GM	WORLDWIDE ENGINEERING STANDARDS	General Specification	GMW14192

Air Conditioning Condenser with Integrated Receiver/Dryer HFC R134a and HFO 1234yf 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 for the Air Conditioning (A/C) condenser with integrated Receiver/Dryer (R/D) that is used in GM automotive air conditioning systems with liquid and gaseous refrigerant. Air conditioning refrigerant system connections shall be validated using GMW15787 and be in accordance with GM specifications.

1.2 Applicability. This specification defines the testing requirements for validating a refrigerant condenser using accelerated testing methods.

2 References

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

2.1 External Standards/Specifications.

ASTM D5035	ASTM G85A3	SAE J639	SAE J2297
ASTM E11	ISO 12103-1	SAE J1344	

2.2 GM Standards/Specifications.

9985751	GMW8758	GMW15443	GMW15787
9986181	GMW14156 (ID)	GMW15531	GMW15920
GMW3059	GMW14157 (ID)	GMW15725	GMW16331
GMW3116	GMW14573	GMW15758	GMW16846
GMW3600	GMW14671	GMW15786	GMW17010

(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.

Note: The supplier will work with the responsible GM Engineer to comprehend these requirements.

- CG2056 - Condenser GMW14192 ADVPR-Validation Cross Reference Index (VCRI) Chart.
- Arizona Test Dust, Powder Technology, Incorporated (PTI) Product Number 10152T.
- Component Data Standard (CDS).
- Engineering Drawings.
- GM1738 GM Packaging and Identification Requirements for Production Parts.
- Release drawing.
- Statement of Requirements (SOR), Appendices B, C2, G2, G3.
- Subsystem Technical Specification (SSTS).
- Test report.
- Vehicle Technical Specification (VTS).

2.3.1 GM Part Numbers.

88862657	88862658	9986319

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. See 3.3.4 for other specific requirements. In addition, the appearance of the condenser 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 PowerPoint document 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 document shall be created by the supplier and submitted into a GM database with the agreed upon CG2056 Analysis/Development/Validation Plan and Report (ADVP&R) (the supplier shall work with the GM Design Responsible 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.

3.1.2.1 Physical Content. A typical A/C condenser consists of a core (channeled tube and louvered fins), manifolds, receiver/dryer, inlet and outlet connection, A/C blocks and brackets to assemble it to a heat exchanger or to the chassis, and in some cases there are jumper lines. The receiver/dryer shall include the desiccant bag**,** according to ASTM D5035, or a robust cartridge design which will avoid desiccant contamination in the air conditioning system, and the tracer dye detector. See Figure 1.

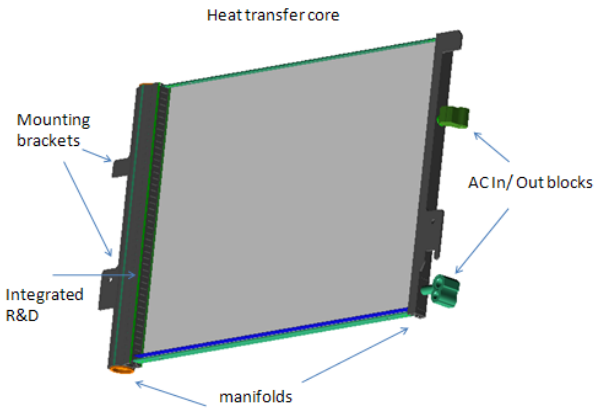


Figure 1: Typical A/C Condenser Assembly

3.1.2.2 Functional Content. The heat transfer is accomplished by passing high pressure refrigerant through the condenser tubes and passing cool air through the condenser core. The refrigerant is cooled to a condensate and liquefied. At the condenser exit, the refrigerant is mostly liquid, but still under high pressure.

The condenser will have an integrated receiver/dryer. The function of the receiver/dryer is to store refrigerant in liquid state to assure the evaporator will always have refrigerant available in the liquid state. The receiver/dryer contains the desiccant bag, which absorbs any moisture which may have migrated into the system.

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 condenser, 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 opportunities to combine testing.

3.1.6 Test Vehicle/Test Piece. All testing shall be performed on the condenser 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, Radiator, 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.

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 give 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:	35 days
Test hours:	1000 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 Analysis/Development/Validation (ADV) plan, CG2056 (the supplier shall work with the GM Design Responsible 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. Refrigerant and oil used herein is defined as refrigerant Hydrofluorocarbon (HFC) R134a (GM part specification: 9985751), Fluorinated Hydrocarbon (HFO) 1234yf (GM part number: 9986319), Polyalkylene Glycol (PAG) compressor oil (GM part specification: 9986181) and Polyolester (POE) compressor oil (GM part number: United States 88862657/Canada 88862658).

Tests shall comprehend HFC R134a and HFO 1234yf refrigerants as well as PAG and POE compressor oils. The acceptance requirements are identical for both HFC R134a and HFO 1234yf refrigerants with all formulations of PAG and POE compressor oils. The exception will be heat transfer tests, where test conditions are specific for every refrigerant type. Both mediums shall be tested and the results shall be provided in Component Data Standard (CDS) format.

The vehicle assembly plant fill process is defined as pulling a vacuum of 26.7 mbar Hg (20 mmHg) in 20 s (vacuum over the entire system, measured at the low side pressure port) and charging at a refrigerant flow rate of 0.4536 kg/s, using the high side pressure port.

All validation and Production Part Approval Process (PPAP) documentation must indicate the type, manufacturer of refrigerant, and oil used.

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 maximum residual material mass in the condenser with integrated receiver/dryer shall not be > 5 mg. No particle shall exceed 0.5 mm in any dimensional direction with the exception of length which can be 1.4 mm maximum. No particle shall exceed 29 HB on Rockwell scale.

Note: Since some particles are too small to measure with a Brinell test, it is highly recommended to use Scanning Electron Microscope (SEM) technology or equivalent to identify the particle's composition and then look up the hardness of the element.

For a mechanically attached condenser (non-brazed) with integrated receiver/dryer, it shall contain not > 10 ppm free chlorides when tested per 4.4.1 Internal Cleanliness. This chloride portion of this testing is not required for brazed condensers.

