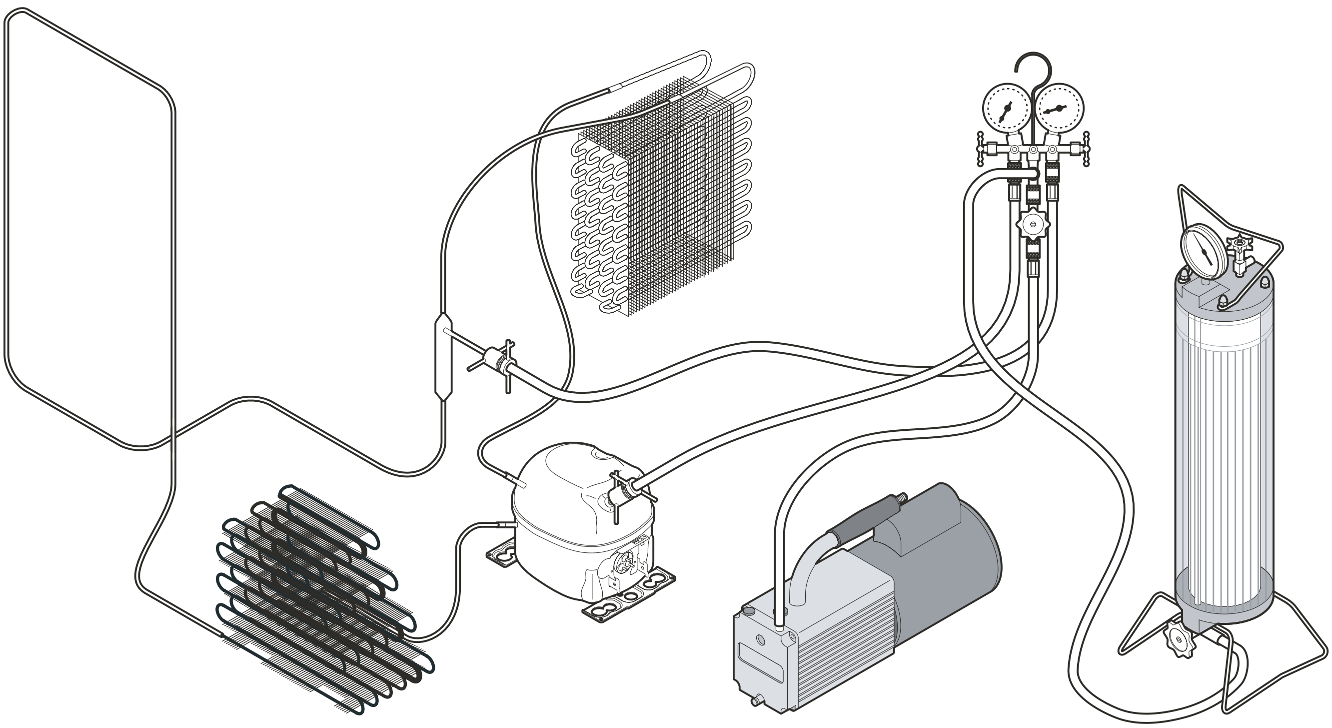
Technical Training Manual

Sealed System Service



Electrolux

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IMPORTANT NOTICE

The purpose of this service manual is to give the service technician an understanding of the changes in refrigerants and sealed system service. Persons attempting to use this service manual to make repairs to sealed system refrigeration systems should have electrical training as well as training in sealed system repairs. The person making the repairs must know and understand all laws (Local and International) governing handling of all refrigerants. The technician must be trained in the use of recovery and recycling equipment. Electrolux Home Products, Inc. cannot be responsible, nor assume any liability, for injury or damage of any kind arising from the use of this manual.

IMPORTANT

Effective July 1, 1992, the United States clean air act governs the disposal of refrigerants such as R-134a. Therefore, when discharging or purging the sealed system use an EPA approved refrigerant recovery system as outlined in the final rule on the protection of stratospheric ozone and refrigerant recycling, which was published in the Federal Register May 14, 1993.

NOTE

Electrolux does not permit the use of recovered refrigerant in the servicing of our products for in-warranty and out-of-warranty repairs or for products covered by service contracts. Therefore, only new refrigerant or refrigerant that has been reclaimed back to new specifications by a refrigerant manufacturer is to be used.

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Safety First

Safe Servicing Practices For All Appliances

Avoid personal injury and/or property damage by observing important Safe Servicing Practices. Following are some limited examples of safe practices:

1. **DO NOT** attempt a product repair if you have any doubts as to your ability to complete the repair in a safe and satisfactory manner.
2. Always use the correct Replacement Parts as indicated in the parts documentation. Substitutions may defeat compliance with Safety Standards Set For Home Appliances. Do not exceed maximum recommended wattage on light bulb replacements. Doing so could blow fuses and/or damage transformers.
3. Before servicing or moving an appliance:
   - Remove power cord from the electrical outlet, trip circuit breaker to the OFF position, or remove fuse.
   - Turn off water supply if applicable.
   - Turn off gas supply if applicable.
4. Never interfere with the proper operation of any safety device.
5. **Use ONLY REPLACEMENT PARTS CATALOGED FOR THIS APPLIANCE. Substitutions may defeat compliance with Safety Standards Set For Home Appliances.**
6. **GROUNDING:** The standard color coding for safety ground wires is **GREEN**, or **GREEN** with **YELLOW STRIPES**. Ground leads are not to be used as current carrying conductors. It is **EXTREMELY** important that the service technician reestablish all safety grounds prior to completion of service. Failure to do so will create a hazard.
7. Prior to returning the product to service, ensure that:
   - All electrical connections are correct and secure.
   - All electrical leads are properly dressed and secured away from sharp edges, high-temperature components, and moving parts.
   - All non-insulated electrical terminals, connectors, heaters, etc. are adequately spaced away from all metal parts and panels.
   - All safety grounds (both internal and external) are correctly and securely connected.
   - All panels are properly and securely reassembled.

ATTENTION!!!

This service manual is intended for use by persons having electrical and mechanical training and a level of knowledge of these subjects generally considered acceptable in the appliance repair trade. Electrolux Home Products, Inc. cannot be responsible, nor assume any liability, for injury or damage of any kind arising from the use of this manual.

Introduction

The replacement of R-12 refrigerant involves changes in materials, choice of lubricant, and processing procedures, with an overall requirement of continuous high quality system performance and reliability. The following information provides a good practical foundation for service needed to maintain long product life. This Service manual is intended as a guide for introducing the service technician to R-134a refrigerant, and the equipment needed to service R-134a systems.

Compressor

In a refrigerating system designed for R-134a refrigerant, only R-134a refrigerant is to be used. The current design of hermetic compressors lead to the situation that some oil (a small percentage) will follow with the refrigerant through the whole system. R-134a compressors require a new lubricant. At this time, only synthetic ester oil is to be used. The R-12 compressors used mineral oil. Mineral oil is not compatible with R-134a and is not to be used in R-134a systems. Ester oil must not be mixed nor replaced with any other lubricant. Compressors used with R-134a systems charged with oil, cannot have any tube fittings exposed to ambient air for more than 15 minutes. Ester oil is more hygroscopic (it will absorb water at a much faster rate) than the mineral oil used with R-12 systems.

⚠ **CAUTION**

Ester oil can be an irritant to eyes and skin. Refer to manufacture safety data sheets from lubricant supplier for handling specifications. As with all current refrigerants, you must have an adequately ventilated work area at all times for sealed system service and repairs.

Refrigeration Systems

The sealed refrigeration system will consist of the same basic components being utilized in the R-12 systems.

There is a 10% to 15% discharge pressure increase using R-134a, with a 5% to 10% decrease in suction pressure when compared to the same product with an R-12 system operating at 90°F (32°C) ambient temperature conditions. Lower suction pressures result from the lower density of R-134a refrigerant which effects refrigerant flow rate. R-134a systems commonly operate in a 1”-2” vacuum on the suction side.

Products using R-134a refrigerant will have a different heat exchanger than a R-12 product. The difference is in the capillary tub, it will be longer to maintain a similar flow rate. On some models, a larger condenser will be used to reduce the discharge pressures and lower start-up sound transmission. A different filter-drier will be used on refrigerating systems with R-134a. The molecules of R-134a are smaller than those of R-12, therefore, a dryer with smaller pores is necessary. Other wise, R-134a could be trapped inside the filter-drier along with the water. On some products you will see some changes to the evaporator and suction line. Ester oil and R-134a mix satisfactorily within the compressor. Lower gas speed increases the risk of oil accumulation in the evaporator. Some changes will be required to ensure good oil returnability.

Sealed System Repair

To prevent any form of cross contamination of R-134a, and R-12 refrigerant, or a cross contamination of ester oil and mineral oil, you must have dedicated equipment. The equipment consists of one set of gauges, manifold, hoses, vacuum pump, charging cylinder, and reprocessing or transfer pump. This means you must have one complete set for CFC, (R-11, R-12) and HCFC, (R-22) systems, and one complete set for HFC, (R-134a) systems. You can not share the use of any of the same equipment on both systems.

Since the R-134a molecule is smaller than the R-12 molecule, R-134a could pass more minor leaks than R-12 and the flow through a certain leak would be larger for R-134a than for R-12. As a consequence, it is critical to maintain very good brazing processes and leak tests.

You must make sure you do not mix refrigeration oil or refrigerant in your bulk storage area. Because moisture infiltration is much higher in ester oil, you must keep it stored in sealed containers and only allow exposure to room air for a very short period of time when changing or adding oil to a system. You must not mix refrigerant in your storage containers for used refrigerant removed from products for service. You must have dedicated cylinders for each refrigerant R-12, R-22, and R-134a.

Refrigerants

Refrigerant Blends

Some of the blends which are replacing the traditional ozone depleting potential (ODP) refrigerants are HCFC-based. At this time Electrolux Home Products Inc. is not recommending any refrigerant blend as direct replacement for R-12 refrigerant. Electrolux Home Products Inc.'s recommendations for R-12 refrigerant products are covered on page 10 of this manual. Replace R-134a with R-134a refrigerant only in an R-134a system. One problem with the blends is calculating the superheat temperature. With a blend such as MP-39 at 20 psia, you have two temperatures involved for the same pressure. The temperatures are -2°F for the saturated vapor phase, and -13°F for the saturated liquid phase. Pure compounds like CFC-12 only have one temperature for both liquid and vapor phases at one given pressure. The evaporator is now vaporizing the refrigerant at a range of temperatures, the range being -13°F to -2°F. This is much different than a pure compound, where at 20 psia both liquid and vapor temperature are - 8°F. With CFC-12 it didn't matter if you chose the liquid or vapor temperature at 20 psia for superheat calculation. However with a refrigerant blend that has an associated temperature range, choosing the wrong temperature for a given pressure will mean a superheat calculation error and possible ruined or inefficient equipment. A similar problem exists with condenser sub-cooling calculation.

	REFRIGERANTS	
	R-12	R-134a
NAME	Dichlorodifluoro-methane	1,1,1,2--Tetra-fluoromethane
Formula	CCl_2F_2	$CH_2F\text{-}CF_3$
Molecular Weight (g/mol)	120.93	102.3
Ozone Depletion Potential (ODP)	1	0
Global Warming Potential (GWP)	3.1	0.3
Boiling Point °F	-21.6	-15.7
Vapor Pressure (77°F)	80 psig	82 psig
Flammability	None	None
Solubility of Water in Refrigerant (wt% @ 77°F)	0.009	0.11
Density of liquid at 30°C (kg/dm^3)	1.292	1.250
Solubility of Water in Refrigerant (wt% @ 77°F)	0.009	0.11
Latent heat of vaporisation (kJ/kg)	165.3	175.6
Solubility of water at 30°C (ppm w/w)	120	773
Viscosity of vapour [cps] at 30°C. 1 atm	0.0127	0.0124
Boiling point at 1 am. (˚C)	-29.8	-26.22

Definitions

Recovery:

To remove refrigerant in any condition from a system and store it in an external container without necessarily testing or processing it in any way.

