GM	WORLDWIDE ENGINEERING STANDARDS	General Specification	GMW15964

Qualifying Transmission and Engine Oil Hose Coupling Assemblies

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 specification describes the quality, reliability, durability, and performance requirements for Engine Oil Cooler (EOC) and Transmission Oil Cooler (TOC) hose coupling assemblies for use in GM vehicles. All requirements of this specification shall be met to demonstrate design and production validation, as well as in process compliance.

1.2 Applicability. This standard cover qualification tests for two hose coupling systems used with external oil cooling line oils designated as "Type E" for engine oils and "Type T" for transmission oils used in automotive applications. And one sub category for each qualification designated as lower case "c", e.g., "Type Ec" and "Type Tc", respectively, for applications where the coupling is subjected to direct system pressure during engine or transmission start operation at cold condition.

1.3 Remarks.

1.3.1 Classification. Four types as follows:

- **Type E:** Engine oil hose, not exposed to cold start system pressure.
- **Type Ec:** Engine oil hose exposed to direct system pressure at cold vehicle condition.
- **Type T:** Transmission oil hose not exposed to direct system pressure at cold vehicle condition, e.g., a hose coupling downstream oil flow after a Thermal Bypass Valve (TBV).
- **Type Tc**: Transmission oil hose exposed to direct system pressure at cold vehicle condition.

2 References

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

2.1 External Standards/Specifications.

ASTM D380	ASTM D7611	SAE J343	SAE J1344

2.2 GM Standards/Specifications.

GMW3059	GMW14157 (ID)	GMW15758	GMW16444
GMW3116	GMW14573	GMW15760	GMW17010
GMW14156 (ID)	GMW15724	GMW16171	GMW18226

(ID) = This standard is limited to internal distribution within General Motors and shall not be distributed outside this company. Contact the GM Lead Engineer for further instructions.

2.3 Additional References.

- Analysis/Development/Validation Plan and Report (ADVP&R).
- Statement of Requirements (SOR).
- Stem Specifications.
- Supplier Production Specifications.
- Validation Cross Reference Index (VCRI).
- Vehicle Technical Specification (VTS) (ID).

3 Requirements

3.1 System/Subsystem/Component/Part Definition.

3.1.1 Appearance. Not applicable.

3.1.2 Content.

3.1.2.1 Physical Content.

3.1.2.1.1 Material Identification. To properly define the performance requirements for the assemblies, the performance specification number is to be followed by a type, e.g., GMW15964, Type T is for transmission oil hose not exposed to direct system pressure at cold vehicle condition or Type Ec is for engine oil hose exposed to direct system pressure at cold vehicle condition. Refer to GMW16171 for hose material construction and category type descriptions.

3.1.2.1.2 Coupling Construction.

3.1.2.1.2.1 Coupling Design. The coupling shall be designed, inserted, and swaged or crimped so that no internal hose abrasions, cuts, flaws or damage of any kind shall result under any condition or combination of assembly component dimensioning or tolerance allowed by supplier production specifications, or under any condition of hose compression allowed by supplier production specifications.

3.1.2.1.2.2 Sharp Corners. Sharp corners shall be avoided where the coupling contacts the hose to prevent cutting of the hose when subjected to internal pressure.

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

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

3.1.2.1.2.5 Tube Collapse. Tube stem total collapse shall be limited to a maximum of 1.5% and have a maximum circular runout of 0.15 mm referenced to the stem itself. Total collapse shall include the sum of collapse caused by forming process and the collapse caused by crimping process and shall be reported as the maximum collapse value over the whole length of the stem.

3.1.2.1.2.6 Skiving. Skiving of the hose is not permissible.

3.1.2.1.2.7 Flow Requirements. The coupling shall be designed for low flow restriction. No more than 15% of reduction of the nominal pipe Inner Diameter (ID) is allowed per design.

3.1.2.1.2.8 Coupling Identification. The coupling shall be stamped with the date of manufacture (month and year) and the manufacturers identification.

3.1.2.2 Functional Content. Not applicable.

3.1.3 Ambient Environment. The hose and coupling shall be capable of withstanding service and intermittent temperatures per GMW16171 hose construction requirements.

3.1.4 Interfaces. Not applicable.

3.1.5 Usage Definition. The transmission or engine oil line will be exposed to under-hood and underbody environments. Hose material and tubing shall be compatible with Dexron® VI (GMW16444), Dexron® HTP, and other GM Specific Program approved transmission or engine fluids, GM and SAE International (SAE) standard engine oils, e.g., SAE 5W30, and any other under-hood fluid, e.g., windshield washer fluid, brake fluid, etc. Transmission or engine fluid shall be approved by the GM Validation Engineer and Design Release Engineer (DRE) before Analysis/Development/Validation Plan and Report (ADVP&R) submission.

3.2 Product Characteristics.

3.2.1 Performance Requirements.

3.2.1.1 Fixed-Value Performance Testing Requirements. See 3.4.1.2 and 3.4.2.2.

3.2.1.2 Endurance Testing Requirements. See 3.4.1.3 and 3.4.2.3.

3.2.2 Physical Characteristics.

3.2.2.1 Dimensions and Capacity. Transmission oil line and engine oil line can be built to several tube dimensions. Typical tube dimensions are 9.525 mm, 12.7 mm, and 15.875 mm.

3.2.2.2 Mass Properties. Refer to Vehicle Technical Specification (VTS) for program requirements.

3.2.3 Reliability.

3.2.3.1 Reliability Evaluation Point. The Reliability Evaluation Point (REP) shall be one life of severe customer usage at the vehicle level.

3.2.3.2 Reliability Requirements. Components shall demonstrate the required Reliability of 99% at a 50% Confidence (R99C50) and slope of 2, at the REP for the TOC line or EOC line. 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. Refer to 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 specified in 3.4.1.3, in contrast to this, the endurance tests specified for Production Validation (PV) in 3.4.2.3, are intended to confirm conformance to the reliability demonstrated during DV.

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.

For TTF, a Weibull graph of the "nominal", "minimum" and "maximum" crimp assemblies test data will demonstrate that R99C50 of the hose crimp population. The Weibull graph shall show individual plot lines; one of the "minimum" crimp assemblies, one of the "nominal" crimp assemblies, one of the "maximum" crimp assemblies and an overall plot line of all the crimp assemblies combined. A Weibull graph will be plotted based on the test data.

For "Success" testing, see 3.4.2.3.3.1.2 for number of assemblies and number of pressure and temperature cycles to meet R99C50 requirements.

Note: The required number of test assemblies may be negotiable if it is not practical to run, e.g., 69 samples. The negotiation of sample size should consider test equipment limitations, physical size of test assemblies, test duration. Weibull slope values available from previous failure testing may be considered as a way to reduce the sample size and/or test duration. For detail refer to GMW14156 Test Reliability Requirements Guidelines, and GMW14157 Statistical Confidence Level for Reliability Validation Testing.

For testing under either of the two methods, "Success" or TTF, the data shall be submitted in tabular format for each tested assembly with the following information: Assembly ID, measured linear and area compression of each joint, and rating at each inspection interval, see Data Sheet A1 in Appendix A.

3.2.4 Serviceability. Not applicable.

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. The assemblies submitted for test to this specification shall have an exposed hose length of 500 mm ± 5 mm and a maximum tube length from coupling to nut of 100 mm ± 5 mm. Only for 4.3.9 and 4.3.14, the assemblies shall be constructed as indicated in Figure B1 in Appendix B. Each assembly for all tests shall be tagged with the following information:

- Hose Coupling Assembly Manufacturer Design Number.
- GM Material Specification Number (GMXXXXM or GMWXXXXX).
- Hose Type (E, Ec, T, or Tc).
- Date.

The submission of assemblies to the releasing division for testing to generate an engineering source approval may be waived upon the decision regarding acceptability of vendor supplied data for this approval. Assemblies manufactured for testing to the requirements of nominal, minimum and maximum hose compression shall be manufactured per the dimensional tolerance defined in C1, Appendix C, and measured per D1 and D2, Appendix D.

Assemblies as manufactured per 3.3.1.1, but with the substitution of nominally dimensioned tube insert Outer Diameter (OD) and nominally dimensioned ferrule wall thickness components may be used for this evaluation with the submittal of Statistical Process Control (SPC) data containing minimal tolerances and acceptable Cpk values for these dimensions. The acceptability of nominal insert OD and ferrule wall thickness dimensions for this testing shall be reviewed beforehand and approved by the GM Bill of Material Family Owner (BFO) issuing the approval. Assemblies manufactured for testing to the requirements for nominal hose compression shall be manufactured as close as possible to mean production values for dimensioning and other assembly properties. For these assemblies, values of hose compression under the crimp shall be within ± 2% of the production mean value.

