EPA 608 Study Guide

Created by HVAC Training 101

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1 Introduction

Federal law requires all HVAC technicians working with refrigerants and/or servicing, repairing, maintaining or disposing equipment that contain ozone-depleting refrigerants to be certified. Starting Jan 1, 2018, this requirement will also apply to appliances containing most substitute refrigerants, including HFCs.

This federal law is a part of the Clean Air Act (Section 608). The Environment Protection Agency (EPA) is an agency of federal government tasked with identifying, implementing and later enforcing such regulations.

Technicians are required to pass an EPA-approved test to earn Section 608 Technician Certification. The tests are specific to the type of equipment the technician seeks to work on. Tests must be administered by an EPA-approved certifying organization. All institutions that are approved to provide the EPA Section 608 technician certification test are listed in the link below.
https://www.epa.gov/section608/section-608-technician-certification-programs

Note that some of them are nationwide and you need to contact the respective institute to check if they have a testing location in your city. There are seven organizations that have locations nationwide (as of Dec'17). Go to their website to check their presence in your city.

Alternatively, just googling "epa 608 test locations" plus "(your city)" will give you available options. These options can be validated against EPA approved institutions to ensure legitimacy.

Section 608 Technician Certification credentials do not expire. Apprentices are exempt from certification requirements provided they are closely and continually supervised by a certified technician. It is the responsibility of the technician to update themselves and be aware of any changes in regulations..

The EPA performs random inspections, responds to tips and pursues potential cases against violators of the Section 608 regulations. The EPA is authorized to assess fines of up to $37,500 per day and/or press criminal charges (which may result in jail time) for any violation of these regulations.

The EPA has developed four types of certification:

Type I Certification for servicing small appliances (<5 lbs of refrigerant).
Type II Certification for servicing or disposing of high- or very high-pressure appliances, except small appliances and motor vehicle air conditioner units (MVACs).
Type III Certification for servicing or disposing of low-pressure appliances like centrifugal chillers.
Universal Certification for servicing all types of equipment.

For technicians handling motor vehicle air conditioning units, Section 609 certification is more relevant. For details on this certification, refer to our post on Section 609.

Technicians certified under Section 608 must keep a copy of their certificate at their place of business. Technicians must maintain a copy of their certificate until three years after no longer operating as a technician.

There are 4 sections in the Section 608 certification test, namely Core, Type I, Type II and Type III. Each section contains 25 questions. To pass a section, you need a score of 72%. This translates to 18 out of 25 questions. Everyone must pass the core exam. Along with core, one must pass the exam for the type of certification they are seeking. To get Universal Certification, you need to pass all 4 sections.

If the technician fails a section of the test, that particular section can be retaken without retaking the passed sections. This is not applicable to core section. All technicians must pass core section for the test to count. That is, if the technician fails in the core section, no other passed sections of that exam will count.

The exams are proctored, so you must go to a testing location to take the exam. When going for the exam, be prepared to present photo ID, social security number and address.

The only outside material allowed in the exam is a pressure-temperature chart. Make sure you carry it with you. Some locations may provide this chart but it's better to have it handy in case your testing location doesn't supply them. Along with the chart, a non-programmable calculator is also typically allowed into the exam. Confirm this with your testing center ahead of time.

There is an appendix with all test topics at the end of this study guide.

For a latest test topics, checkout EPA website. At the time of publication, the test topics are available at the URL below:
https://www.epa.gov/section608/section-608-technician-certification-test-topics

2 Core

2.1 Ozone

Ozone is an essential compound of the earth's atmosphere. It consists of 3 oxygen molecules with the chemical formula of $\mathbf{O_3}$.

Ozone is present throughout the atmosphere but its concentration is highest in the lower stratosphere, roughly 12-19 miles above the surface of the earth. This region where 90% of the atmospheric ozone resides is typically called the Ozone layer.

Ozone molecules act as a blanket of protection against harmful ultraviolet rays emerging from the sun. In the absence of the ozone layer in earth's atmosphere, these rays from the sun will directly reach the earth's surface. This would be detrimental to all life on earth including the plants, animals and humans.

Since the 1970s scientists have observed that the stratospheric ozone is being depleted at a steady rate. The main cause for this is the chemical substances released into the atmosphere by human activity. The chlorine present in chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC) seems to be the biggest culprit. The chlorine within these compounds gets released as a free chlorine radical.

This chlorine radical then reacts with an ozone molecule, forming chlorine monoxide and oxygen. The chemical reaction looks like this.

$$O_3 + Cl \rightarrow O_2 + ClO$$

The chlorine monoxide thus generated will further react with another ozone molecule to form a chlorine radical and oxygen.

$$ClO + O_3 \rightarrow 2O_2 + Cl$$

The chlorine radical is now free to attach to another ozone molecule. This cycle continues, leading to further destruction of ozone layer. Each chlorine molecule is believed to destroy about 100,000 ozone molecules.

This effect is observed only due to CFCs and HCFCs. Hydrofluorocarbons (HFC) don't seem to have the same detrimental effect on the ozone layer since they don't have a chlorine molecule. The fluoride molecule within HFCs is more stable and thus doesn't react with ozone the same way.

The table below shows few of the common refrigerants and their categorization into CFCs, HCFCs and HFCs.

Chlorofluorocarbon (**CFC**)	Hydrochlorofluorocarbon (**HCFC**)	Hydrofluorocarbons (**HFC**)
R11, R12, R13, R113, R114, R115, R500, R502 R503, R13B1	R22, R123, R141B, R142B, R401A, R401B, R402A R402B, R403A, R403B, R406A, R408A, R409A, R409B, R411B, R414B	R134A, R32, R125, R143, R152A, R407A, R407F, R410A

2.2 Ozone Depletion Potential

The ozone depletion potential (ODP) is the ability of a chemical compound to degrade the ozone layer in relation to R11. Thus, R11 has a fixed ODP of 1. In comparison, R22 has an ODP of 0.05. So you can say that R22 causes only 5% of the damage caused by R11.

