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Compressor Start Tests following R-22 Migration to the Oil

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INTRODUCTION

A widely recognized problem in the refrigeration industry is the loss of oil from the compressor crankcase at startup as the result of refrigerant having migrated to the crankcase during a prolonged off cycle. When the compressor is started, the sudden reduction in crankcase pressure causes foaming of the oil-refrigerant mixture. Depending on the amount of refrigerant in the solution, this foam can fill the compressor housing and be pulled into the compressor suction. Valve damage may result. During the period that the oil travels through the system, there may be insufficient oil to lubricate the compressor bearings.

A series of startup tests were conducted on a hermetic compressor in order to determine if commercially available refrigeration grade oils other than the naphthenic type most widely used in air conditioning service would minimize or eliminate foam-out during compressor starts.

DESCRIPTION OF TEST APPARATUS

The compressor was a Copeland 5 ton Copelaweld. The manufacturer recommended oil charge was 2000 grams. A 1-1/2" diameter sight glass was located so that the normal oil level was about in the center of the glass. See Figures 1 and 2. The compressor was connected to an 85,000 Btu/hr secondary refrigerant calorimeter. The calorimeter evaporator was a finned tube bundle having 20 circuits consisting of 10 foot lengths of 3/8" O.D. tubing. The condenser was a 7-1/2 hp water cooled shell and tube heat exchanger with the refrigerant in the shell. The total refrigerant charge was 10 lb. The test loop piping was arranged so that refrigerant could be admitted directly into the compressor shell while the suction and discharge were valved off from the calorimeter. The compressor was located in an enclosure with a thermostatically controlled heater to maintain a 75°F ambient temperature.

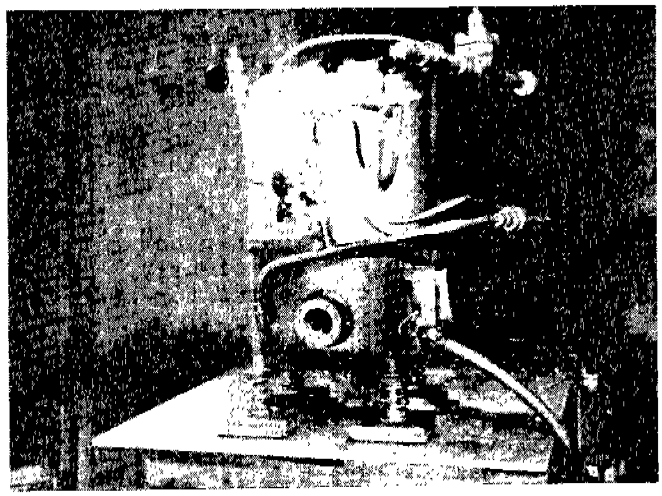


Figure 1

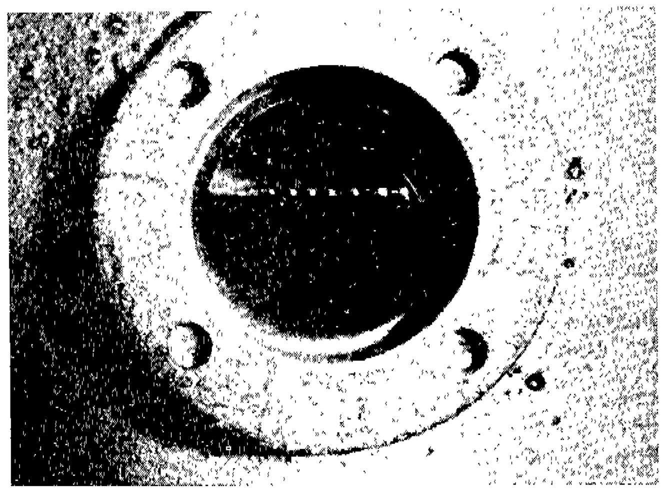


Figure 2

TEST PROCEDURES

The addition of 1800 grams of R-22 to the compressor shell raised the liquid level to the top of the sight glass. In order to permit adequate time for the oil and refrigerant to equilibrate, the refrigerant was charged to the compressor shell on the afternoon of the day preceding a test run. On the morning of the following day, the shell pressure and enclosure temperature were recorded. The water regulating valve to the condenser and air-operated expansion valves were opened. The suction and discharge line valves were opened and the compressor shell pressure recorded again. The liquid level in the sight glass was measured (if below the top of the sight glass) and the compressor started. Thirty seconds after startup the compressor was stopped and the liquid level measured. The compressor was started as soon as the measurement was taken and operated for seven additional minutes at 75 psig suction and 290 psig discharge pressures. It was shut down and the sight glass liquid level was measured for the third time.

