SAE International™ SURFACE VEHICLE STANDARD

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Standard for Refrigerant Risk Analysis for Mobile Air Conditioning Systems

RATIONALE

This standard is necessary due to introduction of new alternative refrigerants for mobile air conditioning. New requirements for the proper handling of these refrigerants are required.

FOREWORD

The potential impact of unintended refrigerant discharges resulting in high refrigerant concentrations shall be investigated and considered.

All reasonable hazards affecting persons inside the vehicle and in the close proximity of the vehicle, as well as the effects of long-term exposure shall be considered. Possible failure scenarios and safety targets shall also be considered.

1. SCOPE

This Standard describes methods to understand the risks associated with vehicle mobile air conditioning [MAC] systems in all aspects of a vehicle's lifecycle including design, production, assembly, operation and end of life. Information for input to the risk assessment is provided in the Appendices of this document. This information should not be considered to be complete, but only a reference of some of the data needed for a complete analysis of the risk associated with the use of refrigerants in MAC systems.

2. REFERENCES

2.1 Applicable Publications

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 724-776-4970 (outside USA), www.sae.org.

SAE J639 Safety Standards for Motor Vehicle Vapor Compression Refrigerant Systems

SAE J1739 Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Process FMEA)

SAE J2683 Refrigerant Purity and Container Requirements for Carbon Dioxide (CO2 R-744) Used in Mobile Air-Conditioning Systems

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SAE J2772 Measurement of Passenger Compartment Refrigerant Concentrations Under A/C System Refrigerant Leakage Conditions

SAE J2844 R-1234yf New Refrigerant Purity and Container Requirements Used in Mobile Air-Conditioning Systems

2.1.2 Other Publications

ISO 13043 Road vehicles - Refrigerant systems used in Mobile Air Conditioning systems (MAC) - Safety requirements

3. GENERAL DEFINITIONS

Safety is the absence of non-acceptable risk. Non-acceptable risk are those that are higher than those already accepted by the general population today (e.g., risks involved with riding in an airplane are considered acceptable by general public today).

Risk: Combination of probability of a harm occurring during an event and the severity of it.

OEM - Original Equipment Manufacturer - unless otherwise stated in this document, this refers to the vehicle manufacturer.

FTA is a methodology that graphically presents the sequences and combinations of failures that lead to a particular outcome. It utilizes a "top-down" approach, starting with the undesired effect as the top event of a tree of logic. Each situation that could cause that effect is added to the tree as a series of logic expressions. This technique analyzes the potential combinations or sequences of events by which an undesired event may occur. FTA can consider such causal effects as human error, equipment failure, and operating and maintenance procedures, though it cannot cover those causes of system failure that cannot be envisioned by risk analysts (Blackwell et al., 2006). FTAs consist of various event "boxes", which reflect the probability or frequency of key events leading up to a system failure. The event boxes are linked by connectors ("gates") which describe how the contributing events may combine to produce the failure.

General Safety Process Requirements - Proper design practices for the application of a refrigerant to MAC systems are required. The following or other equivalent methods shall be used to assess the risks associated with the use of a new refrigerant proposed for use in mobile 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), or equivalent shall be applied to the design and development of mobile air conditioning refrigerant systems.

FTA - Fault Tree Analysis methods.

4. SAFETY ASSESSMENT

This standard provides the guidelines for an assessment of safety with the refrigerants referenced in this standard for mobile air-conditioning systems.

The management of functional safety shall include the following from the concept phase through the lifetime of the vehicle

1. Concept phase
2. Product development phase
3. Production and assembly
4. Operation
5. Service
6. End of life and scrapping

5. RISK ASSESSMENT

Risk characterization represents the step in the analysis where data on acute and chronic toxicity, flammability and anticipated air concentrations are brought together to quantify the potential risks of the refrigerant system. The results of the risk characterization contribute to the FTA and/or DFMEA and allow an estimate of the impact of adverse events that may result from use of the refrigerant. Risk assessment shall be established for all relevant situations.

5.1 At a minimum, the following scenarios shall be considered in the risk assessment for R-744 [CO2]:

- Inhalation exposure to CO2 concentration above health limits due to a small or large refrigerant leak into the passenger compartment
- Inhalation exposure to CO2 concentration above health limits during vehicle service
- Liquid or fragment projectiles resulting from high pressure system burst
- Liquid or fragment projection during vehicle service
- Potential startling of the vehicle driver due to rupture of the high pressure system, resulting in a possible accident

Manufacturers should design systems cognizant of CO2 concentration peak level concentrations that could impact driver performance during vehicle operation, and shall measure the interior concentrations as outlined in SAE J2772. Background levels of CO2 that may exist in the vehicle need to be considered.

5.2 At a minimum, the following scenarios shall be considered in the risk assessment for R-1234yf [HFO-1234yf]:

- Inhalation exposure to R-1234yf concentration above health limits due to a small or large leak in the passenger compartment
- Inhalation exposure to R-1234yf concentration above health limits during vehicle service
- Ignition event associated with large leak in the passenger compartment
- Ignition event due to R-1234yf release during vehicle service
- Inhalation exposure to HF concentration above health limits [AEGL2] resulting from refrigerant thermal decomposition in the event of a refrigerant release

Manufacturers should design systems cognizant of the flammable properties of R-1234yf and the potential for ignition sources that could ignite the refrigerant.

5.3 All other refrigerants considered for MAC usage shall comprehend similar scenarios and the appropriate refrigerant properties in the risk assessment.

6. NOTES

6.1 Marginal Indicia

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

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