EPA Section 608 Certification Study Guide

For Air Conditioning and Refrigeration Technicians

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About this Guide

This study guide is intended to help the user prepare for the EPA 608 Technician Certification Examination and contains all the information required to answer questions on the test. Information in this manual reflects the most current information available at the time of publishing. The information is presented as material and concepts that the exam covers and is not intended to simply be memorized. The more you understand the concepts behind EPA 608 regulations, the better you will do on the exam and the better you will perform your job as it relates to refrigerants.

This guide contains headings and bolded words to help you find and remember important concepts and words. Review questions at the end will help you to quiz yourself on what you just read. If you can answer the review questions, you should be well-prepared for the test.

The EPA may, from time to time, update laws or change test questions based on new information. **It is the responsibility of the technician to comply with future new laws as established by the EPA, even if they differ from the contents of this guide.**

This guide does not cover all EPA 608 regulation details, only those deemed important enough to be considered for test questions by the EPA. Technicians should read the entire EPA regulations before handling refrigerants.

About EPA 608 Testing

The Federal Government of the United States requires all individuals who open a system or container holding a controlled refrigerant to be certified. Persons who work on stationary equipment or use refrigerant designed for these systems can become certified by passing a proctored Section 608 examination. Candidates for this test can be certified in any of three equipment categories plus Universal.

- **Type I:** A Type I technician primarily works on small appliances such as domestic refrigerators, window air conditioners, PTACs and vending machines.
- **Type II:** A Type II technician primarily works on equipment using a high pressure refrigerant such as HCFC-22. The equipment includes residential air conditioners and heat pumps, supermarket refrigeration and process refrigeration.
- **Type III:** A Type III technician primarily works on equipment using a low pressure refrigerant such as HCFC-123 or CFC-11. These units are primarily chillers.
- **Universal:** Any candidate passing all three of these EPA types is certified as Universal.
- To pass any EPA type, a candidate must pass the Core section of the test plus one of the technician types listed above. Once Core is passed, it need not be taken again and it may be used for additional EPA types.

The test is divided into four sections: Core, Type I, Type II and Type III. Each test section has 25 multiple choice questions drawn from a bank of test questions. Questions regarding equipment regulations, safety, shipping and identifying refrigerants appear in every test section, so it is important to know these well. Multiple versions of the test are offered at the same time, each with different questions.

A passing score of 70%, or 18 out of 25 correct, is required in order to be certified. Each section is graded independently, so a technician could pass Core, Type I and Type III and fail Type II. In this case the technician would be certified as a Type I & Type III technician. Core must be passed to receive any certification. All sections must be passed in order to achieve Universal Technician status.

A technician may choose to take Core plus any combination of Type I, Type II or Type III. It is not required to take all four sections on the examination, however, much of the content from section to section relates to Core content, so once the Core content is mastered, reviewing for the other sections is much easier.

Preparing for the Test

Technicians should decide what certifications they need to have before taking the test (Type I, Type II, Type III or Universal). It is critical to know the information in the Core section as you must pass Core to receive any certification and Core content is found throughout all test sections. Passing this exam requires studying this guide over a period of time, not cramming the night before the exam. Set aside time to study over a period of a week or more before the exam. Study in a quiet, well-lighted area where there are no interruptions. Be well-rested the day of the exam.

Tests are closed-book tests. The only outside materials allowed are a temperature/pressure chart and a calculator. Bring the following with you to the test:

- Picture identification
- Home address information
- Any registration paperwork you were given (if applicable)
- Bring the pressure/temperature chart from the back of this guide. You must use a pressure/temperature chart to answer some questions on the exam.

Strategies for Taking the Test

Multiple choice exams require good reading skills. Test writers often use tricks to fool test takers who are not cautious in reading. Reading the test question and answers slowly and deliberately will increase your chances of passing. In particular:

- Read every word of the question. Don't hurry through the question even if you think you know the answer. Pay special attention to clarifying words like: always, never, not, sometimes, minimum, maximum, least, most, best, worst and similar words. Stop to think about the clarifying words.

- Read every answer, even if you think the first one is correct. Many questions are missed because not all the answer options are read. Always look at the last answer to see if it is answer that contains multiple answers such as "All of the above" or "A and B are correct". If you have to guess on one of these answers, choose "All of the above" as this answer is correct most often.
- Mark your answers on the sheet carefully. Completely fill in the circle indicating your choice, like this: ❍❍●❍ If you need to erase an answer, remove as much pencil mark as possible.
- Skip over difficult questions and come back to them later. Place a mark next to the question so that you know to come back and answer the question.
- Answer all questions, even if you have to guess. Eliminate the answers that you think are least likely to be correct and choose between the remaining answers.
- Do not fill in multiple answers on the test. Each test question has only one correct answer. Filling in multiple answers on a question will automatically result in an incorrect answer.
- Spend extra time checking back over your answers before turning in your test. You can usually find a few mistakes by reading the questions over carefully again.

Core Section

The Core section of the exam contains 25 general knowledge questions covering:

- Ozone depletion
- Clean Air Act and the Montreal Protocol
- Section 608 regulations
- Substitute refrigerants and oils
- Refrigeration
- Three Rs
- Recovery techniques
- Dehydration evacuation
- Safety
- Shipping

Ozone

Ozone Depletion

Ozone is a naturally occurring gas molecule that is made up of three oxygen atoms (O3). This gas occurs both in the Earth's upper atmosphere and at ground level. At ground level, ozone is considered "bad" and is a pollutant that causes significant health risks as well as damaging vegetation.

The ozone that occurs in the upper atmosphere or stratosphere is considered "good" ozone. This "good" ozone in the stratosphere is a layer that extends about 6 to 30 miles above earth and creates a protective shield for Earth from the sun's harmful ultraviolet (UV) rays. Depletion of ozone allows more of the sun's harmful UV rays to reach the earth resulting in the following problems:

- Increased temperature of the earth
- Increased cases of skin cancer
- Increased numbers of cataracts in the eyes
- Increased ground level ozone
- Crop and vegetation loss
- Reduced marine life

While the total amount of ozone in the stratosphere varies by location, time and season, the effect of ozone depletion is a global problem.

Destruction Process of Ozone

Ozone can be destroyed by chlorine and bromine atoms emitted into the atmosphere. When a chlorine atom meets with an ozone molecule, it takes an oxygen atom from the ozone molecule. The **ozone molecule (O_3)** changes to an **oxygen molecule (O_2),** while the chlorine atom changes to a compound called **chlorine monoxide (ClO).** When chlorine monoxide meets ozone, it releases its oxygen atom and forms two O_2 oxygen molecules, leaving the chlorine molecule free to attack another ozone molecule and repeat the process. It is estimated that a single chlorine atom can destroy 100,000 ozone molecules.

It was known that oceanic and terrestrial ecosystems naturally emit chlorine and bromine, but it wasn't until the mid 1970s that it was discovered that some human-produced chemicals were being emitted into the air and quickly destroying ozone. These gases come primarily from **CFCs (chlorofluorocarbons)** and **HCFCs (hydrochlorofluorocarbons),** which were once used in almost every refrigeration and air conditioning unit manufactured. A CFC is an organic compound containing carbon, chlorine, and fluorine. An HCFC contains carbon, chlorine, fluorine, and hydrogen.

Despite being heavier than air, CFCs reach the stratosphere through wind motions that carry them upwards. Because CFCs will not dissolve in water or break down into compounds that dissolve in water, CFCs remain in the atmosphere and do not "rain out" easily, which allows them to reach the stratosphere over time. When CFCs and HCFCs reach the atmosphere, they are broken apart, releasing their chlorine atoms, starting the process of attacking ozone molecules.

Proof that CFCs have reached the stratosphere comes from air samples taken in the stratosphere. Determining whether the chlorine emission was from naturally occurring instances like volcanoes or whether from refrigerants used to be debated, but scientific studies have shown than over 80% of the chlorine in the atmosphere is from human-made gasses. The supporting studies revealed the following:

- 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.
- The rise in the amount of chlorine measured in the stratosphere over the past two decades matches the rise in CFC emissions over the same period.
- Samples of air taken from the stratosphere over erupting volcanoes show that volcanoes contribute a small quantity of chlorine to the stratosphere compared to CFCs.

Ozone depletion potential (ODP) is the measurement of the ability of CFCs and HCFCs to destroy the ozone. CFCs have the highest ODP, followed by HCFCs. HFCs do not contain any chlorine and therefore do not have an ODP.

Gas	Example	Elements	ODP
CFC	R-11, R-12, R-500	Chlorine, Fluorine, Carbon	Higher
HCFC	R-22, R-123	Hydrogen, Chlorine, Fluorine, Carbon	Lower
HFC	R-134a	Hydrogen, Fluorine, Carbon	None

Ozone Review Questions

1. What is the ozone layer and why is it important to us on Earth?
2. What is an ozone molecule made of?
3. What is the name of the atom that attacks ozone molecules?
4. Why are refrigerants that are released into the atmosphere depleting ozone?
5. Describe how one chlorine atom can destroy 100,000 ozone molecules.
6. Name the refrigerant types that belong to CFCs, HCFCs and HFCs.
7. What do the letters in HCFC stand for?
8. What is ODP and what gas has the highest ODP rating? What gas has the lowest?
9. Name the health and environmental effects of ozone depletion.
10. What evidence do we have that CFCs and HCFCs are depleting the ozone?
11. What characteristics make it easy for CFCs to reach the stratosphere and how do they get there?
12. Why do we now use R-134A refrigerant?

