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Battery Connections for 42 Volt Electrical Systems Tests and General Performance Requirements

RATIONALE

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

STABILIZED NOTICE

This document has been declared "Stabilized" by the SAE Connector Systems Standards Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

TABLE OF CONTENTS

1. ***Scope***—This SAE Standard defines test methods and general requirements at all phases of development, production, and field analysis of electrical terminals, connectors, and components that constitute the direct connection to the storage battery of road vehicles having 42 volt (nominal) electrical systems.

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 J311—Fluid for Passenger Car Type Automatic Transmissions
SAE J1127—Battery Cable
SAE J1128—Low Tension Primary Cable

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

3.1 Acceptance Criteria—Generally, this is 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 BladeTerminal—This metal blade or pin inserts into the Receptacle Terminal. The Blade terminal is part of the Header Connector assembly

3.4 Engaging Force—The force required to mate a separate pair of contacts (terminals) or a contact and mating test gage.

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

3.6 Receptacle Connector—This connector houses the Receptacle (Female) Terminal(s).

3.7 Header Connector—A connector system that utilizes one or more fixed Blade Male 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.

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

3.9 Leakage—Refers to current passage between two or more conductors separated by a normally non-conductive medium when sufficient voltage potential exists between the conductors. By increasing the potential to 500 volts DC or more, the current flow, or Leakage, becomes measurable even though at a micro or nano-ampere scale. Leakage measured at a known voltage is useful in estimating contact air gap and detecting contaminants without specimen disassembly.

3.10 Mating Force—The force required to mate Blade and Receptacle Connector halves or to completely seat a connector in a device Header or receptacle.

3.11 Maximum Current Capability—This is the maximum current carrying capability at Room Temperature for a specific combination of terminal size, conductor gage, insulation type, etc. This value must be derated for actual conditions in the expected application.

3.12 Mechanical Assist—This is a device used to minimize the operator effort required to mate two connector halves or a connector to a header. Typical means are a bolt, cam, or lever.

3.13 Power Pin—This is the primary current conducting terminal or pin for the battery connector.

3.14 Receptacle Terminal—This electrical receptacle receives the Blade or pin terminal.

3.15 Room Temperature—23 °C ± 5 °C.

3.16 Sense Pin—This is the battery connector terminal or pin that services the temperature and/or 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.

3.17 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.

3.18 Special Tool—A tool specifically designed to mate and/or un-mate a connector, or to insert and/or remove a connector terminal or other component.

3.19 Total Connection Resistance—This is the 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. Included is the "bulk resistance" of the terminal material itself.

3.20 Un-mating Force—The force required to un-mate Blade and Receptacle Connector halves or a connector from a device Header or Blade Connector.

4. Abbreviations

CPA	Connector Position Assurance. This is a secondary 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 Totalizator/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.
TUT	Terminal Under Test.
WEDGE/SPACER	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 = ±3 °C
b. Voltage = ±2%
c. Current = ±1%
d. Resistance = ±1%
e. Length = ±1%
f. Time = ±5%
g. Force = ±5%
h. Frequency = ±5%
i. Flow Rate = ± 5%
j. Relative Humidity = ±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 ± 5 °C
b. Relative Humidity = Ambient
c. Voltage = 42.0 ± 1.0 VDC

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.

5.1.1.5 Sense Pins—This specification is used primarily to test the performance capability of high current battery connections and terminals used with 42 volt electrical systems. Any low current (sense) terminals residing in this battery connection shall also be tested and shall meet the requirements of this document.

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. A person with normal or corrected vision and normal color sensitivity under cool white fluorescent lighting can accomplish examinations in most cases. 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 *Equipment*

Camera
Video Recorder
Magnification Apparatus (as required)

TABLE 1—EQUIPMENT

Item	Description	Requirements[1]
1	DC Power Supply (Regulated)	0-650 A
2	Micro-ohmmeter	Must use either offset compensation or current reversal methods to measure resistance 0-20 mV 0-100 mA
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 mV DC at ≤0.5% full scale
6	Thermocouple	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	–40 °C to 90 °C 0% to 95% RH
10	Temperature Chamber	–40 °C to 90 °C
11	Vibration controller	As required
12	Vibration Table	As required
13	Pressure/Vacuum Source	As required
14	Megohmeter	Capable of measuring ≥100 Megohms at 500 Volts DC ± 5% accuracy

1. 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.

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.

5.1.2.3 *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.

5.1.2.4 *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—Electrical Tests

5.2.1 Engage/Disengage Conditioning Procedure

5.2.1.1 Purpose—This procedure simulates terminal wear and deformation expected during normal assembly and service during the life of the vehicle and battery.

5.2.1.2 Sample Size—As required

5.2.1.3 Procedure

NOTE— When samples are subjected to a series of tests as in 5.6 Flow Charts, this conditioning procedure is to be done only once (at the first procedure where it is called for).

a. Manually engage and disengage each test sample a total of 24 times. Verify that any Mechanical Assist features are fully actuated with each engagement and disengagement. On terminal samples without plastic connectors, use caution to assure that mating and un-mating is done along terminal centerlines to prevent side pressure that may distort either terminal.
b. Re-connect the sample for testing
c. Complete the visual inspection (see 5.1.2)

5.2.1.4 Acceptance Criteria—Samples shall meet the Acceptance Criteria of the Visual Inspection (see 5.1.2.4)

5.2.2 Dry Circuit Resistance

5.2.2.1 Purpose—This test applies only to the 2.8 mm Sense Pins. It does not apply to the positive and negative Power Pins due to the high voltage/current at which they operate.

This test determines the combined resistance of the conductor crimp and the contact interface of a mated terminal pair under low energy (dry circuit: 20 mV open circuit voltage and 100 mA current limit) 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

5.2.2.2 Samples—Samples consist of 10 mated pairs of terminals crimped to the largest size wire appropriate. Crimp the samples per the manufacturer.s specifications.

5.2.2.3 Equipment—Micro-ohmmeter that limits the open circuit voltage to 20 mV and limits the current applied to 100 mA.

5.2.2.4 Procedure

NOTE— Take care to avoid any mechanical disturbance of mated terminal samples submitted for this test. Such disturbance could rupture any insulating film that 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 a and f.

