EPA CERTIFICATION TRAINING

for

Air Conditioning & Refrigeration Technicians

Federal Clean Air Act - 608

Section 608 of the Federal Clean Air Act

REQUIRES

All persons who maintain, service, repair, or dispose of appliances that contain regulated refrigerants, be certified in proper refrigerant handling techniques.

If EPA regulations change after a technician becomes certified, it is the responsibility of the technician to comply with any future changes.

There are Four (4) Categories of Technician Certification

TYPE I

Persons who maintain, service or repair small appliances must be certified as Type I technicians.

TYPE II

Persons, who maintain, service, repair or dispose of high or very high-pressure appliances, except small appliances and motor vehicle air conditioning systems, must be certified as Type II technicians.

TYPE III

Persons, who maintain, service, repair, or dispose of low-pressure appliances must be certified as Type III technicians.

UNIVERSAL

Persons, who maintain, service or repair both low and high-pressure equipment, as well as small appliances, must be certified as Universal technicians.

TEST FORMAT

The test contains four sections, Core (A), I, II, III.

Each section contains twenty five (25) multiple-choice questions.

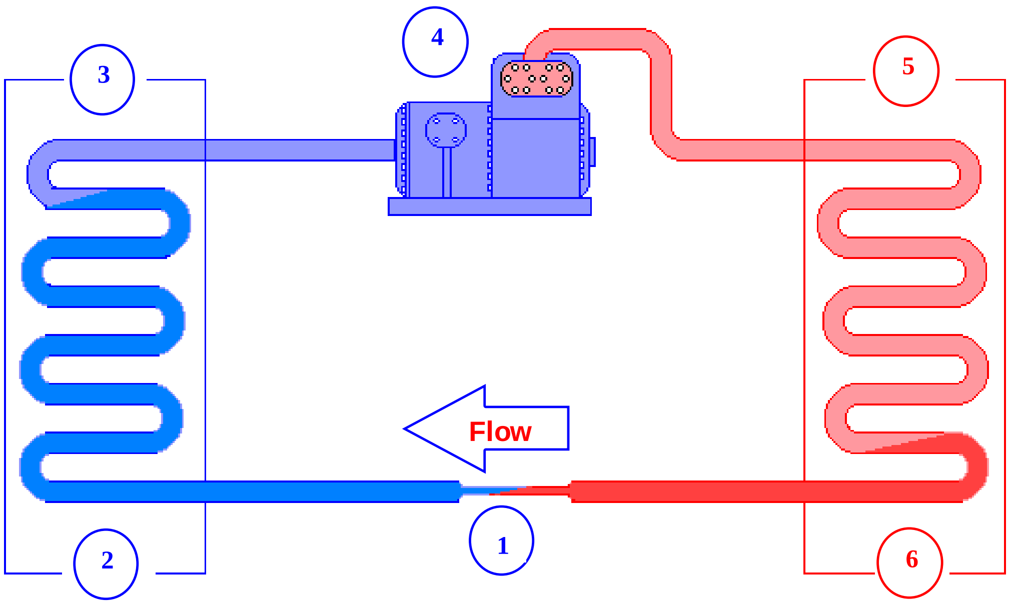
A technician MUST achieve a minimum passing score of 70 percent on the CORE and in each group in which they are to be certified.

If a technician fails one or more of the Sections on the first try, they may retake the failed Section(s) without retaking the Section(s) on which they earned a passing score. In the meantime the technician will be certified in the Type for which they received a passing score.

WHAT IS REFRIGERATION

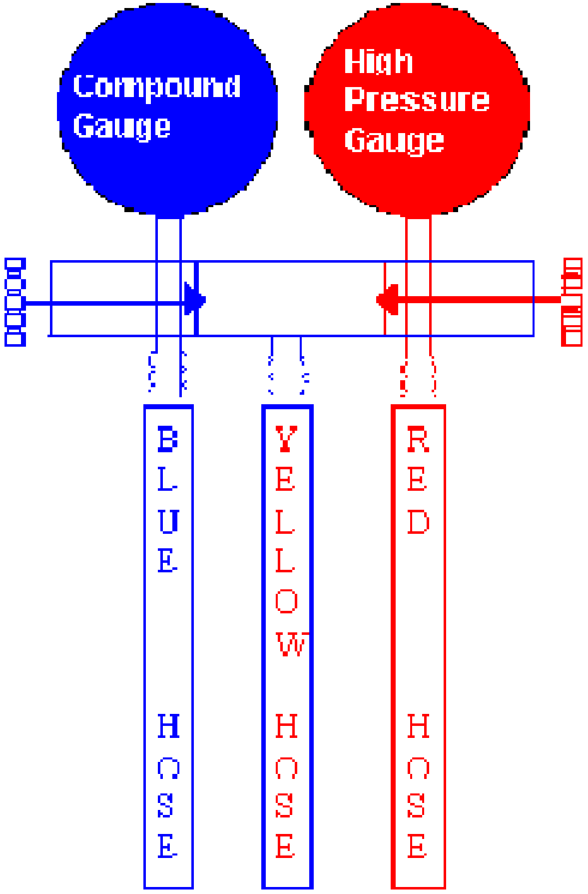
Heat is a form of energy. Refrigeration is the movement of heat from an area where it is not wanted to an area where it is less objectionable. For example, a refrigerator removes heat from the inside of the cabinet and transfers it to the outside.

VAPOR / COMPRESSION REFRIGERATION CYCLE



Liquid refrigerant at a high pressure is delivered to a metering device, (**1**). The metering device causes a reduction in pressure, and therefore a reduction in saturation temperature. The refrigerant then travels to the evaporator, (**2**). Heat is absorbed in the evaporator & causes the refrigerant to boil from liquid to vapor. At the outlet of the evaporator, (**3**), the refrigerant is now a low temperature, low pressure vapor. The refrigerant vapor then travels to the inlet of the compressor, (**4**). The refrigerant vapor is then compressed and moves to the condenser, (**5**). The refrigerant is now a high temperature, high pressure vapor. As the refrigerant expels heat, the refrigerant condenses to a liquid. At the condenser outlet, (**6**), the refrigerant is a high pressure liquid. The high pressure liquid refrigerant is delivered to the metering device, (**1**), and the sequence begins again.

GAUGE MANIFOLD SET



One of the most important tools to the HVAC&R technician is the gauge manifold set. The compound gauge (**BLUE**) and the high pressure gauge (**RED**) are connected to the manifold, and the manifold is then connected by hoses to access ports to measure system pressures. The compound gauge measures low pressure (psig) and vacuum (inches Hg.). The high pressure gauge measures high side (discharge) pressure. The manifold is also equipped with a center port, (usually a **YELLOW** hose), that can be connected to a recovery device, evacuation vacuum pump, or charging device. EPA regulations require that hoses be equipped with **low loss fittings** that will minimize refrigerant loss when hoses are disconnected.

