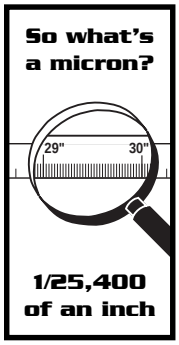
DEEP VACUUM
Its Principle and Application

With deep vacuum, we are sure of our results before we leave the job. No more waiting to see if we get a call back to determine the results of our work. Deep vacuum is the only method we can use to tell us, for sure, that a system is thoroughly dry and free of noncondensables and leaks.

Measuring Evacuation– Microns Or Inches?

A micron is a measurement of pressure starting from a perfect vacuum (no pressure) expressed in linear increments. One inch equals 25,400 microns. It should be noted at this point that when we discuss vacuum in terms of microns, we are referring to total absolute pressure as opposed to gauge pressure. Besides using a more accurate unit of measure (you can't read fractions on a bourdon tube type gauge), we are also starting from the same measuring point (theoretical perfect vacuum).



The bourdon tube type gauge, you will also remember, uses atmospheric pressure as its reference point, which is constantly changing during the day. The weather forecaster always includes this reading, barometric pressure, along with the temperature. When an area is covered by a HIGH, it translates into high barometric pressure and vice versa for a LOW.

Pumps And How To Select Them

Deep vacuum pumps are the first item to come to mind when we think of vacuum tools. Unfortunately the first mistake is usually made in the selection of these pumps with reasoning that goes like this— "The larger the pump I get, the faster I can do the job." Pump capacity has very little to do with evacuation time in refrigeration systems, as is easily seen when we examine the following.

The refrigeration system itself is constructed of several feet of small diameter tubing with return bends and metering devices to offer restriction during evacuation. Compound this with the fact that service valves, when provided, have 1/4" male flare ports which only have a 3/16" orifice.

We also know that the only way to get more flow through a given orifice is by increasing the pressure across that orifice. But does a pump create pressure that increases the flow? No. We tend to forget two basic principles. A vacuum pump creates a void toward which the system pressure flows. The second point is that as pressure decreases in the system during evacuation, flow decreases. Therefore, it's impossible for us to increase pressure or flow through our gauge ports with a larger pump.

Pumps in the 1-1/2 to 10 CFM class are adequate to handle 99% of our work. As a rule of thumb, the CFM rating squared equals the maximum system tonnage. A 7 CFM pump is rated for 49 tons; 3 CFM pump is rated for 9 tons. They are all that should be purchased for service and installation. In many cases, depending on the system line sizes of large tonnage systems, it is better to put two or more of the small, easily handled pumps at different locations. This will overcome some of the pressure drop problems and actually be faster than a single large pump.

Pump Construction

Rotary vane deep vacuum pumps are readily available and are best suited for our work. Piston type pumps, because of the clearance necessary between piston and head, are incapable of producing a deep vacuum or at best are very inefficient. Many single stage compressors, similar to a hermetic compressor will not evacuate a system into a micron range, the last inch of pressure on the compound gauge, nor will it condense any moisture vapor in the system.

Two stage pumps (2 pumps in series) have the best record in our business because they are capable of producing consistently lower pressures and are much more efficient when removing moisture vapor. The pump should be equipped with a blankoff valve which allows us to perform the isolation test (pressure rise) which is required in deep vacuum procedures.

The gas ballast feature should be on all pumps for refrigeration. At the beginning of

Valve Is Open When Screw Threads Are Visible

The gas ballast valve is only effective to 2000 microns. Failure to close valve will result in poor pump performance.

evacuation, water vapor is quickly removed and if a system is laden with moisture, can very quickly contaminate the oil. Through the gas ballast, a fine metering valve connected to the second stage of the pump, a small amount of relatively dry ambient air is admitted to help prevent the moisture vapor from condensing in the oil.

