**Federal Regulations**

Section 608 of the Clean Air Act requires that all persons who maintain, service, repair, or dispose of appliances that contain regulated refrigerants, be certified in proper refrigerant handling techniques as required by the EPA's National Recycling and Emission Reduction Program. Regulated refrigerants currently includes: CFC, HCFC, HFC, and HFO refrigerants.

You cannot work under another person's certification.

**Overview of the Examination**

Distributors can only sell regulated refrigerants to a Section 608 certified technician or company which employs a Section 608 certified technician.

There are four (4) categories of technician certification:

Type I. Persons who maintain, service, repair, or dispose of small appliances must be certified as Type I technicians. A small appliance is defined as a pre-assembled unit, hermetically sealed and factory charged with 5 lbs. or less of refrigerant. Examples include equipment such as water coolers, window units, refrigerators, freezers, de-humidifiers, ice machines, and package terminal air conditioning. Split systems are not included in Type I.

Type II. Persons who maintain, service, repair, or dispose of medium, high and very high pressure appliances containing more than 5 lbs. of refrigerant or if the installation of such equipment requires refrigerant charging, must be certified as Type II technicians.

High-pressure refrigerants have a pressure between 155 psig & 340 psig at a liquid phase temperature of 104°F and medium pressure refrigerants have a pressure between 30 psig & 155 psig at a liquid phase temperature of 104°F. Type II certification does not include small appliances or motor vehicle air conditioning (MVAC) systems.

Type III. Persons who maintain, service, repair, or dispose of low-pressure appliances (centrifugals and chillers) must be certified as Type III technicians. Low-pressure refrigerants have pressures of 30 psig or lower at a liquid phase temperature of 104°F.

Universal To be certified as Universal, a technician must pass all four sections; Core, Type I, Type II, and Type III.

**Test Format**

The test contains four sections: the Core, and sections I, II, and III. Each section contains twenty five (25) multiple-choice questions. A technician MUST achieve a minimum passing score of 70 percent in each group/section in which they are to be certified. For example, a technician seeking Universal certification must achieve a minimum score of 70 percent, or 18 out of 25 correct, on each section of the test. If a technician fails one or more of the sections, they may retake the failed section(s) without retaking the section(s) in which they earned a passing score. In the meantime, the technician will be certified in the Type for which they received a passing score. There is one exception; a technician MUST achieve a passing score on the Core plus any one Type to receive any certification.

The Core contains 25 general knowledge questions relating to stratospheric ozone depletion, rules and regulations of the Clean Air Act, the Montreal Protocol, refrigerant recovery, recycling and reclaiming, recovery devices, substitute refrigerants and oils, recovery techniques, dehydration, recovery cylinders, safety, and shipping.

Section I contains 25 sector specific questions pertaining to small appliances. Section II contains 25 sector specific questions pertaining to medium and high-pressure appliances and Section III contains 25 sector specific questions pertaining to low-pressure appliances.

Federal regulation requires that this exam be conducted as a closed book exam by an authorized test administrator (Proctor). The only outside materials allowed during the test are a temperature/pressure chart and a calculator. Phones are NOT allowed to be used during the examination and MUST be turned off and put away (not on the desktop) during the examination.

**Vapor / Compression Refrigeration Cycle**

The compressor is the heart of the vapor-compression refrigeration cycle. Low-pressure, low-temperature superheated refrigerant vapor entering the compressor is compressed, changing it to a high-pressure, high-temperature, superheated vapor. It then moves to the condenser where the heat is removed, de-superheating and condensing it into a liquid. Before it leaves the condenser, the liquid refrigerant is subcooled to a point below the liquid saturation temperature. It then flows to the metering device as a high-pressure, subcooled liquid. As the refrigerant flows through the metering device, the liquid is reduced to a low-pressure causing a small percentage of the liquid to flash to a vapor (flash-gas) lowering the remaining refrigerant to its saturation temperature. The low-pressure, low-temperature refrigerant flows into the evaporator as a low-temperate liquid. As the refrigerant absorbs heat, it evaporates into a low-temperature vapor. During this process the refrigerant vapor is superheated above its saturation temperature and then enters the suction line. From the suction line, refrigerant enters the compressor as a low-pressure, low-temperature superheated vapor to repeat the cycle. The compressor and the metering device are the dividing points between the low-pressure and high-pressure sides of the system.

Accessories shown in the basic diagram are the liquid receiver and a suction accumulator. Use of these components depends on system design and/or the type of metering device used. A system that uses a thermostatic expansion valve (TEV) is usually equipped with a receiver located in the liquid line directly following the condenser. A system that uses a thermostatic expansion valve (TEV), capillary tube, or fixed bore metering device may be equipped with an accumulator located in the suction line, which prevents liquid from entering the compressor.

A system may have service valves, access valves or process stubs to gain access for service. Never front-seat (turn the valve stem clockwise as far as it will go) a service valve when the system is in operation. The valve must be back-seated (turn the valve stem counter-clockwise as far as possible) to close the service or gauge port before removing the service manifold hoses.

**Gauge Manifold Set**

One of the most important tools for an HVACR technician is the gauge manifold set. The left side, compound gauge (blue) and the right side, high-pressure gauge (red), are attached to the manifold to measure system pressures. Hoses are used to connect the manifold to the refrigeration system's access ports or service valves to gain access to system pressures. The compound gauge measures low-pressure (psig) and vacuum (inches

Hg). The high pressure gauge measures high side (discharge) pressure. Depending on the refrigerant, the high-pressure gauge may be rated at 500 or 800 psig. 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. An electronic manifold may have combined temperature probes to measure refrigerant line temperatures for calculating system superheat and subcooling. EPA recommends that hoses be equipped with low loss fittings or valves that manually close or which close automatically to minimize refrigerant loss when hoses are disconnected. The hoses used for service and with recovery equipment must be equipped with low-loss fittings. A minor release of refrigerant, when connecting or disconnecting hoses for service or recovery is considered to be a de-minimis release.

**Stratospheric Ozone Depletion**

The introduction of Chlorofluorocarbons (CFCs) and Hydrochlorofluorocarbons (HCFCs) have dramatically changed our lifestyles. ASHRAE's safety classifications do not consider a refrigerant's environmental effects. Little did we know that the use and release of these compounds into the atmosphere would have far reaching, long-term effects on our environment. The greatest effect is in the stratosphere, which is far removed from the Earth's surface.

The stratosphere, located between 7 and 30 miles above sea level, is comprised of ozone and other gases. The ozone layer is the Earth's security blanket. An ozone molecule, (O3), which consists of 3 oxygen atoms, protects us from harmful ultraviolet radiation from the Sun, and helps maintain stable Earth temperatures.

Stratospheric ozone depletion is a global issue that can lead to problems such as crop loss, skin cancer, increased eye diseases such as cataracts and reduced plankton and other microscopic marine life.

CFCs (chlorine, fluorine & carbon) and HCFCs, (hydrogen, chlorine, fluorine & carbon), which contain chlorine, have been found in air samples taken from the stratosphere. When CFCs and HCFCs, are released into the atmosphere their chlorine content causes depletion of the ozone layer. When a chlorine atom encounters an ozone molecule, it takes one Oxygen atom from the ozone forming a compound called chlorine monoxide (ClO), leaving an oxygen O2 molecule behind. The chlorine monoxide will collide with another ozone molecule, releasing its Oxygen atom, forming two O2 molecules, leaving the chlorine free to attack another ozone molecule. A single chlorine atom can destroy up to 100,000 ozone molecules.

There has been some controversy over the subject of ozone depletion. Some believed 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 add only small quantities of chlorine to the atmosphere compared to the amount of chlorine added to the atmosphere from chlorine-containing refrigerants. In addition, the rise in the amount of chlorine measured in the stratosphere over the past four 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 by NASA and other agencies in the stratosphere over the past twenty years matches the rise in CFC and HCFC emissions over the same period. The evidence is clear, chlorine containing refrigerants have changed the natural balance, thus depleting the ozone layer.

Unlike other chlorine compounds and naturally-occurring chlorine, the chlorine in CFCs and HCFCs will neither dissolve in water nor break down into compounds that dissolve in water so they do not rain out of the atmosphere.

HFCs are made up of Hydrogen, Fluorine and Carbon. They do not contain chlorine that effects the ozone layer, but most HFCs have a high Global Warming Potential (GWP).

**Ozone Depletion Potential**

Ozone Depletion Potential (ODP) is a measurement of a substance such as CFC’s and HCFC's ability to destroy ozone, and ranges from 0 to 1. CFCs have the highest ODP. HFCs (Hydrofluorocarbons/R-134a, R-32, & 400 series blends) and HFOs (hydrofluoroolefins/ R-1234yf, 1234ze & 1233zd) do not contain chlorine and have an Ozone Depletion Potential of zero.

