ANSI/AHRI Standard 530-2022 (SI)

2022 Standard for

Rating of Sound and Vibration for Positive Displacement Refrigerant Compressors

Approved by ANSI on 13 June 2023

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ICS Code: 17.140.01

Note:
This standard supersedes ANSI/AHRI Standard 530-2011.

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Foreword

This version of the standard differs from that of 2011 Edition by expanding the scope to include testing of modulating compressors per AHRI 540-2020.

Intent

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

Review and Amendment

This standard is subject to review and amendment as technology advances.

2022 Edition

This edition of ANSI/AHRI Standard 530 *Method Rating of Sound and Vibration for Refrigerant Compressors* was prepared by the Testing and Analysis Standards Technical Committee. The standard was approved by the Sound and Vibration Standards Subcommittee on 6 October 2022. The standard was approved as an American National Standard (ANS) on 13 June 2023.

Origin and Development of AHRI Standard 530

ARI Standard 530-89 *Method Rating of Sound and Vibration for Refrigerant Compressors* was published in 1989. Subsequent revisions were:

ARI Standard 530-1995, *Method Rating of Sound and Vibration for Refrigerant Compressors*

AHRI Standard 530-2005, *Method Rating of Sound and Vibration for Refrigerant Compressors*

AHRI Standard 530-2011, *Method Rating of Sound and Vibration for Refrigerant Compressors*

Summary of Changes

ANSI/AHRI Standard 530-2022 (SI) contains the following update(s) to the previous edition:

- Added Section 5.4 to define set of rating conditions for single speed, dual capacity, and variable speed compressors, for inclusion in AHRI 540-2020, *Performance Rating of Positive Displacement Compressors and Compressor Units*
- Incorporated modified rating conditions for dual capacity and variable speed compressors
- Updated Section 4.3 Vibration Measurements with verbiage and new standard for calibration
- Updated reference to AHRI 220-2022 to replace the references to AHRI 250 and AHRI 280 and to ASA S12.51, to cover reverberant room sound testing and sound room qualification
- Updated modulating compressor testing in Section 5.4.

Committee Personnel

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Waterside and Refrigeration Standards Technical Committee Scope:

The Waterside and Refrigeration STC is responsible for development and maintenance of standards and guidelines related to sound and vibration of equipment whose primary function is to move, heat, or cool a liquid.

Out of scope for this STC are standards whose primary purpose is not sound and vibration performance, or that are common to both Airside and Water/Refrigeration.

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These lists represent the membership at the time the Working Group, Standards Technical Committee and Standards Subcommittee were balloted on the final text of this edition. Since that time, changes in the membership may have occurred. Membership in these committees shall not in and of itself constitute an endorsement by the committee members or their employers of any document developed by the committee on which the member serves.

Sound and Vibration Consensus Body List

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Aaron Gunzner Air Movement and Control Association International, Inc.	Testing Laboratory	IL, USA
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RATING OF SOUND AND VIBRATION FOR POSITIVE DISPLACEMENT REFRIGERANT COMPRESSORS

Section 1. Purpose

1.1 *Purpose.* The purpose of this standard is to establish for the rating of sound and vibration for Positive Displacement Refrigerant Compressors: definitions; test requirements; rating requirements; minimum data requirements for published ratings; and conformance conditions.

Section 2. Scope

2.1 *Scope.* This standard applies to Hermetic, Open Type (External-drive), Semi-hermetic, Fixed Displacement, Discrete Modulating, and Continuous Modulating Compressors. In the case of External-drive Refrigerant Compressors, the driving mechanism shall be excluded from the sound and vibration measurements. However, for Semi-hermetic Refrigerant Compressors where the driving mechanism is an integral part of the compressor assembly as defined in Section 3, it shall be included in the measurements.

2.1.1 *Exclusion.* Vibration measurements for an Open Type (External-drive) Refrigerant Compressor, coupling and motor assembly mounted on a common base is excluded from this standard, since the vibration measurement method specified in the standard does not apply to this type of product. Sound Power testing shall exclude the motor assembly's contribution to the Sound Power measurement when applicable. Sound Power, Vibration and Discharge Pulse measurements for Continuous Modulating Compressors during cyclic load intervals are excluded from this standard since steady state conditions are required during measurements.

Section 3. Definitions

All terms in this document will follow the standard industry definitions in the *ASHRAE Terminology* website unless otherwise defined in this section. For acoustic related terms refer to *ASA Standard Term Database* website.

