Now with R-1234yf

Refrigerant Recovery and Recycling

REVIEW AND QUIZ

EPA-Approved Section 609 Program
for Motor Vehicle Air Conditioning (MVAC) Service

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President, ASE

The Next Generation of Air Conditioning Service

We've come a long way since the discovery of the infamous ozone hole over Antarctica. Due in part to your valiant efforts as a service technician, NASA now forecasts that the ozone layer will likely return to its early 1980s status around 2065. It's a big step in the right direction.

Unfortunately, all this progress comes with a side-effect. With roughly two decades of R-134a serving as R-12's successor, we've learned that R-134a poses its own threat as a greenhouse gas. With environmental emphasis now changing, we're at the forefront of another refrigerant transition.

Initially, it appeared that R-1234yf would become the refrigerant heir-apparent to R-134a, due to R-1234yf's low global warming potential (GWP). Then, other alternatives appeared on the refrigerant landscape such as R-744 (CO_2) and R-152a, along with regulatory initiatives from both the U.S. and the European Union. This global combination of regulations, along with continued research on alternative refrigerants, presents the possibility of multiple alternatives to R-134a when all is said and done.

Refrigerants aside, air conditioning systems themselves are going through an unprecedented transformation. What was once a simple creature comfort for upscale motorists, air conditioning systems of today are true thermal management systems, providing not only occupant comfort, but also providing essential cooling to battery packs and onboard computers in hybrid vehicles. It's also possible that other A/C system designs may enter the marketplace, such as secondary-loop systems, so stay on top of the latest developments.

All this uncertainty has also created the perfect breeding ground for counterfeit refrigerants. Rogue refrigerant blends have surfaced in the industry, often convincingly packaged as pirated versions of those from reliable brands and suppliers. Be vigilant with all refrigerants that enter your shop by using a refrigerant identifier. It's your best defense. See the information in this training material for details on refrigerant identification.

The world of alternative refrigerants is changing rapidly, so it's wise to keep a close eye on industry journals for news of other alternatives that may be listed as acceptable, under certain use conditions, by the EPA under its Significant New Alternatives Policy (SNAP). Also, be sure to check state and local regulations as they may differ from federal requirements.

Make a commitment to yourself and your customers to stay informed on any news affecting the world of air conditioning service. Just drop by the ASE website at www.ase.com for major developments. You can access information from the EPA on motor vehicle air conditioning on the web at http://www.epa.gov/mvac.

Thanks for being part of the next generation of air conditioning service.

Timothy A. Zilke
President, ASE

Terms and Acronyms Used In This Training Material

Class I Substance	Ozone-depleting chemical with an ozone-depletion potential greater than 0.2 (i.e. CFCs)
Class II Substance	Ozone-depleting chemical with an ozone-depletion potential less than 0.2 (i.e. HCFCs)
CFCs	Chlorofluorocarbons such as CFC-12 (R-12)
HCFCs	Hydrochlorofluorocarbons such as HCFC-22 (R-22)
HFCs	Hydrofluorocarbons such as HFC-134a (R-134a)
HFOs	Hydrofluoroolefins such as HFO-1234yf (R-1234yf)
MVAC	Motor Vehicle Air Conditioning
MVAC-like appliance	A system used on a vehicle substantially identical to an MVAC. This type of system uses a mechanical vapor compression, open-drive compressor to cool the driver's or passenger's compartment of a non-road vehicle, including agricultural and construction vehicles.
ODS	Ozone-depleting substance

Note: The ASE Refrigerant Recovery and Recycling Review and Quiz is an EPA-approved program that meets Section 609 regulations as set forth in Section 609 of the Clean Air Act Amendments of 1990. This program is intended only for technicians servicing MVACs and MVAC-like appliances. Under no circumstances should this program be considered as acceptable for Section 608 compliance, a separate requirement that applies to the servicing of stationary refrigeration and air conditioning systems, such as those used in commercial and residential applications. Furthermore, some state and local jurisdictions have adopted their own requirements for credentials, so check with your state and local authorities for details. Certification earned as a result of a passing score on the enclosed quiz is only deemed as certification in the context of the U.S. EPA. This credential is not the equivalent of technical certification from the main ASE testing and certification program. For more information, refer to the ASE website at www.ase.com or call ASE Customer Service at 1-800-390-6789 from 8 a.m. to 5 p.m. Eastern Time Monday through Friday.

This 2017 version of the ASE Refrigerant Recovery and Recycling Review and Quiz supersedes all previous versions of the program.

Refrigerants and Their Impact on Health and the Environment

R-12 – From Miracle to Menace

When CFC-12, or R-12 (also referred to by its brand name, Freon) made its debut in 1930, the industry hailed it as a miracle chemical. It was non-poisonous, easy and cheap to manufacture, and stable. The first in a family of chlorofluorocarbons (CFCs) yet to come, R-12's stability and low cost made air conditioning the creature comfort of the 20th century.

Unfortunately, scientists believe that CFCs like R-12, have contributed to depletion of the earth's protective ozone layer located in the stratosphere. Located about 10 to 30 miles above the earth's surface, this precious layer filters out most of the sun's harmful ultraviolet radiation. While ozone is bad near the earth's surface, in the stratosphere it's essential to our survival. The ozone layer acts as a sunscreen, protecting humans, plants and animals from the harmful effects of excessive ultraviolet radiation.

The stability of CFCs, the quality which proved so beneficial to mankind, also makes them a threat to the ozone layer. Once CFCs are released into the atmosphere, they travel high into the stratosphere where they can linger for a hundred years or more. CFCs destroy the ozone in the stratosphere through chemical reaction. Scientific concern about the ozone layer escalated during the 1970s, but it wasn't until 1985 that scientists confirmed their suspicions with solid data. This was when the infamous ozone hole over Antarctica first appeared, prompting international agreement for action on ozone-depleting chemicals. This formal agreement became known as the Montreal Protocol and was signed in 1987.

Ozone is a chemical compound consisting of three oxygen atoms in each molecule. Ozone molecules are similar to oxygen molecules because they contain oxygen atoms. However, the oxygen molecules that sustain our lives contain two oxygen atoms (O_2), whereas the ozone molecules that poison the atmosphere contain three oxygen atoms (O_3). Under the influence of sunlight, a chlorine atom is released from a CFC molecule and reacts with one of the oxygen atoms in the ozone to produce chlorine monoxide and free oxygen. Neither of these can filter out the sun's ultraviolet radiation the way ozone can. For each one percent of ozone reduction, 1-1/2 to 2 percent more UV radiation reaches the surface of the earth.

The EPA mandated the phase-out of R-12 because of its ozone-depleting characteristics. By the 1994 model year, manufacturers had completed their transition away from R-12 and to its successor HFC-134a, commonly known as R-134a. Nonetheless, CFCs like R-12 pose a lingering threat to the ozone layer due to their long atmospheric lifespan. The good news is that the unified efforts to ban CFCs have paid off. NASA estimates that the ozone layer will likely return to its early 1980s state around 2065.

Risks and Effects of Excess UV Radiation

The EPA assessed and detailed some of the key risks associated with excess UV radiation. These include increased reports of skin cancer, negative effects on the body's immune system, an increase in the number of eye cataracts, damage to vegetation, adverse effects on sea life, and an increase in ground-level ozone (a contributor to higher smog levels).

Research indicates that vegetation, particularly crops, can also be adversely affected by increased UV radiation. Combined with a bad growing season such as a drought, severe crop reductions could have a devastating effect on the world's food and bio-fuels supply.

In the sea, plankton (floating or weakly swimming animal and plant life) and some species' larvae may be killed off or reduced by increased UV radiation. Plankton and larvae are near the bottom of the food chain and many other marine animals feed on these life forms. Loss of these food sources could have an impact on the food chain, all the way up to humans.

From Ozone Depletion to Global Warming

The transition from R-12 to R-134a by the 1994 model year was driven by the fact that the chlorine contained in R-12 depleted the earth's stratospheric ozone layer. R-134a, while not ozone depleting, is classified as a Greenhouse Gas (GHG). The gases in this category are believed to be a potential cause of climate change and are assigned a Global Warming Potential (GWP) factor based on the level of impact they may have. The lower the GWP rating of a particular refrigerant, the less it impacts climate change. R-134a carries a GWP rating of 1430 and this relatively high GWP rating encouraged engineers to explore alternative systems and refrigerants. Several alternatives to R-134a have been proposed with lower GWPs that may serve as next-generation refrigerants. Although vehicle manufacturers prefer a single refrigerant that meets environmental regulations around the globe, it's possible that different refrigerants may be used depending on make, model, manufacturer and country of origin.

Three refrigerants represent possible alternatives to R-134a, and have been accepted by the EPA under its SNAP (Significant New Alternatives Policy) program for use only in new systems, subject to the use conditions specified for each. Please see the chart on Page 12 of acceptable alternatives for a complete listing of refrigerants.

R-1234yf carries a GWP rating of 4 and shows great promise as an alternative to R-134a for a couple of reasons. First, R-1234yf's pressure/temperature relationship closely resembles that of R-134a. This may reduce manufacturing conversion costs, because key system components need less redesign. Second, although R-1234y has a higher GWP than its closest rivals, it takes less fuel to power an MVAC system charged with R-1234yf. The end result is less CO_2 emitted from the engine. R-1234yf does possess mild flammability traits, which can be offset through proper system design and service. The EPA lists R-1234yf as an acceptable alternative refrigerant, provided that it's used only in new A/C systems according to specific criteria, along with dedicated fittings and labeling. R-1234yf is not to be used for retrofitting systems that were originally filled with another refrigerant.

