GM	WORLDWIDE ENGINEERING STANDARDS	General Specification	GMW15803

Performance Test for Connections Used in Charge Air Systems

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. This standard defines the requirements for connections, e.g., quick connectors, clamps etc., used on both the cold and hot side of pressurized charge air cooler (CAC) duct systems.

1.2 Applicability. Bill of Material (BOM) row 313.27 Charge Air Cooler Plumbing.

1.3 Remarks. This standard shall be used for the development and validation of connections used on both the cold and hot side of pressurized charge air cooler duct systems. These systems are typically used with either turbo or supercharged engines, gasoline or diesel.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW3059	GMW14872	GMW15408	GMW15760
GMW3600	GMW15272	GMW15758	

2.3 Additional References.

- Component Technical Specification (CTS)
- Subsystem Technical Specification (SSTS)

3 Test Preparation and Evaluation

3.1 Resources.

3.1.1 Facilities. As required to perform the test as described on this document.

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

3.1.1.2 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.

3.1.2 Equipment. As required to perform the test as described on this document.

3.1.3 Test Vehicle/Test Piece. Not applicable.

3.1.4 Test Time. Not applicable.

3.1.5 Test Required Information. As specified for each individual test in detail (see Section 4).

3.1.6 Personnel/Skills. Technician shall be capable of operating the test equipment and record data.

3.2 Preparation. Not applicable.

3.3 Conditions.

3.3.1 Environmental Conditions. As specified for each individual test in detail (see Section 4).

3.3.2 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.

As specified for each individual test in detail (see Section 4).

3.4 Instructions. Not applicable.

3.5 Data. Not applicable.

3.6 Safety. This standard may involve hazardous materials, operations, and equipment. This standard does not propose to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

3.7 Documentation. Samples of components or material released to this standard shall be tested for conformity with the requirements of this standard and approved by the responsible GM Department prior to the start of delivery of production level components or materials.

Any change to the component or material, e.g., design, function, properties, manufacturing process and/or location of manufacture requires a new release of the product. It is the sole responsibility of the supplier to provide the customer, unsolicited, with documentation of any change or modification to the product/process, and to apply for a new release.

If not otherwise agreed to, the entire verification test shall be repeated and documented by the supplier prior to start of delivery of the modified or changed product. In some cases, a shorter test can be agreed to between the responsible GM department and the supplier.

Every 5 years after Start Of Regular Production (SORP) supplier shall requalify/re-Production Part Approval Process (PPAP) the connection. This shall be demonstrated, unsolicited by the supplier to the GM BOM Family Owner.

3.7.1 Test Results. All test results from Design Validation (DV) and Process Validation (PV) shall be documented in a test report, including digital photos of the test samples. The supplier shall provide the test report unsolicited to the GM BOM Family Owner and GM Validation Engineer.

3.8 Deviations from this Standard. Deviations from the requirements of this standard shall have been agreed upon between the supplier and GM BOM Family Owner. Such requirements shall be specified on component drawings, test certificates, reports, etc.

4 Requirements and Procedure

4.1 Test Requirements.

4.1.1 Product Characteristics.

4.1.1.1 Reliability.

4.1.1.1.1 Reliability Evaluation Point (REP). The REP of the component/subsystem is 15 years of exposure and/or 240 000 km (150 000 mi) of customer usage.

4.1.1.1.1.1 Reliability Requirements. This standard has been designed to provide a default reliability performance of 99% at 50% confidence level (R99C50) for the reliability Evaluation Point referenced in 4.1.1.1.1. Reliability demonstration is provided by the DV endurance tests according to Section 4.2. Endurance tests specified for PV, are intended to verify conformance to the reliability demonstrated during DV.

4.1.1.1.2 Serviceability. Special scheduled maintenance or repair procedures are not permitted. All connections shall be reusable and withstand a minimum of five (5) remove and install procedures and pass Air Leak Test requirements per Section 4.2.4 at +100 °C afterwards.

4.1.2 Validation.

4.1.2.1 General. The tests in this GM Engineering Standard are development tests, production tests and in-process tests. Development tests shall be performed and passed in order to obtain the approval from GM BOM Family Owner prior to start of production.