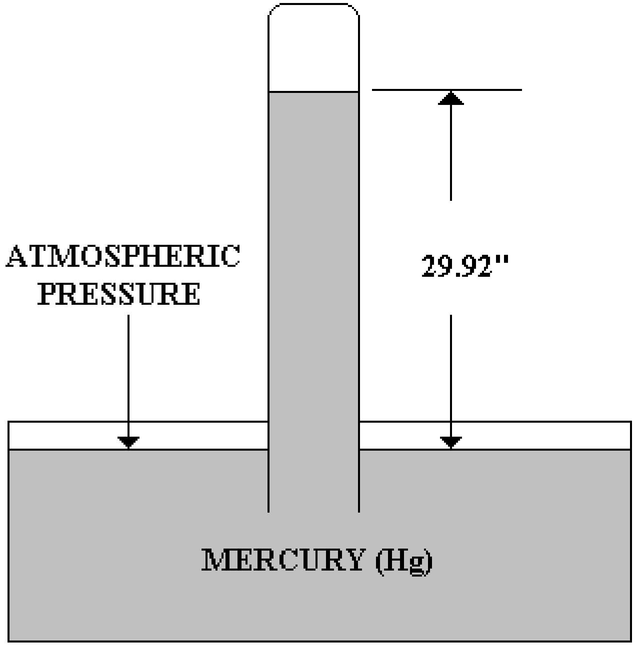
PRESSURE / VACUUM

Pressure is defined as the force per unit area, most often described as pounds per square inch (U.S.).

ATMOSPERIC PRESSURE

Our atmosphere extends about 50 miles above the earth and consists of approximately 78% nitrogen, 21% oxygen, the remaining 1% is composed of other gasses. Even though the gas molecules are very small, they have weight. The atmosphere exerts a pressure of 14.7 lbs. per square inch at sea level. At higher altitudes, the atmospheric pressure will be significantly less.

The most common method of measuring atmospheric pressure is the mercury barometer. Normal atmospheric pressure at sea level (14.7 psia) will support a column of mercury 29.92 inches high.



Mercury barometer

Atmospheric pressure will support a column of mercury 29.92 inches in the sealed tube.

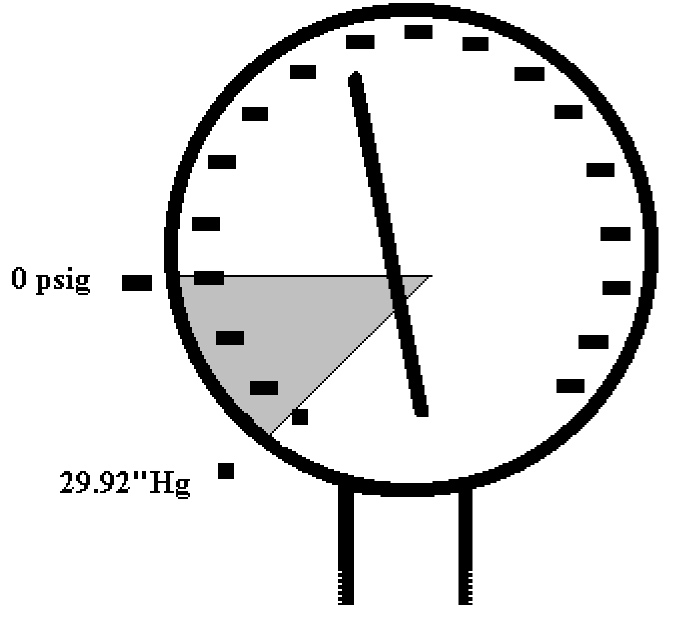
GAUGE PRESSURE

The pressure reading we most often use is called gauge pressure. Atmospheric pressure is shown as 0 psi or psig (pound per square inch *gauge*).

COMPOUND GAUGES

COMPOUND GAUGES

Compound gauges that are used to measure low side pressures in air conditioning systems can measure pressures both above and below 0 psig. Gauge readings are relative to atmospheric pressure. It will be necessary to adjust a compound gauge periodically to compensate for changes in atmospheric pressure.



VACUUM

Pressures below atmospheric are usually read in inches of mercury (in. Hg) or in millimeters of mercury (mm Hg).

A thorough understanding of vacuum principles is an absolute necessity for the air conditioning technician. Since an increase in pressure will increase the boiling point of a liquid, the opposite is also true. Lower pressure will result in a lower boiling point. Any pressure below atmospheric is considered a partial vacuum. A perfect vacuum would be the removal of all atmospheric pressure. For reading deep vacuum, a micron gauge is used. A micron is 1/1000th of a millimeter.

ABSOLUTE PRESSURE

The absolute pressure scale allows measurement of both vacuum and pressure to be made using the same units. Absolute pressure measurements are indicated as psia (pounds per square inch absolute). 0 psia is a pressure that cannot be further reduced.

Since atmospheric pressure will measure 14.7 psia at sea level, gauge pressure can be converted to absolute pressure by adding 14.7 to the gauge pressure reading.