3.3.1.1.1 Test Conditions. All temperatures shall be held to ± 2 °C and all pressures to +34.5/-0.0 kPa unless otherwise noted. Tests or portions of tests in which the test temperature is not specified shall be conducted at ambient temperature. Ambient temperature is defined as 23 °C ± 2 °C.

3.3.1.1.2 Engineering Source Approval Requirements. Approval for all couplings require 3.3.1.1.2.1 thru 3.3.1.1.2.6 information to be submitted to the GM BFO.

3.3.1.1.2.1 Blue prints showing the design, dimensions and tolerances for all components of the assembly, including allowed eccentricity in the hose, tube insert, and coupling OD; in addition, the range of the all hose compression possible under each condition of dimensional tolerance stack up.

3.3.1.1.2.2 The submission of sectioned coupling assemblies to demonstrate that all the material guidelines per 3.3.1.1 have been met.

3.3.1.1.2.3 A description of the SPC procedures for the control of coupling diameter dimensions and the hose compression range.

3.3.1.1.2.4 The value for hose compression necessary to induce:

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

3.3.1.1.2.5 Data presented in both tabular and graph form, showing values of hose compression vs. tensile test performance (4.3.4), hose compression vs. burst test performance (4.3.2), and hose compression vs. the fitting stem collapse (both ID and OD per 4.3.8). The dimensions of the crimped assembly components for each data point need to be listed, as well as the resultant hose compression.

3.3.1.1.2.6 Copies of test fixture traces, confirming pressure and temperature profiles imposed on the assemblies during test.

Note: Values of hose compression shall be reported both in terms of linear compression and area compression, see D1 and D2, Appendix D, for the formula for each calculation.

3.3.1.1.3 Engineering Approval Factors. Engineering source approvals generated through testing to prove compliance to this specification are specific for combinations of the following factors:

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

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

3.3.1.1.4 Preformed Hose. When a preformed hose is used to qualify a coupling under this specification, all test assemblies need to be built with a representative manufacturing process, including but not limited to the use of a mandrel, the curing process, the end hose cutting, and related process variables affecting the material performance.

3.3.1.2 Processes Guidelines. Supplier Process Failure Mode Affects Analysis (PFMEA) shall indicate the proper severity levels per GM Design Failure Mode Affects Analysis (DFMEA) and the corresponding manufacturing controls shall be implemented with proper detection levels, i.e., for failure modes with a severity ranking of 9 or 10, the supplier shall implement the controls to achieve a detection level three, meaning problem detection at source, failure mode detection in-station by automated controls, will detect discrepant parts and automatically lock parts in station to prevent further processing.

3.3.1.3 Parts Guidelines. Materials shall be recyclable per GMW3116. Attempts shall be made to minimize the variety of materials used to make recycling more viable.

3.3.2 Design Guidelines and Constraints. All assemblies manufactured for testing to this specification for engineering source approval purposes shall be completely representative of production level materials, components, processes and tooling.

The exceptions are those assemblies needing to be specially manufactured under extremes of dimensions and/or tolerancing to meet the test requirements of this specification. Any exceptions to this requirement, or to any criteria referenced in this specification shall be reviewed beforehand and approved by the GM BFO issuing the approval.

3.3.2.1 Engineering Source Approval Testing of Minimum and Maximum Dimensioned Hoses/Components. All testing conducted on assemblies and hoses manufactured with minimum and maximum dimensions are to be conducted one time only for the initial engineering source approval.

3.3.2.2 Test Assemblies. All test assemblies shall be qualified dimensionally. All data points shall be reported. For assemblies destructively tested, mode of failure shall be reported. All test assemblies shall be retained by the supplier for a minimum period of one year and supplied to the GM Materials Engineer or GM BFO for review if requested. Test procedures referencing specific minimum or maximum test values, shall meet the Three Sigma (3σ) limit requirement ($+3\sigma$ for maximum values and -3σ for minimum values) of the population per C1, Appendix C.

3.3.2.3 Crimp Compression. Test assemblies throughout this specification will be referred to as minimum hose compression, nominal hose compression or maximum hose compression. The requirements for these conditions are described in C1, Appendix C. If not specified, the test assemblies shall be of nominal hose compression.

3.3.3 Identification and Marking. All assemblies shall 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 and per Society of the Plastics (SPI) Resin Identification Code (RCI) system, ASTM D7611.

3.3.4 Workmanship. Not applicable.

3.3.5 Interchangeability. Not applicable.

3.4 Testing Requirements.

3.4.1 DV Phase (GMW15758, 3.2.1 Design Validation). The performance measurements and durability test results shall be summarized and reported to GM on the supplier ADVP&R for the component or components being tested. Full test reports will be available for viewing by GM personnel by request. Sample sizes will be defined in the Validation Cross Reference Index (VCRI) provided in the Statement of Requirements (SOR) or by the GM Validation Engineer.

3.4.1.1 Test Assemblies. Design representative test assemblies may be produced from prototype tooling or from equivalent production tooling, but shall represent design intent, including design tolerances and material variation within the materials specification. The exceptions are those assemblies needing to be specially manufactured under extremes of dimensions and/or tolerances to meet the test requirements of the specification. Any exceptions to this requirement shall be reviewed beforehand and approved by the GM BFO and Validation Engineer issuing the approval.

3.4.1.2 Fixed-Value Performance Testing. Fixed value performance tests are tests designed to demonstrate the performance of the component but not necessarily the reliability.

3.4.1.2.1 Burst Test. Assemblies shall be tested per 4.3.2.

3.4.1.2.1.1 Acceptance Determination. Minimum burst strength shall be no less 6895 kPa.

3.4.1.2.2 Leak. Leak test to be performed in conjunction with other tests, not as a separated test for DV.

3.4.1.2.3 Tensile Strength. Assemblies shall be tested per 4.3.4. A total of 18 assemblies shall be tested, one set for testing at room temperature and one set for testing at 150 °C. One set consisting of three assemblies manufactured at nominal hose compression per C1, Appendix C, three assemblies manufactured at maximum hose compression per C1, Appendix C, and three assemblies manufactured at minimum hose compression per C1, Appendix C. These parts shall be tested at ambient temperature per Table 1. A second set of three assemblies manufactured at nominal hose compression, three assemblies manufactured at maximum hose compression and three assemblies manufactured at minimum hose compression shall be tested at 150 °C.

3.4.1.2.3.1 Acceptance Determination. The load at failure either by separation of hose from the end fittings or by rupture of the hose structure shall be no less than those in Table 1. The supplier shall report the failure mode observed and shall send pictures of the parts after testing to the GM Validation Engineer and attach the pictures to the test report.

Table 1: Minimum Acceptable Load by Hose Type

Type	Test Temperature	Minimum Load Acceptance
All Types	Ambient Room Temperature	2220 N
All Types	150 °C	1000 N

3.4.1.2.4 Heat Aging. Assemblies shall be tested per 4.3.5. The ends shall be uncapped for testing.

3.4.1.2.4.1 Acceptance Determination. The hose shall show no signs of external or internal cracks, charring, or disintegration and shall not leak when subjected to the leak test per 4.3.3.

3.4.1.2.5 Over-Crimp to 3σ Limits. Assemblies shall be tested per 4.3.6.

3.4.1.2.5.1 Acceptance Determination. No hose rubber or reinforcement damage generated by the crimping operation is permissible in these assemblies when examined per 4.3.6.2. Report shall include pictures of all assemblies.

3.4.1.2.6 Over-Crimp to Damage. Assemblies shall be tested per 4.3.7.

3.4.1.2.6.1 Acceptance Determination. Signs of damage to the cover, tube and/or reinforcement shall be evidence that the over-crimp limit has been exceeded. The supplier shall report the minimum hose compression required to damage any component of the joint.

3.4.1.2.7 Tube Collapse. Assemblies shall be tested per 4.3.8. A total of 16 tube end forms for crimp joints shall be built with stem diameters along the stem (OD and ID) measured and recorded to ensure Stem Specifications are meet. A total of 8 assemblies, 16 crimp joints shall be produced using these tube end forms with half of the assemblies at maximum compression and the other half at nominal compression. Assemblies manufactured for testing to the requirements shall be manufactured per the dimensional tolerance defined in C1, Appendix C.

3.4.1.2.7.1 Acceptance Determination. Tube stem collapse shall be limited to a maximum of 1.5% and a maximum circular runout of 0.15 mm for nominal compression assemblies. For maximum compression assemblies the maximum collapse shall be limited to 5% and the maximum circular runout to 0.2 mm. Total collapse shall include the sum of collapse caused by forming process and the collapse caused by crimping process and shall be reported as the maximum collapse value over the whole length of the stem.

3.4.1.2.8 Cold Weather Pressure Vibration and Temperature. A total of 24 joints, 12 assemblies, shall be tested, 12 joints shall be built at nominal dimensions, six joints at maximum compression and six joints at minimum compression as defined in C1, Appendix C. Assemblies shall be tested per 4.3.9. Assembly construction per Figure B1 in Appendix B.