3.1 *Amplitude Root Mean Square (rms).* Refer to definition in Section 3.23.

3.2 *Anechoic Test Room*. A test room whose surfaces absorb essentially all of the incident sound energy over the frequency range of interest, thereby affording free-field conditions over the measurement surface.

3.3 *Bandwidth.* The difference between the upper and lower frequencies in a contiguous set of frequencies. It is typically measured in Hz.

3.4 *Displacement Capacity.* Theoretical volumetric flow rate through the Compressor expressed in m^3/h.

3.5 *Durometer.* A measure of hardness in polymers, elastomers, and rubbers that are used for compressor mounting.

3.6 *Fixed Displacement Compressor.* A Compressor with one Displacement Capacity.

3.7 *Flat Top Window*. A weighting function applied during fast Fourier transform analysis to obtain the true amplitudes of periodic components of a time signal. It is designed specifically to minimize the amplitude error. It facilitates calibration by using a calibration tone which may lie anywhere between two lines of the analyzer. Maximum amplitude error is less than 0.01 dB.

3.8 *Fundamental Frequency*. The speed in Hz of the compressor drive or shaft.

3.9 *Fundamental Pulsation Frequency*. The dominant frequency observed in the pressure pulse. For reciprocating compressors, where all events are equally spaced in time, this is usually the number of cylinders times the Fundamental Frequency.

3.10 *Harmonics.* Sinusoidal quantity that has a frequency which is an integral multiple of the frequency of the periodic quantity to which it is related.

3.11 *Hemi-anechoic Test Room.* A test room with a hard, reflecting floor whose other surfaces absorb essentially all of the incident sound energy over the frequency range of interest, thereby affording free-field conditions above a reflecting plane.

3.12 *Hermetic Refrigerant Compressor*. A Compressor and motor assembly, both of which are contained within a gas tight housing that is permanently sealed by welding or brazing with no access for servicing internal parts in the field.

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

3.14 *Modulating Compressor.* A compressor with more than one Displacement Capacity. There are two types: Continuous Modulating Compressor and Discrete Modulating Compressor.

3.14.1 *Continuous Modulating Compressor.* A Compressor with more than four Displacement Capacities or variable Displacement Capacities. This includes but is not limited to variable speed, continuously variable mechanical unloading, or cyclic modulation of discrete unloading Steps.

3.14.2 *Discrete Modulating Compressor.* A Compressor with two to four discrete Displacement Capacities.

3.15 *Octave Band*. A band of sound covering a range of frequencies such that the highest is twice the lowest.

Note: The Octave Bands used in this standard are those defined in ASA S1.6.

3.16 *One-third Octave Band.* A band of sound covering a range of frequencies such that the highest is the cube root of two times the lowest.

Note: The One-Third Octave Bands used in this standard are those shown in Table 1 and as defined in ASA 1.6.

3.17 *Open Type Refrigerant Compressor*. A Compressor with a shaft or other moving part extending through its casing to be driven by an outside source of power thus requiring a shaft seal or equivalent rubbing contact between fixed and moving parts.

3.18 *Pulsation.* The fluctuation of the pressure in a discharge or suction line about some mean pressure.

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

3.20 *Reference Rating Condition*. A specific operating condition selected from AHRI 540 (Table 4) for quick reference or comparison.

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

3.22 *Reverberation Test Room (Chamber)*. An acoustically designed room for uniform distribution of acoustic energy. It is used to determine the Sound Power Level of a source and to find the absorption coefficient of a material (sound absorption).

3.23 *Root Mean Square (rms).* The square root of the average of the sum of the squared instantaneous values of a function measured over the sample period.

$$S_{rms} = \left[\frac{\sum_{i=1}^{n} S_i^2}{n}\right]^{1/2} \quad \textbf{1}$$

Where:

i = Individual sample
n = Number of sample measurements
S = Dynamic signal from sound, vibration, or pressure measuring instruments
S_{rms} = Root Mean Square value of S (Figure 1 depicts the peak to peak and the rms wave amplitude levels of a non-sinusoidal vibration or pressure signal.)