Clean Air Act & Montreal Protocol

Clean Air Act

The **United States Environmental Protection Agency (EPA)** regulates the criteria of the 1990 **Clean Air Act (CAA),** which includes Section 608, Refrigerant Recycling and Emissions Reduction Regulations. The purpose of the CAA is to limit how much of a pollutant can be in the air anywhere in the US. Section 608 of the CAA focuses on capturing and ultimately eliminating the use of chlorofluorocarbons. In particular, the CAA calls for the following to limit chlorofluorocarbons damage to the atmosphere:

- **Phase-out:** Set dates to phase out CFCs and HCFCs.
- **Prohibit venting:** Prohibit venting of CFC and HCFC refrigerants and their substitutes.
- **Disposal requirements:** Require the EPA to set standards for recovery of refrigerants prior to appliance disposal.

While the CAA is a federal law, the states do most of the work to carry out the program and create their own laws to comply with CAA. The state laws must comply with the CAA and in some cases are as strict or stricter than the CAA laws.

As of November 14, 1994, a person may not service, maintain, or dispose of appliances designed to contain refrigerants without being appropriately certified.

As of November 14, 1994, only certified technicians may purchase refrigerants. The smallest cylinder a 608-certified technician may purchase is 20 pounds. Only a 609-certified technician (automotive) may purchase smaller containers.

It is a violation of the CAA not to keep records. The technician must:

- Provide the owner with an invoice indicating the amount of refrigerant added if the appliance contains 50 or more pounds of refrigerant.
- Keep a copy of their proof of certification at their place of business.

Punishment for Violating the CAA

Technicians and the companies they work for who violate the CAA face harsh penalties, including:

- Up to $27,500 per day, per violation
- Losing one's certification to handle refrigerants
- Appearing in US Federal Court for the charges

The EPA may ask technicians to demonstrate their ability to properly perform refrigerant recovery and recycling procedures. Those failing to demonstrate may lose their certification.

An award of up to $10,000 is offered by the EPA to those individuals who supply information leading to a penalty against a technician that intentionally vents.

Montreal Protocol

The **Montreal Protocol** on Substances That Deplete the Ozone Layer (commonly known as the Montreal Protocol) is a treaty among nations designed to protect the stratospheric ozone layer. The treaty was originally signed in 1987 and substantially amended in 1990 and 1992. The Montreal Protocol stipulates that the production and consumption of compounds that deplete ozone in the stratosphere: chlorofluorocarbons (CFCs), **halons**, **carbon tetrachloride**, and **methyl chloroform**, were phased out by 2000 (2005 for methyl chloroform).

Clean Air Act and Montreal Protocol Review Questions

1. What is the purpose of the CAA?
2. What three things is the CAA doing to control chlorofluorocarbon emissions?
3. What can states do in addition to the CAA?
4. What three things can happen if you violate the CAA?
5. What incentive do others have to turn you in for violating the CAA?
6. Who can purchase refrigerants and what size cylinders can be purchased?
7. What is the Montreal Protocol?
8. What chemicals does the Montreal Protocol control?

CAA Phase-out of CFCs and HCFCs

CFCs were phased out on December 31, 1995. These refrigerants can no longer be manufactured in or imported to the United Sates. Since the phase out, CFC refrigerant for equipment servicing comes from recovery and recycling.

CAA Venting

Since November 15, 1995, knowingly venting any refrigerant is a violation of the CAA. This includes CFC & HCFCs, CFC & HCFCs refrigerant substitutes. Only the **de minimis** release is allowed during service, maintenance or repair, which refers to the small amounts of refrigerants emitted unintentionally during good faith efforts to recover refrigerants, during the normal course of appliance operation or during the connection/disconnection to charge or service an appliance. **Nitrogen** that is used for holding charges or as leak test gases may be released; however, nitrogen may not be added to a fully charged system for the purpose for leak detection and then released.

All CFCs and HCFCs must be recovered before opening a system for service or disposing of appliances.

CAA Disposal

The EPA has set standards for recovery of refrigerants prior to appliance disposal, including that all refrigerants in disposable containers have been recovered (0 psig or lower) and rendered useless before recycling the cylinder.

Before disposing of any appliance containing a CFC or HCFC refrigerant, the refrigerant must be recovered. The person responsible for ensuring that refrigerants have been removed from household refrigerators before they are disposed of is the final person in the disposal chain.

CAA Phase-Out, Venting, and Disposal Review Questions

1. When was the CFC phase-out date?
2. Where do CFC refrigerants come from for equipment servicing of older systems?
3. When was the HCFC phase-out date?
4. For equipment servicing of older systems ,where do CFC refrigerants come from?

5. Is it allowed to release nitrogen into the atmosphere? How about a mixture of nitrogen and refrigerant?
6. What must be done before scrapping a refrigerant container?
7. What must be done before disposing of an appliance containing CFCs or HCFCs?
8. Who is responsible for removing refrigerants from a system that is being disposed of?

Refrigerant Oils

Due to the change in refrigerant use, you may encounter new refrigerants, old refrigerants, and blends of older refrigerants as well as different oils in the field.

Mineral, or petroleum, oils include paraffin-based oils, napthene-based oils, and mixed oils (a combination of napthene-based and paraffin-based oils).

Synthetic oils include silicate ester, silicone, neo-pentyl ester, dibasic acid ester, polyglycols such as polyalkylglycol (PAG), alkyl benzene (AB), and polyolyester (POE). Synthetic oils must be stored in metal containers. The ester oils are generally used with alternative refrigerants and are typically compatible with mineral oils and existing system components.

Refrigerant oil must be miscible (able to be mixed) at low temperatures; it must lubricate even when it is diluted; it must have electrical insulating properties; it must maintain its stability; and it must provide a pressure seal.

Oil Types

Oil Type	Abbreviation	Use
Mineral Oil	MO	CFC refrigerant systems
Alkylbenzene	AB	R-22 and other refrigerant systems
Polyolester	POE	HFC refrigerant systems
Polyalkylene glycol	PAG	R-134a automotive systems
Polyalphaolefin	PAO	R-717 (ammonia) refrigeration systems

Oil Properties

All refrigerant oils are **hygroscopic** (they attract moisture). All refrigerant oils have certain properties in common. The **viscosity** of an oil refers to its thickness, while the **density** of the oil refers to the composition of the oil at a given viscosity. An oil's **stability** is its ability to lubricate without chemical breakdown; its **solubility** refers to its miscibility with various refrigerants. (Solubility of air refers to the air and moisture entrainment capacity of an oil.) **Miscibility** refers to the ability of an oil to be mixed; **low temperature miscibility** refers to the oil's ability to remain mixed (in other words, not separate) at a low temperature.

Foaming refers to the tendency of the oil to foam when it is subjected to pressure changes. Foaming will reduce the oil's ability to lubricate. The **dielectric strength** of an oil is the threshold at which the oil conducts electricity. An oil's **oxidation value** is its ability to resist sludge accumulation. Its **boundary film-forming ability** is its ability to separate high pressure and low pressure.

Substitute Refrigerants

There is no "drop-in" replacement gas for R-12 systems; all replacement refrigerants require additional retrofit procedures. In particular, the new refrigerants are incompatible with the oils and lubricants used in R-12 systems and therefore, oils must be checked and changed out as part of the retrofit procedure.

R-134A (also called HFC-134a) is the leading replacement option for retrofitting R-12 systems. The oils used in most R-134A systems are **ester based oils** and ester based oils do not mix with other oils. Leak check an R-134A system using **pressurized nitrogen.**

Temperature glide is the difference in temperature that occurs when a refrigerant evaporates or condenses (changing from vapor to liquid or liquid to vapor) under constant pressure. This means the temperature in the evaporator and the condenser is not constant.

Temperature glide can also be understood as the difference between the **dew point** and the **bubble point.** The dew point occurs when the saturation temperature in the evaporator causes the refrigerant to change from a liquid to a vapor. The bubble point occurs when the saturation point in the condenser changes the refrigerant from a vapor to a liquid.

One problem with blended refrigerants is that since the different refrigerants in the blend have different vapor pressures, they leak from systems at uneven rates. Charging a blended refrigerant should be done as a liquid.

Ternary blends are three-part mixtures. They are common types of refrigerant blends that contain HCFCs. Ternary blends are used with a synthetic **alkylbenzene** lubricant. Alkylbenzene lubricant is **hygroscopic**, meaning that it absorbs (takes on) moisture.

A **zeotropic** (or **non-azeotropic**) refrigerant is a blend of components that change their composition and saturation temperatures as they evaporate or condense at constant pressure. In other words, the blend boils out at different temperatures (exhibits temperature glide) but at the same pressure. Zeotropes are blends of two or more refrigerants that retain the characteristics of each refrigerant. Because the components have different boiling points, they can leak at an uneven rate. Zeotropic mixtures should be charged as a liquid.

