GM	WORLDWIDE ENGINEERING STANDARDS	General Specification	GMW14322

Heater Core

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. The 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 coolant to air heat exchangers used for cabin heating.

1.2 Applicability. All passenger vehicles using coolant to air heat exchangers used for cabin heating.

1.3 Remarks. Not applicable.

2 References

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

2.1 External Standards/Specifications.

ASTM D1384	ASTM D2570	ASTM D3306	ASTM G85-A3

2.2 GM Standards/Specifications.

GMW3059	GMW3600	GMW14718
GMW3172	GMW14156 (ID)	GMW14780
GMW3205	GMW14157 (ID)	GMW15290

(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.
- CG2064, Heater Core Analysis Development Validation (ADV) Problem and Resolution (ADVPR). The supplier shall work with the GM Design Responsible Engineer to comprehend this requirement.
- CTS.
- Design Review Based on Test Result.
- Quality assurance report.
- SOR.
- SSTS.
- Test report.
- Validation Cross Reference Index.
- Validation report.

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.

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.

Alternatives require prior approval from the GM Validation Engineer.

3.1.2 Equipment. Not applicable.

3.1.3 Test Vehicle/Test Piece. 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 heater core.

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. Following is an 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 h
Coordination hours:	500 h

3.1.5 Test Required Information. Not applicable.

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. Not applicable.

3.5 Data.

3.5.1 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 4.10, 4.11, and 4.13 for testing which involves reliability.

If any failure occurs in the 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 (ADVPR). If reliability is not met, determine the number of samples required for retest with approval from GM Validation Engineer.

3.6 Safety. This standard may involve hazardous materials, operations, and equipment. This standard does not propose to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

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 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, CG2064 Heater Core ADVPR, provided in the SOR to generate the VCRI for the CTS/Subsystem Technical Specification (SSTS) (the supplier shall work with the GM Design Responsible Engineer to comprehend this requirement).

4 Requirements and Procedure

4.1 General. Heater cores must fulfill the requirements according to the HVAC Module Subsystem Technical Specification (SSTS). See Validation Cross Reference Index (VCRI) table in the SOR for DV and PV tests and sample sizes.

Except as noted, all performance and durability testing shall be performed using a mixture of 50% Water and 50% Dex-Cool ® as coolant in the test. This mixture will be referred to as "coolant" throughout this document. Water is defined as clean, potable water per the recommended limits specified in ASTM D3306.

4.2 Performance Measurement. The heat dissipation, air pressure drop and liquid pressure drop shall be measured to the full matrix of conditions listed in 4.2.1. Samples used for heat dissipation reporting shall be high-limit samples from 4.5.

4.2.1 Test Conditions.

Coolant Flow Inlet Conditions:

- At 90 °C ± 0.5 K:
  - Flow rates (L/minute): 2.0, 5.0, 10.0, 25.0, 50.0, and 75.0 (± 0.5 L/minute for all).
- At 25 °C ± 0.5 K (collect liquid pressure drop data only):
  - Flow rates (L/minute): 2.0, 25.0, and 75.0 (± 0.5 L/minute for all).

Airflow Inlet Conditions:

- At -20 °C ± 0.5 K:
  - 0.3 m^3/minute, 1.5 m^3/minute, 2.7 m^3/minute, 3.9 m^3/minute, 5.1 m^3/minute, 6.3 m^3/minute (± 0.2 m^3/minute for all).

4.2.2 Documentation. The heat dissipation rate, air pressure drop and coolant 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 Standards (CDS) to GM. Comprehensive CDS data must be submitted and approved after the tests have been performed before final Production Parts 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.

4.3 Odor Test. The exterior surfaces of the heater core must fulfill the requirements to GMW3205 Rating 6 minimum (no objectionable odor permitted). If flux residue, manufacturing oil residue, part wash water, coatings, or any other surface material may be present on the final heater core, this material must be present during the test.

4.4 Tightness. The heater core and assembled connections must be tight. For verification the heater core shall be charged with air at a static pressure of 320 kPa ± 5 kPa gauge. No air bubbles may occur when the assembly is submerged in a 40 °C ± 3 K water bath for one (1) minute.

