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Jump Start Connections for 42 Volt Electrical Systems			

RATIONALE

The technical report covers technology, products, or processes which are mature and not likely to change in the foreseeable future.

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1. Scope

This SAE Recommended Practice defines test methods and general requirements at all phases of development, production, and field analysis of electrical terminals (including sense pins), connectors, and components that constitute the jump-start connection for road vehicles having 42 V (nominal) electrical systems. The 42 V jump start connector is always remote from the vehicle battery and may take the form of an in-line or Header Connection, either of which is in an accessible location for attachment of a jumper cable from an assist vehicle or battery charger.

WARNING—The Jump Start Connector requires environmental protection. This specification assumes that such protection is in place and remains effective for the life of the vehicle. The level of protection depends on the vehicle packaging environment and duty cycle.

Appendix B of this document contains the physical specification for the Jump Start Connector.

2. References

2.1 Related Publications

The following publications are for information purposes only and are not a required part of this document.

2.1.1 SAE PUBLICATIONS

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1127—Battery Cable

SAE J1128—Low Tension Primary Cable

SAE J2622—Battery Connections for 42 Volt Electrical Systems, Tests and General Performance Requirements

2.1.2 ISO PUBLICATIONS

Available at <http://www.iso.ch/iso/en/prods-services/ISOstore/store.html>

ISO 8092-2 Road Vehicles—Connections for On-board Electrical Wiring Harnesses

ISO 16750-4 Road Vehicles—Environmental Conditions and Testing for Electrical and Electronic Equipment—Part 4: Climatic Loads

3. Definitions

Terms defined in the definitions or abbreviations sections are capitalized (i.e., Room Temperature, PLR, etc.).

3.1 Acceptance Criteria

Generally the final section in each test description. It specifies the requirements that all test samples must meet during or at the conclusion of that test.

3.2 Authorized Person

One person will be responsible as the final authority for releasing a given part for production and/or for testing that part. Such person may delegate authority for testing that part, or may retain the authority. The Authorized Person, as used in the Specification, is the person with authority for making the final decision as to any question arising during testing to this Specification or for any deviations from any requirement of this Specification. Such Authorized Person is responsible for documenting any deviation he/she authorizes from this Specification. This documentation must be included in the final test report.

3.3 Cable Connector

The cable-side connector that attaches to the on-vehicle or Header Connector for purposes of jump-starting the vehicle or charging the vehicle battery.

3.4 Extraction Force

The force required to completely remove an individual contact (terminal) from its cavity in a connector.

3.5 Header Connector

A connector system that utilizes one or more fixed terminals inserted into a housing. The non-mating ends of the terminals are usually soldered to a printed circuit board or connect internally to the device. See Cable Connector.

3.6 Insertion Force

The force required to insert an individual contact (terminal) into its cavity in a connector.

3.7 Mating Force

The force required to mate the header and mating connector halves or to completely seat a connector in a device Header or receptacle.

3.8 Power Pin

Primary current conducting pin for the Jump Start connector.

3.9 Room Temperature

23 °C $\pm$ 5 °C.

3.10 Sense Pin

Connector terminal or pin which services the connect/disconnect sense function. This pin is low current. When connectors are mated, it must engage after the Power Pin. When connectors are unmated, it must disengage before the Power Pin. Vehicles may be equipped with sensing circuitry that utilizes these terminals to prevent damage from arcing and incorrect voltage or polarity. Maximum current is 0.5 A.

3.11 Soak

Refers to a time period during which the device under test is exposed to stated environmental conditions, such as temperature, humidity, current flow, etc. This exposure may be for the purpose of conditioning the sample prior to another test, or may itself form part of a given test.

3.12 Total Connection Resistance

Electrical resistance of one terminal-to-terminal interface plus the resistance of the conductor to terminal grip for each terminal. For Header type connections, only the resistance of the one conductor to terminal grip is included. The "bulk resistance" of the terminal material itself is also included.

3.13 Un-mating Force

The force required to un-mate the header and Cable Connector halves or to un-mate two cable connectors set up in an in-line configuration.

4. Abbreviations

CPA	Connector Position Assurance. Essentially a lock on the lock that holds the two halves of a connector together or holds a connector to an electrical device. Usually an optional device. It prevents accidental release of the connector lock and serves as an indicator of full connector mating.
CT/A	Continuity Totalizer/Analyzer. A made-up test device composed of a data analyzer and a continuity monitor.
CUT	Component Under Test
DMM	Digital Multimeter
MVD	Millivolt Drop.
PLR	Positive Latch Reinforcement. Also known as a Wedge, Spacer or Terminal Position Assurance (TPA) feature. It is installed or seated after the terminals are inserted into their housing to assure that the terminals are properly positioned. It either reinforces the primary terminal locking mechanism or provides a separate redundant terminal lock.
RH	Relative Humidity.
TPA	Terminal Position Assurance. See PLR.

5. Test and Acceptance Requirements

5.1 General

5.1.1 GENERAL TEST INFORMATION

5.1.1.1 Default Test Tolerances

Default tolerances are as follows and are expressed as a percentage of the nominal value unless otherwise indicated:

- a. Temperature = $\pm 3^{\circ}\text{C}$
- b. Voltage = $\pm 5\%$
- c. Current = $\pm 5\%$
- d. Resistance = $\pm 5\%$
- e. Length = $\pm 5\%$
- f. Time = $\pm 5\%$
- g. Force = $\pm 5\%$
- h. Relative Humidity = $\pm 5\%$

5.1.1.2 Default Test 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:

- a. Room Temperature = $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$
- b. Relative Humidity = Ambient

5.1.1.3 Samples

- a. 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.
- b. Number and appropriately identify all samples

5.1.1.4 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. See Table 1.

