Kikusui's Webinar 2021

Electrical Safety-Tests And Partial Discharge Webinar

Kikusui Electronics Co., Ltd.

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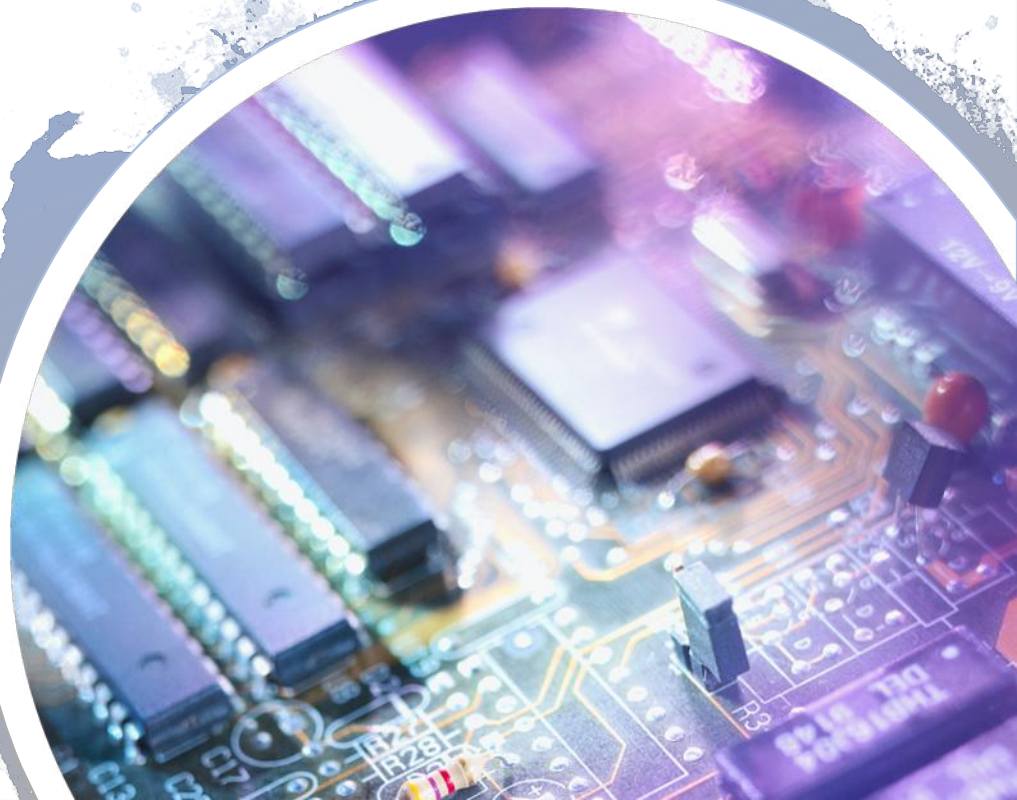


1. Introduction

Electrical product safety

All electrical products must be safe.
They must not endanger people's lives or cause damage to property.

The safety of electrical products used in households is paramount! Consumers must be protected from accidents such as electric shock, fire, injury, and explosion.

1.Introduction

Defining hazardous elements

From International Standard IEC61010

- ☆ Electric shocks or burns
- ☆ Mechanical hazards
- ☆ Excessive high temperatures
- ☆ Spread of flames from equipment
- ☆ Effects of liquids and liquid pressure
- ☆ Effects of radiation, including laser sources, as well as sound and supersonic pressure
- ☆ Free gas, explosion and implosion

The IEC is the international standard for the technical safety of electrical products, and the standard number IEC 60601 defines the hazards posed by electrical products. We supply products related to testing for electric shock and burns hazards.

2. Typical hazards: electric shock

Electric shock is a symptom of an electric current flowing through the body. IEC60990 defines the body's response to an electric shock.

A few hundred mA (a milliamp is 1/1000) of current flowing through the body can cause severe burns or death!

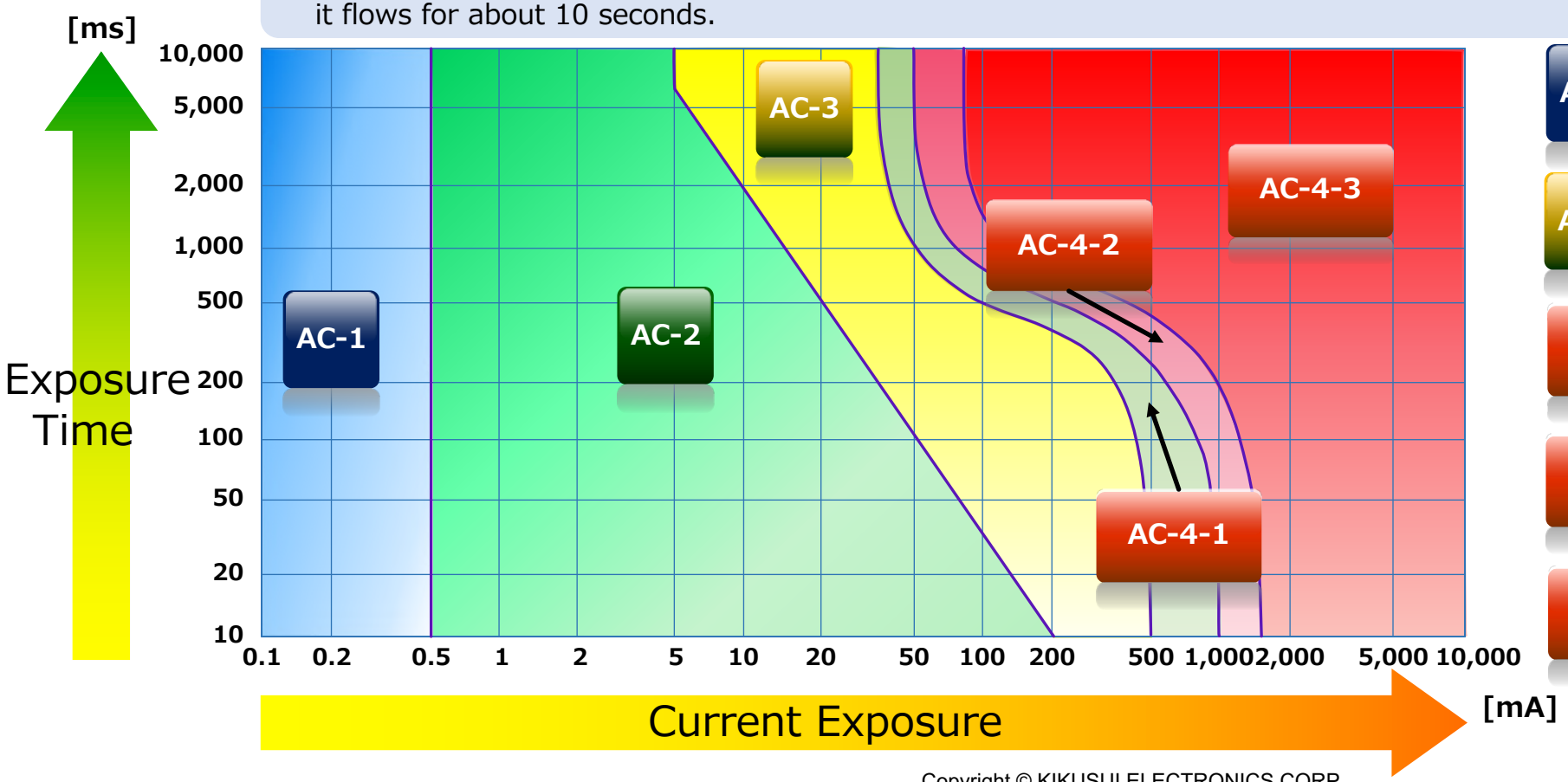
Body Response（From international standard IEC60990)

Perception	Reaction	Let-go	Electric Burn
the minimum amount of current that causes some sensation	the minimum amount of current that causes involuntary muscle contraction	The maximum value at which the person holding the electrode can release it.	Electric current with burns (thermal injury) as a result of electric current flowing through the human body.
Several μA level	**0.5mA level**	**10mA level**	**Several hundred mA level**

2. Typical hazards: electric shock

Reaction to alternating current (15Hz to 100Hz)

This graph shows the magnitude of the current (X-axis) and the time it flows through the human body (Y-axis) in AC. The more to the right, the higher the danger. The units are ms and mA. Even if the current is only a few mA, it can harmful if it flows for about 10 seconds.



AC-1 Usually no Reaction.

AC-2 Touch sensation, but no harmful effects.

AC-3 If current flows for more than two seconds, muscle spasms and breathing difficulties may occur.

AC-4-1 Cardiac arrest, respiratory failure, or severe burns may result. Chance of ventricular fibrillation (less than 5%)

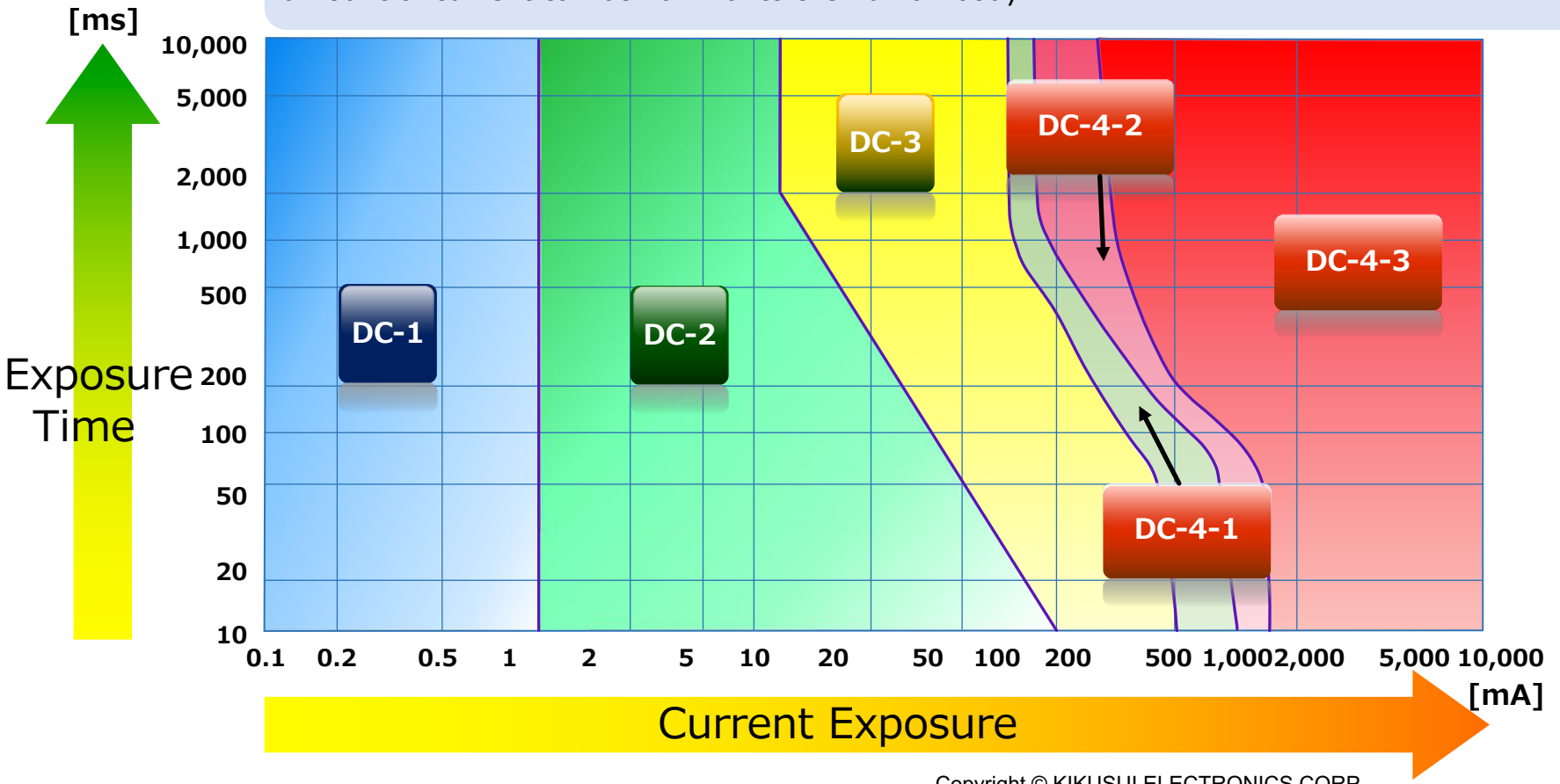
AC-4-2 Results in cardiac arrest, respiratory failure or severe burns. Can cause physiologically dangerous conditions. Chance of ventricular fibrillation (less than 50%)

AC-4-3 Results in cardiac arrest, respiratory failure or severe burns. Can cause physiologically dangerous conditions. Chance of ventricular fibrillation (>50%)

2. Typical hazards: electric shock

Reaction to direct current

This graph shows the magnitude of the current (X-axis) and the time it flows through the human body (Y-axis) in direct current. Compared to AC, DC has a slightly higher current carrying capacity, but even a relatively small amount of current can be harmful to the human body.



DC-1 Usually no response. Slight stinging is possible.

DC-2 Usually not harmful No effects.

DC-3 Recoverable damage to the heart and transmission impairment can occur.

DC-4-1 Dangerous symptoms, e.g., severe burns, are expected. (probability of ventricular fibrillation less than 5%)

DC-4-2 Dangerous symptoms, e.g., severe burns, are expected. (probability of ventricular fibrillation less than 50%)

DC-4-3 Dangerous symptoms, e.g., severe burns, are expected. (probability of ventricular fibrillation >50%)

2. Typical hazards: electric shock

Electric shock from dry cell batteries

Consider the resistance of the body and calculate the electric shock current using Ohm's law!

- **1.5V dry cell battery: 1 unit**

Touching both ends of a battery can cause a low-current electric shock!