Environmental Impact of MVAC Refrigerants

Refrigerant	Global Warming Potential	Ozone Depleting?
R-12 (CFC-12)	10,900	Yes
R-134a (HFC-134a)	1,430	No
R-152a	124	No
R-1234yf (HFO-1234yf)	4	No
R-744 (CO_2)	1	No

Global warming potential values are from the IPCC Fourth Assessment Report: Climate Change 2007 (AR4)

R-152a has a GWP of 124, roughly 90% lower than R-134a and has been used for some time in various manufacturing processes. The advantages of R-152a include a proven history of performance, low cost, and a pressure/temperature relationship similar to R-134a. On the downside, R-152a has flammability traits that surpass R-1234yf. EPA lists R-152a as an acceptable alternative refrigerant, provided that it's used only in new A/C systems according to specific criteria, along with dedicated fittings and labeling.

R-744 (Carbon Dioxide, or CO_2) has a GWP of 1, which is the lowest direct GWP rating of any available refrigerant, and serves as the baseline for the GWP rating system. R-744 was used in some of the earliest refrigeration systems, so its performance characteristics are well understood. The advantages of R-744 MVAC systems include using a naturally occurring refrigerant with the lowest GWP rating. This will require different service procedures, as R-744 systems operate at much higher pressures than other alternatives. Although R-744 does not have flammable characteristics, it does displace oxygen. This presents a potential suffocation risk to vehicle passengers that must be addressed for vehicles using this refrigerant. German auto manufacturers favor R-744 systems, but it's unclear whether vehicles with these systems will appear in the U.S. marketplace. EPA classifies R-744 as an acceptable alternative refrigerant, provided that it's used only in new A/C systems according to specific criteria, along with dedicated fittings and labeling. R-744 is not to be used for retrofitting systems using a different refrigerant.

EPA Regulations

Section 609 of the Clean Air Act Amendments of 1990

The most important parts of the amendments to Section 609 of the Federal Clean Air Act have to do with servicing MVAC systems. These regulations are detailed in 40 CFR Part 82: Protection of Stratospheric Ozone. In Subpart B, Servicing of Motor Vehicle Air Conditioners, specific sections lay the groundwork for responsible refrigerant management practices during system service.

Section 82.34–Prohibitions and required practices

This section requires that anyone repairing or servicing MVAC systems for hire must be properly trained and certified by an EPA-approved organization and the equipment used must also be EPA-approved. Also, this section prohibits the sale of Class I refrigerants in containers smaller than 20 pounds to anyone other than trained and certified personnel. Restrictions and requirements on refrigerant removed prior to motor vehicle disposal are also covered. Finally, refrigerant handling equipment can't be sold unless it meets specific requirements.

Section 82.36–Approved refrigerant handling equipment

In this section, the EPA incorporates numerous standards from the Society of Automotive Engineers (SAE) that apply to the recovery and recycling of refrigerant. Standards that apply specifically to R-12 refrigerant include J1989, J1990, J1991 and J2209.

Similar standards also apply to the recovery and recycling of R-134a refrigerant. These include J2099, J2197, J2210, J2211 and J2788. SAE standard J2788 supersedes the older J2210 standard. J2788 only applies to refrigerant handling equipment manufactured or imported after December 31, 2007.

SAE standards J1990 (for R-12) and J2788 (for R-134a) and J2843 (for R-1234yf) establish requirements for recovery and recycling equipment. This includes hardware-related items, compliance with related SAE standards, and performance criteria.

Refrigerant recovery and recycling equipment for R-1234yf must meet SAE standard J2843. This machine's label demonstrates compliance not only with J2843, but also SAE J2927 which applies to the machine's internal refrigerant identifier.

The EPA requires refrigerant recovery/recycling equipment to be tested by an approved independent standards testing organization. Among other things, these tests confirm that the equipment meets the specifications in the applicable SAE standard.

SAE purity standards for R-12, R-134a, and R-1234yf ensure that recycled refrigerants meet industry specifications:

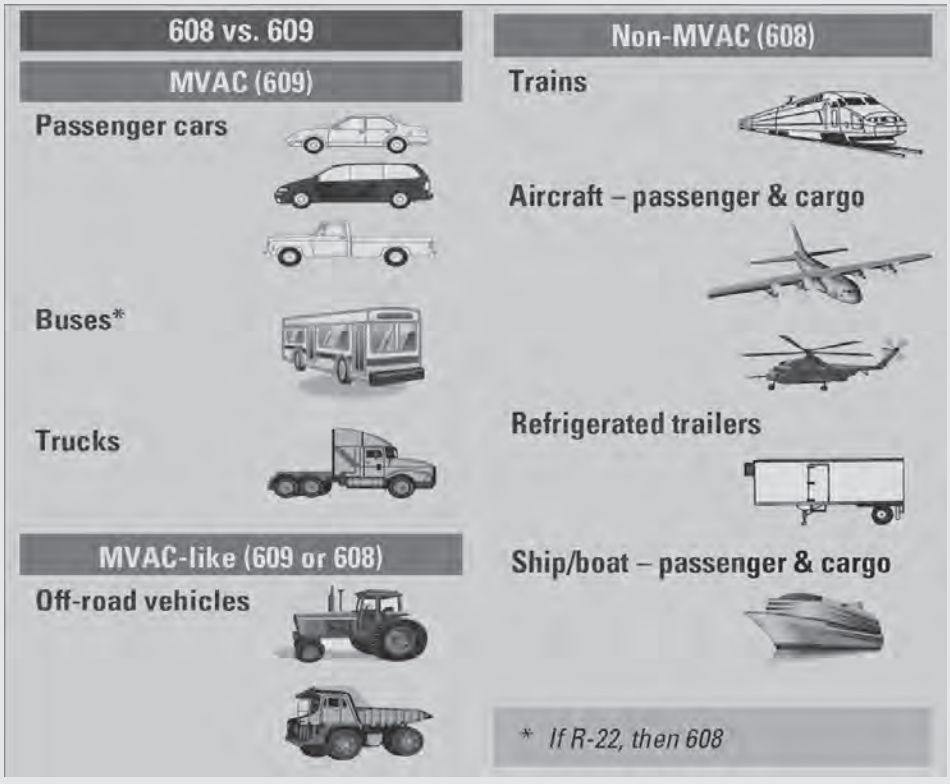
- J1991 is a purity standard for recycled R-12 and specifies a limit, in parts per million (ppm) by weight, for three different contaminants: 1) moisture—15 ppm by weight, 2) refrigerant oil—4,000 ppm by weight, and 3) non-condensable gases (air)—330 ppm by weight.
- J2099 is also a purity standard that sets limits for contaminants in recycled R-134a and R-1234yf: 1) moisture—50 ppm by weight, 2) lubricant—500 ppm by weight, and 3) non-condensable gases (air)—1.5% by volume.

SAE standard J2209 specifies the requirements of equipment used for R-12 recovery-only. SAE standard J2810 states the requirements for equipment used for R-134a recovery only. Recovery-only equipment can't recycle refrigerant or recharge a system, but may be beneficial to some operations such as automotive salvage yards or service businesses with multiple outlets.

SAE standard J2851 applies to recovery-only equipment for extracting a contaminated refrigerant from a system originally filled with R-1234yf. Originally intended to be the standard for R-1234yf recovery-only equipment, this standard was broadened out of concern over recovering any contaminated refrigerant from a R-1234yf MVAC system. Specifics include performance requirements for the recovery process, compliance with related SAE J-standards and certification that all requirements have been met through an independent testing organization.

The EPA allows the use of recovery-only equipment as long as the recovered refrigerant is sent to an off-site facility where the refrigerant is reclaimed, not recycled. Reclaimed refrigerant must meet a more stringent, like-new purity standard detailed in AHRI Standard 700, "Specifications for Fluorocarbon Refrigerants," published by the Air-Conditioning, Heating, and Refrigeration Institute (AHRI).

Under Section 609, refrigerant removed from a system using recovery-only equipment can be transferred to recovery/recyling equipment, recycled and then reused in an MVAC or MVAC-like system. Or, it can be sent to a reclaimer. (Contaminated R-1234yf will always need to be reclaimed because J2843 requires 98% purity before it will recover and recycle.)



Please note: Because of some overlap between Section 608 and Section 609, MVAC-like appliances such as off-road vehicles can be covered by this ASE Section 609 program. Any application using R-22 refrigerant is governed under Section 608 for service and for the purchase of R-22 refrigerant. For more information about Section 608, visit: http://www.epa.gov/section608.

Section 82.42 – Certification, recordkeeping and public notification requirements

This section establishes the requirement that anyone servicing MVAC systems for hire needs to be properly trained and certified by an EPA-approved organization. In addition, credentialed personnel must use recovery, recovery/recycle, or recovery/recycle/recharge equipment that has met EPA approval and details about this equipment must be reported to EPA on an equipment certification form available from the EPA website at: http://www.epa.gov/mvac.

