



Air Conditioning Evaporator General Specification

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. This standard shall define the Design Validation (DV), Production Validation (PV), Post Validation Audit (PVA), measurement conditions, performance requirements, and the minimum durability specification requirements of various forms of refrigerant (i.e., R1234yf or R134a) to air heat exchangers used for automotive cabin cooling and dehumidification.

1.2 Applicability. All passenger vehicles using refrigerant to air heat exchangers used for cabin cooling and dehumidification.

Note: Unless specified, pressures are absolute.

1.3 Remarks. None.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

ASTM D7334	ISO 760:1978	SAE J639	SAE J2842
ISO 2230			

2.2 GM Standards/Specifications.

GMW3059	GMW14157 (ID)	GMW15779	GMW15920
GMW3172	GMW14573	GMW15786	GMW17389
GMW3600	GMW14780	GMW15787	GMW17625
GMW14156 (ID)	GMW15760	GMW15862	GMW17626

(ID) = This standard is limited to internal distribution within General Motors and shall not be distributed outside this company. Contact the GM Lead Engineer for further instructions.

2.3 Additional References.

- Analysis/Development/Validation (ADV) Problem and Resolution
- CG2066 Evaporator VCRI SOR Appendix G3 Template
- Component Technical Specification (CTS)
- GM Global Vehicle Development Process (GVDP)
- Statement of Requirements (SOR)
- Subsystem Technical Specification (SSTS)
- Vehicle Technical Specification (VTS)

3 Test Preparation and Evaluation

3.1 Resources.

3.1.1 Facilities.

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3.1.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.1.2 Equipment. Not applicable.

3.1.3 Test Vehicle/Test Piece. If not otherwise specified, test samples shall include production pipes and/or hoses with production intent attachment methods. The core and plumbing shall be oriented as in the vehicle application. The plumbing connections shall be evaluated concurrently with the evaporator core. All PV test samples shall comply with selection guidelines in GMW15760.

3.1.4 Test Time. Total testing time should be considered when planning delivery of parts to meet GM key dates contained in the GM Global Vehicle Development Process (GVDP) schedule. It is highly recommended to leave a buffer of at least 2 weeks between test completion and the GM milestone when planning, due to an unexpected failure where re-validation would be required. Note the estimated plan of how long it takes to validate and test one (1) heat exchanger product or part number. Times may vary based on test cell availability and capacity.

Calendar time: 105 d

Test time: 3000 h

Coordination time: 500 h

3.1.5 Test Required Information. Test results are to be summarized and reported to GM on the Supplier Analysis/Development/Validation (ADV) plan (see 3.7.1). Referred to in this document as "test report(s)".

3.1.6 Personnel/Skills. The personnel and skill requirements are the responsibility of the supplier.

3.2 Preparation. Not applicable.

3.3 Conditions.

3.3.1 Environmental Conditions. Unless otherwise specified, the standard ambient testing temperature environment is defined as $23\text{ C} \pm 5\text{ C}$.

3.3.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

3.4 Instructions.

3.4.1 Reliability. Supplier to statistically demonstrate reliability for DV and PV separately (see GMW3600). Reliability shall be at 50% confidence level at the Reliability Evaluation Point (REP) for the tests described in this document (see GMW14156 and GMW14157). The supplier shall set up samples "in vehicle" orientations for all testing. See 4.7 and 4.8 for testing which involves reliability.

If any failure occurs in the first (1st) life of customer usage, stop the entire test. Within 24 h, inform and involve GM team (Validation, Design Engineer, etc.) in completing a Design Review Based on Test Result (DRBTR) and root cause analysis. Plot the Weibull slope (see **Note**), calculate reliability and submit the report to GM. Re-design the part/product as required and perform validation per ADV Problem and Resolution. If reliability is not met, determine the number of samples required for retest with approval from GM Validation Engineer.

Note: For Normal stress testing: Statistical analysis (i.e., Weibull Analysis) should be used to estimate reliability at one (1) test life from the observed failure data. Any Weibull analysis shall conform to GMW17626.