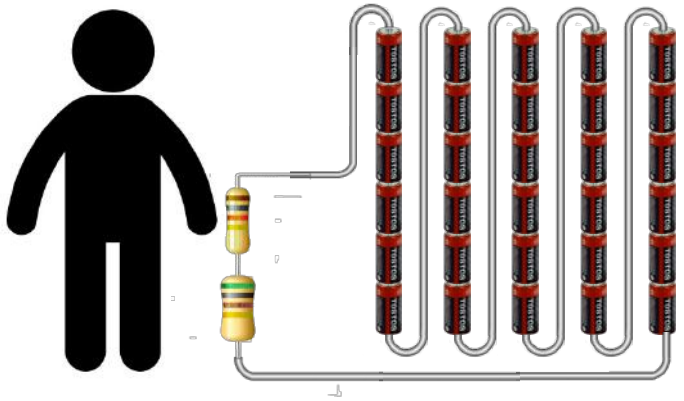
Current flowing through the human body :

$$\text{Current (A)} = \frac{\text{Voltage } \mathbf{1.5\ (V)}}{\text{Skin resistance } \mathbf{1{,}500\ (\Omega)} + \text{Body resistance } \mathbf{500\ (\Omega)}}$$

$$\frac{\mathbf{1.5\ (V)}}{\mathbf{2{,}000\ (\Omega)}} = 0.00075\ (\text{A}) = \mathbf{0.75\ (mA) = 750\ (\mu A)}$$

※With a single battery, the current is so small that it is imperceptible.

- **1.5V dry cell batteries: 30 batteries connected in series**



Voltage at both ends connected in series is

$1.5\ (\text{V}) \times 30 = 45\ (\text{V})$

$$\frac{\mathbf{45\ (V)}}{\mathbf{2{,}000\ (\Omega)}}$$

$$= \mathbf{0.0225(A) = 22.5\ (mA)}$$

Current value when the body is wet and the skin resistance is 0 (Ω)

$$= \frac{\mathbf{45\ (V)}}{\mathbf{500\ (\Omega)}}$$

$$= 0.09\ (\text{A}) = \mathbf{90\ (mA)}$$

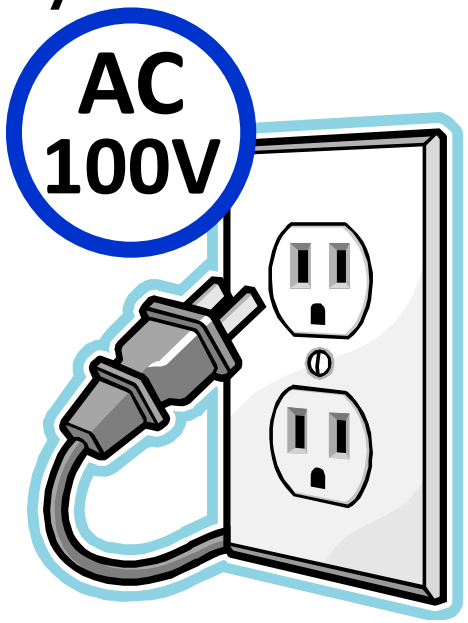
If batteries are connected in series, the current flowing to the body will be high and very dangerous!

2. Typical hazards: electric shock

Electric shock from commercial power supply (AC)

Current flowing through the body:

$$\text{Current (A)} = \frac{\text{Voltage } 100\ (\text{V})}{\text{Skin Resistance } 1{,}500\ (\Omega) + \text{Internal resistance } 500\ (\Omega)}$$



$$= \frac{100\ (\text{V})}{2{,}000\ (\Omega)} = 0.05(\text{A}) = 50\ (\text{mA})$$

Current value when the body is wet and the skin resistance is 0 (Ω)

$$= \frac{100\ (\text{V})}{500\ (\Omega)} = 0.2(\text{A}) = 200\ (\text{mA})$$

An electric shock from an AC socket (outlet) is extremely dangerous!

The breaker used in the normal commercial 100V power line is 20A.Therefore, if no other electrical equipment is connected to this line, it is a dangerous source that can instantaneously carry a current of 20A to an outlet.。

3. Safety standards and laws

Safety standards and laws are established to protect consumers and property from hazards present in electrical products such as electric shock, fire, injury, radiation, and explosions.

- ☆ **IEC（International Electrotechnical Commission）⇒International standards**
- ☆ **UL(Underwriters Laboratories : Established by U.S. private enterprises)**
- ☆ **EN（European Norm : European standards)**
- ☆ **BS（British　Standards)**
- ☆ **Electrical Appliance and Material Safety Law　(Japanese Law)**
- ☆ **CCC（China Compulsory Certification : Chinese law)**
- ☆ **GB（Guó biāo :Chinese standards)**

Standards are defined for each product category (e.g., information processing equipment, lighting equipment, etc.), but there are also standards for test methods and concepts. Recently, international harmonization has been progressing and the content of IEC is being unified.

There are laws and standards for each country, and only some of them have been extracted. If the laws are not followed, penalties will be imposed.

3. Safety standards and laws

Standards and legal conditions

Internationally, the IEC is the top-level standard in the electrical field for harmonization of standards existing in different countries and regions.

☆ **International standards**
☆ **IEC Standard （International Electrotechnical Commission)**

It is a standardization organization established in 1908 that specializes in the field of electricity.
It is a non-governmental organization dedicated to the creation and dissemination of standards and specifications in the field of electrical and electronic technology.

There are two types of international standards: IEC standards for electrical fields and ISO standards (International Organization for Standardization) for non-electrical fields.

3. Safety standards and laws

Standards and legal conditions in Japan

☆ **Electrical products safety law and JIS standard**

Electrical Products and Material Safety Act

This is a law concerning electrical products and materials in Japan, which aims to (1) regulate the manufacture, import, and sale of electrical appliances and materials, (2) promote the voluntary activities of businesses to ensure safety and prevent danger and damage, and (3) deregulate (transfer the authority of the government to the private sector).

Electrical products and materials that are widely used in are designated as "specified electrical products and materials" and "electrical products and materials other than specified electrical products and materials.”

JIS Standard（Japanese Industrial Standards）

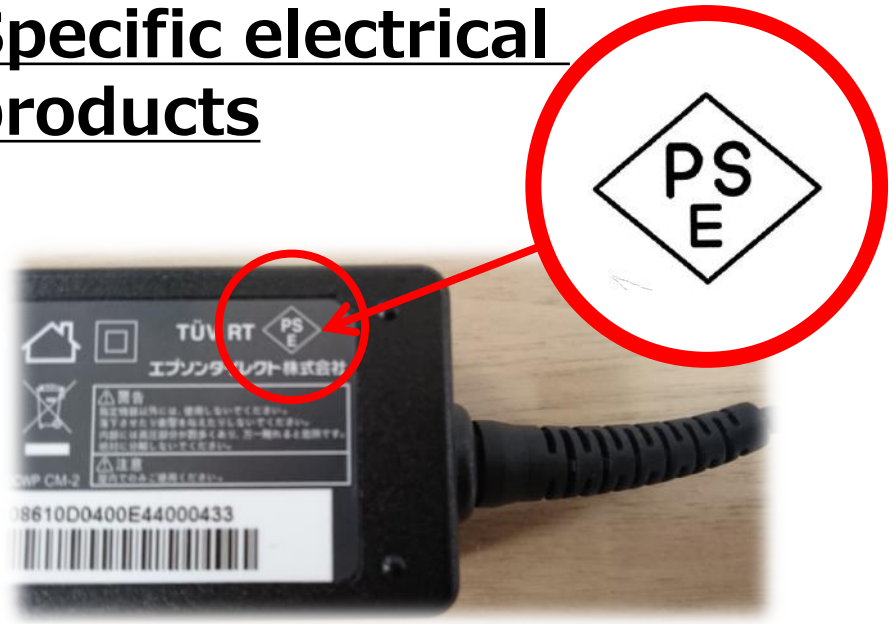
A national standard based on the Industrial Standardization Law and published by the Japanese Standards Association.

3. Safety standards and laws

Status of standards and laws • PSE mark

When selling electrical products and materials outside of the specifications designated by the Electrical Products and Material Safety Law in Japan, it is necessary to obtain and post the PSE mark.

Specific electrical products



Laptop PC AC Adapter

Products outside designated specifications

LCD TV

3. Safety standards and laws

Standards and legal conditions in Europe

☆ **CE marking directive, EN standard**

CE Marking

The CE Marking is a safety mark that must be affixed to designated products sold in the EU (European Union) region, indicating that the product meets the essential requirements of the EC Directive (European Communities Directive: a law enacted in Europe).

EN Standard（European Norm）

The EN standard is established based on the IEC standard, which is a unified standard for the EU region of European countries and is ranked higher than any other regulation or standard in European countries.

3. Safety standards and laws

Standards and laws in North America

-UL and CSA

UL Standards（Underwriters Laboratories）

UL is a non-profit testing organization established in 1894 by the Fire Insurers Association of the United States to conduct certification testing of all electrical products.　Standards issued and certified by the UL.。

CSA Standards（Canadian Standards Association）

CSA is a non-profit organization established in Canada in 1919. Canadian provincial laws require that equipment connected to a commercial power source comply with CSA standards.

3. Safety standards and laws

Standards and laws China

-CCC and GB standards

CCC（China Compulsory Certification）

It was launched in August 2002 on the back of China's accession to the WTO. This is a compulsory certification system for product safety.

GB Standards

It is a national standard that serves as the CCC certification system and technical standard. With its accession to the WTO, it is being harmonized with IEC standards.

3. Safety standards and laws

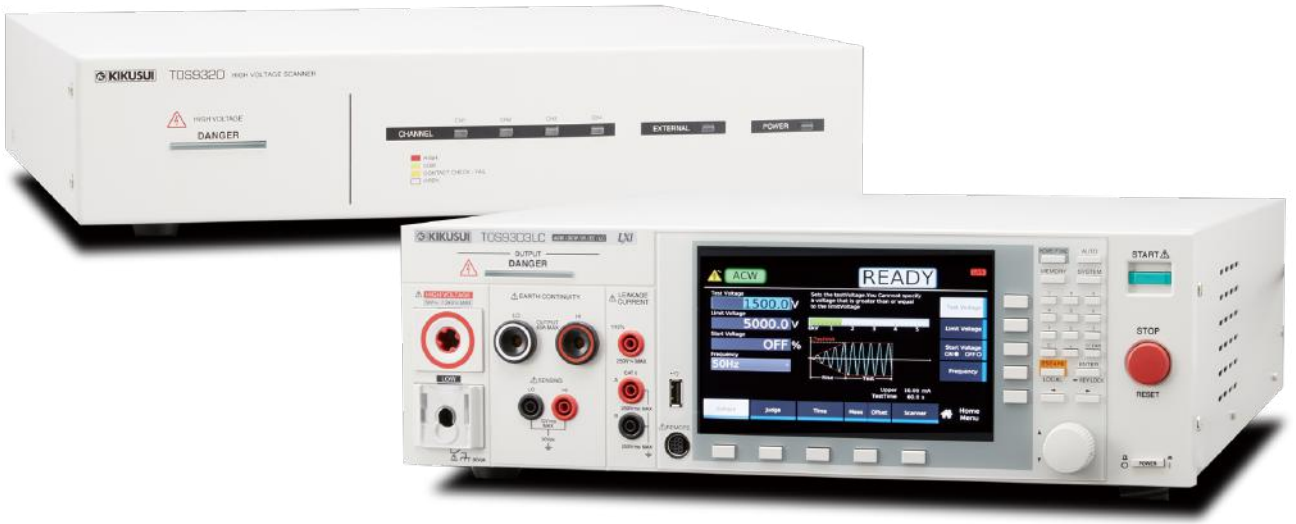
Major safety standard numbers

IEC standards are divided into basic standards describing fundamental principles and concepts, and product standards for each product group. JIS standard numbers, which are consistent with IEC standard numbers, are also listed below.

Type	Standard name	IEC standard number	JIS Standard Number
Basic standards	Insulation coordination of equipment in low-voltage systems	IEC 60664-1	JIS C 0664
	Measurement of contact current and protective conductor current	IEC 60990	
	High Voltage Testing Techniques - Partial Discharge Rules	IEC 60270	
	Method for testing insulation strength of solid electrical insulating materials	IEC 60243	JIS C 2110
Product Standards	Safety requirements for electrical equipment used in measurement, control and laboratories	IEC 61010-1	JIS C 1010-1
	Electrical equipment for household and similar uses - Safety - Part 1: General requirements	IEC 60335-1	JIS C 9335-1
	Audio, Video, Information and Communication Technology Equipment - Part 1: Safety Requirements	IEC 62368-1	JIS C 62368-1
	Medical Electrical Equipment - Part 1: General Requirements for Basic Safety and Basic Performance	IEC 60601-1	JIS T 0601-1
	Machine safety - Electrical equipment for machinery - Part 1: General requirements	IEC 60204-1	JIS B 9960-1
	Luminaires — Part 1: General safety requirements	IEC 60598-1	JIS C 8105-1

4. Tests to verify electrical safety

One of the definitions of hazardous elements in international standards is "electric shock and fire". We manufacture and sell testing equipment that verifies the following four tests to confirm the safety of electrical products.



- ☆ **Withstand voltage test**
- ☆ **Insulation resistance test**
- ☆ **Earth continuity test**
- ☆ **Leakage current test**
- ☆ **Partial discharge test**

The basic principles and concepts will be explained in the next section.

4. Tests to verify electrical safety

What is a withstand voltage test?

The withstand voltage test or hipot test, is a test to evaluate whether the electrically insulating parts of electrical products and components have "sufficient dielectric strength" against the voltage handled.

Withstand voltage tester TOS5200

Withstand voltage/insulation resistance tester TOS9301

4. Tests to verify electrical safety

Withstand voltage test method and judgment

What is the testing method?

Higher-than-normal voltage is applied to the insulating part for a specified period, and the part is tested to see if dielectric breakdown occurs during that time.

What is the method of judgement?

