Performance Specification for Automotive Electrical Connector Systems

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PERFORMANCE SPECIFICATION FOR AUTOMOTIVE ELECTRICAL CONNECTOR SYSTEMS

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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. See section 4.3.

1 SCOPE

Procedures included within this specification are 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 low voltage (0 - 20 VDC) road vehicle applications. These procedures are only applicable to terminals used for In-Line, Header, and Device Connector systems with and without Shorting Bars. They are not applicable to Edge Board connector systems, twist lock connector systems, > 20 VAC or DC, or to eyelet type terminals.
Note: Some tests detailed in this document such as connector environmental or terminal electrical may be applicable to twist lock systems. For twist lock connector system ergonomic requirements refer to USCAR 25.

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 only of example, this includes products that may be subjected to temperatures beyond the extremes of Class 5 in Figure 5.1.4, or 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 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 this 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.

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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 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 Appendix A.

For the purposes of this specification there are only two types of electrical connectors: sealed and unsealed.

3 REFERENCED DOCUMENTS REQUIRED

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

Note: Connector systems that have been tested to and met the requirements of previous revision levels of USCAR 2 and USCAR 25 may not meet the requirements of later levels. These components shall be considered to be compliant to the prevailing revision level at the time of release of component part. Compliance to the current revision level of this document may require testing and acceptance to the requirements of this revision.

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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.
Maximum permissible Temperature Sealing, Vibration, and Ergonomic class (per section 5.1.4) 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.

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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-20: Field Correlated Life Test
SAE/USCAR-21: Performance Specification for Cable-to-Terminal Electrical Crimps
SAE/USCAR-23: Road Vehicles – 60V and 600V single core cables
SAE/USCAR-25: Electrical Connector Assembly Ergonomic Design Criteria
AIAG: Measurement Systems Analysis Reference Manual
ISO TS16949
IEC 68-2-32 – Basic Environmental Test Procedures – part 2
SAE J 1127 and SAE J 1128: Low voltage primary cable

4 GENERAL REQUIREMENTS

4.1 RECORD RETENTION

The supplier shall maintain a central file for the storage of laboratory reports and calibration records. Such record storage must be in accordance with established ISO TS16949 and AIAG policies and practices.

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4.2 SAMPLE DOCUMENTATION

All test samples shall be identified in accordance with the requirements of ISO TS16949 and the AIAG PPAP.

4.3 SAMPLE SIZE

Minimum sample sizes are given for each test in this specification. A greater number of samples may be required by the test request/order. However, no part or device may be represented as having met this specification unless the minimum sample size has been tested and all samples of the group tested have met the applicable Acceptance Criteria for that test. It is never permissible to test a larger group, then select the minimum sample size from among those that passed and represent that this specification has been met.

4.4 DEFAULT TEST TOLERANCES

Default Tolerances, expressed as a percentage of the nominal value unless otherwise indicated:

Temperature	=	± 3 °C
Voltage	=	± 5%
Current	=	± 5%
Resistance	=	± 5%
Length	=	± 5%
Time	=	± 5%
Force	=	± 5%
Frequency	=	± 5%
Flow Rate	=	± 5%
Relative Humidity	=	± 5% (When controlled)
Speed	=	± 5%
Sound	=	± 5%
Pressure	=	± 5%
Vacuum	=	± 5%

Test Default Conditions

When specific test conditions are not given either in the product design specification, the test request/order or elsewhere in this specification, the following basic conditions shall apply:

Room Temperature	=	23 ± 5° C
Relative Humidity	=	Ambient (Uncontrolled as in lab ambient conditions)
Voltage	=	14.0 ± 0.1 VDC

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4.5 EQUIPMENT

Neither this list nor the list in each test section is all-inclusive. It is meant to highlight specialized equipment or devices with particular accuracy requirements. Many other items of customary laboratory equipment and supplies will also be required.

ITEM	DESCRIPTION	REQUIREMENTS*
1	DC Power Supply (Regulated)	⇒ 0-20 V ⇒ 0-150 A
2	Micro-ohmmeter	⇒ 0-20 mV ⇒ 0-100 mA Limits the open circuit voltage to 20 mV and limits the current applied to 100 mA. The micro-ohmmeter must also use either offset compensation or current reversal methods to measure resistance
3	Digital Multimeter (DMM)	* Capable of measuring the following at an accuracy of ≤0.5% of full scale: ⇒ 0-50 Volts DC ⇒ 0-10 Megohms
4	Current Shunts	100 mA or as required with accuracy of ± 1% of nominal
5	Millivolt Meter	Capable of measuring 0-100 mVDC at 0.5% full scale
6	Thermocouples	Type "J" or "T" and as required
7	Insertion/Extraction Force Tester	Capable of 1.0% accuracy, full scale
8	Data Logger	As Required
9	Temperature Chamber	⇒ -40°C to +175°C or as required by Temperature Class ⇒ 0% to 95% RH
10	Vibration Controller	As Required
11	Vibration Table	⇒ 2640N (600 Lbs.) Sine Force ⇒ 2200N (500 Lbs.) RMS Force
12	Vacuum	As Required
13	Megohmeter	Accuracy <5% of full scale
14	High Pressure Spray Equipment	See table 5.8.1.3
15	Decibel Meter	+/- 1.5 dB “A and C” scale

Table 4.6.1: Equipment

NOTE: on requirements: Use of equipment with a lesser range is acceptable for specific tests where the required range for that test can be met. The equipment range specified does not preclude use of equipment with a larger range, but the accuracy must remain within the specified tolerance. For example, a DMM with a range of 0-100 volts could be substituted for one specified as 0-50 volts, with the provision that the accuracy could be maintained as ±0.5% of the 50 volts full scale, or 0.25 volts, not 0.5% of the 100 volt full scale of the substituted equipment.

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4.6 MEASUREMENT RESOLUTION

Unless otherwise specified, meters and gages used in measurements of the test sample(s) shall be capable of measuring with a resolution one decimal place better than the specified value. For example, even though a wire diameter specified as 0.1 mm might actually be the same as one specified as 0.10 mm, calipers capable of 0.01 mm resolution may be used to measure the first wire but a micrometer with 0.001 mm resolution is required to measure the second wire.

4.7 TEST REPEATABILITY & CALIBRATION

All equipment used for test sample evaluation shall be calibrated and maintained according to the applicable standards and requirements set forth by ISO TS16949 and the AIAG publication Measurement Systems Analysis Reference Manual. Copies of this Manual can be obtained from the AIAG. (See Appendix B for contact information.) Documentation is to be recorded and retained in accordance with Section 4.1 of this USCAR/EWCAP specification.

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4.8 CONFORMANCE DETERMINATION

Conformance shall be determined by the specified requirements of the test being conducted. All samples must satisfy the requirements regardless of sample age, test cycles, or test temperature, except where a test to failure is specified.

4.9 DISPOSITION OF SAMPLES

Should a premature non-conformance occur during a test, contact the requesting party to determine if the test is to be continued to gain additional product experience or if testing is to be suspended or terminated. When contact cannot be immediately made, the type of test shall determine the disposition of the samples. If the test order indicates that the test is investigative in nature, continue until the requesting party or parties are available. If the test order is for sample approval or validation, stop the test until the requesting party can be contacted. If the test must be stopped or terminated for any other reason (safety, equipment failure, etc.) the Authorized Person must be contacted for concurrence before the test is restarted. The test request/order should always specify desired sample disposition at the conclusion of the applicable testing.

4.10 PART ENDURANCE

Successful completion of all requirements of this specification is intended to demonstrate that the design and construction of the components and connector systems tested are capable of operating in their intended vehicle environment and application.

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.

The test procedures that follow were written as stand-alone tests and may be used as such. However, they are intended to be performed in sequence as specified in 5.8.2 – 5.8.8 via appendix C and D. Common sense is required to overcome any redundancies in sample preparation or in procedures. For example, if samples have already been prepared for the preceding test in a sequence, it should be obvious that the sample preparation step for that individual test (included so that test can be used as a stand alone test) should be skipped. Should any conflicts or questions arise concerning procedures and/or requirements, contact the Authorized Person.

5.1.1 Performance Requirements

All connection systems must meet all performance test requirements for the appropriate Class as listed in Figure 5.1.4.

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.

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5.1.4 Classifications

5.1.4.1 Temperature Classification

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.

When "Maximum Temperature" is mentioned with respect to Figure 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

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Figure 5.1.4.1: Component Temperature Classes

5.1.4.2 Sealing Classification

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. Note: some heavy duty and off road vehicles require sealed (S3) connectors within vehicle interiors.

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

Figure 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.

Figure 5.1.4.3: Component Vibration Classes

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5.1.4.4 Ergonomic Classification

Components to be tested must be assigned an Ergonomic class from the requirements in SAE/USCAR 25. This Class designation shall be documented in the test plan and listed on the component drawing.

5.1.5 Testing Headers & Direct Connect Components

Cases frequently arise where only one half of a connector, usually the female half, is available and it mates directly to a Header or to a receptacle in an electrical component or device. This presents special problems for testing. In order to completely test the electrical connection, access must be gained to the terminals in the device or header. Great care must be taken in these cases so as not to introduce leak paths that are not present in the vehicle application. Where this risk is unacceptable, or making the necessary electrical connections is not feasible, the tests normally required to verify connection integrity must be modified.

Another problem sometimes arises due to the length of the terminals or buss bars in the device or header when conducting electrical tests. The general rule is to connect one of the millivolt test leads at the point where the Header or device terminal attaches to the circuit board or similar point in the device. The bulk resistance of the terminal "tail" is measured and subtracted during the connection resistance calculation.

However, if there is more than one "tail" length involved, but the bulk resistance per unit length is common, it may be more convenient to attach the millivolt leads at a common distance from the connection to be measured.

Therefore, in situations where there is more than 50 mm from the point of contact in the connection nearest to the Header or device to the point where the terminal "tail" or buss bar connects to the device, these two options are available. (1) Attach the millivolt lead at a convenient common distance 30 to 50 mm from the contact to be measured. Then subtract the bulk resistance of the selected common length when calculating the resistance of the associated Header or device connection. (2) Measure bulk resistance of each individual Header terminal or component buss bar from the connection to be measured to the point of millivolt lead attachment and subtract this resistance when calculating the resistance of the associated Header or device connection.

When attaching millivolt leads, take care that the heat applied does not damage plating or cause stress relaxation in any connection component. Application of an appropriate heat sink may be advisable. Refer to Figure 5.1.5.

Note: Placement of the T1 lead in Figure 5.1.5 may be modified as necessary to fit the application. When using a dimension other than the 75+/-3mm it is important to measure the resistance of a sample with an equal length of the same wire type and use that result as the deduct value.

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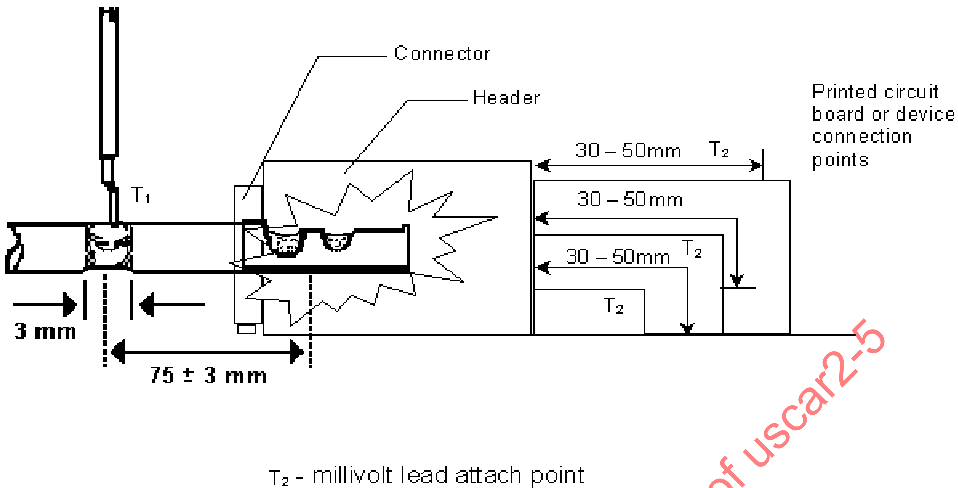

Figure 5.1.5: A - Method 1 - Milli-volt Lead Attachment (typical)

It may be that the electrical component or device being connected is not itself capable of withstanding the tests to which the connector is usually subjected. In these cases samples of just the connector receptacle portion of the device must be obtained. Then the required connections for testing can be made and sealed. Leak paths in devices may need to be sealed in order to test the integrity of mating connectors. Such modifications to the device are appropriate, but must be documented in the test report.

In any case, the Authorized Person must be consulted and must approve any deviation from the normal tests of this performance specification.

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.

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5.1.7 Connector and/or Terminal 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 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.

5.1.7.2 Equipment

None

5.1.7.3 Sample Preparation

No special preparation required.

5.1.7.4 Procedure

Completely mate and un-mate each connector or terminal pair 10 times.

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.

On connectors with Shorting Bars, complete the Dry Circuit measurement across the shorted contacts (connector un-mated) per section 5.3.1. Record the number for later use in calculating the resistance change as part of the Dry Circuit Test procedure.

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

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5.1.8 Visual Inspection

5.1.8.1 Purpose

This test is used to document the physical appearance of test samples. A comparison can then be made with other test samples. Examinations in most cases can be accomplished by a person with normal or corrected vision, and normal color sensitivity, under cool white fluorescent lighting. Photographs and/or videos are encouraged as a more complete means of documentation. An appropriately identified untested sample from each test group must be retained for post-test physical comparisons.

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5.1.8.2 Equipment

- ⇨ Camera
- ⇨ Video Recorder
- ⇨ Magnification Apparatus (as required)

5.1.8.3 Procedure

1. Visually examine each test specimen prior to testing and/or conditioning, noting in detail any obvious manufacturing or material defects such as cracks, tarnishing, flash, etc. When specified in the test request/order, take photographs and/or video recordings of representative samples to be tested and keep a properly labeled control sample.

   After testing and/or conditioning, re-examine each test sample and note in detail any observable changes, such as swelling, corrosion, discoloration, contact plating wear, physical distortions, cracks, etc. Compare the tested and/or conditioned samples to the control samples, the videos, and/or the photographs, recording any differences in the test report. The Authorized Person will need to provide an additional sample for this purpose.

   Return test samples to requestor after all tests are completed and all necessary data have been obtained.

5.1.8.4 Acceptance Criteria

The device under test must not show, any evidence of deterioration, cracks, deformities, etc. that could affect their functionality. No base material on plated parts should be exposed due to plating or coating wear through. Additional criteria are listed under each test.

5.1.9 Circuit Continuity Monitoring

5.1.9.1 Purpose

Some procedures require continuous circuit monitoring of connectors during conditioning. The purpose of circuit monitoring is to detect intermittencies caused by micro-motion and resultant wear or build-up of non-conductive debris at the contact interface. Use this procedure when specified in the individual test.

5.1.9.2 Equipment

⇨ Continuity Tester (CT)

5.1.9.3 Procedure

At least 10 individual terminal and 5 connector pairs must be monitored. Monitored terminal pairs should be distributed as evenly as possible among the connectors tested. Distribution of monitored pairs should be done per the following general patterns. The Authorized Person shall determine the final monitoring pattern. The pattern shall be documented in the test report.

X		X		X

X		X	X
X		X	X

X					X
			X		
		X			
X					X

Figure 5.1.9.3: General Pattern for Circuit Monitoring

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NOTE: An 'X' pattern is suggested if practical
NOTE: Monitored terminals shall not be the same samples used for subsequent Dry Circuit readings for record, since the monitoring equipment may cause the potential across the circuit to exceed 20mvolts. Dry Circuit readings, however, may be taken as an aid in root-cause diagnosis.

1. Solder the conductors from each terminal in the CUT in series to form one continuous current path with only two free ends. Solder one of the free conductor ends to a 2 watt, 120 ± 1.2 ohm resistor. Solder the " – " (negative) lead to the free end of the resistor and the "+" (positive) lead to the remaining free conductor end of the CUT. Connect the Continuity Tester (CT) across the resistor, making sure that the negative lead of the CT is connected to the negative side of the resistor. Adjust the power supply to provide 100 mADC to the circuit. Set the CT to monitor the current through the resistor and record any instance where that current falls below 95 mA. As an option, the CT may be used to monitor one or more terminal pairs instead of the resistor. A reference illustration of the test set-up is shown in Figure 5.1.9.3. Other suitable continuity monitoring equipment may be used. The test fixtures, system layout, and test set-up must be approved by the Authorized Person prior to testing.

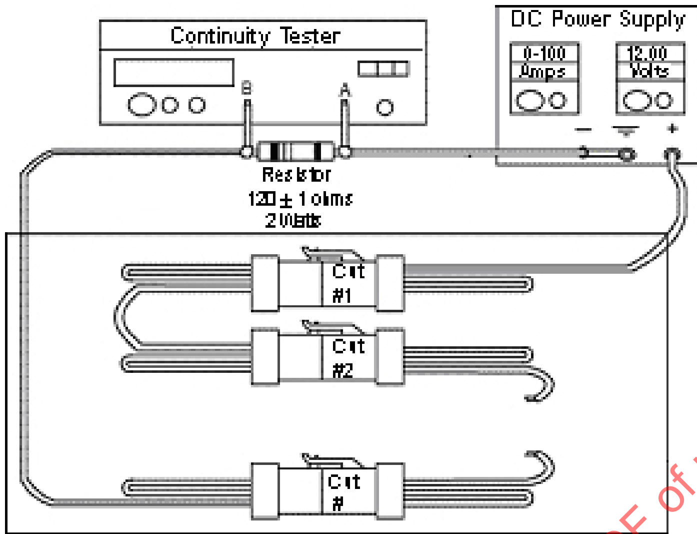

Figure 5.1.9.3: Connector Environmental Test Set-Up

5.1.9.4 Acceptance Criteria

Where continuity monitoring is required during any conditioning procedure, there must be no loss of electrical continuity (any instance of the resistor current dropping below 95 mA), for more than 1 microsecond. If one or more terminal pairs are monitored, rather than the series resistor, there must be no instance in which the resistance of any terminal pair exceeds 7.0 Ω for more than 1 microsecond. Figure 5.1.9.4 illustrates the acceptance criteria graphically.