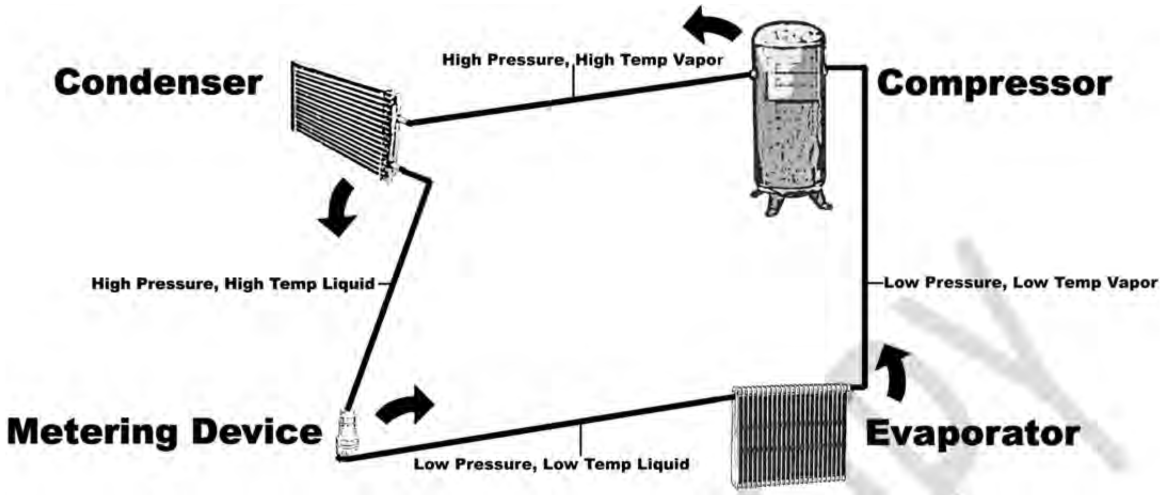
An **azeotropic** refrigerant contains fluids that boil out at the same temperatures (do not exhibit temperature glide) and act as a single refrigerant. Azeotropes are blends of two or more compounds that act like a single compound. Azeotropic refrigerants can be charged as a vapor or a liquid.

A **blended refrigerant,** or **near-azeotropic mixture** (sometimes referred to as NARM) contains refrigerants with different boiling points, but that act as one substance when they are in either a liquid or a vapor state. Near-azeotropic mixtures exhibit temperature glide when they change from vapor to liquid, or vice versa. However, the temperature glide is less than 10ºF. Near-azeotropic mixtures can exhibit fractionation (when the mixture's composition changes as a result of vapor charging) and may affect the leak ratio. Near-azeotropic mixtures should be charged as a liquid.

Substitute Refrigerants and Oils Review Questions

1. Are there "drop-in" replacements for R-12 systems? Why or why not?
2. What type of oil is used in R-134a and what oils will it mix with?
3. What type of lubricant is used with HCFCs?
4. What is the difference between a ternary blend and an azeotropic blend?
5. What is the trait of a hygroscopic lubricant?
6. What is temperature glide and which type of blend won't have it?
7. Will the gases in a ternary blend leak at the same rate? Why or why not?

Refrigeration Process



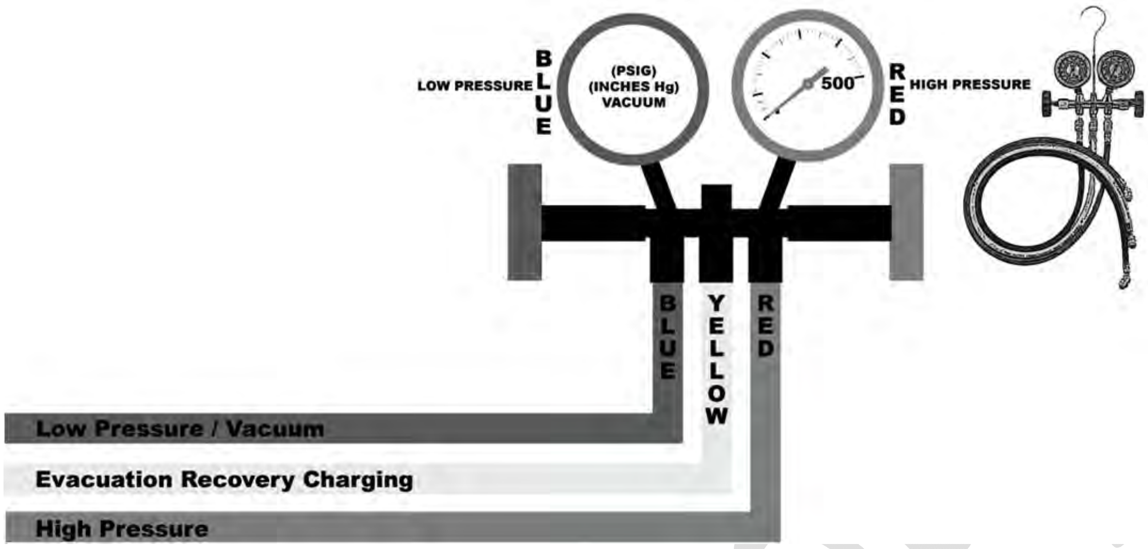
The **refrigeration process** is essentially the transfer of heat from one place to another. In an air conditioning unit, for example, the heat is removed from inside the building and is deposited outside the building. The vapor-compression refrigeration cycle is a repeating cycle consisting of four main components: evaporator, compressor, condenser and metering device.

The **evaporator** absorbs heat into the system from the space to be cooled (removes heat from the space). The absorption of heat into the refrigerant causes it to boil. Upon leaving the evaporator, the refrigerant is a low pressure, low temperature vapor.

The **compressor** takes the low pressure, low temperature vapor and changes it to a high-temperature, high-pressure, superheated vapor and delivers it to the condenser. Because of the vapor pressure difference between refrigerant and oil, the refrigerant will migrate towards the compressor crankcase, while the oil will not. **Hermetically sealed compressors** are often found and they cannot be serviced as their shell is welded shut. Never operate a hermetically sealed compressor when there is a dehydration vacuum in the system.

The **condenser** rejects the heat from the system and changes the refrigerant from a high-temperature, high-pressure vapor into a high pressure, high temperature liquid.

The **metering device** reduces the pressure of the refrigerant and changes the high-pressure, high-temperature liquid into a low pressure, low temperature liquid. The refrigerant goes back to the evaporator, where the process starts all over again.



The **gauge manifold** set (also known as a **service manifold**) is an important tool for the technician that measures pressure readings at different points in the refrigeration system. The **compound gauge** is usually blue and measures low pressure (psig) and vacuum (inches Hg). The **high pressure gauge** is usually red and measures the high side (discharge) pressure. The scale on the high pressure side is a continuous scale and is usually calibrated to read from 0 to 500 psi. The **center port** of the manifold is usually a yellow hose and can be connected to a recovery device, evacuation vacuum pump, or charging device.

Refrigeration Review Questions

1. How does refrigerant change states through each of the four major components of the refrigeration cycle?
2. What does a compressor compress?
3. Explain how cooling of a space occurs in a refrigeration cycle.
4. Why will refrigerant migrate to the crankcase in a compressor?
5. What color is the compound gauge and what does the compound gauge measure?
6. What color is the high pressure gauge?
7. What are three things the center hose is used for and what color is it usually?

General Service & Maintenance

In order to limit the potential of accidental refrigerant emissions, it is important to follow procedures and make sure the refrigeration system is in good operating order. This includes making sure that equipment used is approved by the EPA, checking for leaks, repairing leaks and making sure that all fittings are tight during service and recovery.

Leak detection in a refrigeration system is important to keep the system running well and to prevent refrigerant escaping into the atmosphere. When checking for small leaks, using a **halide torch** is the most effective method. You can also evacuate the system and pull a vacuum on it. If the system will not hold a vacuum, you have a leak. If the system has completely lost its charge and you want to test it for a leak, charge it with dry nitrogen for testing and never use refrigerant gases. Nitrogen is environmentally friendly and is safe to handle.

If you suspect a major leak or major component failure, an oil sample should be taken. If there are contaminants in the oil, the system will need to be flushed. In the event of a burnout of the compressor:

1. Triple-evacuate the system.
2. Install a permanent filter-drier.
3. Conduct a deep vacuum before recharging.

General Maintenance Review Questions

1. What things should you look for in equipment and systems to help limit refrigerant emissions?
2. What is the most effective method for checking for small leaks?
3. How can you test a system for leaks?
4. What should you look for if a compressor burns out?
5. What will need to happen if the oil has been contaminated by a burnout?

The Three Rs

The three Rs of refrigeration are: **recover, recycle**, and **reclaim.**

To **recover** is to remove refrigerant in any condition from a system and store it in an external container without necessarily testing or processing it in any way. Recovery is done in order to have adequate supplies for service after production bans, prevent venting to the atmosphere, and prevent stratospheric ozone depletion.

To **recycle** is to clean refrigerant for immediate reuse by separating the oil from the refrigerant and removing moisture and acidity from the refrigerant by use of products like filter driers.

To **reclaim** is to process refrigerant to the level of new product specifications as determined by chemical analysis. Reclaimed refrigerant must meet the standard set forth in **ARI 700** before it can be resold.

The Three Rs Review Questions

1. How is recovery different from recycling?
2. How is recycling different from reclaiming?
3. Name three reasons recovery is important.

Recovery Techniques

All refrigerant recovery and/or recycling equipment now manufactured must be certified and labeled by an **EPA-approved equipment testing organization** to meet EPA standards. This covers all air conditioning and refrigeration equipment containing CFC and HCFCs.

There are two basic types of recovery devices. **System dependent** devices capture refrigerant with the assistance of the compressor and/or the pressure of the refrigerant in the appliance from which refrigerant is being recovered. **Self-contained devices** have independent means to draw the refrigerant out of the appliance.

The EPA requires 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. **Schrader valves** (which look like bicycle tire air valves) are common on both refrigerant systems and recovery equipment. When using Schrader valves, it is critical to:

- Check the valve core for bends and breakage.
- Replace damaged Schrader valves to prevent leakage.
- Cap the Schrader ports to prevent accidental depression of the valve.

Due to the increased charges for recovering refrigerants, consumers have complained about paying for the process. In order to handle these complaints, let the consumer know that:

- Recovery is the law.
- Recovery is necessary to protect human health and the environment.
- All professional service personnel are duty bound to follow the law and protect the environment.

