the appropriate AHRI sound measurement standard for the product under test. These measured levels are weighted to adjust for psychoacoustic sensitivity to frequency distribution and any discreet tones which may be present; and then, they are converted to a single number Sound Quality Indicator (SQI).

A description of the AHRI calculation procedure is included as Appendix C, and an example of the use of this method is included as Appendix E.

5.2 *ISO 532– Method B (Zwicker)*. This standard specifies a method for calculating the Loudness of steady complex sounds for which one-third octave band data have been obtained. Method B is applicable not only to sounds with smooth broadband spectra but also to sounds with strong line spectra or irregular spectra. The Loudness level in Phons and Loudness in Sones are determined when using Method B.

5.3 *Interpretation of Rating Indicators*. SQI, Sones and Phons provide a convenient method by which complex sounds of various levels and spectra may be ordered and compared on a scale of subjective magnitude. Comparisons should be made only between products from the same or similar product family and thermal capacity. In general, the higher the level of the quality descriptor for a given product, the lower in sound quality it would be judged on a subjective basis. To this end, these methods provide a means to evaluate the quality of product sound.

A spreadsheet that will calculate the SQI, Phon, and Sone Loudness levels simultaneously on the same data set is available with this standard. An example of this worksheet is included as Appendix F.

Section 6. Minimum Data Requirements for Published Values

6.1 *Minimum Data Requirements for Published Sound Quality Values*. When this standard is used to determine AHRI sound quality values, the values based on this standard are identified by the pertinent AHRI sound standard. As a minimum, all claims to values obtained shall include the statement "AHRI sound quality values determined in accordance with the applicable AHRI standard." Wherever application sound quality values are published or printed, they shall include a statement of the conditions at which the values apply.

6.2 *Published Values*. When Standard Rating Conditions have been established for the equipment by the applicable AHRI standard, sound quality values may be published for the equipment if tested at those conditions.

When Standard Rating Conditions have not been established by the appropriate AHRI sound standard, application sound quality values may be published and shall include a statement of the thermal conditions for which the values apply.

6.2.1 *Application Sound Quality Values*. Application sound quality values for conditions other than Standard Ratings shall be based on tests conducted with all components required to produce the application Rating Condition operating at the speed and power levels required to produce that rating.

6.2.2 *Standard Sound Quality Values*. Standard sound quality values shall be based on sound tests conducted with all components required to produce the Standard Rating Condition operating at the speed and power levels required to produce that rating.

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 product 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 shall not 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 the standard.

A1.1 ANSI Standard S1.11-2004 (R2009), *Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters*, 2004, American National Standards Institute, 11 West 42nd Street, New York, NY 10036, U.S.A.

A1.2 *ASHRAE Terminology of Heating, Ventilation, 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.

A1.3 ASHRAE Transactions, *A Procedure for Computing The Subjective Reaction To Complex Noise From Sound Power Data*, Blazier and Wells, 1963, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

A1.4 ISO 532-1975, *Acoustic – Methods for Calculating Loudness Level*, 1975, International Organization for Standardization, 1, rue de Varembe, Case Postale 56 CH-1211 Geneva 20, Switzerland.

APPENDIX B. REFERENCES – INFORMATIVE

B1.1 ANSI Standard S12.10-2010, Acoustics – Measurement of Airborne Noise Emitted by Information Technology and Telecommunications Equipment – Part 1: Determination of Sound Power Level and Emission Sound Pressure Level, 2010, American National Standards Institute, 35 Pinelawn Road, Melville, NY 11747, U.S.A.

APPENDIX C. AHRI SOUND QUALITY INDICATOR CALCULATION PROCEDURE – NORMATIVE

C1 *Overview*. The purpose of this appendix is to provide a procedure for determining the AHRI Sound Quality Indicator (SQI). AHRI's sound quality calculation procedure is based upon the Perceived Noise Level (PNL) calculation procedure, but adjusted on a one-third octave band basis, to reflect subjective response to the presence of discrete frequency components. It performs this adjustment by analyzing measured one-third octave band data in groups of three bands. The magnitude of each One-third Octave Band in the data set is compared to the arithmetic average of the magnitude of its two adjacent One-third Octave Bands. Whenever the magnitude of the octave band of interest exceeds the average of its two adjacent octave bands by more than 1.5 dB, an adjustment is made to the octave band of interest.

