



SURFACE VEHICLE STANDARD

J639™

NOV2020

Issued 1953-04
Revised 2020-11

Superseding J639 DEC2011

(R) Safety and Design Standards for Motor Vehicle Refrigerant Vapor Compression Systems

RATIONALE

This document covers refrigerant system design and safety related requirements for refrigerants used in mobile air conditioning (MAC) systems and is being updated for the addition of a secondary loop R-152a system and general improvements for example and clarity. The intent of this standard is to ensure safe MAC systems by forcing proper risk assessments and appropriate design solutions.

1. SCOPE

This SAE Standard applies to refrigerant vapor compression systems that provide cooling and/or heating for passenger cars, light trucks, and commercial vehicles (on and off road) that use automotive type mobile air conditioning (MAC) systems. Large trucks, buses, and other vehicles that do not use typical automotive A/C systems or use refrigerants not listed in this document are not covered by this standard. This standard covers vehicles with MAC systems using belt driven compressors and electric motor driven compressors.

This document provides industry-recognized standards for the design, assembly, and test of MAC systems, including necessary service equipment, and is intended to cover all phases of the lifetime of MAC systems to minimize environmental, health, and safety impacts. The standards listed in this document cover the currently accepted industry guidelines and procedures. The standards can be used as requirements for regulatory authorities to meet minimum environmental, health, and safety requirements. Also included are cautionary statements for the service industry to alert technicians to the inadvisability and possible health or safety effects associated with venting refrigerant during service. It is not intended to restrict the use, or further development of, other types of refrigerants or refrigeration systems for MAC applications. This document may be amended, or additional safety standards created, should other refrigerants or refrigeration systems become practical. This document addresses only HFC-134a (R-134a), carbon dioxide (R-744), HFO-1234yf (R-1234yf), and HFC-152a (R-152a) refrigerants. For R-152a refrigerants, this standard will only apply to secondary loop systems. To prevent system contamination, all refrigerants used in MAC vapor compression systems require unique service fittings and service equipment. The unique service fittings are intended to significantly reduce the potential for refrigerant cross-contamination during service activities.

CFC-12 (R-12) is no longer in use in new MAC systems. The service fitting description is maintained as a reference for older vehicles still in use. When retrofitting an R-12 system to use R-134a or when removing R-12 (during vehicle disposal), use service equipment designed for R-12 and certified to meet the requirements of SAE J1990 (R-12 recovery and recycle equipment).

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Documents

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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.

2.1.1.1 System Design Guidelines

SAE J2683	Refrigerant Purity and Container Requirements for Carbon Dioxide (CO ₂ R-744) Used in Mobile Air-Conditioning Systems
SAE J2772	Measurement of Passenger Compartment Refrigerant Concentrations Under System Refrigerant Leakage Conditions
SAE J2776	Refrigerant Purity and Container Requirements for New HFC-134a 1,1,1,2-Tetrafluoroethane Refrigerant Used in Mobile Air-Conditioning Systems
SAE J2844	R-1234yf (HFO-1234yf) New Refrigerant Purity and Container Requirements for Use in Mobile Air-Conditioning Systems
SAE J3188*	R-152a (HFC-152a) New Refrigerant Purity and Container Requirements for Use in Mobile Air-Conditioning Systems

2.1.1.2 System Components

SAE J2842	R-1234yf and R-744 Design Criteria and Certification for OEM Mobile Air Conditioning Evaporator and Service Replacements
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2.1.1.3 Service Activities

SAE J2197	HFC-134a (R-134a) Service Hose Fittings for Automotive Air-Conditioning Service Equipment
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 J2670*	Stability and Compatibility Criteria for Additives and Flushing Materials Intended for Aftermarket Use in R-134a (HFC-134a) and R-1234yf (HFO-1234yf) Vehicle Air-Conditioning Systems
SAE J2888	R-1234yf Service Hose, Fittings and Couplers for Mobile Refrigerant Systems Service Equipment
SAE J3223*	R-152a (HFC-152a) Service Hose, Fittings and Couplers for Mobile Refrigerant Systems Service Equipment

2.1.1.4 Technician Service Procedures

SAE J2845*	R-1234yf (HFO-1234yf) and R-744 Technician Training for Service and Containment of Refrigerants Used in Mobile A/C Systems
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2.1.1.5 Service Equipment