CFCs have the highest ODP. HCFC have a lower ODP than CFC. Although HCFCs cause less damage to ozone, they still do cause damage. For this reason, new regulations banned all refrigerants with ODP > 0. HFCs have the lowest ODP in comparison with HCFCs and CFCs.

Ozone layer depletion will result in harmful ultraviolet rays from the sun directly reaching earth's surface. This can cause skin burns, cataracts, skin cancers and reduced crop yields. It can also affect the balance of marine life.

The ultraviolet rays reaching the earth will likely increase the Ozone concentration in the troposphere. This ozone is very harmful when inhaled by humans, especially children, the elderly and people with respiratory disorders.

When stratospheric ozone depletion was first discovered, its cause was very controversial. It was clear that the depletion was caused due to chlorine in the atmosphere. However, the source of this chlorine was debated. Some believed that it was from CFCs and HCFCs while others argued that it could be from naturally-occuring sources like volcanoes.

These were three pieces of evidence which implicated CFCs and HCFCs over natural causes.

1. Air samples taken over volcanoes showed that they don't cause much chlorine release
2. The rise in chlorine in the atmosphere matches the rise in fluorine levels,another compound present in CFCs and HCFCs.
3. The rise in chlorine levels matches the rise in CFC emissions.

Following this realization the world community acted together to ban CFCs and HCFC from production and to phase out their usage. This will be detailed in the next section.

2.3 Montreal Protocol

The Montreal Protocol is an international treaty that is designed to protect the ozone layer by phasing out several chemical compounds responsible for its depletion. This includes ozone-depleting compounds like CFCs, HCFC and halons. It went into effect in *1989*. The Montreal Protocol successfully achieved the phase-out of 98% of the harmful chemicals that deplete ozone within 25 years of signing.

Section 608 of the Clean Air Act is a part of this agreement and is regulated by the EPA in the United States.

2.4 Clean Air Act

The Clean Air Act is a United States federal law aimed at controlling air pollution. It was first enacted in 1963. After the Montreal Protocol, Section 608 was added to the Clean Air Act in 1990 to address the problems of ozone depletion resulting from the use of refrigerants. This section is regulated by the Environmental Protection Agency (EPA).

2.4.1 Phase Out and Prohibition

For easy recollection, all the dates and restrictions are detailed in the table below.

Start Date	**Restriction**
Jul 1, 1992	Venting of CFCs or HCFCs is prohibited (except *de-minimus* releases)
Nov 15, 1993	All refrigerant recovery equipment must be certified by an EPA approved laboratory
Nov 14, 1994	Only certified technicians are allowed to service, maintain or dispose of appliances containing CFCs and HCFCs
Nov 15, 1995	Venting of HFCs is prohibited
Dec 31, 1995	CFCs can no longer be manufactured in or imported into United States.

Other restrictions include:

- Any container used for refrigerant recovery must be recovered to 0 psig before disposal
- Nitrogen may not be added to a fully.charged system for leak detection, as it would cause a release of the mixture
- Venting is not allowed during servicing or disposal of any appliance containing refrigerants
- The final person in the disposal chain is the one responsible to ensure all refrigerant is removed from the appliance

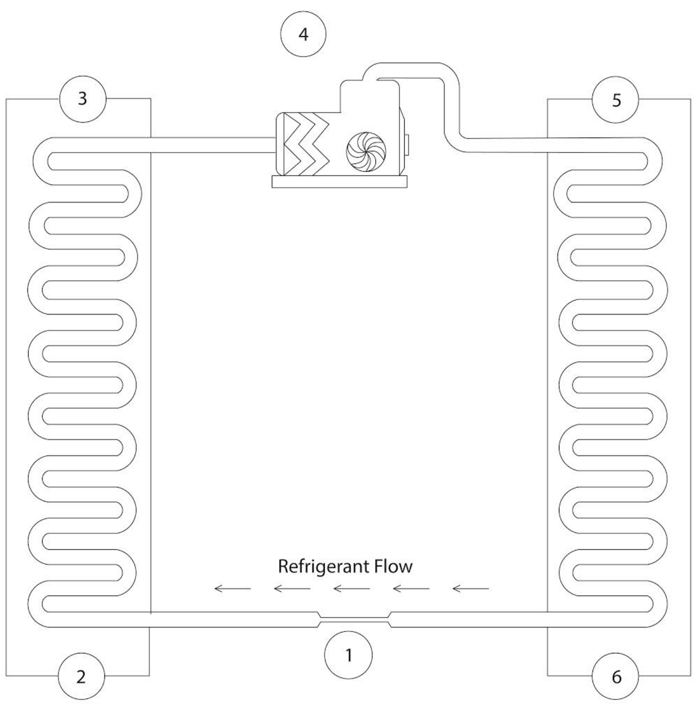
- Individual states and local laws may be stricter than federal regulations stated above.

2.4.2 Penalties

Harsh penalties up to $27,500 per day per violation can be imposed on people and businesses found in violation of this law. There is a reward of $10,000 for anyone who reports a technician intentionally venting refrigerants. Additionally, the technician may also lose their license and may need to appear in federal court. If you find any such violations, you can report them on EPA website.

The EPA may require a technician, at any time, for to demonstrate proper procedures to recover and reclaim refrigerants. Failure to do so may cause the technician to have their license revoked.

2.5 Refrigeration Cycle



1: Metering device

2-3: Evaporator

4: Compressor

5-6: Condenser

Liquid refrigerant enters the metering devices which causes a drop in pressure leading to a drop in saturation temperature of refrigerant. The refrigerant then enters the evaporator where it evaporates into vapor. Heat exchange also happens as a byproduct. The vapor refrigerant then enters the compressor where it is compressed to high pressure vapor. This also leads to an increase in temperature. The refrigerant then moves to condenser where the refrigerant condenses to a liquid expelling heat. This is detailed in the table below.