Recycling:

To clean refrigerant for reuse by oil separation and single or multiple passes through devices, such as replaceable core filter-driers, which reduce moisture, acidity and particulate matter. This term usually applies to procedures implemented at the field job site or at a local service shop.

Reclaim:

To reprocess refrigerant to new product specifications by means which may include distillation, will require chemical analysis of the refrigerant to determine that appropriate product specifications are met. This term usually implies the use of processes or procedures available only at a reprocessing or manufacturing facility.

Charging Sealed Systems

Overcharging a refrigeration system with refrigerant can be dangerous. If the overcharge is sufficient to immerse the major parts of the motor and compressor in liquid refrigerant, a situation has been created which, when followed by a sequence of circumstances, can lead to the compressor shell seam separating.

A hydraulic block occurs preventing the compressor from starting. This condition is known as locked rotor. Electric current continues to flow through the compressor motor windings which become, in effect, electric resistance heaters. The heat produced begins to vaporize the excess refrigerant liquid, causing a rapid increase in system pressure. If the compressor protective devices fail, the pressure within the system may rise to extremes far in excess of the design limits. Under these conditions, the weld seam around the compressor shell can separate with explosive force, spewing oil and refrigerant vapor, which could ignite.

To eliminate this exceedingly rare but potential hazard, never add refrigerant to a sealed system. If refrigerant is required, evacuate the existing charge and recharge with the correct measured amount of the refrigerant specified for the system.

NOTE: Attach an approved self tapping line tap valve to the process tube. Connect refrigerant recovery system to tap valve. Turn on recovery system, open the line tap valve, and allow refrigerant to flow into an approved tank.

Always make sure your equipment is in good condition and all manufacturer's instructions are followed to prevent the accidental rupture of a hose, connection fitting, or a tank, this could cause a serious injury. Run equipment until system has reached 13 inches of vacuum. Shut system down and allow to set for two minutes, if pressure remains below (0) pounds per square inch, disconnect equipment and proceed. If pressure does not stay below (0) pounds per square inch, repeat above procedure until all refrigerant is removed and system remains in a vacuum.

⚠ WARNING

WEAR APPROVED SAFETY GLASSES WHEN WORKING WITH OR ON ANY PRESSURIZED SYSTEM OR EQUIPMENT. HAVE AN APPROVED DRY TYPE FIRE EXTINGUISHER HANDY WHEN USING ANY TYPE OF GAS OPERATED TORCH.

Soldering

1. All joints to be soldered must have a proper fit. Clearance between tubes to be soldered should be from .001" to .006". It is not practical to actually measure this; however, you do not want a dry fit or loose fit. Tubing joints should overlap about the distance of their diameter except for restrictor tubes, which should be inserted 1.25".
2. Clean all joint areas with fine steel wool or preferably an abrasive cloth, such as grit cloth No. 23 or Scotch-Brite.
3. Apply a thin film of liquid flux recommended for silver soldering to surfaces to be joined, and to surfaces immediately adjacent to joint.

⚠ CAUTION

During application of heat, use wet cloths to prevent heat from conducting to areas other than the soldered joint. Use a sheet of metal or torch guard pad as a heat deflector to keep flame away from inflammable materials and painted surfaces.

4. Align tubing so no stress is on joint. Do not move tubing while solder is solidifying or leaks will result.
5. Use a torch of adequate capacity so joint can be quickly heated with a minimum of heat travel to other points. Use a good grade of silver solder.
6. Solder connections. If tubing is properly cleaned and fluxed, solder will flow readily. Use only enough solder to make a good bond.
7. Allow joint to cool, then wash exterior with water to remove flux.

Refrigeration Basics

Basic Components

The basic components of a refrigerator are a compressor, condenser, evaporator, heat exchanger (capillary tube and suction line), drier and perimeter hot tube.

Perimeter Hot Tube

To reduce the possibility of condensation forming on the exterior of the cabinet in high humidity areas, a perimeter hot tube (refrigerant tube) has been installed in the unit. The perimeter tube extends up the left side, across the top of the freezer and down the right side into the filter drier. When the compressor operates, warm refrigerant flows through the primary condenser, then into the primary hot tube, warming the cabinet front exterior.

The perimeter hot tube is not replaceable. In the unlikely event of a leak in the hot tube, a kit is available to bypass the hot tube in the sealed system. An electrical heater wire must be installed within the tubing. The electrical connection for the electrical heater wire for a solid state PTC relay compressor is be connected into the condenser fan circuit. For a variable speed compressor, the electrical connection must be made to the 110V inverter board. Refer to the appropriate parts list of the model being serviced for the correct kit part number.

Refrigerant Cycle

The refrigerant cycle is a continuous cycle that occurs whenever the compressor is in operation. Liquid refrigerant is evaporated in the evaporator by the heat that enters the cabinet through the insulated walls, and by the heat from product load and door openings. The refrigerant vapor is then drawn from the evaporator, through the suction line, to the compressor.

Compression raises the pressure and temperature of the vapor in the compressor and the vapor is then forced through the discharge valve into the discharge line and into the condenser. Air passing over the condenser surface removes heat from the high pressure vapor which then condenses to a liquid. The liquid refrigerant then flows from the condenser to the evaporator through the small diameter liquid line (capillary tube).

Before it enters the evaporator, the liquid refrigerant is sub-cooled in the heat exchanger by the low temperature suction vapor in the suction line. When refrigerant is added, the frost pattern will improve, the suction and discharge pressures will rise, the condenser will become hot and the wattage will increase.

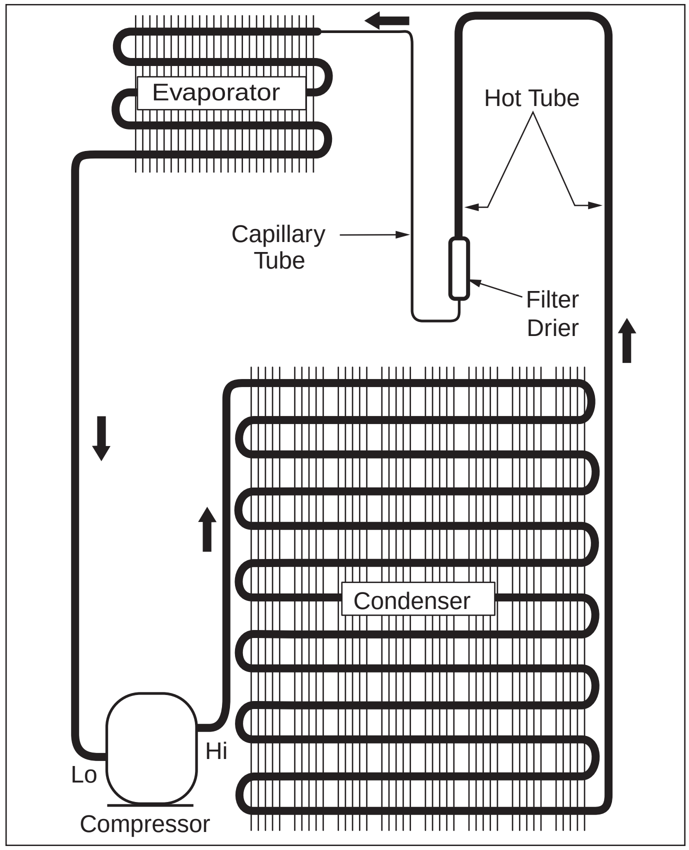

Figure 1. Automatic Defrost Models

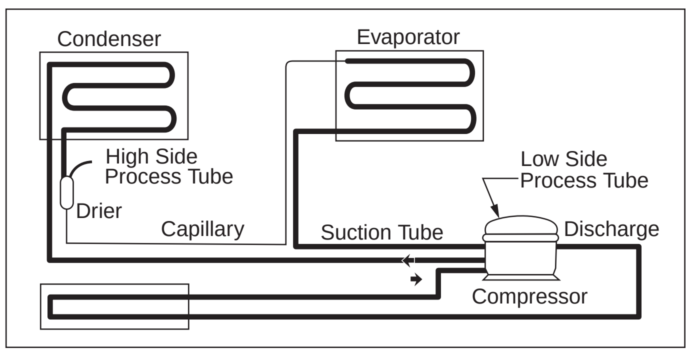

Figure 2. Standard Chest Freezer

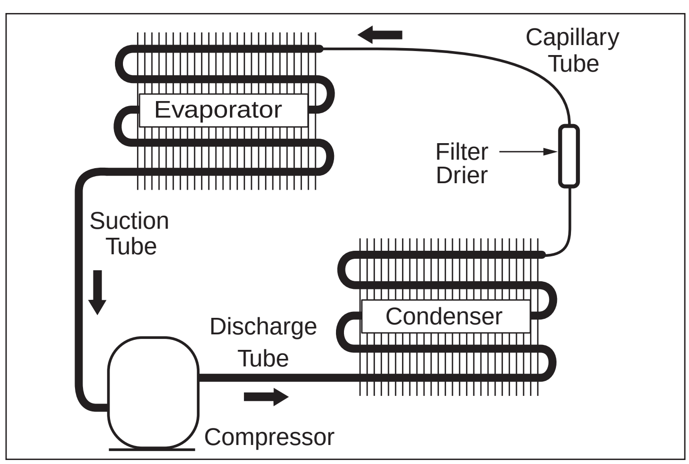

Figure 3. Air-Conditioner

Recovering Refrigerant

Recovering refrigerant is the first step in preventive maintenance or repair of equipment. Simply put, recovery means transferring the system's refrigerant into a refillable refrigerant cylinder.

The first step is to have on hand, clean, safe, refillable cylinders evacuated to 25 microns, and labeled for each different type of refrigerant you will be working with. Example; for repairing Electrolux Home Products Inc. built products you will need one cylinder for R-12, one for R-22, one for R-134a, and one for R-500 if you work on dehumidifiers.

Second step is you must have dedicated equipment (See Equipment Needed) for CFC, (R-12) and HCFC, (R-22) you can also use this equipment for R-500 which is a blend of R-12 and R-152a refrigerant. You need dedicated equipment for HFC (R-134a) refrigerant. Because of the difference in the oil and the refrigerant, you can not use the same equipment on HFC based refrigerants as you use on CFC based refrigerants.

To recover the refrigerant:

1. Disconnect unit from source of power.
2. Attach an approved self tapping line tap valve to the process tube. Connect refrigerant recovery system to tap valve. Turn on recovery system, open the line tap valve, and allow refrigerant to flow into an approved tank. (See Figure 4)

⚠ CAUTION

Always make sure your equipment is in good condition and all manufacture instructions are followed to prevent the accidental rupture of a hose, connection fitting, or a tank, that could cause a serious injury. Always sit the tank on a scale when you are transferring refrigerant into the tank. Always check the weight to see when the tank is full, do not over fill the tank.

3. Allow the recovery pump to run until the system has reached 13 inches of vacuum.
4. Shut system down and allow to set for two minutes. If pressure is below (0) pounds per square inch, disconnect equipment and proceed with repair.
5. If pressure does not stay bellow (0) pounds per square inch, repeat steps 3 and 4 until ail refrigerant is removed and system remains in a vacuum.