4.1.2.2 Design Validation (DV). CAC connections shall be tested according to Table 1.

Table 1: Test Table

Paragraph	Test	No. of Samples -3 Sigma	No. of Samples +3 Sigma	Mating Interface Tolerance
4.2.1.1	Installation Effort	6 at the worst condition for installation effort		maximum tolerance
4.2.1.2	Disassembly Effort	6 at the worst condition for disassembly effort		maximum tolerance
4.2.1.3	Destructive Disassembly Effort	3	3	nominal tolerance
4.2.1.4	Partial Assembly	3	3	minimum tolerance
4.2.2	Pressure Vibration	As required to fulfill R99C50 but minimum 4	As required to fulfill R99C50 but minimum 4	50% minimum and 50% maximum tolerance
4.2.3	Burst Pressure Test	6 at nominal tolerance		nominal tolerance
4.2.4	Air Leakage	6 at the worst condition for Air Leakage Test		minimum tolerance
4.2.5	Oil Leakage	6 at the worst condition for Oil Leakage Test		minimum tolerance
4.2.6	Cyclic Corrosion Test	6		Not applicable

4.1.2.2.1 Test Samples. CAC connection 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 BOM Family Owner. Description of test sample assembly is defined in Figures A1 and A2 in Appendix A. The mating interface for each test as described by Section 4.2, shall be dimensioned as shown in Table 1.

4.1.2.2.2 Test Method.

4.1.2.2.2.1 Test to Failure. For DV testing the Test to Failure test method shall be used. 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 BOM Family Owner and GM Validation Engineer.

Note: If any failure occurs during the first life of customer usage, stop the entire test. Do a Design Review Base on Test Results (DRBTR). Perform root cause analysis. If and as determined, redesign the part/product and start testing all over again.

First life of customer usage shall be normal stress, second and third 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 half of the samples from test stand, evenly distributed with -3 Sigma and with +3 Sigma dimensions, 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.

4.1.2.2.2.2 Success Testing. Not accepted for DV testing. Any deviation requires GM BOM Family Owner approval.

4.1.2.2.3 Design Level Requirements. All connectors manufactured for Engineering Source Approval per this specification 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 tolerances to meet the test requirements of the specification. Any exceptions to this

requirement must be reviewed beforehand and approved by the GM BOM Family Owner and GM Validation Engineer.

4.1.2.2.4 Design Validation (DV) Approval Requirements. The following information shall be submitted in order to obtain DV approval:

- Engineering drawings showing the design, dimensions and tolerances for all components of the assembly, including allowable eccentricity in of the hose duct insert and coupling outside diameter (OD). In addition, the range of potential hose compression under the extremes of dimensional tolerance stack-up shall be provided.
- Sectioned coupling samples to demonstrate that all of the preceding construction requirements have been met.
- A description of the statistical process control procedures for the coupling diameter dimensions and the range of hose compression.

4.1.2.2.5 DV Engineering Approval Factors. Engineering source approval obtained via compliance testing to this standard is limited to a specific CAC duct design with the following combination of design characteristics:

- Size of hose and coupling components.
- Hose material and construction.
- Coupling design.
- Duct insert material, plating, finish and hardness.
- Coupling shell material, plating, finish and hardness.
- For both hose and CAC duct assembly supplier specifications and manufacturing procedures, supplier manufacturing sites.

4.1.2.2.6 Documentation All test samples must be qualified dimensionally. All data points shall be reported. For samples destructively tested, failure mode must be reported. All test specimens shall be retained by the supplier for one year, and be available for review by the GM BOM Family Owner, Design Responsible Engineer and GM Validation Engineer, if requested. Test Procedures referencing specific minimum test values, must be met by the ± 3 sigma limit of the sample population tested.

4.1.2.3. Product Validation (PV). CAC connections shall be tested according to Table 2.

Table 2: Test Table

Paragraph	Test	Number of Samples -3 Sigma	Number of Samples +3 Sigma
4.2.1.1	Installation Effort	6 at the worst condition for installation effort	
4.2.1.2	Disassembly Effort	6 at the worst condition for disassembly effort	
4.2.1.3	Destructive Disassembly Effort	3	3
4.2.1.4	Partial Assembly	3	3
4.2.2	Pressure Vibration	As required to fulfill R99C50 but minimum 4	As required to fulfill R99C50 but minimum 4
4.2.3	Burst Pressure Test	6 at nominal tolerance	
4.2.4	Air Leakage	6 at the worst condition for Air Leakage Test	
4.2.5	Oil Leakage	6 at the worst condition for Oil Leakage Test	
4.2.6	Cyclic Corrosion Test	Note 1	

Note 1: This testing is not required in PV as long as material is identical to material used for DV testing.

4.1.2.3.1. Test Samples. 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 PV Reliability requirements demonstration purposes shall be in concurrence with the guidelines set forth in GMW15760, referenced in GMW3600. Description of test sample assembly is defined in Appendix A.

4.1.2.3.2 Test Method.

4.1.2.3.2.1Test to Failure. See paragraph 4.1.2.2.

4.1.2.3.2.2 Success Testing. If the tester chooses to define tests that are run for a finite number of cycles, the number of samples shall be defined as required to achieve R99C50 with a minimum of 8 but a maximum of 16 samples. Duration shown in Table 3 reflects an example using a Weibull slope of 2.

Note: One (1) life of customer usage is defined as ten (10) cycles of durability testing according Figure G1 in Appendix G.