**Greenhouse Gases**

Greenhouse gases (GHGs) warm the Earth in two ways; by absorbing energy, slowing the rate at which it escapes to space and by acting like a blanket insulating the Earth. Examples of greenhouse gases and their effects on the atmosphere are as follows:

Carbon dioxide (CO2): CO2 is a natural gas, created through respiration and absorbed through photosynthesis, a relatively balanced cycle. The addition of man-made CO2 creates an overabundance and results in excess GHGs that enter the atmosphere as a result of burning fossil fuels (coal, natural gas, and oil), solid waste, wood/products, and is the result of certain chemical reactions such as cement manufacturing. Carbon Dioxide is used as a very high-pressure refrigerant (R-744) with zero (0) ODP and a Global Warming Potential (GWP) of one (1). R-744 is used primarily in commercial and industrial process systems and does not require Section 608 certification for purchasing or servicing. Natural refrigerants such as R744 (carbon dioxide) that do not pose a threat to health or the environment according to EPA may be released back into the environment.

Flammable refrigerants: Equipment with flammable refrigerants requires a red color marking on all process tubes, service connections, and pipes through which a flammable refrigerant passes. The color marking must extend one inch in both directions from service locations. When propane (R-290) is used as refrigerant, it must meet the purity standards set for HVACR equipment. Propane purchased for grilling contains impurities which will damage refrigeration equipment. Propane and Isobutane are examples of “A3” flammable refrigerants that do not require recovery. Propane, Butane and other Hydrocarbon refrigerants are also known as HC refrigerants.

Fluorinated gases: Hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen trifluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes. Fluorinated gases such as CFCs, HCFCs and HFCs are referred to as high Global Warming Potential gases ("High GWP gases").

R-134a: (Tetrafluoroethane) is an HFC with an ozone depletion potential (ODP) of zero (0) and global warming potential (GWP) 1,430 times greater than carbon dioxide. R-134a is a medium-range pressure refrigerant used in auto, domestic refrigeration and commercial industries.

R-410A: (Hydrofluorocarbon) is a high-pressure, HFC refrigerant with an ODP of zero (0) and global warming potential (GWP) 2,090 times greater than carbon dioxide. R-410A is a near azeotrope refrigerant that does not fractionate during phase change in HVACR equipment. One disadvantage of R-410A is the operating pressure is approximately 50% higher than R-22 and cannot be considered as a replacement for retrofitting existing systems.

R-1234yf: (Tetrafluoropropene) R-1234yf is a medium pressure, HFO refrigerant with an (ODP) of 0 and global warming potential (GWP) only 4 times greater than carbon dioxide.

ASHRAE has grouped refrigerants by Class A (safest) or B, depending on their toxicity level to humans. Flammability is indicated by a 1 (no flammability), 2 (low flammability), or 3 (high flammability).

**Clean Air Act**

The United States Environmental Protection Agency (EPA) regulates Section 608 of the Federal Clean Air Act which establishes the rules for regulating all Class I (Ozone Depleting Substances such as CFCs), Class II (HCFCs), and substitute refrigerants. Failure to comply could cost you and your company.

Companies and or service technicians who violate Clean Air Act provisions may lose their certification, be required to appear in Federal Court and be fined up to $44,539 per day, per violation. The EPA may require technicians to demonstrate the ability to properly perform refrigerant recovery/recycling procedures. Failing to demonstrate these skills can result in revocation of certification. State and local jurisdictions may impose regulations that are equal to or greater than those under the EPA's Section 608. Technicians not following stricter state and local government's requirements may lead to other penalties.

It is a violation of Section 608 to:

• Falsify or fail to keep required records.

• Fail to reach required evacuation level prior to opening or disposing of appliances.

• Knowingly release (vent) ozone depleting and substitute refrigerants (such as CFCs, HCFCs or HFCs) while maintaining, installing, repairing or disposing of appliances or industrial process refrigeration with the exception of de-minimus releases.

• Service, maintain, or dispose of appliances designed to contain refrigerants without being appropriately certified.

• Fail to recover regulated refrigerants before opening or disposing of an appliance.

• Fail to have an EPA approved recovery device, equipped with low loss fittings that automatically close or have manually operated shut-off valves on the hoses.

• 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 (to 0 psig) any refrigerant remaining in the cylinder. (Refrigerant must be recovered from the cylinder, the cylinder must be rendered useless, and then the metal cylinder can be recycled.)

• Release refrigerant during vandalism or theft of any HVACR equipment.

It is the responsibility of the final person in the disposal chain to ensure that refrigerant has been removed from appliances before scrapping.

Technicians disposing of mid-sized appliances with 5-50 pounds of refrigerant must keep the following records:

• The location, date of recovery, and type of refrigerant recovered for each disposed appliance.

• The quantity of refrigerant, by type, recovered from disposed appliances in each calendar month.

• The quantity of refrigerant, and type, transferred for reclamation or destruction, the person / company to whom it was transferred, and the date of the transfer.

**Montreal Protocol**

Following several years of negotiations, an international agreement (treaty) regulating the production and use of CFCs, HCFCs, halons, methyl chloroform and carbon tetrachloride entered into force in mid-1989. Known as The Montreal Protocol, this landmark agreement initially required a production and consumption freeze. The Montreal Protocol called for a stepwise reduction and eventual production phase-out of various ozone depleting substances (ODS) in developed countries. In the United States, CFCs were the first substance group that was phased-out of production. Some HCFC refrigerants are scheduled for phase-out as early as 2020, and by 2030 all HCFCs will be phased-out. When virgin supplies of restricted refrigerants are depleted, future supplies will come from only recovered, recycled, or reclaimed refrigerants.

**The Three Rs (Recover - Recycle - Reclaim)**

The processes of recovery, recycling, and reclaiming sound similar, but they are quite different.

Recover: Remove refrigerant, in any condition, from a system and store it in an external container to be put back into the same system, recycled, or reclaimed.

Recycle: Clean refrigerant by separating the oil from the refrigerant and removing moisture and other contaminants from the refrigerant by passing it through one or more filter driers. Recycled refrigerants may be placed back into the same system they came from or another system that is owned by the same owner.

Reclaim: Process refrigerant to a level equal to new (virgin) product specifications as determined by chemical analysis. Reclaimed refrigerants must meet AHRI 700 Standards before they can be reused or sold to another user.

**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.

Sales Restriction

The sale of CFC and HCFC refrigerants has been restricted to certified technicians since November 14, 1994. The sale of HFC and HFO refrigerants are restricted to certified technicians as of January 1, 2018. Only technicians certified under Section 609 of the Clean Air Act (Motor Vehicle Air Conditioning) are allowed to purchase refrigerants in containers smaller than 20 lbs.

CFCs or HCFCs can be used for servicing a system that uses the refrigerant after the phaseout. CFCs or HCFCs cannot be used in new equipment.

Substitute Refrigerants and Oils

Our industry is in a constant state of change. New refrigerants, blends of older refrigerants and different oils have appeared in the field. The potential to effect the internal components or oxidize the copper tubing must be evaluated. The EPA must review and approve new refrigerants before they are introduced for use in HVACR equipment. The Significant New Alternatives Policy program (SNAP) identifies and evaluates substitute refrigerants. EPA's decision on the acceptability of new substitutes proposed by manufacturers, formulators, or users is based primarily on the potential human health and environmental risks posed by the substitutes as compared to other substitutes available for a particular end-use. EPA's classifications of decisions on alternative substitutes may be listed as:

- Acceptable
- Acceptable subject to use conditions
- Acceptable subject to narrowed use limits
- Unacceptable alternatives

Any refrigerants that have not been reviewed and approved by EPA’s SNAP program cannot be used to retrofit existing systems.  The SNAP program limits approved refrigerants for use in the listed types(s) of systems for which they are approved.

R-134a is an HFC and was considered ozone friendly. R-134a was the leading candidate for CFC R-12 retrofit, but it is not a 'drop-in' substitute. In actuality, there is no such thing as a "drop-in" refrigerant, but some refrigerants can be used in most compatible systems by following appropriate retrofit procedures. HFC refrigerants will not mix with most refrigerant oils. The oils used with HFC and HFO HVACR systems are esters. Esters cannot be mixed with other oils. When retrofitting HCFC systems, polyolester (POE) type oil is commonly used as it can tolerate a small percentage of other types of oil. It is also important to remember that, when leak testing an HFC system, use pressurized nitrogen with only a trace amount of refrigerant vapor. In order to avoid contamination use the same refrigerant as the system charge. <u>This is not considered to be a refrigerant that must be recovered.</u>

There are several refrigerant blends commonly in use. Some blends are called ternary, which means they are a three-part blend. HCFC-22 and HCFC ternary blends are used with a synthetic alkylbenzene lubricant. Make certain you are using the correct oil for the particular refrigerant. Most refrigerant oils are hygroscopic. Hygroscopic oil has a high affinity for water. An oil sample should be taken and analyzed if a system has had burned compressor winding failure or a major leak, allowing moisture to enter the system.

