



# Is Your Hipot Tester Safe? Ten Whys of Electric Safety Testing

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## ➤ Foreword

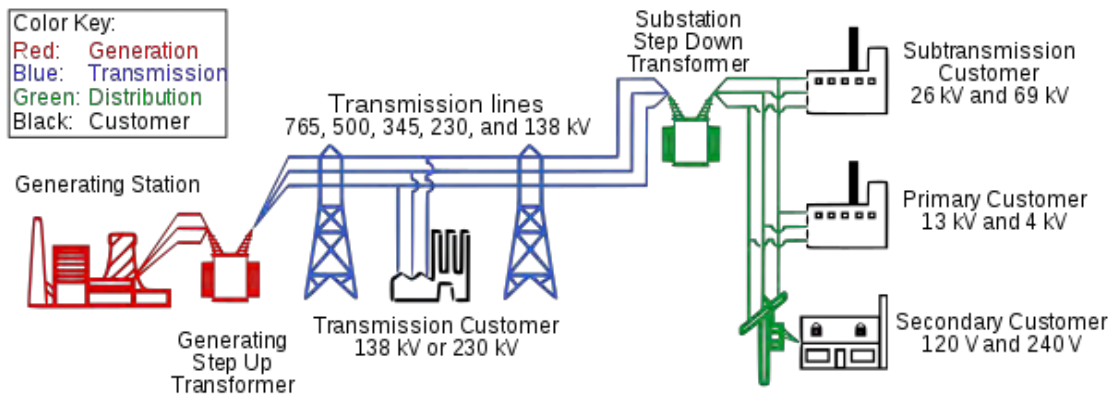
Withstanding voltage, insulation and grounding resistance (Ground Bond) are the test functions of the electric safety tester. Among them, the withstanding voltage test is a required test item for electrical equipment before leaving the factory. Although these tests are widely applied, many engineers still have some questions that they seem to have answers but actually they don't. In this application white paper, we have compiled the ten most frequently asked questions and explored the answers to these questions from the fundamentals. The ten questions are:

1. What voltage is set for the withstanding voltage test? Why is the voltage of the withstanding voltage test much higher than the working voltage?
2. What is the common withstanding test voltage?
3. How long should the test time be set?
4. How to choose the output capacity of the withstanding voltage tester?
5. What is the definition of insulator and insulation breakdown?
6. According to the definition of insulation breakdown, how do we avoid misjudgment?
7. Does the appearance of ARC and Flashover mean that the insulation has broken down?
8. In the test sequence of insulation resistance and withstanding voltage, can the withstanding voltage be excluded after passing the insulation resistance test?
9. Will the high voltage withstanding voltage test damage the expensive chips in the circuit?
10. What is the difference between grounding and continuity measurements?

In addition to these ten frequently asked questions, [due to the safety hazards of high-voltage instruments](#) (instruments used for insulation resistance measurement or withstanding voltage test), IEC has formulated the latest regulations for high-voltage instruments IEC-61010-2-034 to ensure the safety of engineers while using the instrument. This white paper will also discuss these safety hazards and the countermeasures of instrument manufacturers, so that you can safely complete the tests when analyzing insulation materials or conducting production testing. Finally, we will provide effective suggestions for the test plans from R&D to production testing, as well as equipment deployment.

➤ Ten Whys of Electric Safety Testing?

1. What voltage is set for the withstanding voltage test? Why is the voltage of the withstanding voltage test much higher than the working voltage?



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Figure 1 - Schematic diagram of the power transmission and distribution system

Red represents power generation facilities (including generator sets and step-up transformers of power plants); blue represents power transmission facilities (the purpose of using 765, 500, 345, 230 and 135kV high-voltage transmission is to reduce losses on transmission lines); green represents power distribution facilities; Black is users (large factories use UHV power 138, 161 or 230kV; medium-sized factories use extra-high voltage power 26, 69kV; small factories use high voltage power 4, 11, 13, 22kV; residential and commercial power consumption is 110, 120, 220, 240V).

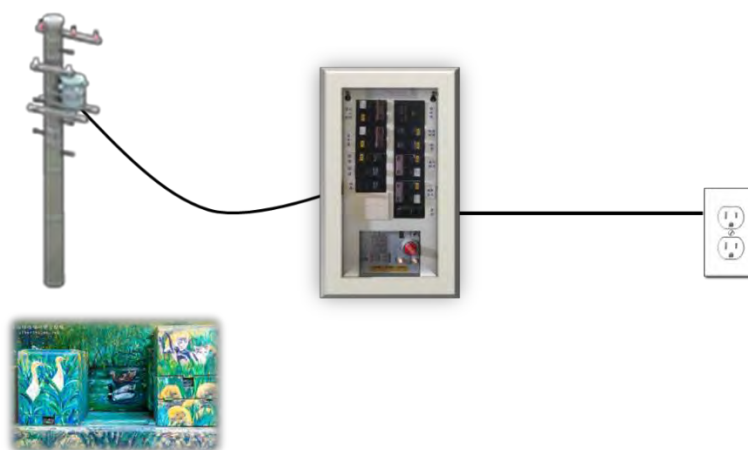
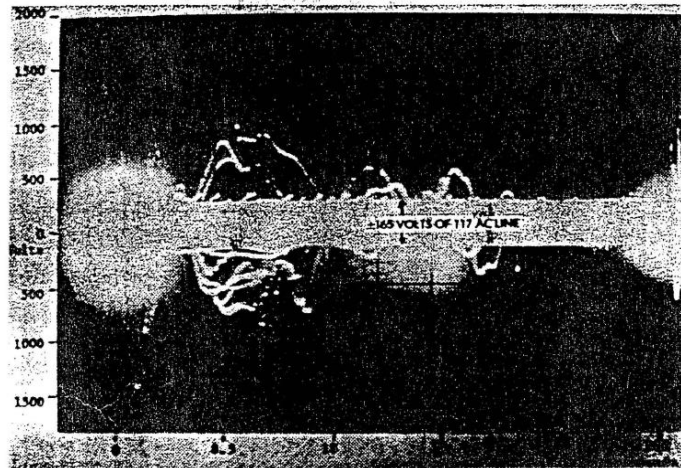


