



SURFACE VEHICLE RECOMMENDED PRACTICE

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Air Conditioning Service Procedures for Off-Road Work Machines and Agricultural Tractors Using HFC-134a or HFO-1234yf Refrigerant

RATIONALE

This SAE Recommended Practice provides the air conditioning (A/C) technician with industry-approved best practices to service and maintain mobile A/C systems that use R-134a or R-1234yf refrigerants. Tools and procedures for servicing the refrigerant portion of A/C systems in off-road work machines and agricultural tractors are similar to those used with other mobile A/C systems, with several differences addressed in this SAE Recommended Practice. The adoption of refrigerant R-1234yf, a low GWP alternative with an A2L classification indicating the refrigerant has a low toxicity but is mildly flammable, requires certain tools and precautions for proper service. These guidelines are superseded by detailed procedures, information, and training provided by the OEM specific to the equipment being serviced.

FOREWORD

Off-road work machine and agricultural tractor air conditioning has typically utilized standards, procedures, and technologies developed by the automotive industry and the SAE Interior Climate Control Standards Committee (ICCSC). These procedures may not adequately address the unique challenges encountered by off-road MVAC technicians.

This SAE Recommended Practice addresses the following challenges when servicing off-road work machine and agricultural tractor HVAC systems:

- **Field service:** Off-road equipment and agricultural tractor HVAC technicians often work on equipment in the field without a shop-style recovery, recycling, and recharge machine. Instead, the technician shall use portable equipment that conforms to EPA refrigerant recovery regulations. This document directs the technician to appropriate equipment and service techniques to properly recover and handle R-134a and R-1234yf refrigerants.
- **Internal volume:** Off-road equipment and agricultural tractor HVAC systems typically have much greater internal volume, hose lengths, and refrigerant charges compared to passenger car systems, which may require different tools and procedures to properly service.
- **Hoses/moisture ingress:** Off-road equipment and agricultural tractor HVAC systems primarily use flexible hoses that are much longer than those found on passenger cars and light trucks. With long hoses, moisture ingress, adequate refrigerant recovery, and vacuum times become a significant concern.
- **Air filtration/cab pressurization and sealing:** Off-highway work machines and agricultural tractors often have a fixed recirculated/outside air mix, which is regulated by filter restriction and cab sealing. The ventilation system is a critical part of proper operator environment conditioning. It is appropriate to include filter and cab sealing maintenance in off-road equipment and agricultural tractor HVAC recommended procedures and training.

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- Leak testing: Due to the larger internal volume and hose lengths found on many off-road equipment and agricultural tractor HVAC systems, the procedure times for vacuum and pressure decay leak detection are often longer than used with smaller passenger car systems.
- R-1234yf is a mildly flammable A2L refrigerant, requiring specific recovery, recycling, recharging, and leak detection tools and training for safe handling.