Startup tests were conducted with three base oils, a 150 SSU naphthenic grade mineral oil, a highly refined 200 SSU white oil and a 150 SSU alkyl benzene. In addition, tests were conducted with white oil containing 0.1% Dow Corning Silicone 200 (anti-foam agent) and containing the anti-foam agent and 2% tricresyl phosphate (TCP). The alkyl benzene was also tested with .1% anti-foam agent added. The anti-foam agent was dissolved in kerosene to facilitate dispersion in the base fluid (1 part DC-200 to 9 parts kerosene). The base oil and additives were stirred for two hours before being charged to the compressor.

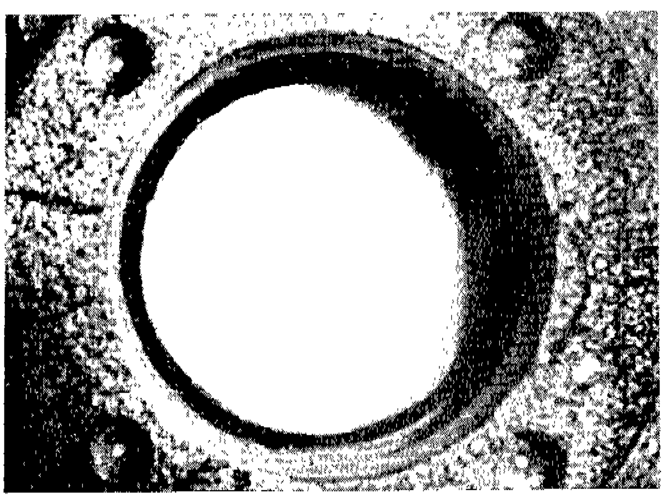
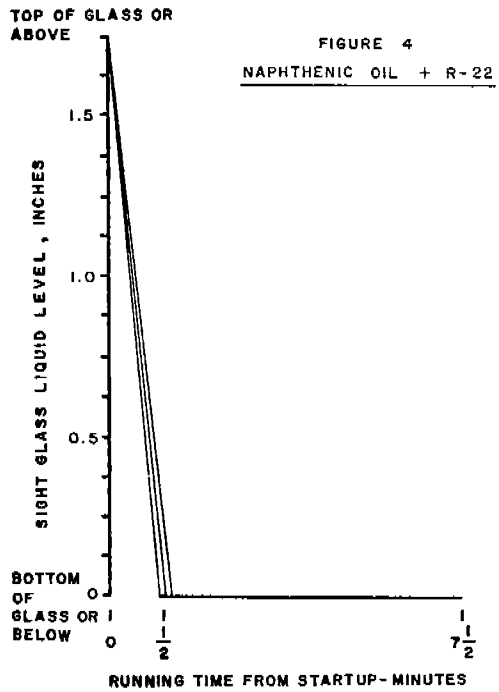


Figure 3

RESULTS

Naphthenic Oil Type

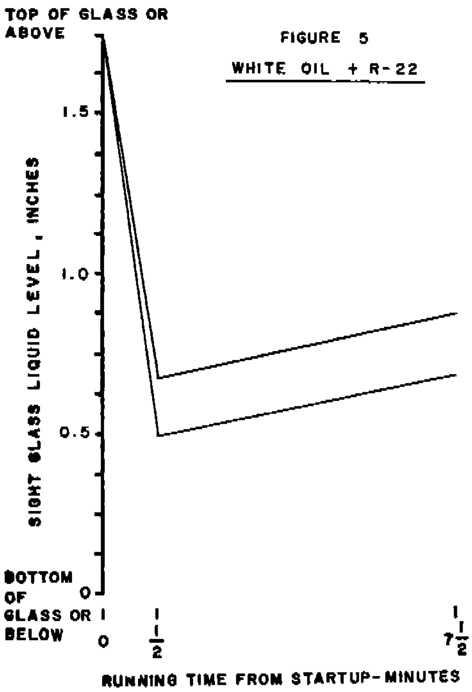
When the compressor was started, the sight glass immediately filled with foam as seen in Figure 3. At the 30-second shutdown, the liquid level was not visible in the sight glass. The oil had still not returned after the seven-minute-run. The same results were obtained in two repeat runs. Figure 4 is an attempt to depict these results graphically.

