



Radiator Product and Test Procedure 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 radiator heat exchangers using GMW3420 engine coolant (dexcool®).

1.2 Applicability. This specification is for Internal Combustion Engine Coolant to Air Radiators connected to the engine coolant systems. It also covers low temperature radiators connected to a propulsion coolant system. This specification also applies to Low Temperature (LT) radiators in special combination cooler applications.

This specification defines the testing requirements for validating a coolant-to-air radiator using accelerated testing methods.

2 References

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

2.1 External Standards/Specifications.

ASTM D1384	ASTM D3306	SAE J639	SAE J1344
ASTM D2570	ASTM G85A3		

2.2 GM Standards/Specifications.

GMW3059	GMW8758	GMW15443	GMW16331
GMW3116	GMW14156 (ID)	GMW15531	GMW17010
GMW3286	GMW14157 (ID)	GMW15725	
GMW3420	GMW14192	GMW15758	
GMW3600	GMW14573	GMW15920	

(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 Plan and Report (ADVP&R).
- CG2057 Radiator GMW14193 ADVP&R (Validation Cross Reference Index (VCRI) Chart).The supplier shall work with the GM Validation Engineer to comprehend this requirement.
- Drawing specifications.
- GM approved engineering drawings.
- GM1738 Packaging and Identification Requirements for Production Parts.
- Part drawing.

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- Release drawing notes.
- Statement of Requirements (SOR) Appendices B, C2, F, G2, G3.
- Statement of Requirements (SOR) drawing guidelines on A/C connections.
- Statement of Requirements (SOR).
- Test reports.

3 Requirements

3.1 System/Subsystem/Component/Part Definition. All requirements of this specification shall be met in order to demonstrate compliance with Design Validation (DV), Product Validation (PV) and Product Validation Audit (PVA) evaluations.

3.1.1 Appearance. The appearance of the radiator shall be submitted in a Boundary Sample document and agreed upon between the supplier, GM Design Release Engineer and GM Manufacturing. The Boundary Sample document shall apply to all GM global production sites. The use of a Boundary Sample document (PowerPoint, a Microsoft product) shall be prepared by the supplier. This document shall contain all cosmetic appearance variation(s) such as "crazy fin", fin bunching, fin drop, braze frame marks, finger bent fins, and any other physical variance acceptability. For example:

GM will accept no more than two (2) crazy fins per core, excluding the top and bottom fins. Maximum number of crazy fins per core including the top and bottom fins is four (4): two (2) in the center of the core and one (1) on both the top and bottom core cover.

A generic or specific picture (computer aided design (CAD) picture not permitted) must accompany each variation showing the type of defect and any agreed upon variation. This Boundary Sample document shall be created by the supplier and submitted into a GM database with the agreed upon CG2057 Analysis Development Validation Plan and Report (ADVP&R) plan (the supplier shall work with the GM Validation Engineer to comprehend this requirement). See 4.2. All appearance variations shall be cosmetic-only in nature and shall not result in the non-conformance of the part to the requirements in this standard. Any part coming into a GM plant that varies from this Boundary Sample document may be rejected at the plant's discretion.

3.1.2 Content. Not applicable.

3.1.2.1 Physical Content. Not applicable.

3.1.2.2 Functional Content. The radiator receives hot coolant from the engine supplied by the water pump and transfers heat through the tubes into the fins which have air passing through them supplied by the cooling fan and/or by ram air.

3.1.3 Ambient Environment. Unless otherwise specified, the standard ambient testing temperature environment is defined as 23 °C ± 5 °C.

3.1.4 Interfaces. All subcomponents and interfaces that build up the radiator including the upper assembly level (if required) must be documented in a block diagram supporting the Design Failure Mode and Effects Analysis (DFMEA), Process Failure Mode and Effects Analysis (PFMEA) and Design Review Based on Failure Mode (DRBFM) as required.

3.1.5 Usage Definition. The passing of these test procedures permit the use of the part globally. If more than one material supplier, or more than one toolset produce the same part in different regions, then a separate round of validation testing shall occur. The supplier shall coordinate this activity with GM Engineering to determine the level of testing required and any other opportunity to combine testing.

3.1.6 Test Vehicle/Test Piece. All testing shall be performed on the radiator alone. However, the vibration durability test and Noise and Vibration (N&V) test shall be tested with any and all components attached as it is installed in the vehicle. This includes fan motor(s) and shroud assembly and attaching subcomponents like Charged Air Cooler, Condenser, Low Temperature Radiator (LTR), Auxiliary Oil Cooler (AOC) and Isolators, etc. The testing setup shall be approved by the GM Validation Engineer. The specified sample quantity shall be agreed prior to testing in the ADVP&R plan. All subsystem components required for validation shall be provided by GM.

