THE CAPILLARY TUBE AND ITS APPLICATION TO SMALL REFRIGERATING SYSTEMS

By: Lloyd A. Staebler
Manager of Advanced Development, Philco Corporation
Appliance Operations, Consumer Products Division

FOREWORD

The capillary tube is an extremely simple device, and its use permits considerable simplification and cost reduction of the small hermetic refrigerating system. Using a capillary will:

1. Allow the use of a low cost, hermetic-type compressor and condensing unit, which has been specifically designed for capillary tube application.

2. Permit elimination of the float valve or expansion valve and the liquid receiver, with consequent reductions in cost and service difficulties.

Because of these advantages, and because the application of a capillary tube may appear to be a relatively simple matter, an increasing number of service engineers are becoming interested in the capillary tube and are attempting to convert refrigerating systems to its use.

Despite the apparent simplicity of the capillary tube, very careful consideration must be given to the proper selection of the tube and to the other components of the system if a successful conversion is to be made. Failure to do so will inevitably result in unsatisfactory performance and service complaints. For this reason, the service engineer is advised not to attempt a conversion to a capillary tube unless he has the facilities and the experience to do a good job.

Although numerous articles have been written on the subject, most of them have been of a highly technical nature. Consequently, the average service engineer may feel that the whole thing is either too complex for him to understand and refuse to have anything to do with it, or he may have had just enough experience with capillary tubes to lull him into the belief that he is an "expert" who knows all there is to know about the subject. This is certainly a case where a little learning becomes a dangerous thing because a wrong application of the capillary tube can result in very deplorable consequences.

There is, however, still another group composed of service engineers who have taken the time to arrive at a thorough understanding of the capillary tube and who have the knowledge, ability and facilities to do a satisfactory job.

It is the purpose of this article to present a simplified explanation of the capillary tube and to describe simply and in a straightforward fashion the steps to be taken in making a conversion. If this article achieves its purpose, the number of service engineers making up the third classification will be greatly increased.

And now just a word of caution. The service engineer should not attempt to use a capillary tube with a refrigerating system unless the system uses a hermetic-type compressor and R-12. For reasons explained in later paragraphs, a capillary tube should not be applied to an open-type compressor. Neither should the service engineer attempt to use any refrigerant except R-12 unless he possesses the highly specialized knowledge necessary for such an application. The capillary tube data included in this article applies only when R-12 is used and must not be applied to the use of other refrigerants.

THE CAPILLARY TUBE

Hand expansion valves, automatic expansion valves, thermostatic expansion valves, low-side float valves, high-side float valves, liquid injectors and all expansion devices have one thing in common: they maintain a pressure differential, making possible correct functioning of the low side and the high side, while metering liquid refrigerant from the high side to the low side at the desired rate. It might then appear possible to simply use a small diameter liquid line (capillary tube) connecting the high side to the low side, which would maintain the desired pressures when metering refrigerant at the proper rate. It is of course, readily apparent that most efficient operation could not be expected under all operating conditions, since such a device does not automatically change its flow rate in accordance with either the requirements of the evaporator or the pumping capacity of the compressor. However, it has been found that the capillary tube when properly applied gives satisfactory performance under widely differing conditions even though maximum efficiency is possible at only one set of operating conditions.

Several factors have combined to make the use of a capillary tube possible. First, the advent of halogenated hydrocarbon refrigerants, which require larger quantities of liquid to be circulated for a given amount of refrigeration, making it possible to use a capillary tube with a sufficiently large bore to be practical. On the other hand, Sulfur Dioxide, which was formerly used, requires that the bore of the capillary tube be so small as to be impractical. Second, the introduction of a successful hermetic compressor makes it possible to build a leak-free, clean, dry system so essential to the successful operation of a capillary tube. The simplicity and the cost saving advantages of the capillary tube are so compelling that today practically all domestic refrigerators being built and many of the smaller size package-type commercial refrigerating systems, employ a capillary tube to the almost complete exclusion of the float valve, the expansion valve, and other refrigerant metering devices.

The word capillary means "hair-like", i.e., very small in diameter. A capillary tube, therefore, is a very small-bore tube of sufficient length to produce the metering effect desired. Capillary tubes with a bore of 0.026" to 0.055" are common, and the lengths may be anywhere from a few feet to several feet, depending upon the application.

