High Voltage Connector Performance Supplement to SAE/USCAR-2

SAE/USCAR-37
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HIGH VOLTAGE CONNECTOR PERFORMANCE SUPPLEMENT TO SAE/USCAR-2

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TO PLACE A DOCUMENT ORDER: (724) 776-4970 FAX (724) 776-0790

WARNING
No electrical connector, terminal, or related component may be represented as having met USCAR/EWCAP specifications unless conformance to all applicable requirements of this specification have been verified and documented. All required verification and documentation must be done by the supplier of the part or parts. If testing is performed by another source, it does not relieve the primary supplier of responsibility for documentation of all test results and for verification that all samples tested met all applicable Acceptance Criteria.

1. SCOPE

Procedures included within this specification supplement are, when used in conjunction with SAE/USCAR 2, intended to cover performance testing at all phases of development, production, and field analysis of electrical terminals, connectors, and components that constitute the electrical connection systems in high voltage (60~600V) road vehicle applications. These procedures are applicable to terminals used for In-Line, Header, and Device Connector systems with and without Shorting Bars.

This supplement applies to both sealed and unsealed connection systems.

IMPORTANT NOTICE: In any intended vehicle application, if the products covered by this specification are, or may be, subjected to conditions beyond those described in this document, they must pass special tests simulating the actual conditions to be encountered before they can be considered acceptable for actual vehicle application. By way of example only, this includes products that may be subjected to conditions beyond the extremes of Classes as defined in Tables 5.1.4.1, ~ 5.1.4.5 or those that may be subjected to shock or vibration in the un-sprung portions of a vehicle, such as the wheel hub. Products certified by their supplier as having passed specific applicable portions of this specification are not to be used in applications where conditions may exceed those for which the product has been satisfactorily tested.

The Authorized Person is the final authority as to what tests are to be performed on his or her parts and for what purpose these tests are required. He or she is also the final authority for resolving any questions related to testing to this specification and to authorizing any deviations to the equipment or procedures contained in this specification. Any such deviation must be documented and included in the final test report.

Guidance as to the recommended tests for selected purposes is given in the charts in SAE/USCAR 2 Appendix C and D. In the absence of contrary direction from the Authorized Person in the test request/order, all electrical connectors and their associated terminals and other components are required to meet all applicable portions of SAE/USCAR 2 and this supplement document with the following exception:

Specific tests that are not required or additional test requirements as specified in any document in the hierarchy of Section 3.0.

2. OUTLINE & GLOSSARY OF TERMS

2.1 General

Diagrams are provided where necessary to clarify the details of the various test procedures. The tests in each section must be performed in the order given unless otherwise specified in the test request/order. Construction details for selected test fixtures and equipment are provided in this specification.

A glossary of terms is provided in USCAR 2, Appendix B. Terms defined in the definitions or glossary are capitalized (i.e. Room Temperature, Steady State, PLR, etc.). A list of definitions is provided in USCAR 2, Appendix A.

3. REFERENCED DOCUMENTS

3.1 Document Hierarchy

In the event there is a conflict between performance specifications, part drawings, and other related standards or specifications, the requirements shall be prioritized as follows:

1st - Applicable FMVSS requirements and other applicable state and Federal requirements.
2nd - Applicable part drawings
3rd - Applicable product design specification(s).
4th - Automotive Industry Action Group (AIAG) Production Part Approval Process (PPAP)
5th - Applicable USCAR/EWCAP performance specifications
6th - Other applicable standards and specifications

3.2 Part Drawing

The part drawing for each connection system component should contain or reference:

All dimensional requirements (which must be in GD&T format).
Performance requirements.
Component part number.
Reference to applicable portions of this specification.
The quantity and part number of terminals used.
The typical mating connector.
Classes per tables 5.1.4.1 ~ 5.1.4.5 for which the part is intended or has been successfully tested.

3.3 Product Design Specification

The product design specification may or may not be an integral part of the part drawing. Instructions must be included in the product design specification for any special tests required for the associated part and for any exceptions or modifications to the general specifications and requirements in this document.

3.4 Test Request/Order

3.4.1 Samples, Test Type and Special Tests

The laboratory test request/order shall provide location and documentation of test samples, identify the type of test to be performed (development, validation, special purpose, etc.) and describe any special tests that are not a part of this specification. Any required revisions to, or deviations from any tests in this specification must include detailed instructions for each change.

3.4.2 Test Request/Order Instructions

Instructions must be included in the test request/order concerning applicable tests and the order in which the tests are to be performed if different than outlined by this specification.

3.4.3 Performance and Durability Test Instructions

Instructions must be given in the test request/order concerning limits for performance and durability tests, including definition of the conditions under which those limits apply, if they are different than outlined in this specification.

3.4.4 Development Tests

Development tests are frequently used to evaluate specific areas of the design. They are tools for evaluating design alternatives, proposed improvements, cost reduction proposals, or determining root causes of field problems.

3.4.5 Validation Tests

Validation tests or sample approval tests are acceptance type tests. Consideration must be given to the inherent repeatability or subjectivity of certain tests outlined by this specification before designating it as a validation or compliance test.

3.4.6 Special Purpose Tests

Portions of this specification may be useful for special purpose testing. For example, verifying a process or material change may, in the judgment of the Authorized Person, require only one or two specific tests, or a portion of a test, to verify that no adverse consequence resulted from the change. Any portion of a test or any combination of tests contained in this specification may be used individually or may be combined with other testing, described outside this specification, in any phase of product development, production testing, or analysis of parts from the field.

3.5 Other Referenced Documents

SAE/USCAR 2: Performance specification for automotive electrical connector systems
SAE/USCAR-21: Performance Specification for Cable-to-Terminal Electrical Crimps.
SAE/USCAR – 25 Electrical Connector Assembly Ergonomic Design Criteria.
IEC 62153 part 4-7
ASTM B117

4. GENERAL REQUIREMENTS AND INFORMATION

See USCAR 2

5. TEST & ACCEPTANCE REQUIREMENTS

5.1 General

The tests detailed in this specification are qualitative in nature and are not expected to stress any part beyond its anticipated application limit, except where tests to failure are specified.