TABLE 1—EQUIPMENT

Item	Description	Requirements*
1	DC Power Supply (Regulated)	$\Rightarrow$ 0 to 650 A
2	Micro-ohmmeter	Must use either offset compensation or current reversal methods to measure resistance. Equipment must limit open circuit voltage to 20 mV and current to 100 mA $\Rightarrow$ 0 to 20 mV $\Rightarrow$ 0 to 100 mA
3	Digital Multimeter (DMM)	Capable of measuring the following at an accuracy of $\leq 0.5\%$ of full scale: $\Rightarrow$ 0 to 50 VDC $\Rightarrow$ 0 to 10 M Ω
4	Current Shunts	100 mA or as required with accuracy of $\pm 1\%$ of nominal
5	Millivolt Meter	Capable of measuring 0 to 100 mVDC at $\leq 0.5\%$ full scale
6	Thermocouples	Type "J" or "T" and as required
7	Insertion/Extraction Force Tester	Capable of 1.0% accuracy, full scale with peak reading feature
8	Data Logger	As required
9	Temperature/Humidity Chamber	$\Rightarrow$ -40 to 90 °C $\Rightarrow$ 0 to 95% RH
10	Temperature Chamber	$\Rightarrow$ -40 to 90 °C
11	Vibration Controller	As required
12	Vibration Table	As required
13	Megohmmeter	Capable of measuring $< 5\%$ of full scale
14	Salt Fog Chamber	Per ASTM B 117
15	Dust Chamber	See ISO 16750

* 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 to 100 V could be substituted for one specified as 0 to 50 V, with the provision that the accuracy could be maintained as $\pm 0.5\%$ of the 50 V full scale, or 0.25 V, not 0.5% of the 100 V full scale of the substituted equipment.

The measurement technique known as the Kelvin or 4-Wire Ohm method should be used as applicable in all resistance/voltage drop measurements in this Specification. This is a measurement technique that places the test probes ahead of the high current connections to eliminate the voltage drop associated with the power connections. It eliminates measurement errors due to the source current present in the test leads when using the 2-Wire Ohm method.

5.1.2 VISUAL INSPECTION

5.1.2.1 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.

5.1.2.2 Samples

Sample quantities and preparation are per the respective test group.

5.1.2.3 Equipment

- a. Camera
- b. Video Recorder
- c. Magnification Apparatus (as required)

5.1.2.4 Procedure

- a. Visually examine each test specimen prior to testing and/or conditioning, noting in detail any 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.
- b. 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.

5.1.2.5 Acceptance Criteria

All samples must be free of defects that could affect the electrical or mechanical performance of the part or degrade its long-term performance.

5.2 Terminal Mechanical

5.2.1 CRIMP MECHANICAL PULL

5.2.1.1 Purpose

This test verifies the mechanical integrity of the wire-to-terminal connection and its ability to withstand rough service as is involved with use in service and recovery vehicles.

NOTE—Pull-out force test will not be used to determine electrical performance of the crimp application. It will only be used to determine the mechanical limits of the crimp application for handling purposes.

5.2.1.2 Samples

Assemble 20 samples of terminals using the applicable cable crimped per the terminal manufacturer's specifications. Terminals may be hand or machine crimped but must use the recommended tools. Samples shall be applied to appropriate cable with overall length no less than 150 mm.

5.2.1.3 Equipment

Mechanical pull tester with peak read feature

5.2.1.4 Procedure

- Pull-out force test shall be performed on taut leads (i.e., remove slack in cable before performing pull-out test to prevent incorrect test results due to "jerking").
- Measure and record pull-out forces in Newtons for each sample.
- Apply an axial force at a rate between 50 and 250 mm/min (100 mm/min is recommended).
- Calculate the mean and standard deviation using the following formulas:

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

Where:

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

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

Report minimum, maximum, mean ($\bar{X}$), standard deviation (s), and the mean minus three standard deviations ($\bar{X} - 3s$).

- Report any observations from visual examination.

5.2.1.5 Acceptance Criteria

The ($\bar{X} - 3s$) value of the pull-out forces are specified in Table 2. The pull-out forces for unlisted conductor sizes can be defined by linear interpolation, (i.e., read out from plotted values in Table 2).

TABLE 2—PULL-OUT FORCE REQUIREMENTS

Metric (mm²)	AWG (approx)	($\bar{X}$ -3s) and Minimum Pull-out Force (N)
.8	18	89
1.0	16	133
2.0	14	222
3.0	12	311
5.0	10	355
8.0	8	400
13.0	6	445

5.3 Terminal - Electrical Tests

5.3.1 ENGAGE/DISENGAGE CONDITIONING PROCEDURE

5.3.1.1 Purpose

This procedure simulates terminal wear and deformation expected during the normal service life of the vehicle and jumper cable connection.

5.3.1.2 Samples

As required.

5.3.1.3 Procedure

NOTE—When samples are subjected to a series of tests as in 5.7, this conditioning procedure is to be done only once (at the first procedure where it is called for).

- Manually engage and disengage each test sample a total of 24 times.
- Re-connect the sample for testing

5.3.1.4 Acceptance Criteria

None – this is a conditioning procedure only

5.3.2 CURRENT CYCLING

5.3.2.1 Purpose

This test simulates the main function of the power 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 zero current conditions. This causes expansion and contraction that may affect connection resistance. Test only the power terminals. Results of this test are NOT to be used for actual terminal application in a vehicle.

5.3.2.2 Samples – 10 mated pairs (connector-to-connector or connector to header).

- a. Number each terminal pair. Then record crimp height and width of a representative group of samples of each terminal.
- b. Terminals are made to production intent design and base material. For purposes of validating the 42 volt Jump Start interface, cable size is 13 mm² (approximately 6 AWG). Crimp samples to the manufacturer's nominal specifications. Test leads are 3000 mm long (maximum).

