SAE International™

SURFACE VEHICLE STANDARD

SAE J2030 JUN2009

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Superseding J2030 MAY2007

Heavy-Duty Electrical Connector Performance Standard

RATIONALE

With the increasing use of urea for emissions, aqueous urea solution is added to the Fluid Immersion test.

FOREWORD

NOTICE: Some test procedures are potentially dangerous. SAE Technical Reports do not purport to address all of the safety problems, if any, associated with their use. It is the responsibility of the user of an SAE Technical Report to establish and employ appropriate safety practices. Tests should only be conducted by individuals who have been properly trained in the test procedure and who are aware of any hazards which may be present. Appropriate safety and health precautions must be employed when conducting any test.

1. SCOPE

This SAE Standard encompasses connectors between two cables or between a cable and an electrical component and focuses on the connectors external to the electrical component. This document provides environmental test requirements and acceptance criteria for the application of connectors for direct current electrical systems of 50 V or less in the majority of heavy-duty applications typically used in off-highway machinery. Severe applications may require higher test levels, or field-testing on the intended application.

2. REFERENCES

2.1 Applicable Publications

The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated, the latest revision of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J163 Low Tension Wiring and Cable Terminals and Splice Clips

SAE J726 Air Cleaner Test Code

SAE J1455 Recommended Environmental Practices for Electronic Equipment Design in Heavy-Duty Vehicle Applications

SAE J1614 Wiring Distribution Systems for Construction, Agricultural, and Off-Road Work Machines

2.1.2 ASABE Publication

Available from the American Society of Agricultural and Biological Engineers, 2950 Niles Road, St. Joseph, MI 49085-9659, Tel: 269-429-0030, www.asabe.org.

ASAEEP455 Environmental Considerations in Development of Mobile Agricultural Electrical/Electronic Components

2.1.3 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D 471 Standard Test Method for Rubber Property—Effect of Liquids

ASTM G 153 Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials

ASTM G 154 Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials

2.1.4 MIL Specification

Available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, http://assist.daps.dla.mil/quicksearch/.

MIL-STD-1344A Method 3002.1 Low-Signal Level Contact Resistance

2.2 Related Publications

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

2.2.1 API Publication

Available from American Petroleum Institute, 1220 L Street, NW, Washington, DC 20005-4070, Tel: 202-682-8000, www.api-ec.api.org.

API 1560 Lubricant Service Designation for Automotive Manual Transmissions and Axles

2.2.2 ISO Publication

Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ISO 8092 Road vehicles—Connections for on-board electrical harnesses

3. DEFINITIONS

3.1 Connector

A coupling device, which provides an electrical and/or mechanical junction between two cables or between a cable(s) and an electrical component. It can also provide for mechanical stability and geometric arrangement.

3.2 Terminal

An electrically conductive device attached to a cable to facilitate connection to an electrical component, cable, or termination.

3.3 Sealed

A system that creates a nonleaking union between mechanical elements when submerged in a water solution as defined in the tests within this document.

3.4 Signal Level Circuit

A circuit in which open circuit voltage is typically less than 5 V and current is typically less than 0.05 A. Circuits of this energy level typically are not able to break through oxides, sulfides, or other contaminants, which may build up on the contact surfaces and prevent continuity.

3.5 Power Circuit

A system using two or more cables where current flows from the source to one or more electronic/electrical devices and back again to the source. The electrical energy is supplied at high levels of current and typical system voltage (system battery voltage).

3.6 Cable

Insulated stranded electrical conductor used to establish a single current path.

3.7 Wiring

Collectively, the cables, harnesses, connectors, terminations, and supporting components used in the electrical wiring distribution system.

4. SAMPLE PREPARATION

Samples shall be made on the connector manufacturer's recommended tooling and checked for conformance to the connector manufacturer's standards.

4.1 Assembly

All connector cavities shall be wired with manufacturer’s minimum approved cable outside diameter size except for test groups ‘A’ and ‘D’ which will be wired with manufacturer’s maximum approved conductor size in lengths sufficient to accommodate testing. Cable diameter shall be checked and be within the connector's manufacturing specification. Crimp characteristics (i.e., height, width, etc.) shall be checked. To prevent capillary action on sealed connectors, all loose wire ends and test points (i.e., millivolt test connection) shall be sealed with alcohol-base RTV silicone or equivalent.