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3.1.7 Test Time. Total testing time shall 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 d

Test hours: 3000 h

Coordination hours: 500 h

3.1.8 Test Required Information. The performance measurements and durability test results are to be summarized and reported to GM on the supplier ADVP&R plan, CG2057 (the supplier shall work with the GM Validation Engineer to comprehend this requirement). Full test reports shall be available for viewing by GM personnel per GMW15920.

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

3.1.10 Testing Conditions. Coolant used herein is defined as a 50/50 blend of coolant, GMW3420 (dexcool®), and water. Water used herein is defined as clean, potable water per the recommended limits specified in ASTM D3306 unless otherwise specified.

The assembly plant fill process is defined as a process of evacuation of the coolant loop/system down to 1 kPa (absolute) in approximately 15 s throughout the entire coolant loop/system, then filling at a dispense rate of 1 L/s at 275 kPa_g with the radiator inlet not to exceed 138 kPa_g (equivalent to 138 kPa_g of pressure drop).

3.2 Product Characteristics.

3.2.1 Performance Requirements.

3.2.1.1 Fixed-value Performance Testing Requirements.

3.2.1.1.1 Internal Cleanliness. The radiator shall not contain more than 0.08 g/L of debris per internal volume of the radiator when tested per 4.4.2.

3.2.1.1.2 Component Data Standard (CDS). CDS data is not only a planning tool for achieving a "near" component accuracy as starting point. It is used for calculating all initial simulations and eventually actual component performance for preproduction and production. Therefore, all CDS data must represent real-world performance and production intent. All CDS data shall be confirmed and reported on the CDS. This includes heat dissipation, air side pressure drop, and coolant pressure drop when tested per 4.4.3, as well as mass and internal volume of the core and end tanks. The results shall be recorded in the release drawing notes as Key Characteristics Designation System (KCDS) "Standard Product Characteristic Documentation Required <DR>" requirements. Results shall represent the "best fit" curve that represents production design. DV part performance shall meet Statement of Requirements (SOR) CDS submission. The Kilowatt of heat rejection, at CDS data test points, during the PV test shall be a minimum of 98% of the DV test part performance or better. Performance minimum tolerances must be met by the ± 3 sigma limit of the sample population tested.

If the SOR includes additional load points, beyond those specified in 4.4.4, include those performance points in the CDS file submitted to GM.

3.2.1.1.3 Leak Test. The radiator shall exhibit a leakage rate ≤ 4 cc/minute dry air when tested per 4.4.1.

3.2.1.1.4 Maximum Pressure Test (Burst). During the procedure recorded in 4.4.4, the radiator shall not present any permanent deformation or leak beyond 4.4.1 or exhibit pressure loss before 345 kPa_g.

3.2.1.2 Endurance Testing Requirements.

3.2.1.2.1 Draincock Wear Test. Radiators with a draincock shall meet Leak Test (4.4.1) after Thermal Cycle Testing (4.4.8). There shall not be any visible cracks on the draincock or the housing after procedure 4.4.5 is completed. The radiator must then pass Leak Test (4.4.1).

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3.2.1.2.2 Filler Neck/Pressure Cap Wear Test (if applicable). Radiators with a fill neck shall meet Leak Test (4.4.1) after Thermal Cycle Testing (4.4.8). Then, after running procedure 4.4.6, the cap must be retained in the filler neck in the safety stop position. The radiator must then pass Leak Test (4.4.1).

3.2.1.2.3 Low Temperature Test (Plastic Tank Radiator). The radiator shall not leak during Leg 1 or Leg 2 of the test procedure in 4.4.7. The radiator must pass Leak Test (4.4.1) after each leg.

3.2.1.2.4 Thermal Cycle Durability Test. The radiator must pass Leak Test (4.4.1) prior to and after radiator thermal exposure test in 4.4.8.

3.2.1.2.5 Vacuum Test. After the radiator is vacuum tested in procedure 4.4.9, verify non-movement of rubber gasket by sectioning tank/gasket/header joint and/or visually inspecting with a camera from the inside looking for gasket displacement. The radiator must pass Leak Test (4.4.1).

3.2.1.2.6 Pressure Cycle Durability Test. Run radiator pressure cycle test in 4.4.10. The radiator must pass Leak Test (4.4.1).

3.2.1.2.7 External Corrosion Test (Sea Water Acetic Acid Test (SWAAT)). After the SWAAT test in 4.4.11, the radiator must pass Leak Test (4.4.1).

