Unique Tracking Number Assigned by MORTS_____

RESEARCH TOPIC ACCEPTANCE REQUEST (RTAR) FORM

TC/TG: TC3.4-Lubrication

Title:

Development of Models for Prediction of Oil:Refrigerant Mixture Properties of Low GWP Refrigerants and Synthetic Compressor Oils.

Applicability to ASHRAE Research Strategic Plan:

This project supports the ASHRAE Research Strategic Plan to facilitate use of natural and low global warming potential (GWP) synthetic refrigerants (goal #8), and to support the development of improved HVAC&R components ranging from residential through commercial to provide improved system efficiency, affordability, reliability, and safety (goal #9).

Research Classification:

Basic/Applied Research

TC/TG Priority:

TC Vote:

Reasons for Negative Votes and Abstentions:

Estimated Cost:

$75K?

Estimated Duration:

12 months

Other interested TC/TGs:

TC3.1-Refrigerants and Secondary Coolants

TC 8.1 – Positive Displacement Compressors

Possible Co-funding Organizations:

Application of Results:

ASHRAE Handbook Refrigeration Chapter 12.

State-of-the-Art (Background):

Today's equipment designers, as a result of climate change concerns, are being asked to consider new lower GWP unsaturated hydrofluorocarbon (HFO) based refrigerants. Many of the candidates are blends of the HFO refrigerants R-1234yf and R-1234ze(E) with currently used hydrofluorocarbon (HFC) refrigerants, like R-32, R-134a, R-152a, and R-125. In some cases, these blends also include one or more 'natural' refrigerant components such as hydrocarbons and/or carbon dioxide (R-744). A large variety of blends have been proposed, and selecting the right refrigerant with the right lubricant for the right application is an overwhelming challenge for today's manufacturers.

Most if not all of the new refrigerant blends are compatible with lubricant chemistries that have already been developed for the HVAC industry for HFC refrigerants, such as polyol ester (POE), polyalkylene glycol (PAG), and polyvinyl ethers (PVE). In order to understand compressor and system design change requirements for a new class of refrigerants, refrigerant:lubricant mixture properties (solubility, density, viscosity, and miscibility) are typically one of the first data sets requested by original equipment manufacturers (OEMs). However, given the current wide variety of new refrigerants and the various lubricant selections, the possible combinations are large.

Acquisition of accurate refrigerant:lubricant mixture properties requires specialized skill sets and equipment, and is a capability that only a few labs in the industry have developed. Because of the time and resources required to generate test data in the range of interest for one refrigerant and lubricant combination, testing multiple blends - or slight variations of those blends - is not a practical option for OEMs. To date, there has been limited information generated through ASHRAE research on the

refrigerant:lubricant mixture properties of the new HFO refrigerants with currently used commercial lubricants. There is even less information available on the mixture properties of the refrigerant blends with HFOs due to the uncertainty on which specific candidates will be selected.

For screening the potential system impacts associated with the selection of new refrigerant candidates, it would be advantageous to develop and refine the means by which refrigerant:lubricant mixture properties can be modeled. Previous research (Wahlstrom and Vamling, 2000) evaluated thermodynamic models for prediction of solubility for HFC working fluids in polyol ester (POE) compressor oils. In that work, they looked at the chemical structure influences on solubility by evaluating five HFCs (R-125, R-134a, R-143a R-152a, and R-32) with four different POEs, and proposed a modified Flory-Huggins-based predictive model to predict mixture solubility data. By comparing their predictions with measured data at specific conditions, they determined a relative deviation of <4%. Since this work, there has been no further simulation based modeling research published on refrigerant:lubricant combinations, but the field of chemical modeling has advanced greatly. Further research is needed to understand the applicability of chemical simulation models for modeling the mixture properties of the new refrigerants and refrigerant blend candidates to speed the introduction of new low GWP refrigerants.

Advancement to the State-of-the-Art:

Limited information exists on the tools to model refrigerant:oil mixture properties and in particular, mixture properties of new refrigerants and refrigerant blends with commercially available oil formulations. The contractor on this project will provide information on the capabilities and limitations of simulation methods to predict refrigerant:oil mixture properties and ideally, provide comparisons between predicted and measured data. The result of this work will advance knowledge to support more efficient screening of refrigerant and lubricant combinations and support the design of systems and components for use with new low GWP refrigerants.

Justification and Value to ASHRAE:

Using simulation methods to understand the design impacts associated with the use of unsaturated hydrofluorocarbon based refrigerants with current commercially available lubricant classes in HVAC systems would be beneficial to manufacturers by:

- enabling more effective selection of a lubricant for a specific application.
- supporting early identification of potential risks associated with the use of new low GWP refrigerants in existing design platforms.
- enabling new component or system technology needs to be identified.
- improving system reliability and performance.

Objective:

Task 1: Investigate and summarize a history of research, tools, and processes that have been or could be used to simulate refrigerant and lubricant mixture properties. Define the current knowledge gaps and limitations for application with both current and next generation fluids.

Task 2: Propose a plan and methodology to develop and/or evaluate simulation methods in comparison to measured data for refrigerant and lubricant combinations of interest.

Task 3: Make recommendations on methods, data required for effective application, and the potential limitations.

Key References:

Wahlstrom, A. and L. Vamling. 2000. Development of models for prediction of solubility for HFC working fluids in pentaerythritol ester compressor oils. *International Journal of Refrigeration* 23(2000):597-608.