GM	WORLDWIDE ENGINEERING STANDARDS	General Specification	GMW16151

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. Not applicable.

2 References

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

2.1 External Standards/Specifications.

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

2.2 GM Standards/Specifications.

GMW3059	GMW14157 (ID)	GMW15290	GMW15787
GMW3172	GMW14573	GMW15760	GMW15862
GMW3600	GMW14780	GMW15786	GMW17389
GMW14156 (ID)			

(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
- 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.

3.1.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label. All measuring variables as specified in this standard shall be determined correctly with respect to their physical definition. Alternatives require prior approval from the GM Validation Engineer.

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 two 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 heat exchanger product or part number. Times may vary based on test cell availability and capacity.

Calendar time:	105 days
Test hours:	3000 hours
Coordination hours:	500 hours

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 Test Results).

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 °C ± 5 K.

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 Design Validation (DV) and Production Validation (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 Test Reliability Requirements Guidelines and GMW14157 Statistical Confidence Level for Reliability Validation Testing). 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, calculate reliability and submit the report to GM. Re-design the part/product as required and perform validation per Analysis/Development/Validation (ADV) Problem and Resolution. If reliability is not met, determine the number of samples required for retest with approval from GM Validation Engineer.

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. 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 Analysis/Development/Validation (ADV) Plan, as referenced in the Statement of Requirements (SOR). Full test reports shall be made available for viewing for GM per GMW15290.

3.7.2 Validation Cross Reference Index. The Validation Cross Reference Index (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 Analysis/Development/Validation (ADV) Plan and Report) 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). 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 with the evaporator installed in a design-intent Heating, Ventilation and Air Conditioning (HVAC) module with design intent seals if available. If a design-intent HVAC module isn't available at the time of early testing, the evaporator may be installed and tested in either a comparable HVAC module or a module-simulating test buck. A functional, design-intent expansion device is not required as part of this testing in order 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 °C ± 0.5 °C in all conditions. The refrigerant superheat at the evaporator outlet shall be 3.0 °C ± 0.5 °C in all conditions. The maximum temperature spread across the outlet face of the evaporator core shall be 3 K in all conditions. The oil circulation rate shall be less than 2% in all conditions.

4.2.1.1 Simulated Outside Air Conditions (OSA).

- Dry Bulb Air Inlet Temperature = 40 °C ± 0.5 °C
- Air Inlet Relative Humidity = 40 ± 2%
- Air Inlet Dew Point Temperature = 22 °C ± 0.5 °C

4.2.1.2 Simulated Recirculated (Recirc) Air Conditions.

- Dry Bulb Air Inlet Temperature = 25 °C ± 0.5 °C
- Air Inlet Relative Humidity = 50 ± 2%
- Air Inlet Dew Point Temperature = 13.5 °C ± 0.5 °C

Table 1: Performance Simulation Measurement Conditions

Condition	Air Inlet Conditions	Air Inlet Flow Rate (± 3 L/s)	Compressor Outlet Refrigerant Pressure (± 10 kPag)	Evaporator Outlet Refrigerant Pressure (± 5 kPag)
1	OSA	70 L/s	800	190
2			1700	330
3			2250	430
4		130 L/s	800	190
5			1700	330
6			2250	430
7	Recirc	70 L/s	800	190
8			1700	330
9			2250	430
10		130 L/s	800	190
11			1700	330
12			2250	430

Note: Outside Air Conditions (OSA), Recirculated (Recirc).

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 release drawing notes as Critical Key Characteristic (CKC) requirements.

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.

4.2.3 Internal Tightness. The evaporator assembly shall be free from any internal braze voids, component miss-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.

4.3 Leak Tightness. This test procedure shall mimic the production intent testing procedures and must follow SAE J2842; Test Procedure and Criteria, unless specified otherwise.

The assembly shall be proof tested with dry, oil-free air or nitrogen at 1470 kPa ± 20 kPa for 20 s prior to leak test. The leak test shall be performed with 100% Helium at a pressure of 1500 kPa ± 20 kPa for 20 s.

The permissible equivalent leak rate shall be ≤ 5 g/year of the representative refrigerant corresponding to 0.55 MPa gauge pressure.

4.4 Tightness Under Vacuum. Prior to beginning this test, the refrigerant side pressure drop shall be performed according to 4.2.1, Table 1, 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 times on each test sample.

The pressure shall not increase in excess of 0.5 kPa per minute during the course of the test procedure. After the completion of three cycles of vacuum application, the assembly shall satisfy 4.3 Leak Tightness. Repeat the refrigerant pressure drop test per 4.2.1, Table 1, Condition 5. Its value shall not vary by more than ± 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. Apply a torque of 22.0 Nm + 3.0/-0.0 Nm in the direction that tightens the stud onto the TXV. Loosen the nut. Repeat the nut installation and removal.