3.4.1.2.8.1 Acceptance Determination. No hose displacement inside the crimp is allowed, no hose damage is allowed, and no leaks are allowed. Use X-Ray inspection on all assemblies to evaluate if hose displacement occurred. Half of the assemblies shall be dissected and no damage on the hose is allowed.

3.4.1.3 Endurance Testing. Endurance test requirements are designed to demonstrate the component reliability. Some examples are fatigue, creep, pressure vibration and temperature cycling, etc. Endurance testing may be conducted using either "Success" or TTF testing.

3.4.1.3.1 Pressure Cycling. Assemblies shall be tested per 4.3.10.

3.4.1.3.1.1 Acceptance Determination. Assemblies shall show no signs of hydraulic leaks during the pressure cycling test or pneumatic leaks prior to or at the completion of the cycling test per 4.3.3 leak test.

3.4.1.3.2 Temperature Cycling. Assemblies shall be tested per 4.3.11.

3.4.1.3.2.1 Acceptance Determination. The hose shall show no signs of pneumatic leakage prior to or at the completion of the temperature cycle test per 4.3.3 leak test.

3.4.1.3.3 Pressure Temperature Cycling. Assemblies shall be tested per 4.3.12. Half (50%) of the total assemblies shall be manufactured with nominal hose compression, 25% of total number of assemblies with minimum compression condition and 25% with maximum compression as defined in C1, Appendix C. The test assemblies shall be tested either "Success" or TTF. If TTF, plot the data in a Weibull chart. Refer to 3.4.2.3.3.1.2 for assembly quantity.

3.4.1.3.3.1 Acceptance Determination and Reporting. After the assemblies have been subjected to R99C50 of test per 4.3.12, no hose damage is allowed, and all joints shall be reported per 4.3.12.2.4 leak inspection, the assembly shall not be considered failed until the joints has reached "H" (Drops Visibly Falling). If a joint exceeds the leak limit, the assembly shall be left in the test chamber to evaluate the progress of that leak, until a leak level "Z" is reached (or the test camber operation might be detrimental).

The data shall be submitted in tabular format by tested assembly with the following information: Assembly ID, measured linear and area compression of each joint, rating at each inspection, see Data Sheet A1 in Appendix A. A Weibull graph will be plotted based on the test data.

3.4.1.3.4 Vibration. Assemblies shall be tested per 4.3.13.

3.4.1.3.4.1 Acceptance Determination. Assemblies shall show no signs of pneumatic leakage prior to or at the completion of the vibration test per 4.3.3 leak test.

3.4.1.3.5 Endurance Pressure Displacement and Temperature. Test assemblies per 4.3.14. One-half (50%) of the total assemblies shall be manufactured with nominal hose compression, (25%) of total number of assemblies with minimum compression and remaining (25%) with maximum hose compression as defined in C1, Appendix C. Stem maximum ID and minimum OD shall be measured and registered before building the assembly. For this test, assemblies shall be tested either "Success" or TTF. If TTF, plot the data in a Weibull chart, or, refer to Table 2 for "Success" quantity of assemblies, however, if "Success" testing is performed it is only allowed to test 18 assemblies to two (2) lives. Assembly construction per Figure B1 in Appendix B.

3.4.1.3.5.1 Acceptance Determination and Reporting. After the assemblies have been subjected to R99C50 of test per 4.3.14, no hose damage is allowed, and all joints shall be reported per 4.3.12.2.4 leak inspection, the maximum leak rate permitted is "L" for the joints at nominal compression and "M" for the joints at minimum and maximum compression. If a joint exceeds the leak limit, the assembly shall be left in the test chamber to evaluate the progress of that leak, until a leak level "Z" is reached (or the test camber operation might be detrimental).

The data shall be submitted in tabular format by tested assembly with the following information: Assembly ID, measured linear and area compression of each joint, rating at each inspection interval, see Data Sheet A1 in Appendix A. A Weibull graph will be plotted based on the test data.

3.4.1.4 Approval. Approval shall be provided by the appropriate GM DRE and GM Program Validation Engineer, except where BFO approval is required in this specification.

3.4.1.5 DV Dimension Qualification Documentation. All DV test assemblies shall be qualified dimensionally. All data points shall be reported. For assemblies subjected to destructive testing, the mode of failure shall be reported. All test assemblies shall be retained by the supplier for one year and be available for review by the GM Thermal Engineer, if requested. Test procedures referencing specific minimum or maximum test values, shall meet the 3σ sigma limit requirement, i.e., $+3\sigma$ for maximum values and -3σ for minimum values, of the population per C1, Appendix C. GM will document this approval using the material approval system.

3.4.2 PV Phase (GMW15758, 3.2.2 Product Validation). The performance measurements and durability test results shall be summarized and reported to GM on the supplier ADVP&R for the component or components being tested. Full test reports will be available for viewing by GM personnel by request. Sample sizes will be defined in the VCRI provided in the SOR or by the GM Validation Engineer.

3.4.2.1 Test Assemblies. Production test assemblies shall be produced on production representative equipment including the effects of manufacturing-induced variation. 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.

3.4.2.2 Fixed Value Performance Testing. The following performance tests shall be run. Refer to the VCRI provided in the SOR or by the GM Validation Engineer.

3.4.2.2.1 Cleanliness. Assemblies shall be tested per 4.3.1.

3.4.2.2.1.1 Acceptance Determination. There shall be no internal free water present in the assemblies and no corrosion of either internal or external metal surfaces. In addition, no foreign material shall be collected on the 60-mesh screen and not more than 0.26 g/m^2 of internal surface shall be collected on the crucible.

3.4.2.2.2 Burst Test. Assemblies shall be tested per 4.3.2.

3.4.2.2.2.1 Acceptance Determination. Minimum burst strength shall be no less 6895 kPa.

3.4.2.2.3 Leak. Leak test to be performed in conjunction with other tests, not as a separated test for PV.

3.4.2.2.4 Tensile Strength. Assemblies shall be tested per 4.3.4.

3.4.2.2.4.1 Acceptance Determination. The load at failure either by separation of the hose from the end fittings or by rupture of the hose structure shall be no less than those values called out in 3.4.1.2.3.1.

3.4.2.2.5 Tube Collapse. Assemblies shall be tested per 4.3.8. Eight assemblies, 16 crimp joints, shall be built following production process and on production tools. The 16 tube end forms shall be measured and recorded the before crimping to identify smallest OD and ID of the stem.

3.4.2.2.5.1 Acceptance Determination. Tube stem collapse shall be limited to a maximum of 1.5% and have a maximum circular runout of 0.15 mm referenced to the stem itself. Total collapse shall include the sum of collapse caused by forming process and the collapse caused by crimping process and shall be reported as the maximum collapse value over the whole length of the stem per 4.3.8.

3.4.2.2.6 Cold Weather Pressure Vibration and Temperature. A total of 24 joints, 12 assemblies, shall be tested. Assemblies shall be tested per 4.3.9. Assembly construction per Figure B1 in Appendix B.

3.4.2.2.6.1 Acceptance Determination. No hose displacement inside the crimp is allowed, no hose damage is allowed, and no leaks are allowed. Use X-Ray inspection on all assemblies to evaluate if hose displacement occurred. Half of the assemblies shall be dissected and no damage on the hose is allowed.

3.4.2.3 Endurance Testing.

3.4.2.3.1 Pressure Cycling. Assemblies shall be tested per 4.3.10.

3.4.2.3.1.1 Acceptance Determination. The assemblies shall show no signs of hydraulic leaks during the pressure cycling test or pneumatic leaks prior to or at the completion of the cycling test per 4.3.3 leak test.

3.4.2.3.2 Temperature Cycling. Assemblies shall be tested per 4.3.11.

3.4.2.3.2.1 Acceptance Determination. The hose shall show no signs of pneumatic leakage prior to or at the completion of the temperature cycle test per 4.3.3 leak test.

3.4.2.3.3 Pressure Temperature Cycling. Assemblies shall be tested per 4.3.12 either "Success" or TTF.

3.4.2.3.3.1 Acceptance Determination and Reporting. For the production validation phase of the pressure temperature cycling test, either "Success" or FFT testing method can be used to demonstrate validation requirements have been met. After the assemblies have been subjected under either method, R99C50 of test per 4.3.12 shall be demonstrated. No hose damage is allowed, and all joints shall be reported per 4.3.12.2.4 leak inspection, the assembly shall not be considered failed until the joints has reached "H" (Drops Visibly Falling). If a joint exceeds the leak limit, the assembly shall be left in the test chamber to evaluate the progress of that leak, until a leak level "Z" is reached (or the test camber operation might be detrimental).

3.4.2.3.3.1.1 TTF. A Weibull Plot of the test assembly test data will demonstrate that R99C50 of the hose crimp population.