Once each One-third Octave Band in the data set has been evaluated and adjusted, where necessary, to account for subjective response, the entire data set is processed to yield a single number SQI which is indicative of the sound quality of that data set. The calculated SQI for a given product shall be compared only against SQI's for products of similar design and thermal capacity. Calculation of the AHRI SQI is performed automatically by entering measured sound data into the spreadsheet provided with this standard. The calculation process contained in the spreadsheet follows the procedure described in C2.

C2 *Sound Quality Rating Procedure*. This calculation procedure shall determine a single number Sound Quality Indicator (SQI) and is based upon one-third octave band test data from 100 Hz to 10,000 Hz. Sound power data obtained in accordance with the appropriate AHRI test standard for the type of equipment being evaluated is preferred, however, sound pressure data obtained in accordance with recognized generic test standards may also be used. The spreadsheet provided with this standard (which performs the SQI calculation) will query the user requesting the data type to be identified and shall compensate accordingly. It is highly recommended that comparison of SQI's be made only when input data describing the equipment to be compared is consistent (i.e. either sound power or sound pressure and equivalent precision level).

C2.1 *Determination of Equipment Sound Levels.* Equipment sound levels may be acquired in accordance with the appropriate AHRI sound rating standard (preferred) or a recognized generic sound measurement standard (i.e. ANSI, ISO, etc.). These one-third octave band sound levels shall be rounded to the nearest 0.1 dB.

C2.2 *Adjustment of Equipment Sound Levels for Subjective Response.* Whenever the sound level of any One-third Octave Band exceeds the average of its two adjacent bands by more than 1.5dB, the level of that band shall be arithmetically adjusted in accordance with Equation C1*.

$$L' = L - P + 10 \cdot \log_{10}(10^{(D+B)} + 1) \qquad \text{C1}$$

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 = Octave band Center Frequency, Hz, where 125 Hz ≤ *F* ≤ 8,000 Hz
L = Measured sound level for the band, dB
L' = Tone adjusted sound level for the band, dB
P = Projection above the average of the two adjacent bands, dB
Y = Natural log (ln) F

Note: In the above equation, L' shall be rounded to the next higher 0.1 dB

*See Table D1 (Informative) for adjustments rounded to the nearest 0.1 dB. This table is the basis for equation C1.

C2.2.1 *Conversion of One-third Octave Band Sound Levels to Rating Indices.* For each tone corrected one-third octave band sound level, determine its rating indices using Table C1. Interpolation will be necessary for points that are not integers.

C2.2.2 *Calculation of Sound Quality Indicator (SQI)*. The Sound Quality Indicator (to the nearest tenth) for each operating condition of interest shall be determined from the indices using Equation C2.

$$SQI = K + 10 \cdot \log_{10} \Sigma I\text{'s} \quad \text{C2}$$

Where:

Σ I's = Arithmetic sum of rating indices for the One-third Octave Bands from 100 to 10,000 Hz.
I_m = Maximum one-third octave band rating index from 100 to 10,000 Hz.
K = $11.83888-4.94569 \ln X + 0.614812 (\ln X)^2$
X = $\Sigma I's/I_m$

C2.3 *Interpolation of Indices for Non-integer Data Points*. For non-integer points, the procedure for interpolating the indices shall use the following method.

$$Index = C+((D-C)\cdot(A-B)) \quad \text{C3}$$

Where:

A = the value, $Lw_{(n)}$
B = the truncated integer value of A
C = the Index for B
D = the Index for B+1

This calculated index shall be rounded to the nearest tenth.

Note: Example calculation of a SQI is included in Appendix E.