1. SCOPE

- 1.1 This SAE Recommended Practice is intended to provide technicians with safe and efficient techniques and general equipment recommendations for servicing mobile air conditioning systems in off-road, self-propelled work machines as defined in SAE J1116 and tractors and machinery for agriculture and forestry as defined in ASABE standard ANSI/ASAE S390. Both refrigerants HFC-134a (R-134a) and HFO-1234yf (R-1234yf) are covered. Many service procedures are similar for both refrigerants, but recovery, recycling, charging, and electronic leak detection tools can be unique to each refrigerant.
- 1.2 This SAE Recommended Practice is intended as a guide toward standard practice and is subject to change to keep pace with experience and technical advances.
- 1.3 This SAE Recommended Practice is not intended to recommend retrofit procedures or specific components (oil types, seal composition, etc.). Refer to OEM service information.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J639	Safety and Design Standards for Motor Vehicle Refrigerant Vapor Compression Systems
SAE J1116	Categories of Off-Road Self-Propelled Work Machines
SAE J1628	Technician Procedures for Refrigerant Leak Detection in Service of Mobile Air Conditioning Systems
SAE J2099	Standard of Purity for R-134a (HFC-134a) and R-1234yf (HFO-1234yf) for Use in Mobile Air-conditioning Systems
SAE J2297	Ultraviolet Leak Detection: Stability and Compatibility Criteria of Fluorescent Refrigerant Leak Detection Dyes for Mobile R-134a and R-1234yf (HFO-1234yf) Air-Conditioning Systems
SAE J2788	HFC-134a (R-134a) Recovery/Recycle/Recharging Equipment for Mobile Air-Conditioning Systems
SAE J2791	HFC-134a Refrigerant Electronic Leak Detectors, Minimum Performance Criteria
SAE J2810	HFC-134a (R-134a) Refrigerant Recovery Equipment for Mobile Automotive Air-Conditioning Systems
SAE J2843	R-1234yf (HFO-1234yf) Recovery/Recycling/Recharging Equipment for Flammable Refrigerants for Mobile Air-Conditioning Systems
SAE J2844	R-1234yf (HFO-1234yf) New Refrigerant Purity and Container Requirements for Use in Mobile Air-Conditioning Systems

SAE J2851	Recovery Equipment for Contaminated R-134a or R-1234yf Refrigerant from Mobile Automotive Air Conditioning Systems
SAE J2913	R-1234yf [HFO-1234yf] Refrigerant Electronic Leak Detectors, Minimum Performance Criteria
SAE J2970	Minimum Performance Requirements for Non-Refrigerant Tracer Gases and Electronic Tracer Gas Leak Detectors
SAE J3030	Automotive Refrigerant Recovery/Recycling/Recharging Equipment Intended for Use with Both R-1234yf and R-134a
TSB 003	Rules for SAE Use of SI (Metric) Units

2.1.2 AHRI Publications

Available from the Air-Conditioning, Heating, and Refrigeration Institute, 2311 Wilson Blvd., Suite 400, Arlington, VA 22201, <https://www.ahrinet.org/>.

AHRI Standard 700 Specifications for Refrigerants

AHRI Standard 740 Performance Rating of Refrigerant Recovery Equipment and Recovery/Recycling Equipment

2.1.3 ANSI Accredited Publications

Copies of these documents are available online at <https://webstore.ansi.org/>

ANSI/ASAE S390 Tractors and Machinery for Agriculture and Forestry - Basic Types - Vocabulary

2.1.4 ASHRAE Publications

Available from ASHRAE Headquarters, 1791 Tullie Circle, NE, Atlanta GA 30329, Tel: 800-527-4723 (U.S. and Canada only) or 404-636-8400, www.ashrae.org.

ASHRAE Psychrometric Chart App, <https://www.ashrae.org/technical-resources/bookstore/psychrometrics>

2.1.5 Code of Federal Regulations (CFR) Publications

Available from United States Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401, Tel: 202-512-1800, www.gpo.gov.

40 CFR Part 82 Protection of Environment - Protection of Stratospheric Ozone

2.1.6 MACS Publications

Available from the Mobile Air Climate Systems Association, 225 S. Broad St., Lansdale, PA 19446, <https://macsmobileairclimate.org/>.

Certification Training Manual, Including Refrigerant Recycling and Service Procedures for Mobile Air Conditioning Technicians and Best Service Practices

2.1.7 UL Publications

Available from UL, 333 Pfingsten Road, Northbrook, IL 60062-2096, Tel: 847-272-8800, www.ul.com.

UL 1963 Standard for Refrigerant Recovery/Recycling Equipment

3. DEFINITIONS

3.1 AIR PURGE

To remove non-condensable gas (air) from a refrigerant cylinder. This can be done automatically by some refrigerant recovery machines or is done manually using the refrigerant saturation pressure and temperature relationship.

3.2 CHARGE OR RECHARGE

The process of adding the correct amount of new or recycled refrigerant into an air conditioning (A/C) system. Before recharging an A/C system, the system shall be evacuated of air and leak tested.