The data shall be submitted in tabular format by tested assembly with the following information: Assembly ID, measured linear and area compression of each joint, rating at each inspection interval, see Data Sheet A1 in Appendix A. A Weibull graph will be plotted based on the test data.

3.4.2.3.3.1.2 "Success" Testing. For "Success" testing, use Table 2 to determine sample size and number of pressure and temperature cycles to meet R99C50 requirements.

The data shall be submitted in tabular format by tested assembly with the following information: Assembly ID, measured linear and area compression of each joint, rating at each inspection, see Data Sheet A1 in Appendix A. A Weibull graph will be plotted based on the test data.

Table 2: Success Testing Sample Size, Pressure and Temperature Cycles Note 1

Lives	Original Sample Size (N_0)	New Smaller Sample Size (N_n)	Original Test Length (X_0)	New Test Length (X_n)	Weibell Slope (β)
1	69	69	6	6	2
1.5	69	31	6	9	2
2	69	18	6	12	2
2.5	69	12	6	15	2
3	69	8	6	18	2

Note 1: Assumes R99C50 "Success" testing.

3.4.2.3.4 Endurance Pressure Displacement and Temperature. Test assemblies shall be tested per 4.3.14. For this test, assemblies shall be tested either "Success" or TTF. If TTF, plot the data in a Weibull chart, or, refer to Table 2 for "Success" quantity of assemblies. Assembly construction per Figure B1 in Appendix B.

3.4.2.3.4.1 Acceptance Determination and Reporting. After the assemblies have been subjected to R99C50 of test per 4.3.14, no hose damage is allowed, and all joints shall be reported per 4.3.12.2.4 leak inspection, the maximum leak rate permitted is "L" for the joints at nominal compression and "M" for the joints at minimum and maximum compression. If a joint exceeds the leak limit, the assembly shall be left in the test chamber to evaluate the progress of that leak, until a leak level "Z" is reached (or the test camber operation might be detrimental).

The data shall be submitted in tabular format by tested assembly with the following information: Assembly ID, measured linear and area compression of each joint, rating at each inspection interval, see Data Sheet A1 in Appendix A. A Weibull graph will be plotted based on the test data.

3.4.2.4 Approval. Approval shall be provided by the appropriate GM DRE and GM Program Validation Engineer, except where BFO approval is required in this specification.

3.4.2.5 Production Part Approval Process (PPAP). Documentation shall be provided as required by the normal PPAP.

3.4.3 Product Validation Audit (PVA) Phase. A post validation audit will be defined in GMW15724.

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

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

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

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

4 Validation

4.1 General.

4.1.1 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 standard shall be determined correctly with respect to their physical definition.

4.1.3 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.1.4 Safety. This Engineering Standard may involve safety requirements for hazardous materials, the method of operations and equipment. This standard does not propose to address all the safety issues associated with its use. It is the responsibility of the user of this standard to ensure compliance with all appropriate safety and health practices. This would include any specific training that may be required. The safety and health standards include site specific rules and procedures, company rules and procedures, and Government Standards. Contact shall be made with the appropriate site Safety and Health personnel for further direction and guidance in these matters.

4.1.5 Inspection and Rejection. Samples of components or materials released to a GM material specification shall be tested for conformity with the requirements of this material specification and approved by the responsible Engineering department prior to commencement of delivery of bulk supplies.

A new approval must be received for any changes, e.g., properties, manufacturing process, location of manufacture, etc. If not otherwise agreed, all testing and documentation normally required for initial release must be completed.

It is the responsibility of the supplier to inform the customer in a timely manner, without solicitation, and to include documentation of all modifications of materials and/or processes and to apply for a new release.

4.2 Validation Cross Reference Index. Refer to VCRI provided in the SOR or by the GM Validation Engineer

4.3 Supporting Paragraphs. Test descriptions.

4.3.1 Cleanliness.

4.3.1.1 Test Procedure. Visually inspect the assemblies for evidence of internal free water and corrosion of internal and external metal surfaces. Bend the coupled hose in a "U" shape and fill with reagent grade Stoddard solvent. Agitate the hose and pour the Stoddard solvent into a clean beaker, cover and place in desiccator. After 15 minutes, visually inspect for free water, i.e., small globules. Collect insoluble contaminants by filtering the liquid through a 60-mesh screen, i.e., 240 µm hole size, then through a 30 mL fritted glass, grade fine filtering crucible of known weight. Alternate solvents may be used with engineering approval. Dry in a desiccator at 65 °C for 1.5 h.

Note: To ascertain the cleanliness of the Stoddard solvent being used in this test, run a blank containing Stoddard solvent equivalent to the amount held in the coupled hose. The final weighing of the fritted crucible shall show no contaminants and weight increase ≤ 0.0004 g.

4.3.2 Burst.

4.3.2.1 Test Procedure. The burst test shall be in accordance with ASTM D380.

4.3.3 Leak Test. There shall be no indication of air leakage at the coupling or in the hose member when the assembly is subjected to 1725 kPa for 5 minutes, while under water. Care shall be taken to ensure that an apparent leak is continuous and not the short term escaping of air entrapped between the inner tube and outer cover.

Note: With GM engineering approval, an equivalent pressure decay leak test procedure or mass flow leak test procedure may be substituted for the air under water procedure.

4.3.4 Tensile Strength.

4.3.4.1 Test Procedure. Let assemblies soak for a minimum of 1 h to reach testing temperature. Apply an increasing tensile load at approximately 25 mm/minute along the hose centerline. Tensile load at failure shall be on a permanent recording and reported.

4.3.5 Heat Aging. The ends shall be uncapped for testing.

4.3.5.1 Test Procedure. Subject the test assemblies to the leak test per 4.3.3. Upon completion of the leak test, coil the test assemblies around a mandrel having a diameter eight times the nominal OD of the hose or the maximum possible to meet the 180 degree Angle (α) per Figure 1. Place the assemblies into an air oven at 125 °C ± 2 °C for 400 h. Remove the assemblies from the oven and allow the hose to cool to room temperature. Uncoil the assemblies to straight lengths and examine for external cracks. Subject the assemblies to a final leak test in accordance with 4.3.3. Cut the hose longitudinally and examine for both internal and external cracks, charring, and disintegration. Also cut crimp shell per the hose examination procedure (4.3.6.2), to remove hose from crimp shell without damage to the hose, and examine hose material heat aged within crimp shell on ID and OD of hose for evidence of cracks, charring, and disintegration.

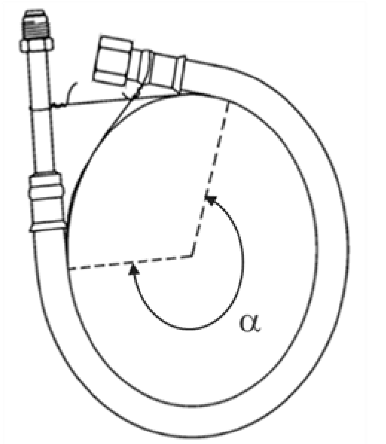

Figure 1: Heat Aging Component Test Positioning on Mandrel

4.3.6 Over-Crimp to 3σ Limits.

4.3.6.1 Test Procedure. Assemblies shall be prepared with maximum hose compression as defined in C1, Appendix C. These assemblies shall be disassembled and examined for hose tube, cover, and reinforcement damage as described in 4.3.6.2. Supplier evaluation of these parts, and the parts themselves, shall be returned to the GM Materials Engineer issuing the approval for evaluation.

4.3.6.2 Hose Examination Procedure. For all 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 cuts 180 degrees from one another. Remove the hose from the tube stem insert, again minimizing damage to the hose during this process. Evaluate both ID and OD of the hose in the areas adjacent to and under the coupling shell for any evidence of damage induced by the manufacturing operation. Also determine the amount of tube stem, collapse. In addition, for half of the assemblies, 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.

4.3.7 Over-Crimp to Damage.

4.3.7.1 Test Procedure. Additional assemblies shall 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 assemblies are to be over crimped per the conditions described in C1 in Appendix C, for maximum hose compression assemblies, 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 < 2%, nor be > 4% incremental hose wall compression. Four assemblies are to be prepared for each increment.

Two assemblies shall be examined for hose damage, and two assemblies for reinforcement damage. Determination of damage shall be in accordance with hose examination procedure as described in 4.3.6.2. After the compression that induces damage is determined, confirmation shall be obtained by a repetition of four additional assemblies. Other engineering experimental plans are permissible, providing that the approval of the GM BFO and GM Materials Engineer issuing the engineering source approval has been obtained. Any exceptions or deviations to 4.3.7.1 shall have the approval of the GM Materials Engineer issuing the engineering source approval and shall be addressed completely and clearly in certification packages.