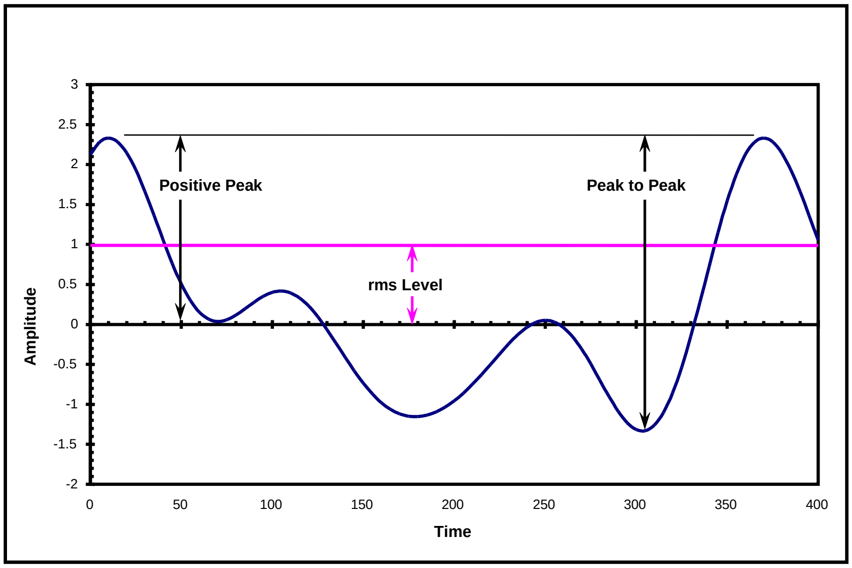

Figure 1. Time Domain Wave Amplitude Descriptors

3.24 *Semi-hermetic Refrigerant Compressor*. A Compressor and motor assembly contained within a gas-tight housing that is sealed by gasketed joints to provide access for servicing internal parts.

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

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

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

3.26 *Step.* A level of modulating achieved by changing the Displacement Capacity not limited to the methods below:

3.26.1 Compressor operating frequency, Hz
3.26.2 Compressor speed, RPM
3.26.3 Mechanical unloading setting (fixed or time weighted average) (%).

Note: This "%" is a representation or name of the Step and not necessarily an actual % Capacity. % Capacity is used as defined in AHRI 540.

3.26.4 VFD frequency, Hz

3.27 *Stiffness of Isolator.*

3.27.1 *Static Stiffness.* Ratio of change of force (or torque) to the corresponding change in translational (or rotational) deformation of an elastic element.

3.27.2 *Dynamic Stiffness.* Complex ratio of the force, taken at a point in a mechanical system, to the displacement, taken at the same or another point in the system.

3.28 *Working Load.* The portion of the compressor weight supported by the individual isolator.

3.29 *Variable Frequency Drive (VFD)*. A power electronic device that regulates the speed of an alternating current (AC) motor by adjusting the frequency and the voltage of the electrical power supplied to the motor.

Section 4. Test Requirements

4.1 *General Test Requirements.*

4.1.1 *Compressor Mounting.* The compressor to be tested shall be mounted on a mass at least four times the mass of the compressor. The isolators used shall be those recommended for that particular compressor by the manufacturer. Isolator information is reported in Section 6.1.1.1.

4.1.2 *Compressor Line Connections.* To minimize the external load on the compressor, discharge and suction line connections shall be made at the compressor with flexible tubing, such as an extruded PTFE tube with a stainless-steel wire braid cover and a length to diameter ratio of at least fifty. The lines need to be supported to minimize the static load on the compressor.

To provide uniform flow, the lines shall have the same nominal inside diameter as the tubing size recommended by the compressor manufacturer. If mechanical connectors are used, the inner diameter of the connector shall be the same as the inner diameter of the refrigerant line, unless the connector is part of the compressor assembly.

In the event that flexible lines are not commercially available, rigid tubing may be used in a setup that provides flexibility for either the suction and/or discharge lines. A complete detailed sketch of the tubing geometry used shall be provided which includes mounting points, suction fittings, and discharge fittings similar to the generic sketch in Figure 2.

All refrigerant lines not part of the compressor assembly shall be installed and treated to minimize their acoustic contribution.

4.1.3 *Electrical Power Supply*. Test voltage and frequency shall be as specified on the compressor nameplate. Where dual voltages (i.e., 230/460 V) are shown, either voltage may be used. Where extended voltage is specified (i.e., 208/230 V), the higher voltage shall be used. When dual frequency is indicated, tests shall be conducted at both frequencies. When compressors with factory integrated or factory specified VFD are used, test voltage and frequency shall be as specified on the VFD nameplate.

Test voltage shall be ± 1 % of that specified and the frequency shall be held to ± 0.5 Hz tolerance.