4.5.3 Acceptance Criteria. After the completion of 4.5.1 Bending Force Application and 4.5.2 Torque Application, the core shall satisfy 4.3 Leak Tightness. No cracks at the evaporator core, pipe couplers, or along the length of the pipes shall be initiated when analyzed by metallurgical inspection at the connection (brazed or other connection) of pipe and surrounding areas to the evaporator core. The effect of any permanent deformation of material will be evaluated by 4.6 Burst Pressure Test and 4.7 Pressure Cycling Test.

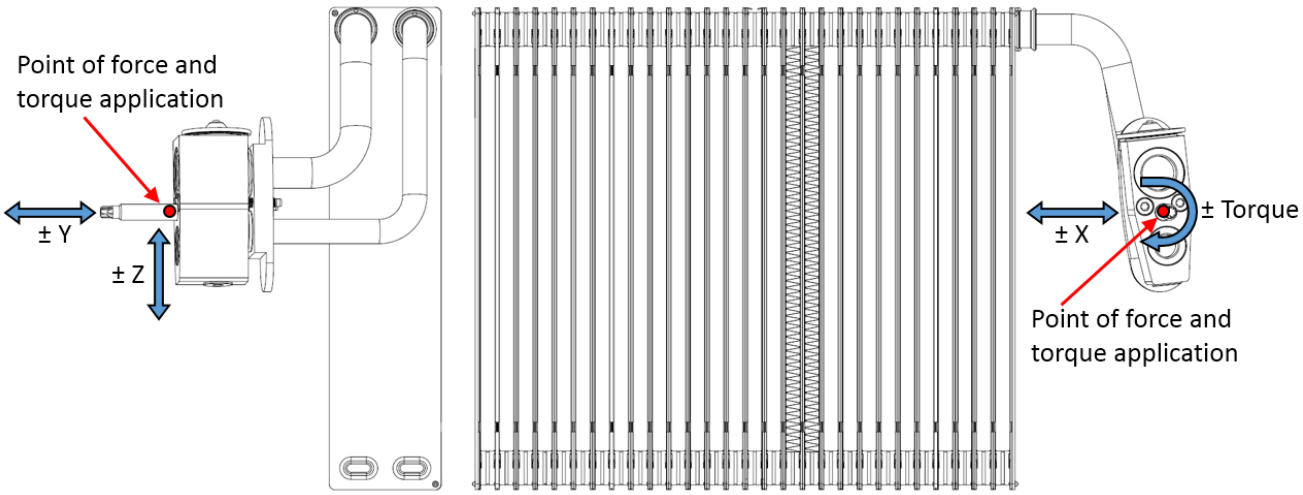

Figure 1: Evaporator Setup for Tube Bending Test

4.6 Burst Pressure Test. Prior to completing this procedure, the evaporator assemblies need to be subjected to the procedures listed in 4.5 Pipe Strength Tests. The test fluid may be oil or water and its temperature shall be +23 °C ± 2 °C. All entrapped air shall be removed from the evaporator prior to pressurizing. The test bench should be placed in an enclosure for safety considerations.

The evaporator assembly shall be pressurized with the test fluid at a rate of 100 kPa/s up to 1500 kPa. The pressurization shall continue at a rate of 10 kPa/s until 3000 kPa is reached. The evaporator assembly must maintain 3000 kPa ± 20 kPa for one (1) minute without leaking or allowing structural damage. The pressurization shall then continue at a rate of 10 kPa/s until actual burst pressure is reached. The test report shall include the pressure at which the first fin collapses and the location and pressure of final leak. Refer to SAE J2842 and SAE J639 for more details.

4.7 Pressure Cycling Test. Prior to pressure cycle testing, the evaporator assemblies must be subjected to the procedures listed in 4.5 Pipe Strength Tests. The evaporator assembly shall be resistant to pressure cycling. Refer to GMW14780 for more details on life cycle.

Note: The evaporator assemblies shall be tested according to 4.7.1 thru 4.7.3 conditions:

4.7.1 Fluid: Hydraulic Oil or Refrigerant Oil.

4.7.2 Fluid Temperature: +60 °C ± 2 °C.

4.7.3 The pressure curve shall follow the pattern 4.7.3 a thru 4.7.3 d (all pressures are ± 40 kPa gauge).

a. Increase pressure to 1000 kPa
b. Hold pressure at 1000 kPa
c. Decrease pressure to 100 kPa
d. Hold pressure at 100 kPa

The pressure peaks and valleys shall be reached within 0.2 s and held for at least 0.2 s (75 cycles/minute = 1.25 Hz). See Figure 2 for a typical pressure cycle curve. The curve may appear trapezoidal, sinusoidal, or "shark-fin" shaped as long as the ramp and dwell times are met.

