EFFECTS OF MOISTURE IN REFRIGERANT SYSTEMS

Supersedes: Nothing | 260 | Form 55.60-NM10

The following quote is from the 1957 edition of "Air Conditioning and Refrigeration Institute".

"The effects of moisture in operating equipment using the fluorinated hydro-carbon refrigerants are both mechanical and chemical.

Water is only slightly soluble in fluorinated refrigerants, and freeze-ups are common in systems containing excess water, where the flow control is operating at temperatures below 32°F. Such freeze-ups cause malfunction of the flow control and also serve as a warning of a wet system. At temperatures above 32°F, as in air-conditioning, equipment failure is more often the sign of excess moisture. In addition, corrosion solids can mechanically plug orifices of flow controls and restrict flow through filters, driers, and screens.

Moisture has a number of chemical effects. As free liquid (water) it can cause rusting of steel. In concentrations above and below full saturation of the refrigerant, hydrolysis may take place. It is believed that the mechanism of corrosion goes through the formation of hydrochloric acid in this hydrolysis, since the corresponding chlorides of copper and iron are formed and hydrogen is isolated. The degree of fluorination of the refrigerant is a determining factor in the tendency of the refrigerant to undergo hydrolysis, with the more highly fluorinated being the most stable.

Moisture is also a major factor in the stability of oil. Barring a combination of wire drawing and abnormally-high compression ratios, oil decomposition does not take place in a dry system. In a wet system, particularly if the operating temperature is high, moisture initiates a chemical reaction between the oil and the refrigerant, causing the formation of both organic and inorganic corrosive acids, resins, gums, and varnishes. The more highly fluorinated refrigerants again appear to be more stable, and they exhibit less tendency to react with the oil.

Hermetic motor burn-out failures have a definite relationship to the dryness of the system. Hydrolysis of the refrigerant destroys the high dielectric strength of the oil-refrigerant mixture, permitting short circuits in windings where breaks in the insulation occur.

Table 1 shows the comparative solubility of water in the various refrigerants."

These refrigerants are thirsty for water and if you multiply the values in the table by the conversion factor of ten thousand (10,000) you will arrive at ppm (parts per million). For example, for Refrigerant-12 at 100 F .0165 is the per cent by weight of water it will be able to hold. In other words, there are 0.000165 grams of water for each gram of R-12.

By multiplying .0165 (%/wt) by the conversion factor

TABLE 1 - SOLUBILITY OF WATER IN LIQUID REFRIGERANTS
(per cent by weight)

Temperature (F)	Refrigerant 11	Refrigerant 12	Refrigerant 22	Refrigerant 113	Refrigerant 114
100	0.0168	0.0165	0.1800	0.0168	0.0148
90	0.0140	0.0128	0.1580	0.0140	0.0120
80	0.0113	0.0098	0.1350	0.0113	0.0095
70	0.0090	0.0076	0.1140	0.0090	0.0074
60	0.0070	0.0058	0.0970	0.0070	0.0057
50	0.0055	0.0044	0.0830	0.0055	0.0044
40	0.0044	0.0032	0.0690	0.0044	0.0033
30	0.0034	0.00233	0.0573	0.0034	0.0025
20	0.0026	0.00166	0.0472	0.0026	0.0018
10	0.0020	0.00118	0.0384	0.0020	0.0013
0	0.0015	0.00083	0.0308	0.0015	0.0010
-10	0.0011	0.00057	0.0244	0.0011	0.0007
-20	0.0008	0.00038	0.0195	0.0008	0.0005
-30	0.0006	0.00025	0.0152	0.0006	0.0003
-40	0.0004	0.00017	0.0120	---	0.0002
-50	0.0003	0.00011	0.0091	---	0.00015
-60	0.0002	0.00007	0.0068	---	0.0001
-70	0.0001	0.00004	0.0050	---	0.00006
-80	0.00008	0.00003	0.0037	---	0.00004
-90	0.00005	0.00001	0.0027	---	0.00002
-100	0.00003	0.00001	0.0019	---	0.00001

at 100°F this is 165 P. P. M. and for Refrigerant-22 this is 1800 P. P. M.

The recommended maximum water content of refrigerant at 100° in a system is below 10 PPM for Refrigerant-12 and less than 45 PPM for Refrigerant-22. This is a variable factor hard to pin down. However, essentially you will not have trouble due to moisture at moisture levels lower than this. These levels are detectable by moisture indicators placed in the warm liquid stream between the charging valve and the evaporator and will indicate at a quick glance any water in the system, beyond tolerable amounts, by color changes. This is also the place to locate the drier because again referring to the table you will note that the warmer the liquid the more water it can hold.

