GM	WORLDWIDE ENGINEERING STANDARDS	General Specification	GMW16295

Coolant Hose Coupled Assembly and Quick-Connectors

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 Scope. This specification defines the Design Validation (DV), Production Validation (PV) and Steady State Part Monitoring (SSPM) requirements for: coolant hose and tube assemblies, coolant quick-connect fittings, crimp connections, over-mold connections, or any non-standard connection that does not meet the GM best practice, Heating, Ventilation, Air Conditioning Powertrain Cooling (HVACPTC) - 264 the global metric coolant connection standards sizes for hoses/fittings. GM engineering may require any connection not described above be subjected to this specification prior to acceptance.

1.2 Mission/Theme. Not applicable.

1.3 Classification. Not applicable.

2 References

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

2.1 External Standards/Specifications.

ASTM A254	ASTM D380	SAE J1344

2.2 GM Standards/Specifications.

GMW3059	GMW3420	GMW14785	GMW15758
GMW3116	GMW8758	GMW14872	GMW15760
GMW3286	GMW14573	GMW15272	GMW15920

2.3 Additional References.

9985809
CG2046

3 Requirements

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

3.1.1 Appearance. Not applicable.

3.1.2 Content. Not applicable.

3.1.2.1 Physical Content. Not applicable.

3.1.2.2 Functional Content. Not applicable.

3.1.3 Ambient Environment. Not applicable.

3.1.4 Interfaces. Not applicable.

3.1.5 Usage Definition. Not applicable.

3.2 Product Characteristics. All crimps, over-molds (plastic molded rings acting as crimps), and non-standard clamp joints shall be described as; coupled assemblies, for the remainder of this document.

3.2.1 Performance Requirements.

3.2.1.1 Fixed-Value Performance Testing Requirements. GM engineering to agree to samples before testing should begin. For sample requirements and quantities, see 3.7.

3.2.1.1.1 Leak Test.

3.2.1.1.1.1 Coupled Assemblies. There shall be no indication of air leakage at the coupling or in the hose member when the assembly is subjected to a minimum of 350 kPa of air pressure when tested per 4.3.1.1.

3.2.1.1.1.2 Quick-Connector Assemblies. There shall be no indication of air leakage from the connector assembly, or from the hose member, after allowance for temperature compression at a minimum of 500 kPa for quick connectors smaller than 20 mm sealing surface diameter, and 400 kPa for quick connectors greater than 20 mm sealing surface diameter when tested per 4.3.1.2. Temperature compression is defined as the compression set of the rubber compounds for either the hose construction or the O-rings in the quick connect which create the sealing. This means that the crimped hose assemblies and the internal seals of the quick connect can experience compression set in the compound but there can be no leakage attributed to this condition. The rubber compound and the coupling or sealing must allow for the compression set and still perform to the standard without leaking.

3.2.1.1.2 Cold Leak Test. Sample must weigh within 3.0 g of original weight when tested per 4.3.1.2.

3.2.1.1.3 Tensile Test. The load at failure either by separation of the hose specimen from the end fittings, or by a rupture of the hose structure, shall not be less than 668 N when samples at nominal hose compression are tested per 4.3.1.3.

3.2.1.1.4 Blow-Off. There shall be no indication of leakage at the coupled assembly, quick connect or in the bulk hose, during the 180 s hold period when samples at nominal hose compression are tested per 4.3.1.4. The final blow-off pressure shall exceed 550 kPa for coupled assemblies and 700 kPa for quick connectors.

3.2.1.1.5 Blow-Off After Heat Aging. There shall be no indication of leakage at the coupled assembly, quick connect or in the bulk hose, during the 180 s hold period when samples at nominal hose compression are tested per 4.3.1.5. The final Blow-off pressure shall exceed 550 kPa for coupled assemblies and 700 kPa for quick connectors.

3.2.1.1.6 Vacuum Test. The assembly must hold the vacuum within 3% during the 10 minute hold period when samples at nominal hose compression are tested per 4.3.1.6.

3.2.1.1.7 Insertion Force Test (Quick Connect). The maximum insertion load shall not be more than 89 N when samples are tested per 4.3.1.7.

3.2.1.1.8 Pull-Out Force Test (Quick Connect). The quick-connector pull-out load must exceed 668 N when samples at nominal hose compression are tested per 4.3.1.8.

3.2.1.1.9 Cleanliness Test. There shall be no visual evidence of corrosion of either internal or external metal surfaces when hoses at nominal hose compression are tested per 4.3.1.9. No greater than 0.25 g/m^2 of internal surface area of contaminants is permitted.

