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Introduction

Abstract
(1) Detailed computer models have been developed and verified by experimental results that predict the solutions and interactions effects of various HFCs, mixtures and POE lubricants. These models and data were developed in large part under an ARRL-sponsored UTRC program (MRC project no. 669-2003) and under corporate sponsorship.

(2) A comprehensive model has been developed under ARRL sponsorship, which describes the concentration of HFCs in air-conditioning systems. In particular, this model includes the effects of various HFCs, mixtures and POE lubricants. The model also takes into account the interactions between different components of the system, including the compressor and the condenser/evaporator units. The model has been validated through numerous test cases.

(3) The model predicts that the concentration of HFCs in air-conditioning systems can be affected by the presence of mixtures and POE lubricants. The model is able to predict the behavior of the system under different operating conditions, including the effects of changes in temperature and pressure.

(4) The model has been used to study the effects of different HFC mixtures and POE lubricants on the performance of air-conditioning systems. The model has been shown to accurately predict the behavior of the system under a wide range of operating conditions.

(5) The model is being used to develop new strategies for reducing the concentration of HFCs in air-conditioning systems. The model is being used to design new systems that are more efficient and less harmful to the environment.

(6) The model is being used to develop new guidelines for the safe operation of air-conditioning systems. The model is being used to identify the most critical components of the system and to develop new strategies for reducing the risk of failures.

(7) The model is being used to develop new guidelines for the disposal of air-conditioning systems. The model is being used to identify the most critical components of the system and to develop new strategies for reducing the risk of failures.

(8) The model is being used to develop new guidelines for the training of personnel who work with air-conditioning systems. The model is being used to identify the most critical components of the system and to develop new strategies for reducing the risk of failures.

(9) The model is being used to develop new guidelines for the maintenance of air-conditioning systems. The model is being used to identify the most critical components of the system and to develop new strategies for reducing the risk of failures.

(10) The model is being used to develop new guidelines for the design of air-conditioning systems. The model is being used to identify the most critical components of the system and to develop new strategies for reducing the risk of failures.
Selected representatives of POE and mineral oil lubricants that covered the range of viscosity and miscibility requirements in HVAC systems were represented. POE and mineral oil lubricants in the second part of this task were reviewed for refrigerants and lubricants and discussed in more detail. This included a review of the ASHRAE design guidelines, as well as discussions with system refrigerant/ambient mixture. A summary of the industry standard procedures and information on vapor velocity, viscosity, and miscibility of the refrigerant/ambient mixture was also discussed along with system refrigerant/ambient mixture. In refrigeration and HVAC systems, which were developed, there was improved understanding of the refrigerant/ambient mixture in refrigeration and HVAC systems. Within Task 1, an

Task 1 consisted of gathering and reviewing available literature on refrigerant and oil return dan. Within Task 1, an

The overall approach undertaken to meet this objective was: (1) identify poor oil return strategies, and (2) develop

Program Approach and Scope

This dynamic least facility was used to obtain data to compare to the analytical predictions. This dynamic least facility was used to obtain data to compare to the analytical predictions. The development of industry guidelines for system refrigerant/ambient mixture was conducted. A dynamic least facility was constructed to model the operational regions where good management can be assessed. A dynamic least facility was constructed to model the operational regions where good management can be assessed. The development of industry guidelines for system refrigerant/ambient mixture was conducted. A dynamic least facility was constructed to model the operational regions where good management can be assessed.
Formal reports for all of the details and complete information.

The material presented in this publication only highlights and summarizes the extensive information developed in the

reference report. Volume II contains all of the detailed test data obtained during the program.

The information presented in this publication note generally follows the three task effort described in Volume I of the

HVAC industry designers, manufacturers and installers.

Finally, broad guidelines as to acceptable flow velocities for "good" and "poor" air management are provided for use by

specific conclusions and results were reached. Much of the data is based on visual observations of poor air flow scum and

test runs were actually conducted in the dynamic test facility, reviewed and assessed for consistency. Bread as well as very

Task 3 consisted of data collection, analysis, results, review and formulation of the program conclusions. More than fifty

sets of tests with the various HFC, HFC and POE and internal air combinations were prepared and extensive data gathered.

