

Noise Standards for HVAC Equipment

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The shift toward improving the energy efficiency and sustainability of buildings has often resulted in HVAC equipment being located closer to the occupants, where sound from the equipment is now critical to the success of the building design. To assist designers, the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) publishes standards on equipment sound measurement and rating. These standards provide a “level playing field” for HVAC equipment manufacturers to rate their products, yet these standards are seldom referenced correctly, if at all, in project specifications. This article provides an overview of AHRI standards related to sound, including methods of test, product ratings and applying these ratings to predicting sound in the built environment.

The past two decades have seen a strong emphasis toward improving the energy efficiency and sustainability of buildings. This shift in building design has created a renewed interest in building occupant comfort and performance, particularly as it relates to indoor environmental quality (IEQ) factors such as acoustics.^{1,2} To meet new building energy and sustainability requirements, HVAC equipment is being located closer to the building occupants, and the sound from this equipment is now critical to the success of new building designs. Now, more than ever, there is a need to understand how to measure, rate, specify and apply sound data from HVAC equipment.

The Air-Conditioning, Heating, and Refrigeration Institute (AHRI) publishes standards related to HVAC equipment sound. The AHRI Technical Committee on Sound (TCoS) has the responsibility for all sound-related standards, and each standard requires a two-thirds majority approval at all stages of development. These standards are available at no cost from the AHRI website.³ Many of these standards are also approved ANSI standards. AHRI sound standards come in three basic types:

- Rating standards for various types of equipment
- Methods of test that are referenced by the rating standards
- Application standards.

Rating Standards

An overview of AHRI rating standards by type of equipment is shown in Table 1. Rating standards cover the scope of equipment and requirements for the test setup, test operating conditions and reporting requirements of HVAC equipment.

AHRI Standard 270 applies to outdoor sections of air-conditioning and heat-pump unitary equipment less than 40 kW capacity (11 tons). AHRI Standard 370 applies to outdoor air-cooled portions of large commercial air-conditioning and refrigeration equipment greater than 40 kW capacity.

AHRI Standard 260 applies to any equipment that has a duct connection, from large air-handlers to small fan coils. Ducted packaged equipment includes outdoor rooftop units and indoor air-conditioning units. Rooftops are an example of equipment that might be rated according to two standards – the air-handler section would be rated to 260, while the outdoor condensing section would be rated to either 270 or 370.

AHRI Standard 350 covers all equipment that operates at free inlet and outlet conditions (ductless), such as unit ventilators and vertical fan coils.

AHRI 880 applies to variable air volume (VAV) terminal units, single-ducted and fan-powered.

Standard 300 applies to packaged terminal air conditioning (PTAC) and heat pump (PTHP) equipment that is mounted through the wall, typically found in motel rooms. Because they also have a

significant airborne path from the outside to inside, the sound transmission loss (TL, STC and OITC) is also part of the product rating.

Table 1 also shows the required sound data that are reported for the product rating. Typically the octave-band sound power levels from 63 Hz to 8000 Hz are required. Smaller equipment such as unitary outdoor condensers and VAV terminal units are only rated from 125 Hz and up. For some products, the overall A-weighted sound power levels are required. These products are usually located outdoor or very near the occupant, where distance attenuation applies.

AHRI Standard 575 is the only standard that reports sound pressure levels. This standard was originally written to define a method of measuring the sound pressure level in equipment rooms, where the risk of hearing loss was the primary concern. Over time, this standard became the *de facto* standard for rating water-cooled chiller sound. This may change soon, since AHRI is working on a sound power standard for water-cooled equipment (AHRI 1280) that is covered in more detail in another NC14 paper.⁴ AHRI 575 is a useful tool for measuring noise in the field and will remain in the AHRI portfolio of standards.

An important part of AHRI ratings standards is the requirements for operating the unit during test. The determination and stability of the operating point can be a significant cause of variability in sound test data between laboratories.⁵ In general, catalog sound ratings are required at the standard thermal rating conditions for the type of equipment. Some standards, however, such as AHRI 260, require that the full operating map be tested. Most standards permit application ratings to be published, and manufacturers often provide these ratings in computer selection programs. Customers will sometimes require units be tested at specific application conditions as part of a sales order.

One major HVAC product is missing from the list in Table 1, variable refrigerant flow (VRF). These systems mix and match several types of outside condensing units with several types of indoor evaporator units, which are typically ductless. These systems are pervasive in Asia and South America, and are now becoming more prevalent in North America. At present the only published data are based on a Japanese test method, JIS B8616. The results are presented as A-weighted or octave-band sound pressure levels at a distance from the unit. Other than fan speeds, little information is provided on operating conditions. This product may be covered by AHRI sound standards in the future.