Figure 2 - Schematic diagram of residential and commercial power distribution

The withstanding voltage test of insulating materials is based on the maximum transient voltage that may be generated at the location of the transmission and distribution lines where the material is located. The sources of transient voltages include lightning strikes, induced voltage ( $V = L \frac{di}{dt}$ ) caused by inductive

load switching in lines, poor grounding, electrostatic discharge (ESD), and troubleshooting of mains power. The maximum transient voltage of each section of the transmission and distribution system is different. Taking residential and commercial 110~240V as an example, the transient voltage will reach 1000 volts (Figure 3), the transient voltage results for 24 hours on the residential power line recorded by GE.



**Typical surge voltages on residential power line; recordings taken over 24-hour period** (Photography courtesy F. Martzloff, General Electric Company)

### **Figure 3 - Transient voltage**

The common withstanding voltage test formula is: 1000V + twice the working voltage, which is based on the research in Figure 3. The insulation materials must be able to withstand the possible transient voltage of 1000V at the power distribution location, and twice the working voltage is the working voltage plus the working voltage, which is used as a Margin to ensure that the insulation of electrical facilities is safe.

Another clue of transient voltage can be found from the measurement category of EN61010-2-030 standards. The measurement categories of the instrument are divided into CAT II (socket to primary side of electrical equipment) surge peak voltage of 2500 volts, CAT III (socket to non-fuse breaker of distribution board) surge peak voltage of 4000 volts, CAT IV (distribution board to low voltage distribution equipment) surge peak voltage of 6000 volts.

## **2. What is the common withstanding test voltage?**

There are three common test voltages for the withstanding testing: AC, DC, and Impulse.

The AC voltage test is most accepted by standard units, because the AC voltage is the same as our actual

electricity environment. Both positive and negative half cycles are tested. For the stray capacitance of the DUT, the AC voltage test does not have the issue of charging and discharging. These are the advantages of AC voltage test. However, AC voltage test also has disadvantages. We will explain the disadvantages in the fourth question with the equivalent circuit of the test. During production line testing, leakage current is usually used as judgment criterion for Pass/Failure. The purpose of using DC voltage test is to solve the problem of larger leakage current measurement error in AC voltage test.

The last test voltage is Impulse. Impulse is mainly focused on testing circuits or components for transient overvoltage limiting devices by simulating the actual appearance on transmission and distribution lines. Transient voltage is divided into pulse and oscillation. Impulse simulates pulse transient voltage such as lightning strike as well as devices used in substation and transmission and distribution systems, such as circuit breakers, isolators, voltage isolators which require to be tested with this applied voltage.

In sum, the test voltage is to restore the appearance of the actual use environment or solve the test issues.

### 3. How long should the test time be set?

The withstanding voltage test is divided into the Type test in the R&D stage and the Routine test in the mass production. Type test is tested in the R&D stage from the selection of insulation materials, the composition of modules to prototype unit. The Type test time is 60 seconds for the prototype. If the material or module is subjected to Margin verification, a destructive experiment will be performed. The test voltage and test time will stop when the material or module appears insulation breakdown.

Routine test takes into account the production capacity and test cost, so the test time is mostly 1~3 seconds. In order to make up for the problem that the test time may not be able to detect defective products, the test voltage is usually increased by 10~20%. For some applications that are not allowed mistakes or manufacturers who have high requirements for their own quality, the 60 seconds of the Type test will still be used as the Routine test time.

**Note: The above test time refers to the premise that sufficient test voltage has been established on the DUT.**

Establish sufficient test voltage: AC withstanding voltage must consider the time required to establish the set test voltage from zero start, and DC withstanding voltage must consider the charging time of stray

capacitance and filter capacitance. The characteristics of capacitors are that the time-varying voltage will generate current. Capacitors do not allow transient voltage changes.

$$Q = C \cdot V = I \cdot t \dots\dots (1) \quad dV/dt = I_{charge}/C \dots\dots (2)$$

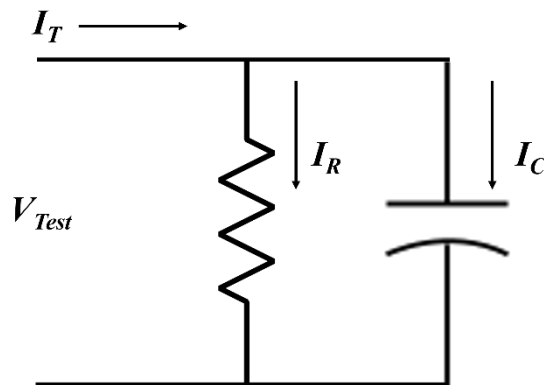
The capacitor does not allow transient voltage changes. From the above formula (2), it can be seen that the voltage change is affected by two variables. The first variable is the charging current (I charge), and the second variable is the capacitance value (C).