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.

a. For virgin terminals, record the crimp height and width of each terminal. Do NOT mate the terminal pairs until after the millivolt leads have been attached, as directed in Step d. For terminals that have been subjected to prior testing, do not disconnect their connector housings or remove any terminal from its housing.
b. Measure and record the resistance across 75 mm ± 3 mm of the conductor to be used for the test. Record the conductor resistance.
c. 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 (Figure1) must be soldered for all stranded cable.

NOTE— For setting up the Header Connector sense terminal for testing, 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.

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 the 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 platings or cause stress relaxation in any connection component. Application of an appropriate heat sink may be advisable. Refer to Figure 1.

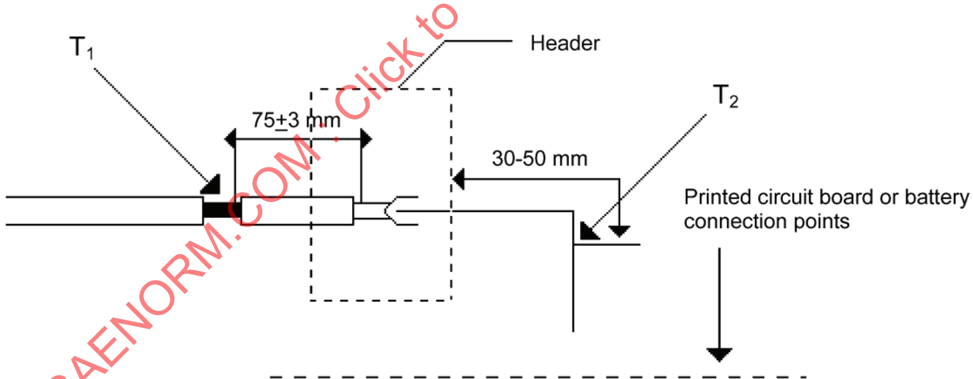


FIGURE 1—HEADER MILLIVOLT LEAD PLACEMENT

d. Attach the millivolt leads if applicable in positions T_1 and T_2 as shown in Figure 1. All millivolt leads must be no larger than 0.22 mm^2 (24 AWG).
e. 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 Blade to Receptacle interface can be maintained.
f. Carefully mate the test terminal pair to the appropriate depth. 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.
g. Measure and record the resistance between T_1 and T_2, as shown in Figure 1 Then deduct the conductor and bus bar resistances to find the total connection dry circuit resistance.
h. Verify conformance to the Acceptance Criteria of 5.2.2.5

5.2.2.5 *Acceptance Criteria*—The Total Connection Resistance calculated in step h shall not exceed 10 m

5.2.3 1008 HOUR CURRENT CYCLING

5.2.3.1 *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 that 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 due to wear, oxidation, inter-metallic growth and stress relaxation. Results of this test are NOT to be used for actual terminal application in a vehicle.

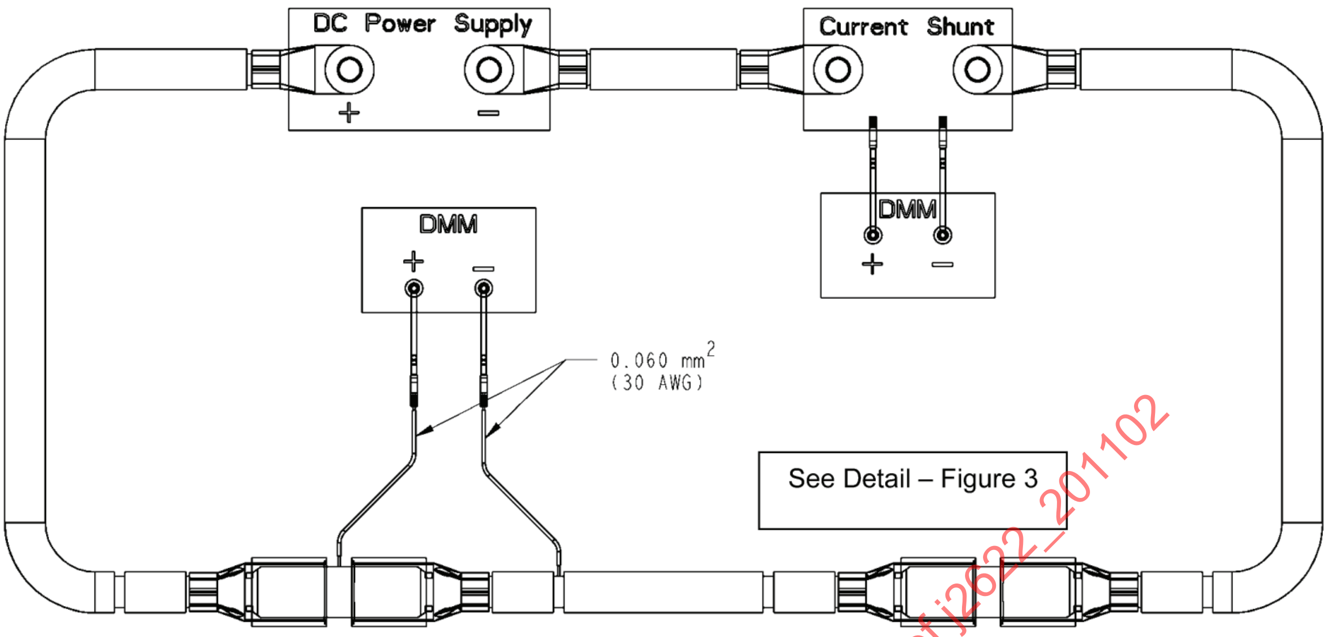
5.2.3.2 *Samples*—10 mated pairs.