5. TEST SEQUENCE

For qualification testing, test samples shall be subjected to the tests in the order shown in Table 1 with a quantity of 6 for each group. The tests are to be carried out in the numerical sequence as described in each group’s column. It is permissible to use separate sample sets for Low Voltage Resistance and Insulation Resistance when both are required in the same test sequence. For those sequences requiring both Low Voltage Resistance and Insulation Resistance, two groups of 6 may be tested, one group going through the test sequence including Insulation Resistance without Low Voltage Resistance, and the second group going through the test sequence including Low Voltage Resistance without Insulation Resistance.

Group ‘A’ emphasizes mechanical, fluid, and thermal performance for sealed signal connectors
Group ‘B’ emphasizes mechanical and thermal performance for signal connectors
Group ‘C’ emphasizes thermal performance for all connectors
Group ‘D’ emphasizes mechanical performance for all connectors
Group ‘E’ emphasizes mechanical, fluid, and thermal performance for sealed power connectors
Group ‘F’ emphasizes mechanical and thermal performance for power connectors

TABLE 1 - TEST SEQUENCES

Test Description	Test Para.	Group A Sequence Sealed Signal Connector Test	Group B Sequence Signal Connector Test	Group C Sequence Connector Test	Group D Sequence Connector Test	Group E Sequence Sealed Power Connector Test	Group F Sequence Power Connector Test
Examination of Product	6.1	1	1	1	1	1	1
Low-Voltage Resistance	6.2	2,14,15	2,11,16				
Insulation Resistance	6.3	3,6,8,17,19	3,14	2		2,5,7,15,18	2,13
Connection Resistance	6.4	4	4	3		3,20	3,15
Pressure Washing	6.5	5				4	
Maintenance Aging	6.6				2		
Temperature Life	6.7		5	4			4
Ultraviolet Effects	6.8				3		
Mating Forces	6.9		6		4		5
Unmating Forces	6.10		7		5		6
Durability	6.11		8		6		7
Salt Fog	6.12	7				6	
Thermal Shock	6.13	9	9	5		8	8
Fluid Immersion	6.14	10				9	
Vibration	6.15	12	10			11	9
Shock	6.16	13	12			12	10
Drop Test	6.17	15		6		13	
Terminal Retention in Connector	6.18				7		
Water Immersion	6.19	16				14	
Connector Retention	6.20			7	8		
Mismating	6.21				9		
Current Test	6.22					16	11
Dust Test	6.23		15				16
Temperature/Humidity	6.24	18	13			17	12
Current Cycling	6.25					19	14
Terminal Crimp Strength	6.26				10		
Visual Examination	6.27	11,20	17	8	11	10,21	17

5.1 Test Groups A, B, C, and D are for sealed signal level connectors.

5.2 Test Groups C, D, E, and F are for sealed power level connectors.

5.3 Test Groups B, C, and D are for unsealed signal level connectors.

5.4 Test Groups C, D, and F are for unsealed power level connectors.

Test Sequence Example using Test Group C as follows:

a. Examination of Product per 6.1.

b. Insulation Resistance per 6.3.

c. Connection Resistance per 6.4.

d. Temperature Life per 6.7.

e. Thermal Shock per 6.13.

f. Drop Test per 6.17.

g. Connector Retention per 6.20.

h. Visual Examination per 6.27.

6. TEST METHODS

All tests shall be carried out at an ambient temperature of 23 °C ± 3 °C and a relative humidity between 20% and 90% unless otherwise stated. Not all test descriptions contained herein describe acceptance criteria. Tests may be conducted for conditioning purposes only.

6.1 Examination of Product

Conduct a visual examination only for identification of product, torn seals, cracked plastic, etc.

6.2 Low-Voltage Resistance (Reference MIL-STD-1344A; Method 3002.1)

Test with applied voltage not exceeding 20 mV open circuit and the test current shall be limited to 100 mA. Utilizing Figure 1, record connection resistance per 6.4. Acceptance criteria are shown in Table 2.