Assuming that the charging current in a line is 1uA and the stray capacitance is 0.0025uF, if we want to establish a voltage of 1500V on this capacitance, after applying the formula (2), we calculate that the rising voltage every 1 second is 400V. Therefore, to establish 1500 volts takes 3.75 seconds, which is a physical limitation.

Hence, it is best to use an LCR meter to measure the equivalent capacitance of the DUT before the test, which helps to accurately confirm the required rising time. From this elaboration, a disadvantage of the DC withstanding voltage test can be obtained that is the charging and discharging time of the capacitors will affect the test throughput of the production test.

**4. How to choose the output capacity of the withstanding voltage tester?**

Now, let's discuss the issue left in question 2. Why is the DC withstanding voltage test necessary? And the reason why the leakage current measurement error is larger during the AC withstanding voltage test.



*Figure 4 - the Equivalent circuit of the DUT.*

I<sub>R</sub> is the current flowing through the insulation resistance; I<sub>C</sub> is the current flowing through the equivalent

capacitance (including stray capacitance and filter capacitance);  $I_T$  is the leakage current measured by the withstanding voltage tester,  $I_C = V_{Test}/X_C$ ,  $X_C = 1/2\pi fC$ . During the AC withstanding voltage test, the frequency (f) is 60Hz. When the capacitance (C) is larger,  $X_C$  will be smaller,  $I_C$  will be larger, and the error of the leakage current  $I_T$  will be larger.

What if DC is used instead? The frequency (f) is 0Hz,  $X_C$  is infinite, and  $I_C$  is 0, so the measured  $I_T$  leakage current =  $IR$ , which will not cause errors.

It is necessary to establish sufficient test voltage on the insulation resistance, and the current required for testing with a DC waveform is smaller, which is relatively safe compared to AC.

After explaining the accuracy of AC/DC withstanding voltage from the equivalent circuit, let's get back to the topic. How to choose the output capacity of the withstanding voltage tester? The output capacity of the withstanding voltage tester is in VA, which refers to the product of the maximum rated AC test voltage and the maximum rated current. At present, 100VA/200VA/250VA/500VA withstanding voltage testers are available on the market. Taking AC 5000V as an example, 500VA can provide 100mA, and 200VA can provide 40mA. The output capacity actually depends on how much current is required to maintain the test voltage. We expect to establish enough test voltage on the insulation resistance to be tested to confirm whether the insulation is good. When the insulation breaks down, the insulation resistance will reduce. If the current at this time is insufficient (insufficient capacity), it cannot establish a sufficient voltage in this resistance with a decreasing value. This phenomenon is similar to the DC power supply switching from CV mode to CC mode. When the insulation resistance is very large (the load current is small), and when the insulation breaks down, the insulation resistance becomes smaller (the load current becomes large), and the capacity is needed to support it. Therefore, the destructive experiment of materials in the R&D unit or the laboratory of the third-party manufacturer will require a capacity of 500VA. The routine test of the production test commonly utilizes 100VA model. The reason is that the yield rate of the product is very high during mass production. Taking the insulation resistance of 100M $\Omega$  as an example, to establish a test voltage of 5000V, the load current is only 50 $\mu$ A and to establish a test voltage of 1500V, the load current is only 15 $\mu$ A, which is more than enough for the capacity of 100VA. Of course, if it is AC withstanding voltage, the influence of equivalent capacitance must be considered.

We summarize the advantages and disadvantages of AC withstanding voltage and DC withstanding voltage testing.

**Table 1 - Advantages and disadvantages of AC and DC withstanding voltage**

	AC withstanding voltage	DC withstanding voltage
Advantages	<ol style="list-style-type: none"> <li>1. Same as real usage environment, so it is favored by standards</li> <li>2. Test both positive and negative half cycles</li> <li>3. There is no charging and discharging time issue for the equivalent capacitance of the DUT</li> </ol>	<ol style="list-style-type: none"> <li>1. The measurement accuracy of leakage current is high</li> <li>2. The overall test current is small, which may reduce the cost of capacity when purchasing. If engineers accidentally touch the output terminal, it is safer than AC.</li> </ol>
Disadvantages	<ol style="list-style-type: none"> <li>1. Measurement error of leakage current due to the current of equivalent capacitance</li> <li>2. The overall test current is relatively large, and it may be necessary to purchase a larger capacity. If engineers accidentally touch the output terminal, it is relatively dangerous.</li> </ol>	<ol style="list-style-type: none"> <li>1. Only test for half cycle</li> <li>2. The capacitor must be charged and discharged, which will increase the test time</li> </ol>

