INVITATION TO SUBMIT A RESEARCH PROPOSAL ON AN ASHRAE RESEARCH PROJECT

1882-TRP, Procedure for Estimating Occupied Space Sound Levels in the Application of UFAD Air Terminals and Air Outlets

Attached is a Request-for-Proposal (RFP) for a project dealing with a subject in which you, or your institution have expressed interest. Should you decide not to submit a proposal, please circulate it to any colleague who might have interest in this subject.

Sponsoring Committee: TC 2.6 Sound & Vibration
Co-sponsored by: TC 5.3 Room Air Distribution

Budget Range: $125,000 may be more or less as determined by value of proposal and competing proposals.

Scheduled Project Start Date: **April 1st, 2026,** or later.

All proposals must be received at ASHRAE Headquarters by 8:00 AM, EDT, December 15th, 2025. NO EXCEPTIONS, NO EXTENSIONS. Electronic copies must be sent to rpbids@ashrae.org. Electronic signatures must be scanned and added to the file before submitting. The submission title line should read: 1882-TRP, Procedure for Estimating Occupied Space Sound Levels in the Application of UFAD Air Terminals and Air Outlets, and *"Bidding Institutions Name"* (electronic pdf format, ASHRAE's server will accept up to 10MB)

If you have questions concerning the Project, we suggest you contact one of the individuals listed below:

For Technical Matters
Technical Contact
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For Administrative or Procedural Matters:
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Contractors who plan to submit a proposal must notify the Manager of Research and Technical Services (MORTS) via email by December 1st. This will ensure that they receive any late or additional information regarding the RFP before the bid due date. Monday, December 1st, 2025, is the deadline for submitting technical inquiries.

All proposals must be submitted electronically. Electronic submissions require a PDF file containing the complete proposal preceded by signed copies of the two forms listed below in the order listed below. **ALL electronic proposals are to be sent to rpbids@ashrae.org.**

All other correspondence must be sent to ddaniel@ashrae.org and shammerling@ashrae.org. In all cases, the proposal must be submitted to ASHRAE by 8:00 AM, EDT, Monday, December 15th 2025. NO EXCEPTIONS, NO EXTENSIONS.

The following forms (Application for Grant of Funds and the Additional Information form have been combined) must accompany the proposal:

(1) ASHRAE Application for Grant of Funds (electronic signature required) and
(2) Additional Information for Contractors (electronic signature required) ASHRAE Application for Grant of Funds (signed) and

ASHRAE reserves the right to reject any or all bids.

State of the Art (Background)

Fan-powered terminal units are widely used in conventional overhead HVAC systems offering commercial building owners numerous benefits; including improved heating performance and reduced reheat compared to non-fan-powered systems. Fan-powered terminals are also used in UFAD systems to boost heating & cooling performance in perimeter zones. One disadvantage with using fan-powered terminals is noise. Integral fans transmit noise into the space via supply air ductwork and through the unit casing/induction ports. Fan-powered terminals are typically located in close proximity to the spaces they serve (above the ceiling or in a floor plenum), therefore HVAC system designers and acousticians are tasked with performing additional calculations to ensure the desired space noise criteria is not exceeded when using fan terminals.

Procedures for performing calculations can be found in AHRI Standard 885 *Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets.* This standard includes a comprehensive set of tables for estimating room noise levels including loss data for various types and sizes of ductwork and linings, sound power splits and room/ceiling correction factors. Standard 885 is currently the only accepted standard in use by terminal unit manufacturers to convert their laboratory sound power data into room sound pressure levels, expressed as NC. The resulting published data allows users to compare manufacturers performance data and select equipment with confidence.

However, the current AHRI Standard 885 only pertains to conventional overhead HVAC systems and does not include procedures for estimating sound levels from equipment located below an RAF. The scope section of the standard states: *"This Standard is not currently applicable for underfloor radiated or discharge sound calculations."*

The procedures laid out in Standard 885 cannot be modified or substituted with other known data (floor tile STL for example) to model the unique acoustical properties of a RAF. Although at first glance, UFAD systems appear to be just overhead HVAC systems flipped upside down (incorrectly leading to the premise that AHRI 885 procedures can be used to perform sound calculations), there are crucial differences that should be understood.