4.1.4 *Test Conditions and Tolerances.* Test conditions shall include Reference Rating Conditions as defined in Section 5.4. The compressor shall be tested with the following test condition tolerances:

4.1.4.1 Compressor suction pressure within ±2% of the absolute compressor suction pressure
4.1.4.2 Suction superheat within ±1 K
4.1.4.3 Compressor discharge pressure within ±1% of the absolute compressor discharge pressure

Compressors operating outside of these conditions and/or tolerances shall be reported.

4.1.5 *Narrow Band Measurements.* When using digital Fourier analyzers to measure discrete spectrum component amplitudes, a Flat Top Window shall be used. Record the amplitude at each peak. The Bandwidth shall be no more than 1/5 of the Fundamental Frequency, but wide enough so that side bands cannot be individually discerned.

4.2 *Sound Level Measurements*.

4.2.1 *Sound Testing Requirements.* Sound tests shall be conducted in an Anechoic or Hemi-anechoic Test Room meeting all the requirements of, and that has been qualified per ASA S12.55/ISO 3745 or in a Reverberation Test Room meeting all the requirements of, and that has been qualified per AHRI 220. The tests shall be conducted at operating conditions specified in Section 4.1.3, Section 4.1.4, and Section 5.4. The RSS shall meet the requirements of AHRI 250.

4.2.1.1 *Determination of Sound Power Levels.* The Sound Power Levels shall be determined in decibels with respect to 1 pW for the One-third Octave Bands from 100 to 10,000 Hz (50 to 80 Hz is optional). The overall A-weighted level shall be calculated from the one-third octave band Sound Power Levels. For testing done in an Anechoic or Hemi-anechoic Test Room, the testing and calculation procedures as specified in ASA S12.55/ISO 3745 shall be followed to determine the required one-third octave band Sound Power Levels and the overall A-weighted Sound Power Level. For testing done in a Reverberant Test Room, the testing and calculation procedures as specified in AHRI 220 shall be followed to determine the required one-third octave band Sound Power Levels and the overall A-weighted Sound Power Level.

4.3 *Vibration Measurements*.

4.3.1 *Operating Conditions*. The tests shall be conducted at the operating conditions described in Section 4.1.3, Section 4.1.4, and Section 5.4.

4.3.2 *Measurement Points*. See Figure 2. Vibration measurements shall be taken at all mounting locations (1, 2, 3, 4), as close to the mounting point as possible. In addition, measurements shall also be taken on the compressor shell or body close to the location of the suction and the discharge fittings.

4.3.3 *Measurement Directions*. See Figure 2. Vibration measurements shall be taken in three orthogonal directions at the suction and discharge fitting locations and in three orthogonal directions at the mounting locations.

At the suction and discharge fitting location, one direction shall be parallel to the centerline of the tubing at the fitting. One of the remaining two directions should describe the tangential motion of the compressor body at the fitting, if applicable, and shall be described in a sketch. The third direction is then defined by the orthogonality requirement (Figure 1).

Note: Vibration measurement data are useful for systems manufacturers to compare compressor manufacturer's products, but the actual boundary conditions used with system suction and discharge lines and mounting causes the vibration not to be the same as published values.

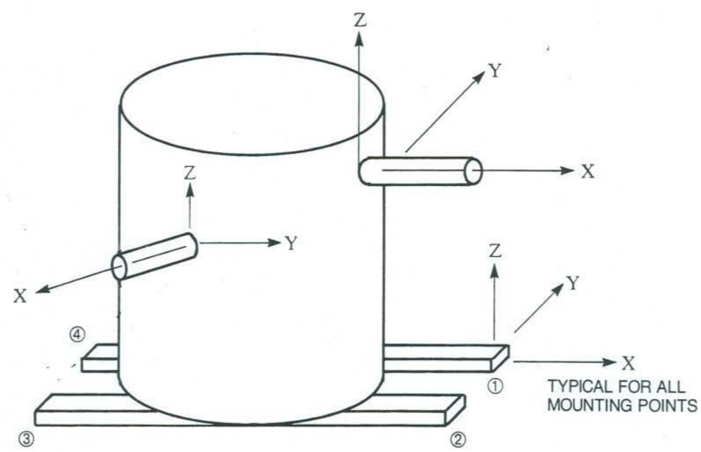

Figure 2. Vibration Test Locations at Suction, Discharge, and Mounting Locations

4.3.4 *Vibration Transducer.* The vibration transducer shall consist of a single axis accelerometer, or a commercially available triaxial accelerometer that meets the following requirements:

4.3.4.1 Any added mass to the compressor assembly must be no more than 1/1000 of the mass of the compressor.

4.3.4.2 Any accelerometer or measurement system used shall have a flat frequency response (± 0.2 dB) from 5 to 1000 Hz.

4.3.4.3 Each accelerometer as mounted to the compressor shall have its first natural frequency in excess of 8000 Hz and shall be mechanically attached or cemented, with or without an intermediate block or stud, to the compressor shell or structure.

