August 26, 2024

The Air-Conditioning, Heating, and Refrigeration Technology Institute (AHRTI) invites your company to submit a proposal for the following research project:

AHRTI Project No. 9020
Low GWP Refrigerants Heat Transfer and Pressure Drop Test Rig Construction

The proposed scope of work is outlined in the attached work statement.

Proposal Submission

Proposals are due by 12:00 PM Eastern Time on Friday, September 20, 2024.

Proposals should be submitted in electronic form (Adobe PDF or MS Word file format), and be emailed to AHRI Research Coordinator Zoey Scancarello (ZScancarello@ahrinet.org)

Contact for technical questions concerning the scope of work:

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Proposal Evaluation Criteria

Proposals will be evaluated per the criteria and weighting listed below:

Understanding the problem (15%)
Approach to solving the problem (20%)
Probability of (timely) success (15%)
Qualifications and experience of key personnel (25%)
Quality of facilities to perform the work (25%)

AHRTI
WORK STATEMENT

AHRTI WS# 9020

Title *Low GWP Refrigerants Heat Transfer and Pressure Drop Test Rig Construction*

About AHRTI

The Air-Conditioning, Heating, and Refrigeration Technology Institute (AHRTI) is a not-for-profit organization established to undertake scientific research in the public interest. AHRTI's mission is to foster applied research on technologies to improve products, systems, and controls that benefit the general public in the areas of Heating, Ventilation, Air-Conditioning, Refrigeration (HVACR), and Water Heating.

AHRTI is an entity associated with the Air-Conditioning, Heating, and Refrigeration Institute (AHRI). AHRI is the national trade association representing manufacturers of HVACR and Water Heating equipment within the global industry.

Background

AHRTI and its partner Oak Ridge National Laboratory (ORNL) are conducting a DOE funded research project. The project goal is to characterize the heat transfer and pressure drop of next generation refrigerants having GWP less than 150 covering an appropriate range of tube diameters, materials, inner surfaces, and operating conditions.

As part of the project, a test rig that can accurately measure refrigerants heat transfer coefficient and pressure drop needs to be designed and constructed. ORNL has conducted a preliminary review of heat transfer and pressure drop experimental test rig configurations and analyzed two approaches: long test section vs. short test section. Main learnings regarding the two types of apparatuses are:

- The long test section approach has more components and instrumentation, making it rather complex. It will tend to take more time to build but can simulate the full evaporation or condensation process happened in the actual heat exchanger. The accuracy is the best as shown in work done by many researchers (Example: NIST).
- The short test section approach has fewer components and instrumentation (lower complexity). The construction would take less time. The accuracy is considered adequate as shown in recent research (Example: University of Illinois).

The ORNL analysis is listed in Appendix A. Note that ORNL analysis and the schematics are for reference purposes only and should not be treated as the final design configuration.

AHRTI seeks a qualified contractor to design and construct a test rig that ORNL research team can use it to perform experimental testing to generate accurate heat transfer and pressure drop correlations for lower GWP refrigerants in typical air-conditioning and refrigeration systems.

Scope

The overall task is to design and construct a test rig that can generate accurate experimental results and is capable of testing a wide range of conditions. It mainly consists of three tasks.

Task 1. Test rig design and construction
Under the guidance of AHRTI and ORNL, the selected contractor will design and build a fully instrumented heat transfer and pressure drop test rig. The test section will allow the proper measurement of local heat transfer by having enough length and number of test sections. The test rig must be capable of testing a full range of refrigerant vapor quality (0-100%).