Table C1. Rating Indices

Tone Adjusted Sound Power Level, dB	One-third Octave Band Center Frequencies, Hz																				
	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000
Note: For All One-third Octave Band Sound Power Levels Below 30 dB the Rating Indices Equals 0.																					
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.1	0.1	0	0	0	0
35	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.1**	**0.1**	**0.2**	**0.2**	**0**	**0**	**0**	**0**
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.2	0.2	0.2	0.1	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.2	0.3	0.3	0.2	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.2	0.3	0.3	0.3	0.2	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.3	0.3	0.4	0.4	0.3	0	0	0
40	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.2**	**0.3**	**0.4**	**0.4**	**0.4**	**0.3**	**0.1**	**0**	**0**
41	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.4	0.4	0.5	0.5	0.4	0.2	0	0
42	0	0	0	0	0	0	0	0	0	0	0	0.1	0.3	0.4	0.5	0.6	0.6	0.4	0.2	0	0
43	0	0	0	0	0	0	0	0	0	0	0	0.1	0.3	0.5	0.6	0.6	0.6	0.5	0.3	0	0
44	0	0	0	0	0	0	0	0	0	0	0	0.2	0.4	0.5	0.6	0.7	0.7	0.6	0.3	0	0
45	**0**	**0**	**0**	**0**	**0**	**0**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.2**	**0.4**	**0.6**	**0.7**	**0.7**	**0.7**	**0.6**	**0.4**	**0.1**	**0**
46	0	0	0	0	0	0	0.2	0.2	0.2	0.2	0.2	0.3	0.5	0.7	0.7	0.8	0.8	0.7	0.5	0.2	0
47	0	0	0	0	0	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.6	0.7	0.8	0.9	0.9	0.7	0.5	0.2	0
48	0	0	0	0	0	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.6	0.8	0.9	1	1	0.9	0.7	0.3	0
49	0	0	0	0	0.1	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.7	0.8	0.8	1	1	0.9	0.7	0.3	0
50	**0**	**0**	**0**	**0**	**0.2**	**0.3**	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**	**0.5**	**0.7**	**0.9**	**1**	**1.1**	**1.1**	**0.9**	**0.7**	**0.4**	**0.1**
51	0	0	0	0.1	0.2	0.3	0.4	0.4	0.4	0.4	0.4	0.6	0.8	0.9	1.1	1.1	1.1	1	0.8	0.5	0.2
52	0	0	0	0.2	0.3	0.4	0.5	0.5	0.5	0.5	0.5	0.6	0.9	1	1.1	1.2	1.2	1.1	0.9	0.6	0.2
53	0	0	0.1	0.2	0.3	0.4	0.6	0.6	0.6	0.6	0.6	0.7	0.9	1.1	1.2	1.3	1.3	1.2	1	0.6	0.3
54	0	0	0.2	0.3	0.4	0.5	0.6	0.6	0.6	0.6	0.6	0.7	1	1.2	1.3	1.4	1.4	1.3	1.1	0.7	0.4
55	**0**	**0**	**0.2**	**0.3**	**0.4**	**0.6**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**0.8**	**1.1**	**1.3**	**1.4**	**1.5**	**1.5**	**1.4**	**1.2**	**0.8**	**0.5**
56	0	0.1	0.3	0.4	0.5	0.6	0.7	0.7	0.7	0.7	0.7	0.9	1.2	1.3	1.5	1.6	1.6	1.5	1.4	0.9	0.6
57	0	0.2	0.3	0.4	0.6	0.7	0.8	0.8	0.8	0.8	0.8	0.9	1.3	1.4	1.6	1.8	1.8	1.6	1.5	1	0.6
58	0	0.2	0.4	0.5	0.6	0.7	0.9	0.9	0.9	0.9	0.9	1	1.3	1.5	1.8	1.9	1.9	1.7	1.6	1.1	0.7
59	0.1	0.3	0.5	0.6	0.7	0.8	0.9	0.9	0.9	0.9	0.9	1.1	1.4	1.6	1.9	2	2	1.9	1.8	1.2	0.8

Table C1. Rating Indices (Continued)

