# 1. APTA PR-E-S-001-98 Standard for Insulation Integrity

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**Abstract**: This standard defines a method for insulation integrity testing on rail passenger vehicles.

**Keywords**: electrical insulation, insulation integrity

## Participants

The American Public Transportation Association (APTA) greatly appreciates the contributions of the following individual(s), who provided the primary effort in the drafting of the *Standard for Insulation Integrity*.

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# APTA PR-E-S-001-98
# Standard for Insulation Integrity

## 1. Overview

### 1.1 Scope

The passenger rail industry phased this standard into practice over the six-month period from July 1 to December 31, 1999. The standard took effect January 1, 2000.

### 1.2 Purpose

This standard defines a methodology for insulation integrity testing on rail passenger vehicles. This standard applies to insulation integrity on passenger rail vehicles.

## 2. References

This standard shall be used in conjunction with the following publications. When the following standards are superseded by an approved revision, the revision shall apply.

Association of American Railroads RP-567 Locomotive DC High Potential Test Procedures

IEC 60077-1999 Electric equipment for rolling stock

IEC 60349-2002 Rotating electrical machines for rail and road vehicles

IEEE Std 11-2000 IEEE Standard for Rotating Electric Machinery for Rail and Road Vehicles

IEEE Std 16-2004 IEEE Standard for Electrical and Electronic Control Apparatus on Rail Vehicles

## 3. Definitions, abbreviations, and acronyms

### 3.1 Definitions

For the purpose of this recommended practice, the following terms and definitions apply:

**3.1.1 "hiPot":** A test procedure in which insulation dielectric strength is tested at a high voltage potential selected in accordance with the nominal operating voltage of the circuit or device.

**WARNING**

High potential testing involves potentially lethal voltages and must be done in strict accordance with all applicable safety precautions.

**3.1.2 megger:** A dc insulation resistance tester, consisting of a generator producing

either 500 or 1000 volts and an ammeter scaled in megohms.

### 3.2 Abbreviations and acronyms

| | |
|---|---|
| APTA | American Public Transportation Association |
| IEEE | Institute of Electrical and Electronic Engineers |
| PRESS | Passenger Rail Equipment Safety Standards |

## 4. Technical requirements

### 4.1 Requirements for new apparatus and equipment

Prior to installation on the vehicle, the circuits of each separately assembled and wired package shall be tested for insulation integrity, according to the procedures herein.

On items with double insulation, such as grid resistors mounted by insulators to a frame insulated from a car body, each set of insulation shall be individually tested (i.e., resistors to frame and frame to car body).

### 4.2 Requirements for new vehicles

After all cable, wiring, and equipment installation on the vehicle, the insulation integrity of all vehicle circuits shall be tested according to the procedures herein. Assemblies that have previously been tested for dielectric strength need not be electrically connected during the vehicle dielectric test. A final insulation resistance test shall be conducted after all equipment has been connected.

### 4.3 Insulation integrity testing

All terminal connections shall be checked for proper tightness at some point in the assembly cycle. The integrity of the electrical insulation shall be confirmed by performing the following tests on individual devices, systems, apparatus, and the vehicle as a whole:

a) Continuity checks

b) Then, insulation resistance tests

c) Then, high potential, dielectric tests

### 4.4 Continuity checks

The continuity of all wiring shall be checked to verify that the wiring has been properly installed. Continuity checks shall be performed prior to insulation resistance tests.

### 4.5 Insulation resistance test

Insulation resistance tests shall be performed using a megger. The battery shall be isolated during this test.

Insulation resistance tests shall be conducted on all circuits within a device, system, or

vehicle. Tests shall be conducted to verify the state of the insulation to the equipment case, between wiring of different voltage classes, and between the input and output circuit of high voltage line switches and circuit breakers. Semiconductor devices may be protected against the test voltage if they are not inherently protected by the circuit in which they are used.

On items with double insulation, such as grid resistors mounted by insulators to a frame insulated from car body, each set of insulation shall be individually tested; *i.e.*, resistors to frame and frame to car body.

The following insulation resistance limits shall apply when all circuits on the vehicle of a given voltage class are connected in parallel under all environmental conditions, including non-condensing high humidity:

| Nominal Circuit Voltage Volts dc or ac rms | Minimum Insulation Resistance |
|---|---|
| Below 90 volts | 2 megohms at 500 Vdc |
| 90 to 300 volts | 4 megohms at 1,000 Vdc |
| Above 300 volts | 5 megohms at 1,000 Vdc |

The test limits for individual devices or apparatus shall be higher than the above listed limits, as is appropriate for that hardware, so that the limits for the completed vehicle can be met.

## 4.6 Dielectric test

The dielectric test shall be conducted after the insulation resistance test is completed and passed. The dielectric test shall be conducted on all circuits within a device, system or vehicle. Tests shall be conducted to verify the state of the insulation to the case or car body, between wiring of different voltage classes, and between the input and output circuit of traction high voltage line switches and circuit breakers. Semiconductor devices may be protected against the test voltage if they are not inherently protected by the circuit in which they are used.

All components and systems shall be in place when the high potential tests are being performed, except as allowed under the Requirements for New Vehicles (Section 4.2).

The various wires in a system shall be shorted to ensure that all parts of a system are tested, and to prevent capacitive or fault currents from passing through and damaging low voltage devices.

The test shall be conducted by applying the test voltage, as listed below, for a period of 1 minute, across the insulation being tested. The test is passed if there is no insulation breakdown. The test voltage shall be at a frequency of 50/60 Hz with a sinusoidal waveform. V, in the formula below, shall be the nominal system voltage for a circuit.

| Nominal Circuit Voltage<br>Volts dc or ac rms | Test Voltage, ac rms |
|---|---|
| Below 300 volts | 2 x V + 1000 volts |
| Equal to or above 300 volts | 2.25 x V + 2000 volts |

Standard apparatus may be production tested for 1 second at a test voltage 20 percent higher than the above listed 1-minute test voltage.

Pass/fail criteria shall be determined by agreement between the manufacturer and the railroad having jurisdiction.

High potential tests using a dc voltage shall only be used by agreement with the railroad. Where a dc test voltage is used, the voltage shall be equal to the peak of the corresponding ac test voltage.

With the agreement of the railroad, manufacturers may select from the following standard requirements for dielectric testing, instead of the voltage and time requirements above:

IEEE 16 and IEC 77 for general control equipment

IEEE 11 and IEC 349 for rotating equipment

## 4.7 Maintenance testing

Replacement apparatus, equipment, cables, and wiring should be tested for insulation integrity. A final insulation resistance test shall be conducted after all equipment has been connected.

Insulation resistance tests on equipment in service should not be expected to exhibit the same insulation resistance as new equipment. (One megohm, under all humidity conditions is the recommended minimum.) The nature of the equipment that is connected during the test and the humidity will cause variations in the readings.

Repeated high potential, dielectric tests should be avoided. For repeated tests, the test voltage shall be 0.85 times the value defined above.

As part of routine maintenance, high potential, dielectric tests should be avoided as a result of cumulative effects of the test. One exception is the use of procedures similar to *Association of American Railroads RP-567 Locomotive DC High Potential Test Procedures*[1] for testing the condition of insulation within rotating equipment.

[1] For references in Italics, see Section 2.