ENVIRONMENTALLY SAFE
R-410A SERVICE TECHNIQUES

R-410A Training Supplement
to the Desktop Reference and Training Guide

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Preface

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The information in this course is intended for educational purposes only. Procedures described are for use only by qualified air conditioning and refrigeration service technicians. **This training course is not a substitute for any equipment Manufacturer's Operator Manual.**

Take safety precautions when using all HVAC equipment. Improper use of HVAC equipment can cause explosion and serious personal injury. Always read the entire Manufacturer's Operator Manual before turning on any equipment for the first time! Use extreme caution when working with refrigerants; hoses may contain liquid refrigerant under pressure. Use only approved refillable storage cylinders. Do not overfill any storage cylinder beyond its rated capacity. Always wear safety glasses. Protect the skin from flash freezing. **Never turn on any equipment if you do not understand its operation. Where procedures described in this manual differ from those of a specific equipment manufacturer, the equipment manufacturer's instructions should be followed.**

Do not leave any refrigerant recovery or recovery-recycling machine ON and unsupervised. All refrigerant recovery and recycling devices are to be used by trained and certified refrigeration technicians only! Again, misuse of refrigerant recovery and recycling devices can cause explosion and personal injury.

Technical and legislative information presented in this book is current as of the date of the manual's latest publication. Due to rapidly advancing technology and changing regulations in the refrigerant recovery and recovery-recycling field, no representation can be made for the future accuracy of the information. Visit the EPA's Internet Home Page at http://www.epa.gov for the latest details.

Mainstream Engineering Corporation assumes no liability for the use of information presented in this publication. This information is presented for educational purposes only. Manufacturer's Operator Manuals must be consulted for the proper operation of any piece of equipment. The content of this course is limited to information and service practices needed to contain, conserve, and reuse R-410A and other very high pressure refrigerants, and to prevent their escape into the atmosphere. This manual is not intended to teach air conditioning-refrigeration system installation, troubleshooting, or repair. Refrigeration technicians should already be knowledgeable in these areas prior to taking this course. This manual was prepared assuming the technician is already very knowledgeable with safety practices normally practiced in the HVAC/R industry and has worked extensively with R-22 and other high pressure refrigerants. This manual seeks to point of some of the significant difference between very high pressure and other high pressure refrigerants.

R-410A Glossary of Terms

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Appliance	Any device that contains and uses a refrigerant and that is used for household or commercial purposes, including any air conditioner, refrigerator, chiller, or freezer. EPA interprets this definition to include all air-conditioning and refrigeration equipment except units designed and used exclusively for military purposes.
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.
Commercial Refrigeration	Refrigeration appliances used in retail food and cold storage warehouse sectors. "Retail food" includes the refrigeration equipment found in supermarkets, convenience stores, restaurants, and other food service establishments. "Cold storage" includes the equipment used to store meat, produce, dairy products, and other perishable goods. All of this type equipment contains large refrigerant charges, typically over 75 pounds.
Compound	A substance formed by a union of two or more elements in a definite proportion by weight.
Disposal	The process leading to and including any of the following: (1) The discharging, depositing, dumping, or placing of any discarded appliance into or on any land or water. (2) The disassembly of any appliance for discharging, depositing, dumping, or placing of its discarded component parts into or on any land or water.

	(3) The disassembly of any appliance for reuse of its component parts.
Fractionation	The separation of a liquid mixture into separate parts by the preferential evaporation of the more volatile component.
Halocarbon	A halogenated hydrocarbon containing one or more of the three halogens: fluorine, chlorine, and bromine. Hydrogen may or may not be present.
High-Pressure Appliance	(prior to March 12, 2004, referred to by the EPA as higher-pressure appliance) An appliance that uses a refrigerant with a liquid phase saturation pressure between 170 psia and 355 psia at 104°F. This definition includes but is not limited to appliances using R-410A, R-22, R-401B, R-402A/B, R-404A, R-407A/B/C, R-408, R-409, R-411A/B, R-502 and R-507A.
Hydrocarbon	A compound containing only the elements hydrogen and carbon.
Industrial Process	Complex customized appliances used in the chemical, Refrigeration pharmaceutical, petrochemical industries, and in manufacturing. This sector includes industrial ice machines and ice rinks.
Isomer	One of a group of substances having the same combination of elements but arranged spatially in different ways.
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 over that period. The rate is calculated using the following formula: (Refrigerant added/Total Charge)x(365 days/year/D)x100% where D = the shorter of: # days since refrigerant last added or 365 days
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.
Major Maintenance	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. Due to the similarities between MVAC and MVAC-like