4.5 Internal Tightness. To verify internal tightness between coolant inlet and outlet of the heater core and assembled connections, the test sample shall be installed in a test setup as described in Appendix A, Figure A1. The inlet pipe of the heater core shall be connected to the reservoir (volume approximately 3 L). The reservoir shall be filled with water up to the overflow outlet (at approximately ⅔ of its height). Within the test period of one (1) minute, < 200 ml of water may drop out of the heater core outlet. High limit internal leakage cores shall be used for SSTS heat dissipation testing. A deviation to this specification is not required when limit samples (components with high internal leakage) meet program SSTS heat dissipation requirements and a report is issued to GM with supporting data.

4.6 Tightness under Vacuum. The heater core and assembled connections shall provide sufficient strength and tightness under vacuum. The assembly shall be exposed for three (3) minutes to an internal static pressure of -100 kPa gauge. Following this test the assembly must fulfill the requirements according to 4.4.

4.7 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.

4.7.1 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 two (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 heater shall not contain > 0.08 g/L of debris per internal volume. No single piece of debris shall be larger in any direction than the smallest internal dimension of the heater tubes (e.g., if the internal dimension of the tubes are 20 mm x 0.85 mm, no single piece of debris shall be > 0.85 mm in any dimension). If the dimensions of the internal flow paths within the heater core are all > 1.0 mm, no single piece of debris shall be > 1.0 mm in any dimension.

4.8 Strength Including Pipes. The heater core and its connecting pipes must be designed to provide adequate strength to withstand all requirements of transportation, vehicle installation and vehicle application. GMW14718 provides pipe requirements.

4.9 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 unbonded portions.

4.10 Temperature Cycle Test. The heater core and assembled connections shall be resistant against temperature cycles. The assembly shall be mounted in a test stand and tested according to the following conditions:

- 120 s of coolant flow at 0 °C ± 2 K

Then change within 30 s to

- 120 s of coolant flow at 100 °C ± 2 K
- Flow rate during two (2) minute soak: 15 L/minute ± 1 L/minute
- Maximum pressure at the heater core not to exceed 160 kPa gauge

See Figure 1 for a typical Temperature Cycle curve.