5.3.2.3 Equipment

- a. Digital Multimeter (DMM)
- b. AC or DC Power Supply (timer controlled)
- c. Current shunts (Size as required)
- d. Thermocouples
- e. Data Logger (As required)

5.3.2.4 Procedure

- a. Conduct this test in an open bench, draft free environment at 23 °C ± 5 °C. An ambient temperature sensor must be placed on the same plane as the test samples, 30 to 60 cm from the nearest sample.
- b. Attach the thermocouples to the hottest accessible point near the contact surface of each mated pair. Experimentation may be needed to locate the point of maximum temperature. All millivolt leads and thermocouple leads must be no larger than 0.22 mm² (24 AWG) wire. When testing headers as half of the mated pair, solder or weld the power supply lead to the header terminal.
- c. Complete the Engage/disengage Conditioning Procedure per 5.3.1 if it has not already been done on this sample set as part of earlier testing.
- d. Measure and record the voltage drop across 75 mm ± 3 mm of the conductor to be used for the test, using a test current of 100 A.
- e. Millivolt readings may be taken by attaching sense leads or by probing with test probes. Choose preferred method of taking voltage readings (soldered/welded test lead or probe), and record the method chosen. Assemble terminals to connectors and attach the millivolt leads (if used) to the terminals as shown in Figure 1. Attach conductor ends of the sample assemblies to form one continuous series circuit from sample to sample. Attach the assembled circuit to a non-conductive surface, such as wood or high temperature plastic, leaving a minimum of 50 mm between test samples.

The thermocouple and test lead attachments must not interfere with the normal contact function.

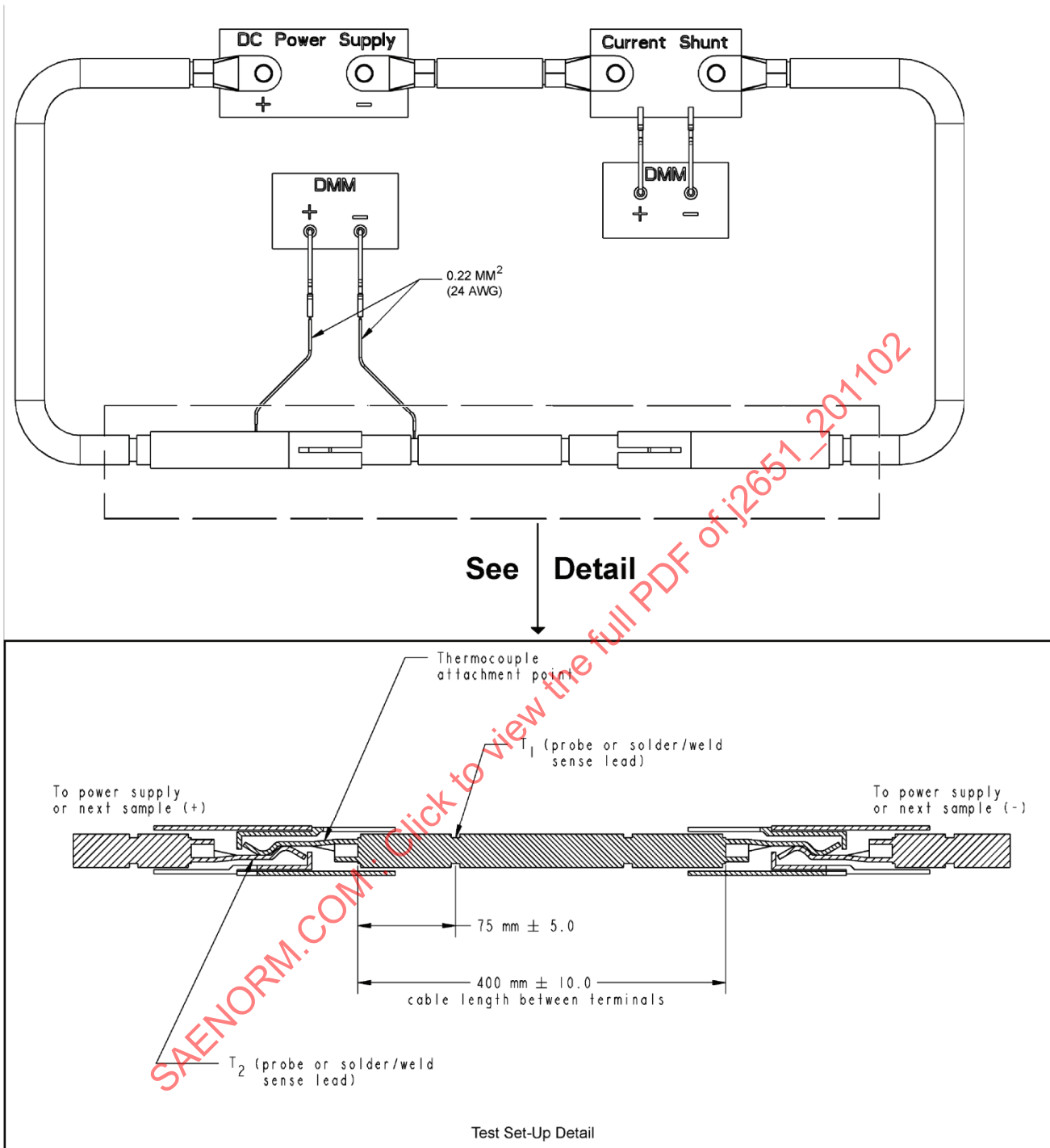


FIGURE 1—CURRENT CYCLING TEST SET-UP

- f. Using the following schedule, cycle for 4 h taking MV drop readings at least once, at the beginning of the test 10 s into the "on" cycle and at the conclusion of the test, 10 s into the final "on" cycle.

