



Electrical Safety Testing Reference Guide

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1. Overview

It is necessary to realize what are hazards before doing electrical product safety. Various electrical equipments are with potential hazards, using the products of electric or electronic components can't cause users hazards. Hazards in safety standard include four kinds as below: electrical shock, mechanical/physical hazard, low voltage/high energy hazard and fire prevention. These four hazards are the basic safe standards in various products safety. In this guide, we mainly discuss about electrical shock and it is the basic safety requirement.

Why the product need to progress electrical safety test?

This question is many manufacturers want to ask, surely the general answer is “because it is regulated in safety standard”. If you can deeply realize the background of electrical safety then will find the concealed responsibility and meaning behind it. Although electrical safety test occupies a little time on production line, yet it let you reduce the risk of reclamation cause by electrical hazard. Do right at first time is the correct way to cost down and maintain goodwill.

The government, folk organization and laboratory can write safety standard cooperatively, regulate common test standard after several times product test and make the similar products with the same test method. In standard, the detailed descriptions aims at test definition, make new technology has related theory as test basis to reduce the delay of product test which cause by writing and researching standard. When the responsibility of product is on manufacturer, producer not only progress basic product test but also progress safety optimization aims at product. Because the using statuses in daily life can't predictable, the reason of many products reclamation is from here.

The chapter of safety standard includes introduction, meaning, performance test, production test, label and appendix. For electrical safety test, the most important is performance tests and production tests, performance tests are testing all of primary products consist of electric hazard, energy, fire and mechanical hazard. These tests also write in production tests but part of test can't use on production line because of time-consuming. Thus, part of safety standard divides performance tests and production tests for describing. The quality of safety standard decides safety coefficient of product, for example medical equipment usually contact with patient thus its' safety coefficient should be higher than other products.

Remarkable is that safety standard offering basic safety test and method, however the final responsibility of product failure attribute to manufacturer not standard. Therefore, producer and designer should do their duty to protect consumer safety on safety protection of special product. Pass safety verification doesn't mean the danger won't be occurred. The designers should browse safety related information on usual days, new standard announcement and new test method will effect on test basis of related product.

Electrical Shock

The factor for causing electrical shock has several types, the mainly electrical shock is caused by current through human body. This kind of electrical shock has direct effect on human body, the differences of injuring serious depends on degree of electrical energy, humidity and

touch area. Image you are bathing in bath tube, suddenly drier in operating dropping into bath tube, the current flows from drier through your body to ground under this situation. Meanwhile, your heart palpitation un-regulated and blood pressure falling down causes tragedy can't be redeemed.

In safety standard can't regulate all errors generated by each operation but offers several basic test and protection to protect human body safety. For example, GFCI (Ground fault current interrupters) design is automatic cut off power within a few ms when grounding current is over the high limit of regulation leakage current. This function largely decreases the death accident of electric shock when people at home, for users of electrical appliances get a safeguard. Power frequency is one factor of decision, the general interior AC power usually is 50/60Hz. Its' injury to human body is higher than DC power, thus electrical appliances requires the design with circuit for protecting human body.

Many safety standards are testing for appropriate leakage current, product mechanics design, withstand insulation to regulate the injury generated when human body touched. Safety standard is divided into general and particular, the manufacturer needs to notice extremely various standards application to make the product match to the correct safety standard.

Electrical shock includes the following four kinds of test.

- Dielectric Withstand / Hipot Test: Withstand test apply high voltage on power and ground terminal circuit of product to measure its collapse status.
- Isolation Resistance Test: Measure product electrical isolation status.
- Leakage Current Test: Inspect whether leakage current of AC/DC power flows to ground terminal is over standard.
- Protective Ground: Inspect whether metal mechanics of accessible part surely grounding.

2. Introduction to Global Safety and Directive

In recent ten years, safety standard of products have greatly changed. World organization desire to integrate safety standard of various countries become globally standard, although it still make effort today. The current safety standards are quite generality, the following separates six areas of market to describe how to progress safety organization and related data.

