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FROM : Tony King/Keith Edwards

SUBJECT : <u>EVACUATION AND VACUUM PUMPS</u>

We are regularly questioned as to why we insist on a 2 stage vacuum pump, electronic vacuum gauge and why we insist on a lengthy evacuation procedure.

It has been our intention to write a detailed application notice on this subject but we uncovered an excellent article written by John D Bopp of Virginia Chemicals Inc, USA, and rather than re-invent the wheel, we decided to attach a copy of the article in its entirety.

We recommend that you read this article in full and when in doubt, refer to it.

There is no alternative to keeping the system dry, clean, acid and oxygen free. To this end we also insist on brazing with Nitrogen flowing through the pipes to minimise oxidisation and that pipes are kept sealed until the last moment before connection.

Hopefully you will note why an old used refrigeration compressor is insufficient for evacuation purposes, it is rude, crude and incapable of achieving the vacuum required, and that anyone not using an electronic gauge is only kidding themselves that they have achieved it.

You will notice that the vacuum procedure in our split system installation instructions (option B - triple evacuation) falls somewhere between the ideal and normal procedures recommended by Virginia.

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THE WAY TO LESS INWARRANTY SERVICE AND GREATER PROFITS

by John D. Bopp *Air Conditioning & Refrigeration Products Division/Virginia Chemicals Inc.*

Warranties and Profits

Most new commercial equipment is installed with the contractor carrying a warranty on the equipment for a period of one to 12 months depending on how the contract is written. During the time the equipment is in warranty, the installing contractor is responsible for any failures which occur, except contract exclusions, including labor, materials, and parts. The only place in a contractor's operation from which money can be derived to pay for inwarranty failures is his profit. In effect, he becomes his own customer when servicing warranty problems. Some contractors carry a revolving fund built by adding a portion of the profit from each installation in order to cover any major inwarranty failures. Others carry no such fund and hope for the best.

Residential air conditioning, a very large and rapidly growing segment of the refrigeration industry, presents challenging problems. Labor allowances have virtually disappeared and those which remain are inadequate. A homeowner who knows that the compressor has a five-year warranty, simply cannot understand why he should bear any expense at all if the unit fails after just a few months operation. In most cases, other than the new compressor, it boils down to who is going to pay for the parts and labor to get the system in operation again. A percentage of these are never satisfactorily resolved and eventually, to preserve his company image, the contractor absorbs the cost. Whether it is called "warranty expense" or "preservation of company image" it still comes out of company profits.

Assuming that the contractor has properly calculated his labor, parts, materials, overhead and profit on the original installation, he will enjoy a profit somewhat proportional to inwarranty failures. Many otherwise profitable organizations have failed because of excessively high failures during the warranty period.

The profitability of a contracting organization depends on many things. High on the list is sound installation and servicing practices. Proper pricing to permit the use of these practices is of prime importance. The good, stable contractor is one who declines certain jobs because price competition will not permit proper installation practices which are an absolute must if he is to become involved in a warranty on the equipment. There is absolutely no question that a properly installed system has the best chance of operating through the warranty period with little or no cost to the installing contractor.

Importance of Evacuating the System

Evacuation of the system with a good vacuum pump is a standard installation recommendation by most equipment manufacturers. Just because it is recommended does not mean that it is being universally followed. In addition, "good vacuum pump" does not necessarily mean the same thing to all people.

For many years, the presence of noncondensibles was recognized as undesirable from a head pressure standpoint. On the other hand, noncondensibles were given far more lip-service than serious consideration. The picture is quite different today. Most systems are hermetic or semihermetic and design conditions with respect to discharge temperatures and head pressures are becoming increasingly difficult with each passing year.

Because of the increasingly severe operational conditions, chemical stability of the internal system becomes a prime focal point. The color and acid number of the oil in the compressor is the best barometer of the overall chemical stability of the system.

Oil breakdown proceeds in two basic steps. The exact mechanisms of these reactions are not yet defined but can be stated in over-simplified terms which are sufficient for our present needs.

The first step in oil breakdown is the reaction of the oil with air (oxygen) in the system to form solids. The solids tend to build up at the hottest point which is at the discharge valve seats. When sufficient material accumulates on the seats the valve reeds no longer seat properly and wire drawing occurs. Wire drawing is the term applied to forcing a gas through a very small leak at high speed, creating temperatures up to 800 to 1000°F. Up to this point, the oil in the compressor usually will not have shown any major color change.

