

## INVITATION TO SUBMIT A RESEARCH PROPOSAL ON AN ASHRAE RESEARCH PROJECT

### 1851-TRP, Dielectric Properties of Lower GWP Refrigerants

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 3.1 – Refrigerant and Secondary Coolants  
Co-sponsor: TC 8.1- Positive Displacement Compressors

Budget Range: \$110,000 may be more or less as determined by value of proposal and competing proposals.

Scheduled Project Start Date: **April 1, 2027**, or later.

**All proposals must be received at ASHRAE Headquarters by 8:00 AM, EST, Tuesday, December 15<sup>th</sup>, 2026. NO EXCEPTIONS.** Electronic copies must be sent to [rpbids@ashrae.org](mailto:rpbids@ashrae.org). Electronic signatures must be scanned and added to the file before submitting. The submission title line should read: 1851-TRP, Dielectric Properties of Lower GWP Refrigerants, 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  
Joshua Hughes.  
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#### For Administrative or Procedural Matters:

Manager of Research & Technical Services (MORTS)  
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Peachtree Corners, GA 30092  
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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. The deadline for submitting technical questions is also Tuesday, December 1st, 2026.**

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](mailto:rpbids@ashrae.org).**

**All other correspondence must be sent to [ddaniel@ashrae.org](mailto:ddaniel@ashrae.org) and [shammerling@ashrae.org](mailto:shammerling@ashrae.org). In all cases, the proposal must be submitted to ASHRAE by 8:00 AM, EST, Tuesday, December 15<sup>th</sup>, 2026. NO EXCEPTIONS.**

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)

Refrigerants, and in some cases lubricants, are in direct contact with electrical motor and magnetic bearing components in hermetic and semi-hermetic compressors used in HVACR. For these applications, it is important to understand the electrical properties of the circulating fluids to ensure optimal design, performance, and reliability. Electrical properties of interest include dielectric strength (breakdown voltage), dielectric constant (relative permittivity), dielectric dissipation factor (loss factor), and resistivity. The dielectric strength of a medium is the maximum electric field that the material can withstand before losing its electrical insulating properties. The dielectric constant is the ability of a material to shield a charge from surrounding charges, and will determine the capability of a system to store electric charge. Dielectric dissipation factor is a measure of the amount of energy loss from the material due to an external electric field. Resistivity quantifies how strongly a material opposes the flow of electric current. It is important to understand these electrical properties for refrigerants, as they can differ significantly from those of air.

The temperature of the breakdown voltage testing is typically at room temperature since the primary effect of temperature is due to its effect on density. For dielectric properties of the saturated liquid phase, room temperature values are typically needed for most applications.

In the early 2000s, ASHRAE Research Project 1074 was conducted to acquire these properties for 17 different refrigerants. The information is included in the ASHRAE Refrigeration Handbook in Chapter 29, along with electrical property data from other sources for the same refrigerants as well as electrical property data for other refrigerants (ASHRAE, 2017; Gbur and Byrne, 2001). The electrical properties of dielectric constant, dissipation factor, and breakdown voltage were determined for R-11, R-12, R-22, R-32, R-123, R-124, R-125, R-134a, R-143a, R-236fa, R-245fa, R-404A, R-407C, R-410A, R-507A, R-508A, and R-508B at saturation pressures at 25°C.

Example of Electrical Properties in ASHRAE Refrigeration Handbook, Chapter 29:

| Table 6 Electrical Properties of Liquid Refrigerants |                                          |           |                     |                          |      |
|------------------------------------------------------|------------------------------------------|-----------|---------------------|--------------------------|------|
| Refrigerant                                          |                                          |           |                     |                          |      |
| No.                                                  | Chemical Name or Composition (% By Mass) | Temp., °F | Dielectric Constant | Volume Resistivity, MΩ·m | Ref. |
| 11                                                   | Trichlorofluoromethane                   | 84        | 2.28                |                          | 1    |
|                                                      |                                          | a         | 1.92                | 63,680                   | 2    |
|                                                      |                                          | 77        | 2.5                 | 90                       | 3    |
|                                                      |                                          | 77        | 2.32                |                          | 9    |
| 12                                                   | Dichlorodifluoromethane                  | 84        | 2.13                |                          | 1    |
|                                                      |                                          | a         | 1.74                | 53,900                   | 2    |
|                                                      |                                          | 77        | 2.1                 | >120                     | 3    |
|                                                      |                                          | 77        | 2.100               |                          | 4    |
|                                                      |                                          | 77        | 2.14                |                          | 9    |
| 13                                                   | Chlorotrifluoromethane                   | -22       | 2.3                 | 120                      | 4    |
|                                                      |                                          | 68        | 1.64                |                          |      |

| Table 7 Electrical Properties of Refrigerant Vapors |                                          |                |           |                     |                                            |                          |
|-----------------------------------------------------|------------------------------------------|----------------|-----------|---------------------|--------------------------------------------|--------------------------|
| Refrigerant                                         |                                          |                |           |                     |                                            |                          |
| No.                                                 | Chemical Name or Composition (% by mass) | Pressure, atm. | Temp., °F | Dielectric Constant | Relative Dielectric Strength, Nitrogen = 1 | Volume Resistivity, GΩ·m |
| 11                                                  | Trichlorofluoromethane                   | 0.5            | 79        | 1.0019              |                                            |                          |
|                                                     |                                          | a              | b         | 1.009               |                                            | 74.35                    |
|                                                     |                                          | 1.01           | 73        |                     | 3.1                                        |                          |
| 12                                                  | Dichlorodifluoromethane                  | 0.5            | 84        | 1.0016              |                                            |                          |
|                                                     |                                          | a              | b         | 1.012               | 452 <sup>c</sup>                           | 72.77                    |
|                                                     |                                          | 1.0            | 73        |                     | 2.4                                        |                          |
|                                                     |                                          | 1.0            | 77        | 1.0064              |                                            |                          |
| 13                                                  | Chlorotrifluoromethane                   | 0.5            | 84        | 1.0013              |                                            |                          |
|                                                     |                                          | 1.0            | 73        |                     | 1.4                                        |                          |

However, there is little to no information yet available on the electrical properties of lower GWP olefin refrigerants or refrigerant blends that are being considered or already being applied in HVACR systems.

### Justification and Value to ASHRAE

Information is needed to ensure short- and long-term reliability of air-conditioning and refrigeration equipment using next generation refrigerants and refrigerant blends.

For example if a manufacturer wants to provide smaller and more efficient compressors and motors, they would need to reduce the spacing between electrical components and the outer shells, and information would be needed to determine if such spacing should be sufficient to provide electrical protection. If a refrigerant in a system is changed, is there increased likelihood of electrical shock or shorts? This project

is designed to help answer these questions and provide tools that are not currently available to designers of air conditioning systems. This research could help promote improved energy efficiency and lower GWP refrigerants in air conditioning systems.

### **Objectives**

Objective 1: Literature review of state-of-the-art test methods and equipment including comparison to those used in RP-1074. Proposal of recommended test methods and equipment to measure the dielectric properties of refrigerants.

Objective 2: As a function of temperature and pressure (or other suitable state variables such as density), at relevant frequency value(s) at similar conditions as the previous ASHRAE RP 1074 at saturation pressure at 25°C for comparison, make measurements for 7-11 refrigerant samples of the following properties:

| <b>Parameter</b>                                            | <b>Subcooled Liquid</b> | <b>Saturated Vapor</b> | <b>Superheated Vapor</b> |
|-------------------------------------------------------------|-------------------------|------------------------|--------------------------|
| Dielectric Strength<br>( Breakdown voltage / Paschen curve) |                         |                        | <b>X</b>                 |
| Dielectric constant<br>(Relative permittivity)              | <b>X</b>                | <b>X</b>               | <b>X</b>                 |
| Dielectric dissipation Factor<br>(Loss factor)              | <b>X</b>                | <b>X</b>               | <b>X</b>                 |
| Resistivity<br>(Volume)                                     | <b>X</b>                | <b>X</b>               | <b>X</b>                 |