The contractor shall review ORNL's preliminary findings on test rig configurations and propose a test rig design with necessary improvement for AHRTI and ORNL approval. The test rig must have the following capabilities:

1. Be capable of measuring the local heat transfer coefficients and pressure drop of low GWP refrigerants for flow boiling and condensation. Suggested refrigerants are listed as follows:
    a. ASHRAE class A1: R-410A, R-134a (benchmark)
    b. ASHRAE Class A2L: R-32, R-454B, R-454C, R-455A, R-1234yf, R-1234ze(E), and at least one new ultra-low GWP refrigerant suggested by the industry.
    c. ASHRAE Class A3: R-290
2. Test rig will be designed with all safety requirements to handle flammable refrigerants class A2L and A3.
3. Be capable of controlling the inlet refrigerant state (saturation temperature and superheat for flow condensation or vapor quality for flow boiling) precisely using PID control algorithms.
    a. Capable of testing Condensation temperatures up to 60 °C and
    b. Evaporating temperatures of 4 to 15 °C.

The design should also include safety considerations as flammable refrigerants are expected in testing:

- This test setup will be in a chamber designated as class 1 Div 2 by the national electric code (NEC).
- All conditioning heating/cooling loops will use secondary fluids with pumps and power supply located outside the main chamber. Any power supply that may need to be located inside the chamber must comply with "class 1 div 2" designation.
- The heat exchangers will have double-wall to avoid contamination with the flammable refrigerant. This is to avoid catastrophic events in case of failure of the heat exchanger materials.
- Any ignition sources will be located outside of the testing environment.

Additionally, the test rig must be transportable either as a whole piece or as components that can be easily reassembled to perform testing at other locations.

Upon the design approval, the contractor shall acquire necessary components, instrumentation, and parts to construct the test rig.

Task 2. Test rig validation
Upon the completion of test rig construction, the contractor shall use known refrigerants such as R-134a and/or R-410A to conduct validation testing. The test rig will be validated by comparing measured results with publicly available data for the known refrigerants. The two sources should agree within the typical experimental uncertainty. Any issues identified will be addressed before the rig is commissioned for testing.

Task 3. Test rig commissioning
The contractor will deliver the test rig to an ORNL designated site and make it fully commissioned for ORNL to perform testing.

Deliverables

The output from this project shall be a test rig that meets the required specifications and a compilation of the information generated throughout the project. The contractor shall provide the following:

- Monthly invoices and letter reports on progress and task results;
- Progress reviews in the contractor's facilities and/or by teleconference, by AHRTI project monitoring committee members, to assess the work-in-progress;
- Draft technical report, executive summary, tabulated data, and recorded video files documenting the procedures, conditions, and findings, for review by and a presentation to an AHRTI project monitoring subcommittee; and
- Final technical report, executive summary and tabulated data resolving review comments provided by AHRTI. Included as part of this deliverable is the source code for any model tools developed, which are expected to be AHRTI properties.

Unless otherwise specified by AHRTI, printed material will be delivered on standard 8-1/2 by 11 inch paper. Electronic documents shall be delivered as a consolidated document file that integrates all text, figures, tables, and photographs into a single file in both Microsoft Word and PDF file format.

Unless otherwise specified by AHRTI, the contractor shall deliver the following as scheduled:

Invoices & Letter Reports on Progress	Monthly, within 30 days of reported period
Review Presentation Materials	Within 1 week after review
Technical Papers/Presentations Upon Approval by AHRTI	30-days prior to submission due date
Draft Final Technical Report; Executive Summary and Tabulated Data	60 days prior to contract completion date

Final Technical Report; Executive Summary; and Tabulated Data	30 days after receipt of AHRTI comments

Level of Effort

The work conducted under this project will be six months with a cost not to exceed $450,000. It is anticipated that the contract for this work will be awarded at the best value based on selection from competitive proposals. However, price will not be the only factor weighed in the selection process. Prior experience and expertise in the field of study, access to laboratory and/or field sites required for completion of this project, and competitive prices will all be consider in selecting a contractor for this project.

Limitation

Solicitation of this project does not commit AHRTI to award a contract, pay any cost incurred in preparing a proposal, or to procure or contract for services or supplies. AHRTI reserves the right to accept any or all proposals received, or to cancel in part or its entirety a solicitation for this work prior to the signing of a contract agreement, when it is in AHRTI's best interest. AHRTI reserves the right to negotiate with all qualified sources.