CORE
SECTION A
General Knowledge

Passing the CORE is a prerequisite to achieving certification

STRATOSPHERIC OZONE DEPLETION

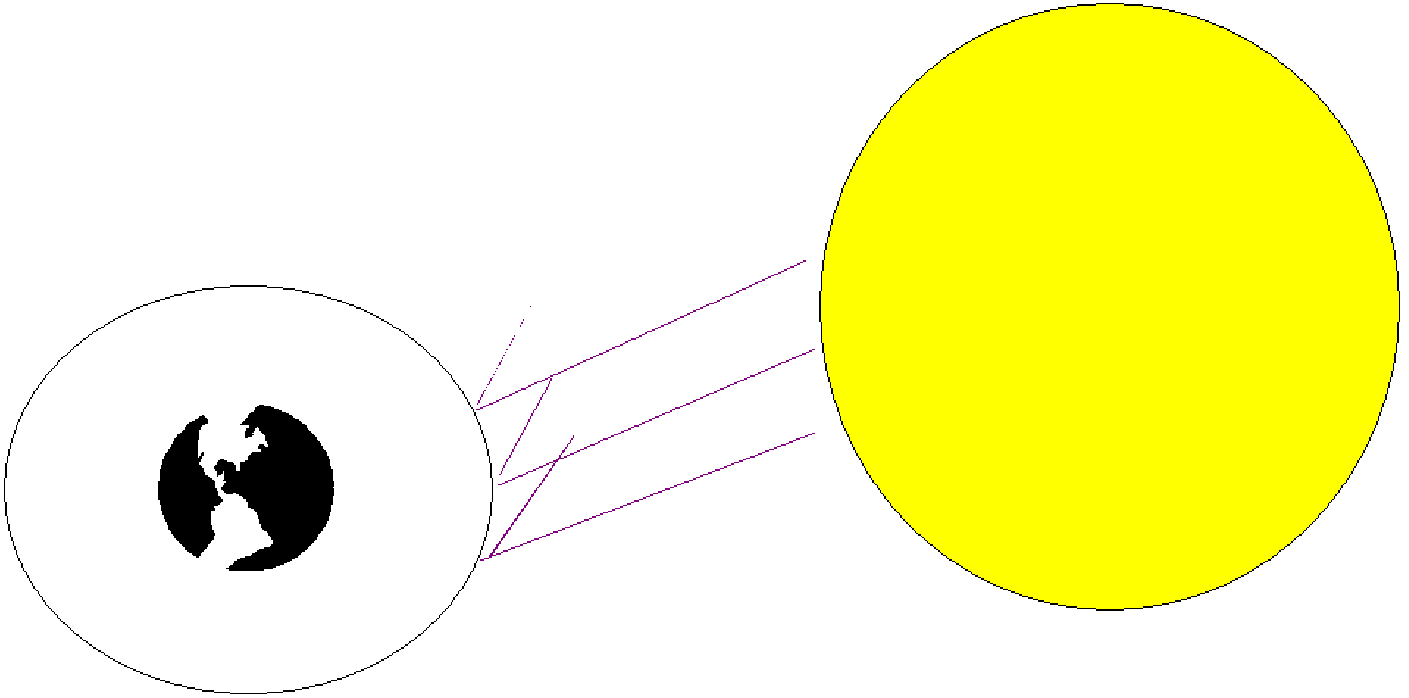
The stratosphere is the Earth's security blanket. It is located between 10 and 30 miles above sea level and is comprised of, among other things, Ozone.

An Ozone molecule consists of three oxygen atoms (0_3).

OZONE PROTECTS US FROM HARMFUL ULTRA VIOLET RADIATION AND HELPS TO MAINTAIN STABLE EARTH TEMPERATURES

Stratospheric Ozone Depletion is a

GLOBAL PROBLEM



Depletion of Ozone in the Stratosphere Causes

- CROP LOSS
- INCREASE IN EYE DISEASES
- SKIN CANCER
- REDUCED MARINE LIFE
- DEFORESTATION
- INCREASED GROUND LEVEL OZONE

CFC's & HCFC's in the STRATOSPHERE

CFC's and HCFC's, when released into the atmosphere deplete the Ozone layer.

The chlorine in these compounds is the culprit.

When a chlorine atom meets with an Ozone molecule, it takes one Oxygen atom from the Ozone. This forms a compound called **Chlorine Monoxide** (ClO) and leaves an O_2 molecule.

CHLORINE IS THE CULPRIT

Chlorine Monoxide will collide with another Ozone molecule, release its Oxygen atom, forming two O_2 molecules, and leave the chlorine free to attack another Ozone molecule.

A single Chlorine atom can destroy 100,000 Ozone molecules.

SOURCE of CHLORINE in the STRATOSPHERE

Some believe that the Chlorine found in the stratosphere comes from natural sources such as volcanic eruptions. However, air samples taken over erupting volcanoes show that volcanoes contribute only a small quantity of Chlorine as compared to CFC's. In addition, the rise in the amount of Chlorine measured in the stratosphere over the past two decades matches the rise in the amount of Fluorine, which has different natural sources than Chlorine, over the same period. Also, the rise in the amount of Chlorine measured in the stratosphere over the past twenty years, matches the rise in CFC emissions over the same period.

Chlorine in CFC's vs. Naturally Occurring Chlorine

The chlorine in **CFC's** will neither dissolve in water nor break down into compounds that dissolve in water, so they **do not rain out of the atmosphere** and return to earth.

Naturally occurring chlorine will dissolve in water (humidity) and rain out of the atmosphere.

OZONE DEPLETION POTENTIAL

Ozone Depletion Potential (ODP) is a measurement of CFC's and HCFC's ability to destroy ozone. **CFC's have the highest ODP**.

HFC's (R-134A) do not contain chlorine and **have no Ozone Depletion Potential.**

The Three (3) Primary Types of REFRIGERANTS

TYPE	EXAMPLE	ELEMENTS
CFC	R-11 R-12 R-500	Chlorine-Fluorine-Carbon
HCFC	R-22 R-123	Hydrogen-Chlorine-Fluorine-Carbon
HFC	R-134a R-410A	Hydrogen-Fluorine-Carbon

THREE PRIMARY REFRIGERANT TYPES:

CFC = CHLORINE - FLUORINE - CARBON
EXAMPLE: R-11, R-12, R-500

HCFC = HYDROGEN - CHLORINE - FLUORINE - CARBON
EXAMPLE: R-22, R-123

HFC = HYDROGEN - FLUORINE - CARBON
EXAMPLE: R-134a

CLEAN AIR ACT

The United States Environmental Protection Agency (EPA) regulates section 608 of the Federal Clean Air Act. Failure to comply could cost you and your company as much as **$27,500**. per day, per violation and there is a **bounty** of up to **$10,000** to lure your competitors, customers and fellow workers to turn you in. Service technicians who violate Clean Air Act provisions may be fined, lose their certification, and may be required to appear in Federal court.

It is a Violation of Section 608 to:

- Falsify or fail to keep required records;
- Fail to reach required evacuation rates prior to opening or disposing of appliances;
- Knowingly release (vent) CFC's, HCFC's or HFC’s while repairing appliances, with the exception of de-minimus releases;
- Service, maintain, or dispose of appliances designed to contain refrigerants without being appropriately certified as of November 14, 1994. (It is the responsibility of the final person in the disposal chain to ensure that refrigerant has been removed from appliances before scrapping.)
- Vent CFC's or HCFC's since July 1, 1992;
- Vent HFC's since November 15, 1995;
- Fail to recover CFC's, HCFC's or HFC’s before opening or disposing of an appliance;
- Fail to have an EPA approved recovery device, equipped with low loss fittings, and register the device with the EPA;
- Add nitrogen to a fully charged system, for the purpose of leak detection, and thereby cause a release of the mixture;
- Dispose of a disposable cylinder without first recovering any remaining refrigerant (to 0 psig.) and then rendering the cylinder useless, then recycling the metal;

STATE & LOCAL REGULATIONS

State & local governments may not pass regulations that are less strict than those contained in Section 608.