3.3 EVACUATION/VACUUM

The process of removing air and moisture from the refrigerant system before charging with refrigerant. Evacuation is done through the service ports using a vacuum pump. Excessive air or moisture remaining in the A/C system during the refrigerant charge process will cause increased pressures during operation, resulting in reduced or poor cooling and greatly reduced compressor life.

3.4 FLUSH AGENT

A liquid used to remove contaminants from a mobile A/C system. Flush agent may be a solvent, a refrigerant, or another liquid material. Flush agents fill the A/C component and should not harm the components at 100% concentration.

3.4.1 Refrigerant as a Flush Agent

Refrigerant can be used as a flush agent in a closed-cycle process with specialized equipment.

3.5 FLUSH PROCEDURE

The process by which a flushing agent is used to remove contaminants and refrigerant oil from a mobile A/C component or system.

3.6 MVAC-LIKE APPLIANCE

The EPA designation for air conditioning found in farm equipment and other off-road equipment. The following link will take you to the EPA page "Servicing Requirements for Farm and Heavy-Duty Equipment," which summarizes the specific regulations that apply to servicing MVAC-like appliances: <https://www.epa.gov/mvac/servicing-requirements-farm-and-heavy-duty-equipment>.

3.7 NITROGEN PURGE

The use of nitrogen gas to accelerate the evaporation of a flush agent or assist in moisture removal during evacuation. When used during evacuation, this is often called "triple evacuation" or "nitrogen sweep."

3.8 RECLAIM

The process of sending recovered refrigerant to a facility that can recondition the refrigerant to meet AHRI Standard 700 or to properly dispose of the refrigerant. EPA-certified refrigerant reclaimers can be found at: <https://www.epa.gov/section608/epa-certified-refrigerant-reclaimers>.

3.9 RECOVERY

The process of removing refrigerant from an A/C system and transferring it into an approved refrigerant container. Adequate refrigerant recovery is required to reduce emissions and provide for accurate recharging of the mobile A/C system.

3.10 RECYCLE

To reduce contaminants in recovered refrigerant by separating oil, removing non-condensable gas, and reducing moisture, acidity, and particulate matter to meet the purity standards of SAE J2099.

3.11 REFRIGERANT PURGE

A process used in A/C recovery and recover-only equipment, after the A/C system recovery process has been completed, to transfer refrigerant remaining inside the recovery unit into the recovery cylinder. This reduces emissions and allows the weighing of the recovery cylinder for more accurate monitoring of the amount of refrigerant recovered.

3.12 LEAK DETECTION

3.12.1 Leak detection (leak testing) is the examination of an A/C system to determine the presence and location of a refrigerant leak (or leaks). Methods include visual and fluorescent tests, bubble tests, and the use of electronic leak detection devices.

3.12.2 Methods that determine whether the system is leaking - but do not determine the location of a leak - such as standing pressure/vacuum decay tests and pressure gauge checks, are not leak inspections by themselves and shall be used in conjunction with methods that can determine the location of a leak.

3.12.3 A verification test is a check to make sure that repairs were successful before refrigerant is added back into the system. This test is performed after the leak has been located and repairs are made but typically before the A/C system has been recharged and returned to normal operating conditions.

3.12.4 Detailed leak testing procedures can be found in the MACS Certification Training Manual and SAE J1628. It is important to be familiar with a variety of leak testing methods since some methods described will only identify the presence of a leak and will not necessarily locate the leak. For example, system vacuum and pressure decay (pressure change or loss over time) are useful for identifying whether a system has a relatively large leak prior to charging with refrigerant but may not pinpoint the leak location. Further test methods may be used to locate the leak.

3.12.5 Many leaks can be identified on a system that has been in service by an initial visual inspection. Oily dirt, particularly around joints or on the face of the condenser, may indicate the presence of a refrigerant leak. Visual inspection may also include the use of a fluorescent dye inspection lamp and protective glasses if the system contains fluorescent dye. See 9.2.4. When a suspected leak is located by visual inspection, it can be verified using an electronic leak detector.