When recovering refrigerants, only put one type of a refrigerant in a tank and do not mix different refrigerant types into one tank. **Mixed refrigerants** in the same tank may be impossible to reclaim. When servicing a system that already has a mix of two or more refrigerants, the mixed refrigerants must be recovered into a separate tank.

The longer it takes to recover the refrigerants, the higher chance of emissions of the refrigerants to the atmosphere. The following factors affect the time it takes to recover refrigerant.

- **Size of refrigeration system and recovery equipment.** The bigger the system, the longer the recovery process. The bigger capacity of the recovery equipment, the faster the recovery.
- **Size of suction hose.** The longer the suction hose and the smaller in diameter it is, the higher the pressure drop in the system and the longer it will take to recover refrigerants.
- **Temperatures.** The colder the ambient temperature, the longer the recovery process. If the refrigerant system is warmer than the recovery cylinder, the recovery process will go faster due to a higher pressure in the refrigerant system and a lower pressure in the recovery cylinder.

Refrigerant Recovery Rate Variables						
Slower	***Longer***	⇦	**Hose length**	⇨	***Shorter***	**Faster**
	Smaller	⇦	Hose diameter	⇨	*Bigger*	
	Colder	⇦	Ambient temperature	⇨	*Warmer*	
	Colder	⇦	Refrigerant system compared to cylinder	⇨	*Warmer*	
	Bigger	⇦	Refrigerant system size	⇨	*Smaller*	

If you smell a strong odor during the recovery process, it is likely that the compressor has burned out. When recovering refrigerant from a system that has a burned out compressor, watch for signs of contamination in the oil.

After completing the transfer of liquid refrigerant between a recovery unit and a refrigeration system, avoid trapping liquid refrigerant between the service valves. Nitrogen may be used to flush debris out of the system after recovering refrigerant. The nitrogen may legally be vented to the atmosphere. A suction line filter-drier should be installed to trap any debris that may cause damage to the new compressor.

Recovery Techniques Review Questions

1. What standards must refrigerant recovery equipment meet and what component must all Type I and Type II refrigeration systems have?
2. What are two types of recovery equipment?
3. What should you tell a consumer who complains about the added cost and time of recovering refrigerant?
4. How should you handle recovery of a system that has mixed refrigerants?
5. After recovery, what are nitrogen and a filter-drier used for?
6. What are the variables that affect the recovery rate and why is it important to have faster recovery?

7. If you smell a strong odor during recovery, what is most likely the problem and what additional problems should you look for?

Dehydration Evacuation

The purpose of **dehydrating** a refrigeration system is to remove water and water vapor. The presence of moisture in an operating refrigeration system can create highly corrosive and toxic acids. The recommended method for dehydration is evacuation. Before evacuating a system, it is important to first recover all refrigerant and attain the mandated vacuum level. The factors that affect the speed and efficiency of evacuation are:

- **Size of equipment being evacuated**. The larger the equipment, the longer it will take to evacuate.
- **Ambient temperature**. The warmer the temperature, the faster it will evacuate. You may heat the refrigeration system to decrease the evacuation time.
- **Amount of moisture in the system**. The more moisture in the system, the longer it will take to evacuate.
- **Size (capacity) of vacuum pump and suction line**. The bigger the capacity of the vacuum pump, the shorter the time.

The piping connection to the pump should be as short in length as possible and as wide in diameter as possible. Vacuum lines (hoses) should be equal to or larger than the pump intake connection.

For the most accurate readings during evacuation, the vacuum gauge should be located as far as possible from the **vacuum pump.** Measuring the vacuum of a system should be done with the system isolated and vacuum pump turned off. If the system will not hold a vacuum, then it has a leak. Dehydration is considered complete when the vacuum gauge shows that have reached and held the required finished vacuum. It is not possible to over-evacuate a system.

Dehydration Evacuation Review Questions

1. Why is it necessary to dehydrate a refrigeration system?
2. What happens if moisture is left in an operating refrigeration system?

3. What must be done before starting evacuation?
4. What are the four factors that affect the evacuation time?
5. Can you increase the temperature of a refrigeration system for evacuation and if so, what purpose does it have?
6. How long and what diameter should the piping connection to the vacuum pump be?
7. How big should the vacuum hoses be in relation to the pump intake connection?
8. For accurate vacuum readings, where should the vacuum gauge be located?
9. When should the measurement of vacuum for a system be done and how do we know when dehydration is complete?

General Safety

Whenever handling or filling refrigerant cylinders, always make certain you are wearing the proper **personal protective equipment (PPE),** including safety glasses, butyl-lined protective gloves and safety shoes. Be certain to read and follow all equipment and product manufacturer's safety precautions. When working with any solvent, chemical or refrigerant, read and understand the manufacturer's **MSDS (Material Safety Data Sheet)** before handling.

Refrigerants can be deadly if inhaled or allowed to be heated. Refrigerants are heavier than air and will displace oxygen in the room, leading to **asphyxia** (lack of oxygen and excess carbon dioxide in the blood caused by respiratory interference), unconsciousness and eventually death. **Oxygen deprivation** is the leading cause of refrigeration accidents that lead to death. In addition to oxygen deprivation, inhaling refrigerant vapors in the air can lead to heart irregularities and direct exposure to the skin can cause frostbite. Never try to siphon refrigerants by mouth. Always work with refrigerants in a well ventilated area to help avoid oxygen deprivation. In the event of a large leak, immediately vacate and ventilate the area or use **Self Contained Breathing Aparatus (SCBA).**

ASHRAE standard 15-1994 requires a refrigerant sensor that will sound an alarm and automatically start a ventilation system in occupied equipment rooms where refrigerant (regardless of refrigerant type) from a leak will concentrate. The alarm will sound before the

TLV-TWA (Threshold Limit Value – Time Weighted Average) is exceeded (oxygen deprivation level).

Never expose refrigerants to open flame, live steam, glowing hot metal surfaces or excessive heat. Some refrigerants, when exposed to flames or steam, change into **toxic materials** such as hydrochloric, hydrofluoric, and halogen acids, as well as carbonyl halides, carbonyl fluorides, and phosgene gas. Because of this, never weld, cut or braze a refrigerant line on a charged system. Always evacuate all refrigerant from the system before using any open flame for repairs. Excessive heat applied to refrigerants causes an increase in pressure and can lead to an explosion.

Refrigerant safety is addressed in **ASHRAE Standard 15-1994,** Safety Code for Mechanical Refrigeration. This standard specifies an oxygen sensor and alarm for A1 refrigerants, and a refrigerant detector for all other refrigerants, as well as specifying ventilation requirements, but may not prevent hazardous accumulations.

Refrigerants are classified by a letter and a number; the letter indicates its toxicity and the number indicates its flammability. Refrigerants in the "A" category have a lower toxicity, while refrigerants in the "B" category have a higher toxicity. Similarly, refrigerants in the "1" category have no flame propagation (minimal flammability), while refrigerants in the "3" category have high flammability.

Refrigerant mixtures are classified based on worst-case fractionation.

ASHRAE Classification	Lower Toxicity	Higher Toxicity
Higher Flammability	A3	B3
Lower Flammability	A2	B2
No Flame Propagation	A1	B1

When checking for leaks in a system, always use dry nitrogen to pressurize the system and never use oxygen or compressed air. Oxygen or compressed air, when mixed with refrigerants, can cause an explosion. When using dry nitrogen in service or installation, always charge through a pressure regulator (make sure the nitrogen cylinder has a regulator on it) and insert a relief valve downstream line from the pressure regulator.

All refrigeration systems must have **safety relief valves.** The valves must n**ot** be installed in series, and must be replaced if corrosion build-up is found within the body of a relief valve.

To determine the safe pressure for leak testing a piece of equipment, read the design or test pressure information located on the **data plate** on the low-side pressure valve.

Sight glasses used for visual inspection of the refrigerant can become dirty and/or iced up. If icing occurs on the sight glass, always use an alcohol spray to remove the ice. Never use a screw driver to chip at ice on the sight glass.

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

General Safety Review Questions

1. What are the risks of inhaling (breathing in) refrigerants?
2. What is the leading cause of refrigeration accidents leading to death?
3. What personal protective equipment should you wear when handling refrigerants?
4. What are the requirements under ASHRAE standard 15-1994?
5. Under what conditions will alarm and ventilation sound under ASHRAE standard 15-1994?
6. What is the safest rating of a refrigerant according to the ASHRAE scale?
7. Why should oxygen or compressed air never be used to test leak a system?
8. When using nitrogen to charge a system, what piece of equipment should it be charged through and where should a relief valve be located?
9. Where can you find the appropriate test pressures for a system?
10. What are the two conditions to be aware of in observing relief valves?
11. What can happen to refrigerants if they are exposed to direct flame or other excessive heat?
12. Before welding, cutting or brazing a refrigerant line, what should be done?
13. In case of a major refrigerant leak, what actions should be taken?

Refrigerant Cylinders

Disposable cylinders are used only for virgin refrigerant and should ***never*** be used for recovery. Before scrapping disposable cylinders, all refrigerant should be evacuated and the pressure on the cylinder should be at least 0 psig. Disposable cylinders use a one-way (check) valve.

Disposable cylinders should be emptied of all contents using a refrigerant recovery device. Once emptied, the cylinder's valve should be opened to allow air to enter, and the cylinder should be punctured with the valve still open (rendered useless). Never leave used cylinders with any residual refrigerant, either outdoors or at a job site. Used cylinders that have been rendered inoperable can be recycled with other scrap metal. The internal pressure of a cylinder with one ounce of liquid refrigerant is exactly the same as a full cylinder. An abandoned cylinder will eventually deteriorate and can explode if the cylinder wall weakens.