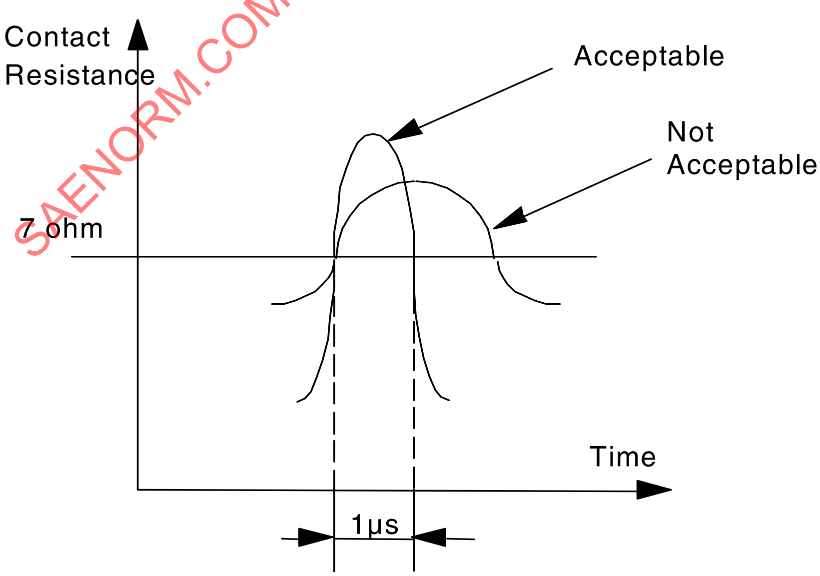

Figure 5.1.9.4: Intermittency Measurement

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5.2 TERMINAL - MECHANICAL TESTS

5.2.1 Terminal to Terminal Engage/Disengage Force

5.2.1.1 Purpose

This test determines the engagement and disengaging forces associated with compatible male and Female Terminal pairs. Determination of the number of terminals that can be packaged in a given connector design without exceeding allowable Mating Force limits is largely dependent on this information. Note that this test is written so that only the first engagement and the last (10^{th}) disengagement are recorded and used to verify compliance with the Acceptance Criteria.

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5.2.1.2 Equipment

- ⇨ Insertion/Extraction Force Tester with peak reading feature
- ⇨ Polished Steel Gage(s) (optional)

5.2.1.3 Procedure

1. Completely identify and number each terminal to be tested. A minimum of 20 samples (10 male and 10 female) are required. If the optional Step 8 is to be used, at least an additional 10 Female Terminal samples will be required.
2. Fixture one male and one Female Terminal so that proper alignment is achieved during testing.
3. Engage the mating terminals at a uniform rate not to exceed 50 mm/min. The force shall be applied parallel to the centerlines of the terminals. Proper alignment of the terminals is critical to avoid side loads and binding which can adversely affect the force measurement.
4. Record the peak force required to completely engage the terminal to its mating part and use this value to verify conformance to the Acceptance Criteria of Figure 5.2.1.4.
5. Disengage the mated terminals at a uniform rate not to exceed 50 mm/min. The force shall be applied parallel to the centerlines of the terminals.
6. Repeat Steps 3 & 5 nine (9) more times and record the 10^{th} disengage force reading. Use this value to verify conformance to the Acceptance Criteria of Figure 5.2.1.4.
7. Repeat Steps 2-6 for each pair (one male and one female) of sample terminals.
8. (Optional) Repeat Steps 2-7 except use the applicable gage in place of the Male Terminals. Use new Female Terminals. The applicable gage is to be of polished steel made to within .01 mm of nominal. Surface finish must be at least .076-.305 micro meters (3-12 micro inches). Polish direction must be parallel to the blade/pin length. Test the additional 10 production Female Terminal samples to determine the force correlation between polished gage and actual samples.

5.2.1.4 Acceptance Criteria

Complete the Visual Examination per section 5.1.8

TERMINAL			GAGE (Optional)	ACTUAL PART	
Size (mm)	Type	Engage Max.(N)	Disengage Min. (N)	Engage Max. (N)	Disengage Min. (N)
0.64	Square Post	*	*	*	*
1.50	Blade	*	*	*	*
2.80	Blade	*	*	*	*
6.35	Blade	*	*	*	*

NOTE: A "*" denotes values to be inserted by the Authorized Person pending design completion and prototype evaluation.

Figure 5.2.1.4: Engage/Disengage Forces

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5.2.2 Terminal Bend Resistance

5.2.2.1 Purpose

This test checks for at least a minimum level of terminal strength so as to resist bending or breakage during crimping, assembly, or service. Insufficient bend strength for the conductor size selected can lead to a high incidence of terminal damage during the assembly process. Since terminal material thickness varies so widely, and the bending force can be applied in any direction, only minimum values have been assigned to this test. Actual bending force values in each of three directions are recorded and it is then up to the Authorized Person to evaluate the results and determine the suitability of the tested terminal for its intended application.

Note: This test is not applicable to terminals where the wire attachment is at 90° to the direction of insertion.

5.2.2.2 Equipment

⇨ Special steel mounting fixture(s) appropriate to the terminal(s) under test.
⇨ Linear Force Tester with peak reading feature or weights per figure 5.2.2.4.

5.2.2.3 Procedure

1. From Figure 5.2.2.3-1, determine which design style most closely resembles the terminal under test (TUT).

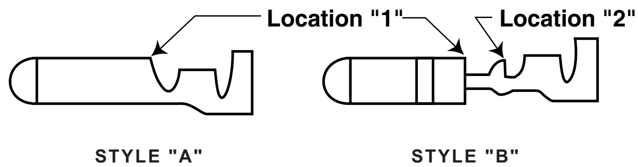

Figure 5.2.2.3-1: Terminal Design Style

2. Prepare terminal samples per section 5.1.6, Terminal Sample Preparation, using the smallest gage size conductor with the thinnest insulation applicable to the design of the terminal to be tested. For Style "A" terminals, prepare a total of at least 15 samples. For Style "B" terminals, prepare a minimum of 30 terminals, in order to test both bend locations.
3. Repeat Step 2 except use the largest conductor gage size with the thickest insulation applicable to the design.
4. Number each terminal.

NOTE: Use at least 5 new samples for each test sequence (Steps 6 - 9).

5. Mount the TUT in a fixture taking care that location "1" is positioned as shown in Figure 5.2.2.3-2.

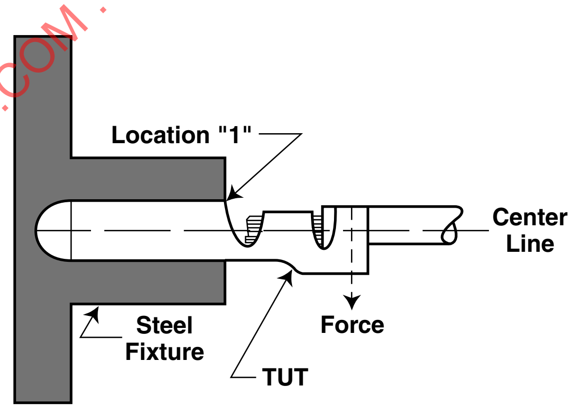

Figure 5.2.2.3-2: Terminal Bend Test

6. Apply force to the sample as shown in figure 5.2.2.3-2, then release. The required forces by material thickness are listed in table 5.2.2.4.

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Terminal Material Thickness (mm)	Applied Force (N)
≤0.20	4.0
≤0.30	10.0
≤0.40	15.0
>0.40	20.0

Table 5.2.2.4: Material Thickness vs. Applied Bending Force

7. Inspect the area around the bend using at least 10X magnification. Note in the test report any signs of metal cracking or tearing. Straighten the terminal to its original position and re-inspect the terminal for cracks.
8. Select a new batch of at least 5 samples and mount them in the test fixture with the terminal rotated 180° from the position shown in Figure 5.2.2.3.2. Repeat Steps –5-7.
9. Select a new batch of at least 5 samples and mount them in the test fixture with the terminal rotated 90° from the position shown in Figure 5.2.2.3.2. Repeat Steps –5-7. Since terminals are typically symmetrical in this "side to side" direction, it is not necessary to test both directions. If the TUT is not symmetrical in this direction, it may be necessary to test both ways. Consult the Authorized Person for guidance in this regard.
10. For terminal style "B" designs (Figure 5.2.2.3.1), repeat Steps 5 - 9 with each TUT mounted such that location "2" is firmly retained at the edge of the fixture.

5.2.2.4 Acceptance Criteria

The TUT must not tear when subjected to the applied force. If the TUT was bent from its original position during the test, it must not tear or crack when straightened to its original position.

5.3 TERMINAL - ELECTRICAL TESTS

5.3.1 Dry Circuit Resistance

5.3.1.1 Purpose

This test determines the combined resistance of the two conductor crimps (or single crimp in the case of a Header Connector) and the contact interface of a mated terminal pair under low energy conditions. Since it tests for the presence of thin insulating films that may have developed on the contact surfaces during field service or environmental type stress tests, it is important that no other electrical test be performed on the samples prior to this test.

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5.3.1.2 Equipment

Micro-ohmmeter

5.3.1.3 Procedure

NOTE: Take care to avoid any mechanical disturbance of mated terminal samples submitted for this test. Such disturbance could rupture any insulating film which may have developed on the contact surfaces.

NOTE: If for any reason the terminals, when submitted for this test, are already contained in their mated connector housings, do not disconnect them unless otherwise directed by the Authorized Person. For terminals in mated connector housings, omit steps 1 and 5 - 7.

NOTE: If the samples submitted for this test have already been subjected to any other electrical test, the purpose of this test has likely been defeated and the Authorized Person must be contacted for approval before proceeding.

1. Prepare 20 (at least 10 male and 10 female) terminal samples per section 5.1.6, Terminal Sample Preparation, using the largest gage size conductor and insulation thickness applicable to the design of the terminal to be tested.
2. Do NOT mate the terminal pairs until after the millivolt leads have been attached, as directed in Step 5. For terminals that have been subjected to prior testing, do not disconnect their connector housings or remove any terminal from its housing.
3. Measure and record the resistance across 150mm of the conductor to be used for the test. For tests using a Header terminal as one half of the test connection, refer to Section 5.1.5 and measure only 75 mm (recommended length for most applications) of the conductor.

NOTE: For attachment points exceeding 75mm per side, the extra wire resistance shall be measured and subtracted per step 8. Record the conductor resistance.

4. Choose the preferred method of taking measurements (e.g. soldered sense lead or probe) and document the method chosen. In either case, the sense point T_1 (Figure 5.3.1.3) must be soldered for all stranded cable. For Header type connectors, T_2 is attached to the Header terminal per Section 5.1.5. All millivolt leads must be no larger than 0.22 mm^2 (24 AWG).

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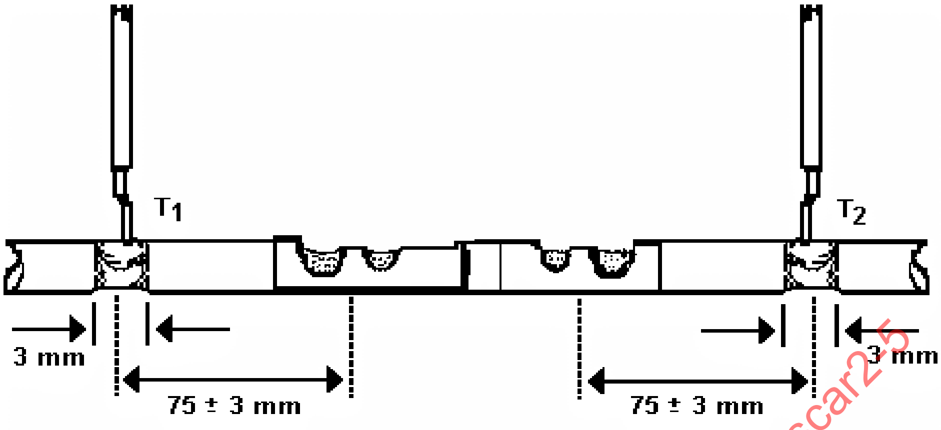
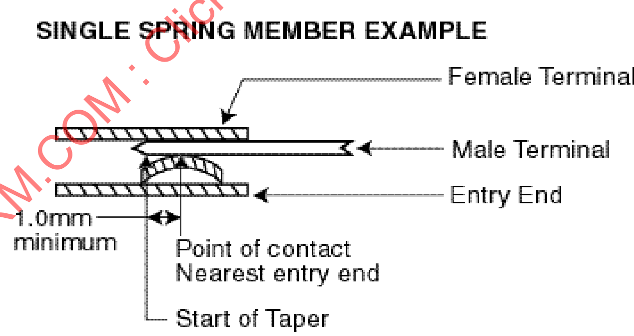


Figure 5.3.1.3: Typical Connection Resistance Millivolt Lead Locations

5. For purposes of this test, the Male Terminal must be inserted to a precise depth into the female. Standard practice is that, in the worst case, there must be at least 1mm of excess insertion between the rearmost contact point with the Female Terminal and the start of any lead-in taper on the Male Terminal, as illustrated in Figure 5.3.1.4. This dimension is to be calculated from the terminal drawings by the Authorized Person, taking into account the worst-case tolerances. Each Male Terminal is to be suitably marked so test personnel can make the one and only mating of the test terminal pairs to the correct depth. Score marks or any other marking that might introduce contaminants or alter the strength or conductivity of the Male Terminal or the interface are not permitted.



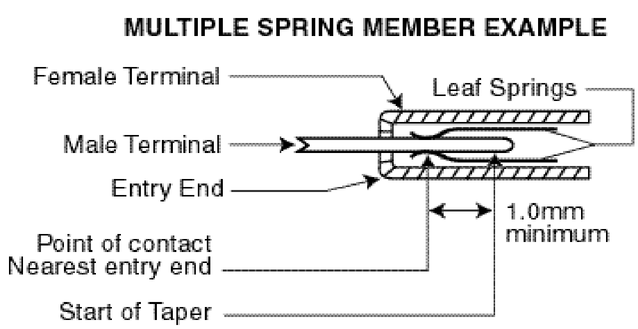


Figure 5.3.1.4: Terminal Insertion

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6. Prior to mating the test terminal pairs, provision must be made for mounting them on an electrically non-conductive surface in such a manner that the mechanical stability of the male to female interface can be maintained.
7. Carefully mate the test terminal pair to the appropriate depth, as specified in Step 5 above. Use caution to assure that mating is done along terminal centerlines to prevent side pressure that may distort either terminal. Secure the TUT to the mounting surface so that the correct insertion depth is maintained throughout the test.
8. Using the appropriate equipment, measure and record the resistance between T_1 and T_2, as shown in Figure 5.3.1.3. Then deduct the conductor resistance to find the total connection Dry Circuit resistance.
9. Verify conformance to the Acceptance Criteria of Section 5.3.1.4.

Note: Both initial and after test dry circuit resistance measurements are suggested. Initial values are for information only and do not have pass/fail requirements. These values can be used to compute resistance change.

5.3.1.4 Acceptance Criteria

The Total Connection Resistance calculated in Step 8 must not exceed the values listed in section 5.3.2.4.

For connectors with Shorting Bars, the change in connection series resistance of both contacts while in the “shorted” position shall be <40mΩ. Other requirements may apply depending on purpose of the shorting circuit.

5.3.2 Voltage Drop

5.3.2.1 Purpose

This test determines the voltage drop associated with the electrical resistance of the conductor crimp(s) and contact interface regions at nominal current conditions. This voltage drop is then used to calculate the Total Connection Resistance.

5.3.2.2 Equipment

⇨ Digital Multimeter (DMM)
⇨ DC Power Supply (0-20 VDC @ 0-150 A)
⇨ Current shunts

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5.3.2.3 Procedure

1. Prepare 20 (at least 10 male and 10 female) terminal samples per section 5.1.6, Terminal Sample Preparation, using the largest gage size conductor and insulation thickness applicable to the design of the terminal to be tested.
2. Complete the Connector and/or Terminal Cycling procedure per section 5.1.7 if not already performed on the sample set.
3. For purposes of this test, the Male Terminal must be inserted to a precise depth into the female. Standard practice is that, in the worst case, there must be at least 1mm of excess insertion between the rearmost contact point with the Female Terminal and the start of any lead-in taper on the Male Terminal, as illustrated in Figure 5.3.1.4. This dimension is to be calculated from the terminal drawings by the Authorized Person, taking into account the worst case tolerances. Each Male Terminal is to be suitably marked so test personnel can make the final mating of the test terminal pairs to the correct depth. Score marks or any other marking that might introduce contaminants or alter the strength or conductivity of either terminal or the interface are not permitted. Do not use the connector housings, even unsealed, to control terminal insertion since the housings will alter heat dissipation during testing. This will compromise test repeatability and will invalidate comparisons of data collected for various terminals.
4. Prior to mating the test terminal pairs, provision must be made for mounting them on an electrically non-conductive surface in such a manner that the mechanical stability of the male to female interface can be maintained.
5. Carefully mate the test terminal pair to the appropriate depth, as specified in Step 4 above. Use caution to assure that mating is done along terminal centerlines to prevent side pressure that may distort either terminal. Secure the TUT to the mounting surface so that the correct insertion depth is maintained throughout the test.
6. Assemble the test circuit shown in Figure 5.3.2.3, Current Resistance Test Set-Up. Adjust the power supply to provide the required test current of 5A per square millimeter of conductor cross section for the conductor selected in Step 1. Refer to SAE Standards J1127 and J1128 or USCAR-23 for the cross sectional area of the conductor selected. More than one terminal pair may be tested in series. Refer to Figure 5.3.1.3: Connection Resistance Millivolt Lead Locations, for placement of the millivolt test leads. Record the test current used.