Component	**Refrigerant enters as**	**Refrigerant exists as**	**Main Function/Action**
Metering Device	High pressure liquid	Low pressure liquid	Lowering saturation temperature by lowering pressure
Evaporator	Low pressure liquid	Low pressure, Low temperature Vapor	Evaporation; cooling the contents inside
Compressor	Low pressure, Low temperature vapor	High pressure, high temperature vapor	Pressurizing refrigerant
Condensor	High pressure, high temperature vapor	High pressure liquid	Expelling heat, condensation to liquid

The gauge manifold set is an important tool used to record pressures at different points in the refrigeration system.

1. The compound gauge is blue in color and measures low pressure (psig) and vacuum (inches Hg).
2. The high-pressure gauge is red in color and measure the high-side discharge pressure.
3. The center port is a yellow hose which connects to the vacuum pump, recovery device or charging device.

EPA regulations require that all the hoses be equipped with-low loss fittings to minimize refrigerant loss.

2.6 Three R’s

The Three R's refer to recover, recycle and reclaim.

Recover is the process of removing the refrigerant from the system in any condition and store it in an external container. Recovery should meet the evacuation rules mentioned in section 2.5.4.

Recycle is the process of cleaning the refrigerant for reuse. This is done by separating the oils and other non-condensables from the refrigerant and removing the moisture by passing the refrigerant through filter dryers.

Reclaim is the process of purifying the refrigerant up to the point that it matches the quality of virgin refrigerant. Reclaimed refrigerant must meet ARI-700 standards.

2.7 Section 608 Regulations

2.7.1 High- and Low-Pressure Refrigerants

Low-pressure refrigerants are the ones that have a boiling point > 10℃ or 50℉ at atmospheric pressure. Common low-pressure refrigerants include R11, R113, R123

High pressure refrigerants are the ones that have a boiling point between -50℃ and 10℃ or -58℉ and 50℉ at atmospheric pressure. Common high-pressure refrigerants include R12, R22, R500, R502

Very high pressure refrigerants have a boiling point below -50℃ or -58℉ at atmospheric pressure. Common very high-pressure refrigerants include R13 and R503.

The table below summarizes the section for easy recollection.

Type of Refrigerant	**Boiling Point**	**Examples**
Low Pressure	> 10℃ (>50℉)	R11, R113, R123
High Pressure	-50℃ to 10℃ (-58℉ to 50℉)	R12, R22, R500, R502
Very High Pressure	<-50℃ (<-58℉)	R13 and R503

2.7.2 Recovery Equipment and Process

Any refrigerant recovery/recycling equipment manufactured after Nov 15, 1993 must be tested and approved by an EPA certified laboratory. The recovery equipment is of two types, namely system-dependent and self-contained.

System-dependent equipment uses the components of the appliance from which the recovery is being performed. For example, they may use the unit's compressor or, if the unit's compressor is not functioning, they may need an independent portable compressor to carry out recovery.

Self-contained recovery equipment has its own means of recovering the refrigerant without depending on the unit's compressor. It's a good practice to always have a self-contained recovery machine at your business location, especially to deal with units with non-functioning compressors.

All air-conditioning and refrigeration equipment containing CFCs or HCFCs must be properly recovered and recycled.

A strong odor during the recovery process indicates a likely compressor burn out. After recovering refrigerant nitrogen can be used to flush the debris. Such nitrogen can be vented as long as there is no refrigerant present in the system (post recovery).

During recovery, the refrigerant moves from the system to the recovery unit due to the difference in pressure between the two. The system needs to be at high pressure and the recovery device must be at low pressure. This recovery process can be sped up by

- minimizing the drop in pressure between system and recovery device by having a connecting hose which is short in length and wide in diameter
- increasing the ambient temperature of the system thereby increasing the pressure and/or decreasing the ambient temperature of the recovery container thereby decreasing the pressure
- using a properly-maintained recovery device

Never mix refrigerants because the mixture is impossible to reclaim. If you ever discover 2 refrigerants are mixed, it should be placed in a separate tank. Always use one tank to recover the same refrigerant.

Recovery cylinders have yellow tops and gray bodies. These are different from disposable cylinders which can be used for new refrigerants only (not for recovery). If the recovery cylinder shows any sign of rust, it must be reduced to 0 psig and discarded.

Recovery cylinders have 2 separate ports, for vapor and liquid. The EPA requires any recovery cylinder to be filled only up to 80% capacity or lower as overfilling may cause explosion. Refillable cylinders must be tested and date-stamped every 5 years.

Recovery cylinders used for transportation must be approved by Department of Transportation (DOT).

2.7.3 Standards For Reclaimed Refrigerants

The Air Conditioning, Heating, and Refrigeration Institute (AHRI) established Standard 700 for refrigerants to establish purity specifications, to verify composition, and to specify the associated methods of testing for acceptability of fluorocarbon refrigerants regardless of source (new, reclaimed and/or repackaged) for use in new and existing refrigeration and air-conditioning products within the scope of AHRI. The ARI 700 purity standard is applicable for both new and reclaimed refrigerants.

2.8 Substitute Refrigerants and Oils

Oils are essential to the system along with refrigerant. Oils help lubricate the compressor. Both oil and refrigerant are present in the same system. So it's important for them to mix and work well together. Different refrigerants work well with different oils.

CFC and HCFC use mineral oil and alkylbenzenes. HFCs work best with ester-based blends. HFCs can't work with the oils used with CFCs/HCFCs and vice versa. Oils which have the tendency to absorb moisture are called *hygroscopic* oils.

It is important to note here that most substitute refrigerants are incompatible with many lubricants used with CFC and HCFC refrigerants. Similarly CFC and HCFC refrigerants are incompatible with many new lubricants,

R-134A is a HFC and is considered as a good alternative to the R-12 (a CFC) present in the older systems. But due to the difference in oils, a drop-in substitution is not possible. There is no drop-in substitute for R-12 or any CFCs due to the difference in oils used with the refrigerants. So to replace a R-12 refrigerant in the older system, a retrofit must be done.