3.2.1.1.2 Internal Dryness. The condenser with integrated receiver/dryer shall contain no > 10 mg of water. Desiccant shall contain no > 2% moisture per unit mass. Desiccant shall not be released into the system when tested per 4.4.2 Internal Dryness.

3.2.1.1.3 Filtration Capacity. The screen and filter shall be a forced flow design and its area shall be application specific. The condenser with integrated receiver/dryer shall pass no particles of debris > 180 µm (0.18 mm) in any dimension. The condenser with integrated receiver/dryer shall guarantee that the filter is not too restrictive when tested per 4.4.3.

Note: Mesh size classification 80 per ASTM E11 is recommended to meet this requirement. Deviations must be approved by GM Engineering.

Condenser shall be tested for maximum pressure drop and heat transfer per 4.4.5. Only particles ≤ 180 µm shall be able to pass the component filter. No clogging of the component filter shall be exhibited. After the heat transfer test, the 180 µm in-line filter from the test equipment, not the component, shall be examined, and no particles shall be found in the filter.

3.2.1.1.4 Moisture Absorption. The water absorption percentage will be:

XH7 Desiccant: 15 g of H_2O/100 g dry desiccant minimum of usable water capacity (total has provision allowance of 1.5 g of H_2O/100 g dry desiccant included).

When calculated as: (final weight - initial weight)/desiccant weight x 100 = usable water capacity when tested per 4.4.4 Moisture Absorption.

3.2.1.1.5 Heat Transfer. All CDS data shall be confirmed and reported on the CDS. This includes heat dissipation, air side pressure drop, and refrigerant pressure drop at the required conditions found in 4.4.5, as well as mass and internal volume. The results shall be recorded in the release drawing notes as Key Characteristics Designation System (KCDS) "Standard Product Characteristic Documentation Required <DR>" requirements. Performance curves must meet Vehicle Technical Specification (VTS) and Subsystem Technical Specification (SSTS) requirements when tested per 4.4.5 Heat Transfer.

If the Statement of Requirements (SOR) includes additional load points, beyond those specified in 4.4.5, include those performance points in the CDS file submitted to GM.

3.2.1.1.6 Leakage Testing. A/C Condenser Assembly with integrated receiver/dryer shall exhibit a leakage rate < 5.0 g/year for HFC R134a or HFO 1234yf refrigerant (maximum 2.32 x 10^{-5} standard cc/s for 100% Helium) when tested per 4.4.6. This specification assumes "zero leakage" at the inlet/outlet plumbing attachments for the purpose of demonstrating conformance to the requirement.

3.2.1.1.7 Internal Blockage. Pressure drop shall not be increased from maximum predicted CDS to assure there is no internal blockage when tested per 4.4.7.

3.2.1.1.8 Vacuum Resistance. The pressure increase shall not exceed 5 kPa per minute when tested per 4.4.8.

3.2.1.1.9 Reverse Flow Resistance. The heat transfer test shall be run and shall not demonstrate blockage of any type. Filtration requirements shall be met when tested per 4.4.9.

3.2.1.1.10 Tracer Dye. The wet or dry wafer contained in the integrated receiver/dryer shall meet the SAE J2297 standard when tested per 4.4.10.

3.2.1.1.11 High Pressure Test. The condenser with integrated receiver/dryer shall not lose any test fluid when tested per 4.4.11.

3.2.1.1.12 External Paint Test. When tested per 4.4.12, paint on condensers shall meet requirements indicated in Section 3 of GMW14671. This requirement shall apply to painted surfaces only.

3.2.1.1.13 Stone Impact Performance. After being subjected to an Energy = 3 J, Condenser failure is determined by a leak in one or more of the following, when tested per 4.4.13:

a. After pendulum hit an obvious open hole is created.

b. During leak test per 4.4.6.

3.2.1.1.14 External Corrosion Test. Sea Water Acetic Acid Test (SWAAT). After test: perform leak test, maximum allowable leakage is 5 g/year helium. If the disposition of the condenser is such that it cannot be tested per 4.4.6, then air under water testing may be used at 2000 kPa_g ± 5 kPa_g. A maximum 10% fin de-bonding over the total core net is allowed. Photomicrographs are required to demonstrate that corrosion mechanism; zinc diffusion layer, dense precipitant band, is not compromised on the tubes.

3.2.1.1.15 Condenser Plastic Grill Protector. Plastic protector screen must meet the GMW15725 requirements. The condenser and plastic protector screen as an assembly shall pass vibration testing requirements in 3.2.1.2.3.

To avoid having a plastic grille protector, the supplier shall choose a robust condenser tube with either an extruded bull nose or a folded tube and pass the stone impact resistance test in 4.4.13.

3.2.1.2 Endurance Tests.

3.2.1.2.1 Thermal Cycle Durability Test. The condenser with integrated receiver/dryer shall not lose any test fluid when tested per 4.4.16. After completion of 4.4.16, if the disposition of the condenser is such that it cannot be tested per 4.4.6, then air under water testing may be used at 2000 kPa_g ± 5 kPa_g.

For mechanically attached condensers only - a maximum heat transfer degradation of 3% is allowed from the initial value. The heat transfer portion of this testing is not required for brazed condensers.

3.2.1.2.2 Pressure Cycle Durability Test. The condenser with integrated receiver/dryer shall not lose any test fluid when tested per 4.4.17. After completion of 4.4.17, if the disposition of the condenser is such that it cannot be tested per 4.4.6, then air under water testing may be used at 2000 kPa_g ± 5 kPa_g.

For mechanically attached condensers only - a maximum heat transfer degradation of 3% is allowed from the initial value. The heat transfer portion of this testing is not required for brazed condensers.

3.2.1.2.3 Vibration Durability Test. Test the condenser with integrated receiver/dryer as described in 4.4.18, the condenser shall pass leak test 4.4.6 before and after test. The condenser shall not lose any test fluid. After each test, the condenser 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.

The integrated receiver/dryer shall be sectioned to verify integrity of the desiccant bag and other internal components are not damaged. Post-test inspection results shall be included in the detailed test report.

3.2.1.3 Vehicle Validation. Vehicle level testing will be completed by GM. If the GM Engineer supplies the condenser back to the supplier (post-test), the condenser shall pass Leak Test (4.4.6). The testing includes, but is not limited to, the following tests:

3.2.1.3.1 General Durability with Corrosion. When vehicle validation test is completed in 4.4.19, the Condenser Radiator Fan Module (CRFM) components must not result in customer complaint.

