The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

# SURFACE VEHICLE DRAFT TECHNICAL REPORT

SAE J2223/2

Issued 1994-02-15
Committee Draft

## CONNECTIONS FOR ON-BOARD ROAD VEHICLE ELECTRICAL WIRING HARNESSES—PART 2: TESTS AND GENERAL PERFORMANCE REQUIREMENTS

This document is technically equivalent to ISO 8092/2.

The purpose of this Draft Technical Report is to give the technical community an opportunity to review, comment on, and use the Draft Technical Report prior to its final approval by SAE.

This Draft Technical Report represents the current thinking of the sponsoring Technical Committee. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringements arising therefrom, is the sole responsibility of the user.

Comments on this draft are welcome and should be submitted in writing to Secretary, Technical Standards Board, SAE Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

This document shall have a life span of no more than 3 years from approval which may not be renewed.

***Foreword***—SAE J2223 consists of the following parts:

SAE J2223/1—Connections for On-Board Road Vehicle Electrical Wiring Harnesses—Part 1: Single-Pole Connectors—Flat Blade Terminals—Dimensional Characteristics and Specific Requirements
SAE J2223/2—Connections for On-Board Road Vehicle Electrical Wiring Harnesses—Part 2: Tests and General Performance Requirements
SAE J2223/3—Connections for On-Board Road Vehicle Electrical Wiring Harnesses—Part 3: Multipole Connectors—Flat Blade Terminals—Dimensional Characteristics and Specific Requirements
SAE J2223/4—Connections for On-Board Road Vehicle Electrical Wiring Harnesses—Part 4: Single- and Multipole Connectors—Pin Terminals—Dimensional Characteristics and Specific Requirements (DRAFT)
SAE J2223/5—Connections for On-Board Road Vehicle Electrical Wiring Harnesses—Part 5: Connectors for Electronic Applications (DRAFT)

1. ***Scope***—This SAE Draft Technical Report defines tests methods and general performance requirements of single-pole and multipole connectors for on-board electrical wiring harnesses of road vehicles.

   These requirements are not intended for connections internal to electronic devices.

   This document applies to connectors designed to be disconnected after mounting in the vehicle in the case of repair and/or maintenance.





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## 2. References

**2.1 Applicable Documents**—The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

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

SAE J1128—Low Tension Primary Cable

SAE J1560—Low Tension Thin Wall Primary Cable

SAE J2183—Unscreened Low Tension Cable (DRAFT)

SAE J2223/1—Connections for On-board Road Vehicle Electrical Wiring Harnesses—Part 1: Single-Pole Connectors—Flat Blade Terminals—Dimensional Characteristics and Specific Requirements

SAE J2223/3—Connections for On-board Road Vehicle Electrical Wiring Harnesses—Part 3: Multipole Connectors—Flat Blade Terminals—Dimensional Characteristics and Specifics Requirements

SAE J2223/4—Connections for On-board Road Vehicle Electrical Wiring Harnesses—Part 4: Single- and Multipole Connectors—Pin Terminals—Dimensional Characteristics and Specific Requirements (DRAFT)

SAE J2223/5—Connections for on-board Road Vehicle Electrical Wiring Harnesses—Part 5: Connectors for Electronic Applications (DRAFT)

2.1.2 ASTM PUBLICATION—Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM B 117—Method of Salt Spray Testing

2.1.3 IEC PUBLICATIONS—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002

IEC-Publication 50—International Electrotechnical Vocabulary - Chapter 581, Electromechanical components for electronic equipment

2.1.4 ISO Publication—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ISO 8092/2—Connections for on-board road vehicle electrical wiring harnesses—Part 2: Test methods and general performance requirements

**2.2 Related Publications**—The following publications are for information purposes only and are not a required part of this document.

2.2.1 IEC PUBLICATIONS—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002

IEC-Publication 529—Classification of degrees of protection by enclosures



2.2.2 ISO PUBLICATIONS—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002

ISO 6722-3—Road vehicles—Unscreened low tension cables—Part 3: Conductor sizes and dimensions of thick insulated cables

ISO 6722-4—Road vehicles—Unscreened low tension cables—Part 4: Conductor sizes and dimensions of thin insulated cables

ISO 9227:1990—Corrosion tests in artificial atmospheres—Salt spray tests

**2.3. Terminology and Definitions**—See SAE J1213 and IEC 50 chapter 581. For the purpose of SAE J2223, the following definitions apply.