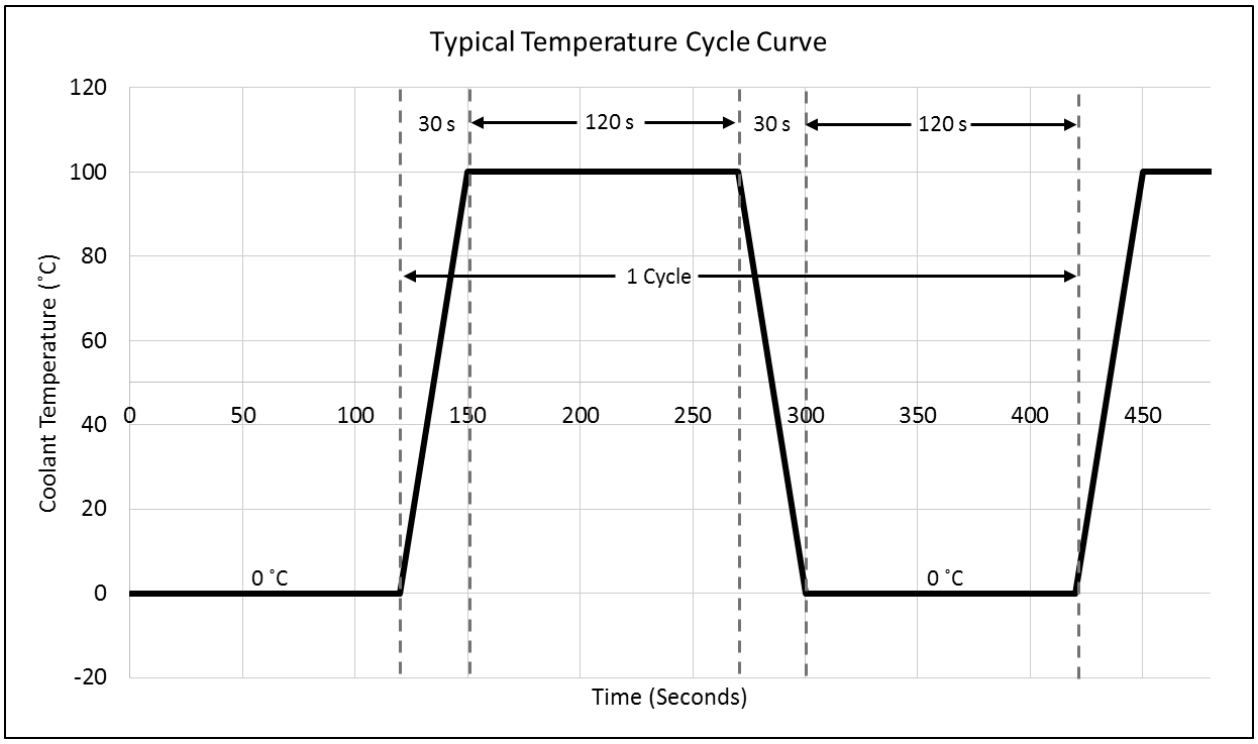

Figure 1: Typical Temperature Cycle Curve (Example)

Requires reliability demonstration of R99C50 to 1500 cycles. Recommend testing six (6) parts to 3000 cycles without any failure. Remove cores from test after 3000 cycles. Following test completion, the unit shall fulfill the requirements according to 4.4, 4.5 and 4.6 and results reported. Use a default slope of 2.0 unless prior data of this slope for this design is available, and agreed to by the GM Validation Engineer and Program Design Release Engineer (DRE). If no failures are observed in the first 3000 cycles, consult with GM Validation Engineer about continuing test to failure with existing or revised test parameters.

4.11 Long Term Heat Aging. The heater core shall be long-term temperature resistant. Coolant pipes shall be connected to core as design intent. The assembly shall be filled with coolant at a pressure of +150 kPa ± 10 kPa gauge. The assembly shall then be stored for 2160 h at an ambient temperature of +130 °C ± 2.5 K.

Requires reliability demonstration of R99C50 to 1080 h. Recommended testing six (6) parts to 2160 h without any failure. Remove cores from test after 2160 h. Following test completion, the unit shall fulfill the requirements according to 4.4, 4.5, and 4.6 and results reported. Use a default slope of 2.0 unless prior data of this slope for this design is available, and agreed to by the GM Validation Engineer and Program DRE. If no failures are observed in the first 2160 h, consult with GM Validation Engineer about continuing test to failure with existing or revised test parameters.

Note: This test is required only for heater cores containing non-metallic components, including any non-metallic clamp material, coolant seal, gasket, O-ring material or any other content susceptible to heat aging.

4.12 Vibration Test. 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 heater core and assembled connections installed into the heater or air conditioning unit.

At the end of the test, no noise may be created by the heater assembly or the mounting to the heater or air conditioning unit. The assembly shall be securely mounted after the test and shall not show any mechanical or functional damage. Following test completion, the unit shall fulfill the requirements according to 4.4, 4.5, and 4.6 and results reported.

4.13 Pressure Cycle Test. The heater core assembly shall pressure-cycle resistant. The heater core and design intent connections shall be tested according to the following conditions:

- Coolant Temperature: +115 °C ± 2.5 °C
  - Temperature may be obtained by heating the coolant and/or the ambient atmosphere surrounding the heater core. Method used shall be noted in test report
- The pressure curve should follow the following pattern (all pressures are ± 10 kPa gauge):
  a. Five (5) pressure cycles from +30 kPa to +180 kPa gauge.
  b. One (1) pressure cycle from +30 kPa to +250 kPa gauge.
  c. Five (5) pressure cycles from +30 kPa to +180 kPa gauge.
  d. One (1) pressure cycle from +30 kPa to +250 kPa gauge.
- After each completion of 50 000 cycles, the heater core and assembled connections shall be submitted to one (1) pressure cycle from +30 kPa to +350 kPa gauge pressure.

The pressure peaks and valleys shall be reached within 150 ms and held for at least 850 ms (0.5 Hz = 30 cycles per minute). See Figure 2 for a typical pressure cycle curve. See Figure 3 for the pressure cycle pattern.