3.2.2 Physical Characteristics.

3.2.2.1 Dimensions and Capacity. The dimensions, mass, and internal volume of the condenser and the Condenser Radiator Fan Module (CRFM) shall meet all drawing specifications. This shall be proven statistically with a multi-part layout at DV and PV according to the ADV plan.

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 241 500 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.

For definition of reliability, 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. The condenser with integrated receiver/dryer shall be serviceable allowing access to the filter and desiccant bag through the receiver/dryer canister. The service shall be made by removal of a plug (fixed by retaining ring or similar mechanism) which seals against receiver/dryer tubular housing through 2 rounded O-ring sealing. GM Engineering must sign off on non-serviceable condenser designs.

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.

3.3.1 Materials, Processes and Parts Selection Guidelines.

3.3.1.1 Material Guidelines. 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.

3.3.1.1.1 Material Compatibility. The Condenser shall be compatible with HFC R134a and HFO 1234yf refrigerants; and PAG and POE compressor oils.

Note: Pre-lube with mineral oil is not permitted for any type of Ethylene Propylene Diene Monomer (EPDM) seals.

3.3.1.2 Processes Guidelines. Not applicable.

3.3.1.3 Parts Guidelines. Not applicable.

3.3.1.4 Recycling Guidelines. 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.

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

3.3.3 Identification and Marking. The A/C condenser 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 A/C condenser assembly manufacturer by the responsible GM Supplier Quality Engineer. Identification methods must be submitted to and approved by the GM DRE. All assemblies must be labeled with the GM part number, date code and tool/cavity number in a visible location to comply with GMW16331. 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 condenser 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 A/C condenser 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, GM Packaging and Identification Requirements for Production Parts.

3.4 Documentation. All documentation for testing shall be approved before final 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 condenser see form CG2056 (the supplier shall work with the GM Design Responsible 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.

3.8 Testing Requirements. Desiccant used herein is defined as XH7 and shall be compatible with HFC R134a and HFO 1234yf refrigerants.

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.

4.1.5.1 Test to Failure. Failure is defined as, but not limited to, the loss of function, unacceptable performance degradation, and nonconformance of the component as stated in this specification. Use of Weibull analysis is required to determine the reliability.

Note: The required number of test samples may be negotiable (considering test equipment limitations, test sample physical size, test duration, etc.) Weibull slope values available from previous failure testing may be considered as a way to reduce the sample size and/or test duration. Reduction of sample size shall not cause demonstration of the reliability requirement to be unfulfilled. In no case shall the sample size be less than four. In no case shall the Weibull slope be higher than 3.0 (even with previous failure data).

Note:

- If any failure occurs in the 1st life of customer usage, stop the entire test. Do a Design Review Based on Test Results (DRBTR), perform root cause analysis. If, as determined necessary by root cause analysis, redesign the part or product and start testing all over again.
- Upon failure after the 1st life, plot Weibull slope and calculate reliability demonstrated.
- If no failures by the completion of required reliability demonstration, remove half of the samples from test stand and do the functional tests followed by DRBTR.
- Continue test to failure with the remaining samples (consider using stepped stress methods to induce failure) and do the functional tests followed by DRBTR to analyze failed samples.

4.1.5.2 Success Testing. Refer to Table 1 for success test.

Table 1: Number of Samples Required for Endurance Tests

Minimum Sample Size Required			
Reliability Requirement	**Quantity of REPs (lives)**	**Slope (beta)**	**Success Testing (samples)**
R99 C50	2.25	3.0	6

Note: The slope values listed may be reduced by the GM Validation Engineer for new design or new suppliers.

Note:

- If any failure occurs in the 1st life of customer usage, stop the entire test. Do a Design Review Based on Test Results (DRBTR) and perform root cause analysis. If necessary, as determined by root cause analysis, redesign the part or product and start testing all over again.
- Upon failure after the 1st life, plot Weibull slope and calculate reliability demonstrated.

4.2 Validation Cross Reference Index.

4.2.1 Analysis/Development/Validation Plan and Report. The ADVP&R template is CG2056 (the supplier shall work with the GM Design Responsible Engineer to comprehend this requirement). This document contains all component requirements, associated test procedures, test flows, and the quantity of parts to be tested at DV, PV, and PVA phases. This document is to be completed by the supplier and approved by the appropriate heat exchanger GM Design Release Engineer and GM Component Validation Engineer. Exceptions and or clarifications may be in SOR Appendix C2, G2, and/or G3, and shall be comprehended in the final approved ADVP&R.

4.2.2 Test and Results Approvals. Both test plans, and test results shall be approved as noted as follows.

4.2.2.1 DV Approval. Approval shall be provided by the appropriate GM Component Validation Engineer.

4.2.2.2 PV Approval. Approval shall be provided by the appropriate GM Component Validation Engineer.

4.2.2.3 PVA Approval. Test results are self-certified by the supplier. Results shall be available for audit by the GM Component Validation Engineer, GM Design Release Engineer, or the GM Supplier Quality Engineer.

4.2.2.3.1 Alternative Compliance. Supplier may request an exemption from Post Validation Testing, provided it can be demonstrated that sufficient process controls are in place so as to make testing unnecessary. The approvals required are to be provided by the GM Validation Engineer, GM Supplier Quality Engineer and GM Bill of Materials (BOM) Family Owner (BFO).

4.2.2.3.2 Lot Retention. In the case of a Post Validation Audit test result not meeting requirement, the affected production lot shall be retained by the supplier until Root Cause Analysis is complete. The supplier shall then

decide the disposition of the affected production lot. The supplier has three options for this retained lot; it shall be either:

a. Scrapped.

b. Corrected and certified (which may mean lot testing the revised part again) based on the root cause analysis.

c. Shipped without correction if deemed to be acceptable based upon the root cause analysis.

In any event, GM Supplier Quality Engineering shall be notified whenever any of the previously listed options is exercised. GM Supplier Quality Engineering approval is required for item c. Lot acceptance test procedure is defined in Appendix B of the SOR documents.

4.2.3 Documentation. Documentation shall be provided as required by the normal Production Parts Approval Process (PPAP) process. Refer to GMW3600 and SOR Appendix G2. Documents shall be managed according to GMW15920.