3.2.1.1.10 Cyclical Corrosion Test. Sample must show no greater than 10% base metal corrosion when tested per 4.3.1.10. The assembly must meet all of the requirements of the Leak Test (3.2.1.1.1) and the Blow-off Test (3.2.1.1.4) after the cyclical corrosion test has been performed. All test samples from this test must be forwarded to GM Global HVAC/PTC engineering for evaluation at the end of the test.

3.2.1.1.11 Salt Spray Test. After 168 h of the salt spray test, assembly shall not exhibit evidence of any red rust on ferrous parts when tested per 4.3.1.11.

3.2.1.1.12 Maximum Crimp Compression Condition (Coupling). No hose rubber or reinforcement damage generated by the crimping operation is permissible in the samples when tested per 4.3.1.12.

3.2.1.1.13 Over-Crimp to Maximum Crimping (Coupling). Hose samples shall be tested per 4.3.1.13. Samples with maximum crimp, but without showing damage, shall be tested per and must meet the acceptance requirements of the Cold Leak Test (See 3.2.1.1.2). Production controls and product design must be such that over-crimp to damage is not possible in production.

3.2.1.1.14 Error-Proofing Pull-Tab Test (Quick Connect Assemblies).

3.2.1.1.14.1 Partially Assembled Connectors. The pull-tab shall break through the finger pull area prior to releasing from the connector when tested per 4.3.1.14. All pull-tab material shall remain with the connector. The force required to break the tab shall be a minimum of 12 N.

3.2.1.1.14.2 Fully Assembled Connectors. The pull-tab shall not break during the removal process. The maximum force required to remove the pull-tab shall not exceed 2.5 N when tested per 4.3.1.14.2.

3.2.1.1.15 Anti-Rotation Feature Torque Resistance (Quick Connect Assemblies). There shall be no loss of the anti-rotation feature, or any other damage that would cause loss of quick connect function when tested per 4.3.1.15.

3.2.1.2 Endurance Testing Requirements. GM engineering to agree to samples before testing should begin. For sample requirements and quantities see 3.7.

3.2.1.2.1 Pressure/Vibration/Temperature Test. Samples must meet the acceptance requirements of GMW14785. Samples must meet the acceptance requirements of the Cold Leak Test (See 3.2.1.1.2), following test completion. For sample quantity guidelines see 3.7.

3.2.1.2.2 Pressure/Temperature Test. Assemblies shall be tested per 4.3.2.2 - Pressure/Temperature Test, no leakage is allowed during the test procedure. Assemblies must pass the requirements of the Cold Leak Test (see 3.2.1.1.2), following test completion.

3.2.1.2.3 Coolant Circulating Test. Assemblies shall be tested per 4.3.2.3 - Coolant Circulating Test. Assemblies must pass the requirements of the 3.2.1.1.4 Blow-Off, following test completion.

3.2.2 Physical Characteristics. Not applicable.

3.2.2.1 Dimensions and Capacity. Not applicable.

3.2.2.2 Mass Properties. Not applicable.

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 10 years of corrosion and 240 000 km (150 000 mi) of severe customer usage at the vehicle level.

3.2.3.2 Reliability Requirements. This specification, as written, supports the demonstration of the required reliability of 99% or greater at a 50% confidence (R99C50), at the REP for the coolant hose assembly. The supplier shall utilize “vehicle equivalent” laboratory test setups to simulate “in-vehicle” orientations. If the orientation may be different from one vehicle to another, use the orientation which will provide the worst case loads for all physical level reliability demonstration testing.

The reliability demonstration is provided by the Design Validation (DV) Endurance Tests specified in 3.7.1.3.

Note: Test to Failure (TTF) is always the preferred method. 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.

Note: The required number of test samples may be negotiable if it is not practical to run, for example, 23 samples. Negotiation of sample size should consider test equipment limitations, physical size of test samples, test duration, etc. However, reduction of the sample size may require inclusion/use of longer test durations or other test methods such as Highly Accelerated Stress Screening (HASS), Highly Accelerated Stress Testing (HAST), Calibrated Accelerated Life Testing (CALT), Highly Accelerated Life Testing (HALT), etc. Weibull slope values available from previous failure testing may be considered as a way to reduce the sample size and/or test duration.

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 Analysis Development Validation (ADV) Test Plan for approval.

3.2.4 Serviceability. Not applicable.

3.2.5 User Interface. Not applicable.

3.3 Design and Construction.

3.3.1 Materials, Processes and Parts Selection Guidelines.

3.3.1.1 Material Guidelines. Not applicable.

3.3.1.2 Processes Guidelines. Not applicable.

3.3.1.3 Parts Guidelines.

3.3.1.3.1 Coupling Design. The coupling shall be designed and manufactured (for example, over-molded, inserted, swaged, or crimped) so that no internal tube abrasions, cuts or flaws shall result under any condition or combination of assembly component dimensioning or tolerances allowed by supplier production specifications, or under any condition of rubber hose compression allowed by supplier production specifications.