	appliances, EPA recommends that technicians servicing MVAC-like appliances consider certification under Section 609. Note that buses using CFC-12 or HFC-134a to cool the driver are MVACs, however buses using HCFC-22 are not MVACs or MVAC-like appliances, but rather high-pressure equipment covered under Type II of the section 608 test. Therefore if you service both the drivers AC system (MVAC) and the passenger AC system both a 609 MVAC and a 608 certification are required. Likewise if your service the AC system for the cab of a truck (MVAC) as well as the refrigerated cargo container then again, you need both a 609 MVAC and a 608 certification.
MVAC-like Appliances	Mechanical vapor compression, open-drive compressor appliances used to cool the driver's or passenger's compartment of a non-road vehicle, including agricultural and construction vehicles. This definition excludes appliances using HCFC-22 refrigerant or their substitutes, such as R-410A or R-407. The regulations implementing Sections 609 and 608 treat MVACs and MVAC-like appliances (and persons servicing them) slightly differently. A key difference is that persons who service MVACs are subject to the Section 609 equipment and technician certification requirements only if they perform "service for consideration", while persons who service MVAC-like appliances are subject to the equipment and technician certification requirements set forth in the Section 608 and 609 regulations regardless of whether they are compensated for their work. Another difference is that persons servicing MVAC-like appliances have the option of becoming certified as Section 608 Type II technicians instead of becoming certified as Section 609 MVAC technicians under subpart B. **Persons servicing MVACs do not have this choice. They must be certified as Section 609 MVAC technicians if they perform the AC service for compensation**.
Non-azeotropic Refrigerant	A synonym for zeotropic, the latter being preferred though less commonly used descriptor. Zeotropic: blends comprising multiple components of different volatilities that, when used in refrigeration cycles,

	change volumetric composition and saturation temperatures (exhibit temperature glide) as they evaporate (boil) or condense at constant pressure. These refrigerants are given a 400 series ASHRAE designation.
Normal Charge	The quantity of refrigerant within the appliance or appliance component when the appliance is operating with a full charge of refrigerant.
Opening an Appliance	Any service, maintenance, or repair on an appliance that could be reasonably expected to release refrigerant from the appliance to the atmosphere unless the refrigerant were previously recovered from the appliance.
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.
Reclamation	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	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.
Recovery Efficiency	The percentage of refrigerant in an appliance that is recovered by a unit of recycling or recovery equipment.
Recycling	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 driers, which reduce moisture, acidity, and particulate matter.
Refrigerant	The fluid used for heat transfer in a refrigeration system which 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.
System-dependent Recovery Equipment	Recovery equipment that relies upon the compressor in the appliance and/or the pressure of the refrigerant in the appliance.
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.
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, or R-503.

Introduction

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On November 14, 1994, the U.S. Environmental Protection Agency (EPA) implemented the Clean Air Act, which requires certification of personnel who work with refrigerants. **Air conditioning and refrigeration personnel today are in a position of increasing**

responsibility, both to implement procedures resulting from refrigerant regulations and to provide answers to customers' questions and technical problems. Safety continues to be a primary concern when using both new and familiar methods and equipment.

Some users of this manual will also be aware of additional information that is not included here. The intent is to present a course concentrating on practical, basic information that is most needed, and that can be readily applied on the job with the most effective results. You should continue to use this manual as a reference source, adding information that you find useful. Refer to our Internet homepage addresses at http://www.qwik.com and http://www.epatest.com.

This manual is in a continual state of evolution and re-writing, partly because of changing EPA regulations and partly because of information feedback from technicians in the field. If you believe sections of this manual require improvement or that additional information should be added, please write to us and we will consider your suggestions for future editions. In the past, we have received very useful comments and suggestions from refrigeration technicians in the field, and to all those who have helped in the past, we owe a sincere debt of gratitude. Suggestions on the improvement of this course or any Mainstream product are always welcome. For suggestions related to this course, please write to Robert P. Scaringe, Ph.D., P.E., Refrigeration Certification Program, Mainstream Engineering Corporation, Pines Industrial Center, 200 Yellow Place, Rockledge, Florida 32955 or e-mail your comments to rps@mainstream-engr.com.

Phase-Out Schedule for HCFCs Including R-22

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Under the terms of the Montreal Protocol, the U.S. has agreed to meet certain obligations relating to the Phase-Out of HCFCs by specific dates.

January 1, 2004:

In accordance with the terms of the Montreal Protocol, the amount of all HCFCs that can be produced nationwide must be reduced by 35% by 2004. In order to achieve this goal, the U.S. ceased production of HCFC-141b, the most ozone-damaging of this class of chemicals, on January 1, 2003. This production ban will greatly reduce nationwide use of HCFCs as a group, and so the 2004 deadline had a minimal effect on R-22 supplies.

January 1, 2010:

After 2010, chemical manufacturers may still produce R-22 to service existing equipment, **but not for use in new equipment**. Air conditioning and heat pump manufacturers will only be able to use pre-existing supplies of R-22 to produce new air conditioners and heat pumps. These existing supplies would include R-22 recovered from existing equipment and recycled. It is likely that rather than depend on this very tentative supply of R-22 for new equipment, manufactures will instead utilize R-410A in all new units.

January 1, 2020:

Use of existing refrigerant, including refrigerant that has been recovered and recycled, will be allowed beyond 2020 to service existing systems, but chemical manufacturers will no longer be able to produce R-22 to service existing air conditioners and heat pumps.

Alternatives to R-22 in Residential Air Conditioning

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As R-22 is gradually phased out, non-ozone-depleting alternative refrigerants are being introduced. Under the Clean Air Act, EPA reviews alternatives to ozone-depleting substances like R-22 in order to evaluate their effects on human health and the environment. EPA has reviewed several of these alternatives to R-22 and has compiled a list of substitutes that the EPA has determined are acceptable. **However there are no drop-in replacements for any refrigerant**. Every substitute refrigerant requires some change in the system design.

One of the new substitutes is R-410A, a blend of hydrofluorocarbons (HFCs), substances that do not contribute to depletion of the ozone layer, but, like R-22, contribute to global warming. There are several reasons why R-410A is becoming the chosen replacement for R-22 in **new systems**. These reasons include.