SAE J1990	Recovery and Recycle Equipment for Mobile Automotive Air-Conditioning Systems
SAE J2099*	Standard of Purity for Recycled R-134a (HFC-134a), R-1234yf (HFO-1234yf) and R-152a (HFC-152a) for Use in Mobile Air-conditioning Systems
SAE J2209	CFC-12 (R-12) Refrigerant Recovery Equipment for Mobile Automotive Air-Conditioning Systems
SAE J2296	Retest of Refrigerant Container
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 J2851*	R-1234yf (HFO-1234yf) Refrigerant Recovery Equipment for Mobile Automotive Air-Conditioning Systems
SAE J2912	Performance Requirements for R-134a and R-1234yf Refrigerant Diagnostic Identifiers for Use with Mobile Air Conditioning Systems
SAE J2913	R-1234yf (HFO-1234yf) Refrigerant Electronic Leak Detectors, Minimum Performance Criteria
SAE J2927	R-1234yf (HFO-1234yf) Refrigerant Identifier Installed In Recovery and Recycling Equipment for Use With Mobile A/C Systems
SAE J3212*	R-152a (HFC-152a) Refrigerant Identifier Installed in Recovery and Recycling Equipment for Use With Mobile A/C Systems
SAE J3221*	R-152a (HFC-152a) Refrigerant Electronic Leak Detectors, Minimum Performance Criteria
SAE J3222*	R-152a (HFC-152a) Recovery/Recycling/Recharging Equipment for Flammable Refrigerants for Mobile Air-Conditioning Systems

2.1.1.6 Retrofit Documents

SAE J1660	Fittings and Labels for Retrofit of CFC-12 (R-12) Mobile Air-Conditioning Systems to HFC-134a (R-134a)
SAE J1661	Procedure Retrofitting CFC-12 (R-12) Mobile Air-Conditioning Systems to HFC-134a (R-134a)

2.1.1.7 Reference Documents

SAE J51	Refrigerant 12 Automotive Air-Conditioning Hose
SAE J1627	Performance Criteria for Electronic Refrigerant Leak Detectors
SAE J1628	Technician Procedures for Refrigerant Leak Detection in Service of Mobile Air Conditioning Systems
SAE J1657	Selection Criteria for Retrofit Refrigerants to Replace CFC-12 (R-12) in Mobile Air-Conditioning Systems
SAE J1658	Alternate Refrigerant Consistency Criteria for Use in Mobile Air-Conditioning Systems

SAE J1659	Vehicle Testing Requirements for Replacement Refrigerants for CFC-12 (R-12) Mobile Air-Conditioning Systems
SAE J1662	Compatibility of Retrofit Refrigerants with Air-Conditioning System Materials
SAE J1732	HFC-134a (R-134a) Refrigerant Recovery Equipment for Mobile Automotive Air-Conditioning Systems
SAE J1739	Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA)
SAE J1770	Automotive Refrigerant Recovery/Recycling Equipment Intended for Use with both R12 and R134a
SAE J1771	Criteria for Refrigerant Identification Equipment for Use with Mobile Air-Conditioning Systems
SAE J1989	Recommended Service Procedure for the Containment of CFC-12 (R-12)
SAE J1991	Standard of Purity for Use in Mobile Air-Conditioning Systems
SAE J2064	Coupled Automotive Refrigerant Air-Conditioned Hose Assemblies
SAE J2065	Desiccant Testing for Vehicle Air Conditioning Systems
SAE J2196	Service Hose for Automotive Air Conditioning
SAE J2211	Recommended Service Procedure for the Containment of HFC-134a (R-134a)
SAE J2298	Ultraviolet Leak Detection: Procedure for Use of Refrigerant Leak Detection Dyes for Service of Mobile Air-Conditioning Systems
SAE J2299	Ultraviolet Leak Detection: Performance Requirements for Fluorescent Refrigerant Leak Detection Dye Injection Equipment for Aftermarket Service of Mobile Air-Conditioning Systems
SAE J2727*	HFC-134a Mobile Air Conditioning System Refrigerant Emission Chart
SAE J2763	Test Procedure for Determining Refrigerant Emissions from Mobile Air Conditioning Systems
SAE J2765	Procedure for Measuring System COP (Coefficient of Performance) of a Mobile Air Conditioning System on a Test Bench
SAE J2766	Life Cycle Analysis to Estimate the CO ₂ -Equivalent Emissions from MAC Operation
SAE J2911	Procedure for Certification that Requirements for Mobile Air Conditioning System Components, Service Equipment, and Service Technician Training Meet SAE J Standards