**5. What is the definition of insulator and insulation breakdown?**

In electrical textbooks, resistivity is often used to define conductors (below  $10^{-5}\Omega\cdot m$ ), semiconductors (resistivity is between conductors and insulators), and insulators (higher than  $10^8\Omega\cdot m$ ). Under this definition, copper is a conductor, and air is an insulator, but from the phenomenon of lightning/lightning strikes in nature, it can be known that insulation is conditional, as long as the voltage is high enough, the insulator can also become a conductor. From a microscopic point of view, copper is a conductor, but nano-copper is an insulator; carbon is an insulator, but nano-carbon is a conductor. Hence, the physical properties of macro and micro may change. Below is the Wikipedia definition of an insulator: An insulator, also known as a dielectric or electrical insulator, is a material that impedes the flow of electric charge. In an insulator, valence band electrons are



tightly bound around its atoms. This material is used as an insulator, or insulation, in electrical equipment. Its role is to support or separate individual electrical conductors so that no current can flow through. This description can be reduced to the best definition that applies everywhere: **an insulator does not allow current to flow.**

After understanding the definition of insulator, next we will explain the definition of insulation breakdown. The following is the original description of insulation breakdown in UL/IEC 60950-1 chapter 5.2.2:

Insulation breakdown is considered to have occurred when the current that flows as a result of the application of the test voltage rapidly increases in an uncontrolled manner that is the insulation does not restrict the flow of the current.

The determination of insulation breakdown is: the current flowing through the insulation to be tested can already generate a corresponding current with the rise of the test voltage (**uncontrollable steep rising**). That is, the insulation to be tested can no longer effectively limit current growth under the test electric field strength. Gaseous and liquid insulation substances have the reversibility of insulation breakdown. When the high voltage causing the insulation breakdown disappears, they can return to the insulation state, while solid insulation does not have this reversibility. Once the insulation breaks down, it will cause permanent damage to its insulation ability.

## 6. According to the definition of insulation breakdown, how do we avoid misjudgment?

Most of the standards only specify the test voltage in the acceptance standard of the withstanding voltage test, and the voltage and test time cannot cause insulation breakdown. Only a few production test standards define how much the leakage current cannot exceed certain current. **The mnemonic phrase for insulation and insulation breakdown is: the insulator does not allow current to flow. When the overvoltage on the insulator becomes larger and larger, the uncontrollable sudden rise of the current is called insulation breakdown.** The V-I characteristic curve of this description is shown as below, Figure 5.

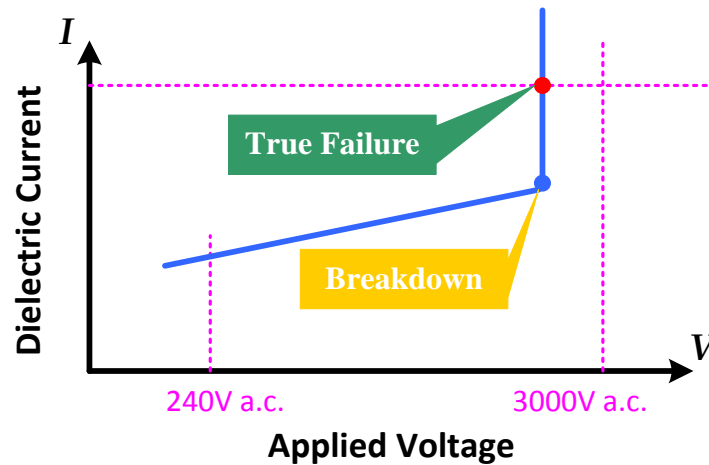


Figure 5 - V-I characteristic curve of insulation breakdown

The possible misjudgment effect of the conventional use of absolute leakage current: How to determine the leakage current acceptance standard of the production line? Some companies use the average method, through the test of the sample, calculate the average value and add 25% as the upper limit of acceptance, or 30mA leakage current value that will cause harm to the human body is used as the upper limit of control (the leakage circuit breaker on the power distribution generally also uses 30mA as the operating current). Please see Table 2.

If your DUT is valuable, using the absolute value leakage current method may cause false failures. Since the definition of insulation breakdown is determined by the uncontrollable step rising current, the V-I characteristic curves of the test results are very important to material verification during R&D stage and production line testing of expensive products. At present, the GPT-9900 series and GPT-12000/15000 series electrical safety analyzers of GW Instek all have the V-I characteristic curve scanning function, which will not cause losses from misjudgment. The actual measurement results are shown in Figure 7.

Table 2 - Effects of human perception of current

Inductive effect	Current value unit (mA)			
	DC		AC 60Hz	
	Male	Female	Male	Female
Perception current	5.2	3.5	1.1	0.7
Let-go current	62	41	9	6
Non-let-go current	74	50	16	10.5
Shock current	90	60	23	15
Cardioplegia current	500	500	100	100