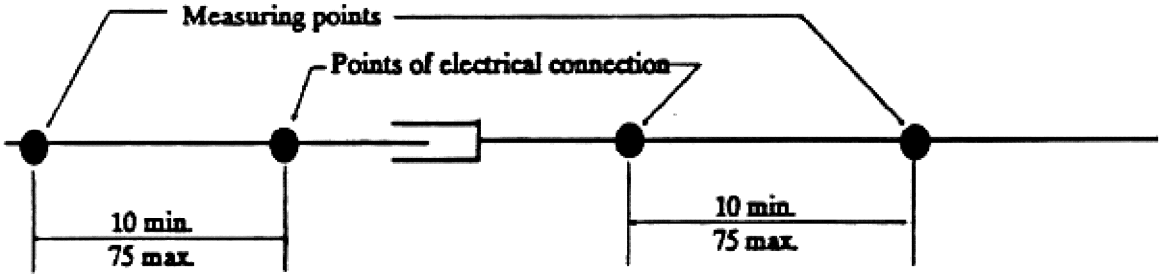
TABLE 2 - CONTACT RESISTANCE

Cable Size mm^2	Maximum Resistance mΩ
0.8	10.0
1	6.7

6.3 Insulation Resistance

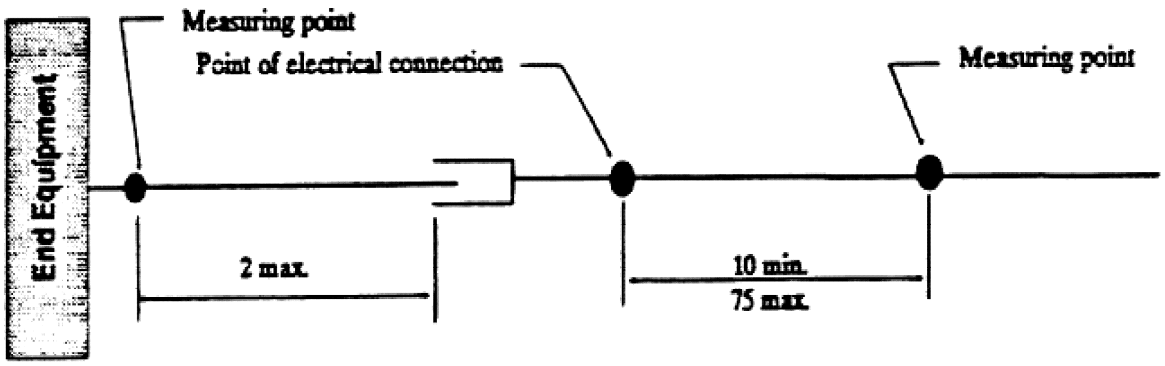
Using a 1000 VDC insulation resistance test measurement device or equivalent, check insulation resistance between each contact to each adjacent contact or housing edge. If the housing edge is plastic, then a metal foil may be applied around it, to create a grounding surface for the tester return. The insulation resistance shall be greater than 20 megohms.

CAUTION: A shock hazard exists with the voltages available from the insulation resistance test measurement device; always use insulation resistance test measurement device procedures when testing.



Note: — All dimensions are in millimeters.
Measuring points are on the cable.
Points of electrical connection are typically the joint of the cable to the terminal.

FIGURE 1 - CONNECTION RESISTANCE, CABLE TO CABLE



Note: — All dimensions are in millimeters.
Measuring points are on the cable.
Points of electrical connection are typically the joint of the cable to the terminal.

FIGURE 2 - CONNECTION RESISTANCE, CABLE TO DEVICE

6.4 Connection Resistance

The measurement of connection resistance shall be per Figures 1 and 2. The resistance of a cable equal in length to that of the two measuring points shall be subtracted from the measured values. The cable used shall be from the same batch of cable as used for the connector wiring.

6.4.1 Measurements at Specified Test Current

Measurements shall be taken after thermal equilibrium at current levels as shown in Table 3. Voltage drops shall not exceed the levels of Table 3.

(Reference SAE J163):

TABLE 3 - MEASUREMENTS AT SPECIFIED TEST CURRENT

Cable Size mm^2	Test Current Amps	Maximum Millivolt Drop (cable to device) (cable to cable)
0.8	10	100
1	15	100
2	20	100
3	30	100
5	40	100
8	55	100
13	70	100
19	90	100

COMMENT: There is a direct relationship between conductor temperature rise and the current flowing through the conductor. The effect of this temperature rise is additive to the ambient temperature conditions. The system working temperature shall not exceed the maximum applicable temperature rating of any component in the current carrying system. Consult the connector manufacturer for these material thermal limitations.