Other requirements in this section relate to recordkeeping:

- The name and address of any facility where refrigerant may be sent
- Any person that sells or distributes Class I refrigerants in a container less than 20 lbs. must verify that the purchaser is properly trained and certified. All records must be kept for a minimum of three years.
- Upon request, EPA personnel are to be allowed on the premises for access to records related to certification and recordkeeping.
- Any person who sells Class I refrigerants in containers less than 20 lbs. must post a sign in a prominent place stating, "It is a violation of federal law to sell containers of Class I refrigerant of less than 20 lbs. of such refrigerant to anyone who is not properly trained and certified to operate approved refrigerant recycling equipment."

Section 608 Programs – Differences and Overlap

Under a separate section of the Clean Air Act, EPA enacted regulations related to the training and certification of technicians that service stationary refrigeration and air conditioning systems. The EPA defines four types of certification under Section 608, relative to the specific type of air conditioning or refrigeration system:

1. Type I for servicing small appliances.
2. Type II for servicing or disposing of high- or very-high-pressure appliances except small appliances and MVACs.
3. Type III for servicing or disposing of low-pressure appliances.
4. Universal for servicing all types of equipment.

Venting Prohibited

Due to potential environmental damage from refrigerants, federal law specifically prohibits the intentional release (venting) of not only ozone-depleting refrigerants like R-12, but also all alternatives, unless specifically exempted, while maintaining, servicing, repairing, or disposing of refrigeration and air conditioning equipment. This includes all HFCs like R-134a, R-152a, and HFOs such as R-1234yf, and their blends. The only exception to the venting prohibition that is approved for use in MVAC systems applies to R-744 (CO_2). Under Section 608 of the Clean Air Act, intentional release (venting) of any refrigerant is illegal unless the refrigerant is specifically exempted from the prohibition. CO_2 is exempted under 608 meaning that it can be legally vented. Although CO_2 may legally be vented, section 609 still requires that all MVAC systems be serviced through the proper use of EPA-certified refrigerant handling equipment. This requirement applies regardless of the refrigerant used in the MVAC system. This means that anyone servicing an MVAC system that uses CO_2 as the refrigerant would need to properly use EPA-certified refrigerant handling equipment.

Alternative Refrigerants

Refrigerant Sales Restriction

The sale of any size container of ozone-depleting refrigerant, including refrigerant blends, is restricted to technicians who have been properly trained and certified through a Section 609 program. The sale of R-12 in containers less than 20 pounds, however, is exclusively restricted to technicians who have been properly trained and certified through a Section 609 program. In the Fall of 2016, the EPA published a final rule that also imposes a sales restriction onto HFOs such as R-1234yf and HFCs such as R-134a, effective January 1, 2018. Cans of refrigerant under 2 pounds with self-sealing valves that are intended for MVAC service are exempt from this restriction. Technicians who earn Section 609 MVAC credentials may only buy refrigerant found acceptable for use in MVAC systems. Section 609 credentials do not enable the purchase of refrigerants used in stationary air conditioning (Section 608) systems.

SNAP Overview

EPA established the Significant New Alternatives Policy (SNAP) Program to review alternatives to ozone-depleting substances like R-12. EPA examines alternative refrigerants for their ozone-depleting potential, global warming potential, flammability, and toxicity characteristics. EPA has determined that several refrigerants are acceptable, subject to use conditions, for use as R-12 replacements in motor vehicle air conditioning systems. Even though R-12 is no longer used in new cars, EPA continues to publish its list of alternative refrigerants in that context.

It's important to understand the meaning of "acceptable, subject to use conditions." EPA believes such refrigerants, when used in accordance with the conditions, are safer for human health and the environment than R-12. This designation does not mean that the refrigerant will work in any specific system, nor does it mean that the refrigerant is perfectly safe regardless of how it's used.

Final SNAP Rule

On July 20, 2015, EPA published a final rule changing the listing status of certain high-global warming potential chemicals that were previously listed as acceptable alternatives under SNAP. This rule is part of the SNAP program's continuous review of alternatives to find those that pose less overall risk to human health and the environment. Specifically, this action changes the listing status for certain HFCs in various end-uses in the aerosols, refrigeration and air conditioning, and foam blowing sectors. This action also changes the status from acceptable to unacceptable for certain hydrochlorofluorocarbons (HCFCs) being phased out of production under the Montreal Protocol on Substances that Deplete the Ozone Layer and section 605(a) of the Clean Air Act, where substitutes are available that pose overall lower risk to human health and/or the environment.

For motor vehicle air conditioning systems, EPA finalized the following changes:

- HFC-134a will be listed as unacceptable for newly manufactured light-duty motor vehicles beginning in Model Year (MY) 2021 except as allowed under a narrowed use limit for use in newly manufactured light-duty vehicles destined for use in countries that do not have infrastructure in place for servicing with other acceptable refrigerants. This narrowed use limit will be in place through MY 2025. Beginning in MY 2026, HFC-134a will be unacceptable for use in all newly manufactured light-duty vehicles.
- The refrigerant blends SP34E, R-426A (also known as RS-24), R-416A (also known as HCFC Blend Beta or FRIGC FR12), R-406A, R-414A (also known as HCFC Blend Xi or GHG-X4), R-414B (also known as HCFC Blend Omicron), HCFC Blend Delta (also known as Free Zone), Freeze 12, GHG-X5, and HCFC Blend Lambda (also known as GHG-HP) will be listed as unacceptable for use in newly manufactured, light-duty vehicles starting with MY 2017.

The final rule and a fact sheet on the final rule are available at http://www.epa.gov/snap.

<u>Acceptable</u> Substitutes in MVAC: Passenger Air Conditioning in Light-Duty, Medium-Duty, Heavy-Duty and Off-Road Vehicles

Note: SNAP-related information published in the Federal Register takes precedence over all information on this page.

Substitute (Name Used in the Federal Register)	Trade Name	Retrofit/ New
Evaporative Cooling		N
Free Zone (HCFC Blend Delta) ①	Free Zone / RB-276	R / N
Freeze 12 ①	Freeze 12	R / N
GHG-HP (HCFC Blend Lambda) ①	GHG-HP	R / N
GHG-X5 ①	GHG-X5	R / N
HFC-134a ②	134a	R / N
HFC-152a		N
HFO-1234yf		N
Ikon A	Ikon-12, Blend Zeta	R / N
R-401C		R / N
R-406A ①	GHG	R / N
R-414A ①	GHG-X4, HCFC-Blend Xi, Autofrost, Chill-it	R
R-414B ①	Hot Shot, Kar Kool	R / N
R-416A ①	FRIGC, FR-12, HCFC Blend Beta	R / N
R-426A ①	RS-24	R / N
R-744 (Carbon Dioxide, CO_2)		N
RS-24 (2002 formulation)		R / N
Small auxiliary power units that include an engine, electrical alternator, water pump, air conditioning compressor and a heat exchanger used in tractor trailers in conjunction with passenger compartment climate control systems that already use an acceptable substitute refrigerant.		R / N
SP34E ①	SP34E	R / N
Stirling Cycle		N

Key: R = Retrofit Uses, N = New Uses

① Unacceptable in New Light-Duty-Systems as of 2017 model year.
② Unacceptable in New Light-Duty Systems as of 2021 model year.

Unacceptable Substitutes for ODS in Refrigeration and Air Conditioning

Note: SNAP Notices and Final Rules published in the Federal Register take precedence over all information on this page.

Substitute (Name Used in the Federal Register)	ODS Being Replaced	End-uses	Reason
All flammable refrigerants, including OZ-12® (Hydrocarbon Blend A), HC-12a® (Hydrocarbon Blend B), and Duracool 12a except HFC-152a and HFO-1234yf in new MVACs	CFC-12	Motor vehicle air conditioning, retrofit and new	Lack of adequate assessment that characterizes incremental flammability risk
OZ-12® (Hydrocarbon Blend A), HC-12a® (Hydrocarbon Blend B), and Duracool 12a	CFC-12	All end-uses other than industrial process refrigeration, retrofit and new	Lack of adequate assessment that characterizes incremental flammability risk
R-141b	CFC-11	centrifugal chillers, new	High ODP; other substitutes with lower overall risk have been identified
R-176 (R-176 contains CFC-12, HCFC-22, and HCFC-142b. It is a different product from RB-276, typically sold under the name "Free Zone.")	CFC-12	All end-uses, retrofit and new	Contains CFC-12
R-403B	R-502	All end-uses, retrofit and new	Contains a perfluorocarbon that exhibits extremely high GWP and very long lifetime
R-405A	CFC-12	All end-uses, retrofit and new	Contains a perfluorocarbon that exhibits extremely high GWP and very long lifetime
MT-31	all CFCs and HCFCs	All end-uses, retrofit and new	Toxicity of a constituent
Hexafluropropylene (HFP) and blends containing it	all CFCs and HCFCs	All end-uses, retrofit and new	HFP is toxic
NARM-22	HCFC-22	All end-uses, retrofit and new	Contains HCFC-22
Self-Chilling Cans using HFC-134a or HFC-152a	CFC-12, HCFC-22, R-502	Household Refrigeration, Transport Refrigeration, Vending Machines, Cold Storage Warehouses and Retail Food Refrigeration; retrofit and new	Unacceptably high greenhouse gas emissions from direct release of refrigerant to the atmosphere

Retrofitting

It's possible to change older R-12 systems over to R-134a or a different accepted refrigerant, through a process known as retrofitting. Although requirements vary depending on the year, make, and model of the vehicle, this procedure usually includes changing certain system components, as well as the addition of compatible refrigerant oil prior to charging. For best results, check with the vehicle manufacturer for specific retrofit guidelines and the availability of retrofit kits. Retrofit kits and information are also available from various aftermarket sources. EPA also provides retrofit guidance on its website at: http://www.epa.gov/mvac. Although some alternatives other than R-134a have been accepted for use, OEM vehicle and system manufacturers recommend that only R-134a be used in their MVAC systems.