100 A continuous for 15 s
45 s off, for a total of 1 min
Complete 240 total cycles (4 h)

These amperages are intended for validation of the 42 V Jump Start connection using 13 mm² (approximately 6 AWG) cable. Other cable sizes may be tested in addition to this depending on specific application requirements.

- g. Record the temperature in the form of a temperature curve for the first 10 cycles and the last 10 cycles
h. Verify conformance to the Acceptance Criteria of 5.3.2.5.

5.3.2.5 Acceptance Criteria

- a. The measured temperature of any mated terminal pair must not exceed a 30 °C rise over ambient for any reading during the test.
b. The calculated Total Connection Resistance shall not exceed 0.5 mΩ for any reading during the test.

5.3.3 VOLTAGE DROP (CONTACT RESISTANCE)

5.3.3.1 Purpose

The purpose of this test is to determine the voltage drop associated with the connection system including cable connection, terminal bulk and interface.

5.3.3.2 Samples

Terminals are made to production intent design and base material. For purposes of validating the 42 V Jump Start interface, cable size is 13 mm² (approximately 6 AWG for the Power Terminals and 0.8 mm (approximately 18 AWG) for the sense pins. Crimp samples to the manufacturer's nominal specifications. Test leads are 3000 mm long (maximum).

Assemble terminals to connectors using all applicable Wedges, TPAs, CPAs, etc.

5.3.3.3 Equipment

- a. Digital Multimeter (DMM)
b. AC or DC Power Supply (timer controlled)
c. Current shunts (Size as required)
d. Data Logger (As required)

5.3.3.4 Procedure

- a. Number each terminal pair. Then record crimp height and width of a representative group of samples of each terminal if required.
- b. When testing headers as half of the mated pair, solder or weld the power supply lead to the header terminal.
- c. Complete the Engage/disengage Conditioning Procedure per 5.3.1 if it has not already been done on this sample set as part of earlier testing.
- d. Measure and record the voltage drop across $75 \text{ mm} \pm 3 \text{ mm}$ of the conductor to be used for the test, using a test current of 100 A for the Power Pins and 0.5 A for the Sense Pins.
- e. Milli-volt readings may be taken by attaching sense leads or by probing with test probes. Choose preferred method of taking voltage readings (soldered/welded test lead or probe), and record the method chosen. Attach the milli-volt leads (if used) to the terminals as shown in Figure 1 as applicable. All milli-volt leads must be no larger than 0.22 mm^2 (24 AWG) wire. Readings may be taken individually on each sample or in groups by attaching conductor ends of the sample assemblies to form one continuous series circuit from sample to sample. Attach the assembled circuit to a non-conductive surface, such as wood or high temperature plastic, leaving a minimum of 50 mm between test samples.
- f. Set the power supply at 100 A for the Power Terminals and 0.5 A for the sense terminals and turn on current to the sample(s).
- g. Record mV drop readings after current has been on for 10 s.
- h. Calculate resulting resistance for each sample.

5.3.3.5 Acceptance Criteria

The calculated Total Connection Resistance shall not exceed 0.5 m Ω for the Power Terminals and 10 m Ω for the sense terminals.

5.4 Connector - Mechanical Tests

5.4.1 TERMINAL - CONNECTOR INSERTION/EXTRACTION FORCE

5.4.1.1 Purpose

This test is done 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 Force testing is done 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 and commercial use in an assist vehicle.

Header push-out testing is done to verify that the terminals will not push back from their position in the header during use.

5.4.1.2 Samples

1. At least 10 female Power and Sense terminals and connectors are required for Insertion Force testing.
2. At least 10 connectors with terminals are required for Extraction Force testing.
3. 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.
4. Machine crimp 20 samples each of Power and Sense Terminals to the manufacturer's nominal specification using the smallest conductor size and insulation type applicable to the design. Crimp both the conductor and insulation grips if applicable.
5. For Header Connectors, 10 assemblies with all associated parts which affect terminal positioning and retention.

5.4.1.3 Equipment

Insertion/Extraction Force Tester

5.4.1.4 Procedure

Vehicle applications using a Header application, proceed directly to Step c.

a. INSERTION FORCE:

1. Number each terminal and connector.
2. Secure the connector shell in an appropriate fixture.
3. Secure the terminal sample in the force tester by gripping the conductor behind the back edge of the terminal.
4. Adjust the force tester to insert the terminal straight into the connector at a uniform rate not to exceed 50 mm/min. Use a fresh terminal and connector cavity sample for each insertion and test each terminal until at least 10 terminal samples have been tested.
5. Record the force required to insert the terminal into the connector for each terminal sample to be tested. To test minimum push-through, continue the test until a force of at least 50 N is reached. Verify conformance to the Acceptance Criteria of 5.4.1.5.

b. EXTRACTION FORCE:

1. Use the assembled samples from Step a.
2. Install the terminal lock (PLR, TPA, Wedge, etc.) if applicable on half of the connectors.
3. Secure the connector shell in an appropriate fixture.
4. Grip the conductor behind the back edge of the terminal.
5. Adjust the force tester to pull the terminal straight back from the connector. Straight back extraction is critical to avoid side loads and binding that can affect force measurements. Increase the pullout force at a uniform rate until pullout occurs or until the force reaches at least 250 N for power or 120 N for Sense Pins. Testing to failure is preferred but may not be practical.
6. 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.
7. Verify that the forces obtained in Step 6 conform to the Acceptance Criteria of 5.4.1.5 for each cavity tested.

c. HEADER TERMINAL PUSH-OUT TESTING:

1. Number each assembly
2. Modify the connector housings as necessary to allow a push tester to push firmly on the nose of the terminal.
3. Using an appropriate holding fixture, gradually apply a force of at least 250 N to the power terminals and 89 N to the sense terminals. Testing to failure is preferred, but may not be practical.
4. Verify conformance to the Acceptance Criteria of 5.4.1.5-b.