3.3.1.3.2 Sharp Corners. Sharp corners are not permitted where the coupling contacts the tube in order to prevent cutting of the hose when the hose assembly is subjected to internal pressure.

3.3.1.3.3 Tube Insert. The tube insert must not extend past the end of the crimp shell after crimping, and the end of the tube insert must have a radius and be manufactured to eliminate burrs or sharp edges which might cause hose damage under conditions of assembly vibration or pressure impulse.

3.3.1.3.4 Damage. Damage to hose rubber or reinforcement generated by the coupling of the hose is not permissible under any possible production manufacturing conditions or supplier production tolerance stack-up, including variations in hose compression concentricity.

3.3.1.3.5 Tube Collapse. Metal tube insert collapse during crimping is not permissible, except when this collapse is limited, predictable, controllable, and does not increase the potential for assembly leakage or other malfunction. Approval is required from the GM global HVAC/PTC engineer.

3.3.1.3.6 Design Restrictions. Grooves, upsets, or serrations are not permitted on the tube stem Outside Diameter (OD), or on the crimp shell Inside Diameter (ID), except that these grooves, upsets, or serrations do not cause hose cutting or other damage under any condition or combination of assembly component dimensioning or tolerance allowed by supplier production specifications, or under any condition of rubber hose compression allowed by the supplier production specifications.

3.3.1.3.7 Skiving, Adhesives. Skiving of the hose is not permissible. Use of adhesives in the joint is not permissible.

3.3.1.4 Recycling. Materials shall be recyclable per GMW3116. Attempts should be made to minimize the variety of materials used, to make recycling more viable.

3.3.2 Design Guidelines and Constraints.

3.3.3 Identification and Marking. All assemblies must be labeled with the GM part number, date code and tool/cavity number in a visible location. All labels shall conform to GMW14573.

All plastic parts shall be identified for recycling per SAE J1344.

3.3.4 Workmanship. Not applicable.

3.3.5 Interchangeability. Not applicable.

3.3.6 Packaging. Not applicable.

3.4 Documentation. See GMW15920 - Record Management for Suppliers.

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

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

3.7 Testing Requirements.

3.7.1 DV Phase (GMW8758 - Design Validation and Production Validation).

Table 1: DV/PV Test Table

Section	Test	Number of Samples for Couplings Note 1	Number of Samples for Quick Connect	Test Type
3.2.1.1.1	Leak	Note 2	Note 2	
3.2.1.1.2	Cold Leak	24	12	Performance
3.2.1.1.3	Tensile	24	12	Performance
3.2.1.1.4	Blow-Off	24	12	Performance
3.2.1.1.5	Blow-Off After Heat Aging	24	12	Performance
3.2.1.1.6	Vacuum	24	12	Performance
3.2.1.1.7	Insertion Force	Not applicable	12	Performance
3.2.1.1.8	Pull-Out Force	Not applicable	12	Performance
3.2.1.1.10	Cyclical Corrosion	24 Note 3	12	Performance
3.2.1.1.11	Salt Spray	24 Note 3	12	Performance

Section	Test	Number of Samples for Couplings Note 1	Number of Samples for Quick Connect	Test Type
3.2.1.1.12	Maximum Crimp Compression Condition	16	Not applicable	Performance
3.2.1.1.13	Over-Crimp to Damage	Design Dependent	Not applicable	Performance
3.2.1.1.14	Error-Proofing Pull-Tab Test	Not applicable	12	Performance
3.2.1.1.15	Anti-Rotation Torque Test	Not applicable	12	Performance
3.2.1.2.1	Pressure/Vibration/Temperature	24	12	Endurance
3.2.1.2.2	Pressure/Temperature	24	12	Endurance
3.2.1.2.3	Coolant Circulating	24	12	Endurance

Note 1: This quantity may change depending on the type of coupling (See 3.7.1.1).
Note 2: Performed for all test samples before conducting test procedures 4.3.1.3 through 4.3.1.6, 4.3.2.1, 4.3.2.2 and 4.3.2.3.
Note 3: This testing not required in PV as long as material is identical to material used in DV testing.

3.7.1.1 Test Samples. Sample or assembly is used to describe the component to be tested which should include the production design intent component or at minimum a 300 mm free length long hose, coupled assembly or quick connect, and production intent spigot if a production intent component is not possible. This is subject to approval by GM engineering.

3.7.1.1.1 For DV - Design representative test samples may be produced from prototype tooling or from equivalent production tooling, but must represent design intent, including design tolerances and material variation within the materials specification.

3.7.1.1.2 For PV - Production test samples must be produced on production representative equipment including the effects of manufacturing-induced variation. Sample selection of components to be utilized for the purpose of PV reliability requirements demonstration shall be in concurrence with the guidelines set forth in GMW15760.