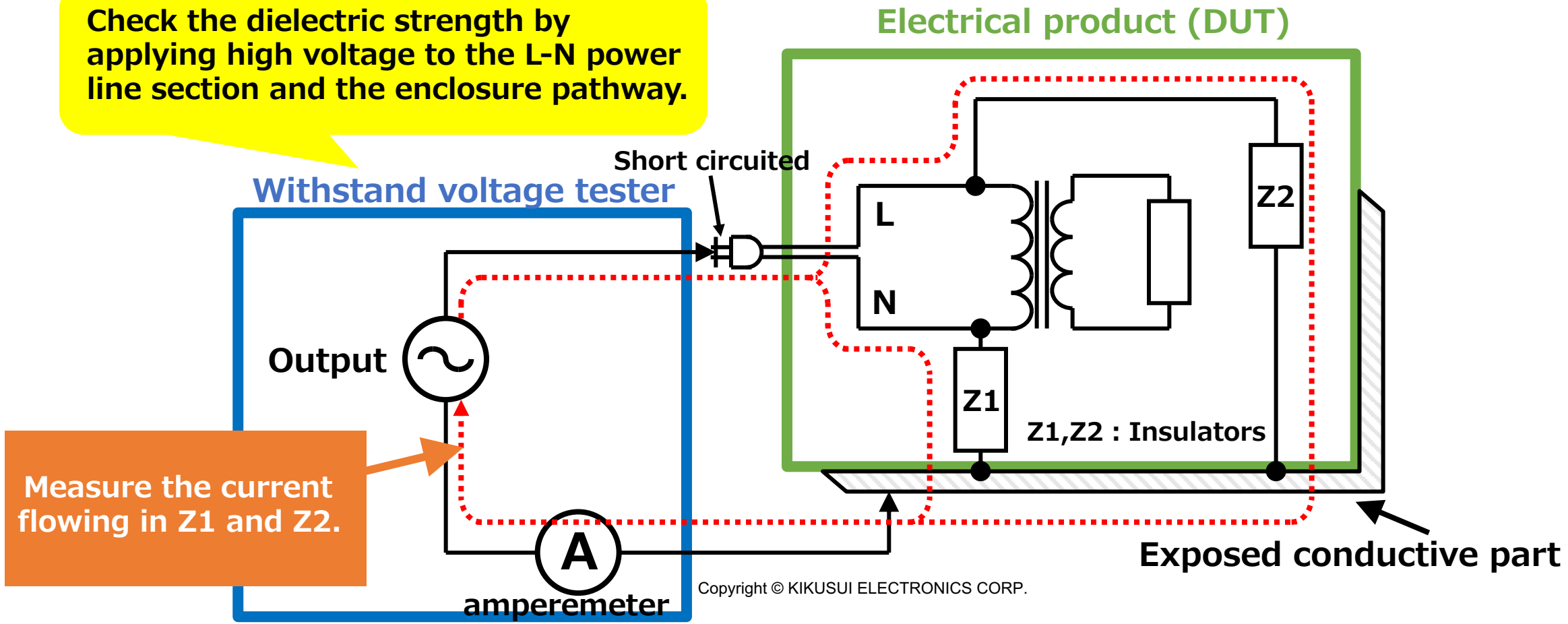
During the test period, if the current flowing through the insulation exceeds the specified limit, it is considered “broken down". If there is no "insulation destruction", the insulator is determined to have sufficient insulation resistance.

4. Tests to verify electrical safety

Withstand voltage test principal diagram

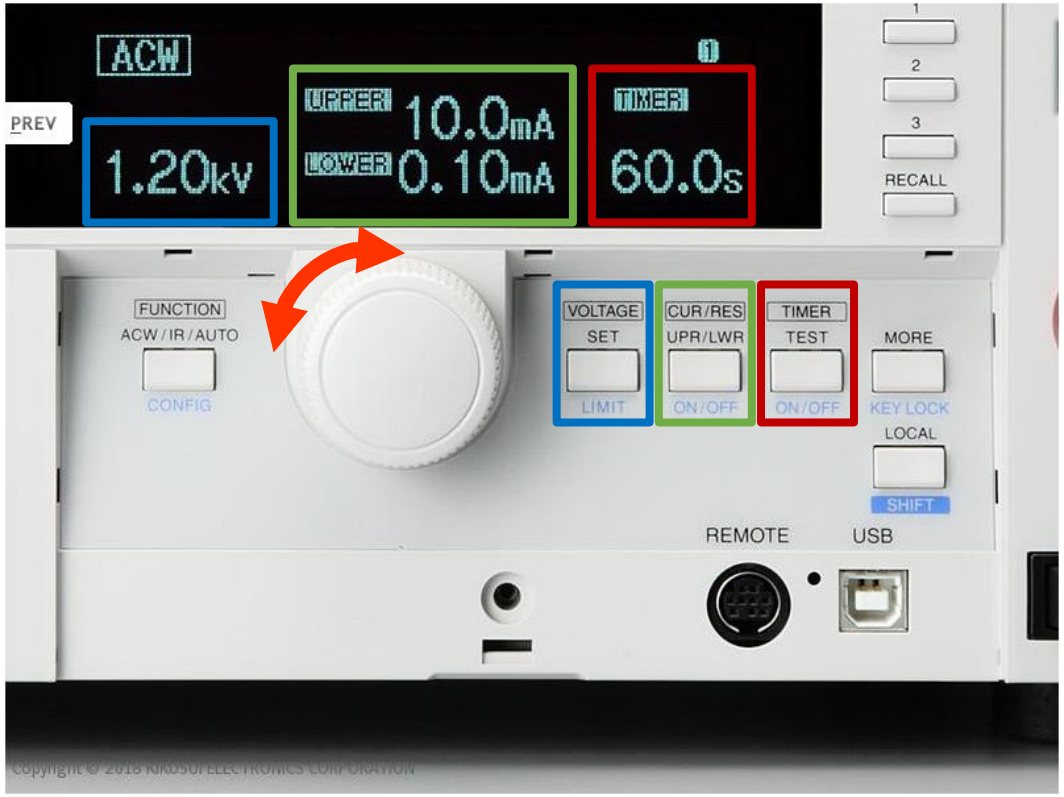
Example: Testing between primary circuits and contactable enclosures in Class I equipment

Check the dielectric strength by applying high voltage to the L-N power line section and the enclosure pathway.



4. Tests to verify electrical safety

Withstand voltage test: Basic settings for test conditions



Setting the output voltage → **【VOLTAGE】 Output Voltage**

Setting the output voltage → **【UPR/LWR】 Judgment value**

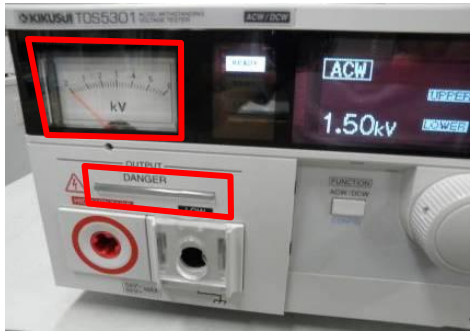
Setting the output voltage → **【TIMER】 Test time**

Select the item you want to set and turn the rotary knob to set the respective value.

4. Tests to verify electrical safety

Withstand voltage test Connect to the DUT

Safety check



If you have an analog voltmeter, check that it is 0V and that the DANGER light is not on.

If the HIGH side (red) test lead is connected, unplug it.

LOW side (black) Connection

Firmly connect the test lead (black) to the LOW terminal of the instrument and connect the other end to the enclosure (metal part) of the DUT.

Turn on the DUT's power switch (don't forget!).

HIGH side (red) Connection

Connect the HIGH side (red) test lead to the AC plug. In this example, a jig that shorts L and N is used.

Tester Connection

Finally, connect the HIGH side (red) test lead to the output of the test equipment.

The HIGH side is the high-voltage part, so connecting it last will reduce the risk of electric shock.

4. Tests to verify electrical safety

Conducting a withstand voltage test

Confirm the test conditions and connection to the DUT before starting the test.

Never touch the item under test or the test leads during the test.
If an abnormality or accident (fire, smoke, or electric shock) occurs during the test, immediately press the STOP switch or shut off the power to the test equipment.

PASS

If the current does not exceed the upper reference value during the test period, PASS is indicated by the PASS display and buzzer sound.

Pass operation can be set in several stages. You can also hold pass operation by setting.

FAIL

During the test period, if the current exceeds the upper limit standard value, FAIL will occur.

FAIL operation will continue until the STOP switch is pressed.

4. Tests to verify electrical safety

Withstand voltage test: example of determining test conditions

Test voltage

Determined by assumed surge voltage

Overvoltage category

2U+1000V
U : Voltage

Decided by expert committees in each field

Test time

60 seconds if not specified IEC60060-1 routine test can be shortened

Electrical Products and Material Safety Act

Decided by expert committees in each field

Limit value

No limit value specified except for some standards

Testers are selected

4. Tests to verify electrical safety

Withstand voltage test: AC and DC

AC test

Basically, the test between the primary circuit and the contactable part is done by applying AC voltage.

But...

Can't be tested properly?

When there is a filter for removing electromagnetic interference at the point corresponding to Z1 and Z2, and its capacitance component is large, it is difficult to distinguish it from the current that is considered to be insulation breakdown.

DC test

It is recommended to test with DC voltage equal to the peak value of the specified AC voltage.

4. Tests to verify electrical safety

What is an insulation resistance test?

The insulation resistance test measures the resistance of insulators and confirms whether the insulation performance is sufficient. It is the same as the withstand voltage test in that it performs a necessary test condition aimed at preventing electric shock and fire accidents and confirms the function and performance of the insulator.

Insulation resistance tester TOS7200

Voltage/insulation resistance tester TOS9301

4. Tests to verify electrical safety

Insulation resistance test method and judgment

What is the testing method?

In many cases, after moisture absorption treatment (not is all cases), a specified DC voltage such as 500V is applied, and the resistance is measured from the current flowing.

What is the method of judgement?

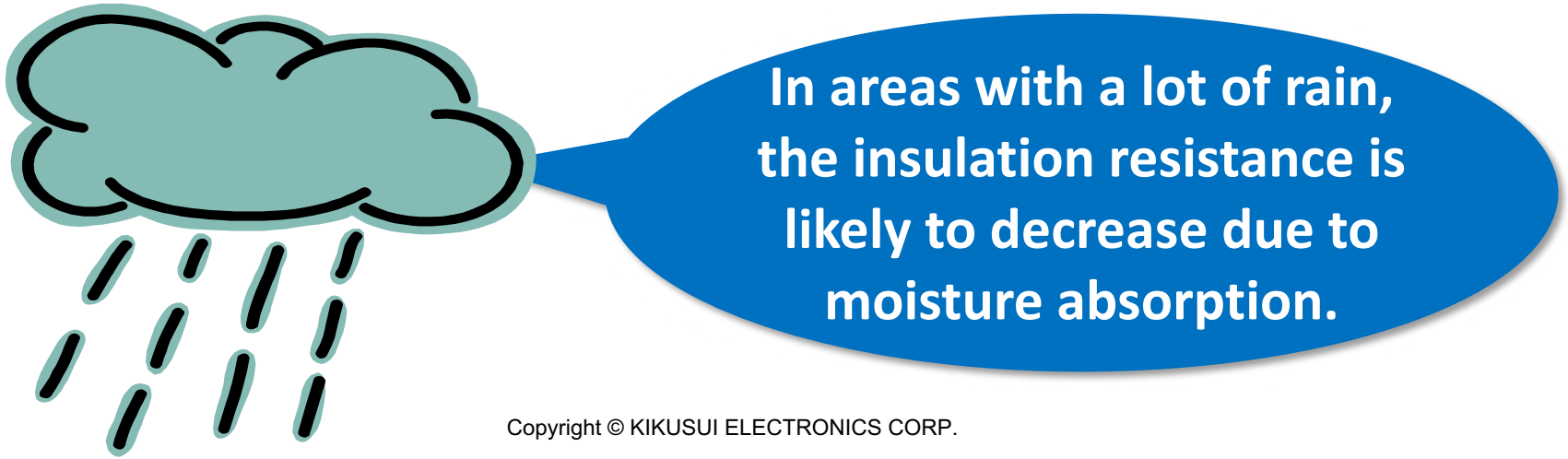
As a result of the measurement, if the insulation resistance value is sufficiently high, the product meets the requirements for preventing electric shock and fire accidents. According to the Japanese Electrical Product and Material Safety Law, "Ministerial Ordinance on the Technical Standards for Electrical Products and Materials, Appendix 8, Table 3, Insulation Performance Test, basic insulation is 1 MΩ, additional insulation is 2 MΩ, and reinforced insulation is 3 MΩ."

4. Tests to verify electrical safety

Insulation resistance test: why do we perform them?

Performance degradation barometer

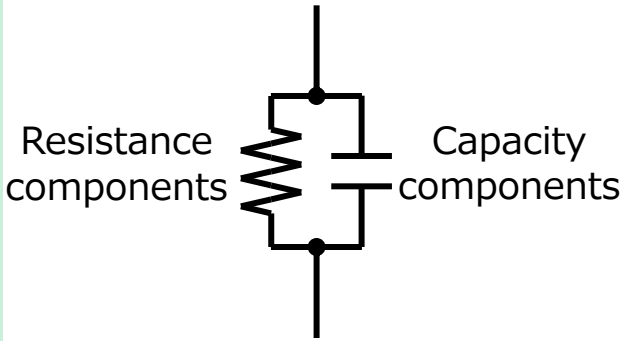
Degradation of insulation performance can be caused by moisture absorption, overheating, deterioration due to ultraviolet rays, and chemical effects. Of these, moisture absorption in particular is a major factor in degradation of insulation performance. Measurement of insulation resistance is effective in confirming insulation performance and has advantages such as non-destructive confirmation of insulation performance, unlike withstand voltage testing.



