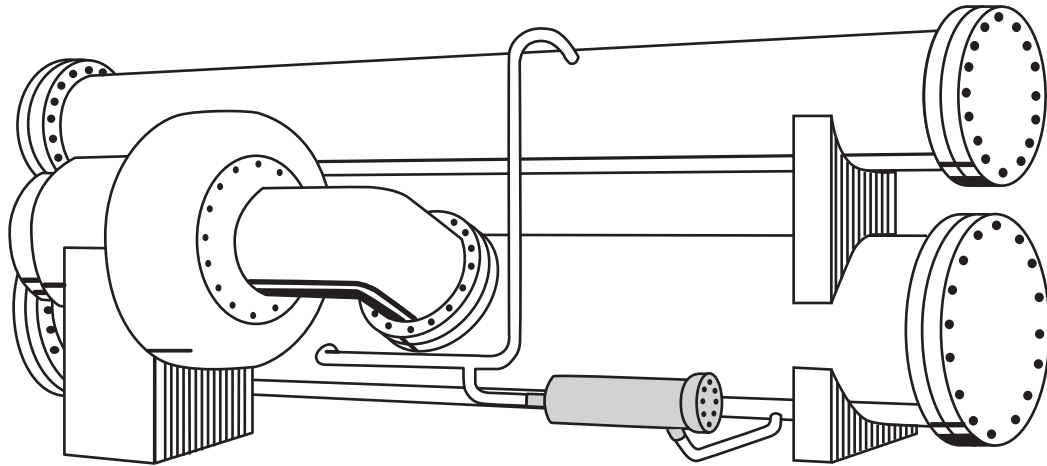


CONTAMINANT REMOVAL FROM CENTRIFUGAL SYSTEMS



Many centrifugal systems get little maintenance. As a result they operate with the refrigerant highly contaminated with moisture and dirt. Eventually these contaminants create operating problems due to system corrosion, failure of metallic parts, or plugging of small orifices in the system. It then becomes necessary to remove these contaminants. For this process the desiccant filter-drier is the main tool. Certain other tools are necessary to check the degree of contamination before and after clean-up. The following information describes the problems that occur in centrifugal systems, how to diagnose the system condition and the recommended methods of cleanup.



HOW MOISTURE AND DIRT ENTER THE SYSTEM

Typical centrifugal systems in service are Refrigerant 11, 113, 123 and 134a water chillers. Since some of these systems operate with a vacuum in the cooler section, any leak will suck in atmospheric air and moisture. A leak source that is often overlooked is the rupture disc on the cooler. The rupture disc is a cold surface on which water will condense. If a small leak exists at the disc, then moisture will be sucked into the cooler. A similar situation exists with respect to the liquid level gauge glass.

Depending on the system, the condenser water pressure can exceed the refrigerant pressure. Therefore, if any leak exists where the cooler tubes are rolled into the tube sheet, then water will be forced into the refrigerant circuit.

When moisture collects in the system it usually ends up floating on top of the refrigerant in the cooler. This “free water” slowly reacts with the refrigerant producing hydrochloric and/or hydrofluoric acids (depending on the refrigerant). Refrigerant 11, 113, 123 and 134a are all subject to chemical reaction with water (hydrolysis) to form acids.

The acids produced are corrosive and attack the metals in the system. This corrosion is called “saddle damage” or “crevice corrosion,” when it occurs at the point where the cooler tubes are held by the tube support sheet. Corrosion also attacks the various parts in the purge unit, the float chamber, and can cause sticking of the guide vanes.

Corrosion of the purge unit damages the float valve and requires expensive repair work. Drying the system properly and keeping it dry will reduce the need for this expensive maintenance.

The *solid contaminants* in most systems consist of scale, metal chips, and other types of residual dirt from the original installation. On close-coupled packaged systems scale is seldom a problem. On other large systems with a complicated piping network, sufficient scale may be present to plug the float valve or in rare cases plug the mist eliminators in the cooler section.