In the case of new evaporator designs or significant changes to evaporator design which may change the typical failure mode or significantly reduce or increase the reliability of the evaporator, durability validation shall be run to failure. Consult with GM Validation Engineer to determine if this requirement is applicable. Upon test completion, complete any required subsequent functional tests, complete a DRBTR with GM Engineering, determine the Weibull Beta value, plot the Weibull slope and confirm that reliability is demonstrated to the requirements

3.5 Data. Not applicable.

3.6 Safety.

This Engineering Standard may involve safety requirements for hazardous materials, the method of operations and equipment. This standard does not propose to address all the safety issues associated with its use. It is the responsibility of the user of this standard to ensure compliance with all appropriate safety and health practices.

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This would include any specific training that may be required. The safety and health standards include site specific rules and procedures, company rules and procedures, and Government Standards. Contact shall be made with the appropriate site Safety and Health personnel for further direction and guidance in these matters.

3.7 Documentation. Samples of components or material released to this standard shall be tested for conformity with the requirements of this standard and approved by the responsible GM Department prior to the start of delivery of production level components or materials.

Any change to the component or material, e.g., design, function, properties, manufacturing process and/or location of manufacture requires a new release of the product. It is the sole responsibility of the supplier to provide the customer, unsolicited, with documentation of any change or modification to the product/process, and to apply for a new release.

If not otherwise agreed to, the entire verification test shall be repeated and documented by the supplier prior to start of delivery of the modified or changed product. In some cases, a shorter test can be agreed to between the responsible GM department and the supplier.

3.7.1 Test Results. The performance measurements and durability test results are to be summarized and reported to GM on the Supplier ADV Plan, as referenced in the Statement of Requirements (SOR). Full test reports shall be made available for viewing for GM per GMW15920.

3.7.2 Validation Cross Reference Index (VCRI). The VCRI is a matrix that GM uses to link each technical requirement for a commodity to its corresponding final validation procedure. The validation procedures that are specified in the VCRI shall be used for the final confirmation that the component/subsystem meets all the requirements in the technical specification. Supplier shall use the Test Matrix Format outlined in the VCRI (CG2066 Evaporator VCRI SOR Appendix G3 Template) in the SOR to generate the VCRI for the Component Technical Specification (CTS)/Subsystem Technical Specification (SSTS).

4 Requirements and Procedure

4.1 General. All tests shall be performed with the appropriate program-specific refrigerant (R1234yf or R134a). If the program may use both refrigerants over time or in different regions, consult the validation engineer for direction. Unless otherwise noted, all tests shall be completed with pipes and expansion devices attached per manufacturing and design intent. If a functioning expansion device would improperly affect the test procedure and/or results, a "dummy" expansion device with open ports and a non-functioning valve mechanism is an allowable substitution with approval from the validation engineer.

For program-specific requirements related to physical characteristics, core dimensions, plumbing, and internal volume requirements, refer to CTS, SSTS, and Vehicle Technical Specification (VTS).

4.2 Evaporator Efficiency and Performance. The heat dissipation, air pressure drop and refrigerant pressure drop shall be measured and reported. Measurements shall be corrected to each of the conditions in 4.2.1. Use the program-intent refrigerant per the SSTS. Evaporator testing shall be performed using a test buck which seals from airflow bypass around the evaporator and distributes airflow evenly across the core for optimal performance. A functional, design-intent expansion device is not required as part of this testing to ensure proper data points.

4.2.1. Test Conditions. The evaporator shall be subjected to the conditions outlined in Table 1, as well as the supporting details found in 4.2.1.

The refrigerant subcool at the inlet to the expansion device shall be $8.0\text{ C} \pm 0.5\text{ C}$ in all conditions. The refrigerant superheat at the evaporator outlet shall be $3.0\text{ C} \pm 0.5\text{ C}$ in all conditions. The maximum temperature spread across the outlet face of the evaporator core shall be 3 C in all conditions. The oil circulation rate shall be $< 2\%$ in all conditions.