2.8.1 Refrigerant Blends

A mixture of 2 or more refrigerants is called a refrigerant blend. A mixture of 3 refrigerants is called *ternary* blend.

A *zeotropic* blend contains refrigerants which keep their own pressure/temperature characteristics in the blend. Due to this, different refrigerants in the blend vaporize and condense differently. Zeotropic blends are numbered in the 400s.

The difference in temperature between the first refrigerant vaporizing and the last refrigerant vaporizing (at constant pressure) is called *temperature glide*.

In case of a leak, the refrigerants in the blend leak at different rates due to different vapor pressures. As a result, the mixture that is left behind in the system will have a different ratio of refrigerants than the original blend. This phenomenon is called *fractionation*. Fractionation may impact the performance of the refrigerant.

When charging such a system, refrigerant should be introduced in the liquid form (not gas) and from the high side.

Azeotropic blends behave like a single refrigerant throughout their pressure temperature range. They do not experience temperature glide. Azeotropic blends are numbered in the 500s.

2.8.2 Dehydration Evacuation

Dehydration is the process of removing the water and vapor from the system. Eliminating air and moisture in the system is important as it helps preserve the system's capacity and maintain efficiency. Lowering the system pressure will cause the water to vaporize. The vapor can then be removed using a pump.

Care should be taken to ensure that desired vacuum levels as set forth by the EPA are reached before evacuating a system to ambient air.

The table below shows the required evacuation level for each type refrigerants. For the definition of each type of refrigerant refer to the section 2.5.1.

Pressure and Lbs of Refrigerant	Inches of Hg vacuum (relative to standard atmospheric pressure of 29.9 inches Hg)	
	Before Nov 15, 1993	After Nov 15, 1993
Very High	0	0
High under 200	0	0
High over 200	4	10
Medium	4	10

Low	25 in of Hg	25 mm Hg absolute (about 29 in of Hg)

Exception:

If a system has a leak large enough to prevent evacuation to the prescribed level, the system must be evacuated to atmospheric pressure (0 psig) before being opened.

A vacuum gauge can be used to measure the vacuum. The system should be able to *achieve and hold* the vacuum suggested above. A loss of vacuum can be caused by one of the following.

1. There is still remnant refrigerant left in vapor form
2. The connections are loose
3. There is a leak in the system
4. There is still water left in the system

2.9 Leak Detection and Repair

It is important to minimize the release of CFCs and HCFCs by proper leak detection. There are several ways to determine leaks. They include:

1. electronic detectors
2. ultrasound detectors
3. applying soap and looking for bubbles on areas under question
4. halide torches for detecting refrigerants
5. adding dye to the system

Use nitrogen and test the system before charging it with refrigerant. If the system doesn’t hold pressure, it shows the possibility of a leak. Only use refrigerant as a trace gas to detect leaks as a last resort.

The EPA requires that all equipment with more than 50 pounds of refrigerant be tested for leaks and repaired regularly. For commercial and industrial equipment, leaks exceeding 35% of charge per year must be repaired. For equipment that is not commercial or industrial, the threshold is set at 15%.

If the system holds less than 50 pounds of refrigerant, it is not an EPA requirement to repair leaks in the equipment. But as a general rule, it is always good practice to test and repair leaks in a system.

2.10 Safety

Exposure to refrigerants can be harmful and may even cause death. Extreme care should be taken when handling refrigerants. Refrigerants at atmospheric pressure are at an extremely low temperature. Exposure may cause frostbite.

Refrigerants are heavier than air, so they displace oxygen and may cause suffocation due to oxygen deprivation. Some refrigerants are toxic. Other refrigerants may not be toxic, but can lead to long-term health hazards with prolonged exposure and are dangerous in high concentrations.

ASHRAE Standard 34 classifies refrigerants based on their toxicity and flammability. Toxicity is rated as A for low toxicity and B for high toxicity. Flammability is rated as 1 for low flammability and 3 for high flammability. For example, a classification of B3 represents a refrigerant that is highly toxic, highly flammable. It is detailed below for easy recollection.

Flammability		**Toxicity**	
1	No flame propagation	A	Low toxicity
2	Low flammability	B	High toxicity
3	High flammability		

Flames or high heat may cause refrigerants (especially R-12 and R-22) to break down into poisonous chemicals like hydrochloric acid, hydrofluoric acid and phosgene gas. Before soldering or welding any components of the refrigeration system, the refrigerants must be completely evacuated.

Protective equipment is essential for a technician handling refrigerants. One should wear safety glasses or goggles, gloves, , a long-sleeve shirt and long pants. In the case of a large leak in a confined area, a self-contained breathing apparatus (SCBA) must be used.

Never use oxygen or compressed air to pressurize the system. It may cause an explosion. Nitrogen can be used to pressurize the system for leak detection. Nitrogen is usually at very high pressure so it’s important to use a pressure regulator and relief valve with it. The relief valve is useful in case the pressure regulator fails.

The relief valve should be installed downstream of the pressure regulator. Never install relief valves in series. If any corrosion is found in the relief valve, it should be immediately replaced. A

Schrader valve is similar to the valve of a tire. They prevent venting. They should be checked regularly and immediately replaced if any corrosion is found.

Reusable cylinders are refillable multiple times whereas disposable cylinders must be used only once and discarded. The cylinders must be Department of Transportation (DOT) approved. Reusable cylinders have a gray body and yellow top and can be used for transportation as well. The cylinders should always be filled to less than 80% capacity. Gas under high pressure can be dangerous.

