Plastic Plumbing for Water/Coolant Applications: Hose Construction and Joint Validation Testing

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 defines the Design Validation (DV), Production Validation (PV) and Steady State Part Monitoring (SSPM) requirements to validate thermoplastic joints and tube constructions for low temperature coolant applications such as High Voltage Battery, Power Electronics and Power controllers, Surge Tank Degassing, Radiator Vent and Heater systems. Any additional requirements shall be defined by the GM Materials Engineer.

1.2 Applicability. Thermoplastic coolant/water plumbing lines (mono or multilayer) with fluid temperatures from -40 °C to 120 °C in continuous state and excursions up to 135 °C.

2 References

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

2.1 External Standards/Specifications.

ASTM D573	SAE J1737	SAE J2260

2.2 GM Standards/Specifications.

GMW3059	GMW14573	GMW14797	GMW16295
GMW3116	GMW14638	GMW15468	GMW17488
GMW3221	GMW14700	GMW15760	

2.3 Additional References.

- 9986100 dexcool® Premix
- Subsystem Technical Specification (SSTS)
- Vehicle Technical Specification (VTS)

3 Requirements

3.1 Requirements on Test Specimens. Reference GMW3221. Unless otherwise specified, the shape and size of test pieces shall be in accordance with the relevant test method. The minimum number of samples (hoses) per test is defined in Table 1. Samples are finished parts or to be taken from finished parts. Where the dimensions on the finished parts do not allow preparing of test pieces, tests are to be performed on material from the same production batch. For testing of a tubing construction to the following performance properties of Table 2 of this specification, each type of quick connector, inline, T connector or Y connector used in a design released to this specification must be incorporated into the samples tested.

3.2 Reliability.

3.2.1 Reliability Evaluation Point. This specification, provides a test exposure representing a Reliability Evaluation Point (REP) required by GM.

3.2.2 Reliability Requirements. This specification supports the demonstration of the required reliability of 99% or greater at a 50% confidence (R99C50), at the REP for the coolant pipe joints. 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 caseloads for all physical level reliability demonstration testing.

The reliability demonstration is provided by the Design Validation (DV) Endurance Tests specified in Table 2.

Note: 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.

3.2.3 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.

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 shall 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.

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.

3.3 Serviceability. Not applicable.

3.4 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.

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

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

3.7 Testing Requirements.

3.7.1 Performance and Material Testing. These are tests designed to demonstrate the performance of the component, but not necessarily the reliability. Table 1 shows a summary of the required testing.

Table 1: DV/PV Test Table: Performance Testing

Reference	Test	Number of Samples	Test Type
3.7.2.1	Vacuum Test	12	Performance
3.7.2.2	Stone Impact Resistance Test	12	Performance
3.7.2.3	Layer Adhesion Test	12	Performance
3.7.2.4	Tube Permeability Test	6	Performance
3.7.2.5	Tube Flexibility	12	Performance
3.7.2.6	Tube Pressure Drop	12	Performance
3.7.3.1	Leak and Blow off Test	12	Performance
3.7.3.2	Cold Leak Test	12	Performance
3.7.3.3	Blow-off after Heat Aging Test	12	Performance
3.7.3.4	Insertion Force Test for Quick Connectors	12	Performance
3.7.3.5	Pressure Drop for Quick connectors	12	Performance
3.7.3.6	Zinc Chloride Test	12	Performance
3.7.3.7	Calcium Chloride Test	12	Performance
3.8.1	Pressure/Motion/Temperature	Per Table 5	Endurance

3.7.2 Tube Construction Tests. Tube Construction Test are as follows and as defined in Table 2, the coupon to validate this portion must be defined following the Figure A4.

3.7.2.1 Vacuum Test.

3.7.2.2 Stone Impact Resistance Test.

3.7.2.3 Layer Adhesion Test.

3.7.2.4 Tube Permeability Test.

3.7.2.5 Tube Flexibility.

3.7.2.6 Tube Pressure Drop.

Table 2: DV/PV Tube Construction Testing

Property	Test Procedure	Unit	Acceptance criteria
3.7.2.1 Vacuum Test.			
All Construction Types	At (23 ± 3) °C, evacuate air from the tube until the internal pressure is stabilized at -1.0 bar (gage), hold this pressure for 40 s, then increase the pressure linearly at a rate of (20 ± 5) kPa/s until reach (200 ± 5) kPa, hold this pressure for 120 s and conduct procedure described on 3.7.3.1 Leak test.	N/A kPa	No visible cracks nor permanent deformation on tube after 200 kPa No leaks at 1.20 times maximum continuous system working pressure per Subsystem Technical Specification (SSTS)

3.7.2.2 Stone Impact Resistance.			
Construction Types (only Hose Type A and B)	Tubing shall be subjected to Stone Impact Test Procedure according to GMW14700 Method B for ten (10) cycles at -40 °C, sample length is set on (305 ± 5) mm and must be installed to keep a constant separation equal to the maximum stone diameter (see GMW14700) to ensure impact on tube surface. After exposure to stone impact, samples shall be subjected to procedure 3.7.3.1 Leak Test.	kPa	No leaks at 1.20 times maximum continuous system working pressure
3.7.2.3 Layer Adhesion Test.			
Multilayer tube construction only	Item 3.16 of GMW14638 Cut a strip of tubing into approximately 6 mm wide helical coil equal in length to five times the circumferences of the tubing using a tool as shown in Figure 4 of GMW14638. Bend the helical coil in reverse of coiling. Apply a weight of 2 kg to the uncoiled end. **Note**: Optional adhesion procedures may be used upon agreement by GM Materials Engineer (refer to SAE J2260 for alternate methods). See Figure A2 for layer adhesion tool.	N/A	No delamination shall occur between layers