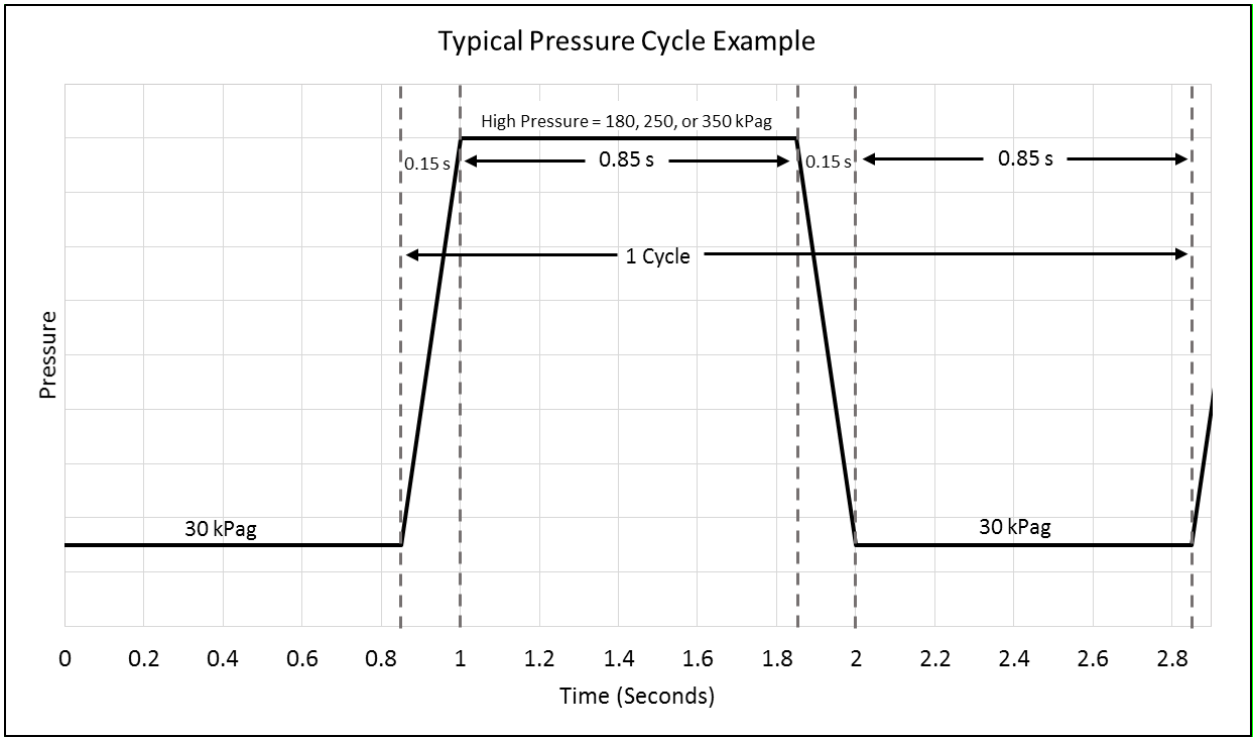

Figure 2: Pressure Cycle Curve (Example)