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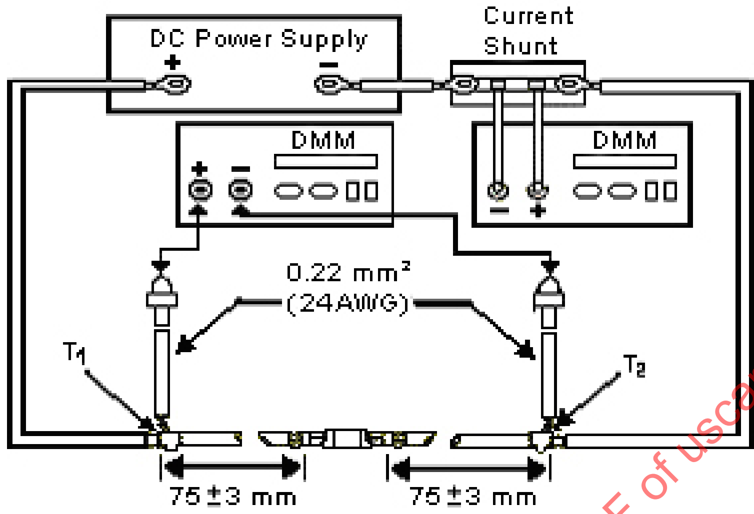

Figure 5.3.2.3: Typical Current Resistance Test Set-Up

7. Measure and record the millivolt drop across 150mm of the conductor size and insulation type to be used during the test, using the test current determined in Step 6. For testing Header type connectors, refer to Section 5.1.5 and measure the millivolt drop across only 75 mm of the conductor used.

NOTE: For attachment points exceeding 75+/-3mm per side, the extra wire resistance shall be measured and subtracted per step 10.

8. Choose the preferred method of taking measurements (soldered sense lead or probe) and document the method chosen. In either case, the sense point T_1 (Figure 5.3.1.3) must be soldered for all stranded cable. For Header type connectors, T_2 is attached to the Header terminal per Section 5.1.5. All millivolt leads must be no larger than 0.22 mm^2 (24 AWG).
9. Set the power supply for the current determined in Step 6 and wait 30 minutes minimum to ensure that the test current stabilizes at the appropriate value. Allow sufficient time for all other test equipment to warm and stabilize per the manufacturer's recommendations.
10. Using the test current determined in Step 6, measure and record the millivolt drop (mVD) readings between test points T_1 and T_2. Use these values in the equation below to calculate the voltage drop across the entire connection, including the crimp(s) and terminal interface. In the case of Header type connectors, T_2 is attached to the "tail" of the Header Connector per Section 5.1.5.

    mVD Entire Connection = mVD (T_1 - T_2) - [mVD Conductor (Step 7)]

    Total Connection Resistance = mVD Entire Connection ÷ Test Current

    Use these results to verify conformance to the Acceptance Criteria of Section 5.3.2.4.

NOTE: These values apply to both before and after environmental conditioning such as Thermal Shock, Temperature/Humidity Cycling, etc. or on field samples.

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5.3.2.4 Acceptance Criteria

Nominal Male Terminal Size[1]	Total Connection Resistance (mΩ) Maximum[3][4]
0.64mm	20.0[2]
1.5mm	10.0
2.8mm	5.0
6.35mm	1.5
> 6.35	1.5

(1) As defined by the male blade portion (width) of the TUT
(2) 10mΩ Max for terminals with precious metal contacts. (see Appendix A: Definitions)
(3) 1mΩ = 1mV/A
(4) Maximum allowable mVD = 50

Figure 5.3.2.4: Maximum resistance Values

NOTE: The "After Test" values are for "crimp - to - crimp" measurements (T_1 to T_2 in Figure 5.3.2.3 less the appropriate conductor resistance). For headers, the values are the “crimp – to – tail” (T_1 to T_2 in Figure 5.1.5) less the appropriate conductor resistance).

Note: Values for other terminal sizes between 0.64 and 6.35 are calculated by interpolation. Terminal sizes outside of this range are usually for specialized use. The requirements for these terminals shall be set by the Responsible Engineer. In no case may the Total Connection Resistance exceed 20 mΩ.

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5.3.3 Maximum Test Current Capability

5.3.3.1 Purpose

This test is used to determine the maximum test current at which a terminal system can operate in a Room Temperature environment before excessive thermal degradation and/or resistance begins to occur. Temperature Rise (Y axis) vs. Current (X axis) shall be plotted for each applicable conductor size. These graphs are NOT to be used for actual terminal application in a vehicle (see Appendix F). This test is conducted on terminals alone, thus eliminating the variation that may be introduced by variations in the heat dissipating characteristics of differing connector housing designs and sizes.

NOTE: A draft free environment is necessary to get accurate measurements.

5.3.3.2 Equipment

- ⇨ Digital Multimeter (DMM)
- ⇨ DC Power Supply (0-20 VDC @ 0-150 A)
- ⇨ Current shunts (Size as required, ± 1%)
- ⇨ Thermocouples (Type "J" or "T")
- ⇨ Data Logger (As required)

5.3.3.3 Procedure

1. Prepare 20 (at least 10 male and 10 female) terminal samples per section 5.1.6, Terminal Sample Preparation, using one of the conductor gage sizes and insulation thicknesses applicable to the design of the terminal to be tested.
2. Complete the Connector and/or Terminal Cycling procedure per section 5.1.7 if not already performed on the sample set.
3. Measure and record the voltage drop across 150mm of the conductor to be used for the test, using the expected Maximum Current Capability of the TUT in combination with that conductor size and insulation type. For testing Header type connectors, refer to Section 5.1.5 and measure the millivolt drop across only 75mm of the conductor used.
4. Assemble the circuit shown in Figure 5.3.3.3 in a draft free enclosure. Use at least 10 terminal pairs. Choose the preferred method of taking measurements (soldered sense lead or probe) and document the method chosen. In either case, the sense point T_1 (Figure 5.3.1.3) must be soldered for all stranded cable. Attach conductor ends of the terminal pairs to form one continuous series circuit and attach the thermocouples to each mated pair as shown in Figure 5.3.3.3. Attach the circuit to a non-conductive surface, such as wood or high temperature plastic, leaving a minimum of 50 mm between test samples.

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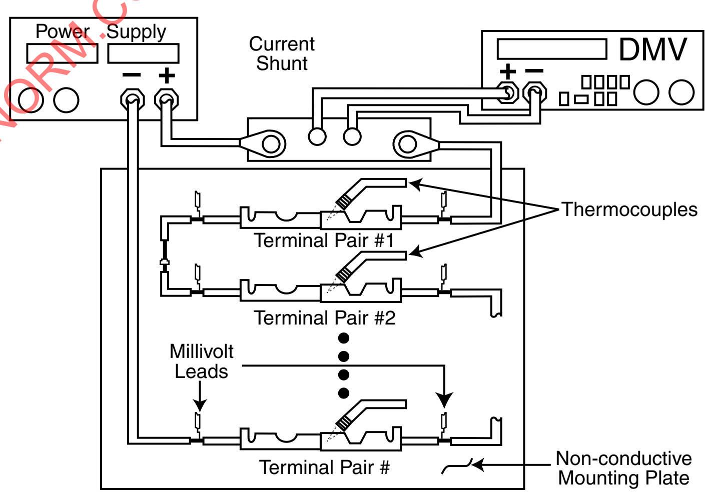

Figure 5.3.3.3: Set-Up for Maximum Test Current

5. Test the sample terminal pairs at 23°C +/- 5 °C (Room Temperature). The ambient temperature sensor must be placed on the same plane as the test samples, 30 to 60 cm from the nearest sample.
6. Adjust the power supply to zero amps output and then turn on the supply and the DMM's.
7. Slowly increase the power supply output until it is providing no greater than 50% of the expected Maximum Current Capability of the TUT.
8. Wait at least 15 minutes for the circuit temperature to reach Steady State. Then record the ambient temperature, the temperature of each terminal pair interface, and the millivolt drop across each terminal pair (T_1 to T_2 in Figure 5.3.1.3, less the millivolt drop of the conductor as determined in Step 3). Then calculate the resistance of the terminal pair interface.
9. Increase the current by no more than 10% of the expected Maximum Current Capability of the TUT and repeat Step 8.
10. Repeat Step 9 until 80% of the expected Maximum Current Capability of the TUT is met.
11. Continue to increase the current in increments of 5% of the expected Maximum Current Capability of the TUT, repeating Step 8 after each incremental increase.
12. For samples to be used in subsequent tests, repeat Step 11 until one of the following conditions occurs:
    a. The temperature of any terminal interface exceeds a 55 °C rise over ambient.
    b. The Total Connection Resistance of any terminal interface exceeds the "After Test" Acceptance Criteria listed in Section 5.3.2.4.
13. The maximum test current of the specific combination of the terminal and the wire conductor gage and insulation type used is then determined to be the current that produces an exact or interpolated value of 55°C rise in the first increment in which either the condition described in 12 a or 12 b above was achieved, less 10% of that value.
14. As an optional step, at the discretion of the Authorized Person for samples that will not be used in subsequent tests, continue to increase the current in steps of 5% of the expected Maximum Current Capability of the TUT until the thermal stability of any one or more samples can no longer be achieved. Data from this test to failure step may be useful for statistical purposes or for estimating safety margins.
15. Repeat Steps 1 – 13 or 14 for each conductor size and insulation type applicable to the TUT.
16. Graph the data with temperature on the Y-axis and current (in amps) on the X-axis for all conductor sizes and insulation types tested.

NOTE: That this data is NOT to be used as guidance for any actual application of the TUT, see APPENDIX F.

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5.3.3.4 Acceptance Criteria

Used to establish "Maximum Test Current" for the TUT:

1. The current required to raise the measured or interpolated temperature of the terminal to 55°C rise over ambient minus 10% of that current = Maximum test current or:
2. The current at which any sample exceeds the "After Test" Acceptance Criteria of Section 5.3.2.4. minus 10% of that current = Maximum test current.

5.3.4 1008 Hour Current Cycling

5.3.4.1 Purpose

This test simulates the main function of the terminal over the expected life of the vehicle. Current cycling is an accelerated aging test which electrically heats terminal interfaces and core conductor crimps, then allows them to cool under no current conditions, causing expansion and contraction that may affect connection resistance due to wear, oxidation, inter-metallic growth and stress relaxation.

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5.3.4.2 Equipment

⇨ Digital Multimeter (DMM)
⇨ DC Power Supply (0-20 VDC @ 0-150 A, timer controlled)
⇨ Current shunts (Size as required, ± 1%)
⇨ Thermocouples (Type "J" or "T")
⇨ Data Logger (As required)

5.3.4.3 Procedure

1. Prepare 60 (at least 30 male and 30 female) terminal samples per section 5.1.6, Terminal Sample Preparation, using one of the conductor gage sizes and insulation thicknesses applicable to the design of the terminal to be tested.
2. Attach the millivolt leads in positions T_1 and T_2 as shown in Figure 5.3.1.3. For Header type connectors, T_2 is attached to the Header terminal per Section 5.1.5. All millivolt leads must be no larger than 0.22 mm^2 (24 AWG).
3. Complete the Connector and/or Terminal Cycling procedure per section 5.1.7 if not already performed on the sample set.
4. Measure and record the voltage drop across 150mm of the conductor to be used for the test, using the maximum test current previously determined (Section 5.3.3.3, Step 13) for the combination of that conductor size, insulation type and the TUT. For testing Header type connectors, refer to Section 5.1.5 and measure the millivolt drop across only 75mm of the conductor used.

NOTE: For attachment points exceeding 75 mm per side, the extra wire resistance shall be measured and subtracted per step 10.

5. Assemble the circuit shown in Figure 5.3.3.3 in a draft free enclosure, except use a timer controlled power supply. Set the power supply to provide 45 minutes 'ON' and 15 minutes 'OFF' at the maximum test current previously determined (Section 5.3.3.3, Step 13) for the combination of that conductor size, insulation type and the TUT. Also connect a data logger to the voltage drop and thermocouple leads.

6. Test the set of sample terminal pairs at 23°+/- 5°C. (Room Temperature). An ambient temperature sensor must be placed on the same plane as the test samples, 30 to 60 cm from the nearest sample.
7. Turn 'ON' the power supply, DMM's, and data logger.
8. After 30 minutes into the first 'ON' cycle, record terminal crimp and interface millivolt drop readings (T_1 to T_2 in Figure 5.3.2.3) as well as thermocouple readings for each terminal pair.
9. Cycle for 1008 hours taking readings at least once daily or as specified by the test request/order, 30 minutes into the 'ON' cycle, and at the conclusion of the test, 30 minutes into the final "on" cycle. mV drop readings should be taken at maximum test current.
10. For each set of data, calculate and record the Total Connection Resistance by subtracting the conductor millivolt drop reading (Step. 4) from the T_1 to T_2 millivolt drop reading (Step 8) and dividing the result by the test current (Step 5).
11. Allow the samples to cool to ambient, then complete the Voltage Drop test section 5.3.2.
12. Verify conformance to the Acceptance Criteria of Section 5.3.4.4.

5.3.4.4 Acceptance Criteria

1. The temperature of any terminal interface must not exceed a 55 °C rise over ambient at any time during the test.
2. The calculated Total Connection Resistance must not exceed the "After Test" Acceptance Criteria in the table in Section 5.3.2.4 for any data set.

5.4 CONNECTOR - MECHANICAL TESTS

5.4.1 Terminal - Connector Insertion/Extraction Force

5.4.1.1 Purpose

This test is to ensure that the Insertion Force of a terminal into its connector cavity is not greater than the column strength of its associated conductor and is also low enough to allow easy and consistent production assembly. Extraction testing is to ensure that the terminal is retained in its housing with sufficient strength to withstand the rigors of the wiring harness and vehicle assembly processes.

5.4.1.2 Equipment

⇨ Insertion/Extraction Force Tester with Peak Reading Feature
⇨ Temperature/Humidity Chamber capable of 95 to 98% RH at 40ºC

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5.4.1.3 Procedure

A. INSERTION FORCE:

Un-sealed Connectors and Sealed Connectors with Individual Cable Seals

1. Prepare terminal samples per section 5.1.6, using the largest gage size conductor and insulation thickness applicable to the design of the terminal to be tested. For connectors with 10 or more terminal cavity locations, use a minimum of 3 connector housings and prepare at least one terminal for each cavity location. Test each terminal cavity location in the CUT at least once. For connectors with 4 ~9 terminal cavity locations, use a minimum of 3 connector housings and prepare enough terminal samples to test each cavity location in each CUT. For connectors with 3 terminal cavity locations use a minimum of 4 connector housings and prepare enough terminal samples to test each cavity location in each CUT. For connectors with 1 or 2 cavity locations use enough connector housings to obtain at least 10 data points and test all cavity locations an equal number of times. See table 5.4.1.3.1

Note: Use these sample sizes and cavity requirements for insertion, extraction, forward stop, and after conditioning force measurements.

# of Terminal Cavity Locations	Minimum # of CUTs	Minimum # of Terminal Samples	Cavity Locations Tested	Minimum # of Data Points
10 or more	3	= # of Terminal Cavity Locations	Each location at least once	= # of Terminal Cavity Locations
4 to 9	3	= # of Terminal Cavity Locations **X** # of CUTs	Each location 3 times or = # of CUTs or Each location an equal number of times	= # of Terminal Cavity Locations **X** # of CUTs
3	4	= # of Terminal Cavity Locations **X** # of CUTs	Each location an equal number of times	12
2	5	10	Each location an equal number of times	10
1	10	10	Each location an equal number of times	10

Table 5.4.1.3.1

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2. Repeat Step 1 using the smallest conductor size and insulation type applicable to the design.
3. Number each connector terminal cavity and, if applicable, each connector.
4. Secure the connector shell in an appropriate fixture.
5. Secure the terminal sample in the force tester by gripping the conductor a minimum of 20mm behind the insulation grip.
6. Adjust the force tester to insert the terminal straight into the connector at a uniform rate not to exceed 50 mm per minute. Upon reaching the forward stop, continue applying force until a minimum 50N of force is exerted or the wire buckles. Use a fresh terminal sample for each insertion and test each terminal cavity location until all terminal samples prepared in step 1 have been used.
7. Record the force required to insert the terminal into the connector for each terminal sample to be tested and verify conformance to the Acceptance Criteria of Section 5.4.1.4.

8. Repeat Steps 4 - 7 using the set of samples with the smallest conductor size and insulation type. It is not necessary to test the forward stop function per step 6 with the small gage samples.

Connectors with Multi-Cavity (Mat) type seals

1. Complete steps 1 – 3 above, except prepare at least one additional set of samples.
2. Complete steps 4 and 5 above.
3. Adjust the force tester to insert the terminal straight into the connector at a uniform rate not to exceed 50 mm per minute. Use a fresh terminal sample for each insertion and test each terminal cavity in the connector at least once. Upon reaching the forward stop, continue applying force until a minimum 50N of force is exerted or the wire buckles. Each test sample lead may be removed after its cavity is tested. This is to prevent possible seal distortion or compression that might affect test results if neighboring seal holes remain filled. For connectors with less than 10 cavities, use a new connector after each terminal cavity in the first connector has been tested and continue until at least 10 terminal samples have been used.
4. Use the extra set of samples prepared in Step 1 above. Using the force tester as in Step 3 above, load each terminal into a separate cavity without removing samples previously inserted. Perform the test in such a sequence that the last cavity to be tested is as centrally located as possible. In addition to the data required in Step 5 below, record the cavity number, the Insertion Force and the order in which the cavities were tested.
5. Record the force required to insert the terminal into the connector for each terminal sample tested and verify conformance to the Acceptance Criteria of Section 5.4.1.4.
6. Repeat Steps 4 - 5 using the set of samples with the smallest conductor size and insulation type appropriate to the design.

