



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 information required to answer questions on the exam. Information in this manual reflects the most current information available at the time of publishing and is matched to the most recent EPA question bank release. The information is not intended to be memorized. The more you understand the concepts and rationale behind the EPA 608 regulations, the better you will do on the exam on the job.

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, but are not intended to be simple exam questions. 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 exam questions by the EPA. Technicians should read and be familiar with the EPA's National Recycling and Emission Reduction Program 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. This includes attaching and detaching hoses and gauges to and from an appliance to measure pressure within the appliance and adding refrigerant to or removing refrigerant from an appliance. 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 receive a certification card, a candidate must pass the Core section plus one of the other sections. Once Core (or any other section) has been passed, the technician does not need to retake it – the record of the passing section will remain valid.

The test, as well as this study guide, 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 for a proctored exam setting to be certified in each section. The Core & Type I sections can be taken in a non-proctored setting, but a passing score of 84%, or 21 out of 25 correct, is required to be certified in each section. 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 a Universal certification card.

A technician is not required to take all four sections of the exam – he/she may choose to take Core plus any combination of Type I, Type II or Type III. Much of the content in the Type I, II, & III sections relate to Core content, so studying the Core section is imperative.

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). 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. The exam is closed-book, although you may reference the Temperature/Pressure Chart, which will be located on the back of the exam booklet. Bring the following with you to the test:

- Pen or pencil
- Picture identification
- Home address information (or where you would like your certification card shipped to)
- Any registration paperwork you were given (if applicable)

Strategies for Taking the Test

Multiple choice exams require good reading skills. 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, etc.. 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".
- Mark your answers on the sheet carefully. Completely fill in the circle indicating your choice, like this: ○○●○ If you need to change an answer, make an "X" over the answer you do not want graded. Do not use white-out!
- 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 will automatically be marked wrong.
- 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 (O_3). 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 damages 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:

- 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 chlorine, fluorine and carbon. A HCFC contains hydrogen, chlorine, fluorine, and carbon.

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, allowing them to reach the stratosphere over time. When CFCs and HCFCs reach the atmosphere, they are broken apart, release their chlorine atoms, and start 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 refrigerants used to be debated, but scientific studies have shown that 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.

Despite the efforts of making refrigerants more environmentally friendly, with past emphasis being solely on ozone depletion, there is more and more scientific evidence supporting how the effects of refrigerants contribute to global warming. Evaluation has now been diverted to both older refrigerants and creating new refrigerants with emphases on both Ozone Depletion Potential (ODP) and Global Warming Potential (GWP). **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. **Global Warming Potential (GWP)** is a relative measure of how much heat a greenhouse gas traps in the atmosphere. It compares the amount of heat trapped by a certain mass of the gas in question to the amount of heat trapped by a similar mass of carbon dioxide. GWP is expressed as a factor of carbon dioxide with carbon dioxide being one (1).

Hydrofluoroolefins (HFOs), also known as alkenes, are composed of hydrogen, fluorine, and carbon. Although CFCs and HFCs also contain hydrogen, fluorine, and carbon, HFOs contain at least one double carbon bond, making it a more stable compound. This characteristic allows for HFOs to have the benefit of having both a zero ODP and a low GWP. **NOTE:** Silicone seals and gaskets are not compatible with HFO refrigerants.

Refrigerant Property Comparison

Class	Name	Chemical Name	ODP ¹	GWP	Flam/Tox	Alternative ²
CFC	R-11	Trichloro-fluoromethane	1	4750	A1	
CFC	R-12	Dichloro-difluoromethane	1	10900	A1	R-1234yf
HCFC	R-22	Chloro-difluoromethane	0.5	1810	A1	R-449A
HFC	R-32	Difluoromethane	0	675	A2	
CFC	R-113	Trichloro-trifluoroethane	1	6130	A1	
CFC	R-115	Chloropentafluoroethane	0.44	7370	A1	
HCFC	R-123	Dichloro-trifluoroethane	0.02	77	B1	R-514A
HCFC	R-124	Chloro-tetrafluoroethane	0.022	609	A1	
HFC	R-125	Pentafluoroethane	0	3500	A1	
HFC	R-134a	Tetrafluoroethane	0	1430	A1	R-513A
HC	R-290	Propane	0	3.3	A3	
HFC	R-404A	Blended R-125, 143a, 134a	0	3922	A1	R-449A
HFC	R-407C	Blended R-32, 125, 134a	0	1744	A1	
HFC	R-410A	Blended R-32, 125	0	2088	A1	
HC	R-441A	Blended R-170, 290, 600	0	3.6	A3	
HFO	R-449A	Blended R-32, 125, 134a	0	1282	A1	
HCFC	R-500	Blended R-12, 152a	0.74	8077	A1	
HFO	R-513A	Blended R-1234yf, 134a	0	573	A2L	
HFO	R-514A	Blended R-1336zzZ, Dichloroethylene	0	2	B1	
HC	R-600a	Isobutane	0	3	A3	
	R-702	Hydrogen		5.8	A3	
	R-717	Ammonia	0	0	B2	
	R-718	Water/Steam	0	0	A1	
	R-728	Nitrogen	0	0	A1	
	R-744	Carbon Dioxide	0	1	A1	
HCFO	R-1233zd	Chloro-trifluoropropene	0	1	A1	
HFO	R-1234yf	Tetrafluoropropene	0	4	A2L	
HFO	R-1234ze	Tetrafluoropropene	0	6	A2L	
HFO	R-1336mzzZ	Hexofluoro-butene	0	858	A1	