4.3.7.2 Hose Examination Procedure. For all 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 cuts 180 degrees from one another. Remove the hose from the tube stem insert, again minimizing damage to the hose during this process. Evaluate both ID and OD of the hose in the areas adjacent to and under the coupling shell for any evidence of damage induced by the manufacturing operation, no hose damaged shall be observed, report when any hose damage is observed. Also determine and report the amount of tube stem collapse, for both OD and ID. In addition, for half of the assemblies, 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.

4.3.8 Tube Collapse.

4.3.8.1 Test Procedure. Cut the ferrule and remove the hose to allow access to the stem, measure and record the maximum stem collapse (OD and ID) along the stem as follows:

$$\left(\frac{\text{Initial Diameter} - \text{Final Diameter}}{\text{Initial Diameter}}\right) \times 100\%$$

Report the maximum collapse along the length of the stem. The maximum collapse includes the sum of the collapse caused by forming process and the collapse caused by crimping process and shall be reported over the whole length of the stem.

Note: ID collapse only needs to be reported, but is not part of the acceptance criteria.

4.3.9 Cold Weather Pressure Vibration and Temperature. Quantities for DV per 3.4.1.2.8 and for PV per 3.4.2.2.6.

4.3.9.1 Test Procedure. Install assemblies on manifold and test for air leaks per 4.3.3 leak test. Fill the internal fluid pressurization circuit with Automatic Transmission Fluid (ATF) defined by the released transmission Regular Production Option (RPO) for Type T assemblies or with engine oil defined by the release engine RPO for Type E. Add a dye sensitive to ultraviolet light at a maximum concentration of 1%. Bleed aid from manifold and attach air supply to reservoir.

4.3.9.2 Profile. See Figure E1 in Appendix E for chamber temperature, internal fluid temperature and pressure profile.

4.3.9.2.1 Pre-Cycle Heat Soak. Raise chamber and engine oil (Type E) or transmission fluid (Type T) to 100 °C while maintaining a hydraulic pressure of 140 kPa. Maintain temperature and hydraulic pressure for 12 h. Fluid temperature, system pressure and chamber temperature shall be recorded continuously, and these recordings shall be included in the test report for review.

4.3.9.2.2 Impulse. Apply pressure pulse per SAE J343 (Category 2, Figure 3). Replace 0 MPa value in SAE J343 with the pressure indicated on Table 3 and record the frequency used. Table 3 also defines the pressure impulse profile for Type E and Type T. Repeat pressure cycle each 3 s (0.33 Hz). Pressure impulse shall remain on during the entire test.

Table 3: Pressure Impulse for Temperature Range

Type	Pressure Impulse from -10 °C to 120 °C	Pressure Impulse from -40 °C to -10 °C
All Types	Pressure cycle from 140 kPa to 1140 kPa	Pressure cycle from 140 kPa to 2068 kPa

4.3.9.3 Fluid Flow. Flow inside the test component shall be as demanded to maintain the temperature and pressure profile indicated in the Figure E1 in Appendix E.

4.3.9.4 Vibration. One side of the test assembly described in the Figure B1 in Appendix B, shall be fixed to a static manifold and the other side of the assembly attached to a manifold and to a shaker. Manifolds and their connections to the assemblies shall be reinforced such that are able to withstand loads induced by the vibration. Shaker vibration input shall be applied per GMW17010, in the three axes as indicated in GMW17010, if the program specific road load data inputs are not available, the DRE and/or Subsystem Validation Engineer shall evaluate the specific GMW17010 vibration profile that would apply.

Note: The selected vibration profile shall be trimmed in the low frequency range. Only frequencies > 15 Hz should be included.

4.3.9.5 Test Duration. Test duration is 48 h/axes.

4.3.9.6 Inspection. Inspections per the following rating scale shall be conducted near room temperature after a completion of one chamber thermal cycle. Inspect all joints with an ultraviolet (black) light for evidence of leakage recording all leaks per the rating system on 3.4.1.3.3.1 and documenting any measurable displacement of the hose relative to the ferrule.

No hose displacement inside the crimp is allowed, no hose damage is allowed, and no leaks are allowed. Use X-Ray inspection on all assemblies to evaluate if hose displacement occurred. Half of the assemblies shall be dissected and no damage on the hose is allowed.

4.3.10 Pressure Cycling.

4.3.10.1 Test Procedure. Subject the test assemblies to the leak test per 4.3.3 prior to and at the end of the Pressure Cycle Test. Subject the assemblies to 150 000 cycles of hydrostatic pressure at the specified temperature and pressure. The pressure shall be applied quickly by means of a quick opening solenoid valve at a rate of 25 cycles/minute to 35 cycles/minute. The pressure medium shall be as shown in Table 4.

Table 4: Pressure Cycling Test Parameters

Suffix	Temperature (°C)	Pressure Test (kPa)	Fluid
All Types	150	1140	Defined by Transmission RPO Code

4.3.11 Temperature Cycling.

4.3.11.1 Test Procedure. Assemblies shall be tested. Subject the assemblies to the leak test per 4.3.3 prior to and at the completion of the following temperature cycling test: Temperature cycle the assemblies between the maximum and minimum temperatures shown in Table 5 for the specified hose type for 10 cycles. Maintain each temperature for 2 h with a 6 h maximum transition between extremes. After the last cycle, allow the assemblies to return to room temperature.

Table 5: Temperature Cycling Test Parameters

Suffix	Maximum Temperature (°C)	Minimum Temperature (°C)
All Types	162	-40

4.3.12 Pressure Temperature Cycling Test. Test assemblies shall be manufactured with nominal and minimal hose compression as described in C1, Appendix C, quantities for DV and PV per 3.4.2.3.3.

4.3.12.1 Test Procedure. Install assemblies on manifold and test for air leaks per 4.3.3 leak test. Fill reservoir and assemblies with engine oil defined by the release engine RPO for Type E/Type Ec or with ATF defined by the released transmission RPO for Type T/Type Tc assemblies. Add a dye sensitive to ultraviolet light at a maximum concentration of 1%. Bleed air from manifold and attach air supply to reservoir.

4.3.12.2 Profile. See Figure F1 and Figure F2 in Appendix F.

4.3.12.2.1 Pre-Cycle Heat Soak. Raise chamber and engine oil (Type E/Type Ec) or transmission fluid (Type T/Type Tc) to 150 °C while maintaining a hydraulic pressure of 140 kPa. Maintain temperature and hydraulic pressure for 48 h. Determination of fluid temperature shall be made so that the reading obtained is representative of the fluid contained in the assembly. Fluid temperature, system pressure and chamber temperature shall be recorded continuously, and these recordings shall be included in the test report for review.

4.3.12.2.2 Impulse. Table 6 defines the pressure impulse profile for Type E and Type T. Repeat pressure cycle 3 times/minute. Impulse shall remain on during the entire cycle (4.3.12.2). Pressure transition pulses to be 1.0 s ± 0.5 s.

Table 6: Pressure Impulse for All Hose Types

Suffix	Pressure Impulse from 20 °C to 150 °C	Pressure Impulse from 20 °C to -40 °C
All Types	Raise the pressure to 1140 kPa (165 psi) and hold for 15 s. Reduce pressure to 140 kPa (20 psi) and hold for 5 s.	Raise the pressure to 2070 kPa (300 psi) and hold for 15 s. Reduce pressure to 140 kPa (20 psi) and hold for 5 s.

4.3.12.2.3 Temperature. See Figure F1 in Appendix F for temperature profile.

Note: One cycle is equal to a 24 h period.

4.3.12.2.4 Leak Inspection. Inspections using Table 7 alphanumeric coding system shall be conducted near room temperature after a completion of each cycle. Inspect all joints with an ultraviolet (black) light for evidence of leakage and record all leaks per Table 7 alphanumeric coding system.

Table 7: Leak Rating Scale and Leak Location [Note 1]

Leak Rating Scale	Leak Location
"N" = No Evidence of Leakage	"1" = Tube and Ferrule
"L" = Damp Surface	"2" = Site Hole
"M" = Drops Visibly Forming	"3" = Hose and Ferrule
"H" = Drops Visibly Falling	"4" = Hose
"Z" = Any larger leak than H	

Note 1: As an example, alphanumeric code M3 means drops visibly forming at the hose and ferrule location.

An assembly shall be left on the test until one of the joints has reached "H" (Drops Visibly Falling). Once drops are visibly falling, i.e., assembly is considered as failed, that assembly can be eliminated from the test.

4.3.13 Vibration. Test assemblies shall be tested per GMW17010, if program specific Road Load Data inputs are not available. The DRE and/or Subsystem Validation Engineer shall evaluate the specific GMW17010 vibration profile.