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B. EXTRACTION FORCE:

1. Prepare terminal samples per section 5.1.6, using the largest gage size conductor and insulation thickness applicable to the design of the terminal to be tested. For connectors with 10 or more terminal cavity locations, use a minimum of 3 connector housings and prepare at least one terminal for each cavity location. Test each terminal cavity location in the CUT at least once. For connectors with 4 ~9 terminal cavity locations, use a minimum of 3 connector housings and prepare enough terminal samples to test each cavity location in each CUT. For connectors with 3 terminal cavity locations use a minimum of 4 connector housings and prepare enough terminal samples to test each cavity location in each CUT. For connectors with 1 or 2 cavity locations use enough connector housings to obtain at least 10 data points and test all cavity locations an equal number of times. See table 5.4.1.3.1 Solder may be added to terminal crimps to assure accurate extraction readings. Connectors are to be tested in "dry as molded" condition and should be protected from high humidity and heat levels between the time they are molded and the time they are tested.
2. Number each connector terminal cavity in each connector housing so there are no duplicate cavity numbers among the housings used.
3. Install a terminal sample into each cavity in the connector being tested. For connectors with less than 10 cavities, use a new connector after each terminal cavity has been tested and continue until all 10 terminal samples have been used. Do not install the terminal lock (PLR, TPA, Wedge, etc.).

4. Secure the connector shell in an appropriate fixture.
5. Secure the terminal sample in the force tester by gripping the wire behind the back edge of the terminal.
6. Adjust the force tester to pull the terminal straight back from the connector. Straight back extraction is critical to avoid side loads and binding which can affect force measurements. Increase the pullout force at a uniform rate not to exceed 50mm/min, until pullout occurs.
7. Record the force required to pull the terminal out of each terminal cavity along with the cavity number and the connector number. If the conductor breaks or pulls out of the terminal grip before the terminal is pulled from the connector, record this force together with a note as to what happened.
8. Verify that the forces obtained in Step 7 above conform to the Acceptance Criteria of Section 5.4.1.4 for each cavity tested.
9. Using an additional set of new (moisture conditioned *) connectors, repeat Steps 1-8 above except install the terminal lock (PLR, TPA, Wedge, etc.). Begin the extraction test after one hour at ambient condition. Complete the test within eight hours of beginning the extraction testing.
   Note: Samples may be sealed in non-moisture transferable plastic (Zip-lock type food storage) bags after moisture conditioning if the testing cannot be completed within 8 hours. In any case testing must be completed within 24 hrs of moisture conditioning.

*Parts are brought to their practical limit of moisture content by exposing “dry as molded parts” to 95-98% Relative Humidity at 40ºC for 6 hours followed by one hour at room ambient temperature and humidity.

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5.4.1.4 Acceptance Criteria

Insertion:

1. The maximum Insertion Force for a terminal is 30 Newtons.
2. Neither the conductor nor the terminal may buckle during the test.*
3. The forward stop must withstand a push-through force of 50N or the column strength of the largest applicable conductor size, whichever is smallest.
4. The Forward stop must withstand a force greater than the force required to insert the terminal into its cavity.

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:

Terminal Size[1]	Max. Blade Width (mm)	Primary Lock (Newtons)	Primary and Secondary Lock[2] (Newtons) per step 5.4.1.3.-B 9,10. After Moisture Conditioning	Primary and Secondary Lock (Newtons) after Temp/Humidity (section 5.6.2)
0.64	1.2	30	60	50
1.5	1.8	45	70	50
2.8	3.0	60	90	50
6.3	6.5	80	120	50
9.5	9.7	100	150	50
>9.5	>9.7	100	200	50

Table 5.4.1.4: Terminal-Connector Minimum Extraction Force

[1] USCAR terminal sizes. Use maximum blade width to determine minimum extraction requirement .
[2] Includes connectors not designed for use with secondary lock.

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Note: Following is the purpose for the various values of terminal extraction force.

- Primary lock only (minimum value) is a harness manufacturing requirement.
- Primary and secondary lock (minimum value) is a vehicle assembly requirement.
- After temperature humidity cycling (minimum value) is an end of life requirement.

5.4.2 Connector-Connector Mating/Unmating Force (Non-mechanical Assist)

5.4.2.1 Purpose

This test determines the mating/Un-mating Forces associated with manual mating and un-mating of complete connector assemblies. Mating Forces are an important consideration in determining the suitability of a given connector design for use in production. Un-mating Forces are important in determining serviceability of the design and ensuring the connection will stay mated for the service life of the vehicle.

5.4.2.2 Equipment

⇨ Insertion/Extraction Force Tester.

5.4.2.3 Procedure

A. MATING FORCE

1. Using any applicable conductor size and insulation type, prepare enough samples of male and Female Terminals to fully populate a minimum of 15 connector assemblies per section 5.1.6, Terminal Sample Preparation. (at least 15 male and 15 female halves)
2. Completely assemble (but do not mate) all connector halves (both male and female) using all applicable components such as terminals, wedges, and seals.
3. Number each connector assembly.
4. Secure the connector halves (one male and one female) in the appropriate fixtures of the force tester. Adjust the force tester to insert the Male Connector straight into the Female Connector. Straight-in engagement is critical to avoid side loads and binding which can affect force measurements.

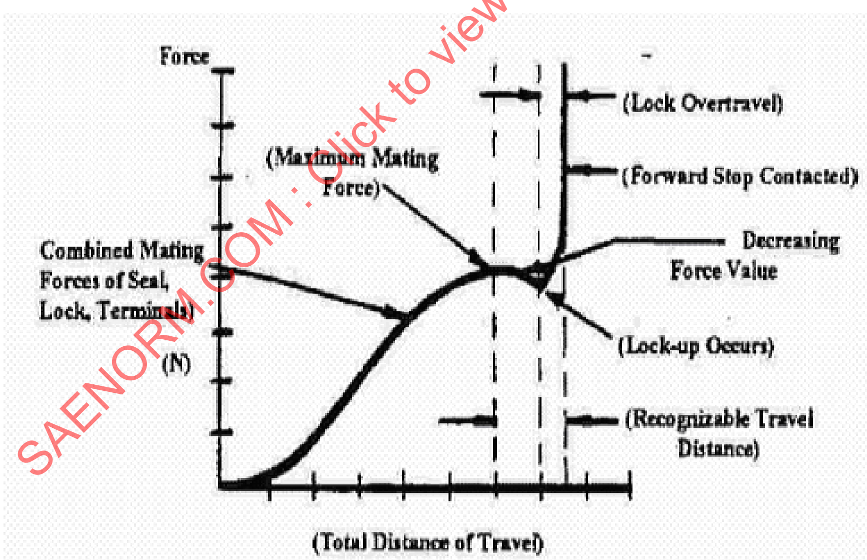

Figure 5.4.2.3: Typical Connector Mating Force Curve

NOTE: If appropriate equipment is available, a continuous graph of applied Mating Force vs. Insertion distance is highly recommended. A properly designed connector (and sealing system where applicable) should produce a graph showing a smooth rise to a single peak force, then a fall off until the connector is fully mated. If the graph shows more than one force peak, the potential for a false lock condition exists.

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5. Increase the Mating Force at a uniform rate 50+/- 10mm/min. until complete mating occurs. Test all samples.
6. Record the force required to completely mate each set of connector halves into their locked position and use these values to verify conformance of each connector pair to the Acceptance Criteria of Section 5.4.2.4.

B. UNMATING FORCE

1. Prepare an additional 15 connector pairs by mating the male and female connectors. This test will be conducted without terminals or wires .
2. Five samples are to be tested with the connector primary locking mechanism (without CPA) fully engaged. For this group, completely un-mate the connector halves by applying a uniform force parallel to the centerlines of the fully mated connector halves. The force tester must be configured to apply the Un-mating Force directly to the connector halves. Straight-out un-mating is critical to avoid side loads and binding which can affect force measurements. For connectors with lock arms that protrude above the protective ribs and have no protective bridge, run this test with the lock arm deflected to make it level with the protective ribs.

*** CAUTION ***

The following step will result in sample breakage. Adequate shielding and personnel safeguards must be employed to ensure the safety of persons and property in the vicinity of the test.

3. Increase the Un-mating Force at a uniform rate not to exceed 50mm/min. until complete separation occurs. Test all samples in the first group.
4. Record the force required to completely separate the connector halves and verify conformance to the Acceptance Criteria of Section 5.4.2.4.
5. Repeat Steps 2, 3 and 4 above using 5 samples except completely remove/disable the primary connector locking mechanism(s).
6. For the remaining 5 samples , apply a force of 70N to the lock mechanism and attempt to un-mate the connection. This force is applied at the appropriate point such that the mated connector halves (or a connector mated to a device) could be unmated in the intended manner with no damage to any component. Note whether the connection can be successfully un-mated. Record results and verify conformance to the appropriate Acceptance Criteria of Section 5.4.2.4.

Note: substitute force values from the part drawing when available.

5.4.2.4 Acceptance Criteria

NOTE: The maximum mating effort is meant to simulate assembly in a vehicle when the assembler's body position and access to the connector being mated is not physically restricted. This specification will cover most operations, but not all conditions of vehicle assembly and connector location can be anticipated.

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NOTE: The forces specified in the Acceptance Criteria must be met regardless of the moisture content of the connector housing material. Consult the test request/order to determine if any conditioning of the test samples is required prior to testing.

NOTE: The acceptance criteria of this section varies with the available contact (grip) area of the connector being tested. Reference SAE/USCAR-25 Electrical Connector Assembly Ergonomic Design Criteria for details of the acceptance criteria.

1. Mating (engage) force shall meet the requirements of SAE/USCAR-25.
2. Un-mating Force must be ≤ 75 Newtons with the primary connector lock completely disengaged/disabled.
3. Un-mating Force must be ≥ 110 Newtons with the primary connector lock fully engaged. A CPA device, if provided for, must NOT be engaged during this test.
4. The force to completely disengage the primary connector lock must meet the value shown on the part print. If no value is given, the force to disengage the latch is ≤ 70N without the CPA engaged in its fully seated position.

Note: Connector designs where it is difficult to apply pressure to the latch while un-mating the connectors it is permissible to visually confirm the latch will clear the locking feature with 70N applied to the locking provision.

5.4.3 Connector to Connector Mating and Un-mating Forces (Connectors with Mechanical Assist)

5.4.3.1 Purpose

This test covers mating and un-mating forces for Mechanical Assist connectors such as lever and slide lock. USCAR-25 Ergonomic guidelines should be used as a further reference.

5.4.3.2 Equipment

- ⇨ Force tester
- ⇨ Fixtures for holding connectors as required.

5.4.3.2.1 Samples

Tests A, B, and C: Using any applicable conductor size and insulation type, prepare enough samples of male and Female Terminals to fully populate connector assemblies per section 5.1.6, Terminal Sample Preparation.
Prepare connector samples with the full compliment of wires, terminals, and secondary pieces as specified in the design and intended for the production application. A minimum of 10 samples is required to be tested in each section below. Samples may be used for multiple tests.

Test D: Prepare 6 connector pairs by mating male to female housings without terminals or wires.

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5.4.3.3 Procedure

A. FORCE TO ENGAGE TO PRE-LOCK POSITION

1. Using the force tester, engage each connector fully to its pre-lock position. The pre-lock position is defined as the point where the connector is positioned on the mating part and the mechanical assist is ready to be activated. Connectors are normally held in the pre-lock position by detents.

2. Reverse the direction and measure the force required to un-seat the connector from the pre-lock position.
3. Verify conformance to the acceptance criteria of section 5.4.3.4-1 and 2.

B. FORCE TO RELEASE LATCH FROM PRE-STAGE POSITION

Note: Connectors may be required to be shipped as part of a wiring assembly with levers or mechanical slides locked in the “open” or “pre-stage” position. This eliminates un-necessary operations at the vehicle assembly plant. This part of the test procedure measures the ability of the connector mechanical assist to remain open during shipping and handling.

1. Using the unmated lever connector, place lever or slide in its shipping (open) position.
2. Using the force tester, gradually apply a force of 50N in a direction so as to move the lever toward the lock position.
3. Verify conformance to the acceptance criteria of section 5.4.3.4-3.

C. LEVER ACTUATION/REMOVAL FORCE

1. With the connector in its pre-stage condition, measure the force required to fully actuate and close the lever. Force shall be applied perpendicular with the contact surface of the lever or slide as nearly as possible.
2. For designs with a secondary release mechanism, without disabling or releasing this feature, gradually apply a force of 60N to the lever in the release direction.
3. Disable or release any existing release mechanism (if applicable) and record the force required to move the lever from the locked position to the open position.
4. Verify conformance to the acceptance criteria of section 5.4.3.4-4 and 5.

D. CONNECTOR TO DEVICE OR CONNECTOR TO CONNECTOR LATCH RETENTION FORCE.

1. Mount the mated connectors in a fixture so as not to distort the housings or any of their associated parts. With connector to connector locking feature **enabled**, pull the connectors apart at a rate of 50mm/minuite +/-10mm/min using a suitable force tester and measure the peak force required to separate the connectors. CPAs and or secondary locks shall be disabled for this test. Repeat on 4 additional samples. (Test 5 samples) Verify conformance to 5.4.3.4-6

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2. Mount one mated connector in a fixture so as not to distort the housings or any of their associated parts. With connector to connector locking feature **disabled**, pull the connectors apart at a rate of 50mm/minuite using a suitable force tester and measure the peak force required to separate the connectors. CPAs and or secondary locks shall be disabled for this test. Verify conformance to 5.4.3.4-7

5.4.3.4 Acceptance Criteria

Note that the acceptance criteria of this section varies with the available contact (grip) area of the connector being tested. Reference SAE/USCAR-25 Electrical Connector Assembly Ergonomic Design Criteria for details of the acceptance criteria.

1. The force to engage the connector to its pre-lock position shall meet the requirements of SAE/USCAR-25.
2. The force required to un-seat the connector from its pre-lock position shall be ≥15 and ≤75.
3. The force required to move the lever or slide from its shipping position while the connector is not in its pre-lock position shall be 50N minimum.
4. The force required to move the lever to and from the locked (engaged) position shall meet the requirements of SAE/USCAR-25.
5. The minimum force to release the assist feature without depressing the release mechanism (if applicable) shall be ≥60N for a fully mated connector
6. Un-mating Force must be ≥ 110 Newtons with the primary connector lock fully engaged. A CPA device, if provided for, must NOT be engaged during this test.
7. Un-mating Force must be ≤ 75 Newtons with the primary connector lock completely disengaged/disabled.

5.4.4 Polarization Feature Effectiveness

5.4.4.1 Purpose

This test ensures that the polarization feature(s) is adequate to meet its intended purpose of preventing incorrect mating of a connector housing with its intended mate, and preventing mating of a connector housing with any unintended mate. It also tests the adequacy of the polarization feature(s) in preventing terminal damage during incorrect assembly attempts. In addition to this objective force test, a jury evaluation shall be conducted among knowledgeable individuals trying "hands-on" mis-mating. This jury will focus on tilting, torqueing, and mis-aligning during mating to evaluate the effectiveness of the polarization features.

5.4.4.2 Equipment

⇨ Insertion/Extraction Force Tester with Peak Reading Feature

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5.4.4.3 Procedure

1. Two factors must be considered: attempting to incorrectly mate two connector halves, or a connector half and a header that are supposed to mate if properly oriented, and attempting to mate a connector with an incorrect mate.
2. Sample size varies depending on the number of incorrect orientations tested. Test at least one sample set for each selected mis-orientation or mis-index.
3. No terminals are required for this test of the polarizing feature(s). However, a suitable mechanical or electrical means must be devised to detect penetration of one half of the CUT into the other to a depth sufficient to contact any Male Terminal in any position if that Male Terminal was installed.
4. Orient the CUT with any possible mate in the same family in one or more incorrect orientations chosen by the Authorized Person as most likely to defeat the polarization. The parts should be tested as follows, using a fresh sample of each half for each orientation:
   a. The correct orientation, but with the wrong index
   b. The incorrect orientation
5. Secure the connector halves (or connector and header) (one male and one female) in the appropriate fixtures of the force tester. Adjust the force tester to attempt insertion of the Male Connector into the Female Connector in the orientation selected in Step 3.
6. Engage the connector halves at a uniform rate not to exceed 50mm/min. until the maximum force specified in the part drawing is applied. If no value is specified, apply a maximum force of 150 N or 3 X (minimum) the average value of properly mated connectors. Note the indication of the penetration detection device installed in Step 3.

5.4.4.4 Acceptance Criteria

The connection system must withstand either a minimum mis-mating force of 150 N or 3 times the average value measured on a fully loaded, properly mated connector without damage to the connector that would prevent subsequent proper mating.

If sufficient mis-mating is achieved to allow contact with any properly installed Male Terminal in any position in its connector housing, the polarizing feature(s) is considered to be inadequate.

5.4.5 Miscellaneous Component Engage/Disengage Force

5.4.5.1 Purpose

This test is to ensure that connector assembly components such as TPAs, PLRs, CPAs, Locator Clips, etc. will be sufficiently retained, yet allow easy and consistent assembly and removal for service where necessary.

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5.4.5.2 Equipment

⇨ Insertion/Extraction Force Tester with Peak Reading Feature

5.4.5.3 Procedure

A. ENGAGEMENT FORCE

1. Completely identify and number each component to be tested. A minimum of 10 samples is required to be tested for each of the applicable conditions found in the acceptance criteria. The same samples may be used for various phases of testing.
2. All components to be tested and their mating parts must be fixtured so that proper alignment is maintained during testing. Straight-in engagement and extraction is critical to avoid side loads and binding which can affect force measurements.
3. Engage each component to be tested, with its retaining mechanism(s) in place, at a uniform rate not to exceed 50 mm/min. Test each applicable condition per table 5.4.5.4.
4. Record the force required to completely engage the component with its mating part and use this value to verify conformance to the Acceptance Criteria of Section 5.4.5.4.

B. DISENGAGING FORCE

*** CAUTION ***

The following step may result in sample breakage. Adequate shielding and personnel safeguards must be employed to ensure the safety of persons and property in the vicinity of the test.