A simulated instrumentation for proper observation and on-the-job measurements were taken, developed, designed and installed. A

regime could be experimentally explored so that broad on-the-fly and instrumentation observations of all regime could be

Task 1 data was used to design and build a dynamic test facility in which both good and poor air management

Task 2 consisted of the design, fabrication, installation, and instrumentation, and then experimental efforts in the dynamic
OVERVIEW

• PROGRAM BACKGROUND, OBJECTIVE, AND SCOPE

• TEST MATRIX, DYNAMIC SYSTEM LAYOUT

• SPECIAL INSTRUMENTATION AND PROCEDURES

• TYPICAL RESULTS AND SAMPLE DATA

• CONCLUSIONS

• SUMMARY
HVAC Systems

Provide guidelines for lubricant circulation behavior in and HFC/mineral oil pairs

Lubricant characteristics with HFC/PoE pairs

Conduct experimental and analytical efforts to determine

Objective

Combinations has not been characterized

Circulation behavior of new HFC refrigerants/lubricants

HFC refrigerant substitutes are needed to replace HCFC's

Background

Program
Central System Diving Heating/cooling Modes

- Evaluate R407C Blends with Mo and POe5 in Residential

Viscosity, System Features and Equipment Type

Focus on Effects of Vapor Velocity, Refrigerant/Lubricant

Oil Measurement

Design and Build Dynamic Test Facility, Including On-Line

Scope

Program
Example

Industry Practices and Design Approach in SS HPs as AN

Velocity

Development of Parameter Limits for Viscosity, Flow

Solubility, Viscosity and Surface Tension

Role of Key Parameters Such as Refrigerant/Oil Miscibility

Circulation Mechanisms

Develop a More Thorough Understanding of Lubricant

- Gather and Review Existing Data

Program Scope
• TEST MATRIX (RESULTS ANALYSIS AND CONCLUSION)

REVIEW

• REVIEW

• DEFINE OR RETURN DATA COLLECTION, ANALYSIS AND RESULTS

• COMBINATION OF VISUAL BEHAVIOR AND MEASUREMENTS USED TO

• TO CHANGE OIL CONCENTRATION

• TESTS WITH IN SITU OIL CONCENTRATION MEASUREMENTS, ABILITY

• TESTS IN COOLING AND HEATING MODES

• CRITICAL PARAMETERS OF FLOW VELOCITY AND VISCOITY

• INSTRUMENTATION

• DESIGN AND BUILD DYNAMIC TEST FACILITY WITH UNIQUE

PROGRAM SCOPE (CONTINUED)
<table>
<thead>
<tr>
<th>Temperature Range</th>
<th>Miscible (high visc.)</th>
<th>Non-miscible (low visc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-30°C at 10 wt% oil</td>
<td>R-407C/ICI RT688</td>
<td>R-407C/ICI SW68</td>
</tr>
<tr>
<td>-50°C at 10 wt% oil</td>
<td>R-407C/ICI RT32S</td>
<td>R-407C/ICI SW32</td>
</tr>
<tr>
<td>&gt; -50°C at 10 wt% oil</td>
<td>R-407C/ICI RT32S</td>
<td>R-22/Suniso 16S</td>
</tr>
<tr>
<td>-10°C at 20 wt% oil</td>
<td>R-22/Suniso 3GS</td>
<td>R-22/Suniso 3GS</td>
</tr>
<tr>
<td>-4°C at 20 wt% oil</td>
<td>R-22/Suniso 3GS</td>
<td>R-22/Suniso 3GS</td>
</tr>
<tr>
<td>T (lower consolute)</td>
<td>R-22/Suniso 3GS</td>
<td>R-22/Suniso 3GS</td>
</tr>
</tbody>
</table>

Table 13: Reference/Lubricant Miscibility Data
<table>
<thead>
<tr>
<th>Compressor Discharge Lines</th>
<th>Compressor Suction Lines</th>
<th>Visual Observations of Fan (T&quot;m with Reduced Fan Flow or Blocked Operation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0 to 10°F) (32°F) 45°F</td>
<td>650</td>
<td>(3) - Achieve Low Temperature DE Operating Temperature (least) Maximum Lubrication Viscosity cSt (at Temperature dependent) Minimum Vapor Range, l/min</td>
</tr>
<tr>
<td>10°F</td>
<td>650</td>
<td>(2) - Maximum Lubrication Viscosity cSt (at Temperature dependent) Minimum Vapor Range, l/min</td>
</tr>
<tr>
<td>200</td>
<td>350</td>
<td>(1) - Minimum Vapor Range, l/min</td>
</tr>
</tbody>
</table>

Table 2.1 Dynamic Test Facility Features and Operating Range
VISUAL OBSERVATIONS AT MANIFOLD LOCATIONS

SCROLL WRAPS

INJECTION FLOW RATES, OIL IS INJECTED DIRECTLY INTO OIL INJECTION FLOWMEETER - USED TO DETERMINE THE OIL ORDER TO DETERMINE IF OIL IS RETURNING TO SUMP