Table 3: Example for Number of Samples Required for Endurance Tests (Weibull Slope = 2)

Reliability Requirement	Success Test (Customer Usage Lives)	Sample Size (No Failures)
R99C50	2.1	16
	2.4	12
	2.9	8

4.1.2.3.3 Test Requirements. PV tests are intended to verify that production parts meet the same requirements as the previously tested DV samples. PV testing shall be performed with the same rigor as DV, especially with respect to Endurance Tests.

4.1.2.3.4 Product Validation Approval. PV approval shall be provided by either the appropriate GM Supplier Quality Engineer or GM Validation Engineer and GM BOM Family Owner.

4.1.3.3.5 Documentation. Documentation shall be per normal Production Part Approval Process (PPAP).

4.1.2.4 Post Validation Audit (Reference GMW15758). These tests must be successfully completed with parts from normal production runs.

Table 4: Test Table

Paragraph	Test	Sample Size
4.2.1.1	Installation Effort	3
4.2.1.2	Disassembly Effort	3
4.2.1.3	Destructive Disassembly Effort	3
4.2.5	Air Leakage	3

4.1.2.4.1 Test Samples. Three (3) test samples shall be selected from a normal production run, or 3000 pieces, whichever is smaller. Samples shall be selected at random per GMW15760 to represent the entire production population. The test in Table 4 shall be performed on these samples.

4.1.2.4.2 Approval. Post validation tests are self-approved by the supplier, and are subject to audit by GM Supplier Quality Engineering.

4.1.2.4.3 Lot Retention. In case of post validation test nonconformance, the affected production lot shall be retained by the supplier until root cause analysis is complete. The supplier shall then decide the disposition of the affected production lot. The supplier has 3 options for this retained lot; it shall be either:

a. Scrapped.

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

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

In any event, GM Supplier Quality Engineering and GM BOM Family Owner shall be notified whenever any of the preceding options are exercised.

4.1.2.4.4 Documentation. Records shall be maintained for one year from date of test.

4.1.2.4.5 Alternative Post Validation Compliance. The supplier may request an exemption from post validation testing provided it can demonstrate that sufficient process controls are in place so as to make post validation testing unnecessary. Approval shall be provided by either GM Supplier Quality Engineering or the GM BOM Family Owner.

4.1.3 Validation Cross Reference Index. Approval for final Validation Cross Reference Index (VCRI) or Analysis/Development/Validation Plan and Report (ADVP&R) shall be provided by GM BOM Family Owner and GM Validation Engineer.

4.1.4 Regulated Emission. If required by the specific vehicle program, the connection shall be capable of complying with Partial Zero Emissions Vehicle (PZEV) demands.

4.2 Test Procedure.

4.2.1 Handling Forces (Applicable for Quick Connectors).

4.2.1.1 Installation Effort.

4.2.1.1.1 Procedure.

a. Mount mating interface on a rigid stable platform.

b. Align the axis of the quick connector with the axis of the interfacing component.

c. Do not apply any assembly aid (e.g., lubricant) to any interfacing component.

d. Using a force measurement gauge, install the mating CAC duct at a constant rate of 100 mm/minute ± 5 mm/minute at +23 °C ± 5 °C along the central axis.

e. Record the installation force for every 1.0 mm traveled.

4.2.1.1.2 Requirement. Use mating interface and quick connector which represent worst case tolerance condition.

- Maximum installation effort: 90 N.
- Nominal diameter D: 35 mm < D < 80 mm.

4.2.1.2 Disassembly Effort (Applicable for Quick Connectors).

4.2.1.2.1 Procedure.

a. Mount mating interface on a rigid stable platform within an environmental test chamber.

b. Assemble the quick connector to the mating interface.

c. Do not apply any assembly aid (e.g., lubricant) to any interfacing component.

d. Precondition the sample per the soak procedure in Appendix B.

e. Remove the test platform from the environmental chamber and allow to cool at +23 °C ± 5 °C for 2 h.

f. Disengage the quick connector locking mechanism.

g. Using a force measurement gauge, disassemble the mating quick connector at a constant rate of 100 mm/minute ± 10 mm/minute along the central axis at +23 °C ± 5 °C.

h. Record the disassembly force for every 1.0 mm traveled.

4.2.1.2.2 Requirement. Use mating interface and quick connector which represent worst case tolerance condition.

- Maximum disassembly effort: 120 N.
- Nominal diameter D: 35 mm < D < 80 mm.

4.2.1.3 Destructive Disassembly Effort (Applicable for Quick Connectors). Test purpose is to investigate the minimum force that is needed to pull off a correct assembled connection.