1. With the component fully installed and properly fixtured, disengage the component at a uniform rate not to exceed 50mm/min. The force must be applied parallel to the centerline of the component being tested to avoid side loads and binding which can affect force measurements. The direction must be opposite to the direction of normal insertion of the component part. Test each applicable condition per table 5.4.5.4.
2. Record the force required to disengage the component from its mating part and use this value to verify conformance to the Acceptance Criteria of Section 5.4.5.4.
3. For locator clips only, repeat Step 1 above in each of the three directions 90°, 180°, and 270° from the initial insertion direction. Then repeat Step 1 in a direction orthogonal to the plane of the first four tests. Do not exceed a force of 110N for any of these subsequent tests.

Note: Use fixture identified in Figure 5.7.2.3-A&B

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5.4.5.4 Acceptance Criteria

Insertion/Extraction Forces shall meet the values indicated on the part print. If no value is specified, the force shall meet the values shown in table 5.4.5.4.

	Force (N)			
	Insertion		Removal	
Device	Insert to lock	Pre-set to lock	Lock to pre-set	Remove
Component with positive retaining feature such as locator clip, wire dress, etc.	60 max	N/A	N/A	110 Minimum (Also see section 5.7.2), Connector mounting feature mechanical strength.)
CPA	60 Min (w/connectors un-mated) 22 max w/connectors mated (loose pc. CPA)	60 Min (w/connectors un-mated) 22 Max w/connectors mated	10 Min. 30 Max.	60 min.
TPA/PLR	60 Max (w/terminals installed in all available cavities)	60 Max (w/terminals installed in all available cavities) 15 Min(w/o terminals)	60 Max (w/terminals installed in all available cavities) 18 Min after initial removal	25 Min

Table 5.4.5.4: Misc. Component Assembly/Dis-assembly Forces

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5.4.6 Vibration/Mechanical Shock

5.4.6.1 Purpose

This test subjects a connector system to variable vibration simulating accelerated exposure to actual vehicle conditions. Vibration and shock can cause wear of the terminal interfaces, intermittent electrical contact and failure of mechanical components of the connector system.

Note that three vibration "profiles" are available. One (5.4.6.3-D) is for components actually mounted on the engine/transmission or on brackets, components, etc. that are directly attached to the engine/transmission and vibrate with it. The second (5.4.6.3-E) is for components mounted everywhere else on the Sprung portion of the vehicle. The third (5.8.2.3-A) is a severe vibration profile that should be considered for sealed systems only. Severe vibration is an optional test and may be specified in the test plan by an authorized person. Unless a special vibration "profile" is specified in the test request/order, the appropriate profile must be used according to the intended location of the CUT on the vehicle.

Since unsealed connectors are not suitable for use outside the passenger and luggage compartments, they would normally be tested only to the non-engine/transmission profile. Sealed connectors may be used in applications requiring direct attachment to the engine/transmission, so they should normally be qualified to the harsher vibration profile.

NOTE: This section does not apply to components mounted on un-sprung portions of the vehicle, such as the wheel hub. Components mounted on un-sprung portions of the vehicle require special testing to ensure they can survive and function properly in the intended application.

5.4.6.2 Equipment

- ⇨ Vibration Table
- ⇨ Vibration Controller
- ⇨ Accelerometers

Map each table /cube or head expander combination.

Typical mapping procedure, Set up note:

When setting up to perform the vibration and mechanical shock test the placement of the control accelerometer will be determined as follows.

Step 1. With the table, cube and or head expander to be used in this test in place, create a map of the vibration equipment by measuring the equipment resonance in at least 5 places as far apart as practical. (see figure 5.6.4.2) No additional mounting features or brackets will be on the equipment for this mapping step.

Step 2 Determine the point of lowest resonance. This is defined as the mid point between the points of lowest measured resonance.

Step 3. The control accelerometer shall be mounted at the point of lowest resonance. Note: Other mapping procedures and control locations are acceptable but must be documented in the test report and must be approved by the authorized person.*

* See scope statement regarding authorized person.

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Other requirements:

- ⇨ Use tri axis accelerometer or sequentially rotate single axis accelerometers for the mapping process.
- ⇨ The cross axis resonance must be no greater than 30% of the control resonance.*
- ⇨ The on axis resonance measured in step 1 must not vary more than 15%.
- ⇨ The mapping procedure used shall be documented in the test report and will include frequency, acceleration, profile (random or sine sweep), and accelerometer locations.

*See Appendix A: Definitions

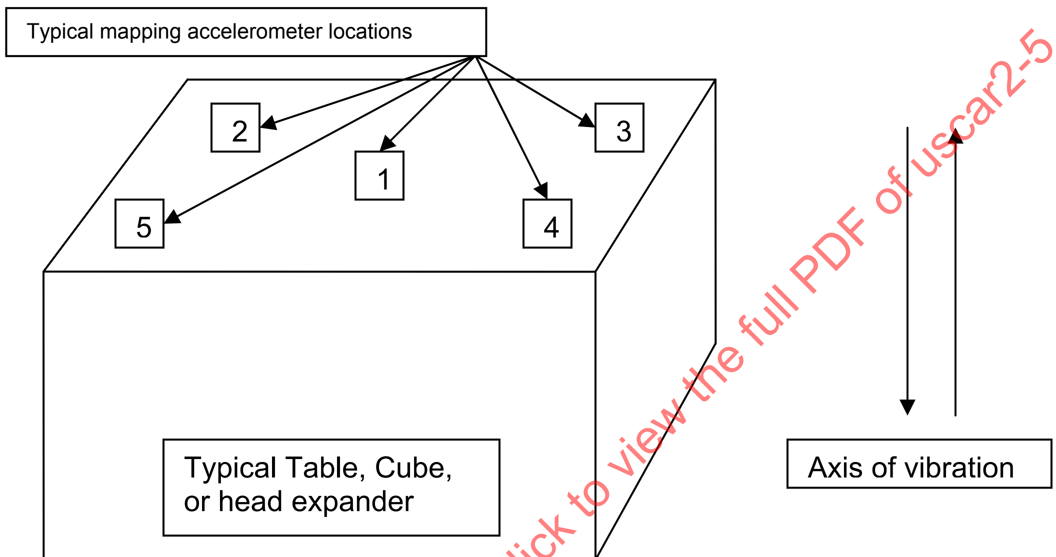

Figure 5.4.6.2 Typical Mapping Accelerometer locations

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5.4.6.3 Procedure

1. Using the largest applicable conductor size and insulation type applicable to the design, prepare enough male and Female Terminals to fully populate a minimum of 10 connector assemblies per section 5.1.6, Terminal Sample Preparation. Prepare each sample by assembling all applicable parts and bundling (with tape, convolute, scroll, etc.) the conductors. Consult the Authorized Person for details on intended bundling. Refer to Fig. 5.4.6.3 for examples of test mounting arrangements. Mounting position A is for in-line type connectors. Position B is for connectors that will mate to an electrical device. At least 10 samples are required unless otherwise specified in the test request/order.
2. Complete the Connector and/or Terminal Cycling procedure per section 5.1.7 if not already performed on the sample set.
3. Verify conformance of each sample connector assembly to the Acceptance Criteria of the Dry Circuit Resistance test, Section 5.3.1.4. Measure at least 10 terminal pairs randomly distributed among the connector sets.

4. Construct a suitable mounting apparatus using the following design criteria:
   See set up note in section 5.4.6.2 for control accelerometer placement.
   a. The mounting apparatus must be constructed and secured to minimize added effects (harmonics, dampening, resonance, etc.).
   b. For In-Line Connectors, mount the mated connector pair directly to the Mounting Bracket using the connector feature provided for mounting. Refer to Figure 5.4.6.3-A. Do not use a "Christmas Tree" or any other type of mounting device. Instead, the Mounting Bracket itself must be constructed so as to include a direct mounting feature to mate with the mounting feature (Dovetail) on the mated connector pair.
   c. For Device Connectors, mount the device directly to the Mounting Bracket. Refer to Figure 5.4.6.3-B. Use the normal device mounting feature(s) used to secure the device in its intended vehicle location. Do not use any intervening bracket or mounting device. Instead, the Mounting Bracket must be fabricated to include any cooperating features necessary to mount the device directly to it.
   d. The conductor attachment points must be 100mm +/-10mm from the rear of the connector body. See figure **5.4.6.3-C**
5. Should an application arise that does not lend itself to either situation described above, consult the Authorized Person. It is his or her responsibility to devise a suitable method for attaching the CUT as directly and firmly as possible to the Mounting Bracket consistent with the intended vehicle mounting.
6. Securely attach the conductor bundle ends to the mounting fixture such that there is a 10 ± 5 mm sag relative to the bisecting plane of the attachment points. See Figure 5.4.6.3-C.
7. Divide the test samples into two groups of 5. The first group shall be used for dry circuit measurement at the end of the vibration and mechanical shock exposure. The second group shall be set up and monitored continuously for discontinuity per section 5.1.9. On connectors with up to 10 cavities, all cavities shall be monitored on the 5 samples. On connectors with more than 10 cavities, all terminal cavities must be represented in the 5 samples, with a minimum of 50 terminals monitored. The chosen cavities shall be evenly distributed across the connectors.

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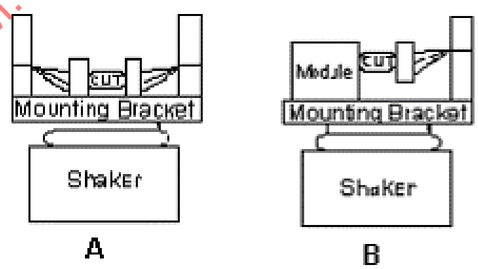

Figure 5.4.6.3- A & B: Mounting Positions

NOTE: It is vital to secure the conductors to their respective connector housings. Terminals "float" in their cavities and will wear rapidly if the associated conductors are allowed unrestrained movement relative to the connector housing. See 5.4.6.3-C

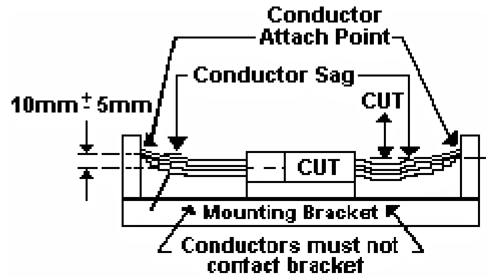

Figure 5.4.6.3-C: Typical Connector Vibration Test Set-up

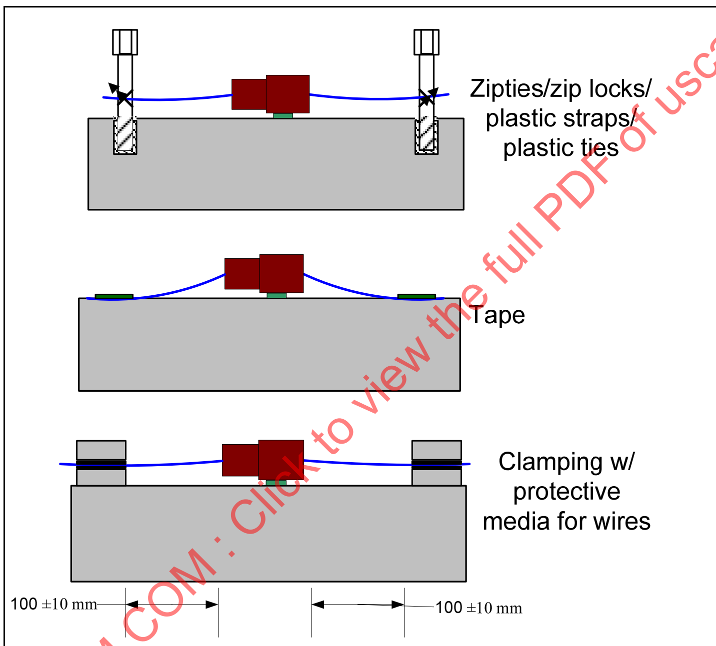

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Figure 5.4.6.3-C continued: Typical wire attachment Test Set-up

8. The test fixtures, system layout, and test set-up must be approved by the Authorized Person prior to testing.
9. Subject the CUT to 10 positive half-sine wave pulses (5~10 millisecond duration at 35 Gs force) in each of the three mutually perpendicular axes. Mechanical shock and vibration testing may be completed in sequence for each axis before proceeding to the next axis.
10. Unless otherwise specified in the test request/order all CUTs mounted directly to the engine or transmission shall be vibrated for 8 hours in each of the three mutually perpendicular axes (X,Y,Z). Vibrate the CUT using the vibration profile in Fig. 5.4.6.3-D.
11. CUTs mounted anywhere else on the Sprung portions of the vehicle, including the engine compartment (but not directly on or to the engine or transmission) use Figure 5.4.6.3-E. Vibration shall be 8 hours in each of the three mutually perpendicular axes (X,Y,Z) unless otherwise specified in the test request/order.
12. Age the samples for 48 hours at ambient conditions.
13. Record the results, inspect the CUT, and verify conformance to the Acceptance Criteria of Section 5.4.6.4.

Frequency (Hz)	Power Spectral Density (g^2/Hz)
60.0	0.00100
200.0	1.50000
210.0	0.10000
1200.0	0.10000
Grms = 12.1	

Figure 5.4.6.3-D All Sprung Portions of Vehicle Coupled to Engine

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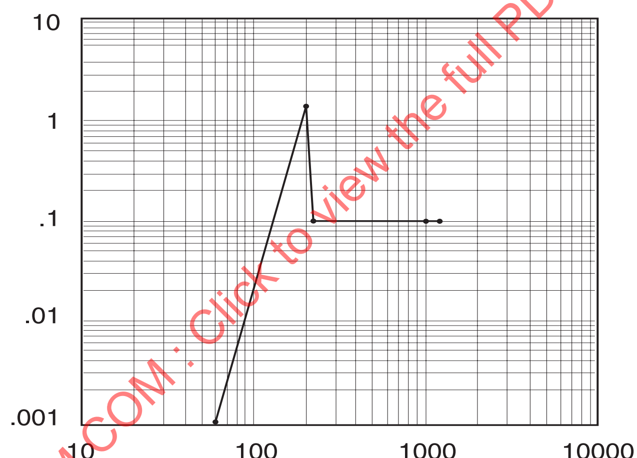

Figure 5.4.6.3-D (cont.): For Components Coupled to Engine (Vibration class 2)

Frequency (Hz)	Power Spectral Density (g^2/hz)
5.0	0.00200
12.5	0.24800
77.5	0.00320
145.0	0.00200
200.0	0.01180
230.0	0.00032
1000.0	0.00002
Grms = 1.81	

Figure 5.4.6.3-E: All Sprung Portions of Vehicle Not Coupled to Engine

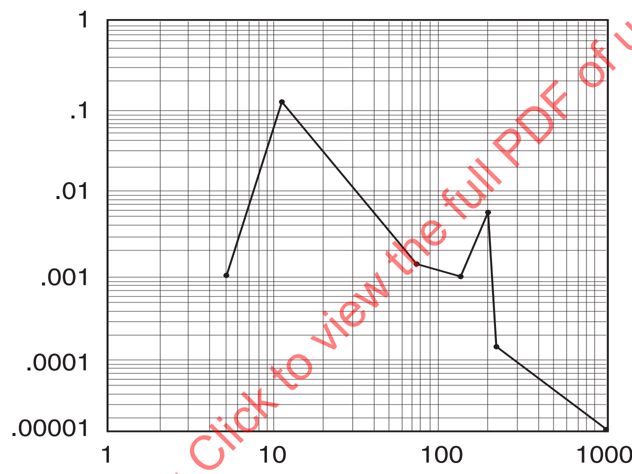

Figure 5.4.6.3-E (cont.): Components Not Coupled to Engine. (Vibration class 1)

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5.4.6.4 Acceptance Criteria

At the conclusion of the test, verify conformance of each terminal pair and each sample connector assembly, as appropriate, to the Acceptance Criteria of section 5.1.9.4 (Continuity Monitoring) and to the following tests:

1. After 48 hours at ambient conditions, terminals must meet the Acceptance Criteria of the Dry Circuit Resistance test of Section 5.3.1.4. Measure at least 10 terminal pairs randomly distributed among the connector sets.
2. Terminals must meet the Acceptance Criteria of the Voltage Drop test, Section 5.3.2. Check the same terminal pairs as in step 1 above.
3. The connector assembly must not show, with the aid of 10X magnification, any evidence of deterioration, cracks, deformities, etc. that could affect its functionality or severely degrade its appearance.
4. The terminals must not show, with the aid of 10X magnification, any evidence of deterioration, cracks, deformities, excessive plating wear, etc. that could affect their functionality.

5.4.7 Connector-to-Connector Audible Click

5.4.7.1 Purpose

Studies show that assembly plant technicians depend on audible queues that indicate full seating of electrical connectors regardless of background noise. This test measures the level of noise generated when two connectors are mated. Connectors are mated by hand for this test rather than being clamped into a fixture which could dampen or amplify the sound. Because ambient sound conditions vary between or within vehicle assembly locations, the results of this test should only be used to compare connectors or connector families to other connectors.

5.4.7.2 Equipment

⇨ dB meter

5.4.7.3 Procedure

16 sample pairs are required. (2 groups of 8) Samples are to be production intent. The connector cavities shall be not be populated with terminals. Include all TPAs, seals, stuffers and auxiliary pieces as applicable.

1. Measure and record the dB (A) level of the ambient sound within the test environment. The ambient noise level must be between 30 and 50 dB (A)..
2. Locate the sound measuring device or microphone 600+/-50mm from the connector.
3. Mate the connectors in group 1 by hand and measure the dB (C) level of the sound generated as the lock engages. Do not bias the connectors toward or away from the latch as they are engaged.
4. Repeat Steps 1 through 3 using the group 2 connectors, post moisture conditioning. Parts are brought to their practical limit of moisture content by exposing “dry as molded parts” to 95-98% Relative Humidity at 40ºC for 6 hours (minimum), then completing the test within 30 minutes.

