

INVITATION TO SUBMIT A RESEARCH PROPOSAL ON AN ASHRAE RESEARCH PROJECT

1923-TRP, Prepare climatic design conditions for the 2025 ASHRAE Handbook – Fundamentals and ASHRAE Standard 169

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 4.1, Load Calculation Data and Procedures
Co-sponsored by: TC 4.2, Climatic Information

Budget Range: \$160,000 may be more or less as determined by value of proposal and competing proposals.

Scheduled Project Start Date: **April 1, 2022** or later.

All proposals must be received at ASHRAE Headquarters by 8:00 AM, EST, December 15, 2021. 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: 1923-TRP Prepare climatic design conditions for the 2025 ASHRAE Handbook – Fundamentals and ASHRAE Standard 169, 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

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For Administrative or Procedural Matters:

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Contractors intending to submit a proposal should so notify, by mail or e-mail, the Manager of Research and Technical Services, (MORTS) by December 1, 2021 in order that any late or additional information on the RFP may be furnished to them prior to the bid due date.

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 mvaughn@ashrae.org. Hardcopy submissions are not permitted. **In all cases, the proposal must be submitted to ASHRAE by 8:00 AM, EST, December 15, 2021. 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)

Over the years, successive editions of the ASHRAE Handbook – Fundamentals have provided engineers with tables of climatic design conditions that help them properly size equipment used in HVAC applications. The usefulness of these tables has grown and they are now referenced in many chapters of the Handbook, such as *Fenestration* (ch. F-15), *Ventilation and Infiltration* (ch. F-16), *Residential cooling and heating load calculations* (ch. F-17), *Nonresidential cooling and heating load calculations* (ch. F-18), *Energy estimating and modeling methods* (ch. F-19), *Airflow around buildings* (F-24), and others. The tables also form the backbone of Standard 169, *Climatic Data for Building Design Standards* (maintained and revised periodically by Standing Standard Project Committee [SSPC] 169), and in 2021 contributed to a significant revision of the data used in the *ASHRAE Handbook of Smoke Control Engineering*.

The tables have evolved over time. Design temperatures for ‘summer’ and ‘winter’ conditions, typical of temperate climates, were replaced by annual design conditions that are applicable to all climates. Monthly design conditions were added to reflect the advent of more sophisticated HVAC sizing methods. Clear-sky irradiance was introduced to enable a more accurate estimate of air-conditioning loads in buildings. All-sky irradiance, precipitation, and other elements were also added to be used in green building applications. The tables published in the 2021 Handbook thus include close to 600 elements; about 20% of these represent annual design conditions while others provide monthly design conditions.

This evolution was also accompanied by an increase in the number of stations tabulated. The wider accessibility of climatic data in electronic format led to a six-fold increase in the number of stations between 1997 and 2021. This was mirrored in the way the data was distributed, from printed tables to tables on CD, then on DVD, and in the most recent edition (2021), available via a web portal and through a web API. This growth in the number of stations is more than anecdotal. The increased density of stations enables the use of climate conditions that are more representative of the actual location where buildings are located. The growth has also been representative of the international mandate of ASHRAE, with stations outside of the USA and Canadian now making up two thirds of stations listed in the Handbook, vs. just over one half in 1997.

Regular updates with each new edition of the Handbook have also enabled climatic design conditions to remain representative of the current climate. The last three research projects that updated the climatic design conditions have also calculated long-term trends in average and design temperatures, degree-days, and other variables. They have shown trends consistent with a generally warming climate; this warming may be a combination of climate change and urbanization. Whatever its causes, one cannot assume that the climate is stationary. The approach taken by TC 4.2 (sponsor for this and previous research projects) has been to use a 25-year sliding period to calculate the climatic design conditions, with the period updated with each new edition of the Handbook (1995-2019 for the 2021 edition; it is assumed that 1999-2023 will be used for the 2025 edition). This enables ASHRAE to provide its membership with data that is current, which supports both the mitigation of climate change (in the sense that more accurate design conditions lead to more efficient systems) and the adaptation to the ongoing evolution of the climate.