So far, we have defined our pump requirement as follows: 2-stage, rotary vane; blankoff valve; gas ballast valve; 1-1/2 to 10 CFM. A system is evacuated to between 300 and 400 microns so obviously these pumps should be able to produce vacuum in the low micron range with a safety factor of at least 25 microns total absolute. Thus, the pump should be able to achieve vacuum readings of at least 25 microns total absolute. We should also look for light weight and rugged construction because we all know the vacuum pump will be at our side as we climb those ladders to the roof top.

Finally, when checking out pumps, look at safety. Belt driven units should never be used without belt guards—if you don't give a darn about your own fingers, etc., give children and others exposed a chance. Hospitals and court rooms around the world are full because of this negligence.

The Electronic Vacuum Gauge

Coupled with good procedures which we will get into later, the electronic gauge tells us positively that we have a noncondensable and a leak free system. In general these gauges are heat sensing devices, in that the sensing element which is mechanically connected to the system being evacuated generates heat. The rate at which this heat is carried off changes as the surrounding gases and vapors are removed. Thus, the output of the sensing element (either thermocouple or thermistor) changes as the heat dissipation rate changes. This change in output is indicated on a meter which is calibrated in microns of mercury.

Evacuation is complete when a system holds at 500 microns. The compound gauge only indicates that a vacuum is being produced. The vacuum gauge on the other hand, is the only tool for accurately reading that low pressure.

The electronic vacuum gauge is the least purchased deep vacuum tool. Yet, without this instrument you might just as well forget about deep vacuum altogether.

Vacuum Gauge Selection And Accuracy

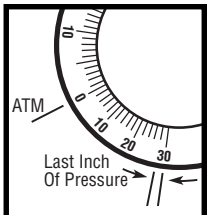
The most important feature of all is range. If the micron gauge only indicates from 50 to 1000 microns, you will not be able to determine whether you are pumping against a leak or against moisture. Look for an instrument that reads from 50 microns to at least 9,000 microns.

Portable micron gauges typically operate from battery power. It's best to buy a micron gauge with AC adaptor capability so you won't run out of power on the job. When batteries are run below the low battery warning, the batteries can cause corrosion and may cause permanent damage to the vacuum gauge.

Another feature to look for is a sturdy case to protect the instrument. Finally, when you buy instruments of this type, remember that you are really only buying answers, and the instrument should give you these answers quickly and accurately. You get paid for adjusting refrigeration systems, not your tools.

As already noted, we are talking about accuracy when we talk about micron type gauges. Gauge accuracy is affected by two factors. Extreme temperatures especially with exposure to the summer sun on a hot roof top or pavement and sensor contamination.

The vacuum sensor is factory calibrated on air. If refrigerant gas or oil is drawn into the vacuum sensor of a remote reading unit or unit connected to the pump during the system evacuation, the gas will cause an erroneous reading. Any oil getting into the vacuum sensor via hose will also affect gauge accuracy. Improper shut down of pump after evacuation and loss of power will suck back oil and contaminate the hose and micron gauge. A hose used for charging or testing will contain droplets of system oil spurted into the hose when the schrader valve is opened. If this same hose is used on the hookup to the gauge, oil will collect in the gauge sensor. This can be prevented by using a dedicated hose, preferably O-Ring type, for evacuation.



The last inch of pressure, as indicated on the compound gauge is 25,400 microns.

Evacuate Through The Gauge Manifold

Evacuate through the gauge manifold if, and only if, it is O-ring sealed, piston construction. Other types leak under vacuum. Next look at the design of the 3/8" center port. In order to handle the full capacity of both the high and low side,

the intake should have double size flow path throughout its length.

Leak-Proof Hook-up

Deep vacuum has it own unique properties which requires leak-proof design not only in the manifold but in all the components, which brings us to the connecting lines. Only soft copper tubing, pure rubber or flexible metal hose are absolutely vacuum tight. Charging and testing hoses are designed for pressure. Even with the advanced technology of today's hoses, permeation through the hose compound still exists. When checking pressure rise, the atmosphere will permeate to the lower pressure in the hoses and the micron reading will slowly rise.

