SURFACE VEHICLE STANDARD

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R-1234yf and R744 Design Criteria and Certification for OEM Mobile Air Conditioning Evaporator and Service Replacements

RATIONALE

This standard provides a testing and certification framework for an evaporator used in the passenger compartment of vehicles, as part of a MAC system. It is intended to appropriately minimize potential risks to persons, during normal use or service of a MAC system using R-744 or R-1234yf refrigerants.

1. SCOPE

The intent of this standard is to establish a framework to assure that all evaporators for R-744 and R-1234yf mobile air conditioning (MAC) systems meet appropriate testing and labeling requirements. SAE J639 requires vehicle manufacturers to perform assessments to minimize reasonable risks in production MAC systems. The evaporator (as designed and manufactured) shall be part of that risk assessment and it is the responsibility of the vehicle manufacturer to assure all relevant aspects of the evaporator are included. It is the responsibility of all vehicle or evaporator manufacturers to comply with the standards of this document at a minimum. (Substitution of specific test procedures by vehicle manufactures that correlate well to field return data is acceptable.) As appropriate, this standard can be used as a guide to support risk assessments.

With regard to certification, most vehicle manufacturers have established formal production part approval processes (PPAP) where compliance certification is established and formally documented. For an evaporator manufacturer of non-original equipment parts (or a vehicle manufacturer that does not have a formal part compliance certification process) then the certification described in this standard is the requirement to which those evaporators shall comply. In this case, the evaporator manufacturer or an independent institution shall complete the evaporator certification according to SAE J2911. An example of the latter would be the completion of witness testing by the evaporator manufacturer with the submission of certification documents by the witness organization.

Refrigerant R-152a was excluded from this standard because a secondary loop refrigerant system is required. This standard also does not apply to R-134a refrigerant evaporators because it is proven in use.

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

SAE J639 Safety Standards for Motor Vehicle Refrigerant Vapor Compressions 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 J2772 Measurement of Passenger Compartment Refrigerant Concentrations Under System Refrigerant Leakage Conditions

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

SAE J2911 Certification Requirements for Mobile Air Conditioning System Components, Service Equipment, and Service Technicians to Meet SAE J Standards

2.1.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

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

ISO/TS16949 Quality management systems - Particular requirements for the application of ISO 9001:2000 for automotive production and relevant service part organizations

VDA Band 3 Ensuring reliability of car manufacturers - Reliability Management (VDA volume 3.1, 3rd edition 2000)

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

3. DEFINITIONS

All physical dimensions and units are expressed in SI units and all indicated pressures are assumed to be gauge pressure unless otherwise noted.

Normal Use - This term represents the use of the vehicle during normal driving and does not address damage that may occur in a vehicle collision (this should be addressed in the vehicle risk assessment by the vehicle manufacturer).

Design Life of the Vehicle - Many vehicle manufacturers interpret this term differently and may recognize differences based on local climate conditions. This standard uses 10 years and 6000 working hours in a moderately corrosive environment similar to Central Europe as a normal design life

Original Equipment [OE] - Designation of products or components from a vehicle manufacturer, or contracted by a vehicle manufacturer, who complies with ISO/TS16949 standards.

Burst Pressure - The minimum pressure which causes a component to structurally fail or rupture, resulting in fluid leakage

4. TECHNICAL REQUIREMENTS

4.1 Introduction

This standard establishes product and process design requirements, along with validation testing and acceptance criteria for evaporators intended for use with R-1234yf or R-744 refrigerants. Significant refrigerant leakage by the evaporator into the passenger cabin could potentially pose a health and safety risk to vehicle occupants. To ensure appropriate risk, evaporators and evaporator assemblies shall:

- Be designed, manufactured and tested to minimize evaporator leakage for the design life of the vehicle.
- Meet certification and documentation standards.
- Meet requirements for evaporator labeling to ensure compliance to this standard and proper handling in service.

4.2 Evaporators Used by Original Equipment [OE] Vehicle Manufacturers

Evaporators installed in new vehicles and made available for service through the distribution channels of the vehicle manufacturer or OEM supplier are considered original equipment [OE] evaporators. These OE evaporators shall comply with this standard as a minimum; substitution of specific test procedures, which correlate well to field return data, by vehicle manufacturers is acceptable. Formal compliance certification and risk assessments have been established and documented.

4.3 Other Evaporators (From non-OE suppliers or used by vehicle manufacturers without formal certification and documentation processes)

An evaporator produced by a non-OE supplier (or used by a vehicle manufacturer without formal certification and documentation processes) may only be installed in vehicles, if the component shall fulfill the requirements described in this standard. Compliance to this standard shall be certified and documented as described below.

Certification of R-1234yf and R-744 evaporators from non original equipment manufacturers shall meet the requirements of SAE J2911.

This SAE J2911 qualified institution shall issue a “Certificate of Conformity”, stating that the examined evaporator meets the essential safety requirements covering design, manufacture and testing; follows appropriate conformity assessment procedures, and carries the necessary labels and other information. Details of certificate are found in Appendix D.

4.3.1 Responsibility for Certification

The manufacturer shall supply documentation to SAE as described in SAE J2911 that includes the information listed in the following sections. The manufacturer shall provide an appropriate number of evaporators that are representative of the evaporator production being certified and the intended HVAC system.

4.3.2 Documentation Submission and Certification Submission

The manufacturer shall complete and submit form SAE J2842 Appendix D as the actual certification document.

5. EVAPORATOR DESIGN AND CERTIFICATION REQUIREMENTS

The evaporator in this standard is defined as a component (the evaporator core body and permanently attached lines and fittings) installed in the heating, ventilation and air conditioning (HVAC) module intended for climate control of the passenger compartment of a vehicle. The evaporator assembly in this standard is defined as a component assembly (with removable attaching lines, fittings or devices) installed in the heating, ventilation and air conditioning (HVAC) module intended for climate control of the passenger compartment of a vehicle. The evaporator or the evaporator assembly shall be treated as the component specified in this standard according to each section.

