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Project Summary

Effect of Lubricant Contamination on the Performance and Reliability of Heat Pumps Charged with R-407c

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The report gives results of the development of new data that can be used to determine the effect of mineral oil contamination on the reliability of a heat pump system operating with a new hydrofluorocarbon (HFC) mixture and polyol ester (POE) lubricant, to assess any performance degradation due to mineral oil contamination in retrofit applications, and to examine the impact of water contamination on the retrofit system. (NOTE: In heat pump refrigerant retrofit applications in the field, errors can occur that can have an impact on subsequent equipment performance.)

As the result of the premature failure of one of the units, the long term reliability of contaminated systems was not determined. Future investigation should reexamine this issue. The effects on performance of various levels of mineral oil contamination were not significant, so further investigation at specific conditions of interest may be justified. The effects of water contamination could be more significant. The increase in total acid number could have potentially led to increased amounts of trace metals in the system as the acid attacked the system components. A more long term study would be necessary to determine if there were any long term effects of water contamination that did not appear during this 15-week trial.

This Project Summary was developed by the National Risk Management Research Laboratory's Air Pollution Prevention and Control Division, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) are two major categories of refrigerants that contain chlorine. These chlorine- containing refrigerants have been found to be stratospheric-ozone-depleting chemicals, and their use must be discontinued as required by international agreement and U.S. law. HCFC-22, a medium pressure refrigerant used in heating, cooling, and refrigeration applications, is scheduled to be phased out of production and must be replaced. During the past several years, industry and government researchers have begun to develop and test new refrigerants for replacing HCFC-22 in air conditioners, heat pumps, and other applications. Currently, no pure non-flammable refrigerant has been identified as an acceptable replacement for HCFC-22. However, several suitable zeotropic mixtures of hydrofluorocarbons (HFCs) have been identified. Most notably, the mixture of HFC-32, HFC-125, and HFC-134a in the proportions of 23/25/52 wt % (industry-designated as refrigerant (R)-407c) is the refrigerant most likely to replace HCFC-22 in retrofit applications.

In retrofit applications, where HCFC-22 in a heat pump or air conditioner is replaced with R-407c in the field, errors can occur which can have an impact on subsequent equipment performance. When

using R-407c, a polyol ester (POE) lubricant must be used, requiring the removal of both the HCFC-22 refrigerant and the associated mineral oil lubricant from the system. It is possible that the existing mineral oil might not be totally cleaned out of the system and remains as a contaminant in the new R-407c/POE system, affecting performance. Another problem could arise because the POE lubricant is highly hygroscopic. If care is not taken during the replacement of the lubricant, moisture could enter the system with the introduction of the lubricant and degrade performance and equipment life.

The objectives of this research were to develop new data that could be used to determine the effect of mineral oil contamination on the reliability of a heat pump system operating with the new HFC mixture and POE lubricant, to assess any performance degradation due to mineral oil contamination in retrofit applications, and to examine the impact of water contamination on a system charged with the replacement fluid and synthetic POE lubricant.

Results

The first set of tests examined the long term reliability of a heat pump operating with an alternate refrigerant when the unit has mineral oil contaminant present. Two identical heat pump units were compared: one operated with HCFC-22 and mineral oil, and the other used R-407c and POE with 11.9% mineral oil contaminant. The two units were first tested in an environmental chamber to obtain a reference performance level for each. They were then to be operated under uncontrolled ambient conditions in semi-continuous cycle for a year to simulate long term performance. Unfortunately, due to the premature failure of the compressor for the HCFC-22 unit after 3 months, only approximately 20% of the test cycles were completed, and project time did not allow for restarting the test with a new set of heat pumps. The compressor from the R-407c unit was examined and showed normal wear for the length of time that the unit had been in operation. Operating data are presented for both units.

In the second set of tests, performance data were collected on two identical heat pump units to determine the effect on performance of mineral oil contamination. Each unit was tested with R-407c refrigerant and POE lubricant. Increased levels of mineral oil contamination, up to 25% by weight, were introduced into the system to characterize any performance degradation as a result of the contamination. Tests were conducted for both heating and cooling modes. Overall, the results showed that mineral oil contamination had minimal effect on the performance (capacity and efficiency) of the heat pumps. Most of the data for capacity and efficiency for different contamination levels were within the uncertainty of the measurements. There did not appear to be a definitive trend between performance and contamination level.

The final phase of the project examined the effects of water contamination in the lubricant on the reliability of a unit charged with R-407c and POE lubricant. Identical units were charged with R-407c refrigerant and POE lubricant. One unit was left as dry as possible, while the second unit was contaminated with 1200 ppm of moisture. The units were operated continuously in the cooling mode for 15 weeks. Analysis of the lubricant extracted from the units showed little to no increase in the three metals (iron, copper, and zinc) tested in the study. The total acid number in the water contaminated unit showed a general increase. This increase in acid number could have potentially led to increased amounts of the trace metals as the acid attacked system components.

Conclusions

As the result of the premature failure of one of the units in the long term reliability study, reliability of contaminated systems was not determined. Future investigation should reexamine the long term reliability of a unit operating with an alternative refrigerant when mineral oil contaminant is present. The potential exists for systems to become contaminated with mineral oil during retrofit operations. Although the effects on performance of various levels of mineral oil contamination were not significant, the effects varied between heating and cooling tests at various test conditions, so further investigation at specific conditions of interest may be justified. The effects of water contamination could be more significant. The increase in total acid number could have potentially led to increased amounts of trace metals in the system as the acid attacked the system components. A longer term study would be necessary to determine if there were any long term effects of water contamination that did not appear during this 15-week trial.

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The complete report, entitled "Effects of Lubricant Contamination on the Performance and Reliability of Heat Pumps Charged with R-407c," (Order No. PB98-127079; Cost: $31.00, subject to change) will be available only from:
National Technical Information Service
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