DIAGNOSING SYSTEM PROBLEMS

The *sightglass* is the simplest device available to the serviceman for diagnosing the condition of a centrifugal system. If large amounts of scale or solid particles are circulating with the refrigerant, then this will be evident in the sightglass. If the journal bearings become black, this is an indication of acid corrosion.

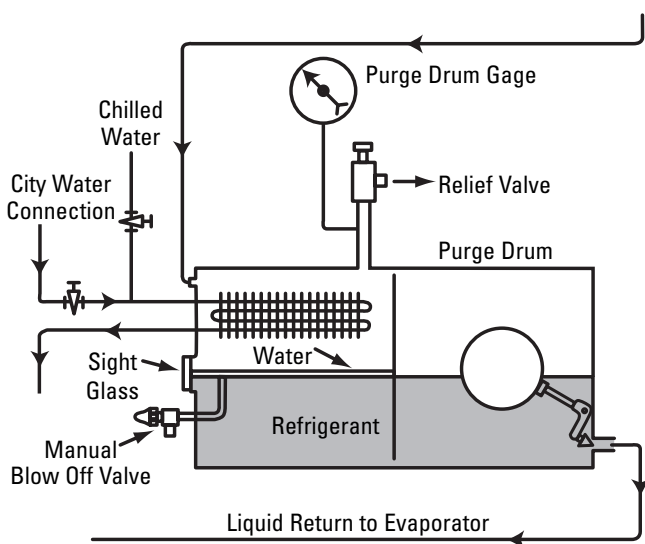


Figure 1 – Diagram of a Purge Unit

The *purge unit* is an important tool for diagnosis of moisture problems. A diagram of a typical purge unit is shown in *Figure 1*. Gas is sucked off the top of the condenser and cooled with chilled water or refrigerant from a separate refrigeration system. The condensed refrigerant is returned to the system, and the air is collected and automatically blown off. Any moisture present collects on top of the liquid refrigerant layer, and is blown off manually. If the purge unit runs excessively, then an air leak is indicated. If moisture is building up within the system, this will be evident from the amount of moisture collected in the purge unit. If the purge unit collects more than a teaspoonful of water per week, this is considered excessive. Systems with a water leak have been known to collect as much as four ounces of water per day.

The moisture content in the system should be kept below the *saturation level* to prevent corrosion problems. The purge unit is designed to remove air from the system. It is generally agreed that the purge unit is incapable of removing moisture to a low level. The only way to keep the moisture content below saturation is to fix any leaks, and then dry the system thoroughly with a Catch-All® Filter-Drier.

While moisture does collect as liquid water and float on top of the refrigerant in the cooler section, this moisture also *migrates throughout the entire system*. For example, in a Refrigerant 123 water chiller where the evaporator temperature is 35°F and the condensing temperature is 100°F, the following conditions apply.

The *solubility of moisture* in the liquid refrigerant in the cooler is approximately 650 ppm. Any moisture in excess of this level will form “free water” and float on top of the liquid refrigerant. The refrigerant vapor in the cooler may contain approximately 350 ppm of moisture. These ppm values are on a weight basis. As refrigerant is evaporated

in the cooler, it will carry moisture with it up to the condenser. The refrigerant vapor in the condenser can hold approximately 750 ppm of moisture. This means the condenser vapor going to the purge unit can remove a significant amount of moisture. If there happens to be liquid water associated with the liquid refrigerant in the condenser, it will drain down into the float chamber and float on the refrigerant at this point. During the off cycle, due to pressure equalization and draining, this water will return to the cooler.

Equipment operators can *sample the refrigerant* for chemical analysis. If this analysis is performed to determine the moisture content, it is important that the sample be obtained in a particular way to get the most reliable information. If the refrigerant is being removed from the system, the sample for moisture analysis should be obtained from the last drum removed from the system, since it is most likely to contain the highest moisture content.