5.1 Evaporator Design

5.1.1 Evaporator Design Requirements and Design Best Practices

The evaporator is located within the heating, ventilation and air conditioning (HVAC) module and is connected to the refrigerant circuit.

Substandard evaporator design, damage or misuse during assembly, shipping or service may increase potential risks to vehicle occupants. The requirements specified in this standard contain an approach for design, assembly to the HVAC housing, production quality and production testing of the assembly. Other relevant manufacturing and transportation practices such as storage, packaging and shipping shall be documented and retained by the manufacturer.

Evaporators shall be designed appropriately for all vehicle operational conditions (AC on or off) as well as vehicle off (storage and soak) as would be expected over the lifetime of a vehicle. The evaporator shall have appropriate corrosion behavior and protection to meet this specification or the equivalent based on evaporator field return data.

Evaporators as assembled in an HVAC module must include consideration of forces and torques from the assembly and disassembly of attaching lines and components. Any attaching tubing/pipe or other components in the evaporator assembly must withstand anticipated production, transport and assembly forces on those components without degradation of the refrigerant retention characteristics from those specified in this standard.

Any tubing or piping used in the assembly may be strengthened with brackets, connecting flanges, etc. to protect them from potentially damaging mechanical loads resulting from assembly operations, handling or transportation that would degrade the refrigerant retention characteristic of the assembly. See 5.7 for the allowable leak rate of an evaporator assembly.

Material composition should comply with local or national environmental rules and requirements (e.g., banned and regulated substances). The materials for the evaporator shall be suitable for the maximum and minimum operating temperature and pressure ranges listed in SAE J639.

Evaporator designs must have adequate material resistance to any chemical reactions with the refrigerant and lubricant (including normal degradation of both over time) to meet this standard and shall be capable of operating without significant degradation of the refrigerant retention characteristics from those specified in this standard under the anticipated working temperature and pressure cycles, for the life of the vehicle. This includes exposure to a deep vacuum (for charge extraction and filling).

The design specifications of the evaporator shall include considerations for changes in material properties due to ageing based upon assembly, shipping, expected usage, exposure to corrosion and storage to achieve evaporator life targets.

If the evaporator or evaporator assembly, including mating or attaching parts, are assembled from different materials, then galvanic corrosion must be considered in the validation/certification process.

5.1.2 Evaporator Manufacturing Requirements

The evaporator production process covers the manufacturing and testing of the evaporator or the assembly of the evaporator and other parts as it is delivered for further assembly or distribution.

Robust manufacturing processes are required to ensure evaporator designs appropriately minimize potential risks to vehicle occupants. Design and process Failure Mode and Effects Analysis (FMEA) must be completed for evaporators used in a MAC system using R-744 or R-1234yf.

The evaporator manufacturing process must take into account and insure the following:

- All critical characteristics coming from the Design-FMEA (on the complete evaporator assembly and on each component in the assembly) must be addressed;

- All critical characteristics coming from Process-FMEA (on process parameters) must be addressed.

- All design and process critical characteristics shall be included in the quality control plan for the evaporator.

5.2 Pressure Strength and Endurance

5.2.1 Burst Requirements

Evaporators shall meet or exceed specific minimum burst pressure requirements as defined in the latest published version of SAE J639. For new evaporator, these values shall be a minimum of 2 times the maximum low-side refrigerant gauge pressure.

5.2.2 Burst Pressure

For R-744 MAC systems increase the pressure 1.0 MPa/s up to 50% of the minimum burst pressure and afterwards by 0.1 MPa/s until the minimum burst pressure is achieved. The evaporator must hold this pressure for 1 min without rupture or structural failure. Continue adding 0.1 MPa/s until the actual burst pressure is reached.

For R-1234yf MAC systems increase the pressure 100 kPa/s up to 50% of the minimum burst pressure and afterwards by 10 kPa/s until the minimum burst pressure is achieved. The evaporator must hold this pressure for 1 min without rupture or structural failure. Continue adding 10 kPa/s until the actual burst pressure is reached.

The values obtained for burst pressures shall be recorded and documented.

As actual burst pressure is achieved, no fragmentation from the evaporator shall occur.

5.3 Fatigue Resistance Under Cycling Pressure

5.3.1 Requirements

The pressure cycle test is targeted to simulate a minimum of 10 years of life or 6000 working hours.

The evaporator shall first be subjected to the Mechanical Structural Resistance test in 5.4. The evaporator shall be tested to the following cycling requirement between lower and upper pressure, with a defined frequency, at a 60 °C working fluid temperature.

The fatigue resistance under cycling pressure shall be determined based on 'Weibull' analysis. The reliability requirement is 95% with a confidence of 50%. Sample size and number of equivalent lives are dependent on the evaporator design and shall be selected to demonstrate the aforementioned reliability requirements. Refer to VDA Band 3 for calculation methods. The calculation is listed below:

$$C = 1 - R^{n\times(r\times Lv)^b}$$

where:

- C = Confidence
- R = Reliability
- r = Factor for acceleration of stress according to Woehler (=1 if using the same amplitude)
- Lv = Number of lives: Extension of testing time longer than default
- b = Measure of scattering of the failures (Weibull slope)
- n = Number of samples

TABLE 1 - PRESSURE CYCLING REQUIREMENTS

	R-744	R-1234yf
Lower/Upper Pressure	5 to 10 MPa (abs)	0.1 to 1 MPa (abs)
Number of cycles equivalent 10 years	130 000 cycles	22 000 cycles
Frequency:	1.25 Hz ± 1 Hz	1.25 Hz ± 1 Hz

TABLE 2 - EXAMPLE CALCULATION FOR R-1234YF WITH R95 AT C50

Weibull Slope	Sample Quantity	Lives	Total Cycles
1	3	4.50	99 098
1	4	3.38	74 324
1	5	2.70	59 459
1	6	2.25	49 549
2	3	2.12	46 692
2	4	1.84	40 437
2	5	1.64	36 168
2	6	1.50	33 016

5.3.2 Test Method

The pressure cycle test can follow a trapezoidal or sinusoidal pattern. Test fluid is a hydraulic oil or refrigerant oil at: +60 °C ± 5 K over the entire test time. This pressure cycle test shall be run until failure (release of hydraulic or refrigerant oil) for new evaporator models. Once the Weibull slope is established, the equation in 5.3.1 can be used to determine the appropriate amount of cycles for a given number of samples. If the required number of cycles is reached, a refrigerant leak test shall be completed and passed (after the evaporator is cleaned) as described in 5.7.2.