5.2.3.3 *Equipment*

Digital Multimeter (DMM)
AC or DC Power Supply (timer controlled)
Current shunts (Size as required)
Thermocouples
Data Logger (As required)

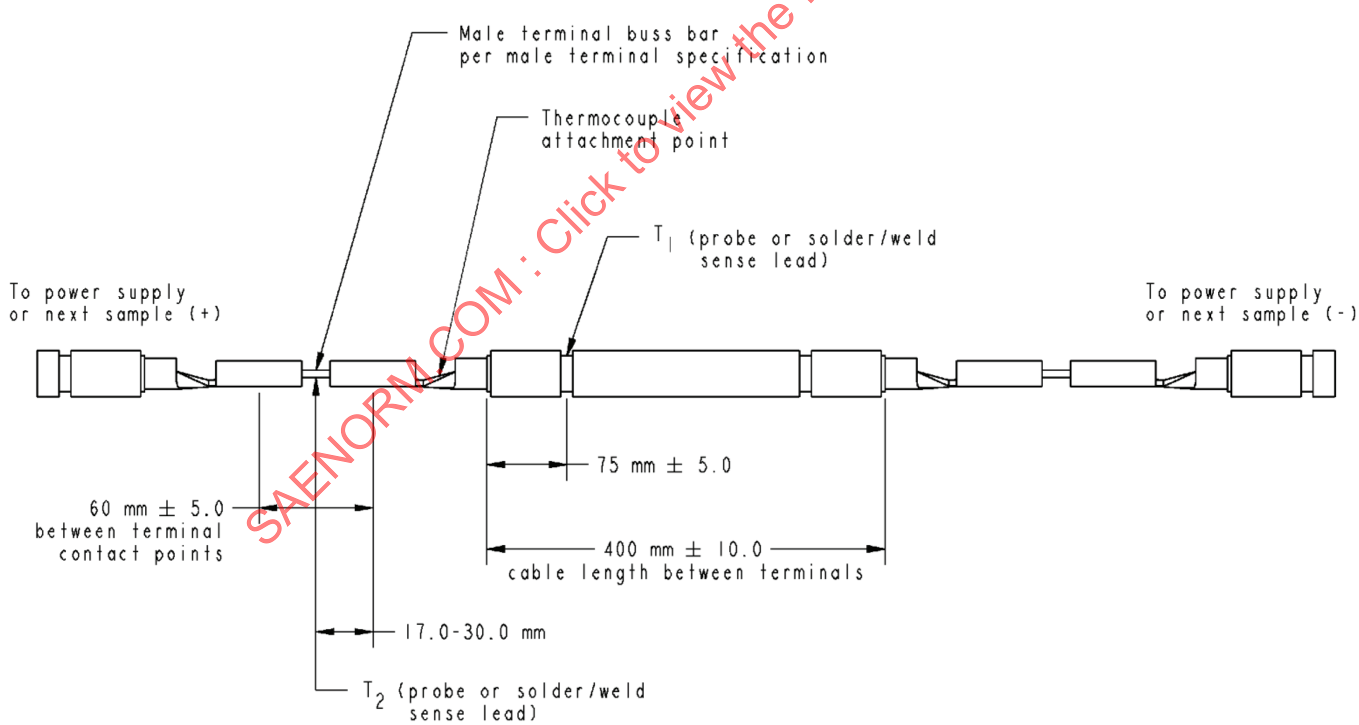
5.2.3.4 *Procedure*

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. BladeTerminals are made to production intent design and base material and plated with silver per SAE J2366-1. For purposes of validating the 42 volt battery interface, cable size is 32 mm^2 to 35 mm^2. (Cable size must be recorded) Crimp samples to the manufacturer.s nominal specifications. Test leads are 200 mm long.
c. Number each terminal pair. Then record crimp height and width of a representative group of samples of each terminal.
d. Complete the Engage/disengage Conditioning Procedure per 5.2.1 if it has not already been done on this sample set as part of earlier testing.
e. Measure and record the voltage drop across 75 mm ± 3 mm 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.
f. 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. Attach the millivolt leads (if used) to the terminals as shown in Figures 2 and 3 as applicable. Attach the thermocouples to the hottest external point of each mated pair (usually on the Receptacle Terminal). Experimentation may be needed to locate the point of maximum temperature. All millivolt leads and thermocouple leads must be no larger than 0.22 mm^2 (24 AWG) wire. 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.



NOT TO SCALE

FIGURE 2—CURRENT CYCLING TEST SET-UP



NOT TO SCALE

FIGURE 3—Typical Test Sample Arrangement

NOTE— This test may be interrupted once every 5 days to accommodate weekend laboratory hours

g. Test the set of sample terminal pairs at 23 °C. (Room Temperature).
h. Using the following schedule, cycle for 1008 hours taking temperature and MV drop 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.

   600 amps for 10 seconds
   120 amps continuous for 44 minutes and 50 seconds
   15 minutes off, for a total of 1 hour
   Complete 1008 total cycles (42 days)

   These amperages are intended for validation of the 42 volt battery connection using 32 or 35 mm^2 cable. Other cable sizes may be tested in addition to this depending on specific application requirements. Current level may need to be adjusted in these cases.

i. Verify conformance to the Acceptance Criteria of 5.2.3.5.

5.2.3.5 Acceptance Criteria

a. The measured temperature of any mated terminal pair must not exceed a 50 °C rise over ambient for any reading during the test.
b. The calculated Total Connection Resistance shall not exceed 0.50 m for any reading during the test.

5.3 Connector—Mechanical Tests

5.3.1 TERMINAL—CONNECTOR INSERTION/EXTRACTION FORCE

5.3.1.1 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.

5.3.1.2 Samples

a. At least 10 Receptacle Power and Signal terminals and connectors are required for Insertion Force testing.
b. Machine crimp 10 samples each of Power and Signal 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. Assemble the terminal with all appropriate conductor seals.
c. At least 20 Receptacle Power and Signal terminals and connectors are required for Extraction Force testing. 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.
d. Repeat Step 2 using the largest conductor size and insulation type applicable to the design.