Justification and Value to ASHRAE

Climatic design conditions in Chapter 14 of the Handbook are essential for sizing and design procedures for HVAC systems; they enable energy system capacity to be sized in such a way that it meets climatic loads in a probabilistic sense. Regular updating of the climatic design conditions has therefore a direct impact on the work of HVAC practitioners and shows due diligence in a world of changing climate.

The update of Standard 169 is also another tangible outcome of this research project that helps ASHRAE remain at the forefront of tools and methods for the design of highly efficient buildings. Standard 169 is referenced by Standards 90.1, 90.2, 90.4, 189.1, among others.

Finally, the prospect of having additional data for under-represented areas will enable to design buildings and HVAC systems with design conditions that are much more representative of their actual environment.

Objectives

The objectives of this project can be summarized as follows:

1. Recalculate the tables of climatic conditions in Chapter 14 of the ASHRAE Handbook – Fundamentals, using for most stations hourly weather stations data for the period 1999-2023 (25 years) from the National Oceanic and Atmosphere Administration (NOAA) and Environment Canada (EC), and supplemented by other sources or data from other periods as required/available. All parameters in the 2021 edition will be included in the 2025 edition, with the exception of cooling degree hours. A limited number of new parameters may also be considered for inclusion.
2. Develop and document methods to be used in Objective 1 above to fix quality issues in the source data, in a format that makes it suitable to be reused in other projects.
3. Subject to its timely completion, incorporate the set of climatic design conditions calculated by 1900-TRP for stations with insufficient data in the NOAA or EC archives. This will represent a limited number of sites, targeting highly populated urban centers currently not available in the Handbook. Depending on the results of 1900-TRP, this may involve a more limited set of design conditions, which could be designated as “Tier 2” locations. This task should be understood as a simple integration of the results of 1900-TRP, and does not involve regenerating the data.
4. Update clear-sky coefficients based on the most recently available remotely sensed aerosol, water vapor, ozone, ground albedo and nitrogen dioxide data.
5. Update all-sky solar radiation using the most recently available remotely sensed or gridded data.
6. Update precipitation data using the most recently available gridded data sets and observational data sources, as appropriate.
7. Update calculations of climatic trends: regional trends that include all stations within a certain radius (200 km in the 2021 edition) of a station; and individual station trends.
8. In coordination with the PMS and ASHRAE, review the format and the contents of the tables provided in the 2021 edition. Based on membership feedback, propose improvements or alternatives for the way the information is presented.
9. Provide material for inclusion in Chapter 14 of the Handbook – Fundamentals, such as updated tables in pdf format.
10. In coordination with ASHRAE electronic media, update (a) the climatic design conditions web portal, and (b) the climatic design conditions web API, which were both developed in conjunction with the 2021 edition of the Handbook.
11. Prepare tables and climate zone maps in support of Standard 169.
12. Prepare publications to disseminate the results of this research.

Scope:

The project will be supervised by a Project Monitoring Subcommittee (PMS) of TC 4.2 and TC 4.1 and includes the tasks described below. Please note that the completion of each task needs to be approved by the PMS before the final tables of climatic design conditions are assembled.

- Task 1: a. Download or obtain the most recent hourly weather observations for the period 1999-2023 from NOAA (see NOAA, 2020c in the references) and Environment Canada for locations around the world.
- b. Research and implement techniques to perform automated quality checks of this data. This should cover the following areas: station location, values in the wrong system of units, values experiencing sudden changes in magnitude, spikes, etc. Document the techniques in such a way that they can be reused by others (for example in the preparation of climatic files for building performance modeling). Report quality issues uncovered in the data back to NOAA and Environment Canada.
- c. Update the software to calculate climatic design conditions. Please note that software used for the 2021 Handbook – Fundamentals Chapter 14 is available from ASHRAE for use in preparing the 2025 edition (see Roth, 2016; Roth, 2017; Roth, 2021). Modification of this software or development of additional software will be needed to produce the data elements for 2021; in particular, results from Task 1b should be incorporated in this updated version. One should also consider other small improvements, for example by revisiting the use of IP units during the processing of US-based stations. The contractor should make a royalty-free copy of the updated software available to ASHRAE after the project, so that it can be used for processing data in future versions of the Handbook.