¹ODP potential is compared to R-11, with R-11 being one (1)

²The best HFO alternative with considerably lower ODP and GWP ratings

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. For example - the phase out date to produce and import HCFC R-22 is January 1st, 2020.
- **Prohibit venting:** Prohibit venting of CFC and HCFC refrigerants and their substitutes.
- **Disposal requirements:** 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. State laws must comply with the CAA and, in some cases, are even stricter than the CAA laws.

Under EPA regulation 40 CFR Part 82, Subpart F, Section 608, only EPA-certified technicians can purchase Ozone-Depleting Substances (ODS) used as refrigerants. As of January 1, 2018, this includes any substitutes for ODSs, including HFCs (examples include R-12, R-22, R-32, R-134a, R-1234yf, but **NOT** R-290, R-600a, R-718, or R-744). To aid in refrigerant substitution, the EPA implemented the Significant New Alternatives Policy (SNAP) program.

Distributors of HCFC and HFC refrigerants must verify that their customers, specifically the individuals doing the purchasing and/or handling, are up to date with their EPA 608 certification. If the technician loses their 608 certification card, he or she must request a replacement from their certifying organization.

It is required under the CAA to maintain records. The technician must:

- Record the type refrigerant that was transferred or recovered
- Record the quantity of refrigerant that was transferred or recovered
- 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 (namely chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform) were phased out by 2000 (2005 for methyl chloroform).

The Montreal Protocol, in conjunction with the Clean Air Act, categorizes Ozone-Depleting Substances (ODS) into two groups; **Class 1 ODS**, such as chlorofluorocarbons (CFCs), and **Class II ODS**, such as hydrochlorofluorocarbons (HCFCs)

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?
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 States. Since the phase out, CFC refrigerant for equipment servicing comes from recovery and recycling. Retrofitting, or converting a unit for use of better, more environmentally friendly, is major maintenance item that requires an EPA 608 certification.

CAA Venting

Since November 15, 1995, knowingly venting any refrigerant is a violation of the CAA. This includes CFCs, HCFCs, and 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 a leak test gas may be released; however, nitrogen may not be added to a fully charged system for the purpose for leak detection and then released. Refrigerants as determined by the EPA to not pose a threat to the environment, like R-290 (propane), R-600a (isobutane), and R-728 (nitrogen), are exempt from

the regulations regarding releasing and venting. Other examples that are NOT considered refrigerant are those used for leak tracing.

All CFCs, HCFCs, and HFCs must be recovered before opening a system for service or disposing of an appliance. This includes cutting a line before removing a component.

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. When was the HCFC phase-out date?
3. For servicing of older systems, where do CFC refrigerants come from?
4. Are technicians allowed to release nitrogen into the atmosphere? How about a mixture of nitrogen and refrigerant?
5. What must be done before scrapping a refrigerant container?
6. What must be done before disposing of an appliance containing CFCs or HCFCs?
7. 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. Taking oil samples may be necessary and is a good maintenance practice when discovering a leak. **Mineral, or petroleum, oils** include paraffin-based oils, naphthene-based oils, and mixed oils (a combination of naphthene-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. Ester oils are generally used with alternative refrigerants and are typically compatible with mineral oils and existing system components.

Refrigerant oil must be miscible at low temperatures, lubricate even when it is diluted, have electrical insulating properties, maintain its stability, and provide a pressure seal. For these reasons, the minimum evacuation must be 500 microns before charging when conducting a major repair on an HFC system using POE oil.

Oil Types

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

Oil Properties

All refrigerant oils have certain properties in common. For example, all refrigerant oils are **hygroscopic**, meaning they attract moisture. 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, while 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, while **low temperature miscibility** refers to the oil's ability to 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 refrigerant for R-12 systems; all replacement refrigerants require additional retrofit procedures. 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 a leading replacement option for retrofitting R-12 systems. With the advent of HFOs, R-1234yf has become the best alternative for R-12 and R-513A for R-134A, at least in terms of ODP and GWP ratings. 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.

R-22 and R-410a CANNOT be mixed together, whether it is for topping off, leak detection, or substituting. These refrigerants operate at different pressures and therefore require different compressors and higher-pressure components.