3.2.1.2.8 External Corrosion Test (Neutral Salt Spray (NSS)). After the Neutral Salt Spray test in 4.4.12, the radiator must pass Leak Test (4.4.1). The dissimilar mating material shall have no $> 1.32 \text{ g} \pm 0.13 \text{ g}$ ($60 \text{ } \mu\text{m} \pm 6 \text{ } \mu\text{m}$) cosmetic mass loss. This procedure is only required when two different materials are in contact with one another which can cause galvanic corrosion. This does not include GM released fasteners nor GM standard parts applied to other different materials.

3.2.1.2.9 Vehicle Validation. Vehicle level testing will be completed by GM. If the GM Engineer supplies the radiator back to the supplier (post-test), the radiator shall pass Leak Test (4.4.1). The testing includes, but is not limited to, the following tests:

3.2.1.2.9.1 General Durability with Corrosion. When vehicle validation test is completed in 4.4.13, the Condenser Radiator Fan Module (CRFM) components must not result in customer complaint.

3.2.1.2.10 Internal Corrosion Test, ASTM D1384 Solution. After the ASTM D1384 test in 4.4.14, the radiator must pass Leak Test (4.4.1).

Pitting depth shall not exceed 30% of tube gauge as measured on a micrograph.

3.2.1.2.11 Internal Corrosion Test Oyama Water (OY) Solution. After the OY Solution test in 4.4.15, the radiator must pass Leak Test (4.4.1).

Pitting depth shall not exceed 30% of tube gauge as measured on a micrograph.

3.2.1.2.12 Stone Impact Test. This test is only required when the radiator is the first component in the airflow. Radiator stone guard material shall be validated through GMW15725, Type 1 (Performance Requirements for Engine Compartment Plastic Parts), and after being subjected externally to 3 J on the Charpy Impact Testing device as described in 4.4.16, the radiator must pass Leak Test (4.4.1). The radiator plastic grill may have limited damage, but must maintain full function (attachments and stone protection) throughout the test procedure without causing further damage to the radiator or itself.

3.2.1.2.13 Vibration Durability Test. Test the radiator as described in 4.4.17, the radiator shall pass Leak Test (4.4.1) before and after testing. After each test, the radiator shall be able to function 100% without leaking. Failure is defined as, but not limited to, the loss of function, loss of structure, unacceptable performance degradation, and nonconformance of the component as stated in this specification. No fractures shall appear in any mounting brackets. No tears shall appear in any isolators. Post-test inspection results shall be included in the detailed test report.

3.2.2 Physical Characteristics.

3.2.2.1 Dimensions and Capacity. The dimensions, mass, and internal volume of the radiator and the CRFM shall meet all drawing specifications. This shall be proven statistically with a multi-part layout at DV and PV according to the Analysis/Development/Validation (ADV) plan.

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3.2.2.2 Mass Properties. The program mass targets provided in the CDS must be met and confirmed before testing can begin.

3.2.3 Reliability.

3.2.3.1 Reliability Evaluation Point. This specification, as written, provides a test exposure representing a Reliability Evaluation Point (REP) of 15 years of corrosion and 240 500 km (150 000 mi) of severe customer usage at the vehicle level. For a REP of 200 000 mi, multiply the test cycles for endurance tests by 1.33.

3.2.3.2 Reliability Requirements. This standard, as written, supports demonstration of the required reliability of 99.0% or greater at a 50% confidence (R99C50) at the REP for the heat exchanger when tested in a component test. The supplier shall utilize "vehicle equivalent" laboratory test setups to simulate "in vehicle" orientations. If the orientation may be different from vehicle to vehicle, use the orientation which will provide the worst case loads, for all physical level reliability demonstration testing.

Reference GMW14156 Test Reliability Requirements Guidelines, and GMW14157 Statistical Confidence Level for Reliability Validation Testing.

The Reliability Demonstration is provided by the Design Validation (DV) Endurance Tests. In contrast to DV, the Endurance Tests specified for Product Validation (PV) are intended to confirm the reliability demonstrated during PV of components manufactured from high volume tooling and at all manufacturing sites.

3.2.3.3 Accelerated Test Methods. GM encourages the use of appropriate Accelerated Test Methods, wherever possible. For example, the use of accelerated stress testing to reduce test time (GMW8758 Calibrated Accelerated Life Testing).

Note: GM Validation Engineering shall review and accept Reliability demonstration test plans prior to the supplier submitting the ADV Test Plan for approval.