2.1 U.S.A.

The safety of America belongs to one kind of federal government law, can see safety regulation of electronic product in article CFR21-1910. Electronic product testing in Nationally Recognized Testing Laboratory (NRTL), includes monitoring, inspection as well as recognition passed. Various areas subordinated to Occupational Safety and Health Administration (OSHA) and execute recognized progressing of laboratory. About OSHA contact information please refer appendix A.

The electronic product needs to pass safety will attach a label of recognized laboratory, such as UL, ETL, MET and FM, these labels denote the product of manufacturer once send to laboratory by testing and evaluating to get safety recognized. In America, the standard of ANSI/UL is the most often used safety recognized for manufacturers.

2.2 Canada

The safety standard of Canada and America are compatible, the difference between them is inspecting for certification by custom and electrical authorized organization of various provinces. Electronic product needs to pass safety of recognized laboratory and attach labels, the majority of safety standard is called CSA and recognized laboratory need to pass recognition by Standards Council of Canada (SCC). In Canada recognized system, recognized laboratory is called as Certification Organization (CO). In America is called as NRTL, a lot of laboratories own two titles simultaneously thus can get two recognitions in one laboratory.

2.3 Europe

Establishment of European Community (EC) is for creating uniform economic system to profit the whole Europe economic growth. For product safety is also to regulate uniform standard, thus to announce Low Voltage 73/23/EEC and Electromagnetic Compatibility (EMC) 89/336/EEC directives. EMC is for preventing products from electromagnetic interference and then cause quality problem of product, also includes Electrostatic Discharge (ESD). Low voltage directive provides structure and procedure of product safety test, includes withstand, ground resistance and various electrical tests.

Here, we mainly discuss low voltage directive, it was announced in 1973 and all electronic products selling on European area should match to this directive. Before announcing low voltage directive, test recognized of electronic product is progressed by standard of various countries and experiment mechanics, this causes recognized cost of manufacturer and

importer over high. Low voltage directive nowadays and EMC directive are common use in European Community, various member countries should obey them. Low voltage directive itself doesn't indicate electronic product needs to pass what kind of test, the meaning of directive is for all electronic products import to Europe match to standard mechanics rules and offer a safety product for users don't be injured in operating.

To institute Harmonized Standard is very important and it let European community member nation has a test standard to obey and responsible for the directive simultaneously. Just as the standard (partly derived from IEC standard) announced by International Electrotechnical Commission (IEC) and Comité Européen de Normalisation Electrotechnique (CENELEC), table 1 lists partly harmonized standard for reference. If a certain of special product isn't in harmonized standard then its' standard by IEC or CENELEC. If it doesn't belong to IEC or CENELEC then it's mainly by various countries domestic standard, often seen European country standard includes DIN(Germany), BS(England) and NF(France).

Example by harmonized standard BS EN 61010-1: 1993 safety standard of measuring, monitoring and laboratory equipment (Part1: general), it derived from IEC1010-1 and definite as including tests of design and production. Design test indicates sample test of design stage and test report should attach to certification of design running. Production tests are the tests often seen generally, such as withstand, leakage current and ground resistance. After electronic product passes these tests and obtains "Declaration of Conformity" then attaches CE label means it passes low voltage directive.

European Community revised low voltage directive on 1 Jan. 1995 and formal executed in member country of European Community, offer two years of transition for CE label common use in European Community area. Please notice that CE label only can be marked and detailed test procedure in "Declaration of Conformity". CE Marking is a pass for products selling on European Community area, 17 items of directives already announced in European Community. If the directives are forced to implement (for example, toy, mechanical and electromagnetic compatibility directive), related products need to match to evaluation procedure then declare that product match to requirement of CE, that is to satisfy the safety of product for appropriate protecting users health safety and essential safety requirements of environmental protection, thus that product can sell free between various member countries of European Community.