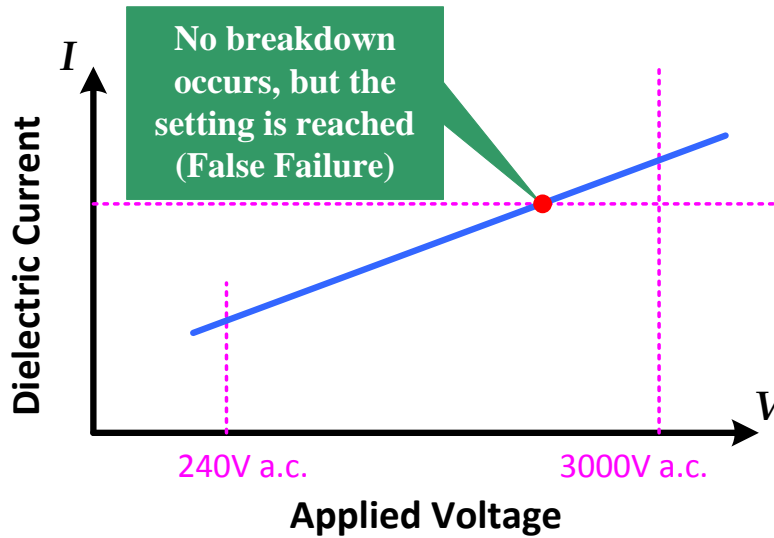


Figure 6 - Impact of false failures

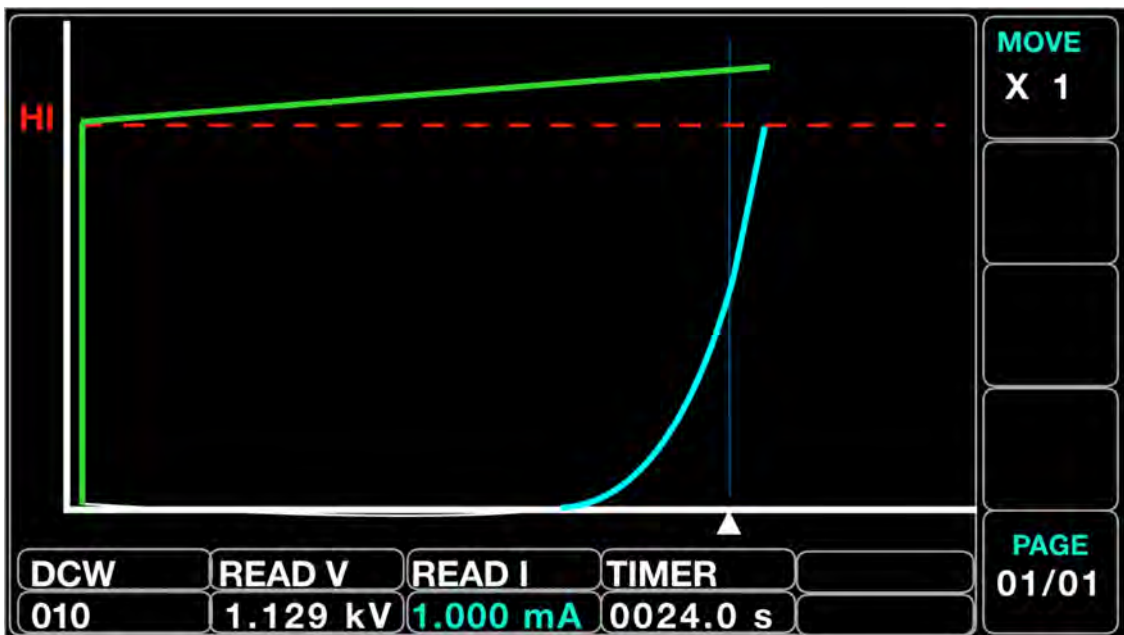


Figure 7 - V-I insulation breakdown case of GW Instek GPT-10000 series

7. Does the appearance of ARC and Flashover mean that the insulation has broken down?

UL/IEC 60950-1 chapter 5.2.2 also has a paragraph about ARC and Flashover in the original text for insulation breakdown. The original text is as follows: Corona discharge or a single momentary flashover is not regarded as insulation breakdown. **Corona discharge and single instant flashover are not considered insulation breakdown.**

You must have the correct concept. The ARC test is actually an industry standard, not an international

regulation. ARC detection and insulation breakdown are two different things.

In the past, when the withstanding voltage tester could not display the V-I characteristic curve to determine the breakdown of the insulation, the conventional method was to watch and listen to see if there was an arc. It was believed that the insulation damage and the arc were cause-and-effect relationship, because the lighting and illumination in the room would affect the arc observation. A dark room was built to observe the arc. Or listening to determine if there is any squeaking sound of the arc. Some of the sound of the arc occurs in the ultrasonic frequency band that the human ear cannot hear. Purchase an ultrasonic converter to convert it into audible audio. However, from the standard definition, we know that arc and insulation breakdown are two different things. We should think about why an arc occurs and the possible harm caused by the arc. The generation of arc is the relationship between voltage and distance. Taking the application of daily life as an example, the piezoelectric material on the lighter generates a voltage through the pressure to generate an arc to ignite the gas. From this example, we can see that the possible harm caused by the arc is fire or dust explosion if there is flammable gas or dust near the electrical facilities. The second hazard is high temperature. For example, industrial electric welding machines deliberately generate arcs through high voltage in order to use its high temperature characteristics to cut hard metals. The maximum temperature of the arc in this application is four times the temperature of the surface of the sun (Celsius 20,000 degrees). The arc energy unit of arc flash is generally expressed in cal/cm<sup>2</sup> or J/cm<sup>2</sup>. Cal/cm<sup>2</sup> (calories per square centimeter) refers to the total energy on a unit area, which is used as the unit of arc magnitude. 1 cal/cm<sup>2</sup> of energy is equivalent to a lit cigarette butt on the fingertip for 1 second. It only takes 1-2 cal/cm<sup>2</sup> to cause second-degree burns to human skin.