d. Using the data from Task 1a and the software from Task 1c, recalculate climatic design conditions such as simple design conditions (e.g. design dry bulb temperatures, dew point temperatures and wet bulb temperatures, etc.) and joint design conditions (e.g. dry bulb temperature coincident with the design wet bulb temperature, or vice-versa, etc.). For a complete list of elements, please consult the 2021 edition of the Handbook-Fundamentals (see ASHRAE, 2021c). It is envisioned that the current number of locations (9,237) will increase to at least 10,000 globally.

Task 2: If results from ASHRAE Research Project 1900-TRP are available in time, use them to supplement the locations obtained in Task 1, particularly in areas that show large gaps. It is envisioned that for the 2025 edition, only major areas of interest (such as large urban centers with insufficient measured data to be successfully processed in Task 1) will be addressed, although the results may be more widely applicable. Note that one of the outputs of 1900-TRP is sets of design conditions for locations with sparse data; this project is therefore not expected to rerun models and recalculate the values, but simply to merge the locations and values calculated by 1900-TRP with those calculated in Task 1.

Task 3: Obtain supplementary information suitable for compiling other climatic data listed in the tables, such as:

- Precipitation-related design conditions. For the 2021 Handbook, station data from the Global Historical Climatology Network (GHCN; NOAA, 2020a) and Global Summary of Day (GSOD; NOAA, 2020b), and gridded data from the Global Precipitation Climatology Centre (GPCC; NCAR-UCAR, 2020) were used. Other sources may be proposed by the contractor if deemed appropriate.
- All sky solar radiation data. For the 2021 Handbook, gridded data from the Cloud and the Earth's Radiant Energy System (CERES; NASA-LARC, 2020) were used. Other sources may be proposed by the contractor if deemed appropriate.
- Clear-sky solar radiation data. For the 2021 Handbook, the REST2 model (Gueymard, 2008) was used in combination with satellite-derived data for aerosols and reanalysis gridded data for water vapor, ozone, etc. Other sources may be proposed by the contractor if deemed appropriate. Consideration should be given that there is no disconnect between all-sky and clear-sky solar radiation values derived in tasks 3b and 3c; for example it can be envisioned that they could or should use the same underlying aerosol data as input.

Task 4: Calculate temperature trends, using a method similar to that used for the 2021 Handbook, and/or use a compilation from published sources such as the IPCC (IPCC, 2020) or reanalysis models, to provide past and anticipated temperature trends on a regional and/or station-by-station basis. Using feedback received from the membership after the publication of the 2021 Handbook, where temperature trends were for the first time included in the tables of climatic design conditions, and in collaboration with the PMS, propose improvements (if needed) to the way that information is presented in the tables. For example, providing confidence intervals for the trends may be considered.

Task 5: Using information prepared in Tasks 1, 2, 3 and 4, assemble the Tables of Climatic Design Conditions for the 2025 Handbook and Standard 169:

- Provide an interim report to the PMS regarding the availability of the data, the number of stations successfully processed in Task 1, additional stations added in Task 2, and any issue uncovered in Tasks 3 and 4, and secure the PMS's approval for the final list of stations. The contractor will provide sample tables in draft format for approval by the PMS. The contractor will be expected to respond to requests from the PMS for small changes or additions to the format of the tables.
- Prepare tables of climatic design conditions in pdf format, in both SI and IP units, for inclusion with online versions of the Handbook (no tables will be provided in the paper edition of the Handbook, except for a sample table).
- Prepare the same tables in flat-file format for inclusion in the Handbook.
- Prepare the same tables in a format suitable for inclusion with Standard 169.

Task 6: In collaboration with SSPC 169, provide updated climate zone maps in a format which can be easily imported into Standard 169 (ASHRAE, 2020) and other documents as required.