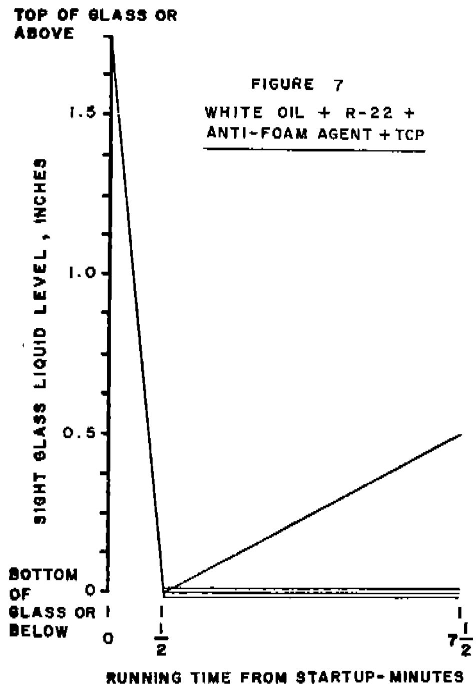


White Oil Type

White oil is used commercially with an anti-foam agent and TCP added to it. It was reported to be less susceptible to "foam-out" than the commonly used naphthenic mineral oils. In order to assess the influence of these additives on foaming, startup tests were conducted first on the base oil, then with an anti-foam agent added and lastly with both additives. The results are shown in Figures 5, 6 and 7.

In two startups with the base oil, most of the oil-refrigerant mixture remained in the compressor shell as the refrigerant boiled away; and at the end of the seven-minute-run, the oil level was close to normal. With both white oil and alkyl benzene, the foam had a different appearance from that found with the naphthenic oil.





In three starts with white oil containing anti-foam agent and TCP, the oil left the compressor and had not returned at the end of the seven-minute-run period. It was concluded that the use of an anti-foam agent did not contribute to foam-out resistance. The addition of 2% TCP made the white oil performance no better than naphthenic mineral oil.

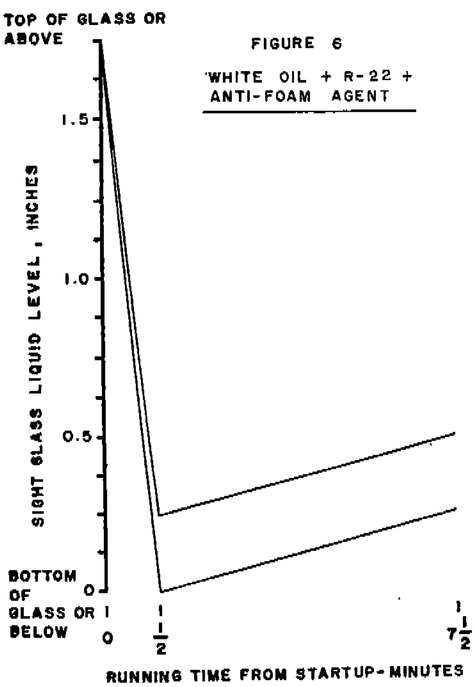


Figure 8 shows the sight glass at startup with alkyl benzene in the compressor. Two tests with anti-foam in the oil gave poorer results.

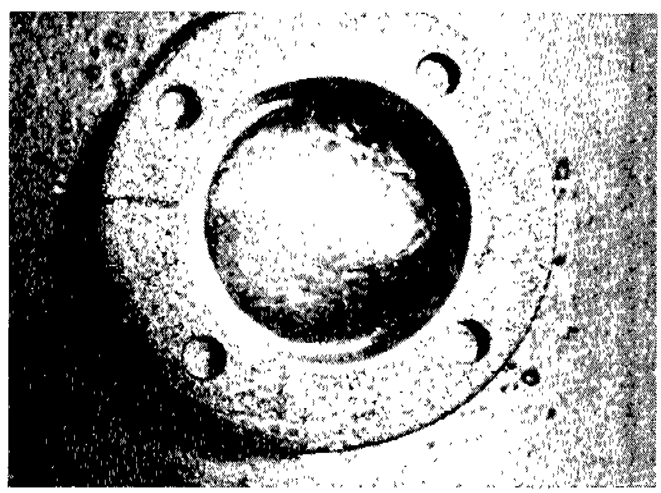
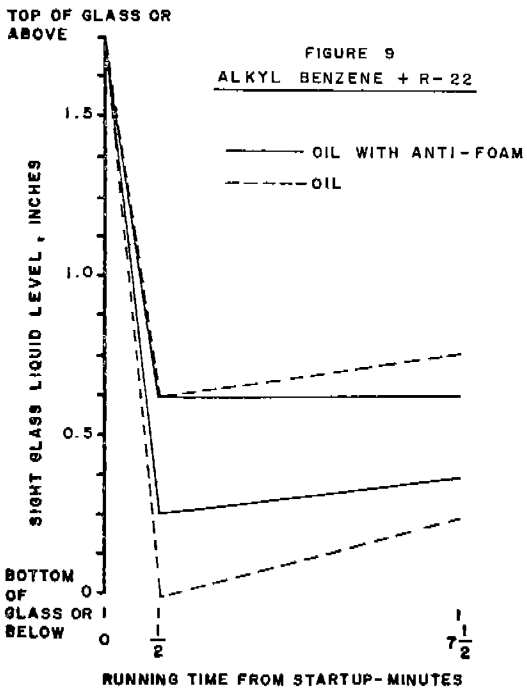