However, once the wire drawing occurs, conditions become grossly different. Step two of oil breakdown begins with the oil and refrigerant chemically reacting to produce water, hydrochloric acid, organic acids, and a variety of oil decomposition products. These products "seed" the oil in the compressor and oil breakdown proceeds at an ever increasing rate with an accompanying color change in the oil and also a rise in the acid number of the oil. If it is allowed to continue the result is usually the loss of the compressor due to a burn-out. We can show the foregoing as follows:

Step 1.	Oil + Oxygen (Air)
Step 2.	Oil + Refrigerant
Products	1. Water
	2. Hydrochloric Acid
	3. Organic Acids
	4. Oil Breakdown Products

If air is absent, Step one is eliminated which essentially prevents "build-up" on the discharge valve seat. This in turn prevents the excessively high temperatures and thus inhibits Step 2 (oil + refrigerant reaction) from taking place. Air along with temperature appears to be a principal key to the chemical stability of a refrigeration system. Air can only be removed by proper evacuation procedures using a *good vacuum pump* and *proper instruments* to measure the vacuum.

Necessary: A Good Vacuum Pump

Very often we find that people at the contractor level have the idea that a vacuum pump is any old used refrigeration compressor which will pull from 25 to 28 inches. We also find that the idea is quite prevalent that a good vacuum pump complete with electronic gauge with a total cost of $350 to $400 is an expenditure which cannot be justified. In the first place, a 25 to 28 inch vacuum is simply running on a tread mill with respect to accomplishing any great amount of dehydration or serious noncondensible removal. One must understand that the gauge may be showing 50 microns at the pump, but if a long run is being pulled it may be a completely different story at the other end of the line. The poorer the vacuum, the worse the situation becomes.

In many cases the situation is further complicated by the contractor using too small a connecting line between the vacuum pump and the system creating a high pressure drop. This greatly reduces the efficiency of the vacuum pump.

In the second place, as so often happens, the contractor finally buys a vacuum pump, after losing one or more compressors during the warranty period, and realizes that the money the burned out compressors cost him certainly would have bought more than one good vacuum pump.

Many people do not seem to understand the terminology when we talk of vacuums in microns. A micron is a unit of measure in the metric system and is equivalent to 1/1000 millimeter. There are 25.4 millimeters to an inch. Therefore, 1 micron is equal to 0.00004 inches. One hundred microns is equivalent to 0.004 inches or 29.996 inches of vacuum at sea level and 65°F. temperature. One inch is equivalent to 25,400 microns. A 28 inch vacuum then is equivalent to 50,800 microns and certainly in no way can be interpreted as a satisfactory vacuum.

What Kind of Vacuum Pump

The most commonly used type of pump is a two stage gas ballast pump. One manufacturer markets a high speed pump which they claim runs sufficiently hot to prevent condensation of water and does not require the gas ballast feature.

With the gas ballast pump the user begins the pull down with the gas ballast valve open. The pump then operates as a single stage pump venting the moisture laden vapor to the air instead of pulling it through and contaminating the oil. Once the 5,000-10,000 micron range has been reached and the gross quantities of moisture removed from the system, the valve is closed and the evacuation completed using the pump as a two stage pump.

The pump must either run very hot or have the gas ballast feature to prevent the oil from becoming wet.

If the oil is wet, a low vacuum cannot be attained.

There are several good brands of domestically made gas ballast and high speed vacuum pumps available from refrigeration wholesalers with repair parts readily available.

Use an Electronic Gauge

Currently there are three methods being used in the field for measuring vacuums but only one is adequate.

Many try to use a compound gauge which, at best, is only accurate to ± one inch of vacuum. When used with a good vacuum pump the only result will be pinning the needle and no actual measurement. Compound gauges are totally impractical.

More frequently used is a U-tube manometer. Its impractability becomes obvious when one realizes that at the 100 micron level the difference in height of the two columns of mercury is the thickness of a human hair. In addition, with any power interruption, oil will be pulled back into the U-tube rendering it useless.

The practical instrument is an electronic (thermocouple) gauge. It is a direct reading instrument calibrated in microns. Anyone who can read an ammeter, voltmeter, clock, etc. can easily read this instrument. The new transistorized gauges are rugged and now widely used in the field.

Recommended Procedures

1. *Ideal*

The following procedure is recommended where ample time is available; where compressors consistently run with high head temperatures; after repeated compressor failures. It is recognized that in a high percentage of instances, time and economics will rule out this rigorous procedure, but it stands as the most effective method of processing a system for removal of air and gross quantities of moisture.