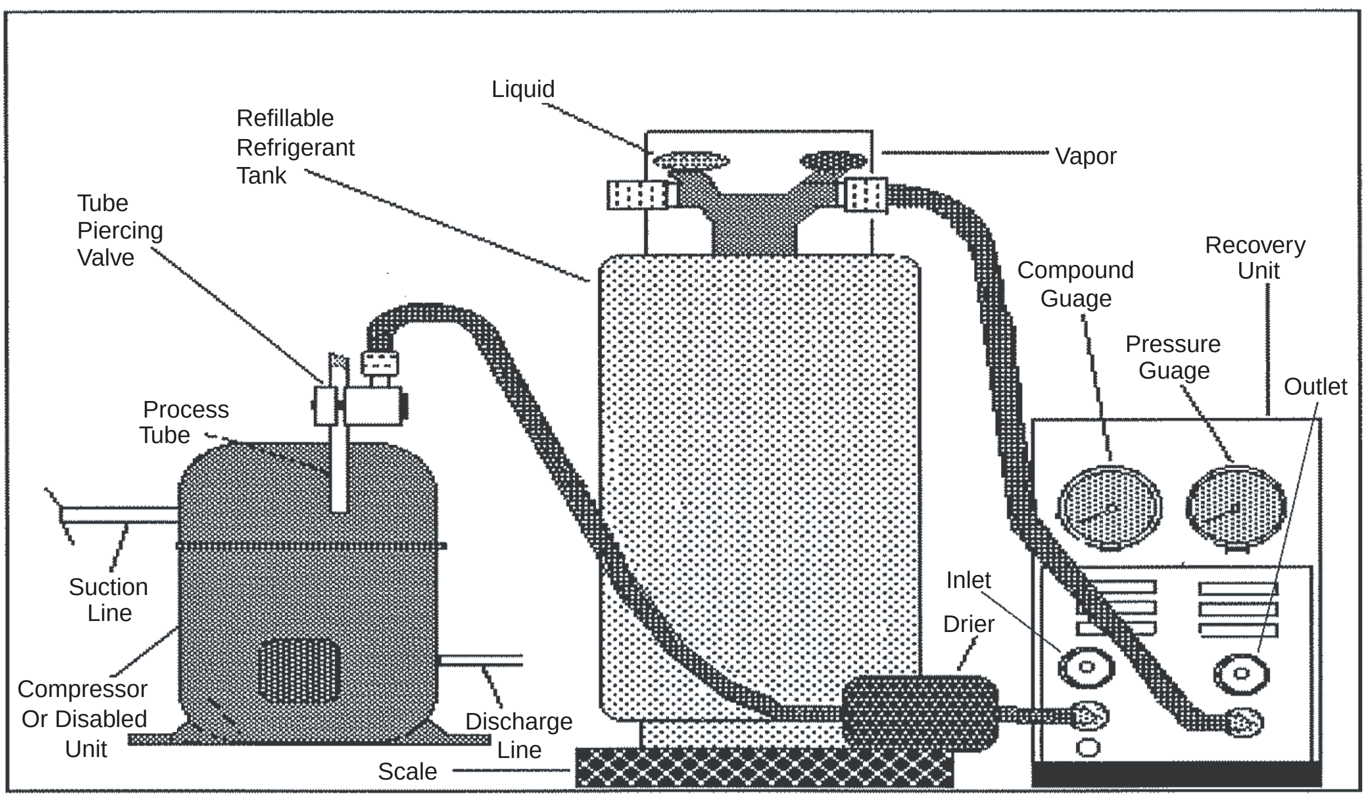

Figure 4. Installation of Recovery Equipment

System Leaks

Low/High Side Leak or Undercharge

A loss of refrigerant can result in any of the following:

1. Excessive or continuous compressor operation.
2. Above normal freezer compartment temperature.
3. A partially frosted evaporator (depending on amount of refrigerant loss).
4. Below normal freezer compartment temperature.
5. Low suction pressure (vacuum).
6. Low wattage.

The condenser will be “warm to cool”, depending on the amount of refrigerant lost.

In the case of a low side refrigerant leak resulting in complete loss of refrigerant, the compressor will run but will not refrigerate. Suction pressure will drop below atmospheric pressure and air and moisture will be drawn into the system, saturating the filter drier. A system with R-134a refrigerant and ester oil will become saturated with moisture much faster than a system with R-12 and mineral oil. Therefore, you must obtain a sample of the oil and check with an oil test kit to determine the amount of contamination. You will find that the oil in an R-134a system will have to be replaced after most low side leaks.

If there is reason to believe the system has operated for a considerable length of time with no refrigerant and the leak occurred in the low side of the system, excessive amounts of moisture may have entered the system. In such cases, the two stage service Dryer Filter part number 5303918288 and vacuum procedure listed under Refrigerant Leaks, need to be followed to prevent repetitive service.

If a slight undercharge of refrigerant is indicated and no leak can be found after a thorough leak test, the charge can be corrected without changing the compressor.

If a high side leak is located and some refrigerant remains in the system it is not necessary to change the compressor.

Testing for Refrigerant Leaks

NOTE

The line piercing valve (clamp-on type) should be used for test purposes only. It must be removed from system after it has served its purpose.

If the system is diagnosed as short of refrigerant and the system has not been recently opened, there is probably a leak in the system. Adding refrigerant without first locating and repairing the leak or replacing the component will not permanently correct the difficulty.

The leak must be found!

Sufficient refrigerant may have escaped to make it impossible to leak test effectively. In such cases, add a ¼” line piercing valve to the compressor process tube. Add sufficient refrigerant vapor to increase the pressure to 75 lbs. per sq. in. Through this procedure, leaks are more easily detected before discharging the system into reprocess/recapture equipment. Check the low side for leaks. Run the compressor 2 or 3 minutes and check the high side for leaks. Recover refrigerant using an EPA approved recovery system.

Checking For Internal Leaks

Before checking for internal leaks, check all accessible system components and joints for leaks.

If an internal leak is suspected, it must be confirmed. Use the following procedure:

1. Discharge the system by using refrigerant recovery equipment.
2. Disconnect the condenser and the drier from the hot tube on refrigerators. On food freezers, separate the high and low pressure sides of the system. Pinch off and solder closed one end of the part of the system to be tested.
3. Solder a 1/4" charging hose fitting to the open end of the part of the system to be tested.
4. Connect a pressure gauge and access valve to the open end of the part of the system to be tested. Pressurize to 250 lbs. using dry nitrogen or carbon dioxide.
5. Leave the pressure on the hot tube for 24 hours. Any drop in pressure is an indication of a leak.

⚠ **WARNING**

NEVER PRESSURIZE WITH OXYGEN. NEVER OPEN A HIGH PRESSURE TANK UNLESS IT IS EQUIPPED WITH A PRESSURE REGULATOR. NEVER PUT HIGH PRESSURE ON THE DOME OF THE COMPRESSOR - IT MIGHT EXPLODE. MAKE SURE GAUGE FITTINGS ARE IN GOOD CONDITION AND DO NOT LEAK.

If dry nitrogen or carbon dioxide is not available. Follow instructions 1 through 3, then use 4 and 5 listed below as an alternative method.

4. Connect gauges to charging hose fittings. Pull a vacuum on each side of the system.
5. Leave the vacuum on each side of the system for 24 hours. Any loss of vacuum is an indication of a leak.

Compressor Replacement

Before installing new compressor, check for possible system contamination by obtaining an oil sample from the old compressor. On R-134a systems use an oil test kit to check for contamination. If oil has a burned odor or shows contamination (dark color), the system should be flushed to remove as much of the contamination as possible before installing a new compressor and filter-drier. On an R-12 system, use an oil test kit to check for contamination, or if oil has a burned odor, but no color change or residue, a normal compressor change may be made. If oil has a burned sugar odor and shows contamination (dark color), system should be flushed to remove as much of the contamination as possible before installing a new compressor and filter-drier. If this contamination is allowed to remain in the system it will mix with the new oil causing it to become contaminated and damage the new compressor, or cause a restriction in the filter-drier or cap tube.

Flushing The System With Nitrogen

It is recommended that system be flushed with dry Nitrogen. However, if refrigerant is used to flush the system you must look at the serial plate to see what type of refrigerant is used in the system. This is the only refrigerant that can be used to flush the system and it must be recovered.

⚠ **CAUTION**

Use extreme care when using Dry Nitrogen to flush systems. Pressure in nitrogen cylinder could be as high as 2000 psi. Nitrogen cylinder must be equipped with approved pressure regulator and pressure relief valve. Ensure that your hoses have adequate ratings for pressure involved and that all of your equipment is in good condition.

When flushing with nitrogen there MUST Be a pressure regulator on the tank with the maximum pressure on the lowside of the sealed system (evaporator) at 150 PSI and at the High side, 300 PSI.

The end of the flushing hose on this tank regulator must be equipped with a hand shut-off valve (Robinair No. 40380). Close hand shut-off valve and adjust nitrogen regulator to correct pressure before proceeding with flushing procedure.

1. Remove compressor and filter-drier. Connect process coupling to outlet tube of condenser.
2. Fasten cloth over other end of coil to prevent old oil from spraying over room.
3. Connect hand shut-off valve on flushing hose to process coupling.
4. Slowly open hand shut-off valve and allow nitrogen to flow through condenser until discharge is clear.

⚠ **CAUTION**

DO NOT exceed 300 PSIG.

5. Disconnect cap tube from evaporator. Flush evaporator in same manner as condenser.

⚠ **CAUTION**

DO NOT exceed 150 PSIG.

6. Flush cap tube. This is only possible if you have a proper service valve adapter.

⚠ **CAUTION**

DO NOT exceed 300 PSIG.

7. Reassemble system.

Alternate Refrigerant Program

In today's market there are a number of refrigerant manufacturers introducing alternate refrigerants to replace the CFC based refrigerants used in production of refrigerating equipment built over the last 50 years. This section addresses the R12 refrigerators and food freezers built by Electrolux Home Products Inc.

Electrolux Home Products Inc. and Americold Compressor Company have approved the use of R401a (MP39), R409a (FS56) and R414b (HotShot).

MP39 - Will work well in the R-12 systems as long as the oil is changed from Mineral to Alkylbenzene (AKB) oil.

R406a - Americold Compressor had a problem with cap-tube blockage in testing, we do not recommend the use of this refrigerant.

R409a and R414b - Will work in Electrolux Home Products Inc. systems with the Mineral oil that is in the system. But in the long term, products have better performance if the oil is changed from Mineral to Alkylbenzene (AKB) oil.

There are other Alternate Refrigerants on the market. The ones listed above are only ones Electrolux Home Products Inc. has approved at this time.

To use R401a (MP39):

1. Recover the refrigerant.
2. Make the repair. If repair is other than a compressor replacement, follow step 3. If compressor is replaced, skip step 3, the compressor in the kit is charged with AKB oil.
3. Remove compressor and heat up to at least 70°F. Point the process tube down into a container and drain out the oil. The R12 reciprocating compressor used by Electrolux Home Products Inc. has 300 cc. mineral oil in the compressor, of which, 270 to 275 cc. may be drained out the process tube. Refill the compressor with 275 cc. AKB oil and reinstall.
4. Pull at least 500 microns of vacuum. Then hold vacuum for at least 5 minutes.
5. Set 30 LB cylinder on electronic charging scales good to 1/4 oz., and set scale for 80% of the data plate charge. Charge the liquid refrigerant to 80% of the data plate charge, and put an in-line regulator on the center hose.
6. Allow product to run and adjust the charge if needed. (Use liquid refrigerant only when adding refrigerant)
7. Pinch off lines and remove gages.

To use R409a (FS56) or R414b (Hot Shot):

1. Recover the refrigerant.
2. Make your repair.

NOTE

If repair is other than a compressor replacement you should change the oil to AKB for best long term performance of the refrigeration system. Follow step # 3 under R401a. If compressor is replaced, the compressor in the kit is charged with AKB oil.

3. Pull at least 500 microns of vacuum. Then hold vacuum for at least 5 minutes.
4. Set 30 LB cylinder on electronic charging scales good to 1/4 oz., and set scale for 80 % of the data plate charge. Charge the liquid refrigerant to 80% of the data plate charge, and put an in-line regulator on the center hose.
5. Allow product to run and adjust the charge if needed. (Use liquid refrigerant only when adding refrigerant)
6. Pinch off lines and remove gages.