5.1.1 Performance requirements

Connection systems must meet all performance test requirements for the appropriate Class as listed in Tables 5.1.4.1~5.1.4.5

5.1.2 Dimensional characteristics

Part construction shall conform to the dimensions, shape, and detail attributes specified on the latest revision of the applicable part drawing(s).

5.1.3 Material Characteristics

Parts are intended to be in their "as furnished for vehicle assembly" condition when testing begins, unless specific instructions as to any pre-test "conditioning" are contained in the test request/order. For example, electrical terminals typically have residual die lubricant on them when finally assembled into a vehicle. This same condition must prevail for test samples unless part cleaning is specified in the Test Request/Order.

All material used in each test sample shall conform to the material specifications shown on the latest revision of the applicable part drawing(s).

The material hardness specified for electrical terminals refers to the blank strip material and not the finished product because the terminal manufacturing process can modify the hardness values.

5.1.4 Classifications

Connection systems shall be assigned a class designation from the following categories.

5.1.4.1 Temperature classifications

Components to be tested must be assigned a class from the table below according to the expected environment in their intended vehicle application. "Rise" is defined as the temperature rise due to electrical heating caused by the maximum Steady State current flow expected for the component under test. Care must be taken to ensure that the conductor and insulation selected for the application or any test will itself withstand the maximum temperature for the class selected without exceeding the conductor manufacturer's maximum temperature recommendations.

Note also that terminals packaged such that they are surrounded by other terminals will dissipate heat more slowly, and thus experience a higher temperature "rise" with the same current flow, than terminals located on the periphery of a connector. See USCAR 2 Appendix F (design notes)

When "Maximum Temperature" is mentioned with respect to Table 5.1.4.1, the highest ambient temperature in the right column, "Ambient Temperature Range" is to be used unless otherwise specified. If not specified in the Test Request/Order, the Authorized Person is expected to select the appropriate Temperature Classification. Considering the cost of testing and the time it takes, it generally will be best to qualify a given terminal and connector system to the highest possible Temperature Classification.

Class	Ambient Temperature Range
1	-40° C to + 85° C
2	-40° C to +100° C
3	-40° C to +125° C
4	-40° C to +150° C
5	-40° C to +175° C

Table 5.1.4.1: Component Temperature Classes

5.1.4.2 Sealing classifications

Components to be tested must be assigned a class from the table below according to the expected environment in their intended vehicle application.

S1: Unsealed connectors are suitable for use in passenger compartment or other dry areas on a vehicle such as the trunk.
S2: Sealed connectors must meet the all requirements of 5.9.7, the Sealed connector environmental test sequence.
S3: Sealed (plus pressure spray) connectors must meet all of the requirements of 5.9.7 plus the requirements of 5.8.1, High pressure spray.

Class	Application Type
S1	Unsealed
S2	Sealed
S3	Sealed plus pressure spray

Table 5.1.4.2: Component Sealing Classes

5.1.4.3 Vibration Classification

Components to be tested must be assigned a class from the table below according to the expected location in their intended vehicle application.

V1: Components intended for use on sprung portions of the vehicle and not coupled to the engine shall be tested to vibration profile figure 5.4.6.3 E. and meet the requirements of 5.4.6.4.
V2: Components intended for use coupled to the engine shall be tested to vibration profile figure 5.4.6.3.D and meet the requirements of 5.4.6.4.
V3: Components intended for use in extreme vibration levels shall be tested to vibration profile figures 5.8.2.3.B and 5.8.2.3.C. and meet the requirements of 5.4.6.4.

Class	Typical application
V1	Components on sprung portions of vehicle not coupled to Engine.
V2	Components coupled to Engine.
V3	Components subject to severe vibration.

Table 5.1.4.3 Component Vibration Classes

5.1.4.4 Ergonomic Classification

Refer to SAE/USCAR 25 for requirements necessary to assign an Ergonomic class to the component under test. This class designation shall be documented in the test plan and listed on the component drawing.

5.1.4.5 Connector mating cycle classification

Connection systems must be assigned a mating cycle classification based on the application descriptions in Table 5.1.4.5. This classification designation shall be documented in the test plan, test report, and identified on the component drawing.

Class	Typical application
M1	In-lines and headers not normally disconnected for service. These are permanent connection systems and are **not** expected to be disconnected after the vehicle is assembled. Example: Bulk head connectors, harness to harness connectors, etc. M1 connectors will be mated 10 cycles prior to testing. (same as USCAR 2)
M2	In-line or header connection systems that are normally disconnected and reconnected when a vehicle is serviced. Example: service disconnect or safety disconnect. M2 connectors will be mated 50 cycles prior to testing
M3	In-line or header connectors that are disconnected and reconnected as a normal function of the part. Example: Charge port, etc. It is the responsibility of the test requester or responsible person to establish the required number of mating cycles for M3 connection systems. The number of conditioning cycles shall be documented in the test report.

Table 5.1.4.5 Connection system mating cycle classification

5.1.5 Testing Headers & Direct Connect Components

See USCAR 2

5.1.6 Terminal Sample Preparation

Terminals used for testing shall be crimped to requirements as defined in SAE/USCAR 21, “Performance Specification for Cable to Terminal Electrical Crimps” Crimp dimension physical characteristics and mechanical pull strength shall be within tolerance as it applies to the respective terminal and wire gage. Crimp both the conductor and insulation grips unless otherwise specified in the individual test procedures. Use the appropriate cable seal as applicable. Assemble insulation displacement type terminals per their manufacturer’s recommended assembly criteria. When testing Header type connectors with mating connectors, prepare samples only for the mating Female Connector. (ref. Section 5.1.5) Record the crimp height and width of a representative group of samples of each terminal (except for insulation displacement type terminals) and number samples for tracking and later identification as appropriate. Crimp information (tooling used to prepare samples, crimp dimensions, and wire type) shall be documented in the test report.