2.3.1 FLAT BLADES AND RECEPTACLES—Flat Blades and receptacles are terminals (or contacts), see Figures 1 and 2.



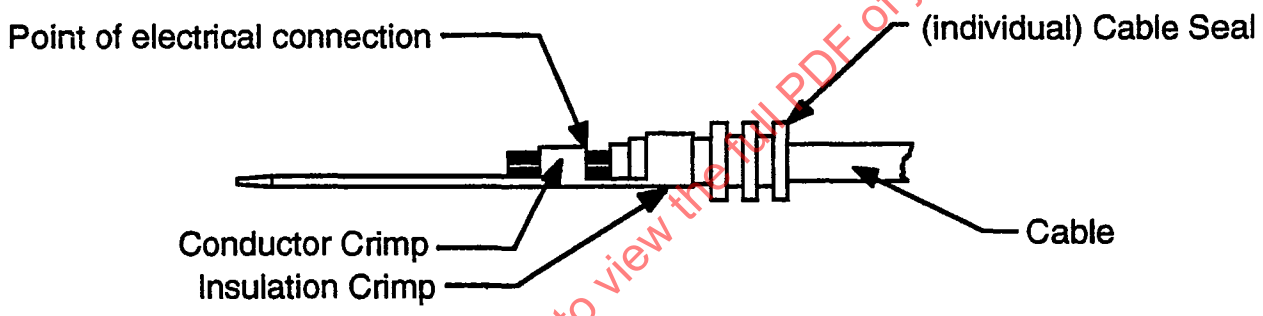



FIGURE 1—MALE TERMINAL

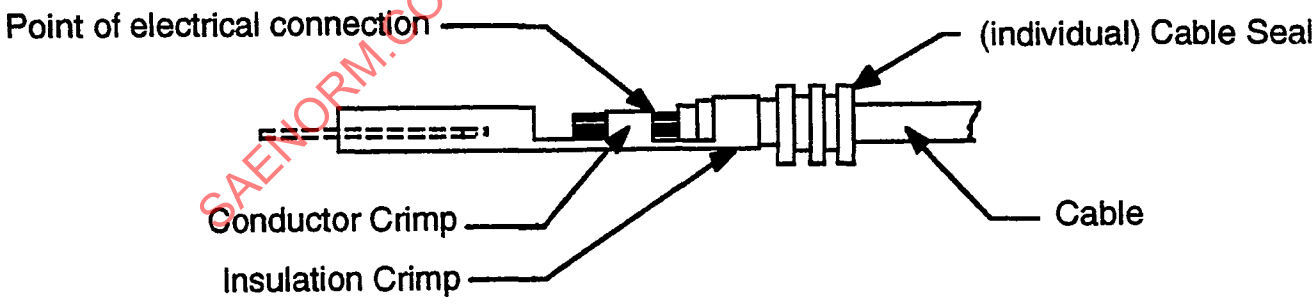



FIGURE 2—FEMALE TERMINAL

*2.3.1.1 Blade*—That part of an electrical terminal which is pushed into a female terminal, forming an electrical connection.

*2.3.1.2 Female Terminal*—That part of an electrical connector which receives the blade, forming an electrical connection.

*2.3.1.3 Positive Locking Female Terminal*—Female terminal with automatic positive locking and manual unlocking device engaging the blade hole.

2.3.2 Detent—Hole in the blade, which engages a raised portion of the female terminal, thus providing a latch for the mating parts.

2.3.3 Reference Point—Specially marked point used when making electrical test measurements.

2.3.4 Typical Examples of Connections—A to D of Figure 3 show typical examples of connections.

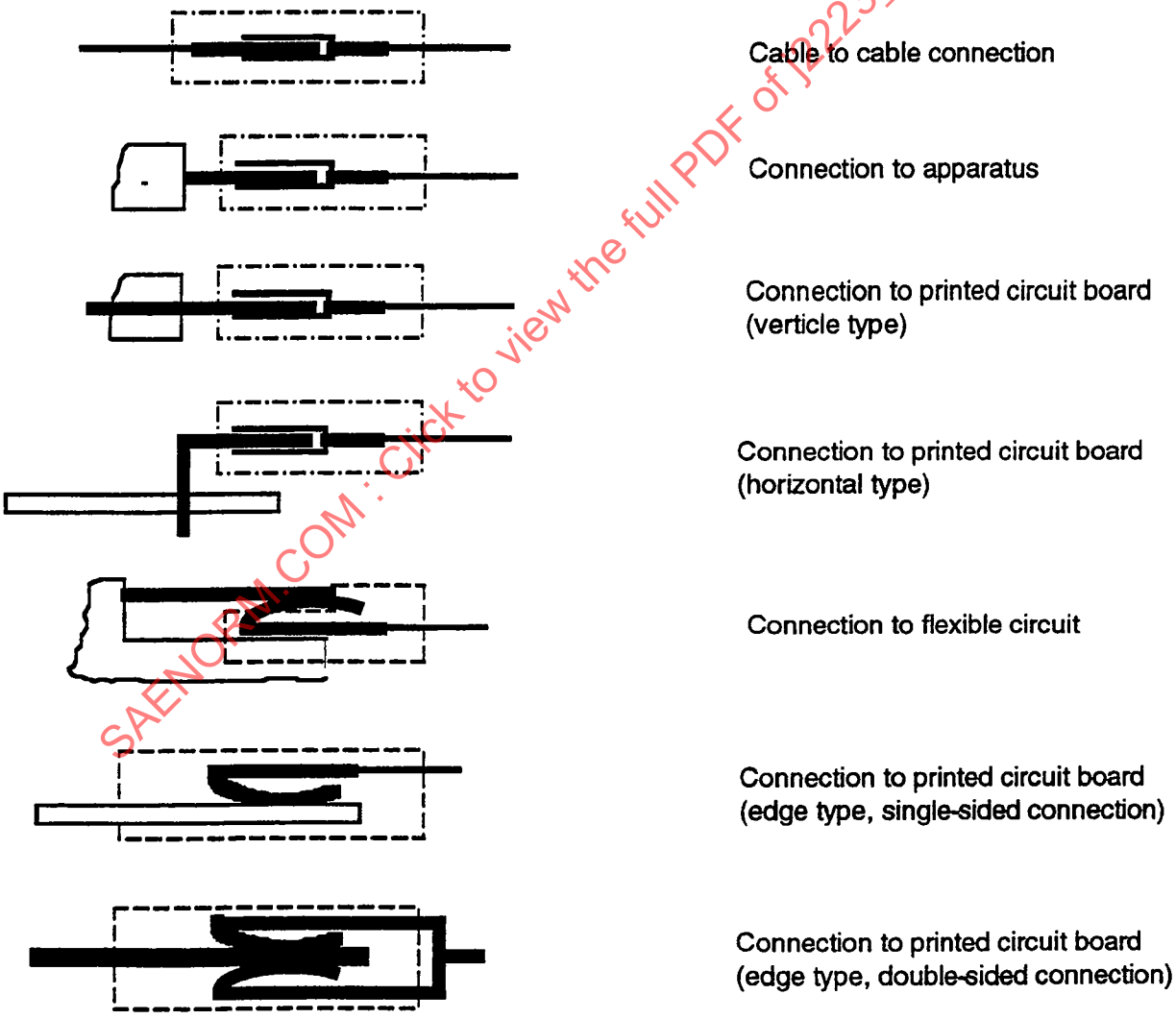
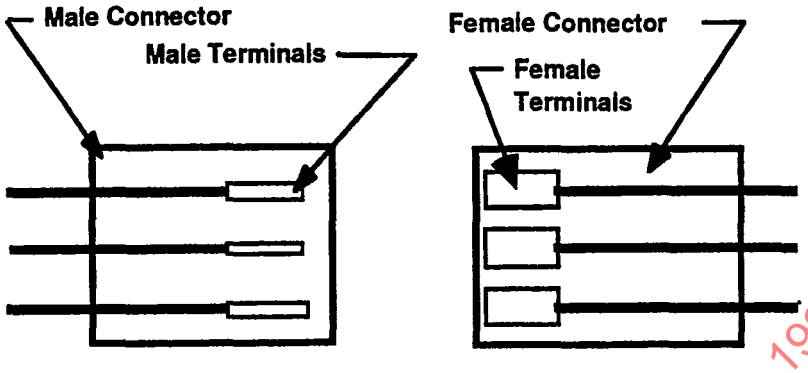
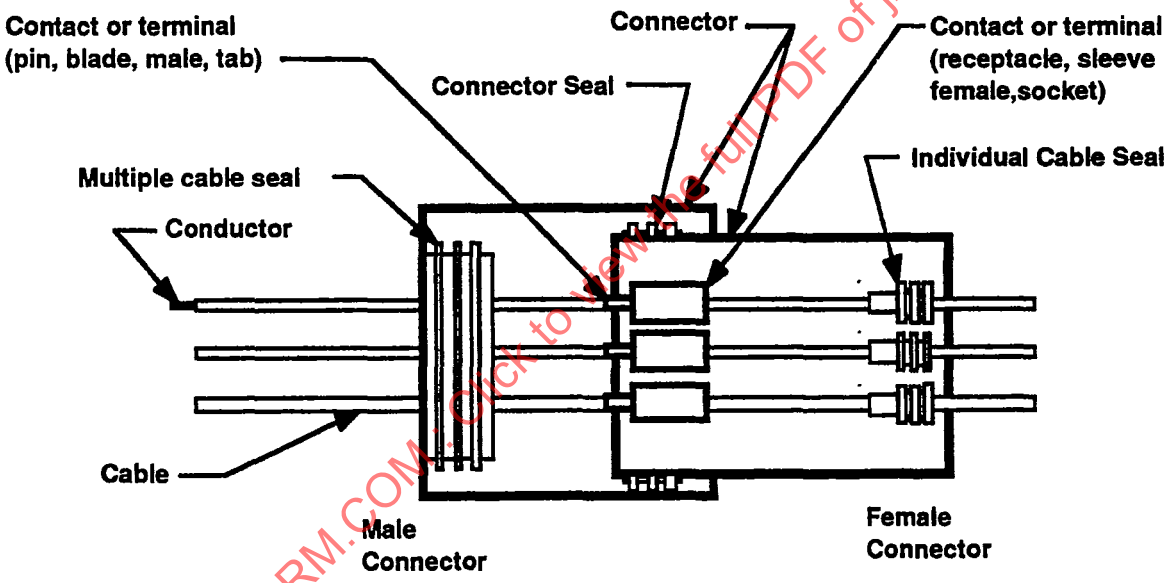