- **Higher Capacity Equipment:** Equipment designed for HFC-410A has demonstrated up to 40% greater capacity when compared to current R-22 equipment.
- **Easy Servicing:** HFC-410A while a blend is a near azeotropic mixture, meaning it behaves almost like a pure refrigerant and therefore it can be repeatedly topped off.
- **Safe and Easy to Use:** HFC-410A has an A1 ASHRAE safety classification.
- **Higher Efficiency:** HFC-410A systems exhibit about a 10% increase in the Coefficient of Performance. That means that A/C and Heat Pump systems can be designed to meet the proposed DOE guidelines of 12 to 14 SEER.

Other possible refrigerants, which are on the list of acceptable substitutes, include R-134a and R-407C. Neither of these two refrigerants have the benefits of R-410A. An R-134a system will have a lower Coefficient of Performance and the system will be larger than a comparable R-410A system. R-407C while not as good a replacement as R-410A, is finding applications in R-22 retrofit applications, because the pressure is comparable with that of R-22 systems, thereby greatly simplifying the refrigerant change over. However is it not a drop-in replacement for R-22. While R-407C has a potential use in retrofit applications, after the necessary system changes have been made, R-410A can never be used in retrofit applications because of the higher pressures associated with R-410A. **You cannot charge existing R-22 systems with R-410A, because the R-22 components were never pressure rated for the higher pressure of an R-410A system**. Of course, the EPA will continue to review new non-ozone-depleting refrigerants as they are developed, but the industry appears to have agreed

on R-410A as the best refrigerant to replace R-22 for new high-efficiency air conditioning and heat pump applications.

Many Names for the Identical Compound

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R-410A is manufactured and sold under various trade names, including GENETRON® AZ-20®, SUVA® 410A, and Puron®. Suva® 410A is DuPont's registered trademark name for R-410A and Puron® is Carrier Corporation's registered trademark for R-410A. All these refrigerants are R-410A, they all have the same chemical composition (Table 1) and they all can be used interchangeably in servicing R-410A units. R-410B has a very similar vapor pressure curve and performance when compared to R-410A. While 410A and 410B are very similar thermodynamically, there is little, if any, R-410B being manufactured since there is no economic or technical justification for two practically identical refrigerants and the industry has chosen one of the two refrigerants, namely R-410A. The industry's choice of R-410A over R-410B is related to patent licensing and legal issues; it is not related to technical superiority of one of these refrigerants compared to the other.

Table 1. Percentage Composition of Substitutes for HCFC-22

Trade Name	ASHRAE Number	HFC-32	HFC-125	HFC-134a
KLEA® 407C, AC9000	407C	23%	25%	52%
AZ-20®, Puron®, Suva® 9100	410A	50%	50%	
AC9100	410B	45%	55%	

Refrigerant 410A

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Refrigerant 410A is a near azeotropic refrigerant, meaning that while it is a non-azeotrope refrigerant it exhibits a very low temperature glide during evaporation or condensation, making it behave very nearly like an azeotropic refrigerant. This means that while it is still best when charging to remove the R-410A as a liquid from the storage cylinder, there are no concerns about fractionation of the R-410A refrigerant should a leak occur. That means that a R-410A system can be topped-off without any concern about altering the composition of the blend. Typically, these are all items of concern when dealing with non-azeotropic refrigerants, but again R-410A behaves nearly like an azeotropic refrigerant.

Many manufacturers have already started building R-410A systems, and these systems operate at higher pressure. While most new tools, gauges, and recovery/recycling equipment are being fabricated to accommodate the higher pressure of R-410A, most of the older tools were never designed for the higher operating pressure of R-410A. Depending on the age of some of your tools, working with R-410A, may require new tools, recovery tanks, and recovery/recycling machines that are rated for R-410A's higher operating pressure. The high-pressure gauge on a service manifold set has a continuous scale, usually calibrated to read from 0 to 500 psig. This does not mean the gauge set is actually rated for use up to 500 psia. A typical rating on older gauge sets and/or hoses is only 340 psig. When using R-410A you must use a gauge set rated for at least 800 psig (with a 4,000 psig burst pressure on the manifold and the hoses). R-410A requires recovery tanks and recovery/recycling machines rated for at least 400 psig.

Table 2. Theoretical Air Conditioner Performance Comparison

Assuming 110°F Condenser, 45°F Evaporator, 5°F Subcooling, 15°F Superheat			
	R-22	R-407C	R-410A
Compression Ratio	2.66	2.83	2.62
Compressor Discharge Temperature	171°F	167°F	166°F
Compressor Discharge Pressure	226 psig	241 psig	364 psig
Temperature Glide	0°F	9°F	0°F

As can be seen from Table 2, the higher discharge pressure of the R-410 means that old line sets and recovery tanks, which where normally rated for 350 psig maximum operating pressures are inadequate for use with R-410A. Check your equipment to see if it has been designed for use with R-410A. Figure 1 displays a plot of the saturation pressure of various new refrigerants. R-22 has also been plotted on this graph to

provide a means of comparison. Table 6 contains a more detailed table of the Saturation Pressure-Temperature behavior of R-410A.