Firstly, the acoustical properties of the floor tiles separating the noise-generating equipment and occupants are quite different from typical ceiling tiles. Floor tiles comprise a cementitious material cast in a sheet steel tray, so are vastly denser than lightweight ceiling tiles, therefore have a significantly higher sound transmission loss. However, unlike ceiling tiles, floor tile manufacturers do not publish sound transmission data, so acoustical engineers must either estimate or ignore sound transmission through floor tiles when performing floor plenum to room sound transmission calculations.
The following table compares the approximate sound transmission loss (STL) of a typical mineral fiber ceiling tile with the calculated STL of a typical raised access floor tile:

		Octave Band Mid Frequency, Hz					
Tile Type	**Data Source**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Mineral Fiber Ceiling Tile	AHRI 885	16	18	20	26	31	36
RAF Tile (9lbs/ft^2)	Calculated	28	34	40	46	52	58

The STL difference between RAF and ceiling tiles is significant, which suggests that the predominant sound path of UFAD borne noise is likely to be through air transfer diffusers and not though the floor tiles. This theory will be tested as part of this research project.

Secondly, raised access floor plenums are acoustically less absorbent than overhead ceiling plenums as most of the exposed surfaces are either concrete, masonry or steel. The internal surfaces of ceiling plenums have extensive sound-absorbing materials such as the underside of the ceiling tiles and fireproofing treatments. Sheet steel ductwork is also wrapped with sound absorbing thermal insulation.

The *ASHRAE UFAD Design Guide,* lacks procedures, tables or any methodology to calculate the transmission of plenum borne noise into occupied spaces. Quoting an excerpt from page 111:*"The calculation of the sound from*

underfloor devices passing through the UFAD plenum and through the raised floor/diffuser combination ***has not been studied sufficiently*** *to be able to provide a reliable calculation path."*

Terminal Unit Manufacturers Sound Data

While all terminal unit manufactures provide sound power data tested in accordance with ASHRAE Standard 130, none were found to publish room corrected NC's levels for their UFAD products. The data published by the following manufacturers excludes NC sound levels or any means to calculate:

Price Industries:
https://www.priceindustries.com/content/uploads/assets/literature/fdu-underfloor-fan-powered-booster--terminal-unit-sound-data.pdf

Nailor Industries Inc:
https://nailor.com/sites/nailor.com/files/documents/PDUFFP38SDS.pdf

Titus HVAC:
https://www.titus-hvac.com/file/8385/LHKperf_underfloor_2018.pdf

Justification and Value to ASHRAE
The *ASHRAE Applications Handbook, Chapter 48 Noise and Vibration Control*, contains equations and algorithms for the calculation of space sound levels based on equipment, system design, and room design. These equations were all developed through ASHRAE funded research. They are used by mechanical engineers and acoustical consultants, incorporated into commercial tools, and applied in standards such as *AHRI Standard 885*.

Underfloor air distribution is a common application, yet there are no equations, algorithms, or tools available for acoustic design. Addressing this current gap in the industry knowledge will enhance the value of the *ASHRAE HVAC Applications Handbook* and the *UFAD Design Guide*, which acknowledges the need for this research.

Objectives
The project objectives will include:

- Construction of a 30 x 10 ft RAF test stand which will be used to perform sound tests to characterize the unique sound properties of an underfloor air distribution system. A calibrated reference sound source (RSS) will be placed beneath the RAF to simulate the sound produced by an underfloor fan terminal or other noise producing equipment.
- The following variables will be tested:
    - Two common types of RAF tile.
    - Three common styles/sizes of UFAD air diffusers, square high projection and swirl low projection.
    - Orientation of the diffuser air inlet relative to the reference sound source.
    - UFAD air diffuser distances from the reference sound source: 4', 6', 8', 10', 12', 14'.

- Using the sound data collected during the testing phases, develop a set of calculation procedures and tables that can be used to estimate the sound transmission octave band insertion loss of RAF plenum borne noise passing through the UFAD air diffusers into the occupied rooms above the RAF.

Develop a spreadsheet application (similar to the *AHRI-885-2008* tool) to automate the calculation procedures to present the user with octave band room sound pressure levels and NC values based on various scenarios such as varying diffuser quantities, various distances from the sound source and two styles of air diffusers.