They may pass regulations that are as strict or stricter than Federal regulations.

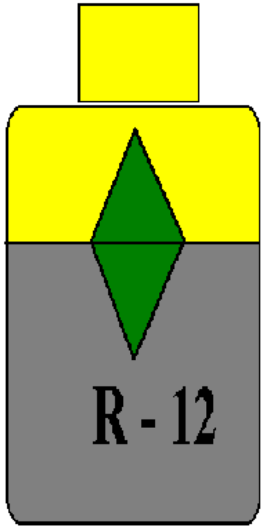
THE MONTREAL PROTOCOL

The Montreal Protocol is an international treaty.

It regulates the production and use of CFCs, HCFC’s, halons, methyl chloroform and carbon tetrachloride.

CFC's were phased out of production on December 31, 1995. HCFC refrigerants are scheduled of phase out in the future.

When virgin supplies of CFC's are depleted, future supplies will come from recovered, recycled, or reclaimed refrigerants.



RECOVERY

To remove refrigerant in any condition from an appliance and store it in an

EXTERNAL CONTAINER

RECOVERY & REUSE

Refrigerant that has been recovered from a unit (if it is not contaminated) may be reused in the unit from which it was removed.

It may be reused in another unit so long as the equipment that it was removed from and the unit to which it is being introduced is owned by the same owner. This requirement is designed to prevent excessive cross-contamination

RECYCLE

To clean refrigerant for reuse by separating the oil from the refrigerant and removing moisture by passing it through one or more filter driers

RECLAIM

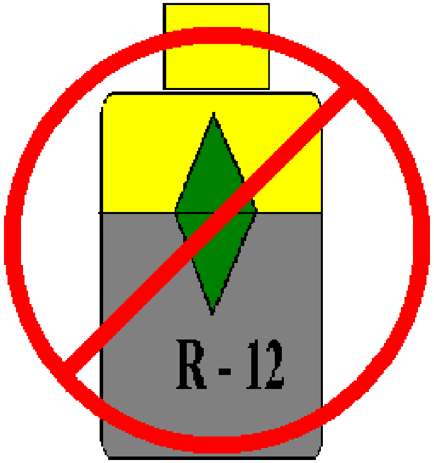
To process refrigerant to a level equal to new product standards as determined by chemical analysis. Reclaimed refrigerant must meet standards set forth in ARI 700 before it can be resold.

RECOVERY DEVICES

Refrigerant Recovery and/or Recycling equipment manufactured after November 15, 1993, must be certified and labeled by an EPA approved equipment testing organization to meet EPA standards. There are two basic types of recovery devices.

1) **“System-dependent”** which captures refrigerant with the assistance of components in the appliance from which refrigerant is being recovered.

2) **"Self-contained”** which has its own means to draw the refrigerant out of the appliance (a compressor).



SALES RESTRICTION

As of November 14, 1994, **the sale of CFC and HCFC refrigerants were restricted to certified technicians**.

Only technicians certified under Clean Air Act Section 609 (Motor Vehicle Air Conditioning) are allowed to purchase R-12 in containers smaller than 20 lbs.

SUBSTITUTE REFRIGERANTS & OILS

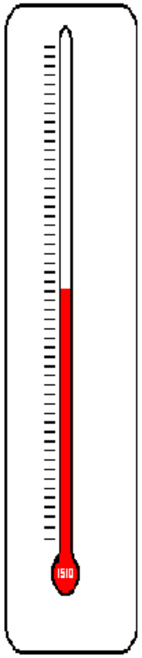
HFC’s are considered Ozone friendly. R-134A is the leading candidate for CFC R-12 retrofit, but it is not a drop-in substitute. Actually, there is not a drop-in alternative, but R-134A can be used in most R-12 systems by following appropriate retrofit procedures. HFC’s will not mix with most refrigerant oils used with CFC’s & HCFC’s. The oils used in most HFC systems are ESTERS. Esters cannot be mixed with other oils. It is also important to remember that when leak testing an HFC system to use pressurized nitrogen.

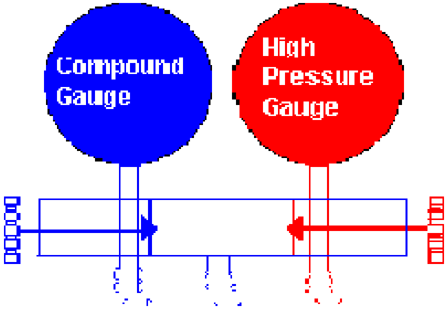
REFRIGERANT BLENDS

There are several refrigerant blends commonly in use. Some of the blends are called **Ternary**, which means they are a **three-part blend**. Ternary blends are used with a **synthetic alkylbenzene oil**.

REFRIGERANT BLEND CHARGING

The components of a **blended refrigerant will leak** from a system **at uneven rates due to different vapor pressures** and, the proper **charging method** for blended refrigerants is to **weigh into the high side of the system as a liquid**.





TEMPERATURE GLIDE

Temperature glide refers to a refrigerant blend that has a **range of boiling points and / or condensing points** throughout the evaporator and condenser respectively.

AZEOTROPIC REFRIGERANTS

An **azeotropic mixture acts like a single component** refrigerant over its entire temperature / pressure range. An azeotrope does not have a temperature glide.

HYGROSCOPIC OIL

Most refrigerant oils are hygroscopic.

A Hygroscopic oil is one that easily absorbs & releases moisture (has a high affinity for water).

An oil sample should be taken and analyzed if a system has had a major component failure.

RECOVERY and CUSTOMER RELATIONS

Some customers have complained about the increased cost of service. To justify the increase, simply explain that you are duty bound and required by law to recover refrigerants in order to protect the environment and human health.

EPA REQUIREMENT OF EQUIPMENT MANUFACTURERS

EPA regulations require a service aperture or process stub on all appliances that use a Class I or Class II refrigerant in order to make it easier to recover refrigerant.

MIXED REFRIGERANT RECOVERY

Do not mix refrigerants in a recovery cylinder.

A refrigerant mix may be impossible to reclaim.

If you discover that two or more refrigerants have been mixed in a system, you must recover the mixture into a separate tank.

Badly contaminated and mixed refrigerants must be destroyed.

REFRIGERANT RECOVERY with a COMPRESSOR BURN-OUT

A strong odor is an excellent indicator of a compressor burn-out .

If you suspect a compressor burn-out, flush the system & watch for signs of contamination in the oil.