4.2.1.1 Air Inlet Condition 1.

- Dry Bulb Air Inlet Temperature = $40\text{ C} \pm 0.5\text{ C}$
- Air Inlet Relative Humidity = $40\% \pm 2\%$
- Air Inlet Dew Point Temperature = $22\text{ C} \pm 0.5\text{ C}$

4.2.1.2 Air Inlet Condition 2.

- Dry Bulb Air Inlet Temperature = $25\text{ C} \pm 0.5\text{ C}$

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- Air Inlet Relative Humidity = 50% $\pm$ 2%
- Air Inlet Dew Point Temperature = 13.5 C $\pm$ 0.5 C

Table 1: Performance Measurement Conditions

Test Condition	Air Inlet Conditions	Air Inlet Flow Rate ($\pm$ 3 L/s)	Refrigerant Pressure Before Expansion Device ($\pm$ 10 kPag)	Evaporator Outlet Refrigerant Pressure ($\pm$ 5 kPag)	Maximum Refrigerant Pressure Drop (kPa)
1	Condition 1	70 L/s	800	190	130
2			1700	330	110
3			2250	430	60
4		130 L/s	800	190	130
5			1700	330	110
6			2250	430	60
7	Condition 2	70 L/s	800	190	130
8			1700	330	110
9			2250	430	60
10		130 L/s	800	190	130
11			1700	330	110
12			2250	430	60

4.2.2 Documentation. The heat dissipation rate, air pressure drop and refrigerant pressure drop at the required conditions noted in the SSTS shall be reported and recorded in the evaporator release drawing notes.

All data points shall be submitted via Component Data Standard (CDS) to GM. Comprehensive CDS data must be submitted and approved after the tests have been performed before final Production Part Approval Process (PPAP) can be approved. All data points must be experimentally measured for initial PV testing. For early development, DV testing, and change point validation, the amount of data points that are simulated and experimentally measured must be agreed upon with the GM Computer Aided Engineering (CAE) Engineer. The simulated data points may only be used if prior correlation between simulation data and experimental data studies have shown to be acceptable to the GM Validation Engineer. When available from testing to GMW17625, the evaporator-level heat dissipation rate from Test Conditions 2 and 5 from Table 2 should be compared with the Heating, Ventilation and Air Conditioning (HVAC) Module-level dissipation in order to understand the losses associated with HVAC module integration.

4.2.3 Internal Tightness. The evaporator assembly shall be free from any internal braze voids, component mis-builds, or other conditions that result in improper refrigerant flow paths through the evaporator that vary from the design-intent flow paths. If present, these defects may cause reduced performance, noise, and other customer dis-satisfiers. Internal tightness shall be verified during performance testing with the use of thermal imaging during at least one of the flow conditions to confirm refrigerant is flowing via the design-intent flow paths. Internal Tightness shall be verified in production per 4.23.7.

4.3 Leak Tightness. The maximum permissible leak rate for the evaporator assembly is 5 g/year of the representative refrigerant at 550 kPa gauge pressure when tested to (SAE J2842, Section 5.7). For production leak testing requirements, see 4.23.2. When used as a post-test evaluation, the evaporator should be rinsed and dried internally and externally to remove any water, oil, or debris that may mask a leak or contaminate a test chamber.

When available for development-level testing, helium mass spectrometry is preferred. If mass spectrometry cannot be made available, consider the following procedure for air-under-water testing.

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The evaporator shall be pressurized with dry, oil-free air or nitrogen at $1500 \text{ kPa} \pm 20 \text{ kPa}$. The evaporator shall be submerged under warm water (35 C to 42 C) for at least 20 minutes. Bubbles emerging from the evaporator core indicate a leak and indicate a test failure.

4.4 Tightness Under Vacuum. Prior to beginning this test, the refrigerant side pressure drop shall be performed per Table 1, Test Condition 5. The assembly shall be evacuated to an absolute pressure of 2.0 kPa and maintained for 5 minutes. This procedure must be repeated three(3) times on each test sample.

The pressure shall not increase more than 0.5 kPa per minute during the test procedure. After the completion of three (3) cycles of vacuum application, the assembly shall satisfy the requirements of 4.3. Repeat the refrigerant pressure drop test per Table 1, Test Condition 5. Its value shall not vary by more than $\pm 5\%$ from the pre-test value.