2.11 Shipping

Refrigerant cylinders should have 2 labels - the refrigerant type and the DOT classification tag. Each cylinder should be properly marked with the type and amount of refrigerant. Additionally, each cylinder should also be marked with a DOT classification tag stating it is a “2.2 non-flammable gas”.

Cylinders should be tested and stamped every five years. They should be transported in an upright position. Disposable cylinders are designated as DOT Specification 39, non-reusable cylinders.

3. Type 1 (Small Appliances)

3.1 Definition

Any refrigeration unit manufactured, charged and hermetically sealed at the factory with less than 5 pounds of refrigerant is defined as a small appliance. Such units include products like refrigerators, freezers, heat pumps, drinking water coolers, window air conditioners, room air conditioners and ice makers. Any technician servicing such a system must be certified under type 1 certification or universal certification. Motor vehicle air conditioner servicing is not covered under type 1. It comes under EPA 609 which is a different certification.

3.2 Recovery requirements

EPA guidelines require a certain level of evacuation for small appliances as detailed in the table below.

Equipment manufacture date	**Compressor status**	**Evacuation required**
Before Nov 15, 1993	Both (Functional or not)	80% or 4 in of hg vacuum
After Nov 15, 1993	Functional	90%
	Non-Functional	80% or 4 in of hg vacuum

All the equipment must be fitted with low-loss fittings to minimize refrigerant loss. The EPA does not require leak repair on small appliances, but it’s recommended to test and fix leaks whenever possible.

3.3 Recovery Techniques

After recovering a refrigerant into a recovery tank, you can use a pressure/temperature chart to detect the presence of non-condensables. Once the temperature of the tank stabilizes at room temperature, check the pressure against the expected pressure from the pressure/temperature chart. Higher-than-expected discharge pressure indicates the presence of air and other non-condensables

Self-contained, or active, recovery equipment has its own means of recovering refrigerant and achieving the desired evacuation levels without depending on the system’s compressor. Active equipment recovers refrigerant into a pressurized recovery tank. The technician must ensure that the tank is free of air and condensables before recovering the refrigerant.

System-dependant, or passive, recovery equipment depends on the compressor of the appliance to recover the refrigerant. It captures the refrigerant in a non-pressurized tank. If the compressor is functional, the recovery can be done only from the high side of the system.

If the compressor is not operational, connecting to both the high and low side may be necessary to achieve desired evacuation levels. In cases of non-operating compressors, use of an external heat source/vacuum pump and/or sharply striking the compressor (to release refrigerant from oil) can aid in the recovery process.

The EPA requires every technician to have at least one active recovery device to handle non-operating compressor systems. The only exception is technicians dealing exclusively with small appliances. Only appliances with less than 15 pounds of refrigerant can be recovered using system-dependant (passive) recovery equipment.

For more details about active and passive recovery equipment, refer to Section 2.5.2 (Recovery Equipment and Process)

3.4 Recovery Restrictions

Refrigeration systems built before 1950 contain sulfur dioxide, methyl formate and methyl chloride. Similarly, refrigeration units in trailers and RVs use ammonia, hydrogen and water. They should not be recovered using the same recovery equipment even when using a different recovery tank.

3.5 Access fittings

Small appliances are equipped with tubing to install piercing-type access fittings. These fittings should be leak-tested before proceeding with recovery. Such solderless piercing type access fittings can only be used with copper or aluminium tubing material. These solderless fittings tend to leak over time and should be immediately removed at the conclusion of service.

3.6 Safety

For information on safety for small appliances refer to Section 2.10 (Safety).

4. Type 2 (High-Pressure Appliances)

4.1 Definition

Any technician servicing a high-pressure or very high-pressure unit must be certified with type 2 certification or universal certification (except small appliances as defined under type 1 and motor vehicle units which is EPA 609 certification).

4.2 Leak Detection and Repair Requirements

It's important to perform leak detection before charging a new system or recharging an old system with refrigerant. To do this, the unit must be pressurized with inert gas. It's best to use pure nitrogen for leak detection. It's acceptable (but not preferred) to use R-22 as a trace gas if needed.

Leak detection and repair should also be performed when signs of leakage are found during inspection. Signs of leaks include:

- Excessive superheat (caused by low refrigerant charge)
- Traces of oil (refrigerant blend leaks but refrigerant vaporizes, leaving oil behind)

For different methods of leak detection, refer to Section 2.9 (Leak Detection and Repair)

Commercial and industrial process refrigeration equipment with more than 50 pounds of refrigerant must be repaired when the leak exceeds more than 35% of the charge per year.

All other equipment (excluding commercial and industrial process refrigeration) containing more than 50 pounds of refrigerant must be repaired when the leak rate exceeds 15% of the charge per year.

4.3 Recovery Techniques

Recovery equipment must be certified by an EPA-approved facility meeting or exceeding ARI standards. The recovery equipment must be properly maintained by frequently checking the oil levels and filter status and changing them whenever necessary. Recovered old refrigerants typically contain moisture, oil and acids that tend to slowly deteriorate the recovery equipment if it is not properly maintained.

Before recovering a new type refrigerant, the recovery equipment must be properly cleared of any existing refrigerant and the filter should be changed to prevent cross-contamination.

Technicians working with R-134A should use dedicated equipment including hoses, gauges and oil containers.

It is possible to speed up the recovery process by following the techniques below:

- recovering refrigerant as liquid in the beginning.
- minimizing the drop in pressure between the system and recovery device by having a connecting hose which is short in length and wide in diameter
- Additionally, since the refrigerant moves from a high-pressure to a low-pressure region, the recovery can be sped up further by:
    - heating the appliance from which refrigerant is being recovered (increasing the system pressure)
    - chilling the recovery vessel (dropping the pressure)

4.4 Recovery Requirements

According to the EPA any repair is considered "major" if it involves any of the following components: compressor, condenser, evaporator or auxiliary heat exchange coil. The EPA requires all systems opened to the atmosphere for servicing, diagnosis or repair (including major repairs) to meet a certain level of evacuation as shown below. This also applies when disposing of the appliance.