Refrigerant blends are made up of two or more single component refrigerants. Depending on how strongly the refrigerant molecules are attracted to each other, they may be classified as azeotropic or zeotropic. An azeotropic mixture acts like a single component refrigerant over its entire temperature/pressure range. An azeotrope does not have a temperature glide, whereas, a zeotropic blend behaves like a mixture of the individual components with predictable properties based on combinations of the original refrigerant's properties. Temperature glide refers to the range of boiling or condensing temperature points that a refrigerant blend might experience at a specific pressure. Refrigerant fractionation can occur from a continuous leak due to the difference in pressures from the combined refrigerants.

The R-400 series of refrigerants are zeotropic blends that can leak from a system at uneven rates due to different vapor pressures which can effect the percentage of each refrigerant remaining in the system. The proper charging method for R-400 series blended refrigerants is to weigh the refrigerant into the high side of the system as a liquid. When adding refrigerant to an undercharged system, liquid refrigerant is throttled into the low side with the system operating.

Zeotropic blends use Bubble and Dew points to indicate condensing and evaporation temperatures on a pressure temperature saturation chart. Bubble point is used when charging by condenser subcooling and Dew point is used for charging by suction or evaporator superheat. The relationship of pressures and temperatures are based on the refrigerant's temperature glide. Temperature glide can range a few tenths of a degree to 12 degrees or more.

Even though the pressure temperature relationship, and the operating characteristics may be almost the same, the refrigerants cannot be interchanged. Due to flammability of some of the HC's and HFO's equipment must be designed to handle the refrigerant. Therefore, EPA regulates the maximum amount of refrigerant that can be used in the new systems by their type and use.

Recovery Techniques

EPA regulations require a service aperture or process stub on all hermetically-sealed appliances that use a regulated refrigerant in order to make it easier to recover refrigerant.

When servicing a system, if you discover that the refrigerant is contaminated, two or more refrigerants have been mixed in a system, you must recover the mixture into a separate tank to be turned in for reclamation. It is important NOT to mix different refrigerants in the same recovery tank because the mixture may be impossible to reclaim. Recover only one type of refrigerant into a recovery tank. The number of recovery tanks required by a person or company depends on the variety of equipment worked on and their types of refrigerants.

If a strong odor is detected during the recovery process, a compressor burn-out has likely occurred. When recovering refrigerant from a system that experienced a compressor burn-out, watch for signs of oil contamination. The contamination may be in the oil as sludge, moisture and acid. After recovering refrigerant, if nitrogen is used, with or without a flushing solution to flush debris out of the system, the nitrogen may be legally vented. A suction line filter drier should be installed to trap any debris that may damage the new compressor.

The size of the equipment, amount of moisture, length of the hose between the unit being recovered from and the recovery machine, and the ambient temperature can all effect the efficiency of the recovery process. Long hoses will cause excessive pressure drop, increased recovery time, and have a potential for increased emissions or venting from the recovery machine. Excessive venting of the recovery machine or cylinder is illegal. Since all refrigerants have a pressure temperature relationship, the lower the ambient temperature surrounding the equipment being serviced, the slower the recovery rate.

After completing the transfer of liquid refrigerant between a recovery unit and a refrigeration system, you should guard against trapping liquid refrigerant between the service valves.

Recovered refrigerant may not meet AHRI standard for virgin refrigerant therefore it can only be reused in the same system or another system of the same owner. It cannot change ownership.

**Leak Detection**

In order to determine the general area of a leak, use an electronic or ultrasonic leak detector after pressurizing the system with nitrogen and a trace amount of refrigerant. Once the general area of the leak is located, the use of soap bubbles will aid in pinpointing the leak. Finding and repairing leaks in a system will conserve refrigerant for future use.

When leak testing any flammable hydrocarbon or HFO refrigerant, install a fresh filter-drier and complete a standing-pressure leak check at the maximum system pressure before evacuating to 500 microns or lower.

Two verification tests are required when an appliance containing 50 pounds of refrigerant or more has triggered the leak rate threshold and subsequently has been repaired. One must be performed before the appliance is recharged and one after the appliance returns to normal operating conditions.

Section 608 of the Clean Air Act uses three categories to define applicable leak rates for systems other than small appliances.

Industrial Process Refrigeration (IPR), refrigeration equipment used in agriculture, crop production, oil and gas extraction, ice rinks, manufacture of frozen food, dairy products, food and beverages, ice, petrochemicals, chemicals, machinery, medical equipment, plastics, paper, and electronics.
Commercial Refrigeration, refrigerated warehousing and storage facilities, supermarkets, grocery stores, warehouse clubs, supercenters, convenience stores, and refrigerated transport.

Comfort Cooling, air conditioning equipment, and others not listed.

Note: When an appliance is designed for multiple uses, the category will be considered industrial process refrigeration equipment if 50 percent or more of its operating capacity is used for industrial process refrigeration.

**Dehydration**

The reason for dehydrating a refrigeration system is to remove water and water vapor and it is important to follow proper dehydration procedures. If moisture is allowed to remain in an operating refrigeration system, hydrochloric and hydrofluoric acids may form. Evacuation of a system is the suggested method of dehydration. It is not possible to over evacuate a system. Most manufacturers require an evacuation to 500 microns or lower which can be measured with a micron gauge

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

The factors that affect the speed and efficiency of evacuation are; size of equipment being evacuated, ambient temperature, amount of moisture in the system, the size of the vacuum pump and suction line. In addition, 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 away from the vacuum pump as possible. Measuring a system's 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. During evacuation you may wish to heat the refrigeration system to decrease dehydration time. Tapping a compressor with a rubber mallet will aid in releasing trapped refrigerant from the oil.

Never operate the compressor while the system is in a deep vacuum; internal electrical arcing could occur, burning the motor windings.

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

**Recovery Cylinders**

Recovery cylinders differ in many ways from disposable cylinders. Disposable cylinders are used only with virgin refrigerant and may NEVER be used for recovery. If the refrigerant in a recovery cylinder is suspected to be contaminated, a pressure reading of the cylinder should be taken and compared to a pressure temperature chart.

Recovery cylinders are specifically designed to be refilled. Recovery cylinders have 2 ports, one liquid and one vapor. Care must be taken not to overfill or heat these cylinders, as it could cause an explosion. The EPA requires that a refillable refrigerant cylinder MUST NOT BE FILLED ABOVE 80% of its capacity by weight, and that the safe filling level can be controlled by mechanical float devices, electronic shut off devices (thermistors), or weight. Refillable cylinders must be hydrostatically tested and date stamped every 5 years.

Refillable cylinders must be Department of Transportation (DOT) approved. Approved refrigerant recovery cylinders can easily be identified by their colors; yellow tops and grey bodies. All refrigerant recovery cylinders should be inspected for rust. If a refillable cylinder shows signs of rust or appears to have been heated or damaged in any way, it should be reduced to 0 psig by recovering to another cylinder and discarded. Reclaimers will not accept visibly burned recovery tanks.

**Safety**

The EPA is concerned not only with the prevention of refrigerant venting, but with the technician's overall safety. When handling and filling refrigerant cylinders or operating recovery or recycling equipment, you should wear safety glasses, protective gloves, and follow all equipment manufacturer's safety precautions. Make sure your recovery machine is grounded when in use, especially when recovering a flammable refrigerant.

When pressurizing a system with nitrogen, you should always charge through a pressure regulator and a relief valve in the downstream line from the pressure regulator. Relief valves MUST NOT be installed in series. If corrosion build-up is found within the body of a relief valve, the valve MUST be replaced.

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

When using recovery cylinders and equipment with Schrader valves, it is critical to inspect the Schrader valve core for leaks, bends, and breakage. Replace damaged valve cores to prevent leakage, and always cap Schrader ports to prevent accidental depression of the valve core. NEVER heat a refrigerant cylinder with an open flame. Do not cut or braze refrigerant lines on a charged unit.