Another source of leakage is the coupler. The gasket seal in a charging hose requires frequent attention and replacement to keep its leak rate tolerable. An O-ring coupler, such as that made by J/B, has a small rubber mass that forms around irregularities in the flare fitting. When the flare is screwed down, we get a metal to metal seat and the o-ring lays around the flare to give a positive seal.

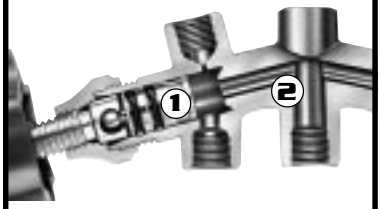
Evacuation Hook-Up

Evacuation should always be done from both sides of the system. We have now covered the simplest hookup to this point; gauge manifold with two 1/4" I.D. connecting lines to the system and a 3/8" connection to the pump via line or fittings. Much has been said and written regarding line size, which would lead us to believe the bigger line we connect, the faster job we'll do. This would be true except for the compressor's 3/16" orifice. Therefore, we only need to keep the connecting lines' I.D. larger than 3/16" This is one of the limiting time factor in evacuation.

Evacuating from both the high and low sides will save 3/4 of the time required to evacuate from only one side of the system. Short connecting lines will save some time; however, not nearly what some maintain. In relation to the lengths of tubing in the system, we add very little restriction via connecting lines.

Now we need to connect the vacuum gauge. The lowest reading will be at the pump, the vacuum source. If the micron sensor is at the pump, when we blank-off, the micron gauge falls back to atmosphere. The reason is that the sensor is too close to the pump and it does not give the system time to equalize. If you are connecting the micron gauge to the 1/4" pump intake, we suggest the line be a minimum of 3 feet.

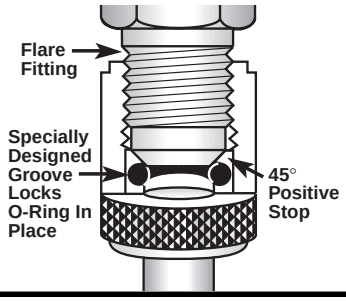
J/B Piston Type Manifolds



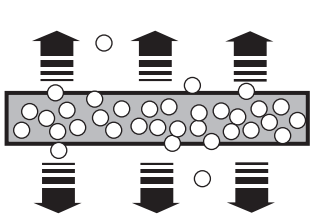
1. *Stem seats retract completely from flow path.*

2. *Double size flow path throughout length of center port*

Deep Vacuum O-Ring Coupler Cut-Away

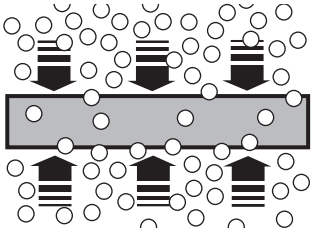


Direction of Permeation Through Hose Wall



Charging System

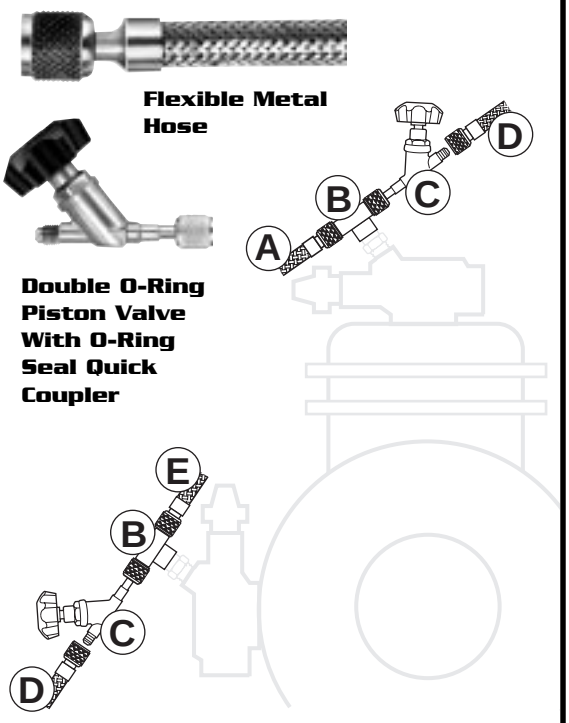
Gas under pressure in the hose will permeate to the lower pressure of the atmosphere.