Type and lbs of Refrigerant	**Inches of Hg vacuum**	
	Equipment manufactured *before* Nov 15, 1993	Equipment manufactured *after* Nov 15, 1993
Very High Pressure	0	0
HCFC-22 under 200 lbs	0	0
HCFC-22 over 200 lbs	4	10
CFC-22 under 200 lbs	4	10
CFC-22 over 200 lbs	4	15
Low Pressure	25 in of Hg	25 mm Hg absolute (about 29 in of Hg)

After finishing recovery, it is essential to wait for a few minutes to ensure the system pressure is stable. Rising pressure may be due to vaporization of liquid refrigerant trapped in the system or in the oil. So, if the pressure continues to rise, continue the recovery. It could also be due to a leak. If the presence of leak is making the desired evacuation levels unattainable, it is acceptable to evacuate the system to 0 psig (atmospheric pressure).

It is not permissible to use a system-dependent recovery equipment on appliances containing more than 15 pounds of refrigerant. For a complete definition of system dependant vs self-contained recovery equipment, refer to Section 2.5.2 (Recovery Equipment and Process)

4.5 Refrigeration

With the advancement of research into refrigeration systems, many new and innovative refrigerants are available in the market. Always read the label to identify the type of refrigerant in the appliance. A pressure/temperature chart can also be used to identify common refrigerants.

Both *psig* and *psia* are used to measure the pressure exerted by a gas (like refrigerant vapor) in a closed container. Pounds Per Square Inch Gauge (*psig*) is the pressure relative to atmospheric pressure. Pounds per Square Inch Absolute (*psia*) is the pressure relative to vacuum. Since atmospheric pressure at sea level is 14.7, psia can be obtained by adding 14.7 to psig. The reading on a measuring device is typically psig. For example, an inflated tire could show 35 units on the gauge. So it has a psig of 35 and psia of 35+14.7 or 49.7 psia.

This conversion is very important when referring to the pressure/temperature charts. Pay close attention to the units on the chart compared to the units on your measuring device. Convert the units if necessary to get an accurate pressure/temperature relationship.

For details on how a refrigeration system works, refer to Section 2.7 (Refrigeration Cycle)

4.6 Safety

ASHRAE Standard 34 which we learned in Section 2.10 (Safety) is a safety classification of refrigerants. This designates each refrigerant based on their toxicity.

Flammability		**Toxicity**	
1	No flame propagation	A	Low toxicity
2	Low flammability	B	High toxicity
3	High flammability		

ASHRAE Standard 15 is a safety standard for refrigeration systems. This standard requires that every room containing refrigeration systems be equipped with sensors which will sound alarms and start ventilation automatically upon sensing a refrigerant leak in an occupied room (above a threshold value when it starts to become harmful to the inhabitants).

High-pressure systems may have hermetically-sealed compressors. Do not start the compressor under deep vacuum. This may cause a compressor burnout and damage because such compressors are dependent on the flow of refrigerant for cooling. A strong odor indicates compressor burnout.

For additional information on safety refer to Section 2.10 (Safety).

5. Type 3 (Low-Pressure Appliances)

5.1 Definition

Any technician servicing, maintaining or disposing a low-pressure appliances must be certified with type 3 certification or universal certification.

5.2 Leak Detection

Low-pressure systems operate in a vacuum. So the pressure in the system is far below the atmospheric pressure. Any leak in the system will cause the air and moisture to leak in (rather than refrigerant leaking out).

Low-pressure appliances are equipped with a purge unit to remove air, moisture and other non-condensables. Excessive activity of a purge unit indicates the presence of a leak. If the system pressure increases over 2.5 mm (of Hg) during vacuum testing, the system should be tested for leaks.

The preferred way to leak-test is to increase the pressure by increasing the temperature. This can be achieved by running hot water through the unit or by covering the unit with heat blankets. If that is not possible then the technician can recover the refrigerant and pressurize the system with nitrogen.

These units have a rupture disc which breaks and releases pressure when it exceeds a certain level. Hence, the pressure should never exceed 10 psig when pressurizing the system for leak detection.

Always check the shaft seal for units with open compressors. If a leak in water tubes is suspected, a hydrostatic tube test can be performed.

5.3 Repair Requirements

The EPA does not require repair of leaks in units holding less than 50 pounds of refrigerant. However, it is a good practice to find and repair leaks.

Commercial and industrial process refrigeration equipment with more than 50 pounds of refrigerant must be repaired when the leak exceeds more than 35% of the charge per year.

All other equipment (excluding commercial and industrial process refrigeration) containing more than 50 pounds of refrigerant must be repaired when the leak rate exceeds 15% of the charge per year.

Leaks must be repaired within 30 days of discovery. The only exception is if the owner has a plan to retrofit or retire the equipment within one year. If such a plan is to be carried out, documentation should be kept on site for verification.

5.4 Recovery Techniques

Recovering liquid refrigerant first can speed up the recovery process. However, in a low-pressure system a considerable amount of refrigerant is still left in vapor phase even after recovering all the liquid refrigerant. It's important for the technician to be patient and recover all the refrigerant in vapor phase as well.

Oil should be heated to 130℉ before removing it. This minimizes the presence of refrigerant trapped in the oil.

Water is used in low-pressure systems to cool the condenser. During refrigerant recovery, water present in the system can freeze and rupture the tubes. To prevent such damage, it is necessary to either remove water completely or circulate the water by connecting the recovery unit to a water supply. Circulating water will not freeze.

Recovery machines for low-pressure chillers should be equipped with a pressure-relief device set to 10 psi. This is lower than the inbuilt pressure relief system of the unit. Rupture disks of the system are usually set at a cut-out level of 15 psig to prevent explosion.

5.5 Recovery Requirements

All refrigerant must be recovered before disposing of appliances containing CFCs or HCFCs. The last person in the supply chain is responsible for recovery. This person must also keep records documenting the recovery.