4.3.4.4 Sufficient magnetic force or adhesive mountings are acceptable provided they provide stable mounting during testing. Handheld, beeswax, or other soft adhesive mounting methods are excluded.

4.3.5 *Measurement System Calibration*. The system used shall be calibrated in accordance with ISO 16063-21.

4.4 *Gas Pulsation Measurements*.

4.4.1 The tests shall be conducted at the operating conditions described in Section 4.1.3, Section 4.1.4, and Section 5.4.

4.4.2 To avoid the build-up of a standing wave, which could influence the results, the length of the refrigerant line shall be a minimum of 12.2 m in which there are no variations in inside diameter or sharp bends. At least two pressure transducer test locations shall be used in the refrigerant line. The pressure transducers shall be spaced ¼ wavelength apart based on the Fundamental Pulsation Frequency for the design. The wavelength is calculated as follows:

$$\lambda = c/f \qquad \textbf{2}$$

Where:
c = speed of sound in the refrigerant at the measurement point, m/s
f = frequency, Hz
λ = wavelength, m

Note: It is recommended that a coil of tubing with a minimum radius of thirty tube diameters be used.

Note: To avoid heat transfer with the surrounding environment, it is recommended that the coil either be insulated or buried in sand.

4.4.2.1 *Exclusion.* Compressors operating at a cooling capacity less than 440 W, where test conditions may be difficult to control with long line lengths, may be tested with as little as 1.25 m between the compressor and the condition control element (valve or heater). Two transducers spaced ¼ wavelength apart shall be used, but no more than a distance of 1.00 m.

4.4.3 The pressure transducer shall have a minimum of ten diameters of straight tube upstream of the measurement location. The closest transducer may not be more than twenty tube diameters from the compressor connection.

4.4.4 The transducer shall be mounted in an adaptor such that the face is on a plane, parallel to the gas flow and as close as possible to the inner surface of the refrigerant tube. The face of the transducer shall be no larger than the inside diameter of the tube. The opening between the face and the tube shall not be less than the diameter of the transducer face. Any pressure transducer and measurement system used shall have a flat frequency response (± 0.2 dB) from 5 to 5000 Hz.

Note: Use this measurement only as an estimate of the comparative pulses measured. The final installed configuration contains line turns and cross-sectional changes causing reflected pressures (standing waves) wholly unrelated to the stand measured ones, and these not only result in wave interference but can upset the source impedance itself giving different Pulsations. Since the actual use Pulsations can be different from the stand measured pulse, the actual installed configuration should be thoroughly examined for the true pressures.

Section 5. Rating Requirements

5.1 *Sound Power Level Ratings.* One-third octave band Sound Power Levels from 100 to 10,000 Hz (50 to 10,000 Hz is optional) and the resulting overall A-weighted level are required.

5.1.1 Compressor Sound Power Levels for each One-Third Octave Band shown in Table 1 shall be determined in accordance with Section 4.2.1.1. The sound power level test data shall be expressed in dB re 1 pW for each One-Third Octave Band and shall be rounded to the nearest 0.1 dB.

5.1.2 *A-weighted Sound Power Level.* The A-weighted Sound Power Level shall be calculated per Equation 3 and rounded to the nearest decibel.

$$L_{wA} = 10 \cdot \log \sum_{j=j_{min}}^{j_{max}} 10^{0.1(L_{wj}+C_j)} \qquad 3$$

Where:

C_j and j = Values given in Table 1

j_{min} and j_{max} = Values given in Table 1 of j corresponding, respectively, to the lowest (j_{min}) and highest (j_{max}) One-Third Octave Bands of measurement