4.2.1.3.1 Procedure.

a. Mount mating interface on a rigid stable platform within an environmental chamber.

b. Assemble the mating quick connector.

c. Precondition the sample per the soak procedure in Appendix B.
d. Remove the test platform from the environmental chamber and allow to cool at +23 °C ± 5 °C for 2 h for testing.
e. Instrument the spigot and record reaction forces on X, Y and Z direction, indicate where the forces are measured.
f. Using a force measurement gauge, pull connector off the mating component at 100 mm/minute ± 10 mm/minute along the central axis.
g. Record the maximum disassembly force.
h. Repeat steps (a) thru (g) by pulling in a direction, 45° and 90° against the central axis.

Note: For safety reasons, it is best to perform this procedure within a protective area using a machine to do the pull force.

4.2.1.3.2 Requirement. The destructive disassembly effort at room temperature +23 °C ± 5 °C shall be greater than/equal to the force equivalent to 1000 kPa pressure minimum at +23 °C ± 5 °C (calculated at the minimum flow area in the connection). Provide record of reaction forces at the spigot indicating where those forces were measured. For 45° and 90° the measured forces shall be provided.

4.2.1.4 Partial Assembly (Applicable for Quick Connectors).

4.2.1.4.1 Procedure.

a. Mount mating interface on a rigid, stable platform.
b. Do not apply any assembly aid (e.g., lubricant) to any interfacing components.
c. Align the axis of the Quick connector and axis of the mating interface as described in Figure F1 in Appendix F.
d. Manually install the mating connector at a rate of 75 mm/minute ± 25 mm/minute at +23 °C ± 5 °C.
e. Stop when an audible “click” is heard.
f. Carefully inspect if all sections of the retainer clip are fully engaged or not.
g. Repeat test for all directions described in Appendix F.

4.2.1.4.2 Requirement. The quick connector assembly shall fully engage independent from assembly direction or angle, as described in Figure F1 in Appendix F.

4.2.2 Pressure Vibration Temperature (PVT) Test.

4.2.2.1 Procedure.

a. Mount appropriate interface on a rigid, stable platform within an environmental chamber. Mount the mating interface on an articulating test fixture. Completely seal all components except for the interface being used for this test. Axial alignment between the two interfaces shall be measured and documented.
b. Install the sample per Appendix A to the mating interfaces.
c. The articulating test fixture shall move in a motion per Appendix C.
d. Connect a regulated air supply to the sample in the fixed end. The regulated air supply shall be electronically controlled and capable of generating the pressure profiles shown in Appendix D.
e. Apply maximum deflection per Appendix C and measure reaction forces in X, Y and Z direction.
f. Precondition the sample per the Soak Procedure in Appendix B.
g. Maintain chamber (ambient) and regulated charge air temperature per profiles shown in Appendix E.
h. Apply the pressure profile per Appendix D. Note the differences in pressure profile for hose-spigot clamp connection and quick connect joint.
i. Subject the test sample to the pressure, temperature and vibration inputs per Figure G1 for the duration of 1 Life (10 cycles/150 h).
j. Inspect the test sample for any damage or degradation. Document in the test report all observations/findings from the inspection.
k. Perform leak test per Section 4.2.4

For DV continue testing until failure to establish Weibull slope. Inspect all test samples, document the failure mode. The test report must include digital photographs of the failure mode(s), duration at failure and all technical requirements given in this GM specification.

For PV continue testing until success, based on Weibull slope established during DV or considering a slope of 2 (see Table 3).

4.2.2.2 Requirements. After the test sample has been subjected to the testing per 4.2.2.1 a reliability/confidence level of R99C50 shall be demonstrated.

Prior to testing, the reaction forces in X, Y and Z direction shall be measured and documented at -30 °C (preconditioned for 4 h) and at room temperature (+25 °C ± 2 °C).

4.2.3 Burst Test.

4.2.3.1 Procedure.

a. Mount the mating interfaces (e.g., spigot, hose barb, etc.) in a test chamber.
b. Assemble the mating test sample. Both ends of the duct shall be attached to the test chamber and sealed.
c. As testing fluid either oil, coolant or air can be used. The test equipment shall be capable of supplying sufficient pressure until burst.
d. Completely fill the CAC duct test sample with testing fluid.
e. Maintain test chamber ambient temperature at +100 °C ± 2 °C for 4 h.
f. Increase pressure at a rate of 20 kPa/s ± 5 kPa/s until either burst or leakage occurs. A diagram of pressure vs. time must be recorded.

4.2.3.2 Requirements. The minimum burst pressure shall be 1000 kPa. Burst pressure and failure mode shall be documented in final test report.