5.4 Mechanical Structural Resistance

5.4.1 Requirements for the Structural Resistance of Tube Connections

Integrity of the tube or pipe connection to the evaporator core is essential to refrigerant retention. The appropriate resistance of the tubes/pipes is tested by bending and rotating the connection tubes/pipes in one direction followed by applying a torque or force that returns them to the original location. After testing, a metallurgical check shall be performed to locate any cracks that may have formed. The test is intended to be performed once.

5.4.2 Test for Structural Resistance of Tube Connections

The evaporator assembly (with attaching lines or fittings) shall be installed on the test bench and the following test sequence shall be carried out (the following forces/torques shall be applied at the interface position to the thermal expansion device or at the pipe connections outside of the HVAC module):

a. Apply a vertical force in the Z-direction to the evaporator tubes and increase until either a minimum displacement of +5 mm with reference to the zero position or a maximum of 100 N is reached. Then, change the direction of the force to -Z-direction and increase until either a minimum displacement of -5 mm with reference to the zero position or a maximum of 100 N is reached. Again, change the direction of the force and increase until the reference zero position or a maximum of 100 N is reached.

b. Apply a horizontal force in the Y-direction to the evaporator tubes and increase until either a minimum displacement of +5 mm with reference to the zero position or a maximum of 100 N is reached. Then, change the direction of the force to the –Y-direction and increase until either a minimum displacement of -5 mm with reference to the zero position or a maximum of 100 N is reached. Again, change direction of the force and increase until the reference zero position or a maximum of 100 N is reached.

c. Apply a horizontal force in the X-direction to the evaporator tubes and increase until a minimum displacement of +5 mm with reference to the zero position or a maximum of 100 N is reached. Then, change the direction of the force to the –X-direction and increase until a minimum displacement of -5 mm with reference to the zero position or a maximum of 100 N is reached. Again, change the direction of the force and increase until the reference zero position or a maximum of 100 N is reached.

d. Apply a torque equal to production assembly torque but not less than 5 Nm ± 0.5 Nm to the tube in the direction of expansion device assembly.

e. Apply a torque equal to the assembly torque, but not less than 5 Nm ± 0.5 Nm, in the opposite direction of expansion device assembly.

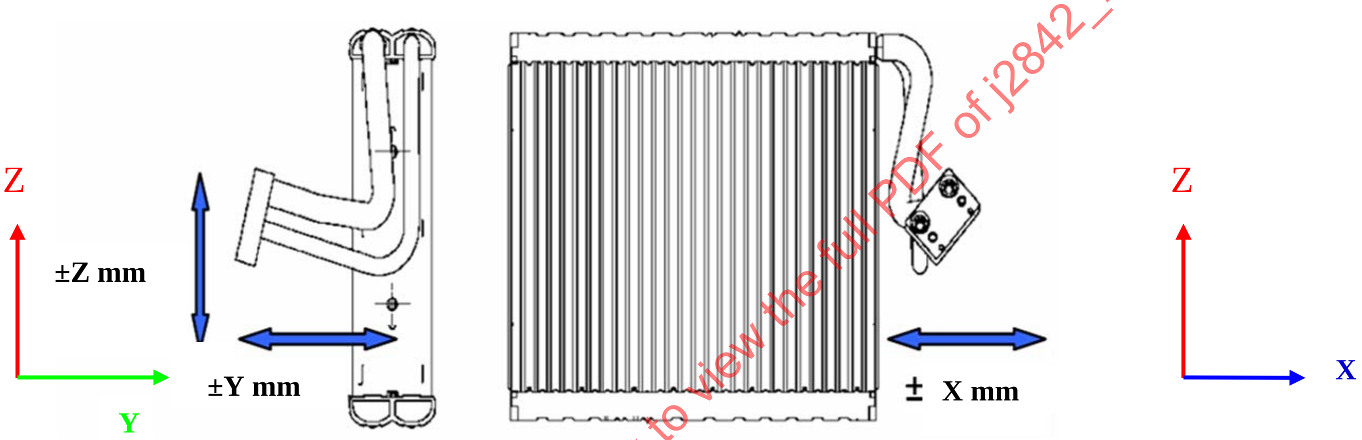

FIGURE 1 - MULTI DIRECTIONAL PIPE BENDING FOR EVAPORATOR

5.4.3 Acceptance Criteria

The evaporator assembly must not leak (as described in 5.7.2) after performing test sequence a. through e. above. No cracks should be initiated when analyzed by metallurgical inspection at the connection (brazed or other connection) of pipe to the evaporator core.

5.5 Structural Resistance to Corrosion

5.5.1 Requirements for Corrosion Resistance

Evaporator manufacturers shall perform the corrosion testing procedure described below in 5.5.2.2 HEREL and Appendix B. Original equipment manufacturers of evaporators can substitute corrosion test procedures based on historical standards that give good correlation to field return data. The intent of this standard is to achieve 10-year (or 6000 working hours) corrosion leakage resistance in a moderately corrosive environment.