Tone Adjusted Sound Power Level, dB	One third Octave Band Center Frequencies, Hz																				
	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000
60	**0.2**	**0.3**	**0.5**	**0.6**	**0.7**	**0.9**	**1**	**1**	**1**	**1**	**1**	**1.2**	**1.5**	**1.7**	**2**	**2.2**	**2.2**	**2**	**1.9**	**1.4**	**0.9**
61	0.2	0.4	0.6	0.7	0.8	0.9	1.1	1.1	1.1	1.1	1.1	1.3	1.6	1.8	2.2	2.4	2.4	2.2	2	1.5	1
62	0.3	0.5	0.6	0.7	0.9	1	1.1	1.1	1.1	1.1	1.1	1.3	1.7	2	2.4	2.6	2.6	2.4	2.2	1.7	1.1
63	0.3	0.5	0.7	0.8	0.9	1.1	1.2	1.2	1.2	1.2	1.2	1.4	1.8	2.2	2.6	2.8	2.8	2.6	2.4	1.8	1.2
64	0.4	0.6	0.7	0.9	1	1.1	1.3	1.3	1.3	1.3	1.3	1.5	2	2.4	2.8	3	3	2.8	2.6	2	1.4
65	**0.5**	**0.6**	**0.8**	**0.9**	**1.1**	**1.2**	**1.4**	**1.4**	**1.4**	**1.4**	**1.4**	**1.6**	**2.1**	**2.6**	**3**	**3.2**	**3.2**	**3**	**2.8**	**2.2**	**1.5**
66	0.5	0.7	0.9	1	1.2	1.3	1.5	1.5	1.5	1.5	1.5	1.7	2.3	2.8	3.2	3.4	3.4	3.2	3	2.4	1.7
67	0.6	0.7	0.9	1.1	1.3	1.4	1.6	1.6	1.6	1.6	1.6	1.8	2.4	3	3.4	3.6	3.6	3.4	3.2	2.6	1.8
68	0.6	0.8	1	1.2	1.4	1.5	1.7	1.7	1.7	1.7	1.7	2	2.6	3.2	3.6	3.9	3.9	3.6	3.4	2.8	2
69	0.7	0.8	1.1	1.3	1.5	1.6	1.9	1.9	1.9	1.9	1.9	2.1	2.8	3.4	3.9	4.1	4.1	3.9	3.6	3	2.2
70	**0.8**	**1**	**1.2**	**1.4**	**1.6**	**1.7**	**2**	**2**	**2**	**2**	**2**	**2.3**	**3**	**3.6**	**4.1**	**4.4**	**4.4**	**4.1**	**3.9**	**3.2**	**2.4**
71	0.9	1	1.3	1.5	1.7	1.9	2.1	2.1	2.1	2.1	2.1	2.4	3.2	3.9	4.4	4.7	4.7	4.4	4.1	3.4	2.6
72	0.9	1.1	1.4	1.6	1.9	2	2.3	2.3	2.3	2.3	2.3	2.6	3.5	4.1	4.7	5	5	4.7	4.4	3.6	2.8