3.7.2.4 Tube Permeability.			
All construction types for EV and Power Electronics cooling systems	**Resources/Facilities:** - An environmental chamber capable of maintaining operating temperature of 70 °C ± 2 °C during the completion of the test. - A circulation pump capable of flowing coolant through the pipe samples at a rate of 25 L/minute. - A pressurization system capable of pressurizing the coolant to 200 kPa with an allowable tolerance of ±3.4 kPa - A coolant heater capable of heating the coolant to a maximum 80 °C ± 2 °C - An air drier/conditioner - A canister with a desiccant (Anhydrous Calcium Chloride) trap to catch the moisture and a system to measure its weight. The tubes samples must be mounted vertically to always be in contact with the coolant flow coming from the pump in a closed single cell that allows the entrance of dry air coming from the Air drier/conditioner this air flow shall pass through the cell and then transferred to the canister which will trap the moisture, the measurements in the canister shall be conducted at least twice per week with a test duration of eight (8) weeks. The Figure A6 shows a schematic of the bench used to run this procedure. **Note:** Review with GM Bill of Materials (BOM) Family Owner if Permeability Procedure per SAE J1737 can be used. **Note**: Tube samples Inner Diameter (ID) is set at 16 mm by default.	$g/m^2/day$	≤ 3.1 in the last eight (8) canister measurements (last four (4) weeks of testing)

3.7.2.5 Tube Flexibility.			
Tubes with convoluted (bellows) regardless of tube construction	Follow procedure described in 4.3.3 of GMW17488 and record maximum load achieved to bend the tube at 45° after this remove the tube sample from the bench and expose it to procedure 3.7.3.1 Leak and Blow off to set pressure for leak	kPa	No indications of permanent deformation (tube collapsing) in the area where the deformation occurred No leaks at pressure for leaks.
3.7.2.6 Hose Pressure Drop.			
All hoses (smooth and with corrugated sections)	Coupon for testing shall be built following the dimensions shown in the Figures A7, A8, A9 and A10 for straight and bent hoses with the next consideration: - To evaluate pressure drop on 90° bend corrugated hoses the length of smooth/free hose section and corrugated section shall be 100 mm instead 80 mm. Hose sample shall be mounted in a bench that allows a constant flow of a 50/50 coolant per 9986100 dexcool® Premix at 25 L/minute with a temperature of 55 °C ± 2 °C and 175 kPa of static pressure. **Note**: The hose coupon shall be defined with NW16 VDA In-line Quick connectors as standard connection method.	kPa	Straight hoses -Smooth hoses (no convolutes) ≤ 2.4 kPa (Figure A7) -Corrugated hoses (bellows) ≤ 3.5 kPa (Figure A8) Bent hoses: -Smooth hoses (no convolutes) ≤ 2.8 kPa (Figure A9) -Corrugated hoses (bellows) ≤ 4.7 kPa (Figure A10)

NW Nominal Width

3.7.3 Performance Testing for Joint Validation. Performance Testing is as follows and as defined in Table 3 the coupon to validate this portion must be defined following the Figure A4 except for Zinc or Calcium chloride test.

3.7.3.1 Leak and Blow-off Test.

3.7.3.2 Cold Leak Test.

3.7.3.3 Connection Blow-off after Heat Aging.

3.7.3.4 Insertion Force Test for Quick Connectors.

3.7.3.5 Pressure Drop for Quick connectors.

3.7.3.6 Zinc Chloride Test.

3.7.3.7 Calcium Chloride Test.

Table 3: DV/PV Testing for Joint Performance

Property	Test Procedure	Unit	Acceptance criteria
3.7.3.1 Leak and Blow Off Test.			
All joints in assembly	GMW16295 Leak and Blow off test per 4.3.1.2	kPa	No leaks at 1.2 times the maximum system working pressure. Connection blow off shall be at least two (2) times the maximum system working pressure
3.7.3.2 Cold Leak Test.			
All joints in assembly	Fill the coupled hose assembly with 60% Ethylene Glycol and 40% 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 (-40 ± 1) °C and stabilize for 2 h, then apply an internal pressure of (200 ± 5) kPa. Hold the pressure and chamber temperature for 20 minutes. Reduce the pressure to (0 ± 5) kPa, remove the assembly from the environmental chamber and allow to warm at room temperature for 2 h.	N/A	No stains that could indicate leaks. Inspection using UV light equipment is recommended.

3.7.3.3 Connection Blow-off after Heat Aging.			
All Joints in assembly	Fill samples with 50/50 glycol water mix and expose samples to heat age for 1000 h at the temperatures listed as follows: - Tube type A: (80 ± 5) °C - Tube type B: (100 ± 5) °C - Tube type C: (120 ± 5) °C Stabilize test samples for 1 h at +23 °C then apply pressure at a rate of 7 MPa/minute until the tube disconnects from fitting (any middle hardware connection such as quick connectors, T, Y or inline couplings). The test apparatus shall be defined to handle samples with a free tube length of (305 ± 5) mm, samples must be connected to a manifold (external reservoir system) to allow coolant flow through the samples during the completion of the test. **NOTE:** Test can be completed on straight pipes with the requested free tube length.	kPa	Blow-off > 2 times maximum system working pressure per SSTS
3.7.3.4 Insertion Force Test for Quick Connectors.			
All Construction types with Quick Connectors	GMW16295 item 4.3.1.5 **Note**: To execute this test all the Quick Connectors shall be equipped with features/provisions to provide notification that connection has been completed successfully (DET Level 3 for PFMEA purposes)	N/A	≤ 45
3.7.3.5 Pressure Drop for Quick Connectors			
Quick connectors with tube angled fittings	Angled quick connectors shall meet the pressure drop profiles shown on Figure B3. The angled quick connector should have a smooth radius inside to reduce pressure drop. Compliance shall be demonstrated with coolant at 23 °C. **Note**: Figure B3 shows pressure drop profiles for NW12 and NW16 connections.	kPa	as shown on Figure B3