Refrigerant Blends

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. Since zeotropes retain the characteristics of each refrigerant in the blend, they can leak at an uneven rate. Zeotropic mixtures should be charged as a liquid.

An **azeotropic** refrigerant is a blend of components that boil out at the same temperatures (do not exhibit temperature glide) and act as a single refrigerant or 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 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 10°F. 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.

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.

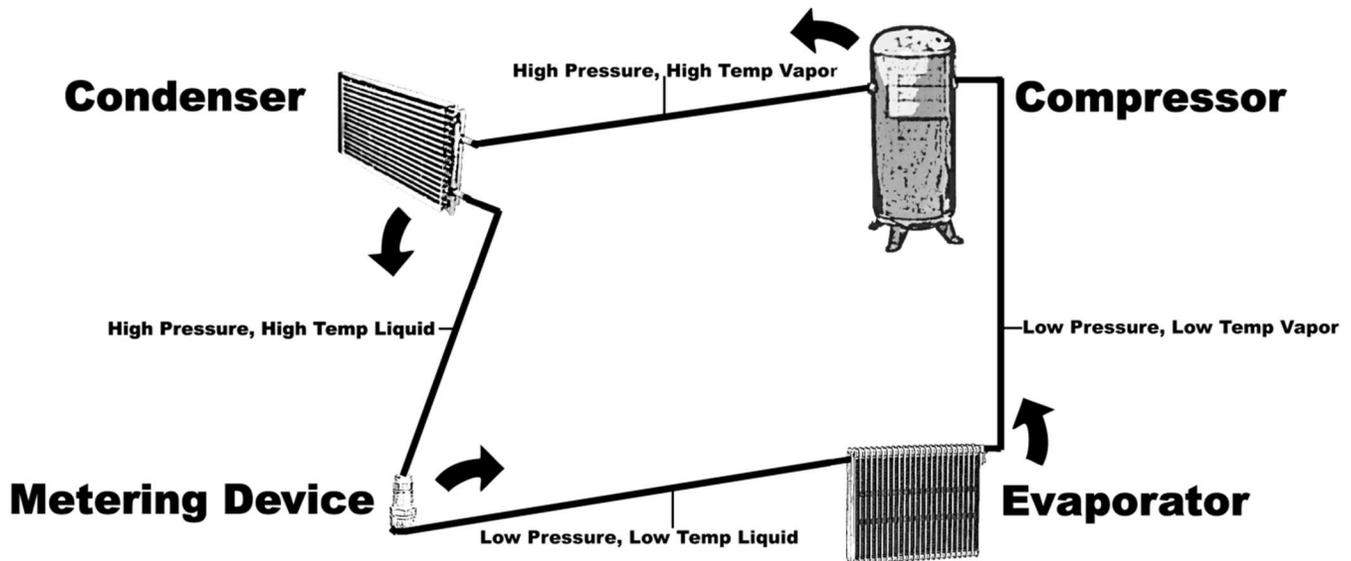
Fractionation is a separation process in which a certain quantity of mixture is divided during a phase transition (liquid to gas, gas to liquid, etc.) into any number of smaller quantities. R-407C is particularly susceptible to fractionation.

Ternary blends are common three-part mixtures that contain HCFCs. Ternary blends are used with a synthetic **alkylbenzene** lubricant. Alkylbenzene lubricant is hygroscopic.