73	1	1.2	1.5	1.7	2	2.1	2.5	2.5	2.5	2.5	2.5	2.8	3.7	4.4	5	5.3	5.3	5	4.7	3.9	3
74	1.1	1.3	1.6	1.9	2.1	2.3	2.6	2.6	2.6	2.6	2.6	3	4	4.7	5.3	5.7	5.7	5.3	5	4.1	3.2
75	**1.2**	**1.4**	**1.7**	**2**	**2.3**	**2.4**	**2.8**	**2.8**	**2.8**	**2.8**	**2.8**	**3.2**	**4.3**	**5**	**5.7**	**6.1**	**6.1**	**5.7**	**5.3**	**4.4**	**3.5**
76	1.3	1.5	1.9	2.2	2.4	2.6	3	3	3	3	3	3.5	4.6	5.3	6.1	6.5	6.5	6.1	5.7	4.7	3.7
77	1.4	1.7	2	2.4	2.6	2.8	3.2	3.2	3.2	3.2	3.2	3.7	5	5.7	6.5	7	7	6.5	6.1	5	4
78	1.5	1.8	2.2	2.6	2.8	3	3.5	3.5	3.5	3.5	3.5	4	5.3	6.1	7	7.5	7.5	7	6.5	5.3	4.3
79	1.7	2	2.4	2.8	3	3.2	3.7	3.7	3.7	3.7	3.7	4.3	5.7	6.5	7.5	8	8	7.5	7	5.7	4.6
80	**1.8**	**2.2**	**2.6**	**3**	**3.2**	**3.5**	**4**	**4**	**4**	**4**	**4**	**4.6**	**6.1**	**7**	**8**	**8.7**	**8.7**	**8**	**7.5**	**6.1**	**5**
81	2	2.4	2.8	3.2	3.5	3.7	4.3	4.3	4.3	4.3	4.3	5	6.5	7.5	8.7	9.3	9.3	8.7	8	6.5	5.3
82	2.2	2.6	3	3.5	3.7	4	4.6	4.6	4.6	4.6	4.6	5.3	7	8	9.3	10	10	9.3	8.7	7	5.7
83	2.4	2.8	3.2	3.7	4	4.3	4.9	4.9	4.9	4.9	4.9	5.7	7.5	8.7	10	11	11	10	9.3	7.5	6.1
84	2.6	3	3.5	4	4.3	4.6	5.3	5.3	5.3	5.3	5.3	6.1	8	9.3	11	11	11	11	10	8	6.5
85	**2.8**	**3.2**	**3.7**	**4.3**	**4.6**	**5**	**5.7**	**5.7**	**5.7**	**5.7**	**5.7**	**6.5**	**8.7**	**10**	**11**	**12**	**12**	**11**	**11**	**8.7**	**7**
86	3	3.5	4	4.6	5	5.4	6.1	6.1	6.1	6.1	6.1	7	9.3	11	12	13	13	12	11	9.3	7.5
87	3.3	3.7	4.3	5	5.4	5.9	6.5	6.5	6.5	6.5	6.5	7.5	10	11	13	14	14	13	12	10	8
88	3.6	4	4.6	5.4	5.9	6.4	7	7	7	7	7	8	11	12	14	15	15	14	13	11	8.7
89	3.9	4.3	5	5.9	6.4	6.9	7.5	7.5	7.5	7.5	7.5	8.7	11	13	15	16	16	15	14	11	9.3