Requires reliability demonstration of Reliability (R) 99 Confidence (C) 50 to 75 000 cycles while testing a minimum of six (6) samples. Recommended testing six (6) parts to 150 000 cycles without any failure. In the case of new evaporator designs or significant design changes, follow the guidelines in 3.4.1 Reliability. Otherwise, remove cores from test after 150 000 cycles. Following test completion, the unit shall not show any physical defect and must fulfill the requirements according to 4.3 Leak Tightness and results reported. If no failures are observed in the first 150 000 cycles, consult with GM Validation Engineer about continuing test to failure with existing or revised test parameters.

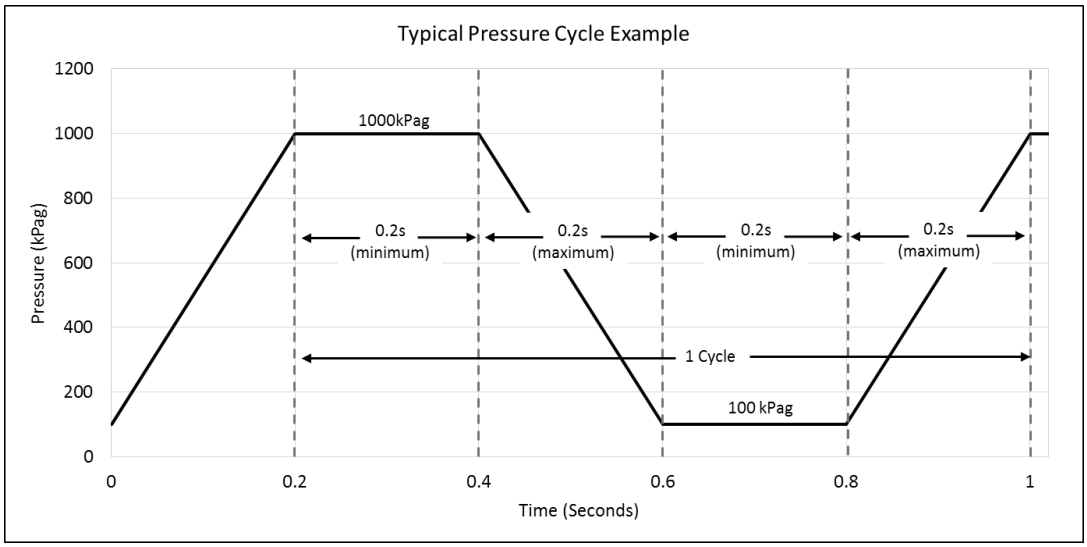

Figure 2: Typical Pressure Cycle Test Curve

4.8 External Corrosion Test. The exterior surfaces of the evaporator shall be resistant to corrosion caused by exposure to various environments. Evaporator assemblies shall be exposed to the corrosion testing procedure described in SAE J2842 Sec 5.5.2 (Heat Exchanger RELiability (HEREL) Test) to 65 days with a minimum of nine (9) parts. Suppliers can use alternative corrosion test procedures if good correlation to field return data can be established and agreed to by GM engineering.

4.8.1 Contamination Measurement Pre-Test. In the case of a new or modified HVAC module or blower assembly design or manufacturing process change, the evaporator contamination pre-test per SAE J2842 Sec. 5.5.2.4 shall be run to determine if the evaporator may be subjected to excess contamination during its life. A design-intent HVAC module and blower assembly shall be used for this analysis. The evaporator shall be replaced with a filter with an air-side pressure drop equal to two times the pressure drop of the evaporator. Record and report the amount of copper, sulfur, and other contaminants captured in the filter. Consult with GM Validation Engineering prior to beginning any corrosion testing to determine if module design and blower motor components contribute to a high contamination risk to the evaporator and whether the test solution should be adjusted.