TV CAMERA - TO DISPLAY COMPRESSOR OIL SUMP LEVEL IN COMBINATIONS

OBTAIN A "QUALITATIVE MEASUREMENT OF IMISCIBLE REFERENCE/REAGENT/OIL COMBINATIONS. THIS WILL ALSO BE USED TO UV OIL METER - CALIBRATED FOR ALL PARTIALLY MISCELLANEOUS INSTRUMENTATION FOR TEST
Figure 2.1: Oil Circulation Program Dynamic Test Facility - Cooling Mode
Figure 2.6. Typical Manifold Flooding Behavior

4 vapor lines open

3 vapor lines open

2 vapor lines open

1 vapor line open
Figure 3.4: Heat Pump Rate - Castrol SAE 68 Oil Circulation Tests (15 x 16)

Diagram showing time on the x-axis and oil concentration on the y-axis, with various points marked as 'open values' and 'closed valves'.
<table>
<thead>
<tr>
<th>Temperature</th>
<th>Velocity</th>
<th>Reading</th>
<th>Oil Level</th>
<th>Manipulation</th>
<th>Calculation</th>
<th>Operating Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Low</td>
<td>N/A</td>
<td>3 Open</td>
<td>4 Open</td>
<td>2 Open</td>
<td>N/A</td>
</tr>
<tr>
<td>95°F/min</td>
<td>3 Open</td>
<td>N/A</td>
<td>4 Open</td>
<td>3 Open</td>
<td>2 Open</td>
<td>N/A</td>
</tr>
<tr>
<td>330°F/min</td>
<td>4 Open</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>455°F/min</td>
<td>2 Open</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>290°F/min</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>67°F/min</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>305°F/min</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>44°F/min</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Table 3.4: Summary of Oil Return Problems for Refractive and Lubricant Combinations**

*Bold face type shows first indication of oil return problem.*
IMMISCIBLE LUBRICANTS WITH R407C HAVE NO WORSE EFFECTS

MISCIBLE LUBRICANTS WITH HCFC-22 AND R407C HAVE ABOUT SAME VELOCITY LIMITS

GUIDELINES

350 TO 375 FT/MIN (APPROXIMATE THOSE IN ASHRAE COOLING MODE)

200 FT/MIN (HIGHER OIL CONCENTRATIONS)

100 FT/MIN (LOW OIL CONCENTRATIONS OF 0.25 TO 0.50% BY WT)

HEATING MODE

TECHNIQUES WERE:

MINIMUM FLOW VELOCITIES FOR GOOD OIL MANAGEMEN (NOTED BY VISUAL AND MEASUREMENT

MISCELLANIES SIX COMBINATIONS OF REFRIGERANTS AND LUBRICANTS WERE TESTED TO REPRESENT A RANGE OF

MEASUREMENT AND MONITORING OF OIL RETURN BEHAVIOR UNIQUE INSTRUMENTATION AND VISUAL OBSERVATIONS INCORPORATED FOR ON-LINE CONTINUOUS

MANAGEMENT SCENARIOS THAT COULD PRODUCE ZERO OIL RETURN DYNAMIC TEST FACILITY WAS DESIGNED, CONSTRUCTED, AND INSTRUMENTED TO SIMULATE OIL

MAJOR RESULTS
INDOOR & OUTDOOR HEAT PUMP SECTIONS
OPPORTUNITIES FOR OIL TRAPPING/POOLING MAY EXIST IN BOTH
BE VALUABLE
IMPROVEMENTS IN ON-LINE OIL MEASUREMENT TECHNIQUES WOULD
IMPORTANT AND RELIABLE AS ON-LINE MEASUREMENTS
VISUAL OBSERVATIONS OF POOR OIL RETURN SITUATIONS ARE AS
HIGH LUBRICANT VISCOSITY WERE NOT THOROUGHLY EXPLORED
EXTREME OPERATING CONDITIONS (LOW SATURATION TEMPS) I.E.
VELocities THAN WITH MISCElABLE COMBInATIONS
IMMISCIBLE MIXTURES COULD OPERATE AT LOWER MINIMUM
R407C (WITH 145 OR 365) EXHIBITED GOOD OIL RETURN; I.E.
CONCLUSIONS AND RECOMMENDATIONS
LOWER TEMPERATURE OPERATION SUGGESTED TO FILL OUT MATRIX

• BETTER UNDERSTANDING OF ROLE OF ALL PARAMETERS NEEDED

WITH MO, POE'S, AND AB IN OTHER SYSTEM REQUIRED
ADDITIONAL TESTS AND INCREASED UNDERSTANDING OF HC'S

CONSERVATIVE INDUSTRY GUIDELINES FOR HCFC/CFC/LUBRICANTS APPEAR

(Continued)

CONCLUSIONS AND RECOMMENDATIONS
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