5.5.2 Corrosion Reliability Tests

5.5.2.1 Requirement for Evaporator Resistance to Corrosion

a. General Test Requirements

Successful completion of the corrosion testing is contingent on passing the refrigerant leakage test in 5.7.2. All brazed joints may show surface corrosion but not separation. For the braze joint between the tube/plate to fin, this is demonstrated via inspection of the remaining bond. For braze joints that provide refrigerant containment integrity of the evaporator (including, but not limited to: plate to plate, tube to header, connecting tube to evaporator, etc.) this is demonstrated via the leakage test mentioned previously.

As mentioned earlier, original equipment manufacturers of evaporators can substitute corrosion test procedures based on historical standards that show good correlation to field return data and meet the intent as mentioned above.

b. Initial Leak Rate

When tested to the loss of pressure integrity, the leak rate shall be less than 0.03 g/s at 0.55 MPa for R-1234yf and 0.1 g/s at 6.4 MPa for R-744, which is the practical values, given the nature of the corrosion test, judged to be representative of a corrosion leak in the field. The leak rate after the corrosion testing shall be documented. The corrosion test is also intended to reproduce a similar failure mode to that observed in the field.

5.5.2.2 HEREL [Heat Exchanger Reliability] Test

The HEREL test is intended to cover 10 years or 6000 working hours of usage in a moderately corrosive environment. Original equipment manufacturers of evaporators can substitute corrosion test procedures based on historical standards that give good correlation to field return data.

Optionally, if 10 years in a severe corrosive environment is desired, then the HEREL test run in conjunction with the HVAC unit contamination test in 5.5.2.3 is recommended.

TABLE 3

	Contamination Recommendation § 5.5.2.3	Moderate (Central Europe) Climate	Severe Climate
Requirement	not fulfilled	10 years	N/A
Optional	fulfilled	10 years	10 years

See Appendix B for test condition details.

5.5.2.2.1 Corrosion Test Cycle Description and Solution Concentration

See Appendix B for test cycle and solution.

5.5.2.2.2 Acceptance Criteria for Corrosion Testing

Passing both sections a. and section b. is required for acceptable HEREL performance.

a. Leak tightness and corrosion pit depth after 30 days

   The evaporator must be considered leak tight based on pressure decay or air under water test in 5.7.2 and the maximum pit depth in an active surface (defined as a surface exposed to the airflow) after 30 days of testing must be smaller than 50% of the material thickness. A minimum of 6 tubes/plates shall be checked for each evaporator. The selected tubes/plates shall be selected based on worst-case corrosion from visual inspection.

b. Reliability is demonstrated based on the number of parts tested using Weibull analysis where Beta >2.4 (original equipment manufacturers may have different criteria). 21 days of the HEREL test is the equivalent of 10 years and 6000 working hours.

Reliability requirement of 95% shall be demonstrated with 50% confidence, refer to the equation in 5.3.1.

TABLE 4 - EXAMPLE CALCULATION FOR WITH R95 AT C50

Beta	Sample Quantity	Lives	Total Days
2	3	2.12	45
2	4	1.84	39
2	5	1.64	35
2	6	1.50	32
8	3	1.21	25
8	4	1.16	24
8	5	1.13	24
8	6	1.11	23

5.5.2.3 Optional - Recommendation for HVAC Unit for 10 Years in a Severe Corrosive Environment

To some degree, the HVAC unit and blower can contribute to evaporator corrosion. Specifically, evaporator core deposits can be formed from blower motor and brush degradation compounds.

The following test is established to ensure the actual contamination amount specified in the HEREL (heat exchanger reliability test) is representative of what can be expected from the HVAC module and blower motor.

5.5.2.4 Evaporator Contamination Test in the HVAC Unit

To establish the evaporator contamination amount, use only new components (evaporator, HVAC blower). Install the evaporator in the intended HVAC module then operate the HVAC blower continuously for no less than 10 days at maximum blower speed. The ambient conditions for the test are defined by ISO 554-1976-07. The evaporator is not connected to a refrigerant or coolant loop. Air distribution mode is set to the mode that provides the highest current draw for the blower motor. Temperature for the test is the ambient temperature defined in ISO 554-1976-07.

The evaporator can be replaced by a filter with similar pressure drop. In this case, other acceptance criteria for contamination can be proposed as long as correlation with the original test method is demonstrated.

After the test, remove the evaporator from the HVAC module and test for contaminants (per Appendix A).

5.5.2.5 Acceptance Criteria for Contamination Test

Copper <15 mg/part
Sulfur <5 mg/part

The criteria for copper and sulfur are the differences between a contaminated and an unused evaporator

5.6 Resistance to Temperature Cycling

For R-1234yf, this test is only required for evaporators that consist of non-metallic components other than seals for mating connections. For R-744 this test is required in all cases.

5.6.1 Requirements for Temperature Cycling

The evaporator assembly shall withstand ambient temperature cycles between -40 and +90 °C. The temperature cycle test shall simulate component temperature changes during the vehicle lifetime [6000 working hours]. The component shall meet requirements in 5.7.2 after performing the tests.

Finite element analysis can be substituted if the temperature cycling test is difficult to complete.

5.6.2 Temperature Cycling Test Procedure

The evaporator (with expansion valve) is sealed and pressurized with nitrogen to 1.4 MPa at room temperature and is exposed to the following test cycle shown in Figure 2 and described below.