4.3 Supporting Paragraphs. Not applicable.

4.4 Test Procedures. See 3.2.1 for Performance requirements.

4.4.1 Internal Cleanliness.

Equipment list:

- Less than 10 µm pore size filter.
- Filtering assembly.
- Vacuum filtering flask.
- Graduated Beakers.
- Analytical balance sensitive to 0.05 mg.
- Drying oven.
- Desiccator.
- Tweezers.
- Magnification device with scale.
- Reagent grade solvent, i.e., methanol or acetone or equivalent.

Note: Reagent grade solvents are highly volatile and flammable and should be handled with extreme care and safety. The reagent grade solvent shall be compatible with the condenser component parts and assemblies. If possible, condenser component part compatibility with the reagent grade solvent shall be confirmed on a test sample prior to testing.

4.4.1.1 Facilities. All glassware and the test area used for determining condenser cleanliness compliance with this document must be clean and free from debris.

4.4.1.2 Pre-instructions Step 1. Filter the selected test solvent through the filter paper and discard filter paper.

4.4.1.3 Pre-instructions Step 2. Place new filter paper and the condenser in the drying oven at 100 °C (212 °F) for 15 minutes. Remove the condenser and allow to cool. Remove the filter paper from drying oven and place in a desiccator to cool to 20 °C (68 °F). Remove filter paper from the desiccator and weigh it to the nearest 0.1 mg (3.5×10^{-6} oz) with an analytical balance. Set the tare weight of the scale to 0 with the filter paper on the scale.

4.4.1.4 Process Instructions Step 1. Pour a volume of filtered solvent equal to 40% of the total internal volume of the condenser into the condenser inlet port.

4.4.1.5 Process Instructions Step 2. Tip/rotate and shake the condenser back and forth in such a manner to loosen any particles. Repeat the back and forth tipping for 10 cycles to ensure that the solvent flushes all the internal surfaces and passes. One cycle shall be the tipping of the condenser back and forth, so that all of the solvent flows from inlet of the tank to the outlet and then back to the Inlet tank (as much as possible).

4.4.1.6 Process Instructions Step 3. Drain half of the solvent from outlet port of the condenser into a graduated beaker. The inlet port may need to be capped during this process. Drain the other half of the solvent from the inlet port of the condenser into a graduated beaker. The outlet port may need to be capped during this process. Filter the solvent through the previously prepared and weighed filter paper which has been set up in the vacuum filtering assembly.

Note: The spent filtrate can be used for future condenser testing after it has been filtered through filter paper.

4.4.1.7 Post-instructions. Remove the filter paper from the filtering assembly and place it in the drying oven at 100 °C (212 °F) for 15 minutes. Remove the filter paper from the drying oven and place paper in desiccator to cool to 20 °C (68 °F). Remove the filter paper from the desiccators and weigh it to the nearest 0.05 mg (3.5×10^{6} oz) with an analytical balance.

4.4.1.8 Data Collection. The dry filter paper with the debris minus the dry filter paper without the debris equals the debris weight. Compare the measured debris weight to the debris weight limit to determine if this requirement has been met.

4.4.2 Internal Dryness. The quantity of desiccant used shall be specified on the detail drawing. Extract all water from the condenser with integrated receiver/dryer using standard laboratory practices. Remove and dry the desiccant bag, determine the percentage of moisture per unit mass. Ambient Temperature: 23 °C ± 5 °C.

4.4.3 Filtration Capacity. The purpose of this test is prove that there is enough filter area available and that the correct filter capacity (micrometers (µm)) is selected appropriately to adequately support debris accumulation without restricting the system flow characteristics. Add standard laboratory debris into the filter cartridge and reseal the unit. Use nominal 0 µm to 600 µm (0 mm to 0.6 mm) Arizona Test Dust, Powder Technology, Inc. (PTI) Product Number 10152T or equivalent into the condenser with integrated receiver/dryer using ISO 12103-1 or similar standard laboratory practices.

One (1) g (+10 mg tolerance) shall be added to the system. This represents the maximum debris in the air conditioning system allowed. This amount of debris will be added into the component receiver/dryer filter and shall be re-assembled at the condenser.

The supplier may place a 180 µm filter between the thermal expansion valve (TXV) and sub-cool charge reservoir while running this test to protect the test equipment if necessary. All Heat transfer points in 4.4.5 shall be run and be achieved without increasing head pressure beyond specified points to achieve test output and sub cooling requirements.

4.4.4 Moisture Absorption. Dry and weight the condenser with integrated receiver/dryer. Flow air at 25 °C, 60% Relative Humidity (RH). Flow air for ten minutes. Seal and re-weigh the condenser with integrated receiver/dryer. Ambient Temperature: 23 °C ± 5 °C.

4.4.5 Heat Transfer. The heat dissipation, air pressure drop and refrigerant pressure drop shall be measured and reported per the condenser CDS for both R134a and 1234yf. In addition, a set of tables like shown in Figure 2 and in Table 1 shall be provided to the GM DRE for each test condition to show that the GM target(s) have been met or exceeded. See CG2056 (the supplier shall work with the GM Design Responsible Engineer to comprehend this requirement) Validation Cross Reference Index (VCRI) for table in electronic format in the SOR. All performance measurements shall comprehend the effect of oil recirculation. The amount of oil recirculation is vehicle/application dependent and, therefore, must be specified by the responsible GM Engineer. All calculations shall be corrected for standard temperature and pressure conditions.