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

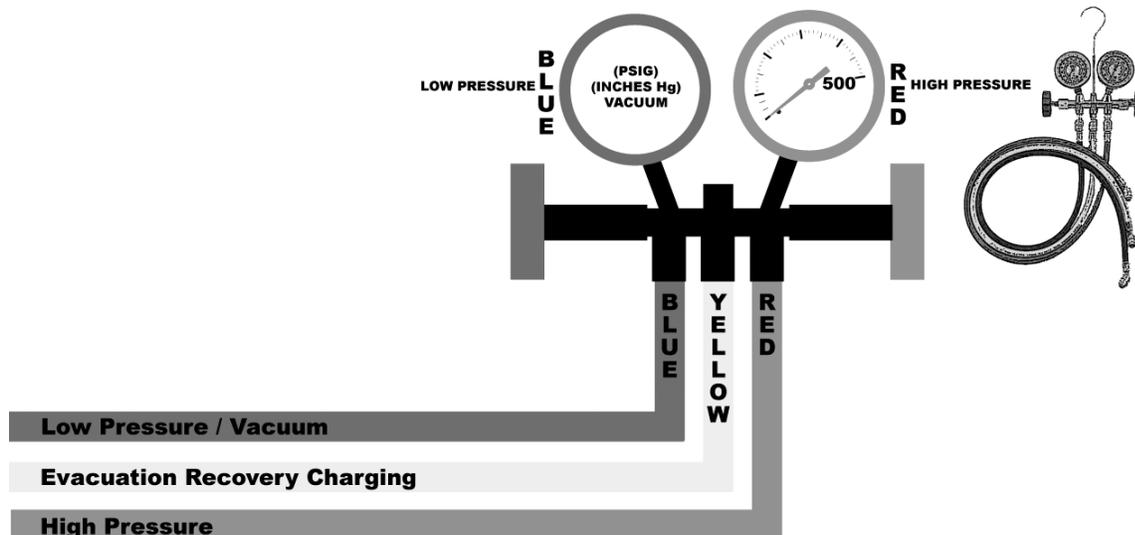


The **refrigeration process** is essentially the transfer of heat from one place to another. For example, in an air conditioning unit, the heat is removed from inside the building and is deposited outside the building. The vapor-compression refrigeration cycle is a repeating cycle consisting of four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

The **evaporator** exchanges heat into the system from the space to be cooled. The absorption of heat into the refrigerant causes it to boil. Upon leaving the evaporator, the refrigerant is a low pressure, low temperature superheated 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 in a system 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. Many manifolds have a fourth hose for vacuum, usually larger in diameter and black in color.

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

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, regularly 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. Never use refrigerant gases! Nitrogen is environmentally friendly and 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.

Only maintenance that involves the possibility of releasing refrigerant, like working on any part of the mechanical portion of the HVAC unit, requires the technician to be EPA 608 certification.

Other maintenance, like rewiring, changing filters, cleaning coils, fan motor replacement, and controls, does not require an EPA 608 certification.

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.

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 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 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 system and equipment.** The bigger the system, the longer the recovery. 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 system is warmer than the recovery cylinder, the recovery will go faster due to a higher pressure in the refrigerant system and a lower pressure in the recovery cylinder.
- **Oxidation.** Some refrigerants have a potential to oxidize copper tubing.

Refrigerant Recovery Rate Variables						
Slower	<i>Longer</i>	⇐	Hose length	⇒	<i>Shorter</i>	Faster
	<i>Smaller</i>	⇐	Hose diameter	⇒	<i>Bigger</i>	
	<i>Colder</i>	⇐	Ambient temperature	⇒	<i>Warmer</i>	
	<i>Colder</i>	⇐	Refrigerant system compared to cylinder	⇒	<i>Warmer</i>	
	<i>Bigger</i>	⇐	Refrigerant system size	⇒	<i>Smaller</i>	

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. If allowed by the compressor manufacturer, 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 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 the system has 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 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 **SDS (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. Inhaling refrigerant vapors in the air can also 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 a **Self-Contained Breathing Apparatus (SCBA)**.

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.

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 not be installed in series and must be replaced if corrosion build-up is found within the body. 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. Never energize a reciprocating compressor if the discharge service valve is closed.

Refrigerant safety is addressed in **ASHRAE Standard 15**, Safety Code for Mechanical Refrigeration. This standard specifies an oxygen sensor and alarm for A1 refrigerants and a refrigerant detector for all other refrigerants. It also 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). The ASHRAE Standard 15 also specifies 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. For any refrigerant that is rated above the lower flammability level and below the higher flammability level, an explosion is likely to occur if there is sufficient concentration of the refrigerant and an ignition source. For example, R-702 (Hydrogen) will not ignite when its concentration is less than 20% or greater than 80%. When charging or recovering flammable refrigerant, the refrigeration system and the recovery unit must be grounded.

Refrigerant mixtures are classified based on worst-case fractionation. The chart below is the International Organization for Standardization (ISO) 817 Refrigeration Classification Scheme.

ASHRAE Classification	Lower Toxicity	Higher Toxicity
Higher Flammability	A3	B3
Flammable	A2	B2
Lower Flammability	A2L	B2L
Non-Flammable	A1	B1

The color marking for process tubes and pipes which flammable refrigerant flows and where a service connection is red. The marking must extend at least one inch in both directions from the service connection. In general, when recharging flammable HFO refrigerant, the technician must ensure the unit and recovery vessel are grounded, evacuated to 500 microns or lower, has a new filter-drier installed, and a successful standing-pressure leak check has been completed.

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.

General Safety Review Questions

1. What are the risks of inhaling 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?
5. Under what conditions will an alarm sound and ventilation start under ASHRAE Standard 15?
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 leak test 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 while observing relief valves?
11. What can happen to refrigerants if they are exposed to direct flame?
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 only used for virgin refrigerant and should never be used for recovery. Before scrapping disposable cylinders, all refrigerant should be evacuated using a refrigerant recovery device and the pressure on the cylinder should be at most 0 psig. Disposable cylinders use a one-way (check) valve. The cylinder should be punctured with the valve still open, rendering the cylinder useless. Never leave used cylinders with any residual refrigerant. 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. Used cylinders that have been rendered inoperable can be recycled with other scrap metal. 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. All recovery cylinders must be labeled to avoid accidental

mixing of recovered refrigerants, to allow the recycler to identify the contents, and to allow the technicians company to determine the amount of refrigerant that was recovered for record keeping. 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, 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 be calculated as Refrigerant Capacity (RC) = 0.8 the water capacity (WC of the cylinder times the specific gravity (SG) of the refrigerant at 77 degrees Fahrenheit or 25 degrees Celsius plus the tare weight of the cylinder (TW).