Other Information to Bidders (Optional)

This is work-for-hire for AHRTI. Results of this work will be held confidential and releasable only to AHRTI, unless otherwise released by AHRTI.

Appendix A

Multiple-segments (Long length) Test Section (in Figure 1)

A pumped refrigerant loop is typically used for this type of setup. Figure 1 shows a preliminary schematic of this loop. The facility can measure heat transfer coefficient for a wide range of heat flux, mass flux and wall temperature. It also allows to collect date for pressure drop. There are four loops in this setup: 1) refrigerant loop (red loop), 2) coolant (water) loop (green loop), 3) chiller (glycol) loop (purple loop), and 4) pre-heating loop (yellow loop).

Starting from the receiver in the refrigerant loop, subcooled refrigerant is pumped by a gear pump with mass flow measured using a Coriolis flow meter. Two pre-heaters controlled by two PID controllers are used to heat the refrigerant to the desired state at the inlet of test section. The test section consists of several segments. Energy balance through each segment allows to define the state for the subsequent segment. This allows to measure the local heat transfer and pressure drop in each segment.

Both evaporation and condensation experiments can be done on the same facility because heat is exchanged by water (or a secondary fluid if needed) heating or cooling each segment. After the test section, two post coolers are used to condense the refrigerant. Openings located at the inlet and outlet of test section is for charging and evacuation.

Distillated water in the coolant loop is pumped by a cylindrical pump to a heater. When a lower temperature is needed water in the coolant loop could be replaced by a glycol mixture.
A pump with VFD controller is used to pump the fluid. A reservoir tank is installed at the suction of the pump to maintain a minimum suction pressure. The pressure at the discharge is measured by a pressure sensor and this signal is used to adjust the pump speed to maintain discharge pressure. Fluid is supplied to an inlet header from where it goes to each test/conditioning segment. The fluid temperature at the inlet is adjusted by a heater while the flow rate is adjusted by a stepper motor valve. The mass flow rate is measured by two Coriolis mass flow meters per test section (heat transfer in upper and lower blocks are measured independently) and a Coriolis mass flow meter per conditioning section. Temperature measurements are done by RTD sensors inserted into the coolant tube. Coolant from test sections and conditioning sections returns to the outlet header. A plate heat exchanger and a heater are installed after the header to adjust coolant temperature supplied to the pump.

The chiller loop provides cooling to the refrigerant sub-cooler, refrigerant condenser, and brazed plate heat exchanger in the coolant loop. The chiller loop consists of a chiller with pump and reservoir tank and is running with 50–50% ethylene–glycol water mixture. After the pump, glycol flows to a sub-cooler which provides subcooling to make sure that liquid refrigerant flows into the receiver. A heater is used to adjust the condenser inlet temperature of glycol. A bypass has been made for the condenser to reduce pressure drop when the system is in condensation mode. A plate heat exchanger is used for glycol so that the coolant loop can be cooled.
The pre-heating loop consists of two pre-heaters. Both can precisely control the heat transfer rate and supply temperature of the fluid to the refrigerants.

Vapor quality or superheat at the inlet to the first test section is determined based on measured heat transfer rate and refrigerant flow rate. Pressure measured at the inlet to the first test section is a starting point for the pressure calculation of entire test section. Pressure drop through the test segments is measured by two differential pressure transducers that are connected to the test line at the connectors.

Single-segment (short length) test Section (in Figure 2)

The principle of operation is like the multiple-segment one (pumps, loops). The main difference is that conditions at the inlet must vary to the desired state, which can go from superheated vapor all the way to subcooled state for both condensing and evaporating evaluations. Hence, precautions need to be taken to ensure that the flow is thermally developed at the entrance of the test section.