If the refrigerant is to be sampled without removing it from the system, then the unit should be shut down and the cooler section allowed to warm up for several hours before the sample is taken. If the liquid water is floating on the refrigerant, this technique will ensure that this water will dissolve and show up in the analytical results. At 35°F the saturation value for Refrigerant 123 is 650 ppm. A test result of 650 ppm would indicate the refrigerant was saturated, but would not indicate if excess water was present. By allowing the cooler to warm up to 60°F, the moisture saturation value rises to 800 ppm. Therefore, an analysis of the refrigerant in the range of 650 to 800 ppm would indicate free water existed on top of the refrigerant.

Analyzing the refrigerant as a means of diagnosing system problems has not been too successful. It requires special sampling techniques, and even then misleading results are sometimes obtained. Potential time elapses before the operator gets the results of a chemical analysis, and then the results are frequently difficult to interpret. A given ppm level of moisture or a specific acid content of the refrigerant does not always tell the equipment operator if the equipment is safe, or what service procedure should be performed to correct the contaminant problem. Servicemen usually prefer a test that can be performed right on the job, such as a moisture indicator or an acid test kit.

The *Sporlan See-All® Moisture and Liquid Indicator* installed in a hot refrigerant liquid line will indicate the moisture level in the system by a simple color change. A yellow color indicates a wet system and a green color indicates a dry system. Since centrifugal systems frequently operate with considerable moisture present, a chartreuse color is also considered satisfactory for these systems.



Sporlan See•All® Moisture and Liquid Indicators

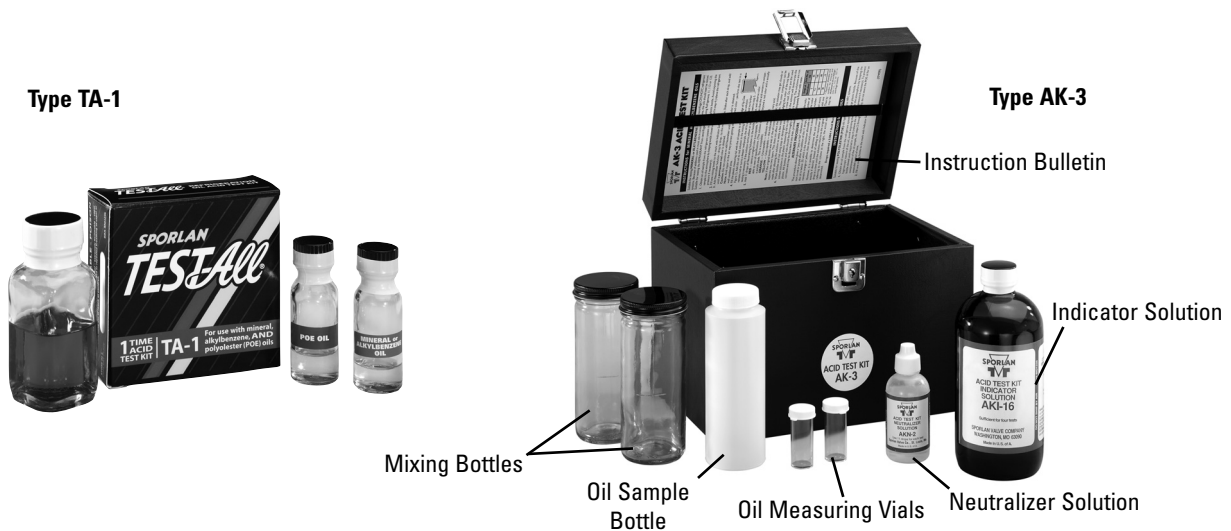
The See-All permits the operator to get an immediate answer on the job concerning the moisture content of the system. By observing the See-All frequently, the operator can learn what conditions lead to moisture infiltration, and how many core changes are necessary for drying. The color of the See-All is reversible – it will change back and forth according to the moisture content of the system. However, the indicator can be damaged by liquid water. If this happens, it will remain a yellow color. See page 5 for comments on See-All location.

The *Sporlan Acid Test Kit* can be used to test the acidity of oil from reciprocating refrigeration machines. This kit is not recommended for testing the oil from centrifugal systems, since these systems can use special oils containing additives that react like an acid with the reagents in the acid test kit. Even new oil can give a false acid reading. However, the Acid Test Kit can be used to test the acidity of low pressure refrigerants, such as Refrigerant 11, 113 or 123. The refrigerant itself is tested with the Acid Test Kit.