Recovery/recycling equipment manufactured after Nov 15, 1993 must be certified by a EPA approved laboratory. All equipment must have low-loss fittings to minimize refrigerant loss while connecting and disconnecting.

When performing refrigerant recovery on a low-pressure system, a certain level of evacuation must be met as per EPA.

25 in of Hg with recovery equipment manufactured before Nov 15, 1993.
25 mm Hg absolute (~ 29 in of Hg) with recovery equipment manufactured after Nov 15, 1993.

These evacuation levels are valid for equipment with any amount of refrigerante (over or under 200 lbs).

Once the desired vacuum level is reached, the technician should wait for a few minutes while monitoring the system pressure. Rising pressure indicates the presence of liquid refrigerant in the system or oil. If this happens, continue the recovery. This process must be repeated several times until the desired vacuum level is reached and maintained for a few minutes.

If the presence of leak make the desired vacuum levels unattainable, it is okay to evacuate to the lowest possible level.

Any work done on the compressor, condenser, evaporator or heat exchanger is considered a major repair.

5.6 Recharging Techniques

Centrifugal compressors should be charged through the lowest access point on the low-pressure side of the system, which is the evaporator charging valve.

When charging a low-pressure system, introducing liquid refrigerant can freeze the water and rupture the tubes. It's important to introduce refrigerant in vapor phase until the pressure builds up enough so that the saturation temperature is over the freezing point of water (0℃). This can be derived from the pressure/temperature chart.

5.7 Safety

ASHRAE Standard 15 is a safety standard for refrigeration systems. This standard requires that every room containing refrigeration systems be equipped with sensors which will sound alarms and start ventilation automatically upon sensing a refrigerant leak in an occupied room (above a threshold value when it starts to become harmful to the inhabitants).

All refrigeration systems must have pressure-relief valves. Never install pressure-relief valves in series.

Low-pressure refrigerant R-11 (a CFC) is classified as A1 while R-123 (an HCFC) is classified as B1 according to ASHRAE Standard 34.

For details on ASHRAE Standard 34 and other additional information on safety refer to Section 2.10 (Safety).

Appendix A: Test Topics by Section in Study Guide

For the most updated version of test topics, check the EPA website. Core section is mandatory for all types. A technician needs to pass all 4 sections for universal certification.

CORE

Topic	Section
Ozone Depletion	
Destruction of ozone by chlorine	2.2
Presence of chlorine in chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC) refrigerants	2.2
Identification of CFC, HCFC, and hydrofluorocarbon (HFC) refrigerants (not chemical formulas, but idea that R-12 is a CFC, R-22 is an HCFC, R-134 is an HFC, etc.)	2.2
Idea that CFCs have higher ozone-depletion potential (ODP) than HCFCs, which in turn have higher ODP than HFCs	2.2
Health and environmental effects of stratospheric ozone depletion	2.2
Evidence of stratospheric ozone depletion and role of CFCs and HCFCs	2.2
Clean Air Act and Montreal Protocol	
CFC phaseout date	2.4.1
Venting prohibition at servicing	2.4.2
Venting prohibition at disposal	2.4.1
Venting prohibition on substitute refrigerants	2.4.1
Maximum penalty under the Clean Air Act	2.4.2
Montreal Protocol (the international agreement to phase out production of ozone-depleting substances)	2.3
Section 608 Regulations	
Definition/identification of high and low-pressure refrigerants	2.7.1
Definition of system-dependent versus self-contained recovery/recycling equipment	2.7.2
Identification of equipment covered by the rule (all air-conditioning and refrigeration equipment containing CFCs or HCFCs except motor vehicle air conditioners)	2.1
Need for third-party certification of recycling and recovery equipment	2.7.2
Standard for reclaimed refrigerant [Air Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 700-1995]	2.7.3
Substitute Refrigerants and oils	
Absence of "drop-in" replacements	2.8

Incompatibility of substitute refrigerants with many lubricants used with CFC and HCFC refrigerants and incompatibility of CFC and HCFC refrigerants with many new lubricants (includes identification of lubricants for given refrigerants, such as esters with R-134; alkylbenzenes for HCFCs)	2.8
Fractionation problem--tendency of different components of blends to leak at different rates	2.8.1
Refrigeration	
Refrigerant states (vapor versus liquid) and pressures at different points of refrigeration cycle; how/when cooling occurs	2.5
Refrigeration gauges (color codes, ranges of different types, proper use)	2.5
Three R Definitions	
Recover	2.6
Recycle	2.6
Reclaim	2.6
Recovery Techniques	
Need to avoid mixing refrigerants	2.7.2
Factors affecting speed of recovery (ambient temperature, size of recycling or recovery equipment, hose length and diameter, etc.)	2.7.2
Dehydration Evacuation	
Need to evacuate system to eliminate air and moisture at the end of service	2.8.2
Safety	
Risks of exposure to refrigerant (e.g., oxygen deprivation, cardiac effects, frost bite, long-term hazards)	2.10
Personal protective equipment [gloves, goggles, self-contained breathing apparatus (SCBA)-in extreme cases, etc.]	2.10
Reusable (or "recovery") cylinders versus disposable cylinders [ensure former Department of Transportation (DOT) approved, know former's yellow and gray color code, never refill latter]	2.10
Risks of filling cylinders more than 80 percent full	2.10
Use of nitrogen rather than oxygen or compressed air for leak detection	2.10
Use of pressure regulator and relief valve with nitrogen	2.10
Shipping	
Labels required for refrigerant cylinders (refrigerant identification, DOT classification tag)	2.11

TYPE 1 (Small Appliances)

Type 1 test includes topics from Core section and the topics mentioned below.