Scope:

The project will entail four activity phases: in Phase 1, the contractor shall construct a RAF test stand consisting of floor tiles supported on pedestals/jacks laid out on a 24" x 24" grid. During Phase 2, the contractor shall perform sound tests by installing a noise generator under the RAF and capture sound intensity readings at the air diffuser

openings which are placed at various distances from the noise source. The noise generator could be either a fan powered terminal unit or a calibrated Reference Sound Source (RSS, a B&K Type 4204 for example), there are pros/cons with both approaches. A FPTU seems the obvious choice as the overall test setup would closely simulate a real-world installation, however, the FTPU would require sound power verification by means of ASHRAE Standard 130 reverberation room testing, increasing the project costs. Also, the FPTU may not develop high enough sound pressure levels at the diffuser openings furthest from the FTPU, which will impact the measurement accuracy. An RSS produces higher sound levels and is easier to install beneath the test stand so is the recommended option for the project. In Phase 3, the contractor shall analyze the results and develop tables and/or equations that characterize the acoustic properties and attenuation with distance of the RAF plenum and air diffusers. Phase 4 involves development of the Research Report and software calculation tool.

Phase 1: Construction of Raised Access Floor System Test Stand

The contractor shall construct a RAF test stand comprising 24" x 24" floor tiles supported on floor jacks/pedestals with the exposed room side surface finished with carpet tiles. The open perimeter sides of the RAF shall be enclosed with concrete blocks.

RAF Test Stand Construction Specification and Tasks

Task P1-1: Test Stand Location

Choose a suitable indoor area to assemble the RAF test stand. The stand shall be constructed on a flat concrete surface. A smooth surface is preferred but not essential, refer to the International Concrete Repair Institute CSP classifications for guidance and aim for a CSP classification of 5 (medium shotblast) or lower. The test stand should be constructed in an acoustically controlled environment that ensures the background noise level is at least 10 dB lower than the measured sound intensity levels obtained at the air diffusers, which are predicted to exceed NC 30. The test stand area shall be made clean and free from loose debris before the test stand is installed.

Task P1-2: Test Stand Construction

Contractor shall construct a RAF test stand comprising 24" x 24" pressed steel waffle construction floor tiles filled internally with a cementitious core material having a minimum overall panel weight of no less than 8 lbs/ft^2. Floor tiles shall be laid onto 96 floor pedestals arranged on 24" x 24" (centers) grid and adjusted to obtain an approximate 14" clear plenum height from the base floor to the underside of the tiles. Floor jacks/pedestals are usually glued to the base floor to ensure stability, however, this is not a requirement but recommended to ensure a safe and stable installation.

The RAF perimeter shall be sealed with a frame constructed with concrete blocks of nominal size 16"x 8"x8". All gaps between the concrete blocks, base floor and RAF tiles must be sealed with dense mastic sealant to reduce sound transmission from and to the plenum. The interior facing surfaces of the concrete blocks shall be fitted with 4" or thicker fibrous insulation to acoustically replicate a large unobstructed plenum for some of the sound tests.

The finished RAF dimensions shall be 10' wide x 30' long consisting of 5 x 15 qty of 24" x 24" floor tiles. Carpet tiles shall be fixed to the surface of the floor tiles with the carpet tiles overlapping the floor tile joints in common with standard practice. At least six (6) floor tiles shall have cutouts in the center of the tile to accommodate the various types and sizes of floor diffusers to be tested. Refer to the air diffuser manufacturers technical literature to determine the exact size of the floor tile cutouts.

Refer to attached drawing set WS-1882 for details of the RAF test stand construction.

Phase 2: Sound Testing

The sound testing strategy involves setting up a reference sound source (RSS) below the RAF and perform sound intensity measurements above a reference floor tile (RFT) with an opening cut in the center to match the test air diffuser size. A sample diffuser will then be inserted into the RFT and the sound intensity measurements will be repeated. The results of the tests will be compared so the insertion loss of the sample diffuser can be calculated.

Note that these tests require the use of specialist sound intensity measuring equipment and bidding contractors will be expected to demonstrate their expertise and project experience in the use of such equipment.