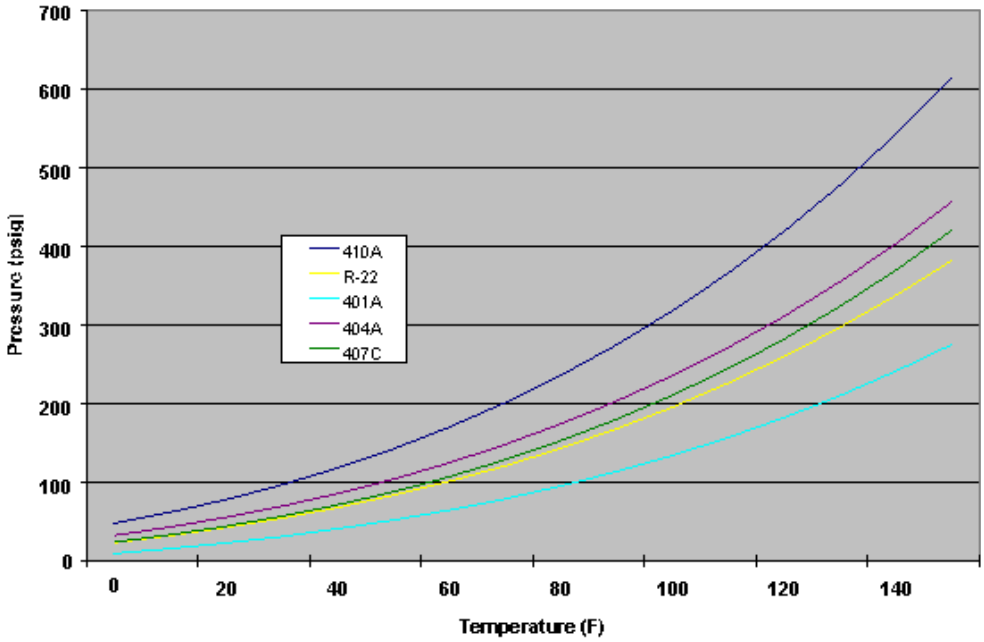

Figure 1. Comparison of the Saturation Pressure of Common 400 Series Blends

Servicing Existing Units

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Existing units using R-22 can continue to be serviced with R-22. There is no EPA requirement to change or convert R-22 units for use with a non-ozone-depleting substitute refrigerant. In addition, the new substitute refrigerants cannot be used without making some changes to system components. As a result, service technicians who repair leaks to the system will probably continue to charge R-22 into the system as part of the repair.

R-410A be not be used to retrofit existing R-22 equipment because of the much higher discharge pressure and cooling capacity. R-410A can **ONLY** be used in equipment designed specifically for R-410A.

R-22 systems can be retrofitted for R-407C, and since the saturation pressures are similar, many of the components of the R-22 system can be used in the R-407C system. However, R-407C is **not a direct drop in replacement**. Since R-22 can still be used, and because there are no current or future proposed requirements to force the conversion of R-22 systems, there is no incentive to convert existing R-22 systems to R-407C. As a practical matter, there are very few R-407C conversions.

Installing New Units

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The transition away from ozone-depleting R-22 to systems that rely on replacement refrigerants like R-410A has required redesign of heat pump and air conditioning systems. New systems incorporate compressors and other components specifically designed for use with specific replacement refrigerants. Because of the higher pressure for R-410A, most system components have been designed with increased wall thickness. In addition, expansion valves and filter-driers specifically designed for R-410A **must be used**.

Disposable Refrigerant Cylinders

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New virgin refrigerant for use by air conditioning and refrigeration service personnel are usually packaged in disposable containers. Disposables are manufactured in three sizes: 15-, 30-, and 50-pound capacities and should never be refilled. **New disposable containers use a check valve and cannot be refilled.** Refrigerant manufacturers voluntarily color code cylinders for their products. Table 3 lists the color-coding for common refrigerant blends; however, the shade of color may vary somewhat among manufacturers.

Table 3. Tank Color Coding for Common 400 Series Blends

400 Series Blend	Color
R-401A	light purple
R-401B	yellow-brown
R-401C	blue-green
R-402A	light green-brown
R-402B	green-brown
R-404A	orange
R-407C	medium brown
R-410A	Pink

DOT 39 (DAC) cylinders which are used for CFCs, HCFCs, and most HFCs are manufactured to handle the highest-pressure refrigerant, CFC-502; however, they cannot be used for R-410A. **DOT 39 (400) cylinders are designed to handle R-410A**.. The DOT requires that disposable cylinders for R-410A be rated for a service pressure of 400 psig. **Cylinders rated for R-410A must be rated for a service pressure of 400 psig**. The R-410A cylinders are leak tested at 500 psig. Also, per DOT Specification 39, one cylinder per thousand is pressurized to the point of failure and this cylinder must not rupture below 1000 psig for the R-410A cylinders. These tests are intended to assure that users receive safe, high-pressure and leak-free containers. A comparison of the disposable cylinder design details for R-410A cylinders and R-22 cylinders is presented in Table 4.

Every cylinder is equipped with a safety-relief device that will vent pressure from the cylinder before it reaches the rupture point. Two versions are approved for DOT 39 refrigerant cylinders. The most common is a rupture disk, typically welded to the cylinder shoulder. Should R-410A cylinder pressure exceed the safety-relief pressure (minimum pressure is 525 psig for R-410A), the disk will burst and the cylinder content will vent and prevent an explosion. The second design is a spring-loaded relief port integrated in the valve stem. When the internal pressure on this design exceeds the relief pressure, the pressure forces the spring to open and the contents are vented through the relief port.