The following note applies to wire harness fabricators: Production crimps shall be tested, validated, and approved separately per SAE/USCAR-21 Performance Specification for Cable-to-Terminal Electrical Crimps based on wire size, stranding, and insulation wall thickness.

5.1.7 Connector and/or Terminal, Mate Cycling

5.1.7.1 Purpose

This procedure preconditions a connection system pair or terminal system pair prior to a test sequence. Connectors may be subjected to repeated mate cycling due to in-plant and/or service repair prior to and during the life of the connector. Complete this procedure only once when conducted as part of a series of test as in section 5.9.

See Table 5.1.4.5 for mating class description and required number of mate cycles.

5.1.7.2 Equipment

None

5.1.7.3 Sample Preparation

No special preparation required.

5.1.7.4 Procedure

Completely cycle (mate and un-mate) each connector or terminal pair the number of times shown in table 5.1.4.5 based on the Mating class identified in the test plan or test request.

When working with terminals only, use caution to assure that mating and un-mating is done along terminal centerlines to prevent side pressure that may distort either terminal.

Re-mate connectors or terminals for one last time in preparation for future test sequences or follow directions in the respective procedure to follow.

5.1.7.5 Acceptance Criteria

None: This is a conditioning step and is intended to be performed as required by various tests in this document.

5.1.8 Visual Inspection

See SAE/USCAR 2

5.1.9 Circuit Continuity Monitoring.

See SAE/USCAR 2

5.2 Terminal Mechanical

5.2.1 Terminal to terminal engage/disengage force.

See SAE/USCAR 2

5.2.2 Terminal bend resistance.

See SAE/USCAR 2

5.2.3 CONDUCTOR/TERMINAL ATTACHMENT PULL-OUT FORCE

5.2.3.1 Purpose

This procedure details a standard method to measure the retention capability of crimped terminals to bare or tin coated copper wire or welded .to bare copper wire.

Note: Pull-out force test will not be used to determine electrical performance of the crimp application.
It will only be used to determine the mechanical limits of the crimp application for handling purposes.
Refer to USCAR 21 for production crimp, process validation requirements.

5.2.3.2 Equipment

1. Measuring device capable of measuring crimp heights and widths.
2. De-crimping tool or other suitable means of opening insulation crimps without damaging the cable conductor. (Note: it is acceptable to make the samples with the insulation crimp not crimped to avoid this step.)
3. Force tester
4. Cable strippers, long-nose pliers and/or side cutters.

5.2.3.3 Samples

1. A minimum of 20 samples is required to be tested for each production crimp height. Data shall be obtained and recorded for minimum, maximum, and nominal crimp heights.
   Note: Samples crimped on >5mm^2 may be used for electrical testing prior to tensile testing.

5.2.3.4 Procedure

1. Pull-out force test shall be performed on leads with the insulation crimp wings open (not crimped).

2. Pull-out force test shall be performed on taut leads (i.e., remove slack in cable before performing pull-out test to prevent incorrect test results due to "jerking").

3. Measure and record the conductor crimp and insulation crimp heights and widths in millimeters for each sample.

4. If the insulation crimp is not already open, open the insulation crimp with the de-crimper or other suitable tool so that the pull-out force will reflect only the conductor crimp connection.

5. Visually inspect the de-crimped area to ensure that none of the conductor strands have been damaged. Do not use any samples that have damaged conductor strands.

6. Measure and record pull-out forces in Newtons for each sample.

7. Apply an axial force at a rate between 50 and 250 mm/minute (100 mm/min. is recommended).

8. For double, triple, or multiple crimp setups with conductor sizes within one step, pull the smallest conductor. (e.g. for a .35/.50 double, pull the .35mm^2 wire)

9. For double, triple, or multiple crimp setups with conductor sizes more than one step apart, one of the smallest and one of the largest gage size cables must be tested. (e.g. for a .50/1.0 double, pull both wires individually, for a .50/1.0/2.0 triple, pull the .50mm^2 and the 2.0 mm^2 wires, for a .50/.50/2.0 triple, pull one of the .50 mm^2 and the 2.0 mm^2 wires.) In this case, 20 samples per wire size tested will be required.

10. Calculate the mean and standard deviation using the following formulas:

$$\text{Mean} \quad (\overline{X}) = \frac{\sum_{i=1}^{n} X_i}{n}$$

Where X_i = individual pull-out force.
n = number of samples.

$$\text{Standard Deviation (s)} = \sqrt{\frac{\sum_{i=1}^{n} X_i^2 - n\overline{X}^2}{n-1}}$$

Report minimum, maximum, mean ($\overline{X}$), standard deviation (s), and the mean minus three standard deviations ($\overline{X}$ -3s) for each crimp height set.

11. Report any observations from visual examination.

5.2.3.5 Acceptance Criteria

The ($\overline{X}$ -3s) value of the pull-out forces are specified in Table 5.2.3.5.
Note: The pull-out forces for unlisted conductor sizes can be defined by linear interpolation, (i.e. read out from plotted values in Table 5.2.3.5. Pull out forces on >10mm^2 wire sizes are minimum values only and do not require statistical conformance.

Approx. Metric (mm^2)	AWG[(a)]	($\overline{X}$ -3s) And Minimum Pull-out Force (N)
≤0.22	≤24	40[(b)]
0.35	22	50 (Annealed Core)
0.35	22	70 (Hard Drawn Core)
0.5	20	75
0.8	18	90
1.0	16	120
1.5		150
2.0	14	180
2.5		210
3.0	12	240
4.0		265
5.0	10	290
6.0		320
8.0	8	350
10.0		450
>10		600

Table 5.2.3.5 – Pull-out Force Requirements

(a) ≤ AWG means smaller wire size (larger gage size number)
(b) Or as defined by responsible person.