The following tasks describe the capture of sound measurements and should be read in conjunction with the

Test List shown on drawing # WS-1882-06. All sound levels shall be obtained using Type 1. classification (IEC 61672-1:2013, BS EN 61672-1:2003 or DIN EN 61672-1:2014) sound level meters and/or analyzers and sound intensity wands. Sound intensity measurement procedures should be consistent with ISO 9614-2:1993 standard. Room background sound measurement procedures should be consistent with ANSI S12.72 standard. Equipment calibration should be checked before and after each set of tests. All sound data must be captured in third-octave band resolution.

Task P2-1: Background Noise
The contractor shall measure the background sound pressure levels in the lab or room where the RAF test stand is installed. Background sound tests shall be undertaken without the RSS running. The maximum background sound pressure levels must be at least 10dB below the sample sound intensity measurements recorded at the RFT's which are estimated to be higher than NC 30, therefore the background sound pressure levels must not exceed approximately NC 20.

Task P2-2: Tile Insertion Loss Tests
With the RSS running, sound intensity measurements shall be obtained above a solid carpet covered floor tile directly above the RSS. The tile shall then be replaced with a RFT with a 10.5" x 10.5" cutout, (without an air diffuser inserted into the opening) and the sound intensity measurements repeated. The purpose of these tests is to establish the insertion loss of the floor/carpet tile. Test is repeated with a quantity of 5 waffle tiles replaced with solid type tiles, refer to drawing # WS-1882-05B

Task P2-3: Plenum Attenuation Tests
The RFT shall then be relocated at each of the RSS distances shown on the Test List and the sound intensity measurements repeated. The purpose of these tests is to establish the plenum sound attenuation properties at various distances from 4' to 14' from the RSS.

*Task P2-4: Plenum Acoustic Insulation Installation and Test*s
The floor tiles around the perimeter of the test stand shall be removed to gain access to the concrete block perimeter blocks so 4" thick glass fiber acoustic insulation material can be applied to the interior surfaces of the perimeter wall. The acoustic insulation will reduce sound reflections from the concrete blocks and thereby acoustically simulate a larger open floor plenum. The acoustic material must not be installed on the base floor surfaces or underside of the floor tiles. Refer to drawing # WS-1882-02 for installation detail.

The sound measurements detailed in *Task P2-3* shall be repeated to establish the plenum sound attenuation properties at various distances from the RSS with the acoustic wall plenum lining installed.

Task P2-5: Round Air Diffuser Tests
The RFT (with 10.5" x 10.5" cutout) shall be replaced with an RFT with a 6" diameter cutout and installed at an RSS distance of 6'. Sound intensity readings shall be captured above the 6" diameter hole. The sound tests shall be repeated with an 8" diameter air diffuser installed in the tile cutout hole. The purpose of this test is to establish the insertion loss of an 8" diameter air diffuser. These two tests shall be repeated with an RFT with 8" diameter hole and 10" diameter air diffuser.

Multiple diffuser tests: additional RFT's with 6" diameter cutouts shall be installed and the tests repeated. The purpose of this test is to establish the effect of installing multiple diffusers in the near proximity of the test diffuser. Refer to drawing # WS-1882-05A for further information.

Task P2-6: Square Air Diffuser Tests
Perform a repeat of *Task P2-5* using a 10.5" x 10.5" cutout RFT fitted with and without a square style air diffuser again, placed at an RSS distance of 6'. Note two additional sound tests are required to determine the effect of air inlet orientation relative to the RSS. Refer to drawing # WS-1882-05 for further information. Also note that the multiple diffuser array is not required for this test set i.e. all of these tests shall be performed with a single RFT/diffuser.

Phase 3: Data Analysis of Test Results & Format of Results

Task P3-1: Results Analysis & Formatting of Results

The contractor shall analyze the tests results and conduct further or repeat sound tests if the results show a need to do so. Once complete, the final sound data shall be analyzed and a set of tables and equations developed to predict sound attenuation and plenum effect at various distances from an underfloor noise source. Tables representing insertion losses for the two styles of air diffusers shall be produced, including correction factors for air inlet orientation and diffuser size as applicable. Tables and equations should also include corrections for conversion to room sound pressure levels, although note that testing to establish room effect and distance to occupant is not required as these procedures are known and published.

Phase 4: Research Report & Development of Calculation Tool

Task P4-1: Report & Spreadsheet Calculator Tool

Produce a Research Report, refer to the *Deliverables* section for requirements.