Refrigerant cylinders are color-coded. The actual shade of color depends on the manufacturer and may change over time, so *do not* rely on color alone to identify a refrigerant.

Recovery cylinders are specifically designed to be refilled. For safety reasons, only cylinders designated as "refillable" by the **Department of Transportation (DOT)** can be used for refrigerant recovery. DOT approved refrigerant recovery cylinders are easy to identify as they have yellow tops and gray bodies. Refillable cylinders must be **hydrostatically tested** and date stamped every five years. When checking or using refillable cylinders, make sure the cylinder has been tested within the last five years and is free of rust and damage. If the cylinder is damaged and requires scrapping, it should first be completely evacuated of all refrigerants and have a pressure of 0 psig or lower before scrapping.

Cylinders should always be stored and moved in the upright position and secured so they won't fall over. Cylinders should never be stored by an open flame or in very hot areas. The excessive heat may cause the cylinder to explode, it may change the state of the refrigerant into a toxic material and/or the added pressure may cause the cylinder to leak refrigerant.

When using vapor recovery, the fill level should never exceed 80% of its capacity by weight. Overfilled cylinders may rise in internal pressure when exposed to heat, resulting in an explosion. The fill level may be controlled by mechanical float devices, electronic float devices, or weight. Sight glasses are ***not*** an acceptable means for determining filling capacity.

Refrigerant Cylinder Review Questions

1. What types of cylinders can be used for recovery and how can you visually identify them?
2. How often should refillable cylinders be hydrostatically tested?
3. What must be done to a cylinder (disposable or refillable) before scrapping it?
4. Why should cylinders not be filled above 80% of their capacity by weight?
5. What can happen if cylinders are exposed to flames or excessive heat?
6. What are the three ways you can control the fill level of a refillable cylinder?

Refrigerant Cylinder Shipping

Used refrigerant cylinders or recovery cylinders that are shipped or transported require the following:

- Cylinders must be shipped in the upright position.
- Recovery cylinders must be DOT-approved (yellow top and gray bodies).
- Cylinders must contain a DOT classification tag indicating it is a "2.2 non-flammable gas."
- Cylinders must be labeled with the type and amount of refrigerant.
- Number of cylinders in shipment must be recorded.

Certain states may have additional requirements. Please check with your state DOT before shipping refrigerant.

Refrigerant Shipping Review Questions

1. In what position should cylinders be shipped?
2. What type of DOT tag is required for shipping refrigerant cylinders?
3. What type of information about the refrigerant must the cylinder label contain?

Type I

The Type I section of the exam contains 25 questions covering

- Recovery requirements
- Recovery techniques

Type I may also cover information found in Core content, such as:

- Substitute refrigerants and oils
- General service and maintenance
- Recovery techniques
- General safety
- Refrigerant cylinders
- Refrigerant cylinder shipping

Recovery Requirements

According to the EPA, a **small appliance** is one that is manufactured, charged, and hermetically sealed in a factory and contains five pounds or less of refrigerant. A **pressurized terminal air conditioner (PTAC)** is a common name used for a hermetically sealed air conditioning system. MVAC or motorized vehicle air conditioning systems ***do not*** fall under the small appliance regulations.

Technicians that handle refrigerant during service, maintenance, or repair of small appliances must have a Type I or Universal certification. The sales of CFCs and HCFCs are restricted to certified technicians. If the EPA changes regulations after the technician is certified, it is the responsibility of the technician to comply with any future changes in the law.

Refrigerant Recovery Requirements for Small Appliances		
	Before November 15, 1993	**After** November 15, 1993
Operating compressor	80% or 4" of vacuum	90% or 4" of vacuum
Non-operating compressor	80% or 4" of vacuum	80% or 4" of vacuum
Fittings	Low-loss required	Low-loss required
Approvals	None specified	EPA Laboratory-Approved

Recovery equipment manufactured *before* November 15, 1993 must be capable of recovering 80% of the refrigerant whether or not the compressor is operating or achieve a 4 inch vacuum under conditions of ARI 740.

Recovery equipment manufactured *after* November 15, 1993 must be capable of recovering 80% of the refrigerant without the compressor operating or achieve a 4 inch vacuum under conditions of ARI 740; be capable of recovering 90% of the refrigerant with the compressor operating or achieve a 4 inch vacuum under conditions of ARI 740; and must be approved by an EPA approved third-party laboratory.

Recovery equipment fittings must be equipped with **low-loss fittings** which can be manually or automatically closed when disconnecting hoses in order to prevent refrigerant loss.

All appliances must have a **service aperture** valve for recovering and charging refrigerants. For small appliances, the service aperture valve is typically a straight piece of tubing that is entered with a piercing access valve.

When servicing a small appliance, it is not mandatory to perform a leak repair; however, it should be done whenever possible.

Recovery Requirements Review Questions

1. What is the EPA definition of a small appliance?
2. Does a PTAC fall under small appliances? What about an MVAC?
3. What is the maximum amount of refrigerant a small appliance can have by definition?
4. Who is responsible for complying with the laws if the EPA changes the laws after technician certification?
5. What standards must recovery equipment manufactured before November 15, 1993 must meet?
6. What standard must recovery equipment manufactured after November 15, 1993 must meet if using a compressor? With no compressor?
7. What is a low-loss fitting and why is it needed?
8. What does the service aperture on a small appliance typically look like?
9. What should be done with leaks in small appliances?

Recovery Techniques

Before beginning the refrigerant recovery process, you should always know the type of the refrigerant in the system first. One way to identify the refrigerant is by using the **temperature/pressure chart** (see back page). Never mix refrigerants in a recovery cylinder. If a reclamation facility receives a tank of mixed refrigerants, they may either refuse to process the refrigerant and return it at the owner's expense or they may destroy the refrigerant, but charge a substantial fee.

For small appliances, the technician may use either a self-contained recovery device or use a system dependent recovery system.

Self-contained (active) recovery equipment uses its own power to recover the refrigerant from systems and is capable of reaching the required recovery rates with or without the compressor operating. The recovered refrigerant in a self-contained system is stored in a pressurized recovery tank.

Before operating a self-contained recovery device, make sure the tank inlet valve is open and that the tank does not contain excessive air or non-condensables. Not opening the tank inlet valve or having excess air will cause higher discharge pressures.

Checking for air or non-condensables can be done by checking the pressure inside the recovery tank. References to the pressure/temperature chart are only valid if the temperature is known; therefore, when checking for non-condensables inside a recovery cylinder, allow the temperature of the cylinder to stabilize to room temperature before taking a pressure reading.

Refer to the recovery equipment instructions in order to purge air and non-condensables. All refrigerant recovery equipment should be checked for oil level and refrigerant leaks on a daily basis.

A **system-dependent (passive) recovery process** captures refrigerant into a non-pressurized container. The system-dependent equipment uses the system's compressor, an external heat source, or a vacuum pump to recover the refrigerant. A vacuum pump can only be used as a recovery device in combination with a non-pressurized container and can not be used with self-contained recovery equipment (pressurized container).

When using a system-dependent recovery process with an operating compressor, run the compressor and recover from the high side of the system. Normally, one access fitting on the high side will be enough to reach the required recovery rate as the compressor should be able to push the refrigerant to the high side.

When using a system-dependent recovery process with a non-operating compressor, it may be necessary to access both the low and high side of the system to achieve the required recovery level and it will speed the recovery. In order to release the trapped refrigerant from the compressor oil, it will be necessary to heat and tap the compressor with a mallet several times and/or use a vacuum pump.

If the appliance has a **defrost heater** as commonly found in domestic refrigerators, operating the defrost heater will help to vaporize any trapped liquid refrigerant and will speed the recovery process.

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

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. These fittings tend to leak over time and should not be left on appliances as a permanent service fixture. After installing an access fitting, if the system pressure is 0 psig, do not start the recovery process.

Small appliances used in campers or other recreational vehicles may use refrigerants not covered in Section 608, such as **ammonia, hydrogen** or **water** and therefore, should not be recovered using current EPA-approved recovery devices. Similarly, systems built before 1950 may have **methyl formate, methyl chloride,** or **sulfur dioxide** as refrigerants and require special recovery equipment.

Recovery Techniques Review Questions

1. How can you tell what type of refrigerant is in a system?
2. Find the pressure for: R-12 refrigerant at 80ºF, R-22 at 70ºF and R-134A at 90ºF.
3. What might happen if a cylinder containing mixed refrigerants is given to a reclamation center?
4. What is the difference between a self-contained recovery tank and a system-dependent recovery tank?

1. What are two things that can cause high discharge pressures?
2. How can you check if a tank contains excess air or non-condensables?
3. What temperature must a cylinder be at to check for excess air?
4. What type of system can a vacuum pump be used on for recovery?
5. When using a system-dependent recovery system with an operating compressor, where should the refrigerant be recovered from? With a non-operating compressor?
6. How can you release trapped refrigerants in the oil?
7. How will activating a defrost heater aid in the recovery process?

8. When should piercing type valves be used? What is a common problem with these valves?
9. What are some other small refrigeration systems that contain other types of refrigerants? Should these refrigerants be recovered with standard EPA equipment?

Type II

Type II certification is primarily for equipment using a high-pressure refrigerant such as HCFC-22. The equipment includes residential air conditioners and heat pumps, supermarket refrigeration and process refrigeration.