The maximum permissible acid content of Refrigerant 11, 113 and 123 systems is believed to be .05 acid number. Although both the Sporlan TA-1 and AK-3 Acid Test Kits can be used to test the refrigerant itself, the AK-3 Kit is ideal for these systems because the relative concentration of acid can be tracked over time. The TA-1 is a pass-fail kit, whereas the drops of neutralizer in the AK-3 Kit can be added to the indicating solution until the original neutral color is attained. Using the AK-3 in this manner provides useful information to the technician if significant increases in acid number are noticed. Information on how to use the TA-1 and AK-3 Acid Test Kits with these systems is provided with each kit.

Acid levels of .02 to .05 should be considered a caution range. Refrigerant over .05 acid number should have the acid removed with a Sporlan Catch-All. The type TA-1 Acid Test Kit will show “acid” at values over .02 acid number.

The AK-3 Acid Test Kit cannot be used on centrifugal systems containing Refrigerant 134a or other high pressure refrigerants. In these instances the only way to check for acid is to obtain a laboratory test of the refrigerant and/or lubricant.



Sporlan Acid Test Kits

METHODS OF CLEANUP

The most common method of cleaning up a contaminated centrifugal system is to use a replaceable core type filter-drier in one of the circulating refrigerant lines. The *Sporlan Catch-All* is ideal for this service because the molded porous core removes solid contaminants, as well as moisture and any acid associated with the refrigerant. Because of the high flow rate and large amount of refrigerant in most centrifugal systems, the filter-drier chosen should be a large size, such as Sporlan’s C-19211 Catch-All, containing four cores. The C-19211 Catch-All will have a pressure drop less than 2 psig at flow rates up to 100 tons R-11, R-123 and R-134a. This drier has 1-3/8” ODF solder connections. If pipe connections are desired, request a type C-19212-P for 1-1/2” pipe connections.

The Sporlan high water capacity RCW-48 cores should be used in preference to the standard RC-4864 cores. The RCW-48 cores in a C-19211 Catch-All will collect a total of 7 ounces of water from a Refrigerant 134a system.

In the past the filter-drier was most often applied by *locating it in a bypass line* between the condenser and the cooler. As shown in *Figure 3*, the bypass line size is chosen according to the system size in order to limit the refrigerant flow to an appropriate value. The See-All Moisture-Liquid Indicator is installed ahead of the filter-drier to give a visual indication of the moisture content of the system. This type of installation gives a slow drying effect that has been found adequate on many systems. This method is particularly appropriate as a preventive maintenance technique for moisture removal.