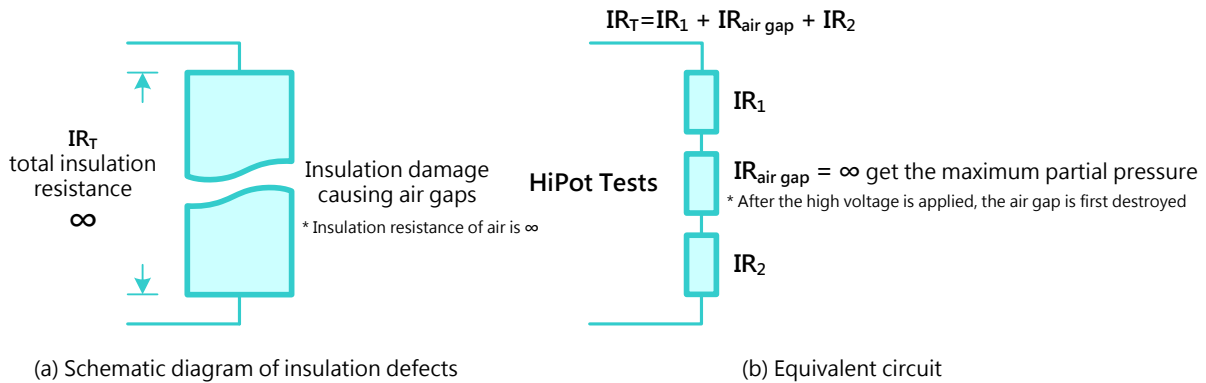
**8. In the test sequence of insulation resistance and withstanding voltage, can the withstanding voltage be excluded after passing the insulation resistance test?**

Many standards require the test sequence to be insulation resistance (IR) + withstanding voltage (ACW or DCW) + insulation resistance (IR). The first thing to consider is why the insulation resistance should be measured twice? Furthermore, if the insulation resistance is high, does it mean that there is no problem with the insulation, so there is no need to measure the withstanding voltage?

Insulation resistance is measured by normal working voltage (non-destructive test), and withstanding

voltage test is to measure leakage current (destructive test) by several times higher than the working voltage.

Next, don't be too thrilled when you measure a very high insulation resistance!



**Figure 8 - Insulation defect and its equivalent circuit**

The left diagram (a) of Figure 8 is a schematic diagram of an air gap caused by a defect in the insulation material. This air gap will reflect a large insulation resistance when measuring the insulation resistance, but when we measure the insulation resistance, we perform a withstand voltage test. , from the equivalent circuit of the right figure (b) of Figure 8, it is known that the air gap of the insulation defect is due to the high resistance, and most of the voltage will be divided on it as a result of the series voltage division, so it will be destroyed first, and wait until the first When the insulation resistance is measured twice, it will show a lower insulation resistance.

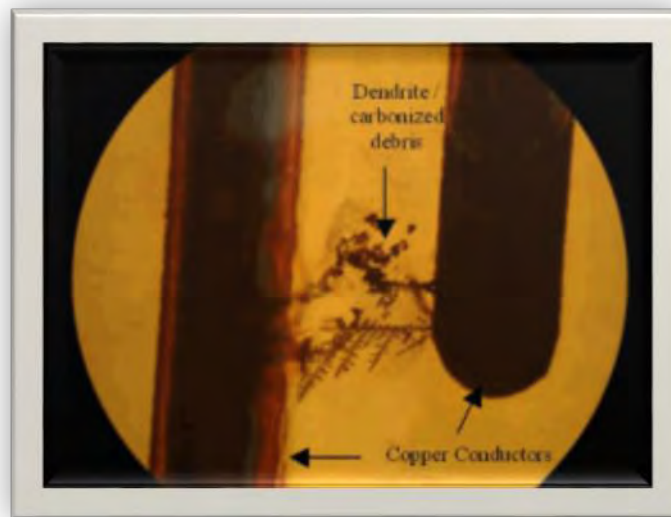
Therefore, the order of the test is meaningful starting from insulation resistance (IR) + withstanding voltage (ACW or DCW) + insulation resistance (IR). If the difference between the two insulation resistances is too large, it means that there is a prior insulation defect, and the defective insulation material is destroyed after the destructive test of the withstanding voltage, so the second insulation resistance is very different from the first measurement.

### 9. Will the high voltage withstanding voltage test damage the expensive chips in the circuit?

If your withstanding voltage test passes, there must be no damage. Because damage to the chip is either overvoltage or overcurrent, neither of which will happen when the insulation is good.

However, in the application of withstanding voltage test, there is a very special test called ion migration. The test method of ion migration is to set the relative humidity of the environment to 85% through the

environment test equipment, and the temperature is usually 80° C or above, and then apply the high voltage on the copper foil of the PCB. Figure 9 Under the electron microscope, the short-circuit phenomenon caused by the dendrite in the insulating layer between the two traces is called ion migration.



*Note : This figure is referenced from NTS website*

**Figure 9 - Ion migration phenomenon under electron microscope.**

Carrying out this test around key components of the PCB helps to detect layout issues early. Once the problem in Figure 9 occurs around the key components, it may cause a short circuit and burn the key components.