Evacuation

The atmosphere which has a higher pressure permeates to the lower pressure in the hose.

Suggested Micron Gauge Hook-Up



A*. 1/4" Flexible Metal Hose To High Side Manifold*

B. *Flare Tee*

C. *Shut-Off Valve*

D. *1/4" Flexible Metal Hose To Micron Gauge*

E. *1/4" Flexible Metal Hose To Low Side Manifold*

The most accurate reading is obtained at the compressor using both the high and low sides. At this point, we need some additional connections for our electronic gauge, and some provisions for charging must be considered.

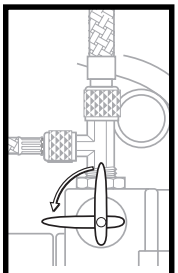
Depending on the gauge, it should be remembered that the electronic gauge's sensors will not take pressure beyond 1 to 100 pounds. Therefore you must be able to valve it off before charging. Any additional valves should be the o-ring seal quick coupler with double O-ring piston seal type to avoid packing and diaphragm leakage.

Pressure Rise Test

We previously mentioned that the only difference between deep vacuum and the methods of the past is that we can measure what we have done. This is called the Pressure Rise Test.

When the sensor reads between 300 and 400 microns, close the pump's blank-off valve to isolate pump from the electronic vacuum gauge and system. Wait for at least 5 to a maximum of 20 minutes to allow system pressure to equalize. The reading you see at the end of this test will be very close to what you actually have in the system. A rapid rise during this test to atmospheric pressure indicates a leak, while a slower rise to around 1500 microns indicates moisture is present.

Many evacuation level recommendations are offered for us to choose from, including the statement "evacuate the system to below 200 microns." This should not be considered. Note we say "system" because it is possible to evacuate piping or some component other than the compressor to below this level. Refrigeration oil has a vapor pressure (it boils) at between 200 and 250 microns. Thus, to get a system below this level, you would have to boil all the oil out, which is not likely to happen.



Preventing "Hard Start-Up"

After closing the isolation valve, open the gas ballast valve and shut the pump off.

300-400 Microns	**Close Blank-off Valve**
READINGS AFTER 5-20 MINUTES	
Under 500 Microns	**Evacuation Complete**
Slow Rise To 1500 Microns	**Moisture**
Rapid Rise To ATM	**Leak**

Dispelling The Argument Of "No Deep Vac On Heat Pumps, Etc."

The word "sublimation," the ability of moisture to go directly from solid ice to vapor without passing through a liquid state, is commonly used in vacuum. This phenomenon is observed when the wash is hung out in the winter and freezes solid. Still, in time it dries due to sublimation (drying). If lines are in a cold ambient, it is possible to have ice in the system. It will be removed during evacuation. Of course, the addition of heat (heat gun only) at these cold spots speeds up the job.

Evacuation Brings Out The Worst In A System!

Remember, hydrofluoric and hydrochloric acids and their pal, moisture, do collect in the oil. Having nothing but time on their hands, they effectively destroy pull down and act as an abrasive on internal surfaces. If left sitting in an idle pump these culprits keep busy by rusting and corroding internal surfaces.

Honestly, deep vacuum pumps need a fill or two for every job. . .

So if your pump is in the dumps, maybe it's something he picked up on the job.

In order for your pump to pull a near perfect vacuum, oil must be clean and moisture free throughout evacuation. Just take a few minutes during and after each job to drain, flush and refill. Keep your pump running at peak performance and maintenance free for years to come.

Always store your vacuum equipment plugged or capped to prevent contamination due to condensation and dirt. Because a slight cut or dirt on the o-ring seals can cause leaks, the mating flare fitting faces should be wiped and checked for damage before hookup. Vacuum pump oil makes a fine lubricant at these connections.

Printed in U.S.A.

J/B INDUSTRIES INC.
P.O. Box 1180 • Aurora, IL 60507-1180
e-mail: sales@jbind.com