Task 7: Provide updates to the following web-based tools:

- Web interface (ASHRAE, 2021a). The contractor will update the web interface that lets the membership

access the tables of climatic design conditions in an interactive way. Hosting of the web interface will need to be coordinated with ASHRAE.

b. Web API (ASHRAE, 2021b). Similarly, the contractor will update the REST API available to the membership to access climatic design conditions programmatically, with 2025 data. Again, hosting of the web API will need to be coordinated with ASHRAE who are in charge of hosting the API.

Task 8: *Final Report and Technical Paper*. The contractor will prepare a complete final report documenting project results. A technical paper suitable for publication in ASHRAE Transactions will also be prepared.

Deliverables:

Progress, Financial and Final Reports, Technical Paper(s), and Data shall constitute the deliverables (“Deliverables”) under this Agreement and shall be provided as follows:

a. 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.

The following deliverables shall be provided to the Project Monitoring Subcommittee (PMS) as described in the Scope/Technical Approach section above, as they are available:

Furthermore, the Institution’s Principal Investigator, 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.

b. For Tasks 1-7 above:

1. Task 1: Provide an interim report to the PMS reviewing techniques developed to ensure data quality, the number of stations available with adequate data and any issues found thus far, along with an update of the project plan detailing the schedule for deliverables
2. Task 2: Provide the PMS with a short interim report regarding the number and geographical distribution of stations with climatic design conditions calculated by 1900-TRP which will be used.
3. Task 3: Provide the PMS with a short interim report regarding the data sources being considered for precipitation, all-sky solar radiation, and clear-sky solar radiation.
4. Task 4: Provide to the PMS a short interim report with results of the trend calculations and suggestions on how to incorporate these results in the Tables of Climatic Conditions.
5. Task 5: Provide the PMS with sample tables in draft format (samples include individual PDF files, tables in flat file format, and others as appropriate). The PMS will provide feedback and the contractor will respond with any requested changes. Then, after any issues are resolved, provide to the PMS the final climatic design data (for all locations) for Chapter 14 of the Handbook – Fundamentals and Standard 169. Once the processing is complete, provide the PMS with a royalty-free copy of the software used to calculate the climatic design conditions.
6. Task 6: Provide climate zone maps for Standard 169, in a format approved by the PMS.
7. Task 7: Provide the PMS with a beta version of the web portal, and the REST API. Then, after approval by the PMS, provide the PMS and ASHRAE with all code, databases, etc. necessary for deployment of these applications on a third party server.

c. Final Report

A written report, design guide, or manual, (collectively, “Final Report”), in a form approved by the Society, shall be prepared by the Institution and submitted to the Society’s Manager of Research and Technical Services by the end of the Agreement term, containing complete details of all research carried out under this Agreement, including a summary of the control strategy and savings guidelines. Unless otherwise specified,

the final draft report shall be furnished, electronically for review by the Society's Project Monitoring Subcommittee (PMS).

Tabulated values for all measurements shall be provided as an appendix to the final report (for measurements which are adjusted by correction factors, also tabulate the corrected results and clearly show the method used for correction).

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

- An executive summary in a form suitable for wide distribution to the industry and to the public.
- Two copies; one in PDF format and one in Microsoft Word.

d. *Science & Technology for the Built Environment* or ASHRAE Transactions Technical Papers

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 as either Research Papers for HVAC&R Research or Technical Paper(s) 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 an ASHRAE Transactions Technical or HVAC&R Research papers. The paper title shall contain the research project number (1814-RP) at the end of the title in parentheses, e.g., (1814-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.

e. Data

Data is defined in General Condition VI, "DATA"

f. 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 expected project budget is \$160,000 and anticipated project duration is 24 calendar months, spanning 4 ASHRAE meetings. Effort is expected around 10 full-time equivalent person-months, equally divided between the Principal Investigator and an assistant. Although this is not a requirement of this work statement, ASHRAE also recommends involving students in research projects, whenever the nature of the work lends itself to it.

Other Information to Bidders (Optional):

Responsive proposals will demonstrate familiarity with the data sources and analysis methods required to perform the specified tasks. As expected in a Research Project, some tasks are less precisely defined (in particular: methods for fixing quality issues in Task 1b) and the proposals should address how they intend to deal with that uncertainty.