L_{wA} = A-weighted Sound Power Level

L_{wj} = Sound Power Level in the j^{th} One-Third Octave Band

Table 1. One-Third Octave Bands and A-Weighting Factors

Band Number (j)	Octave Band Center Frequency, Hz	A-Weighting Factor (Cj), dB	Band Number (j)	Octave Band Center Frequency, Hz	A-Weighting Factor (Cj), dB	Band Number (j)	Octave Band Center Frequency, Hz	A-Weighting Factor (Cj), dB	Band Number (j)	Octave Band Center Frequency, Hz	A-weighting Factor (Cj), dB
1	50	-30.2	7	200	-10.9	13	800	-0.8	19	3150	1.2
2	63	-26.2	8	250	-8.6	14	1000	0.0	20	4000	1.0
3	80	-22.5	9	315	-6.6	15	1250	0.6	21	5000	0.5
4	100	-19.1	10	400	-4.8	16	1600	1.0	22	6300	-0.1
5	125	-16.1	11	500	-3.2	17	2000	1.2	23	8000	-1.1
6	160	-13.4	12	630	-1.9	18	2500	1.3	24	10000	-2.5

5.2 *Vibration Data.* Narrow band vibration data using the Flat Top Window per ISO 18431 Parts 1 and 2 shall be obtained from a spectrum analysis of the vibration signal. These data shall be presented as rms displacement in mm [mils] for comparison purposes. Data shall be obtained in the frequency range of 5 to 500 Hz.

5.3 *Gas Pulsation Data*. Narrow band pressure Pulsation using the Flat Top Window per ASA S2.1/ISO 2041 data shall be obtained from a spectrum analysis of the Pulsation signal. If two transducers, ¼ wavelength apart are used, the highest value from either transducer at each frequency peak shall be used. These data shall be presented as kPa rms, for comparison purposes. Data shall be obtained in the frequency range of 5 to 1000 Hz.

Additionally, the time domain highest single cycle peak-to-peak pressure over each of the pressure transducers used shall be measured and their average value reported, with a plot of the trace closest to that average.

5.4 *Rating Conditions*. All tests on a positive displacement compressor shall be conducted with the compressor operating at Reference Rating Conditions specified in AHRI 540 (Table 4 (SI)) for the specific application. Fixed Displacement Compressors shall be rated at their Displacement Capacity. Discrete Modulating Compressors shall be rated at each discrete Displacement Capacity. Continuous Modulating Compressors shall be rated at the manufacturer's specified designed

Displacement Capacity steps. Continuous Modulating Compressors with cyclic load intervals shall be rated at their steady state discrete steps. For compressors not covered by AHRI 540, the equipment shall be operated at the conditions for which the compressor was specifically designed.

5.5 *Rating Tolerances.* Any Refrigerant Compressor selected at random and tested in accordance with this standard shall have an AHRI standard sound and vibration rating, when tested, not higher than its published rating.

Section 6. Minimum Data Requirements for Published Ratings

6.1 *Required Data to Be Published.*

6.1.1 *Operational Data*. The following operational data and information in the fields for a compressor shall be recorded.

6.1.1.1 *Compressor Specifications*.

6.1.1.1.1 Test number and date
6.1.1.1.2 Model, serial, and manufacturer
6.1.1.1.3 Rated compressor speed, Hz
6.1.1.1.4 Capacity, kW
6.1.1.1.5 Rated load current, A
6.1.1.1.6 Voltage, V
6.1.1.1.7 Frequency, Hz
6.1.1.1.8 Type of drive
6.1.1.1.9 Type of compressor
6.1.1.1.10 Oil type designation, viscosity and quantity
6.1.1.1.11 Compressor Step
6.1.1.1.12 Accessories (Normally furnished as part of the Compressor Assembly (shall be in place during test), such as Gears
6.1.1.1.13 Comments

6.1.1.2 *Compressor Test Conditions.*

6.1.1.2.1 Refrigerant
6.1.1.2.2 Measured saturated suction temperature, °C, and pressure, kPa
6.1.1.2.3 Measured saturated discharge temperature, °C, and pressure, kPa
6.1.1.2.4 Measured return gas temperature, °C
6.1.1.2.5 Nominal compressor test speed, Hz
6.1.1.2.6 Driver speed, Hz
6.1.1.2.7 Electric motor current, A, and voltage, V
6.1.1.2.8 Capacitor(s) (if used), μF
6.1.1.2.9 Isolator Static Stiffness at Working Load, N/mm
6.1.1.2.10 Isolator Dynamic Stiffness at Working Load, N/mm
6.1.1.2.11 Isolator Durometer, unitless (Shore A scale)
6.1.1.2.12 Isolator part number (provided per end user's request)