The most outstanding characteristic of the capillary tube lies, of course, in the simplicity of refrigerating system allowed (see Figure 18F52B). The capillary tube merely replaces the conventional liquid line and is usually soldered to the suction line for heat exchange purposes. There are no moving parts required, such as float valves or expansion valves. In addition, the liquid receiver should be omitted and the refrigerant charge requirements accordingly reduced. Also, the unloading characteristics of the capillary tube enables the system pressures to balance during the compressor "off" cycle. Thus, the compressor starts in an unloaded condition, which permits the use of a low starting torque motor.

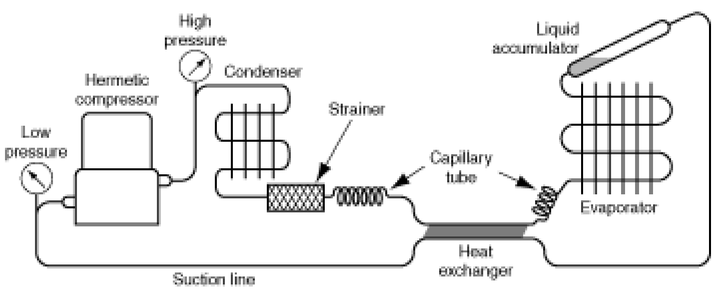

Figure 18F52B Hermetic System Incorporating Capillary Tube

THE OPERATING CYCLE

Let us here examine in detail the cycling operation of a refrigerating system incorporating a capillary tube. For the purpose of this discussion, please refer to Figures 18F52B and 18F53. Figure 18F52B is a schematic diagram of a system using a capillary tube and Figure 18F53 shows the pressure relationship in the high side and low side during a typical operating cycle. During the running period, the high side and low side pressures are dictated by the operating temperatures encountered, the high side being at a relatively high pressure as compared with the low side. During this portion of the cycle, the pressures encountered are the same as those obtained with a float valve or expansion valve under like conditions.

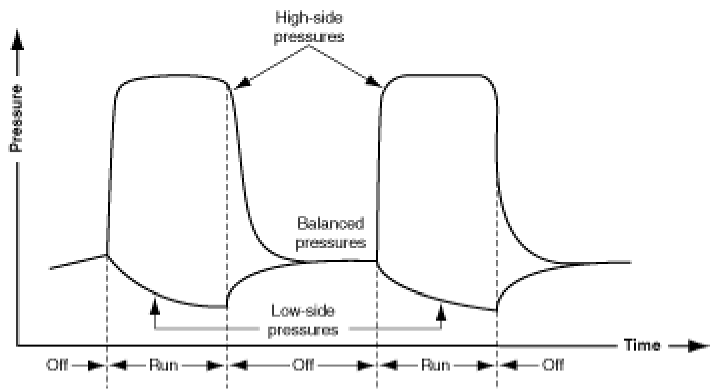

Figure 18F53 Cycling Pressures in a System Using a Capillary Tube

It is during the compressor "off" cycle, however, that the big difference between the two systems first becomes apparent. A float valve or expansion valve retains a seal between the high and low side of the system even when the compressor is not running, and the high side pressure is retained at a value only a little below that obtained during the running cycle. The capillary tube, on the contrary, does not maintain a seal during the "off" cycle, and when the compressor stops, the high side of the system immediately begins to reduce its pressure as the high side refrigerant continues to bleed through the capillary tube to the low side. After an interval of a few minutes the high side refrigerant has completely passed to the low side and the pressures in the two sides become equal.

The compressor is now in an unloaded condition, and comparatively little torque is required to start it. This usually permits the use of the low cost hermetic motor-compressor with low starting torque, which has been specifically designed for capillary tube application. When the unit restarts, the high side pressure immediately begins to build up, and in a short time liquid again feeds through the capillary tube.

NOT SUITABLE FOR USE WITH OPEN-TYPE COMPRESSORS

It should be pointed out here that, in general, an open-type compressor is not suitable for capillary tube application and that, for the following reasons, attempts to do so are usually doomed to failure.