Standard	Description
EN 50091	Uninterruptible Power Supply (UPS)
EN 50144	Safety standard of portable electronic motor appliance
EN 60034	Rotatory electronic mechanical equipment
EN 60035	Household appliance equipment
EN 60204	Safety standard of mechanical equipment
EN 60335	Safety standard of household appliance
EN 60950	Safety standard of information product and enterprise information equipment
EN 60967	Safety standard of electric blanket, electric pad and household related heating equipment
EN 60968	Safety standard of electric lamps for general lighting
EN 61010	Safety standard of measuring, monitoring and laboratory equipment
EN 60601	Safety standard of medical equipment

Table 1 Harmonized Standard of European Community Member Country

2.4 Germany

Germany is a manufacture important city in European area, it is mainly index sign for many products certification. The procedure for certificating is very strict, the mainly certification markings include three types: VDE, TUV and GS. Large-scale recognized laboratory includes two administrations of VDE and TUV and German national recognized administration is DAR (Deutscher Akkreditierungs Rat, German Accreditation Council).

VDE (Verband Deutscher Elektrotechniker) belongs to VDE testing recognized administration of Offenbach. This administration includes VDE testing and recognized system. VDE recognized marking is a certification given by VDE testing recognized administration to evaluate factory management procedure, and the product quality of attaching VDE recognized marking must match VDE testing standard. The manufactures of all European or outside of Europe countries need to pass this test when the product manufactured in Germany. VDE had signed cooperative agreement with a lot of countries in world. Thus, the product attached ENEC marking of VDE doesn't need to accept other organization testing belong to the range of European recognized procedure.

TUV is another long history organization. Germany established the first one DÜV in 1872, its' inspector progress periodic monitoring on steam boiler and pressure container, DÜV is the forerunner of TÜV Rheinland. Follow by the establishment and development of TÜV Rheinland, it become government monitor organization of German official authorized in 1962, offer all services from inspection and evaluation of crane to electricity equipment of whole factory. According to safety health standard of Germany and Europe, TÜV Rheinland offer test and recognized services for electrical, electronic and machine products, also issue some individual test markings for various domains (e.g. EMC marking).

GS(Geprüfte Sicherheit) certification marking is enforced requirement in Germany, GS is a safety recognized marking announced by TUV and VDE organizations which authorized by Department of Labor in Germany. GS is suitable for consumption products, such as information product, household appliances, electrical and electronic office equipment, industry mechanics, leisure equipment and furniture. European Community CE regulate to control Low Voltage Directive(LVD) from 1997/1/1 and apply GS can obtain LVD certification. The voltage in Germany is 230V/ 50Hz, it is the same with other CE country.

Factory quality control system has restrict request for examining and yearly checking, according to ISO 9000 standard to establish document and production, inspection procedures when the factory to get delivered goods. After examining is passed to issue GS certification, this means the inspected products correspond to up-to-date European or German standard. The products which are with GS marking not only common use in Germany but also usable in 12 member countries of Europe and other 5 countries of Austria, Finland, Norway, Sweden and Switzerland.

2.5 Mainland China

According to enforced product recognized management regulation of 2001 General Administration of the People's Republic of China for Inspection and Quarantine, any product which list in "Product catalog of the People's Republic of China implement enforced product recognized" should be qualified by nation specified recognized administration to get CCC certification issued by specified CCC recognized administration. After labeling 3C marking then can leave the factory for selling, importing and using on business activity.



National recognized supervision committeemen are responsible for establishing related system in accordance with the authority by law regulation and Department of State, announce with General Administration of Nation Quality Inspection. The specified recognized administration take responsibility for recognized of concrete product and issue CCC certification. Administration of local for quality technology supervision and administration of various areas immigration for inspection and quarantine are responsible for executing law and supervising products, if all products in catalog didn't get CCC recognition, can't sell in this administrative district. The first lot of enforced product recognition includes 19 types and 132 kinds of products, and the products exempted from enforced recognition also be noted particularly.

2.6 Japan

Before April 1, 2001, electrical appliances and DENTORI in Japan divided control product into two types of A and B. Type A has 165 kinds of products which consists of power cord, fuse, switch, transformer and ballast. Type B has 333 kinds of products which consists of lamps, household appliances and office equipment. Type A products need to obtain enforced recognition of government, that is T marking and only can be issued by Ministry of International Trade and Industry (MITI). The conformances of Type B products need to declare by itself or apply the third-party assurance.