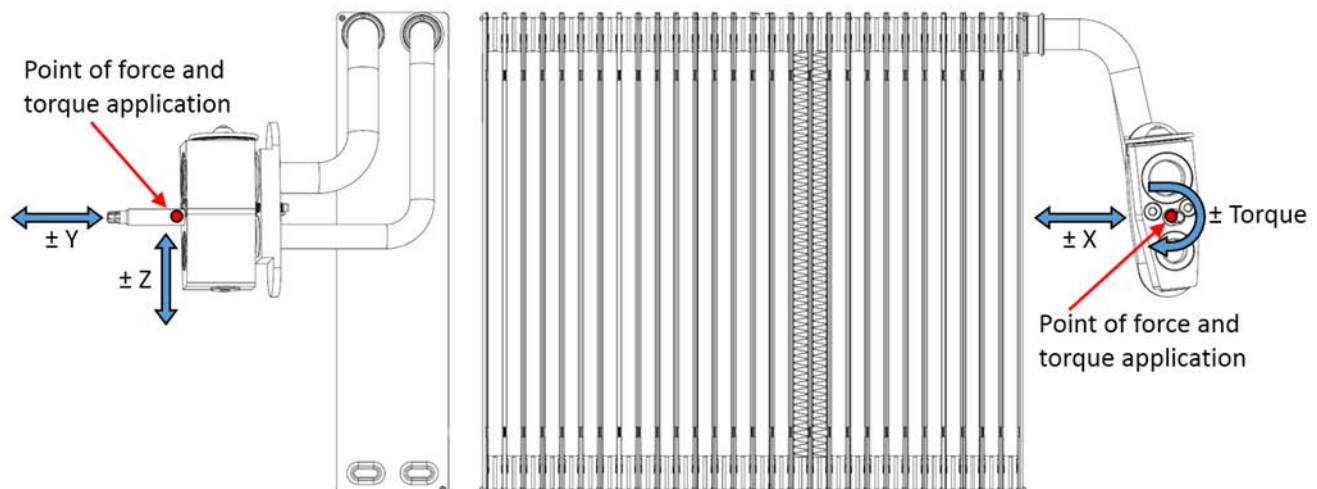
4.5 Pipe Strength Tests. The evaporator assembly must be resistant to applied forces. The bending and torque applications shall be performed sequentially on the same evaporator assemblies.

4.5.1 Bending Force Application. Clamp the evaporator in four (4) corners to prevent movement or rotation of the core block. As shown in Figure 1:

- Apply a horizontal force to the Thermostatic Expansion Valve (TXV) in the (X) direction and increase the force until either a minimum displacement of 10 mm or a maximum force of 100 N is reached. Apply a horizontal force to the TXV in the (-X) direction and increase the force until either a minimum displacement of 10 mm or a maximum force of 100 N is reached. Repeat the horizontal force in the (X) direction.
- Apply a horizontal force to the TXV in the (Y) direction and increase the force until either a minimum displacement of 10 mm or a maximum force of 100 N is reached. Apply a horizontal force to the TXV in the (-Y) direction and increase the force until either a minimum displacement of 10 mm or a maximum force of 100 N is reached. Repeat the horizontal force in the (Y) direction.
- Apply a vertical force to the TXV in the (Z) direction and increase the force until either a minimum displacement of 10 mm or a maximum force of 100 N is reached. Apply a vertical force to the TXV in the (-Z) direction and increase the force until either a minimum displacement of 10 mm or a maximum force of 100 N is reached. Repeat the vertical force in the (Z) direction.

4.5.2 Torque Application. Install the evaporator assembly into the HVAC module and secure the module to a surface in a way that does not influence the evaporator assembly. To simulate TXV to Air Conditioning (A/C) line production attachment, thread a nut onto the TXV stud. As shown in Figure 1, apply a torque of $22.0 \text{ Nm} +3.0/-0.0 \text{ Nm}$ in the direction that tightens the stud onto the TXV. Loosen the nut. Repeat the nut installation and removal.

Figure 1: Evaporator Setup for Tube Bending Force Application and Torque Tests



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