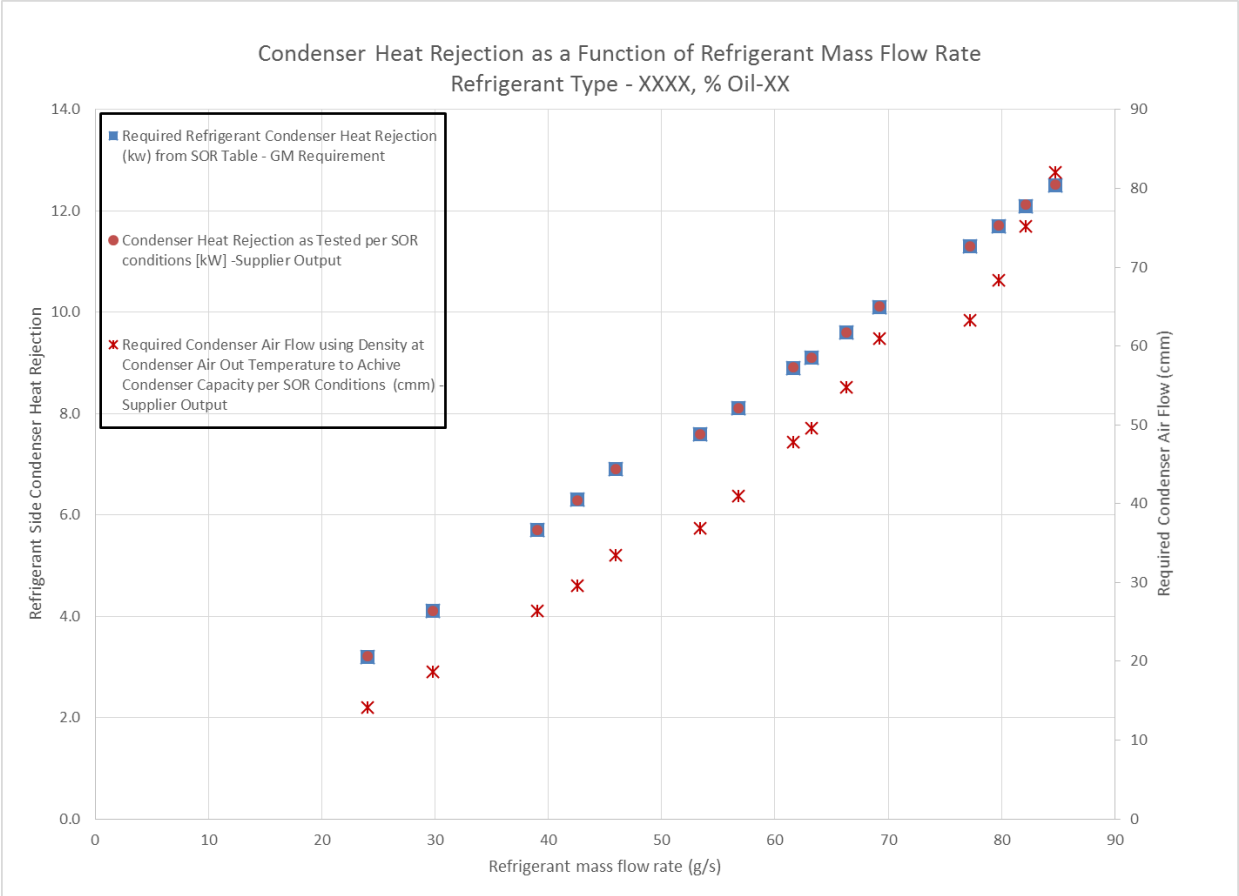


Figure 2: Example of Refrigerant Mass Flow Rate versus Refrigerant Side Condenser Heat Rejection

Table 1: Example of Test Conditions, Input and Output

Test Input	Test Conditions				Test Output	
Refrigerant Mass Flow Rate (g/s)	High Side Pressure (kPa Gauge)	Refrigerant Inlet Temperature (°C)	Condenser Sub Cooling (°C)	Air Temperature Entering Condenser (°C)	Condenser Capacity (kW)	Airflow Requirement to Achieve kW Capacity (m/s)
13	2100	82	7	50	2.1	
16	2100	83	7	50	2.7	
22	2100	84	7	50	3.6	
24	2100	84	7	50	4.0	
26	2100	85	7	50	4.4	
33	1750	77	9	50	5.9	
35	1750	77	9	50	6.2	
38	1750	78	9	50	6.8	
39	1750	79	9	50	7.0	
40	1750	79	9	50	7.3	
42	1750	80	9	50	7.7	
47	1750	81	9	50	8.7	
49	1750	82	9	50	9.1	
51	1750	82	9	50	9.4	
52	1750	83	9	50	9.8	

4.4.6 Leakage. The condenser with integrated R/D shall be leak tested prior to shipping. It must be placed in an appropriate test chamber at a room temperature of 23 °C ± 2 °C. The assembly shall be pressurized with helium or other suitable medium to 2000 kPa_g ± 5 kPa_g using a calibrated alarm system with mass spectrometry to measure leakage. The condenser shall be held at that pressure until condenser can demonstrate compliance to leakage performance requirements specified in 3.2.1.1.6. Test pressures and helium concentration percent can be substituted based on standard practice, however, all substitutions must demonstrate compliance with standard conditions and leakage rates.

4.4.7 Internal Blockage. This test shall only be run when there is an issue with heat transfer which could be related to a suspected internal blockage (i.e., baffle out of position or a closed internal tube). Refrigerant pressure drop test of the condenser with integrated receiver/dryer shall establish a minimum and maximum gas flow rate of cubic meters per hour (m^3/h) at a calibrated pressure drop of kilopascals (kPa) and temperatures 80 °C, 90 °C and 110 °C.

4.4.8 Vacuum Resistance. The condenser with integrated receiver/dryer shall be exposed to a vacuum of 5 kPa to 8 kPa absolute for a minimum period of five (5) minutes. The evacuation time shall be one (1) minute. Ambient Temperature: 23 °C ± 2 °C.

4.4.9 Reverse Flow Resistance. The condenser (with integrated receiver/dryer) shall be exposed to refrigerant flow entering the outlet as follows (simulated fill):

- Pressure: 2000 kPa_g ± 5 kPa_g.
- The flow will be maintained entering through the condenser outlet, and exiting from the condenser inlet into a collection vessel.
- The refrigerant flow time shall be one (1) minute. Ambient Temperature: 23 °C ± 5 °C.

4.4.10 Tracer Dye. The wet or dry wafer contained in the integrated receiver/dryer shall be tested following the SAE J2297 standard.

4.4.11 High Pressure Test.

Fill condenser with PAG or hydraulic oil. Water may be used as an option. Pressurize the condenser as follows:

- Maintain 9000 kPa_g minimum for 60 s minimum with a pressurization rate of 1000 kPa_g/minute.

- Fluid Temperature: 23 °C ± 5 °C.
- Ambient Temperature: 28 °C ± 5 °C.

4.4.12 External Paint Test. Test per GMW14671. Since there are seven (7) types of paint covered by this paint specification, type of paint shall be specified on the drawing.