NOTE

R409A and R414B Contains material that is flammable. This material is in small amounts so the products are listed as nonflammable as formulated, and in worst cases fractional.
Use extra caution when using these refrigerants in conjunction with your welding equipment.

Installing a New Compressor

NOTE

Entirely new compressors have been developed for use with R-134a and Ester oil refrigeration systems. Both compressor and electric motor have been modified. Old compressors intended for R-12 refrigerant must not be used for new systems charged with R-134a.

Replacement of compressor and installation of filter-drier must be done in a continuous sequence so the system is exposed to atmosphere no longer than necessary.

All replacement compressors are shipped with rubber plugs in the suction, discharge and process tubes, and contain the correct oil charge and a holding charge of inert gas. Compressors have a low-side process tube attached to the compressor shell. A high-side process tube is attached to the filter-drier.

Replacement compressors for refrigerators may have an oil cooler even if the original compressor did not. If the product is not equipped for an oil cooler, leave the plastic caps in place and install the compressor, connecting only to the suction and discharge lines of the new compressor.

Before installing the replacement compressor, remove the discharge plug and check for the pop sound of the inert gas leaving the compressor.

⚠ **CAUTION**

DO NOT use compressor if you do not hear this sound.

If the compressor checks OK, reinstall the plug. Do not remove any of the plugs again until the compressor is in position and you are ready to braze the lines.
A new compressor which is cold (e.g. after having been kept in a cold service van) should be left to warm to the surrounding temperature before the plugs on the compressor connections are removed. This will help prevent condensation from forming in the oil and the compressor. Also, avoid opening the system when any of the components or lines are cold.

A process tube is connected onto the high-side process tube of the filter drier. This tube is located at the top of the filter-drier.

⚠ **WARNING**

DO NOT OPERATE RECIPROCATING COMPRES-SORS WHEN CHARGING LIQUID REFRIGERANT INTO SYSTEM THROUGH ITS PROCESS TUBE.

Follow the numbered sequence for all products:

1. Disconnect electrical supply to unit.
2. Remove all components needed to pull the compressor assembly from the unit.
3. Pull compressor assembly straight out.
4. Attach an approved self tapping line tap valve to the process tube. Connect refrigerant recovery system to tap valve. Turn on recovery system, open the line tap valve, and allow refrigerant to flow into an approved tank.
5. Remove leads from compressor motor terminals.
6. Remove mounting clips and washers.
7. After refrigerant is completely recovered, cut suction and discharge lines as close to compressor as possible. Leave only enough tubing to pinch off and seal defective compressor. Plug or tape any open system tubing to avoid entrance of moisture and air into system. Remove inoperable compressor and transfer mounting parts to new compressor.
8. Release holding charge (release slowly to avoid oil discharge) on new compressor to ensure there is no leak in seam or tubing. Reinstall rubber plug.
9. Install new compressor in exact same manner as original compressor.
10. Reform both suction and discharge lines to align with new compressor. If they are too short, use additional lengths of tubing. Joints should overlap 0.5” to provide sufficient area for good solder joints. Clean and mark area where tubing should be cut. Cut tubing with tubing cutter. Work quickly to avoid letting moisture and air into system.

NOTE

If low-side process tube is too short, silver solder four inch piece of tubing onto process tube at this time.

⚠ **CAUTION**

On R-134a systems, compressor must NOT be left open to atmosphere for more than 10 minutes to prevent moisture contamination of oil.

Evaporator and Condenser Replacement

11. Solder all connections according to soldering procedure.
12. Remove original filter-drier.

> ⚠ **CAUTION**
>
> **DO NOT unbraze old filter-drier from system. This will vaporize and drive moisture from desiccant back into system. The old filter-drier should be cut out of system.**

13. Install new filter-drier at condenser outlet.
14. Evacuate and charge system using recommended procedure described under Evacuating and Recharging.
16. Reconnect compressor terminal leads in accordance with unit wiring diagram.
17. Reassemble unit.

Evaporator and Suction Line Replacement

1. Disconnect electrical supply to unit.
2. Disassemble the product enough to get access to the compressor (refer to service manual for the product you are servicing for instructions to dissemble).
3. Attach an approved self tapping line tap valve to the process tube. Connect refrigerant recovery system to tap valve. Turn on recovery system, open the line tap valve, and allow refrigerant to flow into an approved tank.
4. With refrigerant recovered, disconnect capillary tube from filter-drier and suction tube solder joint from compressor.
5. Obtain a sample of the oil and check for contamination, if contamination is present, the oil must be replaced and the system flushed.
6. Remove evaporator from its installation position.
7. Remove heat exchanger and evaporator on a refrigerator. Remove just the evaporator on all other products.
8. Clean suction and capillary lines with abrasive cloth. Connect lines to replacement evaporator and solder joints.
9. Install evaporator assembly in refrigerator. Connect suction line to compressor and solder joint.
10. Remove original drier and install new filter-drier at condenser outlet.

> ⚠ **CAUTION**
>
> **DO NOT unbraze old filter-drier from system. This will vaporize and drive moisture from desiccant back into system. The old filter-drier should be cut out of system.**

11. Evacuate and charge system using recommended procedure described under Evacuating and Recharging.
12. Reassemble unit. All sealing materials must be replaced where lines and wires pass through cabinet.

Condenser Replacement

1. Disconnect electrical supply to unit.
2. Disassemble the product enough to get access to the compressor (refer to service manual for the product you are servicing for instructions to dissemble).
3. Attach an approved self tapping line tap valve to the process tube. Connect refrigerant recovery system to tap valve. Turn on recovery system, open the line tap valve, and allow refrigerant to flow into an approved tank.
4. After refrigerant is completely recovered, disconnect inlet and discharge lines from condenser.
5. Remove condenser. (All products except food freezers)
6. Install replacement condenser.
7. Remove original drier and install a new filter-drier at the condenser outlet of refrigerators and freezers. On air conditioners, remove the strainer and replace with a filter-drier.

> ⚠ **CAUTION**
>
> **DO NOT unbraze old filter-drier from system. This will vaporize and drive moisture from desiccant back into system. The old filter-drier should be cut out of system.**

8. Evacuate and charge system using recommended procedure described under Evacuating and Recharging.
9. Reassemble unit.

Filter-Drier Installation

Any time the sealed system is opened and the refrigerant charge is removed, the liquid line filter-drier must be replaced and the system thoroughly evacuated before recharging.

1. Disconnect electrical supply to unit.
2. Attach an approved self tapping line tap valve to the process tube. Connect refrigerant recovery system to tap valve. Turn on recovery system, open the line tap valve, and allow refrigerant to flow into an approved tank.
3. Using a 3 cornered file, score a groove around capillary tubes as close to old filter-drier as possible. Break capillary tubes along score mark from filter-drier.

⚠ CAUTION

DO NOT unbraze old filter-drier from system. This will vaporize and drive moisture from desiccant back into system. The old filter-drier should be cut out of system.

4. Cut condenser outlet tube at filter-drier. Discard filter-drier.
5. Thoroughly clean condenser outlet tube and capillary tube.
6. Place inlet connection of filter-drier over condenser tube approximately ¼" and solder.
7. Insert capillary tube input end into filter-drier outlet. Do not allow tube to bottom against screen. Solder carefully so that solder does not plug capillary tube.
8. Install process tube adapter to filter-drier.
9. Evacuate and charge system using the recommended procedure described under Evacuating and Recharging.
10. Reassemble unit.

Evacuating and Recharging

Equipment Needed for Evacuation & Recharging:

1. 2 - Heated Dial-A-Charge charging cylinders.
2. 2 - Recovery/Recycling equipment.
3. 1- Tank for each type of refrigerant you use in service. (Do not mix refrigerants in the same tank)
4. 2 - External vacuum pumps.
5. Process tube adapter kit (Robinair No.12458)
6. Tubing cutter.
7. Pinch-off tool capable of making leak proof seal.
8. Leak detector.
9. Complete brazing torch set.
10. Small 3-corner file.
11. Grit cloth or Scotch-Brite.
12. 45% silver solder and flux.
13. 2 -Gauge and Manifold sets.
14. 4 - Tube piercing valves.
15. Oil test kits.
16. Heat Gun.

Installing Evacuation and Recharging Equipment

1. Disconnect electrical supply to unit.
2. Attach an approved self tapping line tap valve to the process tube. Connect refrigerant recovery system to tap valve. Turn on recovery system, open the line tap valve, and allow refrigerant to flow into an approved tank.
3. If compressor was replaced, install correct sized process tube adapter on process tube.
   If compressor was not replaced, cut process tube with tubing cutter, leaving as much tube as possible, but removing the line tap valve installed to remove the refrigerant. Install the correct sized process tube adapter.
4. Attach refrigeration service gauge manifold to system in following order:
   a. Low-side (compound gauge) hose to suction side process tube adapter.
   b. High-side (pressure gauge) hose to high-side process tube adapter.
   c. Center port manifold hose before hand shut-off valve to charging cylinder.
   d. Center port manifold hose after hand shut-off valve to vacuum pump.

Evacuating the System

To achieve the required levels of evacuation, a properly maintained two stage vacuum pump in good condition is required. It is absolutely essential to maintain your vacuum pump according to the manufacturer's instructions, including required oil changes at the recommended intervals. Vacuum pump oil should always be changed after evacuating a contaminated system. Vacuum pump performance should be checked periodically with a micron gauge.

1. Ensuring that the valve on the charging cylinder is closed, start the vacuum pump. Slowly open both manifold valves, counterclockwise, for two full turns.

⚠ **CAUTION**

If high vacuum equipment is used, just crack both manifold valves for a few minutes and then open slowly for the two full turns counterclockwise. This will prevent the compressor oil from foaming and being drawn into the vacuum pump.

2. Operate vacuum pump for 30 minutes to a minimum of 29.5 inches of vacuum or until a vacuum of 600 microns is obtained.
3. Close the manifold valve connected to the vacuum pump. Watch the compound gauge for several minutes. If the reading rises, there is a leak in the system, go to step 4. If no leak is indicated, stop the vacuum pump. The system is now ready for charging.
4. If a leak is indicated, stop the vacuum pump and introduce a small charge of refrigerant into the system by cracking the valve on the bottom of the charging cylinder until the system is pressurized to 40 or 50 lbs. P.S.I.
5. Leak test the low side. Run the compressor for a few minutes and leak test the high side. When leak is found, connect refrigerant recovery system. Turn on recovery system, open the line tap valve, and allow refrigerant to flow into an approved tank. Repair and go back to step 1.
6. See page 19 for instructions on heating the compressor crankcase on products that have ran with a low side leak.