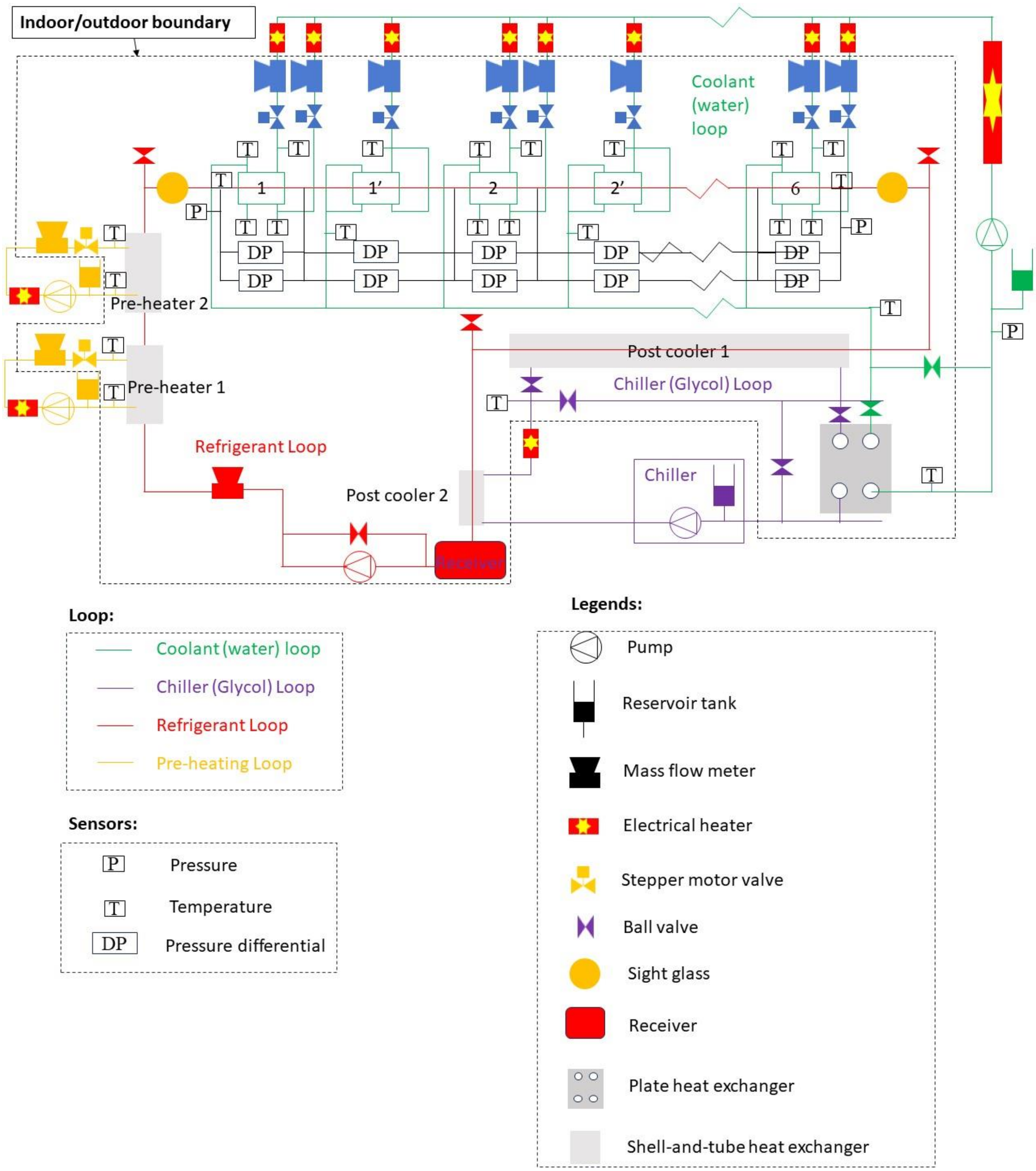

Figure 1: Schematic of the multiple-segment (long length) test section.