After April 1, 2001, DENAN replaced DENTORI and cancelled T marking to authorize the third-party assurance organization to progress evaluation testing of product and issue of certification. New regulation divided products into SPs and NSPs. The products for entering SPs of Japanese market need to obtain the third-party assurance, labeled with PSE(rhombus) marking. NSPs products need to declare by oneself or apply the third-party assurance, labeled with PSE(round) marking.

Another S marking of voluntary product recognition in Japan is based on IEC standard and Japan national particular standard, draw into Japan by two non-government organizations of Japan Quality Assurance Association(JQA) and Japan Electrical Safety and Environmental Technology Laboratories(JET) and Steering Council of Safety Certification for Electrical and Electronic Appliances and Parts of Japan(SCEA) take responsibility for propeling now.

2.7 Safety Development in the Future

European Community(EC) occupies important position in the future safety development, European Community progress integrating for various safeties from 1992. IEC and UL also integrated with safety of various electrical products until lately, and develop a common use verification mode. This make the product designers don't limit standard mainly instead of reaching safety design idea when design for products. To plan a mode of product safety design, the product design don't be limited any more, also don't re-design product cause by safety standard. It is a good news for the manufacture.

Therefore, when various safeties toward to the way of integration, how to up to the most efficiency status by coordinating production line adjustment with development design is the direction of all companies need to consider seriously. If you need to search the glossary of safety standard, please go to IEC website or purchase IEEE std 100-1988.

International Electrotechnical Commission <http://std.iec.ch/glossary>

3. Electrical Safety Test

3.1 Hipot Test

Hipot test is one of safety test being often seen. Often seen dielectric withstand, high potential and hipot test all denote withstanding test. The mainly purpose of hipot test is for testing insulating capability of DUT(Device under Test). When the equipment is operating, apply a high voltage to test point for testing whether insulation breakdown or electrical flashover/ARC are occurred. The insulation is divided into four types: Basic, Supplementary, Double and Reinforced. Because product inside may be over dirt, wet or other reason cause discharge along surface, thus judge if circuit design inside product has problems of distance along surface or insulation insufficiency by hipot test.

Test method is operating DUT and under the status of all switches, link cables etc components are connected, add high voltage test to two test points for 60 seconds. Generally speaking high voltage is 1250V or 1500V, it is different by rated voltage and insulation type. Figure 1 is 2-wire or 3-wire power test.

Hipot test is the most important one in safety test, the product pass hipot test mostly can protect consumer from electrical hazards under the general using condition. Thus, the design and production terminals are all accepted strict hipot test then can reach safety standard.