Topic	Section
Recovery Requirements	
Definition of "small appliance"	3.1
Evacuation requirements for small appliances with and without working compressors using recovery equipment manufactured before November 15, 1993	3.2
Evacuation requirements for small appliances with and without working compressors using recovery equipment manufactured after November 15, 1993	3.2
Recovery Techniques	
Use of pressure and temperature to identify refrigerants and detect noncondensables	3.3
Methods to recover refrigerant from small appliances with inoperative compressors using a system-dependent or "passive" recovery device (e.g., heat and sharply strike the compressor, use a vacuum pump with non-pressurized recovery container)	3.3
Need to install both high and low side access valves when recovering refrigerant from small appliances with inoperative compressors	3.3
Need to operate operative compressors when recovering refrigerant with a system-dependent ("passive") recovery device	3.3
Should remove solderless access fittings at conclusion of service	3.5
Hydrofluorocarbon (HFC)-134a (also called R-134a) as likely substitute for chlorofluorocarbon (CFC)-12 (also called R-12)	2.8
Safety	
Decomposition products of refrigerants at high temperatures	2.1

TYPE 2 (High Pressure)

Type 2 test includes topics from Core section and the topics mentioned below.

Topic	Section
Leak Detection	
Signs of leakage in high-pressure systems (excessive superheat, traces of oil for hermetics)	4.2
Need to leak test before charging or recharging equipment	4.2
Order of preference for leak test gases [nitrogen alone best, but nitrogen with trace quantity of hydrochlorofluorocarbonHelphydrochlorofluorocarbonA compound consisting of hydrogen, chlorine, fluorine, and carbon. The HCFCs are one class of chemicals being used to replace the CFCs. They contain chlorine and thus deplete stratospheric ozone, but to a much lesser extent than CFCs. HCFCs have ozone depletion potentials (ODPs) ranging from 0.01 to 0.1. Production of HCFCs with the highest ODPs are being phased out first, followed by other HCFCs. A table of ozone-depleting substances (http://www.epa.gov/ozone/science/ods/classtwo.html) shows their ODPs, GWPs, and CAS numbers. HCFCs are numbered according to a standard scheme (http://www.epa.gov/ozone/geninfo/numbers.html). (HCFC)-22 (also called R-22) better than pure refrigerant]	4.2
Leak repair requirements	
Allowable annual leak rate for commercial and industrial process refrigeration	4.2
Allowable annual leak rate for other appliances containing more than 50 pounds of refrigerant	4.2
Recovery Techniques	
Recovering liquid at beginning of recovery process speeds up process	4.3
Other methods for speeding recovery (chilling recovery vessel, heating appliance or vessel from which refrigerant is being recovered)	4.3
Methods for reducing cross-contamination and emissions when recovery or recycling machine is used with a new refrigerant	4.3
Need to wait a few minutes after reaching required recovery vacuum to see if system pressure rises (indicating that there is still liquid refrigerant in the system or in the oil)	4.4
Recovery Requirements	
Evacuation requirements for high-pressure appliances in each of the following situations: - Disposal - Major versus non-major repairs - Leaky versus non-leaky appliances - Appliance (or component) containing less versus more than 200 pounds - Recovery/recycling equipment built before versus after November 15, 1993	4.4
Definition of "major" repairs	4.4

Prohibition on using system-dependent recovery equipment on systems containing more than 15 pounds of refrigerant	4.4
Refrigeration	
How to identify refrigerant in appliances	4.5
Pressure-temperature relationships of common high-pressure refrigerants [may use standard temperature-pressure chart--be aware of need to add 14.7 to translate pounds per square inch gauge (psig) to pounds per square inch absolute (psia)]	4.5
Components of high-pressure appliances (receiver, evaporator, accumulator, etc.) and state of refrigerant (vapor versus liquid) in them	4.5
Safety	
Shouldn't energize hermetic compressors under vacuum	4.6
Equipment room requirements under American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard 15 (oxygen deprivation sensor with all refrigerants)	4.6

TYPE 3 (Low Pressure)

Type 3 test includes topics from Core section and the topics mentioned below.

Topic	Section
Leak Detection	
Order of preference of leak test pressurization methods for low-pressure systems 1. Hot water method or built-in system heating/pressurization device such Prevac 2. Nitrogen	5.2
Signs of leakage into a low-pressure system (e.g., excessive purging)	5.2
Maximum leak test pressure for low-pressure centrifugal chillers	5.2
Leak repair requirements	
Allowable annual leak rate for commercial and industrial process refrigeration	5.3
Allowable annual leak rate for other appliances containing more than 50 pounds of refrigerant	5.3
Recovery Techniques	
Recovering liquid at beginning of recovery process speeds up process	5.4
Need to recover vapor in addition to liquid	5.4
Need to heat oil to 130°F before removing it to minimize refrigerant release	5.4
Need to circulate or remove water from chiller during refrigerant evacuation to prevent freezing	5.4
High-pressure cut-out level of recovery devices used with low-pressure appliances	5.4
Recharging Techniques	
Need to introduce vapor before liquid to prevent freezing of water in the tubes	5.6
Need to charge centrifugals through evaporator charging valve	5.6
Recovery Requirements	
Evacuation requirements for low-pressure appliances in each of the following situations: - Disposal - Major versus non-major repairs - Leaky versus non-leaky appliances - Appliance (or component) containing less versus more than 200 pounds - Recovery/recycling equipment built before versus after November 15, 1993	5.5
Definitions of "major" and "non-major" repairs	5.5
Allowable methods for pressurizing a low-pressure system for a non-major repair (controlled hot water and system heating/pressurization device such as Prevac)	5.2
Need to wait a few minutes after reaching required recovery vacuum to see if system pressure rises (indicating that there is still liquid refrigerant in the system or in the oil)	5.5

Refrigeration	
Purpose of purge unit in low-pressure systems	5.2
Pressure-temperature relationships of low-pressure refrigerants	5.6
Safety	
Equipment room requirements under ASHRAE Standard 15 (oxygen deprivation sensor with all refrigerants)	5.7