3.7.1.1.2.1 Coupled Assemblies. Twelve coupled hose assemblies crimped at nominal hose compression and twelve coupled hose assemblies crimped at minimum hose compression shall be tested. For over-mold designs the supplier must choose samples representing the full extent of the design parameters, as well as proposed production parameters. This may mean more than 24 samples for the DV tests, and would require the Analysis, Development and Validation Performance Review (ADVPR) to reflect this sample increase. A minimum of two samples per parameter configuration is required.

3.7.1.1.2.2 Quick Connect Assemblies. Twelve assemblies at maximum dimension tolerance (largest female connection features, smallest male spigot features) shall be tested per Table 1. GM engineering to agree to samples before testing should begin. The exception will be for test 3.2.1.1.7 Insertion Force, where the assemblies shall be at minimum dimension tolerance (smallest female connection features, largest male spigot features).

3.7.1.2 Fixed-Value Performance Testing. Hose assemblies shall be tested for conformance per Table 1.

3.7.1.2.1 Crimp Compression. Test samples throughout this specification will be referred to as minimum hose compression, nominal hose compression or maximum hose compression samples. The requirements for these conditions are described in Appendix A. If not specified, the test samples shall be of nominal hose compression.

3.7.1.3 Endurance Testing. Hose assemblies shall be tested for endurance per Table 1.

3.7.1.4 Design Level Requirements. Not applicable.

3.7.1.5 Approval Requirements. Approval shall be provided by the GM Design Responsible Engineer and the GM Validation Engineer.

Note: DV and PV approval will require the information in 3.7.1.5.1 thru 3.7.1.5.6 to be submitted.

3.7.1.5.1 Drawings and Unigraphics (UG) math data showing the design, dimensions and tolerances for all components of the assembly including allowed eccentricity in the hose, tube insert, and coupling Outside Diameter (OD). In addition, the range of the all-hose compression possible under each condition of dimensional tolerance stack-up shall be provided.

3.7.1.5.2 The submission of sectioned coupling samples to demonstrate that all of the above mentioned construction requirements have been met.

3.7.1.5.3 A detailed description of the statistical process control procedures for the coupling diameter dimensions and the hose compression range. Include a sample of Statistical Process Control (SPC) data once available.

3.7.1.5.4 The value for hose compression necessary to induce (referred to Hose Compression to Damage):

- Hose rubber damage (any layer).
- Hose reinforcement damage.

3.7.1.5.5 Data presented in both tabular and graph form, showing values of hose compression (calculated using both linear and area methods) vs. Tensile Test performance (4.3.1.3), Blow-Off performance (4.3.1.4), and fitting insert collapse. The dimensions of the crimped assembly components for each data point must be listed, as well as the resultant hose compression, refer to Appendix A, Table A1 for calculations.

3.7.1.5.6 Copies of the test fixture parameter data, confirming pressure and temperature regiments imposed on the samples during test.

Note: Values of hose compression must be reported both in terms of linear compression and area compression (See Appendix B, Table B1 for the formula for each calculation).

3.7.1.6 Documentation. All test samples must be qualified dimensionally. All data points must be reported. For samples destructively tested, mode of failure must be reported. Failure mode(s) must be recorded with digital photograph and supplied to GM engineering upon request. All test specimens must be retained by the supplier for one (1) year and be available for review by the GM global HVAC/PTC engineer, upon request. Test procedures referencing specific minimum test values, must be met by the –3 sigma limit of the sample population tested.

Note: Approval shall be provided by the GM global technology engineer and the GM validation engineer. For DV approval requires the information in 3.7.1.7 be submitted.

3.7.1.7 DV/PV Engineering Approval Factors. Engineering source approvals generated through testing to prove compliance to this specification are specific for combinations of the following:

- Size of hose and coupling components.
- Hose material and construction, including supplier.
- Coupling design.
- Tube - insert material, plating, finish and hardness.
- Coupling shell material, plating, finish and hardness.
- Supplier specifications, manufacturing procedures and supplier (both hose and assembly) manufacturing sites.

Note: Testing of one construction of assembly can result in engineering source approvals for two crimp designs or materials by placing each design or material variant on one end of the assembly.

3.7.2 Steady State Part Monitoring (GMW15758).

Table 3: Steady State Part Monitoring (SSPM) Test Table

Section	Test	Number of Samples
3.2.1.1.1	Leak	Per GMW15760 Note 1
3.2.1.1.4	Blow-Off	Per GMW15760
3.2.1.1.6	Vacuum	Per GMW15760

Note 1: Performed for all test samples before conducting test procedures 3.2.1.1.4 and 3.2.1.1.6.