Evacuating and Recharging Connections

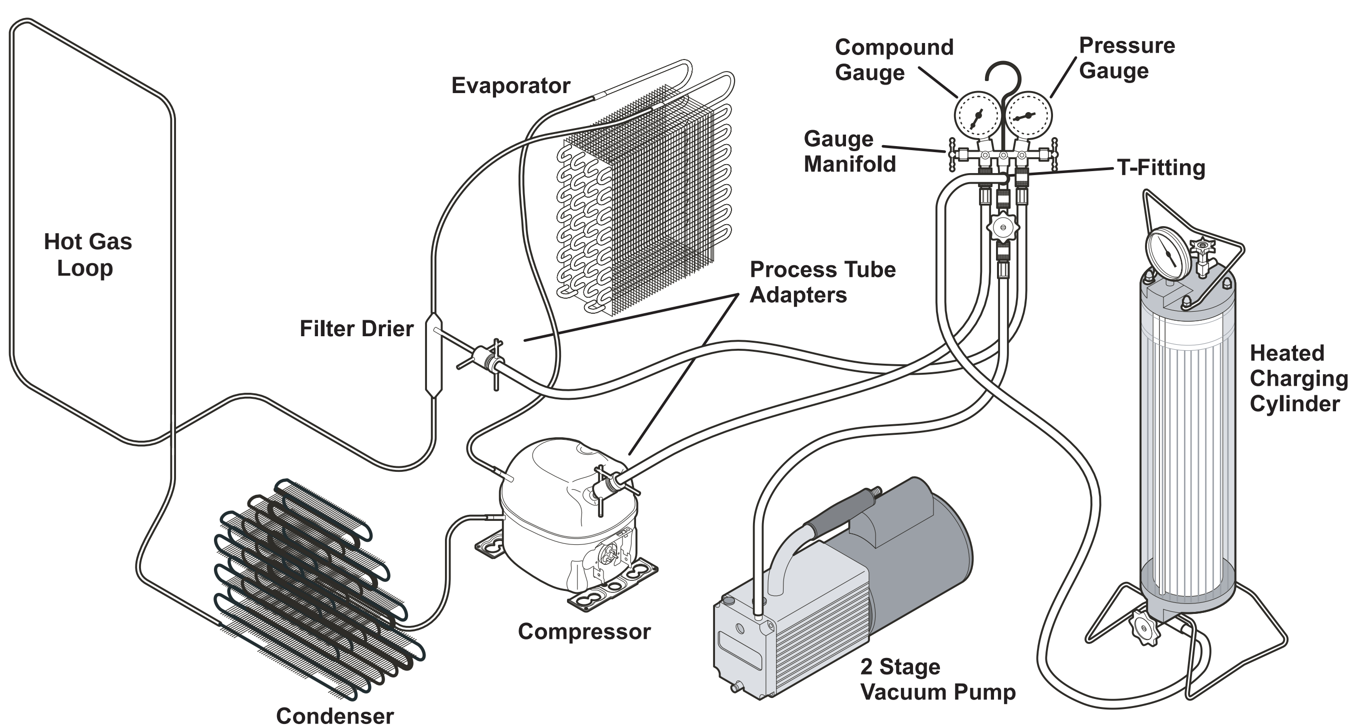

Figure 5. Installation of Recovery Equipment

Charging The System

⚠ CAUTION

Check the serial plate for the correct refrigerant type. It is extremely important to verify the type of refrigerant in the system before starting any sealed system repairs. After charging the system with liquid, be certain to wait at least 5 minutes before starting the compressor to give the refrigerant a chance to disperse throughout the system. Otherwise the compressor could be damaged by attempting to pump excessive quantities of liquid.

Preparing The Charging Cylinder:

1. Charging cylinder must have at least eight (8) ounces more refrigerant than required charge.
2. Plug in cylinder heater and bring pressure up 30 pounds above gauge pressure at ambient temperature.

⚠ WARNING

DO NOT USE EXTERNAL HEAT SOURCE ON CYLINDER OR EXCEED MAXIMUM GAUGE PRESSURE ON CHARGING CYLINDER.

To charge the system:

1. Make certain that hand shut-off valve to vacuum pump is closed.
2. Close high-side manifold gauge valve.
3. Set charging cylinder scale to pressure indicated on cylinder pressure gauge.
4. Observe refrigerant level in sight glass. Subtract amount to be charged into system and note shut off point.
5. Open charging cylinder valve slowly and allow proper charge to enter system.
6. As soon as refrigerant in sight glass has gone down to predetermined level, close charging cylinder valve.

⚠ CAUTION

Disconnect charging cylinder heater at this time to prevent cylinder pressure from exceeding its maximum limits.

7. Allow system to sit for five minutes.
8. Turn on refrigerator compressor. Run compressor for a few minutes and monitor system pressures.
9. When satisfied unit is operating correctly, clamp the process tube with pinch-off tool with the unit still running. Using a tubing cutter, cut the process tube about 2 inches from the pinch-off tool. Use Sil-fos solder and solder process tube closed.
10. Turn off the product and allow the unit to set for a few minutes. Check the process tube for refrigerant leaks.

Final Leak Test

1. With the refrigerator turned OFF leak test all low-side system components.
2. Turn the unit ON and run until the condenser is warm. Leak test the high-side system components.

Dedicated Equipment

R-134a must not be mixed with other types of refrigerants. R-134a must be recovered in dedicated and properly identified recovery bags and tanks.

It will be necessary to check with the manufacturer of your recovery equipment to determine R-134a compatibility. Some recovery equipment manufacturers have changeover instructions for switching between refrigerant types. Protect yourself and your equipment by following all manufacturer guidelines.

Also, ensure that your refrigeration hoses are specified for use with R-134a refrigerant. Research has shown that compounds in standard refrigeration hoses may enter sealed systems and ultimately restrict the cap tube in an R-134a system.

For example, hoses that were used for a refrigeration system operating on R-12 may contain small quantities of mineral oil which can block the capillary tube in a system operating on R-134a. As little as one milligram may be sufficient to cause a blockage. In addition, sealed system components that have been used with CFC systems must not be used with R-134a systems. These components may contain residual amounts of refrigerant and oil which could damage an R-134a system.

At the earliest stage of development work on R-134a, tests were carried out on a different type of synthetic oil known as Poly-Alkaline Glycol (PAG). This oil is also used in certain air conditioning systems for cars. PAG and Ester oil DO NOT mix with one another. Service equipment used for R-134a / Ester oil must not come into contact with PAG.

Vacuum Pump Maintenance

It is absolutely essential to maintain your vacuum pump according to the manufacturer's instructions, including required oil changes at the recommended intervals. Vacuum pump oil should always be changed after evacuating a contaminated system. Vacuum pump performance should be checked periodically with a micron gauge.

Vacuum pump suppliers may or may not recommend changing the vacuum pump oil to the same type that's in the system being evacuated. Some manufacturers may recommend a vacuum pump that's dedicated to R-134a systems.

Robinair has stated that their current and discontinued vacuum pump models, using mineral oil currently specified for use in their vacuum pumps, can be used to evacuate R-134a/Ester oil systems. Robinair also states that it is acceptable to alternate between evacuating R-12/mineral oil and R-134a/Ester oil systems without adversely effecting the vacuum pump's performance.

For other brands of vacuum pumps, check with the manufacturer for restrictions and guidelines when using with R-134a.

⚠ **CAUTION**

If you use a vacuum pump with mineral oil to evacuate an R-134a system, it is ABSOLUTELY ESSENTIAL to have a shut-off valve between pump and your manifold gauge set. The hand valve must be closed during all times when vacuum pump is not operating. This will prevent migration of mineral oil vapor into R-134a/Ester oil systems. If the vacuum pump should stop during evacuation for any reason, the hand pump shut-off valve must be closed immediately.

VACUUM CHART		
Vacuum Inches Hg.	Microns	Boiling Point of Water °F
28.940	25000	77.9
29.530	10000	52.0
29.832	4600	32.0
29.882	1000	1.0
29.901	500	-11.2
29.915	150	-32.8
29.917	100	-38.2
29.919	50	-49.0

To achieve the required 29.9 inch (500 micron) vacuum, a properly maintained two-stage vacuum pump in good condition is required. A two stage pump can reach a deeper vacuum than a single stage because the exhaust from the first pumping stage is discharged into the second pumping stage. This means the second stage begins pumping at a lower pressure so a lower ultimate vacuum can be achieved.

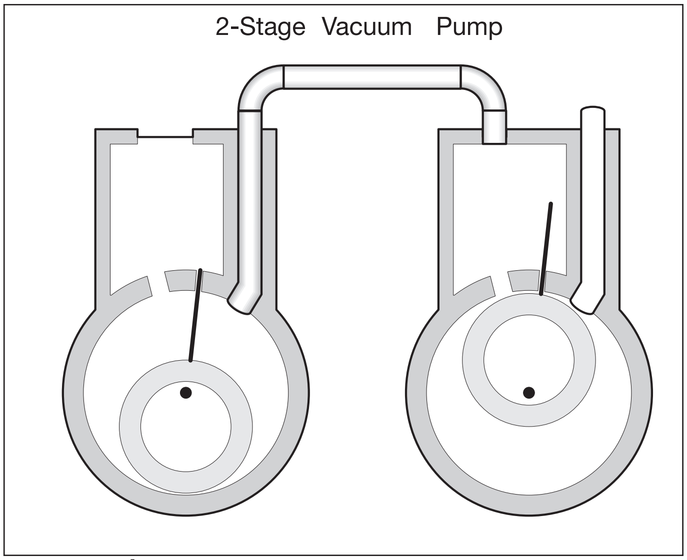

Figure 6. Two Stage Vacuum Pump

Service Diagnostic Tips

A prime requisite on the initial contact is: Always allow the customer to explain the problem. Many times the trouble can be diagnosed more quickly, based on the customer's explanation. Most of all, do not jump to conclusions until you have heard the full story and have evaluated the information obtained from the customer. Then proceed with your diagnosis.

Before starting a test procedure, connect the product service cord to the power source, through a wattmeter, combined with a voltmeter. Then make a visual inspection and operational check of the refrigerator to determine the following:

1. Is the product properly leveled?
2. Is the product located for proper dissipation of heat from the condenser? Check recommended spacing from walls.
3. Feel condenser. With compressor in operation, condenser should be hot, with gradual reduction in temperature from entry to exit of condenser.
4. Are door gaskets sealing properly? (Refrigerators and freezers)
5. Does the door actuate the light switch? (Refrigerators and freezers)
6. Is evaporator fan properly located on motor shaft?
7. Is the thermostat sensing element properly positioned?
8. Observe frost pattern on evaporator.
9. Check thermostat knob setting.
10. Inscribe bracket opposite slotted shaft of defrost timer to determine if timer advances (Refrigerators and freezers - auto defrost models only).

The service technician should inquire as to the number of people in the family to determine the service load and daily door openings. In addition, he should know the room temperature for refrigerator and freezers. For air-conditioners, check room size, temperature, amount of people, windows, and other factors that increase the load on the product.

After this phase of diagnosis is completed, a thorough operational check should be made of the refrigeration system.

Refrigerator and Freezer Air Temperatures

Temperatures are affected by improper door seal, frost accumulation on the evaporator, service load, ambient temperature, percent of relative humidity, thermostat calibration (cut-in and cut-out), location of evaporator fan blade on motor shaft, and by compressor efficiency.

Air-Conditioner Air Temperatures

Temperatures are affected by frost accumulation on the evaporator, service load, ambient temperature, percent of relative humidity, thermostat calibration (cut-in and cut-out),and by compressor efficiency.

Line Voltage

It is essential to know the line voltage at the product. A voltage reading should be taken at the instant the compressor starts, and also while the compressor is running. Line voltage fluctuation should not exceed 10% plus or minus, from nominal rating. Low voltage will cause overheating of the compressor motor windings, resulting in compressor cycling on thermal overload, or the compressor may fail to start. Inadequate line wire size, and overloaded lines, are common reasons for low voltage at the product.

IMPORTANT

Your Country may have regulations or restrictions governing the discharging of chlorofluorocarbons (CFC's) such as R-12 and R-22 to the atmosphere. Therefore, when discharging or purging the sealed system, use an approved refrigerant recovery system.

Refrigerant Exposure

HFC 134a COMPARISON WITH CFC 12

HFC 134a (1,1,1,2-tetrafluoroethane) is being studied as part of the PAFT I programme sector, which began in December 1987. It is a prime candidate for the replacement of CFC 12 (dichlorodifluoromethane) in refrigeration and air conditioning systems, medical aerosols, and in certain foam blowing applications. HFC 134a is similar to CFC 12 in that it has a low chemical reactivity and a high degree of stability. Both chemicals are gases.