In the event of a “large” release of refrigerant in a confined area, Self-Contained Breathing Apparatus (SCBA) is required. If a large leak of refrigerant occurs in an enclosed area, and SCBA is not available, IMMEDIATELY VACATE AND VENTILATE the area. In large quantities, all refrigerants can cause suffocation because they can displace oxygen. Inhaling refrigerant vapors or mist may cause heart irregularities, unconsciousness, and oxygen deprivation leading to death (asphyxia).

NEVER expose refrigerants to open flames or glowing hot metal surfaces. At high temperatures, refrigerants decompose and form acids. Hydrochloric acid is formed if the refrigerant contains chlorine and hydrofluoric acid is formed if the refrigerant contains fluorine. If oxygen is also present, it is possible to form carbon monoxide, carbon dioxide and phosgene gas. If a hydrocarbon refrigerant is released into a space, an explosion can occur if the refrigerant concentration is above the Lower Flammability Limit and below the Upper Flammability Limit with an ignition source.

Always review the Safety Data Sheets (SDS) when working with any solvents, chemicals, or refrigerants. Silicone elastomers, for use in seals and gaskets, are not compatible with HFO refrigerants.

Only use an alcohol spray to remove or clean ice from a sight glass when required.

Shipping & Transporting

Before shipping any used refrigerant cylinders, check that the cylinder meets DOT standards. Complete the shipping paperwork including the number of cylinders of each refrigerant, and properly label the cylinder with the type and amount of refrigerant before it is returned for reclaiming. Cylinders should be transported in an upright position. Each cylinder must be marked with a DOT classification tag indicating it is either a non-flammable or flammable gas. Some states may require special shipping procedures to be followed based on their classification of used refrigerants. Check with the DOT in your state.

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, with the exception of motor vehicle air conditioning (MVAC). The EPA definition of a small appliance includes; products manufactured, charged, and hermetically sealed in a factory containing five pounds or less of refrigerant. Split-systems may not be serviced by Type I technicians. The sale of regulated refrigerants such as CFCs, HCFCs, HFCs and HFOs is restricted to certified technicians.

Note: MVAC certification is covered under Section 609 of the Clean Air Act.

**Equipment Requirements**

Passive (system dependent) or active (self-contained) recovery equipment must be certified by an EPA-approved testing laboratory, (example, U.L. or E.T.L). When using recovery equipment manufactured after November 15, 1993, it must be able to recover 90% of the refrigerant when the compressor in the appliance is functioning, or 80% of the refrigerant when the appliance's compressor is not functioning. Evacuating the appliance to four inches of mercury vacuum is low enough to satisfy the rules.

All recovery 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.

Note: Isobutane (R-600a), an HC, is approved as a substitute refrigerant for new household refrigerators, freezers, and combination refrigeration/freezers. R-600a cannot be used for retrofitting a small appliance.

**Leak Repair Requirements**

The EPA does not require leak repair for small appliances, but leaks should be repaired whenever possible to conserve refrigerant. Make sure the valve cores are tight and the caps are on the Schrader ports to prevent accidental depression and leaking from the valve cores.

**Recovery Techniques**

Before beginning a refrigerant recovery procedure, it is necessary to know the type of refrigerant that is in the system. After recovery, if contaminants are present in the oil, the system will have to be flushed with a cleaning solvent designed for the type of refrigerant in the system. To speed up the process, recover from both the low and high side of the system.

If a reclamation facility receives a tank of mixed refrigerant, they may refuse to process the refrigerant and destroy it at the owner's expense. Do not mix refrigerants in a recovery tank.

Self-contained (active) recovery equipment has its own means of pumping and removing refrigerant from an appliance and is capable of reaching the required recovery levels whether or not the appliance compressor is operable. Self-contained recovery equipment pumps the refrigerant into a recovery tank. Before operating a self-contained recovery machine, make sure that the tank inlet valve is open, and that the recovery tank does not contain excessive non–condensables (air). Obtaining accurate pressure and temperature measurements of refrigerant inside a recovery cylinder is necessary to detect excessive non-condensables and the type of refrigerant. The only way to identify the refrigerant is to measure the refrigerant pressure accurately at a stable, known temperature. Air in a refrigeration system will cause higher discharge pressures in the system and recovery equipment. 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, and replace filters as required. When using a recovery machine on very low horsepower systems such as domestic refrigerators and freezers that contain a few ounces of refrigerant, it is important to recover the refrigerant from the low and high sides to prevent oil migration.

A system-dependent (passive) recovery process for small appliances captures refrigerant into a non-pressurized container. This may be a special plastic “bag” container large enough to contain a few ounces of refrigerant. A standard vacuum pump can only be used as a recovery device in combination with a non-pressurized container. The vacuum pump is only used to reduce the pressure of a recovery cylinder or container into a vacuum before the recovery process.

With system-dependent recovery equipment, some special procedures may be necessary depending on the condition of the appliance. System dependent devices may only be used on appliances containing 15 lbs. of refrigerant or less. 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 pumping the refrigerant to the high side.

If the appliance has a non-operating compressor, access to both the low and high side of the system may be necessary. In order to achieve the required recovery efficiency, it will be necessary to take measures such as heating and tapping the compressor several times to help release trapped refrigerant from the compressor oil, turning on the defrost heater to warm the evaporator. Because appliances with non-operating compressors cannot always achieve desired evacuation level 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 persons working on their own small appliances. The rule is stated as: "Persons who maintain, service, repair, or dispose of only appliances that they own and that contain pumpout units are exempt from the requirement to use certified, self-contained recovery and/or recycling equipment."

Small appliances are equipped with a straight piece of tubing, called a process tube, onto which a piercing type access fitting can be installed. When installing an access fitting onto a sealed system, the fitting 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. These fittings tend to leak over time and should not be left on an appliance as a permanent service fixture. If, after installing an access fitting, you find that the system pressure is 0 psig, do not begin the recovery process. If a strong odor is detected during the recovery process, a compressor burn-out has likely occurred. When recovering refrigerant from a system that experienced a compressor burn-out, watch for signs of contamination in the oil. After recovering refrigerant, if nitrogen is used to flush debris out of the system, the nitrogen may be legally vented.

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.

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

**Safety & Shipping**

Safety and shipping requirements are covered in the Core section of this manual.

Note: None of the hydrocarbon refrigerants are approved for retrofit into existing household refrigerators. The appliance must designed for a hydrocarbon refrigerant and labeled as to the type of refrigerant. This label must be placed on the outside of the appliance in view of the service location.

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

**Leak Detection**

After the installation of any type of system, the unit should first be pressurized with nitrogen (an inert gas) and leak checked. To determine the general area of a leak use an electronic or ultrasonic leak detector. Once the general area of the leak is located the use of soap bubbles will pinpoint the leak. In order to use an electronic leak detector on a system that is pressurized with nitrogen, a trace of refrigerant must be added to the system.

A refrigeration unit using an open compressor that has not been used in several months is likely to leak from the rotating shaft seal. During a visual inspection of any type of system, traces of oil are an indication 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**

EPA regulations require all comfort cooling (air conditioning) appliances containing 50 lbs. or more of a regulated refrigerant to have annual leak inspections to determine if the appliance is leaking. The appliance must be repaired within 30 days when the annual leak rate exceeds 10% of the total charge. A leak-test must be performed after each repair attempt, and a follow-up verification leak-test must be conducted within 10 days of the repair.

The time frame for mandatory leak repair can only be extended by a certified service technician. If the leaking appliance is not going to be repaired, it must be retired or mothballed. When an appliance is mothballed, the leaking component of the system must be isolated and the refrigerant recovered to prevent further leaking.

Type II appliances that will not be repaired must be retrofitted or retired in 12 months. If the appliance is using an exempt refrigerant then the owner has 18 months to retire the leaking system.

All commercial and industrial process refrigeration (IPR) containing more than 50 lbs. of refrigerant MUST be repaired when the annual leak rate is exceeds 20% for commercial appliances and 30% for IPR. When one appliance is used for both industrial process refrigeration and other applications, it will be considered industrial process refrigeration equipment when 50% or more of its operating capacity is used for industrial process refrigeration.

Commercial refrigeration appliances and IPR with a full charge of 500 pounds or more of a regulated refrigerant will require a leak inspection to be conducted every three months unless a refrigerant leak monitoring system is installed or it has not exceeded the leak rate for four quarters.