It is not anticipated that many new elements will be added to the table; however the proposals should discuss possible new elements and methods for deriving them. Suggestions about other elements are welcome.

Project Milestones:

No.	Major Project Completion Milestone	Deadline Month
1a-c	Obtaining sources of climate data, implement techniques to perform automated checks of data, update the software to calculate climatic design conditions.	8
1d	Recalculate climatic design conditions.	11
2	Use the results from 1900-TRP to expand the climatic design conditions to areas with limited data.	14
3	Obtain supplementary precipitation, all-sky radiation and clear-sky radiation.	16
4	Calculate temperature trends.	18
5	Assemble the tables for the 2025 Handbook and Standard 169.	20
6	Provide climate zone maps for SSPC 169.	24
7	Provide final versions of the tables and updated versions of web software (WDView, Web interface, Web API).	24
8	Submit final report and technical paper.	24

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

No	Proposal Review Criterion	Weighting Factor
1	Contractor's demonstrated understanding of Work Statement as revealed in proposal.	15%
2	Quality of methodology proposed for conducting research.	25%
3	Contractor's capability in terms of facilities and relevant prior research.	15%
4	Qualifications of personnel for this project.	20%
5	Probability of contractor's research plan meeting the objectives of the Work Statement.	25%

Proposal Evaluation Criteria

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

No.	Proposal Review Criterion	Weighting Factor
1	Contractor's demonstrated understanding of Work Statement as revealed in proposal.	15%
2	Quality of methodology proposed for conducting research.	25%
3	Contractor's capability in terms of facilities and relevant prior research.	15%

4	Qualifications of personnel for this project.	20%
5	Probability of contractor's research plan meeting the objectives of the Work Statement.	25%

References

1. ASHRAE (2020) ANSI/ASHRAE Standard 169-2020, Climatic Data for Building Design Standards. ASHRAE Inc., Atlanta, GA.
2. ASHRAE (2021a) ASHRAE climatic data portal. To be available from ASHRAE Inc., Atlanta, GA in 2021.
3. ASHRAE (2021b) ASHRAE climatic data REST API. To be available from ASHRAE Inc., Atlanta, GA in 2021.
4. ASHRAE (2021c) Handbook – Fundamentals. Chapter 14, Climatic Design Information. To be available from ASHRAE Inc., Atlanta, GA in 2021.
5. Gueymard CA (2008) REST2: High-performance solar radiation model for cloudless-sky irradiance, illuminance, and photosynthetically active radiation – Validation with a benchmark dataset. Solar Energy 82 (3) 272-285.
6. IPCC (2020). Climate Change reports, available from <https://www.ipcc.ch/reports/>.
7. NASA-LARC (2020) Clouds and the Earth's Radiant Energy System (CERES). <https://ceres.larc.nasa.gov/>.
8. NCAR-UCAR (2020) Global Precipitation Climatology Center (GPCC). <https://climatedataguide.ucar.edu/climate-data/gpcc-global-precipitation-climatology-centre>.
9. NOAA (2020a) Global Historical Climatology Network (GHCN). <https://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/global-historical-climatology-network-ghcn>.
10. NOAA (2020b) Global Surface Summary of the Day (GSOD). <https://www.ncei.noaa.gov/metadata/geoportal/rest/metadata/item/gov.noaa.ncdc%3AC00516/html#>.
11. NOAA (2020c) Integrated Surface Database (ISD). www.ncdc.noaa.gov/isd.
12. Roth M (2016) ASHRAE Research Project 1699-RP, Update Climatic Design Data in Chapter 14 of the 2017 Handbook of Fundamentals. Final Report. Available from ASHRAE Inc., Atlanta, GA.
13. Roth M (2017) Updating the ASHRAE climate design data for 2017. ASHRAE Transactions 123(2).
14. Roth M (2021) ASHRAE Research Project 1847-RP, Updating climatic design information for the 2021 ASHRAE Handbook, Standard 169, and the Handbook of Smoke Control Engineering. To be available from ASHRAE Inc., Atlanta, GA in 2021.