



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.

4.1.2.3.2.1 Test 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 $\pm$ 5 mm/minute at $+23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ 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: $35\text{ mm} < D < 80\text{ mm}$.

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 $+23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ 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 $\pm$ 10 mm/minute along the central axis at $+23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$.
- 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: $35\text{ mm} < D < 80\text{ mm}$.

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.

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