APTA STANDARDS DEVELOPMENT PROGRAM

STANDARD

American Public Transportation Association
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APTA PR-E-S-001-98, Rev. 3

First Published: Jan. 22, 1998
First Revision: Feb. 13, 2004
Second Revision: June 15, 2006
Third Revision: January 15, 2021

PRESS Electrical Working Group

Electrical Insulation Integrity

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

Keywords: electrical insulation, insulation integrity

Summary: This standard was titled “Insulation Integrity” in the previous publication of this document. This standard contains requirements for electrical insulation integrity testing, including requirements for new apparatus and equipment prior to on-vehicle installation; maintenance testing; and testing of complete vehicles. Specific test requirements detailed include continuity checks, insulation resistance testing and dielectric testing.

Scope and purpose: This standard defines a methodology for electrical insulation integrity testing on rail passenger vehicles. Its purpose is to provide requirements to identify material and manufacturing defects.

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Introduction

This introduction is not part of APTA PR-E-S-001-98, Rev. 3, "Electrical Insulation Integrity," (Insulation Integrity).

This standard applies to all:

1. Railroads that operate intercity or commuter passenger train service on the general railroad system of transportation; and
2. Railroads that provide commuter or other short-haul rail passenger train service in a metropolitan or suburban area, including public authorities operating passenger train service.

This standard does not apply to:

1. Rapid transit operations in an urban area that are not connected to the general railroad system of transportation;

2. Tourist, scenic, historic, or excursion operations, whether on or off the general railroad system of transportation;
3. Operation of private cars, including business/office cars and circus trains; or
4. Railroads that operate only on track inside an installation that is not part of the general railroad system of transportation.

Electrical Insulation Integrity

1. Technical requirements

1.1 Requirements for new apparatus and equipment prior to on-vehicle installation

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).

1.2 Requirements for testing of complete 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.

1.3 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 as per Section 1.4
b. Then, insulation resistance tests as per Section 1.5
c. Then, high-potential dielectric tests as per Section 1.6
d. Then, repeat insulation resistance tests as per Section 1.5

1.4 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.

> **NOTE:** Acceptable means of testing include a calibrated ohmmeter or automatic testers capable of indicating (e.g., by lamp, bell or buzzer) an unbroken circuit.

1.5 Insulation resistance test

Insulation resistance tests shall be performed using a DC insulation tester, often called a “megger.” The vehicle battery as well as any independent power sources 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 or other sensitive equipment 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 the car body, each set of insulation shall be individually tested—i.e., resistors to frame and frame to car body.

The testing shall also be performed for conductor-to-shield and shield-to-ground insulation resistance.

The insulation resistance limits in **Table 1** 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:

TABLE 1
Insulation Resistance Limits

Nominal Circuit Voltage, Volts DC or AC RMS	Minimum Insulation Resistance
Below 90 V	2 megohms at 500 VDC
90 to 300 V	4 megohms at 1000 VDC
Above 300 V	5 megohms at 1000 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.

1.6 Dielectric test

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

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 or other sensitive 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 of Section 1.2, “Requirements for testing of complete vehicles.”

The various wires in a system shall be connected together for test purposes 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 in **Table 2**, 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 in **Table 2**, shall be the nominal system voltage for a circuit.

TABLE 2
Test Voltage Formula

Nominal Circuit Voltage, Volts DC or AC RMS	Test Voltage, AC RMS
Below 300 volts	(2 × V) + 1000 volts
Equal to or above 300 volts	(2.25 × V) + 2000 volts

NOTE: Communication cables (category and network cables) and wiring shall be tested in accordance with cable manufacturer specifications.

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.

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:

a. IEEE 16 or IEC 60077 for general control equipment
b. IEEE 11 or IEC 60349 for rotating equipment

1.7 Maintenance testing

Replacement apparatus, equipment, cables and wiring should be tested for insulation integrity as per Section 1.3. 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 (1 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 (AAR), RP-567, “Locomotive DC High Potential Test Procedures” for testing the condition of insulation within rotating equipment.

References

This standard shall be used in conjunction with the following publications. The most recent revision shall apply.