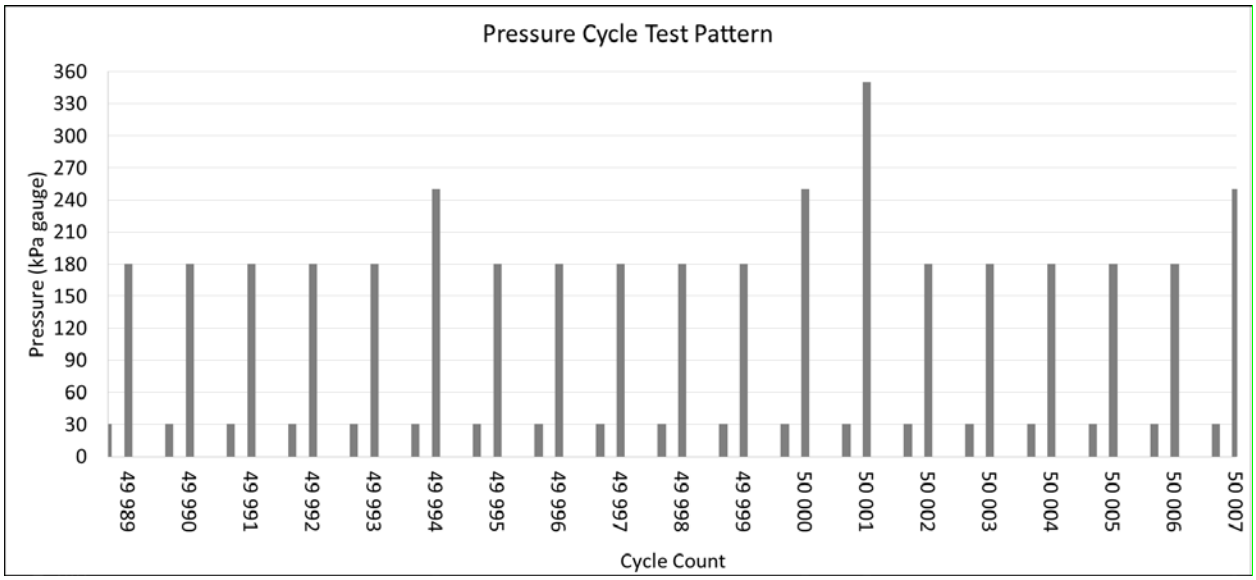

Figure 3: Pressure Cycle Test Pattern

Requires reliability demonstration of R99C50 to 250 000 cycles. Recommended testing six (6) parts to 500 000 cycles without any failure. Remove cores from test after 500 000 cycles. Following test completion, the unit shall not show any physical defect and must fulfill the requirements according to 4.4, 4.5, and 4.6 and results reported. Use a default slope of 2.0 unless prior data of this slope for this design is available and agreed to by the GM Validation Engineer and Program DRE. If no failures are observed in the first 500 000 cycles, consult with GM Validation Engineer about continuing test to failure with existing or revised test parameters.

4.14 Burst Pressure. The heater core and assembled connections shall be charged with water and subjected to an internal pressure increasing at a rate of 200 kPa/minute until a leak occurs. No fin damage may occur until a pressure of 400 kPa is reached. No leaks may occur until a pressure of 800 kPa gauge is reached. The test report shall include the pressure at which the first fin collapses and the location and pressure of final leak.

4.15 External Corrosion Test. Heater core and assembled connections made of aluminum or aluminum alloys must fulfill ASTM G85-A3 for 10 days (360 cycles). Following test completion, the heater core shall be rinsed and dried within 24 h. The heater core must be tested to the requirements of 4.4, 4.5, and 4.6 within five (5) days and results reported. If the heater core has external components not considered an aluminum alloy, the supplier must consult with GM engineers about testing alternatives.

4.16 Internal Corrosion Tests. The heater core must be resistant to corrosion under depleted coolant conditions and in all environments. Separate heater cores may be used for each test version but both versions must be validated to on every design that may be used globally.

4.16.1 Internal Corrosion Test 1: ASTM D1384 Water. Test to procedure described in ASTM D2570 except as noted as follows:

- Coolant Composition:
  a. First 72 h: 50% Dex-Cool®, 50% ASTM D1384.
     - To be run continuously without shutdowns.
  b. Final 2928 h: 17% Dex-Cool®, 83% ASTM D1384.
     - To be run at least 150 h per week.
- Coolant Temperature: 104 °C ± 2 K.
- Coolant Flow Rate: 1.8 m/s heater core tube velocity, not to exceed 55 L/minute total flow rate.
- Pressure: Not to exceed 150 kPa gauge at the heater core.

Note: The radiator in the coolant loop must be a modern aluminum automotive style.

Following test completion, the heater core shall be rinsed and dried within 24 h. The heater core must be tested to the requirements of 4.4, 4.5, and 4.6 within five (5) days and results reported. Pitting depth shall not exceed

30% of material gauge for coolant-containing components (e.g., tubes, tanks, headers, etc.) as measured on a micrograph. Evidence of flow erosion is not acceptable.

4.16.2 Internal Corrosion Test 2: Oyama Water. Test to procedure described in ASTM D2570 except as noted as follows:

- Coolant Composition:
  a. First 72 h: 50% Dex-Cool®, 50% Oyama Water (See 4.16.2.1 for Oyama water composition).
     - To be run continuously without shutdowns.
  b. Final 2928 h: 17% Dex-Cool®, 83% Oyama Water.
     - To be run at least 150 h per week.
- Coolant Temperature: 104 °C ± 2 K.
- Coolant Flow Rate: 1.8 m/s heater core tube velocity, not to exceed 55 L/minute total flow rate.
- Pressure: Not to exceed 150 kPa gauge at the heater core.