The total system refrigerant charge can be calculated by adding the charge for each component and the piping. Using the calculated charge, the leak rate percentage can be determined for the quantity of refrigerant added to a system that is new, retrofitted, or adjusted for seasonal variance. When an appliance containing 50 lbs. of a regulated refrigerant or more leaks 125% or more, the owner must submit a report to EPA describing efforts to identify leaks and repair. All records for leak inspections, initial verification, verification tests and records of recovered refrigerant from equipment with 5 to 50 lbs. must be kept for 3 years by the owner or operator. This includes the quantity of refrigerant, by type added, recovered from disposed appliances in each calendar month and quantity of refrigerant, by type, sent for reclamation or destruction. Topping off a system is considered adding refrigerant due to a leak and must be accounted for in the leak-rate calculation.

**Recovery Techniques**

Proper recovery techniques begin with the use of appropriate recovery equipment that has been certified by an EPA approved laboratory (UL or ETL) to meet or exceed AHRI Standards.

Recovered refrigerants may contain acids, moisture, and oil. It is necessary to frequently check and change both the oil and filter on a recovery/recycling unit. Both 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 oil level of the recovery unit, and evacuate and recover any remaining refrigerant from the unit and receiver.

Technicians working with multiple refrigerants, before recovering and/or recycling a different refrigerant, must 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 HFCs who must provide a special set of hoses, gauges, vacuum pump, recovery or recovery/recycling machine, and oil containers to be used with HFCs only.

Although recovering refrigerant in the vapor phase will minimize the loss of oil, recovering as much as possible in the liquid phase from the liquid line or receiver 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 removed and condensed by the recovery equipment.

Very large capacity recovery machines may have a water-cooled condenser to aid in faster recovery. The water-cooled condenser requires connection to a potable or municipal water supply.

When performing refrigerant system service on an operating unit that has a receiver/storage tank, refrigerant should be pumped into the receiver. Refrigerant should be removed from the condenser outlet if the condenser is below the receiver. The compressor in a parallel-rack system with an open equalization connection must be isolated before recovering refrigerant.

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. The technician should always evacuate an empty recovery cylinder before transferring refrigerant to the cylinder. Quick couplers, self-sealing hoses, or hand valves should be used (as low-loss fittings) to minimize refrigerant release when hoses are connected and disconnected.

**Recovery Requirements**

Anyone that services, repairs, or disposes of Type I, II or III equipment must have recovery equipment and/or recycling equipment that is certified and labeled by an EPA-approved equipment testing organization to meet EPA Standards. The purchase of recovery equipment does not need to be reported to the EPA.

After reaching the desired vacuum, the technician should 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 (0 psig) if leaks make recovery (evacuation) to the prescribed level unattainable.

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

A “major repair,” according to EPA regulations, is defined as 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.

Refrigeration Notes (Review vapor/compression system in introduction)

With the phase-out of CFCs and HCFCs, the industry has developed many different refrigerant blends for retrofit use. Read the nameplate and look for labels attached to a system to help identify the type of refrigerant used and the total charge.

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. In cold climates, use isopropyl alcohol to remove or clean ice from a sight glass.

The filter-drier should be replaced any time a system is opened for servicing. Filter driers will remove moisture from the refrigerant and oil in a system, but there is a limit to their capacity. If a strong odor is detected during the recovery process, a compressor burn-out may have occurred.

When recovering refrigerant from a system that experienced a compressor burn-out, watch for signs of and test for contamination of the oil.

A crankcase heater is often used to prevent refrigerant from migrating into the oil during periods of low ambient temperature. Refrigerant in the oil will cause oil foaming in the compressor at start-up.

The more accurate and preferred method of measuring a deep vacuum is in microns. When evacuating a vapor compression system, the vacuum pump should be capable of pulling 500 microns (29.90” hg) of vacuum.

Do not energize a hermetic compressor's motor under a deep vacuum, as the compressor's motor windings can become damaged, also NEVER energize a compressor if the discharge service valve is closed, this can cause severe damage.

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.

The source of most non-condensables in a system is air. Non-condensables will cause higher discharge pressures. All refrigeration systems must be protected by one or more internal or external pressure relief valves.

When charging a large system, it is best to charge liquid through the liquid-line service valve. Large systems usually have service valves which will enable the system to be pumped-down allowing for faster liquid charging.

When there is a risk of freezing a liquid-type heat exchanger, charging should begin by introducing refrigerant vapor into the system until the system pressure corresponds, by means of the pressure temperature relationship, to a temperature that is above 32 degrees. Once this pressure is reached, liquid charging can follow through the liquid-line service valve. This is the proper method to charge any water source system that contains a large quantity of refrigerant.

Safety (Additional safety and shipping/transportation information is covered in the Core section of this manual.)

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. Equipment rooms with ammonia, R-717 refrigerant, do not require a leak sensor if the room's mechanical ventilation system is continuously operated.

Technicians maintaining, servicing, repairing or disposing of low-pressure appliances must be certified as a Type III Technician or a Universal Technician. Most low-pressure appliances are used for comfort cooling and are subject to a lower allowable leak rate.

The owner and/or operator of the equipment is responsible for keeping records of all leak inspections and any completed leak repair verification tests. It is their responsibility to obtain service records from the servicing company doing any work on an appliance.

As of November 14, 1994, the sale of CFC and HCFC refrigerants is restricted to certified technicians. As of January 1, 2018, the sale of HFCs and HFOs are also restricted to certified technicians.

Note: If EPA regulations change after the technician is certified, it is the technician's responsibility to comply with these changes.

**Leak Detection**

Low-pressure systems are semi-hermetic and operate below atmospheric pressure (in a vacuum); leaks in the gaskets or fittings will cause air and moisture to enter the system. Leaks must be repaired to reduce the operation of the purge unit and loss of refrigerant.

The most efficient method of leak checking a charged, low-pressure refrigeration unit is to pressurize the system using controlled hot water or heater blankets. When controlled hot water or heater blankets are not feasible, use nitrogen to increase system pressure. When pressurizing a system, do not exceed 10 psig. Exceeding 10 psig can cause the rupture disc to fail. When leak testing a water box, be certain the water has been removed before placing the leak detector probe through the drain valve. To leak test a tube, use a hydrostatic tube test kit. Systems with open drive compressors are prone to leaks at the shaft seal.

Controlled hot water or heating blankets can be used to raise the pressure in a low-pressure system for the purpose of opening the system for a non-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 any auxiliary heat exchanger coil.

**Leak Repair Requirements**

Starting in 2019, EPA regulations require that systems containing more than 50 lbs. of refrigerant be repaired when the annual leak rate exceeds a percentage of the refrigerant charge. The appliance must be checked after each repair to verify the leak was successfully repaired.

Comfort cooling and other types of appliances 10% (Such as dehumidifiers)
Commercial refrigeration 20%
Industrial process refrigeration 30%

When the leak rate exceeds the maximum percentage on a low-pressure system, the system owner must repair the appliance enough to bring the leak rate below the threshold, or retrofit or retire the appliance. An appliance may be mothballed if it is shut down and the leaking section or component is isolated and evacuated of refrigerant to the EPA's required level.

When a system with a refrigerant charge of 50 lbs. or greater has exceeded the threshold leak rate, and it will be retrofitted or replaced using a refrigerant exempt from the venting prohibition, owners or operators have 18 months to replace/retrofit the appliance.

A low-pressure appliance leaking above the leak rate threshold must be repaired so that it leaks below the threshold and the initial verification test conduct within 30 days unless granted additional time.

An initial leak-test verification must be performed within 30 days (or 120 days if an industrial process shutdown is required) of an appliance exceeding the applicable leak rate. The follow-up leak-test must be performed within 10 days of the initial leak-test. When calculating the leak rate, the total system refrigerant charge can be calculated by adding the charge for each component and the piping. Each time a system is topped off or recharged the leak-rate must be recalculated.

The deadline to replace or retrofit an appliance cannot be extended when a certified service technician is not available to do the work. All records for leak inspections, initial verification, verification tests and records of recovered refrigerant from equipment with 5 to 50 lbs. of refrigerant must be kept for 3 years just as in Type II appliances.

**Recovery Techniques**

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.

Refrigerant recovery from a system using R-11 or R-123 starts with liquid removal and is followed by vapor recovery.

A substantial amount of vapor will remain in the appliance after all liquid is removed. For example, an average 350 ton, R-123 chiller at 0 psig still contains approximately 100 lbs. of vapor after all the liquid has been removed.

Most low-pressure recovery machines utilize a water-cooled condenser that is connected to the potable or municipal water supply. Using a water-cooled recovery machine and cooling recovery cylinders will reduce the recovery time. When recovering refrigerant, the system water pumps, the recovery compressor, and the recovery condenser water should all be on circulating water to prevent freezing. Increasing the temperature in an equipment room will aid in faster recovery. If a chiller is suspected of tube leaks, the water sides of the evaporator and condenser should be drained prior to recovering the refrigerant.