Task P4-2: Spreadsheet Calculator Tool

The contractor shall develop a spreadsheet application tool designed for use by engineers to predict room sound pressure levels at a range of distances from an underfloor sound source (such as a fan powered terminal). The tool shall present the user with various scenarios and variables including room size, quantity of diffusers and diffuser style and size. An example of a similar spreadsheet calculator is the *AHRI Standard 885-2008* tool (link below) which is used for calculating sound transmission from conventional overhead HVAC fan terminals through a ceiling.

Task P2-5: Round Air Diffuser Tests

The RFT (with 10.5" x 10.5" cutout) shall be replaced with an RFT with a 6" diameter cutout and installed at an RSS distance of 6'. Sound intensity readings shall be captured above the 6" diameter hole. The sound tests shall be repeated with an 8" diameter air diffuser installed in the tile cutout hole. The purpose of this test is to establish the insertion loss of an 8" diameter air diffuser. These two tests shall be repeated with an RFT with 8" diameter hole and 10" diameter air diffuser.

Multiple diffuser tests: additional RFT's with 6" diameter cutouts shall be installed and the tests repeated. The purpose of this test is to establish the effect of installing multiple diffusers in the near proximity of the test diffuser. Refer to drawing # WS-1882-05A for further information.

Task P2-6: Square Air Diffuser Tests

Perform a repeat of *Task P2-5* using a 10.5" x 10.5" cutout RFT fitted with and without a square style air diffuser again, placed at an RSS distance of 6'. Note two additional sound tests are required to determine the effect of air inlet orientation relative to the RSS. Refer to drawing # WS-1882-05 for further information. Also note that the multiple diffuser array is not required for this test set i.e. all of these tests shall be performed with a single RFT/diffuser.

https://www.ahrinet.org/system/files/2023-06/AHRI%20Standard%20885-2008%20Duct%20Discharge%20Calculation%20Spreadsheet%20%285%29.xls

Deliverables:

a. Interim Report

An intermediate progress report should be provided to the Project Monitoring Subcommittee at 25% and 50% progress internal, as determined by % complete of the test matrix attached. An intermediate draft of the Research Report should be submitted to the Project Monitoring Subcommittee as determined by the project milestones below.

Deliverable 1 - Interim Report

The sound data captured during Tasks P2-1 to P2-4 shall be processed and prepared for inclusion within an Interim Report and submitted to the PMS for approval. The remaining Phase 2 sound tests can commence

only when comments or issues with the initial results have been addressed and written approval to proceed is received from the PMS. Photographs of the test stand shall be included in the Interim Report.

Deliverable 2 - Preliminary Report
On completion of all Phase 2 sound tests and data analysis, the formatted data, tables and equations shall be prepared for inclusion within a Research Report and submitted to the PMS.

The following shall also be included in the Research Report:

- All sound measurements captured throughout the testing phase including the test space background noise levels
- Procedures and tables used to predict the sound pressure levels within a typical office space with the following variables:
    - Size of room
    - Diffuser quantity
    - Diffuser type
    - Distance from the sound source to the occupant
- A beta version of the Spreadsheet Calculator Tool
- Photographs of the test stand
- Shop drawings of the floor tiles and air diffusers
- Product data sheets for the carpet/RAF tiles and plenum acoustic insulation
- Manufacturers specifications of the sound measuring equipment used throughout the project

Deliverable 3 - Final Report & Spreadsheet Calculator
After the review and acceptance of the preliminary report by the PMS, the contractor shall prepare and submit a final report to the PMS addressing all comments received from the PMS. The final version of the Spreadsheet Calculator Tool shall be submitted with the report.

b. Progress and Financial Reports

Progress and Financial Reports, in a form approved by the Society, shall be made to the Society through its Manager of Research and Technical Services at quarterly intervals; specifically, on or before each January 1, April 1, June 10, and October 1 of the contract period.

Furthermore, the Project Manager, subject to the Society's approval, shall, during the period of performance and after the Final Report has been submitted, report in person to the sponsoring Technical Committee/Task Group (TC/TG) at the annual and winter meetings, and be available to answer such questions regarding the research as may arise.

c. Final Report

A written report (collectively, "Final Report"), in a form approved by the Society, shall be prepared by the Project Manager, containing complete details of all research carried out under this Agreement. Unless otherwise specified, four copies of the final report shall be furnished for review by the Society's Project Monitoring Subcommittee (PMS).