1. A liquid receiver is not conventionally used with a system employing a capillary tube and the amount of refrigerant charge is consequently very critical. A system using an open-type compressor is susceptible to refrigerant leaks. First, the refrigerant lines are usually connected to the compressor by flare fittings, which may in time be a source of leaks. Further, the compressor itself may leak sufficiently, especially through the shaft seal, to make the system inoperative in a relatively short time.

2. The refrigerating system must be exceedingly clean and dry to prevent plugging or "freeze-ups" of the capillary tube. It is possible to maintain sufficiently high standards of cleanliness and dehydration as well as to achieve a leak-free system when a hermetic compressor is used, but this is difficult with an open-type compressor. Furthermore, the open-type compressor is subject to occasional field servicing of such a nature as to aggravate service difficulties after conversion to a capillary tube system.

3. The hermetic compressor circulates oil with the refrigerant at a controlled uniform rate of flow. This is not usually the case with an open-type compressor where oil slugging may be so severe as to cause temporary blockage of the capillary with resulting unsatisfactory performance.

THEORY OF OPERATION

The capillary tube is essentially a non-adjustable restrictor device and its capacity to pass liquid refrigerant is determined largely by the pressure difference between the two ends, in the same manner that the electric current through a resistor is dependent on the voltage applied. Thus, we see that the capacity of the capillary tube generally increases with the difference between high side and low side pressure and decreases when the pressure difference is reduced. The condensing unit capacity is also influenced by this same pressure difference but in the reverse direction. As the pressure difference between high side and low side increases (discharge pressure increases and/or suction pressure decreases) the pumping capacity of the unit is reduced; and conversely is increased as the pressure difference (ratio of compression) decreases.

It is thus obvious that only rarely are the operating conditions such that the capacity of the capillary tube and the capacity of the condensing unit are exactly balanced. Under such conditions of "capacity balance" a liquid seal will exist at the entrance to the capillary tube and the system will operate at its maximum efficiency. Since it is impossible for the system to operate always at this capacity balance condition, it is necessary to exercise care in selecting a compromise design of capillary tube that will achieve satisfactory performance over a wide range of operating conditions.

If the capillary tube is too short or has too large a bore, it will be capable of passing more liquid refrigerant than can be supplied by the condensing unit under the particular operating conditions. This will result in a loss of the liquid seal and an excess amount of hot gas will enter the capillary tube. Although this reduces their efficiency somewhat, capillary tube systems are usually designed with the capillary tube a little too short, or with somewhat too large a bore, so as to allow this condition to occur throughout most of the operating range. Figure 18F54 illustrates the condition of capacity balance with a liquid seal at the entrance to the capillary.

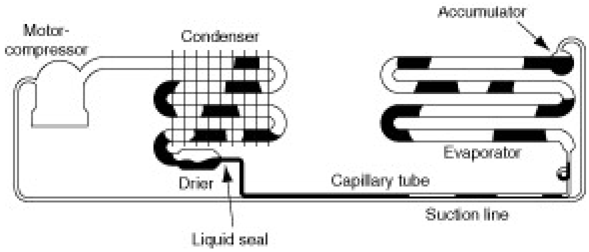

Figure 18F54 No liquid storage in condenser. Liquid seal at entrance to capillary. Discharge and suction pressures normal. Evaporator property charged and active throughout. Condenser uniformly warm throughout.

If the capillary tube is too long or if the bore of the tube is too small, its resistance will prevent it from passing all of the liquid refrigerant being pumped at the particular conditions. This, of course, causes liquid refrigerant to back up in the condenser and may increase the discharge pressure abnormally. Of more serious consequence, however, is the fact that storage of liquid in the high side robs refrigerant from the low side and may result in an undercharged condition with too low a suction pressure (see Figure 18F55). If refrigerant is added to the system under these conditions, until the low side is properly charged, the system will obviously be overcharged when operating at conditions where no liquid is stored in the condenser.