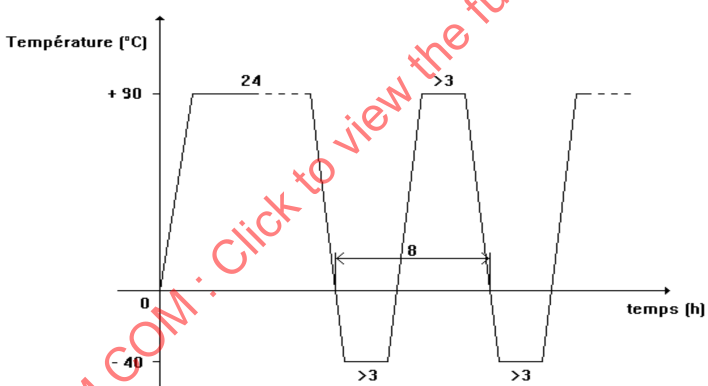

FIGURE 2 - TEMPERATURE CYCLING TEST

The evaporator is placed in a thermal chamber and heated to 90 °C ± 2 K (without control of the pressure) and held for 24 h. Afterward the evaporator shall be exposed to 12 cycles lasting 8 h of -40 °C ± 2 K to +90 °C ± 2 K with a greater than 3 h hold time at the minimum and maximum conditions. The total test time is intended to be 120 h, or 5 days.

5.7 Leak Testing

The leak rate for R-744 evaporators shall always be specified in “g/year” corresponding to a pressure of 6.4 MPa. The leak rate of R-1234yf evaporators shall always be specified in “g/year” corresponding to a pressure of 0.55 MPa. The considered evaporator assembly covers the brazed evaporator inclusive of tubing and mating connections (i.e., TXVs) as delivered to the OEM. The test pressure for both development and production shall not be below the respective reference pressure listed above.

The leak rate requirements for the evaporator assembly for each of the tests in this section are:

5.7.1 Helium Test for Production and Certification

All evaporators being checked by helium mass spectrometry shall meet the leak rates in 5.7.3 corresponding to the test pressure. Figure 3 depicts an example of such correlation. The leak rate shall be determined using test equipment with a maximum Gage R & R of 10% based on an allowable tolerance of ±0.2 g/y.

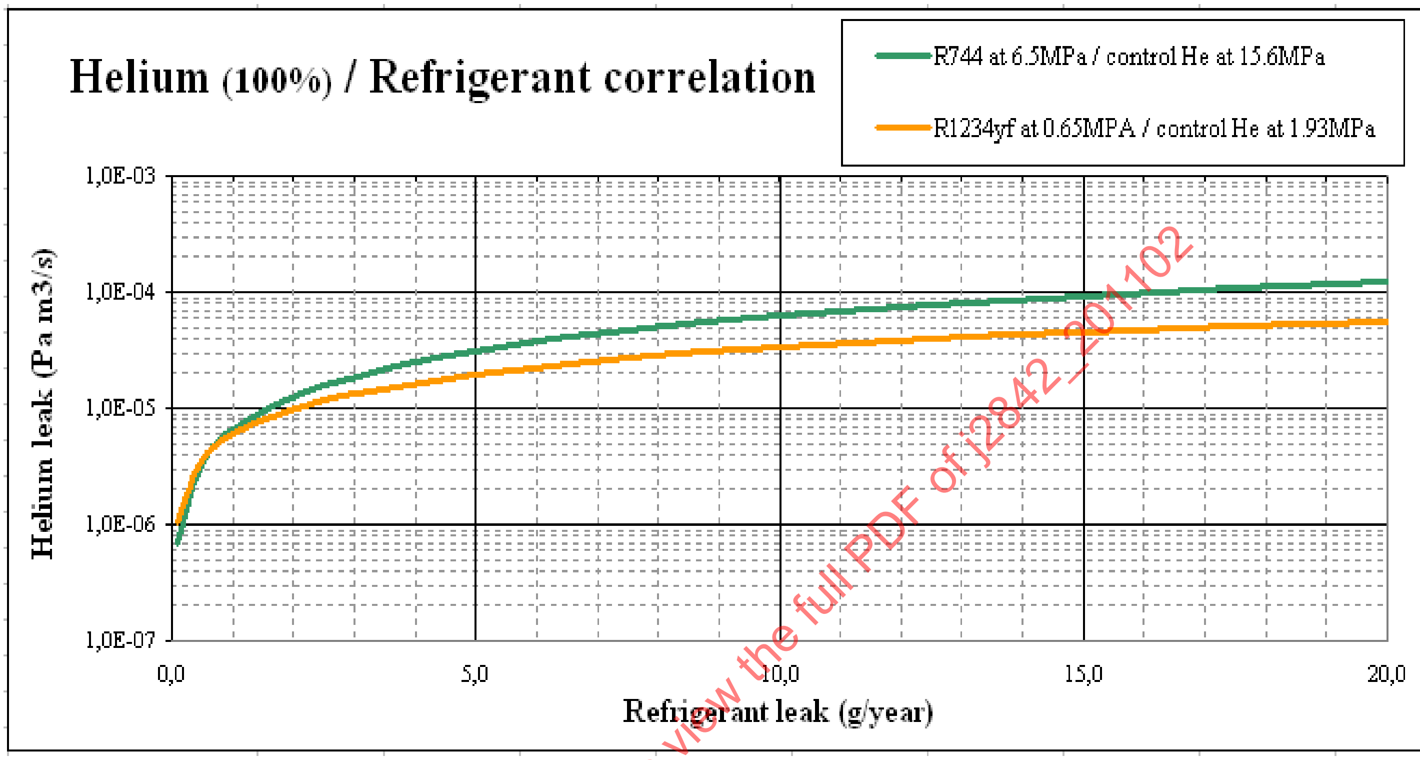

FIGURE 3 - HELIUM/ REFRIGERANT CORRELATION FOR DETERMINATION OF EVAPORATOR LEAKAGE WITH HELIUM AT SPECIFIED PRESSURES

5.7.2 Leak Testing Before Production

5.7.2.1 Leak Testing with Air/Gas During Development

For leak testing after other component validation tests involving oil, the evaporator leak test shall be carried out for more than 20 min to ensure detection of small leaks, which could be masked by oil at the beginning of the test. This section is for the development phase only and is not suitable for a production test. For production tests, 5.7.3 is to be followed.