Note: The radiator in the coolant loop must be a modern aluminum automotive style

Following test completion, the heater core shall be rinsed and dried within 24 h. The heater core must be tested to the requirements of 4.4, 4.5, and 4.6 within five (5) days and results reported. Pitting depth shall not exceed 30% of material gauge for coolant-containing components (e.g., tubes, tanks, headers, etc.) as measured on a micrograph. Evidence of flow erosion is not acceptable.

4.16.2.1 Oyama Water Composition.

- Chloride (Cl-): 195 mg/L ± 1 mg/L.
- Sulfate (SO42-): 60 mg/L ± 0.2 mg/L.
- Iron (Fe3+): 30 mg/L ± 0.1 mg/L.
- Copper (Cu2+): 1 mg/L ± 0.01 mg/L.

4.17 Supporting Paragraphs.

4.17.1 Validation. The validation report shall be delivered to GM.

4.17.2 Interfaces. The heater core is connected with the system by engine coolant lines. No interchange between heater core inlet and outlet connectors shall be possible. System mechanical connections shall be located outside the passenger compartment or are designed such that design-intent leak tightness is ensured if connections must be made inside the passenger compartment.

4.17.3 Quality Assurance in Production. To ensure quality assurance in production, it shall be ensured by testing that zero non-conforming parts arrive at GM. Therefore, each part shall be tested according to the tests listed under 4.17.3. To guarantee conformance, the supplier can perform additional tests which are not specified in this standard. Additional tests shall be agreed to by GM. Alternative tests and configurations can be performed if the supplier can demonstrate to GM that such tests shall ensure zero non-conforming parts arrive at GM.

All tests listed under 4.17.3 shall be performed with production-like sealing and production-like connectors. The quality assurance report shall be available to GM Validation Engineering. Heater core and assembled connections per supplier production processes must meet the minimum requirement for variations specified in the control plan and agreed to by GM. Process Capability Index (Cpk) shall be recorded for Quality Assurance testing.

4.17.3.1 Visual Inspection. 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 minimally "Ω" where used.

4.17.3.1.1 Appearance. The appearance of the heater core 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.

4.17.3.2 Leak Test. 100% of production heater core and assembled connections shall pass a leak rate and test pressure, equivalent to the requirement of the acceptance criteria. The specified process leak rate reject level must include capability to protect against measurement error.

Leak rate must be ≤ 2.5 SCCM (Standard Cubic Centimeter per Minute) leak rate limit subject to test pressure of 310 kPa of air. Where a test medium different than air at 310 kPa is utilized, the equivalency detail shall be provided.

Note: Resulting process reject level will require a level lower than the specified acceptance criteria due to process measurement error.

4.17.3.3 Burst Test. Burst test shall be tested as described in 4.14. Frequency of testing to be agreed to in the process control plan but must ensure that cores from each manufacturing flow path are regularly tested.

4.17.3.4 Production Process Control. The process control plan shall include periodic quality assurance audit tests of production parts. Process control plan shall incorporate limitations of the process capability. Frequency of testing to be agreed to in the process control plan.

4.17.3.5 Performance Measurement. Shall be conducted using conditions as described in 4.2. Results shall be reported and recorded as Critical Key Characteristic (CKC) requirements.

4.17.3.6 Tube to Fin Bond and Feeler Gage Test. Part shall meet bonding requirements described in 4.9. Fin-to-tube bonding shall be checked by using a feeler gage with no > 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.

4.17.3.7 Sectional Cuts. Shall be conducted on production parts, at end tube to side plate and at every tube to fin joint 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.

4.17.4 Validating Rework Parts. For heater cores that were reworked by supplier, supplier shall select the most severe samples of the reworks and repeat all tests mentioned in 4.1 through 4.16. Frequency of testing to be agreed to in the process control plan.

5 Provisions for Shipping

Not applicable.