The drier should not be of the silica-gel type because it dusts (attritions) thus leaving the drier and causing controls to stick. "Solv-A" beads manufactured by Standard Oil Company are satisfactory since they do not dust off. The filter cores in driers have a high capacity for moisture and neutralizing action against acids as well as accumulation of solids, etc. They must be sized for the inventory of refrigerant in the system and not necessarily the tonnage accomplished by the compressor and system.

Referring to Mr. J. R. Chamberlain's paper presented at Indianapolis in 1957, he pointed out hazards of placing a motor in a corrosive atmosphere in a hermetic system.

"Speaking in general terms, any Hermetic System is especially susceptible to production of acids by the combination of any water contamination and the refrigerant itself. This acid can react with the oil in the lubrication system and produce sludges. Once "triggered" by contamination, this chemical reaction is a progressive item. IT THEREFORE IS ABSOLUTELY NECESSARY THAT A HERMETIC SYSTEM BE KEPT FREE OF MOISTURE."

An open type system while not quite so critical, must also be kept free of moisture.

In order to make sure the system is dry, fabrication of the piping should proceed with dry pipe and components.

As a general precaution, all charging hoses and manifold should be capped off after charging so that there will be no moisture free on re-use.

Extreme caution must be exercised in purging the completed system of water. This can be accomplished by evacuating the system with a good vacuum pump to obtain 29.7" vacuum, then leaving the system stand for 24 hours. If the vacuum at the end of this period is 29.6" or better, it proves the system is tight and reasonably dry. A wet bulb indicator should then be used and the procedure prescribed in Instruction 2J followed to obtain a dry system.

An alternate method is the use of what is known as triple evacuation where the system is evacuated with a good vacuum pump to as low a value as possible and then the vacuum is broken with dry refrigerant 12 three times successively. Refrigerant 12 is used because of its high capacity for water. You therefore sweep out water vapor from the completed system three times, each time the gas becoming saturated with moisture. In this method the refrigerant is used as the drier. This method is more expensive and therefore we recommend the former method using the wet bulb indicator.

After the system is made initially dry it then becomes essential to maintain the system dry. This can best be accomplished by using a drier in the warm liquid line to the system with an indicator to signal the degree of dryness.

Concerning moisture indicators, they are susceptible to too much moisture contamination and bright light, such as from arc-welding. Therefore, these indicators should be kept capped or covered until inspection is required and renewed when they become contaminated.

It is also most important that refrigerant grade oil be kept capped. The manufacturer of the oil goes to a great deal of effort to furnish moisture-free oil and therefore the oil should be capped to keep it dry.

Refrigerant 11 and 114 water cooling systems are susceptible to crevice corrosion as a result of moisture in the refrigerant. This occurs at the outside of the tube at the tube support and usually at the liquid level when the plant is down, in other words, in the lower section of the tube bundle. The attack is caused by corrosion in the crevice between the tube and the tube support hole. As is well known, a crevice is a location favorable to the development of an oxygen concentration cell. An oxygen concentration cell is formed when adjacent area of a liquid in contact with a metal differ in dissolved oxygen content. A crevice, if not too large, creates an inequality of oxygen concentration by hindering oxygen diffusion.