5.2.4 Shield termination ferrule retention test. (Mechanical)

Note: See figures 5.2.4.5 (a. & b.) and figure 5.2.5.4 (a. & b.) for fixture and cable graphic description.
Note: Perform the 5.2.5 isolation resistance test prior the ferrule retention test.

5.2.4.1 Purpose

This test is intended to be used to establish and standardize the tensile fixture and procedure necessary to evaluate a crimped, ferrule type shield termination designed to provide cable retention. It will establish the mechanical capability of the ferrule termination as measured by tensile. This test does not apply to ferrules designed to provide electrical continuity without cable retention.

5.2.4.2 Application

This test will be used to evaluate crimped shield connections on single conductor shielded cable to be used in wire harnesses intended for sale in the North American Market. This includes braided and foil shield types on single core, multi stranded cable types.

5.2.4.2 Equipment

- ⇨ Force tester
- ⇨ Fixtures

5.2.4.3 Sample preparation

1. Crimped ferrule samples shall be prepared per the specific design requirements of the component under test. These design requirements shall be provided by the component supplier and included as a supplement to the test report. Prepare 10 crimped samples for each wire size and wire size under test. It is recommended (but not required) that the samples be at least 300mm long to facilitate clamping and fixturing.

Note: Where separate insulation grips are used in conjunction with a crimped ferrule type shield terminations, the insulation grip shall not be crimped.

Note: The retention test may be performed on the samples after being subjected to the electrical test 5.4.5. When using the sample previously used for the electrical performance test, each end shall be pull tested separately. It is permissible to cut the sample in half to fixture each ferrule individually. The cable must be securely clamped so there is no movement between the insulation and wire core.

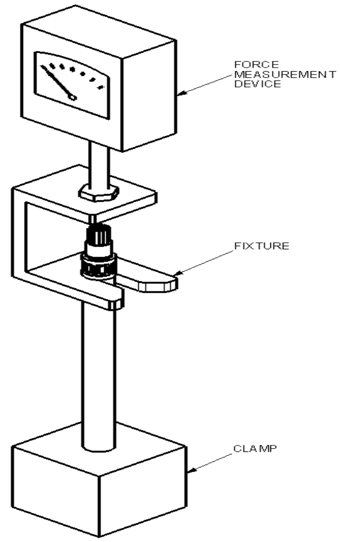
5.2.4.4 Procedure

1. Mount the specimen under test in the fixture as shown in Figure 5.2.4.5. The sample cable shall be securely clamped so as to prevent the insulation from sliding on the wire core.
2. Apply force in an axial direction at a maximum speed of 50mm/miniute.
3. Record the peak force required to move the crimped ferrule from its installed position.
4. A new specimen shall be used for each force measurement. When samples are prepared with a ferrule crimped on both ends, each end is considered a specimen.
5. A minimum of 10 measurements will be taken for each wire type and wire size.
6. Verify conformance per 5.2.4.5

Note: At the request of the responsible person, the actual mounting component or yoke may be used lieu of the fixture described below.

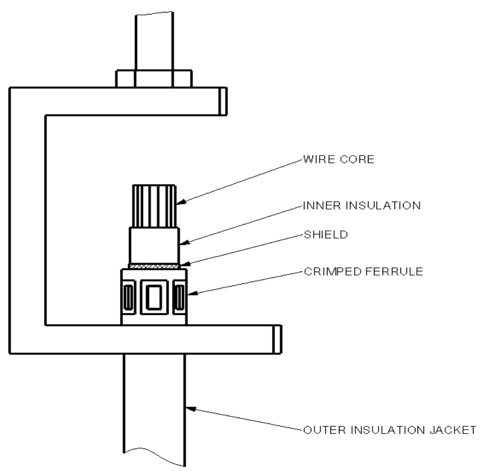
5.2.4.5 Acceptance criteria

The minimum force required to move the ferrule from its installed position shall be ≥150 N.



Typical ferrule retention test fixture set up
Figure 5.2.4.5 – a.

Note: Dimension for slot width in fixture to be determined as follows: Measure the finished cable outside diameter in at least 3 places 60° ± 15° around the circumference of the cable at a point 50 mm ±15mm from the center point on the ferrule type termination under test. The slot in the fixture shall equal the average finished cable outside diameter +0.0 - 0.1mm. In cases where the ferrule termination diameter is less than the outside diameter of the finished cable, the outer insulation jacket may be removed. Using the same method and tolerance as above, substitute the shield outer diameter for the finished cable diameter.



Typical ferrule retention test fixture set up (continued)
Figure 5.2.4.5 – b.

5.2.5 Shield termination Isolation Resistance test (Electrical)

Note: See figure 5.2.6.4 for graphic shielded cable description.

5.2.5.1 Purpose

This test will use isolation resistance to evaluate the affect of the shield/ferrule crimping process. NOTE: This test can be performed as a stand alone test but is often used in conjunction with another test that subjects the insulation to the chance of some form of moisture or other contaminant intrusion. It may also identify any damage to the shield or conductor insulation due to the ferrule crimping process.