3.7.3.5 Zinc Chloride Test.			
All joints intended to be used on underbody applications	The sample (per A4.1 Coupon) is bent to the minimum bend diameter as specified in Appendix A, Figure A3 and immersed in a 50% aqueous solution (by weight) of zinc chloride for 200 h at (+23 ± 2) °C. All interfaces between the tubing and the components directly connected to the tubing shall also be immersed for the duration of the test when performing this procedure. The ends of the assembly are to remain unplugged, the sample is removed from the solution and rinsed with clean water to clear salt residue from tubing, expose the samples to procedure 3.7.3.1 Leak test. Once leak pressure value is reached, continue increasing pressure at a rate of 7 MPa/minute to set connection blow-off pressure, acceptance criteria for this condition is set on procedure 3.7.3.3.	kPa	No visible cracks or crazing in the sample No leaks at 1.20 times maximum system working pressure Blow-off: ≥ 2 times maximum system working pressure
3.7.3.6 Calcium Chloride Test.			
All Joints intended to be used on underhood applications	The sample (per A4.1 Coupon) is bent to the minimum bend diameter as specified in Appendix A, Figure A3 and immersed in a 50% aqueous solution (by weight) of calcium chloride for 200 h at (60 ± 2) °C and 200 h out of solution at (60 ± 2) °C. All interfaces between the tubing and the components directly connected to the tubing shall also be immersed for the duration of the test when performing this procedure. The ends of the assembly are to remain unplugged, the sample is removed from the solution and rinsed with clean water to clear salt residue from tubing, expose the samples to procedure 3.7.3.1 Leak test, once leak pressure value is reached continue increasing pressure at a rate of 7 MPa/minute to set connection blow-off pressure, acceptance criteria for this condition is set on procedure 3.7.3.3.	kPa	No visible cracks or crazing in the sample No leaks at 1.20 times maximum system working pressure Blow-off: ≥ 2 times maximum system working pressure

3.8 Endurance Testing for Joints. These tests are designed to demonstrate the component reliability. The coupon to validate this portion must be defined following the Figure A5. See Table 4.

Table 4: DV /PV Test Table - Joint Endurance Testing

	Test	Number of Samples	Test Type
3.8.1	Pressure/Motion/Temperature	per Table 5	Endurance

3.8.1 Procedure.

3.8.1.1 Test Samples. Test samples shall be made using production intent process/techniques/parameters for tube extrusion and the assembly of any additional hardware such as quick connectors. Connection coupons shall be made per Figure A5, endurance testing can be completed by using straight tube sections between connections.

Test samples that have the worst-case tolerance stack-up, (both ±3 sigma), shall be used for Design Validation (DV) testing. An equal number of +3 sigma and -3 sigma shall be used. The tolerance distribution of parts to be tested shall be decided in agreement with GM Design Release Engineer and GM Validation Engineer.

3.8.1.2 Test to Failure. If the decision is made to define tests that are run to failure, the number of samples shall be defined as required to achieve R99C50 and use Weibull analysis to determine slope. This shall be decided in agreement with GM Design Responsible Engineer and GM Validation Engineer by exposing the samples to procedure 3.8.1.4.

Note:

- If any failure occurs in the first life of customer usage, stop the entire test. Do a Design Review Base on Test Result (DRBTR). Perform root-cause analysis. If and as determined, redesign the part/product and start testing all over again.
- First life/customer usage shall be normal stress, 2nd and 3rd life can be Accelerated and/or Step Stress.
- Upon failure, plot Weibull slope and calculate reliability demonstrated.
- If no failures by the end of the 3rd life, remove ½ of the samples from test stand and do the functional tests followed by a DRBTR.
- Continue test to failure with the other remaining samples using steps of stress method to induce failure and do the functional tests followed by a DRBTR to analyze failed samples.

3.8.1.3 Success Testing. If the decision is made to define tests that are run for a finite number of cycles by exposing the samples to procedure 3.8.1.4, the number of samples shall be defined as required to achieve R99C50 with a minimum of eight (8) samples, using a Weibull slope of two (2), see Table 5.

Note: One (1) life of customer usage is defined as ten (10) cycles of endurance testing. Appendix B, Figure B1 shows a preview of the temperature (for coolant and chamber), pressure and motion profiles per one cycle.

Table 5: Example of Number of Samples Required for Endurance Testing Tests (based on Weibull slope of two)

Reliability Requirement	Success Test (per 3.8.1.3)	Minimum Sample Size Required	
		Test to Failure (TTF)	Success Testing
		Sample Size	Sample Size
R99C50	N/A	See 3.8.1.2	
R99C50	2.1 customer usage lives		16 samples (no failures)
R99C50	2.4 customer usage lives		12 samples (no failures)
R99C50	2.9 customer usage lives		8 samples (no failures)

3.8.1.4 Procedure.

a. Prior to testing, visually inspect all hoses for evidence of bloom, cuts/damage or residual oils or other residue from the manufacturing process and capture findings.

b. Expose all the joints to heat aging at maximum environment continuous temperature per Vehicle Technical Specification (VTS) for 168 h using apparatus described in ASTM D573.

c. After completion, leave the test samples at ambient temperature for 1 h and conduct procedure 3.7.3.1 to set pressure for Leak, begin endurance testing as follows.

(Appendix A includes a graphical representation of the profile, pressure signal and coolant flow)

3.8.1.4.1 Segment 1. Raise chamber temperature linearly at a range of 1.5 °C/minute up to 90 °C (194 °F) and stabilize for 540 minutes while keeping the following conditions:

- Coolant heater: ON. **See Note 1.**
- System Pressure: ON (Maximum Flow Rate 26 L/minute). **See Note 2**
- Coolant pump: ON
- Motion: ON

3.8.1.4.2 Segment 2. Increase coolant temperature at a rate of 1.0 °C/minute until the fluid reaches the excursion temperature set by VTS, stabilize for 30 minutes, keep chamber at 90 °C and finish segment under the conditions listed as follows:

- System Pressure: ON (Maximum Flow Rate 26 L/minute). **See Note 2**
- Coolant pump: ON.
- Motion: ON.

3.8.1.4.3 Segment 3. Reduce chamber temperature until it reaches -40 °C keeping the next conditions:

- System Pressure: OFF
- Coolant pump: OFF
- Coolant heater: OFF
- Motion: OFF

3.8.1.4.4 Segment 4. Maintain chamber temperature at -40 °C for 120 minutes. Stabilize coolant temperature at -40 °C for 90 minutes, then raise coolant temperature at rate of 3.6 °C/minute until fluid reaches excursion temperature.

- System Pressure: ON (Maximum Flow Rate 26 L/minute). **See Note 2**
- Coolant Pump: ON.
- Coolant heater: OFF 90 minutes/ON 30 minutes

3.8.1.4.5 Segment 5. Increase chamber temperature up to 90 °C while keeping the following conditions:

- System pressure: ON (Maximum Flow Rate 26 L/minute) **See Note 2**
- Coolant pump: ON
- Motion: ON.
- Coolant heater: ON. See Note 1.