4.4.13 Stone Impact Resistance. An object "A" (specified in Appendix A, Figure A1, Figure A2) shall be mounted to the pendulum of the Charpy Impact Testing apparatus (or equivalent), shown also in Appendix A. The condenser shall face toward the pendulum, be fixed by two blocks (approximately 152 mm x 152 mm x 13 mm (6 in x 6 in x 0.5 in) thick) with a minimum of two clamps, and have a rigid vertical structure (supported backer plate) touching the back side of the core. See Appendix A, Figure A3, for information on backer plate. This rigid structure will prevent the core from deflecting when the pendulum hit occurs. When the pendulum is swinging at an angle (θ), the block mounted to the end of the pendulum shall hit the front edge of the condenser tube perpendicularly at the lower position. The test will include only one hit and the hit shall be on the tube nose closest to the center point [(x, y) or (Width/2, Height/2)] of the core. Core must be subjected to 3 J of energy. Use the Potential Energy formula provided to determine the Length (L), Mass of the Block + Arm (m), and Swing Angle (θ) needed to apply a 3 J load onto the core. The length is measured from the center of the bearing to the center of the block in the vector along the pendulum's arm. To ensure the 3 J Potential Energy calculation will equal 3 J of Kinetic Energy, use a bearing with minimal rotational friction for the pendulum. The energy loss due to rotational friction shall be negligible. Each testing apparatus shall be qualified by GM Engineering.

4.4.14 External Corrosion Test. Sea Water Acetic Acid Test (SWAAT). ASTM G85A3; 450 cycles, each cycle = 2 h.

4.4.15 Condenser Plastic Grille Protector. When applicable, the Condenser Plastic Grille Protector shall be on the condenser testing during the following tests: Heat Transfer, Thermal Cycle Durability, Pressure Cycle Durability, Vibration Durability, External Corrosion, and Stone Impact Resistance.

4.4.16 Thermal Cycle Durability Test (Brazed).

Expose the condenser with integrated receiver/dryer to 150 cycles as follows:

a. Chamber temperature: -40 °C ± 2 °C to 150 °C ± 2 °C.
b. Condenser with integrated receiver/dryer is to be charged with refrigerant to 1750 kPa_g at 150 °C.
c. Cycle: Condenser shall be stabilized for 10 minutes at -40 °C, 15 minute transition time to 150 °C, 10 minutes stabilized at 150 °C, 15 minute transition time to -40 °C.

4.4.16.1 Thermal Cycle Durability Test Exception (Mechanically Attached). This exception is only for mechanically attached condensers. Run heat transfer per 4.4.5, and then run the thermal cycle durability test 4.4.16, then leakage test 4.4.6, and finally heat transfer test 4.4.5.

4.4.16.2 Reliability. The Reliability Evaluation Point (REP) for this procedure is 150 cycles. This is a component test. This is an endurance test. Weibull analysis shall be used to determine the reliability. Refer to 4.1.5 for Weibull parameters.

4.4.17 Pressure Cycle Durability Test (Brazed).

Expose the condenser with integrated receiver/dryer to 225 000 cycles as follows:

a. Pressure: maximum low pressure of 100 kPa_g to minimum high pressure of 3500 kPa_g.
b. Frequency: 1.25 Hz (75 cycles/minute). Cycle rate is not critical, as long as minimum hold time is achieved.
c. Cycle: pressure increase (0.08 s), hold (0.32 s minimum), pressure decrease (0.04 s), hold (0.36 s minimum).
d. Fluid: PAG or hydraulic oil.
e. Fluid Temperature: 80 °C ± 5 °C.
f. Ambient Temperature: 23 °C ± 5 °C.

4.4.17.1 Pressure Cycle Durability Test Exception (Mechanically Attached). This exception is for mechanically attached condensers only. First, run heat transfer 4.4.5, and then run the pressure cycle durability test 4.4.17, then leakage test per 4.4.6, and finally heat transfer test again 4.4.5.

4.4.17.2 Reliability. The REP for this procedure, is 225 000 cycles. This is a component test. This is an endurance test. Weibull analysis shall be used to determine the reliability. Refer to 4.1.5 for Weibull parameters.

4.4.18 Vibration Durability Test. Vibration durability testing shall be conducted per GMW17010 as a complete CRFM unless the condenser is a stand-alone part.

4.4.18.1 Reliability. This is a subsystem test. This is an endurance test. Weibull analysis per 4.1.5 shall be used to determine the reliability.

4.4.19 Vehicle Validation. Vehicle level testing, including but not limited to the following procedures, will be conducted: GMW15443, Vehicle Established Road General Durability Test or GMW15531, Passenger Vehicle Developing Road Regions General Durability Test. These tests are run by GM. The supplier shall participate in solutions for concerns discovered during testing.

4.5 Deviations from This Standard. Deviations from the requirements of this standard shall have been agreed upon by the responsible GM Design Release Engineer and GM Validation Engineer and submitted into the GM database for historical and reference purposes (see 4.2). Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.6 Safety. This standard may involve hazardous materials, operations, and equipment. This standard does not propose to address all of the potential 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 local, regional, state and national regulatory limitations prior to use. See SAE J639 for more information.

4.6.1 Caution. This specification refers to the usage of testing pressurized vessels. These tests shall be performed only by properly trained qualified personnel in using equipment capable of withstanding the pressures, temperatures and exposure of these tests with adequate safety margins. Standard laboratory safety precautions must be followed to prevent accidental bodily injury. All material shall be used in accordance with the manufacturer Material Safety Data Sheet (MSDS).

4.7 Additional Requirements.

4.7.1 Changes. Any change to the component or material, i.e., design, function, properties, manufacturing process and/or location of any change or modification to the product/process and manufacture requires a new release of the product. This includes changes in Tier 1 sub-supplier chains. It is the sole responsibility of the supplier to provide the customer, unsolicited, with documentation of any change or modification of the production product/process and to apply for a new release. If not otherwise agreed to, the entire DV/PV 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 Validation Engineer and the supplier.

4.7.2 Design Review Based on Failure Mode (DRBFM). Required for all changes, a DRBFM shall be conducted by the supplier for all product and process changes as described in 4.7.1. This process may also be used to determine applicability of surrogate data for specific DV and PV tests.