FIGURE 3—TYPICAL EXAMPLES OF CONNECTIONS

2.3.5 MULTIPOLE CONNECTIONS—Figure 4 shows multipole connections and their parts. Two connector halves mated form a connection.




Connection System

FIGURE 4—MULTIPOLE CONNECTORS/CONNECTIONS



2.3.6 DEFINITIONS—Definitions of wording changes from ISO-8092/2. (See Table 1.)

**TABLE 1—WORDING CHANGES**

| ISO | SAE |
|---|---|
| Tab | Flat Blade |
| Housing | Connector |
| Connector | Terminal |
| Single Cable Seal | Individual Cable Seal |

## 3. Test Procedures and Performance Requirements

### 3.1 General

3.1.1 TEST METHODS AND GENERAL SPECIFICATIONS—All test procedures shall be carried out at an ambient temperature of 23 °C ± 5 °C and a relative humidity between 45% and 75%, unless otherwise stated.

Each test sequence (see Figure 5) shall be started with unused test samples manufactured to conform to the dimensions specified in the applicable part of this document. Female connectors for positive locking terminals shall be tested with blades with holes to permit locking.

Crimped connections shall be fixed to the cable with a crimping tool used in accordance with the manufacturer's recommendations.

Cables shall be according to SAE J2183, SAE J1560, or SAE J1128 or equivalent. The cable(s) used shall be noted in the test report.

Care shall be taken that test samples do not influence each other, e.g., in a heat chamber.

3.1.2 GENERAL PERFORMANCE REQUIREMENTS—Connectors and/or contacts that allow connections for multiple positions, e.g., nonoriented, 90 degree or 180 degree orienting, shall meet requirements in all intended positions.

Electrical connectors of other types, for example, circuit board and flexible circuits, shall also meet the following requirements. Particular requirements are under consideration.

3.1.3 TEST SEQUENCES—For each test sample group in Table 1, a test sequence is indicated by Xs from top to bottom.

For unsealed connectors, apply tests as in the test sample groups A, B, C, D, E, F, H, I.

NOTE—Test sample group G is for sealed connectors.

For sealed connectors, apply tests as in the test sample groups A, B, C, D, E, G, H, I.

NOTE—Test sample group F is for unsealed connectors only.

Each test sample group shall contain at least:

a. 20 test samples in the case of single-pole connectors
b. 10 test samples in the case of 2-pole connectors
c. 7 test samples in the case of 3-pole connectors
d. 5 test samples in the case of 4-pole connectors
e. In connectors with mixed types of contacts a minimum of 20 contacts of each type shall be tested

All test samples shall be used for all tests in a test sample group.

Each connector shall have the full complement of contacts fitted, unless otherwise specified in the test method.