5.3.1.3 Equipment

a. Insertion/Extraction Force Tester
b. Temperature/Humidity Chamber (May be required)

5.3.1.4 *Procedure*

a. Insertion Force:

1. Number each terminal and record crimp height and width. Number each connector.
2. Secure the connector shell in an appropriate fixture.
3. Secure the terminal sample in the force tester by gripping the conductor 2 cm behind the back edge of the terminal. For terminals requiring a gripping distance other than 2 cm, obtain approval from the Authorized Person.
4. 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 and connector 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 5.3.1.5.

b. Extraction Force:

1. Use the assembled samples from 5.3.1.2.4 (largest conductor size)
2. Number each terminal and record crimp height and width. Number each connector.
3. Install a terminal sample into each cavity in 20 connectors. Install the terminal lock (PLR, TPA, Wedge, etc.) on half of the connectors.
4. Secure the connector shell in an appropriate fixture.
5. Grip the conductor 2 to 5 cm 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 that can affect force measurements. Increase the pullout force at a uniform rate until pullout occurs or until the force reaches 220 N for power or 100 N for Sense Pins.
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 f conform to the Acceptance Criteria of 5.3.1.5 for each cavity tested.

5.3.1.5 *Acceptance Criteria*

a. Insertion:

1. The maximum Insertion Force for a terminal with a ≤1 mm^2 conductor core is 15 N.
2. The maximum Insertion Force for a terminal with a >1 mm^2 conductor core is 30 N.
3. Neither the conductor nor the terminal may buckle during the test.
4. The forward stop must withstand a push-through force of 50 N.

b. Extraction: Minimum Extraction Force of a terminal from its cavity shall meet the values shown in Table 2:

TABLE 2—TERMINAL—CONNECTOR MINIMUM EXTRACTION FORCE

Terminal Size	Primary Lock (Newtons)	Primary and Secondary Lock (Newtons) (moisture conditioned)(1)	Primary and Secondary Lock (Newtons) after High Temperature Exposure (see 5.5.3)
≤2.8 mm	60	90	48
Battery Power terminal	150	200	150

1. The forces specified in t he Acceptance Criteria must be met regardless of the moisture content of the connector housing material. Additional testing with moisture-conditioned parts maybe required for connectors made with plastics subject to significant moisture absorption.

5.3.2 CONNECTOR-CONNECTOR MATING/UN-MATING FORCE

5.3.2.1 Purpose—This test determines the Mating/Un-mating Forces associated with manual mating and un-mating of complete connector assemblies. The force measured is the required force to manually operate the Mechanical Assist in mating and un-mating the fully populated connector. 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.

5.3.2.2 Samples

a. 10 Receptacle and 10 header (Blade) connector and terminal assemblies are required. Machine crimp sample terminals using any conductor size and insulation type applicable to the design. Use the manufacturer.s nominal crimp specification. Crimp both the conductor and insulation grips. Assemble the connector with all appropriate conductor seals.
b. Completely assemble (but do not mate) all connector halves (both Blade and Receptacle) using all applicable components such as terminals, wedges, and seals.

5.3.2.3 Equipment

a. Force Tester
b. Temperature/Humidity Chamber (May be required)

5.3.2.4 Procedure

a. Mating Force

1. Secure the connector halves (one header and one Receptacle) in the appropriate fixtures of the force tester. Manually start the insertion until the lever or cam can be engaged and then apply the force to the cam or lever at the mid point on the thumb or finger grip.
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 5.3.2.5.

b. Un-Mating Force

1. This test uses the same samples as in 5.3.2.4 Step a. If the test equipment permits, each sample may be mated and then unmated without removing it from the force tester.
2. Half of the samples (at least 5) are to be tested with the connector cam lever 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, not through the conductor(s). Straight-out un-mating is critical to avoid side loads and binding which can affect force measurements.

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.

3. Apply pressure in the un-mate direction at a uniform rate until complete separation occurs or a force of 300 N is reached (whichever is lower). Test all samples (at least 5) in the first group. A CPA device, if provided for, must NOT be engaged during this test.
4. Record the force required to completely separate the connector halves or if the 300 N force was reached without separation and verify conformance to the Acceptance Criteria of 5.3.2.5.

5. For the remaining samples (at least 5) measure the force required to disengage the primary connector lock. This is the force a person would apply to 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. Apply the force perpendicular to the appropriate unlocking surface or cam/lever handle at a uniform rate. Record the force required to displace the lock so it just clears its mating feature. Verify conformance to the appropriate Acceptance Criteria of 5.3.2.5.

5.3.2.5 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.

NOTE— The forces specified in the Acceptance Criteria must be met regardless of the moisture content of the connector housing material. Additional testing with moisture-conditioned parts may be required for connectors made with plastics subject to significant moisture absorption.

a. Mating Force must be ≤75 N (includes Mechanical Assist feature).
b. Un-mating Force must be ≤75 N (includes Mechanical Assist actuation force).
c. Battery connector Un-mating Force must be ≥200 N with the primary connector lock fully engaged.

5.3.3 POLARIZATION FEATURE EFFECTIVENESS

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

5.3.3.2 Samples—5 samples are required for each polarization scheme to be tested. 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 BladeTerminal in any position if that Blade Terminal was installed.

5.3.3.3 Equipment

a. Insertion/Extraction Force Tester Procedure

1. Two Factors must be Considered—Attempting to incorrectly mate a Receptacle Connector half and a header, that are supposed to mate if properly oriented, and attempting to mate a connector with an incorrect mate.
2. 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, with the right index

3. Secure the Blade (header) and Receptacle connector in the appropriate fixtures of the force tester. Adjust the force tester to attempt insertion of the Receptacle Connector into the Header in the orientation selected in Step 5.3.3.2.

4. Engage the Receptacle 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. Note the indication of the penetration detection device installed in Step 5.3.3.2. Manually engage the Mechanical Assist feature as applicable and note whether actuation engages the lock pins and pulls the connector toward the seated position.

5.3.3.4 *Acceptance Criteria*—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.

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

5.3.4 MISCELLANEOUS COMPONENT ENGAGE/DISENGAGE FORCE

5.3.4.1 *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 as well as removal for service where necessary.

5.3.4.2 *Samples*—10 samples are required.

5.3.4.3 *Equipment*

a. Insertion/Extraction Force Tester

5.3.4.4 *Procedure*

a. Engagement Force

1. 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 that can affect force measurements.
2. Engage each component to be tested, with its retaining mechanism(s) in place, at a uniform rate, gradually increasing the force to 40 N or until the part fully engages.
3. 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 5.3.4.5.

b. Disengaging Force

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.