NOTE: Design application currents should be obtained from SAE J1614.

6.5 Pressure Washing

Test Method (Reference SAE J1455)—The mated and cabled connectors under test shall be mounted in its normal operating position with drain holes, if used, open. The test apparatus should be designed to provide 100% coverage of the exposed surface of the mated and cabled connectors using flat fan spray nozzles located 20 cm to 30 cm (7.9 in to 11.8 in) away. This apparatus should provide a source pressure of approximately 7000 kPa gage (1020 lbf/in^2 gage) with a flow rate of approximately 9460 cm^3/min (150 gal/h). The test item should be exposed to the spray for 3 s of a 6 s period for a total of 375 cycles. The test should be run at 40 °C (104 °F) with water/detergent. An Insulation Resistance test (see 6.3) shall be conducted after this test.

A sample test device is illustrated in Figure 3.

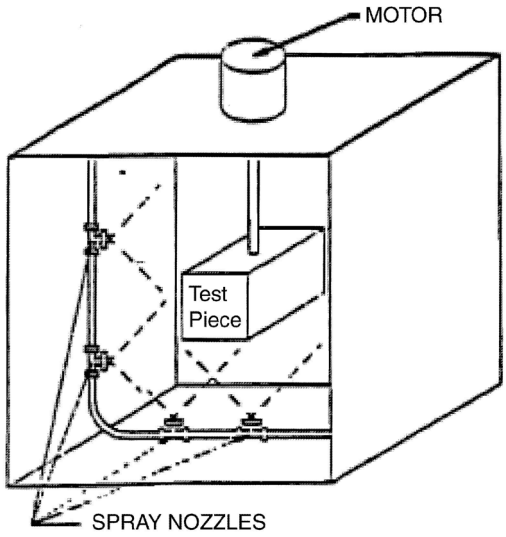


FIGURE 3 - PRESSURE WASH CHAMBER

6.6 Maintenance Aging

Subject at least 10% of the cavities to ten cycles of inserting and removing its respective contact. The ten cycles shall also include any disassembly required to remove the contacts. The connectors shall be mated and unmated during each cycle. Insertion and removal shall be performed using manufacturer's recommended practice.

6.7 Temperature Life

The cabled-mated connectors shall be subject to 1000 h at 125 °C ± 3 °C without current flowing. There shall be no evidence of cracking, distortion, or detrimental damage.

6.8 Ultraviolet Effects

Test the mated connectors for 1000 h per ASTM G 155 with extended UV filter or ASTM G 154 using an unfiltered UVA 340 lamp with 20 h UV and 4 h of condensation for each cycle.

6.9 Mating Forces

For connectors without mechanical assist, test the maximum required force to mate the plug and receptacle pair and engage the latching mechanism. The force is not to exceed 135 N.

6.10 Un-mating Forces

For connectors without mechanical assist, test the maximum force required to separate the plug and receptacle with the latch mechanism fully disengaged. The force is not to exceed 135 N.

6.11 Durability

The connector shall be mated and unmated for a total of 50 complete cycles.

6.12 Salt Fog

The connector shall be fully mated then submerged in a fine mist of 5% by weight salt solution for 96h at 35 °C ± 3 °C. After salt fog exposure, it is permissible to wash off the salt before moving to the next test in the sequence. Allow the connector to dry for 4 h after test. There shall be no detrimental evidence of corrosion on the connector or contacts after the connector is removed from the test. Perform 6.3 Insulation Resistance test 4 to 8 h after the conclusion of the test.

6.13 Thermal Shock

The cabled-mated connector shall be subjected to 10 cycles of thermal shock with no evidence of cracking, chipping, or other damage detrimental to the normal operation of the connector. One cycle shall consist of a soak time at –55 °C ambient, then a transition within 2 min to an ambient of 125 °C, with a soak time there and then a transition back to -55 °C ambient within 2 min. The soak times shall be established as the time necessary to bring the internal connector temperature on test to within 5 °C of each of the ambient temperatures. The connectors shall be mounted, as they would be in practice—in plate steel or sheet steel surfaces.

6.14 Fluid Immersion

Subject each connector to one fluid only in the cabled and mated condition. Submerge the mated connector in fluid from Table 4 at the specified temperature ±3 °C for 5 min, then remove and allow to air dry for 24 h. This completes one cycle. Each connector is to be subjected to a total of five cycles. Inspect for damage after the test.