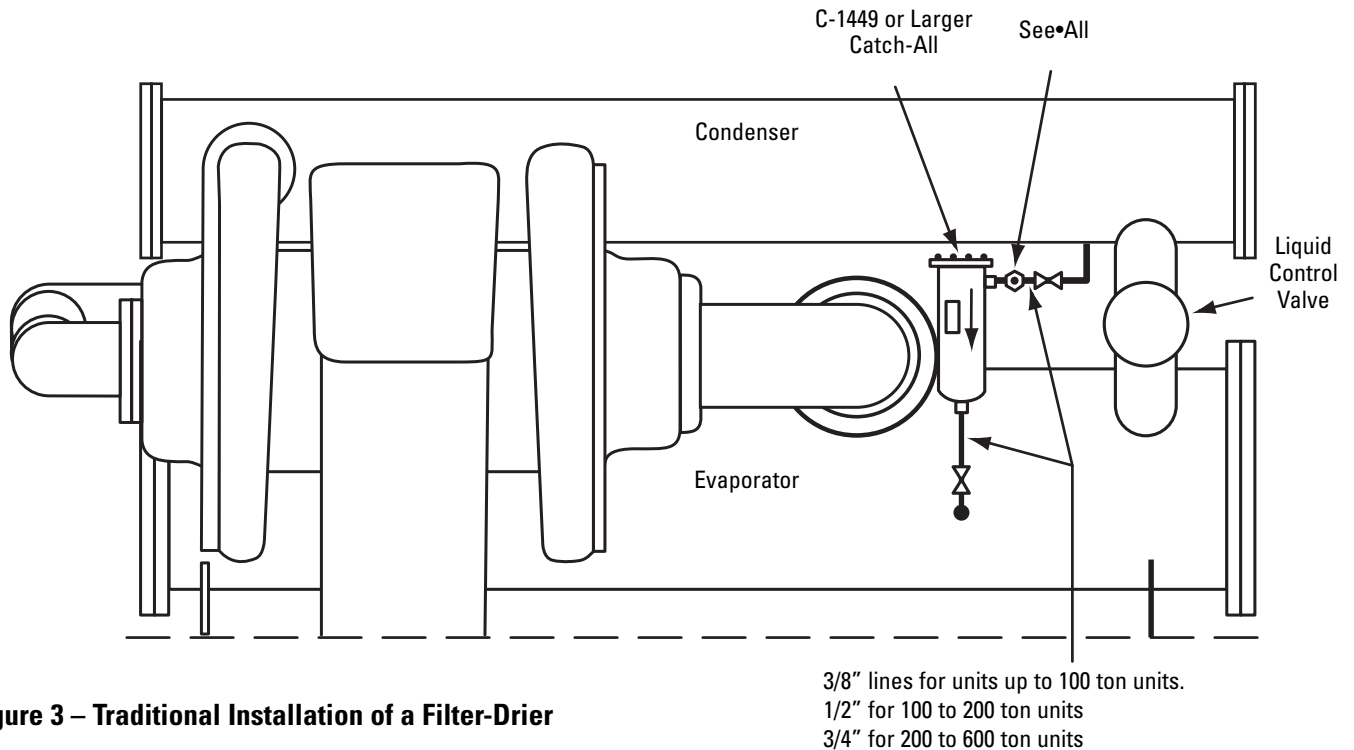


Figure 3 – Traditional Installation of a Filter-Drier

In recent years the *most popular drying technique is to use a jet pump* to get rapid circulation of the refrigerant through the filter-drier. This installation method is shown in *Figure 4*. Another big advantage of this method is that the jet pump sucks liquid refrigerant from the *bottom* of the cooler, passes it through the filter-drier, and then returns it to the cooler just above the liquid level. In this way all the scale from the bottom of the cooler is removed by the filter-drier. After several weeks of operation the refrigerant will be perfectly clear. When making the installation, the filter-drier and the jet pump (ejector) should be located below the refrigerant level in the cooler. To keep the pressure drop to a minimum, the entire added piping should use long radius elbows. It is especially important that the discharge line downstream of the jet pump be designed for low pressure drop. Penberthy Models GH-3/4 or LH-3/4 have been found satisfactory for this application. These jet pumps are available in either bronze or cast iron from the Penberthy Division, Houdaille Industries, Inc., Prophetstown, Illinois 61277 (Telephone 815-537-2311).

The high pressure gas passing through the jet pump to the low side of the system creates a vacuum on the side connection which sucks liquid from the cooler thru the Catch-All Filter-Drier. When installed as shown in *Figure 4*, the liquid from the cooler can enter either through valve #1 or valve #2. When removal of scale and other solid particles is desired, use valve #1 which permits entry of refrigerant from the bottom of the cooler where these particles have collected. Moisture and acid tend to float on top of the boiling refrigerant liquid. Therefore when removal of these contaminants is desired, entry through valve #2, just below the liquid level, is preferred.

In cleaning up a contaminated system, the cores should be changed every few days until the See-All shows a char- treuse color. When the cores are to be changed the following procedure is used. Close valve 1 (or 2) and allow the jet pump to empty all the refrigerant from the filter-drier. (Valves 2 and 3 are closed.) Then close valves 4 and 5. Open valve 3 to vent the Catch-All section, then change the cores. With valve 3 open, crack valve 4 and purge the air out of the line and the drier. Close vent and open valves 1, 4 and 5 to put the assembly back in operation.

