KIKUSUI

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Safety evaluation test

A Glossary

B Four Principal Tests for Evaluating the Safety of Electrical and Electronic Products

- Withstanding Voltage Test
- Insulation Resistance Test
- Earth Continuity Test
- Leakage Current Test

A Glossary

The terms used in the description of the electrical safety tests is explained below. For a specific definition of each term, refer to the relevant safety standard.

The definitions of the terms indicated here are basically excerpts from the IEC 61010-1 2nd Edition. Excerpts from other standards are indicated in parentheses.

General terms concerning safety

Hazard	Potential source of harm.
Hazardous Live	Capable of rendering an electric shock or electric burn in normal condition or single fault condition.
Accessible (of a part)	Able to be touched with a standard test finger or test pin.
Basic Insulation	Insulation, the failure of which could cause a risk of electric shock.
Supplementary Insulation	Independent insulation applied in addition to basic insulation in order to provide protection against electric shock in the event of a failure of basic insulation.
Double Insulation	Insulation comprising both basic insulation and supplementary insulation.
Reinforced Insulation	Insulation which provides protection against electric shock not less than that provided by double insulation.
Safety extra low voltage (SELV)	Voltage across two locations that are safe to touch under normal or single fault condition.
Clearance	Shortest distance in air between two conductive parts
Creepage Distance	Shortest distance along the surface of the insulating material between two conductive parts.
Enclosure	Part providing protection of equipment against certain external influence and, in any direction, protection against direct contact.
Type Test	Test of one or more samples of equipment (or parts of equipment) made to a particular design, to show that the design and construction meet one or more requirements of the standard.
Routine Test	Test to which each individual device (equipment) is subjected during or after manufacture to ascertain whether it conforms to certain criteria.
Mains	Low-voltage electricity supply system to which the equipment concerned is designed to be connected for the purpose of powering the equipment.
Mains Circuit (Primary Circuit)	Circuit which is intended to be conductively connected to the mains for the purpose of powering the equipment.

Terms concerning the equipment classes and conditions

Class 0 Equipment	Equipment where protection against electric shock is achieved only by basic insulation.
Class 0I Equipment	Equipment in which protection against electric shock is achieved by using basic insulation and a connection to an external protective earthing system. Equipment that cannot be connected to the fixed mains socket with an earthing terminal using a mains power cord that contains a protective earthing conductor. (JIS C 1004-96)
Class I Equipment	Equipment in which protection against electric shock is achieved by using basic insulation and also providing a means of connection to the protective earthing conductor wiring those parts that are otherwise capable of assuming hazardous voltages if the basic insulation fails.
Class II Equipment	Equipment in which protection against electric shock does not relay on basic insulation only, but in which additional safety precautions, such as double insulation or reinforced insulation are provided, there being no reliance on protective earthing.
Class III Equipment	Equipment in which protection against electric shock relies upon supply from SELV circuits and which hazardous voltages are not generated.
Normal Condition	Condition in which all means for protection against hazards are intact.
Single Fault Condition	Condition in which one means for protection against hazard is defective or one fault is present which could cause a hazard.

Terms concerning withstanding voltage and insulation resistance tests

Voltage Test, Dielectric Strength Test, Hipot Test	These terms are all equivalents of the withstanding voltage test. Dielectric strength test is commonly used in the safety standards. Various names are used on the products of equipment manufacturers.

Terms concerning earth continuity test

Protective Conductor Terminal	Terminal which is bonded to conductive parts of an equipment for safety purposes and is intended to be connected to an external protective earthing system.
Protective Bonding	Electrical connection of accessible conductive parts or protective screening to provide electrical continuity to the means of connection of an external protective conductor.