One final note, VAV terminal units are the only products that

EQUIPMENT TYPE	AHRI RATING STANDARD						
	260	270	300	350	370	575	880
Air-Handling Units, Fan Coils, etc.	✓						
Water-Cooled Chillers*						✓	
Air-Cooled Chillers		✓			✓		
Air-Terminal Devices							✓
Outdoor Condensing Units		✓			✓		
Water-Source Heat Pumps	✓			✓			
Ducted Packaged Equipment							
Indoor	✓						
Outdoor		✓			✓		
PTAC/PTHP			✓				
OCTAVE-BAND SOUND POWER							
Lw (63 - 8000 Hz)	✓			✓	✓		
Lw (125 - 8000 Hz)		✓	✓				
Lw (125 - 4000 Hz)							✓
LwA		✓		✓	✓		
TL, STC and OITC			✓				
OCTAVE-BAND SOUND PRESSURE							
Lp (63 - 8000 Hz)						✓	
LpA						✓	

*AHRI Standard 575 is not a rating standard, but it is used like one.

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have certified sound data (according to AHRI Standard 880). The certification program requires annual verification testing by a third party laboratory. The products to be tested are selected by AHRI staff and not by the manufacturer. A certification program for other HVAC products is difficult, given the variety of configurations and options that are available from most manufactures. Nevertheless, we may see more certification programs for AHRI sound ratings in the future.

Test Methods

HVAC Equipment ratings start with a basic understanding of how the equipment is tested. Table 2 is an overview of all the test standards referenced by AHRI standards. There are three general categories of test standards: comparison method in a reverberation room, sound intensity and free field.

AHRI Standard 220 describes the methodology for determining sound power levels in a reverberation room by comparing with a reference sound source (RSS). This standard is based on ANSI S12.51/ISO 3741, and was written in 2007 to overcome several issues with the ISO 3741 and ANSI S12.51 standards. These general test standards allow multiple source positions and do not require measurements below the 100 Hz third-octave band. Moving the source is generally not feasible for large HVAC equipment. Moreover, the HVAC industry for large air handlers and chillers demands data down to and including the 63-Hz octave band. This requires a fairly large reverberation room and a method for calibrating the reference sound source (RSS) down to the 50-Hz third-octave band.

To address the RSS calibration issue, AHRI also developed AHRI Standard 250 that permits use of sound intensity in the low frequencies and transfer calibration in a reverberation room at 100 Hz and higher.

Finally, AHRI 220 was the first industry standard to require discrete frequency qualification of the reverberation room. This is an option in all other reverberation room test standards.

AHRI Standard 230, sound intensity method of test, was approved in 2013. Presently only AHRI 260 includes sound intensity testing. By the end of 2016, however, it is likely that most of the rating standards will include this method of test. AHRI Standard 230 is based on ISO 9614-1 (grade 2), ISO 9614-2 (grade 2) and ANSI S12.12. Sound intensity can be performed in environments that are not ideal, but the methodology can be tedious and requires a high level of skill with the instrumentation. AHRI Standard 230 borrows the “performance verification with a reference sound source” concept from ANSI S12.12. This assures that the person performing the test has the requisite skills. Sound intensity is an excellent method to use where a limited number of operating conditions are needed, such as a customer sales order test.

One of the AHRI TCoS’s objectives is to assure that all AHRI test methods have equivalent uncertainty (reproducibility).^{5,6} The sound intensity and reverberation room methods have equivalent test reproducibility so that when these standards are referenced there is no question about the “grade” or quality of the test data. AHRI TCoS is presently conducting an interlaboratory comparison on all referenced test methods: AHRI 220, AHRI 230 and ISO

3744/3745. Several member firms and one independent laboratory are testing a standardized sound source to determine broadband and discrete frequency reproducibility for all test methods. This work is being conducted by the University of Nebraska and will be the basis of a new AHRI Standard 1150P on declaration and bias.⁷

Application Standards

AHRI 885 provides a uniform method of calculating the sound pressure level and NC (Noise Criteria) value in an occupied space served by VAV air terminals and/or air outlets. This standard was initially drafted in 1998. The method uses AHRI 880 radiated and discharge sound ratings and requires a detailed knowledge of the mechanical and architectural elements in the room. The standard provides normative sound attenuation values (Appendix E) for ceiling-mounted VAV terminals to determine the NC value of the occupied space. These attenuation values assume a favorable installation of a mineral-fiber ceiling system and lined duct at the unit discharge. The resulting NC values are published in manufacturer’s catalogs and provide a reasonable method of comparison between manufacturer’s units. Unfortunately, they do not represent actual NC values in most spaces, particularly for modern open-ceiling designs. Building designers must use actual mechanical and architectural design details to make accurate NC predictions using this standard.

AHRI 275 is a simple method of calculating the A-weighted sound pressure levels for outdoor unitary equipment applications. The standard accounts for equipment location near reflective surfaces, shielding from nearby structures, distance attenuation and multiple units. Recommended practices for unit selection, operation and installation are also discussed. This standard was initially drafted in 1984 and has changed very little since 1997.