Note 1: Coolant temperature must reach maximum continuous temperature per VTS, value is set by GM Design Release Engineer and GM Validation Engineer.

Note 2: The pressure signal is shown in Appendix B, Figure B2.

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

3.8.1.6 Dimensional report of the parts prior testing, the report must include all the KPC attributes indicated by GM Design Release Engineer, such as diameters, length, angles, thickness or other parameters that could ensure the correct functionality of the parts.

Note: If connections fittings are machined due to absence of vehicular representative parts, a dimensional report must be included in the validation report to prove that parts are according to GM specification, this is a requirement for report approval.

3.8.1.7 Report the parameters such as chamber temperature, fluid pressure/temperature, transition times etc., reached by test equipment.

3.9 Test Samples. Sample or assembly is used to describe the component to be tested which shall include the joint/hose with production design intent. and production design intent fitting

3.9.1 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.

3.9.2 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.

3.10 Design and Construction.

3.10.1 Tubing Sizes and Processing Requirements for Samples. All sizes of tubing incorporated into a design released to this specification must be tested to all of the requirements of this document. All processes used to manufacture the production tubing/assemblies for which material approval is being sought must be incorporated into the samples tested to this specification, including forming operations. If tubing is to be formed, representative samples of the formed tube must be selected as a part of validation testing. The effect of forming operations can be tested with straight tubing samples that have been subjected to heat exposure equivalent to that of the production forming operation final approval is up to GM Validation Engineer.

3.10.2 Tube Construction Types. Materials covered by this specification are divided into several types that define the material content, construction, and performance limits of each specific type of tubing. Base materials must be tested for hydrolytic resistance as per GMW15468.

3.10.2.1 Type A. Extrusion grade, heat stabilized and hydrolysis resistance tube capable to work at continuous temperature of 80 °C with excursion up to 90 °C.

3.10.2.2 Type B. Extrusion grade, heat stabilized, and hydrolysis resistance tube capable to work at continuous temperature of 90 °C with excursion up to 120 °C.

3.10.2.3 Type C. Extrusion grade, heat stabilized and hydrolysis resistance tube construction capable to work at continuous temperature of 120 °C with excursion up to 135 °C.

3.11 Labeling. Tubing released to this specification shall be labeling based on the requirements of the region in which it is released. Tubing for GM North America (GMNA) shall be labeled according to Appendix A, Figure A1. Labeling requirements for other regions shall be coordinated with the regional Materials Engineer.

3.12 Rules and Regulations.

3.12.1 Legal Regulations. All materials must satisfy applicable laws, rules, regulations and recommendations valid in the country of usage.

3.13 Other Material Requirements.

3.13.1 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.

3.13.2 Material Safety Data Sheets/Safety Data Sheets (MSDS/SDS). For new product submissions, or when a change in chemical composition of an existing product has occurred, a complete copy of the Material Safety Data Sheet/Safety Data Sheet must be submitted in compliance with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS) requirements or other country-specific MSDS/SDS requirements.

3.13.3 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) or via a completed GMW3059 report form.

3.13.4 Approved Sources.

Materials supplied to this specification must be approved by General Motors.

A list of approved materials can be found in GM Materials Approved List. This GM Material File is provided to third parties to reduce redundant testing of materials. If approved material already listed is used, the part supplier can use GM Material File reference for Production Part Approval Process (PPAP) material approval. The material approval process must be completed prior to PPAP start date of the part supplied to General Motors.

4 Validation

4.1 Validation requirements are part of this GMW standard.

4.2 Deviations from the requirements of this specification shall have been agreed upon. Such deviations shall be specified on component drawings, test certificates, reports, etc.

5 Provisions for Shipping

Not applicable.

6 Notes

6.1 Glossary.

6.2 Acronyms, Abbreviations, and Symbols.

ADV	Analysis Development Validation
APOPS	Approved Paint on Parts
BOM	Bill of Materials
CALT	Calibrated Accelerated Life Testing
DRBTR	Design Review Base on Test Result
DV	Design Validation
GHS	Globally Harmonized System of Classification and Labeling of Chemicals
GMNA	General Motors North America
GMW	GM Worldwide
HALT	Highly Accelerated Life Testing
HASS	Highly Accelerated Stress Screening
HAST	Highly Accelerated Stress Testing
IMDS	International Material Data System
lpm	Liters per minute
Min	Minute
MSDS	Material Safety Data Sheet
NW	Nominal Width
OD	Outer Diameter
PN	Part Number
PPAP	Production Part Approval Process
PV	Production Validation
R	Radius
REP	Reliability Evaluation Point

SDS Safety Data Sheet
Sec second
SSPM Steady State Part Monitoring
SSTS Subsystem Technical Specification
TTF Test to Failure
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:

Material per GMW18152 Type X

Where:

GMW = GM Worldwide

18152 = Sequential Number

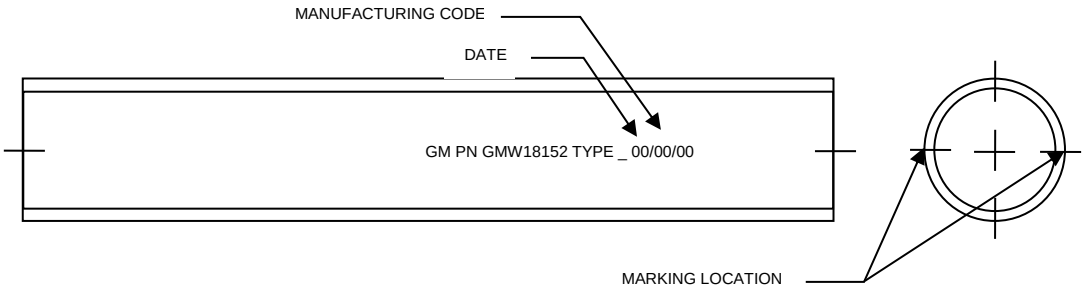
9 Release and Revisions

This standard was originated in March 2019. It was first approved by HVAC - Refrigerant - Coolant Plumbing and Hardware in October 2019. It was first published in October 2019.