1. Hold *at** 50 - 100 microns for 1 hour.
2. Break to zero gauge (not more than 2-5 lbs. positive pressure) with dry nitrogen or R-22.
3. Allow R-22 or dry nitrogen to remain in system for one hour.
4. Hold *at** 50 - 100 microns for 30 minutes.
5. Break as in (2).
6. Hold *at** 50 - 100 microns for not less than 6 hours.
7. Charge system using normal size drier.

2. *Normal*

With the high cost of materials, labor, and pressure of time it is necessary to provide a procedure which can be followed and will at least rid the system of dangerous quantities of air.

1. 30 minutes *at** 1500 - 2000 microns.
2. Break to zero gauge with dry nitrogen or R-22 and allow to remain in the system for 10 minutes.
3. 15 minutes *at** 1500 - 2000 microns.
4. Break to zero gauge with dry nitrogen or with R-22.
5. 30 minutes *at** 1500 - 2000 microns and charge using a drier one size larger than usual.

Even if the evacuation times above must be reduced to ten minutes each and the ten minute holding time in (2) eliminated, good air removal will be accomplished. It cannot be stressed strongly enough that the evacuation process *must not* be eliminated entirely.

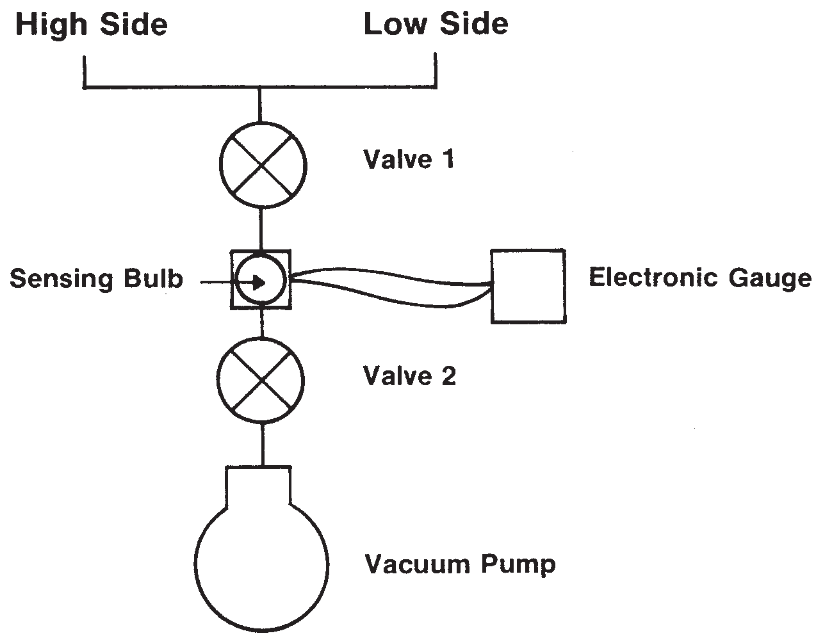
** Do not start timing until recommended vacuum range is reached.*

Precautions In Evacuation

1. Always use a large enough line between the vacuum pump and the system to prevent pressure drop and loss of pump efficiency. The line size should never be smaller than 10mmØ preferably 12 or 16 mmØ.
2. Two types of connecting lines are recommended. Fresh, dead soft copper tubing or a braided metal vacuum hose with internal construction similar to a vibration eliminator.
3. Use an electronic gauge.
4. Where long liquid and suction lines are involved the vacuum pump should be connected to the system by a manifold so that a vacuum is pulled on both the high and low side of the system. If the hook-up is as shown in the following diagram the pump can be checked for its efficiency, the system can be evacuated and the electronic gauge used to check for leaks.

When Valve 1 is closed and Valve 2 is open the guage is reading only the pump. When Valves 1 and 2 are open the gauge is reading the combined pump and system. If Valve 2 is closed and Valve 1 is open, the gauge is reading the blanked off system and determines the true system reading after the needle stops moving. If the needle continues to move upward toward the higher vacuum range a leak somewhere in the system is indicated.

Note: 0.1 mm Mercury = 100 microns
0.2 mm Mercury = 200 microns



Conclusion: Proper Installation = Better Profits

No matter how detailed one gets in outlining installation procedures, everything that is done to prepare a system before making it operational really is aimed at arriving at four conditions. These four conditions are vitally necessary to start the system out in good shape, free of contaminants, free of noncondensibles, dry and in a condition which will assure living through the warranty period. These conditions are: (1) clean, (2) dry, (3) acid free and (4) oxygen free. Everything that the careful contractor does when installing a system is aimed at arriving at these four conditions. If they are met, experience throughout the country clearly shows that the contractor can expect very little in the way of inwarranty service. The profit that he has accrued from that installation will not be spent in rectifying troubles during the warranty period.

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