Measurements shall be taken on a minimum of four contacts per connector unless otherwise specified in the test methods. For 1-, 2-, and 3-pole connectors, all contacts shall be measured.

| Test Title | Clause | Test Sample Group A | B | C | D | E | F | G | H | I | Performance Requirements Clause |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Visual Examination | 3.2.1 | X | X | X | X | X | X | X | X | X | 3.2.2 |
| Tensile strength of cable attachment | 3.4.1 | | | | | | | | | X | 3.4.2 |
| Contact insertion | 3.6.1 | X | | | | | | | | | 3.6.2 |
| Contact retention | 3.7.1 | X | | | | | | | | | 3.7.2 |
| 1st insertion of connector | 3.3.1 | | X | | | | | | | | 3.7.2 |
| Connection resistance @ mV level & specified current | 3.8.1 | | X | X | X | X | X | | | | 3.8.3 |
| 1st disconnection to 10th connection of the connector | 3.3.1 | | X | | | | | | | | 3.3.2 |
| Current cycling | 3.17.1 | | | X | | | | | | | |
| Insulation resistance | 3.12.1 | | | | X | | | X | | | 3.12.2 |
| Dielectric strength | 3.13.1 | | | | X | | | X | | | 3.13.2 |
| Temperature/Humidity cycling | 3.10.1 | | | | X | | | | | | |
| Vibration | 3.11.1 | | | | | X | | | | | 3.11.2 |
| Aging | 3.18.1 | | | | | | | X | | | 3.18.2 |
| Water tightness | 3.9 | | | | | | | X | | | 3.9.2 |
| Temperature rise | 3.14.1 | | | | | | | | X | | 3.14.2 |
| Polarizing key | 3.15.1 | | | | | | | | X | | 3.15.2 |
| Connection resistance @mV level & specified current | 3.8.1 | | X | X | | X | | | | | 3.8.2 |
| Locking device strength | 3.5 | | X | | | | | | | | 3.5.2 |
| Insulation resistance | 3.12.1 | | | | X | | | X | | | 3.12.2 |
| Dielectric strength | 3.13.1 | | | | X | | X | X | | | 3.13.2 |
| Salt spray | 3.16.1 | | | | | | X | | | | |
| Connection resistance @ mV level & specified current | 3.8.1 | | | | X | | X | | | | 3.8.2 |
| Visual Examination | 3.2.1 | X | X | X | X | X | X | X | X | X | 3.2.2 |
| The arrows between the X's indicate that the subsequent test shall be performed without interruption. | | | | | | | | | | | |



FIGURE 5—TEST SEQUENCES AND PERFORMANCE REQUIREMENTS

### 3.2 Visual Examination

3.2.1 TEST METHOD—The visual examination shall be carried out with naked eye (normal strength of vision, normal color perception) at the most favorable viewing distance, and with suitable illumination.

3.2.2 PERFORMANCE—Visual examination as detailed in 3.2.1 shall allow identification, appearance, workmanship and finish of the item to be checked against the relevant specification.

If the connector has a cable insulation support, the insulation grip shall not cut through the insulation and shall firmly enclose the cable.

Both insulation and the cable conductor shall be visible between the conductor crimp and the insulation support on the tab and the female connector (see Figure 6), except insulation displacement connections.

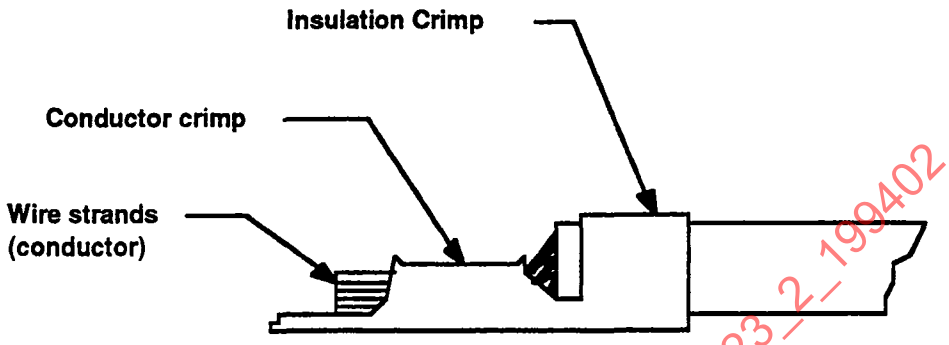



FIGURE 6—CONDUCTOR AND INSULATION CRIMP

Conductors shall protrude from the conductor crimp but shall not interfere with the mating part. All wire strands of the conductor shall be enclosed by the conductor attachment. There shall be no damaged wire strand(s).

During visual examination, after tests as in the test sample groups A to I, special care shall be taken to ensure that as a minimum requirement no cracking, discoloration, deformation, and no water ingress (test sample group G only) is in evidence.

### 3.3 Connection and Disconnection

3.3.1 TEST METHOD—Connection and disconnection of connectors shall be performed as intended or as specified in the particular specification of the product.

The rate for connection and disconnection shall be a constant speed between 50 and 150 mm/min. The applied speed shall be noted in the test report.

The connector shall be subjected to test 3.3.1.1 or 3.3.1.2 as appropriate.

*3.3.1.1 Female Terminals (Without Positive Locking)*—The terminals shall be subjected to 10 connections and disconnections. The force necessary shall be measured at:

a. First connection
b. First disconnection
c. 10th disconnection

*3.3.1.2 Positive Locking Female Connector*—Eleven cycles of connection and disconnection shall be performed as follows:

a. The first 10 cycles shall be performed operating the locking device at each cycle in accordance to the manufacturer's instruction and normal use.
b. The eleventh cycle shall be performed with the locking device engaged for the locking device strength test as in 3.5.2.2.

The force necessary shall be measured at:

a. First connection
b. First disconnection
c. 10th disconnection

3.3.2 PERFORMANCE REQUIREMENTS—Single-pole connectors, as tested in 3.3.1, shall conform to the requirements specified in the applicable part of this document.

For multipole connectors the connection and disconnection forces, as tested in 3.3.1, shall be as in the particular specification of the user, supplier, or of a standard.

### 3.4 Tensile Strength of the Cable Attachment

3.4.1 TEST METHOD—The tensile strength of the cable attachment shall be tested by using suitable test apparatus at a constant speed within the range of 50 to 150 mm/min. The applied speed shall be noted in the test report.

Each test sample shall be attached to the corresponding cable(s) as specified by the connector manufacturer.

If the connector has a cable insulation support it shall be rendered mechanically ineffective.

When more than one cable is attached, the force according to Table 1 shall be applied to each cable by using separate samples.

3.4.2 PERFORMANCE REQUIREMENTS—The tensile strength of the crimped connection, as tested in 3.4.1, shall withstand the minimum values specified in Table 1.