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

EN Std 50343, “Rules for the installation of cabling”

International Electrotechnical Commission standards:
IEC 60077, “Electric equipment for rolling stock”
IEC 60349, “Rotating electrical machines for rail and road vehicles”

Institute of Electrical and Electronics Engineers standards:
IEEE Std 11, “IEEE Standard for Rotating Electric Machinery for Rail and Road Vehicles”
IEEE Std 16, “IEEE Standard for Electrical and Electronic Control Apparatus on Rail Vehicles”

Definitions

The IEEE Standards Dictionary Online shall be consulted for terms not defined in this clause.

DC insulation tester: A DC insulation resistance tester, consisting of a generator producing either 500 or 1000 V and an ammeter scaled in megohms. This is also known as a “megger” test.

dielectric withstand test: 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. This is also commonly known as a “hipot” test.

Abbreviations and acronyms

AAR	Association of American Railroads
AC	alternating current
DC	direct current
EN	Euronorm
Hz	Hertz
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
NATSA	North American Transportation Services Association
PRESS	Passenger Rail Equipment Safety Standards
RMS	root mean squared
V	volts
VDC	voltage direct current

Summary of document changes

- Document formatted to the new APTA standard format.
- Sections have been moved and renumbered.
- Scope and summary moved to the front page.
- Sections of definitions, abbreviations and acronyms moved to the rear of the document.
- Two new sections added: “Summary of document changes” and “Document history.”
- Some global changes to section headings and numberings resulted when sections dealing with references and acronyms were moved to the end of the document, along with other cosmetic changes, such as capitalization, punctuation, spelling, grammar and general flow of text.

- Added “Electrical” to title to differentiate from thermal insulation.
- Scope and purpose: Added that the purpose of this standard “is to provide requirements to identify material and manufacturing defects.”
- Section 1.1: Added “prior to on-vehicle installation” to section title to clarify temporal nature of the requirements therein.
- Section 1.2: Replaced “new” with “testing of complete” in section title to clarify that the requirements therein apply to the entirety of the vehicle and not just one particular system.
- Section 1.3: Added letter identifiers for each test.
- Section 1.3: Added “d. Then, repeat insulation resistance tests as per Section 1.5,” as is the standard industry practice.
- Section 1.4: Used non-trademarked term “DC insulation tester” in place of “megger.”
- Section 1.4: Added “vehicle” and “as well as any independent power sources” to update language to better reflect industry practices.
- Section 1.4: Added “or other sensitive” to update language to better reflect industry practices
- Section 1.5: Added “The testing shall also be performed for conductor-to-shield and shield-to-ground insulation resistance,” to better clarify application.
- Section 1.5: Moved high-potential test warning to beginning of section.
- Section 1.6: Added “or other sensitive” to better reflect industry practices.
- Section 1.6: Changed internal citation to Section 1.2 to match section title change.
- Section 1.6: Added “NOTE: Communication cables (category and network cables) and wiring shall be tested in accordance with cable manufacturer specifications.” This added a critical exception for communication cables, which would likely be damaged/destroyed under the procedure described in the text and formula above.
- Section 1.6: Changed “and” to “or” for alternate standards, as one can only use one alternate, not both.
- Section 1.7: Added “as per Section 1.3” to add a pointer back to order-of-testing section.
- References: Deleted date specifications on references, as it is the standard users’ responsibility to identify the most recent version of the reference.
- Definitions: Replaced “hiPot” with the non-slang term “dielectric withstand test.” Also added, “This is also commonly known as a “hipot” test.”
- Definitions: Replaced “megger” with “DC insulation tester.” Also added “This is also known as a ‘megger’ test.”

Document history

Document Version	Working Group Vote	Public Comment/ Technical Oversight	CEO Approval	Policy & Planning Approval	Publish Date
First published	Jan. 22, 1998	—	—	—	March 17, 1999
First revision	—	—	—	—	Feb. 13, 2003
Second revision	—	—	—	—	June 15, 2006
Third Revision	Sept. 14, 2018	Oct 31, 2018	May 20, 2019	Dec. 31, 2021	Jan. 15, 2021

This document was retitled to its current title from “Insulation Integrity” as part of Rev. 3. For all previous publications of this document prior to Rev. 3, unless otherwise indicated, this document was titled “Insulation Integrity.”