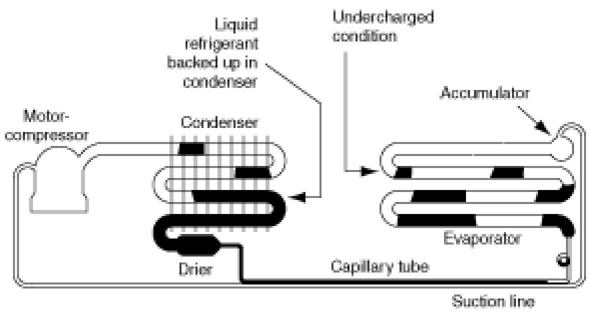

Figure 18F55 Liquid refrigerant backs up in condenser, and causes evaporator to be undercharged. Discharge pressure abnormally high. Suction pressure slightly below normal. Outlet of condenser cool.

During the compressor "off" cycle, the refrigerant in the high side continues to pass through the capillary tube until the pressures equalize throughout the system. In order to expedite this unloading process and to achieve more efficient operation, liquid traps in the high side should be avoided. If liquid is trapped so that it must evaporate before it passes into the capillary tube, not only is the unloading time prolonged, but the warm gas adds undesired heat directly to the low side and lowers the overall efficiency.

The capillary tube also requires that the evaporator have a low side accumulator of sufficient volume to accept not only the high side refrigerant during the compressor "off" cycle but also the excess refrigerant charge not required by the complete low side during certain operating conditions.

It is evident, then, that the successful application of a capillary tube, simple as it may appear, cannot be accomplished in a haphazard manner. It is, therefore, one of the purposes of this article to outline the procedure necessary to make a successful application possible.

PRECAUTIONS NECESSARY IN APPLYING CAPILLARY TUBES

The service engineer may wish to convert an existing refrigerating system from a float valve or expansion valve to a capillary tube, and install a hermetic compressor or condensing unit; or he may wish to replace some of the components of a system that already uses a capillary tube. To do this successfully in the field or service shop, extreme caution is necessary. In spite of the apparent simplicity of the capillary tube, very careful balancing of the system is required to insure satisfactory performance. Improper balance will be evidenced by excessive running time, abnormal operating pressures, or by extreme difficulty in adjusting the refrigerant charge properly.

Failure to take the following factors into account will inevitably result in unsatisfactory performance; and unless the service engineer is able and willing to do a good job, he would do well to avoid the capillary tube entirely.

1. Both the high side and low side must be suitable for use with a capillary tube.

2. The capillary tube must be properly matched to the capacity of the condensing unit.

3. High standards of cleanliness and dehydration during processing are essential and the system must be properly evacuated and charged.

ARRANGEMENT OF THE HIGH SIDE

During certain portions of the normal operating cycle the compressor may pump more refrigerant than the capillary tube can pass. This will result in liquid refrigerant backing up in the high side. If a liquid receiver is located in the circuit in the conventional location after the condenser, it will fill with liquid refrigerant during these operating conditions and will result in the evaporator being severely undercharged (see Figure 18F56). Therefore, the receiver should never be located in this manner. Usually it should be entirely omitted from the circuit. However, as a safety precaution it may occasionally be desirable to locate it ahead of the condenser so that it will receive liquid refrigerant only in the event of an unnatural restriction in the capillary such as might be occasioned by plugging or by a "freeze up." In this manner the discharge pressure will be prevented from becoming excessive. If it is necessary to charge the system with a larger amount of refrigerant than the condenser can hold, and if there is reason to suspect trouble of the type mentioned, the latter arrangement may prove advantageous.

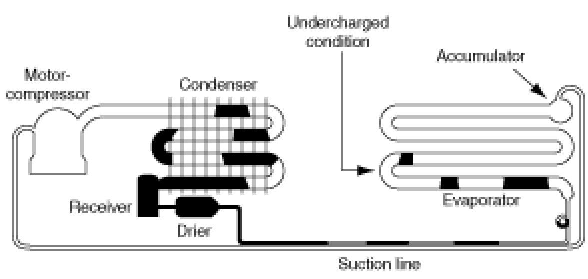

Figure 18F56 At times, liquid will gather in the receiver and cause the evaporator to be severely undercharged and not fully active. Discharge pressure below normal. Suction pressure very low. This illustrates why a conventional receiver, as shown, should be avoided with a capillary tube.