For R-123 and R134a systems, *one See-All is required* between the Catch-All and jet pump (see *Figure 4*). With R-11 systems, *two See-Alls are required* to properly check the condition of the refrigerant. The See-All installed between the Catch-All and jet pump will show the flow induced by the jet pump. However, the See-All in this location for R-11 systems does not give a useful moisture indication because the liquid R-11 is too cold (35°F). The See-All changes color based on the relative saturation of the refrigerant. At 35°F, R-11 is saturated with 40 ppm moisture,

and the See-All changes from yellow to chartreuse at 5 ppm. This moisture level is so low that it is doubtful that the R-11 system will ever be dried sufficiently to observe a color change. For R-123 and R-134a systems, this application is suitable for moisture indication.

To obtain worthwhile *moisture indication* for R-11 systems, a second See-All should be installed in a by-pass line carrying hot liquid from the condenser to the cooler. This See-All, being exposed to 100°F liquid R-11, will change from yellow to chartreuse at 30 ppm of moisture in the refrigerant. Proper drying will give a moisture level below 30 ppm, and a resulting chartreuse color in the See-All. Installation of this See-All may be difficult due to a lack of connections on the condenser. Connecting to the economizer drain valve may be appropriate.

In addition to cleaning up a highly contaminated system, this method can be used for *preventative maintenance*. When used in this manner the cores are usually changed every three months. This procedure keeps the moisture level at a value low enough so acid does not form and corrosion is greatly reduced, thus extending the life of the