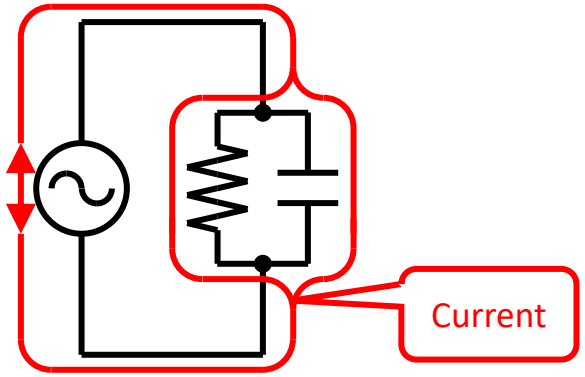
4. Tests to verify electrical safety

Insulation resistance testing: why test with direct current?

Simple equivalent circuits of insulators

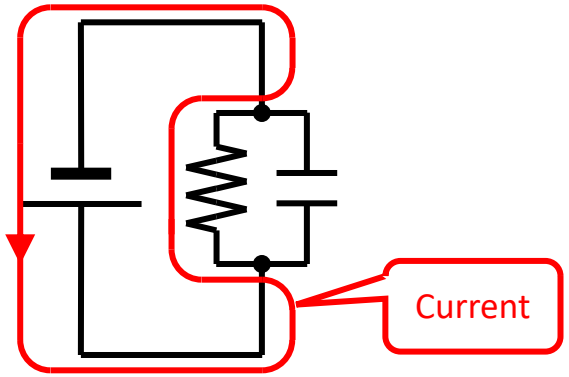


AC



If the insulation test is performed with AC voltage, the impedance of the capacitance component is also measured, and the required insulation resistance value cannot be obtained.

DC

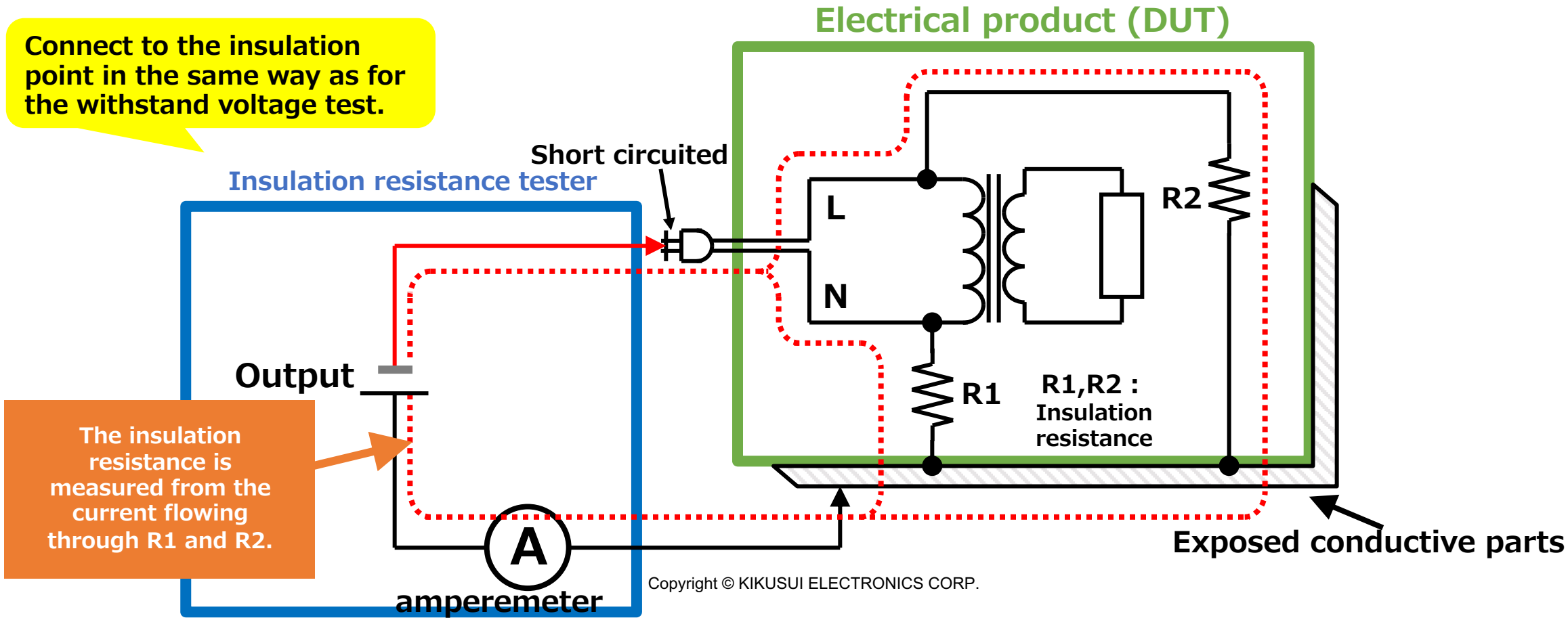


If measured with DC voltage, no current flows through the capacitance component, and only the insulation resistance can be measured.

4. Tests to verify electrical safety

Insulation resistance test principal diagram

Typical example: Testing between primary circuit and contactable enclosure in Class I equipment



4. Tests to verify electrical safety

Insulation resistance test: is the test voltage negative?

The insulation resistance test is performed with a negative test (output) voltage in consideration of the following, traditional technical documents.

Some excerpts are shown below.

The reason for this is that the measurement (resistance) is usually smaller when the negative pole of the power supply is connected to the straight core wire and the positive pole to the ground, and this provision is more appropriate for detecting insulation defects.

4. Tests to verify electrical safety

What is an earth continuity test?

Tests the integrity of the protective connection of equipment designed to ensure safety through protective grounding to earth (e.g. Class I equipment). It is sometimes referred to as the ground bond test.

Earth continuity tester
TOS6210

Withstand voltage / Insulation resistance / Earth continuity tester
TOS9303

4. Tests to verify electrical safety

Earth continuity test: method and judgment

What is the testing method?

Usually, a current of 10A to 60A AC is applied for 60 seconds to several minutes, and the voltage is measured to determine the resistance. The test current may be determined to be 1.5 or 2 times the rating of the power distribution system.

What is the method of judgement?

Many standards use a resistance value of 0.1Ω or less to determine the resistance (some standards specify it in terms of voltage drop), and the open circuit voltage (no-load voltage) is generally limited to 6V or less or 12V or less.

If the continuity of the protective connection is confirmed, it can be judged that it has the necessary conditions to prevent electric shock even if the insulation between the primary circuit and the conductive part that can be contacted fails and a fault current flows through the distribution system.

4. Tests to verify electrical safety

Earth continuity test principal diagram

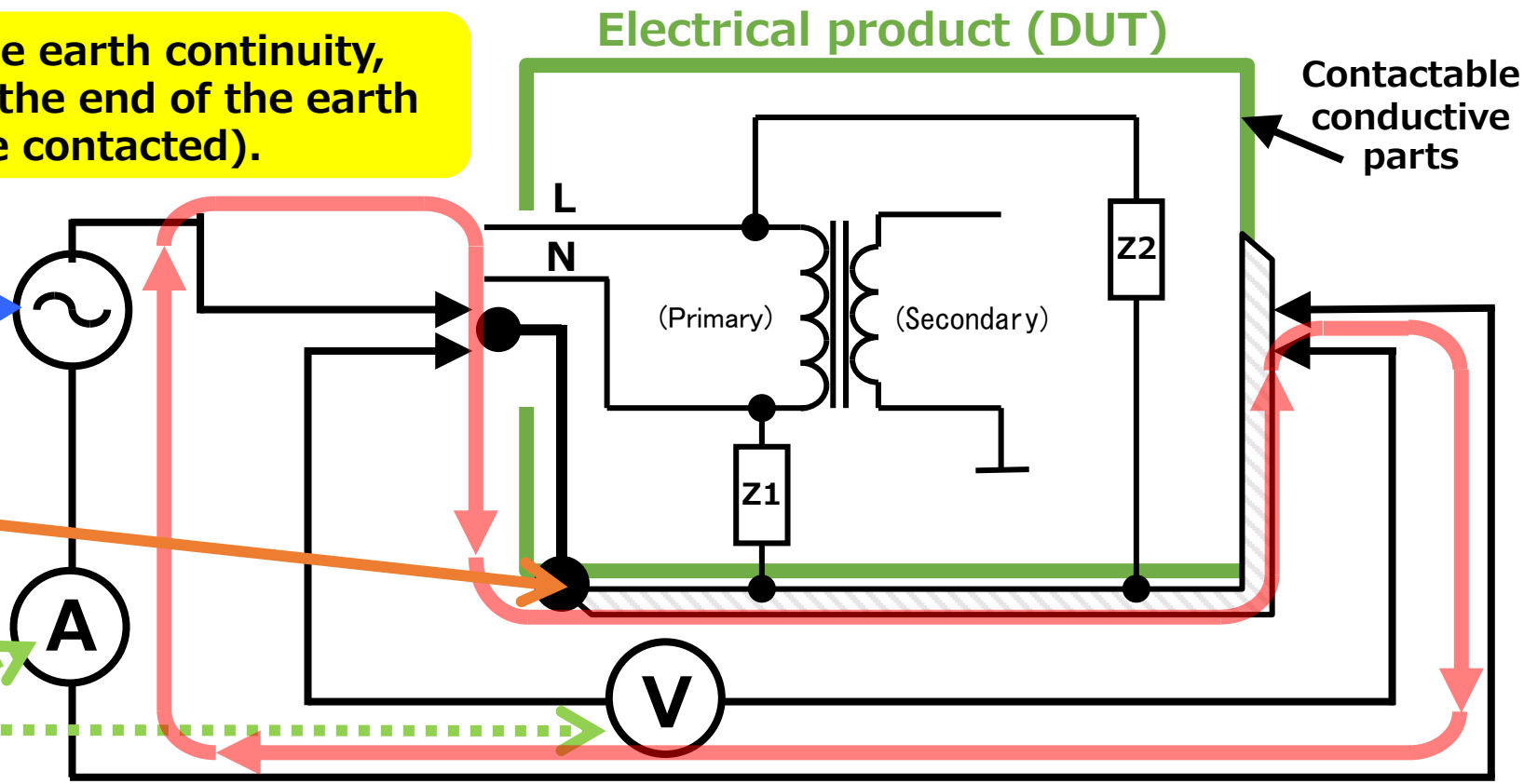
Example: Testing between primary circuits and contactable enclosures in Class I equipment

Since this test is to check the earth continuity, connect the ground (PE) to the end of the earth (conductive part that can be contacted).

Earth continuity tester output AC 50Hz/60Hz 10A to 60A

Protective Earth (PE)
It is important to be connected with a low impedance. If this impedance is high, there is a risk of electric shock.

Calculate the resistance value from the voltage between the measurement terminals and the output current value



4. Tests to verify electrical safety

What is a leakage current test?

International standard IEC60990"Method for measuring touch current and protective conductor current" does not use the word "leakage current.“

-Touch Current

-The Protective Conductor Current

In addition, the international standard IEC60601 defines "leakage current" for medical electrical equipment as **patient leakage current.**

Patient Leakage current tester
TOS3200

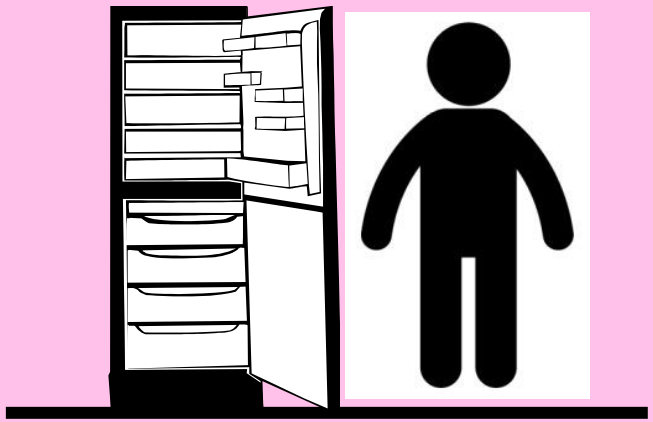
Withstanding voltage/Insulation resistance/
Earth continuity/Patient leakage current tester
TOS9303

4. Tests to verify electrical safety

Leakage current test: touch current and protective conductor current

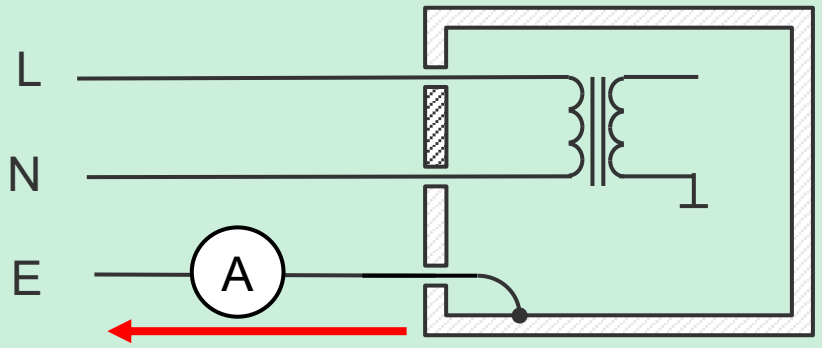
What is touch current?

Touch current refers to the current that flows through the body when it comes into contact with a device.



What is the protective conductor current?