The EPA developed the chart on page 12 to list accepted alternative refrigerants. This chart not only lists the refrigerant names, but also contains other important information regarding the status of acceptability. Only the refrigerants listed with an "R" in the Retrofit/New column may be legally installed as a retrofit, provided the use conditions for that refrigerant are met.

Retrofitting from one refrigerant to another will require the installation of unique fittings and a different system label. Refrigerants should never be mixed or used in systems designed for other refrigerants. There's no such thing as a "drop-in" alternative refrigerant.

The unique service fittings prevent the mixing of different refrigerants, known as cross-contamination. These fittings are attachment points on the vehicle itself, on all recovery and recycling equipment, on charging equipment, and on all refrigerant containers. Any service fittings not converted to the new refrigerant must be permanently disabled. The EPA publishes complete fitting and label specifications as "MVAC Refrigerants Fitting Sizes & Label Colors" on its website at: http://www.epa.gov/mvac.

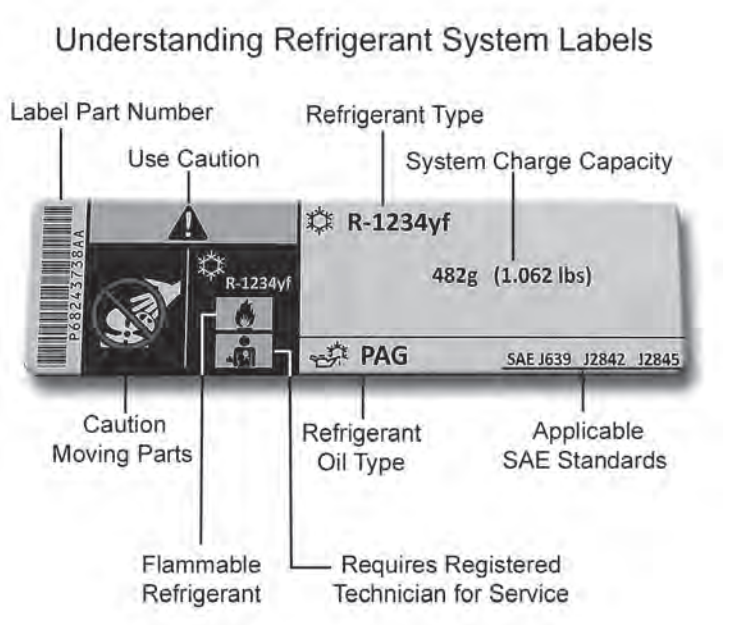
The new refrigerant's label gives specific details about that alternative. This label covers up information about the old refrigerant, and provides valuable details on the alternative and how it was used.

The label's background color is chosen by the refrigerant manufacturer to be unique and shows:

- the name and adress of the technician and the company performing the retrofit;
- the date of the retrofit;
- the trade name, charge amount, and (when applicable) the ASHRAE numerical designation of the refrigerant;
- the type, manufacturer, and amount of lubricant used; and
- if the refrigerant is or contains an ozone-depleting substance, the phrase "ozone depleter."

MVAC System Hoses

SAE Standard J2064 covers refrigerant hose and hose assemblies for MVACS with R-134a or R-1234yf systems. This includes requirements for labeling, hose dimensions, materials, construction, permeation rates, burst strength, connection integrity, and the required testing procedures. Be



Refrigerant Fitting Sizes		
Refrigerant	Low Side	High Side
R-12 (pre-1987)	Threaded 7/16 in. x 20	Threaded 7/16 in. x 20
R-12 (post-1987)	Threaded 7/16 in. x 20	Threaded 3/8 in. x 24
R-134a	Quick-coupler Unthreaded 13mm O.D.	Quick-coupler Unthreaded 16mm O.D
R-152a	Quick-coupler Unthreaded 14.1mm O.D.*	Quick-coupler Unthreaded 15mm O.D.*
R-744	Quick-coupler Unthreaded 16.6mm O.D.	Quick-coupler Unthreaded 18.1mm O.D.
R-1234yf	Quick-coupler Unthreaded 14mm O.D.	Quick-coupler Unthreaded 17mm O.D.
*Proposed, not yet finalized for production		

sure to use hose components labeled as being compliant with J2064.

- Hoses marked "J2064" or "J2064 R-134a" meet the requirements of J2064 for R-134a only.
- Hoses marked "J2064 R-134a/R-1234yf" or "J2064- R-1234yf" meet the requirements of J2064 for both R-134a and R-1234yf.

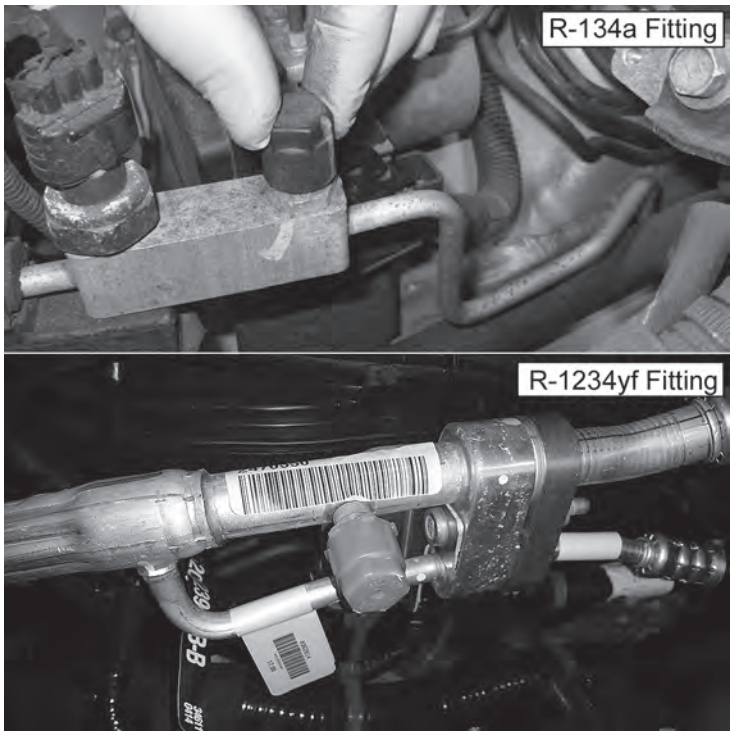
Caution with Flammable Refrigerants, Including Hydrocarbon Refrigerants

It's illegal to use any refrigerant with flammable characteristics, except R-152a and R-1234yf, in an MVAC system. This includes, but is not limited to, hydrocarbon refrigerants.

Next-Generation Air Conditioning Systems

Although R-1234yf was initially regarded as the sole successor to R-134a in new vehicle MVACs, factors within the industry may lay the groundwork for the potential of several different refrigerants to be used. With EPA classifying R-152a and R-744 as acceptable substitutes, it opens the door to the possibility of eventually seeing MVACs with these alternatives. Further, research continues on other refrigerants that may also prove to be feasible alternatives. For more details about R-744, R-152a, and R-1234yf, refer to the section "From Ozone Depletion to Global Warming" on page 6 of this training material.

One of the most important SAE standards regarding MVACs is SAE J639, "Safety Standards for Motor Vehicle Refrigerant Vapor Compression Systems." This document plays a key role in helping standardize key elements of next-generation MVACs. SAE J639 spells out details for system design, implementation and service, ranging from pressures to key components, to service details. Additionally, and perhaps most importantly, this standard serves as an "umbrella standard", where it invokes many other SAE standards, as well as other industry documents, as references relating to systems using R-134a, R-744 and R-1234yf. For these reasons, a growing number of states require compliance with J639. As an MVAC technician, check your state and local regulations to see if this applies to you.



Although both R-134a and R-1234yf systems use quick-coupler service fittings, they have different sizes to prevent cross-contamination.

SAE J639 also specifies refrigerant fitting types and sizes for each refrigerant. Please note that all fitting sizes have not yet been formally adopted, so they remain subject to change. Also, R-12 fitting sizes are provided for historical reference.

Responsible Refrigerant Management

Safety First

As an MVAC technician, check your state and local regulations to see if your state requires compliance with SAE J639, "Safety Standards for Motor Vehicle Refrigerant Vapor Compression Systems." This standard covers all aspects of MVAC design, implementation and service.