Although it is not the primary mission of AHRI to provide application guidance, these two legacy standards are still in great demand. AHRI standard 275 is downloaded more often than any other AHRI sound standard. These standards provide a good starting point for more detailed application guidance as found in the ASHRAE Application Handbook or from a qualified acoustical consultant.

Project Specifications

AHRI sound standards are intended to be referenced in building specifications and represent a uniform method of comparing the acoustic performance of equipment from manufacturers. Conformance with AHRI sound standards is voluntary. Manufactures must select which products to publish sound ratings for and, in some cases, what setups or operating conditions in the standard to report. For example, there are many test setups described in AHRI Standard 260: ducted discharge, ducted inlet, casing radiated, free discharge, free inlet, and free discharge or (free inlet) combined with casing radiated. The manufacturer must understand how the product is typically used and publish what is considered appropriate for the application. Likewise, mechanical engineers should specify only what is appropriate for their building application.

Most standards provide sound power levels that are independent of the test environment. For this reason, sound power levels are the preferred starting point for predicting sound pressure levels in the built environment.

Unfortunately AHRI standards are seldom referenced correctly in building mechanical specifications. With few exceptions, AHRI standards are performance standards. Other than the unit options or operating conditions, no further requirements are needed in the specification. Often AHRI standards are comingled with standards for building elements, such as ASTM E90 and C423, or with HVAC unit components, such as AMCA 300. The result is an equipment material/component specification that is not compatible with the performance requirement. Building mechanical specifications often have sound test requirements that do not conform with any test standard or are a blend of pieces from several different test standards. To avoid this type of confusion, specify AHRI performance ratings and test methods for HVAC equipment.

Finally, many building mechanical specifications have requirements for meeting sound pressure requirements, such as room NC

Table 2. AHRI test methods for determination of sound power.

METHOD OF TEST	AHRI RATING STANDARD						
	260	270	300	350	370	575	880
REVERBERATION ROOM							
AHRI 220	✓	✓	✓	✓	✓		✓
AHRI 250	✓	✓	✓		✓		✓
ASHRAE 130 ^a							✓
SOUND INTENSITY							
AHRI 230 ^b	Y15	Y14	Y14	Y14	Y15		
ISO 9614-Parts 1&2	✓						
FREE-FIELD							
ISO 3745 ^c					✓		
ISO 3744 ^c					✓		
SOUND TRANSMISSION							
ASTM E-90 (TL)			✓				
ASTM E413 (STC)			✓				
ASTM E1332 (OITC)			✓				

a - Unit setup and configuration per ASHRAE 130. Sound power determination per AHRI 220

b - Estimated year when AHRI 230 MOT will be approved in rating standard

c - As adapted for large AC chillers in Appendix D of AHRI 370

values. Unless detailed architectural and mechanical drawings are provided in the bid document, equipment manufacturers cannot guarantee NC values in the occupied space. If construction of a mockup is required to confirm NC values, the acoustic consultant should provide the AHRI sound power levels that are the basis for the predicted levels in the occupied space.


Conclusions

AHRI sound standards facilitate comparing equipment from various manufactures and are an essential tool for predicting the background noise in the built environment. These standards are continuously being updated to reflect new equipment types and improvements in test methods. These standards should be referenced in building mechanical specifications.

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References

1. C. Eichelberger, "IEQ/Acoustics," *Performance Measurement Protocols: Best Practices Guide*, ASHRAE, Atlanta, GA, 2012.
2. M. Frontczak, S. Stefano, *et al.*, "Quantitative Relationships between Occupant Satisfaction and Aspects of Indoor Environmental Quality and Building Design," Center for the Built Environment, Berkeley, CA, 2007.
3. Air-Conditioning, Heating, and Refrigeration Institute (AHRI), <http://www.ahrinet.org/>
4. P. Marks, D. Unger, "AHRI 1280P – A New Standard for Rating the Sound Power of Water-Cooled Chillers," *INCE NoiseCon14 Proceedings*, 2014.
5. S. Lind, "Uncertainty of Sound Power Levels Determined Following Air Conditioning Heating and Refrigeration Institute Standard 220," *Acoustical Society of America, Proceedings of Meetings on Acoustics*, Vol. 8, 015002, 2010.
6. C. Eichelberger, "Update on AHRI Standard 260, Sound Rating of Ducted Equipment," ASHRAE Annual Meeting, San Antonio, TX, 2012.
7. M. Blevins, L. Wang, and S. Lau, "Bias and Reproducibility of Sound Power Test Methods," *Acoustical Society of America, Proceedings of Meetings on Acoustics*, Vol.135, No. 4, Pt .2, Session2aAA, 2014. 

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