1. With the component fully installed and properly fixtured, disengage the component at a uniform rate gradually increasing the force to 40 N or until the part fully disengages. The force must be applied parallel to the centerline of the component being tested to avoid side loads and binding that can affect force measurements. The direction must be opposite to the direction of normal insertion of the component part.
2. Record the force required to completely disengage the component from its mating part and use this value to verify conformance to the Acceptance Criteria of 5.3.4.5.

5.3.4.5 *Acceptance Criteria*

a. For Insertion—Device (TPA, PLR, CPAs, etc.) Insertion Force must conform to the value(s) specified on the part drawing. If no value is specified, Insertion Force must be greater than 15 N and less than or equal to 30 N.
b. For Extraction—For devices such as a TPA, CPA or PLR meant for manual removal for service, the disengaging force must conform to the value(s) specified on the part drawing. If no value is specified, disengaging force must be >15 N and ≤30 N.

There must be no damage to the connector or part that would render it non-functional if re-engaged.

5.3.5 VIBRATION/MECHANICAL SHOCK

5.3.5.1 *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 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.

5.3.5.2 *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.

5.3.5.3 *Equipment*

a. DC Power Supply (0 to 20 VDC)
b. Vibration Table
c. Vibration Controller
d. Continuity Totalizator/Analyzer (CT/A or equivalent)
e. Accelerometers

5.3.5.4 *Procedure*

a. Complete the Engage/Disengage Conditioning Procedure as specified in 5.2.1.
b. Construct a suitable mounting apparatus using the following design criteria:
    1. The mounting apparatus must be constructed and secured to minimize added effects (harmonics, dampening, resonance, etc.). In most cases, the battery connector should use the mounting set-up shown in Figure 4A). Clamping or nesting of the Header Connector is preferable to making modifications to the header itself (drilling, machining or otherwise changing the physical characteristics of the part).
    2. Mount the Header directly to the Mounting Bracket. Refer to Figure 4.
    Should an application arise that does not lend itself to the situation described previously, then 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.
    3. The distance between conductor attachment points to the fixture must not exceed 750 mm in overall length. The conductor attachment points must both be within 100 mm of the centerline of the CUT.

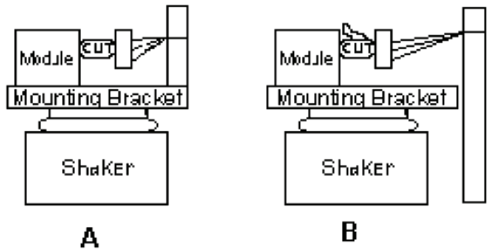


FIGURE 4—MOUNTING POSITIONS

c. 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.

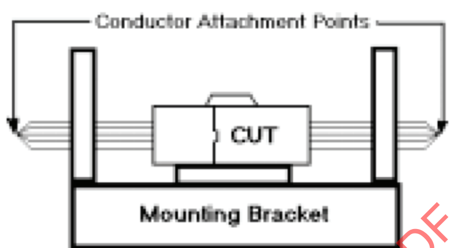


FIGURE 5—TYPICAL CONNECTOR VIBRATION TEST SET-UP

d. Solder the conductors for Sense Pin terminals to the adjacent header pin tail 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 ohm ±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 Totalizator/ Analyzer (CT/A) across the resistor, making sure that the negative lead of the CT/A is connected to the negative side of the resistor.
Adjust the power supply to provide 100 mA DC to the circuit. Set the CT/A to monitor the current through the resistor and record any instance where that current falls below 95 mA. As an option, the CT/A 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 6 Other suitable continuity monitoring equipment may be used.

CAUTION—Monitoring is required for the sense leads only. It is not necessary to monitor the power leads since high normal force and high operating voltage and current makes testing for low level intermittences unnecessary.

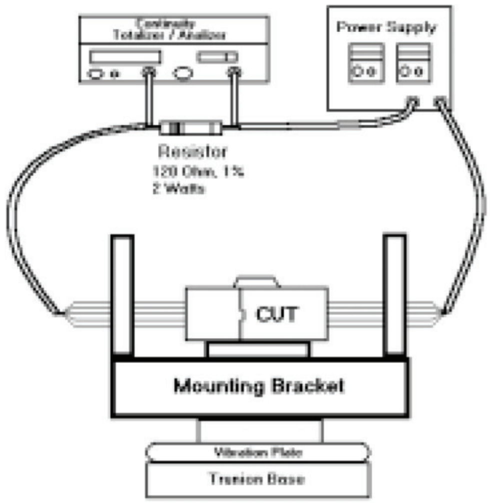


FIGURE 6—TEST SET-UP

NOTE— Voltage on the power supply must be limited, so that a high resistance or open circuit will not result in increasingly higher voltage being applied to the circuit in an attempt to maintain the 100 mA current. This would obscure detection of any current interruption and might invalidate subsequent Dry Circuit Resistance measurements.

e. Subject the CUT to 10 half-sine wave impulses (10 millisecond duration at 35 Gs force) in each of the three mutually perpendicular axes.
f. Following Mechanical Shock, proceed with the vibration schedule.
g. Vibration shall be 8 hours 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 Figure 7.

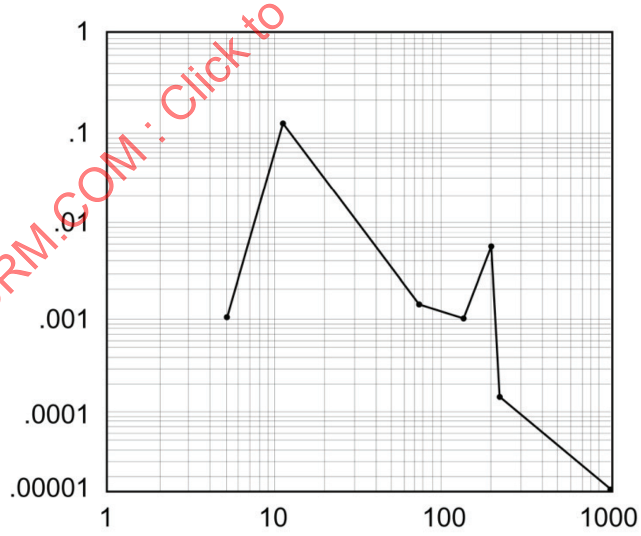


FIGURE 7—BATTERY CONNECTION VIBRATION PROFILE

h. Following vibration, using the basic set-up and procedure from the 1008 Hour Current Cycling Test (see 5.2.3), measure and record the voltage drop and calculate resistance for the power pin at 120 amps.
i. Measure and record the dry circuit resistance of the sense pin (see 5.2.2)
j. Record the results, inspect the CUT, and verify conformance to the Acceptance Criteria of 5.3.5.5.