4.8.2 Corrosion Test Analysis. At 50% test completion, remove three of the samples. Rinse and dry the samples within 24 h to prevent further corrosion. At this point, "white rust" which may flake off of the surface of the evaporator and into the airstream is unacceptable. Within five days, the samples must prove to satisfy 4.3 and results reported. The removed samples must demonstrate with R99C50 that pit depth will not exceed 30% of material thickness. If the core has 18 tubes or more, a minimum of one third of the tubes must be analyzed per sample. If the core has less than 18 tubes, a minimum of six tubes must be analyzed per sample. For the purposes of reliability, each analyzed tube may be considered a separate sample (e.g., three (3) cores and six (6) tubes yields 18 samples for reliability analysis). Pit depth must be reported for each pit analyzed. The selected tubes/plates shall be selected based on worst-case corrosion from a visual inspection. The 50% test analysis is required regardless of the test method used.

Upon 100% test completion, remove the remaining samples. Rinse and dry the samples within 24 h to prevent further corrosion. Within five days, the samples must demonstrate satisfaction of 4.3 to R99C50 with results reported. If the core has 18 or more tubes, a minimum of one third of the tubes must be analyzed per sample. If the core has less than 18 tubes, at least six tubes must be analyzed per sample. Pit depth must be reported for each pit analyzed. There is no pit depth requirement for end of test when testing to 65 day HEREL testing. The selected tubes/plates shall be selected based on worst-case corrosion from a visual inspection.

The same reliability and confidence levels apply to suppliers using an alternate corrosion test method. Consult the CTS/SSTS/VTS to determine required lifetime/mileage. The requirements can be demonstrated using success testing or failure testing using Weibull analysis. Validation results from Design Validation (DV) are acceptable to use for Production Validation (PV) if material system and processing have not changed.

4.9. Antimicrobial Surface Requirement. In order to prevent odors caused by microbial activity on the evaporator, all applicable evaporator surfaces shall have antimicrobial properties that last the life of the evaporator. Material coupons shall be prepared by using raw material that is intended for production. It shall pass it through the same process flow (i.e., cleaning, fluxing, brazing, and surface treatment) that is manufacturing design intent. These samples shall meet the requirements for antimicrobial efficacy per GMW17389.

4.10 Surface Wettability. In order to promote surface cleaning during use, reduce the risk of condensate spitting, and improve heat transfer, the surfaces of the evaporator shall be hydrophilic for the life of the evaporator core. Use evaporators as produced (including any flux, carbon fouling, and variation in coating application). The cores may be cut to expose surfaces for testing, but shall not be wiped or cleaned beyond what is part of manufacturing intent.

Following the guidelines of ASTM D7334 and using distilled water as the liquid, measure the contact angle on five (5) tubes/plate surfaces and five (5) air center surfaces. The surfaces measured shall represent the four (4) corners and the center of the core, resembling an "X". Complete the measurement on a minimum of six (6) evaporator cores. No surface contact angle shall exceed 45 degrees. Provide results for each water drop in a table format.

4.11 Water Drain-Off Test. The surfaces of the evaporator and form of the tubes, plates and air centers shall be designed to prevent retention of condensate.

Seal any openings to the evaporator core with plugs that will not retain water. In a tank representative of the setup shown in Figure 3, set the core at the in-vehicle angle (including any compound angles) using rods of different lengths linked to a digital scale. Measure the dry weight of the evaporator and support system.

Fill the tank with water and agitate the core to ensure all exterior surfaces are wetted. Quickly evacuate the tank of water in < 5 s. Record weight data at least once per second using a digital scale capable of data collection. Measure the weight until the weight change has stabilized and water has stopped coming out of the core or a minimum of five (5) minutes. The setup shall not be touched or moved during the draining process.

Complete the test twice per core at the in-vehicle angle. Complete testing on a minimum of six (6) cores. Repeat this test without an evaporator on the test stand as a baseline.

Subtract the baseline test data from the evaporator test data to get evaporator only data. Present data in the form of water retention versus time plots. The amount of water shall not exceed 75 g/m^2 of core face area after one (1) minute.