Cylinders can become over-pressurized for several reasons. However, the primary cause is overfilling. When temperatures increase, the liquid refrigerant expands into the vapor space above the liquid causing pressure to rise gradually as long as a vapor space is available for expansion. However, if no vapor space is available due to an overfilled cylinder (and no pressure-relief valve exists), the liquid will continue to expand and the cylinder will rupture to provide room for the expanding liquid. When a cylinder ruptures, the pressure drop causes the liquid refrigerant to flash into vapor and sustains the explosive behavior of the rupture until all the liquid is vaporized. **The rupture of a refrigerant cylinder containing liquid refrigerant that flashes into vapor is far worse than the rupture of a compressed-air cylinder under the same pressure.**

If a refrigerant cylinder reaches a full-of-liquid (no vapor space) condition, the internal pressure rises very rapidly under minor increases in temperature. If the safety valve is not able to vent this rapid increase in pressure, the cylinder will explode. Safety valves are very important. Never tamper with a cylinder safety device.

Cylinders can be over-pressurized if they are connected to the discharge side of a refrigeration, air conditioning, or recovery system. In such a case, the compressor can create a pressure and flow that is greater than the flow capacity of the relief device on the cylinder, thereby defeating the purpose of the relief valves and possibly resulting in cylinder rupture.

Disposable cylinders should be emptied of all contents using a refrigerant recovery device. Once emptied, the cylinder's valve should be opened to allow air to enter, and the cylinder should be punctured with the valve still open (rendered useless). Used cylinders can be recycled with other scrap metal. Never leave used cylinders with any residual refrigerant, either outdoors or at a job site. **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. Never refill a disposable cylinder.

Table 4. Disposable Cylinder Design Details

Cylinder Type:	R-410A	R-22
Service Pressure	400 psig	260 psig
Test Pressure	500 psig	325 psig
Burst Pressure	1000 psig	650 psig
Minimum Rupture-Disk Relief Pressure	525 psig	340 psig
Maximum Rupture-Disk Relief Pressure	800 psig	520 psig

WARNING:

Hot-weather recovery operations can result in very high storage-tank pressures and therefore disposable cylinders should never be refilled or used as a recovery tank. Rust, dents, and other damage can significantly reduce the burst pressure of disposable cylinders.

WARNING:

Transportation of refilled DOT 39 cylinders is illegal and subject to a penalty of a fine up to $25,000 and five years' imprisonment. The use of a refilled DOT 39 cylinder also violates OSHA workplace regulations and may violate state laws.

Refillable Cylinders

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Special R-410A refillable cylinders, also referred to as "recovery cylinders" or "recovery tanks", are available for the transportation of R-410A used in the air conditioning and refrigeration. These refillable cylinders are also regulated in their design, fabrication, and testing by the DOT for use in transportation of R-410A.

Recovery cylinders are painted yellow in the shoulder area and 12 inches down the side; the manufacturer paints the remainder of the cylinder body gray. We recommend that a pink color stripe (in accordance with the color-coding convention for new refrigerant cylinders) and the words "Contains R-410A" be painted on the tank in order to indicate the type of recovered refrigerant being stored in the tank and also to minimize the potential for accidental refrigerant mixing. If R-410A is mixed with R-22 (or any other refrigerant) it may be impossible to reclaim. Refrigerants should never be mixed. For refrigeration technicians using recycling machines, we further suggest that a "CLEAN" recovery tank be used for recycled refrigerant and a "DIRTY" recovery tank be used for recovered but not recycled refrigerant. Marking the recovery tanks as "CLEAN" and "DIRTY" will help avoid contamination of otherwise clean refrigerant by putting it into a recovery tank that once held dirty refrigerant.

R-410A refillable cylinders satisfy the DOT requirements of either 4BA400 or 4BW400 specifications (rated for 400 psig). The 4BA cylinder is comprised of two deep-drawn, carbon-steel heads welded together with one girth seam; the 4BW cylinder is comprised of two separate heads on opposite ends of a center cylindrical section.

The 4BA cylinders are generally sized for refrigerant capacities of 50 lbs. or less, with the most widely used sizes being 15 lbs., 30 lbs., 37 lbs., and 50 lbs., respectively. The R-410A cylinders **must be rated for at least 400 psig**. However, not every recovery tank is rated for 400 psig! Be careful, and read the nameplate, only use recovery tanks rated for use with R-410A. The pressure rating should be indicated on all pressure vessels. If not contact the specific cylinder manufacturer to verify capacity, suitability for R-410A and the design operating pressure.

WARNING:

According to the American Society of Mechanical Engineers Pressure Vessel Code, the pressure rating must be 285 psig or higher for R-407C, and 400 psig or higher for R-410A. Do not use any storage or recovery tank with a maximum pressure rating less than 400 psig for R-410A. Recovery tanks for R-410A should be specified as DOT 4BA400 or 4BW400.

Evacuation Requirements for R-410A

(Except small appliances)

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Recovery or recycling equipment must be certified for R-410A use by an EPA-approved equipment testing organization. Use Table 5 below to determine the required level of evacuation.