5.2.5.2 Equipment

- ⇨ Meg-ohm meter

5.2.5.3 Procedure.

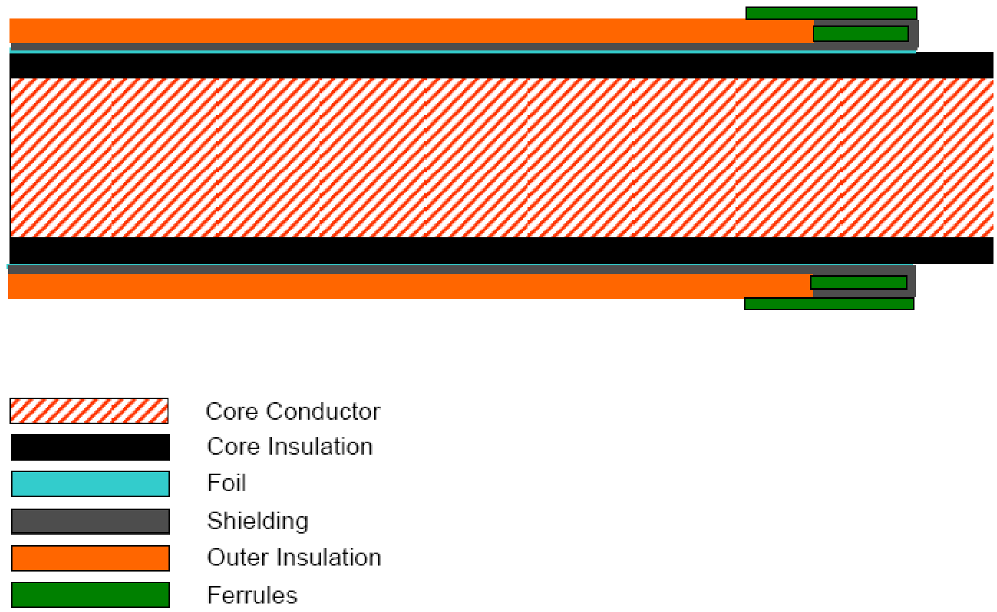
2. Prepare 5 samples with the shield ferrule crimped at the intended design dimension on both ends of the cable. If these samples are to be used for the 5.2.4 ferrule retention test, it is recommended (but not required) that the samples be at least 600mm long to facilitate clamping and fixturing.
3. Set the Meg-ohmmeter to 1,000VDC. Connect one of the Meg-ohmmeter leads to the conductor core and the other lead to the ferrule (terminated) shield.

Note: For special applications, the test voltage may be modified with the approval of the Responsible Person.
Note: The Responsible Person shall define the Meg-ohmmeter lead connection method. (Clip, solder, other)

4. Use the Meg-ohmmeter to measure the resistance between the terminated shield and the conductor core. Apply the test voltage, allow for meter to stabilize.
5. Record the resistance measured and verify conformance to the Acceptance Criteria of Section 5.2.5.4

5.2.5.4 Acceptance Criteria

The isolation Resistance between the core and shield must be >100 MΩ at 1000 VDC before or after environmental conditioning.



Note: Foil is optional and not used on all applications. Shielding is typically braided wire material.

Figure 5.2.5.4-a Typical cable shield termination cross sectional view

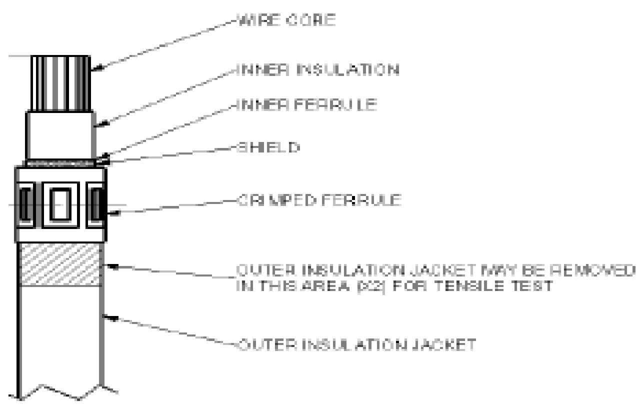


Figure 5.2.5.4-b Typical cable shield termination view

5.3 Terminal electrical

5.3.1 Dry circuit resistance test

Not required for high voltage terminal to terminal interface. See 5.6.7 for electrical requirement after exposure to salt fog.

5.3.2 Voltage drop test

See SAE/USCAR 2

5.3.3 Maximum test current capability test

See SAE/USCAR 2

5.3.4 1008 Hour current cycling test

See SAE/USCAR 2

5.4 Connector Mechanical

5.4.1 Terminal - connector insertion/extraction force.

5.4.1.1 Purpose

See SAE/USCAR 2

5.4.1.2 Equipment

See SAE/USCAR 2

5.4.1.3 Procedure

See SAE/USCAR 2

5.4.1.4 Acceptance Criteria

Insertion:

1. The maximum Insertion Force for a terminal is 30 Newtons for terminals crimped on ≤ 2.0mm^2 (14gage) wire. The maximum insertion force for a terminal crimped on > 2.0mm^2 is 75 Newtons.
2. Neither the conductor nor the terminal may buckle during the test.*
3. The Forward stop must withstand a force greater than the force required to insert the terminal into its cavity or 50N whichever is greater. .

Note: The column strength of the wire is defined as the point where the wire buckles.
Note: Where wire buckling and operator sensitivity cause problems in obtaining test repeatability, terminals may be crimped to a gage pin or other metal dowel material and used to measure terminal insertion or forward stop push through. Samples prepared in this manner require additional connector samples and cannot be used for terminal to connector extraction tests.

*The following alternative method of verifying insertion effort and forward stop strength requirement may be used as necessary: Cut the wire off the CUT near the insulation grip and use a rod with a diameter similar to the cut off wire. Push directly on the wire stub.

Extraction:

The minimum Extraction Force of a terminal from its cavity shall meet the values shown in the table 5.4.1.4:

Cable Size (mm^2)	Primary Lock (Newtons)	Primary and Secondary Lock * (Newtons) per step 5.4.1.3.-B 9,10 of USCAR 2	Primary and Secondary Lock (Newtons) after Temp/Humidity (Section 5.6.2, USCAR 2)
		Before and After Moisture Conditioning	
≥.3 ~.<5	30	60	50
≥.5 ~ <.75	45	70	50
≥.75 ~< 2.0	60	90	50
≥2.0 ~ <5.0	80	110	50
≥5.0 ~ <8.0	125	175	75
≥ 8 ~ < 32	200	235	115
≥ 32	330	450	225

Table 5.4.1.4 – Terminal/Connector Minimum Extraction Force

5.4.2 Connector - connector Mating/Un-mating force (non mechanical assist)

See SAE/USCAR 2

5.4.3 Connector - connector Mating/Un-mating force with mechanical assist

See SAE/USCAR 2

5.4.4 Polarization feature effectiveness

See SAE/USCAR 2

5.4.5 Miscellaneous component engage/disengage force

See SAE/USCAR 2

5.4.6 Vibration and mechanical shock,

See SAE/USCAR 2

5.4.7 Connector to connector audible click.

See SAE/USCAR 2

5.4.8 Connector drop test

See SAE/USCAR 2

5.4.9 Cavity damage susceptibility

See SAE/USCAR 2

5.5 Connector Electrical

5.5.1 Isolation Resistance

See 5.2.5 for shield to core IR and SAE/USCAR 2 - 5.5.1 for IR between cavities.