4.3.13.1 Non-Quick Connect. Requirement in GMW15724 (test with whole vehicle assembly).

4.3.13.2 Quick Connect. Quantity of quick connects is to be determined by Weibull calculation to meet reliability requirements, nominal hose and quick connector coupling assemblies shall be tested per GMW17010. Half of the assemblies shall be tested per 4.3.13.2.1 and the other half per 4.3.13.2.2.

4.3.13.2.1 Test assemblies containing a quick connector, shall be mounted in the test fixtures such that the vibration shall be imparted to the assembly through a male tube which is inserted into the female bore of the quick connector. The dimensions of the male tube in those areas which seal against the O-rings of the quick connector and lock into the retainer of the quick connector shall be the minimum dimensions permitted by part drawing. Alternate dimensions for test purposes may be specified by the GM DRE of the assembly to be tested. The pressurization of the assemblies during the test shall be through the male tube end connections to the female bore of the quick connector.

4.3.13.2.2 Test assemblies containing a quick connector, shall be mounted in the test fixture such that the vibration shall be imparted to the quick connect crimp assembly through a rigid connection made to the body of the quick connector. An alternate test assembly, consisting of a tube insert replacement for the male stem of the quick connector, may be specified by the GM DRE to better facilitate the rigid connection. The material, hardness, and dimensions of this tube insert replacement, and all crimp component dimensions, both before and after the crimping of the assembly, must be identical to that of the crimped quick connector containing assembly.

4.3.13.3 Test Procedure. Subject the assemblies to the leak test per 4.3.3 prior to and at the completion of the following Vibration Test. Attach one end of the hose to a fixture to be vibrated. Bend the hose horizontally to form a quarter circle with the axis of the couplings at right angles to each other. Continually expose the hose to the temperature and air pressure shown in Table 8. Test per GMW17010, if program specific Road Load Data inputs are not available

Table 8: Vibration Temperature and Pressure Test Parameters

Suffix	Maximum Temperature (°C)	Pressure (kPa)
All Types	132	1140

4.3.14 Endurance Pressure Displacement and Temperature Cycling Test. Test assemblies per Figure B1 in Appendix B, quantities for DV per 3.4.1.3.5 and for PV per 3.4.2.3.4.

4.3.14.1 Test Procedure. Install assemblies on manifold and test for air leaks per 4.3.3 leak test. Fill reservoir and hose assemblies with engine oil defined by the release engine RPO for Type E/Type Ec or with ATF defined by the released transmission RPO for Type T/Type Tc assemblies. Add a dye sensitive to ultraviolet light at a maximum concentration of 1%. Bleed air from manifold and attach air supply to reservoir.

4.3.14.2 Profile. See Figure G1 in Appendix G for one cycle. One life consists of 15 cycles.

4.3.14.2.1 Pre-Cycle. Chamber temperature, fluid temperature shall be stabilized to the initial temperatures of the test cycle defined in Figure G1 in Appendix G.

4.3.14.2.2 Impulse. Pressure impulse defined per SAE J343 (Category 2) using the values in Table 11 for the two different pressures defined in Figure G1 in Appendix G. Repeat pressure cycle with a frequency of 1.0 Hz.

Table 9: Pressure Impulse Values for High and Low Pressure Cycles

Test Cycle Portion	Pressure Impulse Value (kPa)
0 to 1st	0 (No impulse)
1st to 2nd	Pressure cycle from 0 to 1400
2nd to 15th	Pressure cycle from 0 to 700

4.3.14.2.3 Temperature. Refer to Figure G1 in Appendix G for chamber and internal fluid temperature, no cooling required for internal fluid, but heating is required to rise internal fluid temperature at the 2nd hour and the 12th hour of the cycle as indicated in the Figure G1 in Appendix G. During the first 2 h of the cycle no flow is required, between the 2nd hour and the 13th hour of the cycle, the requirement is to have enough flow to follow the internal fluid temperature indicated at Figure G1 in Appendix G.

4.3.14.2.4 Displacement. Test assemblies shall be dimensionally compliant with Figure B1 in Appendix B. During test set up, a motion feature able to create a circular motion to the lower manifold shall be installed in such a way the assembly on the moving manifold can initiate the test in this circular position. Displacement shall have a cycle frequency of 0.75 Hz and a diameter of 18 mm.

4.3.14.2.5 Inspection. Inspections per the following rating scale must be conducted near room temperature after a completion of each cycle. Inspect all joints with an ultraviolet (black) light for evidence of leakage and record all leaks per 4.3.12.2.4 leak inspection.

No hose damage is allowed, the maximum leak rate permitted is "L" for the samples at nominal compression and "M" for the samples at minimum and maximum compression. If a joint exceeds the leak limit, the sample must be left in the test chamber to evaluate the progress of that leak, remove the sample until a leak level "Z" is reached.

5 Provisions for Shipping

Not applicable.

6 Notes

6.1 Glossary.

3σ: In a normal distribution, 99.7% of all the values remain within three standard deviations of the mean.

Cpk: Number representing variation and centering. distance between the process average and the closest specification limit divided by one-half of the process variation.

R99C50: Reliability of 99% at a 50% confidence.

Type E: Engine oil hose, not exposed to cold start system pressure.

Type Ec: Engine oil hose exposed to direct system pressure at cold vehicle condition.

Type T: Transmission oil hose not exposed to direct system pressure at cold vehicle condition, e.g., a hose coupling downstream oil flow after a Thermal Bypass Valve (TBV).

Type Tc: Transmission oil hose exposed to direct system pressure at cold vehicle condition.

6.2 Acronyms, Abbreviations, and Symbols.

α	Angle
3σ	Three Sigma
ADVP&R	Analysis/Development/Validation Plan and Report
ATF	Automatic Transmission Fluid
BFO	Bill of Material Family Owner
DFMEA	Design Failure Mode Affects Analysis
DRE	Design Release Engineer
DV	Design Validation
EOC	Engine Oil Cooler
ID	Inner Diameter
IMDS	International Material Data System
OD	Outer Diameter
PFMEA	Process Failure Mode Affects Analysis
PPAP	Production Part Approval Process
PV	Production Validation
PVA	Product Validation Audit
RCI	Resin Identification Code
REP	Reliability Evaluation Point
RPO	Regular Production Option
SAE	SAE International
SOR	Statement of Requirements
SOR	Statement of Requirements
SPC	Statistical Process Control
SPI	Society of the Plastics
TBV	Thermal Bypass Valve
TOC	Transmission Oil Cooler
TTF	Test to Failure
VCRI	Validation Cross Reference Index
VCRI	Validation Cross Reference Index
VTS	Vehicle Technical Specification

7 Additional Paragraphs

7.1 All materials supplied to this standard must comply with GMW3059, **Restricted and Reportable Substances**, including the requirement to submit a full material composition disclosure to GM via the International Material Data System (IMDS).

8 Coding System

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

GMW15964

9 Release and Revisions

This standard was originated in May 2008. It was first approved by Global HVAC Powertrain GSSLT in October 2009. It was first published in October 2009.

Issue	Publication Date	Description (Organization)
1	OCT 2009	Initial publication.
2	MAY 2011	Updated per the new CTS Template and updated Tensile Test Procedure. (HVAC and Powertrain Cooling)
3	FEB 2014	Updated material identification, reliability requirements, pressure temperature cycling procedure, corrosion requirements and procedure, and vibration procedure. (HVAC/PTC/Thermal - Fluid Management Systems)
4	SEP 2015	Updated vibration procedure referring to GMW17010 Mechanical Shock and Vibration Durability Test - Thermal Under-Hood Procedure Specification and Appendix B Pressure Temperature Cycling Figures. Updated REP to R99C50. (HVAC - Fluid & Plumbing GSSLT)
5	SEP 2019	Added Cold Weather Pressure Displacement and Temperature, Added Cold Weather Pressure Vibration and Temperature, Added Endurance Pressure Displacement and Temperature Cycling Test, Added minimum and maximum compression requirement for Tensile, Added maximum compression requirement for PTC. Additional changes made. (HVAC – Chassis Propulsion Integration and Thermal Systems)
6	FEB 2020	Restructured for clarity. (HVAC – Chassis Propulsion Integration and Thermal Systems)