Table 5. Required Levels of Evacuation for High-Pressure Appliances

Except for Small Appliances, Motor-Vehicle AC, and Motor-Vehicle-Like Appliances
(Revised by the EPA March 12, 2004)

Type of Appliance	Inches of Vacuum that Recovery or Recycling Equipment Must Achieve[a]	
	If Recovery Device Manufactured Before 11/15/93	If Recovery Device Manufactured on or After 11/15/93
High-Pressure (formerly Higher-Pressure)[b] Appliance normally containing less than 200 pounds of refrigerant (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)	0.0	0.0
High-Pressure (formerly Higher-Pressure)[b] Appliance normally containing 200 pounds or more of refrigerant (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)	4.0	10.0

[a] Relative to standard atmospheric pressure of 29.9" Hg.
[b] Or isolated component of such an appliance.

Evacuation Requirements for Small Appliances using R-410A

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When using recycling and recovery equipment manufactured on or after November 15, 1993, 90% of the refrigerant from the small appliance must be recovered if the compressor on the appliance is operational, and 80% of the refrigerant must be recovered if the compressor is not operational. When using recycling and recovery equipment manufactured before November 15, 1993, 80% of the refrigerant from the small appliance must be recovered.

Storage Requirements

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The storage requirements for R-410A are the same as R-22 and other refrigerants and include the requirement to:

- Store in a clean dry area out of direct sunlight
- Never heat cylinder above 125°F (52°C), or allow refrigerant cylinders to be stored in an area that will exceed this temperature
- Keep the valves tightly closed.
- Keep the valve caps and hoods in place when the cylinder is not in use.
- Always label and secure the cylinders.

Safety Precautions

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1. Always wear protective goggles when working with refrigerant. If liquid refrigerant gets in your eye, permanent blindness may result.

2. Do not allow refrigerant to come in contact with your skin. Refrigerant has a very low boiling point, which will cause frostbite.

3. All refrigerant handling, charging, and recycling operations should be performed in locations with adequate ventilation of at least four air changes per hour. Avoid prolonged breathing of the vapor. Prolonged inhalation of refrigerant is extremely dangerous; death can occur without warning.

4. Do not use a recovery unit in the vicinity of spilled or open containers of gasoline, thinners, or any other flammable liquid or vapor unless the equipment is expressly designed (explosion proof designs) for such environments. Do not operate where flammable vapor is present.

5. Do not leave any recovery or recycling machine on and unsupervised.

6. Do not attempt to fill any vessels, containers, cylinders, charging equipment, or storage tanks that are not DOT-approved and equipped with a safety-vent valve. Do not transfer refrigerant to non-refillable cylinders.

7. Do not fill any storage tank or vessel with refrigerant beyond 80% of its capacity.

8. Do not disconnect or tamper with the electrical high-pressure, low-pressure, or liquid-level safety shut-off.

Additional Safe Handling Practices for R-410A

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The pressure of R-410A is significantly higher than R-22. This does not mean that R-410A, or equipment containing R-410A is unsafe, but it does mean you need tools and equipment that were designed for this higher pressure. You must use AC equipment; cylinders and service tools have been re-engineered to handle the higher pressure.

When servicing R-410A equipment make sure you use reversing valves, expansion valves, filter-driers, and other components specifically designed for R-410A.

Cylinders used for new R-410A, as well as recovered R-410A have both been redesigned for the higher pressure.

Service equipment must also be designed for R-410A:

- High-pressure manifold gauge and hose sets (must have 4000 psi burst pressure and 800 psi working pressure).
- High-pressure recovery machine certified for use with R-410A.
- High-pressure recovery tanks, such as DOT 4BA400 or 4BW400.

Frequently Asked Questions

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What is Puron®?

Both Puron® and Suva® 410A are marketing brands for ASHRAE R-410A refrigerant. Puron® is Carrier Corporation's brand name and Suva® 410A is the DuPont brand for R-410A. Both have the same chemical composition and can be used interchangeably.

Can R-410A be used to retrofit existing R-22 equipment?

NO! Because of the much higher discharge pressure and cooling capacity, R-410A should ONLY be used in equipment designed specifically for R-410A.

Do I need different service tools to work on R-410A systems?

Yes. Because of the higher pressure, you should use manifold gauge sets designed for R-410A. In addition, you should use a recovery machine and recovery tanks designed for the higher pressure of R-410A. Recovery tanks should be specified as DOT 4BA400 or 4BW400.

What type lubricant should be used with R-410A?

A high-quality POE (polyolester) specified by the compressor or system OEM.

Since R-410A is a high-pressure refrigerant, can I store it in the back of my service van like I did with R-22?

Yes, as long as the temperature does not exceed 125F. **This is the same guidance given for R-22 and other common refrigerants.** However, you must realize that on a hot sunny day, the temperature inside a closed van or truck can exceed 125°F, so if you are storing any refrigerants in your vehicle, don't let the temperature get to 125°F.

Is R-410A a blend refrigerant?

Yes. It is a blend of HFC-32 and HFC-125 (50/50 wt%) that performs very much like a single component refrigerant.

Is PURON® is different than R-410A?

R-410A is the same refrigerant whether it is called Puron®, Suva 410A, Genetron® AZ20®, Forane 410A or Klea® 66. Puron® is Carrier's brand name for R-410A.

Is R-410A is more toxic than R-22?