Table C1. Rating Indices (Continued)

Tone Adjusted Sound Power Level, dB	One third Octave Band Center Frequencies, Hz																				
	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000
90	**4.2**	**4.6**	**5.4**	**6.4**	**6.9**	**7.5**	**8**	**8**	**8**	**8**	**8**	**9.3**	**12**	**14**	**16**	**17**	**17**	**16**	**15**	**12**	**10**
91	4.6	5	5.9	6.9	7.5	8	8.6	8.6	8.6	8.6	8.6	10	13	15	17	19	19	17	16	13	11
92	5	5.4	6.4	7.5	8	8.7	9.2	9.2	9.2	9.2	9.2	11	14	16	19	20	20	19	17	14	11
93	5.4	5.9	6.9	8	8.7	9.3	9.8	9.8	9.8	9.8	9.8	11	15	17	20	21	21	20	19	15	12
94	5.9	6.4	7.5	8.7	9.3	10	10.6	10.6	10.6	10.6	10.6	12	16	19	21	23	23	21	20	16	13
95	**6.4**	**6.9**	**8**	**9.3**	**10**	**11**	**11.3**	**11.3**	**11.3**	**11.3**	**11.3**	**13**	**17**	**20**	**23**	**24**	**24**	**23**	**21**	**17**	**14**
96	6.9	7.5	8.7	10	11	11	12	12	12	12	12	14	19	21	24	26	26	24	23	19	15
97	7.5	8.3	9.3	11	11	12	13	13	13	13	13	15	20	23	26	28	28	26	24	20	16
98	8.3	9.1	10	11	12	13	14	14	14	14	14	16	21	24	28	30	30	28	26	21	17
99	9.1	10	11	12	13	14	15	15	15	15	15	17	23	26	30	32	32	30	28	23	19
100	**10**	**11**	**11**	**13**	**14**	**15**	**16**	**16**	**16**	**16**	**16**	**19**	**24**	**28**	**32**	**35**	**35**	**32**	**30**	**24**	**20**
101	11	11	12	14	15	16	18	18	18	18	18	20	26	30	35	37	37	35	32	26	21
102	11	12	13	15	16	17	19	19	19	19	19	21	28	32	37	40	40	37	35	28	23
103	12	13	14	16	17	19	20	20	20	20	20	23	30	35	40	42	42	40	37	30	24
104	13	14	15	17	19	20	21	21	21	21	21	24	32	37	42	45	45	42	40	32	26
105	**14**	**15**	**16**	**19**	**20**	**21**	**23**	**23**	**23**	**23**	**23**	**26**	**35**	**40**	**45**	**47**	**47**	**45**	**42**	**35**	**28**
106	15	16	17	20	21	23	24	24	24	24	24	28	37	42	47	50	50	47	45	37	30
107	16	17	19	21	23	24	26	26	26	26	26	30	40	45	50	55	55	50	47	40	32
108	17	19	20	23	24	26	28	28	28	28	28	32	42	47	55	60	60	55	50	42	35
109	19	20	21	24	26	28	30	30	30	30	30	35	45	50	60	63	63	60	55	45	37
110	**20**	**21**	**23**	**26**	**28**	**30**	**32**	**32**	**32**	**32**	**32**	**37**	**47**	**55**	**63**	**67**	**67**	**63**	**60**	**47**	**40**
111	21	23	24	28	30	32	34	34	34	34	34	40	50	60	67	71	71	67	63	50	42
112	23	24	26	30	32	35	37	37	37	37	37	42	55	63	71	75	75	71	67	55	45
113	24	26	28	32	35	37	39	39	39	39	39	45	60	67	75	80	80	75	71	60	47
114	26	26	30	35	37	40	42	42	42	42	42	47	63	71	80	86	86	80	75	63	50
115	**28**	**30**	**32**	**37**	**40**	**42**	**45**	**45**	**45**	**45**	**45**	**50**	**67**	**75**	**86**	**93**	**93**	**86**	**80**	**67**	**55**
116	30	32	35	40	42	45	49	49	49	49	49	55	71	80	93	100	100	93	86	71	60
117	32	35	37	42	45	47	52	52	52	52	52	60	75	86	100	108	108	100	93	75	63
118	35	37	40	45	47	50	56	56	56	56	56	64	80	93	108	116	116	108	100	80	67
119	37	40	42	47	50	55	60	60	60	60	60	69	86	100	116	125	125	116	108	86	71
120	**40**	**42**	**45**	**50**	**55**	**60**	**64**	**64**	**64**	**64**	**64**	**74**	**93**	**108**	**125**	**133**	**133**	**125**	**116**	**93**	**75**

APPENDIX D. ADJUSTMENTS FOR SUBJECTIVE RESPONSE TO DISCRETE FREQUENCIES (TONES) - INFORMATIVE

Listed in Table D1 are tone adjustments as a function of one-third octave band center frequencies for specific values of projection (P), rounded to the nearest 0.1 dB.

Table D1. One-third Octave Band Adjustments for Tone Response[1]

One-third Octave Band Center Frequency, Hz	Projection (P) of One-third Octave Band Above the Arithmetic Average of the Two Adjacent Bands, dB												
	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
100	-0.3[2]	-0.4[2]	-0.5[2]	-0.5[2]	-0.6[2]	-0.6[2]	-0.7[2]	-0.7[2]	-0.7[2]	-0.8[2]	-0.8[2]	-0.8[2]	-0.8[2]
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	+	+	+	+	+	+	+	+	+	+	+	+	+

Notes:
1. Data rounded to the nearest 0.1 dB.
2. Adjustment not applicable for these points.