2.1.1.8 Referenced Standards with Asterisk (*)

All referenced standards that have an asterisk (*) following the standard may not be fully approved and available relative to the content for refrigerant R-152a in a secondary loop. If an application with R-152a secondary loop is under consideration and the referenced standard does not include R-152a, then please contact the SAE International Interior Climate Control Committee (ICCS) Chairman via the SAE International website, www.sae.org.

2.1.2 Other Industry Standards

2.1.2.1 ISO Publications

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

ISO/CD 13043	Road Vehicles - Refrigerant Systems Used in Mobile Air Conditioning Systems (MAC) - Safety Requirements
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2.1.2.2 AHRI Publications

Available from Air-Conditioning, Heating and Refrigeration Institute, 4100 North Fairfax Drive, Suite 200, Arlington, VA 22203, Tel: 703-524-8800, www.ahri.org.

AHRI Standard 700-2006 with Addendum 1: Specification for Fluorocarbon Refrigerants

2.1.2.3 ANSI Accredited Publications

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

ANSI/UL 969-1991 Standard for Marking and Labeling Systems

2.1.3 Regulatory Requirements

2.1.3.1 All refrigerants used in the USA shall comply with requirements for proper use as defined by the Environmental Protection Agency's (EPA) Significant New Alternatives Program (SNAP) Regulation. The full SNAP list with refrigerants and use conditions can be found in the U.S. federal register at U.S. EPA 40 CFR Part 82 Subpart G Appendix B. Certain state regulations in the USA also refer to SAE J639.

2.1.3.2 All motor vehicles automotive refrigerants may be subject to and must comply with all legal regulations as required by local, national, or international authorities.

2.1.3.3 Mobile air conditioning (MAC) systems originally designed by an OEM vehicle manufacturer and modified to use aftermarket refrigerant circuit components and/or up-fitted with additional refrigerant components or a complete MAC system and labeled to this standard shall continue to meet SAE J639 and all related SAE Standards when modified.

3. DEFINITIONS

3.1 System Definitions

3.1.1 MOBILE AIR CONDITIONING (MAC) SYSTEM

A MAC system provides occupant comfort and inclement weather window clearing by heating or cooling and dehumidifying the air that is delivered to the passenger compartment through various air distribution outlets in the interior of the vehicle.

3.1.2 HEATING/COOLING PHASE

The heating phase may include the use of waste engine heat, electric heating elements, or a refrigerant heat pump cycle. The cooling phase is provided by a mechanical vapor compression refrigerant cycle referred to as a refrigerant system. Air filtering devices (if equipped) protect the heating, ventilation, and air conditioning (HVAC) unit and occupants of the vehicle from certain particulate contaminants that can be in the airflow.

3.1.3 HEATING, VENTILATION, AND AIR CONDITIONING (HVAC) SYSTEM

The HVAC system generally includes a module or an assembly of related modules that have a blower motor to move air into or around the vehicle, a cooling system to remove heat and dehumidify the air (evaporator core or cooler core for secondary loop systems), a heating system to warm the air (heater core, positive temperature coefficient (PTC) heaters or heat pump interior condenser), air dampers, actuators, and relevant housings. It may also include an air distribution system and controls. The HVAC unit is usually located between the vehicle firewall (front of dash) and the instrument panel and may be integrated into a cockpit assembly that includes the instrument panel. Additional units may also be located inside the vehicle for additional cooling/heating zones.

3.1.4 AIR DISTRIBUTION SYSTEM

The air distribution system generally includes ducts, air inlet openings for outside or recirculated air, and the outlet/grille openings to the passenger compartment.

3.1.5 MECHANICAL VAPOR COMPRESSION REFRIGERANT SYSTEM

A mechanical vapor compression refrigerant system is used to condition the air for a passenger compartment of a motor vehicle. The air conditioning refrigerant system is designed to cool, dehumidify or heat the air for the passenger compartment. A heat pump refrigerant system may provide cooling/dehumidifying and heating modes.