**TABLE 1—MINIMUM TENSILE STRENGTH OF CRIMPED CONNECTIONS**

| **Nominal cross-sectional area of cable ($mm^2$)** | **0.22** | **0.35** | **0.5** | **0.75** | **1.0** | **1.5** | **2.0** | **2.5** | **3.0** | **4.0** | **5.0** | **6.0** | **10.0** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum tensile strength (N) | 40 | 50 | 70 | 90 | 115 | 155 | 195 | 235 | 260 | 320 | 360 | 400 | 600 |

NOTE—The minimum tensile strength of connections for cables with nonspecified nominal cross-sectional areas shall be determined by interpolation.

Other types of cable attachment are under consideration.

### 3.5 Connector Disengage Force

3.5.1 LOCKING DEVICE STRENGTH—The purpose of this test is to check the ability of a locked connector to withstand a specific and static actual load. Single-pole connectors and multipole connectors shall be subjected to test 3.5.1.1 or 3.5.1.2 as appropriate.

3.5.2 TEST METHOD

*3.5.2.1 Single-Pole Connectors and Multipole Connectors with Locking Devices Being Part of Their Housings (Without Positive Locking Female Connector)*—The procedure shall be carried out with the connector:

a. Empty
b. Full complement of contacts fitted

A fixture (fixtures) shall be made which can be secured to the connector halves to be tested. The securing of this (these) shall not distort either half of the connector during testing. The housing shall be mounted on the fixture(s) with the locking device engaged. The force shall be applied to the fixture in the disconnection direction and held constant for 10 s ± 2 s.

*3.5.2.2 Single-Pole Connectors and Multipole Connectors with Positive Locking Female Connectors*—After the 11th connection specified in 3.2.1.2, the force shall be applied on the test sample with the locking device engaged in the disconnection direction and held constant for 10 s ± 2 s.

3.5.3 PERFORMANCE REQUIREMENTS—Single-pole connectors with locking devices tested as in 3.5.1 shall conform to the requirements specified in the applicable part of this document.

The locking device of multipole connectors tested as in 3.5.1 shall withstand a force of 100 N ± 2 N.

### 3.6 Contact Insertion Force

3.6.1 TEST METHOD—The insertion force of the contact into the cavity shall be tested by using the minimum and maximum size of cable which can be attached, and be applied in the insertion direction via a test fixture, to be positioned as close as possible to the cable attachment.

Care shall be taken that the contact under test is locked as provided for.

The rate for insertion shall be a constant speed between 50 and 150 mm/min. The applied speed shall be noted in the test report.

3.6.2 PERFORMANCE REQUIREMENTS—The contact insertion force, tested as in 3.5.1, shall be a maximum of 15 N for contacts, having cables attached with a nominal cross-sectional area of up to and including 1 $mm^2$. For contacts with a cable having larger nominal cross-sectional areas, the force shall be a maximum of 30 N.

In the case of sealed connectors or splash-proof connectors the force imposed by the seal shall be included.

### 3.7 Contact Retention in Housing

3.7.1 TEST METHOD—The test for contact retention forces shall be carried out using a suitable test apparatus. The contacts shall have all locking devices effective.

A constant force shall be applied to front and/or back of contact in an axial direction and held for 10 s ± 2s.

The applied constant force shall be noted in the test report.

3.7.2 PERFORMANCE REQUIREMENTS—The contacts, tested as in 3.7.1, shall withstand 60 N. Higher forces may be required according to connection, disconnection forces, material, and design.

### 3.8 Connection Resistance (Voltage Drop)

3.8.1 TEST METHOD

*3.8.1.1 Measurements at Millivolt Level*—The test voltage shall not exceed 20 mV DC or peak voltage AC, even in open circuit, in order to prevent the breakdown of possible insulating films of the contacts. The flow of the test current shall not exceed 50 mA.

The measurement of the connection resistance shall be taken considering the test arrangements as shown in the Figures 7 and 8.

The resistance of the conductor(s) associated shall be subtracted from measured values.