5.3.5.5 *Acceptance Criteria*—The following criteria must be verified during or after the Connector System Vibration/Mechanical Shock Test of this Section.

a. There must be no loss of electrical continuity (any instance of the resistor current dropping below 95 mA), for more than 1 microsecond. There must be no instance in which the resistance of any terminal pair exceeds 7.0 Ω for more than 1 microsecond (applies to Sense Pin only for battery connectors).
b. The calculated Total Connection Resistance for the power pin shall not exceed 0.50 mΩ for any reading after the test.
c. The Total Dry Circuit Connection Resistance for the sense pin shall not exceed 10 mΩ for any reading after the test.
d. The connector assemblies must not show any evidence of deterioration, cracks, deformities, excessive plating wear or fretting, etc. that could affect their functionality.

5.4 Connector—Electrical Tests

5.4.1 Isolation Resistance

5.4.1.1 *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.

5.4.1.2 *Samples*—10 connector assemblies with terminals are required for this test

5.4.1.3 *Equipment*

a. Megohmeter

5.4.1.4 *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 5.5.1.4, Step a. All seals and all other 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 Megohmeter, set to 500 VDC, to the bared conductor ends from the power to the signal terminal 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 Megohmeter 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 5.4.1.5.
d. Wrap the connector with conductive foil and measure the isolation resistance between both cavities of the connector and the foil wrap.

5.4.1.5 *Acceptance Criteria*—The resistance between the two adjacent terminals or any terminal and the foil wrap in the CUT must exceed 20 Mega-Ohms at 500 VDC.

5.5 Connector Environmental Tests

5.5.1 THERMAL SHOCK

5.5.1.1 *Purpose*—This test subjects the connector assembly to extreme temperature cycles which 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.

5.5.1.2 *Samples*—Samples consist of 10 mated pairs of terminals crimped to the largest size wire appropriate. Crimp the samples per the manufacturer's specifications.

5.5.1.3 *Equipment*

a. DC Power Supply
b. Continuity Totalizator/Analyzer (CT/A)
c. Data Logger
d. Temp. Chamber(s)

5.5.1.4 *Procedure*

a. Record the crimp height and width of each terminal.
b. Assemble the terminals and connectors including all applicable Wedges (TPAs, PLRs, etc.), Seals, etc. Number each mated connector pair.
c. Complete the Engage/Disengage Conditioning Procedure as specified in 5.2.1.
d. Using the basic set-up and procedure from the 1008 Hour Current Cycling Test (see 5.2.3), measure and record the voltage drop and calculate resistance for the power pin at 120 amps.
e. Measure and record the dry circuit resistance of the sense pin (see 5.2.2)
f. Solder the conductors for Sense Pin terminals to the adjacent header pin tail 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 ohm ±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 Totalizator/ Analyzer (CT/A) across the resistor, making sure that the negative lead of the CT/A is connected to the negative side of the resistor.
   Adjust the power supply to provide 100 mA DC to the circuit. Set the CT/A to monitor the current through the resistor and record any instance where that current falls below 95 mA. As an option, the CT/A 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 6 Other suitable continuity monitoring equipment may be used.

NOTE— For battery connectors, monitoring is required for the sense leads only. It is not necessary to monitor the power leads since high normal force and high operating voltage and current makes testing for low level intermittences unnecessary.

g. 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.
h. Set the temperature chamber to the minimum ambient temperature (–40 °C). Allow the chamber to stabilize, and then cold soak the samples an additional 30 min.
i. At the conclusion of the 30 minute cold soak, transfer the samples to another chamber set to the maximum ambient temperature (85 °C). 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.

j. At the conclusion of the 30 minute heat soak, transfer the samples back to the minimum ambient temperature. 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.
k. Repeat Steps 9 and 10 ninety-nine (99) more times.
l. Using the basic set-up and procedure from the 1008 Hour Current Cycling Test (see 5.2.3), measure and record the voltage drop and calculate resistance for the power pin at 120 amps.
m. Measure and record the dry circuit resistance of the sense pin (see 5.2.2)
n. Verify conformance to the Acceptance Criteria of 5.5.1.5.

5.5.1.5 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:

a. The Total Dry Circuit Connection Resistance for the Sense Pin shall not exceed 10 mΩ.
b. The calculated Total Connection Resistance for the Power Pin shall not exceed 0.50 mΩ for any reading after the test.
c. During the test, there must be no loss of electrical continuity (resistance ≥7.0 ohms, which corresponds to a drop in current flow below 95 mA) for more than 1 microsecond. (sense terminals only)

NOTE— If samples are to be subjected to further testing (for example as part of the test sequence shown in 5.6), then the following steps may be deferred until the sequence is complete.

d. The connector assemblies must not show any evidence of deterioration, cracks, deformities, excessive plating wear or fretting, etc that could affect their functionality.

5.5.2 TEMPERATURE/HUMIDITY CYCLING

5.5.2.1 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 that may cause electrical and mechanical degradation. Temperature cycling promotes relative movement of the contact surfaces that can cause wear and fretting corrosion.

5.5.2.2 Samples—10 mated connector pairs are required. Machine crimp a minimum of 10 sense pin and 10 power pin samples using a conductor of the largest applicable gage size, and insulation thickness appropriate to the application.

5.5.2.3 Equipment

a. DC Power Supply
b. Continuity Analyzer/Totalizator — Data Logger
c. Temperature/Humidity Chamber(s)

5.5.2.4 Procedure

a. Record the crimp height and width of each terminal.
b. Assemble connectors and terminals.
c. Complete the Engage/Disengage Conditioning Procedure per 5.2.1.
d. When this test is performed stand-alone, using the basic set-up and procedure from the 1008 Hour Current Cycling Test (see 5.2.3), measure and record the voltage drop and calculate resistance for the power pin at 120 amps.
e. When this test is performed stand-alone, measure and record the dry circuit resistance of the sense pin (see 5.2.2).

f. Solder the conductors for Sense Pin terminals to the adjacent header pin tail 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 ohm ±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 Totalizator/ Analyzer (CT/A) across the resistor, making sure that the negative lead of the CT/A is connected to the negative side of the resistor.