Whenever you service air conditioning systems or operate service equipment. Follow these guidelines:

- Always wear safety goggles with side shields and insulated gloves to avoid direct contact with refrigerant.
- Work in a well-ventilated area to avoid asphyxiation from refrigerant and follow common shop safety practices.
- Follow all manufacturers' instructions for equipment operation.
- Obtain and keep readily available the Safety Data Sheet (SDS) for each refrigerant serviced. Familiarize yourself with the specifics of each. SDS information is available from your supplier.
- Exposure to refrigerant may cause frostbite. Rub the affected area with lukewarm water and consult a physician immediately.
- Consult a physician immediately should exposure to high refrigerant concentrations cause labored breathing, breathlessness, headache, accelerated pulse, or dizziness.
- Avoid breathing A/C refrigerant lubricant vapor or mist. To remove refrigerant from the A/C system, use service equipment designed for recovery of that refrigerant which is certified to meet the requirements of the appropriate SAE standards.

In addition, NEVER:

- mix refrigerants with air for the purpose of leak testing. If the mixture contains enough air and is under pressure, the mixture could ignite if it contacts a source of ignition.
- use a disposable refrigerant tank for storing recycled refrigerant.
- transfer refrigerant into another tank unless it is DOT-approved (look for DOT-4BA or DOT-4BW on the tank).
- fill a storage tank to more than 60% of its gross weight rating.
- attempt to use any piece of equipment until you are fully trained to do so.
- Service the recovery/recycling equipment (other than routine filter changes) without first consulting authorized service personnel.
- use electrical equipment in which switches are not at least 18 inches above the floor.
- use extension cords that are worn, frayed, have a lighter gauge than 14 AWG, or are any longer than necessary.
- use two-wire ungrounded extension cords.
- use a pigtail-type grounding adapter to bypass the ground circuit of an extension cord.

Recovery/Recycling/Recharge Equipment

Each refrigerant and its resulting regulations impact the overall design of refrigerant handling equipment. This ranges from service fittings, their related hoses, to the actual performance of the equipment. Keep in mind that SAE standards may be updated, superseded, or additional ones may be added in the future.

R-12 Systems – SAE standard J1990, "Recovery and Recycle Equipment for Mobile Automotive Air-Conditioning Systems," establishes minimum equipment specifications needed to recycle R-12 properly from an MVAC system for reuse in an MVAC system. J1990 also references SAE J1991 as the purity specification for recycled refrigerant. Equipment compliant with SAE J1990 uses service hoses marked "SAE J2196" to show that they meet that standard. The low-side hose will be solid blue or black with a blue stripe; the high-side hose will be solid red or black with a red

stripe. The utility hose will be either solid yellow or white, or black with a yellow or white stripe.

R-134a Systems – SAE standard J2788 (supersedes J2210), "HFC-134a (R-134a) Recovery/Recycling Equipment and Recovery/Recycling/Recharging for Mobile Air-Conditioning Systems", establishes minimum equipment performance requirements for recovery and recycling of R-134a that has been directly removed from, and intended for reuse in, MVACs. J2788 also cites SAE J2099 as the purity standard for the recycled refrigerant.

Service hose specifications for R-134a are also covered under SAE standard J2196. Since R-134a is made up of smaller molecules than R-12, R-134a tends to leak through hoses easier than R-12. R-134a service hoses will be labeled "SAE J2196/R-134a." These hoses will be color-coded as follows: solid blue with a black stripe for the low-side hose, solid red with a black stripe for the high-side hose, and solid yellow with a black stripe for the utility hose.

To minimize the chances of mixing R-134a with other refrigerants during service, SAE also specifies different fittings for service hoses. Standard J2197 requires hoses for R-134a service to have a 1/2-in.-16 ACME thread for connection to manifold gauges or recovery/recycling/recharging equipment. The vehicle connection end of R-134a service hoses can connect directly to a quick coupler on the vehicle, or an optional M14 X 1.5 fitting can be used between the hose and quick coupler.

R-1234yf Systems – SAE standard J2843, "R-1234yf (HFO-1234yf) Recovery/Recycling/Recharging Equipment for Flammable Refrigerants for Mobile Air-Conditioning Systems", establishes minimum equipment requirements for the recovery/recycle/recharge of R-1234yf refrigerant that has been directly removed from, and intended for reuse in, MVACs and system recharging of recycled or virgin R-1234yf. J2843 also references SAE J2099 as the purity standard for the recycled refrigerant.

Recovery/recycling/recharging equipment for R-1234yf requires integration with a refrigerant identifier—whether internal or external—to help avoid contamination with other refrigerants. Identifiers built into J2843-compliant equipment must meet SAE J2927, "R-1234yf Refrigerant identifier Installed In Recovery and Recycling Equipment for Use With Mobile A/C Systems." All external refrigerant identifiers must meet SAE J2912, "Performance Requirements for R-134a and R-1234yf Refrigerant Diagnostic Identifiers for Use with Mobile Air Conditioning Systems."

SAE standard J2888, "R-1234yf Service Hose, Fittings and Couplers for Mobile Refrigerant Systems Service Equipment", covers hardware specifications for fittings, couplers and hoses. This hardware connects the recovery/recycle/recharge unit to the vehicle and the refrigerant tank. R-1234yf service hoses will bear an "SAE J2888" marking with an adjacent stripe. For easy identification, the high-side hose is red, the low-side hose is blue, and the supply hose is yellow. The high-side service hose includes a 17mm O.D. quick coupler (specified in SAE J639) and at the shutoff device of the connection to the serviced system or equipment, an M12 x 1.5-6g male thread on both ends. The low-side service hose includes a 14mm O.D quick coupler (specified in SAE J639) and at shutoff device of the connection to the serviced system or equipment, an M12 x 1.5-6g male thread on both ends.

Note: Approved Recovery/Recycling/Recharge equipment for R-152a and R-744 has not yet entered the marketplace. This may change if these systems become prevalent, thus driving the need for standards on related service equipment.

Best Practices for Working with Refrigerant Systems

Responsible refrigerant management requires more than using the right equipment; it means using that equipment the right way. For that reason, SAE developed standards addressing the procedures used not only with recovery/recycle/recharge equipment, but also refrigerant identifiers and leak detection equipment.

R-12 Systems - SAE standard J1989, "Recommended Service Procedure for the Containment of CFC-12 (R-12)," was the first standard to be used with recovery/recycle/recharge equipment. J1989 details how to use approved equipment properly during recovery, recycling and recharging. J1989 pairs up with equipment defined in SAE J1990, "Recovery and Recycle Equipment for Mobile Automotive Air-Conditioning Systems," along with the SAE J1991 purity standard for R-12. SAE J1989 also covers service with manifold gauges and the refrigerant checking procedure for stored portable containers.

R-134a Systems – A similar set of standards apply to refrigerant recovery/recycling/recharging on R-134a systems. SAE standard J2211, "Recommended Service Procedure for the Containment of HFC-134a (R-134a)," incorporates equipment defined in SAE J2210, "HFC-134a (R-134a) Recovery/Recycling Equipment for Mobile Air-Conditioning Systems," along with the SAE J2099 purity standard for R-134a. SAE J2211 also addresses service with manifold gauges and the refrigerant checking procedure for stored portable containers.

R-1234yf Systems - SAE standard J2845, "R-1234yf (HFO-1234yf) and R-744 Technician Training for Service and Containment of Refrigerants Used in Mobile A/C Systems," establishes requirements during service and also refers to other relevant SAE J-standards. These include J2843 for recovery/recycling/recharging equipment, J2912 for refrigerant identification equipment and other related standards.

Used R-134a Refrigerant from Non-Mobile Sources

Since EPA regulations prevent the venting of R-134a, your sources for refrigerant may include "used" refrigerant. Because R-134a is used in applications other than motor vehicles, there is a potential for used refrigerant to be from a non-MVAC source. This introduces the possibility that used refrigerant could contain contaminants different from those that may exist in MVAC systems. These contaminants, which may not be removed by the normal MVAC recycling process, may cause damage to MVAC systems, and also to your MVAC recovery and recycling equipment. Never use MVAC recovery and recycling equipment to remove refrigerant from non-MVAC systems. Also, do not charge non-MVAC refrigerant into an MVAC system unless the refrigerant is first reclaimed by an EPA-certified facility to meet the "like new" purity standard AHRI Standard 700, established by the Air-Conditioning, Heating and Refrigeration Institute (AHRI).

Checking Recycled R-12 and R-134a Stored In Portable Containers

To make sure recycled refrigerant is ready for use, follow these steps and refer to the charts on page 21 to check for excess non-condensable gases (air):

1. Keep the container at 65°F (18.3°C) or above for at least 12 hours, out of direct sunlight.
2. Connect a pressure gauge, calibrated in 1-psi divisions (0.1 kg/cm^2), to the container and read the pressure. A pressure gauge calibrated in kilopascals (kPa) can be used when checking recycled R-134a against its metric pressure chart.
3. Measure the air temperature within 4 in. (10cm) of the container with an accurate thermometer.
4. Compare the pressure to the charts. See if the pressure is at, or below, the limits shown.
5. If the pressure of the recycled refrigerant is lower than the limit shown for a given temperature, the refrigerant is OK to use as is.
6. If the refrigerant's pressure is higher than the limit shown for a given temperature, slowly vent the vapor from the top of the container into the recovery/recycling unit. Continue until the pressure falls below the limit shown in the charts.
   Note: If the recycled refrigerant is R-134a, and the pressure still exceeds the limits in the charts on page 21, shake the container and let it stand for several minutes. If the pressure then falls below the limits, it is OK to use.
7. Should the pressure inside the container still exceed the pressure limit shown, recycle the entire contents.