3.7.2.1 Test Samples. Production parts selected at random per GMW15760.

3.7.2.2 Testing Requirements. Hose assemblies shall be tested for conformance with the sections in Table 3. The supplier must get GM engineering buy-in defining test frequency to prove capability. It is required for any new production to start with a minimum test per 3.2.1.1.1 completed weekly, and test per 3.2.1.1.4 and 3.2.1.1.6 completed monthly.

3.7.2.3 Approval. Tests are self-approved by the supplier, subject to audit by GM supplier quality engineering.

3.7.2.4 Lot Retention. In the case of a Steady State Part Monitoring 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 1) scrapped; or 2) corrected and certified (which may mean lot testing the revised parts again) based on the root cause analysis; or 3) 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 above options is exercised.

3.7.2.5 Documentation. Records shall be maintained at the manufacturing facility per the GM Production Part Approval Process (PPAP) process.

3.7.2.6 Alternative Compliance. Supplier may request an exemption from Steady State Part Monitoring Testing, provided it can be demonstrated that sufficient process controls are in place so as to make testing unnecessary. The approval is to be provided by either GM supplier quality engineering or the GM Design Responsible Engineer.

4 Validation

4.1 General.

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

4.1.2 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.

4.2 Validation Cross Reference Index. See CG2046. Contact GM engineering on how to get the latest version of this ADVPR.

4.3 Supporting Paragraphs. Test Procedures.

4.3.1 Fixed-Value Performance Testing Procedures.

4.3.1.1 Leak Test. This test shall be conducted on test samples prior to conducting the test procedures 4.3.1.2 through 4.3.1.12, 4.3.2.1 and 4.3.2.2.

4.3.1.1.1 Coupled Hose Assemblies. Seal one end of the hose test sample with a plug that is appropriately designed for that end. Connect the other end of the hose assembly to a regulated compressed air source. Submerge the test sample in room temperature water bath and subject the assembly to minimum of 350 kPa pressure for 3 to 5 minutes. Pressure decay or other leak testing methods may be substituted for the air under water method when equivalence is proven and engineering approval is granted by the GM global HVAC/PTC engineer issuing the engineering source approval.

4.3.1.1.2 Quick Connector Assemblies. Seal one end of the hose assembly with a plug that is appropriately designed for that end. Connect the other end of the hose assembly to a regulated compressed air source. Step 1) Submerge the test sample(s) in room temperature water bath and subject the assembly to 70 ± 7 kPa pressure for 3 to 5 minutes. Inspect the hose assembly for air leaks (air bubbles emanating from the hose assembly). Step 2) While the sample is still submerged, increase air pressure to a minimum of 400 or 500 kPa as specified in 3.2.1.1.1 within 90 s. Inspect the hose assembly for air leaks (air bubbles emanating from the hose assembly). Care must be taken to ensure that an apparent leak is continuous and not the short term escaping of air entrapped between the inner tube and the outer cover. This is accomplished by subjecting the assembly to pressure for 3 to 5 minutes. Pressure decay or other leak testing methods may be substituted for the air under water method when equivalence is proven and engineering approval is granted by the GM global technology engineer issuing the engineering source approval.

4.3.1.2 Cold Leak Test. Fill the coupled hose assembly with 50% Ethylene Glycol: 50% water solution making sure it is colored. Wrap clean white cloth or paper towel around each joint of the assembly and secure to the assembly (a tie strap is recommended). Place the assembly in an environmental chamber oriented so that each joint is completely wet at all times during the test. It is recommended the coolant reservoir used is located higher vertically than the assemblies to insure the joints are kept wet. Subject assemblies to –30 ± 2 °C and pressurize the assembly to 280 kPa. Hold the pressure and temperature for 2 h. Reduce the pressure to

0 ± 7 kPa, remove the assembly from the environmental chamber and allow to warm to room temperature. Making sure the outer hose surface is dry. Inspect cloth or towel for stains indicating leakage.

4.3.1.3 Tensile Test. Apply an increasing tensile load at approximately 25 mm/minute along the hose centerline. Tensile load at failure shall be on a permanent recording.

4.3.1.4 Blow-Off Test. Subject the assembly to internal pressure using water. Apply pressure at a rate of 10 kPa/10 s starting from 200 kPa. Hold 310 kPa pressure for 180 ± 5 s, then increase pressure to minimum required Blow-off pressure +10%. Production assemblies containing a water valve, flow restrictor, or any sensor assembly should have the valve or assembly removed and replaced with a straight short pipe length clamped in place.

4.3.1.5 Blow-Off After Heat Aging. Subject the assembly to internal pressure using water. Test sample shall be oven aged for 168 h at 165 °C. Assembly, including each hose (if multiple hoses in the assembly) of the test sample will be flexed immediately upon return to room temperature (24 °C). Determine according to ASTM D380, applying pressure at a rate of 10 kPa/10 s starting from 200 kPa. Hold 310 kPa pressure for 180 ± 5 s, then increase pressure to minimum required blow-off pressure +10%.