$$(RC = 0.8 (WC) + TW)$$

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 Shipping

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

- Must be shipped in the upright position
- Recovery cylinders must be DOT-approved (yellow top and gray bodies)
- Must contain a DOT classification tag indicating it is a "2.2 non-flammable gas"
- 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 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?
7. In what position should cylinders be shipped?
8. What type of DOT tag is required for shipping refrigerant cylinders?
9. What type of information about the refrigerant must the cylinder label contain?

Type I

Type I certification is for technicians who service small appliances. Small appliances include domestic refrigerators, window air conditioners, PTAC's and vending machines.

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

- Recovery requirements
- Recovery techniques
- Safety

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 **Packaged Terminal Air Conditioner (PTAC)** is an air conditioner unit commonly used in small dwellings such as hotel rooms. A **Motorized Vehicle Air Conditioning (MVAC)** system **does not** fall under 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.

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.

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

As of February 2012, the EPA's Significant New Alternatives Policy (SNAP) program states that isobutane (R-600a), propane (R-290) and R-441A are acceptable alternatives, subject to use conditions, for CFC-12 and HCFC-22 in household refrigerators, freezers, and combination refrigerators and freezers (40 CFR Part 82). Prior to December of 2017, these refrigerants were not approved for refitting. Rule 22 of SNAP, implemented December 11, 2017, allows for the use of R-600a, R-290, and R-441A in retrofit applications.

Recovery equipment fittings must be equipped with **low-loss fittings** which can be manually or automatically closed when disconnecting hoses 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. By definition, what is the maximum amount of refrigerant a small appliance can have?
4. Are technicians responsible for complying with changes in the EPA law after their date of certification?
5. What are the standards for recovery equipment manufactured before November 15, 1993?
6. What are the standards for recovery equipment manufactured after November 15, 1993 with 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. If a recovery cylinder is suspected of being contaminated, the recovery cylinder must be turned in for reclamation.

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 in the tank 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 cannot 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 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 as there is no refrigerant in the system.

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.

Safety

As with any work with possible handling of hazardous chemicals or when working with fluids under pressure, butyl-lined gloves and safety glasses are required. When using nitrogen in repairing a sealed refrigeration system, the nitrogen tank must be equipped and use of the regulator are required.

When CFC and HCFC refrigerants decompose at high temperatures, they create hydrochloric acid, hydrofluoric acid, and phosgene gas. If a large leak from CFC or HCFC refrigerant cylinders occur, immediate vacate the area and naturally ventilate the area if possible. These substances are heavier than air and will settle on the floor. If someone is observed to be unresponsive on the floor in an enclosed area near a refrigerator or cylinder with CFC or HCFC refrigerants, do not attempt to go in after them. - this will make you a victim. Instead, immediately call emergency services.

Permanent safety markings usually red in color, are required on household refrigerators that use any refrigerant with an A3 flammability rating such as HCs, on or near any evaporators, any exposed refrigerant tubing, near the machine compartment, and on the exterior of the refrigerator.

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 80°F, R-22 at 70°F and R-134A at 90°F.
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?
5. What are two things that can cause high discharge pressures?
6. How can you check if a tank contains excess air or non-condensables?
7. What temperature must a cylinder be at to check for excess air?
8. What type of system can a vacuum pump be used on for recovery?
9. When using a system-dependent recovery system with an operating compressor, where should the refrigerant be recovered from? With a non-operating compressor?
10. How can you release trapped refrigerants in the oil?
11. How will activating a defrost heater aid in the recovery process?

12. When should piercing type valves be used and what is a common problem with them?
13. 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, process refrigeration, and high-pressure chillers.

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. If 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.

As of January 1, 2018, technicians evacuating refrigerant from appliances with a full charge of more than 5 lbs and less than 50 lbs of refrigerant for purposes of disposal of that appliance must keep records for three years. Owners/operators must maintain hard or electronic copies of:

- Records documenting the full charge of appliances
- Records, such as invoices, showing when service or maintenance is performed, when refrigerant is added to an appliance (or removed, in case of disposal), when a leak inspection is performed, and when a verification test is conducted
- If using an automatic leak detection system, documentation that the system is installed and calibrated annually and records of when the monitoring system identifies a leak and the location of the leak
- Retrofit and/or retirement plans
- Requests submitted the EPA to extend the repair or retrofit deadlines
- If a system is mothballed to suspend a deadline, records documenting when the system was mothballed and when it was brought back online
- Records to demonstrate a seasonal variance
- Reports on appliances that leak 125% or more of the full charge in a calendar year

Beginning January 1, 2019, the following are changes to the EPA's refrigerant management requirements:

- The new leak repair regulations apply to industrial process refrigeration (IPR), commercial refrigeration, and comfort cooling appliances containing 50 pounds or more of ODS or substitute refrigerant.
- The EPA defines industrial process refrigeration as complex, customized appliances that are directly linked to the processes used in the chemical, pharmaceutical, petrochemical and manufacturing industries. This sector also includes industrial ice machines,

appliances used directly in the generation of electricity and ice rinks. Where one appliance is used for both IPR and other applications, it will be considered IPR equipment if 50% or more of its operating capacity is used for IPR.