3.1.6 REFRIGERANT CIRCUIT

The refrigerant circuit is defined as follows:

- 3.1.6.1 The refrigerant system is connected by lines forming a closed loop refrigerant cycle between system components where the refrigerant circulates at different temperatures and pressures. The refrigerant lines make connections between the system components including the compressor, condenser(s)/gas cooler, refrigerant control device(s), evaporator(s)/chiller(s), refrigerant storage devices (accumulator or receiver/drier), and (if used) internal heat exchanger (IHx).
- 3.1.6.2 The high-pressure side of the refrigerant system is defined as the portion of the circuit from the compressor discharge port to the inlet of the refrigerant flow control device before the evaporator(s)/chiller. Heat pump systems, depending upon the operating mode (cooling or heating), may have different high or low side operating pressures.
- 3.1.6.3 The low-pressure side of the refrigerant system is defined as all parts of the refrigerant system not included in the definition of 3.1.6.2. Heat pump systems, depending upon the operating mode (cooling or heating), may have different high or low side operating pressures.
- 3.1.6.4 The refrigerant is used to transfer heat by absorbing heat at low temperatures and pressures and by rejecting heat at higher temperatures and pressures.

3.1.7 MAC REFRIGERANT SYSTEM

A MAC refrigerant system provides cooling for the passenger compartment by vaporizing refrigerant at the evaporator or chiller. When a MAC refrigerant system is used as a heat pump, a heat exchanger inside the vehicle may act as a condenser (gas cooler) and provides heat to the passenger compartment.

- 3.1.7.1 A multiple evaporator system uses a single compressor and condenser (gas cooler), but employs more than one evaporator in parallel refrigerant paths. Additional evaporators chillers are generally used to cool another part of the passenger compartment or cool specific parts such as electrical/electronic components for hybrid or electric vehicles.

3.1.8 SECONDARY LOOP SYSTEM

A secondary loop system uses a primary refrigerant loop located in the engine compartment and a secondary fluid loop with a circulating pump and a cooling core in the interior of the vehicle. This isolates the primary refrigerant from the passenger compartment. The cooling core provides cooled airflow into the passenger compartment, replacing the traditional MAC evaporator. The secondary loop system is sometimes called an "indirect system." The secondary loop fluid is generally a water and ethylene glycol mixture.

3.1.9 REFRIGERANT PRESSURE RELIEF DEVICE

A refrigerant pressure relief device is a mechanically or electrically activated (not temperature actuated) valve or rupture membrane designed to automatically relieve pressure to avoid exceeding the system maximum operating pressure. The maximum system pressure is defined for each refrigerant in this standard.

3.1.10 PRESSURE/TEMPERATURE SENSORS

Pressure sensors, temperature sensors, or pressure/temperature sensors may be used to control conditions in a refrigerant circuit.

3.2 REFRIGERANT SYSTEM

The refrigerant system can consist of:

3.2.1 COMPRESSOR (PUMP)

A compressor (pump) that raises the pressure of the refrigerant vapor and, in so doing, also raises its temperature.

3.2.1.1 The compressor mechanically increases the pressure of the refrigerant vapor by drawing the low temperature, low pressure refrigerant from the evaporator, internal heat exchanger, or chiller outlet and compressing it to a high temperature, high pressure refrigerant to be sent to the condenser/gas cooler inlet.

3.2.1.2 The compressor can be belt driven using the engine or transmission or other power transmission source or electrically driven (hermetic and/or semi-hermetic).

3.2.1.3 The mechanically driven compressor is generally mounted on the engine and must be designed to accept the varying refrigerant loads as well as the varying belt loads and speeds of the engine over the lifetime of the vehicles.

3.2.2 CONDENSER (GAS COOLER)

A condenser (gas cooler) is the heat exchanger (typically located in the vehicle front end behind the air inlet grille) which is used to reject heat to the ambient environment. When the refrigerant system is operating as a heat pump, it may operate as an evaporator and absorb heat from the ambient environment (or other energy source).

3.2.2.1 In the condenser of a traditional MAC system, vaporized refrigerant is condensed to a liquid by removal of heat from the refrigerant, which is released to the ambient airflow.