Alternative 1: Air under water test

Using this method, the evaporator may be tested for leakage with 1.4 MPa air pressure under water:

- A leak rate of 3 g/y for an R-744 evaporator (at 6.4 MPa) corresponds to a bubble with an approximate diameter of 2 mm every 2 to 3 min.
- A leak rate of 5 g/y for an R-1234yf evaporator (at 0.55 MPa) corresponds to a bubble with an approximate diameter of 2 mm each 4 to 5 min.

Alternative 2: Pressure decay test with Nitrogen (N_2)

A pressure differential exists across a leak path, which causes flow. The flow pattern across that leak path is viscous and within this flow pattern for refrigerant systems it changes between laminar and turbulent.

The mathematical description of the individual flow pattern is complex. A simplified version of the computation is used in the appendix. As a basis for leak determination, the "viscous/laminar" flow pattern is used because of its common occurrence in refrigeration systems.

The evaporator leakage therefore may be tested with pressurized Nitrogen. After charging the evaporator at a pre-determined pressure and allowing for stabilization, the test is performed by measuring the pressure decay over test time.

See Appendix C for details, test conditions and procedures.

5.7.3 Production Test

All evaporators inclusive of all brazed fittings and pipes must be 100% leak checked, by the manufacturer, by helium mass spectrometry (or an equally accurate method) to the following specification. During the course of the leak test, the evaporator shall be subjected to a proof test at a pressure no less than the 1.0 times the maximum low side refrigerant pressure. The test time for the leak test shall be sufficiently long enough to detect a leak that may be temporarily masked by elastomers or oil. The test pressure for leak rate determination is independent of this proof test and must be correlated to the following refrigerant leak rates:

- 3 g/y (with reference of 6.4 MPa) refrigerant leakage for an R-744 evaporator assembly
- 5 g/y (with reference of 0.55 MPa) refrigerant leakage for an R-1234yf evaporator assembly

All evaporator assemblies inclusive of the evaporator (from above) and including all non-brazed fittings or devices (e.g., TXV), capable of leaking refrigerant within the cabin or within the HVAC airflow path to the cabin must be 100% leak checked, by the evaporator manufacturer, before assembly to the vehicle. This leakage specification is not intended as a design requirement but an appropriate certification that fittings and devices have been assembled properly.

5.8 Life Cycle Test Sequencing for R-744 Evaporators

5.8.1 Requirements

Due to the lack of field history for R-744 evaporators, a life cycle test is required. For R-744, the evaporator shall be exposed to the appropriate system operating conditions to simulate the refrigerant system life (temperature, pressure, pressure cycling, vibration, corrosion, etc.) for vehicle usage reflecting 10 years of life or 6000 working hours. This durability shall be demonstrated by achieving the leakage and pressure targets after the other durability testing is completed.

5.8.2 Test Sequences

The life cycle test was originated to simulate an R-744 evaporator exposed to extreme conditions for the life of the vehicle. It is not required for R-1234yf evaporators. The specified tests shall be run in sequence as shown below. The life cycle test is a combination of the single tests described in this standard. The following sequence shall be used for at least 4 test samples:

The required test sequences and the acceptance criteria are in Tables 5 and 6.

TABLE 5 - TEST SEQUENCE FOR USING CONDITIONS LIFETIME PRIOR BURST TEST

Test	Document Reference
Tube bending	5.4
Leak test	5.7.2
50% pressure cycling	5.3.1 number of cycles equivalent to 3000 working hours
50% of temperature cycling	5.6
50% Corrosion test	5.5.2.2 11 days HEREL (or other life time test to be agreed between supplier and customer)
50% of pressure cycling	5.3.1 number of cycles equivalent to 3000 working hours
Leak test	5.7.2
Burst test	5.2

5.8.3 Acceptance Criteria

Evaporator assembly shall pass the leak test per 5.7.2 after completing the previous testing listed.

Evaporator assembly shall pass the burst test per 5.2 after completing the previous testing listed

TABLE 6 - TEST SEQUENCE INTENDED FOR RELIABILITY PROOF

Test	Document Reference
Tube bending	5.4
Leak test	5.7.2
50% pressure cycling	5.3.1 number of cycles equivalent to 3000 working hours
50% of temperature cycling	5.6
50% Corrosion test	5.5.2.2 11 days HEREL (or other life time test to be agreed between supplier and customer)
Pressure cycling until failure	5.3

The number of cycles achieved must be greater than those specified in 5.3.

5.9 Process/Quality Controls

The evaporator manufacturing process covers the manufacturing and testing of the evaporator or the sub assembly of the evaporator and other parts as it is delivered for further assembly or distribution.

The evaporator manufacturer shall maintain a Quality Management System which encompasses advance quality planning, production accompanying quality assurance, quality analysis and documentation. (To ensure the product requirements, the evaporator manufacturer must have a Quality Management System such as one according to ISO 9000:2000 with the complement of the requirement of ISO/TS 16949: 2002.)

A systematic advance quality planning shall be conducted (Reference: APQP, VDA Volume 4, etc.) Important features include ‘Machine Capability’ and ‘Continuous Process Capability’.

- The machine capability determines the quality of new or modified machines, tools and equipment and shall involve a random check of at least 50 parts. The minimum requirement for variations is x-bar ± 6 s which represents a Cpk ≥ 2.0.

- The Continuous Process Capability is a long-term investigation, accompanying a production process, to determine lasting process capability, which is a combination of: manufacturing personnel, machinery, tooling, equipment, materials and the working environment. Therefore, in this standard, consistent with the scope, vehicle manufacturer's can set acceptable values and that the Cpk value here is applied to evaporator production processes that do not supply a vehicle manufacturer. The minimum requirement for variations is x-bar ± 5 s which represents a Cpk ≥ 1.67.

Geometrical characteristics, e.g., size, thickness:

The conformity of each characteristic identified by the risk assessment as key to compliance with this specification must be shown to be capable.