- Commercial refrigeration is the refrigeration appliance used in the retail food and cold storage warehouse sectors. Retail food appliances include the refrigeration equipment found in supermarkets, convenience stores, restaurants and other food service establishments. Cold storage includes the refrigeration equipment used to store meat, produce, dairy products, and other perishable goods.
- Comfort cooling is the air-conditioning appliances used to provide cooling in order to control heat and/or humidity in occupied facilities including, but not limited to, residential, office, and commercial buildings. For example, comfort cooling appliances include chillers, commercial split systems, and packaged roof-top units.
- Retrofitting is defined as converting an appliance from one refrigerant to another refrigerant. Retrofitting includes the conversion of the appliance to achieve system compatibility with the new refrigerant and may include, but is not limited to, changes in lubricants, gaskets, filters, driers, valves, o-rings or appliance components. Retrofitting does not involve any addition of refrigerant, but a replacement of refrigerant.
- Owners/operators must calculate the leak rate every time ODS or substitute refrigerant is added to an appliance. The EPA allows for determining full charge by calculating the component and pipe sizes.
- Owners/operators must identify and repair leaks that exceed 30% for IPR, 20% for commercial refrigeration, and 10% for comfort cooling within 30 days of when the ODS or substitute refrigerant is added.
- Owners/operators of all three appliance types must perform and document both an initial and follow-up verification test of leak repairs for appliances that exceed the applicable leak rate. An **initial verification test** must be performed before any additional refrigerant is added to the appliance. 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. The verification test must demonstrate that leaks were successfully repaired. If either the initial or follow-up verification test indicates that repairs were not successful, owners/operators may conduct as many additional repairs and verification tests as needed within the 30-day repair period.
- In accordance with 40 CFR 82.157, the owner or operator must conduct both initial and follow-up verification tests on each leak that was repaired. A follow-up verification test must be performed within 10 days of the initial verification test.
- Owners/operators of IPR, commercial refrigeration, and comfort cooling equipment may request limited extensions to the 30-day (120 days if an industrial process shutdown is required) repair deadline. If owners/operators fail to bring the leak rate below the

threshold leak rate, owners/operators must create and implement a retrofit or retirement plan.

- Owners/operators must conduct leak inspection for appliance that have exceeded the applicable leak rate using the following table. Leak inspections must be conducted by a certified technician. All visible and accessible components of an appliance must be inspected.

Equipment	Full Charge	Frequency of Leak Inspections
Commercial Refrigeration and Industrial Process Refrigeration	>500 pounds	Once every three months until the owner/operator can demonstrate through leak rate calculations that the leak rate has not exceeded 20% (commercial) or 30% (IPR) for four quarters in a row.
	50 to 500 pounds	Once per calendar year until the owner/operator can demonstrate through the leak rate calculations that the leak rate has not exceeded 20% (commercial) or 30% (IPR) for one year.
Comfort Cooling	50 or more pounds	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.

- Quarterly or annual leak inspections are not required on appliances (or portions of appliances) that are continuously monitored by an automatic leak detection system that is audited and calibrated annually.
- Owners/operators must create a retrofit or retirement plan within 30 days of an appliance leaking ODS or substitute refrigerant above the applicable leak rate if:
 - ~ The owner/operator intends to retrofit or retire rather than repair the leak; or
 - ~ The owner/operator fails to identify and repair the leak; or
 - ~ The appliance continues to leak above the applicable leak rate after required repairs and verification tests.
- Retrofit or retirement plans must contain: identification and location of the appliance; type and full charge of the refrigerant in use; type and full charge of alternative refrigerant (if retrofitting); itemized procedure for converting the appliance to a different refrigerant, including changes required for compatibility with new refrigerant (if retrofitting); plan for disposition of recovered refrigerant, plan for disposition of the appliance (if retiring); and a schedule for completing within one year.
- The retrofit or retirement must be completed within one year of the plan's date unless granted extra time. Owners/operators must repair all identified leaks as part of any retrofit. Owners/operators may request relief from the obligation to retrofit or retire an appliance if they can establish within 180 days of the plan's date that the appliance no

longer exceeds the applicable leak rate and agrees in writing to repair all identified leaks within one year of the plan's date.