3.12.6 Leak sizes can vary. Leak detection methods can vary based on number and location.

3.13 TYPE OF LEAK DETECTION (LEAK TEST) METHOD

3.13.1 Soap bubble leak test. Low sensitivity and equally usable in shop and field environments. Requires system pressurization. Useful to confirm leak tightness of repairs. See 9.2.1.

3.13.2 Electronic leak detection with refrigerant. High sensitivity and equally usable in shop and field environments. Provides quantitative results and indicates a leak site. Needs pressurized refrigerant lines. Can be susceptible to airflow and can give false-positive indications when used around some common fluids. See 9.2.2.

3.13.3 Electronic leak detection with trace gas (aka tracer gas leak test). High sensitivity and provides quantitative results. Indicates a leak site. Needs refrigerant lines pressurized to be pressurized with forming gas. A portable forming gas tank is required for field use. Can be susceptible to airflow and can give false-positive indications when used around some common fluids. See 9.2.3.

- 3.13.4 Fluorescent leak detectors. High sensitivity and equally usable in shop and field environments. Especially useful in finding the exact sources of leakage, multiple leaks, and intermittent leaks. Compressor shall be operational when dye is first injected to circulate the dye. Once dye is injected, it remains operational for the life of the compressor oil. Shading is required if inspections are to be performed in bright, ambient lighting. See 9.2.4.
- 3.13.5 Ultrasonic leak detection. Low sensitivity and equally usable in shop and field environments. Easily used in conjunction with other pressure-based procedures. Confirms the exact location of a leak. It can be affected by background noises, wind, or echoes. See 9.2.5.
- 3.13.6 Vacuum decay/pressure decay leak test. Moderate sensitivity and equally usable in shop and field environments. Easily used in conjunction with other pressure-based procedures. Confirms the presence of a leak without indicating its location. See 9.2.6 and 9.2.7.

4. ACRONYMS, ABBREVIATIONS, AND SYMBOLS

°C	degrees Celsius
°F	degrees Fahrenheit
A/C	Air Conditioning
AHRI	Air-Conditioning, Heating, and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
CFM	Cubic Feet per Minute
ELD	Electronic Leak Detector
EPA	Environmental Protection Agency
GWP	Global Warming Potential
HFC	Hydrofluorocarbon
HFO	Hydrofluoroolefin
HVAC	Heating Ventilation and Air Conditioning
ICCSC	Interior Climate Control Standards Committee
kPa	kilopascal
MAC	Mobile Air Conditioning
MVAC	Motor Vehicle Air Conditioning
OEM	Original Equipment Manufacturer
P/T Chart	Pressure/Temperature Chart
psig	pounds per square inch gauge
RH	Relative Humidity
RRR:	Recover, Recycle, and Recharge. Refers to RRR equipment (aka RRR machine, aka charge cart, aka refrigerant management system).

SDS Safety Data Sheet(s)

UV Ultraviolet

5. UNITS OF MEASURE

- 5.1 As per the SAE TSB 003 guidelines, vacuum will be listed in units of kPa (kilopascal) and microns. Performance standards are typically written in units of kPa. However, technicians typically work with inches of mercury (inHg) or microns (1 mbar = 0.1 kPa; 1 torr is equivalent to 1 mmHg or 1000 microns). See Table 1 for conversions.