6.1.1.3 *Report By*

6.1.2 *Sound Power Level Rating Data.* The following sound test data and information in the fields shall be reported:

6.1.2.1 Model
6.1.2.2 Test number and date
6.1.2.3 One-third octave band sound power levels from 100 Hz to 10,000 Hz (50 through 80 Hz is optional), dB re 1 pW.
6.1.2.4 Calculated overall A-weighted sound power level, dBA. The overall A-weighted sound power level shall be for the full range of one-third octave band sound power levels reported.
6.1.2.5 Test method used
6.1.2.6 Comments
6.1.2.7 Tested by

6.1.3 *Vibration Data to be Reported.* The following information in the fields shall be reported.

6.1.3.1 Amplitude rms (mm)
6.1.3.2 Model
6.1.3.3 Test number and date
6.1.3.4 Three highest rms displacement levels, mm (to the nearest 0.002 mm), taken in X, Y, and Z directions presented in the frequency range of 5 to 500 Hz at the following locations (see Figure 2):

6.1.3.4.1 All mounting locations (1,2,3, and 4)
6.1.3.4.2 Suction fitting
6.1.3.4.3 Discharge fitting

These displacements shall be obtained from narrow band analysis. Conversion methods are defined in Appendix C. Since displacement amplitudes decrease with an increase in frequency at constant acceleration, maximum acceleration and maximum displacement may not occur at the same frequency. Care shall be used to ensure that maximum rms displacements are obtained for frequencies only at the fundamental mechanical rotating frequency and Harmonics of the Fundamental Frequency.

6.1.3.5 Frequency for each reported rms displacement, Hz
6.1.3.6 Sketch of actual geometry and measurement points
6.1.3.7 Comments
6.1.3.8 Tested by

6.1.4 *Gas Pulsation Data to Be Reported*. The following information in the fields shall be reported.

6.1.4.1 Model
6.1.4.2 Test Number and date
6.1.4.3 Suction Line

6.1.4.3.1 Frequency for each narrow band gas pulsation. (range of 5 to 1000 Hz), Hz
6.1.4.3.2 Ten highest narrow band gas pulsation pressure levels (to the nearest 0.5 kPa), kPa rms
6.1.4.3.3 Average of time domain highest single cycle peak-to-peak pressure over each of the pressure transducers used for suction (to the nearest 0.5 kPa), kPa

6.1.4.4 Discharge Line

6.1.4.4.1 Frequency for each narrow band gas pulsation, Hz
6.1.4.4.2 Ten highest narrow band gas pulsation pressure levels (to the nearest 0.5 kPa), kPa rms
6.1.4.4.3 Average of time domain highest single cycle peak-to-peak pressure over each of the pressure transducers used for discharge (to the nearest 0.5 kPa), kPa

6.1.4.5 Comments
6.1.4.6 Tested by

6.1.5 *Optional Information*. As an option, narrow band acceleration data may be supplied in chart form. These data shall be clearly labeled in units and amplitude, i.e., peak, peak-to-peak or rms. If the data is presented in dB levels, then the reference value and applicable sensitivity factors shall be stated.

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 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 this standard.

A1.1 Acoustical Society of America Standard Term Database. Acoustical Society of America. Accessed 25, 2021. http://asastandards.org/asa-standard-term-database/.

A1.2 AHRI Standard 220-2022, *Reverberation Room Qualification and Testing Procedures for Determining Sound Power of HVAC Equipment*, 2022, Air-Conditioning, Heating, and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, USA.

A1.3 AHRI Standard 250-2022 (SI), *Performance and Calibration of Reference Sound Sources, 2022, Air-Conditioning and Refrigeration Institute*, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, USA.

A1.4 AHRI Standard 540-2020, *Performance Rating of Positive Displacement Refrigerant Compressors and Compressor Units*, 2020, Air-Conditioning, Heating, and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, USA.

A1.5 ANSI/ASA S1.1 & S3.20, *Standard Acoustical & Bioacoustical Terminology Database*. Accessed August 25, 2021. https://asastandards.org/asa-standard-term-database/.

A1.6 ASA/ANSI Standard S1.6-2016 (R2020), *Preferred Frequencies and Filter Band Center Frequencies for Acoustical Measurements*, 2016 (Reaffirmed 2022), Acoustical Society of America, 1305 Walt Whitman Road, Suite 300, Melville, NY 11747, USA.