5.4.1.5 *Acceptance Criteria*

a. Insertion:

1. The maximum Insertion Force for a terminal to connector is 30 N.
2. Neither the conductor nor the terminal may buckle during the test.
3. The forward stop must withstand a push-through force of 50 N.

b. Extraction:

Minimum Extraction Force of a terminal from its cavity and minimum push-out force for header terminals shall be 89 N for Sense Terminals and 250 N for Power Terminals

5.4.2 CONNECTOR-CONNECTOR MATING/UN-MATING FORCE

5.4.2.1 *Purpose*

This test determines the Mating/Un-mating Forces associated with manual mating and un-mating of complete connector assemblies

5.4.2.2 *Samples*

- a. 10 mating connector pairs with terminals are required. Crimp sample terminals using any conductor size and insulation type applicable to the design. Use the manufacturer's nominal crimp specification and recommended tooling. Crimp both the conductor and insulation grips as applicable.
- b. Completely assemble (but do not mate) all connector halves using all applicable components such as terminals, and wedges.

5.4.2.3 *Equipment*

Force Tester

5.4.2.4 Procedure

a. MATING FORCE:

1. Secure the connector halves in the appropriate fixtures of the force tester. Apply the force to the connector housing and not to the conductors.
2. Increase the Mating Force at a uniform rate until complete mating occurs. Test all samples.
3. 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 5.4.2.5.

b. UN-MATING FORCE:

1. This test uses the same samples as in 5.4.2.4 Step a. If the test equipment permits, each sample may be mated and then unmated without removing it from the force tester.
2. 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, not through the conductor(s). Straight-out un-mating is critical to avoid side loads and binding which can affect force measurements.
3. Apply pressure in the un-mate direction at a uniform rate until complete separation occurs. Test all samples (at least 5) in the first group.
4. Record the force required to completely separate the connector halves and verify conformance to the Acceptance Criteria of 5.4.2.5.

5.4.2.5 Acceptance Criteria

1. Mating Force must be ≤ 135 N.
2. Un-mating Force must be $\geq 75 \leq 135$ N.

5.4.3 POLARIZATION FEATURE EFFECTIVENESS

5.4.3.1 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. 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, it is recommended that a jury evaluation be conducted among knowledgeable individuals trying "hands-on" mis-mating.

5.4.3.2 Samples

5 samples are required assembled with cables and terminals

5.4.3.3 Equipment

Insertion/Extraction Force Tester Procedure

5.4.3.4 Procedure

- a. 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
- b. Connect a suitable continuity tester to each terminal
- c. Secure the connectors in the appropriate fixtures of the force tester. Adjust the force tester to attempt mating of the connector pairs in the orientation selected in Step 5.4.3.4-a.
- d. Engage the connector and header at a uniform rate until the maximum force specified in the part drawing is applied. If no value is specified, apply a maximum force of 220 N.

5.4.3.5 Acceptance Criteria

- a. The minimum mis-Mating Force that must be resisted by the polarizing feature(s) is the value given on the part drawing. If no value is specified, the minimum value is 220 N. No continuity is permitted between any terminals in the opposing connectors.
- b. If sufficient mis-mating is achieved to allow contact between opposing connector terminals, the polarizing feature(s) is considered to be inadequate.

5.4.4 CONNECTOR DROP TEST

5.4.4.1 Purpose

This test evaluates the ability of the connection to withstand impact due to dropping on a hard surface.

5.4.4.2 Samples

3 samples are required. Prepare samples using any applicable size cable at least 1250 mm in length. This test is done on the jumper cable side only.

5.4.4.3 Equipment

Devise a test arrangement as shown in Figure 2

5.4.4.4 Procedure

- a. Complete the Visual Examination per 5.1.2.
- b. Complete the Isolation Resistance Test per 5.5.1.
- c. Condition samples for 1 hour at -20°C .
- d. Remove samples from the conditioning chamber and within 2 minutes, perform the following:
- e. Attach the cable(s) to a fixed point and allow a free swinging of the test sample (a simple attachment on a hook can be sufficient).
- f. Hold the un-mated test sample horizontally and let it swing down to hit a concrete surface or steel plate of minimum dimensions 300 mm x 500 mm x 6 mm (thickness). Repeat a minimum of 3 times or as often as agreed between manufacturer and user.
- g. Complete the Isolation Resistance Test per 5.5.1.
- h. Complete the Visual Examination per 5.1.2.

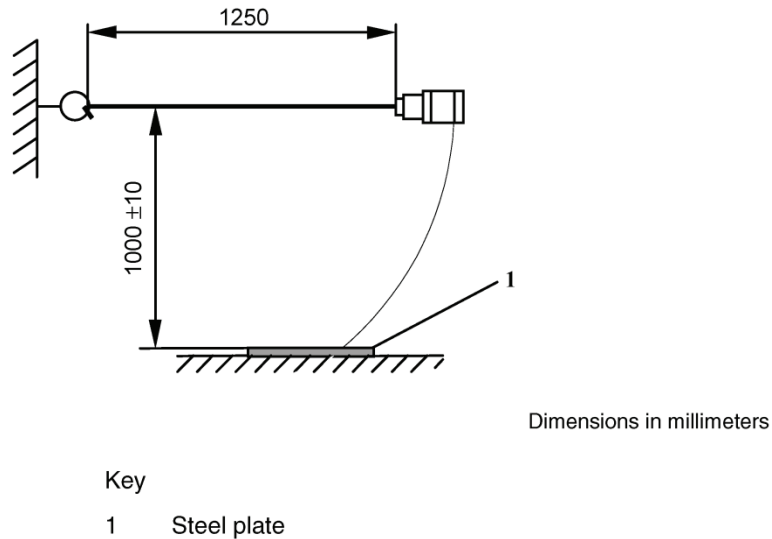


FIGURE 2—DROP TEST ARRANGEMENT

5.4.4.5 Acceptance Criteria

Samples shall meet the Acceptance Criteria of the Isolation Resistance Test, 5.5.1.5.