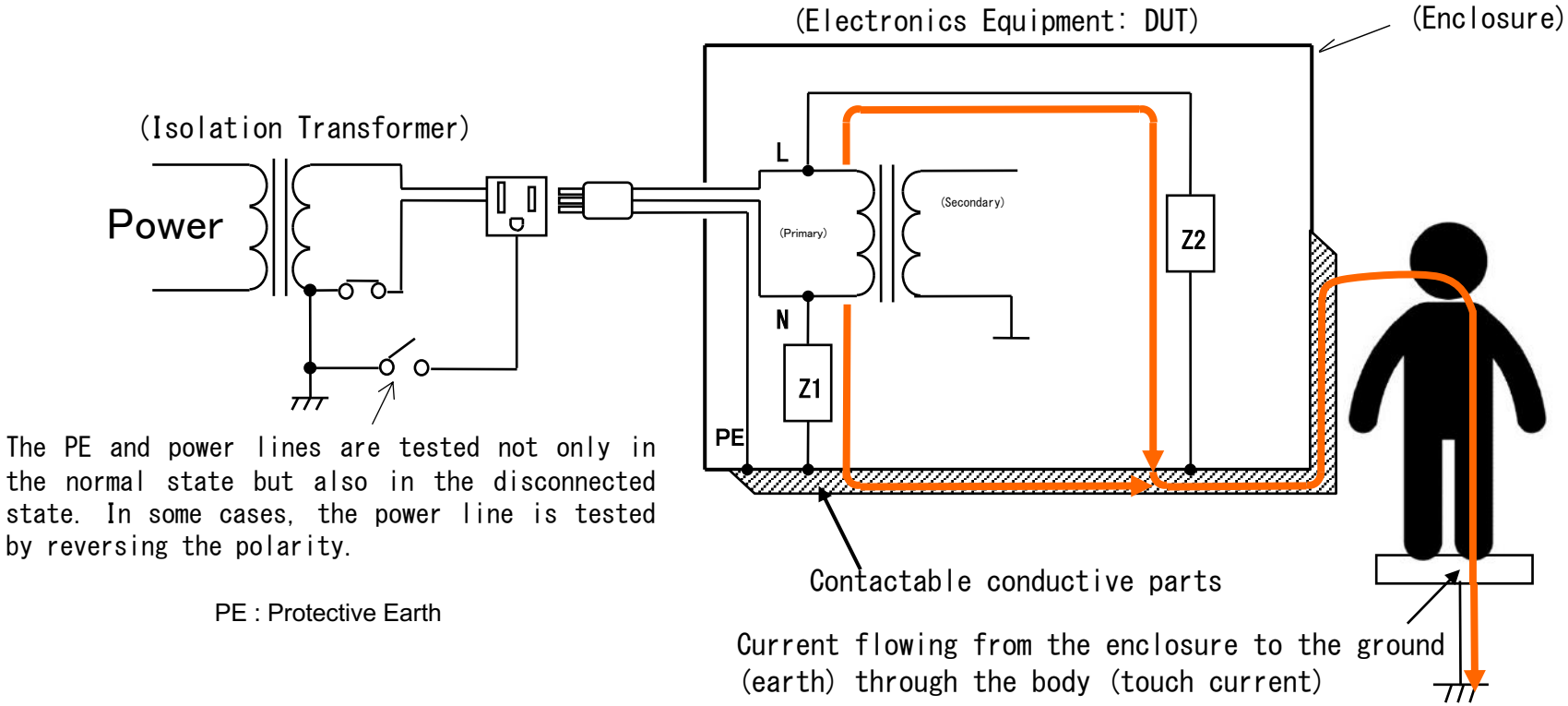
This refers to the current flowing in the protective conductor of normally protected connected equipment.



4. Tests to verify electrical safety

Leakage current test: measuring touch current

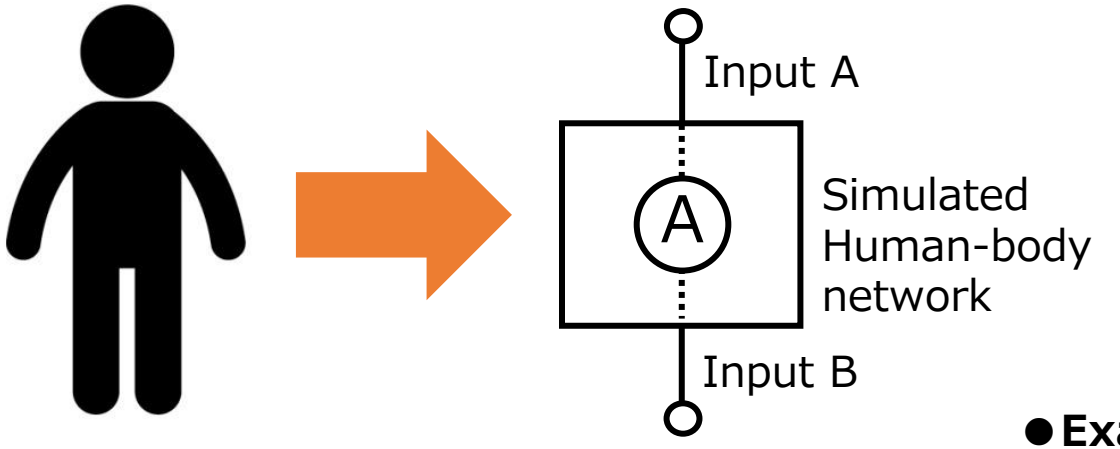
Class I equipment: Testing between enclosure (housing) and grounding



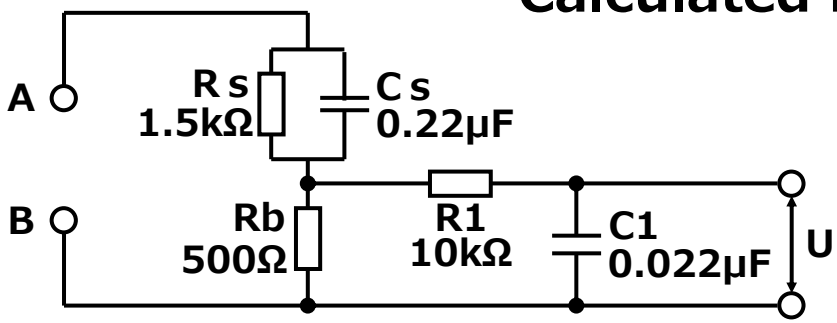
4. Tests to verify electrical safety

Leakage current test: measuring touch current

Touch current testing uses a defined network to simulate human-body resistance and measure the current flow. Touch currents may be measured not only between the enclosure (chassis) and ground, but also between the enclosure and the power line, and between points on the enclosure itself. (The circuit configuration of the simulated human body network differs depending on the standards of each country.



Touch current
Calculated by I = U/ 500

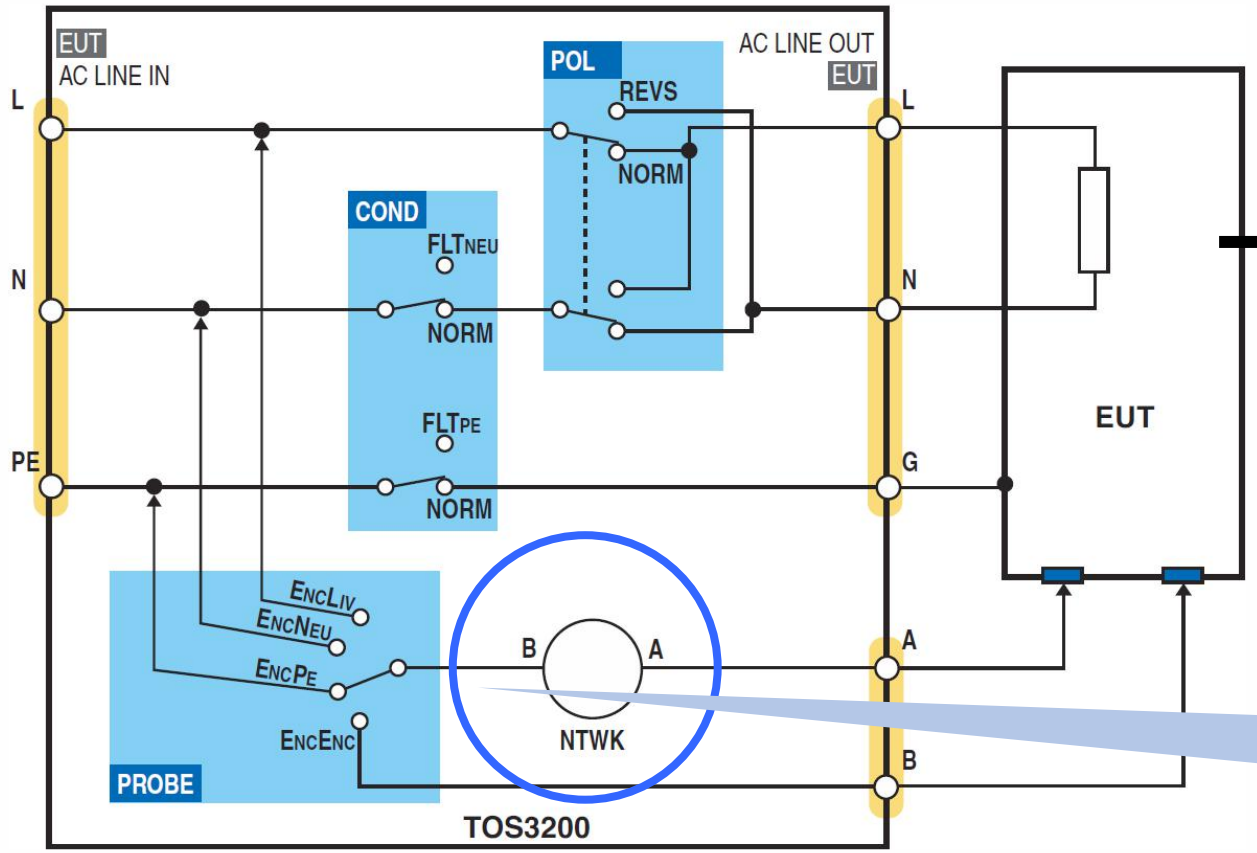


Measures the voltage U during this time

● **Example of a simulated human body network**

4. Tests to verify electrical safety

Leakage current test: block diagram of touch current

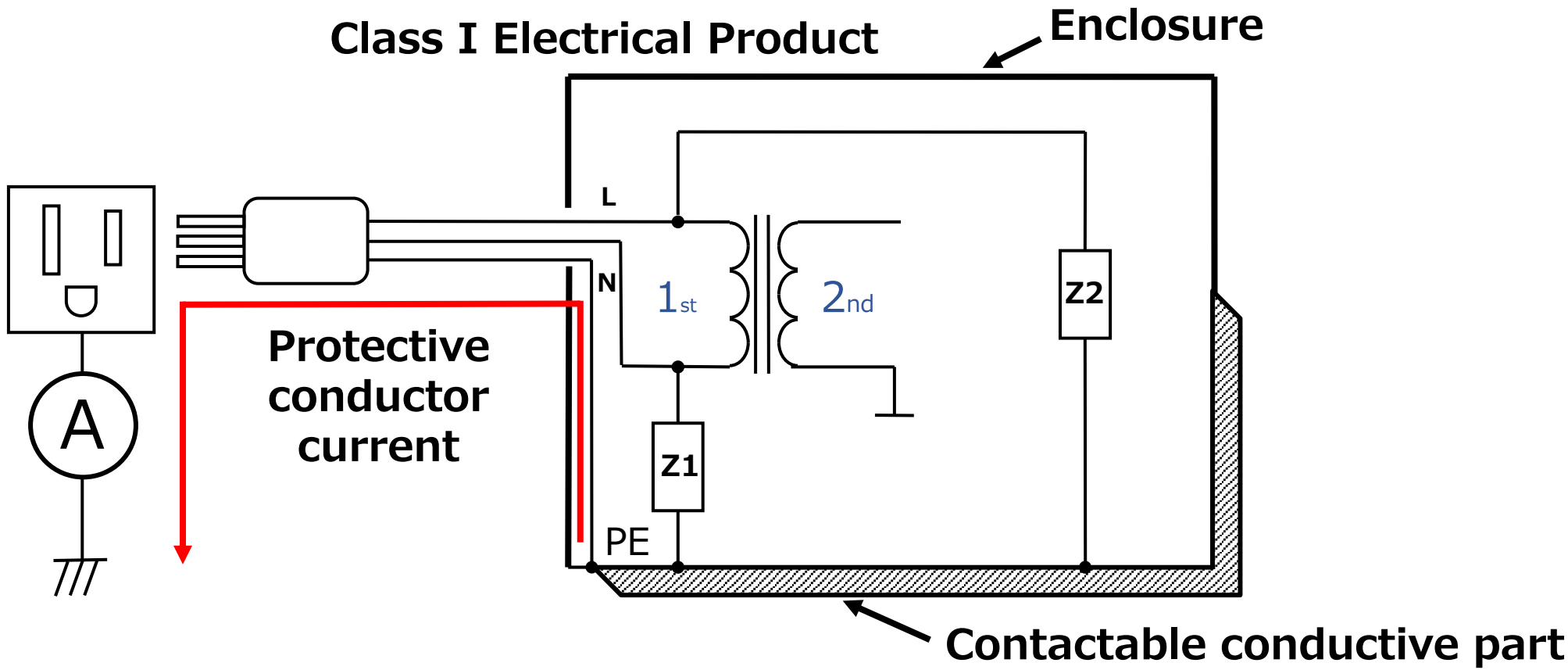


Leakage current testers themselves measure current, not voltage sources as in voltage/insulation resistance tests. It is connected between the external commercial voltage and the EUT for measurement and can be set to switch the power supply polarity (POL), simulate a single fault condition (COND), and select the connection point of the simulated human network (PROBE).

Measures the network voltage and calculate the current.