If nitrogen is used to flush debris out of the system, the nitrogen may be vented.

A suction line filter drier should be installed to trap any debris that may damage the new compressor.

RECOVERY SPEED

Long hoses will reduce pressure resulting in increased recovery time.

Since all refrigerants have a pressure temperature relationship, lower ambient temperatures, result in slower recovery rate.

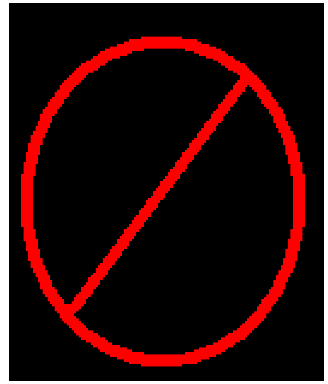
DEHYRATION

To remove water and water vapor from a refrigeration system

If moisture is allowed to remain in an operating refrigeration system, hydrochloric & hydrofluoric acids may form.

Evacuation of a system is the suggested method of dehydration.

It is not possible to over evacuate a system.



EVACUATION

Never evacuate a system to the air without first following proper recovery procedures and attaining the mandated vacuum level.

EVACUATION ESSENTIALS for Accurate Readings & Speed

Vacuum lines should be equal to or larger than the pump intake connection.

The piping connection to the pump should be as short a length as possible and as large in diameter as possible.

The system vacuum gauge should be connected as far as possible from the vacuum pump.

EVACUATION
SPEED & EFFICIENCY

FACTORS

Size of equipment being evacuated

Ambient temperature

Amount of moisture in the system

The size of the vacuum pump and suction line

Heating the refrigeration system will decrease dehydration time

EVACUATION Precautions

The use of a large vacuum pump could cause trapped water to freeze.

During evacuation of systems with large amounts of water, it may be necessary to increase pressure by introducing nitrogen to counteract freezing.

COMPLETING THE DEHYRATION PROCESS

Measuring a systems vacuum should be done with the system isolated and the vacuum pump turned off.

A system that will not hold a vacuum probably has a leak.

Dehydration is complete when the vacuum gauge shows that you have reached and held the required finished vacuum.

MEASURING DEHYDRATION EFFECTIVENESS

It is difficult to determine dehydration effectiveness using a compound gauge that reads in inches of Hg *(MERCURY)*

The use of a Micron Gauge & achieving 500 microns of vacuum assures proper dehydration.

MICRONS	INCHES OF Hg	Vaporization Temp of Water at each Pressure
0	29.921	------
20	29.92	-50
100	29.92	-40
150	29.92	-33
200	29.91	-28
300	29.91	-21
500	29.90	-12
1,000	29.88	1
4,000	29.76	29
10,000	29.53	52
20,000	29.13	72
50,000	27.95	101
100,000	25.98	125
200,000	22.05	152
500,000	10.24	192
760,000	0	212

RECOVERY CYLINDERS

Recovery cylinders are designed to be refilled.

Recovery cylinders have 2 ports, one liquid and one vapor.

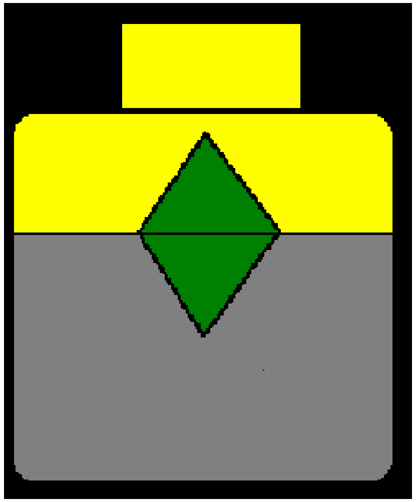
They must not be overfilled or heated.

Overfilling or heating can cause an explosion.

NEVER heat a refrigerant cylinder with an open flame

The EPA requires that refillable refrigerant cylinders MUST NOT BE FILLED ABOVE 80% of their capacity by weight, and that the safe filling level can be controlled by either mechanical float devices, electronic shut off devices (thermistors), or weight.

Refillable cylinders must be hydrostatically tested and date stamped every 5 years.



Refillable cylinders used for transporting recovered pressurized refrigerant must be DOT (Department of Transportation) approved. Approved refrigerant recovery cylinders can easily be identified by their colors, YELLOW TOPS AND GRAY BODIES. All refrigerant recovery cylinders should be inspected for RUST. If they show signs of rust or appear to not be secure they should be reduced to 0 psig and discarded.

DISPOSABLE CYLINDERS

Disposable cylinders are used with virgin refrigerant and may NEVER be used for recovery.

SCHRADER VALVES

It is necessary to inspect Schrader valve cores for leaks, bends and breakage, & replace damaged valve cores to prevent leakage.

Always cap Schrader ports to prevent accidental depression of the valve core.

PERSONAL SAFETY - WEAR

When handling and filling refrigerant cylinders, or operating recovery or recycling equipment, you should wear

SAFETY GLASSES

PROTECTIVE GLOVES

NITROGEN PRESSURE–TESTING SAFETY

When pressurizing a system with nitrogen, you should:

1. **Charge through a pressure regulator**
2. **Insert a relief valve in the downstream line from the pressure regulator**
3. **NEVER install relief valves in series**
4. **Replace the relief valve if corrosion is found within the body of a relief valve**

To determine the safe pressure for leak testing, check the data plate for the low-side test pressure value

OXYGEN & COMPRESSED AIR

When leak checking a system, NEVER pressurize the system with oxygen or compressed air.

When mixed with refrigerants, oxygen or compressed air can cause an explosion.

SAFETY
&
LARGE REFRIGERANT LEAKS

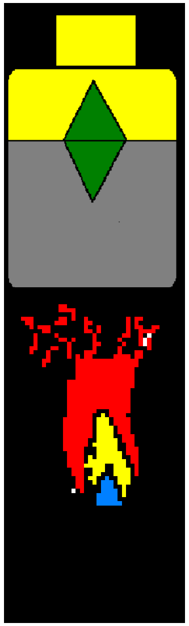
If a "large" release of refrigerant in a confined area occurs;

Self Contained Breathing Apparatus (SCBA) is required.

If SCBA is not available, IMMEDIATELY VACATE AND VENTILATE the area.

In large quantities, refrigerants can cause suffocation because they are heavier than air and displace oxygen.

Inhaling refrigerant vapors or mist may cause heart irregularities, unconsciousness, and oxygen deprivation leading to death (asphyxia).



REFRIGERANT SAFETY
&
OPEN FLAMES

NEVER expose R-12 or R-22 to open flames or glowing hot metal surfaces. At high temperatures, R-12 and R-22 decompose to form Hydrochloric acid, Hydrofluoric acid, and Phosgene gas.