Inhalation Toxicity

(Short-term exposures to high concentrations, such as accidental leakages)

Both HFC 134a and CFC 12, are very low in toxicity by the inhalation route. The 4-hour LC_{50} for HFC 134a is greater than 500,000 ppm, and for CFC 12 it is 760,000 ppm. As with other halogenated hydrocarbons, CFC 12 and HFC 134a can, at high dose levels, sensitize the heart to adrenaline. For CFC 12, the threshold level for cardiac sensitization is 50,000 ppm, while for HFC 134a it is 75,000 ppm.

HFC-134a poses no acute or chronic hazard when it is handled in accordance with DuPont recommendations and when exposures are maintained at or below the DuPont Acceptable Exposure Limit (AEL) of 1,000 ppm (8 and 12 hour Time-Weighted Average or TWA).

An AEL is an airborne exposure limit established by DuPont scientists that specifies time-weighted average (TWA) airborne concentrations to which nearly all workers may be repeatedly exposed without adverse effects. The AEL for HFC-134a has the same value as the Threshold Limit Values (TLVs) established for CFC-12 and HCFC-22. TLVs are established by the American Conference of Governmental and Industrial Hygienists (ACGIH).

However, inhaling high concentrations of HFC-134a vapor may cause temporary central nervous system depression with narcosis, lethargy and anesthetic effects. Other effects that may occur include dizziness, a feeling of intoxication and a loss of coordination. Continued breathing of high concentrations of HFC-134a vapors may produce cardiac irregularities (cardiac sensitization), unconsciousness, and with gross overexposure, death. Intentional misuse or deliberate inhalation of HFC-134a may cause death without warning. This practice is extremely dangerous.

If you experience any of the initial symptoms, move to fresh air and seek medical attention.

Cardiac Sensitization

If vapors are inhaled at a concentration of 75,000 ppm, which is well above the AEL, the heart may become sensitized to adrenaline, leading to cardiac irregularities and, possibly, to cardiac arrest. The likelihood of these cardiac problems increases if you are under physical or emotional stress.

Medical attention must be given immediately if exposed to high concentrations of HFC-134a. DO NOT treat with adrenaline (epinephrine) or similar drugs. These drugs may increase the risk of cardiac arrhythmia and cardiac arrest. If the person is having difficulty breathing, administer oxygen. If breathing has stopped, give artificial respiration.

Skin and Eye Contact

At room temperature, HFC-134a vapors have little or no effect on the skin or eyes. However, in liquid form, HFC-134a can freeze skin or eyes on contact, causing frostbite. Following contact, soak the exposed area in lukewarm water, not cold or hot. If medical treatment cannot begin immediately, apply a light coat of a nonmedicated ointment, such as petroleum jelly. If the exposed area is in a location where the presence of the ointment would be awkward, such as on the eye, apply a light bandage. In all cases of frostbite, seek medical attention as soon as possible. Always wear protective clothing when there is a risk of exposure to liquid HFC-134a. Where splashing is possible, always wear eye protection and a face shield.

Refrigerant Leaks

A system with R-134a and Ester oil will become saturated with moisture much faster than a system with R-12 and mineral oil. If your leak was in the low side of the refrigeration system when the compressor is running the pressure in the low side will go into a vacuum. As additional refrigerant leaks out, the system will go deeper into a vacuum. The system running in this vacuum will allow air and moisture to be pulled into the sealed system. The moisture pulled in can then be mixed in to the Ester oil in the compressor.

If the product has had a low side leak you will need to install the two stage service dryer filter part number 5303918288. You must heat the crankcase area of the compressor using a heat gun on the high heat setting throughout the 30 minutes you are running your vacuum pump to pull a vacuum on the system. Every 4 to 5 minutes while you are running your vacuum pump and heating the crankcase area, shake the compressor. By heating the crankcase you are heating the oil in the compressor. This will drive the moisture out of the oil. By shaking the compressor this will allow the moisture to come to the top of the oil faster so the vacuum pump can remove the moisture from the system.

Electrolux Home Products Inc. does not approve the use of the Sweep Charge for sealed system repair. This method of servicing sealed systems is often used to repair products in the field. The Sweep Charge does not adequately remove moisture from the oil in the compressor. In a R-134a system you will need to replace the compressor if the product has had a low side leak and you are servicing with the Sweep Charge procedure.

R-134a refrigerant molecules are smaller than R-12 molecules. This means that R-134a will pass more minor leaks and the rate of flow will be greater than for R-12. Therefore, it is now more important than ever to follow good brazing practices. Use a good grade of silver solder. A 45% silver solder is recommended.

Spills or Leaks

If a large release of vapor occurs, such as from a large spill or leak, the vapors may concentrate near the floor or low spots and displace the oxygen available for breathing, causing suffocation.

Evacuate everyone until the area has been ventilated. Use blowers or fans to circulate the air at floor level. DO NOT re-enter the affected area unless you are equipped with a self-contained breathing apparatus or unless an area monitor indicates that the concentration of HFC-134a vapors in the area is below the AEL.

Always use self-contained breathing apparatus or an air-line mask when entering tanks or other areas where vapors might exist. Use the buddy system and a lifeline. Refer to the Material Safety Data Sheet (MSDS) for HFC-134a information.

HFC-134a vapors have a slightly sweet odor that can be difficult to detect. Therefore, frequent leak checks and the installation of permanent area monitors may be necessary in enclosed spaces. Refer to ASHRAE Standards 15 and 34 for refrigeration machinery rooms.

To ensure safety when working with HFC-134a in enclosed areas:

1. Route relief and purge vent piping (if present) outdoors, away from air intakes.
2. Make certain area is well ventilated, using auxiliary ventilation if needed to move vapors.
3. Make sure area is clear of vapors prior to beginning work.
4. Install air monitoring equipment to detect leaks.

Refrigerant Properties

Combustibility of HFC-134a

HFC-134a is nonflammable at ambient temperatures and atmospheric pressure. However, tests have shown HFC-134a to be combustible at pressures as low as 5.5 psig (139.3 kPa absolute) at 177°C (350°F) when mixed with air at concentrations generally greater than 60% volume air. At lower temperatures, higher pressures are required for combustibility. (HCFC-22 is also combustible at pressures above atmospheric in the presence of high air concentrations). Test results and calculations have shown:

- At ambient temperature, all concentrations of HFC-134a in air are nonflammable at pressures below 15 psig (205 kPa absolute).
- Combustible mixtures of air and HFC-134a will not form when liquid HFC-134a is pumped into closed vessel if initial air pressure in vessel is limited to one atmosphere absolute and final pressure is limited to 300 psig (2,170 kPa absolute). If initial air pressure is greater than one atmosphere, combustible mixtures may form as tank is filled.

Based on above information, the following operating practices are recommended:

Leak Testing

- Equipment should NEVER be leak tested with a pressurized mixture of HFC-134a and air. HFC-134a may be safely pressured with dry nitrogen.

Bulk Delivery and Storage

- Tanks should normally be evacuated at start of filling, and should never be filled while under positive air pressure.
- Tank pressure should never be allowed to exceed 300 psig (2,170 kPa) when filling with HFC-134a. Relief devices on either tanks or HFC-134a supply system usually prevent this.
- Tank pressures should be monitored routinely.
- Air lines should never be connected to storage tanks.

Filling and Charging Operations

- Before evacuating cylinders or refrigeration equipment, any remaining refrigerant should be removed by recovery system.
- Vacuum pump discharge lines should be free of restrictions that could increase discharge pressures above 15 psig (205 kPa) and result in formation of combustible mixtures.
- Cylinders or refrigeration equipment should normally be evacuated at start of filling, and should never be filled while under positive air pressure.
- Final pressures should not exceed 300 psig (2,170 kPa).
- Filled cylinders should periodically be analyzed for air (nonabsorbable gas or NAG).

Refrigerant Recovery Systems

Efficient recovery of refrigerant from equipment or containers requires evacuation at the end of the recovery cycle. Suction lines to a recovery compressor should be periodically checked for leaks to prevent compressing air into the recovery cylinder during evacuation. In addition, the recovery cylinder pressure should be monitored, and evacuation stopped in the event of a rapid pressure rise indicating the presence of noncondensable air. The recovery cylinder contents should then be analyzed for NAG, and the recovery system leak checked if air is present. DO NOT continue to evacuate a refrigeration system that has a major leak.

Thermal Decomposition

HFC-134a vapors will decompose when exposed to high temperatures from flames or electric resistance heaters. Decomposition may produce toxic and irritating compounds, such as hydrogen fluoride. The pungent odors released will irritate the nose and throat and generally force people to evacuate the area. Therefore, it is important to prevent decomposition by avoiding exposure to high temperatures.

R-134a Physical Properties:

Chemical formula	CF_3CH_2F
Molecular weight	102.03
Boiling point at 1 atm.	-15.1°F (-26.2°C)
Critical temperature	214.0°F (101.1°C)
Critical pressure, psia.	589.9
Critical density. Ib./cu. tt.	31.97
Liquid density at 80°F (26.7°C). Ib./cu. ft.	75.0
Heat of vaporization at boiling point, Btu/lb.°F	92.4
Specific heat of liquid at 80°F (26.7°C). Btu/lb.°F	0.341
Specific heat of vapor at constant pressure (1 atm.) and 80°F (26.7°C), (Btu/lb.°F)	0.204
*Flammable range, %volume in air.	None
Ozone depletion potential	0
Greenhouse warming potential (estimate)	0.285

* Flame limits measured using ASTM E681 with electrically activated kitchen match ignition source per ASHRAE Standard 34.

Comparative Cycle Performance:
Evaporator temperature = 20°F
Condenser temperature = 110°F
Suction superheat = 30°F
sub-cooling = 10°F
Compressor isentropic efficiency = 65%

	Refrigerant		
	12	**22**	**134a**
Evaporator pressure, psig	21.0	43.0	18.5
Condenser pressure, psig	136.4	226.3	146.4
Compression ratio	4.23	4.17	4.86
Compressor discharge temperature, °F	188.1	227.0	178.3
Coefficient of performance	2.90	2.79	2.83
Refrigerant circulation per ton, Ib./min.	3.80	2.78	3.00
Compressor displacement per ton, cfm	4.51	2.82	4.55
Liquid flow per ton, cu. in. /min.	83.2	67.4	71.7
Latent heat at evaporator temp., Btu/lb	66.5	90.6	86.9
Net refrigeration effect. Btu/lb	52.7	72.0	66.7

HFC-134a, CFC-12 Pressure Temperature Chart

°F	°C	HFC-134a	CFC-12		°F	°C	HFC-134a	CFC-12
-60	-51.1	21.8*	19.0*		55	12.8	51.1	52.0
-55	-48.3	20.4*	17.3*		60	15.6	57.3	57.7
-50	-45.6	18.7*	15.4*		65	18.3	63.9	63.8
-45	-42.8	16.9*	13.3*		70	21.1	70.9	70.2
-40	-40.0	14.8*	11.0*		75	23.9	78.4	77.0
-35	-37.2	12.5*	8.4*		80	26.7	86.4	84.2
-30	-34.4	9.8*	5.5*		85	29.4	94.9	91.8
-25	-31.7	6.9*	2.3*		90	32.2	103.9	99.8
-20	-28.9	3.7*	0.6		95	35.0	113.5	108.3
-15	-26.1	0.0	2.4		100	37.8	123.6	117.2
-10	-23.3	1.9	4.5		105	40.6	134.3	126.6
-5	-20.6	4.1	6.7		110	43.3	145.6	136.4
0	-17.8	6.5	9.2		115	46.1	157.6	146.8
5	-15.0	9.1	11.8		120	48.9	170.3	157.7
10	-12.2	12.0	14.6		125	51.7	183.6	169.1
15	-9.4	15.0	17.7		130	54.4	197.6	181.0
20	-6.7	18.4	21.0		135	57.2	212.4	193.5
25	-3.9	22.1	24.6		140	60.0	227.9	206.6
30	-1.1	26.1	28.5		145	62.8	244.3	220.3
35	1.7	30.4	32.6		150	65.6	261.4	234.6
40	4.4	35.0	37.0		155	68.3	279.5	249.5
45	7.2	40.0	41.7		160	71.1	298.4	265.1
50	10.0	45.3	46.7		165	73.9	318.3	281.4