Some attention should also be given to the length and diameter of the tube used in the condenser and the volume of this tube as related to the total amount of refrigerant charge in the system. If the condenser volume is so great that it will easily hold all of the refrigerant, the condenser becomes in effect a receiver, and we are liable to encounter the same difficulties as shown in Figure 18F56. If the capillary tube is then only slightly over-restricted, refrigerant will back up in the condenser, severely undercharging the low side. When such a condenser is used, extreme care must be taken in selecting a capillary tube to insure that the tube selected does not offer too much resistance.

If a hermetic condensing unit is being reworked for capillary tube application, all liquid traps in the high side must be avoided to insure rapid unloading during the compressor "off" cycle and to avoid loss in refrigerating capacity. If no liquid traps are present in the high side, the high side will unload to the low side within a few minutes after the compressor has stopped and the pressures will become equalized. During this unloading period the unbalanced pressures may prevent the compressor from starting. An overload protector, usually built as an integral part of the motor-compressor, will protect the motor from damage during this period. If excessive time is required for the pressures to balance, it is probable that liquid is being trapped in the high side, or that some abnormal restriction exists in the cap-tube or elsewhere in the high side.

ARRANGEMENT OF THE LOW SIDE

Arrangement of the low side is equally important. To avoid excessive loads on the condensing unit during pull-down, the low side should not require more than one or two pounds of refrigerant charge for satisfactory operation. A small refrigerant charge is essential because of the necessity of operating without a receiver for liquid storage. If the evaporator is of the dry expansion type with single pass circuiting, originally designed for use with the expansion valve, it will usually be necessary to add a liquid accumulator outlet in order to allow for some variation in refrigerant charge. Common sense must be employed in selecting an accumulator for this purpose. To prevent the accumulator from trapping an excessive amount of oil, it should never be made larger than necessary to give desirable charge tolerance. Furthermore, it is recommended that the inlet to the accumulator be located at the bottom and the suction outlet at the top.

REMOTE INSTALLATIONS

Remote installations employing a capillary tube are usually not recommended, although there may be certain exceptions when such an installation is practical. If a remote installation is made, the recommendations that appear in this article regarding design of the high side, the low side, and heat exchanger must be followed. However, some adjustment of the capillary tube may be desirable if the condensing unit is located where an abnormal temperature condition exists.

If the manufacturer of the refrigerator being serviced has specific recommendations as to the proper capillary tube and heat exchanger arrangement, his recommendations should, of course, be followed. In lieu of such information from the manufacturer, the capillary tube data in Figure 18F587 will be helpful.

Figure 18F587 APPROXIMATE CAPILLARY TUBE DATA FOR SERVICE REPLACEMENT PURPOSES WITH A HERMETIC COMPRESSOR AND FREON-12 REFRIGERANT

HERMETIC COND. UNIT	**EVAPORATION TEMPERATURE AND TYPICAL APPLICATIONS**		
	High temperature (30°F) WATER COOLERS, ETC.	**Medium temperature (10°F) HOUSEHOLD REFRIGERATORS**	**Low temperature (–10°F) HOME AND FARM FREEZERS**
1/8 H.P	5' of 0.036", or 8' of 0.042", or 16' of 0.049"	5' of 0.031", or 9' of 0.036",or 18' of 0.042"	10' of 0.031", or 20' of 0.036",
1/5 H.P.	5' of 0.042" or 10' of 0.049"	6' of 0.036", 12' of 0.042"	8' of 0.031", or 16' of 0.036"
1/4 H.P	5' of 0.049", or 7' of 0.54"	6' of 0.042", or 12' of 0.049", or 18' of 0.054"	7' of 0.036", or 14' of 0.042"
1/3 H.P.	5' of 0.054"	7' of 0.049", or, 11' of 0.054".	5' of 0.036", or 10' of 0.042", or 20' of 0.049"

This data generally holds if approximately 4 ft or more of the capillary tube are soldered to an equal length of suction line for heat exchange. Some or all of the excess capillary may be coiled at the low-side end of the heat exchanger, but not in actual contact with the evaporator.

The capillary tube should be high-grade restrictor tubing sold for this specific purpose and should have a uniform bore within a tolerance of plus or minus 0.001 inch. Take care in fabricating the heat exchanger and in making the tubing connections. A kinked or flattened capillary tube or a restricted connection may make the system inoperative.