ASHRAE Guideline 3 states that if the pressure in a system rises from 1 mm Hg to a level above 2.5 mm Hg during vacuum testing, the system should be leak checked.

When removing oil from a low-pressure system, a temperature of 130°F should be attained to reduce the amount of refrigerant in the oil.

Recharging Techniques

Always read the nameplate and look for labels attached to a system to help identify the type of refrigerant used and the total charge.

Refrigerant is added through the lowest access point on the system such as the evaporator charging valve. However, introducing liquid refrigerant into a deep vacuum will cause the refrigerant to boil freezing water in the tubes. Therefore, initial charging is in the vapor phase to a pressure high enough to increase the saturation temperature of the refrigerant above the freezing temperature of water. Low-pressure refrigeration systems with refrigerants such as R-123 require a vapor pressure equal to a saturation temperature of 36° F. or higher, to prevent freezing of water-tubes when charging. Topping off a system is considered adding refrigerant due to a leak and must be accounted for in the leak-rate calculation. Adding refrigerant to a system that is new, retrofitted, or adjusted for seasonal variance does not need to be accounted for in the leak-rate calculation.

**Recovery Requirements**

Refrigerant recovery and/or recycling equipment must be certified and labeled by an EPA approved equipment testing organization to meet EPA standards. All equipment must have low loss fittings to minimize refrigerant loss when hoses are disconnected.

Recovery or recycling equipment manufactured or imported before or after Nov. 15, 1993, must be able to achieve a recovery level of 25 mm Hg absolute.

Once the required vacuum has been achieved, the technician should wait for a few minutes and monitor the system pressure. If the pressure rises, indicating that there is refrigerant remaining in the system, recovery must be repeated. When leaks in an appliance make evacuation to the prescribed level unattainable, the appliance should be evacuated to the lowest attainable level prior to a major repair.

Refrigeration Notes (Review vapor / compression system in introduction)

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.

If a strong odor is detected during the recovery process, a compressor burn-out may have occurred. When recovering refrigerant from a system that experienced a compressor burn-out, watch for signs of contamination in the oil and perform an oil test.

Low-pressure chillers using refrigerants such as R-123 operate below atmospheric pressure, require a purge unit. The primary purpose of a purge unit is to remove non-condensables from the system. A centrifugal chiller's purge unit takes its suction from the top of the condenser, separates air and other non-condensables from the refrigerant, and then returns the refrigerant back to the evaporator.

Although a high efficiency purge unit discharges a low percentage of refrigerant with the air they remove, frequent purging and subsequent refrigerant loss can indicate that a leak is allowing air into the system. High discharge pressure is also an indication of air in the system. Excessive moisture collection in the purge unit can indicate tube leakage. To prevent air accumulation in an idle system, a slight positive internal pressure above atmosphere should be maintained.

To protect the system from over-pressurization, low-pressure chillers typically use a rupture disc mounted on the evaporator housing. The typical design burst pressure for a rupture disc is 15 psig.

Safety (Additional safety and shipping/transportation information is covered in the Core section of this manual.)
ASHRAE Standard 15 requires a refrigerant monitor to sense refrigerant leaks that will sound an alarm and automatically start a ventilation system in equipment rooms before the refrigerant concentration reaches the TLV-TWA, (threshold limit value-time weighted average).
A refrigerant monitor is required for all ASHRAE refrigerant safety groups.

Refrigerants are divided into two groups according to toxicity:
• Class A signifies refrigerants for which toxicity has NOT been identified at concentrations less than or equal to 400 ppm;
• Class B signifies refrigerants for which there is evidence of toxicity at concentrations below 400 ppm.

ASHRAE code classification for refrigerants CFC-12, CFC-11, and HFC-134a are grouped as A-1. Refrigerant HCFC -123 is code grouped as B-1.

All refrigeration systems must be protected by a pressure relief valve. If more than one relief valve is required they must be piped in parallel not series. Another safety device is the rupture disc located on the evaporator of a low-pressure chiller. The rupture disc should be piped to the outdoors in case of rupture to prevent the equipment room from filling with refrigerant.

| | Low-Pressure Refrigerant Less than 30 psig | | | Medium-Pressure Refrigerant 30 to 155 psig | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HCFC | HFC | HFO | CFC | HCFC | HCFC | | HFC | Hydrocarbon | HFO | HFO | |
| | **R-123** | **R-245fa** | **R-1233zd** | **R-12** | **R-124** | **R-409A** | | **R-134a** | **R-600a** | **R-1234yf** | **R-1234ze** | |
| °F | | | | | | Bubble | Dew | | | | | °F |
| -40° | * | ***-13.9*** | ***28.3*** | ***11.0*** | ***22.1*** | 6.7 | ***14.8*** | ***14.8*** | ***21.6*** | ***11.5*** | ***19.1*** | -40° |
| -35° | * | ***-13.7*** | ***28.0*** | ***8.4*** | ***20.9*** | 3.5 | ***12.5*** | ***12.5*** | ***20.4*** | ***8.9*** | ***17.4*** | -35° |
| -30° | * | ***-13.5*** | ***27.6*** | ***5.5*** | ***19.4*** | 0.0 | ***9.9*** | ***9.8*** | ***18.9*** | ***6.0*** | ***15.4*** | -30° |
| -25° | * | ***-13.2*** | ***27.2*** | ***2.4*** | ***11.8*** | 1.9 | ***7.0*** | ***6.9*** | ***17.4*** | ***2.8*** | ***13.3*** | -25° |
| -20° | ***27.8*** | ***-13.0*** | ***26.7*** | 0.5 | ***16.0*** | 4.0 | ***3.8*** | ***3.1*** | ***15.6*** | 0.4 | ***10.9*** | -20° |
| -15° | ***27.4*** | ***-12.7*** | ***26.1*** | 2.4 | ***14.0*** | 6.3 | 2.0 | ***0.1*** | ***13.7*** | 2.3 | ***8.2*** | -15° |
| -10° | ***26.9*** | ***-12.2*** | ***25.5*** | 4.5 | ***11.8*** | 8.8 | 1.8 | 1.9 | ***11.5*** | 4.4 | ***5.3*** | -10° |
| -5° | ***26.4*** | ***-11.9*** | ***24.7*** | 6.7 | ***9.3*** | 11.6 | 4.0 | 4.1 | ***9.2*** | 6.7 | ***2.0*** | -5° |
| 0° | ***25.9*** | ***-11.4*** | ***23.9*** | 9.1 | ***6.6*** | 14.6 | 6.3 | 6.5 | ***6.6*** | 9.1 | ***0.8*** | 0° |
| 5° | ***25.2*** | ***-11.0*** | ***23.0*** | 11.7 | ***3.6*** | 17.8 | 8.8 | 9.1 | ***3.8*** | 12.0 | 2.7 | 5° |
| 10° | ***24.5*** | ***-10.4*** | ***22.0*** | 14.6 | ***0.3*** | 21.3 | 11.6 | 11.9 | ***0.7*** | 14.9 | 4.8 | 10° |
| 15° | ***23.8*** | ***-9.5*** | ***20.8*** | 17.7 | 1.6 | 25.1 | 14.7 | 15.0 | 1.3 | 18.1 | 7.2 | 15° |
| 20° | ***22.8*** | ***-9.1*** | ***19.5*** | 21.0 | 3.6 | 29.2 | 18.0 | 18.4 | 3.1 | 21.6 | 9.7 | 20° |
| 25° | ***21.8*** | ***-8.0*** | ***18.1*** | 24.6 | 5.7 | 33.6 | 21.6 | 22.1 | 5.0 | 25.4 | 12.5 | 25° |
| 30° | ***20.7*** | ***-7.5*** | ***16.5*** | 28.4 | 8.0 | 38.4 | 25.5 | 26.1 | 7.1 | 29.4 | 15.4 | 30° |
| 35° | ***19.5*** | ***-6.8*** | ***14.7*** | 32.5 | 10.5 | 43.4 | 29.7 | 30.4 | 9.4 | 33.8 | 18.7 | 35° |
| 40° | ***18.1*** | ***-5.6*** | ***12.8*** | 36.9 | 13.2 | 48.9 | 34.2 | 35.0 | 11.8 | 38.4 | 22.2 | 40° |
| 45° | ***16.6*** | ***-4.2*** | ***10.7*** | 41.6 | 16.1 | 54.7 | 39.1 | 40.1 | 14.4 | 43.4 | 26.0 | 45° |
| 50° | ***14.9*** | ***-2.8*** | ***8.3*** | 46.6 | 19.3 | 60.9 | 44.3 | 45.4 | 17.2 | 48.8 | 30.0 | 50° |
| 55° | ***13.0*** | ***-1.8*** | ***5.8*** | 51.9 | 22.7 | 67.5 | 49.9 | 51.2 | 20.2 | 54.5 | 34.4 | 55° |
| 60° | ***11.2*** | 0.0 | ***3.0*** | 57.6 | 26.3 | 74.5 | 55.9 | 57.4 | 23.5 | 60.6 | 39.1 | 60° |
| 65° | ***8.9*** | 1.9 | 0.0 | 63.7 | 30.2 | 81.9 | 62.3 | 64.0 | 26.9 | 67.0 | 44.1 | 65° |
| 70° | ***6.5*** | 3.5 | 1.6 | 70.1 | 34.4 | 89.8 | 69.2 | 71.1 | 30.6 | 73.9 | 49.5 | 70° |
| 75° | ***4.1*** | 5.9 | 3.4 | 76.8 | 38.9 | 98.2 | 76.5 | 78.7 | 34.5 | 81.3 | 55.2 | 75° |
| 80° | ***1.2*** | 7.9 | 5.3 | 84.0 | 43.7 | 107 | 84.2 | 86.7 | 38.6 | 89.0 | 61.3 | 80° |
| 85° | 0.9 | 10.2 | 7.3 | 91.6 | 48.8 | 116 | 92.5 | 95.2 | 43.0 | 97.2 | 67.8 | 85° |
| 90° | 2.5 | 12.8 | 9.5 | 99.6 | 54.3 | 126 | 101 | 104 | 47.7 | 106 | 74.8 | 90° |
| 95° | 4.3 | 15.8 | 11.9 | 108 | 60.1 | 137 | 111 | 114 | 52.7 | 115 | 82.1 | 95° |
| 100° | 6.1 | 19.0 | 14.4 | 117 | 66.2 | 148 | 120 | 124 | 57.9 | 125 | 89.9 | 100° |
| 104° | 7.7 | 21.3 | 16.6 | 124 | 71.4 | 157 | 129 | 133 | 62.3 | 133 | 96.5 | 104° |
| 105° | 8.1 | 23.0 | 17.1 | 126 | 72.7 | 159 | 131 | 135 | 63.4 | 135 | 98.2 | 105° |
| 110° | 10.3 | 26.0 | 20.0 | 136 | 79.6 | 171 | 142 | 146 | 69.3 | 146 | 107 | 110° |
| 115° | 12.6 | 30.0 | 23.1 | 146 | 86.9 | 184 | 153 | 158 | 75.4 | 157 | 116 | 115° |
| 120° | 15.1 | 33.0 | 26.5 | 157 | 94.6 | 197 | 166 | 171 | 81.9 | 169 | 126 | 120° |
| 125° | 17.8 | 36.0 | 30.0 | 169 | 103 | 211 | 179 | 185 | 88.7 | 182 | 136 | 125° |
| 130° | 20.6 | 41.0 | 33.8 | 181 | 111 | 226 | 192 | 199 | 95.8 | 195 | 147 | 130° |
| 135° | 23.6 | 46.0 | 37.8 | 193 | 120 | 241 | 207 | 214 | 103 | 209 | 158 | 135° |
| 140° | 26.8 | 52.0 | 42.0 | 206 | 130 | 257 | 222 | 229 | 111 | 223 | 171 | 140° |
| 145° | 30.2 | 57.0 | 46.5 | 220 | 140 | 274 | 237 | 246 | 120 | 239 | 183 | 145° |
| 150° | 33.9 | 61.0 | 51.3 | 234 | 150 | 291 | 254 | 263 | 128 | 255 | 196 | 150° |