5.4.7.4 Acceptance Criteria

The values measured in this test shall be documented in the test report. These values should be considered for information only and are used to compare connector designs or to assist in the connector selection/wire harness design process.

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5.4.8 Connector Drop Test

5.4.8.1 Purpose

This test evaluates the ability of the connection to withstand impact due to dropping on a hard surface. This test does not apply to headers or any other connector not designed for use in a wiring harness.

5.4.8.2 Equipment

No specific equipment is required.

5.4.8.3 Procedure

1. 10 samples are required. Assemble connectors with all parts to be used in the intended application (CPA, TPA, PLR, etc). Do not insert leads or terminals
2. Drop each sample 3 times (or as agreed upon by the supplier and user) onto a horizontal concrete surface from a height of 1 meter, orienting the sample in various directions each time. The Responsible Engineer may direct specific orientations in order to expose areas of the design that may be vulnerable to damage.

5.4.8.4 Acceptance Criteria

Samples shall meet the Acceptance Criteria of section 5.1.8, Visual Inspection.

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5.4.9 Cavity Damage Susceptibility

5.4.9.1 Purpose

This test is intended to demonstrate resistance to damage when the connector TPA/PLR is forcefully inserted on a connector with one or more terminals in the incorrect (un-seated) position. The cavity and other plastic and metal parts must subsequently be able to be assembled correctly and retain full function following such an event. This procedure does not apply to connectors where the TPA is designed to push the terminal into its seated and locked position or to TPAs that are designed such that their mating direction interferes or is perpendicular with a terminal that is unseated.

5.4.9.2 Equipment

Force tester

5.4.9.3 Procedure

1. Samples consist of five connectors with terminal secondary locks in the un-seated position and five leads terminated with each terminal size in the connector.
2. Randomly select one cavity of each terminal type from each sample for testing.
3. Determine the force to be applied to the secondary lock by adding 40N to the maximum force required to seat the device when all terminals are located properly (section 5.4.5.3 A, step 4). The minimum force is 80N for ≥1.5 nominal size terminals and 60N for <1.5 terminals.
4. Partially insert a terminated lead into the selected cavity. The terminal should be inserted until it is just short of locking into position. While holding the terminal in this position, apply a force as determined in step 3 to the terminal secondary lock in the direction of normal seating. Record whether the TPA seated and locked.
5. Remove the force and seat the terminal in its normal position. Seat the secondary lock.

5.4.9.4 Acceptance Criteria

1. When the force in step 4 is fully applied, the TPA must not seat in its final position.
2. Verify that terminal retention meets the extraction forces in table 5.4.1.4. Moisture conditioning is not required.

5.4.10 Terminal/Cavity polarization test

5.4.10.1 Purpose

This test is conducted to ensure that the design of the cavity and terminal polarization features will prevent insertion of the terminal in any incorrect orientation. This procedure is not required for multi-directional (round) or other designs where the terminal is meant to plug and lock in any (360^{o}) orientation.

Note: Mechanical equipment may not simulate the action of an operator to finesse terminals and connectors during assembly. Therefore, in addition to this procedure, a jury evaluation shall be conducted and documented to show that it is not reasonably possible to incorrectly assemble terminals to connectors. A summary of the results shall be included in the test report.

Note: Surrogate data may be used to fulfill the requirements of this test. If surrogate data is used, the design of the cavity, terminal, cable, and all materials (except terminal plating) shall be identical. Other factors such as connector wall thickness, double or single row, etc. may also influence the test outcome. The Responsible Engineer shall determine the need for individual testing in such cases.

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5.4.10.2 Equipment

Insertion Force Tester with peak reading feature and fixtures or jigs as necessary.

5.4.10.3 Procedure

1. By analyzing the cavity and terminal design, choose the incorrect terminal orientations to be tested. At a minimum, each incorrect orientation in increments of 90^o must be tested. Rectangular designs where improper insertion at 90^o from horizontal is clearly not possible do not need to be tested at these positions. It is permissible to test these designs in 180^o increments. The Responsible Engineer is the final authority for determining the positions to be tested.
2. Prepare enough terminated leads to test each orientation selected in step 1 at least 10 times. Prepare leads per section 5.1.6, Terminal Sample Preparation, using the largest gage size conductor and insulation thickness applicable to the design.
3. Procure connectors sufficient to test each incorrect orientation determined in step one at least 10 times using a fresh cavity for each test. Use no less than 3 connectors. Number each connector and each cavity.
4. Secure the connector shell in an appropriate fixture. The fixture shall not distort the natural state, shape, or geometry of the connector or the terminal cavities
5. Secure the terminal sample in the force tester by gripping the conductor a minimum of 20mm behind the insulation grip.
6. Adjust the connector holder and force tester to insert the terminal in one of the "incorrect" orientations chosen in step 1. Adjust the force tester to insert the terminal straight into the connector at a uniform rate not to exceed 50 mm per minute.
7. The test force is 1.5 times the maximum force recorded in step 5.4.1.3-7 (Terminal-Connector Insertion Force) or 15N, whichever is greater.
8. Insert the terminal into the cavity until the force determined in step 7 is reached.
9. Record results (terminal seated in cavity, terminal inserted but did not seat and to what approximate depth, terminal did not enter cavity, cable buckled, etc.).
10. Repeat steps 4 through 9 using fresh terminals and cavities/connectors until all combinations determined in step 2 have been tested.
11. Complete the visual examination of the terminals and connectors per section 5.1.8.

5.4.10.4 Acceptance Criteria

1. Terminals inserted in any incorrect orientation shall not fit or lock into a connector cavity beyond the insulation wings (grips) or cable seal (See Figure 5.4.10.5) at a force 1.5 times the normal insertion force, 15N, or the column strength of the largest applicable wire size, whichever is greater.
2. There shall be no visible damage to either the terminal or connector that would prevent subsequent correct insertion and function following any attempt at incorrect insertion per this procedure.
3. The jury evaluation shall be completed and documented.

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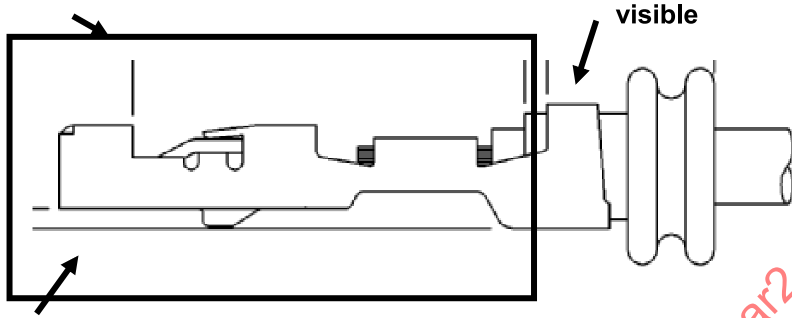

Figure 5.4.10.5 – Incorrectly Plugged Terminal, Maximum allowable Insertion Into Connector Cavity

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5.5 CONNECTOR - ELECTRICAL TESTS

5.5.1 Isolation Resistance

5.5.1.1 Purpose

This test verifies that the electrical resistance between any two cavities in a connector system will be sufficient to prevent detrimental electrical conductivity between the various circuits passing through that connector system. This test is typically done after other environmental stress tests to ensure that any contaminants that may have entered the connector during testing are not sufficient to create an unintended electrical path. This test shall be performed on all connector types both sealed and unsealed.

5.5.1.2 Equipment

⇨ Megohmeter

5.5.1.3 Procedure

NOTE: This test is typically used only in conjunction with another test that subjects the connector to the chance of some form of moisture or other contaminant intrusion. Test the same samples used for the related test.

NOTE: For un-sealed connector pairs, the test samples shall rest in ambient environment for ≥3 hours prior to measuring isolation resistance after any prior environmental conditioning.

NOTE: When Sealed Connector systems are to be tested following exposure to moisture or other contaminants (except fluid resistance test) it is important that this Isolation Resistance test be performed on each sample within one hour of concluding the associated test. Otherwise, particularly where samples are exposed to elevated temperatures in the preceding test, any contaminant that might invade the samples may dry to the point of being undetectable by this Isolation Resistance test.

1. If this test is to be performed to check isolation resistance of a new connector housing, prepare cut leads as specified in Section 5.1.6, Terminal Sample Preparation
2. Connect the Megohmeter, set to 500 VDC, to the bared conductor ends as illustrated in Figure 5.5.1.3 so that adjacent cavities have opposite polarization. For special applications, the test voltage may be reduced or increased with the approval of the Authorized Person.
3. Use the Megohmeter to measure the resistance between the adjacent terminals: Apply the test voltage, allow for meter to stabilize. . Test both halves of the connector system (if applicable for new connector housings. Test the mated connector assembly for those samples that have been subjected to prior stress testing.
4. Record the minimum resistance measured and verify conformance to the Acceptance Criteria of Section 5.5.1.4

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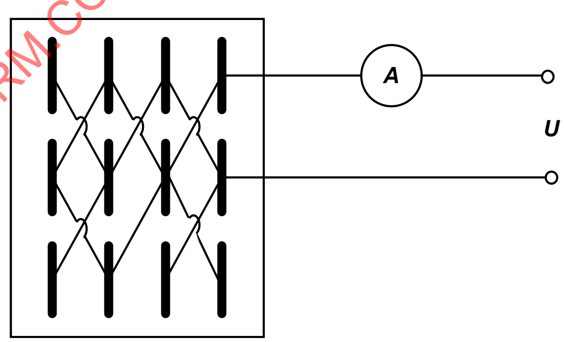

Figure 5.5.1.3: Method of Connecting Leads for Isolation Resistance Test

5. For connectors with Shorting Bars, take the isolation resistance measurement between the two terminals designed to be shorted together by the Shorting Bars (Shorting Bars “open”)

5.5.1.4 Acceptance Criteria

The resistance between every combination of two adjacent terminals in the CUT must exceed 100 MΩ at 500 VDC. This includes terminals that may be separated by one or more vacant terminal cavities.

5.6 CONNECTOR ENVIRONMENTAL TESTS

5.6.1 Thermal Shock

5.6.1.1 Purpose

This test subjects the connector assembly to extreme temperature cycles that cause expansion and contraction of the various materials used in the connector system. This is intended to produce accelerated wear at the terminal-to-terminal interface.

5.6.1.2 Equipment

⇨ Temp. Chamber(s) (-40° C to +175° C *)

* As required by the Temperature Class selected from Figure 5.1.4.

5.6.1.3 Procedure

1. Using leads prepared per section 5.1.6, assemble a minimum of 10 pairs of fully populated connectors (at least 10 male and 10 Female Connector halves). Leads may be of any size and insulation type appropriate to the TUT. Assemblies must include all applicable Wedges (TPAs, PLRs, etc.), Seals, etc. Number each mated connector pair.
2. Complete the Connector and/or Terminal Cycling procedure per section 5.1.7 if not already performed on the sample set.
3. Verify conformance of each sample connector assembly to the Acceptance Criteria of the Dry Circuit Resistance test, Section 5.3.1.4. Measure at least 10 terminal pairs randomly distributed among the connector sets.
4. Divide the test samples into two groups of 5. The first group shall be used for dry circuit measurement at the end of the thermal shock exposure. The second group shall be set up and monitored continuously for discontinuity per section 5.1.9. On connectors with up to 10 cavities, all cavities shall be monitored on the 5 samples. On connectors with more than 10 cavities, all terminal cavities must be represented in the 5 samples, with a minimum of 50 terminals monitored. The chosen cavities shall be evenly distributed across the connectors.
5. Place the samples in the chamber so that there is no substantial obstruction to air flow across and around the samples, and the samples are not touching each other.

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6. Determine the Temperature Class for the intended application of the connector system from Figure 5.1.4. Then set the Temperature chamber to the minimum ambient temperature for that class. Allow the chamber to stabilize, then cold Soak the samples an additional 30 min.
7. At the conclusion of the 30 minute cold Soak, transfer the samples to another chamber set to the maximum ambient temperature for the Temperature Class selected in Step 6. It is important to complete the transfer of all samples from the cold to hot chamber (or, optionally, to transition one chamber from the coldest to the hottest extreme) in less than 30 seconds. Allow the samples to heat Soak for 30 minutes.
8. At the conclusion of the 30 minute heat Soak, transfer the samples to another chamber set to the minimum ambient temperature for the Temperature Class selected in Step 6. It is important to complete the transfer of all samples from the hot to cold chamber in less than 30 seconds. Allow the samples to cold Soak for 30 minutes.
9. Repeat Steps 7 and 8 ninety nine (99) more times.
10. Measure the Dry Circuit resistance (section 5.3.1) of the same terminal pairs selected in step 3. Do not use monitored circuits for Dry Circuit measurements
11. Measure the voltage drop per section 5.3.2. At least 10 terminal pairs must be measured.

Verify conformance to the Acceptance Criteria of Section 5.6.1.4

5.6.1.4 Acceptance Criteria

At the conclusion of the test, verify conformance of each terminal pair and each sample connector assembly, as appropriate, to the Acceptance Criteria of section 5.1.9.4 (continuity Monitoring) and to the following tests:

First, the Dry Circuit Resistance test, Section 5.3.1.4.

Second, the Voltage Drop test, Section 5.3.2.4.

NOTE: If samples are to be subjected to further testing (for example as part of the test sequence shown in Section 5.9.6), the following steps may be deferred until the sequence is complete.

The connector assemblies must not show, with the aid of 10X magnification, any evidence of deterioration, cracks, deformities, etc. that could affect their fit or function, or distort their appearance.

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5.6.2 Temperature/Humidity Cycling

5.6.2.1 Purpose

This test simulates actual operating conditions using temperature and humidity variations as aging mechanisms for evaluation of a connector system's electrical durability. High humidity and temperature can promote galvanic and electrolytic corrosion of the terminals which may cause electrical and mechanical degradation. Temperature cycling promotes relative movement of the contact surfaces that can cause wear and fretting corrosion. Certain plastic materials may also degrade.

5.6.2.2 Equipment

⇨ Data Logger
⇨ Temperature Chamber(s) (-40° C to +175° C *, 0%-95% Relative Humidity)

*As required by the Temperature Class selected from Figure 5.1.4.

5.6.2.3 Procedure

1. Using leads prepared per section 5.1.6, assemble a minimum of 10 pairs of fully populated connectors (at least 10 male and 10 Female Connector halves). Leads may be of any size and insulation type appropriate to the application. Assembly must include all applicable Wedges (TPAs, PLRs, etc.), Seals, etc. Number each mated connector pair.
2. Complete the Connector and/or Terminal Cycling procedure per section 5.1.7 if not already performed on the sample set.
3. Verify conformance of each sample connector assembly to the Dry Circuit Resistance test, Section 5.3.1.4 when this test is performed stand-alone. Measure at least 10 terminal pairs randomly distributed among the connector sets.
4. The test fixtures, system layout, and test set-up must be approved by the Authorized Person prior to testing.
5. Place the samples in the chamber so that there is no substantial obstruction to air flow across and around the samples, and the samples are not touching each other.
6. Determine the Temperature Class for the intended application of the connector system from Figure 5.1.4. Then set the Temperature chamber to the minimum temperature for that class. Allow the chamber to stabilize before proceeding.
7. Cycle the test samples 40 times using the cycling schedule shown in Figure 5.6.2.3. Extended transition times may be used as long as the dwell times at temperature are maintained. The cycle begins with the sample at –40°C and un-controlled relative humidity. Completion of the schedule shown in Figure 5.6.2.3 will constitute one cycle. Use the Maximum Ambient Temperature for hours 5 through 7 as determined from Figure 5.1.4 in Step 6 above.
8. Using the separate set of samples designated for that purpose, complete the Connector/Terminal Extraction Force Test (Section 5.4.1.3-B, Steps 4-8, except do not increase the force above 50N. Test 3 samples (minimum) to complete the terminal extraction test. Each cavity location must be tested at least once but not all cavities in all housings need to be tested.
9. Verify conformance to the Acceptance Criteria of Section 5.6.2.4.

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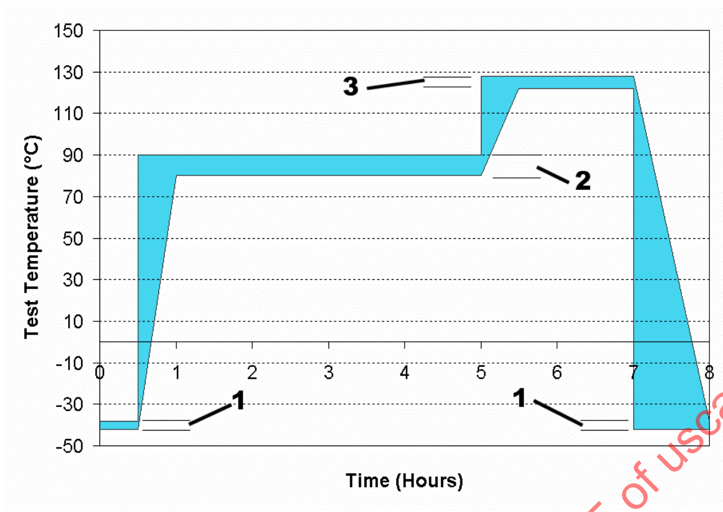

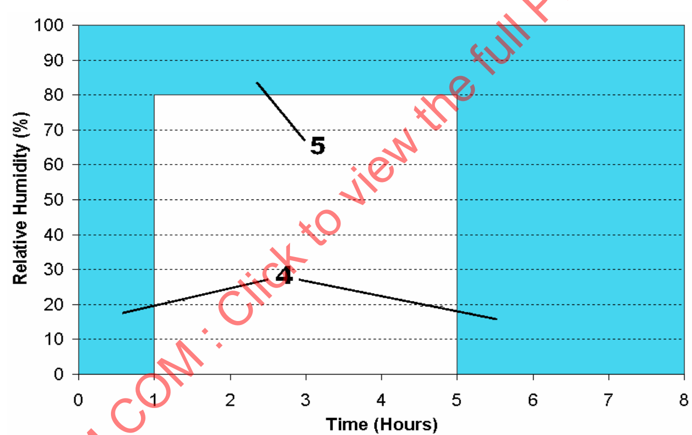

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Key:
1 (-40)°C
2 (80 – 90)°C
3 Test temperature, see Figure 5.1.4 (Class 3 shown for illustration only)
4 Relative humidity, uncontrolled. Do not vent chamber at hour 5
5 (80 – 100)% Relative humidity

Figure 5.6.2.3: Temperature/Humidity Cycling Schedule

5.6.2.4 Acceptance Criteria

1. At the conclusion of the test, verify conformance of each terminal pair and each sample connector assembly, as appropriate, to the Acceptance Criteria of the following tests:
   a. First, the Dry Circuit Resistance test, Section 5.3.1.4. Measure at least 10 terminal pairs randomly distributed among the connector sets.
   b. Second, Voltage Drop test, Section 5.3.2.4. Measure at least 10 terminal pairs randomly distributed among the connector sets.
   c. Finally, the Isolation Resistance test, Section 5.5.1.
   d. Pull test samples shall meet the connector/terminal Extraction Force test requirements of section 5.4.1.4 These post test extraction forces are minimum values only and are not intended to be statistically managed.