Following approval by the PMS and the TC/TG, in their sole discretion, final copies of the Final Report will be furnished by the Project Manager as follows:

-An executive summary in a form suitable for distribution to PMS and TC/TG
-Two bound copies
-Two copies on USB drive; one in PDF format and one in Microsoft Word.
- All data must be provided to ASHRAE in Microsoft Excel or similarly editable spreadsheet software

d. Data

The contractor agrees to maintain true and complete books and records, including but not limited to notebooks, reports, charts, graphs, analyses, computer programs, visual representations etc., (collectively, the "Data"), generated in connection with the Services. Society representatives shall have access to all such Data for examination and review at reasonable times. The Data shall be held in strict confidence and shall not be released to third parties without prior authorization from the Society. The original Data shall be kept on file by the contractor for a period of two years after receipt of the final payment and upon request the Institution will make a copy available to the Society upon the Society's request.

e. *Science & Technology for the Built Environment*

One or more papers shall be submitted first to the ASHRAE Manager of Research and Technical Services (MORTS) and then to the "ASHRAE Manuscript Central" website-based manuscript review system in a form and containing such information as designated by the Society suitable for publication. Papers specified as deliverables should be submitted to Research Papers for HVAC&R Research for ASHRAE Transactions. Research papers contain generalized results of long-term archival value, whereas technical papers are appropriate for applied research of shorter-term value, ASHRAE Conference papers are not acceptable as deliverables from ASHRAE research projects. The paper(s) shall conform to the instructions posted in "Manuscript Central" for HVAC&R Research papers. The paper title shall contain the research project number (1882-RP) at the end of the title in parentheses, e.g., (1882-RP).

All papers or articles prepared in connection with an ASHRAE research project, which are being submitted for inclusion in any ASHRAE publication, shall be submitted through the Manager of Research and Technical Services first and not to the publication's editor or Program Committee.

f. Data

Data is defined in General Condition VI, "DATA"

g. Project Synopsis

A written synopsis totaling approximately 100 words in length and written for a broad technical audience, which documents 1. Main findings of research project, 2. Why findings are significant, and 3. How the findings benefit ASHRAE membership and/or society in general shall be submitted to the Manager of Research and Technical Services by the end of the Agreement term for publication in ASHRAE Insights

The Society may request the Institution submit a technical article suitable for publication in the Society's ASHRAE JOURNAL. This is considered a voluntary submission and not a Deliverable. Technical articles shall be prepared using dual units; e.g., rational inch-pound with equivalent SI units shown parenthetically. SI usage shall be in accordance with IEEE/ASTM Standard SI-10.

Level of Effort

The project anticipates a 18-month timeframe, 3 months to construct the raised access floor system, 5 months to obtain the sound data and 7 months to analyze the data, develop the algorithms and tables and 3 months to develop the software tool. Costs are estimated to be $125,000.

Other Information to Bidders (Optional):

Donations from RAF floor manufacturers and air diffuser manufacturers will reduce the project cost.

Project Milestones:

No.	Major Project Completion Milestone	Deadline Month
1	Phase 1 - Construction of Raised Access Floor	3
2	Phase 2 - Sound Tests	8
3	Phase 3 - Analysis of Test Results	15

4	Phase 4 – Research Report & Spreadsheet Calculation Tool Completion	18

Proposal Evaluation Criteria

Proposals submitted to ASHRAE for this project should include the following minimum information:

No.	Proposal Review Criterion	Weighting Factor
1	Contractors' capability in terms of facilities	30
2	Contractors' previous experience with sound intensity measurements and algorithm development	40
3	Quality and detail of contractor's proposal and methodology,	30

References

1. AHRI 885
   https://www.ahrinet.org/system/files/2023-06/AHRI_Standard_885_2008_with_Addendum_1_0.pdf
2. ASHRAE UFAD Guide
   https://www.ashrae.org/technical-resources/bookstore/ufad
3. ASHRAE Standard 130
   https://store.accuristech.com/ashrae/standards/ashrae-130-2016?gateway_code=ashrae&product_id=1935829