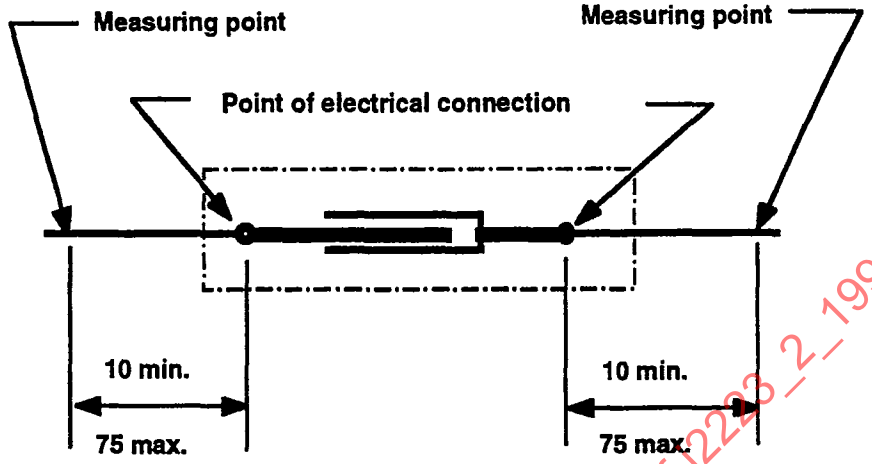



FIGURE 7—CONNECTION RESISTANCE—CABLE-TO-CABLE CONNECTION

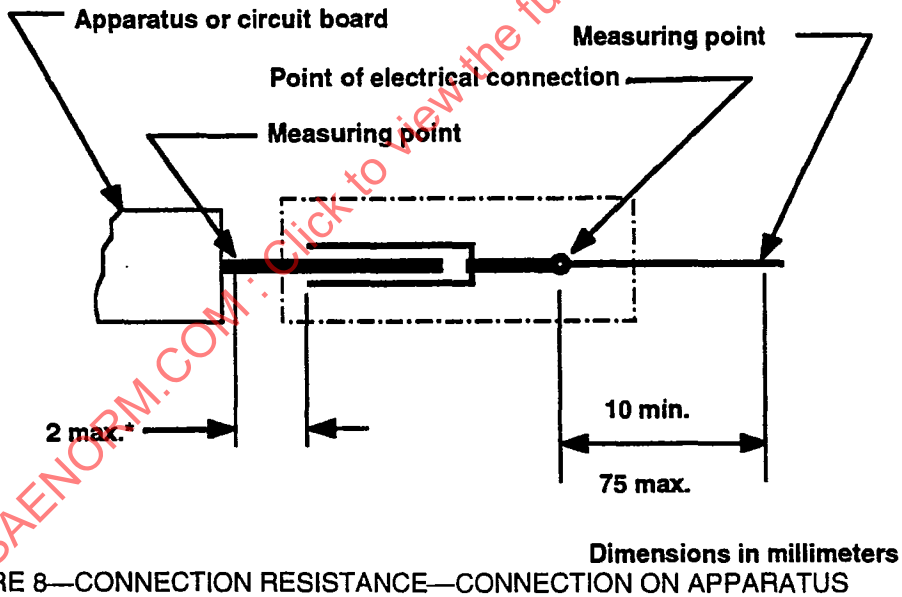



FIGURE 8—CONNECTION RESISTANCE—CONNECTION ON APPARATUS

*3.8.1.2 Measurements at Specified Test Current*—Measurements shall be taken after thermal equilibrium at a current density of 5 A/mm$^2$ nominal cross-sectional area of attached cable(s) unless otherwise stated. Thermal equilibrium is determined by taking a minimum of five readings 2 min apart and having five consecutive readings that vary less than ±2 °C.

NOTE—If the measuring cables are soldered at the measuring points, they shall not influence the connections.

3.8.2 PERFORMANCE REQUIREMENTS—The connection resistance, tested as in 3.8.1, shall conform to the requirements specified in the applicable part of this document.

### 3.9 Water Tightness

a. Sealed connector—For test see 3.9.1.1.

The connector shall be assembled with the full complement of contacts fitted. The cables attached shall be of the minimum and maximum overall diameter that the connector sealing system allows. The cable ends shall be sealed.

The test sample shall be preconditioned in a temperature chamber at the test temperature as per the designated class in Table 2, for a period of 4 h.

**TABLE 2—CLASS ENVIRONMENTAL AND TEST TEMPERATURES**

| Class | Environmental Temperature | Test Temperature |
|---|---|---|
| 1 | -40 °C up to +85 °C | 85 °C |
| 2 | -40 °C up to +100 °C | 100 °C |
| 3 | -40 °C up to +125 °C | 125 °C |
| 4 | -40 °C up to +155 °C | 155 °C |



3.9.1 TEST METHOD

*3.9.1.1 Sealed Connectors*—Immerse test sample immediately after preconditioning into a liquid of de-ionized water with 5% NaCl (m/m), and 0.1 g/L wetting agent be added. The liquid temperature shall be 23 °C ± 5 °C.

Include a dye so that ingress of liquid into the test sample can be visually checked after the electrical test. Immerse the test samples, as per Figure 9, for a period of 1 h.

Dimensions are in mm

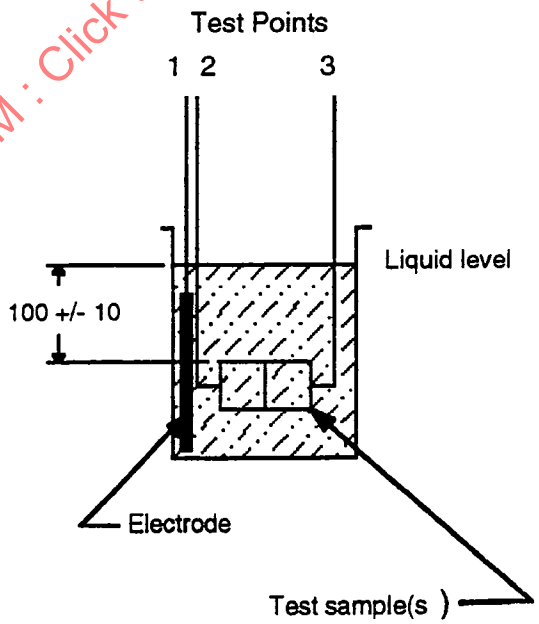



FIGURE 9—WATER TIGHTNESS TEST

Take leakage current measurements of the test sample which is immersed in the liquid. The measurements shall be taken between each contact and the electrode, and between each adjacent contact as for example shown in Figure 10.

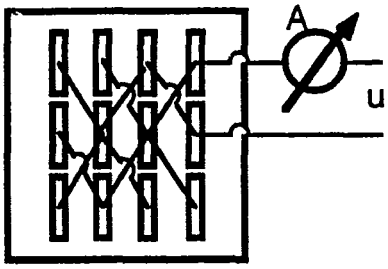



FIGURE 10—LEAKAGE CURRENT MEASUREMENTS BETWEEN ADJACENT CONTACTS (EXAMPLE)

3.9.2 PERFORMANCE REQUIREMENTS

*3.9.2.1 Sealed Connectors*—The leakage current measured as in 3.9.1.1 shall not exceed 50 µA at 48 V applied voltage.

**3.10 Temperature/Humidity**

3.10.1 TEST METHOD—The temperature/humidity cycling test shall be carried out using cable-to-cable connections (see Figure 7) with housing having the full complement of contacts. This test shall also be carried out with connections on apparatus, if required by user (see Figure 8).

The connector shall be tested with cables assembled of minimum and maximum cross-sectional area that the contact system allows.

The test samples are to be subjected to 10 cycles of 24 h of the following test sequence. The class of temperature is chosen from Table 2.

a. Hold at 23 °C ± 5 °C for 4 h at 45 to 75% relative humidity (RH).
b. Raise chamber temperature (CT) to 55 °C ± 2 °C at 95 to 99% RH within 0.5 h.
c. Hold CT at 55 °C ± 2 °C at 95 to 99% for 10 h.
d. Lower CT to -40 °C ± 2 °C within 2.5 h.
e. Hold CT at -40 °C ± 2 °C for 2 h.
f. Raise CT to Class test temperature ±2 °C within 1.5 h.
g. Hold CT to Class test temperature ±2 °C for 2 h.
h. Recover to 23 °C ± 5 °C within 1.5 h.