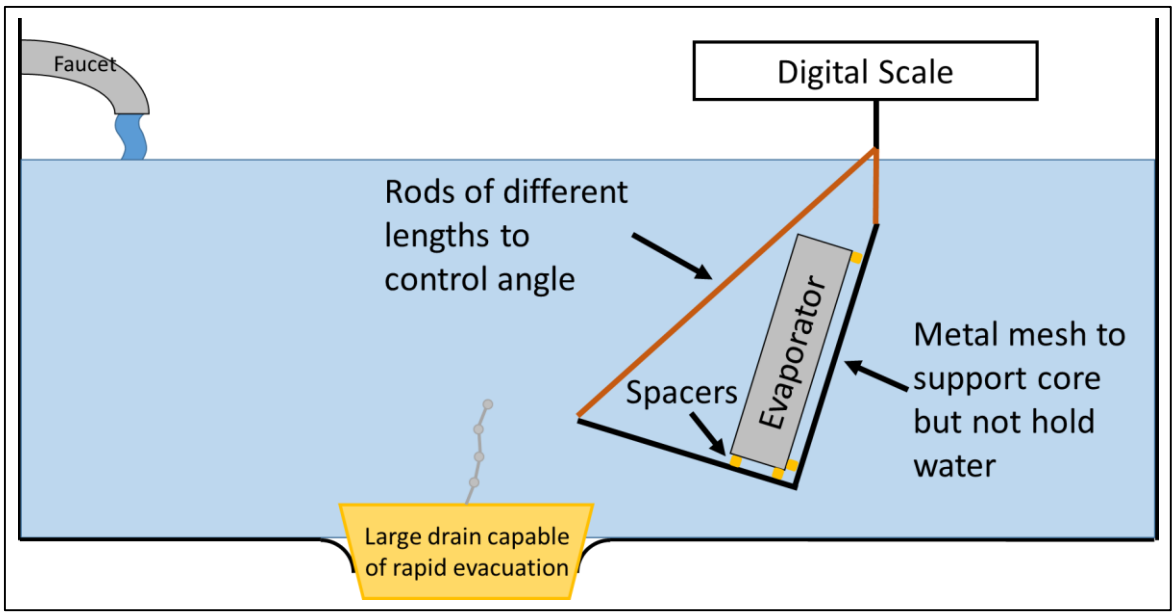

Figure 3: Evaporator Drain-Off Test

4.12 Water Freeze Test. The evaporator shall be designed to withstand expansion forces in the event that evaporator condensate freezes during vehicle operation with A/C on or when vehicle is turned off. Prior to starting the test, the evaporator shall be weighed and subjected to a Leak Rate Test according to 4.3.

The evaporator shall be submersed in three (3) °C or less water for two (2) minutes and then immediately placed on a test rig with tubes/plates in vertical orientation. The evaporator shall be weighed after a drip time of one (1) minute and then placed in a test chamber at -20 °C for 30 minutes. The evaporator shall be removed from the cold chamber and allowed to thaw. The submersion, freezing and thaw cycle shall be repeated a total of thirty times. The evaporator must satisfy 4.3. If no visual deformation of the tubes, plates, tanks or plumbing is found, discontinue testing. If visual deformation is found, continue the submersion, freezing, and thaw cycle with leak testing to 4.3 every five (5) cycles, until failure.

4.13 Vibration and Resonance Tests. Vibration testing shall be conducted using road load data whenever possible, otherwise per GMW3172 Random Vibration Profile for Sprung Masses, and GMW14780 (reference code letter sequence C C C E B IP5K2), with the evaporator core and assembled connections installed into the heater or air conditioning unit. Prior to Vibration and Resonance Testing, a Tube Bending Test according to 4.5 shall be performed.

4.14 Tube to Fin Bonding. To determine bond count, count every convolution that is supposed to braze to the tube surface. If the fin is bonded to ½ of the width of the tube or less, it counts as a whole loss. If the fin is bonded to less than the whole width but more than ½ of the tube width, it counts as half of a loss. Sum the total losses

and divide by the number of expected convolutions to determine tube and core bond percentage. The fin to tube bonding integrity must be maintained evenly over at least 95% of the entire core and at least 90% on any given tube surface. No more than three (3) convolutions in a row can have un-bonded portions.

4.15 Internal Cleanliness. The internal parts of the heater core and pipes shall be clean and free of all contamination that could impair the operation and/or the performance of the heater or contribute contamination of the coolant system including, but limited to, metal particles and chips, dust, dirt, flux flakes and residue, and manufacturing debris and oils.

4.15.1 Internal Cleanliness Test Procedure. All glassware and test surfaces must be clean and free of debris. Place the heater cores in a drying oven at 100 °C for 15 minutes. Remove the heater cores and allow to cool. Place 0.5 µ membrane filter paper on analytical scale and measure weight to nearest 0.1 mg. Place filter into vacuum filtering assembly.

Perform this test on one heater core at a time. Fill the heater core with enough solvent (i.e., methanol or acetone) to fill half of the internal volume. Cap and seal the core pipes. Tip and agitate the heater core back and forth for 2 minutes, ensuring to flush all internal surfaces, including pipes. Immediately pour contents of heater core into a graduated cylinder, ensuring to collect at least 95% of original liquid volume. Filter the solvent through a vacuum filtering assembly using the previously weighed filter paper. Dry the filter paper in a dry off oven. Weigh the dried filter paper.