According to the following state of the art: If CpK < 1.6 the production must be protected by poke- yoke or 100% control on line.

5.10 Parts History

The documentation is mandatory for all evaporator models in compliance to this standard.

The evaporator manufacturer shall ensure a qualified part history is maintained for each evaporator model produced. This assumes that test documents have been kept and stored. The obligation to keep documentation covers a period of no less than 5 years after the model is no longer in production. The parts history shall contain information such as, but is not limited to certification test results, tool and process changes, new materials, and other relevant modifications.

6. LABELING

6.1 All evaporators, including OE and replacement, shall have a permanent marking (label, stamp, or etching) that indicates that this evaporator design meets SAE J2842, the refrigerant for which it was designed, and shall include the wording below or optionally the symbols as shown in 6.3:

“Conforms to SAE J2842 (Evaporator Manufacturer’s Name or Trademark) Replace only with new evaporator certified to meet SAE J2842 Refrigerant R-XXXX” where R-XXXX is replaced with R-744 or R-1234yf as appropriate.

6.2 Label Requirements

6.2.1 Color

The two color label shall use PMS color standards.

The symbol version of the label shall use Pantone Orange [151] or yellow per ANSI Z535 “caution” with Pantone Black (or equivalents).

The text version of the label may use Pantone Black and White or equivalents.

6.2.2 Performance

The label material and construction shall conform to all specifications and requirements appropriate for the intended installed location on the evaporator. The label shall remain permanently attached and legible for the life of the vehicle. Testing of decals shall meet ANSI/UL 969-1991. ***NOTE: It is permissible to decal or stamp in conformance to the ANSI standard. ****

6.3 Symbol only Label Design is shown below (label to replace text label in 6.1, at the discretion of the manufacturer). See SAE J639 for symbol graphics.

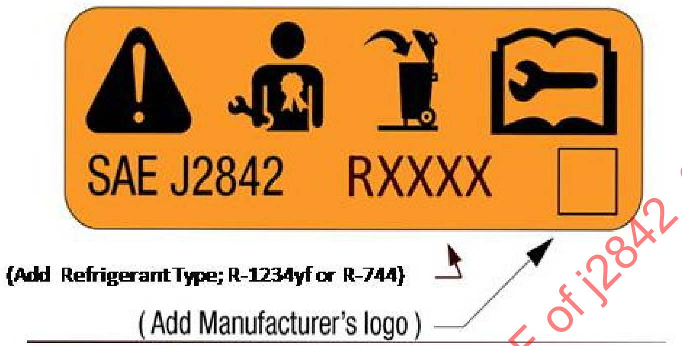

FIGURE 4

6.4 It is permissible to utilize the SAE J2842 label on an evaporator used for multiple refrigerants (i.e., a certified R-1234yf evaporator used in an R-134a system).

7. REPAIR OF DAMAGED OR LEAKING EVAPORATORS OR RE-USE OF USED EVAPORATORS

No leaking evaporators may be repaired or reworked in the vehicle assembly process or in service. Work in process evaporators at the evaporator manufacturing facility that are found to have a leak may be reworked to meet specifications using melted filler metal of a composition compatible with the other evaporator metals. Any fluxes or agents used must not degrade the corrosion performance of the evaporator.

In the case of all vehicles being serviced and identified as having a leaking evaporator, the leak shall not be repaired and the system shall only be serviced by replacing the leaking evaporator with a new evaporator meeting SAE J2842 requirements.

An evaporator from a salvaged vehicle air conditioning system shall not be repaired or removed from any vehicle air conditioning system with the intention of using it again in the same or a different vehicle. However, if the evaporator assembly includes a refrigerant control device (TXV/ Block valve) and is operational, re-use of the refrigerant control device is permitted.

8. NOTES

8.1 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.

PREPARED BY SAE INTERIOR CLIMATE CONTROL STANDARDS COMMITTEE

APPENDIX A - DETAILED TEST CONDITIONS

(Related to 5.5.2.3 Evaporator contamination test in the HVAC Unit)

This methodology describes how to evaluate sulfur and copper content on the evaporator external surface.

Main steps are:

- Washing external surface of evaporator

- Cleaning the external surface of evaporator with nitric acid

- Measuring the pollutants collected

1) Washing external surface of evaporator

The evaporator is closed in order to prevent water entry.

Method must fulfill the steps described below:

- dip the evaporator in a clean plastic box with 7 L of de-mineralized water (Conductivity < 20 µS/cm)
- Shake for a period of 1 h
- remove the core from the plastic box and blow air across the evaporator above the plastic box in order to extract the maximum quantity of water
- put the core inside a clean plastic bag, with traceability on the bag
- Sample 100 ml of washing water in a bottle with label and keep it for pH and conductivity measurement (stir water for homogeneity before sampling)
- Sample accurate quantity of solution for sulfur measurement (500 ml is necessary for the Plasma method and addition of 5 ml of HNO_3 nitric acid concentrated at 68%)

2) Cleaning the external surface of evaporator with nitric acid

The evaporator is closed in order to prevent nitric acid entry.

The evaporator is placed in a nitric acid bath (plastic box) built by mixing 50% volume of demineralized water and 50% volume of concentrated nitric acid. The concentrated nitric acid grade is reagent ISO 68% wt/wt concentration. The diluting water shall be purified via electro osmosis or ion exchange and have a conductivity <20 µS/cm. Thus, the final concentration is 34% wt/wt nitric acid. The evaporator is placed in the bath until the end of chemical reaction or a maximum of 3 h. Part of the liquid from reaction is made homogeneous and used for copper analysis.

3) Measuring the pollutants collected

2 methods are proposed for copper and sulfur measurement but others can be applied.

Determination of selected elements by inductively coupled plasma optical emission spectrometry (ICP-OES) (ISO 11885:2007).