The safety and toxicity characteristics of R-410A have been thoroughly studied by reputable companies and organizations around the world. They have concluded that R-410A can be handled safely when the proper protective equipment is used and when appropriate safety guidelines are followed. These safety practices are very similar to the practices that have been used with R-22 and other HFC and HCFC refrigerants. The physical and chemical properties of R-410A are very similar to those for R-22 as well as most of today's HFC refrigerants. The major difference is the higher pressure. Since certain concentrations of R-410A with air can become combustible, never mix R-410A with air or oxygen for either leak testing or pressurizing a system. Nitrogen should be used for leak testing or pressurizing a system, and if a refrigerant trace gas is necessary only a nitrogen/R-22 trace gas can be vented after use. As with any refrigerant, another safety concern is the exposure to the evaporating liquid.

Is R-410A more dangerous because of its higher pressures?

The pressure of R-410A is significantly higher than R-22. This does not mean that R-410A, or equipment containing R-410A is unsafe. It does mean that technicians must use AC equipment; cylinders and service tools have been re-engineered to handle these higher pressures.

Are you required to have a license or to be certified to handle and purchase R-410A?

You are required to have an EPA Section 608 Type II or Universal certification license.

Should I charge R-410A as a liquid or vapor into a system?

Even though R-410A performs very similar to a single component refrigerant, it should be removed from the cylinder as a liquid to insure optimum and consistent performance.

If you have a leak from an R-410A system, does the entire charge have to be replaced, or can the system be topped off?

Since R-410A acts very much like a single component refrigerant, any change in composition due to a leak is minimal. The system can be topped off, without removing the entire charge. There is no practical limit to the number of times a unit can be topped-off or the refrigerant recovered from a unit. However, we do recommend that all leaks be repaired before topping a system off. Excessive superheat is an indication of low charge, and the possibility of a leak in the system should be considered.

Can R-410A be used to retrofit existing R-22 equipment?

There has been some confusion around this issue. Retrofit normally refers to the process of replacing the refrigerant in an existing piece of equipment with some equipment changes. The magnitude of the changes depends on the refrigerant as well as the equipment design. **Existing R-22 systems are not designed to handle the much higher cooling capacity and discharge pressure of R-410A**. To retrofit an existing R-22 system, nearly all of the components would need to be replaced. This is very labor intensive and costly and would not be justified economically. R-22 can still be used, and there is no current, future, or proposed EPA requirement to force the conversion of R-22 systems, so there is no incentive to convert existing R-22 systems.

Why are so many of the new refrigerants "blends"?

Manufacturers combine refrigerant components into blends to develop cost-effective alternatives that match CFC performance and properties. Blends are not new; R-502 is a blend of 22/115 developed in the 1950s to improve on R-22's low-temperature performance. Blends have 400 or 500 series ASHRAE numbers, e.g., 401A, 404A, 409A, 507. When a refrigerant mixture exhibits a distinct boiling point (e.g. it behaves as a single "new" refrigerant), it is designated as an azeotropic blend and is given a 500 series ASHRAE designation. When the refrigerant mixture has a boiling range it is referred to as a non-azeotropic or zeotropic refrigerant and is given a 400 series ASHRAE designation. R-410A is a "near-azeotropic" refrigerant since it behaves almost like a 500 series azeotropic blend with almost no difference between the saturated vapor and saturated liquid pressures at the same temperature (see Table 6)- This means it can be topped-off like a pure refrigerant or 500 series refrigerant. However, it is recommended that it be removed from the cylinder as a liquid during system charging.

Review Topics

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- Oils that will be used with most HFC-410A air conditioning applications are ester-based synthetic (POE) oils.
- If you use a recovery machine that is certified for R-410A as well as being certified for either HCFC or CFC or refrigerants, special precautions must be taken to avoid contamination of the synthetic POE oil (used with HFC-410A) with the mineral oil used with the HCFC and CFC refrigerants. It is recommended that a set of hoses, gauges, vacuum pump, recovery machine, and oil containers be dedicated for HFCs only. (It is an EPA regulation that any person who opens an appliance for maintenance, service or repair must have at least one self-contained recovery machine available at their place of business. The only exception to this rule are persons working on small appliances.)
- R-410A requires recovery tanks and recovery/recycling machines rated for at least 400 psig. The R-410A high-pressure manifold gauge and hose set must have a 4000 psig burst pressure and 800 psig working pressure.
- The high pressure gauge on a service manifold set has a continuous scale, usually calibrated to read from 0 to 500 psig. This does not mean the gauge set is actually rated for use up to 500 psia. A typical rating on older gauge sets and/or hoses is only 340 psig. When using R-410A you must use a gauge set rated for at least 800 psig (with a 4,000 psig burst pressure on the manifold and the hoses).
- Technicians receiving a passing grade on the Type II (medium-pressure, high-pressure and very high pressure) examination are certified to recover refrigerant during the maintenance, service, or repair of medium, high and very high-pressure equipment (Medium-Pressure CFC-12, CFC-114, HFC-134a, CFC-500, High-Pressure HFC-410A, HCFC-22, CFC-502, Very-High Pressure CFC-13, CFC-503, as well as the other 400 Series Replacement Blends). Only Type II or Universal certified technicians can recover refrigerant from these units.
- The proper charging method for blended (non-azeotropic) refrigerants (400 Series) is to use a remove the charge from the cylinder as a liquid. Typical blended refrigerants will leak from a system in uneven amounts due to different vapor pressures of the components, and therefore they should not be topped off. However, while R-410A is a blend (thus the 400 series designation), it behaves as a near azeotropic refrigerant, and can be topped off, unlike other 400 series refrigerants.
- Never heat a refrigerant storage or recovery tank with an open flame because: it can result in venting refrigerant to the atmosphere; the tank may explode, causing serious injury to people nearby; and the refrigerant in the tank may decompose, forming a toxic material.
- Only mixtures of nitrogen and R-22 can be used as a leak-test gas (trace gas) in an R-410A system. The R-22-nitrogen leak test gas is not subject to the prohibition on venting because in these cases, the ozone-depleting compound is