4.2.4 Air Leak Test.

4.2.4.1 Procedure.

a. Mount the mating interfaces in an environmental test chamber.
b. Assemble the quick connector to the mating interface.
c. Do not apply any assembly aid (e.g., lubricant) to any interfacing component.
d. Completely seal the free end of the quick connector.
e. Lower the environmental chamber temperature to -40 °C, stabilize for 30 minutes.
f. Set the CAC duct test pressure to 200 kPa. Measure the leakage.
g. Stabilize the chamber temperature at -30 °C, for 30 minutes.
h. Set the CAC duct test pressure to 200 kPa. Measure the leakage.
i. Stabilize the chamber temperature at -20 °C for 10 minutes, set the CAC duct test pressure to 300 kPa and measure the leakage. Repeat procedure at 0 °C, +50 °C, +100 °C (include +150 °C, +200 °C and maximum temperature per SSTS/CTS, if applicable).

4.2.4.2 Requirements. The CAC duct leak rate shall not exceed 10 000 mm^3/s, corrected to standard conditions, when the CAC duct is subjected to the following test conditions:

- -40 °C ≤ T ≤ -30 °C.
- Test pressure: 200 kPa ± 10 kPa.

The CAC joint leak rate shall not exceed 50 mm^3/s, corrected to standard conditions, when the CAC duct is subjected to the following test conditions:

- -20 °C ≤ T ≤ +100 °C.
- (+150 °C, +200 °C and maximum temperature, if applicable).
- Test pressure: 300 kPa ± 15 kPa.

4.2.5 Oil Leak Test.

4.2.5.1 Procedure.

a. Mount the mating interfaces in an environmental test chamber.
b. Assemble the quick connector to the mating interface.
c. Do not apply any assembly aid (e.g., lubricant) to any interfacing component.
d. Completely seal the free end of the quick connector. Alternatively, the test sample per Appendix A can be used which allows to test two (2) parts at the same time.

e. Fill the entire test assembly with oil and pressurize with air to 300 kPa.

f. Place a clean white sheet of paper below the sample.

g. Maintain chamber temperature at +100 °C ± 2 °C for 168 h while maintaining the CAC duct pressure at 300 kPa ± 5 kPa.

h. Inspect quick connector and white sheet of paper for leakage.

4.2.5.2 Requirement. There shall be no evidence of oil leakage at either test sample (quick connector) or the white sheet of paper at the end of the test.

4.2.6 Cyclical Corrosion Test.

4.2.6.1 Test Procedure. Subject the test assembly (e.g., quick connector, clamp, etc.) to cyclical corrosion test procedure per GMW14872, UH; All; 4 per cycle; method SH/SM, Exposures B and E with the full assembly.

4.2.6.2 Requirements. Cosmetic corrosion requirements per GMW15272 after Exposure B, shall be met. Assembly must meet all of the requirements of the Leak Test (Section 4.2.4) and the Burst Test (Section 4.2.3) after Exposure E. Assembly must meet the functional corrosion requirement per GMW15272 after exposure E. All test samples from this test shall be forwarded to the GM BOM Family Owner/GM Validation Engineer for evaluation at end of test (EOT).

5 Provisions for Shipping

Part and container shall be designed to avoid that any component (e.g., seal, retainer) come out of place during shipping. Part shall be designed in a way that no other part in the container gets damaged during shipping. Any part contamination during shipping shall be avoided.

6 Notes

6.1 Glossary. Not applicable.

6.2 Acronyms, Abbreviations, and Symbols.

ADVP&R	Analysis/Development/Validation Plan and Report
BOM	Bill of Material
CAC	Charge Air Cooler
DRBTR	Design Review Based on Test Result
DV	Design Validation
EOT	End of Test
GSSLT	Global Subsystem Leadership Team
OD	Outside Diameter
PPAP	Production Part Approval Process
PV	Process Validation
PVT	Pressure Vibration Temperature
PZEV	Partial Zero Emissions Vehicle
QC	Quick Connector
REP	Reliability Evaluation Point
SORP	Start of Regular Production
Temp	Temperature
VCRI	Validation Cross Reference Index

7 Additional Paragraphs

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

7.2 All pressure values stated in this GMW shall be considered as relative to normal atmosphere (gauge).

8 Coding System

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

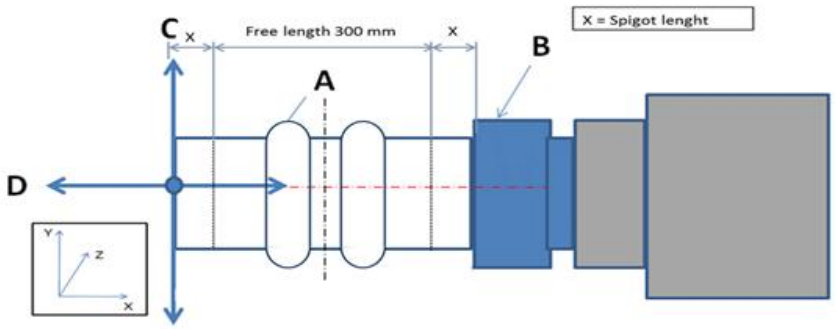
GMW15803

9 Release and Revisions

This standard was originated in February 2008. It was first approved by the HVAC Plumbing GSSLT in August 2009. It was first published in August 2009.