4. Tests to verify electrical safety

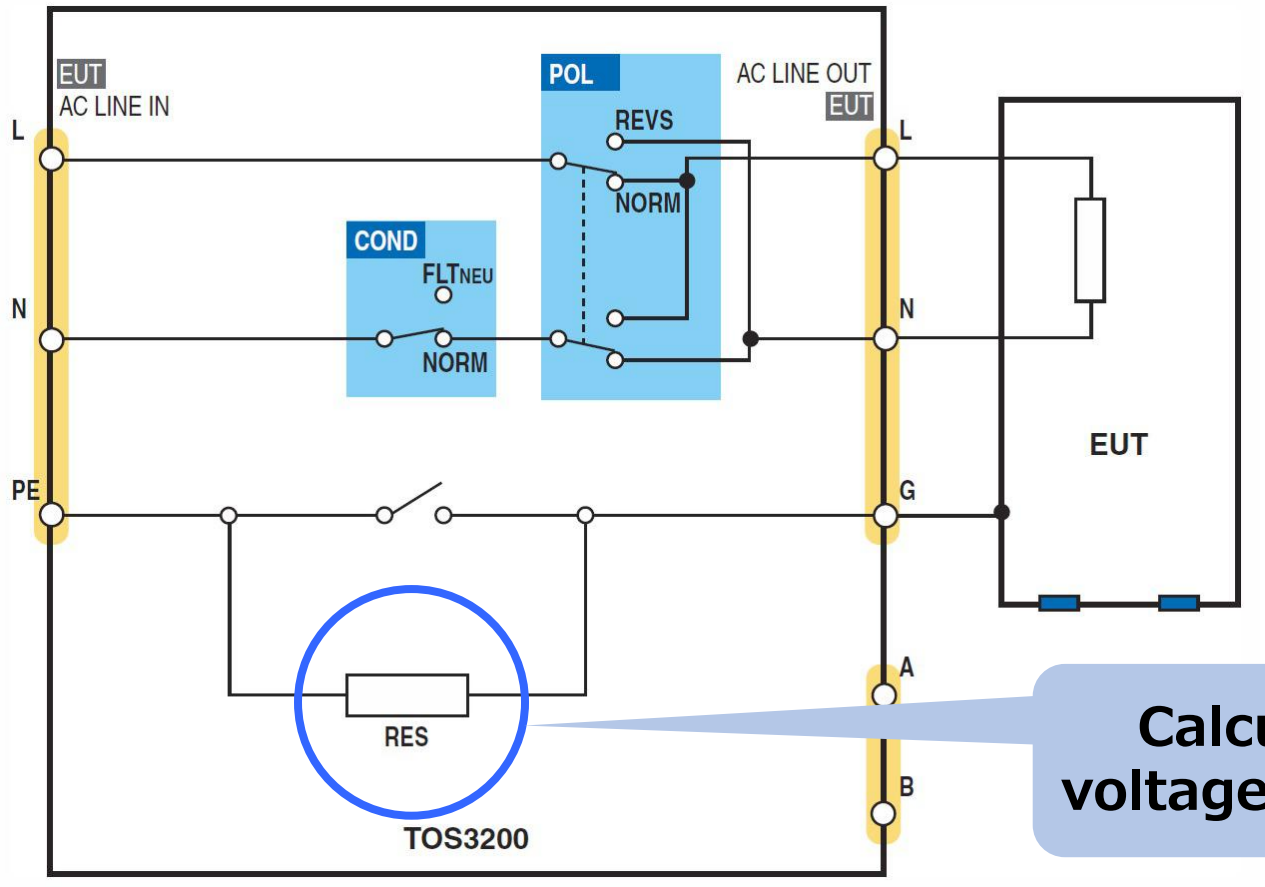
Leakage current test: measurement of protective conductor current



*Measures the current flowing through the protective conductor while the DUT is powered and operating normally.

4. Tests to verify electrical safety

Leakage current test: block diagram of protective conductor current



As in the touch current test, the current flowing in the protective conductor is measured by connecting it between the external commercial voltage and the DUT. It can be set to switch the power supply polarity (POL) or simulate a single fault condition (COND).

Calculates the current by measuring the voltage at both ends of the detection resistor.

4. Tests to verify electrical safety

Leakage current test: condition of judgment

- How is it judged?

If the touch current is measured and does not exceed a dangerous current value for the human body specified in the safety standard, it means that the device has the necessary conditions to prevent electric shock.

The measurement of the protective conductor current also serves the purpose of confirming the suitability of the equipment for the power distribution system.

4. Tests to verify electrical safety

Test format

Type Test

A test to verify design conformance to a standard, usually performed on multiple representative samples.

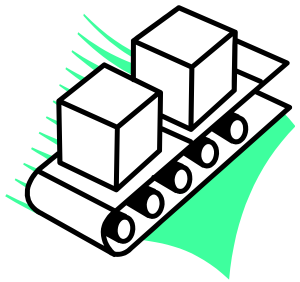
Various tests are conducted in accordance with safety standards.

sequential sampling inspection (with reposition)

Some of the safety standards will be tested for all products produced.

Routine Test

This test is conducted on all products to confirm that the conformance to the standard verified by the type test is maintained during product production.



Full inspection

4. Tests to verify electrical safety

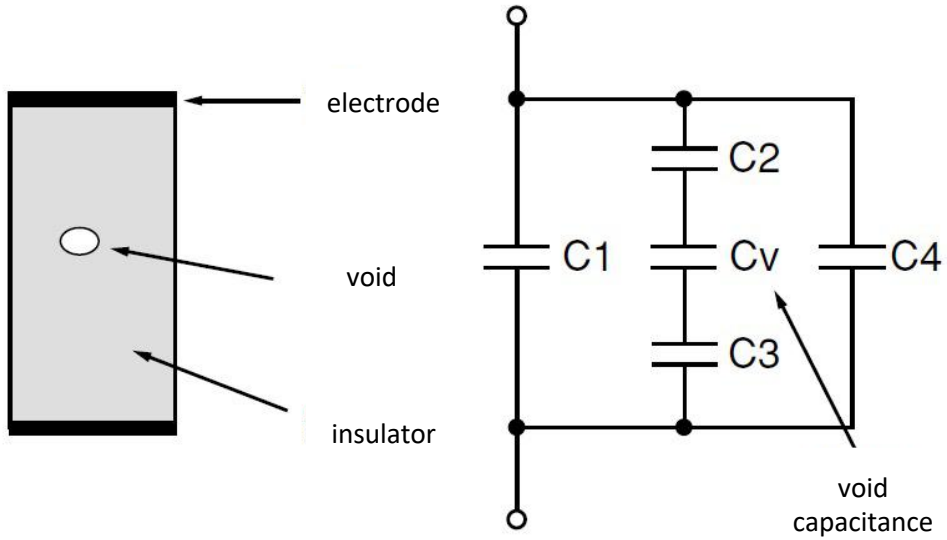
What is a partial discharge test?

It’s a discharge phenomenon that causes partial dielectric breakdown of a part of an insulating material.
It is an airborne discharge that occurs mainly in voids (gaps, voids, gaps, bubbles, etc.) in insulators.
Corona discharge is also a type of partial discharge.

Withstand voltage/ insulation resistance/ partial discharge
TOS9301PD

4. Tests to verify electrical safety

Principles of Partial Discharge Testing



Normally, voids are made of air or other gases, and their size is very small, so the capacitance of voids is also small.

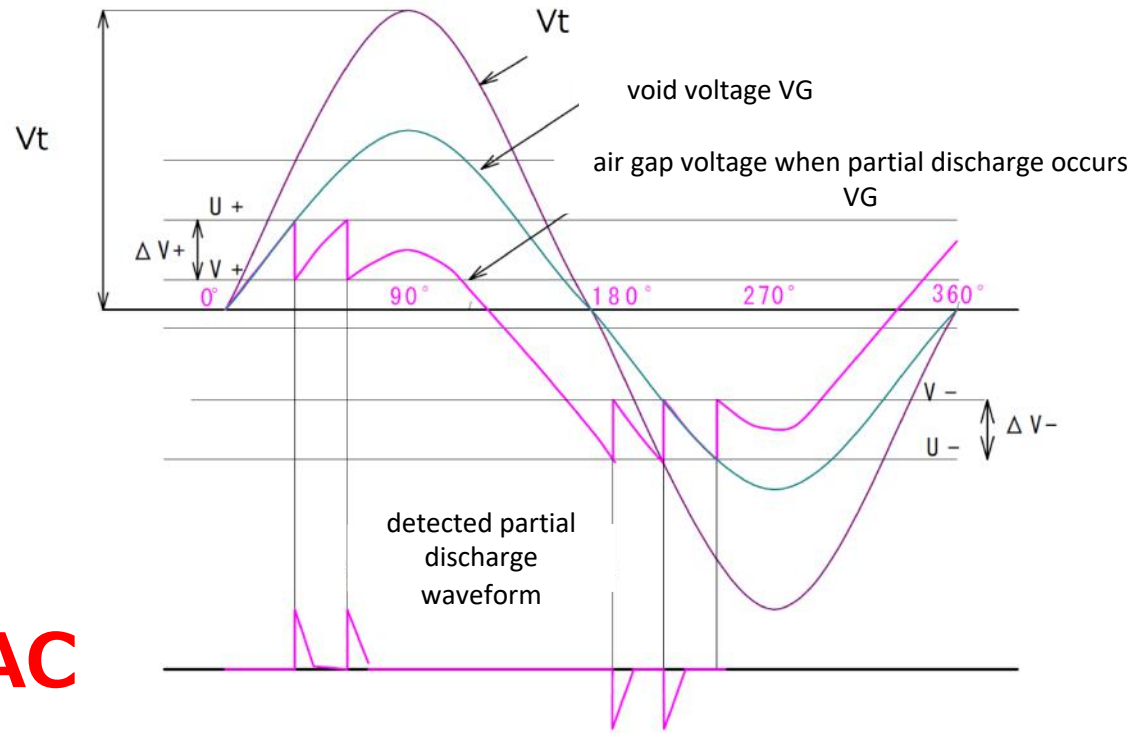
When a voltage is applied between the electrodes, a large voltage is applied to the part of the void with small capacitance.

In other words, when a high voltage is applied to a small void, it exceeds the breakdown electrolysis of the air and discharges, a phenomenon called partial discharge.

4. Tests to verify electrical safety

Will partial discharge continue?

Once discharged, the voids will be shorted, and the discharge will stop immediately.
Therefore, the behavior varies greatly depending on whether the test voltage is DC or AC.
With AC, the discharge voltage rises again as shown in the figure on the right, and then reaches the breakdown electric field and discharges again.
With DC, there is no change in the discharge voltage, so it usually does not recur.



For partial discharge
it's much easier to detect with AC

4. Tests to verify electrical safety

What is the difference between a partial discharge test and a withstand voltage test?

In the withstand voltage test, an AC high voltage is applied to the object under test. For voltage resistance testing, high AC voltage is applied to the object under test, and the leakage current that flows through the DUT is measured, and a judgment is made.

In short, "dielectric breakdown = increase in current," and the test object that fails the test is in many cases damaged and unrecoverable.

Additionally, if there is no breakdown (increase in current) in the withstand voltage test, the product is judged to be good even if there are voids, etc., which can cause insulation failure. 。

Partial discharge testing, on the other hand, captures the increase in charge before dielectric breakdown occurs, so in most cases the DUT will not be destroyed.

4. Tests to verify electrical safety

Relationship between partial discharge and dielectric breakdown

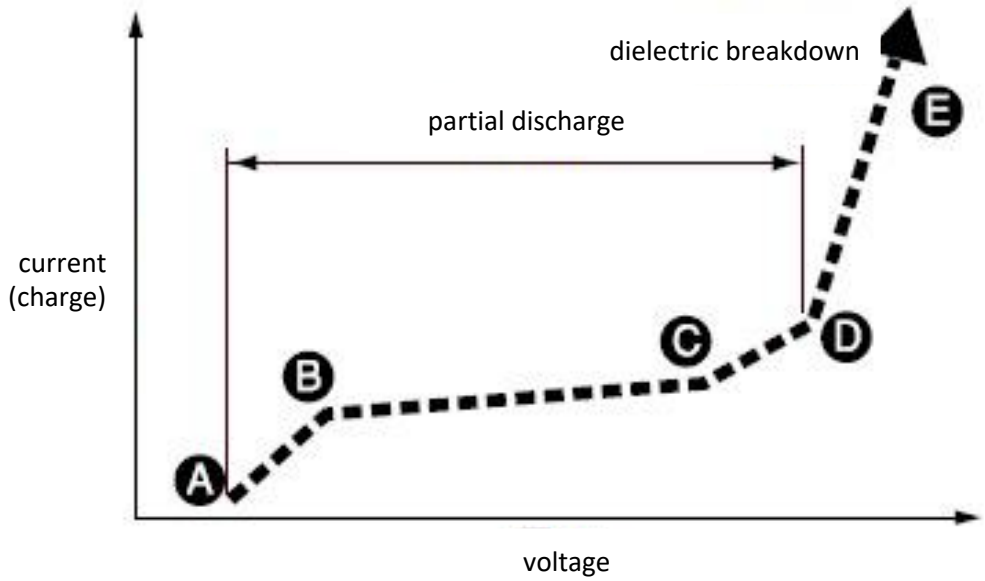
Partial discharge testing is an effective means of examining the insulation condition.

When the voltage applied to the object under test is gradually increased, (A) discharge begins.

Sparks are then generated, and the process shifts to arcing, leading to dielectric breakdown.

Between (B) and (C), partial discharge starts and then enters the stable region for a period of time, but a surge in partial discharge occurs from (C) to (D) leading to dielectric breakdown.

Partial discharge voltage conceptual diagram of current characteristics



4. Tests to verify electrical safety

Now... let's see some actual partial discharge!