4.3.1.6 Vacuum Test. At 24 ± 3 °C, evacuate the hose and tube assembly until the internal pressure of the assembly is stabilized at a maximum pressure of 3.5 kPa (equivalent to a maximum internal pressure of 25 mm Hg absolute pressure). Disconnect the pump and hold the vacuum for 10 minutes.

4.3.1.7 Insertion Force Test. Position the connector in a compression force tester (Instron or equivalent) with a simulated tube end, starting entry into the connector. The simulated tube end must be equivalent in dimensioning to the production intent tube end. Additionally, the dimensions of the tube end must be the maximum values allowed by the tolerance of the tube end. Apply an increasing compression load at approximately 50 mm/minute along the connector centerline until the simulated tube end has seated behind the retainer ears, usually signaled by an audible click and a corresponding drop in compression load. The compression load before seating shall be on a permanent recording.

4.3.1.8 Pull-Off Force Test. Attach the quick-connector and a portion of the hose assembly to an Instron, or equivalent, tensile tester so that the female part of the quick-connector assembly is orientated toward the complimentary jaws of the fixture. Attach to the quick-connector a mating tube end identical to that of the production intent tube end. Apply a pull-apart load at approximately 50 mm/minute until the tube end is pulled from the quick-connector.

4.3.1.9 Cleanliness Test. Visually inspect the hose assembly for evidence of corrosion of internal and external metal surfaces. Quantify internal foreign substances and internal corrosion of the metal components of the assembly using ASTM A254.

4.3.1.10 Cyclical Corrosion Test. Six hose assembly samples at nominal hose compression are to be tested. Perform corrosion test on line assembly specimens per GMW14872 Underbody-All-4-Method 1\2-Exposure D Option 4 Thermal Soak addition: 121 °C ± 2 °C for 2 h per cycle. Following this test, subject the assemblies to the Leak Test (4.3.1.1) and the Blow-Off Test (4.3.1.4). Cyclic Corrosion testing is to be done only for Engineering Source (DV) approval. GMW14872 will also refer to GMW15272 - Corrosion Performance Specification.

4.3.1.11 Salt Spray Test. Six hose assembly samples at nominal hose compression are to be tested. Subject the assembly to 168 h salt spray per GMW3286.

4.3.1.12 Maximum Crimp Compression Condition. Sixteen coupled hose assembly samples must be prepared with maximum hose compression as defined in Appendix A. These assemblies shall be disassembled and examined for hose tube, cover, and reinforcement damage as described in 4.3.1.12.1. Supplier evaluation of these parts, and the parts themselves, must be returned to the GM global HVAC/PTC engineer issuing the approval for evaluation.

4.3.1.12.1 Hose Examination Procedure. For eight (8) of the assemblies, cut and remove the coupling shell carefully, avoiding damage to the hose. Carefully cut through the hose along the length of the hose, either with one cut (preferable) or with two cuts, 180 degrees from one another. Remove the hose from the tube stem insert, again minimizing damage to the hose during this process. Evaluate wall thickness of the hose in the areas adjacent to and under the coupling shell for any evidence of damage induced by the manufacturing operation.

For the remaining eight (8) assemblies, perform the hose wall thickness evaluation as noted in the paragraph above. After this is complete, separate the hose cover stock from the tube stock by carefully peeling the cover from the tube, starting at a point away from the portion of the hose adjacent to or under the coupling and progressing to the end of the hose which was under the coupling. After the cover and tube have been separated, evaluate the reinforcement for any evidence of damage induced by the manufacturing operation.

For all sixteen (16) assemblies, amount of tube stem collapse must be determined.

4.3.1.13 Over-Crimp to Damage. Additional crimped hose assembly samples must be crimped and examined to determine the values of hose compression necessary to induce damage to either the hose rubber material, or to the reinforcement. These samples are to be over-crimped per the conditions described in Appendix A for maximum hose compression samples, except that progressive increments of increased hose compression are to be induced through reduction of crimp OD until hose damage is incurred. These increments may not number less than two, nor be more than 4% incremental hose wall compression. Four samples are to be prepared for each increment. Two shall be examined for hose damage, and two for reinforcement damage. Determination of damage shall be in accordance with 4.3.1.12.1, the Hose Examination Procedure. After the compression that induces damage is determined, confirmation shall be obtained by a repetition of four additional samples.

4.3.1.14 Error-Proofing Pull-Tab Test. (If equipped.)

4.3.1.14.1 Partial Assembly. Partially assemble the connector onto a mating end form with the seal engaged, but without engaging the latching mechanism. Using a tensile force tester (Instron or equivalent) measure the force required to remove the error-proofing tab. Use a 20 mm diameter pin to actuate the pull tab.