Determination of dissolved anions by liquid chromatography of ions - : Determination of sulfate (ISO 10304).

Advice:

Before any measurement, the ability of the laboratory to make accurate measurement must be validated.

Measurement on a new evaporator must be done before testing a polluted one for comparison.

APPENDIX B - DETAILED TEST CONDITIONS
(Related 5.5.2.2 Requirement for Evaporator)

B.1 CORROSION TEST ON EVAPORATOR: HEREL

B.1.1 Field of Application

This procedure is done for all design of aluminum evaporators (fin and plates or fin and tubes evaporators, brazed or mechanical assembly.)

B.1.2 Test Definition

B.1.2.1 Corrosion Bench Characteristics

The corrosion bench must be in conformance with ASTM G85-02, Chapter 4

B.1.2.2 Cleaning Procedure

Bench must be cleaned before new test.

Conductivity measurement of water in the collectors after cleaning must be lower than 20 µS/cm.

B.1.2.3 Preparation of the Test Fluid

Preparation of a solution containing: Sulfur, Chlorine, and Copper.

In 140 L of de mineralized water (conductivity < 20 µS/cm), are added:

- Chlorine (in the form of sodium chloride, NaCl). The concentration is 5 g/l of NaCl, concluding 700 g NaCl in 140 L of solution.

- Copper (in the form of cuprous chloride, $CuCl_2$). The concentration is 20 mg/l of Copper ion Cu_2^+ i.e., 0.042 g/l of anhydrous $CuCl_2$. The quantity of anhydrous $CuCl_2$ which has to be introduced into 140 L of solution is 5.88 g.

- Sulfur (in the form of sulfurous acid, H_2SO_3). The pH- Value shall reach 3.5. The quantity of H_2SO_3 to add is between 45 and 80 ml (add 10 by 10 ml), depending on the degradation of sulfurous acid in time with air.

Recommendation: To limit the impact of sulfurous acid degradation, using containers of a maximum capacity of 1 l is recommended, 500 ml or less are better.

TABLE B1

Reactants	g/l	g / 140 l
NaCl	5	700
$CuCl_2$	0.042	5,88
H_2SO_3	0.3 - 0.6 ml/l	45 - 80 ml / 140 l

The following parameters of the solution have to be checked once a week, at the laboratory temperature (22 °C ± 2 K):

- pH: 3.5 ± 0.2

- Conductivity: 9 mS/cm ± 2 mS/cm

B.1.2.4 Preparation of the Evaporators

Evaporator is maintained under charged compressed air during the test with a pressure of 0.4 to 0.5 MPa

Depending on the nozzle position, the target for pollutant spray direction is to be normal to the inlet face of evaporator

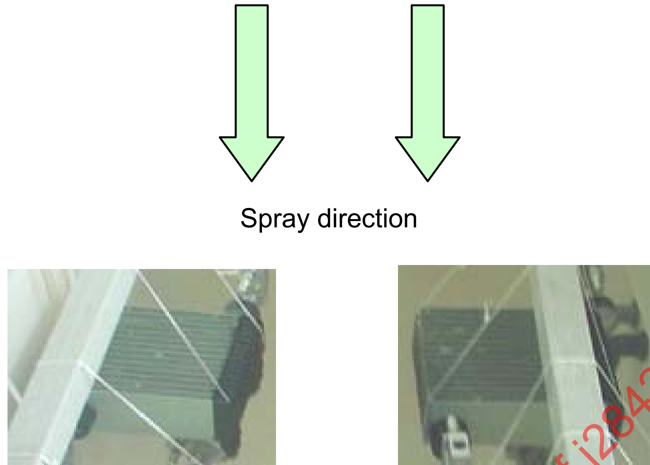

FIGURE B1 - SAMPLES POSITIONING

Recommendations:

Parts shall not be in contact with each other to avoid the risk of influencing each other.

Parts of the evaporator out of the airflow can be insulated in order to simulate airflow management inside HVAC or for corrosion analysis we consider only active surface

The active surface is the area crossed by the air in the HVAC assembly configuration. Therefore tanks at bottom and top, end plates when they are covered by the housings of the HVAC assembly, and pipes when they are out of the unit are not included in the corrosion analysis. When pipes or tanks are in the airflow, evaporator criteria are applicable.

B.1.3 Test Conditions

The cycle consists of 3 steps and is defined as below:

TABLE B2

	Duration (min)	Temperature (°C)	RH [%]
Test Fluid mist (spray phase)	20	49 ± 2	100
Resting (humidity phase)	30	49 ± 2	95
Flushing with dry air (drying phase)	20	49 ± 2	50%*

*reached during 5 minutes

The volume of condensate during the test is collected (surface collectors: 80 cm²).

To ensure the homogeneity of test conditions (temperature, humidity) during all the phases, it may be necessary to change part position in the chamber during the test.

B.1.3.1 Follow-up of the Test Parameters

The following parameters are recorded:

TABLE B3

Parameters	Target
pH of the condensates (twice a week)*	3.5 to 4.5
Conductivity of the condensates (twice a week) *	9 to 15 mS/cm
Volume of the condensates (twice a week)	< 0.2 ml/h/80cm²
Temperature (continuously)	49 °C ± 2 K
Liquid consumption during the spray phase	0.9 l/h ± 0,1
Humidity during drying phase	Not measured

* the measurement is carried out at T = 22 °C ± 2 K

In case of too low quantity of condensates for pH and conductivity measurement, those parameters can be followed on original solution (see B.1.2.3)

In the event that the condensate quantity is too low, volume measurements can be done at the beginning of the test on the spray phase only. In this case, condensate volumes are from 1 to 2 mL/h/80 cm^2.

B.1.3.2 Test of the Evaporators

It is recommended to verify the tightness of the evaporators twice a week. After detection of a leak, the part is tested (dry air or Nitrogen under water), in order to locate the leakage precisely.