NOTE 1—During periods d, e, f, g, and h, the relative humidity is uncontrolled.
NOTE 2—If necessary, step f may be increased according to the relevant class test temperature, this shortening period 3.10.1(a).
NOTE 3—At the end of a cycle, the test may be interrupted. During the interruption test, samples shall remain at ambient conditions as defined in a. Interruption time shall be noted in the test report.
NOTE 4—See Figure 11 for graphic test cycles.

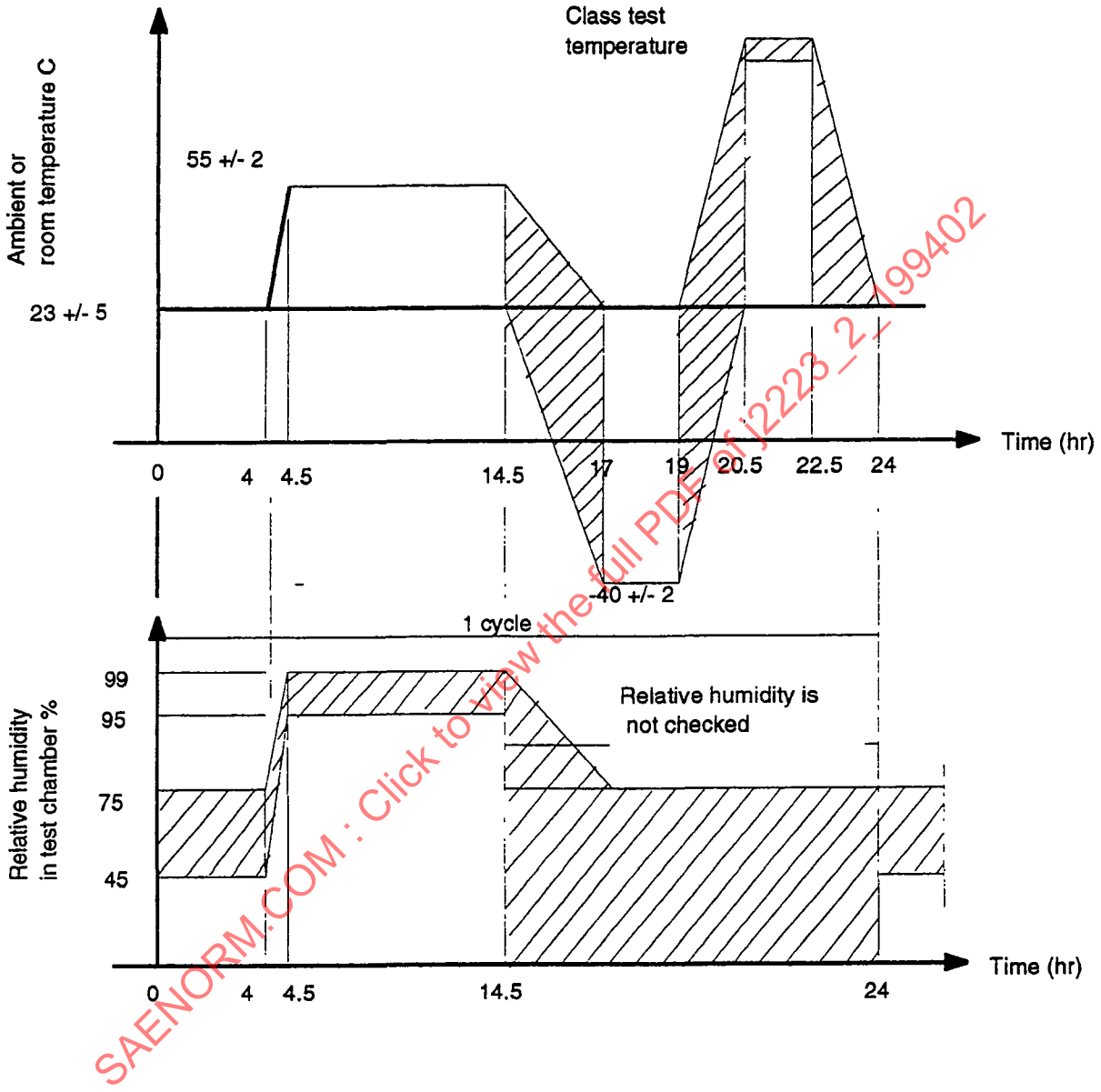


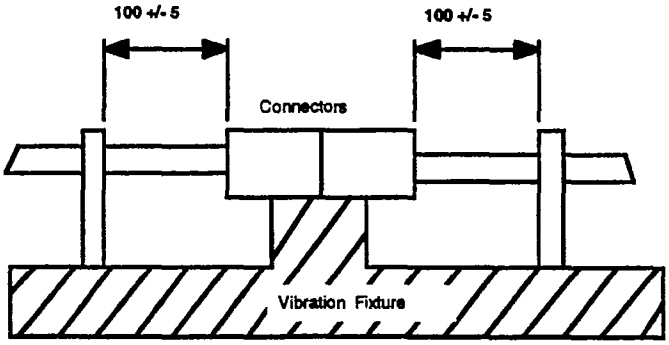



FIGURE 11—TEMPERATURE/HUMIDITY CYCLING

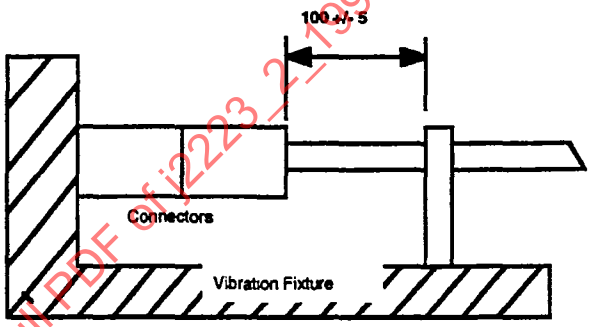
### 3.11 Vibration

3.11.1 TEST METHOD—The vibration shall be carried out with mated connectors suitably mounted on a vibration table as shown in Figure 12. The mounting method(s) (1, 2, 3, or 4, see Figure 12) used shall be noted in the test report.