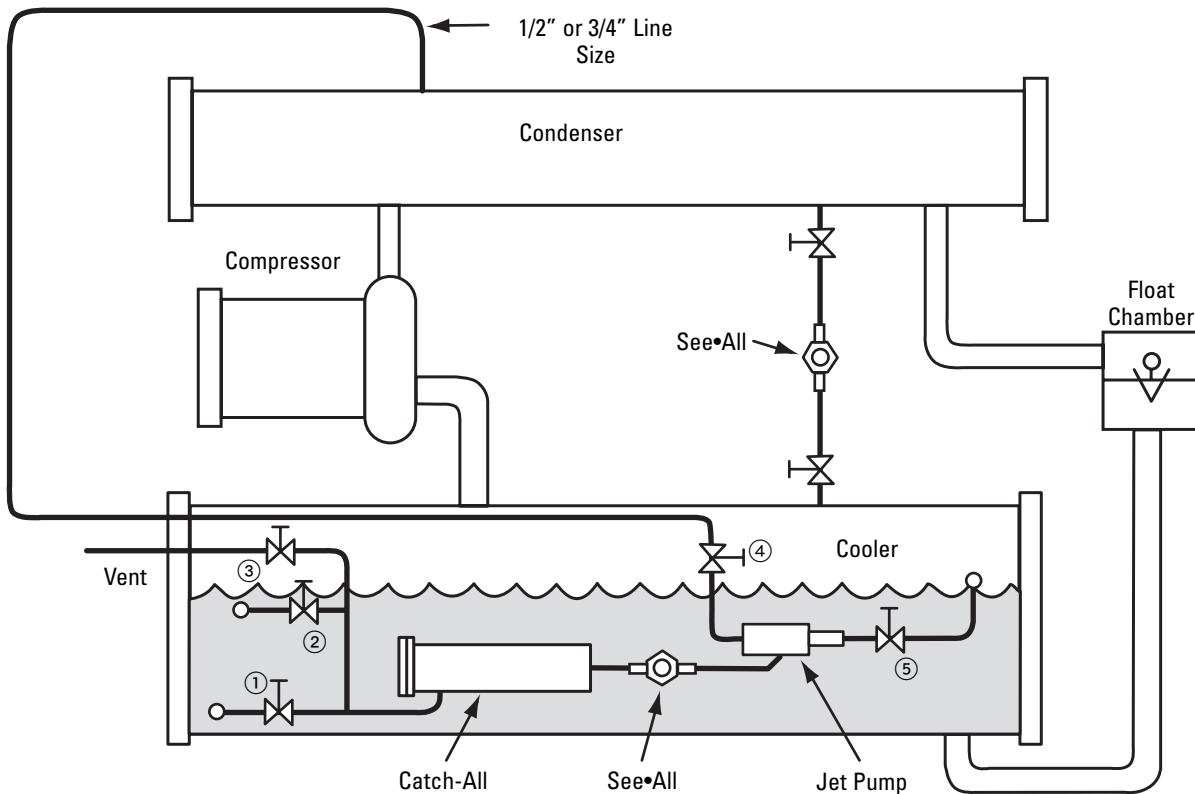


Figure 4 – Using a Filter-Drier with a Jet Pump

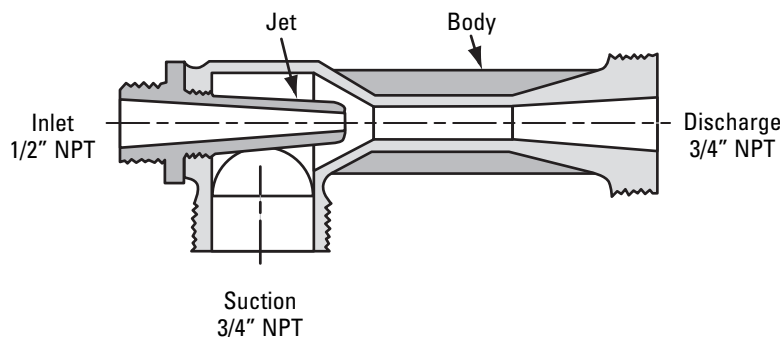


Figure 5 – Jet Pump

equipment. If the system picks up moisture, the See-All moisture indicator should be used as a guide for changing cores. A chartreuse or green color indicates satisfactory operation for R-11 systems. For R-123 and R-134a systems, a green color indicates satisfactory operation. Eliminating the scale particles from the refrigerant avoids plugging orifices and extends the life of the float valves and controls. Eliminating moisture and acid from the refrigerant will also greatly extend the life of the purge unit. Many users have reported that the cost of the filter-drier installation can be justified by the *savings in maintenance of the purge unit alone*.

Replaceable core type filter-driers have also been installed in other locations on centrifugal systems. For example, on a large system the drier can be installed in the line from the auxiliary pump used to transfer the refrigerant from the system to the storage receiver. Moisture and other contaminants are removed whenever the refrigerant is transferred through the filter-drier. Filter-driers have also been applied in the line leading from the oil system to the reboiler.

Selecting the Catch-All Filter-Drier for Use on Centrifugal Systems

Type Number	Connection Size	Number of Cores	Suggested Application
C-967	7/8" ODF	2	Wherever cramped space requires a small filter-drier.
C-966-P	3/4" FPT	2	
C-1449	1-1/8" ODF	3	For use on most systems up to 150 ton capacity.
C-1448-P	1" FPT	3	
C-19211	1-3/8" ODF	4	For use on systems over 150 tons or where extensive piping, a large charge, or considerable contaminants indicate the need for a larger filter-drier.
C-19212-P	1-1/2" FPT	4	
All of the above types should be used with the type RCW-48 drier core.			
C-40016-P	2" FPT	For installation requiring the largest size filter-drier available. Uses four type RCW-100 cores.	

SUMMARY

Moisture and other contaminants can be a considerable problem in centrifugal systems. Contaminant problems can be diagnosed by observing the purge unit and can be measured using a See-All Moisture and Liquid Indicator or an AK-3 Acid Test Kit. By applying a Sporlan replaceable core Catch-All Filter-Drier to the system, the initially high level of contaminants can be removed, and a preventative maintenance program will maintain the moisture, acid, and solid contaminants at a satisfactory low level. This procedure reduces corrosion and greatly extends the life of the system.

For more information on Catch-All Filter-Driers and Acid Test Kits request Bulletin 40-10. For information on See-All Moisture-Liquid Indicators request Bulletin 70-10.