Terms concerning leakage current test

Limited Current Circuit	A circuit which is so designed and protected that, under both normal operating conditions and single fault conditions, the current which can be drawn is not hazardous.(IEC 60950-1)
Touch Current	Electrical current through a human body when it touches one or more accessible parts. Current that is measured using a body impedance network (body model) that matches the body responses.
Protective Conductor Current	Current flowing through the protective earthing conductor under normal operating conditions.
Body Impedance Network, Measurement Network	Circuit network (body model) representing the human body impedance that is used in the measurement of the TC. There are differences in the body response types and safety standards. However, it is usually defined using resistors and capacitors.
Body Responses	Body responses when a hazardous current flows. There are four types of responses: perception, reaction, let-go, and electric burn. (IEC 60990)

B Four Principal Tests for Evaluating the Safety of Electrical and Electronic Products

Electrical products consists of many parts. Mostly, they are composed of electric parts that conduct electricity (conductors) and those that block electricity (insulators). If the insulator between parts that are accessible by humans and parts that are hazardous is defective, electric shock may occur if a human being touches the electric equipment. If the defective insulating part heats up, it may cause a fire. To prevent such accidents, evaluating the safety of electric equipment is extremely important. The typical tests are withstanding voltage test, insulation resistance test, leakage current test, and earth continuity test.

- Withstanding voltage and insulation resistance tests

  These tests check whether the insulation performance of insulation section (solid insulation, clearance, etc.) between hazardous section and accessible section are sufficient.

- Leakage current test

  This test measures the amount of current that flows assuming the case in which a human actually touches the electric equipment.

- Earth continuity test

  This test checks whether the protective bonding is achieved by low resistance for equipment designed to use protective earthing for securing safety.

These four tests are mandatory type tests that must be executed under the safety standards such as IEC and UL as well as the Electrical Appliance and Material Safety Law. The withstanding voltage and earth continuity tests that are performed between the primary circuit (parts connected to the commercial power line that may become an immediate threat) and accessible locations are routine tests that must be performed on all products on a regular basis.

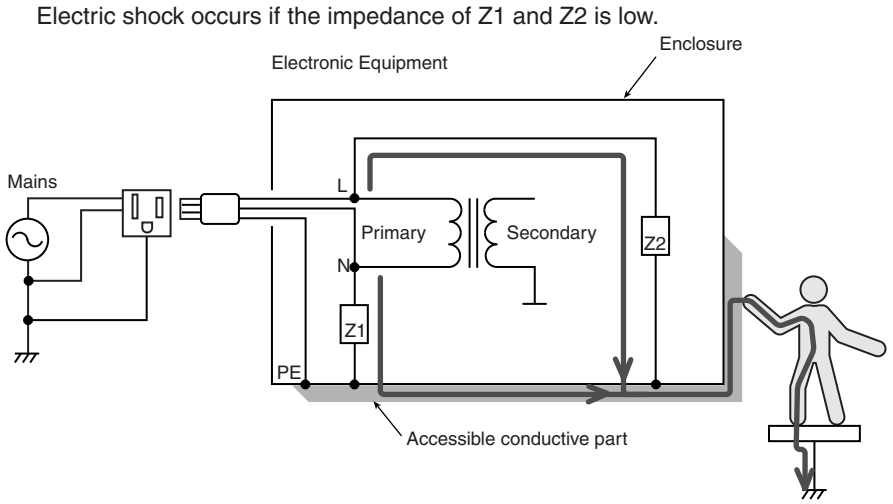

Fig. B-1 Safety evaluation test

Withstanding Voltage Test

The withstanding voltage test evaluates whether the electric insulation section of an electric equipment or parts have sufficient dielectric strength for the working voltage. It is also called dielectric withstand test or hipot test.

In this test, a voltage stress that is much higher than the voltage that is normally applied to the insulation section for a specific time to see whether a dielectric breakdown occurs. If a current flowing through the insulation section exceeds the limit during the test period, it is assumed that a dielectric breakdown occurred. If a dielectric breakdown does not occur, the insulator is assumed to have sufficient dielectric strength.