Appendix A

Data Sheet A1: Pressure Temperature Cycling Test Report Example

TEST Title	Inside	Crimp Compression			Test Cycle																	
Test Sample Number/Crimp	Diameter	Minimal	Nominal		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1A																						
1B																						
2A																						
2B																						
3A																						
3B																						
4A																						
4B																						
5A																						
5B																						
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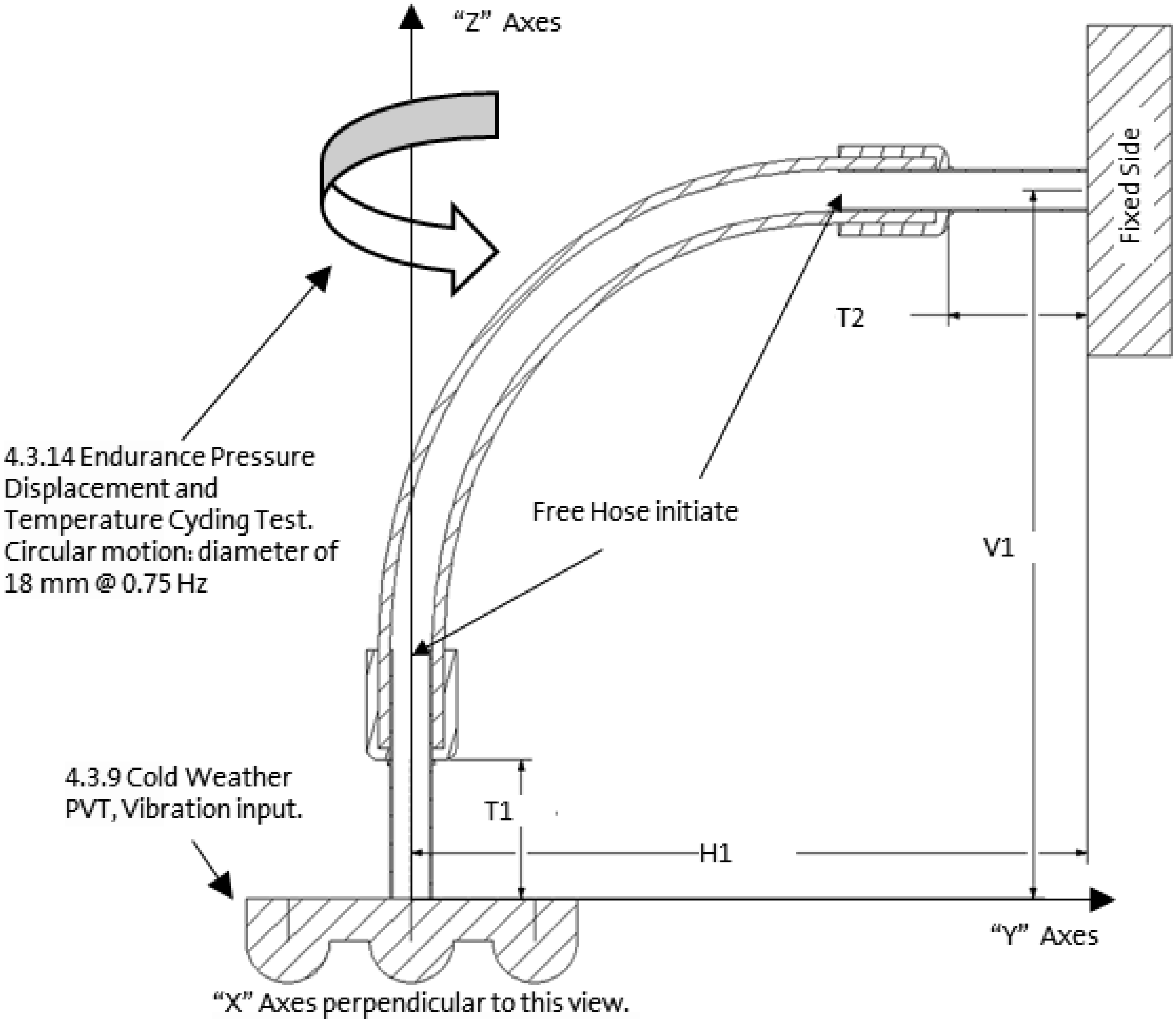
12B																						

Appendix B



Where:

Pipe OD (mm)	PTD Displacement (mm)	Hose Free Length (mm)	T1 (Free tube) (mm)	T2 (Free tube) (mm)	H1 (mm)	V1 (mm)
9.525	± 12.5	169	42	42	172	180
12.7	± 12.5	212	42	42	204	214
15.875	± 20	220	63	63	257	275

Figure B1: Test Assembly Construction

Appendix C

C1 Crimp Compression

Test assemblies throughout this specification will be referred to as minimum hose compression, nominal hose compression, or maximum hose compression. C1.1 through C1.3 describe the requirements for these conditions. If not specified, the test assemblies shall be of nominal hose compression.

Compression shall be measured at the crimp row that, under nominal conditions, produces the maximum compression of the hose.

C1.1 Minimum Crimp Compression Condition. Test assemblies referred to in this specification, as minimum hose compression assemblies, shall adhere to C1.1.1 thru C1.1.5.

C1.1.1 Hose ID Area Calculation. Minimum hose ID (as determined by 3σ value of the hose manufacturer).

C1.1.2 Hose Wall. Minimum wall thickness (as determined by the 3σ value of the hose manufacturer).

C1.1.3 Crimp/Swage OD. Maximum crimp/swage OD (3σ value of the assembly manufacturer).

C1.1.4Tube Insert OD. Minimum tube insert OD (3σ value of the metal insert manufacturer).

C1.1.5 Ferrule Wall. Minimum ferrule wall thickness (3σ value of the ferrule manufacturer).

Assemblies manufactured as in to C1.1.1 thru C1.1.5, 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 a Cpk of at least 1.67 for these dimensions. The acceptability of nominal insert OD and ferrule wall thickness dimensions for this testing shall be reviewed beforehand and approved by the GM Materials Engineer and GM BFO 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 shall 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 the assemblies.

C1.2 Nominal Crimp Compression Condition. Test assemblies referred to in this specification as nominal hose compression assemblies shall consist of components manufactured to nominal dimensions and crimped to a mean specification value of crimp/swage OD.

C1.3 Maximum Crimp Compression Condition. Test assemblies referred to in this specification as maximum hose compression assemblies shall adhere to C1.3.1 thru C1.3.3.

C1.3.1 Hose Wall. Maximum wall thickness (as determined by the 3σ value of the hose manufacturer).

C1.3.2 Crimp/Swage OD. Minimum crimp/swage OD (3σ value of the assembly manufacturer).

C1.3.3 Tube Insert OD. Maximum tube insert OD (3σ value of the metal insert manufacturer).

C1.3.4 Ferrule Wall. Maximum ferrule wall thickness (3σ value of the ferrule manufacturer).

Assemblies manufactured as in C1.3.1 thru C1.3.3, 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 dimensions for this testing shall be reviewed beforehand and approved by the GM Materials Engineer and GM BFO issuing the approval. If the use of nominal insert OD and ferrule wall thickness dimensions are found to be acceptable, the crimp OD shall 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 the assemblies.

Appendix D

D1 Linear Compression

Compression shall be measured at the crimp row that, under nominal conditions, produces the maximum compression of the hose.

Linear Hose Wall Compression = $[(T_O - T_f)/T_O] \times 100\%$

Where:

T_O = Initial hose wall thickness (prior to crimping)

T_f = Final hose wall thickness (after crimping)

D2 Area Hose Wall Compression

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

Where:

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

$R_{OD\text{-}I}$ = Initial OD radius of the hose (prior to crimping)