CAPILLARY TUBE SELECTION AND HEAT EXCHANGER DESIGN

Although good engineering practice demands that the proper capillary tube be determined by laboratory tests for each piece of equipment at standard operating conditions, this procedure is not practical from the service engineer's standpoint. However, it is possible to recommend the approximate size capillary tube to be used with the various size hermetic condensing units and compressors for the particular low side application. Figure 18F57 gives capillary tube recommendations in tabular form and enables one to choose a capillary tube best suited to the application. It is usually desirable to solder at least four feet of the capillary tube to an equal length of suction line to provide good heat exchange for increased system capacity and for elimination of sweating of the suction line (see Figure 18F58). For best performance, some or all of the remaining capillary tube should be coiled at the low side end of the heat exchanger. However, it is important to locate the excess capillary tube so that it does not come in actual contact with any part of the low side. Recommendations of Figure 18F57 hold only if this precaution is observed. Care must also be exercised in fabricating the heat exchanger and in making the necessary joints to make sure that the capillary tube does not become kinked or flattened and that the joints are not restricted in any way.

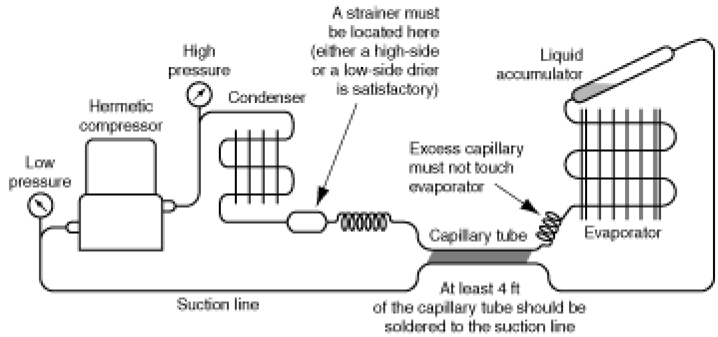

Figure 18F58 Recommended Capillary Tube, Drier, and Heat-Exchanger Arrangements

The service engineer may occasionally be tempted to use a heat exchanger consisting of a conventional, large bore liquid line soldered to the suction line for heat exchange, all of the capillary tube then being coiled and located at the outlet of the liquid line (see Figure 18F59). <u>This arrangement must never be used</u> . At best the arrangement is inefficient. At worst, the system may lose almost all of its capacity if the low side is even slightly overcharged, so that the suction line frosts back into the heat exchange section. This peculiarity of operation can best be understood when it is realized that under normal conditions of operation the liquid line section of this type of heat exchanger really acts as a part of the condenser and an overcharge in the suction line refrigerates the high side. For this reason it is imperative that the heat exchanger arrangement of Figure 18F58 be used.

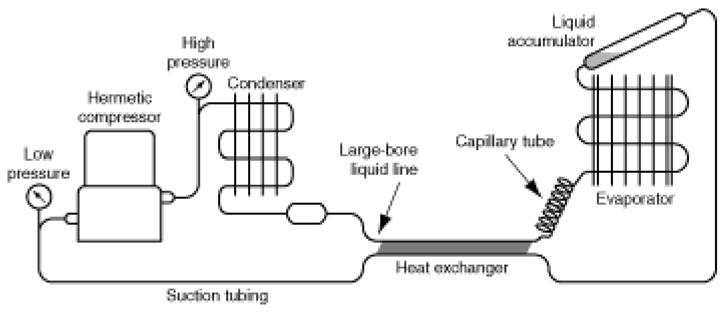

Figure 18F59 Undesirable Heat Exchanger Arrangement (All capillary at evaporator) This arrangement should not be used. The large liquid line acts as part of the condenser. A slight overcharge refrigerates the highside and results in unstable operation.

The capillary tube lengths and bores recommended in the table of Figure 18F57 are based on the assumption that a four foot (or longer) section of the capillary tube will be soldered to an equal length of suction line to provide heat exchange as shown in the accompanying sketch of Figure 18F58. Recommended lengths will apply only if this is done. If no heat exchange is provided, the length of capillary tube must be reduced considerably below that shown in the table. The capillary tube used should be a good grade restrictor tubing fabricated for this specific purpose by a manufacturer who takes the necessary precautions regarding cleanliness and who can guarantee a uniform bore with a tolerance no greater than plus or minus .001 inch.