The Type II section of the exam contains 25 questions covering:

- Leak detection and repair
- Refrigeration
- Recovery requirements
- Recovery techniques

Type II questions may also cover information included in Core content, such as:

- Refrigeration process
- General safety

Leak Detection & Repair

After installation of any type of refrigeration system and before charging it with refrigerant, the unit should first be pressurized with nitrogen (classified as an **inert gas**) and leak checked.

Using an electronic or ultrasonic leak detector will locate the general area of the leak. Once the general area has been found, using soap bubbles will pinpoint the leak. When a refrigerant **trace gas** becomes absolutely necessary, HCFC-22 can be used to find the leak.

A refrigeration system with an open compressor that has not been used in several months is likely to leak from the rotating shaft seal. Visual inspection of leaks can be done by looking for traces of oil. Excessive superheat, caused by low refrigerant charge, is also an indication of a leak in a high-pressure system.

EPA leak repair requirements state that a system containing more than 50 pounds of refrigerant must be repaired if:

- The leak rate exceeds 15% in comfort cooling appliances.
- The leak rate exceeds 35% in all commercial and industrial process refrigeration.

Leak Detection and Repair Review Questions

1. What should be done before charging a new system with refrigerant?
2. What tools can you use to find general area of leaks and pinpoint leaks?
3. Describe three ways you can visually look for leaks.
4. What are the leak repair requirements for comfort cooling appliances and commercial appliances containing 50 pounds or more of refrigerant?

Refrigeration

The most common refrigerant used before 1995 was R-22, but with the variety of refrigerants in the market, the technician should always read the nameplate to determine the type of refrigerant used in the system.

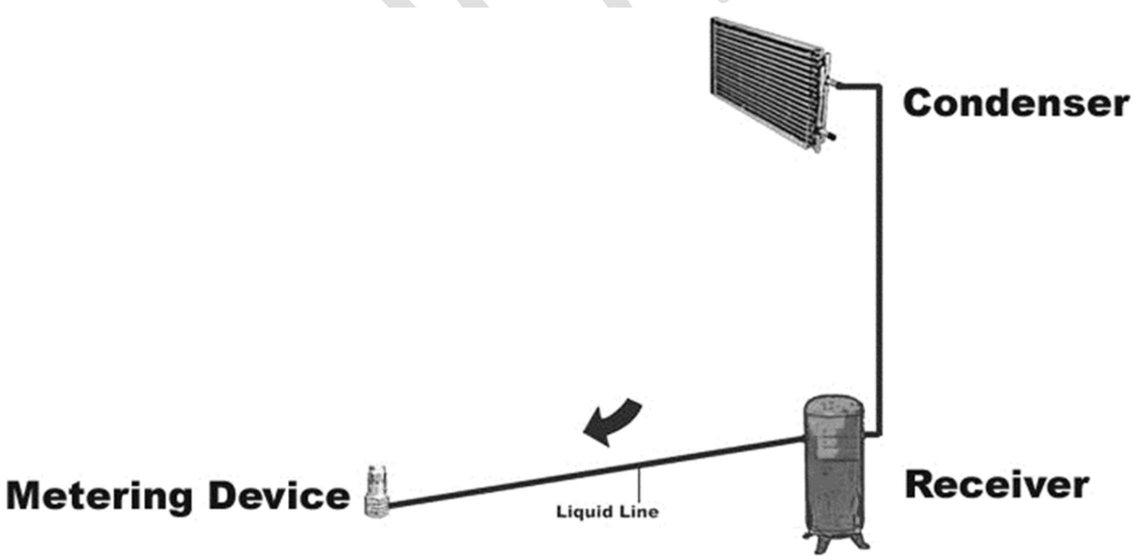
Filter-driers are designed to remove moisture from the refrigerant in a system; however, in order to remain effective, these must be replaced on a routine basis or any time a system is opened. In addition to helping identify what type of refrigerant is in the system, using the **sight**

glass can also help determine if there is excess moisture in a system by looking for color changes of the refrigerant. Always use an alcohol spray to clean the sight glass.

The use of a large vacuum pump can 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. Where there is a risk of freezing, liquid charging of an R-12 refrigeration system should 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.

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

Vacuum can be measured in either **microns** or **inches of mercury (inches Hg).** 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 (or 29.90" Hg) of vacuum. Never start a hermetic compressor when under a deep vacuum as the motor winding could be damaged if energized.



Systems using thermal expansion valves will have a receiver/tank on the outlet side of the condenser, designed to hold liquid refrigerant. When leaving the condenser directly or the receiver, the refrigerant remains a high pressure/high temperature liquid until it goes to the metering device. The line between the condenser and the metering device is also referred to as the **liquid line.**

Refrigeration Review Questions

1. What type of refrigerant was the most common before outlawing CFCs and HCFCs?
2. What is the best way to determine the refrigerant type in the system?
3. What is the purpose of the filter drier and when should it be changed?
4. How can you tell through a sight glass if there is excess moisture in the system?
5. Using large vacuum pumps can lead to freezing of water in the system. What are two ways the technician can help prevent freezing?
6. Foaming at start-up may be found in what component? What does this mean?
7. What are two ways to measure a deep vacuum and what is the preferred method?
8. What does inches Hg stand for?
9. When evacuating a vapor compression system how many microns does the vacuum need to achieve?
10. Why should you never start a hermetic compressor when under deep vacuum?
11. What is a receiver, where is it located and what is the state of the refrigerant after leaving the receiver?
12. What is the liquid line?

Recovery Requirements

Recovery equipment manufactured after November 15, 1993 must be certified by an EPA laboratory, be equipped with low-loss fittings, and must meet stringent vacuum standards. System-dependent recovery equipment cannot be used on appliances containing more than 15 pounds of refrigerant.

Required Level of Evacuation (Except for Small Appliances & MVAC)		
Type of Appliance	Manufactured before 11/15/93	Manufactured after 11/15/93
	Inches Hg	
HCHF-22 appliance* < 200 lbs. refrigerant	0	0
HCFC-22 appliance* > 200 lbs. refrigerant	4	10
Other high-pressure appliance* < 200 lbs. refrigerant	4	10
Other high-pressure appliances* >200 lbs. refrigerant	4	15
Very high-pressure appliance	0	0
Low-pressure appliance	25	25

**or isolated component*

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.

EPA has established limited exceptions to its evacuation requirements for:

1. Repairs to leaky equipment. Appliances can be evacuated to atmospheric pressure (0 psig) if leaks make evacuation to the prescribed level unattainable.
2. Non-major repairs. 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. A non-major repair would not fall into any of these categories.

Repairs that are ***not*** major and that are ***not*** followed by an evacuation of the equipment to the environment must be evacuated to at least 0 psig before it is opened if it is a high or very high pressure appliance, **or** must be pressurized to 0 psig before it is opened if it is a low-pressure appliance.

Recovery Requirements Review Questions

1. What criteria must recovery equipment manufactured after November 15, 1993 meet?
2. How many inches of mercury (inches Hg) vacuum is required for HCFC-22 Appliances containing more than 200 pounds refrigerant using equipment manufactured after

November 15, 1993? Equipment before 11/15/1993? What about other appliances under the same conditions?

3. What does the EPA consider major repairs?
4. What exceptions are there for evacuation for non-major repairs?
5. What can you do if you can't reach the required evacuation levels on leaky equipment?

Recovery Techniques

Before using a recovery unit you should always:

- Check the service valve positions.
- Check the oil level of the recovery unit.
- Evacuate and recover any remaining refrigerant from the unit's receiver.
- Evacuate an empty recovery cylinder before transferring refrigerant to the cylinder.

On a routine basis, you should always:

- Check both the oil and filter on a refrigerant recycling machine as recovered refrigerants may contain acids, moisture, and oil.
- Use quick couplers, self-sealing hoses, or hand valves should be used to minimize refrigerant release when hoses are connected and disconnected.

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, so be aware of this problem.

Before charging a new system with refrigerant, technicians working with multiple refrigerants but the same recovery equipment must:

- Purge the recover/recycle equipment by recovering as much of the first refrigerant as possible.
- Change the filter.
- 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/recycling machine, and oil containers to be used with R-134A ***only.***

In order to reduce recovery time and thereby reduce chances for refrigerant emissions, the technician may choose to:

- Pack the recovery cylinder in ice and/or apply heat to the appliance.
- Recover as much as possible in the **liquid phase.** In order to recover liquid refrigerant, you must connect one hose to the system's liquid line. After recovering liquid refrigerant, any remaining vapor is condensed by the recovery system.

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 or MVAC-like appliance.

Recovery Techniques for Different Systems

- When performing refrigerant system service on a unit that has a receiver/storage tank, refrigerant should be placed in the receiver.
- 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.
- When recovering from a system with parallel compressors, 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.

Recovery Techniques Review Questions

1. What steps are taken before using recovery equipment?
2. What types of hoses and couplings should be used during the recovery process? Why?
3. What common contaminants can be found in refrigerant oils?

4. What maintenance task should you take to help limit the damage of contaminated oils?
5. Why might recovery equipment using hermetic compressors overheat?
6. If switching from recovering one refrigerant to another, what three steps must be taken before recovering the new refrigerant? What if the refrigerant is R-134A?
7. Describe two ways to speed up recovery.
8. Under what circumstances can recovered refrigerant be reused?
9. Where should you remove the refrigerant in a system that has a condenser below the receiver?
10. How must you recover refrigerant from a parallel system? Why?

Type III

Type III certification is for equipment using low-pressure refrigerant.