   Adjust the power supply to provide 100 mA DC to the circuit. Set the CT/A to monitor the current through the resistor and record any instance where that current falls below 95 mA. As an option, the CT/A 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 6. Other suitable continuity monitoring equipment may be used.

NOTE— Monitoring is required for the Sense leads only. It is not necessary to monitor the power leads since high normal force and high operating voltage and current makes testing for low level intermittences unnecessary.

g. 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.
h. Set the Temperature/Humidity Chamber to the minimum temperature (–40 °C). Allow the Chamber to stabilize before proceeding.
i. Cycle the test samples 40 times using the cycling schedule shown in Figure 8.

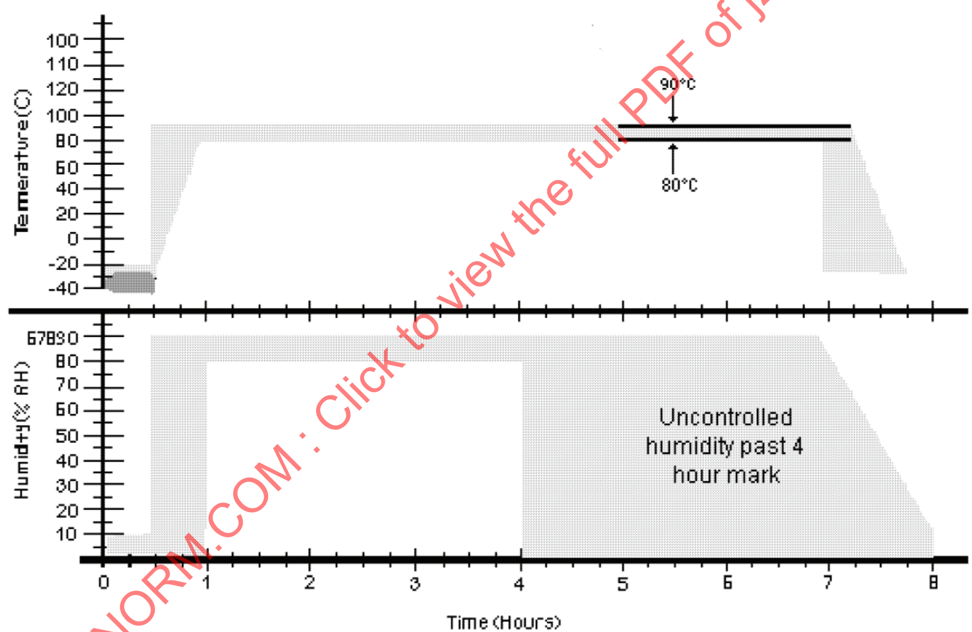


FIGURE 8—TEMPERATURE/HUMIDITY CYCLING SCHEDULE

j. Complete the Dry Circuit test (5.2.2), voltage drop measurement (5.5.1.4 step l) and the Isolation Resistance tests (5.4.1).
k. Verify conformance to the Acceptance Criteria of 5.5.2.5.

5.5.2.5 Acceptance Criteria

a. The Total Dry Circuit Connection Resistance for the Sense Pin shall not exceed 10 mΩ.
b. The calculated Total Connection Resistance for the Power Pin shall not exceed 0.50 mΩ for any reading after the test.
c. Isolation Resistance shall meet the requirements of 5.4.1.5.
d. During the test, there must be no loss of electrical continuity (Resistance ≥7.0 ohms, which corresponds to a drop in current flow below 95 mA) for more than 1 microsecond (applies to Sense Pins only).

NOTE— If samples are to be subjected to further testing (for example as part of the test sequence shown in 5.6) the following steps may be deferred until the sequence is complete.

e. The connector assemblies must not show any evidence of deterioration, cracks, deformities, excessive plating wear or fretting, etc. that could affect their functionality.

5.5.3 HIGH TEMPERATURE EXPOSURE

5.5.3.1 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.

5.5.3.2 Samples—Samples consist of 10 mated pairs of terminals crimped to the largest size wire appropriate. Crimp the samples per the manufacturer.s specifications.

5.5.3.3 Equipment

a. Temperature Chamber(s)

5.5.3.4 Procedure

a. Record the crimp height and width of each terminal.
b. Assemble the fully populated connectors. Assemblies must include all applicable Wedges (TPAs, PLRs, etc.), Seals, etc. Number each mated connector pair.
c. Complete the Engage/Disengage Conditioning Procedure per 5.2.1.
d. Using the basic set-up and procedure from the 1008 Hour Current Cycling Test (5.2.3), measure and record the voltage drop and calculate resistance for the power pin at 120 amps.
e. Measure and record the dry circuit resistance of the sense pin (5.2.2)
f. Set the temperature chamber to the maximum ambient temperature (+85 °C). Allow the chamber to stabilize before proceeding.
g. Place the samples in the chamber, set to the maximum ambient temperature, so that there is no substantial obstruction to airflow across and around the samples, and the samples are not touching each other. Leave the samples in the chamber for 1008 hours.
h. Sample evaluation is required only at the beginning and end of the test, but the Authorized Person may request additional measurement intervals.
i. Using the basic set-up and procedure from the 1008 Hour Current Cycling Test (5.2.3), measure and record the voltage drop and calculate resistance for the power pin at 120 amps.
j. Measure and record the dry circuit resistance of the sense pin (5.2.2)

5.5.3.5 Acceptance Criteria

a. The Total Dry Circuit Connection Resistance for the Sense Pin shall not exceed 10 mΩ.
b. The calculated Total Connection Resistance for the Power Pin shall not exceed 0.50 mΩ for any reading after the test.