Measurement principle of the withstanding voltage test

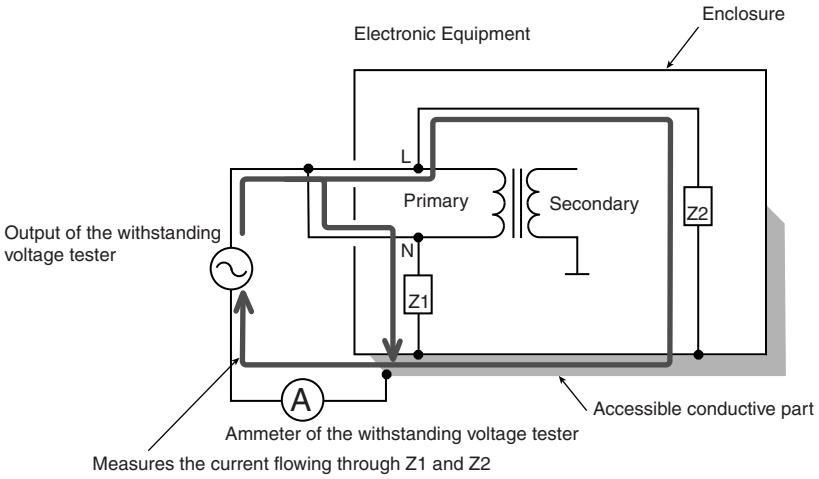

Fig. B-2 Withstanding voltage test

AC test and DC test

For the test between the primary circuit and an accessible section as shown in Fig. B-2, an AC voltage is normally applied. If a filter for eliminating the electromagnetic interference is present in the location corresponding to Z1 or Z2 and its capacitive component is large, the distinction between the current flowing through the filter and the current used to assume a dielectric breakdown will be difficult. In this case, it is recommended that the test be performed using a DC voltage equal to the peak value of the specific AC voltage.

Insulation Resistance Test

This test is the same as the withstanding voltage test in that it is mandatory to prevent electric shock and fire accidents from using the equipment and that it checks the functionality or performance of the insulator. The withstanding voltage test detects insulation defects by checking whether dielectric breakdown occurs. The insulation resistance test detects insulation defects by measuring the resistance.

After absorbing the moisture of the equipment (sometimes this is not done), a specific DC voltage that is 5 to 10 times higher than the normal voltage is applied, and the resistance is measured from the amount of current that flows. If the insulation resistance is sufficient, the equipment meets the requirements for preventing electric shock and fire accidents.

Measurement principle of the insulation resistance test

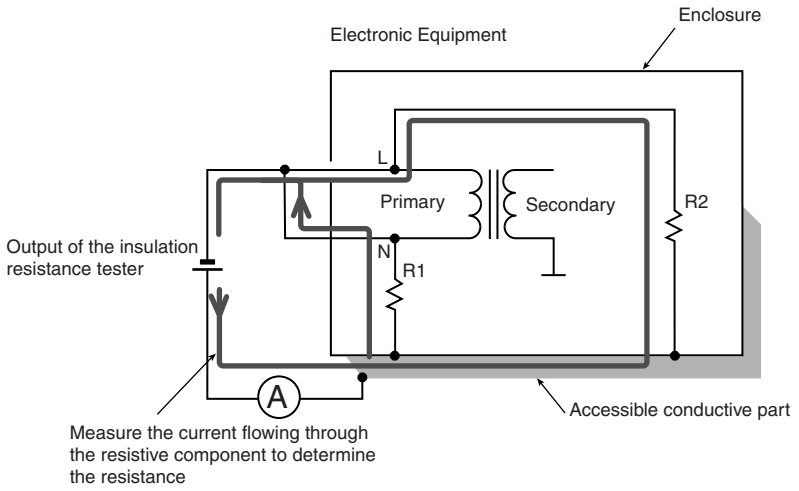

Fig. B-3 Insulation resistance test

Why DC voltage is used to perform the insulation resistance test

The insulation resistance test measures the resistive component of the insulator. The capacitive component is ignored. The equipment is only safe if at least a given insulation resistance (a value specified by a standard) is maintained. The insulation resistance test is performed to check this resistance. If the insulation resistance test is performed using an AC voltage, we end up measuring the impedance of the capacitive component and prevents us from obtaining the required insulation resistance. This is the reason why the insulation resistance test is performed using a DC voltage.