A capillary tube of insufficient resistance will give poor overall efficiency due to the blowing of an excessive amount of hot gas into the capillary tube. On the other hand, too much resistance will result in liquid refrigerant backing up in the high side, thus increasing the discharge pressure and short changing the low side. Thus, proper matching of the capillary tube to the compressor is essential to insure satisfactory performance of the system.

If the manufacturer's recommendations for capillary tube and heat exchanger are known for the specific refrigerator being serviced, these recommendations should be followed, even though they are not strictly in agreement with the information appearing in this article.

It is understood that there are several types of "calibrated restrictor assemblies" and "adjustable capillaries" being offered the trade for service replacement purposes. In general, a prefabricated capillary tube and heat exchanger assembly that does not conform to the arrangement shown in Figure 18F58, and which does not conform to the capillary tube recommendations of Figure 18F57, should be avoided.

CAREFUL PROCESSING

It is obvious that extreme care must be taken to insure a dry, clean system. Excess moisture in the system will freeze out of the refrigerant in the capillary tube and stop the flow of refrigerant to the evaporator. This results in a warming up of the evaporator and melting of ice in the tube. The flow starts again with resulting refrigerating effect. The ice soon forms again and the cycle repeats. This cyclic process is a good indication of ice formation in the tube. If the system is dirty, the entrance to the capillary tube or other component parts of the system, may be restricted, and flow of refrigerant to the evaporator will likewise be retarded or stopped completely.

The hermetic condensing unit is usually dry and clean when it leaves the factory, and the service engineer must endeavor to keep it that way during installation. This necessitates careful processing and workmanship, and also requires the rest of the system to be clean and dry before final assembly to the unit.

As an additional precaution against freeze-ups, an approved high side drier may be installed in the system directly ahead of the entrance to the capillary tube and positioned to give good drainage during the compressor "OFF" cycle. If a low-side drier is used instead, it is recommended that it be installed between the outlet end of the capillary tube and the entrance to the low side. In either case, it will be necessary to install an auxiliary fine mesh strainer at the entrance to the capillary tube. The use of a commercial antifreeze agent is not generally recommended as a substitute for the drier, and several unit manufacturers state that the use of such an antifreeze agent will void their warranty.

All air and other non-condensables must be exhausted from the system before the final refrigerant charge is introduced. Non-condensables in the system, will result in an abnormally high discharge pressure and will otherwise penalize the performance. It is therefore recommended that a good vacuum (at least 29 in. of mercury or no more than 1 in. absolute) be drawn on the complete system for 30 minutes prior to final charging.

Finally, the system must be charged with the proper amount of refrigerant. Like the high side float valve system and unlike the low side float or expansion valve systems, which provide for continuous storage of surplus refrigerant in the high side, the capillary tube system is especially critical to refrigerant charge.

The best method is to charge refrigerant slowly into the system through a good drier (to insure a dry refrigerant) with the unit running under normal conditions of room and evaporator temperatures, until frost forms on the suction line to a point just beyond the outlet of the evaporator.

The system should then be allowed to cycle a few times and the charge again adjusted, if necessary, to insure that this frost line is being maintained. If the system is overcharged, the suction line will frost back. If the system is undercharged, the evaporator will not be completely refrigerated.

If the suction line frosts back severely at the start of each operating cycle, clearing after a few minutes operation, or if the evaporator appears correctly charged at the beginning of the cycle, only to show signs of undercharge later in the cycle, it is probable that liquid refrigerant is backing up in the condenser. This condition may be verified by feeling the condenser. If the last few tubes are noticeably cooler, it is probable that the condenser is at least partially filled with liquid. See Figure 18F55.

This condition is, of course, the result of some abnormal restriction in the system, such as a plugged strainer, a kinked or flattened capillary tube, a restricted joint, or perhaps a capillary that is too long or has too small a bore. The situation can never be remedied by adding more refrigerant; this will merely make matters worse. The only solution is to remove the restriction or to use a capillary tube with less resistance.