4.8 Documentation.

4.8.1 Conformity. 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.

5 Provisions for Shipping

See GMW15786 for the specifications and testing on the Refrigerant Fitting Cap. If the cap is a GM Corporate Common Component and the supplier has followed the SSTS requirement for the condenser block, then no testing per GMW15786 is required.

6 Notes

6.1 Glossary.

Desiccant: XH7 and shall be compatible with HFC R134a and HFO 1234yf refrigerants and meet GMW16846.

Vehicle Assembly Plant Fill Process: Pulling a vacuum of 26.7 mbar Hg (20 mmHg) in 20 s (vacuum over the entire system, measured at the low side pressure port) and charging at a refrigerant flow rate of 0.4536 kg/s, using the high side pressure port.

6.2 Acronyms, Abbreviations, and Symbols.

A/C	Air Conditioning
ADV	Analysis/Development/Validation
ADVP&R	Analysis/Development/Validation Plan and Report
AOC	Auxiliary Oil Cooler
BFO	Bill of Materials Family Owner
BOM	Bill of Materials
CAD	Computer Aided Design
CDS	Component Data Standard
CRFM	Condenser Radiator Fan Module
DFMEA	Design Failure Mode and Effects Analysis
DRBFM	Design Review Based on Failure Mode
DRBTR	Design Review Based on Test Results
DRE	Design Release Engineer
DV	Design Validation
EPDM	Ethylene Propylene Diene Monomer
GVDP	Global Vehicle Development Process
HFC	Hydrofluorocarbon
HFO	Fluorinated Hydrocarbon
KCDS	Key Characteristics Designation System
L	Length
LTR	Low Temperature Radiator
MSDS	Material Safety Data Sheet
N&V	Noise and Vibration
PAG	Polyalkylene Glycol
PE	Potential Energy
PFMEA	Process Failure Mode and Effects Analysis
POE	Polyolester
PPAP	Production Part Approval Process
PTI	Powder Technology Incorporated
PV	Product Validation
PVA	Post Validation Audit
R/D	Receiver/Dryer
REP	Reliability Evaluation Point
RH	Relative Humidity
RT	Room Temperature
SEM	Scanning Electron Microscope
SOR	Statement of Requirements
SSTS	Subsystem Technical Specification
SWAAT	Sea Water Acetic Acid Test
TTF	Test to Failure
TXV	Thermal 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:

GMW14192

9 Release and Revisions

This standard was originated in June 2005. It was first approved by the CRFM SSLT in August 2005. It was first published in August 2005.

Issue	Publication Date	Description (Organization)
2	JUN 2008	3.3.2.1 thru 3.3.2.1.5 added. 4.3.1.1 Added conditions (per ISO 12103 A4 and ISO 12103-2 A4). 4.4.1 Revised. 4.4.2 Changed Air Inlet flow to 5.0 from 4.0. 4.4.4 Changed Air Inlet Flow to .50 from .75. 4.5.1.2 Revised. 4.9.1 Changed Ambient Temp to 28 from 23. 4.10.1 Revised. (CRFM SSLT)
3	SEP 2011	**Testing.** DV and PV tables were deleted, everything now refers to VCRI. **Test Samples.** Samples used for testing must comprehend manufacturing process variation; limit and nominal samples are recommended. **Serviceable.** The condenser with integrated receiver/dryer is to be serviceable allowing access to the filter and desiccant bag through the receiver/dryer canister. The service shall be made by removal of a plug (fixed by Retaining Ring) which seals against R/D tubular housing through two (2) rounded O-ring sealing. **VCRI.** Quantities updated. **Leakage.** DV and PV requirement is 1 gr/year. "In-process testing" requirement is 5 gr/year. **SWAAT Test.** removed requirement for 10 years life Change requirement from 30 days to 35 days which now covers 15 years. **Acceptance Requirements.** No de-bonding is allowed. Photomicrographs are required to demonstrate that corrosion mechanism; zinc diffusion layer, dense precipitant band, is not compromised. **Provisions for Shipping.** Peel-Off shipping covers are not allowed. The shipping cap must be easy to align and assemble onto the fitting, and must not tear or rupture prior to removal. The shipping cap must remain firmly in place until it is removed just prior to assembly of the refrigerant fitting on the subassembly or the vehicle. This includes any/all conditions it may experience during production processing, packing, shipping, unpacking, and queuing at the component and/or vehicle assembly plant. The shipping cap should provide adequate protection to the refrigerant fitting so that damage does not occur to the threads or sealing surfaces of the fitting. It should also keep non-liquid contaminants from entering into the fitting as a result of shipping. Sealing caps (as specified on the detail drawing) must also provide protection against ingression of liquid contaminants as a result of exposure to water mist, spray, immersion or environmental humidity, unless otherwise specified. Reference GMW 15876, Refrigerant Fitting Cap specification. Heat transfer degradation was changed from 10% to 3%. Condenser Mounted Grille protector test was added. Cleanliness, maximum residual material allowed in Condenser with Integrated R/D has been updated. Filtration capacity has been updated, need to consider the total amount of debris in the system, then perform refrigerant pressure drop and heat transfer test. (HVAC and Powertrain Cooling)
4	APR 2015	Specification updated to latest format and brought up to date with GM requirements. (HVAC - CRFM Global Subsystem Leadership Team)
5	AUG 2016	Validation Sections 4.1 and 4.2 revised. Endurance tests require Weibull reliability analysis. Appendix A: Object A pick geometry revised. (HVAC - Powertrain Cooling and Thermal Integration)

Appendix A

A1 Calculations

Potential Energy Calculation:

$$PE = mgL\left[1 - cos\left(\frac{\theta\pi}{180}\right)\right]$$

Where:

PE = Potential energy = 5 [J]

m = Mass of the block + arm [kilograms]

g = Acceleration of gravity = 9.8 m/s^2

L = Distance between the supporting point of the pendulum and the center of gravity of the Block [meters]

θ = Swing angle of the pendulum [degrees]

Swing Angle Calculation:

$$\theta = arc\ cos\left[-\left(\frac{PE}{mgL} - 1\right)\right] \times \frac{180}{\pi}$$

