



SURFACE VEHICLE STANDARD

J2772™

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Measurement of Passenger Compartment Refrigerant Concentrations Under System Refrigerant Leakage Conditions

RATIONALE

This standard is being updated to include references to the United States Environmental Protection Agency's Significant New Alternatives Policy (SNAP) use restrictions with regard to R-744 and R-152a (now supported as a secondary loop application only). The standard was originally developed to provide a consistent method for measuring refrigerant concentrations in a motor vehicle to be used in conjunction with risk assessments that are done for new refrigerants being developed for mobile air conditioning systems. This standard has not been updated for heat pump systems that use an interior condenser for heating. Interior condensers may create a new risk associated with a high-pressure heat exchanger in the cabin interior air flow path. Manufacturers should appropriately consider additional risks associated with using an interior condenser heat exchanger.

1. SCOPE

This Standard is restricted to refrigeration circuits that provide air-conditioning for the passenger compartments of passenger and commercial vehicles.

This Standard includes analytical and physical test procedures to evaluate refrigerant concentration inside the passenger compartment. In the early phases of vehicle evaluation, usage of the analytical approach may be sufficient without performing physical tests.

The physical test procedure involves releasing refrigerant from an external source to a location adjacent to the evaporator core (inside the HVAC module). An apparatus is used to provide a repeatable, calibrated leak rate. If the system has multiple evaporators, leakage could be simulated at any of the evaporator locations.

This standard gives detail information on the techniques for measuring R-744 (CO₂) and R-1234yf (HFO-1234yf), but the general techniques described here can be used for other refrigerants as well.

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1.1 Purpose

The purpose of this SAE Standard is to provide a uniform test procedure to evaluate the refrigerant concentration level inside of a vehicle passenger compartment resulting from leakage of refrigerant from a mobile air conditioning (MAC) system. This Standard does not establish concentration limits; however, legal limits may exist based on regulations or laws from local, national, or international authorities.

Refrigerant can leak from the evaporator, hoses, lines, and connectors that are directly exposed to the passenger compartment or the cabin air distribution system. Refrigerant concentration is influenced by leak rate, refrigerant charge, ambient temperature, recirculation door position, temperature door position, HVAC operation mode, blower speed, body sealing, vehicle speed, number of occupants in the vehicle, vehicle interior volume, and potentially other parameters specific to a vehicle design.

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 Standards for Motor Vehicle Refrigerant Vapor Compression Systems

SAE J2773 Standard for Refrigerant Risk Analysis for Mobile Air Conditioning Systems

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

2.1.2 Other Publications

Refrigerant Material Safety Data Sheet.

Safe use and handling guidelines available from refrigerant suppliers.

“Air change rates of motor vehicles and in-vehicle pollutant concentrations from second hand smoke,” Wayne Ott, Neil Klepeis, and Paul Switzer, Journal of Exposure Science and Environmental Epidemiology (2007), 1-14.

2.2 Legal Requirements

The United States Environmental Protection Agency's Significant New Alternatives Policy (SNAP) regulation defines acceptable refrigerants for the use in mobile air conditioning (MAC) systems. The listed substances may have use conditions, including restrictions for refrigerant concentration in the vehicle. 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. All motor vehicles' automotive refrigerants may be subject to, and must comply with, all legal regulations as required by local, national, or international authorities.

3. DEFINITIONS

ORIGINAL EQUIPMENT MANUFACTURER (OEM): Unless otherwise stated in this document, this refers to the vehicle manufacturer.

4. VEHICLE SYSTEM DESCRIPTION

4.1 Vehicle Interior Volume

The vehicle interior volume is the space available to the occupants. It can change, depending on vehicle interior variants. It includes volumes such as HVAC housing and duct internal volumes. For the determination of an interior volume, the net free space of the interior of the vehicle as built is to be considered. Net free space is defined as the volume of the interior of the cabin minus all components inside the vehicle (seats, trim, instrument panel components and structure, steering wheel, etc.). CAE models may be used to determine the vehicle interior volume. Table 1 shows typical vehicle volumes.