## 10. What is the difference between grounding and continuity measurements?

Good insulation is the first line of defense for equipment users (no leakage, no electrical shock to people). When there is a problem with the first line of defense, good grounding is the second line of defense to protect users (After electricity leakage, lead the electricity to the ground), When the equipment leaks current, people touch the outer casing of the product, and if the human body is a relatively high resistance to the ground, it is known from the equivalent circuit that the two resistances are connected in parallel, and the shunt of the large resistance is small, which is the meaning of the second line of defense. Therefore, the ground wire of the electrical equipment must be installed correctly, and the current can be quickly conducted to the ground when there is leakage.

Ground bond (GB) test is through a large current of 25 to 40 amperes to have the voltage drop on the

grounding wire by 4~12 volts. Via the conversion of Ohm's law, this grounding resistance is  $m\Omega$  level, GB test time is two minutes required by some standards, or at least 5 to 10 seconds.

Safety tests include single-function models with AC withstanding voltage (ACW) or two-in-one models with AC withstanding voltage (ACW)/DC withstanding voltage (DCW); AC withstanding voltage (ACW)/DC withstanding voltage (DCW)/insulation resistance (IR) three-in-one models; and AC withstanding voltage (ACW)/DC withstanding voltage (DCW)/insulation resistance (IR)/grounding resistance (GB) four-in-one models. If you want to have the grounding resistance GB test function, you must choose a four-in-one model, so the price will be more expensive. However, there are some withstanding voltage analyzers such as GW Instek's GPT-10000 series electrical safety analyzers, its ground Continuity test (GC) is the standard configuration. The ground continuity test (GC) uses a small current to measure the resistance, which is the same as the continuity test principle of the multimeter. That is, to measure whether the grounding path is connected, and the test time is fast (about 1 second). But the measurement accuracy (in  $\Omega$  level) is not as good as GB. When your device does not have the GB function, the test function with GC can at least evaluate the continuity of the ground.

Instruments used for insulation resistance measurement or withstanding voltage test are to output high voltage, measure small current, and then convert resistance through Ohm's law. The past standards did not consider many safety hazards to users. These hazards include:

1. The original basic insulation requirements are not enough to ensure the safety of users
2. Accidental output: the button for operating the high-voltage output of the instrument may be pressed by mistake
3. The instrument may be in a dangerous state of automatic output after the power system is cut off and the power is restored
4. The device fails to effectively discharge the residual voltage tested to a safe potential
5. No warning is provided on the rear panel when using rear panel for outputs

IEC/EN 61010-1:2010 safety requirements for electrical equipment for measurement, control and laboratory use - Part 1: General requirements. The instrument itself must comply with the IEC/EN61010 standards. Due to the above safety hazards, the IEC 61010-2-034: 2017 Safety Requirements for Measurement,

Control and Laboratory Electrical Equipment was added to insulation resistance and withstanding voltage test equipment in 2017. Special requirements for insulation resistance measurement equipment and withstanding voltage testing equipment, provided that the instruments for insulation resistance measurement equipment and withstanding voltage testing equipment with an output voltage exceeding 50 volts (AC) or 120 volts (DC) shall apply this new standard. After the standard was published, it took effect in 2021. On July 12, 2019, UL released the UL61010-2-034 standards with reference to the IEC standards. On December 24, 2020, China issued the fourth batch of recommended national standards for 2020. (File No. National Standards Committee Fa [2020] No. 53) serial number 115 complied IEC61010-2-034 as plan number 20204746-T-604, which shows that this safety issue has been taken seriously by major countries.

On April 16, 2020, GW Instek released the GPT-10000 series electrical safety analyzer that is the world's first safety analyzer to comply with the IEC-61010-2-034 standards, and provided a complete countermeasure against the above-mentioned safety hazards.

1. High-voltage relays and high-voltage transformers adopted double-insulated parts, and the trace distance of high-voltage boards also meets the requirements of double-insulation. The design of the measurement circuit is changed, and protective impedance is added to isolate the dangerous voltage on the high-voltage to meet the double-insulation requirements.
2. One of the following countermeasures can be taken to deal with the provisions of the new IEC standard for unexpected output.
  - 2-1: The high-voltage output switch must be pressed for 1 second before it can output ([Considering the convenience and efficiency of safety and production testing, GW Instek GPT-10000 series adopt this countermeasure](#)).
  - 2-2: Output switch requires a key to activate
  - 2-3: The output switch needs to be under a spring cover. When starting, the spring cover needs to be opened before pressing the output switch.
  - 2-4: Need to use both hands to press two switches at the same time to output
3. After the power supply at the input end of the device fails and then recovers, even if the output switch is pressed, the device should still be in a safe condition (no harm). [After GW Instek GPT-10000 series detect](#)



the disappearance of the input power supply for 10 cycles, output will stop.