TABLE 4 - FLUIDS

Fluid	Concentration	Temperature	Classification
Motor oil 30 wt	100%	85 °C	ASTM D 471, IRM-902
Brake fluid (disc type 1)	100%	85 °C	SAE RM66-04
Diesel fuel #2	90/10%	60 °C	IRM-903/T-Xylene
50/50 antifreeze mixture	50/50	85 °C	ASTM Service Fluid 104
Roundup Original	7.5% (48 oz to 592 oz)	23 °C	EPA Reg. No. 524-445
Gear oil 90 wt	100%	85 °C	ASTM STP 512, API GL-5
Aqueous Urea	32.5%	23 °C	AUS 32 ISO 22241

6.15 Vibration

a. Sweep time and duration. The entire frequency range of 10 to 2000 Hz and return to 10 Hz shall be traversed in 20 min. This cycle shall be performed 12 times in each of three mutually perpendicular directions (total of 36 times), so that the motion shall be applied for a total period of approximately 12 h. Interruptions are permitted provided the requirements for rate of change and test duration are met. Completion of cycling within any separate band is permissible before going to the next band. When the procedure of method 201 of this standard is used for the 10 to 55 Hz band, the duration of this portion shall be the same as the duration for this band using logarithmic cycling (approximately 1-1/3 h in each of three mutually perpendicular directions).

b. Initial displacement 1.78 mm DA

c. Maximum acceleration 20 g (the transition from displacement to acceleration occurs at 75 Hz)

d. Connectors under test are to be fixed to the vibrating plane with the wire harness fixed to non-vibrating objects no closer than 100 mm and not farther than 300 mm from the rear of the connector.

e. Duration of test to be 24 h

f. X, Y, and Z-axis to be tested 8 h each

g. Apply current as specified in Table 3 for the first 3 h in each axis

Monitor each circuit for discontinuity greater than 10 Ω in excess of 1 microsecond at 100 mA during last hour of vibration in each axis.

6.16 Shock

10 cycles of 1/2 sine pulses, 50 g, 11 ms duration X, Y, and Z axis are to be tested. Monitor for discontinuity greater than 10 Ω in excess of 1 microsecond at 100 mA. Connector under test to be fixed to the shock plane with the wire harness fixed to non-shocked objects no closer than 100 mm and not farther than 300 mm from the rear of the connector.

6.17 Drop Test

The free end of the cord or cable, which shall be 1500 mm ± 25 mm long, shall be fixed to a wall at a height of 750 mm ± 25 mm above a concrete floor, as shown in Figure 4. The specimen shall be held so that the cord or cable is horizontal and allowed to fall to a concrete floor eight times. Rotate the specimens through approximately 45 degrees at its fixing each time.

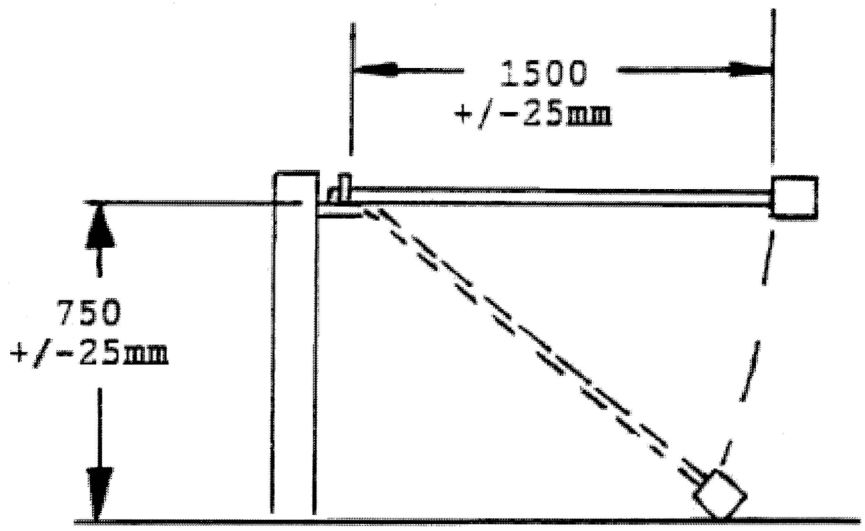


FIGURE 4 - IMPACT TEST EQUIPMENT

6.18 Terminal Retention in Connector

The contacts shall be subjected to a direct pull. The minimum value specified in Table 5 shall be applied for 1 min. The pull is to be exerted on the conductor by means of a tension-testing machine or equivalent to prevent sudden or jerking force during test. The terminal shall maintain its original position in the connector throughout the test.