3.2.4 Serviceability. All serviceable parts shall be able to be disassembled within the assembly (if required) and returned without showing signs of degradation. For example, a screw into a plastic tank boss shall be able to disassemble and reassemble without losing thread engagement. Plastic clips must be able to return to their "before" and "after" positions without cracks or breakage. GM's requirement is that the part must be able to be disassembled and reassembled at least 10 times without damage. The supplier must demonstrate by test, using real or surrogate data, that the design can withstand re-use without breakage. The supplier must choose the right design, torque, and consider all other factors that might influence serviceability. In-vehicle serviceability to be approved by GM Service Engineer prior to first design freeze.

Service parts shall be adequately protected to ensure satisfactory assemblies after a storage period of five years beyond the date of shipment from the manufacturer's plant.

3.2.5 User System/Subsystem/Component/Part Interface. Not applicable.

3.3 Design and Construction. Not applicable.

3.3.1 Materials, Processes and Parts Selection Guidelines.

3.3.1.1 Material Guidelines.

Refer to SOR Appendix F. Elastomeric and aluminum materials supplied under this specification must be homogeneous, free of defects and surface contamination such as bloom, talc, mold release agents, and flash. Machine surface finish must be measured on a 30 part layout and be according to drawing specification. See SOR for drawing guidelines on A/C connections.

3.3.1.2 Processes Guidelines. Not applicable.

3.3.1.3 Parts Guidelines. Not applicable.

3.3.1.4 Recycling. Materials shall be recyclable per GMW3116 (Recyclability/Recoverability). Attempts shall be made to minimize the variety of materials used to make recycling more viable. All plastic parts shall be identified for recycling per SAE J1344.

3.3.2 Design Guidelines and Constraints.

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3.3.2.1 Drawing Requirements. Radiator assemblies supplied under this specification must conform to the detailed drawing approved by Design Release Engineer (DRE).

3.3.3 Identification and Marking. The radiator assemblies supplied under this specification shall be visually identified in a manner exclusive and unique to each supplier to permit rapid identification of each respective radiator assembly manufacturer by the responsible GM Supplier Quality Engineer. Identification methods must be submitted to and approved by the GM Design Release Engineer. All assemblies must be labeled with the GM part number, date code and tool/cavity number in a visible location to comply with GMW16331, Identification and Branding Requirements on GM Parts. All labels shall conform to GMW14573.

3.3.4 Workmanship. All exterior surfaces shall be clean and free of weld and/or braze splatter, flash, ridges, sharp edges, flux paste, roughness and manufacturing lubricants.

All radiator connections shall have the sealing surfaces and threads free of damage, and foreign material (e.g., paint, dirt, etc.) Sealing surfaces shall be smooth and free of nicks, and scratches to assure positive sealing.

KCDS requirements shall be defined on the GM approved engineering drawings. The radiator assembly shall have manufacturing capability such that all dimensions are targeted at print nominal dimensions. The supplier shall submit a detailed improvement plan which describes how their manufacturing process for each part/operation shall achieve a process distribution of a value determined by the GM Supplier Quality Engineer.

3.3.5 Interchangeability. Not applicable.

3.3.6 Packaging. See GM1738, Packaging and Identification Requirements for Production Parts.

3.4 Documentation. All documentation for testing shall be approved before final Production Part Approval Process (PPAP) can be approved. For PV, the supplier shall submit a completed and signed off GMW3600 Validation Commodity form in order to finalize that all the requirements for the component(s) have been met. For Radiator see form CG2057 (the supplier shall work with the GM Validation Engineer to comprehend this requirement).

3.5 Support of System/Subsystem/Component/Part After Sale. Not applicable.

3.6 System/Subsystem/Component/Part Operator Training. Not applicable.

3.7 System/Subsystem/Component/Part Characteristics. Not applicable.

3.7.1 System/Subsystem/Component/Part Definition. Not applicable.

4 Validation

4.1 General.

4.1.1 Validation Phase Definitions. Reference GMW15758 (ADV Process Development and Validation Terminology) for the definitions of Design Validation, Product Validation, and Post Validation Audit.

4.1.2 Test Samples. Reference GMW15758 for explanations of how parts for Design Validation, Product Validation, and Post Validation Audit shall be produced and selected. Test samples' dimensions and materials must be within specification.

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

4.1.3.1 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this specification shall be determined correctly with respect to its physical definition. When test facilities or test equipment are changed between DV and PV testing, GM Component Validation Engineer approval is required.

4.1.4 Performance Test Requirements. These are tests designed to demonstrate the performance of the component, but not necessarily the reliability.

4.1.5 Endurance Test Requirements. These tests are designed to demonstrate the component reliability. Endurance testing may be conducted using either Test to Failure, 4.1.5.1 or Success Testing, 4.1.5.2. Test to Failure (TTF) is always the preferred method.

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