Issue	Publication Date	Description (Organization)
1	OCT 2019	Initial publication.
2	DEC 2019	Updated 3.7.2.6 Hose Pressure drop; 3.8 Endurance Testing for Joints: Appendix A4 Testing Coupon Definition: Appendix B1 Endurance Testing Profiles (HVAC – Chassis Propulsion Integration and Thermal Systems)

Appendix A

A1 Tube Labeling



Note: GMW18152 Type A, B or C according with 3.10.2
PN Part Number

Figure A1: Tube Labeling

A1.1 Markings. As shown in Appendix A, Figure A1.

A1.1.1 General Requirements.

A1.1.1.1 Markings shall be legible.

A1.1.1.2 Markings shall be typical for all fuel lines including coextruded tubing.

A1.1.2 Markings shall appear on at least one side, parallel to the fuel line axis. If markings are printed on both sides, the markings shall be (180 ± 10)° apart.

A1.1.2.1 Markings shall be a minimum of 2.5 mm high for ≥ 8 mm Nominal Outer Diameter (OD) tubing.

A1.1.2.2 Markings shall be a minimum of 2.0 mm high for <8 mm Nominal OD tubing.

A1.1.2.3 The open space between the markings shall be not more than 100.0 m.

A1.1.3 Color. Markings shall be White or yellow.

A1.1.4 Printing shall be placed on tubing as extruded (**No pre- and post-treatment allowed**).

A1.1.5 Printing shall conform per GMW14797: Approved Paint on Parts (APOPS) and PPAP Requirements for Engine Compartment Components.

A1.1.6 Tubing Color. Black**.**

A2 Adhesion Test Tool

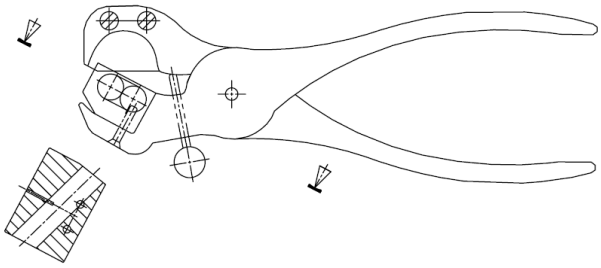


Figure A2: Adhesion Test Tool

A3 Zinc/Calcium Chloride Test Fixture

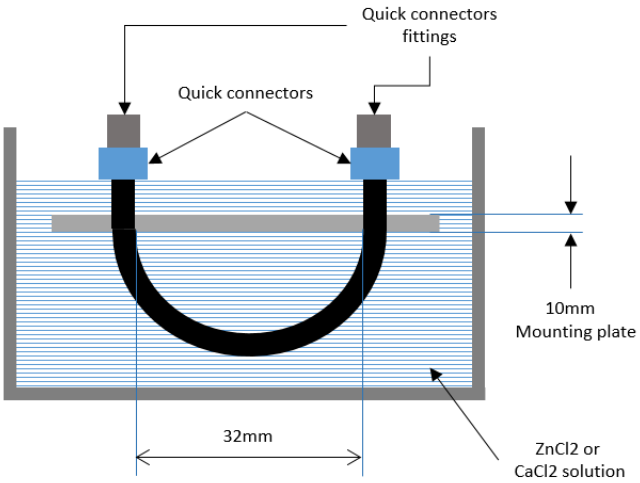
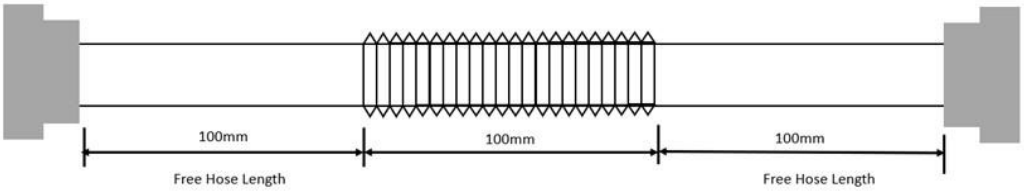


Figure A3: Setup for Zinc/Calcium Chloride Joint Exposure Example

A4 Testing Coupon Definition

A4.1 Coupon for Performance Testing.

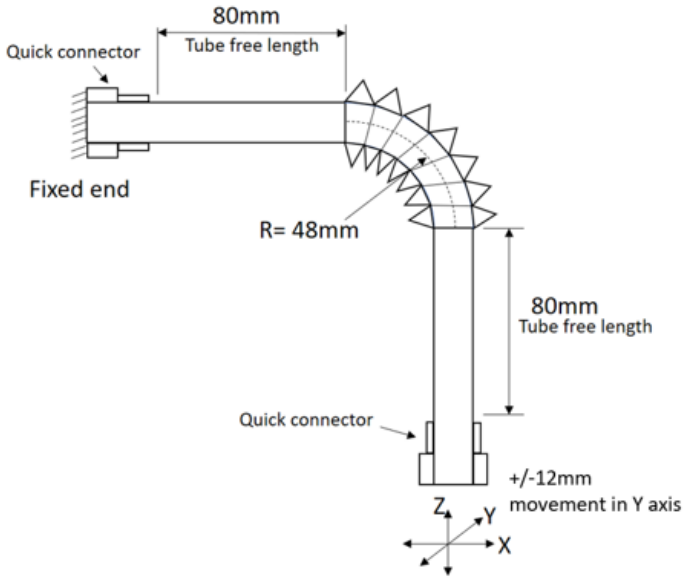


Hose ID: 16 mm Hose thickness: 1.25 mm

ID Inner Diameter

Figure A4: Straight Coupon for Performance Testing

A4.2 Coupon for Endurance Testing.



R Radius

Hose ID: 16 mm Hose thickness: 1.25 mm

Figure A5: Coupon Definition for Endurance Testing

A4.3 Bench to Evaluate Coolant Permeation.