4.3.1.14.2 Complete Assembly. Completely assemble the connector onto a mating end form. Using a tensile force tester (Instron or equivalent) measure the force required to remove the error-proofing tab. Use a 20 mm diameter pin to actuate the pull tab.

4.3.1.15 Anti-Rotation Feature Torque Resistance (if equipped). Completely assemble the quick connector onto a mating end form. At a rate of 1 Nm/s, apply a torque to the quick connect fitting, up to a maximum torque equivalent to 20% the mating fitting seal diameter. For example, if the sealing diameter is 20 mm, the maximum applied torque shall be 4 Nm.

4.3.2 Endurance Testing Procedures.

4.3.2.1 Pressure/Vibration/Temperature Test. Test assemblies shall be tested per GMW14785. After test completion, remove the assembly from the cabinet and allow it to return to room temperature. Subject the assembly to the Cold Leak Test (3.2.1.1.2). If using the 300 mm long hose sample the movement for the Pressure Vibration Temperature (PVT) shall be perpendicular to the spigot. Test runs about 2.3 days per sample. Total test time depends on the number of samples test facility can run at one time.

4.3.2.2 Pressure/Temperature Test. Place the assembly in an environmental chamber and attach one end to a reservoir filled with a 50 ± 5% (9985809): 50 ± 5% water (v:v) solution. Allow the assembly to fill with the engine coolant per GMW3420 (9985809): water solution and bleed off any air, plugging all assembly outlets other than the pressurized outlet after the air is completely bled. The reservoir must have temperature and pressure control to affect the conditions of the hose appropriately. Subject the assembly to 180 cycles according to Table 4.

Table 4: Pressure/Temperature Test Cycle

Internal Pressure	Temperature	Hold Time	Maximum Transition Time
Increase to 140 ± 5 kPa	110 ± 2 °C	1 h	1.5 h
Decrease to 100 ± 5 kPa	–40 ± 2 °C	8 h	1.5 h
Increase to 200 ± 5 kPa	125 ± 2 °C	0.5 h	1.5 h
Decrease to 0 ± 5 kPa	–20 ± 2 °C	2 h	1.5 h

Note: After 100 cycles (about 71 days), remove the assembly from the cabinet and allow it to return to room temperature. Subject the assembly to the Cold Leak Test (4.3.1.2). Total test time depends on the number of samples test facility can run at one time.

4.3.2.3 Coolant Circulation Test. Determine according to ASTM D380, except as follows: Use test fluid consisting of 10% water and 90% engine coolant concentrate per GMW3420 (9985809) maintained at 130 ± 2 °C and 200 kPa minimum pressure. Circulate fluid for 400 h while deflecting hose 10 mm each side of center position at a rate of 200 cycles per minute. Shut off pump 6 h out of each 24 h period, and allow coolant to return to room temperature during this period. Renew fluid after each test. Within 24 h after test subject the assembly to the Cold Leak Test (4.3.1.2). Test runs about 22 days. Total test time depends on the number of samples test facility can run at one time.

4.4 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.

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 Validation Engineer. Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.6 Additional Requirements. 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 the changes in sub-supplier chains that Tier-1 supplier has. 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 schedule 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 Supplier Quality Engineer and the supplier.

4.7 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.

5 Provisions for Shipping

Not applicable.

6 Notes

6.1 Glossary.

Test to Failure (TTF): Is defined as, but not limited to, the loss of function, unacceptable performance degradation and nonconformance of the component as stated in this specification.

6.2 Acronyms, Abbreviations, and Symbols.

ADV	Analysis Development Validation
ADVPR	Analysis, Development and Validation Performance Review
BOM	Bill of Materials
CALT	Calibrated Accelerated Life Testing
ccm	cubic centimeters per minute
Cpk	Process Capability
DRBTR	Design Review Base on Test Result
DV	Design Validation
HALT	Highly Accelerated Life Testing
HASS	Highly Accelerated Stress Screening
HAST	Highly Accelerated Stress Testing
HVAC	Heating, Ventilation and Air Conditioning
HVACPTC	Heating, Ventilation, Air Conditioning Powertrain Cooling
ID	Inside Diameter
IVER	Integration Vehicle Engineering Release
MATSPC	Global repository of GM approved materials for corresponding GM Engineering Standards.
OD	Outside Diameter
PPAP	Production Part Approval Process
PTC	Powertrain Cooling

PV	Production Validation
PVA	Post Validation Audit
PVT	Pressure Vibration Temperature
REP	Reliability Evaluation Point
scc	Standard Cubic Centimeters
sL	Standard Liters
SPC	Statistical Process Control
SSPM	Steady State Part Monitoring
TTF	Test To Failure
UG	Unigraphics
VDC	Validation Documentation Complete
VTC	Validation Test Complete

7 Additional Paragraphs

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

8 Coding System

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

GMW16295

9 Release and Revisions

This standard was originated in September 2009. It was first approved by HVAC and Powertrain Cooling in April 2010. It was first published in April 2010.