> **NOTE:**
>
> **When an expansion valve is used, it is common practice to charge the system until a liquid seal appears at the inlet to the valve. When a capillary tube is used, its resistance is such that a liquid seal rarely appears at the entrance to the tube, regardless of the quantity of refrigerant charge introduced. Therefore, the lack of a liquid seal at this point does not indicate that the system is undercharged.**

Needless to say, the system must be carefully checked for refrigerant leaks and every precaution taken to insure a leak-free job. Since a refrigerating system incorporating a capillary tube is especially critical with regard to refrigerant charge, even a very small leak will soon penalize performance and result in a service complaint.

SUMMARY

Although proper application of a capillary tube requires considerable design and test in the laboratory to achieve the best balanced system with maximum operating efficiency, it is possible for the service shop to make successful conversion to a capillary tube providing the service engineer is willing to follow instructions outlined in this article, vis a vis:

1. Both the high side and the low side must be properly arranged for capillary tube application.
2. The proper capillary tube must be selected.
3. It must be processed carefully to insure a clean, dry, leak-free job, and properly charged with refrigerant.

Unless it is possible to comply with the instructions outlined, it is strongly advised the use of a capillary tube be avoided.

SERVICE CHARTS

Complaints Resulting From Improper Capillary Tube Application

This assumes that the recommendations regarding capillary tube selection and the design of the heat exchanger and the system have been followed.

A. Insufficient capacity; unit runs too much or ice cubes freeze too slowly.

1. Evaporator only partly frosted and cabinet too warm.

    a. Low on charge.

    Correction - Find and repair the leak, and add refrigerant.

    b. Refrigerant being robbed from the evaporator by liquid backing up in the high side as a result of the capillary tube being too long or having too small a bore.

    Correction-Replace the capillary tube with the correct size.

    Tests:

    1. Check condenser temperatures. Liquid back-up in the condenser will be indicated by high discharge temperature, and by the condenser outlet being noticeably cooler than the rest of the condenser.

    2. Turn off the unit for a few minutes and allow liquid refrigerant in the high side to pass through the capillary tube into the evaporator. Turn on the unit and observe the evaporator. If the evaporator is properly charged, or overcharged at the beginning of the cycle, but becomes undercharged as the unit runs, liquid refrigerant is backing up in the condenser.

2. Evaporator fully frosted or uniformly cold.

    a. Unit overcharged.

    Correction-Remove charge accordingly.

    Test:

    Check for suction line frost-back, which indicates overcharge.

    b. Insufficient capillary tube - Tube is too short or the bore is too large.

    Correction-Replace capillary with correct size.

c. Air or other noncondensables in the system.

Correction-Purge and recharge.

Test:

Very high inlet discharge temperature; outlet of the condenser noticeably cool. High wattage.

3. Rapid Cycling

a. Liquid traps in the high side and evaporates during the compressor off-cycle, adding hot gas to the evaporator and causing rapid cut-in.

Correction-Arrange high side to achieve good liquid drainage.

Test:

Excessive unloading time. Also portions of the high side trapping liquid, may cool noticeably during off-cycle.

B. No refrigeration

1. Unit runs continuously.

a. Unit has lost its charge.

Correction - Repair leaks and recharge.

b. Capillary tube or inlet screen plugged.

Correction - Replace accordingly.

Test:

Open refrigerant line in the high side; liquid refrigerant will escape.

c. Moisture in the system, and the capillary tube freezes up.

Correction - Replace the drier, dehydrate the system, and recharge.

Test:

Refrigerating effect will be intermittent as the ice plug warms up and melts, and then refreezes. Also, turn the unit off and allow the evaporator to warm up. Refrigeration will be temporarily restored when the unit is restarted.

2. Unit cycles on overload protector, or will not run at all.

a. Same as (b) and (c), above under B. If the capillary tube plugs up, pressure will not balance and the motor may not have sufficient torque to start under the unbalanced pressures experienced.

1. Noisy compressor.
    a. May be operating at excessive discharge pressure due to:
        1. Capillary tube is too long or bore is too small.
        2. Restriction in capillary tube or inlet screen.
        3. Noncondensables in system.
    b. Overcharged system.
2. Gurgling sound in condenser during "off" cycle.
    a. Poor liquid drainage resulting in a percolating action.
3. Noisy evaporator.
    a. Vibration of capillary tube at evaporator inlet.

       Correction - Dampen vibrations of excess capillary tube by winding it in a tight coil and taping or soldering together.