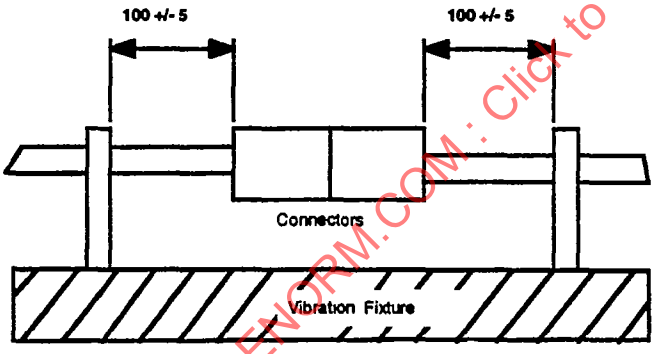
Dimensions in millimeters



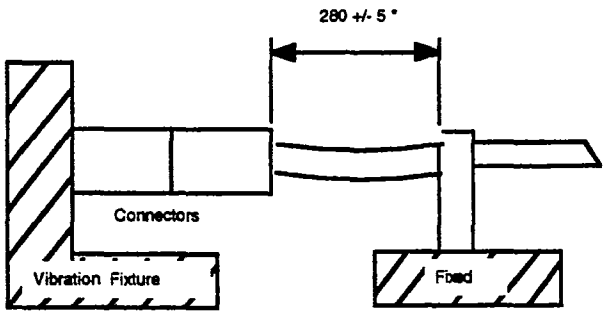

Method 1




Method 2




Method 3




Method 4

*cable length (300 mm ± 5 mm)

FIGURE 12—VIBRATION TEST—MOUNTING METHODS

All connectors are wired in series and connected to a DC source allowing a current flow of 100 mA to monitor connection resistance variation during the entire test (see test arrangement in Figure 13).

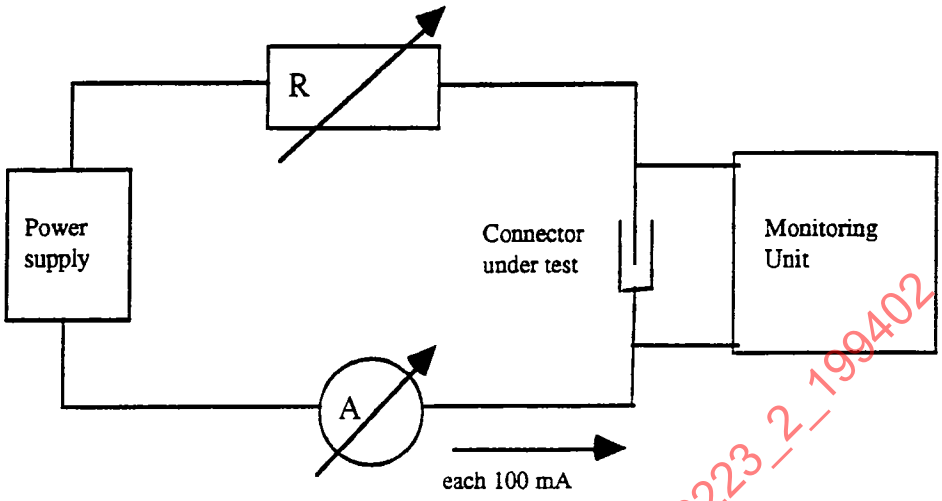



FIGURE 13—CONNECTOR RESISTANCE MONITORING AT VIBRATION TEST

While being monitored, the connector shall be subjected to a simple harmonic motion. The parameters shall be as follows:

a. 10 to 55 Hz at an amplitude of positive or negative 0.75 mm.
b. 55 to 500 Hz at 100 m/s$^2$ acceleration.
c. The frequency variation is carried out by logarithmic sweepings of 1 octave/min.
d. The motion shall be applied for a period of 16 h on each of the three mutually perpendicular directions (total test time 48 h).

NOTE—Alternatively, the test sample can be subjected to a measured vehicle vibration profile for the same duration.

3.11.2 PERFORMANCE REQUIREMENTS—During vibration test, as in 3.11.1, the connection resistance variation shall not exceed 7 Ω for a period of more than 1 μs, see Figure 14.

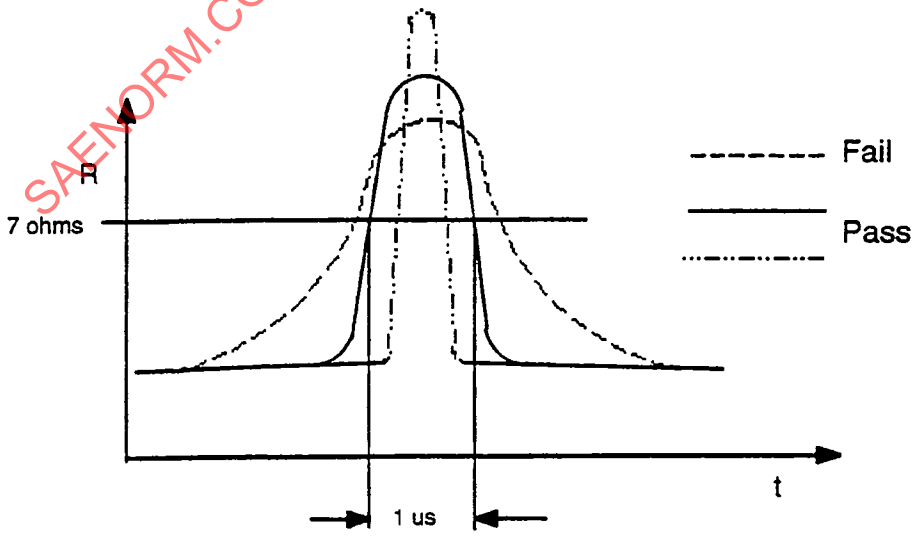



FIGURE 14—CONTACT RESISTANCE VARIATION AT VIBRATION TEST