Issue No.	**Publication Date**	**Description (Organization**)
1	APR 2010	Initial publication.
2	MAY 2010	Table 1: 1st seven section numbers corrected and note 1 updated from 4.3.8 to 4.3.7. Table A1: For DV test only, line item 3.2.1.1.8 removed. (HVAC and Powertrain Cooling)
3	FEB 2013	Revise GMW to include Blow-Off After Heat Aging. Restructure GMW to streamline. (Fluid Handling (Hoses, Lines and Fittings) GSSLT)

Appendix A

A1 Crimp Compression

Test samples throughout this specification will be referred to as minimum hose compression, nominal hose compression or maximum hose compression samples. The following sections describe the requirements for these conditions. If not specified, the test samples shall be of nominal hose compression.

A1.1 Minimum Crimp Compression Condition. Test samples referred to in this specification, as minimum hose compression samples shall adhere to the requirements in Table A1.

Table A1: Minimum Crimp Compression Requirements

Hose Wall	Minimum wall thickness (as determined by the 3 sigma value of the hose manufacturer)
Crimp/Swage OD	Maximum crimp/swage OD (3 sigma value of the assembly manufacturer)
Tube Insert OD	Minimum tube insert OD (3 sigma value of the metal insert manufacturer)
Ferrule Wall	Minimum ferrule wall thickness (3 sigma value of the ferrule manufacturer)

Note: Assemblies manufactured as above, but with the substitution of nominally dimensioned tube insert OD and nominally dimensioned ferrule wall thickness components, may be used for evaluation with the submittal of Statistical Process Control (SPC) data confirming minimal tolerances and acceptable Process Capability (Cpk) values for these dimensions. The acceptability of nominal insert OD and ferrule wall thickness dimension for this testing must be reviewed beforehand and approved by the GM global HVAC/PTC engineer issuing the approval. If the use of nominal insert OD and ferrule wall thickness dimensions for the testing is found to be acceptable, the crimp OD must be adjusted to result in a value of minimum hose compression which would have resulted if minimum ferrule wall thickness and minimum tube insert OD had been used in the preparation of samples.

A1.2 Nominal Hose Compression Condition. Test samples referred to as “nominal hose compression samples” shall consist of components manufactured to nominal dimensions and crimped to a mean specification value of crimp/swage OD.

A1.3 Maximum Crimp Compression Condition. Test samples referred to in this specification, as maximum hose compression samples shall adhere to the requirements in Table A2.

Table A2: Maximum Crimp Compression Requirements

Hose Wall	Maximum wall thickness (as determined by the 3 sigma value of the hose manufacturer)
Crimp/Swage OD	Minimum crimp/swage OD (3 sigma value of the assembly manufacturer)
Tube Insert OD	Maximum tube insert OD (3 sigma value of the metal insert manufacturer)
Ferrule Wall	Maximum ferrule wall thickness (3 sigma value of the ferrule manufacturer)

Note: Assemblies manufactured as above, but with the substitution of nominally dimensioned tube insert OD and nominally dimensioned ferrule wall thickness components, may be used for evaluation with the submittal of SPC data confirming minimal tolerances and acceptable CPk values for these dimensions. The acceptability of nominal insert OD and ferrule wall thickness dimension for this testing must be reviewed beforehand and approved by the GM Global HVAC/PTC Engineer issuing the approval. If the use of nominal insert OD and ferrule wall thickness dimensions for the testing is found to be acceptable, the crimp OD must be adjusted to result in a value of maximum hose compression which would have resulted if maximum ferrule wall thickness and maximum tube insert OD had been used in the preparation of samples.

Appendix B

Table B1: Hose Compression Calculations

I. Linear Compression:

Linear Hose Wall Compression = $[(T_o - T_f)/ T_o]$ X 100%

Where:

T_o = Initial hose wall thickness (prior to crimping)

T_f = Final hose wall thickness (after crimping)

II. Area Hose Wall Compression:

Area Hose Wall Compression = $(1 - ([R^2_{OD-F} - R^2_{ID-F}]/[R^2_{OD-1} - R^2_{ID-I}]))$ X 100%

Where:

R_{ID-I} = Initial ID radius of the hose (prior to crimping)

R_{OD-1} = Initial OD radius of the hose (prior to crimping)

R_{ID-F} = Final ID radius of the hose (after crimping)

R_{OD-F} = Final OD radius of the hose (after crimping)