NOTE: Secondary-locking devices should be utilized if available.

TABLE 5 - PULLOUT FORCES

Cable Size mm^2	Minimum Pull-Out Force N
0.8	110
1	110
2	110
3	110
5	175
8	175
13	220
19	220

6.19 Water Immersion

The wired mated connectors shall be placed in an oven at 125 °C ± 3 °C for 1 h then immediately be placed in water with a 5% salt in weight content and 0.1 g/L wetting agent, to a depth of 1 m for 4 h. Water temperature is to be 23 °C ± 3 °C. Test samples for insulation resistance per 6.3 and visually inspect for moisture inside the connector. The ends of the cable are to be sealed during this test.

6.20 Connector Retention

Apply a pulling force to the wire bundle of the mated connector at 111 N times the number of contacts or a maximum of 444 N. The load shall be applied for 30 s. If the connector is designed to uncouple under tension, the maximum force required shall be 222 N.

6.21 Mismating

Connectors with two or more contacts shall be keyed or of such a design that any intended polarization will not be defeated by improper assembly during installation. Polarization shall resist a minimum of 178 N axial force without damage.

6.22 Current Test

Apply maximum rated current (per Table 3) to all terminals. Ambient test temperature shall be 125 °C ± 3 °C for a 24 h period at the end of which the connection resistance is to be measured per 6.4.

6.23 Dust Test (Reference ASAE EP455 Section 5.3)

Test the component in a dust chamber containing the equivalent of air cleaner fine dust (particle size as defined by SAE J726). Sufficient air movement must maintain a minimum suspended concentration of 0.88 g/m^3. Test to be run for 24 h.

6.24 Temperature/Humidity

Test samples to be placed in a temperature/humidity chamber and shall be subjected to 42 cycles described as follows:

a. Chamber temperature raised to 55 °C at 3 °C/min ± 1 °C/min.

b. Chamber held for 16 h at a relative humidity of 95% ± 5%.

c. Chamber temperature lowered to –55 °C at 3 °C/min ± 1 °C/min.

d. Chamber held for 2 h.

e. Chamber temperature raised to 125°C at 3 °C/min ± 1°C/min.

f. Chamber held for 2 h.

g. Chamber temperature lowered to 25°C at 3 °C/min ± 1°C/min.

h. Chamber held for remainder of 24 h cycle.

The customer may specify higher temperature requirements. Relative humidity is not controlled unless it is specified. Samples will be tested for voltage resistance per 6.4 for power circuits or 6.2 for signal circuits dependent upon power level requirements of contacts, and for insulation resistance per 6.3.

6.25 Current Cycling Test

This test is to determine the effects of crimp relaxation via current (thermal) cycling.

6.25.1 Subject samples to 500 cycles of current per Table 3.

a. 200 off/on cycles, at ambient of 125 °C ± 3 °C, each cycle to consist of 45 min on, 15 min off.

b. 50 cycles of following: 20 min on at 125 °C ± 3 °C, 60 off at 21 °C ± 1 °C. Transition rate is to be 3 °C/min +3/-0 °C/min without current applied.

c. repeat a. and b. to complete 500 cycles

6.25.2 Acceptance criteria per 6.4.

6.26 Terminal Crimp Strength

The tensile strength of the crimped connection shall be tested by using suitable apparatus at a constant speed within the range of 20 mm to 100 mm/min. If the terminal has a cable insulation crimp it shall be rendered mechanically ineffective. Minimum acceptable values for terminals outside the connector are shown in Table 6. All samples are to be pulled to destruction.

TABLE 6 - MINIMUM TENSILE STRENGTH FOR CRIMPED CONNECTIONS

Cable Size mm^2	Minimum Tensile N
0.8	130
1	155
2	265
3	335
5	375
8	445
13	665
19	1110

6.27 Visual Examination

Conduct a visual examination for identification of product such as torn seals, cracked plastic, evidence of fluid or dust ingress in sealed connector systems, arcing, charring, melting, or anything that could affect the performance and serviceability of the product.

7. NOTES

7.1 Marginal Indicia

A change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

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