5. Safe operation

Preparing for withstand voltage testing

Electric insulation gloves

Electric insulating boots

Insulated mat

Warning light unit (PL02-TOS, etc.) notifies people of danger

Connection jig
Made it accordance to the DUT with safety in mind

Guide poles, partitions

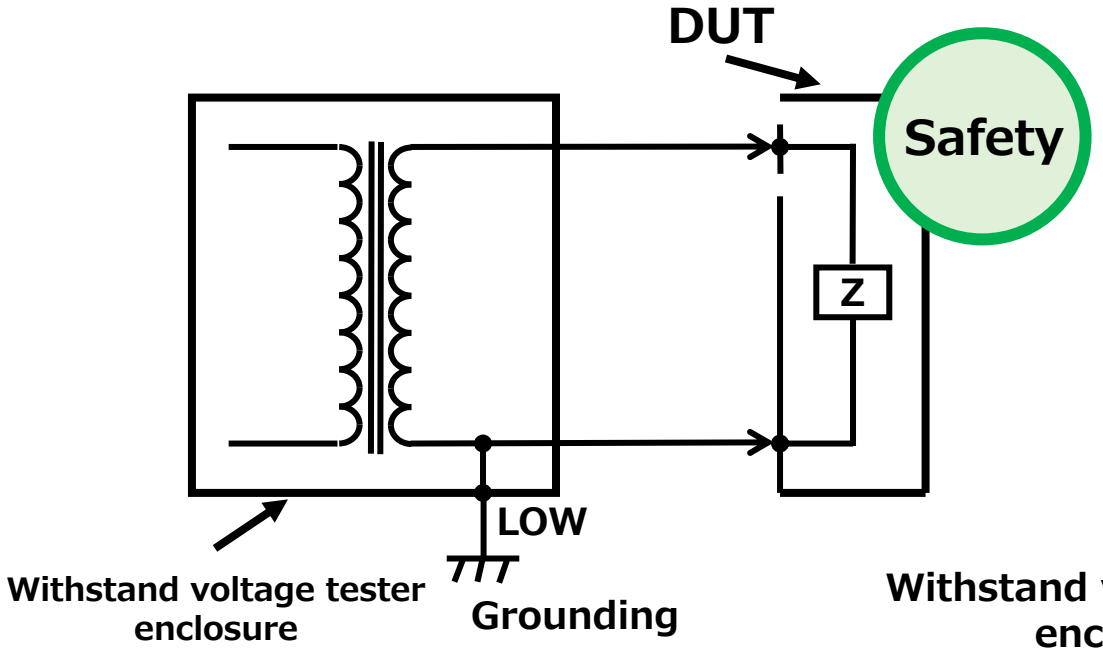
Create separation and display a high-voltage warning

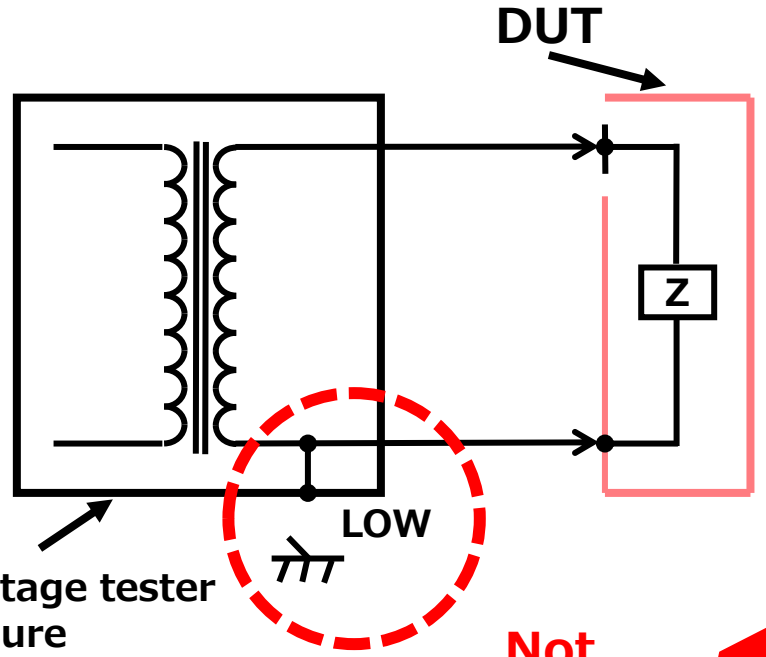
5. Safe operation

Connecting to the power source

Connect to a grounded three-pole power outlet.

※ Our withstand voltage testers are Class I instruments.





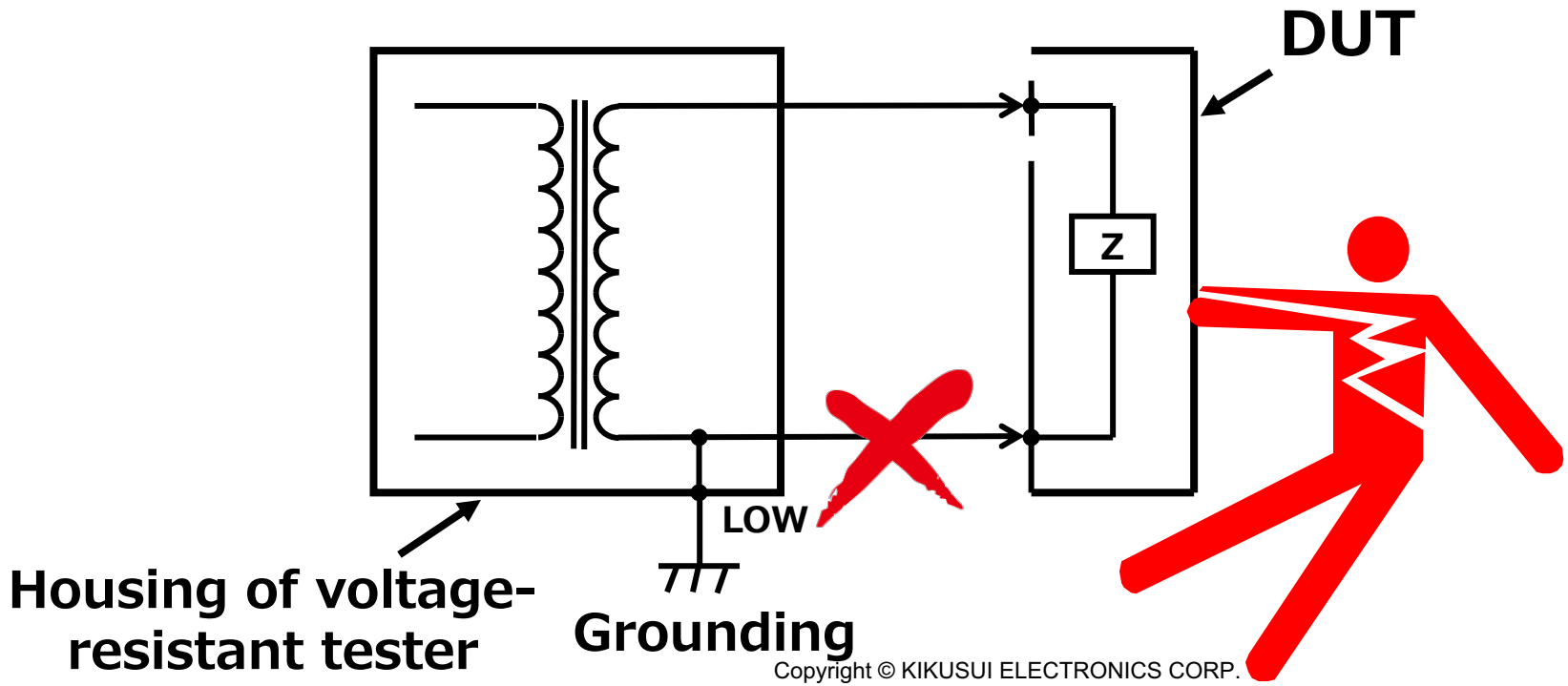
If a short circuit occurs due to a breakdown of the insulation of the DUT, the chassis of the withstand voltage tester will momentarily become flooded with high voltage, which is dangerous.

Not grounded

5. Safe operation

Connecting test leads on the LOW side

Make sure to connect the LOW-side test leads of the withstand voltage/insulation resistance tester as shown in the figure below. An incomplete connection of the LOW-side test leads is dangerous because the test DUT will be charged with high voltage.



5. Safe operation

Daily inspection (simple confirmation method)

▶Inspecting the test leads

Before inspecting the main unit, check the coating of the test leads for cracks. Never use test leads with cracks or damage, as they may cause electric shock.

▶ Confirmation of PASS/FAIL operation

With the HIGH side (red) cable unplugged, press the "START" switch to execute the test. The test voltage is displayed, and after the timer expires, the "PASS" display is confirmed. Next, connect the HIGH side (red) cable and short-circuit (connect) the test leads of the LOW side (black) cable, and execute the test. Check the FAIL judgment operation with "FAIL" indication and buzzer sound.

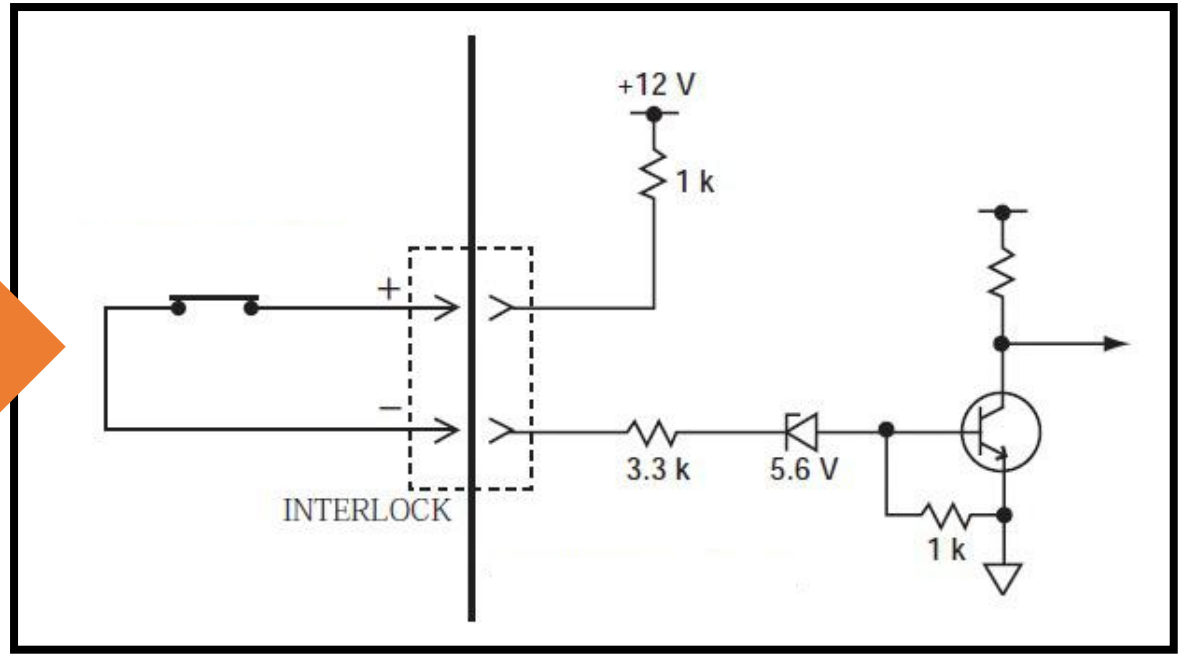
5. Safe operation

Utilizing the interlock function

▶ What is the interlock function?

This function is used to prevent accidental operation by interlocking with an external device just as a door switch does.

When the door is open, pressing the test START key will not start the test!

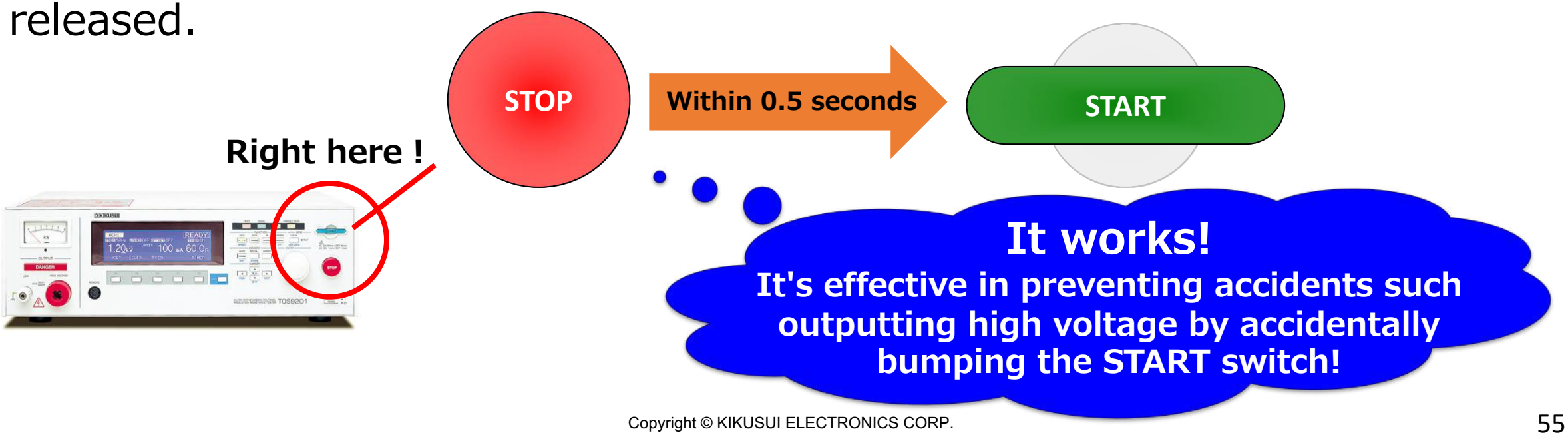


5. Safe operation

Utilizing the double-action function

▶What is the double-action function

This function prevents the test from starting unless the START switch is pressed within 0.5 seconds after the STOP switch is pressed and released.



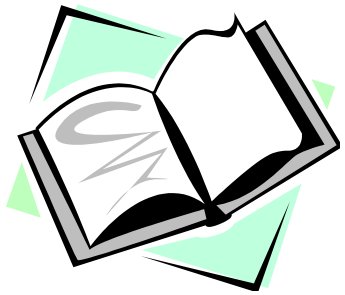
5. Safe operation

In summary

While the voltage tester is outputting voltage, observe the following in order to prevent electric shock.

1. **Do not touch the output terminals.**
2. **Do not touch the lead wires connected to the output terminal.**
3. **Do not touch the DUT.**
4. **Do not touch the above 3 parts immediately after shutting off the output.**

Be sure to read the instruction manual before use.



5. Safe operation

Withstand voltage test　FAQs

Q Is certification or special training required to conduct a withstand voltage test?