Physical Data	113	141b	123	11	114	124	134a	12	500
Chemical Formula	$C_2Cl_3F_3$	$C Cl_2 F C H_3$	$Ch Cl_2C F_3$	$C Cl_3F$	$C_2Cl_2F_4$	$Ch Cl F C F_3$	$C F_3C H_2F$	$C Cl_2F_2$	---------
Boiling Point @ 1 Atmosphere (°F)	187.4	116.95	152.91	137.4	170.9	136.5	102.03	120.9	99.3
Molecular Weight	117.6	89.7	82.2	74.9	38.8	10.3	-15.08	-21.6	-28.3
Freezing Point @ 1 Atmosphere (°F)	-31	-154.3	-160.6	-168	-137	---------	-141.9	-252	-254
Critical Temperature (°F)	417	410.4	363.2	388	294	252	214	234	222
Critical Pressure (psia)	499	673.0	540	640	473	525	589.8	597	642
Saturated Liquid Density @ 86°F *	96.8	76.31	90.41	91.4	89.8	83.6	74.17	80.8	71.2
Specific Heat of Liquid @ 86°F (Btu/lb.°F)	0.22	0.35	0.21	0.21	0.24	0.27	0.36	0.24	0.30
Specific Heat of Vapor at Constant Pressure (Cp)@86°F and 1 atmos. (Btu/lb.°F)	0.15 (1)	0.17 (1)	0.17	0.14	0.17	0.17	0.21	0.15	0.18
Specific Heat Ratio of Vapor (k=Cp/Cv) @86°F and 1 atmosphere	1.08 (1)	---------	1.10	1.13	1.08	1.09	1.12	1.14	1.14
Flammability and Explosivity Based on ASHRAE Standard 34 (3)	None	7.6 - 17.7 (2)	None	None	None	None	None	None	None
Toxicity Rating **	4-5	Not Avail.	Not Avail.	5	6	Not Avail.	Not Avail.	6	5

(1) @.2 Atmos. Pressure
(2) Upper and Lower Vapor Flammability (Vol%)
(3) ASTM E681-85 Match Ignition Ambient Conditions

Note: Genetron 500 is an azeotropic mixture consisting of CFC12 ($C Cl_2F_2$) 73.8% by weigl and HFC 152a (CH_3CHF_2) 26.2% by weight.

Performance Data

At Standard Ton Conditions (5°F Evaporating 86°F Condensing)	113	141b	123	11	114	124	134a	12	500
Evaporating Pressure (psig)	27.9****	---------	25.2****	23.9****	16.2****	3.5****	9.104	11.8	16.4
Condensing Pressure (psig)	13.9****	---------	1.20	3.62	21.8	50.0	97.004	93.3	112.8
Compression Ratio	7.89	---------	6.91	6.24	5.41	4.98	4.69	4.07	4.11
Compressor Discharge Pressure °F	86	---------	91	104	86	87	97	100	105
Temperature of Suction Gas °F	10	---------	5	5	20	5	5	5	5
Specific Volume of Suction Vapor (cu. ft./lb)	26.9	---------	13.93	12.2	4.32	2.68	1.93	1.46	1.50
Latent Heat of Vaporization (Btu/lb.)	70.6	---------	79.0	83.5	61.1	71.3	89.3	68.2	82.4
Net Refrigerating Effect (Btu/lb.)	54.8	---------	61.0	67.2	42.6	50.4	63.1	50.1	60.6
Coefficient of Performance (C.O.P.)	5.77	---------	4.93	5.09	4.69	4.65	4.60	4.69	4.69
Horsepower per Ton of Refrigerant	0.817	---------	.956	0.926	1.061	1.01	1.02	1.005	1.01
Refrigerant Circulated per Ton (lbs/min)	3.65	---------	3.28	2.98	4.44	3.97	3.17	3.99	3.30
Compressor Suction Gas Volume per Ton ***	98.3	---------	45.7	36.4	20.3	10.7	6.1	5.84	4.96
Liquid Circulated per Ton (cu. in./ min)	65.2	---------	62.9	56.3	90.4	82.1	73.90	85.5	80.2

* (lbs. / cu. ft.) ** Based on Underwriters' system *** (cu. ft./ minute) **** Inches of Mercury Vacuum

Refrigerant Data

Physical Data	22	502	AZ-50	125	AZ-20	13	23	503
Chemical Formula	$CHClF_2$			CHF_2CF_3		$CClF_3$	CHF_3	
Boiling Point @ 1 Atmosphere (°F)	86.5	111.6	97.1	120.0	67.3	104.5	70.0	87.5
Molecular Weight	-41.4	-49.8	-50.5	-55.8	-62.5	-114.6	-115.7	-126.1
Freezing Point @ 1 Atmosphere (°F)	-256	---------	---------	-153	---------	-294	-247	--------
Critical Temperature (°F)	205	180	160	151	164	84	78	67
Critical Pressure (psia)	722	591	538	525	733	561	701	632
Saturated Liquid Density @ 86°F *	73.0	74.5	63.0	72.3	63.4	82.4 (4)	74.7	78.5 (4)
Specific Heat of Liquid @ 86°F (Btu/lb.°F)	0.31	0.30	0.37	0.35	0.42	0.24 (4)	0.33 (4)	0.28 (4)
Specific Heat of Vapor at Constant Pressure (Cp)@86°F and 1 atmos. (Btu/lb.°F)	0.20	0.17	0.21	0.19	0.20	0.13 (4)	0.16 (4)	0.14 (4)
Specific Heat Ratio of Vapor (k=Cp/Cv) @86°F and 1 atmosphere	1.18	1.14	1.11	1.09	1.17	1.18 (4)	1.24 (4)	1.21 (4)
Flammability and Explosivity Based on ASHRAE Standard 34 (3)	None	None	None	None	None	None	None	None
Toxicity Rating **	5	5	Not Avail.	Not Avail.	Not Avail.	6	Not Avail.	6

(4) @-30°F

(5) Performance Data: Based on a -100 °F evaporating/ -30 °F Condensing Cycle

Performance Data At Standard Ton Conditions (5°F Evaporating 86°F Condensing)	22	502	AZ-50	125	AZ-20	13 (5)	23 (5)	503 (5)
Evaporating Pressure (psig)	28.3	35.9	39.5	44.1	56.6	7.9	9.0	16.9
Condensing Pressure (psig)	158.2	176.6	194.2	213.5	261.3	89.6	111.3	132.9
Compression Ratio	4.03	3.78	3.86	3.88	3.87	4.61	5.31	4.65
Compressor Discharge Pressure °F	127	98	94	86	127	-1	36	14
Temperature of Suction Gas °F	5	5	5	5	5	-100	-100	-100
Specific Volume of Suction Vapor (cu. ft./lb)	1.24	0.80	.084	0.63	0.92	1.54	2.18	1.30
Latent Heat of Vaporization (Btu/lb.)	93.2	67.3	77.2	61.5	109.5	62.1	74.7	72.7
Net Refrigerating Effect (Btu/lb.)	69.8	44.9	48.8	37.1	79.3	46.5	78.2	53.7
Coefficient of Performance (C.O.P.)	4.75	4.43	4.21	4.01	4.47	4.21	4.19	4.10
Horsepower per Ton of Refrigerant	0.99	1.06	1.12	1.18	1.05	1.12	1.12	1.16
Refrigerant Circulated per Ton (lbs/min)	2.86	4.46	4.1	5.4	2.52	4.30	2.56	3.73
Compressor Suction Gas Volume per Ton ***	3.55	3.57	3.5	3.4	2.3	6.74	5.6	4.83
Liquid Circulated per Ton (cu. in./ min)	67.7	103.4	112.4	129.0	68.8	90.3	56.8	81.6

* (lbs. / cu. ft.) ** Based on Underwriters' system *** (cu. ft./ minute) **** Inches of Mercury Vacuum

Refrigerant Uses

113 - Trichlorotrifluoroethane
Used in low capacity centrifugal chiller packaged units. operates with very low system pressures, high gas volumes.

141b - Dichlorofluoroethane
Genetron 141b is the leading substitute for CFC 11 in foam blowing insulation applications, such as construction (residential and public) appliances and transport vehicles.

123 - Dichlorotrifluoroethane
Genetron 123 is a very low ozone depleting compound that serves as a replacement for CFC 11 in centrifugal chillers.

11 - Trichlorofluoromethane
A refrigerant used in centrifugal chillers.

114 - Dichlorotetrafluoroethane
Intermediate in pressure and displacement. Principally used with chillers for higher capacities or for lower evaporator temperature process type applications.

124 - Chlorotetrafluoroethane
A potential medium pressure refrigerant for chiller applications.

134a - Tetrafluoroethane
Refrigerant of choice in automotive industry. Genetron134a replaces CFC12 for air conditioning and refrigeration systems in commercial residential and industrial applications.

12 - Dichlorodifluoromethane
A versatile and widely used refrigerant. Common in reciprocating and rotary type equipment. For all types of applications, household to industrial. Also employed in some centrifugal designs and in several special applications.

500 - Azeotrope
An azeotrope of Genetron 12 which has slightly higher vapor pressures and provides higher capacities from the same compressor displacement.

22 - Chlorodifluoromethane
As a refrigerant operates with higher system pressures but offers low compressor displacement requirement. Popular in residential, commercial and industrial applications. Used as an intermediate to produce fluoropolymers.

502 - Azeotrope
An azeotrope of CFC-115 and HCFC-22 which is suited to low evaporation temperature applications. Handles high temperature lifts well and simultaneously provides capacity gains.

AZ-50 - Azeotrope
Az-50 is an azeotropic mixture of HFC-125 45% by weight and HFC-143a 55% by weight. It has been designed to replace R502 in low temperature commercial refrigeration applications.

125 - Chlorotetrafluoroethane
A candidate substitute for use in low temperature refrigeration applications. Low critical temperature may limit use as a stand alone fluid.

AZ-20 - Azeotrope
Az-20 is an azeotropic mixture of HFC-32 60% by weight and HFC-125 40% by weight. Primarily designed to replace HCFC-22 in residential air conditioning applications. U.S.Patent 4978467 Allied Signal

13 - Chlorotrifluoromethane
A specialty low temperature refrigerant used in the low stage of cascade systems to provide evaporator temperatures in the range of -100°F.

23 - Trifluoromethane
A candidate specialty low temperature refrigerant that may be used to replace CFC-13 and R-503 in the low stage of cascade systems.

503 - Azeotrope
An azeotropic mixture of CFC-13 59.9% by weight and HFC-23 40.1% by weight which is used in the low stage of cascade type systems where it provides gains in compressor capacity and in low temperature capability. U.S.Patent 3640869 Allied Chemical Corp.