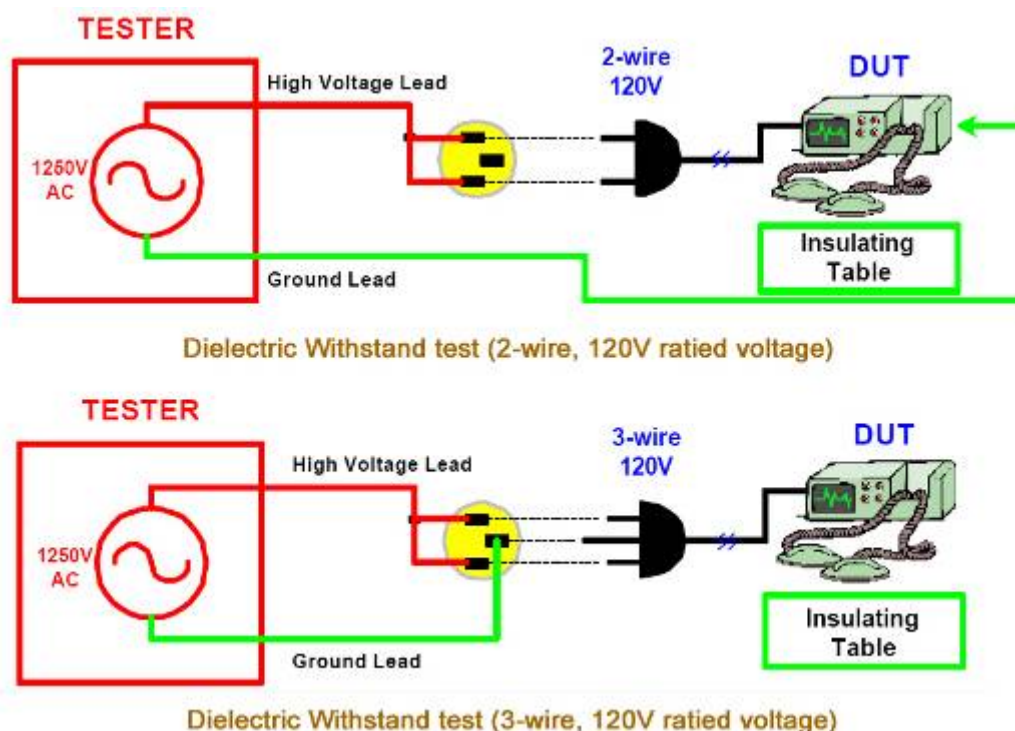


Figure 1 2-wire or 3-wire Power Test

3.1.1 AC/DC Hipot Test

Test power is DC or AC dependent on power source of DUT using, DC hipot test can replace AC hipot test, test voltage of DC is 1.414 times of AC, but we suggest you based on voltage output of product design. AC hipot test is destructive test, partly manufacturers increase voltage for saving test time. About this part, safety doesn't regulate definitely the formula for converting, this only judge by manufacturer after several times test.

AC hipot test usually doesn't need too long ramp time and fall time. Please notice that may has difference between total current and real current cause by partly internal capacitive reactance(figure 2). The current is outputting, if capacitive reactance is higher and reactive is higher, this makes real current lower relatively. If the user can't measure output current accurately, it will cause a blind spot in testing.

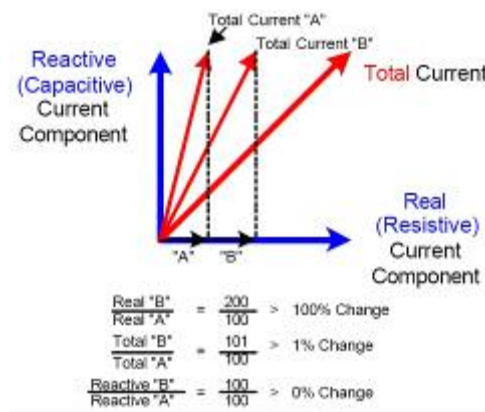


Figure 2 Real and Reactive Current

DC hipot test usually need to add ramp time and fall time, because mostly DUTs are with capacitance and causes charging current generated(figure 3). For charging current steady, ramp time is needed for buffering then leakage current won't over high because of charge current and judge as FAIL. The more DUT capacitance, the more ramp time. During ramp time period can simulate judge whether breakdown or flashover is occurred.

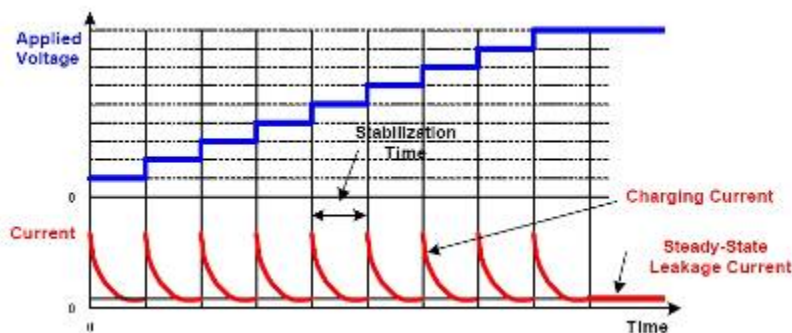


Figure 3 Ramp Voltage and Charge Current

Because DC hipot test will cause DUT discharge, thus need a period of time for discharging after hipot test is ended. A fine hipot test equipment will decrease fall time to the minimum and mark danger warning before reaching discharge standard for protecting the testers from electrical shock.