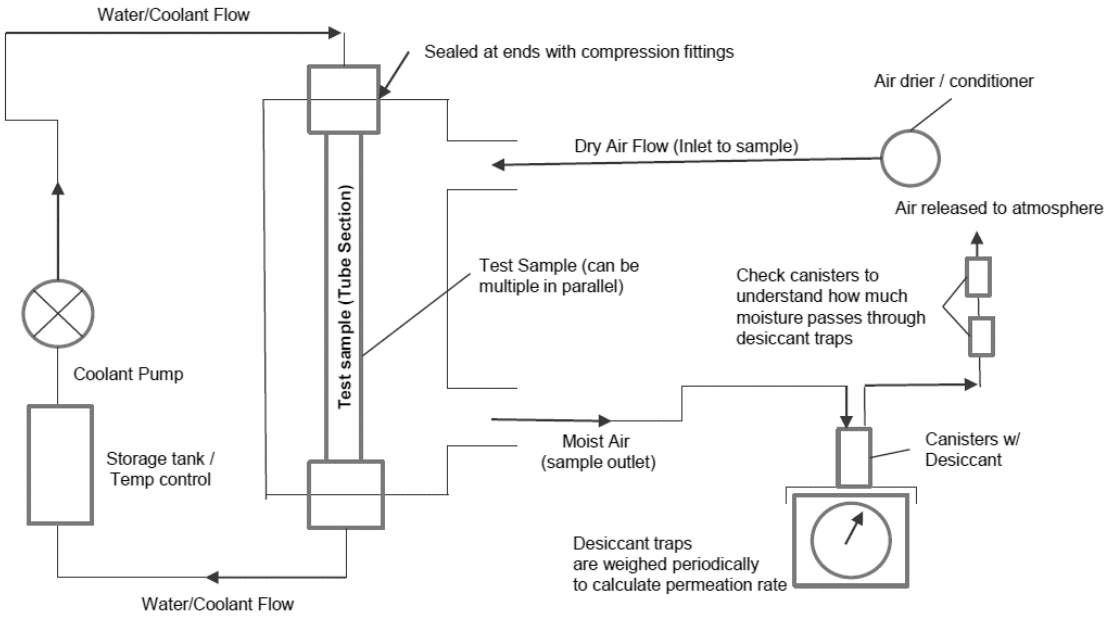
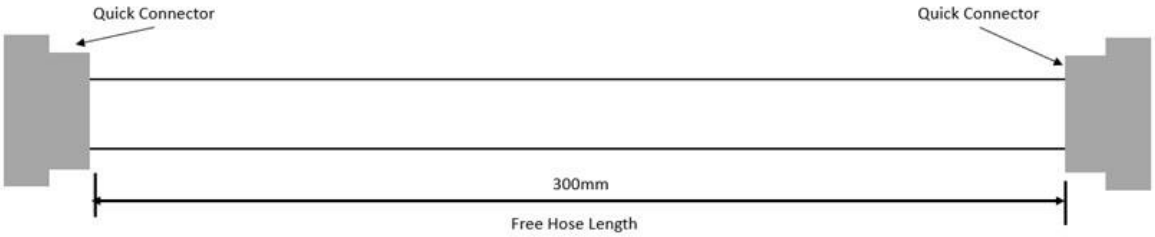


Figure A6: Bench Test for Tube Permeability

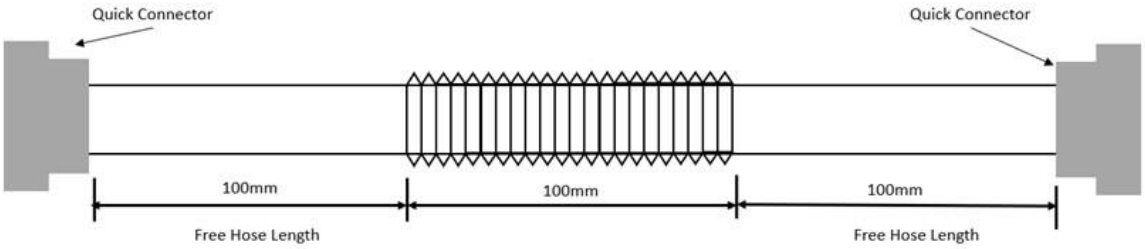
A4.4 Coupons for Hose Pressure Drop.