not used as a refrigerant. Before nitrogen can be added to a R-410A system, the system MUST be evacuated to 0.0 psig. Otherwise, the R-410A-nitrogen-R-22 mixture will be considered a refrigerant, and its release will be a violation of EPA regulations and subject to fine.

- Never use oxygen or compressed air to leak-check hardware because R-410A, when mixed with air or oxygen, can explode.
- After reaching the required recovery vacuum on a system, turn off the recovery device (isolate the system) and wait for a few minutes to see if the system pressure rises, indicating that there is either refrigerant in liquid form, refrigerant trapped in the oil, or a leak in the system.
- Whenever possible to avoid unnecessary venting of refrigerant, systems should be leak checked with pressurized nitrogen before charging.
- The best leak-checking procedure is a standing pressure test using a pressure source that will not change an appreciable amount with temperature changes. Nitrogen is a good gas to use (it will not harm the environment and does not support combustion or oxidation, as does air or oxygen). Never use air or oxygen.
- A vacuum test is **not** the best method of leak testing a system because it allows air, and thus moisture, to enter the system, and the technician cannot determine from the vacuum where the leak is located, only that there is a leak. Also, when a vacuum is used to test for leaks, it only proves that the system will not leak under a pressure difference of 14.7 psi. (When all of the atmosphere is removed from a system, only the atmosphere's pressure is trying to get back into the system, therefore a 14.7 psi pressure difference.) When checking for a leak using a vacuum, the technician is using a reverse pressure (the atmosphere trying to get into the system) of only 14.7 psi; however, under normal operating conditions, the system may be operating under an operating pressure of several hundred psig, that is, 10 to 20 times the vacuum pressure difference. In addition, using a vacuum for leak checking may hide a leak. For example, if a pin-sized hole is in a solder connection that has a flux buildup on it, the vacuum will tend to pull the flux into the pinhole and may even hide it to the point that a deep vacuum can be achieved, but when pressure is applied to the system, the flux will blow out of the pinhole, and a leak will exist.

Table 6. Saturation Data for R-410A

Temperature (°F)	Liquid Pressure (psig)	Vapor Phase Pressure (psig)
-50	5	5
-48	6	6
-46	7	7
-44	8	8
-42	9	9
-40	11	11

-38	12	12
-36	13	13
-34	15	15
-32	16	16
-30	18	18
-28	19	19
-26	21	21
-24	23	23
-22	25	24
-20	26	26
-18	28	28
-16	30	30
-14	32	32
-12	34	34
-10	36	36
-8	39	39
-6	41	41
-4	43	43
-2	46	46
0	48	48
2	51	51
4	54	54
6	57	56
8	59	59
10	62	62
12	65	65
14	69	68
16	72	72
18	75	75
20	79	78
22	82	82
24	86	86
26	90	89
28	93	93
30	97	97
32	101	101
34	106	105
36	110	109
38	114	114
40	119	118
42	123	123
44	128	128
46	133	133
48	138	138
50	143	143

52	148	148
54	154	153
56	159	159
58	165	164
60	171	170
62	177	176
64	183	182
66	189	188
68	195	195
70	202	201
72	208	208
74	215	214
76	222	221
78	229	229
80	237	236
82	244	243
84	252	251
86	259	258
88	267	266
90	275	274
92	284	283
94	292	291
96	301	300
98	310	309
100	319	318
102	328	327
104	337	336
106	347	346
108	356	355
110	366	365
112	377	376
114	387	386
116	398	396
118	408	407
120	419	418
122	431	430
124	442	441
126	454	453
128	466	465
130	478	477
132	490	489
134	503	502
136	516	515
138	529	528
140	543	541

142	556	555
144	570	569
146	584	583
148	599	598
150	614	613
152	629	628
154	645	644
156	660	660
158	676	676
160	693	693

Instructions for the R-410A Certification Exam

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This exam consists of 25 Questions. You can use this manual or any other notes or papers during the exam; however, you cannot get assistance from any other person during the exam. You will be required to pledge that you received no help from any other person in completing the exam. False statements may subject you to civil and criminal penalties. This manual contains all the information needed to correctly answer the R-410A Exam Questions. You must get a minimum of 21 of 25 questions correct to pass this open book exam.

To obtain your R-410A refrigeration technician certification, you must:

1) Correctly answer 21 of the 25 questions in both sections, (84% passing), without any help from any other person.

2) Complete the Self-Certification Statement, where you pledge that you received no help from anyone in completing the test.

3) Your exam will be automatically graded; however, you will not be certified until you contact Mainstream Engineering and provide us your exam code and personal information.

If you fail the exam, you can continue to study the manual and take the practice exam. When you are confident you have addressed your weakness, you can re-take the exam. You can take the exam as often as necessary (the test changes each time you take the exam).