5.5.1.1 Purpose

See SAE/USCAR 2

5.5.1.2 Equipment

See SAE/USCAR 2

5.5.1.3 Procedure

See SAE/USCAR 2

5.5.1.4 Acceptance criteria

The resistance between every combination of two adjacent terminals in the CUT shall exceed 100 MΩ at 1000 VDC. This includes terminals that may be separated by one or more vacant terminal cavities.

5.5.2 Dielectric withstand voltage test.

5.5.2.1 Purpose

This test is used to determine the potential for break-down of the insulating materials between adjacent circuits in the connector.

5.5.2.2 Equipment

High Potential Tester with Load meter as required.

5.5.2.3 Procedure

1. Prepare 10 mated connector samples per section 5.1.6. using the largest wire gage size appropriate to the design of the component under test.

   Note: When conducting this test as part of a sequence in section 5.9, all dielectric tests on sealed connector pairs shall be started within one hour and completed within 8 hours of any environmental conditioning. Unsealed connector pairs shall be conditioned for ≥ 3 hours at laboratory ambient conditions prior to conducting Dielectric strength testing.

2. Select the voltage to be applied to the samples from Table 5.5.2.3. Either AC or DC voltage may be used.

Connector Rated Voltage	AC Applied Voltage	DC Applied Voltage
20-100	1000	1600
110-300	1600	2500
300-600	1000+ 2X (where X is the connector rated voltage	1600+ 3.2X (where X is the connector rated voltage)

Table 5.5.2.3 – Dielectric Withstand Voltage

3. Connect all circuits together and apply a foil wrap to the outside of the connector.

   Note: If the connector has an external metallic shield use the shield in place of the foil.

4. Apply the voltage between foil or shield and circuit array for one minute.

5.5.2.4 Acceptance Requirements

There shall be no dielectric break-down or flash over between cavities or between circuits in cavities and the outside of the connector or shield.

5.5.3 Transfer Impedance (Shielding Effectiveness)

The responsible person will determine the requirement and procedure for this test.

5.6 Connector or terminal Environmental

5.6.1 Thermal shock

See SAE/USCAR 2

5.6.2 Temperature humidity cycling

See SAE/USCAR 2

5.6.3 High temperature exposure

See SAE/USCAR 2

5.6.4 Fluid resistance

See SAE/USCAR 2

5.6.5 Environmental sealing – Submersion

See SAE/USCAR 2

5.6.6 Environmental sealing – Pressure Vacuum

See SAE/USCAR 2

5.6.7 Salt Fog Exposure

5.6.7.1 Purpose

This procedure shall be performed to evaluate the ability of electrically shielded circuits to survive environmental conditions in applications exposed to road salt.
Note: This procedure only applies to connection systems where the shield is exposed to the outside environment.

5.6.7.2 Equipment

- ⇨ Salt spray chamber in compliance with ASTM B117

5.6.7.3 Procedure

This procedure shall be preformed as described in ASTM B117

1. Prepare 10 mated connector samples per section 5.1.6. using the largest wire gage size appropriate to the design of the component under test. Seal the cable end (the end not fitted with a connector) with adhesive lined shrink tubing.
2. In line connectors: Measure the total dry circuit resistance of each mated connector assembly from the cable shield, thru the connector housings to the other cable shield
   or:
3. Device/direct connect connector: Measure the total dry circuit resistance of each mated connector assembly from the cable shield, thru the connector housings to the device or housing.
4. Secure the mated samples to a plate using suitable clips or with the appropriate devices.
5. Position the mounting plate so as to expose the sample under test directly to the salt fog spray.
6. The exposure zone of the chamber shall be maintained at 35°C +/-2°.
7. The samples shall be exposed to the salt spray for 96 hours.
8. At the conclusion of the salt fog exposure remove any salt solution from the sample with compressed air and measure the total dry circuit resistance of each mated connector assembly as described in steps 2 or 3.
9. Un-mate the sample and perform an isolation resistance test between any conductor within the connector and the shield.

Note: Dry circuit measurement leads may be attached to the cable shield and sealed with adhesive lined shrink tubing prior to the salt for exposure.

5.6.7.4 Acceptance criteria

1. The dry circuit resistance shall be no greater than the 2 times the initial measured value.
2. All samples shall meet the isolation resistance requirements of 5.5.1.4