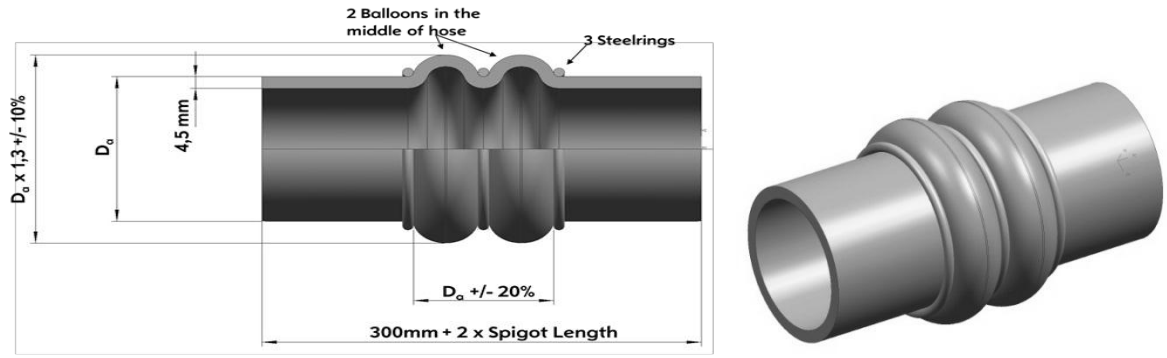
Issue	Publication Date	Description (Organization)
1	AUG 2009	Initial publication.
2	APR 2015	Shortened test duration for each duct based on PUMA data; changed from same movement frequency on each axis to different frequency; updated requirements around disassembly and associated forces in different directions; updated samples necessary to meet reliability requirement; added a test for partial connections. (HVAC - Underhood/Underbody Functional Black Plastics and Charge Air Cooler Ducts GSSLT)

Appendix A: PVT Test Setup and Test Sample



A: Hose
B: Quick connector/clamp, etc.
C: Y and Z axis
D: X axis

Figure A1: PVT Test Setup



- Hose Material: GMW15408 Type G.
- Wall thickness: 4.5 mm ± 0.5 mm.
- D_a is determined by the individual mating interface.

Note: Test sample and setup shall be reviewed and approved by GM BOM Family Owner prior to testing.

Figure A2: Test Sample

Appendix B

B1 Soak Procedure

B1.1 Lower chamber ambient temperature to -40 °C ± 1 °C.

B1.2 Maintain temperature at -40 °C for 2 h.

B1.3 Raise chamber ambient temperature to:

- +100 °C ± 1 °C for “Cold side” = downstream of the CAC heat exchanger.
- +150 °C ± 1 °C for “Hot side” = upstream of the CAC heat exchanger.

B1.4 Maintain the chamber ambient temperature at the specified level (either +100 °C or +150 °C) for 4 h.

Appendix C: Movement in Pressure Pulsation Test

Movement in Pressure pulsation test (4.2.2) shall be performed as follows.

The CAC duct SSTS, CAC duct CTS or GM approved drawing shall document the maximum deflection in the normal coordinate system. See Table C1.

Table C1: Movement Parameters

Axis	Maximum Deflection	Frequency
X	± 12 mm	0.9 Hz
Y	± 12 mm	1.0 Hz
Z	± 3 mm	1.1 Hz

The movement shall be applied to the turbo compressor or the throttle housing side of the duct. The fixed end shall be the connection to the Charge air cooler side. Figure C1 shows an example of the resultant 3D motion in standard coordinate system. A linear (1D) motion is not accepted.