- For all appliances subject to leak repair requirements, the timelines may be suspended if the appliance has been mothballed. Mothballing means to evacuate refrigerant from an appliance, or the affected isolated section or component of an appliance, to at least atmospheric pressure, and to temporarily shut down the appliance.
- Owners/operators must submit reports to the EPA if any appliance leaks 125% or more of its full charge in one calendar year. This report must describe efforts to identify leaks and repair the appliance. Lack of an available certified technician is NOT a reason to extend a deadline.

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

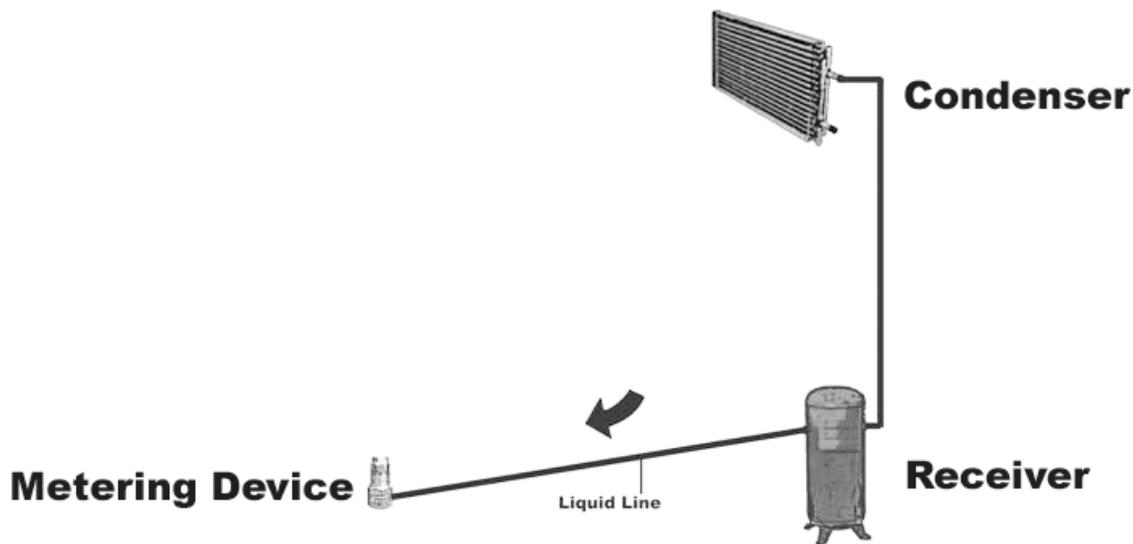
The most common refrigerant used before 1995 was R-22, but with the variety of refrigerants in the market today, the technician should always read the nameplate to determine the type of refrigerant used in the system.

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, 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, and chiller evaporators, 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 may 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 and recycling of equipment used for stationary refrigeration must be tested by an EPA-approved third party, must be equipped with low-loss fittings, and be designed to recover flammable refrigerant while meeting the specific UL safety standard. System-dependent recovery equipment cannot be used on appliances containing more than 15 pounds of refrigerant.

For safety reasons, be aware that a reciprocating compressor may be damaged when the discharge service valve is closed while the compressor is energized, every refrigerating system must be protected by a pressure relief device, and pressure relief valves can only be installed in parallel.

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

**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. When

beginning recovery, the refrigerant should be removed in its liquid phase to save recovery time and the hose should be connected to the liquid line to affect this. Although it is best to remove refrigerant while it's in its liquid phase, the appliance should still be checked for any remaining vapor and it too shall be removed using the recovery system.

The EPA has established limited exceptions to its evacuation requirements for:

- Repairs to leaky equipment. Appliances can be evacuated to atmospheric pressure (0 psig) if leaks make evacuation to the prescribed level unattainable.
- 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 a major repair?
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 such as R-11. The equipment includes chillers that operate with the low side in a vacuum.

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 allows 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 mmHg during vacuum testing, the system should be leak checked.

Purge Units

Because low pressure systems will suck in non-condensable substances 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 refrigerant. 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

In accordance with 40 CFR 82.157, the owner or operator must conduct both initial and follow-up verification tests on each leak that was repaired. A follow-up verification test must be performed within 10 days of the initial verification test.

The most efficient method of leak checking a charged low-pressure refrigeration unit is to increase the pressure in the system using 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. Owners or operators must take corrective action when an appliance with a full charge of 50 or more pounds is discovered to be leaking ODP refrigerant at a rate that exceeds the applicable trigger rate. Starting January 1, 2019, these requirements will also apply to appliances containing substitute refrigerants. Once the threshold leak rate has been exceeded on any low-pressure system with ODP refrigerant, repair, or a plan to retrofit or retire must be conducted within 30 days. The repair must at least bring the leak rate below the leak threshold.