A No. It doesn't require certification as stipulated in the Industrial Safety Satellite Regulations. In the law on handling high-voltage and special high-voltage electricity, operating testers are designated as a classification of handling electric circuits connected to switchboards, etc., which are handled by electricians, so voltage withstand testing professionals are not a requirement.

However, it is necessary to provide education on the product including understanding existing dangers, work procedures that should be followed, and the types of necessary protection for ensuring safety.

6. Examples of failure

Safety	Misjudgment	Testers	Test conditions	Test method	DUT	External control

Classification of failure cases

Case	Situations of failure・Trouble
Causes and adverse effects	Causes of failure or trouble
Countermeasures and preventive measures	Measures and precautions to prevent failure

6. Examples of failure

Case①

Safety	Misjudgment	Testers	Test conditions	Test method	DUT	External control

Case

An operator was shocked when her arm touched the cable sheath on the HIGH side, while touching the workbench (connected to the ground).

Reason

- ☆ **The test leads were touched during high voltage output.**
- ☆ The withstand voltage tester and the DUT were not placed on an insulating object.
- ☆ **The test leads were cracked.**

6. Examples of failure

Case①

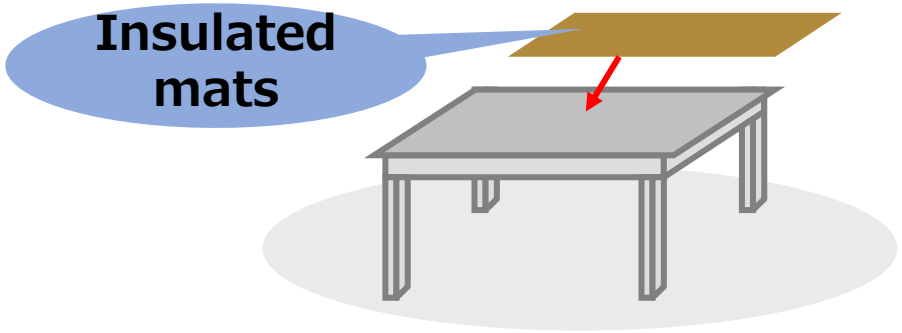
Safety	Misjudgment	Testers	Test conditions	Test method	DUT	External control

Preventive measures

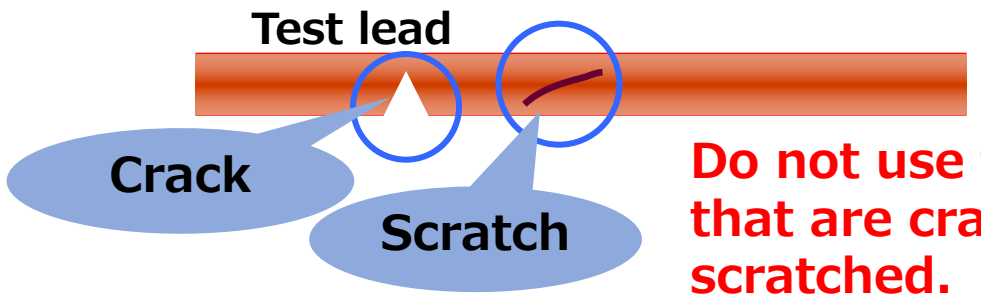
When the withstand voltage tester is outputting high voltage

① Do not touch the output terminals.
② Do not touch the test lead connected to the output.
③ Do not touch the DUT.

Put an insulating mat on the workbench!



Don't forget to check your test leads!



Do not use test leads that are cracked or scratched.

6. Example of failure

Case②

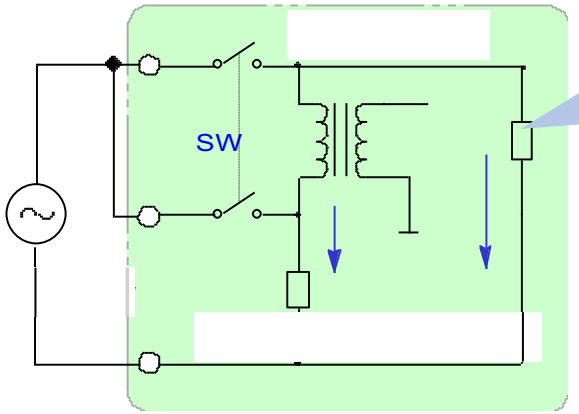
Safety	Misjudgment	Testers	Test conditions	Test method	DUT	External control

The problem

The withstand voltage test was done while the power switch of the DUT was turned off, and the test was redone.

Reason

☆ If the power switch is off, the circuitry inside the switch cannot be tested, and defective products may be shipped.



If the switch is off, even if there is a defect in the insulation of this part, it cannot be detected.

6. Examples of failure

Case②

Safety	Misjudgment	Testers	Test conditions	Test method	DUT	External control

Preventive measures

☆ **Use the lower-limit judgment function.**

A window comparator is used for the judgment function. FAIL detection is possible even when only a current below the lower-limit judgment criteria is detected. (Although there is a limit, it is possible to detect if the power switch hasn't been turned on or if the test leads are disconnected.

6. Examples of failure

Case③

Safety	Misjudgment	Testers	Test conditions	Test method	DUT	External control

The problem

Upon taking the new test equipment out of the box and trying to test it right away, the warning lamp remained on and the test couldn't be conducted.

The reason

☆ **The interlock signal was open upon delivery.**

For safety reasons, our withstand voltage testers have an interlock function that prevents them from operating if the power is turned on while packaged.

Solution

Follow the instruction manual to properly process the interlock signal before starting use.

6. Examples of failure

Case④

Safety	Mis-judgment	Testers	Test conditions	Test method	DUT	External control

The problem

The insulation resistance test of a fault-free DUT will results in a FAIL judgment.

The reason

☆ Short judgement wait time.

In many cases, the primary circuit of electronic equipment contains a capacitor for noise reduction. Immediately after the insulation resistance test has started, the resistance value is measured to be lower than the actual insulation resistance value due to the charging current flowing through this capacitor.

6. Examples of failure

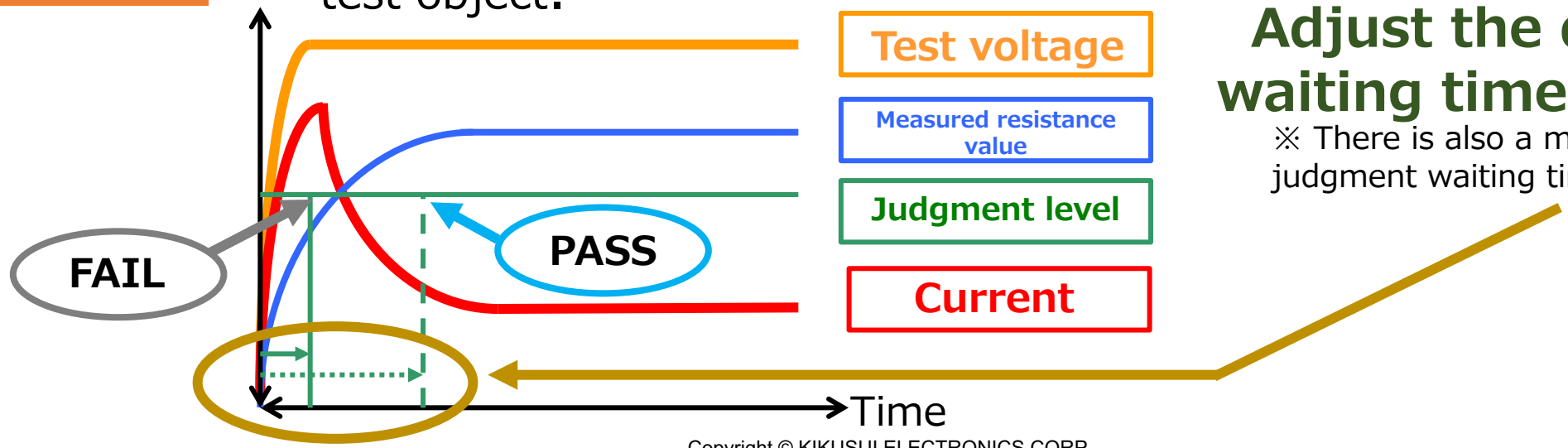
Case④

Safety	Mis-judgment	Testers	Test conditions	Test method	DUT	External control

Preventive measures

☆Adjust the judgement wait time.

☆ The relationship between voltage, current, resistance, and judgment level is shown in the figure below. It is possible to avoid FAIL by adjusting the judgment waiting time according to the difference of the test object.



Adjust the decision waiting time to PASS!

※ There is also a model with a fixed judgment waiting time.

6. Examples of failure

Case⑤

Safety	Mis-judgment	Testers	Test conditions	Test method	DUT	External control

The problem

The DANGER lamp, which had gone out after the DC withstand voltage test, came on. When the voltage was measured, it was over 100V. It would result in an electric shock.

The reason

☆ **The voltage increase may be due to dielectric absorption factors.**

Our DC withstand voltage testers are equipped with a built-in discharge circuit that discharges the voltage charged on the DUT after the test is completed until it becomes 30V or less. However, the voltage may rise again, and the DANGER lamp may light up after the discharge is completed due to dielectric absorption factor depending on the test object.

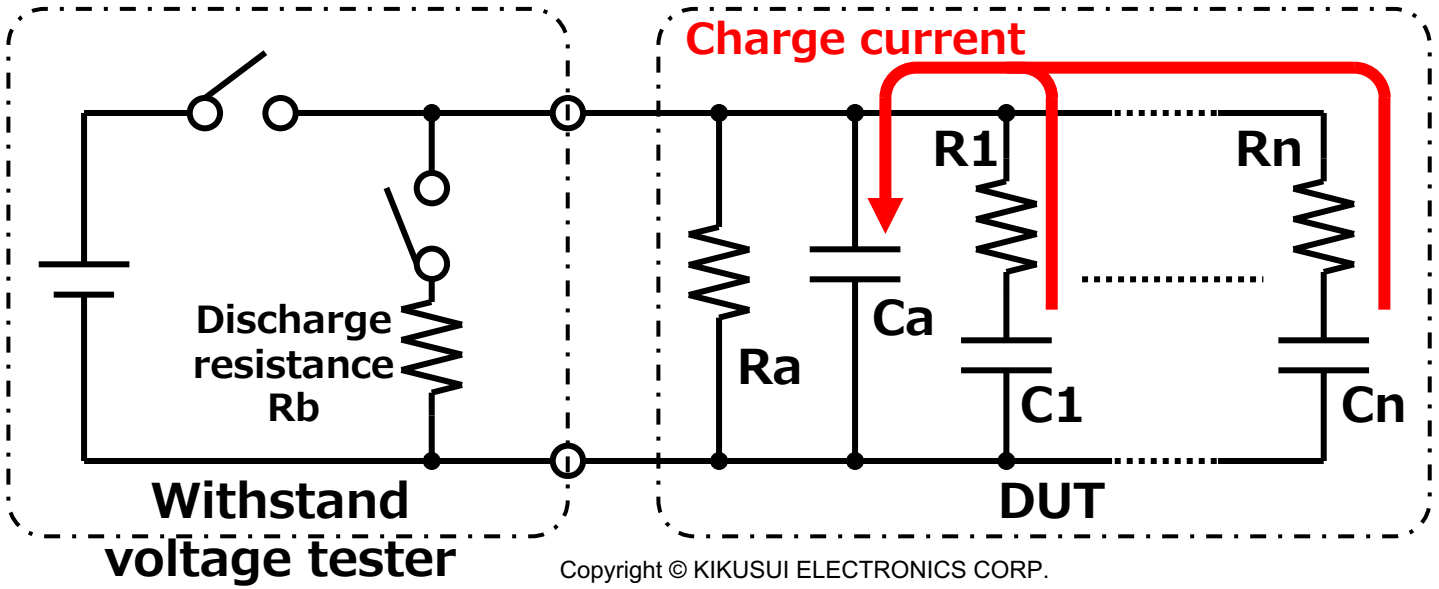
6. Examples of failure

Case⑤

Safety	Mis-judgment	Testers	Test conditions	Test method	DUT	External control

Preventive measures

In order to ensure the safety of the work, please set up a separate discharge circuit and discharge the DUT sufficiently. Once the DANGER lamp is turned off, the voltage may rise again, so it is also important not to touch the DUT immediately after the discharge ends.



After the end of the discharge, the voltage rises as the charges of C1 to Cn charge Ca.

6. Examples of failure

Case⑥

Safety	Mis-judgment	Testers	Test conditions	Test method	DUT	External control

The problem

When testing the voltage resistance of the film, it did not FAIL even though there were still traces of discharge.

The reason

☆No response to small discharges

The tester cannot detect minute or high-speed discharge phenomena called corona discharge or instantaneous flashover, which are allowed by safety standards.

※Dielectric breakdown is defined in the safety standard as follows (from J60950)
A breakdown shall be considered to have occurred when the current flowing as a result of the application of a test voltage increases so rapidly that the current cannot be controlled, i.e., the insulator is no longer able to keep the value of the current flowing below a certain level. Corona discharges or flashovers that occur instantaneously shall not be considered as dielectric breakdown.

6. Examples of failure

Case⑥

Safety	Mis-judgment	Testers	Test conditions	Test method	DUT	External control

Solution

If you use the TOS9300 series, which can switch the current detection response, you may be able to detect it.

The sensitivity adjustment (response) of the TOS9300 series can be set to five levels.

All in One!

ACW	5kV/100mA（500VA）
DCW	5kV/20mA,7.2kV/13.9mA（100W）
IR	0.001MΩ～ 100.0GΩ（DC-25V～- 1000V/DC+50V～+7200V）
EC	0.001Ω～ 0.600Ω（3.0A～42.0A）
LC	1μA～ 100mA（rms）

▲TOS9303LC

KIKUSUI
KIKUSUI ELECTRONICS CORP.

Thanks for your time!

Kikusui Electronics Co., Ltd.
Market Planning Department

August 2021