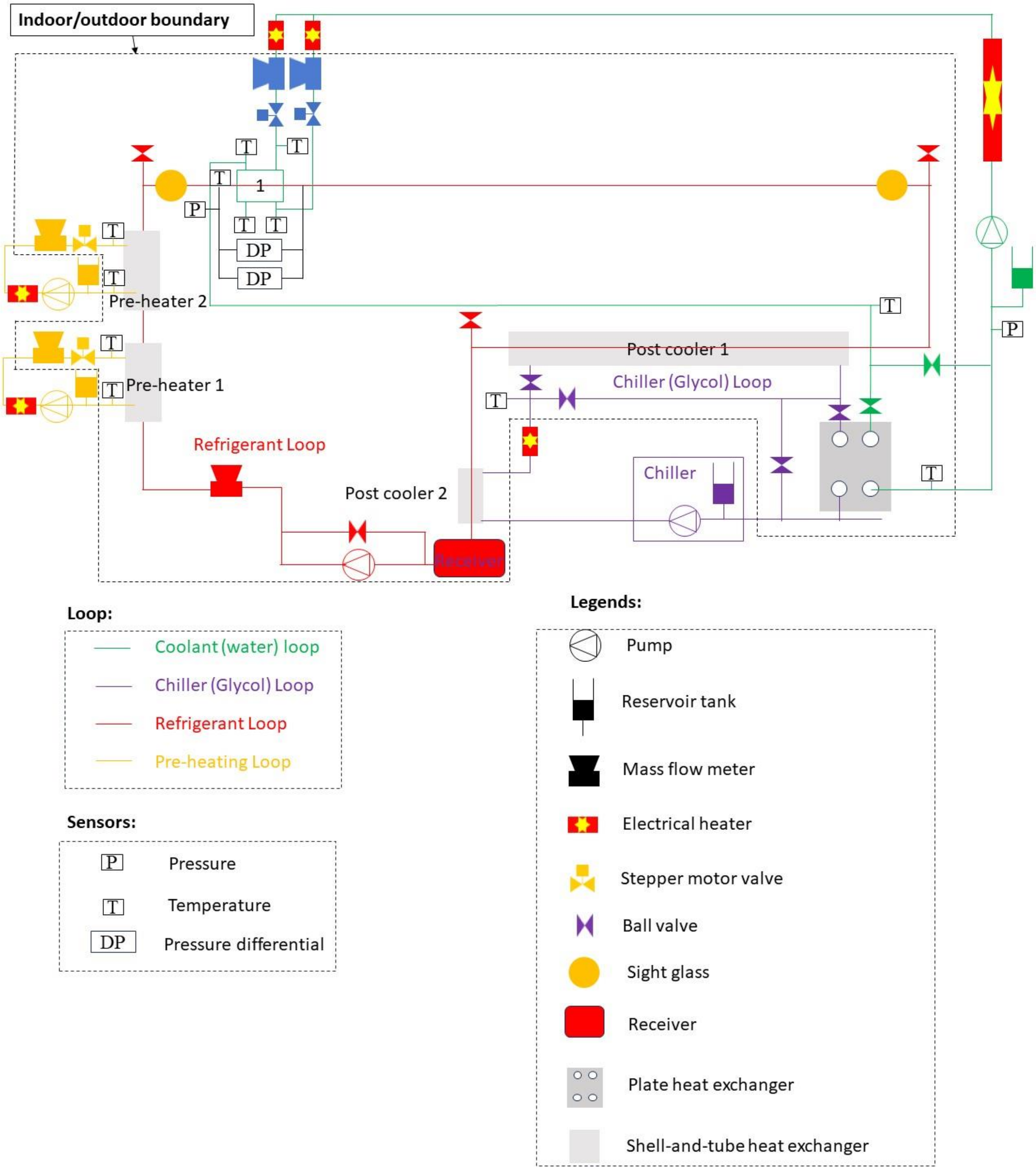

Figure 2: Schematic of the single-segment (short length) test section setup.