4.2 Passenger Volume Considerations

To determine the refrigerant concentration of the vehicle interior, the volume displaced by passengers shall be considered. Therefore, the effective vehicle interior volume is reduced by 75 L/passenger. For the measurement of the interior concentration, mannequins shall be placed on the seats according to the rated seating capacity of the vehicle. Physical mannequins and the displacement volumes used in testing shall be constructed of impermeable materials (metal, hard plastic), or shall be taped with aluminum foil backed tape or encased in an impermeable plastic material to avoid the possible diffusion of the refrigerant into the mannequins.

Table 1 - Typical vehicle interior volumes

Vehicle Type	Interior Size (m ³)	Number of Seats	Adjusted Interior Volume (m ³)
Compact Sports Vehicle	1.6	2	1.4
Sub-Compact Vehicle	1.7	4	1.4
Compact Vehicle	2.4	4	2.1
Full Size Car	2.8	5	2.4
Large size vehicle	3.1	6	2.6
SUV	4.0	6	3.5
Mini Van	6.0	9	5.2

4.3 Air Exchange Rate Considerations

Vehicle cabins are not hermetically sealed in relation to their environment. An additional air exchange with the environment around the vehicle takes place via openings in the vehicle body. These openings include pressure release valves (PRV), body structure gaps, leaking sealing elements, etc. This air exchange is affected by the driving speed and other operating and ambient conditions. The air exchange rate (AER) expresses the frequency in which the interior air of a vehicle cabin is replaced. Air exchange is also referred to as "body leakage." Table 2 shows typical air exchange rates.

Table 2 - Typical air exchange rates

Vehicle Operation Condition	HVAC Status	AER (h ⁻¹)
Standstill	Off	0.5 to 1.0
Idle	Low Blower, 100% RECIRC	2.0 to 3.0
Driving	Low Blower, RECIRC	4.0 to 6.0

Table 2 is for reference only (Ott et al., 2007). The vehicle OEM can consider the AER to use for physical test and analysis evaluations. In the analysis situation, the locations for the air exchange shall be specified in the analytical model.

5. REFRIGERANT RELEASED DURING A LEAK

5.1 Nominal Charge

The vehicle manufacturer specifies the nominal amount of charge in the refrigerant circuit. The determination of that charge is in context of the development process. It can be determined under high climatic load.

The durable nameplate or tag mounted in the engine compartment, as described in SAE J639, contains information about the lubricant type and the amount of refrigerant charge. This may be the starting point for determining the refrigerant charge to use during the test. This amount can be reduced due to oil absorption, as described below.

5.2 Refrigerant Absorption in Oil

When the system is charged, part of the refrigerant dissolves into the compressor lubricating oil. This will reduce the amount of refrigerant released during a leak.

5.3 Factors to Consider Regarding Leaks

When a refrigerant leak occurs, only the available refrigerant will be released out of the refrigerant circuit. The refrigerant dissolved in the lubricant remains in the circuit and will be released over a longer period. The OEM shall consider how much refrigerant may be dissolved in the oil and not released. In a rapid leak (e.g., mechanical breakage, collision scenarios), more refrigerant will be retained in the system compared to a corrosion leak of refrigerant into the passenger compartment. The amount of oil retained in the system will also be variable; this shall be considered when evaluating retained refrigerant. The refrigerant amount used in test shall be adjusted based on this analysis. Additional factors to be considered may include other component failures releasing refrigerant outside the passenger compartment, collision activated devices that limit the amount of refrigerant that can be released into the cabin, and/or other HVAC module design features.

5.4 Calculation of Charge Amount Released into Passenger Compartment

The following is an example calculation:

Table 3 - Example of calculation for released refrigerant

Charge Consideration	Charge Amount (g)
SAE J639 charge label (or an estimate, if not yet determined)	600
Amount of refrigerant estimated to be retained in the system in a rapid discharge of refrigerant (0 g for corrosion leaks)	-40
Amount not released due to other design feature of the AC system (i.e., system internal volume or component layout and design)	-50
Amount released by breakage in another component failure	-150
Amount discharged into passenger compartment for test:	360

5.5 Passenger-Generated CO₂ Due to Respiration

In the case of R-744, background CO₂ concentration shall be taken into account, due to passenger respiration. The respiration rate of 20 L of CO₂ per hour per passenger shall be considered for determining the background concentration. The background CO₂ value shall be recorded in the test report.