4. Add a 56k ohm discharge resistor to the discharge circuit to ensure that the discharge mechanism after the large capacitance test in DC mode must be discharged to a safe voltage lower than 30% within 10 seconds.
5. The IEC standard requires the use of flashing (50-300 times/min, at least 40% of the flashing time) or a permanent red warning light, or adopting either a visible/variable indicator in a high contrast color, or a high volume audible warning (above 70 dBA/less than 5kHz). **GW Instek adopts the method of installing output warning lights on the front and rear panels.**

### ➤ Self-protection in the use of high-voltage instruments

Even if an instrument that complies with the latest safety standards of IEC61010-2-034 is used, if the safe installation and operation methods are not followed at the use site, the instrument operator will still have safety concerns.

1. **The instrument must be properly grounded.** The importance of grounding has been discussed in question 10 of this white paper. But, how do we determine the grounding condition of the building? Is it grounded when you see three holes in the socket?



*Note : This figure is referenced from Amprobe's website*

**Figure 10 - Power Socket Checker**

A multimeter can be used to check or use the simple power checker in Figure 10. This checker can confirm whether the grounding is properly grounded, and whether the live wire and neutral wire are reversed and other power distribution issues. GW Instek GPT-10000 series have an additional ground connection terminal on the rear panel. When the three plugs of the power supply are not properly grounded, you can use this terminal to make another grounding. **Furthermore, the instrument itself has a grounding failure detection function. When the grounding failure is detected, the output will be stopped to meet the protection requirements** (this function can also be turned off).



*Figure 11 - GW Instek GPT-10000 series rear panel*

2. Safety measures such as insulation table mats, insulation floors, insulation gloves, and goggles are indispensable. Since insulation gloves are required during operation, it is not recommended to use the touch screen operation interface design for the withstanding voltage tester.

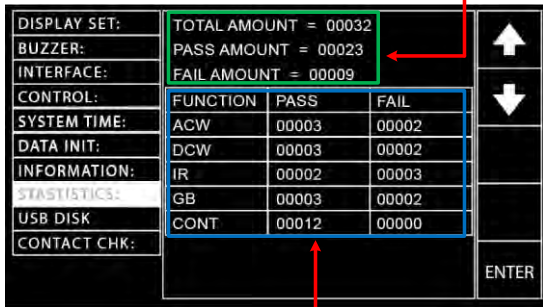
### ➤ Test planning and equipment deployment from R&D to production testing

Research and development stage: Through destructive experiments to understand the margin of insulating materials. The safety analyzer must have the V-I curve scanning function to confirm insulation breakdown. Next, through the statistical function, the average value is calculated, and the production test acceptance standard is set. The insulation breakdown V-I curve in Figure 7 can be reviewed, and the statistical analysis is shown in Figure 12.

The GPT-10000 series provide screen capture function, which can store test images to simplify your standard operating procedure (SOP) work for making test reports or production testing so as to save time.

Deployment of production testing: When the process is stable and the yield is high, the efficiency of production testing can be improved through an external multiplex scanner boxes or a built-in multi-channel safety analyzers (see Figure 13). If the safety analyzer for production test supports the setting copy function of USB flash drive, it can save the test deployment time of the production line.

PASS, FAIL amounts & TOTAL amounts



PASS & FAIL amounts distributions in each test function

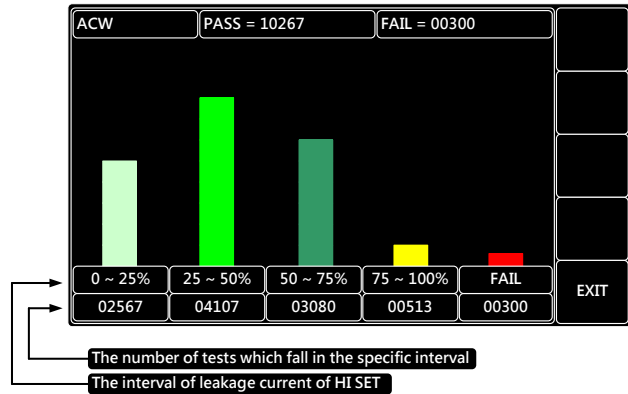
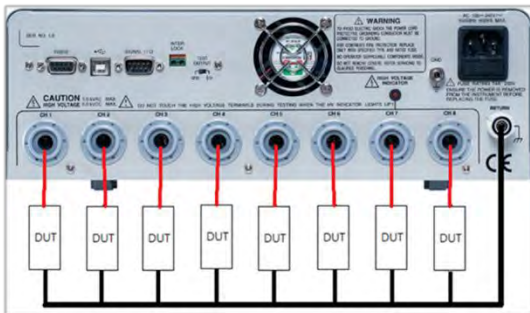


Figure 12 - Statistical analysis



(a) Built-in multi-channel scanner: GPT-9500 series

(b) External multiplex scanner box: GPT-9000 series

Figure 13: Multi-channel testing solution

## ➤ Conclusion

Selecting the withstanding voltage/insulation test equipment that complies with the latest safety standard IEC 61010-2-034:2017 and correct grounding is the first priority to ensure safe use. The only way at the application level is to understand the test standards and the working principle of the instrument. Through the explanation of these ten questions, we hope that the work of safety engineers will be benefited. According to the statistics of Taipei City from 2017 to 2019, fires caused by electric factors accounted for 20.1% (783 cases/2560 cases), and the casualties caused by electric fires were 29 injured, accounted for 46.8%, and 15 deaths, accounted for 34.1%. These data told us that safety engineers should strictly inspect the electrical safety of products, so that these unfortunate incidents can be minimized.

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