Always review the material safety data sheets, when working with any solvents, chemicals, or refrigerants.

SHIPPING & TRANSPORTATION

Before shipping used refrigerant cylinders, complete the shipping paperwork include the number of cylinders of each refrigerant, and properly label each cylinder with the type and amount of refrigerant.

Cylinders should be transported in an upright position.

Each cylinder must have a DOT classification tag indicating it is a “2.2 non-flammable gas”.

Some states may require special shipping procedures to be followed based on their classification of used refrigerants. Check with the DOT in the state of origin.

TYPE I

Technicians servicing small appliances must be certified in refrigerant recovery if they perform sealed system service. The EPA definition of a small appliance includes products manufactured, charged, and hermetically sealed in a factory with five pounds of refrigerant or less. Persons handling refrigerant during maintenance, service or repair of small appliances must be certified as either a Type I Technician or as a Universal Technician.

RECOVERY EQUIPMENT MANUFACTURED BEFORE NOVEMBER 15, 1993

Must be capable of removing 80% of the refrigerant, whether or not the compressor is operating, or achieve 4 inch vacuum under the conditions of ARI 740.

RECOVERY EQUIPMENT MANUFACTURED AFTER NOVEMBER 15, 1993

Must be certified by an EPA approved testing laboratory, (example, U.L. or E.T.L) as capable of recovering 90% of the refrigerant if the compressor is operating, 80% of the refrigerant if the compressor is not operating, or achieving a 4 inch vacuum under the conditions of ARI 740.

IT'S AS SIMPLE AS ABC

A = After November 15, 1993

B = Before November 15, 1993

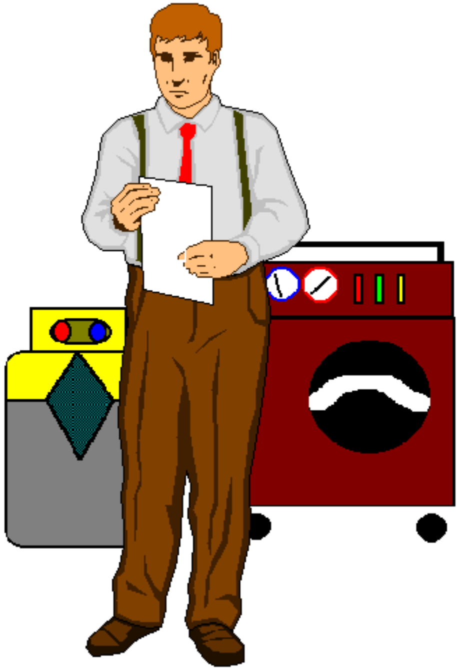
C = Non-Operating Compressor

Then:

A = 90% or 4 inches of vacuum

B = 80% or 4 inches of vacuum

C = 80% or 4 inches of vacuum



RECOVERY EQUIPMENT

All equipment must be equipped with low loss fittings that can be manually closed, or close automatically, when hoses are disconnected to minimize the refrigerant loss.

LEAK REPAIR REQUIREMENTS

Although leaks should be repaired whenever possible, the EPA does not require leak repair for small appliances.

RECOVERY TECHNIQUES
Self-Contained (Active) Equipment

Active recovery equipment stores refrigerant in a pressurized recovery tank. Before operating a self-contained recovery machine, open the tank inlet valve, and remove excessive non–condensables (air) from the recovery tank.

An accurate pressure reading of refrigerant inside a recovery cylinder is required to detect excessive non-condensables. The only way to read refrigerant pressure accurately is at a stable, known temperature. Air in a refrigeration system will cause higher discharge pressures. Follow the operating instructions supplied by the recovery equipment manufacturer regarding purging of non-condensables. All refrigerant recovery equipment should be checked for oil level and refrigerant leaks on a daily basis.

RECOVERY TECHNIQUES

System-Dependent (Passive) Equipment

System-dependent recovery process for small appliances captures refrigerant into a non-pressurized container. These are special charcoal activated plastic “bag” containers.

System-dependent equipment captures refrigerant with the assistance of the appliance compressor, an external heat source, or a vacuum pump.

A standard vacuum pump can only be used as a recovery device in combination with a non-pressurized container

When using a system dependent recovery process on an appliance with an *operating compressor*, run the compressor and recover from the high side of the system. Usually, one access fitting on the high side will be sufficient to reach the required recovery rate, as the appliance compressor should be capable of pushing the refrigerant to the high side.

Appliances with a *non-operating compressor*, access to both the low and high side of the system is necessary. In order to achieve the required recovery efficiency, it will be necessary to take measures to help release trapped refrigerant from the compressor oil, (heat and tap the compressor several times and/or use a vacuum pump).

Because appliances with non-operating compressors can not always achieve desired evacuation rates utilizing system-dependent recovery equipment, the EPA requires technicians to have at least one self-contained recovery device available at the shop to recover refrigerant from systems with non-operating compressors. The exception to this rule is technicians working on small appliances only.

System dependent devices may only be used on appliances containing 15 lbs. of refrigerant or less.

INSTALLING PIERCING TYPE ACCESS FITTINGS

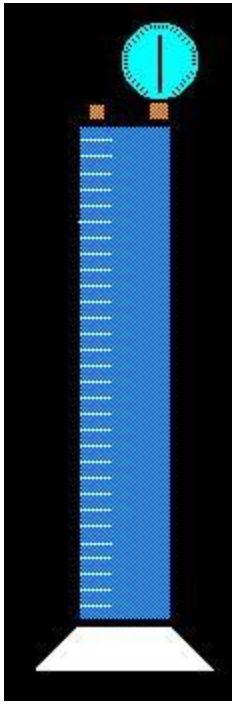
Fittings should be leak tested before proceeding with recovery. It is generally recommended that solderless piercing type valves only be used on copper or aluminum tubing material. Fittings tend to leak over time and should not be left on an appliance as a permanent service port. After installing a fitting, if you find that the system pressure is 0 psig, do not begin the recovery process.

DEFROST HEATERS

If the appliance is equipped with a defrost heater, such as in a domestic frost-free refrigerator, operating the defrost heater will help to vaporize any trapped liquid refrigerant and will speed the recovery process.

DO NOT RECOVER

Refrigerators built before 1950 may have used Methyl Formate, Methyl Chloride, or Sulfur Dioxide as refrigerant and should not be recovered with current recovery devices. Small appliances used in campers or other recreational vehicles may use refrigerants such as Ammonia, Hydrogen, or Water, and therefore should not be recovered using current recovery equipment.