Appliance Type	Current Leak Rate	Leak Rate Effective 1/1/2019
IPR	35%	30%
Commercial	35%	20%
Comfort Cooling	15%	10%
All others	15%	10%

System Mothballing

For all appliances subject to leak repair requirements, the timelines may be suspended if the appliance has been mothballed. Mothballing means to evacuate refrigerant from an appliance, or the affected isolated section or component of an appliance to at least atmospheric pressure, and

to temporarily shut down that appliance. However, the timelines pick up again as soon as the system is brought back on-line.

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 system.

When recovering refrigerant from a system using R-11 or R-123, remove the liquid first, to minimize the risk of freezing the water in the chiller tubes, then 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.

Raising the temperature in the room of a low-pressure chiller or using a water-cooled recovery unit will result in faster refrigerant recovery.

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 130°F 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 36° F or the vapor pressure reaches 16.9" Hg vacuum.(for R-11)
- 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 mm 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 to prevent air accumulation in the system.

To prevent freezing when recharging an evacuated water-cooling chiller system with R-123, the system must be at 20 Hg vacuum when beginning charging, this is when R-123 reaches a saturation temperature of 32°F. At 18.1 inches Hg vacuum, the saturation temperature is 40°F and at 14.7 psia at 82°F, R-123 will boil.

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.

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.

Blended refrigerant: A mixture of refrigerant that has been formulated to provide a match to certain properties of the refrigerants originally used. These blends have been researched and developed since the issue of the ODS phase-out emerged and are being produced by many chemical companies.

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.

$(\text{Refrigerant added}/\text{Total charge}) \times (365 \text{ days}/\text{year}/D) \times 100\%$ where D = the shorter of either the # 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. This occurs in zeotropic blends and NARMS.

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, whichever 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.

SDS (Safety Data Sheet): A safety data sheet (SDS) 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 104°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.

Near-Azeotropic Mixture (NARM): 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 10°F. 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.

Non-Azeotropic Refrigerant: see definition for **Zeotropic Refrigerant**

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 that requires the assistance of recovery components contained in an appliance to remove the refrigerant from the appliance.

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

Zeotropic Refrigerant: Also called a **non-azeotropic mixture**, it is a 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.



Refrigerant Temperature / Pressure Chart									
Temperature (°F)	Pressure (PSI)								
	Red numbers = inches Hg Black numbers = psig								
	R-11	R-12	R-22	R-123	R-134A	R-404A	R-410A	R-500	R-502
-100	29.8	27.0	25.0	29.9	27.8	-	20.9	26.4	25.3
-90	29.7	25.7	23.0	29.8	26.9	-	17.3	24.9	20.6
-80	29.6	24.1	20.2	29.7	25.6	-	12.6	22.9	17.2
-70	29.4	21.8	16.6	29.6	23.8	-	6.4	20.3	12.8
-60	29.2	19.0	12.0	29.5	21.5	-	1.3	17.0	7.2
-50	28.9	15.4	6.2	29.2	18.5	5.9	4.3	12.8	0.2
-40	28.4	11.0	0.5	28.9	14.7	4.3	10.1	7.6	4.1
-30	27.8	5.4	4.9	28.5	9.8	9.6	17.2	1.2	9.2
-20	27.0	0.6	10.2	27.8	3.8	16.0	25.9	3.2	15.3
-10	26.0	4.4	16.4	27.0	1.8	23.6	36.1	7.8	22.6
0	24.7	9.2	24.0	26.0	6.3	32.6	48.2	13.3	31.1
10	23.1	14.6	32.8	24.7	11.6	43.1	62.3	19.7	41.0
20	21.1	21.0	43.0	23.0	18.0	55.3	78.7	27.2	52.4
30	18.6	28.4	54.9	20.8	25.6	69.3	97.5	36.0	65.6
40	15.6	37.0	68.5	18.2	34.5	85.4	118.9	46.0	80.5
50	12.0	46.7	84.0	15.0	44.9	103.6	143.3	57.5	97.4
60	7.8	57.7	101.3	11.2	56.9	124.2	170.7	70.6	116.4
70	2.8	70.2	121.4	6.6	70.7	147.4	201.5	85.3	137.6
80	1.5	84.2	143.6	1.1	86.4	173.4	235.9	101.9	161.2
90	4.9	99.8	168.4	2.6	104.2	202.4	274.3	120.4	187.4
100	8.8	117.2	195.9	6.3	124.3	234.6	316.9	141.1	216.2
110	13.1	136.4	226.4	10.5	146.3	270.4	364.1	164.0	247.9
120	18.3	157.7	259.9	15.4	171.9	309.9	416.4	189.2	282.7
130	24.0	181.0	296.8	21.0	199.4	353.5	474	217.0	320.8
140	30.4	206.6	337.2	27.3	230.5	401.7	537.6	247.4	362.6
150	37.7	234.4	381.5	34.5	264.4	455.1	607.6	280.7	408.4