5.7 Special Tests

See SAE/USCAR 2

5.7.1 Header pin retention

See SAE/USCAR 2

5.7.1 Connector mounting feature mechanical strength.

See SAE/USCAR 2

5.8 Severe duty tests

See SAE/USCAR 2

5.8.1 High pressure spray

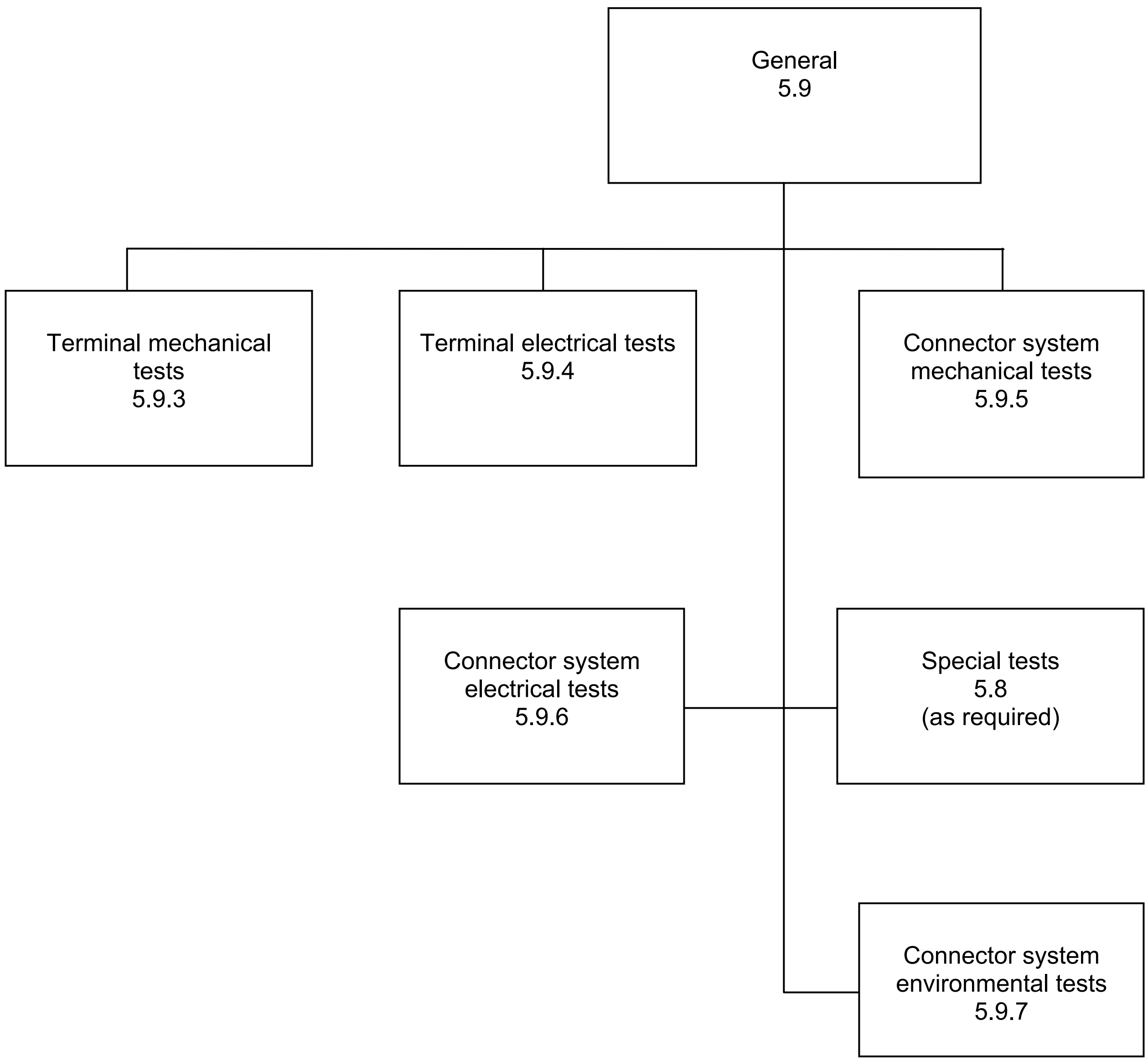
See SAE/USCAR 2

5.9 Test sequence

5.9.1 Test sequence general notes

1. Test sequence is the order in which tests are performed. The sequence should be logical and interrelated in order to accurately establish the performance characteristics of the component or assembly.
2. Numbers in the body of charts 5.9.3 ~ 5.9.9 indicate the order in which the tests or conditioning procedures are performed. Where there are duplicate numbers in the same column, the procedures are performed concurrently.
3. Destructive tests should be performed only on samples that are not intended for use in further test sequences.
4. Fixtures and test set-ups should be reviewed by the Authorized Person prior to the start of testing.
5. The sequential test tables in section 5.9 are base sequences and may be altered according to the Authorized Person's request.
6. The total number of test samples needed for sequential tests is shown at the top of each column. It is important to note that, where parallel test paths are shown, a separate set of samples is required for each path. The same set of samples is never run through one path and then used again for a parallel test path unless specifically required in the test request/order. Exceptions are noted in each flow chart.

General test flow chart



5.9.2 General test flow chart

5.9.3 Terminal Mechanical test sequence

5.9.4 Terminal electrical test sequence

5.9.5 Connector system mechanical test sequences

		5.9.3			5.9.4		5.9.5								
	Test	Terminal/conductor crimp pull out force	Term. - Term. Engage/Disengage Force	Terminal Bend Resistance	Maximum Current/Current Cycling	Shield termination performance	Term.-Conn. Insertion/Extraction	Misc. Component Engage/Disengage	Audible Click	Conn. Conn Mating/Un-mating	Polarization Effectiveness	Drop	Cavity Damage	Header Pin Retention	Mounting Feature Mech Strength
	Sequence ID	**Y**	**A**	**B**	**C**	**Z**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
	Sample Size (Refer to individual procedures)	10	10	15/30	10/30	10	10	10[1]	8	15	[2]	3	5	20	20
5.1	General	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5.1.8	Visual Inspection	2	2, 4	2, 4	2, 5	2	2, 4	2, 4	2, 4	2, 4	2, 4	2, 4	2, 4	2, 4	2, 4
5.2.1	Terminal to Terminal Engage/Disengage Force		3												
5.2.2	Terminal Bend Resistance			3											
5.2.3	Conductor/Terminal Crimp Pull out Force	3													
5.2.4	Shield termination ferrule retention test					4									
5.2.5	Shield/Wire Core Isolation Resistance					3									
5.3.3	Maximum Test Current Capability				3										
5.3.4	1008 Hour Current Cycling				4										
5.4.1	Terminal - Connector Insertion/Extraction Force						3								
5.4.2	Connector-Connector Mating/Unmating Force (Non-mechanical Assist Connectors)									3					
5.4.3	Connector to Connector Mating and Unmating forces (Connectors with Mechanical Assist									3					
5.4.4	Polarization Feature Effectiveness										3				
5.4.5	Miscellaneous Component Engage/Disengage Force							3							
5.4.7	Connector-to-Connector Audible Click								3						
5.4.8	Connector Drop Test											3			
5.4.9	Cavity Damage susceptibility												3		
5.7.1	Header Pin Retention													3	
5.7.2	Connector Mounting Feature Mechanical Strength														3

Test sequence chart: 5.9.3 Terminal Mechanical
5.9.4 Terminal Electrical 5.9.5 Connector System Mechanical

Notes: [1] 10 samples each for misc. component engage/disengage test [2] Sample size for polarization effectiveness determined by procedure.