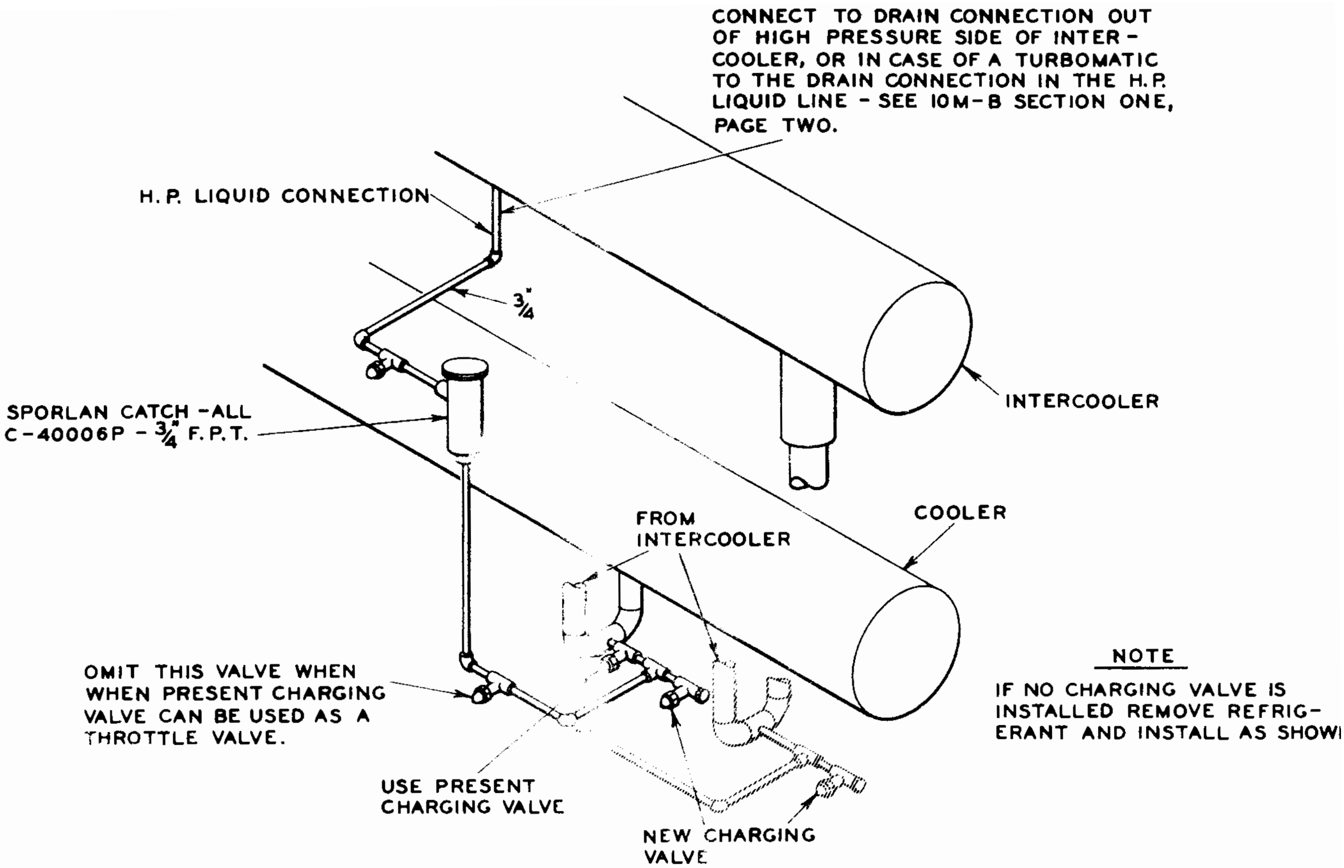
The corrosion current produced by an oxygen concentration cell varies with the metal, the composition, velocity, temperature, and electrical conductivity of the liquid, the ratio of the anode and cathode areas and the difference in oxygen concentration.

Since functioning of the oxygen concentration cell requires an electrolyte, attack cannot occur if the refrigerant is moisture free.

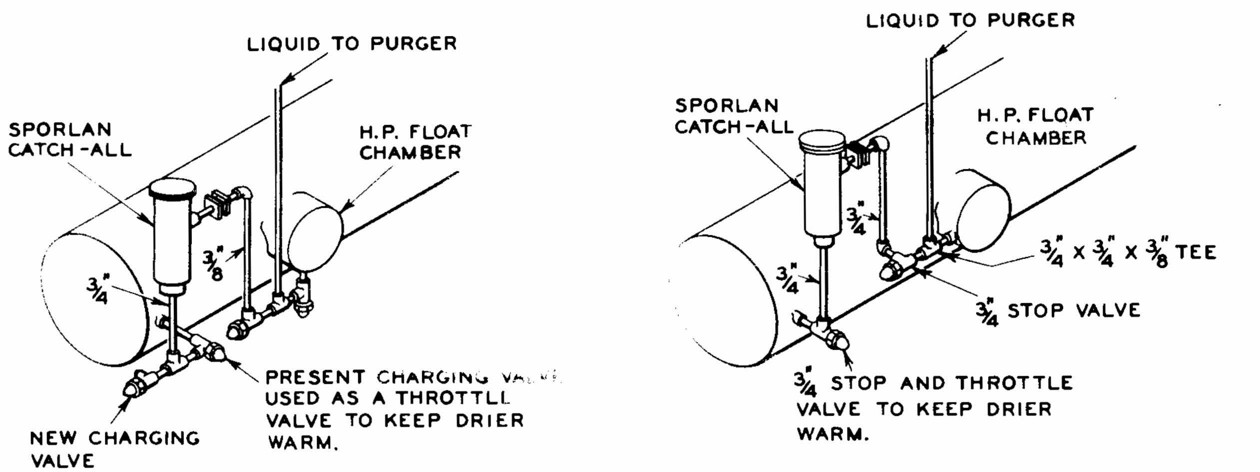
This crevice corrosion is easy to identify as a groove eaten into the tube about the width of the tube support and partially around the tube, the greatest depth being on the bottom. The hole in the tube support usually becomes ellipical with the long dimension vertical. The first reaction is that this must be the result of the tube wearing in the hole due to vibration. This is not correct, because micro-film analysis of the metal at this point shows no difference in grain structure of the metal as it would if it has been beaten.

