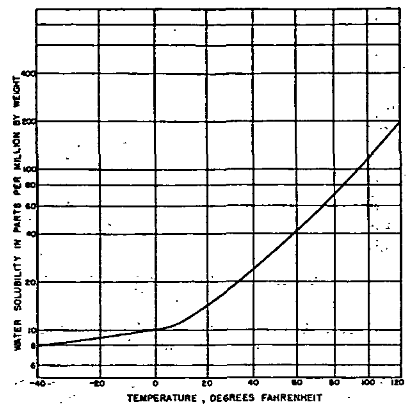

Normally refined transformer oil. Redrawn from Reference 31.

Fig. 41 .... Solubility of Water in Mineral Oil

white paraffin base oil and a medium refined naphthene base oil were heated for 30 days at 302 F in sealed tubes containing copper, steel and various refrigerants in addition to the oil. The refrigerants employed were Refrigerants 12, 13, 22 and 23. For a given oil, the order of decreasing plating was 12 $>23\geq22>13$. However, some copper plating was observed in all tests, even in the absence of refrigerant. Also, more copper plating occurred with the medium refined naphthenic oil than with the highly refined paraffinic oil, with the same refrigerant in both instances.

Other investigators have shown that mineral oils may differ in ability to withstand attack by refrigerants at the elevated

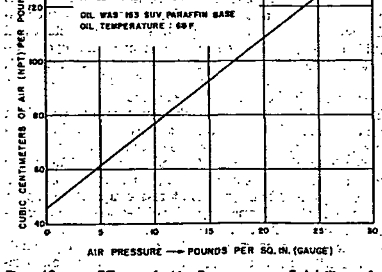

Fig. 42 .... Effect of Air Pressure on Solubility of Air in Mineral Oil[3]

temperature (e.g., 347 F) of a refrigerant resistance test. Based on an extensive laboratory testing program, Walker, Rosen, and Levy[47] have concluded that color darkening, corrosion, wall deposits and copper plating are generally less in paraffin base than in naphthene base oils. Type and severity of refining is also important.[40]

Refrigerants also differ among themsleves in ability to attack mineral oils. Carbon dioxide and the plain hydrocarbons (ethane, propane, isobutane, etc.) are said to have no significant chemical effect on petroleum oils.[3] Ammonia has no chemical effect on well refined, dry oils, but may form soaps and emulsions with poorly refined oils, especially if water happens to be present.[5,48] The halogenated refrigerants show considerable variation; some (e.g., Refrigerant 14) are practically inert and others (e.g., Refrigerant 11) react with oils quite readily in sealed tubes at 347 F.[42,47]

When the test is made with a reactive refrigerant, so far as one can judge visually, the reaction seems to follow much the same pattern with all mineral oils. However, the reaction rate may be slow with one oil and comparatively fast with another. Hence refrigerant resistance is usually evaluated on a time basis. The reaction itself, assuming the oil is tested with one of the more reactive halogenated refrigerants, is almost invariably accompanied by a gradual destructive decomposition of the oil hydrocarbons so that, in time, only a black char remains (see References 42–45, 47, 49–51). The blackening and charring appears to be associated with the number and kind of atoms in the halogenated refrigerant molecule. It has been observed, in the case of a given mineral oil heated at 347 F with a number of different refrigerants and for time periods up to five years, that the charring reaction occurred only with those halogenated refrigerants which contain more than one chlorine atom in the molecule, e.g., Refrigerant 11, methylene chloride, Refrigerants 12, 21, 113, etc. Moreover, Refrigerant 11 (CCl_3F) with three chlorine atoms in the molecule reacted with the oil much more rapidly than Refrigerant 12 (CCl_2F_2) which contains only two chlorine atoms.[42] Increasing the number of fluorine atoms at the expense of the chlorine atoms seems to decrease the reactivity; thus an arrangement of common and potential refrigerants in order of increasing chemical stability in oil mixtures at 347 F is as follows:

Refrigerant 11 <methylene chloride <Refrigerant 21 Refrigerant 12 <methyl chloride <Refrigerant 22 <Refrigerant 13 <Refrigerant 115 <Refrigerant 14.

Owing to the widespread use of Refrigerants 12 and 22, the chemical stability of systems containing these refrigerants has been of greatest interest. So far as destructive attack on the oil is concerned, Refrigerant 22 appears less reactive than Refrigerant 12. This difference has been borne out in all comparative studies, some of which were based on the rate of darkening described in the previous paragraph[42,47] and others were actual quantitative measurements of the decomposition products of the reaction.[50,51]

Recent evidence obtained by Spauschus and Doderer[51] shows that the oil-Refrigerant 12 reaction, catalyzed by iron at 347 F or 400 F, produces substantial quantities of Refrigerant 22 as a primary reaction product. Lagging behind this primary decomposition is a complex effect by which acidic decomposition products and carbonized sludges are formed.

Oil-refrigerant reactions are not yet well understood. The lack of understanding stems in large part from the fact that a mineral oil itself is a complex mixture of many different substances. Differences in base types, differences in viscosity grades, differences in refinement, and the catalytic effects of metals, additives, and possible contaminants all are influential in altering the reaction possibilities. Other system components (e.g., hermetic motor insulation, etc.) introduce

further complications (see Chapter 60), and the results of laboratory tests are not always indicative of actual behavior under service conditions. At the present time it is virtually impossible and certainly inadvisable to assess the chemical stability of different oil types, or even different oil brands, on general considerations. After screening by laboratory tests, the recommended practice for the ultimate selection of a new oil is to evaluate the stability on the basis of *accelerated life tests in the system, or in a similar type of system, in which the oil is to be used.*

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