5.9.6 Connector system electrical test sequence

5.9.7 Sealed connector system environmental test sequence

5.9.8 Un-sealed connector system environmental test sequence

5.9.9 Stand Alone pressure Vacuum Test

5.9.10 Stand alone Salt Fog

		5.9.6				5.9.7					5.9.8	5.9.9	5.9.10
	Test	Vibration	Thermal Shock	Temp /Humidity	High Temp Exposure	Fluid Resistance	Temp/Humidity-Submersion	Temp/Humidity-PV Leak	High Temp Exposure-Submersion	High Temp Exposure- PV Leak	Temp/Humidity	Pressure/Vacuum Stand Alone	Salt Fog Stand alone test
	Sequence ID	**M**	**N**	**O**	**P**	**Q**	**R**	**S**	**T**	**U**	**V**	**W**	**X**
	Sample size	10	10	10	10	8	10	10	10	10	10	10	10
5.1	General	1	1	1	1	1	1	1	1	1	1	1	1
5.1.8	Visual Inspection	2, 7	2, 8	2, 9	2, 8	2,6	2,9	2,11	2, 9	2, 10	2, 7	2,6	
5.1.7	Connector Cycling	3	3	3	3		3	3	3	3		3	
5.1.9	Circuit Continuity Monitoring	4	4										
5.3.2	Voltage Drop	6	5	5	5								
5.4.1	Terminal-Connector Extraction Force			8				10			6		
5.4.6	Vibration/Mechanical Shock	4											
5.5.1	Isolation Resistance(3)	5	6	6	6	4	5, 7	5, 8	5, 7	5, 8	4	5	3
5.5.2	Dielectric Strength		7	7	7	5	8	9	8	9	5		
5.5.3	Transfer impedance(1)												
5.6.1	Thermal Shock		4										
5.6.2	Temperature/Humidity Cycling			4			$4^{(8,7)}$	$6^{(8,7)}$			3		
5.6.3	High Temperature Exposure				4				$4^{(8,7)}$	$6^{(8,7)}$			
5.6.4	Fluid Resistance					3							
5.6.5	Submersion						$6^{(6,8,9)}$		$6^{(6,8,9)}$				
5.6.6	Pressure/Vacuum Leak							$4,7^{(5,8,9)}$		$4,7^{(5,8,9)}$		4	
5.6.7	Salt Fog												2

Test sequence chart: 5.9.6 Connector System Electrical,
5.9.7 Sealed Connector System Environmental, 5.9.8 Unsealed Connector Environmental,
5.9.9 Stand Alone Pressure Vacuum, 5.9.10 Stand alone Salt fog Exposure
See Test sequence chart notes on following page

Test sequence 5.6 ~5.10 chart notes

Notes:
(1) This test to be determined by responsible person.

(2) NA

(3) Isolation Resistance required on all high voltage connector test sequences

(4) This test sequence 5.9.7 is for sealed systems only.

(5) Use 48kPa prior to High Temp. Exposure test (5.6.3) and Temperature/Humidity Cycling test (5.6.2). Use reduced pressure/vacuum of 28 KPa (4 psig) following High Temp. Exposure test (5.6.3) and Temperature/Humidity Cycling test (5.6.2).

(6) Submersion test 5.6.5 reduced to one (1) cycle following High Temperature Exposure Test 5.6.3, and Temperature/ Humidity Cycling Test (5.6.2).

(7) When Temperature/Humidity cycling or High Temperature Exposure are done as part of this table, complete the conditioning procedure only. Voltage drop readings and monitoring are not required.

(8) In order to reduce sample size, the Pressure/Vacuum Leak (5.6.6) and Submersion (5.6.5) may be run in series. This allows Sequences R and S to be combined and T and U to be combined. When tests are done in series, do not open the connectors as directed in section 5.6.5.4 and 5.6.6.4. Isolation resistance must be run between the PV Leak and Submersion tests.

(9) Mat seal terminal insertion per section 5.6.5.3-2, 5.6.6.3-4 may be done prior to beginning the table sequence, or may be done prior to Submersion or P/V Leak.

Test sequence chart notes:
5.9.6 Connector System Electrical
5.9.7 Sealed Connector System Environmental
5.9.8 Un-sealed Connector System Environmental
5.9.9 Stand Alone Pressure Vacuum
5.9.10 Salt Fog Exposure

Appendix A - Definitions
See SAE/USCAR 2

Appendix B - Glossary of terms

Ferrule:
A ring or cup crimped on shielded wire or coaxial cable and used to provide an electrical and or mechanical termination to the shield or insulation jacket. Some systems may use both an inner and outer ferrule.

Shield:
An electrically conductive covering applied over a circuit to protect the circuit from emitting or absorbing electrical interference.

Also see SAE/USCAR 2

Appendix C - Tests Required for New Tooling, Tool Transfer or Material change
See SAE/USCAR 2

Appendix D - Tests for new /existing terminal or connector designs
See SAE/USCAR 2:

Appendix E - Source list
See SAE/USCAR 2:

Appendix F - Design notes
See SAE/USCAR 2:

Appendix G - Revision record

Date	Section	Summary of change	Notes
TBD	All	Initial release	