Refrigerant Vapor Pressures

Temp °F	113	141b	123	11	114	124	134a	12	500	22	502	AZ-50	125	AZ-20	13	23	503
-150.0								29.6	29.5	29.4	29.1	29.3	28.7	28.6	20.9	21.2	16.9
-140.0						29.7	29.6	29.4	29.2	29.1	28.5	28.9	28.1	27.9	16.8	17.1	11.1
-130.0						29.6	29.4	29.1	28.8	28.5	27.8	28.2	27.2	26.8	11.5	11.4	3.5
-120.0						29.5	29.1	28.6	28.3	27.7	26.7	27.3	25.9	25.3	4.5	3.9	3.1
-110.0					29.7	29.3	28.7	27.9	27.5	26.6	25.3	25.9	24.2	23.3	2.1	2.9	9.3
-100.0				29.7	29.5	29.0	28.0	27.0	26.9	25.1	23.3	23.9	21.8	20.5	7.6	9.0	16.9
-90.0				29.6	29.3	28.5	27.1	25.8	24.9	23.0	20.6	21.2	18.7	16.7	14.3	16.8	26.3
-80.0			29.7	29.5	29.0	27.8	25.7	24.1	22.9	20.2	17.2	17.6	14.7	11.9	22.5	26.3	37.7
-70.0	29.7	29.7	29.6	29.4	28.6	26.9	24.0	21.9	20.3	16.6	12.7	13.0	9.6	5.7	32.3	38.0	51.3
-60.0	29.7	29.5	29.4	29.1	28.0	25.7	21.6	19.0	17.0	11.9	7.2	7.0	3.1	1.1	43.9	52.0	67.3
-50.0	29.6	29.3	29.2	28.8	27.1	24.1	18.6	15.4	12.8	6.1	0.2	0.3	2.4	5.9	57.6	68.7	86.1
-40.0	29.4	29.0	28.8	28.3	26.1	22.0	14.7	11.0	7.6	0.6	4.1	4.8	7.3	11.8	73.3	88.4	107.8
-35.0	29.3	28.8	28.6	28.0	25.4	20.7	12.3	8.4	4.6	2.6	6.5	7.5	10.1	15.2	82.2	99.4	119.9
-30.0	29.2	28.6	28.3	27.7	24.7	19.3	9.7	5.5	1.2	4.9	9.2	10.4	13.2	18.9	91.6	111.3	132.8
-25.0	29.1	28.3	28.1	27.4	23.8	17.7	6.8	2.3	1.2	7.5	12.1	13.6	16.5	23.0	101.7	124.1	146.7
-20.0	29.0	28.1	27.7	26.9	22.9	15.9	3.6	0.6	3.2	10.2	15.3	17.0	20.2	27.5	112.5	137.8	161.4
-15.0	28.8	27.7	27.3	26.5	21.8	13.9	0.0	2.5	5.4	13.2	18.8	20.8	24.3	32.4	123.9	152.5	177.1
-10.0	28.6	27.3	26.9	25.9	20.6	11.6	2.0	4.5	7.8	16.5	22.6	25.0	28.6	37.8	136.1	168.2	193.9
-5.0	28.4	26.9	26.4	25.3	19.3	9.1	4.1	6.7	10.4	20.1	26.7	29.5	33.4	43.5	149.1	185.0	211.6
0.0	28.1	26.4	25.8	24.6	17.8	6.4	6.5	9.2	13.3	24.0	31.1	34.3	38.6	49.8	162.9	203.0	230.5
5.0	27.8	25.8	25.2	23.9	16.2	3.4	9.1	11.8	16.4	28.3	35.9	39.5	44.1	56.6	177.4	222.0	250.5
10.0	27.5	25.2	24.5	23.0	14.4	0.1	12.0	14.7	19.7	32.8	41.0	45.1	50.2	63.9	192.8	242.4	271.7
15.0	27.1	24.5	23.7	22.1	12.4	1.7	15.1	17.7	23.3	37.8	46.5	51.2	56.6	71.8	209.1	263.9	294.1
20.0	26.7	23.7	22.8	21.0	10.2	3.7	18.4	21.1	27.2	43.1	52.5	57.7	63.6	80.2	226.3	286.9	317.8
25.0	26.2	22.8	21.8	19.8	7.8	5.8	22.1	24.6	31.4	48.8	58.8	64.6	71.1	89.3	244.4	311.2	342.8
30.0	25.7	21.8	20.7	18.5	5.1	8.1	26.1	28.5	36.0	54.9	65.6	72.0	79.1	99.0	263.5	337.1	369.3
35.0	25.1	20.7	19.5	17.1	2.2	10.6	30.4	32.6	40.8	61.5	72.8	79.9	87.7	109.4	283.6	364.5	397.2
40.0	24.4	19.5	18.1	15.5	0.4	13.3	35.0	37.0	46.0	68.5	80.5	88.3	96.9	120.5	304.8	393.5	426.6
45.0	23.7	18.1	16.6	13.8	2.1	16.2	40.0	41.7	51.6	76.1	88.7	97.3	106.7	132.4	327.1	424.3	457.5
50.0	22.9	16.7	15.0	12.0	3.9	19.4	45.4	46.7	57.5	84.1	97.4	106.8	117.1	145.0	350.4	457.0	490.2
55.0	21.9	15.1	13.1	9.9	5.9	22.8	51.2	52.1	63.8	92.6	106.6	116.9	128.2	158.4	375.0	491.5	524.5
60.0	20.9	13.4	11.2	7.7	8.0	26.5	57.4	57.8	70.6	101.6	116.4	127.6	140.0	172.6	400.9	528.3	560.7
65.0	19.8	11.5	9.0	5.3	10.3	30.4	64.0	63.8	77.7	111.3	126.7	139.0	152.5	187.7	428.1	567.3	598.7
70.0	18.6	9.4	6.6	2.7	12.7	34.6	71.11	70.2	85.3	121.4	137.6	151.0	165.7	203.7	456.8	608.7	
75.0	17.2	7.2	4.1	0.1	15.3	39.1	78.6	77.0	93.4	132.2	149.1	163.7	179.7	220.6	487.2	652.7	
80.0	15.8	4.8	1.3	1.6	18.2	43.9	86.7	84.2	101.9	143.7	161.2	177.1	194.5	238.5	519.4		
85.0	14.2	2.3	0.9	3.2	21.2	49.0	95.2	91.7	110.9	155.7	174.0	191.3	210.2	257.4			
90.0	12.4	0.2	2.5	4.9	24.4	54.4	104.3	99.7	120.5	168.4	187.4	206.2	226.7	277.3			
95.0	10.5	1.7	4.2	6.8	27.8	60.2	113.9	108.2	130.5	181.8	201.4	222.0	244.1	298.4			
100.0	8.5	3.2	6.1	8.8	31.4	66.3	124.1	117.0	141.1	196.0	216.2	238.6	262.4	320.5			
105.0	6.2	4.8	8.1	10.9	35.3	72.8	134.9	126.4	152.2	210.8	231.7	256.1	281.6	343.8			
110.0	3.8	6.6	10.2	13.2	39.4	79.7	146.3	136.2	163.9	226.4	247.9	274.6	301.8	368.2			
115.0	1.2	8.4	12.6	15.7	43.8	87.0	158.4	146.5	176.3	242.8	264.9	294.0	323.1	393.9			
120.0	0.7	10.4	15.0	18.3	48.4	94.7	171.1	157.3	189.2	260.0	282.7	314.4	345.3	420.9			
125.0	2.2	12.4	17.7	21.1	53.3	102.8	184.5	168.6	202.7	278.1	301.3	335.9	368.7	449.2			
130.0	3.8	14.6	20.5	24.0	58.4	111.4	198.7	180.5	219.9	297.0	320.6	358.6	393.1	478.9			
135.0	5.5	16.9	23.5	27.1	63.9	120.4	213.5	192.9	231.8	316.7	341.2	382.4	418.6	510.0			
140.0	7.3	19.3	26.7	30.5	69.6	129.9	229.2	205.9	247.4	337.4	362.6	407.5	445.4	542.5			
145.0	9.2	21.8	30.2	34.0	75.6	139.9	245.6	219.5	263.7	359.1	384.9	433.9	473.3	576.5			
150.0	11.3	24.4	33.8	37.7	82.0	150.4	262.8	233.7	280.7	381.7	408.4	461.7	502.4	612.1			

CFCs

Chlorofluorocarbons (CFCs) are compounds consisting of chlorine, fluorine, and carbon atoms which are very stable in the troposphere. They are degraded only in the stratosphere by the sun's radiation where released chlorine may contribute to ozone depletion. They can persist in the troposphere for a hundred years or longer.

Fluorocarbons

These chemical compounds include CFCs, hydrochlorofluorocarbons (HCFCs), and hydrofluorocarbons (HFCs). For many years, CFCs have served vital functions in society. They are used in a variety of applications including refrigeration, air conditioning, energy efficient insulation, medical products, and cleaning of electronic and precision engineering components. HCFCs and HFCs retain many of the desirable properties of CFCs but because they exist for a shorter time in the atmosphere, ozone depletion and global warming concerns are significantly reduced.

Global Warming

Global warming, which is an increase in the natural greenhouse effect, refers to the physical phenomenon that may lead to heating of the earth. Most of the sun's energy reaches the earth as visible light. After passing through the atmosphere, part of this energy is absorbed by the earth's surface and in the process is converted into heat energy. The earth, now warmed by the sun, radiates heat energy back into the atmosphere toward space.

Naturally occurring gases, such as carbon dioxide, water vapor, and ozone, absorb and thus retain some of the outgoing heat energy. This process slows the heat loss, making the earth's surface warmer than it would be if this heat energy had passed unobstructed through the atmosphere into space. The warmer earth's surface, in turn, radiates more heat until a balance is established between incoming and outgoing energy. This warming process, caused by the atmosphere's absorption of the heat energy radiated from the earth's surface, is called the greenhouse effect.

Increasing concentrations of gases from man-made sources (e.g., carbon dioxide, methane, and CFCs) that absorb the heat radiation could lead to a slow warming of the earth. This phenomenon is commonly referred to as global warming.

Global Warming Potential (GYP)

An index developed to provide a simplified means of describing the relative ability of each greenhouse gas emission to affect radiative forcing and thereby the global climate. GYPs are defined on amass basis, relative to either CFC-11 (the Halocarbon GYP or HGWP) or carbon dioxide. Because CFC-11 has a finite lifetime in the atmosphere, the HGWP can be calculated explicitly and is a single number. Because carbon dioxide does not have a finite lifetime in the atmosphere, GYPs relative to it have to be calculated up to a particular time horizon, for example, 20, 100, or 500 years.

Greenhouse Gases

Gases present in relatively small quantities in the atmosphere that strongly absorb infrared radiation or "heat" emitted by the earth. The primary greenhouse gases are water vapor, carbon dioxide, methane, nitrous oxide, ozone, and some of the chlorofluorocarbons. Concentrations of several greenhouse gases are increasing, primarily as a result of human activities.

Glossary of Terms

HCFCs

Hydrochlorofluorocarbons (HCFCs) are compounds comprised of hydrogen, chlorine, fluorine, and carbon atoms. These compounds have many of the useful properties of CFCs, but are destroyed naturally in the lower atmosphere and do not persist to the same extent as CFCs. Only a fraction of HCFCs emitted can be transported to the ozone layer in the stratosphere where their chlorine could deplete ozone. HCFCs typically have an ozone depletion potential 2 to 10 percent that of CFCs.

HFCs

Hydrofluorocarbons (HFCs) are compounds consisting of hydrogen, fluorine, and carbon atoms which, like the HCFCs, are destroyed naturally in the lower atmosphere. They have many of the useful properties of the CFCs. Because they do not contain chlorine, they are not involved in ozone depletion.

NOT-IN-KIND (NIK) Technologies

Technologies that do not rely on the use of fluorocarbons.

Ozone

Ozone, formed in the stratosphere by the action of sunlight on oxygen, is also an airborne pollutant near ground level. Low altitude (tropospheric) ozone is formed by reactions between hydrocarbons and oxides of nitrogen in sunlight.

Ozone Depletion

Ozone is continually being formed and destroyed by chemical reactions occurring in the stratosphere. There are large natural changes in ozone concentration in the stratosphere; for example, between summer and winter there is a change of about 25 percent at mid-latitudes. Ozone depletion occurs if the rate of ozone destruction is increased due to human activities.