CHARGING CYLINDERS

When filling a graduated charging cylinder with a regulated refrigerant, the refrigerant vapor that is vented off the top of the cylinder must be recovered.

TYPE II

Technicians maintaining, servicing, repairing or disposing of high pressure or very high-pressure appliances, except small appliances and motor vehicle air conditioning systems, must be certified as a Type II Technician or a Universal Technician.

LEAK DETECTION

After installation of a system, pressurize the unit with nitrogen and leak check.

In order to determine the general area of a leak use an electronic or ultrasonic leak detector.

To pinpoint the leak use soap bubbles.

A refrigeration unit using an open compressor that has not been used in several months is likely to leak from the shaft seal. During a visual inspection of any type of system, traces of oil are an indicator of a refrigerant leak. Excessive superheat, caused by a low refrigerant charge, is also an indication of a leak in a high-pressure system.

LEAK REPAIR REQUIREMENTS
Comfort Cooling

EPA regulations require that all comfort cooling appliances *(air conditioners)* containing more than 50 lbs. of refrigerant MUST be repaired when the annual leak rate exceeds 15%.

LEAK REPAIR REQUIREMENTS

Commercial & Industrial Process Refrigeration

EPA regulations require that all Commercial and Industrial Process Refrigeration containing more than 50 lbs. of refrigerant MUST be repaired when the annual leak rate exceeds 35%.

Commercial Refrigeration includes appliances used in the retail food and cold storage warehouse sectors, including equipment found in supermarkets, convenience stores, restaurants and other food establishments, and equipment used to store meat, produce, dairy products and other perishable goods.

Industrial Process Refrigeration means complex customized appliances used in the chemical, pharmaceutical, petrochemical and manufacturing industries, including industrial ice machines and ice rinks.

RECOVERY EQUIPMENT

Recovery equipment must be certified by an EPA approved laboratory (UL or ETL) to meet or exceed ARI standards.

RECOVERY REQUIREMENTS

Recovered refrigerants can contain acids, moisture, and oil. Frequently check and change both the oil and filter on a recycling machine. Recycling and recovery equipment using hermetic compressors have the potential to overheat when drawing a deep vacuum because the unit relies on the flow of refrigerant through the compressor for cooling. Before using a recovery unit you should always check the service valve positions, the recovery units oil level, and evacuate and recover any remaining refrigerant from the unit's receiver.

When working with multiple refrigerants, before recovering and/or recycling a different refrigerant, purge the recover/recycle equipment by recovering as much of the first refrigerant as possible, change the filter, and evacuate. The only exception to this rule is for technicians working with R-134A who must provide a special set of hoses, gauges, vacuum pump, recovery or recovery/recycling machine, and oil containers to be used with R-134A only.

Recovering refrigerant in the vapor phase will minimize the loss of oil, recovering as much as possible in the liquid phase can reduce recovery time. The technician may choose to speed up the recovery process by packing the recovery cylinder in ice and/or applying heat to the appliance. After recovering liquid refrigerant, any remaining vapor is condensed by the recovery system.

RECOVERY NOTES

Refrigerant should be placed in the receiver of units that have a receiver/storage tank.

Refrigerant should be removed from the condenser outlet if the condenser is below the receiver.

In a building that has an air-cooled condenser on the roof and an evaporator on the first floor, recovery should begin from the liquid line entering the evaporator.

After recovery, refrigerant may be returned to the appliance from which it was removed or to another appliance owned by the same person without being recycled or reclaimed, unless the appliance is an MVAC (Motor Vehicle Air Conditioner) like appliance.

Always evacuate an empty recovery cylinder before transferring refrigerant (recovering) to the cylinder.

Type of Appliance	Manufactured Before 11/15/93	Manufactured After 11/15/93
HCFC-22 appliances or isolated components of such appliances normally containing less than 200 lbs. of refrigerant.	0	0
HCFC-22 appliances or isolated components of such appliances normally containing more than 200 lbs. of refrigerant.	4	10
Other high pressure appliances or isolated component of such appliance normally containing less than 200 lbs. of refrigerant.	4	10
Other high pressure appliances or isolated component of such appliance normally containing more than 200 lbs. of refrigerant.	4	15
Very high pressure appliances *There are no questions on the exam about Very high pressure appliances*	0	0

After reaching the desired vacuum, wait a few minutes to see if the system pressure rises, indicating that there is still refrigerant in liquid form or in the oil.

Appliances can be evacuated to atmospheric pressure (O psig) if leaks make evacuation to the prescribed level unattainable.

The technician must isolate a parallel compressor system in order to recover refrigerant. Failure to isolate a parallel compressor system will cause an open equalization connection that will prevent refrigerant recovery.

System-dependant recovery equipment cannot be used on appliances containing more than 15 pounds of refrigerant.

MAJOR REPAIR

Under EPA regulations, a “major repair” means any maintenance, service or repair involving the removal of any or all of the following components: the compressor, the condenser, the evaporator or an auxiliary heat exchanger coil.

REFRIGERANT TYPE

To determine the type of refrigerant used read the nameplate.

FILTER / DRIER

Filter driers will remove moisture from the refrigerant in a system, but there is a limit to their capacity.

Some systems are equipped with a moisture indicating sight glass. When the sight glass changes color, the system contains excessive moisture and will need to be evacuated.

The filter-drier should be replaced anytime a system is opened for servicing.

CRANKCASE HEATER

A crankcase heater is used to prevent refrigerant from migrating to the oil during periods of low ambient temperature.

Refrigerant in the oil will cause oil foaming in the compressor at start-up.

WARNING

A hermetic compressor's motor winding could be damaged if energized when under a deep vacuum.

NEVER energize a reciprocating compressor if the discharge service valve is closed.

LIQUID CHARGING

There is a risk of freezing during liquid charging of an R-12 refrigeration system

Begin with vapor from a vacuum level to a pressure of approximately 33 psig. Followed by a liquid charge through the liquid-line service valve. This is also the proper method to charge a system that contains a large quantity of refrigerant.

ASHRAE STANDARD 15

Requires a refrigerant sensor that will sound an alarm and automatically start a ventilation system in occupied equipment rooms where refrigerant from a leak will concentrate.

ASHRAE SAFETY CLASSIFICATION FOR REFRIGERANTS

HIGHER FLAMMABILITY	A3	B3
LOWER FLAMMABILITY	A2	B2
NO FLAME PROPAGATION	A1	B1
	Lower Toxicity	Higher Toxicity

CFC-12 CFC-11 HFC-134a

are all categorized as A-1

TYPE III

Technicians maintaining, servicing, repairing or disposing of low-pressure appliances must be certified as a Type III Technician or a Universal Technician.