How to Recover Refrigerant on R-12 and R-134a Systems

To keep the discharge of refrigerant to a minimum when recovering it, follow these guidelines outlined in SAE standards J1989 (R-12) and J2211(R-134a).

1. Service equipment hoses must have shutoff valves within 12 in. (30 cm) of the service ends. These may be manual shutoffs located in the service hoses or automatic shutoffs located in the quick-couplers that attach to service fittings. With the valves closed, connect the hoses to the vehicle's air conditioning service fittings.

2. Always follow the equipment manufacturer's recommended procedures for use. Recover the refrigerant from the vehicle and continue the process until the vehicle's system shows vacuum instead of pressure. Turn off the recovery/recycling unit for at least five minutes. If the system still has pressure, repeat the recovery process to remove any remaining refrigerant. Continue until the A/C system holds a stable vacuum for two minutes.

3. Close the valves in the recovery/recycling unit's service lines and disconnect them from the system's service fittings. On recovery/recycling stations with automatic shutoff valves, make sure they work properly. SAE standard J2211 offers the following additions to the recovery procedure:
   - Verify that the system has a refrigerant charge before recovery to prevent the recovery of non-condensable gases (air).
   - Evacuate the system to a minimum of 102mm (4 in. Hg.) vacuum.
   - If components show signs of icing during recovery, mild heat may be applied to ease the recovery process.
   - After the refrigerant is completely recovered, measure and replace any recovered oil with the same amount and type.

4. Evacuating disposable refrigerant containers:
   - Disposable containers that appear to be empty still have traces of refrigerant in them. Remove all remaining refrigerant before disposing of the container.
   - Connect the recovery/recycling unit to the container and remove the remaining refrigerant. Once the container shows a vacuum rather than pressure, close its valve. Mark the container EMPTY and dispose of it in the trash.

An Important Note About Recovering R-1234yf Refrigerant

Recovery/recycle/recharge equipment for R-1234yf meeting SAE J2843 must use either an internal or external refrigerant identifier. The identifier ensures that the refrigerant is at least 98% pure R-1234yf before the machine allows recovery of the refrigerant.

Portable Container Pressure Charts

Standard Temperature/ Pressure Chart for R-12

°F	PSI	°F	PSI	°F	PSI	°F	PSI	°F	PSI
65	74	75	87	85	102	95	118	105	136
66	75	76	88	86	103	96	120	106	138
67	76	77	90	87	105	97	122	107	140
68	78	78	92	88	107	98	124	108	142
69	79	79	94	89	108	99	125	109	144
70	80	80	96	90	110	100	127	110	146
71	82	81	98	91	111	101	129	111	148
72	83	82	99	92	113	102	130	112	150
73	84	83	100	93	115	103	132	113	152
74	86	84	101	94	116	104	134	114	154

Metric Temperature/ Pressure Chart for R-12

°C	kg/cm²	°C	kg/cm²	°C	kg/cm²
18	5.2	28	7.0	38	9.0
19	5.3	29	7.1	39	9.2
20	5.5	30	7.2	40	9.4
21	5.6	31	7.5	41	9.6
22	5.8	32	7.7	42	9.9
23	6.0	33	7.9	43	10.0
24	6.1	34	8.1	44	10.4
25	6.3	35	8.3	45	10.7
26	6.6	36	8.5	46	10.9
27	6.8	37	8.7	47	11.0

Standard Temperature/ Pressure Chart for R-134a

°F	PSI	°F	PSI	°F	PSI	°F	PSI	°F	PSI
65	69	77	86	89	107	101	131	113	158
66	70	78	88	90	109	102	133	114	160
67	71	79	90	91	111	103	135	115	163
68	73	80	91	92	113	104	137	116	165
69	74	81	93	93	115	105	139	117	168
70	76	82	95	94	117	106	142	118	171
71	77	83	96	95	118	107	144	119	173
72	79	84	98	96	120	108	146	120	176
73	80	85	100	97	122	109	149		
74	82	86	102	98	125	110	151		
75	83	87	103	99	127	111	153		
76	85	88	105	100	129	112	156		

Metric Temperature/ Pressure Chart for R-134a

°C	kPa	°C	kPa	°C	kPa
18	476	29	676	40	945
19	483	30	703	41	979
20	503	31	724	42	1007
21	524	32	752	43	1027
22	545	33	765	44	1055
23	552	34	793	45	1089
24	572	35	814	46	1124
25	593	36	841	47	1158
26	621	37	876	48	1179
27	642	38	889	49	1214
28	655	39	917		

Service Hoses

Service hoses allow access to A/C systems so you may diagnose system problems and also charge, recover, and/or recycle refrigerant. Unique fittings must be permanently attached to the ends of the hoses that connect to vehicle A/C systems. For each refrigerant, you must use a hose that has a fitting unique to that refrigerant. This fitting must be permanently attached to the end connecting to the vehicle or other refrigerant source. The guiding principle is that once attached to a hose, the fitting is permanent and is not to be removed.

Observe the following to minimize refrigerant discharge:

1. Hoses with manual shutoff valves must be closed before removing them from an A/C system's service fittings. Automatic shutoff valves are used on the ends of service hoses that connect to quick-coupler style service fittings.
2. Manual shutoff valves must be closed at all times when the gauge hoses are not connected to an A/C system or charging source. This keeps the amount of refrigerant escaping into the atmosphere to a minimum and limits the amount of air entering the hoses.

R-1234yf Systems and R-744 Systems

SAE standard J2845 "R-1234yf (HFO-1234yf) and R-744 Technician Training for Service and Containment of Refrigerants Used in Mobile A/C Systems" contains essential information to promote safe and responsible refrigerant management practices. This standard contains general safety information covered under, "Safety First" on Page 17, but there are also specific safety issues specific to each refrigerant. J2845 also covers refrigerant identification and leak detection, which will be covered separately in this training under "Refrigerant Identification and Cross-Contamination" and "Leaks and Leak Detection."

When servicing R-1234yf systems, J2845 stresses these key safety aspects:

- Maintain good ventilation in the work area
- Open vehicle windows and doors when charging the MVAC to prevent an accumulation of refrigerant in case of a major refrigerant leak.
- Clean all dirt, grease and debris from on and around the connection joints before servicing and disassembly of refrigerant connections.
- Carefully inspect refrigerant connections, joint seals and seal surfaces for signs of wear, deformation, contamination or damage after disassembly. Prior to disassembly, look for presence of refrigerant oil on adjacent surfaces that could be the sign of a leak.
- Seals and O-rings should never be reused; always replace them with new ones.
- Make sure fittings and connections are properly aligned to avoid stressing the fitting connection.
- Always tighten the refrigerant connection to the specified torque value of the manufacturer.
- Never repair or replace the system evaporator with one from another vehicle or a salvaged part. Instead, replace the evaporator with one meeting SAE standard J2842, "R-1234yf and R-744 Design Criteria and Certification for OEM Mobile Air Conditioning Evaporator and Service Replacements."
- Hybrid and electric vehicles require special service procedures to disable the high-voltage system prior to MVAC service. When disabling a high-voltage system, manufacturer's procedures must be strictly followed to ensure high voltage is not present during vehicle service.
- Do not smoke or have an open flame while working on and/or servicing systems which contain R-1234yf refrigerant.
- Avoid bringing R-1234yf refrigerant into contact with open flames and hot surfaces, sparks and high-energy ignition sources as ignition may occur.
- Use tools and service equipment specifically designed for R-1234yf.

Machines used to recover/recycle/recharge R-1234yf systems must meet SAE standard J2843. Before recharging a system, the machine first places the system under a vacuum of 0.09 MPa gauge (26.9 in. of mercury). The machine then monitors the applied vacuum, and notes if it decays. If the vacuum decays to a level of -0.088 MPa gauge (25.9 in. mercury) or more in 5 minutes, a leak is indicated and the machine will not permit the recharge process to continue. Any leaks must be found and repaired before again attempting to recharge the system. You should be aware that recover/recycle/recharge equipment has automatic functions that operate differently from previous equipment for other refrigerants.

If the system passes the vacuum decay check, the machine automatically charges the refrigerant into the system equivalent to 10% of the amount the machine was programmed to deliver. The machine then monitors the subsequent pressure rise in the system. After 5 minutes, if pressure decreases by 10% or more, this indicates that a leak is present. The remaining 90% of the refrigerant will not be administered. Once again, any leaks need to be located and repaired before proceeding.

Key R-744 Safety Points from J2845

- Proper recovery of CO_2 from high-pressure systems is necessary to ensure harmless depressurization and avoid technician exposure to unacceptable concentrations of CO_2 in the work area. Similar considerations apply when recharging the system.
- R-744 systems operate at much higher pressures than current systems. Be aware that the release and rapid expansion of CO_2 can cause serious injury and asphyxiation by displacing air.
- If a CO_2 system is overcharged, it can lead to high-pressure build-up in the system and you need to be aware of potential pressure differences. If a CO_2 system is overcharged and a leak into the passenger compartment occurs, the concentration there could exceed the health-based limit for CO_2.
- Never repair or replace the system evaporator with one from another vehicle or a salvaged part. Instead, replace the evaporator with one meeting SAE standard J2842, "R-1234yf and R-744 Design Criteria and Certification for OEM Mobile Air Conditioning Evaporator and Service Replacements."