In bid provide costing information to include 10 refrigerants including R-1234yf, R-1234ze(E), R-1233zd(E), R-1132(E), R-1132a, R-1123, R-1336mzz(Z), R-1336mzz(E), R-32 (for validation to compare with earlier study and published values), and R-454B for refrigerant properties.

Objective 3: Report summarizing the results, conclusions and any critical considerations relevant to the subject matter under study for application of new refrigerants in current or new equipment designs.

### **Scope:**

Task 1: Review previous test methods such as those in the ASHRAE handbook and in RP-1074 (<3 months);

Task 2: Review current state-of-the-art and make proposal on the test apparatus and procedures to be used. (<3 months);

### **PMS: Decide to if Milestone is met based on task 1 & 2**

Task 3: Recommend a validation plan summarizing the validation procedures and methods to assess if successful or unsuccessful. If unsuccessful, changes will be proposed and the validation will be re-assessed prior to moving to the next phase (<3 months)

Task 4: Measure 10 new refrigerants including R-1234yf, R-1234ze(E), R-1233zd(E), R-1132(E), R-1132a, R-1123, R-1336mzz(Z), R-1336mzz(E), R-32 (for validation to compare with earlier study and published values), and R-454B for refrigerant properties as outlined in objective two. Report data to PMS. (3-4 months)

Example Test Result Table – AC Resistivity, Dissipation Factor, and Dielectric Constant for Liquid and Vapor Phase, Temperature = 25°C

| <b>Medium</b>           | <b>Resistivity<br/>(Mohms x cm)</b> | <b>Dissipation Factor</b> | <b>Dielectric Constant</b> |
|-------------------------|-------------------------------------|---------------------------|----------------------------|
| Fluid 1 Saturated Vapor |                                     |                           |                            |

|                         |  |  |  |
|-------------------------|--|--|--|
| Fluid 1 Vapor at 1 atm  |  |  |  |
| Fluid 1 Liquid          |  |  |  |
| Fluid 2 Saturated Vapor |  |  |  |
| Fluid 2 Vapor at 1 atm  |  |  |  |
| Fluid 2 Liquid          |  |  |  |

Example Test Result Table - Dielectric Breakdown Voltage (Paschen Curve)

Utilizing raw data, calculate line equations and plot Paschen curves following the formula:

$$BDV = A/Pd + B + C*Pd + D*Pd^2 + E*Pd^3$$

Where:

BDV = Dielectric breakdown voltage in Volts

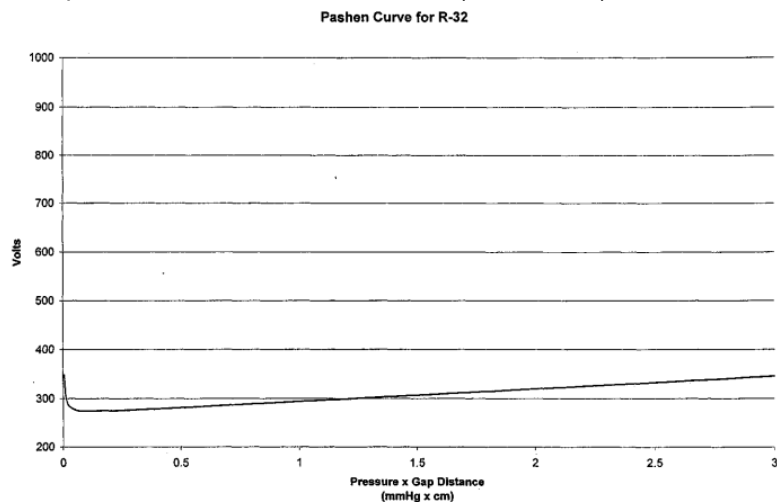
P = Pressure of the refrigerant in mmHg

d = Gap distance in centimeters

A, B, C, D, E are constants specific to the refrigerant

|         | A | B | C | D | E | Std. Dev. |
|---------|---|---|---|---|---|-----------|
| Air Exp |   |   |   |   |   |           |
| Air Lit |   |   |   |   |   |           |
| Fluid 1 |   |   |   |   |   |           |
| Fluid 2 |   |   |   |   |   |           |

Example Test Result - Paschen Curve (Gbur, 2001)



#### Additional Technical Approach:

The experimental apparatus shall match the experimental apparatus in the previous RP1074 - "Determination of Dielectric Properties of Refrigerants" (Gbur, 2001) or have equivalent, or exceeding capability and accuracy. This will be validated by testing at least one validation refrigerant, R-32, to compare with earlier study.

For breakdown voltage testing, the test cell shall be designed as detailed, and in accordance with, ASTM D2477, Standard Test Method for the Dielectric Breakdown Voltage and Dielectric Strength of Insulating Gases and Commercial Power Frequencies, except modifications may be necessary to accommodate pressures from vacuum to saturation pressure at 25°C for the refrigerants of interest.

A vernier mechanism or similar in the breakdown voltage test cell can provide the gap spacings from 0 to 8mm. The electrodes shall be inspected at regular intervals to ensure pitting does not invalidate the dimension or shape requirements defined in ASTM D2477 which could lead to a distorted electrical field. The test cell shall be shielded from light and other radiation sources to decrease the dark current and increase the sensitivity of detecting electrical breakdown of the refrigerants.

For dielectric constant, AC resistivity, and dissipation factor testing the test cell shall be designed as detailed, and in accordance with, ASTM D924, Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids, except modifications may be necessary to accommodate pressures from vacuum to saturation pressure at 25°C for the refrigerants of interest.

Test cell temperature shall be regulated at 25°C and allowed sufficient time to equilibrate to ambient temperature. Test cell pressure shall be controlled, monitored, and reported.

Refrigerant samples shall be tested to ensure that the requirements of AHRI 700, Specifications for Refrigerants, were met in order to minimize the effects of contaminants on the dielectric properties' measurements. For refrigerants that are not currently listed in AHRI 700, the refrigerant should not exceed any contaminant limits for single component refrigerants defined in AHRI 700. Since it is known that moisture can significantly impact electrical properties it should be ensured that moisture is minimized in the test apparatus and refrigerant samples.

**Deliverables:**

The results of this investigation will be published as a research report and summarized as an ASHRAE technical paper for use by the general membership of ASHRAE.

Part of the research, general conclusions, or trends will be included in updating Chapter 29 – Refrigerants, of the Fundamentals Handbook.

**Deliverables:**

1. Contractor will meet with the Project Monitoring Subcommittee (PMS) to kick-off the project and confirm understanding of goals and the details of the work statement.
2. Contractor will prepare a project plan with timeline. The PMS will review and discuss any remaining details with the contractor.
3. Intermediate report 1: Contractor shall prepare a presentation relating to Task 1
4. Intermediate report 2: Contractor shall prepare a presentation relating to Task 2
5. Intermediate report 3: Contractor shall prepare a presentation relating to Task 3
6. Report 4: Contractor shall prepare a presentation relating to Task 4

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. 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.

a. Research Paper(s)

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 for publication in the Science and Technology for the Built Environment (STBE). The paper(s) shall conform to the instructions posted in "Manuscript Central" for Science and Technology for the Built Environment papers. The paper title shall contain the research project number at the end of the title in parentheses, e.g., (XXXX-RP). ASHRAE Conference papers are **not** acceptable as deliverables from ASHRAE research projects unless explicitly approved by a vote of the PMS and TC and communicated to MORTS. Conference paper(s) shall conform to the instructions posted in "Manuscript Central" for ASHRAE Conference papers and the title shall contain the research project number at the end of the title in parentheses, e.g., (XXXX-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.