NOTE: If samples are to be subjected to further testing (for example as part of the test sequence shown in Section 5.9.6). The following steps may be deferred until the sequence is complete.

2. The connector assemblies must not show, with the aid of 10X magnification, any evidence of deterioration, cracks, deformities, etc. that could affect their functionality or distort their appearance.

5.6.3 High Temperature Exposure

5.6.3.1 Purpose

This test evaluates the effects of long-term exposure to elevated temperature on connector assembly components. Thermal aging may cause changes in metal and plastic materials, including stress relaxation in important flexing members of the terminal or its connector. These changes may be detrimental to electrical and physical performance.

5.6.3.2 Equipment

⇨ Temperature Chamber(s) (+175^{o} C *)

*As required by the Temperature Class selected from Figure 5.1.4.

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5.6.3.3 Procedure

1. Using leads prepared per section 5.1.6, assemble a minimum of 10 pairs of fully populated connectors (at least 10 male and 10 Female Connector halves) Leads may be of any size and insulation type appropriate to the application. The assembly must include all applicable Wedges (TPAs, PLRs, etc.), seals, etc. Number each mated connector pair.
2. Complete the Connector and/or Terminal Cycling procedure per section 5.1.7 if not already performed on the sample set.
3. Verify the performance of each sample connector assembly to the Acceptance Criteria of the Dry Circuit Resistance test, Section 5.3.1.4. Measure at least 10 terminal pairs randomly distributed among the connector sets.
4. The test fixtures, system layout, and test set-up must be approved by the Authorized Person prior to testing.
5. Determine the Temperature Class for the intended application of the connector system from Figure 5.1.4. Then set the temperature chamber to the maximum ambient temperature for that class. Allow the chamber to stabilize before proceeding.
6. Place the samples in the chamber, set to the maximum ambient temperature, so that there is no substantial obstruction to air flow across and around the samples, and the samples are not touching each other. Leave the samples in the chamber for 1008 hours.
7. Sample evaluation is required only at the beginning and end of the test, but additional measurement intervals may be requested by the Authorized Person.
8. At the conclusion of the test, verify conformance to the Acceptance Criteria of Section 5.6.3.4.

5.6.3.4 Acceptance Criteria

At the conclusion of the test, verify conformance of each terminal pair and each sample connector assembly, as appropriate, to the Acceptance Criteria of the following tests, in the order shown:

a. The Dry Circuit Resistance test, Section 5.3.1.4. Measure at least 10 terminal pairs randomly distributed among the connector sets.
b. The Voltage Drop test, Section 5.3.2.4. Measure at least 10 terminal pairs randomly distributed among the connector sets.

NOTE: If samples are to be subjected to further testing (for example as part of the test sequence shown in Section 5.9.6) do not perform any steps beyond this point.

c. The visual inspection, section 5.1.8.4

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5.6.4 Fluid Resistance

NOTE: This test is to be used for sealed (S2 and S3) connector systems only.

5.6.4.1 Purpose

This test evaluates the sealing capability and material compatibility of a sealed connector system when immersed in various fluids commonly found in and around road vehicles. Since the same materials are commonly used for numerous connection systems, the use of surrogate data is acceptable for this test. If surrogate data is used, all references to the original test(s) shall be included in the test report.

5.6.4.2 Equipment

⇨ Laboratory Fume Hood
⇨ Stainless steel tanks or Pyrex beakers
⇨ Explosion-proof Heat Chamber

5.6.4.3 Procedure

1. Using leads prepared per section 5.1.6, assemble a minimum of 8 pairs of fully populated connectors. Use leads of the smallest conductor size and insulation type appropriate to the terminals and connector being tested. Assembly must include all applicable Wedges (TPAs, PLRs, etc.), Seals, etc. Number each mated connector pair.
2. Completely submerse at least 1 test sample in each fluid listed in table 5.6.4.3 for 30 minutes. Fluids are to be stabilized at the temperatures indicated. A fresh sample is to be used for each fluid and each sample is to be submersed in one fluid only, unless otherwise requested by the Authorized Person.

CAUTION: Follow all Federal, state, and local safety regulations, standards, and procedures when performing this test.

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Fluid	Specification*	Test temp.°C
Gasoline	ISO1817, liquid C	23 ± 5
Diesel fuel	90% ISO 1817, Oil No. 3 + 10% p-xylene	23 ± 5
Engine oil	ISO 1817, Oil No. 2	50 ± 3
Ethanol	85% Ethanol + 15% ISO 1817 liquid C	23 ± 5
Power steering fluid	ISO 1817, Oil No. 3	50 ± 3
Automatic transmission fluid	Dexron VI (North American specified material)	50 ± 3
Engine coolant	50 % ethylene glycol + 50 % distilled water	50 ± 3
Brake Fluid	SAE RM66xx**	50 ± 3

*Solutions are determined as percent by volume
**Use latest available SAE reference fluid
See appendix E for fluid source list

Table 5.6.4.3: Fluid Test

1. At the conclusion of the submersion period, remove the sample from the fluid. Do NOT shake off any excess fluid. Use care not to splash any fluid on unintended surfaces. Leave the samples "wet" and store them in a suitable container or area at lab ambient temperature for 7 days. Do not allow samples submersed in different fluids to touch each other and do not allow any dissimilar fluid drippings to intermingle.
2. At the conclusion of the storage period, samples may be dried sufficiently to allow inspection and to avoid contamination of test apparatus.
3. Verify conformance of each test sample to the Acceptance Criteria of Section 5.6.4.4.

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5.6.4.4 Acceptance Criteria

1. There must be no visible degradation*, cracking, or loss of mechanical function evident on any test sample, examined with the aid of a 10X magnifying glass.

*Swelling of cable and seals is permissible. within the limits of that specific material specification.

5.6.5 Submersion

NOTE: This test is to be used for sealed (S2 and S3 sealing classification) connector systems only.

5.6.5.1 Purpose

This test is an accelerated simulation of the "breathing" that may occur in a sealed connector system when it is heated and suddenly cooled by submersion in a cooler liquid. Salt water is used as the liquid to facilitate detection of any leakage into the connector. As a further aid to detecting any leakage that may occur, it is recommended that a suitable ultraviolet dye be added to the salt water solution.

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5.6.5.2 Equipment

- ⇨ Stainless steel tanks or Pyrex beakers
- ⇨ Megohmeter
- ⇨ Temperature Chamber (-40° C to +175° C*)

*As required by the Temperature Class selected from Figure 5.1.4.

5.6.5.3 Procedure

1. Using leads prepared per section 5.1.6 assemble a minimum of 10 pairs of fully populated connectors. Use leads of the smallest conductor size and insulation type appropriate to the terminals and connector being tested. The assembly must include all applicable Wedges (TPAs, PLRs, etc.), Seals, etc. Number each mated connector pair.
2. For multiple conductor (mat) type seals only, select 10 cavities at random among the sample set and record the connector and cavity numbers. Remove and re-insert the terminals in the selected cavities. The purpose of this step is to ensure the terminal does not damage the seal during service operations.
3. Complete the Connector and/or Terminal Cycling procedure per section 5.1.7 if not already performed on the sample set
4. Verify conformance of each mated sample connector assembly to the Isolation Resistance test, Section 5.5.1.4. This establishes a reference for the concluding Isolation Resistance test.
5. Place the samples in the chamber such that there is no substantial obstruction to air flow across and around the samples, and the samples are not touching each other.
6. Determine the Temperature Class of the connector system from Figure 5.1.4 and set the chamber to the Maximum Ambient Temperature for that class. Allow the chamber to stabilize before proceeding. Heat Soak the samples at the elevated temperature of the chamber for 2 hours. If the internal temperature of a representative sample of the parts to be tested can be shown to stabilize at oven temperature in less than two hours, the shorter time may be used. The demonstration sample may not be used as an actual test sample.

7. Prepare enough salt water solution to completely submerse the samples. Use tap water and 15-16 grams of table salt per liter. Then add 10 ml of liquid dish washing soap per liter. Mix well before adding to test apparatus. It is recommended that an appropriate ultraviolet dye be added to assist in visual inspection for any ingress of solution into the test samples.
8. Remove the samples from the chamber. Within 30 seconds, submerse them in the Room Temperature salt water solution to a depth of 30 - 40 cm. The samples shall remain submersed at this depth for a period of 30 minutes.
9. At the end of the 30 minute submersion, remove the samples from the salt water solution, shake off the excess solution, and then carefully dry the exterior surfaces of the samples. Immediately perform the Isolation Resistance test of Section 5.5.1 on each sample.
10. Repeat Steps 6, 8, and 9 four (4) more times, except do not repeat when this test is done on samples that have completed the Temperature/Humidity Cycling test of Section 5.6.2 or the High Temperature Exposure Test of Section 5.6.3.
11. Immediately upon concluding the test, verify conformance of each sample to the Acceptance Criteria of Section 5.6.5.4.
12. SPECIAL TEST for connectors with multi-cavity (mat) type conductor seals. This test is not applicable to single cavity connector designs. This is an additional test and requires use of new samples. Its purpose is to check for seal distortion from extremes of conductor size that may produce a leak.
    a. Repeat Step 1, except prepare one male and one female terminal (smallest conductor size) for each connector pair to be tested.
    b. Repeat Step 1 except use the largest conductor size and insulation type for the terminals to be used in the intended application. Prepare only enough terminal samples to fully populate all connector pairs, less one cavity for each connector half.
    c. Prepare a minimum of 10 connector pairs so that all but one randomly selected cavity in each connector half is populated with a terminal crimped to the largest conductor size, prepared in Step b above. Then fill the remaining cavity in each connector half with the appropriate terminals crimped to the smallest conductor size, prepared in Step a. above. Number each connector pair.
    d. Repeat Steps 3, 4, 5, 6, 8, 9, 10, and 11 using the samples prepared in Step C above.
13. At the conclusion of the test, disconnect each mated sample pair and perform the Visual Inspection test of Section 5.1.6. When disconnecting the samples, use care not to allow any residual solution to enter the interior of any connector half. Careful examination is required to detect any trace of fluid leakage that escaped detection by the Isolation Resistance test. Use of a dye in the solution, as recommended in Step 7 above, will aid in this inspection.

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5.6.5.4 Acceptance Criteria

1. There should be no trace of fluid ingress in any connector at the conclusion of this test.
2. Samples shall meet the Acceptance Criteria of the Isolation resistance Test, Section 5.5.1.4.

5.6.6 Pressure/Vacuum Leak

5.6.6.1 Purpose

This test evaluates the sealing capability of sealed (S2 and S3 sealing classification) connector systems when subjected to a specified pressure differential between the inside and outside of the sealed area.

5.6.6.2 Equipment

⇨ Pressure/Vacuum Source (Regulated)
⇨ Container (for sample immersion)
⇨ Temperature Chamber (-40° C to +175° C *)

* As required by the Temperature Class selected from Figure 5.1.4.

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5.6.6.3 Procedure

NOTE: When using samples that have been subjected to any prior testing that includes the Temperature/Humidity Cycling test, Section 5.6.2 or High Temperature Exposure test, section 5.6.3, proceed directly to Step 17. This assumes that the samples have already been prepared with vacuum tubes per steps 1 through 15.

1. Refer to section 5.1.6 and prepare leads using the smallest conductor size and insulation type appropriate to the terminal and connector under test. Crimp enough samples of male and Female Terminals to assemble a minimum of 10 pairs of connector assemblies, less one cavity for each connector pair. Crimp both the conductor and insulation grips.
2. For convenience, and to minimize loose conductor ends, conductor lengths may be terminated on both ends and looped between samples.
3. Using the terminals prepared in Step 1, assemble a minimum of 10 pairs of fully populated connectors, leaving one conveniently located cavity open in each connector pair. Determination of which connector half has the vacant cavity will have been determined in Step 1. Assembly must include all applicable Wedges (TPAs, PLRs, seals, etc). Number each mated connector pair.
4. For multiple conductor (mat) type seals only, select 10 cavities at random among the sample set and record the connector and cavity numbers. Remove and re-insert the terminals in the selected cavities. The purpose of this step is to ensure the terminal does not damage the seal during service operations. (Not required if previously done on this sample set.)
5. Into the one open cavity in each connector pair, insert a tube of sufficient diameter and wall strength to ensure that there is not a possible leak path between the outer tube surface and the conductor seal. Be sure the tube is inserted far enough to engage the full sealing capability of the conductor seal. After completing Steps 6 and 7 below, connect the free end of the tube to a regulated pressure source. Alternative methods of adding a pressure/vacuum port are acceptable as long as the integrity of the part is not compromised.

6. Complete the Connector and/or Terminal Cycling procedure per section 5.1.7 if not already performed on the sample set
7. Verify conformance of each mated sample connector assembly to the Isolation Resistance test, Section 5.5.1.4. This establishes a reference for the concluding Isolation Resistance test.
8. Prepare enough salt water solution to completely submerse all of the samples. Use tap water and 15-16 grams of table salt per liter. 10 ml of liquid dish washing soap per liter of water may be added. Mix well before adding to test apparatus. It is recommended that an appropriate ultraviolet dye be added to assist in visual inspection for any ingress of solution into the test samples.
9. Bend all conductors in the same direction, 90^{o} to the back of each sample connector half and secure them in this position, using actual conductor dress shields if available. This is to simulate dressing of the conductors as they exit the connector and is intended to stress the conductor seal(s) as in actual applications. If actual production dress shields are not available, simulate production application intent as closely as possible. Ensure that the tube is not kinked, squeezed shut or otherwise obstructed. The tube should be left out of the 90^{0} bend if feasible. Seal all loose conductor ends to eliminate possible Leakage through the conductor strands.
10. Completely submerse all samples into a container of the Room Temperature salt water solution prepared in Step 8 above. Use care to avoid submersing any wire ends or the open end of the tube.
11. Slowly increase the air pressure of the regulated pressure source supplying the tube in each sample until the gage reads 48 KPa (7psig).
12. Observe samples for 15 seconds and verify that there are no air bubbles.[1.]
13. Switch the regulated source from pressure to vacuum and slowly apply 48 KPa (7psig) of vacuum to the samples for 15 seconds.[1.]
14. Remove the samples from the salt water solution, shake off excess fluid and then carefully dry all exterior surfaces of the sample.
15. Strip 10 mm of insulation from the conductor ends of each terminal in one connector half and perform the Isolation Resistance test of Section 5.5.1.
16. Place the samples in a temperature chamber stabilized at the maximum ambient temperature for the Temperature Class selected from Figure 5.1.4 for the CUT. Heat Soak all samples for 70 hours.
17. After the heat Soak, remove the samples from the chamber and allow the samples to cool to Room Temperature, then repeat steps 9 - 15, except limit pressure in Step 11, and vacuum in Step 13, to 28 KPa (4 psig).
18. Verify conformance of all test samples to the Acceptance Criteria of Section 5.6.6.4.

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19. SPECIAL TEST for connectors with multi-cavity (mat) type conductor seals. This test is not applicable to single cavity connector designs. This is an additional test and requires use of new samples. Its purpose is to check for seal distortion from extremes of conductor size that may produce a leak.
    a. Repeat Step 1, except prepare one male and one Female Terminal (smallest conductor size) for each connection pair to be tested.
    b. Repeat Step 1 except use the largest conductor size and insulation type for the terminals to be used in the intended application. Prepare only enough terminal samples to fully populate all connector pairs, less one cavity for each connector half and less the one cavity left open for the pressure/vacuum tube.
    c. Prepare a minimum of 10 connector pairs so that all but one randomly selected cavity in each connector half is populated with a terminal crimped to the largest conductor size, prepared in Step b above. Leave one cavity in each connector pair open for the pressure/vacuum tube, as directed in Step 1. Then fill the remaining cavity in each connector half with the appropriate terminal crimped to the smallest conductor size, prepared in Step a. above. Unless the size of the connector makes it impossible, do not place the smallest conductor in a cavity adjacent to the pressure/vacuum tube. Number each connector pair.
    d. Repeat Steps 4 through 18 using the samples prepared in Step c above.

[1.] The length and inner diameter of the pressure/Vacuum supply tubing as well as the volume within a mated connector can have an effect on the time required to reach the pressure/vacuum values within the CUT. The pressure/vacuum within the mated connector housing shall be monitored to determine if and when the pressure vacuum reaches the specified value. The 15 seconds is considered to be a minimum time, starting when the space within the CUT actually comes up to the specified pressure/vacuum levels. In the case of 1 and 2 position connectors the Authorized Person shall determine the method for pressure/vacuum monitoring within the mated connectors.