Procedures for the use of R-744 recover/recycle/recharge have not yet been fully developed, as there is not yet any approved equipment for this refrigerant.

Refrigerant Identification and Preventing Cross-Contamination

An electronic refrigerant identifier is an essential tool to guard against refrigerant cross-contamination.

As a service technician, you need to be aware of the hazards involved when an A/C system becomes cross-contaminated. Simply put, cross-contamination means the system has been partially charged with refrigerant other than the type designated on the system information label.

The best defense against cross-contamination is a program of prevention. If possible, the first step before servicing any A/C system is to find out the vehicle's service history. Be extremely wary if the vehicle has been to several shops to cure a mysterious A/C problem.

Next, inspect the service fittings for signs of tampering. Makeshift or damaged fittings could be

another clue that the system has been cross-contaminated. Even still, service fittings can be temporarily modified by using adapters, so use caution. Finally, refuse to service the vehicle if your inspection makes you suspicious about the system's refrigerant charge.

If cross-contaminated, the A/C system can suffer reduced performance, damage from chemical breakdown, and lubrication problems. If a recovery/recycling machine is connected to a cross-contaminated system, the machine will have to be cleaned out and major components like filters and dehydrators will have to be replaced. Additionally, should a contaminated recovery/recycling machine be connected to other A/C systems before the problem is discovered, the cross-contamination can spread like a virus and infect other systems serviced by that equipment.

Unfortunately, a cross-contaminated system may be difficult to detect. Electronic refrigerant identifiers are a common means of detecting refrigerant cross-contamination. Short of sending a sample to a lab, a refrigerant identifier may be your best protection against cross-contamination. SAE established the J1771 standard for R-12 and R-134a refrigerant identification equipment. When claiming to meet this standard, manufacturers of identifier equipment are required to label the unit, stating its level of accuracy.

SAE also established refrigerant identifier standards for R-1234yf refrigerant. An identifier must be used with R-1234yf recover/recycle/recharge equipment meeting SAE J2843 as a deterrent to cross-contamination. SAE J2912 applies to external identifiers that connect to the R-1234yf recover/recycle/recharge machine. SAE J2927 details specifics for built-in refrigerant identifiers in recover/recycle/recharge machines.

If contaminated or unknown refrigerant is detected, it must be disposed of properly. The EPA prohibits venting of any contaminated refrigerant into the atmosphere (including "unacceptable" refrigerants), no matter what combination of chemicals is in the refrigerant. The best way that you can recover contaminated or unfamiliar refrigerant is to dedicate a recovery-only unit to any refrigerant that cannot be positively identified.

Unknown refrigerant should be recovered into a standard DOT-approved, gray-with-yellow top recovery tank. Make sure that you never fill a tank beyond 60% of its gross weighted capacity. When storing this tank, check local ordinances that govern the storage of combustible or hazardous materials.

There are various ways to legally dispose of contaminated or unknown refrigerants. If you have a contract with a waste processor, contact them regarding disposal of the material. You may also want to contact one or more reclaimers, which will send the refrigerant off-site for either destruction or reclamation. Due to the expense involved with either procedure, be sure to investigate all expenses that may be incurred for processing the material. The EPA maintains a list of EPA-certified refrigerant reclaimers on its website at: http://www.epa.gov/section608.

Leaks and Leak Detection

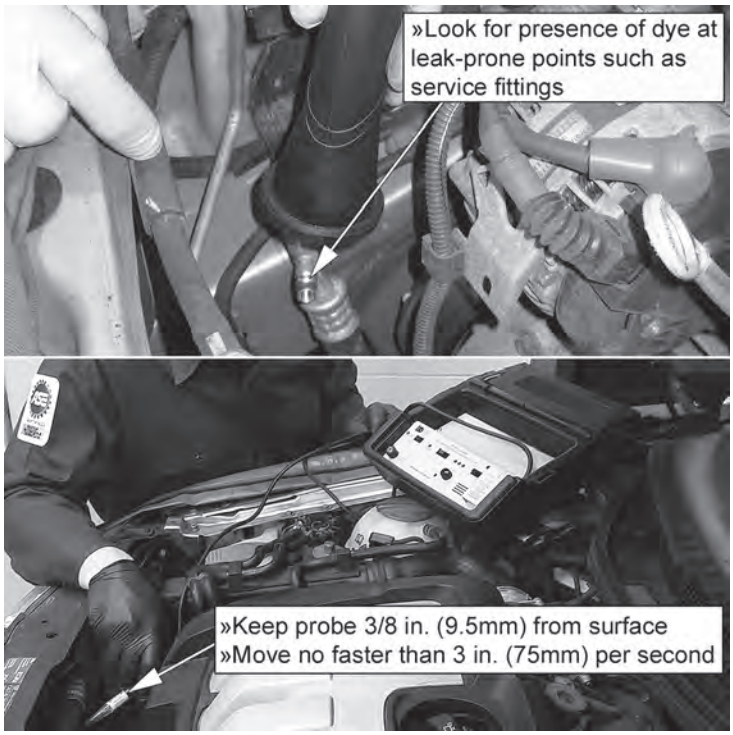
It's wise to advise your customer of the economy of a leak-free system. Leak repair often pays for itself in the long run by avoiding repeated "top-offs" of increasingly expensive refrigerant. Although this is sound advice, you should never imply that leak repair is required under federal law. To do so would constitute consumer fraud. In most areas of the country, customers can simply choose to have their systems "topped-off," if they desire. However, remember some states and localities have enacted restrictions that supersede federal requirements, so leak repair is required. Make sure to check with your local and state authorities to see what applies in your area.

Locating and Repairing MVAC Refrigerant Leaks

A low refrigerant charge often contributes to insufficient MVAC cooling. Finding and repairing MVAC system leaks represents a high percentage of MVAC service work.

You have two primary tools to choose from when performing the essential task of leak detection: 1) electronic detectors, and 2) fluorescent dye detectors.

Electronic Leak Detectors – SAE Standard J2791 establishes minimum performance requirements for detectors used on MVAC systems that contain R-134a refrigerant. Among these requirements is a minimum of three leak-detection scales that you can manually select: (1) 4 grams (0.15 oz.) per year; (2) 7 grams (0.25 oz) per year; and (3) 14 grams (0.5 oz) per year. J2791 also requires the detector manufacturer to supply a list of common underhood chemicals that will cause "false-triggering" of the detector. Older electronic leak detectors that originally met SAE standard J1627 are not as accurate or sensitive as those that meet SAE Standard J2791. Detectors that meet the J2791 standard feature a label stating, "Design certified by (name of independent testing laboratory) to meet SAE J2791."



The procedures for using leak detection dyes (top) are covered by SAE standard J2298. Similarly, SAE standard J1628 covers the procedures for using electronic leak detectors (bottom).

SAE standard J2913 applies to electronic leak detectors for R-1234yf and incorporates the same three leak detection sensitivity scales as cited in the J2791 standard.

Detectors that meet the J2913 design criteria will carry a label stating, "Design certified by (name of independent testing laboratory) to meet SAE J2913." Remember that R-1234yf is a mildly flammable refrigerant so safety needs to be strictly followed when searching for leaks.

SAE standard J1628 establishes procedures for using leak detection equipment. Specifically addressed are electronic leak detectors meeting the SAE Standard J2791 and J2913 requirements. SAE J1628 states:

- Leak test when the system is not operating.
- Ensure that the MVAC system static charge pressure is at least 50 psi (340 kPa), and that ambient system temperature is a minimum of 59° F (15° C).
- Perform a visual inspection of the system, locating potential leaks by the accumulation of system lubricant or by visible hose/line damage.
- Continue to check the entire system, even if one leak is detected.
- Check the service valves with the caps in place, and also with the caps removed.
- Maintain a distance of 3/8 in. (9.5mm) between the detector probe and the surface being checked, and move the probe at a speed no faster than 3 inches (75mm) per second.
- Use the 7 grams (0.25 oz) per year setting to retest a leak found on the 4 grams (0.15 oz) setting to help determine if the leak is of a repairable size.
- Leak test an evaporator core by operating the A/C system blower on the high setting for a minimum of 15 seconds. Turn off the blower, and wait at least 13 minutes for any potential

leaking refrigerant to accumulate in the evaporator case. Next, insert the leak detector probe into the blower motor resistor block opening, or the evaporator condensate drain hole (provided no moisture is present — it could damage the probe's sensing tip), or the closest duct opening to the evaporator.
- Leak test the service ports and also the repair area after a repair is performed.

Fluorescent Leak Detectors – These provide another means to detect leaks in MVAC systems. These dyes glow when exposed to ultraviolet (UV) "black" light. Since they circulate inside the system with the refrigerant and lubricant, dye residue will accumulate at the point of any leak. SAE Standard J2297 establishes standards for stability and compatibility of fluorescent dyes for use in mobile R-134a systems and R-1234yf systems.

Fluorescent dye leak-detection "starter kits" are available from a number of manufacturers, and normally include the dye, a tool used to inject the dye into the system, and a UV "black" light to detect leaks. Suppliers of leak-detecting dyes meeting SAE Standard J2297 requirements must provide underhood labels you can use to indicate that fluorescent dye was installed and to identify the dye manufacturer. The label must also state: "Caution— System to be Serviced by Qualified Personnel."