The evaporator shall not contain > 0.05 g of debris per liter of internal volume. The maximum particle size shall not exceed 0.3 mm in any dimension.

4.16 Internal Moisture. Maximum permissible residual moisture inside an evaporator core shall be 50 mg per evaporator assembly. Karl-Fisher per ISO 760:1978, baking, or other suitable method may be used.

4.17 General Life Cycle Test. This is an aging test according to the vehicle lifetime for each evaporator family. The life cycle test shall not be repeated for each small design change or each vehicle program. This test is run for informational purpose and non-mandatory. In case of unproven/new evaporator design (no history behind the design), GM could include this test as part of the requirements. Supplier may elect to run it to demonstrate reliability. The life cycle test is a combination of selected tests described here in Section 4. The sequence 4.17 a thru 4.17 g shall be used for at least six (6) test samples:

a. Tube Bending per 4.5.
b. Leak Rate Test per 4.3.
c. Fifty Percent (50%) of pressure cycling per 4.7.
d. Fifty Percent (50%) corrosion testing per 4.8.
e. Fifty Percent (50%) of pressure cycling per 4.7.
f. Fifty Percent (50%) corrosion testing per 4.8.
g. Tightness under vacuum per 4.4. (Pressure drop analysis is not required).

At the end of the test, the evaporator must pass the Leak Rate Test according to 4.3. Finally, the core must be pressurized to failure per 4.6. The burst pressure must exceed 2250 kPa. The results and failure modes of each sample must be reported.

4.18 Further Requirements.

4.18.1 Serviceability. Evaporators are not to be repaired or reused per SAE J2842. Refer to CTS/SSTS for requirements for evaporator service requirements.

4.18.2 Material Guidelines. Evaporator shall be verified for material compatibility with GM service treatments for odor.

4.18.3 Design Guidelines and Constraints. The design shall be in close cooperation and in compliance with the GM drawing, package, safety, material and acoustic requirements. Combination of materials shall be selected in such a way that contact corrosion will be avoided. The configuration of the connectors on the component and in the car shall assure reliable and process-safe installation and/or removal. The detachable connectors of the evaporator pipe group to the refrigerant lines shall not be located in the vehicle interior compartment. They must be tested for integrity when serviced, if they are located inside the vehicle compartment. The connectors shall be mutually matched as required per GMW15787. Non-interchangeable connectors shall be assured. Within the interior compartment, brazed or welded joints to the evaporator block are preferred. The

evaporator piping group, fittings, and connectors, shall be bracketed at the HVAC unit to limit mechanical loading at the piping group/evaporator block joint. No bending of the evaporator piping group is allowed.

4.19 Identification and Marking. The evaporator shall be permanently identified with the date of manufacture, manufacturing location, and assembly part number. In addition, the evaporator shall be marked with the appropriate GM part number according to GMW15862. Refer to GMW14573 for additional details on label requirements.

Identification of the evaporator as an R1234yf component and SAE International symbol for non-reuse is required (see Figure 4 or SAE J2842). The background color for this label shall be Pantone Orange 151 and the text font shall be a minimum of 2 mm high. This label may be incorporated with the manufacturers' identification label or a barcode may be added for error-proofing purposes as long as the content and dimensions of the content shown in Figure 4 are preserved.

A text alternative to the symbols shown in Figure 4 is described in SAE J2842. If used, this text must read, "Conforms to SAE J2842 – General Motors - Replace only with new evaporator certified to meet SAE J2842 using Refrigerant R-1234yf". If used, the background color of the text shall be Pantone Orange 151 and the text font shall be a minimum of 2 mm high.

The identification may be placed on the evaporator pipes or any other component attached to the core block as long as that component is visible upon removal of the evaporator, it is serviced as part of the core block replacement, and is not a separate serviceable component. The label may not be placed on the expansion device or any attached component that may be serviced individually. The label cannot be covered by the evaporator seals or any other attached component. All evaporators provided for service requirements shall meet the same labeling requirements. The evaporator label is not required for R134a.

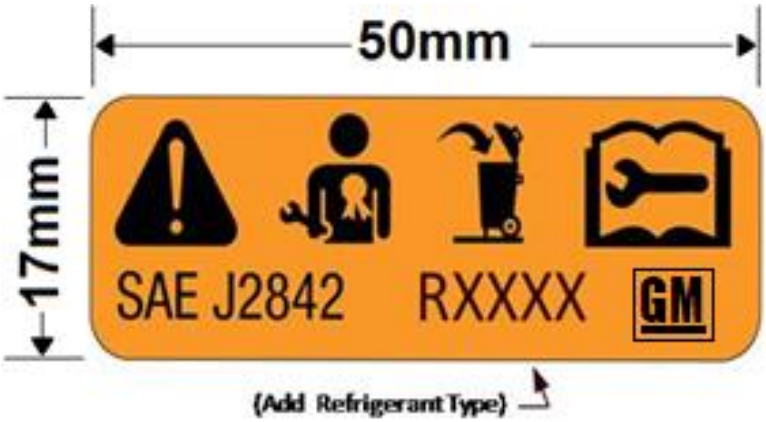

Figure 4: Evaporator Label

4.20 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 per GM's Production Part Approval Process (PPAP), and to apply for a new release.