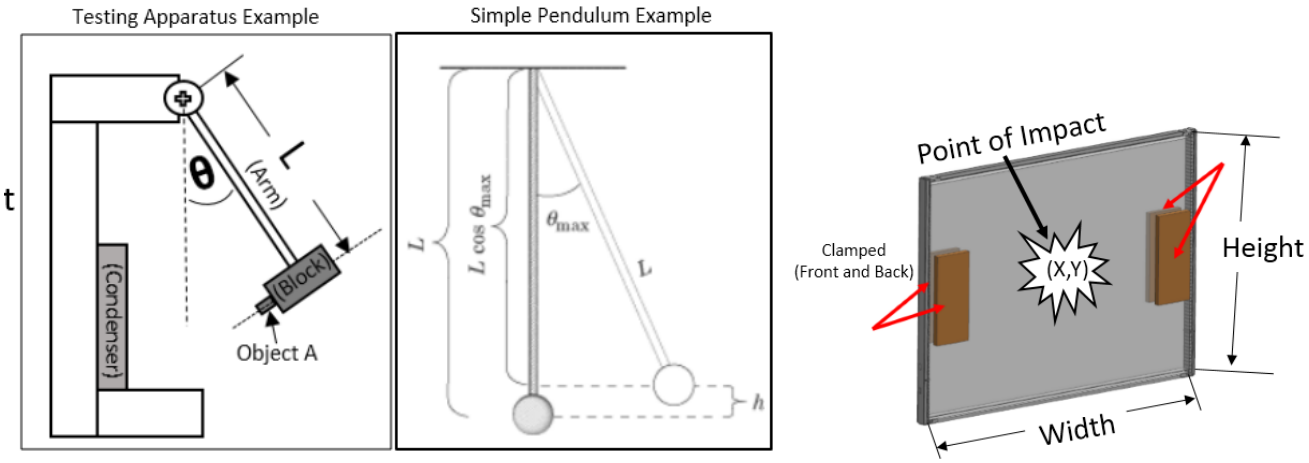
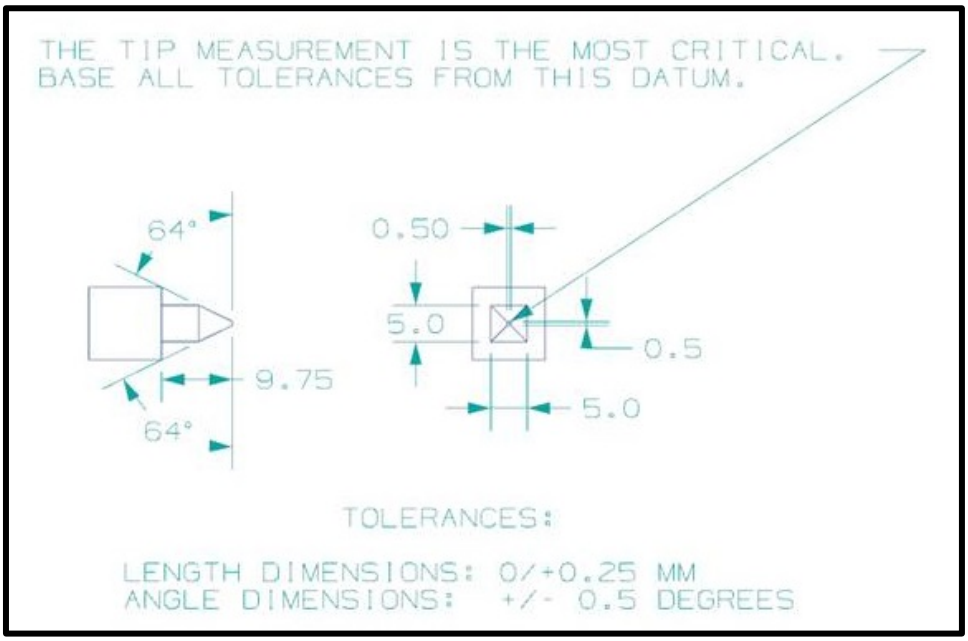


Figure A1: Example of Test Setup and Pendulum

The Object A pick, as detailed in Figure A2, needs to be finely-positioned in-line with the centerline of the tube/vane. The testing apparatus should include an adjuster at the pivot point of the pendulum in order to enable this fine-positioning.

A **backer plate**, as illustrated in Figure A3, is used to stop deflection of the fin when hit by the pendulum. This ensures all the energy will be transferred at a point and not distributed. The backer plate's "Bottom" portion shall be fixed by bolts, or welded to the table. The material for the plate shall be metal. The backer plate's design shall be rigid and not able to move or rotate. The backer plate's top dimensions shall cover the impact area of the pendulum hit.



Note: Dimensions in millimeters.

Figure A2: Dimensions of Object A (Shown in Figure A1)

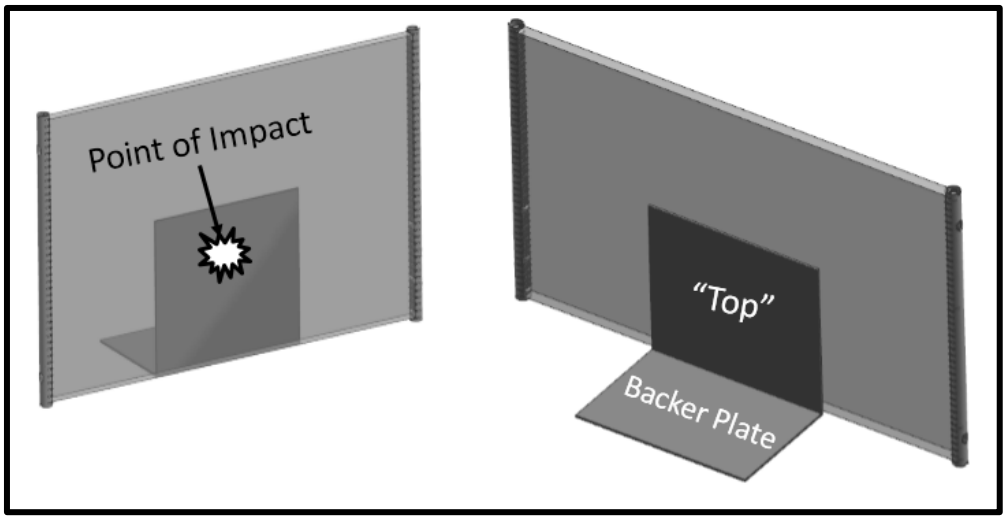


Figure A3: Backer Plate Diagram