| | **High-Pressure Refrigerant 155 to 340psig** | | | | | | | | | | | | | Over 350 psig | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HCFC | HFC | | HFC | | HFC | | HFC | | Hydrocarbon | | HFC | Ammonia | CO2 | |
| | **R -22** | **R-404A** | | **R-407C** | | **R-422D** | | **R-422B** | | **R-441A** | | **R-410A** | **R-717** | **R744** | |
| °F | | Bubble | Dew | Bubble | Dew | Bubble | Dew | Bubble | Dew | Bubble | Dew | | | | °F |
| -40 | 0.6 | 4.9 | 4.3 | 2.7 | ***4.6*** | 2.4 | ***2.3*** | 0.9 | ***2.7*** | 4 | 2 | 11 | ***9*** | 132 | -40 |
| -35 | 2.6 | 7.5 | 6.8 | 5.1 | ***0.9*** | 4.6 | 0.8 | 3.0 | ***0.9*** | 8 | 4 | 14 | ***6*** | 147 | -35 |
| -30 | 4.9 | 10.3 | 9.6 | 7.7 | 1.6 | 7.1 | 3.0 | 5.4 | 1.1 | 9 | 5 | 18 | ***2*** | 163 | -30 |
| -25 | 7.4 | 13.4 | 12.7 | 10.6 | 3.9 | 9.9 | 5.4 | 7.9 | 3.2 | 13 | 9 | 22 | 1 | 181 | -25 |
| -20 | 10.2 | 16.8 | 16.0 | 13.7 | 6.5 | 12.9 | 8.1 | 10.7 | 5.7 | 14 | 10 | 26 | 4 | 200 | -20 |
| -15 | 13.2 | 20.5 | 19.7 | 17.2 | 9.3 | 16.2 | 11.0 | 13.8 | 8.3 | 17 | 14 | 31 | 5 | 221 | -15 |
| -10 | 16.5 | 24.6 | 23.6 | 20.9 | 12.3 | 19.8 | 14.3 | 17.1 | 11.3 | 18 | 15 | 36 | 9 | 243 | -10 |
| -5 | 20.1 | 28.9 | 27.9 | 25.0 | 15.7 | 23.7 | 17.8 | 20.7 | 14.5 | 25 | 21 | 42 | 12 | 266 | -5 |
| 0 | 24.0 | 33.7 | 32.6 | 29.5 | 19.4 | 27.9 | 21.7 | 24.7 | 18.0 | 28 | 24 | 48 | 16 | 291 | 0 |
| 5 | 28.3 | 38.8 | 37.7 | 34.3 | 23.5 | 32.5 | 25.8 | 29.0 | 21.9 | 33 | 27 | 55 | 20 | 318 | 5 |
| 10 | 32.8 | 44.3 | 43.1 | 39.5 | 27.9 | 37.5 | 30.4 | 33.6 | 26.1 | 38 | 33 | 62 | 24 | 346 | 10 |
| 15 | 37.8 | 50.2 | 49.0 | 45.2 | 32.7 | 42.8 | 35.3 | 38.6 | 30.6 | 44 | 35 | 70 | 28 | 376 | 15 |
| 20 | 43.1 | 56.6 | 55.3 | 51.2 | 37.9 | 48.5 | 40.7 | 43.9 | 35.5 | 49 | 44 | 78 | 33 | 407 | 20 |
| 25 | 48.8 | 63.4 | 62.2 | 57. 7 | 43.5 | 54.7 | 46.4 | 49.7 | 40.8 | 54 | 47 | 87 | 39 | 441 | 25 |
| 30 | 55.0 | 70.7 | 69.3 | 64.7 | 49.6 | 61.3 | 52.6 | 55.9 | 46.6 | 66 | 51 | 97 | 45 | 476 | 30 |
| 35 | 61.5 | 78.6 | 77.1 | 72.2 | 56.1 | 68.4 | 59.3 | 62.5 | 52.7 | 66 | 60 | 107 | 51 | 513 | 35 |
| 40 | 68.6 | 86.9 | 85.4 | 80.2 | 63.2 | 75.9 | 66.4 | 69.6 | 59.4 | 74 | 68 | 118 | 58 | 553 | 40 |
| 45 | 76.1 | 96.8 | 94.2 | 88.8 | 70.7 | 84.0 | 74.0 | 77.2 | 66.5 | 80 | 74 | 130 | 66 | 595 | 45 |
| 50 | 84.1 | 105 | 104 | 97.9 | 78.8 | 92.6 | 82.2 | 85.3 | 74.1 | 88 | 80 | 143 | 74 | 638 | 50 |
| 55 | 92.6 | 115 | 114 | 108 | 87.5 | 102 | 90.9 | 94.0 | 82.2 | 97 | 89 | 156 | 83 | 684 | 55 |
| 60 | 102 | 126 | 124 | 118 | 96.8 | 111 | 100 | 103 | 90.9 | 105 | 97 | 170 | 93 | 733 | 60 |
| 65 | 111 | 137 | 136 | 129 | 107 | 122 | 110 | 113 | 100 | 115 | 106 | 185 | 103 | 784 | 65 |
| 70 | 121 | 159 | 147 | 141 | 117 | 133 | 121 | 123 | 110 | 125 | 117 | 201 | 114 | 838 | 70 |
| 75 | 132 | 162 | 160 | 153 | 129 | 144 | 132 | 134 | 120 | 133 | 124 | 218 | 126 | 895 | 75 |
| 80 | 144 | 175 | 173 | 166 | 141 | 156 | 144 | 145 | 132 | 145 | 135 | 236 | 138 | 955 | 80 |
| 85 | 156 | 190 | 188 | 180 | 153 | 169 | 156 | 158 | 143 | 155 | 145 | 255 | 151 | 1018 | 85 |
| 90 | 168 | 205 | 202 | 194 | 167 | 183 | 170 | 170 | 156 | 167 | 157 | 275 | 166 | * | 90 |
| 95 | 182 | 220 | 218 | 209 | 181 | 197 | 184 | 184 | 169 | 180 | 171 | 296 | 181 | * | 95 |
| 100 | 196 | 237 | 235 | 226 | 196 | 212 | 198 | 198 | 183 | 193 | 182 | 318 | 197 | * | 100 |
| 104 | 208 | 251 | 249 | 239 | 209 | 225 | 211 | 210 | 195 | 203 | 192 | 336 | 210 | * | 104 |
| 105 | 211 | 254 | 252 | 242 | 212 | 228 | 214 | 213 | 198 | 210 | 200 | 341 | 214 | * | 105 |
| 110 | 226 | 273 | 270 | 260 | 229 | 245 | 231 | 229 | 213 | 218 | 207 | 365 | 232 | * | 110 |
| 115 | 243 | 292 | 290 | 279 | 247 | 262 | 248 | 246 | 230 | 235 | 225 | 391 | 251 | * | 115 |
| 120 | 260 | 312 | 310 | 299 | 266 | 281 | 266 | 263 | 247 | 251 | 240 | 418 | 271 | * | 120 |
| 125 | 278 | 333 | 331 | 319 | 286 | 300 | 286 | 281 | 265 | 267 | 255 | 447 | 293 | * | 125 |
| 130 | 297 | 356 | 354 | 341 | 307 | 320 | 306 | 301 | 284 | 282 | 275 | 477 | 315 | * | 130 |
| 135 | 317 | 379 | 377 | 363 | 329 | 341 | 327 | 321 | 304 | 305 | 292 | 508 | 339 | * | 135 |
| 140 | 337 | 404 | 402 | 387 | 352 | 364 | 350 | 342 | 326 | 319 | 307 | 541 | 364 | * | 140 |
| 145 | 359 | 430 | 428 | 412 | 377 | 387 | 373 | 364 | 348 | 333 | 315 | 576 | 390 | * | 145 |
| 150 | 382 | 457 | 455 | 438 | 403 | 411 | 398 | 387 | 387 | * | * | 613 | 417 | * | 150 |