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5.6.6.4 Acceptance Criteria

1. When samples are subjected to positive pressure, there must be no loss in the applied pressure and no bubbles visible exiting any test sample.
2. After samples are subjected to negative pressure (vacuum), all must meet the Acceptance Criteria of the Isolation Resistance test, Section 5.5.1.4.
3. At the conclusion of the test, all samples must meet the Acceptance Criteria of the Visual Inspection test, Section 5.1.8.4. When disconnecting the samples, use care not to allow any residual solution to enter the interior of any connector half. Careful examination is required to detect any trace of fluid Leakage that escaped detection by the Isolation Resistance test. There should be no trace of fluid ingress in the connector at the conclusion of this test.

5.7 SPECIAL TESTS

5.7.1 Header Pin Retention

5.7.1.1 Purpose

The terminal push-out test is used to determine the retention of the Male Terminal in certain stitched or insert molded Header Connectors. It may also be used to test the attachment of male pins when staked or soldered directly to circuit boards. Proper pin retention assures that the terminal will not be displaced by forces associated with normal engagement and disengagement of the mating connector. These requirements apply to finished devices only and not to “in-process” products such as pin blocks or other sub-assemblies. The module and/or connector suppliers need to determine at what stage of the process these requirements will be tested and verified.

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5.7.1.2 Equipment

⇨ Insertion/Extraction Force tester with peak reading feature
⇨ Appropriate fixtures to hold the connector
⇨ Collets, mandrels, or jaws to grip the terminal or pin in a longitudinal direction as needed

5.7.1.3 Procedure

NOTE: Samples are to be production intent. For designs where pins are closely spaced, pins or terminals may need to be selectively removed or cut to allow space for attachment of jaws, collets or mandrels. Pins may be shortened if necessary to allow for gripping and fixturing. All pin locations for a given design shall be tested and in no case less than 10 pins.

1. Moisture condition samples by exposing “dry as molded parts” to 95-98% Relative Humidity at 40ºC for 6 hours, then immediately complete the extraction test.
2. Measurements shall be taken in both directions if possible, i.e. force to push the pin longitudinally through the connector, and to pull it out as if removing a female plug from the header. Depending on individual design, “pushing” or “pulling” may be reversed in order to get the proper reading. It may also be appropriate to apply the loads from the back of the connector on certain designs. Pressure or tension must be applied parallel with the axis of the pin to achieve accurate results. In the case of headers with bent pins it may be necessary to cut the pins in the straight section near the header. If the pins need to be cut prior to taking the force measurement care should be used to avoid affecting the test result.
3. Secure the connector body to the appropriate fixture.

4. Using the force tester, apply a ramping pressure to the terminal pin. Note and record the maximum force required to displace the pin a maximum of 0,2mm, within the plastic housing or board attachment. Repeat for each pin location. Where resultant damage to the connector housing would affect readings on adjacent cavities, move to an undamaged pin or use a fresh connector.
5. Using fresh samples as needed, reverse force direction and repeat step 3.

5.7.1.4 Acceptance Criteria

The minimum force required to displace the pin longitudinally in either direction shall meet the values specified in table 5.7.1.

Terminal Family	Minimum Displacement Force
0.64	15N
≥1.5	50N

Table 5.7.1: Minimum Header Pin Displacement Force

NOTE: Values for terminal sizes falling between 0.64 and 1.5 are calculated by interpolation based on nominal blade width.

5.7.2 Connector Mounting Feature Mechanical Strength

5.7.2.1 Purpose

This test is designed to test the mechanical strength of clip slots and other designed-in mounting features for electrical connectors. Such features must withstand mechanical stresses (pulling, pushing, etc.) expected in the vehicle including vehicle assembly, service and repair without functional damage to the housing.

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5.7.2.2 Equipment

⇨ Force Tester

5.7.2.3 Procedure

1. Test a minimum of 20 connectors (five in each direction).
2. One non-mounting (mating) connector may be used to test all connectors.

3. Secure a virgin connector with the designed-in mounting feature to a bracket with a fixture simulating the coordinating mounting feature (see Figure 5.7.2.3-A&B). No additional reinforcement of the connector slot is permitted.
4. With the connector assembly attached to the bracket, apply a downward force with a probe (at a rate of 50 mm/min) to the non-mounted mating connector in direction F1 until breakage of the mounting feature or until the force specified in the Acceptance Criteria of section 5.7.2.4 is reached. The force shall be applied 5 mm from the rear and side of the connector to affect the greatest moment arm (see Figures 5.7.3.2-B, C & D).
5. Remove the connector from the fixture.
6. Repeat steps 2 – 5 with four additional connectors.
7. Repeat steps 2 – 6 in the other three directions (F2, F3, & F4 - 90 degrees apart, each perpendicular to the direction of mating of the mounting feature). The same samples may be used for testing various force directions if not damaged.

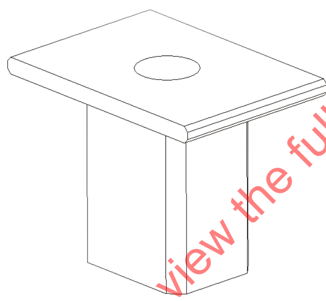

Figure 5.7.2.3-A: Mounting Fixture - Example

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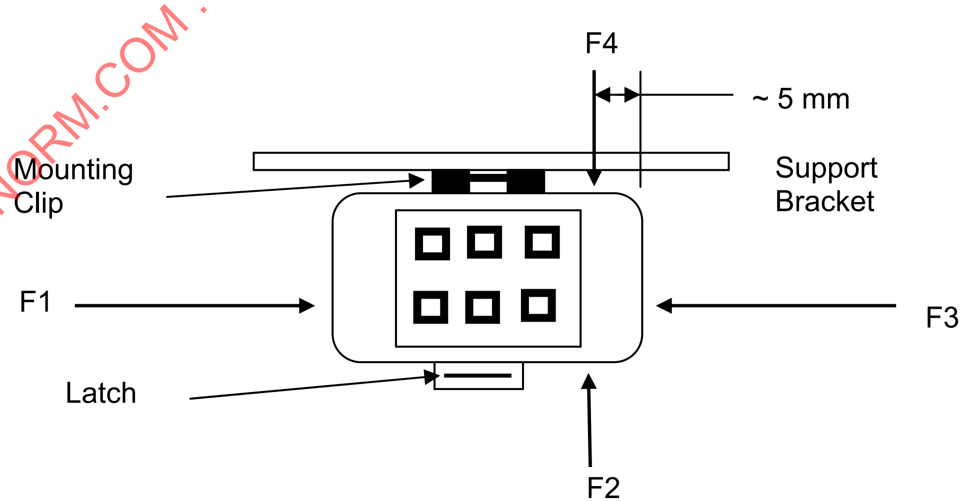

Figure 5.7.2.3-B: Test Set-up (End View)

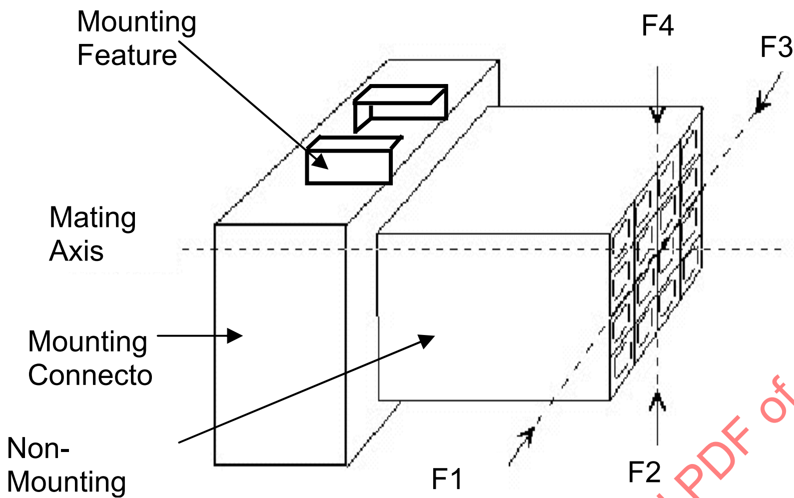

Figure 5.7.2.3-C (3d View)

NOTE: "F" Arrows indicate direction of applied force, not location of probe.

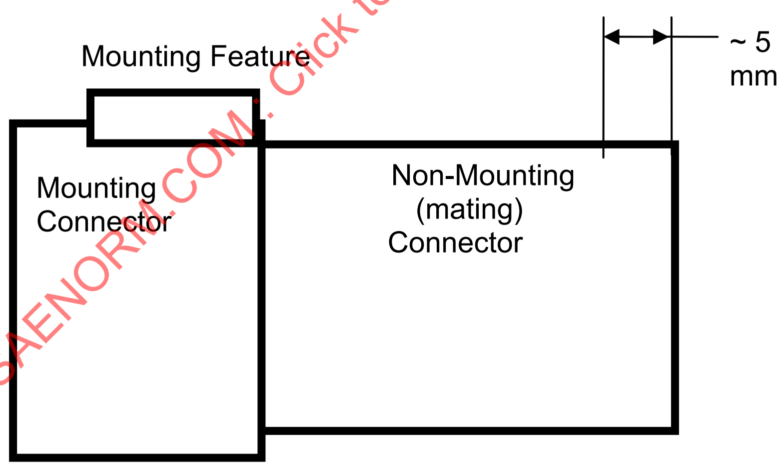

Figure 5.7.2.3-D (Side View)

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5.7.2.4 Acceptance Criteria

The minimum force required to break the mounting feature shall be > 50 N.

5.8 SEVERE DUTY TESTS

The following test procedures are optional and are intended for use when, in the judgment of the Authorized Person, additional testing is needed to demonstrate acceptability of the connection system for severe duty applications. Because these situations are unique, the procedures may have to be modified according to data gathered from prototype vehicles or field experience. These procedures and acceptance criteria are not required for general validation, but rather are intended to lend consistency to the test procedures when such tests are deemed necessary.

Special design provisions will likely be needed for connectors required to pass these tests.

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5.8.1 High Pressure Spray

5.8.1.1 Purpose

The purpose of this test is to determine the ability of sealed (S3 sealing classifications) connection systems to withstand high pressure spray during use. Such conditions may be encountered where there is direct road splash or in cases where high-pressure washing may be expected. This test is optional at the discretion of the Authorized Person and may be specified in addition to the Water Submersion and Pressure/Vacuum Leak Tests (sections 5.6.5 and 5.6.6). Perform this test for sealed connectors only.

This test and the associated equipment are intended to conform to ISO16750, with a 9K degree of protection.

5.8.1.2 Equipment

- ⇨ Fan jet nozzle
- ⇨ Device holder
- ⇨ Swiveling table

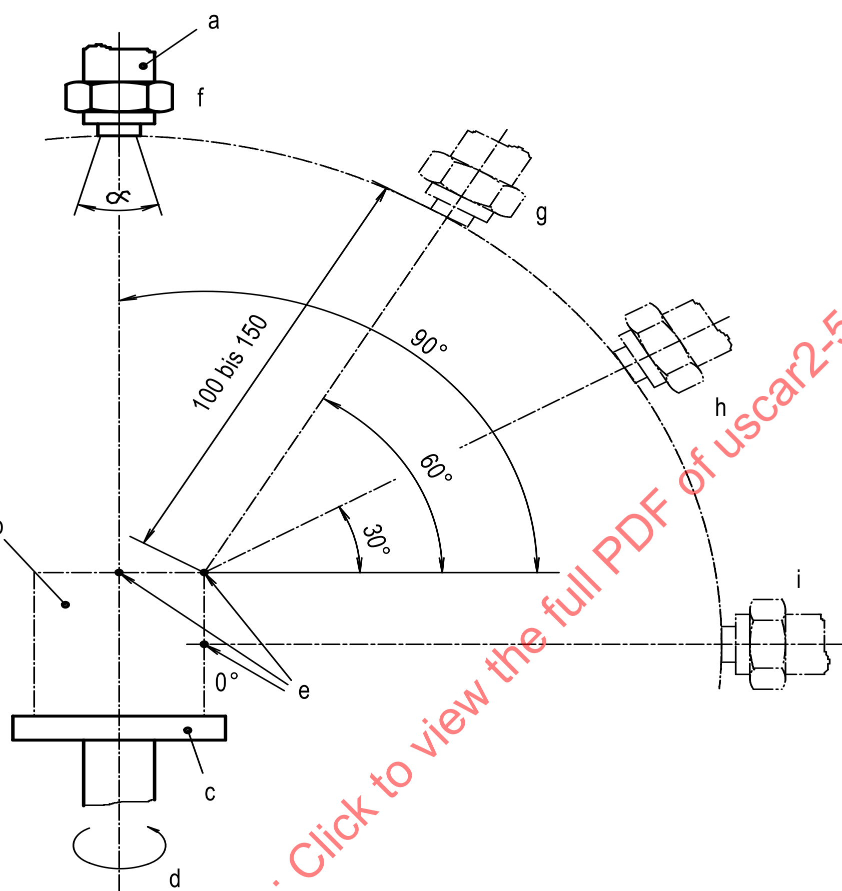

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Figure 5.8.1.2: Spray Nozzle and Table Arrangement

Equipment	Spray Requirements	Water flow rate	Water Pressure	Water temperature	Exposure Time
Fan jet nozzle	Turntable Speed of (5±1) rpm Position Angle of (0°, 30°, 60°, 90°)±5° Distance of (100 to 150) mm	14 to 16 l/min	Approx. (8000 to 10000) KPa	(20±5) °C (Deviating temperatures may be agreed)	30s / position of spray angle

Table 5.8.1.3: Specification for High Pressure Spray Testing

5.8.1.3 Procedure

1. A minimum of 10 mated connector pairs are required for this test. Use the smallest gage wire and insulation appropriate to the application and prepare leads per section 5.1.6. Prepare complete connector samples fitted with all terminals, seals, TPAs and grommets or shields intended for the production application. For mat type cable seals, Select and mark 10 leads at random. Remove and reinsert the selected leads.
2. If specified, attach a vacuum port to the connector or connector mating device so that a vacuum can be pulled on the interior of the connection system. The vacuum port must be completely sealed and must not affect the normal sealing system of the connector. Vacuum tubes may also be inserted through the cable seals per section 5.6.6.3, step 5.
3. Complete the Visual Examination per section 5.1.6.
4. Complete the Isolation Resistance test per section 5.5.1
5. Mount the connector under test onto the device holder such that the connector lays flush against the turntable.
6. If specified in the test request, expose the connection system to a 48 KPa (7 psig) vacuum, Position the sprayer at a 0° and initiate spray and turntable rotation.
7. With the table rotating, spray the connector under test for 30s. Repeat at each of the spray angles specified in table 5.8.1.3.
8. Complete the Isolation Resistance per section 5.5.1.
9. Condition samples at ambient conditions for 168 hours.
10. Complete the Visual Examination of section 5.1.8. Dis-assemble each connector pair and examine for any water intrusion or corrosion.

5.8.1.4 Acceptance Criteria

1. All parts shall meet the isolation resistance acceptance criteria specified in section 5.5.1.4.
2. Upon examination of the interior of the connection system, no water or corrosion products shall be visible inside the connector.
3. All parts shall meet the visual examination acceptance criteria specified in section 5.1.8.4.

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5.8.2 Severe Vibration

5.8.2.1 Purpose

The vibration test method specified is applicable to in-line and Header Connectors. It considers extreme vibration levels applicable to (vibration classification V3) connector systems that are mounted directly to the drive train. Severe vibration testing should be considered for sealed connection systems only. This test is optional at the discretion of the Authorized Person.

This test has two components: Sinusoidal vibration which results from the unbalanced mass of rotating parts and random vibration due to various engine mechanics like closing of valves. The sine component of the schedule is intended to duplicate vibration profiles of both <5 cylinder and $\geq$5 cylinder engines.

The vibration profiles contained in this procedure are very severe and are not representative of all situations. Actual measurement may need to be taken to determine a vibration and temperature profile for each application. In any case, vibration profiles used for validation of connection systems must never be accelerated. This results in non-representative failure modes such as severe terminal wear and cable failure.
Note: This severe vibration test is required for components classified as V3.

5.8.2.2 Equipment

⇨ Vibration Table with temperature control capability (-40°C to Class Ambient)
⇨ Vibration Controller
⇨ Temperature Control Unit
⇨ Accelerometers

5.8.2.3 Procedure

The sine and random components of this test may be run concurrently or separately. A temperature cycling component (Figure 5.8.2.3-A, Table 5.8.2.3-A) is also included and is to be run simultaneously with all vibration schedules.

1. Prepare samples and monitoring set-up per section 5.4.6.3.
2. Construct a suitable mounting apparatus using the following design criteria:
   a. The mounting apparatus must be constructed to minimize added effects (harmonics, dampening, resonance, etc.).
   b. For In-Line Connectors, mount the mated connector pair directly to the Mounting Bracket with a metallic clamp such that the connector lays flush against the cube or vibration table.
   c. For Device Connectors, mount the device directly to the Mounting Bracket. Refer to Figure 5.4.6.3-B. Use the normal device mounting feature(s) used to secure the device in its intended vehicle location. The mounting method(s) used shall be noted in the test report.
   d. The conductor attachment points must be 100mm +/-10mm from the rear of the connector body.
   e. When only one conductor attachment point is specified, as when testing the connection to a device, the distance between the vertical centerline of the electrical receptacle portion of the device and the attachment point is 100 mm.
3. Set up the samples to monitor continuity per section 5.1.9.
4. Complete the sine (Table 5.8.2.3-B) and random (Table 5.8.2.3-C) or combined sine and random profiles concurrently with temperature cycling (Figure 5.8.2.3-A). Carry out the frequency variation by logarithmic sweeping of 1 octave/min for sinusoidal tests.
5. Unless otherwise specified in the test request/order all CUTs mounted directly to the engine or transmission shall be vibrated for 22 hours in each of the three mutually perpendicular axes (X,Y,Z) for each vibration profile (sine and random) or 22 hours for the combined sine and random.
6. Without un-mating the connectors, condition samples for 48 hours @ ambient conditions.
7. Verify conformance of each sample to the Acceptance Criteria of Section 5.8.2.4.

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