A1.7 ANSI/ASA Standard S12.55/ISO 3745-2012 (R2019), *Determination of Sound Power Levels and Sound Energy Levels of Noise Sources Using Sound Pressure – Precision Methods for Anechoic Rooms and Hemi-anechoic Rooms*, 2012 (Reaffirmed 2019), Acoustical Society of America, 1305 Walt Whitman Road, Suite 300, Melville, NY 11747, USA.

A1.8 ANSI/ASA Standard S2.1/ISO 2041-2009 (R2020), Mechanical vibration, shock and condition monitoring – Vocabulary, 2009 (Reaffirmed 2020), Acoustical Society of America, 1305 Walt Whitman Road, Suite 300, Melville, NY 11747, USA.

A1.9 ASHRAE Terminology. ASHRAE. Accessed August 25, 2021. https://www.ashrae.org/technical-resources/free-resources/ashrae-terminology.

A1.10 ANSI/ASHRAE Standard 23.1-2019, *Methods for Performance Testing Positive Displacement Refrigerant Compressors and Condensing Units that Operate at Subcritical Pressures of the Refrigerant,* 2019, ASHRAE, 180 Technology Parkway NW, Peachtree Corners, Georgia 30092, USA.

A1.11 ISO 16063-21:2003 (R2019) *Methods for the calibration of vibration and shock transducers — Part 21: Vibration calibration by comparison to a reference transducer*, 2003 (Reaffirmed 2019), International Organization for Standardization, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland.

A1.12 ISO 18431-1-2005 Corrigendum 1, *Mechanical vibration and shock -- Signal processing -- Part 1: General introduction*, 2009, International Organization for Standardization, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland.

A1.13 ISO 18431-2-2004 Corrigendum 1, *Mechanical vibration and shock -- Signal processing -- Part 2: Time domain windows for Fourier Transform analysis*, 2008, International Organization for Standardization, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, 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 this standard.

B1.1 ANSI/ASA Standard S12.50 - 2002/ISO 3740-2000 (R2017), *Acoustics – Determination of sound power levels of noise sources – Guidelines for the use of basic standards,* 2002 (Reaffirmed 2017), Acoustical Society of America, 1305 Walt Whitman Road, Suite 300, Melville, NY 11747, U.S.A.

B1.2 ASTM D5992–96 (2018), *Standard Guide for Dynamic Testing of Vulcanized Rubber and Rubber-Like Materials Using Vibratory Methods*, 2018, ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA, 19428-2959 U.S.A.

B1.3 ISO 18437-1-2012, *Mechanical vibration and shock -- Characterization of the dynamic mechanical properties of visco-elastic materials -- Part 1: Principles and guidelines*, 2012, International Organization for Standardization, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland.

B1.4 ISO 458-1-1985 (R2021), *Plastics -- Determination of stiffness in torsion of flexible materials -- Part 1: General method*, 1985 (Reaffirmed 2021), International Organization for Standardization, Case Postale 56, CH-1211, Geneva 21 Switzerland.

B1.5 ISO 4664-1-2022, *Rubber, vulcanized or thermoplastic -- Determination of dynamic properties -- Part 1: General guidance,* 2022, International Organization for Standardization, Case Postale 56, CH-1211, Geneva 21 Switzerland.

B1.6 ISO 6721-1-2019, *Plastics -- Determination of dynamic mechanical properties -- Part 1: General principles*, 2019, International Organization for Standardization, Case Postale 56, CH-1211, Geneva 21 Switzerland.

APPENDIX C. CONVERSION METHODS - INFORMATIVE

C1 *To convert from acceleration or velocity to displacement*

For sinusoidal signals:

Displacement: $x(t) = Xe^{j\omega t}$ C1

Velocity: $v = \dot{x}(t) = j\omega \cdot x(t)$ C2

Acceleration: $a = \ddot{x}(t) = -\omega^2 \cdot x(t)$ C3

Therefore the following relation shall be used in vibration measurements:

$V = \omega \cdot X$, and $a = \omega \cdot V$ or $a = \omega^2 \cdot X$

$X = V/\omega$ and $X = a/\omega^2$

Where:

j = square root of negative one
t = time, seconds
V = amplitude of the velocity, m/s
$\omega = 2\pi f$, radians/s (where f = frequency, Hz)
$\dot{x}$(t) = v = velocity, m/s
$\ddot{x}$(t) = a = acceleration, m^2/s
X = amplitude of the displacement, m