There are additional SAE Standards relating to fluorescent dyes. SAE Standard J2298 covers the procedures for using leak detection dyes, and SAE Standard J2299 establishes the standards for the performance of leak-detection dye injection equipment.

To follow the "Best Practices" outlined in the SAE Standard J2298 for using leak-finding dyes, you should:
- Use only dyes that meet the SAE J2297 Standard.
- Before injecting dye, check the engine compartment for a sticker indicating that dye is already installed. An alternate method is to remove the low side service port cap and depress the valve stem for an instant to determine if dye is in the system. If dye is present at the low-side service port, proceed to check for leaks.
- Add dye as per the manufacturer's instructions, provided that no dye was previously added to the system.
- Place the identification label supplied by the dye manufacturer in a prominent place in the engine compartment, near the A/C charge label if possible.
- Verify that the A/C system has sufficient refrigerant as per factory specifications, then operate the system for a minimum of 15 minutes to circulate the dye.
- Inspect the entire A/C system with an ultraviolet lamp with the engine not operating.
- Trace the entire refrigerant system, concentrating on areas that are leak-prone, such as hose-to-line couplings, service ports, etc. Check for evaporator leaks by illuminating the condensate drain hole. Only large leaks may be detected at this stage, due to the limited length of time the dye has been allowed to accumulate at any leakage site. If a leak cannot be found, ask the customer to return in a week or more after operating the A/C system as much as possible. This extended operating time should cause sufficient dye to collect at the leak

General warnings and cautions for the use of leak-detecting dyes include:

- **Warning!** Ultraviolet light is hazardous if eyes and skin are exposed over time. Ultraviolet light exposure should be minimized by wearing UV-blocking eyewear, always directing the light source away from one's body, and protecting bare skin.
- **Caution!** Any dyes used must be either expressly endorsed by the A/C system and/or vehicle manufacturer, or meet the requirements of SAE J2297.

Refrigerant Cylinder Identification and Fitting Size		
Refrigerant	**Color**	**Fitting**
R-12	White	7/16 in. x 20
R-134a	Light blue (PMS color 2975)	RH Thread, ½ in. 16 ACME
R-1234yf	White with red band	LH Thread, ½ in. 16 ACME
R-744	Gray (PMS color 352)	TBD

site, allowing detection.

- Continue to check the rest of the system if a leak is found, as other leaks may be present.
- Verify any small leak by using an electronic leak detector as per SAE Standard J1628 to determine whether the leak is of a repairable size as defined by the vehicle or MVAC system manufacturer. Some compressor shaft seal lubricant leakage may be normal for the system in question.
- After the leak is repaired, remove any fluorescent residue using a cleaner approved by the dye, vehicle, or MVAC system manufacturer.

Although the use of fluorescent dyes is widespread in the MVAC service industry, some OEM manufacturers may prohibit using dyes in their systems, and others only permit specific dyes to be used. Therefore, you should always service vehicles following the manufacturer's recommendations.

Locating leaks is the first part of the service job, but stopping the leaks is what keeps refrigerant out of the atmosphere, and also makes for happy customers. Correctly repairing leaks depends on a number of factors relating to where the leak is located and which components are leaking. If you replace a component, you should verify correct system lubricant levels, lubricate fitting O-rings before installing new ones, tighten fittings and connection-flange bolts to manufacturer's recommended torque specifications, and always check for leaks after you recharge the system.

Refrigerant Charging

Please use caution when storing refrigerant cylinders. Generally, do not expose cylinders to temperatures in excess of 52 degrees C (125 degrees F), as this will result in cylinders becoming liquid full.

Refrigerant cylinders shall not be:

- exposed to direct sunlight or any other heat source,
- subject to mechanical stress (ex. dropping, throwing),
- stored in shafts or in front of cellar windows,
- filled in the workshop or by workshop personnel,
- filled with another refrigerant, or
- transported without being securely stowed.

Please note that R-744 cylinders may be at a higher pressure than previously experienced in the shop. Be aware of this higher pressure.

Warning! Never attempt to add refrigerant to the high-pressure side of an operating MVAC system! Doing so could result in excessive pressure being transferred from the MVAC system into the charging apparatus, causing possible severe bodily injury!

Caution! When servicing MVAC systems, always work in a well-ventilated area, away from sparks or open flame. Wear eye protection at all times, and wear gloves to protect the skin whenever handling chemicals, including refrigerants and refrigerant oils.

System Charge Calculations

Today's MVAC systems use smaller refrigerant capacities than the systems of just a few years ago. Proper design ensures that these lower-capacity systems will perform well, but cooling performance can decrease dramatically if the refrigerant charge level is not correct. An overcharged system will produce higher-than-normal operating pressures, causing reduced cooling and possible system damage.

Systems that are low on refrigerant also exhibit reduced cooling, and may suffer component damage from lack of lubrication, because the refrigerant in MVAC systems circulates the lubricant. A seemingly small amount of additional or missing refrigerant can have a significant impact on system performance.

The first step in accurate MVAC system charging involves determining the manufacturer's refrigerant charge specification. This information is usually found in the capacities section of the vehicle Owner's Manual, on the MVAC identification label located in the vehicle engine compartment, or in technical resources such as service manuals or online service information.

There are instances when simply finding the charge amount is not enough because some vehicle manufacturers list MVAC refrigerant capacities in ounces and some list them in pounds and tenths of pounds. You can use these methods shown on page 29 to convert the system capacity listing to match the measurement units of your charging equipment.

After you determine the required charge level for the MVAC system, make sure that the correct amount of refrigerant actually enters the system being serviced. Since the charge level accuracy is so critical with smaller capacity MVAC systems, OEM vehicle manufacturers often specify that systems should be charged by weight, using an accurate scale or other device. Charging equipment scales may lose calibration, so the equipment manufacturers require regular calibration checks. One calibration method would be to place a static weight of known value on the scale to verify the scale reading.

Recalibration may also be as simple as pressing the "reset" button to zero the scale. Information on the testing frequency and the methods for verifying accuracy are usually included in the operating instructions for the equipment, or you can contact the equipment manufacturer.

Before charging an empty MVAC system, the industry standard procedure calls for placing the system in a vacuum, using the appropriate equipment. This removes air and moisture so that the refrigerant encounters a minimum amount of contamination, ensuring good cooling performance.

- If the refrigerant charge specification of the system is listed in ounces, and the charging equipment is calibrated in pounds, divide the system capacity by 16 to convert from ounces to pounds.
  Example: The system capacity is 28 ounces. 28 oz. ÷ 16 = 1.75 lbs (0.794 kg).

- If the refrigerant charge specification of the system is listed in pounds and tenths of pounds, and the charging equipment is calibrated in ounces, multiply the system capacity by 16 to convert from pounds to ounces.
  Example: The system capacity is 2.25 pounds. 2.25 lbs. X 16 = 36 oz (1020 g).

- If the refrigerant charge specification of the system is listed in pounds and ounces, and the charging scale is calibrated in ounces only, multiply the total number of whole pounds by 16, then add the number of additional ounces to arrive at the total system capacity in ounces.
  Example: The system capacity is 1 pound, 12 ounces. 1 lb. X 16 = 16 oz. Then 16 oz. + 12 oz. = 28 oz. (794 g) total system capacity.

- To convert tenths of a pound into ounces, multiply each tenth of a pound by 16 to arrive at the total ounces represented.
  Example: Convert 4/10 of a pound into ounces. 0.4 lbs. X 16 = 6.4 oz. (181 g).

- To convert ounces into tenths of a pound, divide the number of ounces by 16 to arrive at the tenths of pounds.
  Example: Convert 8 ounces into tenths of a pound. 8 oz. ÷ 16 = 0.5 lbs. (0.227 kg).

- If the refrigerant charge specification is listed in grams, and the charging equipment is calibrated in ounces, multiply the system capacity by .0353 to convert grams to ounces.
  Example: Convert 600 grams into ounces. 600g X .0353 = 21.18 oz.

- If the refrigerant charge specification is listed in kilograms, and the charging equipment is calibrated in pounds, multiply the system capacity by 2.20 to convert kilograms to pounds.
  Example: Convert 1.5 kg into pounds. 1.5 kg X 2.205 = 3.307 lb.

NOTES

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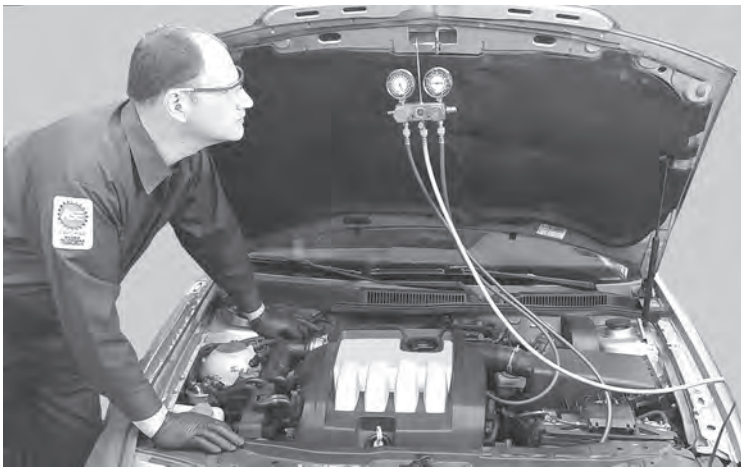

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