5.4.5 CONNECTOR 200 CYCLE LIFE TEST

5.4.5.1 Purpose

This test exercises the jumper cable side of the connection to determine functionality of the part with repeated use in a commercial environment.

5.4.5.2 Samples

Prepare 10 mated pairs of assembled connectors and terminals using 400 mm of the intended cable size on the jumper cable side. Header Connectors should be per production intent.

5.4.5.3 Equipment

Hand operated or automatic (hydraulic or pneumatic) cycling equipment may be used. The cycling mechanism should grip and engage the jumper connector to the header or mating in-line connector repeatedly without binding or un-natural interference between the parts.

5.4.5.4 Procedure

- a. Complete the voltage drop measurement per 5.3.3.
- b. Cycle the parts 200 times using an engage/disengage speed of 100 to 200 mm/min. Connectors should fully engage and disengage with each cycle.
- c. Complete the voltage drop measurement per 5.3.3.
- d. Complete the visual examination per 5.1.2.

5.4.5.5 Acceptance Criteria

- a. Samples shall meet the minimum voltage drop per 5.3.3.5.
- b. Samples shall meet the visual requirements of 5.1.2.5

5.4.6 VIBRATION/MECHANICAL SHOCK

5.4.6.1 Purpose

This test subjects the Header or in-vehicle connector to variable vibration simulating accelerated exposure to actual vehicle conditions. Vibration and shock can cause failure of mechanical components of the connector system.

Note that this test is intended to represent location of the connection system on the body of the vehicle. The test and vibration profile may have to be adjusted if validation to more severe requirements is needed.

5.4.6.2 Samples

Prepare 10 samples minimum by assembling all applicable parts and bundling (with tape, convolute, scroll, etc.) the conductors according to the intended application of the parts being tested. Include all applicable mounting features.

5.4.6.3 Equipment

- a. Vibration Table
- b. Vibration Controller
- c. Accelerometers

5.4.6.4 Procedure

- a. The mounting apparatus must be constructed and secured to minimize added effects (harmonics, dampening, resonance, etc), but must include applicable brackets, module cases, etc. as intended in the actual vehicle environment. See Figure 3 for typical set up.
- b. Header Connectors – Secure the un-mated Header Connector to the vibration table. The header will usually be part of a control module as shown in Figure 3A.
- c. “In-line” applications – Where the vehicle application uses a mounted in-line connector for its jump start power point, mount the un-mated connector including bundled cables to the fixture. Use the same mounting provisions as the intended vehicle application. A typical example is shown in Figure 3B.
- d. Securely attach the conductor bundle ends to the mounting fixture. To relieve tension on the cable, up to a 5 mm sag in the wire bundle is permissible.

e.

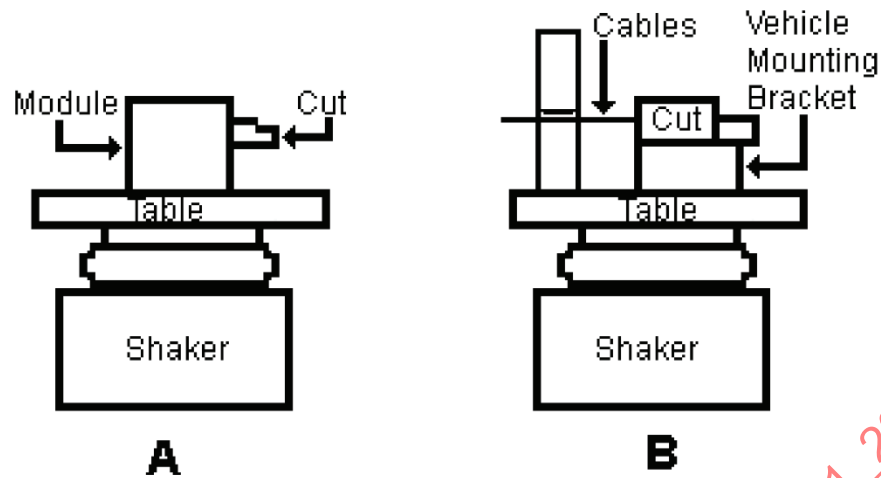


FIGURE 3—TYPICAL CONNECTOR VIBRATION TEST SET-UP

- f. Subject the CUT to 10 half-sine wave impulses (10 ms duration at 35 Gs force) in each of the three mutually perpendicular axes.
- g. Following Mechanical Shock, proceed with the vibration schedule.
- h. Vibration shall be 8 h in each of the three mutually perpendicular axes (X,Y,Z) (unless otherwise specified in the test request/order) using the vibration profile shown in Table 3 and Figure 4.