Unless otherwise agreed to, the entire verification test shall be repeated and documented by the supplier prior to start delivering the modified or changed product. In some cases, a shorter verification test can be agreed to between the responsible GM department and the supplier.

The information, 4.20 a thru 4.20 e shall be included on the released math data/drawing notes.

a. Performance and pressure drop certification limit
b. Proof Test/Leak Rate Certification Limit
c. Internal Moisture Certification Limit

d. Fin Damage Certification Limit

e. Internal Cleanliness Certification Limit

4.21 Deviations from this Standard. Deviations from the requirements of the General Specification shall have been agreed upon between GM and supplier. Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.22 Evaporator Interfaces. The evaporator and/or the entire HVAC module shall be decoupled acoustically so that no compressor pulsation, engine vibrations or other noises will transfer to or from the HVAC module, body, refrigerant plumbing, or other interfacing component.

The female block of the connection shall be part of the evaporator/TXV assembly, while the male part shall be part of the connecting pipes or hoses.

4.23 Quality Assurance in Production. It shall be ensured by testing that non-conforming parts would not be delivered to GM. Each part (100%) shall be tested according to the following tests. The supplier can perform additional tests which are not specified in this standard to assure conformance. These additional tests shall be agreed to by GM.

All subsequent tests shall be performed with production-like sealing and connectors. The quality assurance report shall be delivered to GM validation engineering.

Evaporator supplier production processes must meet the minimum requirement for variations of x-bar ± 5 s which represents a Process Capability Index (Cpk) ≥ 1.67.

4.23.1 Performance. Every evaporator assembly is expected to match the heat transfer, air-side pressure drop, and refrigerant-side pressure drop of the original validation (or latest validation if performance improvement were made) within ± 5%. The process control plan shall include periodic performance simulation measurement conditions as described in 4.2. Results shall be reported and recorded as Critical Key Characteristic (CKC) requirements. Frequency of testing shall be agreed on in the process control plan.

4.23.2 Leak Rate. One Hundred percent (100%) of evaporator assemblies shall be tested as described in paragraph 4.3. The amount of time required for each stage of pressure application and leak detection may be optimized based on tester design, but shall allow sufficient time to detect a leak that may be temporarily masked by oil, elastomers, or other materials. Helium/Nitrogen mixtures may be used for production testing with appropriate modifications to the acceptable leak rate in order to maintain the permissible equivalent leak rate of ≤ 5 g/year of the representative refrigerant corresponding to 0.55 MPa gauge pressure.

4.23.3 Burst Test. Every evaporator is expected to match the initial fin collapse pressure, burst pressure, and failure mode of the original validation (or latest validation if improvements were made). Burst test shall be tested as described in 4.6. The pipe bending pre-conditioning is not required for the quality assurance in production. Frequency of testing to be agreed to in the process control plan.

4.23.4 Internal Cleanliness. Every evaporator assembly is expected to satisfy 4.15. The process control plan shall include testing for internal cleanliness as described in 4.15. Frequency of testing shall be agreed on in the process control plan.

4.23.5 Internal Moisture. Every evaporator assembly is expected to satisfy 4.16. The process control plan shall include testing for internal moisture as described in 4.16. Frequency of testing shall be agreed on in the process control plan. Based on evaporator design and coating, 100% inspection during mass spectrometry may be required. Frequency of testing shall be agreed on in the process control plan.

4.23.6 Appearance. One hundred percent (100%) of production parts shall be checked visually for any damages, defects, or non-conformance to dimensional specifications. A visual containment positive marking shall be minimal "Ω" where used.

The appearance of the evaporator assembly and its components shall be submitted and agreed upon between the supplier, GM Design Release Engineer and GM Manufacturing. The same document shall apply to all GM global production sites. The use of a boundary sample Microsoft PowerPoint document shall be prepared by the supplier. This document shall contain all appearance variation(s) such as any abnormal fin form (e.g., bunching, shape, louver angle variation), fins out of plane from the rest of the core face (dropped fins), fin comb-back near headers, braze frame marks, core damage, and any other physical variance acceptability. Proof of appropriate validation for each visual defect shall be available before use in GM vehicles.