DESCRIPTION

A typical low-pressure centrifugal chiller operating below atmospheric pressure uses a “Shell” style evaporator with tubes of running water routed through the evaporator.

The low pressure refrigerant within the shell absorbs the heat carried by the water in the tubes.

The cold water within the tube system circulates throughout the area where objectionable heat is to be removed.

The water then absorbs the heat from the area where it is not wanted and transfers the heat to the refrigerant in the shell evaporator.

The refrigerant travels through a normal vapor compression circuit releasing its heat through a condenser.

The system is protected from over-pressurization by a rupture disc located at the evaporator.

A rupture disc differs from a relief valve in that when it opens it remains open. Most system rupture discs are set at 15 psig.

Low pressure equipment operates below atmospheric pressure (in a vacuum).

The ambient air pressure surrounding gaskets & fittings is greater than the internal pressure.

Because the internal pressure is less than the external air pressure, leaks in gaskets or fittings will cause air & moisture to enter the system. For this reason it is extremely important to maintain a tight system.

Low – Pressure chillers are equipped with a method of eliminating air and other non-condensables that will leak into the system.

The PURGE Unit

The purge unit is located at the condenser.

(Purge units will be covered later in this section)

LEAK DETECTION

Detecting a leak in a low pressure system is unlike that of a high pressure appliance.

Refrigerant does not leak out of a charged low pressure chiller air & moisture leaks in.

The systems internal pressure must be raised above the ambient pressure before leak testing can be performed.

The best method of pressurizing the system is through the use of **“Controlled Hot Water”** (rising the temperature of the circulating water within the tubes).

Heater blankets may also be used to aid in raising the system pressure. When controlled hot water or heater blankets are not feasible, use **nitrogen** to increase pressure.

When pressurizing a system, **do not exceed 10 psig.** Exceeding 10 psig can cause the rupture disc to fail.

Leak testing a water box is accomplished by removing the water and placing the leak detector probe through the drain valve.

To leak test a tube, use a hydrostatic tube test kit.

Controlled hot water can also be used to pressurize a system for the purpose of opening the system for a non-major repair

The EPA defines a “major repair” as any maintenance, service or repair involving the removal of any or all of the following components: the compressor, the condenser, the evaporator or any auxiliary heat exchanger coil.

LEAK REPAIR REQUIREMENTS

EPA regulations require that all comfort cooling appliances *(air conditioners)* containing more than 50 lbs. of refrigerant MUST be repaired when the annual leak rate exceeds 15%.

EPA regulations require that all Commercial and Industrial Process Refrigeration containing more than 50 lbs. of refrigerant MUST be repaired when the annual leak rate exceeds 35%.

Commercial Refrigeration includes appliances used in the retail food and cold storage warehouse sectors, including equipment found in supermarkets, convenience stores, restaurants and other food establishments, and equipment used to store meat, produce, dairy products and other perishable goods.

Industrial Process Refrigeration means complex customized appliances used in the chemical, pharmaceutical, petrochemical and manufacturing industries, including industrial ice machines and ice rinks.

LOW-PRESSURE RECOVERY EQUIPMENT

A recovery unit's high pressure cut-out is set for 10 psig when evacuating the refrigerant from a low-pressure chiller and a rupture disc on a low-pressure recovery vessel relieves at 15 psig.

Most low-pressure recovery machines utilize a water-cooled condenser that is connected to the municipal water supply.

Recovery Techniques

- Refrigerant recovery from an R-11 or R123 system begins with liquid removal and is followed by vapor recovery.
- Water must be flowing through the tubes while refrigerant is drained to prevent freezing. The recovery compressor and condenser should also be operating.
- Substantial vapor remains within the system even after liquid is removed

An average 350 ton R-11 chiller after liquid recovery will still contain approx.* 100 lbs *of refrigerant in vapor form.

- In an R-11 system, 10% of refrigerant can remain in the system in vapor form even after liquid recovery.

Recovery Tips

- If a system is suspected of water tube leaks, the water sides of the system should be drained prior to recovering the refrigerant.
- When vacuum testing a system, if the absolute pressure rises from 1mm Hg to any point above 2.5mm Hg, the system should be checked for leaks

  (***ASHRAE Guideline 3-1996)***
- System Oil should be heated to 130ºF prior to draining to ensure the release of refrigerant from the oil.

Recharging Requirements

- Initial charging must occur in the vapor phase until the system's pressure has reached 16.9" hg vacuum. This insures that water will not freeze and the refrigerant will not boil. *R-11 at 32º F has a saturation pressure of 18.1" Hg.*

- The system is charged through the lowest access point on the system, the evaporator charging valve

Recovery Requirements

- Levels of evacuation for low-pressure appliances:

For Refrigeration Recovery & Recycling Equipment manufactured or imported **Before** November 15th, 1993:

25 inches Hg

For Refrigeration Recovery & Recycling Equipment manufactured or imported on or **After** November 15th, 1993:

25 mm Hg absolute

Recovery Tips

- System pressure should be monitored after evacuation for a few minutes to ensure the maximum amount of refrigerant has been removed. If pressure rises, recovery must be repeated.
- Systems that cannot attain or maintain stated levels of evacuation should be evacuated to the highest possible level prior to repair.

Refrigeration Pointers

- Freezing water must be avoided. If necessary, use nitrogen to increase pressure to counteract freezing while evacuating a system.
- Strong odors and contaminated oil are possible indications of a compressor burn-out.
- The purge unit operates with suction from the top of the condenser. It removes air, moisture and other non-condensables from the system and returns refrigerant ot the evaporator. If frequent purge operation occurs, or excessive moisture is detected in the purge unit, one of the system’s tubes may be leaking.

Rupture Disc

- Releases pressure in a low-pressure system when it exceeds 15 psig.
- Protects the system from over-pressurization.

SAFETY

Equipment rooms must be monitored for high refrigerant levels, in which case an alarm must sound, and a ventilation system must be automatically activated.

-ASHRAE standard 15

(for all ASHRAE refrigerant safety groups)

All refrigeration systems must be protected by a pressure relief valve(s)

Never install relief valves in series

ASHRAE SAFETY CLASSIFICATION FOR REFRIGERANTS

HIGHER FLAMMABILITY	A3	B3
LOWER FLAMMABILITY	A2	B2
NO FLAME PROPAGATION	A1	B1
	Lower Toxicity	Higher Toxicity

CFC-12 CFC-11 HFC-134a are all categorized as A-1

R-123 (an HCFC) is categorized as B1