Good preventative maintenance requires that the systems be kept free of moisture. This can be accomplished by pulling a low enough vacuum using a wet bult indicator all as covered in Instruction 2J prior to charging. It then becomes essential to maintain the system dry during operation. This can best be accomplished by using a drier in the warm liquid line.

Standard systems, as furnished from the factory by manufacturers, do not include a special dryer. This device is somewhat in the same nature as the specialized oil filters which are frequently sold as an optional extra feature on automobiles. The



SKETCH "A" - TYPICAL PIPING FOR INSTALLATION OF DRIER ON TURBO SYSTEMS



EARLIER SYSTEMS

LATER SYSTEMS

SKETCH "B" - TYPICAL PIPING FOR INSTALLATION OF DRIER ON TURBOPAK SYSTEMS automobile (or the refrigerant system) can be operated and maintained without them. However, maintenance and trouble-free system performance are improved by the use of devices such as these. Consequently, to assist in simplified maintenance and trouble-free operation, installation of dryers as indicated on sketches "A" and "B" is recommended. Sketch "A" applies to open type systems, and sketch "B" to the hermetic turbopak.

On all systems placed under York Certified Maintenance Agreements, the dryer should be installed as soon as the system is placed under contract, and cost of installation charged to the first year of Maintenance Contract costs. Installation of the dryer at its slight additional cost should be recommended by York Field Representatives whenever they have occasion to be in touch with the customer during the startup of these systems. A record of having made such a recommendation to the customer should be kept for future reference to be sure that the customer has been notified of the availability of this feature at a slight additional cost. The cost of installation of the dryer will be almost negligible if made at the time of initial installation.

A word of caution. The drier on the system can perform its function of drying only when the plant is in operation. Refrigerant systems subjected to prolonged shut down should be kept at atmospheric pressure or slightly above to prevent moisture and air infiltration under vacuum as per Instruction 10M-4.

In the event of a failure due to crevice corrosion, elaborate precautions are necessary depending on the degree of damage to clean up and dry up the system as described in another section.

In the event of a hermetic failure elaborate precautions are necessary as described in another section to wash out contaminents as a "spark" or complete burnout of the motor can produce a great quantity of various compounds including acids, varnishes, sludges, and generally a black deposit throughout the system. The condenser, compressor, evaporator and piping must be completely cleaned of all deposits as small quantities once again can "trigger" a progressive chemical reaction and further contamination. Systems which have had a hermetic failure and which are not completely cleaned of contamination prior to installation of the new motor and recharging, can result in failure of the hermetic motor again in as short as one year for the first new motor. The second motor could go out in as short a time as six months, the third in a period of weeks, and the fourth or fifth measured in days. In the long run it behooves the installer of the equipment to make absolutely sure he has a clean system free of moisture. (Refer to Instruction 2J for information on cleaning system after hermetic failure).

After starting up a hermetic system repaired from failure, a sample of new fresh oil charge should be kept in a small glass container (capped) for comparison purposes.

The oil in the crankcase must be again inspected after two or three days and any change in the color of the oil, that is, darker or turning white, indicated contamination and the cleaning process must be repeated. There is no short-cut. This oil should be watched for a several week period by this method, inspecting some every several days.

Tolerable amounts of water in a refrigerant system will have various values depending on the source of information. However, you can rest assured if the moisture content is below the amounts indicated, there will be minimum of repeat service calls and maintenance costs.

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