4.23.6.1 External Cleanliness. All exterior assembly and component parts shall be clean and free of all contamination that could impair the operation and/or assembly, including but not limited to, metal particles, dirt, foreign material, residual manufacturing material, manufacturing lubricants, flux, soluble flux residue, metal chips, scale, and other contaminants that are not associated with the function. Flux residue shall not be considered a corrosion contaminant if it is insoluble in water or the refrigerant and oil used in the evaporator and not contribute to corrosion in the system.

Appearance and finish of parts shall be free of weld and/or braze splatter, flash, ridges, roughness, and of tool lubricants and other contamination. The exterior and component parts shall be free of burrs, sharp corners, etc., which may be detrimental to assembly and function.

4.23.6.2 Fin Bonding Quality. A maximum of 1% of the frontal area of the fins may be bent. In addition, none of the defective points may be > 2 cm^2. This requirement shall be monitored by means of visual check and boundary samples (for purpose of comparison).

Every evaporator assembly shall meet bonding requirements described in 4.14. Tube-to-fin bonding may be checked by using a feeler gage of ≤ 0.07 mm thickness and run through each of the tube to fin joints. Frequency of testing to be agreed to in the process control plan.

Sectional cuts shall be conducted on production parts. The cuts shall be made through fins between the end tubes to side plates and between every tube to verify bonding integrity. Supplier may choose to cut selected locations of the heater core, if it can prove such method would be equivalent. Frequency of testing to be agreed to in the process control plan.

5 Provisions for Shipping

The evaporator assemblies shall be compatible with commercial shipping by air, land, and water. Include retaining provisions if necessary. Performance and/or durability degradation and visible damages of the evaporator assemblies due to shipping are not acceptable. Upon successful completion of required manufacturing quality levels, the evaporator assemblies shall be prepared for delivery in accordance with the requirements specified.

5.1 Shipping Caps. All assemblies shall have shipping caps as specified by the detail drawing which maintain a fully installed position, until the hose/pressure relieve valve/compressor, etc., assembly is installed into a final system assembly.

The shipping caps shall conform to GMW15786. During removal, there shall be no damages of features as represented by the detail drawings. This would include, but not be limited to, dislodging of sealing mechanism (if required), damage to threads or sealing areas.

5.2 Damaged and/or Fallen Parts. By appropriate measures (e.g., Failure Mode and Effect Analysis (FMEA), instructions procedures, transport container, etc.,) it shall be guaranteed that fallen down parts are not dispatched and/or are not assembled in the line. Rework, repair, and/or re-brazing of a defective evaporator, including its pipes are not permitted.

5.3 Storage Capability. All parts shall have the capability to be stored for at least 24 months after production date according to ISO 2230.

6 Notes

6.1 Glossary. Not applicable.

6.2 Acronyms, Abbreviations, and Symbols.

A/C Air Conditioning
ADV Analysis/Development/Validation
C Confidence
CAE Computer Aided Engineering
CDS Component Data Standard
CKC Critical Key Characteristic
Cpk Process Capability Index
CTS Component Technical Specification

DRBTR Design Review Based on Test Result
DV Design Validation
FMEA Failure Mode and Effect Analysis
GVDP Global Vehicle Development Process
HEREL Heat Exchanger RELiability
HVAC Heating, Ventilation and Air Conditioning
OSA Outside Air Conditions
PPAP Production Part Approval Process
PV Production Validation
PVA Post Validation Audit
R Reliability
Recirc Recirculated
REP Reliability Evaluation Point
SAE SAE International
SOR Statement of Requirements
SSTS Subsystem Technical Specification
TXV Thermostatic Expansion Valve
VCRI Validation Cross Reference Index
VTS Vehicle Technical Specification

7 Additional Paragraphs

7.1 All parts or systems supplied to this standard must comply with the requirements of GMW3059, **Restricted and Reportable Substances.**

8 Coding System

This standard shall be referenced in other documents, drawings, etc., as follows:
GMW16151

9 Release and Revisions

This standard was originated in November 2008. It was first approved by Interior Airflow Global Subsystem Leadership Team in May 2009. It was first published in December 2011.

Issue	Publication Date	Description (Organization)
1	DEC 2011	Initial publication.
2	MAR 2016	5-Year Refresh. Added 4.9 and 4.10. Modified 4.2, 4.5, 4.6, 4.8, 4.11, 4.14, 4.15, 4.19 and 4.23. (Thermal – HVAC).