TABLE 3—VIBRATION PROFILE

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	

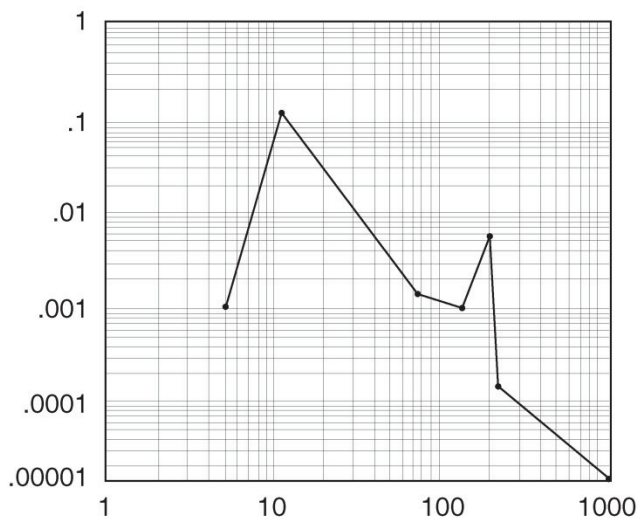


FIGURE 4—JUMP START CONNECTION VIBRATION PROFILE

- i. Verify conformance to the Acceptance Criteria of 5.4.6.5.

5.4.6.5 Acceptance Criteria

- a. The connector assemblies must not show any evidence of deterioration, cracks, deformities, etc. that could affect their functionality.

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.

5.5.1.2 Samples

10 connector assemblies with terminals are required for this test

5.5.1.3 Equipment

Megohmmeter

5.5.1.4 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. If this test is to be performed to check isolation resistance of a new connector housing, prepare samples as specified in 5.3.3.2. All components of the connector assembly must be installed.

NOTE—When samples are to be tested following exposure to moisture or other contaminants, 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.

- a. Connect the Megohmmeter, set to 500 VDC, to the bared conductor ends in the connector system. For special applications, the test voltage may be reduced or increased with the approval of the Authorized Person.
- b. Use the Megohmmeter to measure the resistance between the adjacent terminals. Apply the test voltage continuously for at least 15 s.
- c. Record the minimum resistance measured and verify conformance to the Acceptance Criteria of 5.5.1.5.

5.5.1.5 Acceptance Criteria

The resistance between the two adjacent terminals must exceed 20 M Ω at 500 VDC.

5.6 Connector Environmental Tests

5.6.1 HIGH TEMPERATURE EXPOSURE

5.6.1.1 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.

5.6.1.2 Samples

Samples consist of 10 mated pairs of connectors and terminals. Use 13 mm² (approximately 6 AWG) for the Power Terminals and 0.8 mm² (approximately 18 AWG) for the Sense terminals. Crimp samples to the manufacturer's nominal specifications. Test leads are 3000 mm long (maximum).

5.6.1.3 Equipment

Temperature Chamber(s)

5.6.1.4 Procedure

- a. Record the crimp dimensions for each terminal.
- b. Assemble the fully populated connectors. Assemblies must include all applicable Wedges (TPAs, PLRs, etc.). Number each mated connector pair.
- c. Complete the Engage/Disengage Conditioning Procedure per 5.3.1.
- d. Complete the Voltage Drop test procedure per 5.3.3.
- e. Set the temperature chamber to the maximum ambient temperature (+85 °C). Allow the chamber to stabilize before proceeding.
- f. 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 h.
- g. Sample evaluation is required only at the beginning and end of the test, but additional measurement intervals may be requested by the Authorized Person.
- h. Complete the Voltage Drop test procedure per 5.3.3.
- i. Complete the Visual Examination per 5.1.2.

5.6.1.5 Acceptance Criteria

- a. The calculated Total Connection Resistance for the Power Pin shall meet the acceptance requirements of the Voltage Drop (Contact Resistance) test procedure, 5.3.3.5 both before and after conditioning.

NOTE—If samples are to be subjected to further testing (for example as part of the test sequence shown in 5.7) do not perform any steps beyond this point.

- b. The connector assemblies must not show any evidence of deterioration, cracks, deformities, excessive plating wear or fretting, etc. that could affect their functionality. Connector locking mechanisms must function without breakage.

5.6.2 FLUID RESISTANCE

5.6.2.1 Purpose

This test evaluates the material compatibility of the connector system when immersed in various fluids commonly found in and around road vehicles.

5.6.2.2 Samples

8 fully assembled connector pairs are required for this test. Prepare samples using a conductor of the smallest applicable gage size, and insulation thickness appropriate to the application. Machine crimp a minimum of 16 each of the sense and power terminals and assemble to connectors using all applicable Wedges TPAs, PLRs, etc.).

5.6.2.3 Equipment

- a. Laboratory Fume Hood
- b. Stainless steel tanks or Pyrex beakers

5.6.2.4 Procedure

- a. Verify conformance of each mated sample connector assembly to the Isolation Resistance test, 5.5.1. This establishes a reference for the concluding Isolation Resistance test.
- b. Completely submerge at least 1 test sample in each fluid listed in Table 4 for 30 min. 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.

TABLE 4

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 III	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 A for fluid source list

- a. Table 4 – Chemicals for Fluid Compatibility Test - 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 for one week. Do not allow samples submersed in different fluids to touch each other and do not allow any dissimilar fluid drippings to intermingle.
- b. At the conclusion of the storage period, samples may be dried sufficiently to allow inspection and to avoid contamination of test apparatus.
- c. Mate the connectors to an appropriate mating part and complete the Isolation Resistance Test procedure, 5.5.1.

5.6.2.5 Acceptance Criteria

At the conclusion of this test:

- a. Each mated terminal pair in every test sample must meet the Acceptance Criteria of the Isolation Resistance test, 5.5.1.5.
- b. There must be no visible degradation, swelling, cracking, or loss of mechanical function evident on any test sample.

5.6.3 BIASED SALT FOG

5.6.3.1 Purpose

Conduct this test only on connection systems intended to be packaged in wet areas of the vehicle. Interior/trunk applications are not required to complete this procedure as long as no salt/moisture environment is encountered for the life of the vehicle.