3.2.2.2 In a gas cooler (e.g., R-744 system), heat is removed from a supercritical refrigerant in a trans-critical refrigerant system.

3.2.2.3 Some heat pump systems use a cabin (or inside) condenser in the HVAC module to heat air for the passenger compartment.

3.2.3 EXPANSION OR REFRIGERANT METERING DEVICE

An expansion or refrigerant metering device regulates the refrigerant flow into the evaporator/chiller. Typical refrigerant flow control device may consist of a thermal expansion valve (TXV), a fixed metering device (orifice tube or ejector/capillary tube), an electronic expansion valve (EXV), or other expansion devices.

3.2.3.1 Sensors, wiring, hoses, tubing, connections, blowers, cooling fans, non-evaporative heat transfer fluid circulating pumps (secondary loop systems), and mode selecting valves (for switching between cooling and heat pump systems) may also be used.

3.2.4 RECEIVER/DRIER (RD) OR ACCUMULATOR/DEHYDRATOR (AD)

A receiver/drier (RD) or accumulator/dehydrator (AD) is used as a refrigerant storage device that may also contain desiccant material for moisture adsorption. An RD is used to separate liquid from a liquid/vapor mixture to improve the liquid quality before expansion. An AD is used to separate vapor from a liquid/vapor mixture to improve the quality of the vapor at the compressor inlet.

3.2.5 INTERNAL HEAT EXCHANGER (IHX)

An internal heat exchanger (IHX) may be used to transfer heat between the low-pressure and high-pressure refrigerant flow circuits. Its function is to improve system performance by further sub-cooling the refrigerant being supplied to the evaporator through the refrigerant control device. It may also help ensure that vapor is supplied to the compressor.

3.2.6 EVAPORATOR

An evaporator is an air to refrigerant heat exchanger, located in the HVAC module, used to cool and dehumidify the air for the vehicle air conditioning system. When a MAC system is used as a heat pump, the evaporator may also act as a condenser (gas cooler), providing heat to the passenger compartment.

3.2.7 COOLER CORE

A cooler core is an air to cooling fluid heat exchanger located in the HVAC module with secondary loop systems and is used to cool and dehumidify air for the vehicle air conditioning system. The cooling fluid (usually water and ethylene glycol) is cooled by a chiller under the hood of the vehicle prior to being pumped to the cooler core.

3.2.8 CHILLER

A chiller is a fluid to refrigerant heat exchanger that is generally located underhood that removes heat from the cooling fluid by evaporating low pressure refrigerant to a vapor. Chillers may be used to help cool components or other fluids in the vehicle (batteries, electronics, oil, etc.). With a secondary loop MAC system, the chiller is used to chill the cooling fluid that is then pumped to the cooler core, which replaces the evaporator, in the HVAC module for cooling or dehumidifying air for the passenger compartment.

3.3 BURST PRESSURE

Burst pressure is the internal pressure which causes a refrigerant component to structurally fail resulting in refrigerant leakage.

NOTE: All physical dimensions and units are expressed in SI units and all indicated pressures are in kPa gauge unless otherwise noted.

3.4 WORKING PRESSURE

Working pressure is the measured refrigerant pressure in a component of the MAC system when it is in normal operation. It may be referenced in gauge or absolute pressure values. This document uses gauge values as reference if not otherwise specified.

3.5 MAXIMUM WORKING PRESSURE

Maximum working pressure is the maximum pressure in a component of the MAC system (measured as gauge or absolute pressure) for which the system is designed. It shall not exceed the system's pressure control devices settings (e.g., electric shutoff or mechanical pressure relief specification).

4. REFRIGERANTS

4.1 Safety Requirements for Refrigerants Used in Mobile Air Conditioning (MAC) Systems

4.1.1 The toxicity and flammability of the refrigerants or refrigerant blends, including their decompositions created as a result of normal refrigerant system operating conditions, shall be considered in the design of safe MAC systems and must be included in any risk assessments completed in the design process.

4.1.2 R-134a is considered non-toxic and non-flammable and does not require risk mitigation for toxicity or flammability. Formal risk assessments for toxicity and flammability must be completed for all new refrigerants to ensure risks are similar to established refrigerants like R-134a (considered proven in usage).