The Type III section of the exam contains 25 questions covering:

- Leak detection and repair
- Recovery techniques
- Recharging techniques
- Recovery requirements
- Refrigeration

Type III may also include information found in Core content, such as:

- Refrigeration process
- General safety

Type III may also include information found in Type I content, such as:

- Recovery techniques – identifying refrigerants

Type III may also include information found in Type II content, such as:

- Leak detection and repair
- Recovery requirements

Leak Detection And Repair

Leaks in a Low-Pressure System

A low-pressure system operates in a vacuum (below atmospheric pressure) which allow air and moisture to enter the refrigeration system. The most common place for air or moisture to enter the system is through leaks in gaskets or fittings. The shaft seal in open-drive compressor low pressure refrigeration systems is particularly susceptible to leaks.

The **ASHRAE guideline 3-1996** states that if the pressure in the system rises from 1 mm Hg to a level above 2.5 mm Hg during vacuum testing, the system should be leak checked.

Purge Units

Because low pressure systems will suck in non-condensables and moisture, the systems have purge units to vent the unwanted properties. The **purge unit** prevents the accumulation of non-condensable substances (air and moisture) in order to keep the system clean and maintain efficiency. The purge unit removes air and moisture to prevent reduced condenser surface area, increased head pressure, compressor surge, increased pressure differential, and system corrosion.

A centrifugal system's purge unit takes its suction from the top of the condenser, removes the air from the system, and returns the refrigerant to the evaporator. A high efficiency **purge system** will expel very little refrigerant along with the air, while an inefficient purge unit will continue to leak refrigerants. In order to reduce refrigerant loss through the purge unit, the technician should leak test and repair the chiller.

Visual Leak Inspection

The following are indications of leaks in a low-pressure system:

- Excessive running of a purge system.
- Continuous excessive moisture in the purge unit could indicate a leak in the condenser or the chiller barrel.
- High head pressure.

Leak Checking

The most efficient method of leak checking a charged low-pressure refrigeration unit is to increase the pressure in the system by the use of controlled hot water or heater blankets. If using hot water or heater blankets is not possible, use nitrogen to increase the pressure. Do not exceed 10 psig when pressurizing with nitrogen, as this can cause the rupture disc to fail. When leak testing a water box, be certain the water has been removed, then place the leak detector probe in through the drain valve. To leak test a tube, use a hydrostatic tube test kit.

Controlled hot water can be used to pressurize a system for the purpose of opening the system for 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 an auxiliary heat exchanger coil. A non-major repair would not fall into any of these categories/

EPA leak repair requirements are the same as Type II. EPA leak repair requirements state that a system containing more than 50 pounds of refrigerant must be repaired if:

- The leak rate exceeds 15% in comfort cooling appliances.
- The leak rate exceeds 35% in all commercial and industrial process refrigeration.

Leak Detection and Repair Review Questions

1. Where do leaks commonly occur in low pressure systems? What about open-drive type compressor systems?
2. Does refrigerant go out of the system in low pressure systems or does air and moisture go in? Why?
3. When should a low pressure system be leak checked according to ASHRAE guideline 3-1996?
4. What does a purge unit do and what is a high efficiency purge unit?
5. How does a centrifugal purge unit work?
6. What are three visible ways to check for leaks in a low pressure system?
7. What needs to be done to leak check a low pressure system?

8. What are two ways you can increase the pressure in the system?
9. What can happen if you exceed 10 psig while pressurizing the system?
10. How should a water box be leak tested?
11. What equipment should be used to test a tube?
12. What are the leak repair requirements for comfort cooling appliances and commercial appliances containing 50 pounds or more of refrigerant?

Recovery Techniques

A rupture (safety) disc is typically welded to the cylinder shoulder. If cylinder pressure exceeds the safety-relief pressure, the disc will burst and the cylinder content will vent and prevent an explosion. The rupture disc on a low pressure system is set for 15 psig while the recovery unit's high pressure cut-out is typically set for 10 psig in order to help prevent damage to the low pressure.

When recovering refrigerant from a system using R-11 or R-123:

- Remove the liquid first.
- Recover remaining vapor.

A substantial amount of vapor will remain in the appliance after all liquid is removed. For instance, an average 350-ton R-11 chiller at 0 psig still contains 100 pounds of vapor after all the liquid has been removed. A heater on the recovery vessel side will help to evacuate the vapor faster.

Water-Cooled Condensers

Most low-pressure recovery machines use a water-cooled condenser that is connected to the municipal water supply. When recovering refrigerant, the system water pumps, the recovery compressor, and the recovery condenser water should all be on. Water must be circulated through the tubes when evacuating refrigerant in order to prevent freezing the water. If a chiller is suspected to have tube leaks, the water sides of the evaporator and condenser should be drained prior to recovering the refrigerant.

Oil Removal

A temperature of 130ºF should be attained when removing oil from a low-pressure system, as less refrigerant is contained in the oil at higher temperatures.

Recovery Techniques Review Questions

1. What are the typical pressure settings for rupture discs on low pressure systems and recovery equipment?
2. How should a technician recover refrigerant from a system using R-11 or R-123?
3. After removal of liquid, about how much vapor will remain in the system on a 350 ton R-11 chiller?
4. How can you speed up the vapor recovery process?
5. In a system using a water cooled condenser, what components should be kept on and why?
6. Where does the water typically come from in a water cooled condensing system?
7. What parts of the system should be drained of water before recovering refrigerant?
8. How should a technician treat the oil before removal and why?

Recharging Techniques

Never introduce liquid refrigerant into a system that is in a deep vacuum. Introducing liquid refrigeration into a deep vacuum will cause the refrigerant to boil and may lower the temperature enough to freeze the water in the tubes. To charge a low pressure system:

Charge through the evaporator charging valve as this is the lowest point on a low pressure system.

First charge the system with vapor until the refrigeration saturation temperature reaches 36º F or the vapor pressure reaches 16.9" Hg vacuum.

Complete the charge with liquid refrigerant.

Recharging Techniques Review Questions

1. Why should you never charge liquid refrigeration into a deep vacuum?

2. At what point in the system should you charge a low pressure system and what should you start the charge with?
3. How can a technician determine when it is safe to start charging with liquid refrigerant?

Recovery Requirements

As with all refrigerant recovery and recycling equipment manufactured after November 15, 1993, the equipment must be EPA-approved by third party, have low-loss fittings and meet evacuation levels more stringent than equipment made prior to that date. Required levels of evacuation for low-pressure systems are:

- 25" Hg for equipment manufactured *before* November 15, 1993.
- 25 mm Hg absolute for equipment manufactured *after* November 15, 1993.

Once the required vacuum has been achieved, the technician should wait a few minutes to monitor the system pressure. If the pressure rises, this indicates that there is still refrigerant in the system (liquid or trapped in the oil) and the recovery process must be repeated. When leaks in the system make evacuation to the required level unattainable, the system should be evacuated to the lowest attainable level before a major repair.

Recovery Requirements Review Questions

1. What general standards do recovery/recycling equipment need to meet?
2. What are the required levels of evacuation for low pressure systems for equipment manufactured before 11/15/1993? How about after 11/15/1993?
3. Why should a technician wait a few minutes after reaching the required vacuum level and what should be done if the pressure begins to rise?
4. What should be done if a leak makes reaching the required vacuum level unattainable?
5. What does the EPA consider a major repair?

Refrigeration

In a centrifugal system, the rupture disc is located on the evaporator and discharge from the disc should be vented outside. Charging a centrifugal system should be done through the evaporator charging valve.

The use of a large vacuum pump can 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. Make certain not to exceed 10 psig.

When a system is sitting idle (not in use), the pressure of the system should be increased to slightly above atmospheric pressure in order to prevent air accumulation in the system.

Refrigeration Review Questions

1. Where is the rupture disc on a low pressure centrifugal system and where should the disc be vented to?
2. What problem can using large vacuum pumps lead to and how can a technician prevent it?
3. What step should you take for low pressure systems that will be sitting idle and why?

Glossary

This glossary is intended to highlight some terms important for comprehension of EPA 608 regulations. It does not cover all terms used in the study guide.

ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers): An international organization that advances heating, ventilation, air conditioning and refrigeration; among other things, they developed a standard for classifying the safety of refrigerants.

Blended refrigerant: Also called a **near-azeotropic mixture** (sometimes referred to as NARM), a blended refrigerant contains refrigerants with different boiling points, but that act as one substance when they are in either a liquid or a vapor state. Near-azeotropic mixtures exhibit temperature glide when they change from vapor to liquid, or vice versa. However, the temperature glide is less than 10ºF. Near-azeotropic mixtures can exhibit fractionation (when the mixture's composition changes as a result of vapor charging) and may affect the leak ratio. Near-azeotropic mixtures should be charged as a liquid.

Azeotrope: A blend of two or more components whose equilibrium vapor phase and liquid phase compositions are the same at a given pressure. These refrigerants are given a 500 series ASHRAE designation and behave like a single refrigerant. They can be charged as a liquid or vapor.

Disposal: The process leading to and including any of the following:

- The discharging, depositing, dumping, or placing of any discarded appliance into or on any land or water.
- The disassembly of any appliance for discharging, depositing, dumping, or placing of its discarded component parts into or on any land or water.
- The disassembly of any appliance for reuse of its component parts.

(Refrigerant added/Total charge) x (365 days/year/D) x 100% where D = the shorter of: # days since refrigerant last added or 365 days

Filter-Drier: An accessory that filters the refrigerant and protects it from dirt and moisture, as well as acids.

Fractionation: The separation of a liquid mixture into separate parts by the preferential evaporation of the more volatile component.

Halocarbon: A halogenated hydrocarbon containing one or more of the three halogens: fluorine, chlorine, and bromine. Hydrogen may or may not be present.