Table 1

Old Units	New Units	Multiply by
lbf/in ²	kPa	6.894757
lbf/in ² (absolute)	kPa	6.894757
lbf/ft ²	kPa	0.04788026
inHg (60 °F)	kPa	3.37685
inH ₂ O (60 °F)	kPa	0.24884
ftH ₂ O (60 °F)	kPa	2.98608
mmHg (0 °C) (torr)	kPa	0.133322
kgf/cm ²	kPa	98.0665
bar	kPa	100
atm (standard = 760 torr)	kPa	101.325
torr (mmHg, 0 °C)	kPa	0.133322
micron	kPa	0.0001333

6. SAFETY REQUIREMENTS

- 6.1 Service technicians shall follow safety guidelines learned during Section 609 or Section 608 certification training, from OEM training materials, and from SAE J639. This will include reading and following the appropriate Material Safety Data Sheets for the refrigerant they are working with. These documents provide information on safety and the proper personal protective equipment to use when handling R-134a and R-1234yf refrigerants. If a technician's Section 609 certificate was issued prior to January 1, 2015, it is recommended they review the updated training material, which includes safe handling of refrigerant R-1234yf.

6.2 Fluorescent Leak Detection Safety

- 6.2.1 Safety glasses should always be worn whenever working on a pressurized system. The safety glasses provided with the inspection lamp should be worn during all dye injections and leak inspection procedures. These glasses protect from accidental exposure to a pressurized stream of dye or refrigerant and direct exposure to the light emitted by the lamp. In addition, these glasses aid in the detection of small, hard-to-find leaks by neutralizing the color of the light emitted from the lamp, which may mask the fluorescence of the leak.
- 6.2.2 Do not direct fluorescent inspection lamps at eyes.
- 6.2.3 Refer to the fluorescent dye's SDS to assess any chemical safety hazards.

7. REGULATIONS

7.1 EPA Servicing Requirements for MVAC-Like Appliances: Agricultural and Off-Road Equipment

7.1.1 Certification

7.1.1.1 Technicians servicing or repairing farm equipment and off-road equipment shall be trained and certified by an EPA-approved organization. Certification is obtained by passing an EPA-approved examination. This is referred to as Section 608 Type-II certification or Section 609 certification and training. Certification is required for all technicians servicing mobile A/C systems (including off-road work machine and agricultural tractor air conditioners).

7.1.2 Venting

Release of refrigerant is prohibited; the refrigerant shall be recovered.

7.1.3 Technician Certification

Anyone servicing an MVAC-like appliance shall recover and recycle refrigerant in accordance with the regulations specified in 40 CFR Part 82, Section 82.32.

7.1.4 Equipment

Certified recovery and recycling equipment shall be used: <https://www.epa.gov/mvac/section-609-certified-equipment>.

7.1.5 Recharging Refrigerant

Technicians shall recycle refrigerant before recharging it into an MVAC-like appliance, even if the refrigerant is returned to the same equipment from which it was extracted.

7.1.6 EPA servicing requirements for farm and heavy-duty equipment: <https://www.epa.gov/mvac/servicing-requirements-farm-and-heavy-duty-equipment>.

7.1.7 This list is not exhaustive. For a more complete and updated list of EPA requirements, refer to <https://www.epa.gov/mvac/servicing-requirements-farm-and-heavy-duty-equipment>.

7.1.8 EPA-certified reclaimers: <https://www.epa.gov/section608/epa-certified-refrigerant-reclaimers>.

7.1.9 Reuse of Recovered Refrigerant

7.1.9.1 EPA regulations require that refrigerant shall be recycled or reclaimed before reuse. Recovered refrigerant shall be recycled to the SAE J2099 purity standard using a recycling machine that meets SAE J2788 (for R-134a), SAE J2843 (for R-1234yf), or SAE J3030 (for either R-134a or R-1234yf). Reclaimed refrigerant shall be processed by an EPA-approved reclaimer to meet AHRI Standard 700.

7.1.9.2 Prior to recycling, R-134a should be identified using an SAE-certified refrigerant identifier.

7.1.9.3 Prior to recycling, R-1234yf shall be identified using an SAE-certified refrigerant identifier.

7.2 Additional local requirements may also apply.

8. RECOMMENDED EQUIPMENT

8.1 Recover, Recycle, and Recharge Equipment

8.1.1 EPA-approved recovery, recycling, and recharging equipment shall be used when servicing farm and heavy-duty off-road HVAC systems. See 7.1.4.