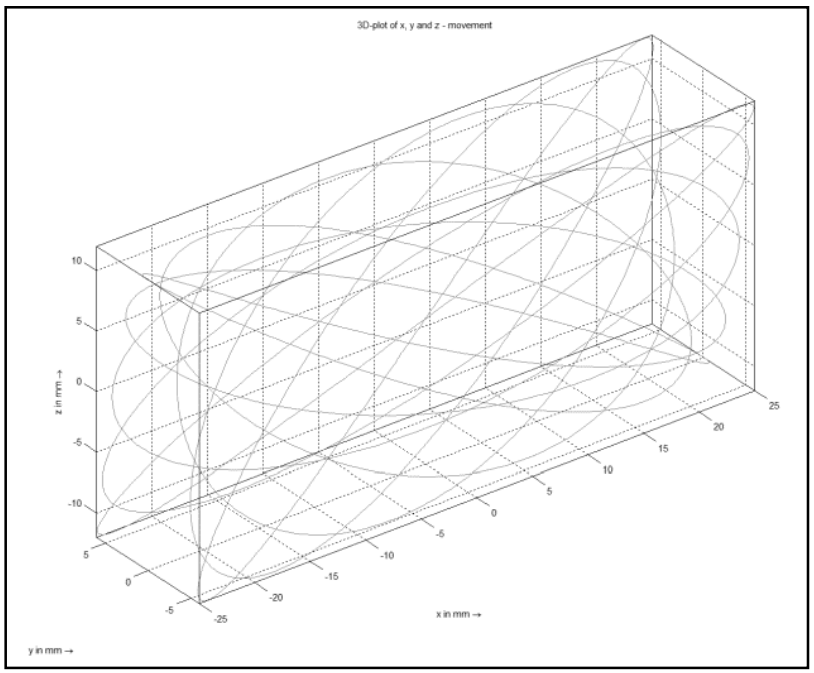


Figure C1: 3D Motion

Appendix D

D1 Pressure Impulse Profile

D1.1 Clamp Joint. See Figure D1.

Maintain pressure at 50 kPa ± 10 kPa for 10 minutes.

Rapidly increase pressure to 250 kPa ±10 kPa within 3 s.

Hold pressure constant for 3 minutes.

Rapidly release pressure to 50 kPa within 3 s.

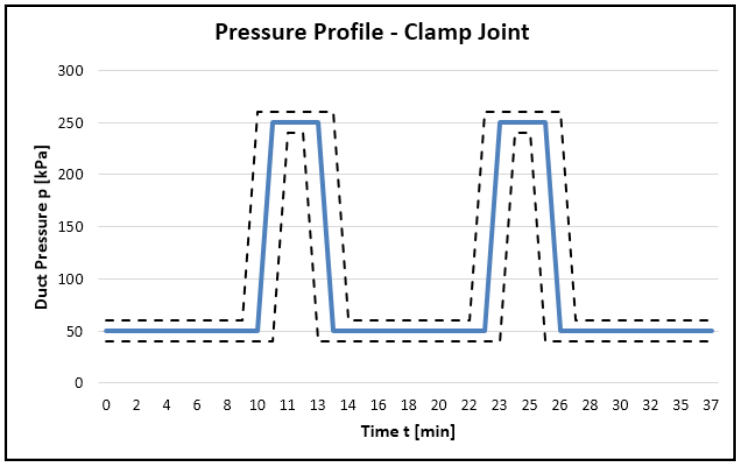


Figure D1: Pressure Profile for Hose-Spigot-Screw Clamp Connection

D1.2 Quick Connector Joint. See Figure D2.

Maintain

$$p = \frac{p_{max}}{2} \times [sin(\pi \times t) + 1]$$

for pressure profile with a maximum pressure of 250 kPa ± 10 kPa at 0.5 Hz. Lowest pressure shall be 0 kPa with the tolerance of +50 kPa/-0 kPa.

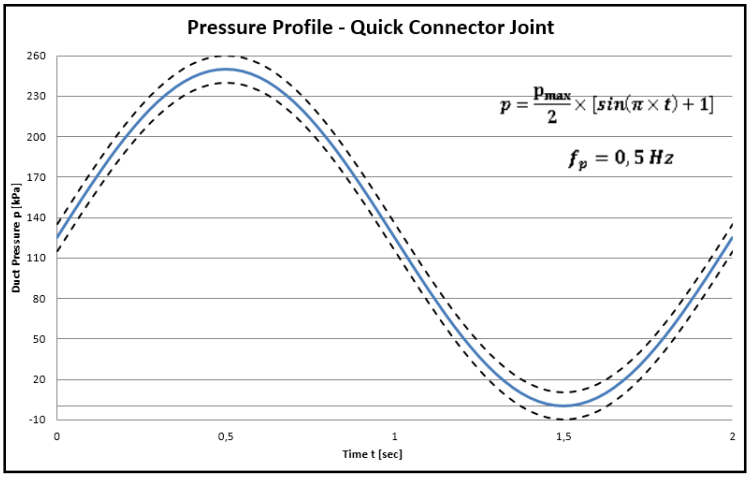


Figure D2: Pressure Profile for Quick Connectors

Appendix E

E1 Temperature Setting

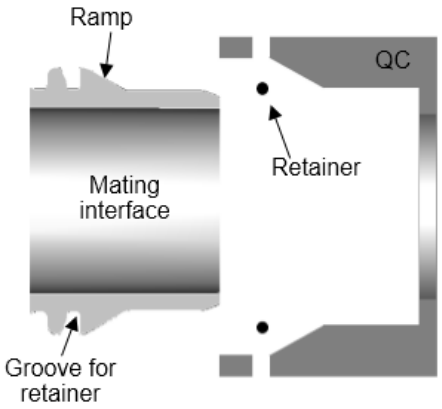
E1.1 Test Chamber (Ambient Environment). From -30 °C to +135 °C (see Appendix G).