6 Notes

6.1 Glossary. Not applicable.

6.2 Acronyms, Abbreviations, and Symbols.

ADV	Analysis Development Validation
ADVPR	Analysis Development Validation Problem and Resolution
C	Confidence
CAE	Computer-Aided Engineering
CDS	Component Data Standard
CKC	Critical Key Characteristic
Cpk	Process Capability Index
DRBTR	Design Review Based on Test Result
DRE	Design Release Engineer
DV	Design Validation
GSSLT	Global Subsystem Leadership Team
GVDP	Global Vehicle Development Process
PPAP	Production Parts Approval Process
PV	Production Validation
PVA	Post-validation Audit
R	Reliability
REP	Reliability Evaluation Point
SCCM	Standard Cubic Centimeters per Minute

VCRI Validation Cross Reference Index

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:

GMW14322

9 Release and Revisions

This standard was originated in September 2005. It was first approved by HVAC Module GSSLT Team in February 2006 It was first published in March 2006.

Issue	Publication Date	Description (Organization)
1	MAR 2006	Initial publication.
2	FEB 2011	Additional test requirements added. (HVAC and Powertrain Cooling)
3	DEC 2014	Modified for 15 year customer usage, and external leakage reduced to 2.5 SCCM from former 6.0 level due to customer odor dissatisfaction. Internal leak requirement modified. Internal leakage requirement increased to 200 ml/minute. (HVAC - HVAC Interior Airflow)
4	FEB 2016	Expanded data points required for performance measurement. Revised items 4.7, 4.9, 4.10, 4.11, 4.13, 4.14, 4.15, 4.16, and 4.17. (HVAC – Thermal, Cabin Comfort)

Appendix A

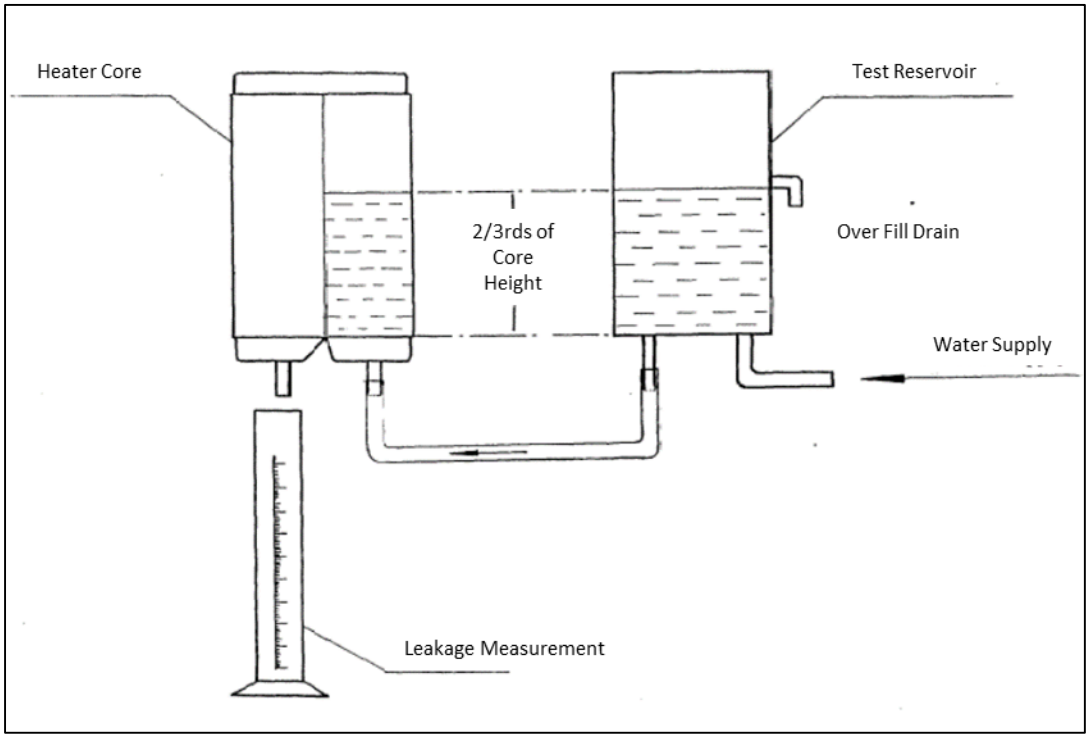

Figure A1: Equipment Configuration for Internal Leakage Measurement