NOTE— If samples are to be subjected to further testing (for example as part of the test sequence shown in 5.6) do not perform any steps beyond this point.

c. 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.
d. Each terminal must meet the extraction requirements of 5.3.1.5 of the Terminal-Connector Insertion/ Extraction Force test, except do NOT increase the force beyond 55 N for sense terminals and 160 N for power terminals.

5.5.4 FLUID RESISTANCE

5.5.4.1 *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.

5.5.4.2 *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 8 each of the sense and power terminals.

5.5.4.3 *Equipment*

a. Laboratory Fume Hood
b. Stainless steel tanks or Pyrex beakers
c. Explosion-Proof Heat Chamber

5.5.4.4 *Procedure*

a. Verify conformance of each mated sample connector assembly to the Isolation Resistance test, 5.4.1. This establishes a reference for the concluding Isolation Resistance test.
b. Completely submerse at least 1 test sample in each fluid listed in Table 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.

TABLE 3—CHEMICALS FOR FLUID COMPATIBILITY TEST

Fluid	Specification(1)	Test Temp. °C
Gasoline	ISO 1817 liquid C	23 ± 5
Diesel fuel	90% ISO 1718, 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 ± 3
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(2)	50 ± 3

1. Solutions are determined as percent by volume
2. Use latest available reference fluid

See appendix A for fluid source list

c. 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.
d. At the conclusion of the storage period, samples may be dried sufficiently to allow inspection and to avoid contamination of test apparatus.
e. Verify conformance of each test sample to the Acceptance Criteria of 5.5.4.5.

5.5.4.5 *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, 5.4.1.
b. There must be no visible degradation, swelling, cracking, or loss of mechanical function evident on any test sample. Minimal swelling of cable, cable seals, and connector seals is permissible.

5.5.5 SUBMERSION

5.5.5.1 *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.

5.5.5.2 *Sample Size*—10 connector pairs

5.5.5.3 *Equipment*

a. Stainless steel tanks or Pyrex beakers
b. Megohmeter
c. Temperature Chamber

5.5.5.4 *Procedure*

a. Using a conductor of the smallest applicable gage size, and insulation thickness appropriate to the application, machine crimp a minimum of 10 each of the sense and power Receptacle Terminal samples. Crimp both the conductor and insulation grips.
b. Assemble a minimum of 10 pairs of fully populated connectors using the terminals prepared in Step a previously. Assembly must include all applicable Wedges (TPAs, PLRs, etc.), Seals, etc. Number each mated connector pair. For Seals designed for plug-thru terminals, insert and remove the terminal from its cavity twice, then re-insert for testing. The purpose of this step is to ensure the terminal does not damage the seal during service operations.
c. Complete the Engage/Disengage Conditioning Procedure per 5.2.1.
d. Verify conformance of each mated sample connector assembly to the Isolation Resistance test, 5.4.1. This establishes a reference for the concluding Isolation Resistance test.
e. 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.
f. Set the chamber to the Maximum Ambient Temperature (+85 °C). Allow the chamber to stabilize before proceeding. Heat Soak the samples 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.
g. Prepare enough salt-water solution to completely submerse all samples to a depth of 30 to 40 cm below the surface. Use tap water and add 15 to 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. This should result in a solution holding approximately 5% of the maximum weight of salt that each liter of water can dissolve at Room Temperature. Soap is added to approximate a 1% solution by volume. It is recommended that an appropriate ultraviolet dye be added to assist in visual inspection for any ingress of solution into the test samples.
h. Remove the samples from the chamber. Within 30 seconds, submerse them in the Room Temperature salt- water solution to a depth of 30 to 40 cm. The samples shall remain submersed at this depth for a period of 30 minutes.
i. 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 5.4.1 on each sample.

j. Repeat Steps f, h, and i four (4) more times, except do not repeat when this test is done on samples that have completed the High Temperature Exposure Test of 5.5.3 or the Temperature/Humidity Cycling test of 5.5.2 or Thermal Shock 5.5.1.
k. At the conclusion of the test, disconnect each mated sample pair and perform the Visual Inspection test of 5.1.2. 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 g previously, will aid in this inspection.
l. Immediately upon concluding the test, verify conformance of each sample to the Acceptance Criteria of 5.5.5.5.

5.5.5.5 Acceptance Criteria—There shall be no trace of fluid ingress in any connector at the conclusion of this test.

5.5.6 PRESSURE/VACUUM LEAK

5.5.6.1 Purpose—This test evaluates the sealing capability of a sealed connector system when subjected to a specified pressure differential between the inside and outside of the sealed area.

5.5.6.2 Sample Size—10 connector pairs

5.5.6.3 Equipment

a. Pressure/Vacuum Source (Regulated)
b. Container (for sample immersion)
c. Temperature Chamber

5.5.6.4 Procedure

a. Using a conductor of the smallest applicable gage size, and insulation thickness appropriate to the application, machine crimp a minimum of 10 samples (10 Receptacle Terminals for both Sense and Power Pins). Crimp both the conductor and insulation grips.
b. Modify the header side of the connector with a special vacuum/pressure port using an appropriate sealant or fitting in the wall of each cavity of the Header Connector.
c. Using the terminals prepared in Step a, assemble the fully populated connectors. Assembly must include all applicable Wedges (TPAs, PLRs, etc.), Seals, etc. Number each mated connector pair.
d. Complete the Engage/Disengage Conditioning Procedure per 5.2.1.
e. Connect the free end of the tube to a regulated pressure source.
f. Verify conformance of each mated sample connector assembly to the Isolation Resistance test, 5.4.1. This establishes a reference for the concluding Isolation Resistance test.
g. Bend all conductors in the same direction, 90 degrees 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. Heavy cables (over 5.0 mm) cannot be practically dressed at 90 degrees. In this situation, dress the cables as expected in the production application. Ensure that the tube is not kinked, squeezed shut or otherwise obstructed. Seal all loose conductor ends to eliminate possible Leakage through the conductor strands.
h. Prepare enough salt-water solution to completely submerse samples. Use tap water and add 15 to 16 grams of table salt per liter. This should result in a solution holding approximately 5% of the maximum weight of salt that each liter of water can dissolve at Room Temperature. It is recommended that an appropriate ultraviolet dye be added to assist in visual inspection for any ingress of solution into the test samples.