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

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

Appendix E

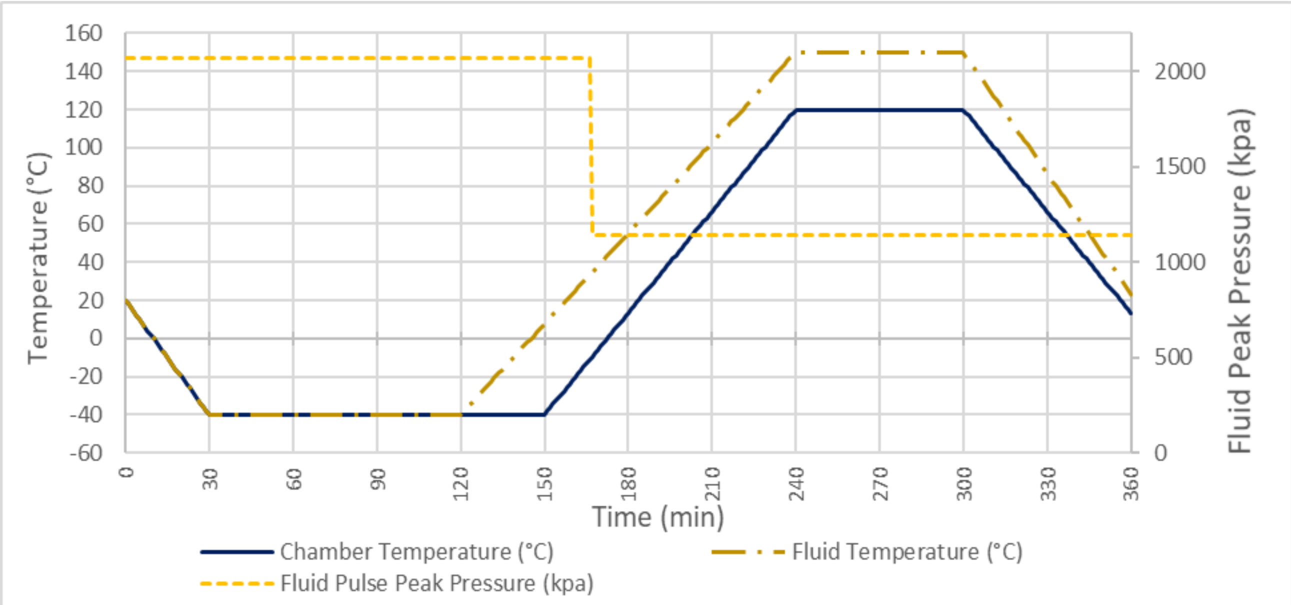


Figure E1: Cold Weather Pressure Vibration and Temperature Test Profile

Appendix F

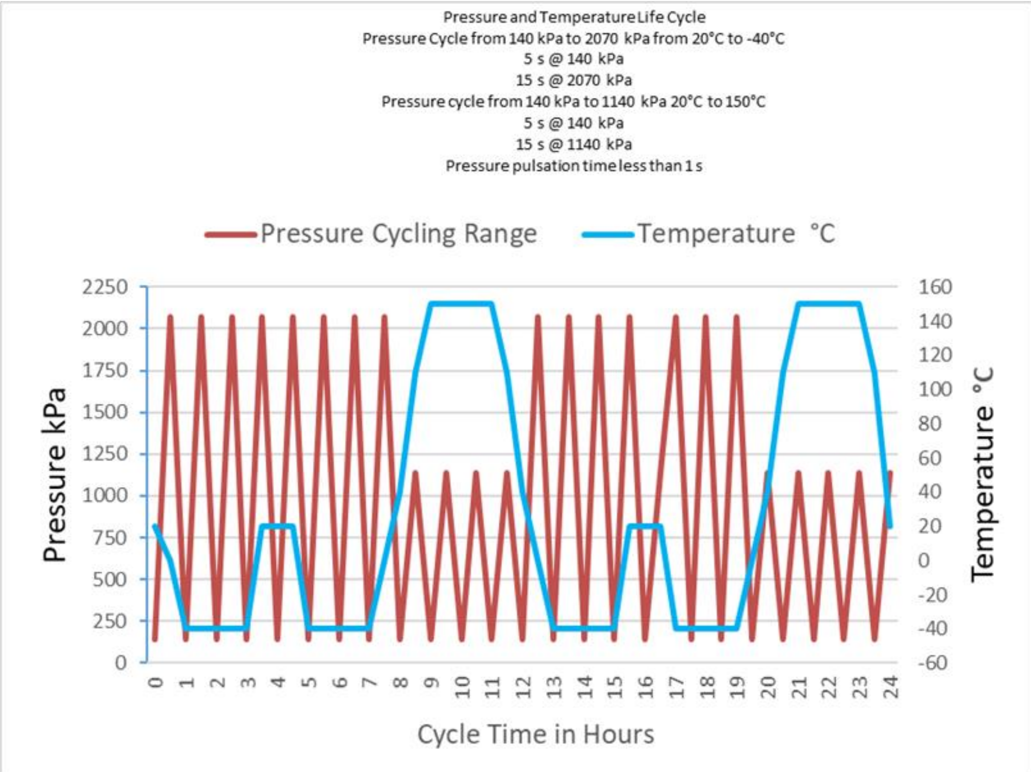


Figure F1: Pressure Temperature Life Cycle Example All Type Hoses

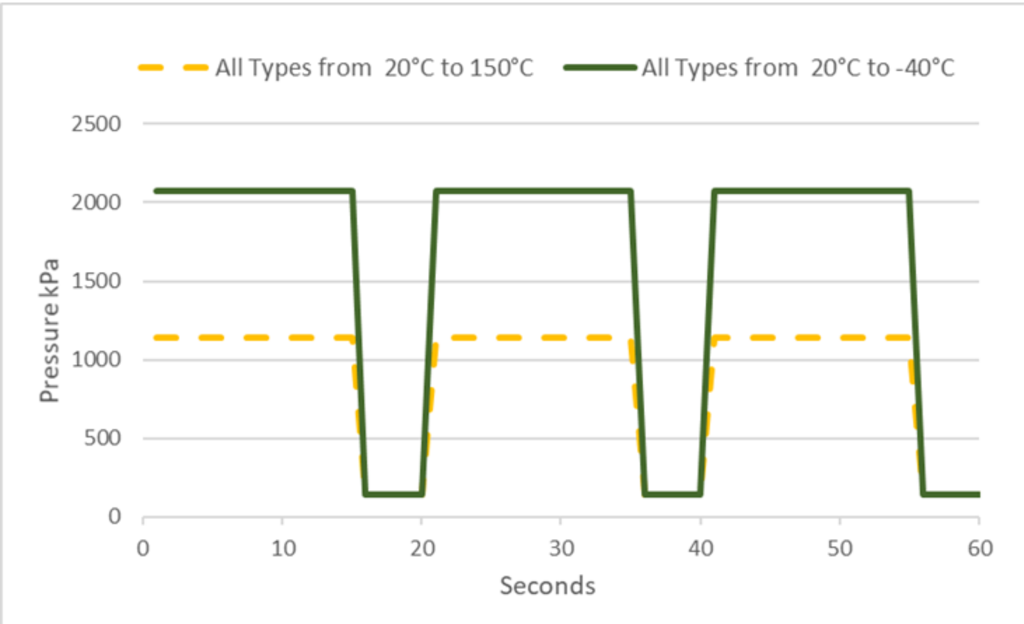


Figure F2: Pressure Pulse Width Duty Cycle Profile

Appendix G

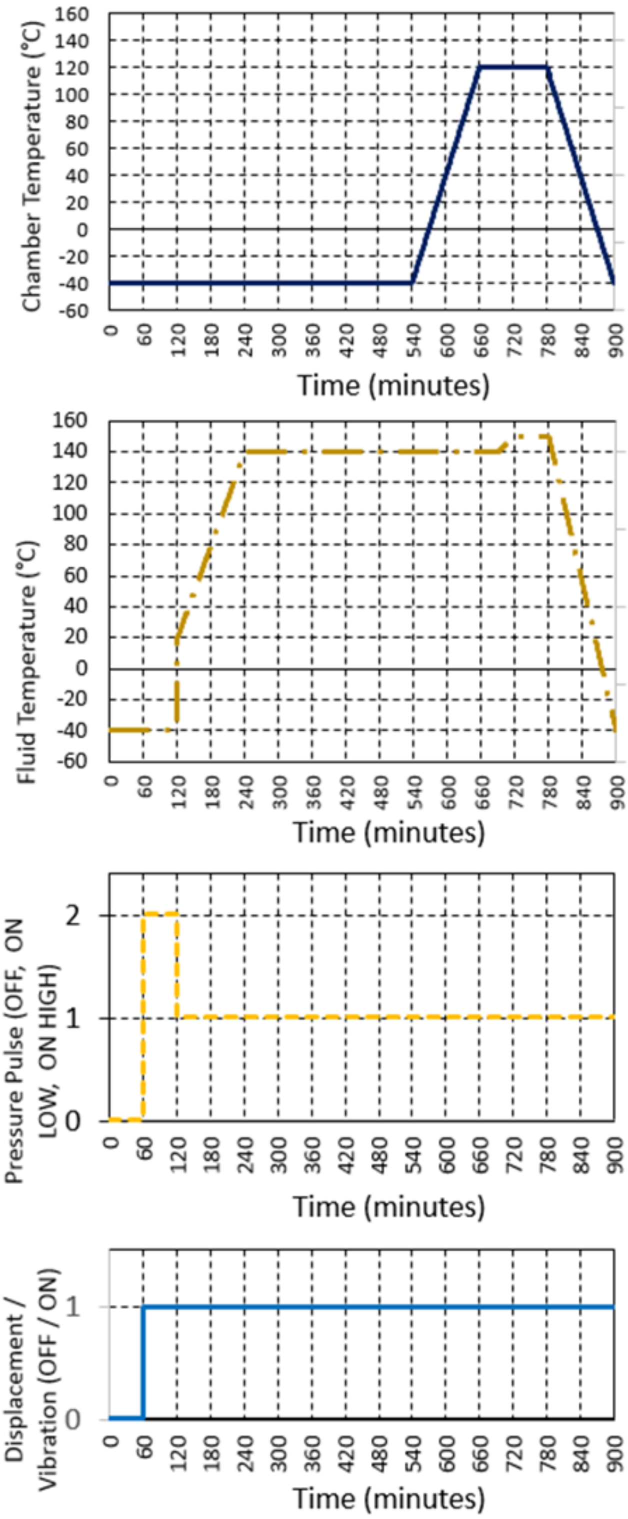


Figure G1: Endurance Pressure Displacement and Temperature Cycling Test Profile