The following table lists refrigerants with characteristics that may be covered in each of the sections; Core, Types I, II & III.

| Ref. No. | Type | Ozone Depletion Potential (ODP) | Global Warming Potential (GWP) | Common Use | EPA Pressure Range | ASHRAE Class |
|---|---|---|---|---|---|---|
| R-11 | CFC | 1 (Base) | 4000 | Air-conditioning Chillers (Phased Out) | Low | A1 |
| R-12 | CFC | 1 | 10900 | Automotive, Domestic, Commercial (Phased Out) | Medium | A1 |
| R-22 | HCFC | .055 | 1810 | Air-conditioning | High | A1 |
| R-123 | HCFC | 0.012 | 76 | Commercial Chillers | Low | B1 |
| R-502 | CFC + HCFC | .283 | 4657 | Low-temperature Commercial | High | A1 |
| R-134a | HFC | 0 | 1430 | Automotive, Domestic, Commercial | Medium | A1 |
| R-404A | HFC | 0 | 3920 | Medium and low-temperature commercial and industrial | High | A1 |
| R-407C | HFC | 0 | 1770 | Air-conditioning R-22 retrofit | High | A1 |
| R-410A | HFC | 0 | 2090 | Air-conditioning | High | A1 |
| R-422B | HFC | 0 | 3143 | Retrofit for medium & low temp., R-22, R-407C, R-502 & HCFC blends | High | A1 |
| R-441 | HC | 0 | 0 | Domestic Refrigerators & Freezers, Vending machines, & Self contained Commercial Refrigerators & Freezers | High | A3 |
| R-170 | HC | 0 | 6 | Manufacturing | Very High | A3 |
| R-290 | HC | 0 | 3 | Commercial & Industrial Process Refrigeration | High | A3 |
| R-600a | HC | 0 | 3 | Domestic Small Appliances, Commercial & Industrial Process Refrigeration | Medium | A3 |
| R-744 | | | 1 (Base) | Commercial & Industrial Process Refrigeration | Very High | A1 |
| R-717 | | | 0 | Air-conditioning, Commercial & Industrial Process Refrigeration | High | B2 |
| R-1234yf | HFO | 0 | 4 | Automotive | Medium | A2L |
| R-1234ze | HFO | 0 | 6 | New Chillers, heat pumps, and vending | Medium | A2L |
| R-1233zd | HFO | 0 | 1 | New Chillers & Foam blowing | Low | A2L |

## ASHRAE REFRIGERANT CLASSIFICATION
## (American Society of Heating Refrigeration and Air Conditioning Engineers)

| | | |
|---|---|---|
| A3 | B3 | *Highly Flammability* |
| A2 | B2 | *Low Flammability* |
| A2L | B2L | *Very Low Flammability* |
| A1 | B1 | *No flammability* |
| *No Toxicity* | *High Toxicity* | |

**REQUIRED LEVELS OF EVACUATION FOR TYPE II & III APPLIANCES**
[Except for small appliances, MVACs, and MVAC-like appliances]

| Type of appliance | Using recovery and/or recycling equipment manufactured or imported | |
|---|---|---|
| | **Before November 15, 1993** | **After November 15, 1993** |
| Very high-pressure appliance | 0" Hg | 0" Hg |
| High-pressure appliance, or isolated component of such appliance, with a full charge of less than 200 lbs. of refrigerant. | 0" Hg | 0" Hg |
| High-pressure appliance, or isolated component of such appliance, with a full charge of 200 lbs. or more of refrigerant. | 4" Hg | 10" Hg |
| Medium-pressure appliance, or isolated component of such appliance, with a full charge of less than 200 lbs. of refrigerant. | 4" Hg | 10" Hg |
| Medium-pressure appliance, or isolated component of such appliance, with a full charge of 200 lbs. or more of refrigerant. | 4" Hg | 15" Hg |
| Low-pressure appliance | 25 mm Hg absolute | 25 mm Hg absolute |

<table>
<tr><th colspan="3">Section 608 Leak Repair Regulations</th></tr>
<tr><td colspan="3">The updated Section 608 regulations include new leak inspection and verification test requirements for owners/operators that will affect technicians starting January 1, 2019:</td></tr>
<tr><td colspan="3">Leak inspections are required for appliances that have exceeded the applicable leak rate, according to the schedule below. All visible and accessible components of an appliance must be inspected, using a method or methods that are appropriate for that appliance.</td></tr>
<tr><td>Equipment</td><td>Full Charge</td><td>Frequency of Leak Inspections</td></tr>
<tr><td rowspan="2">Commercial Refrigeration and Industrial Process Refrigeration</td><td>> 500 pounds</td><td>Once every three months until the owner/operator can demonstrate through leak rate calculations that the leak rate has not exceeded 20% (commercial refrigeration) or 30% (IPR) for four quarters in a row.</td></tr>
<tr><td>50 to 500 pounds</td><td>Once per calendar year until the owner/operator can demonstrate through the leak rate calculations that the leak rate has not exceeded 20% (commercial refrigeration) or 30% (IPR) for one year.</td></tr>
<tr><td>Comfort Cooling</td><td>50 or more pounds</td><td>Once per calendar year until the owner/operator can demonstrate through the leak rate calculations that the leak rate has not exceeded 10% for one year.</td></tr>
<tr><td colspan="3">Initial and follow-up verification tests: leak repairs are required for appliances that exceed the applicable leak rate. The verification tests must demonstrate that leaks were successfully repaired.<br>• An initial verification test must be performed before any additional refrigerant is added to the appliance.<br>• A follow-up verification test must be performed only after the appliance has returned to normal operating characteristics and conditions. There is no minimum timeframe.</td></tr>
</table>