APPENDIX E. EXAMPLE CALCULATION OF AHRI SOUND QUALITY INDICATOR – INFORMATIVE

Table E1. Example Calculation of AHRI Sound Quality Indicator (SQI)

One-third Octave Band Center Frequency, Hz	Un-weighted Unit Sound Power Level L_w, dB	Band Projection, dB	Tone Adjustment, dB	Un-weighted Unit Sound Power Level Plus Tone Adjustment L_w, dB	Rating Indices
100	84.5			84.5	2.7
125	91.5	5.0	-0. 7	90.8	4.9
160	88.5			88.5	4.8
200	84.5			84.5	4.2
250	82.0			82.0	3.7
315	83.0	2.0	1.2	84.2	4.7
400	80.0			80.0	4.0
500	79.0			79.0	3.7
630	77.5			77.5	3.4
800	77.0			77.0	3.2
1000	78.0	2.3	2.7	80.7	4.2
1250	74.5			74.5	3.1
1600	73.0			73.0	3.7
2000	71.5			71.5	4.0
2500	69.5			69.5	4.0
3150	69.0			69.0	4.1
4000	68.0			68.0	3.9
5000	66.0			66.0	3.2
6300	65.0			65.0	2.8
8000	64.0			64.0	2.0
10000	62.5			62.5	1.2
				Sum of indices =	75.5
				Max index =	4.9
				Sum/Max =	15.4
				K of Sum/Max =	2.9
				10·Log Summed Indices =	18.8
				SQI =	21.7

APPENDIX F. EXAMPLE OUTPUT FROM AHRI CALCULATION SOFTWARE INCLUDING AHRI SQI METRIC AND ZWICKER ISO 532B LOUDNESS METRICS – INFORMATIVE

Calculated Sound Quality Indicators
(Based on Un-weighted One-third Octave Band Data)

One-third Octave Band Center Frequency, Hz	Input Un-weighted Data, Lw
50	0.0
63	0.0
80	0.0
100	84.5
125	91.5
160	88.5
200	84.5
250	82.0
315	83.0
400	80.0
500	79.0
630	77.5
800	77.0
1000	78.0
1250	74.5
1600	73.0
2000	71.5
2500	69.5
3150	69.0
4000	68.0
5000	66.0
6300	65.0
8000	64.0
10000	62.5

CALCULATED FROM INPUT Lw DATA

AHRI Sound Quality Indicator, SQI

SQI = 21.7

Zwicker Loudness, B

Loudness N = 23.3 Sone GD

Loudness Level LN = 85.4 Phon GD

COMMENTS:

Notes:

Data has been calculated as: Diffused Field Data (GD)

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AHRI SNDQL Rev 16 SCI

Note: Lw is Un-weighted Sound Power Level and Lp is Un-weighted Sound Pressure Level. The labels will change accordingly once the "Calculate Data" button has been depressed and a selection of Sound Power or Sound Pressure has been made.

APPENDIX G. TONE PROMINENCE CALCULATION - INFORMATIVE

G1 Many noise generating mechanisms can result in discrete frequency sound such as those due to blade passage frequency of fans, motor tones, and compressor operation. If these are perceived as a tone, they can be annoying or disruptive to nearby people. The method presented in ANSI/ASA S12.10-2010 Annex D provides a method of determining how the tone will likely be perceived by the affected people.

As described in ANSI/ASA S12.10-2010 Annex D, a discrete tone which occurs together with broadband noise is partially masked by that part of the noise contained in a relatively narrow frequency band, called the critical band, which is centered at the frequency of the tone. Noise at frequencies outside the critical band does not contribute significantly to the masking effect. The width of a critical band is a function of frequency.

The standard provides two methods of determining tone prominence and criteria for determining if a tone is prominent. The tone-to noise ratio method is recommended for HVAC equipment. The method requires acquisition of narrow-band sound. A bandwidth of 1 Hz or less is recommended.

The criteria presented in the standard are frequency dependent and are intended to delineate when a tone is indeed prominent. It is recommended that tones be well below the prominence criteria. Often a 3 dB clearance is acceptable.