This is a benchmark conditioning procedure to determine the ability of the connection system to withstand a salt and moisture environment without significant corrosion or loss of isolation resistance between connector cavities or increased connection resistance. Correlation of this test to the application depends on final packaging and protection in the vehicle. Therefore the test set-up must mimic the vehicle environment as closely as possible. This includes any close-out covers or protective caps. Nearby components including sheet metal from the packaging environment can affect the outcome of the test and may therefore also have to be included. Testing may also be done without protective covers if directed by the OEM.

Final correlation to the particular vehicle application and duty cycle may require modification of this test and/or vehicle level testing.

5.6.3.2 Samples

Prepare 10 connector assemblies per 5.3.3.2. The test set-up must include all applicable close-out covers or protective caps to simulate the actual vehicle environment. Connectors are tested in the unmated condition. Test leads must be of sufficient length so that open ends are outside the fog chamber.

10 additional cable side mating connectors are required for completing the voltage drop test following the conditioning procedure.

For in-line style connectors, mount the connectors to a mounting bracket that would simulate vehicle installation. If the vehicle installation uses a conductive metal bracket, then a like bracket must be used for testing.

5.6.3.3 Equipment

- a. Salt fog cabinet operating at a temperature of $35 \pm 1.1/-1.7$ ° C, The Albert Singleton Corporation Model 4911-31 or other suitable equipment (reference ASTM B 117)
- b. Multimeter
- c. Regulated 42 VDC Power Supply
- d. $5\% \pm 1\%$ sodium chloride solution, prepared with de-mineralized water and with pH adjusted to yield salt fog with a pH in the range of 6.5 to 7.2

5.6.3.4 Procedure

- a. Complete the Visual Examination procedure per 5.1.2.
- b. Verify conformance of each mated sample connector assembly to the Isolation Resistance test, 5.5.1. This establishes a reference for the concluding Isolation Resistance test.
- c. Arrange the parts in the salt fog chamber and connect a power supply set at 42 VDC to the positive and negative Power Pins in each connector to create a biased condition. Voltage bias is applied during the entire conditioning procedure including soak periods. The Sense Pins are not connected to the power supply.
- d. For in-line style connections, connect the simulated mounting bracket to the power supply negative (-)
- e. Refer to the flow chart in Figure 5 for the test sequence. Complete 4 cycles of the total sequence (96 h total).
- f. Connect each part to an un-conditioned mating connector and complete the Voltage Drop test procedure per 5.3.3. Measure both the Power and Sense Pins.
- g. Complete the Visual Examination procedure per 5.1.2.

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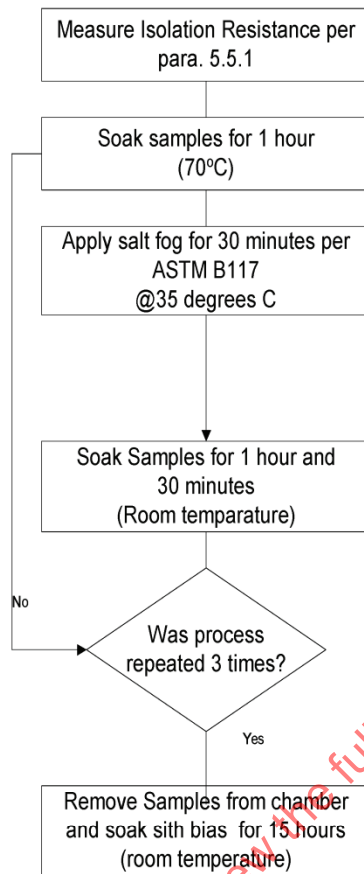


FIGURE 5—BIASED SALT FOG TEST FLOW CHART

5.6.3.5 Acceptance Criteria

- There shall be no significant corrosion on the mating surfaces of the connector or terminals so as to inhibit proper electrical function.
- The samples shall meet the isolation resistance requirements of 5.5.1.5
- The assembled connectors shall meet the voltage drop requirements of 5.3.3.5.
- Connectors shall meet the Visual Examination Acceptance Criteria of 5.1.2.5

5.6.4 DUST ENVIRONMENT

5.6.4.1 Purpose

This procedure tests the capability of the jump start connector to function after extended exposure to dust as encountered in the engine compartment environment.

Perform the following test on the jump-start vehicle (Header) connector only.

This is a benchmark conditioning procedure to determine the ability of the connection system to withstand a dust environment without significant increase in connection resistance. Correlation of this test to the application depends on final packaging and protection in the vehicle. Therefore the test set-up must mimic the vehicle environment as closely as possible. This includes any close-out covers or protective caps. Nearby components from the packaging environment can affect the outcome of the test and may therefore also have to be included.

This is a benchmark test only. Final correlation to the particular vehicle application and duty cycle may require modification of this test.

5.6.4.2 Samples

Prepare 10 connector assemblies per 5.3.3.2. The test set-up must include all applicable close-out covers or protective caps to simulate the actual vehicle environment.

10 additional mating connectors are required for completing the voltage drop test following the conditioning procedure. Connectors are tested in the un-mated condition. All protective covers/shields as intended for the vehicle application must be in place.

5.6.4.3 Equipment

See ISO 16750 (DIN 40050)

5.6.4.4 Procedure

- a. Complete the Visual Examination per 5.1.2.
- b. Complete the Isolation Resistance Test per 5.5.4.
- c. Complete the Voltage Drop Test per 5.3.3
- d. Mount the test samples in an orientation similar to that in which they are mounted in the vehicle. Orient connectors with respect to the direction of the blowing dust such that they will experience maximum erosion effects. Condition parts at room temperature per ISO 16750-4 (DIN 40050) for a total of 12 h using a 1 min on, 59 min off cycle.
- e. At the end of the exposure cycle, without cleaning of any kind, mate the connectors to the appropriate cable side connector and complete the voltage drop test per 5.3.3 and the isolation resistance procedure per 5.5.1.
- f. Complete the Visual Examination per 5.1.2.