d. Data

Data is defined in General Condition VI, "DATA"

e. 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 estimated level of effort for each of the tasks is estimated as follows:

Task 1: Review of previous work (<3 months)

Task 2: Proposal of apparatus/procedures (<3 months)

Task 3: Validate test apparatus/measurements (<3 months)

Task 4: Measure & Report (3-4 months)

The estimated cost is \$110,000 and the project is expected to take 9-12 months.

#### **Project Milestones:**

:

| <b>No.</b> | <b>Major Project Completion Milestone</b>                                                                                       | <b>Deadline Month</b> |
|------------|---------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| 1          | Quarterly progress and financial report to the Society's Manager of Research and Technical Services (MORTS)                     | 3, 6, 12              |
| 2          | Review of findings from literature review and proposed test plan (Phase I). Review Phase 2 scope based on findings from Phase 1 | 1                     |
| 3          | Review results and conclusions from Phase 2. Review proposed test plan for Phase 3.                                             | 6                     |
| 4          | Review results and conclusions from Phase 3.                                                                                    | 11                    |
| 5          | Final Report, including recommendations for potential future work (Phase 4)                                                     | 12                    |

#### **Proposal Evaluation Criteria**

| <b>No.</b> | <b>Proposal Review Criterion</b>                                                                                                                                                                                                                                                                                                | <b>Weighting Factor</b> |
|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| 1          | Contractor's understanding of Work Statement as revealed in proposal.<br>a) Logistical problems associated<br>b) Technical problems associated                                                                                                                                                                                  | 15%                     |
| 2          | Quality of methodology proposed for conducting research.<br>a) Organization of project<br>b) Management plan                                                                                                                                                                                                                    | 25%                     |
| 3          | Contractor's capability in terms of facilities<br>a) Managerial support<br>b) Data collection<br>c) Technical expertise                                                                                                                                                                                                         | 15%                     |
| 4          | Qualifications of personnel for this project<br>a) Project team 'well rounded' in terms of qualifications and experience in related work<br>b) Project manager person directly responsible; experience and corporate position<br>c) Team members' qualifications and experience<br>d) Time commitment of Principal Investigator | 20%                     |

|   |                                                                                                                                                                                                                                                               |     |
|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 5 | Student involvement<br>a) Extent of student participation on contractor's team<br>b) Likelihood that involvement in project will encourage entry into HVAC&R industry                                                                                         | 5%  |
| 6 | Probability of contractor's research plan meeting the objectives of the Work Statement.<br>a) Detailed and logical work plan with major tasks and key milestones<br>b) All technical and logistic factors considered<br>c) Reasonableness of project schedule | 15% |
| 7 | Performance of contractor on prior ASHRAE or other projects.<br>(No penalty for new contractors.)                                                                                                                                                             | 5%  |
| 8 | Other:                                                                                                                                                                                                                                                        |     |

### **References**

1. AHRI Standard 700-2024, Specifications for Refrigerants, Air-Conditioning, Heating and Refrigeration Institute, Arlington, VA.
2. ASHRAE Standard 34-2024, Designation and Safety Classification of Refrigerants, ASHRAE, Atlanta, GA.
3. ASHRAE. 2021. Handbook of Fundamentals. Chapter 29 – Refrigerants.
4. ASTM D2477-2020, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Insulating Gases at Commercial Power Frequencies, ASTM International, 2020.
5. ASTM D924-2023, Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids, ASTM International, 2023.
6. Gbur, A.M., and J.J. Byrne, 2001. Determination of Dielectric Properties of Refrigerants. ASHRAE Research Project RP-1074, Final Report.