Figure 8

Alkyl Benzene

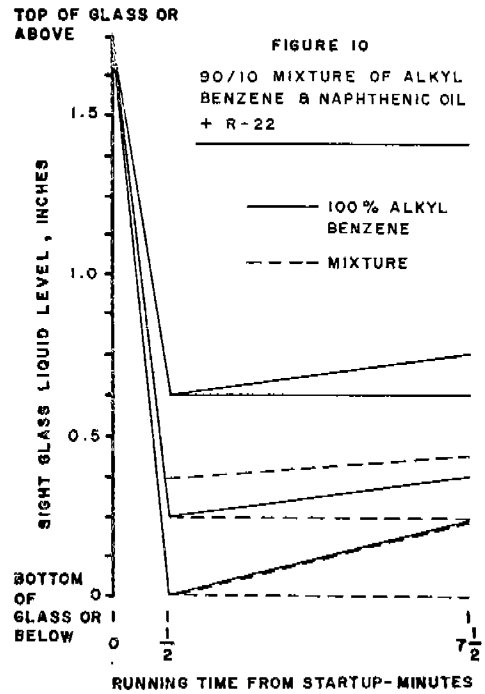
Four startups were conducted with alkyl benzene in the compressor. Two were with the base lubricant and two with the anti-foam agent added. In one of the base oil tests, enough oil left the compressor so that at the 30-second shutdown the oil level was below the sight glass.

At the end of the seven-minute-run period, the oil was visible in the sight glass. In the other three start tests, both with and without anti-foam agent, oil was visible in the sight glass at the 30-second interval. See Figure 9. Due to the limited number of runs, it was concluded that the difference in results with anti-foam were probably not significant.



Alkyl Benzene/Naphthenic Oil Mixtures

Four start tests were conducted with a 90/10 weight % mixture of alkyl benzene and naphthenic oil. The results are shown in Figure 10. For comparison, the results from Figure 9 are shown also. Some reduction in effectiveness results with small additions of mineral oil to the alkyl benzene. In three starts, mixtures of equal quantities of these materials left the compressor and the oil level was still below the sight glass after seven minutes.



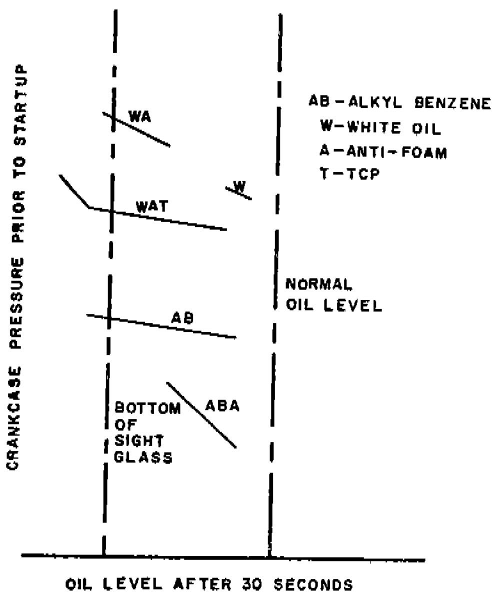
DISCUSSION

In an attempt to explain the variation in day-to-day results with both alkyl benzene and white oil, the oil level after the 30-second-run period was plotted against the shell pressure prior to startup. This is shown in Figure 11. Even though the soak periods, refrigerant-oil concentrations and ambient temperature were held relatively constant the pressures did vary. This pressure variation correlated with the degree of foam-out. It is believed that incomplete mixing produces an upper liquid layer richer in refrigerant (thereby causing a higher vapor pressure above the liquid). This suggests that given enough refrigerant any lubricant will foam sufficiently to leave a compressor at startup.

SUMMARY

In this experimental test program, the extent to which oil left the compressor following a significant addition of refrigerant to the oil in the compressor crankcase was shown to be related to the type of lubricant used. White oil without additives appeared to resist foam-out the best. However, because of its poor lubricity characteristic, white oil is never used as a refrigeration compressor lubricant without an anti-wear additive. At the 2% addition level, tricresyl phosphate reduced the white oil performance to that of naphthenic oil.

FIGURE II



Alkyl benzene resisted foam-out better than the naphthenic oil and white oil with TCP. Small quantities of mineral oil with alkyl benzene such as might be found after a field conversion do not eliminate the favorable results found with the use of alkyl benzene. Anti-foam agents do not appear to be effective foam breakers when the foam is due to a vaporizing liquid fraction of a binary solution.