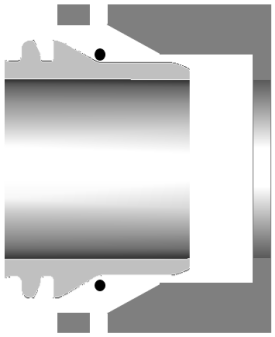
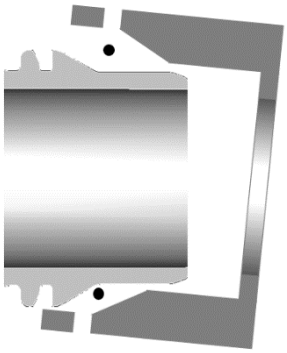
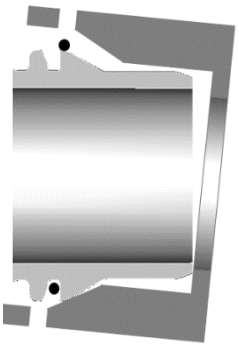
E1.2 Charge Air Side (Charge Air Temperature).

E1.2.1 Cold Side (Downstream the CAC). From -30 °C to maximum (excursion) temperature per SSTS; CTS or GM approved drawing (see Appendix G), but minimum +100 °C.

E1.2.2 Hot Side (Upstream the CAC). From -30 °C to maximum (excursion) temperature per SSTS; CTS or GM approved drawing (see Appendix G), but minimum +170 °C for gasoline engines and +200 °C for diesel engines.

Appendix F



Step 1		Place quick connector onto mating interface. Stop at the position where the retainer rests right in front of the ramp.
Step 2		Tilt quick connector on mating interface until touch condition. Keep position.
Step 3		Slowly install quick connector, keep tilted position until retainer snaps into groove. **Note:** The retainer shall be fully engaged. A situation as shown on the image on the left is not acceptable.

Note: QC = Quick Connector

Figure F1: Principal Sketch for Partial Assembly

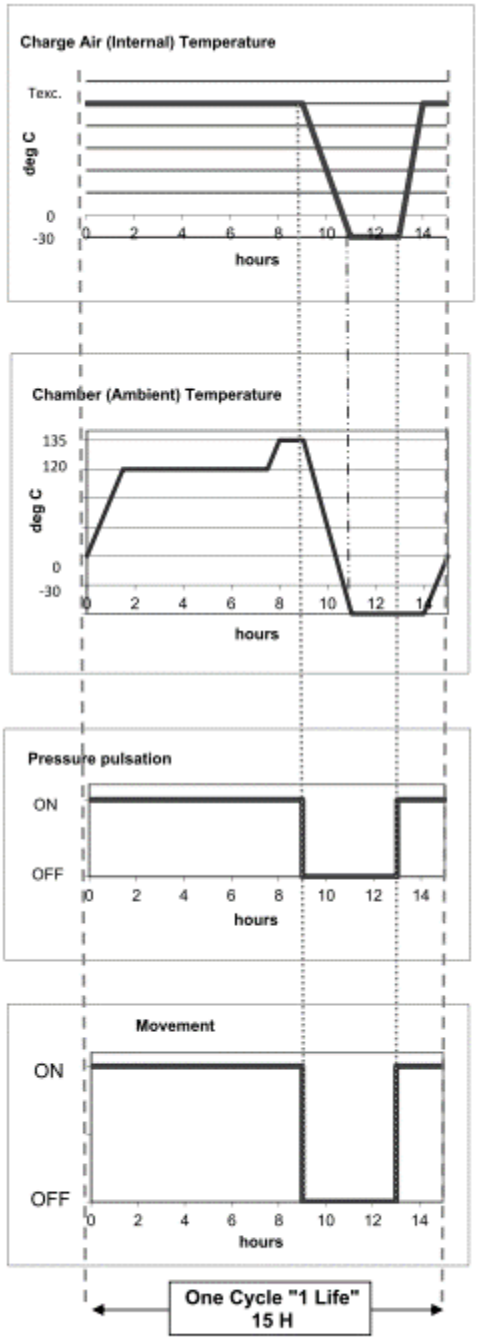
Appendix G

Time (h)	Charge Air Temp (C)
0	Texc.
9	Texc.
11	-30
13	-30
14	Texc.
15	Texc.

Time (h)	Chamber (Ambient) Temp (C)
0	30
1,5	120
7,5	120
8	135
9	135
11	-30
14	-30
15	30

Time (h)	Pressure Pulsation 1=ON ; 0=OFF
0	1
9	1
9	0
13	0
13	1
15	1

Time (h)	Movement circular
0	ON
9	OFF
13	ON
15	ON



Temperature Cycling according to appendix E
Pressure Cycling according to appendix D

One Cycle 15 h
Total Test Time ("1 Life"): 10 Cycles = 150h

Note: Temp = Temperature

Figure G1: PVT Test