ID = Inner Diameter
R = Radius



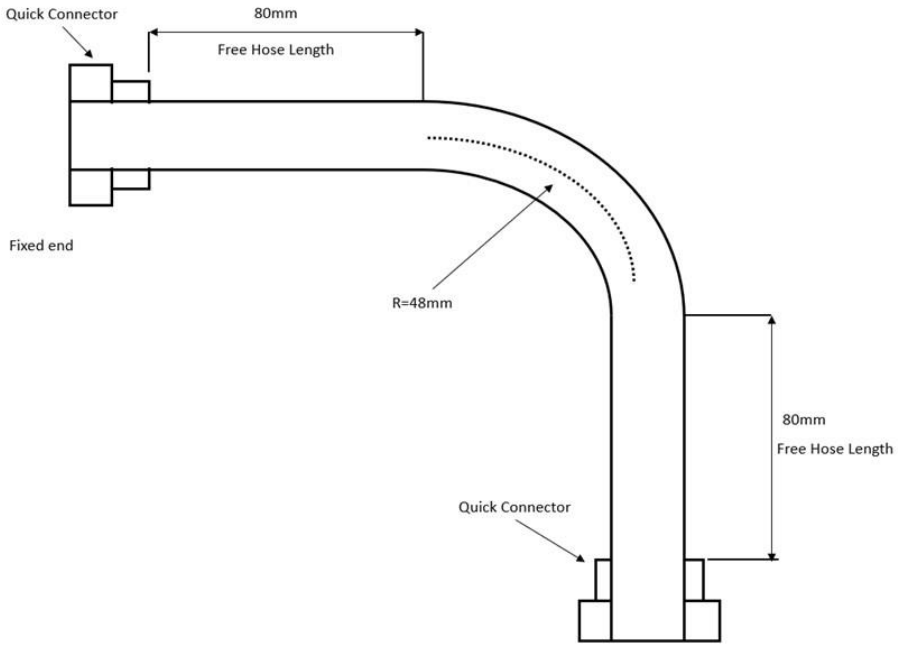
Hose ID: 16 mm Hose thickness: 1.25 mm

Figure A7: Straight Coupon with Smooth Section



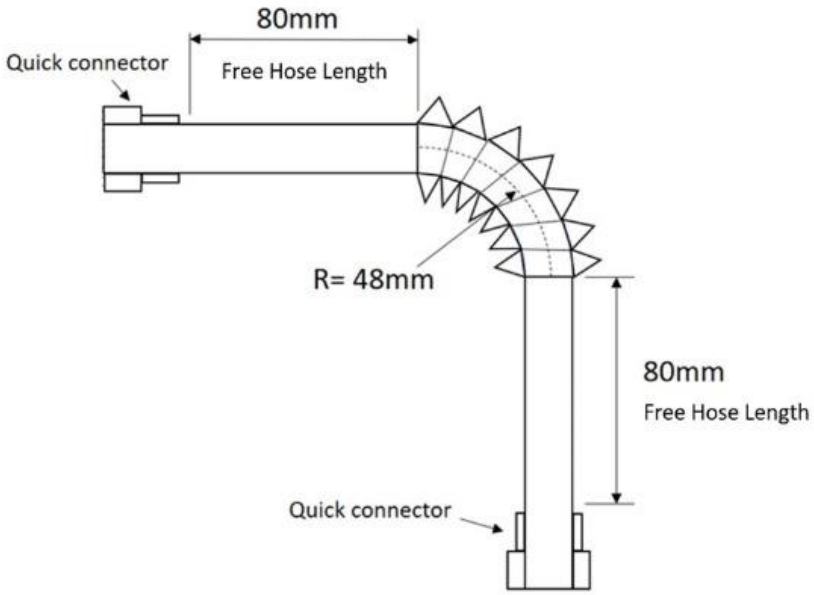
Hose ID: 16 mm Hose thickness: 1.25 mm

Figure A8: Straight Coupon with Corrugated Section



Hose ID: 16 mm Hose thickness: 1.25 mm

Figure A9: Bent Coupon with Smooth Section

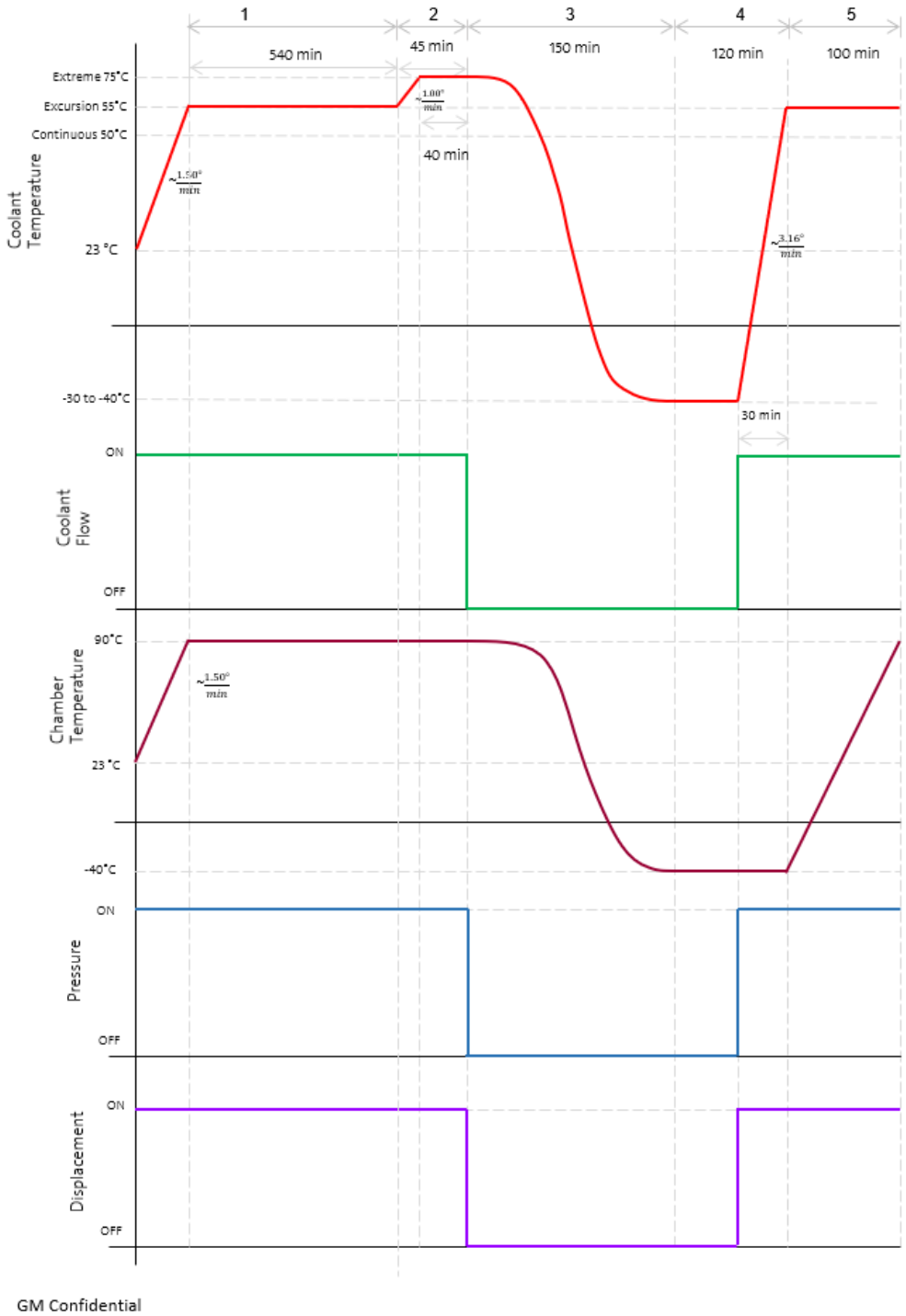


Hose ID: 16 mm Hose thickness: 1.25 mm