High-Pressure Appliance: (prior to March 12, 2004, referred to by the EPA as higher-pressure appliance) An appliance that uses a refrigerant with a liquid phase saturation pressure between 170 psia and 355 psia at 104°F. This definition includes but is not limited to appliances using R-410A, R-22, R-401B, R-402A/B, R-404A, R-407A/B/C, R-408, R-409, R-411A/B, R-502 and R-507A.

Hydrocarbon: A compound containing only the elements hydrogen and carbon.

Leak Rate: The rate at which an appliance is losing refrigerant, measured between refrigerant charges or over 12 months, which ever is shorter. The leak rate is expressed in terms of the percentage of the appliance's full charge that would be lost over a 12-month period if the current rate of loss were to continue. The rate is calculated using the following formula:

Low-Loss Fitting: Any device that is intended to establish a connection between hoses, appliances, or recovery/recycling machines, and that is designed to close automatically or to be closed manually when disconnected to minimize the release of refrigerant from hoses, appliances, and recovery or recycling machines.

Low-Pressure Appliance: (definition unchanged by the EPA's March 12, 2004 rule change): An appliance that uses a refrigerant with a liquid phase saturation pressure below 45 psia at 104°F. Evacuation requirements for the low-pressure category apply to these appliances. This definition includes but is not limited to appliances using R-11, R-113, and R-123.

MSDS (Material Safety Data Sheet): A material safety data sheet (MSDS) is a form with data regarding the properties of a particular substance. An MSDS provides workers with physical data and information about handling that substance in a safe manner.

Major Repair: Maintenance, service, or repair that involves removal of the service or repair appliance compressor, condenser, evaporator, or auxiliary heat exchanger coil.

Medium-Pressure Appliance: (prior to March 12, 2004, referred to by the EPA as high-pressure appliance) An appliance that uses a refrigerant with a liquid phase saturation pressure between 45 psia and 170 psia at 104Â°F. R-114 appliances are at the low-pressure end since the saturation pressure of R-114 at 104°F is slightly above 45 psia. This definition includes but is not limited to appliances using R-12. R-114, R-124, R-134A, R-401C, R-406A and R-500.

Mixture: A blend of two or more components that do not have a fixed proportion to one another and that no matter how well blended, still retain a separate existence (oil and water, for example).

Motor Vehicle Air Conditioner (MVAC): Mechanical vapor compression refrigeration equipment used to cool the driver or passenger compartments of any motor vehicle. This definition is NOT intended to encompass the hermetically sealed refrigeration system used on motor vehicles for refrigerated cargo or the air conditioning systems on passenger buses. Section 609 certification is required for working on MVAC systems, while either Section 608 Type II or Section 609 certification is required for MVAC-like A/C systems (e.g. farm equipment and other non-roads vehicles). Section 608 certification is required for working on hermetically sealed refrigeration systems used on motor vehicles for refrigerated cargo or the air conditioning systems on passenger buses.

Non-Azeotropic Refrigerant: A synonym for zeotropic, the latter being the preferred, though less commonly used term. Zeotropic: blend with multiple components of different volatilities that, when used in refrigeration cycles, change volumetric composition and saturation temperatures (exhibit temperature glide) as they evaporate (boil) or condense at constant pressure. These refrigerants are given a 400 series ASHRAE designation.

Normal Charge: The quantity of refrigerant within the appliance or appliance component when the appliance is operating with a full charge of refrigerant.

Person: Any individual or legal entity, including an individual corporation, partnership, association, state, municipality, political subdivision of a state, Indian tribe, and any agency, department, or instrumentality of the United States and any officer, agent, or employee thereof.

Process Stub: A length of tubing that provides access to the refrigerant inside a small appliance or room air conditioner that can be resealed at the conclusion of repair or service.

psia: The absolute pressure in pounds per square inch, where 0 psia corresponds to 29.9 inches of mercury vacuum and 14.7 psia corresponds to 0 psig (pounds per square inch gauge).

psig: The gauge pressure in pounds per square inch, where 0 psig corresponds to atmospheric pressure (14.7 psia). A positive psig value indicates the pressure in pounds per square inch above the ambient pressure.

Reclaim: To reprocess refrigerant to at least the purity specified in the ARI Standard 700, Specifications for Fluorocarbon Refrigerants, and to verify this purity using the analytical test procedures described in the Standard.

Recovery Efficiency: The percentage of refrigerant in an appliance that is recovered by a unit of recycling or recovery equipment.

Recover: To remove refrigerant in any condition from an appliance and to store it in an external container without necessarily testing or processing it in any way.

Recycle: To extract refrigerant from an appliance and to clean refrigerant for reuse without meeting all of the requirements for reclamation. In general, recycled refrigerant is refrigerant that is cleaned using oil separation and single or multiple passes through devices such as replaceable-core filter dryers, which reduce moisture, acidity, and particulate matter.

Refrigerant: The substance used for heat transfer in a refrigeration system. A refrigerant absorbs heat during evaporation at low temperature and pressure, and releases heat during condensation at a higher temperature and pressure.

Refrigerant: Any class I or class II substance used for heat transfer purposes, or any substance used as a substitute for such a class I or class II substance by any user in a given end-use, except for the following substitutes in the following end uses:

- Ammonia in commercial or industrial process refrigeration or in absorption units.
- Hydrocarbons in industrial process refrigeration (processing of hydrocarbons).
- Chlorine in industrial process refrigeration (processing of chlorine and chlorine compounds).
- Carbon dioxide in any application.
- Nitrogen in any application.
- Water in any application.

Self-Contained Recovery: Recovery or recycling equipment that is capable of removing refrigerant from an appliance without the assistance of components contained in the appliance.

Small Appliance: Any of the following products that are fully manufactured, charged, and hermetically sealed in a factory with five pounds or less of refrigerant: refrigerators and freezers designed for home use, room air conditioners (including window air conditioners and packaged terminal air conditioners), packaged terminal heat pumps, dehumidifiers, under-the-counter ice makers, vending machines, and drinking water coolers.

Substitute: Any chemical or product substitute, whether existing or new, that is used by any person as a replacement for a class I or II compound in a given end-use.

System-Dependent Recovery Equipment: Recovery equipment that relies upon the compressor in the appliance and/or the pressure of the refrigerant in the appliance.

System-Dependent: Recovery equipment that requires the assistance of recovery components contained in an appliance to remove the refrigerant from the appliance.

Technician: Any person who performs maintenance, service, or repair that could reasonably be expected to release Class I (CFC) or Class II (HCFC) substances into the atmosphere, including but not limited to installers, contractor employees, in-house service personnel, and in some cases, owners. Technician also means any person disposing of appliances except for small appliances.

Very-High-Pressure Appliance: (definition unchanged by the EPA's March 12, 2004 rule change) An appliance that uses refrigerants with a critical temperature below 104°F or with a liquid phase saturation pressure above 355 psia at 104°F. This category includes but is not limited to appliances using R-13, R-23, R-503.

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Refrigerant Temperature / Pressure Chart Bring this chart to the test with you.							
Temperature (°F)	**Pressure PSI**						
	Red numbers = inches Hg Black numbers = psig						
	R-11	**R-12**	**R-22**	**R-123**	**R-134A**	**R-500**	**R-502**
-100	**29.8**	**27.0**	**25.0**	**29.9**	**27.8**	**26.4**	**25.3**
-90	**29.7**	**25.7**	**23.0**	**29.8**	**26.9**	**24.9**	**20.6**
-80	**29.6**	**24.1**	**20.2**	**29.7**	**25.6**	**22.9**	**17.2**
-70	**29.4**	**21.8**	**16.6**	**29.6**	**23.8**	**20.3**	**12.8**
-60	**29.2**	**19.0**	**12.0**	**29.5**	**21.5**	**17.0**	**7.2**
-50	**28.9**	**15.4**	**6.2**	**29.2**	**18.5**	**12.8**	**0.2**
-40	**28.4**	**11.0**	0.5	**28.9**	**14.7**	**7.6**	4.1
-30	**27.8**	**5.4**	4.9	**28.5**	**9.8**	**1.2**	9.2
-20	**27.0**	0.6	10.2	**27.8**	**3.8**	3.2	15.3
-10	**26.0**	4.4	16.4	**27.0**	1.8	7.8	22.6
0	**24.7**	9.2	24.0	**26.0**	6.3	13.3	31.1
10	**23.1**	14.6	32.8	**24.7**	11.6	19.7	41.0
20	**21.1**	21.0	43.0	**23.0**	18.0	27.2	52.4
30	**18.6**	28.4	54.9	**20.8**	25.6	36.0	65.6
40	**15.6**	37.0	68.5	**18.2**	34.5	46.0	80.5
50	**12.0**	46.7	84.0	**15.0**	44.9	57.5	97.4
60	**7.8**	57.7	101.3	**11.2**	56.9	70.6	116.4
70	**2.8**	70.2	121.4	**6.6**	70.7	85.3	137.6
80	1.5	84.2	143.6	**1.1**	86.4	101.9	161.2
90	4.9	99.8	168.4	2.6	104.2	120.4	187.4
100	8.8	117.2	195.9	6.3	124.3	141.1	216.2
110	13.1	136.4	226.4	10.5	146.3	164.0	247.9
120	18.3	157.7	259.9	15.4	171.9	189.2	282.7
130	24.0	181.0	296.8	21.0	199.4	217.0	320.8
140	30.4	206.6	337.2	27.3	230.5	247.4	362.6
150	37.7	234.4	381.5	34.5	264.4	280.7	408.4

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