Earth Continuity Test

This test verifies the integrity (continuity) of the protective bonding of the equipment (Class I equipment) designed to secure safety through the basic insulation and protective earthing. It is also called earth (ground) bonding test.

In this test, a current in the range of 10 A to 60 A is applied for 60 seconds to few minutes. The resistance is measured by measuring the voltage. The test current is determined by the rating of the distribution system (such as 1.5 or 2 times the distribution system). Many standards define the resistance limit to less than or equal to 0.1 Ω (some standards define the limit by the voltage drop) and the open-circuit voltage (no-load voltage) to less than or equal to 6 V or 12 V.

If the continuity of the protective bonding is confirmed, we can conclude that the equipment has the requirements for preventing electric shock even if the insulation between the primary circuit and the accessible conductive section fails and a fault current flows through the distribution system.

Measurement principle of the earth continuity test

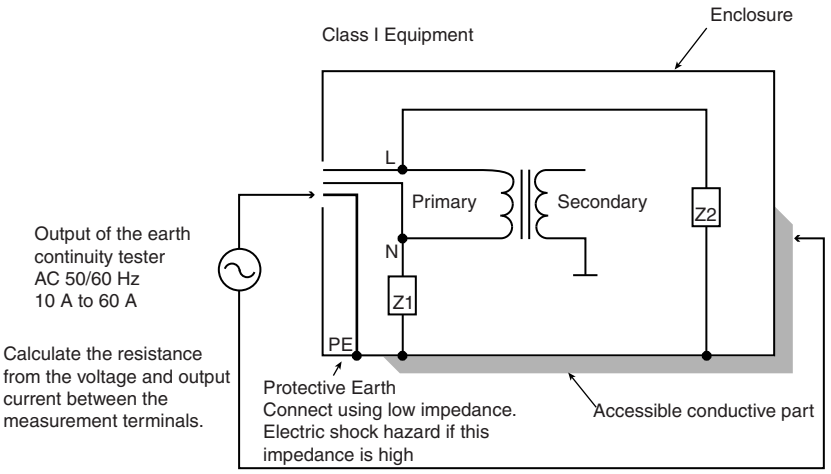

Fig. B-4 Earth continuity test

Leakage Current Test

The term *Touch Current* and *Protective Conductor Current* are defined in the latest international standard, IEC 60990. These terms were previously referred to as *Leakage Current*.

- Touch Current (TC)

  Current that flows when a human body touches the equipment. If the measured TC does not exceed the value hazardous to a human body as defined by a safety standard or the like, the equipment meets the requirements for preventing electric shock.

- Protective Conductor Current (PCC)

  Current that flows through the protective conductor of equipment that is furnished with normal protective bonding. The measurement of the PCC also serves the purpose of checking the compatibility with the distribution system of the equipment.

Differences from the withstanding voltage and insulation resistance tests

The withstanding voltage and insulation resistance tests measure the current flowing through the insulator of the EUT. The TC test measures the current flowing through a body impedance network, and the PCC test measures the current flowing through the protective conductor. The term *leakage current* applies to all these cases. However, the term *leakage current test* generally refers to tests that measure the TC or PCC.

Measurement principle of the leakage current test

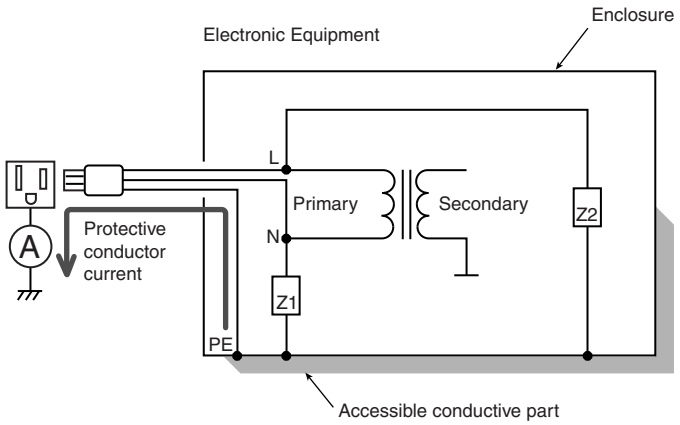

Fig. B-5 Leakage current test 1
Typical example of PCC measurement

In this test, power is fed to the EUT, and the current flowing through the protective conductor is measured under normal operation.