Figure A10: Bent Coupon with Corrugated Section

Appendix B

B1 Endurance Testing Profiles

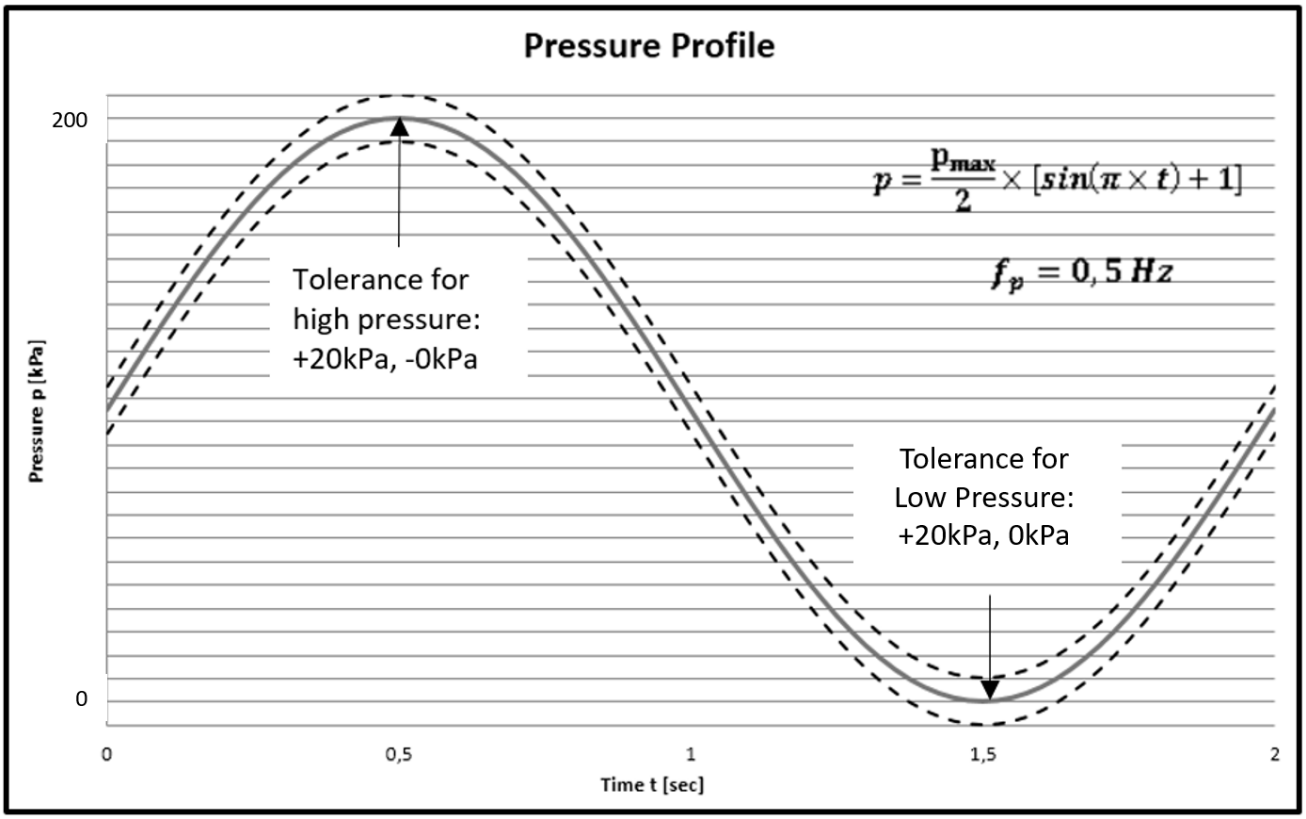


GM Confidential

Min Minute

Figure B1: Endurance Testing Profile Example

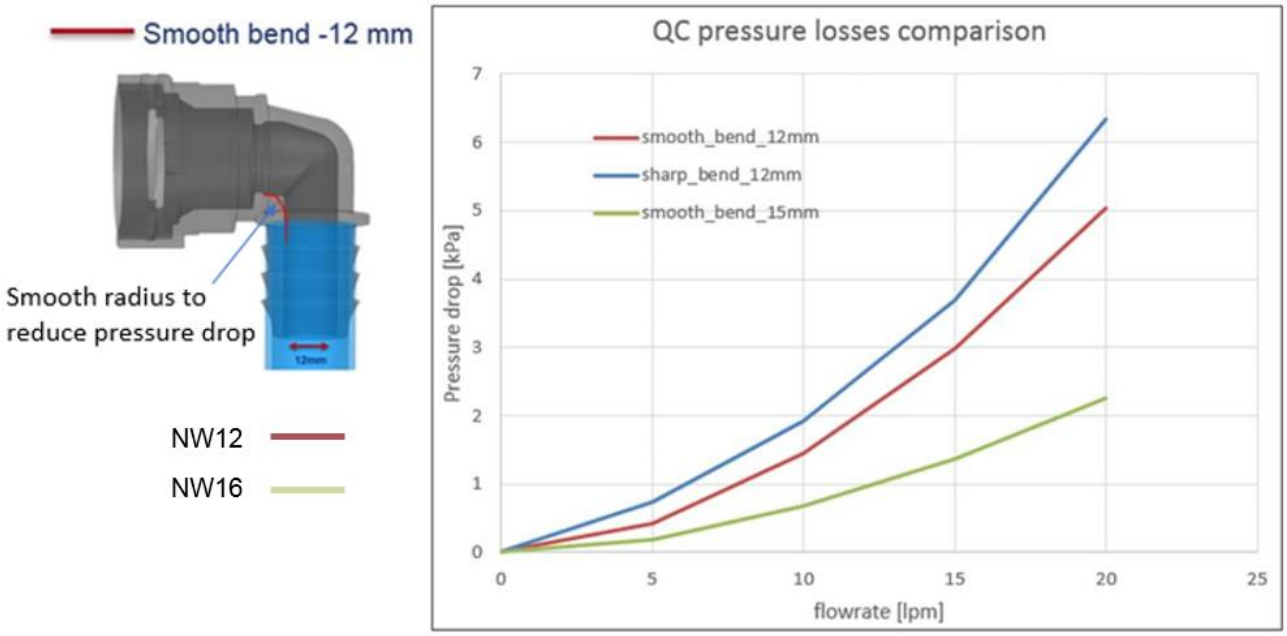
B2 Pressure Profile for Endurance Testing



Sec second

Figure B2: Pressure Profile for Endurance Testing

B3 Pressure Drop profiles for Angled Quick Connectors



lpm Liters per minute

Figure B3: Pressure Drops Profiles for NW12 and NW16 Quick Connectors.