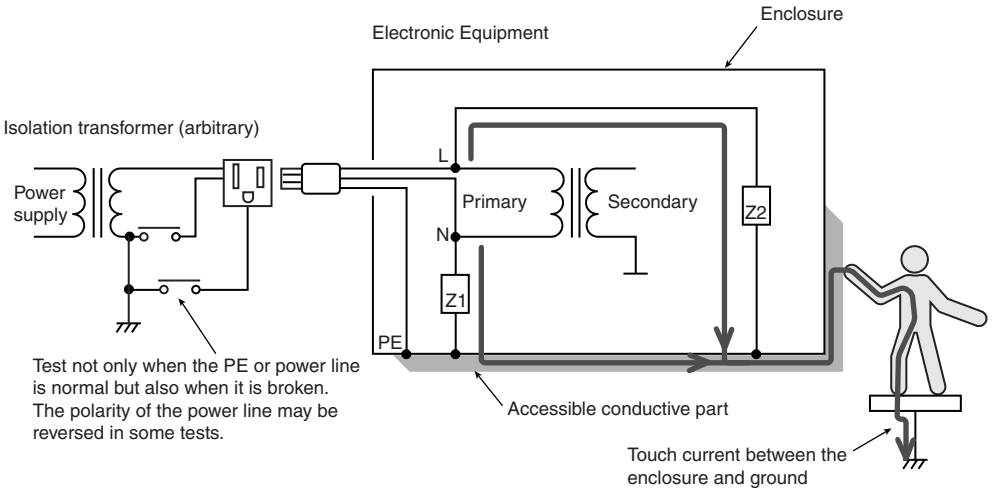

Fig. B-6 Leakage current test 2
Typical example of TC measurement

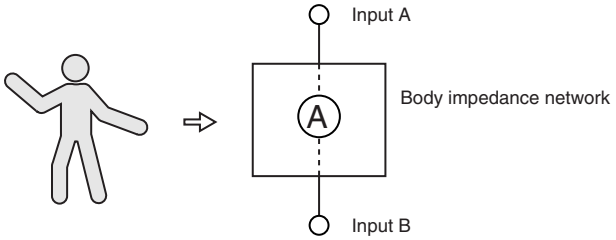

Fig. B-7 Body impedance network

A body impedance network is connected in place of an actual human body, and the current flowing through the network is measured. In some cases, the TC between the enclosure and the power line or that between the enclosure and another enclosure is also measured in addition to the TC between the enclosure and ground.

Reference

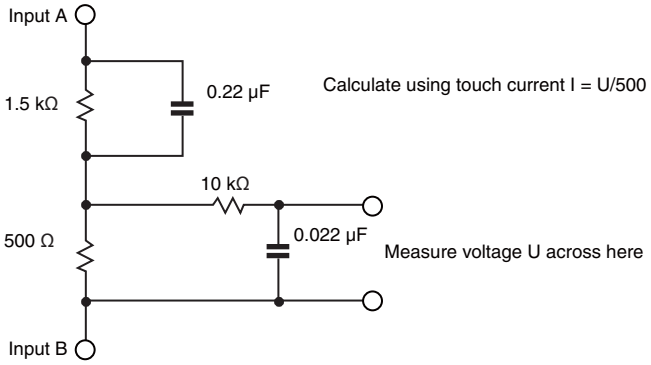

Fig. B-8 Example of a body impedance network