3.1.2 ARC Test

Obviously indicate that can't occur breakdown in safety standard and partly safety standard request can't occur Flashover/ARC (figure 4), and without definite test standard. ARC belongs to a kind of electrical discharge, when ARC occurred it means insulation capability insufficient. If ARC occurred several times then it will result in breakdown. ARC occurred may be within 10 μ s, thus resolution and sensitivity of ARC judgement will influence the test result.

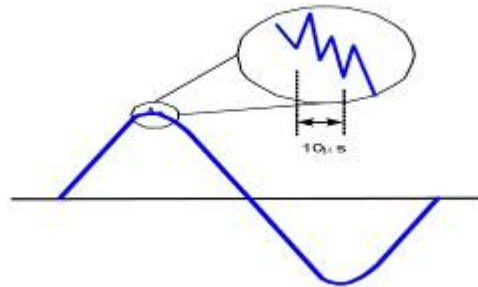


Figure 4 Flashover/ARC

3.1.3 Load Regulation

The standard of test voltage is the mainly factor for judging good product in hipot test. A lot of hipot test equipment convert low voltage into high voltage by transformer then output it, but internal impedance of instrument will cause divider especially in some bad quality hipot test equipment, its actual output voltage can't reach safety standard. For avoiding error to judge as good product and cause unnecessary trouble, fine hipot test equipment will auto gain compensation to modify and compensate voltage to needed voltage value and design the voltmeter on the output terminal for measuring accurately whether output voltage is insufficient.

3.1.4 DUT Load Regulation

When the resistance (load) inside DUT is over low it also happened the similar condition, drop voltage will be direct proportion with the time of the current through DUT. Especially when change different DUTs to notice if drop voltage condition is occurred. This condition can also be regulated by the method of Auto Gain Compensation.

3.1.5 Line Regulation

The various safeties request the test equipment with the standard sine wave output but the older test equipment causes waveform distortion after boosted, however happens surge or several times transient current on the waveform of voltage. The excellent hipot test equipment of nowadays reduces the occurred of waveform distortion by electronic control, zero start and ramp voltage, thus meets to the safety test standard actually.

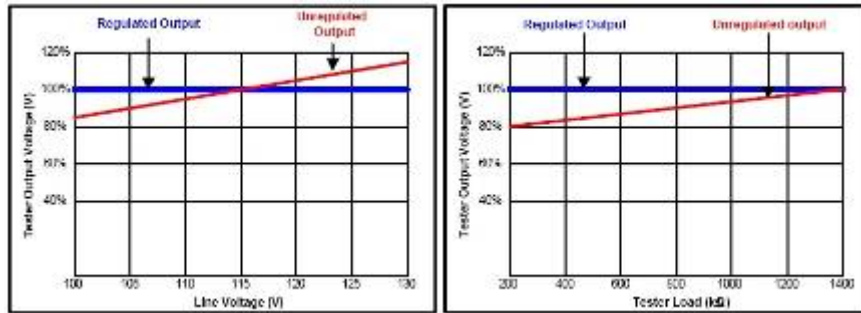


Figure 5 Line Regulation and Load Regulation

3.1.6 Ramp Voltage Design

The design of ramp time is not only for resolving the condition of charge current but also for avoiding the damage of DUT inner component causes by insulation destruction as hipot testing. Otherwise users are by the method of multi-ramp to analyze the insulation capability of DUT.

3.1.7 Hipot Test 500VA

The writing of safety standard is mainly based on technology and test equipment of manufacturer at that time. In recent years, many safety standards can't reach the steps of technology fast progress, the most obviously example is 500VA hipot test. Many years ago when hipot test appear, the mainly voltage source combination was by transformer or autotransformer. The transformer step voltage up to several thousands volt then adjust to test voltage by autotransformer.

The most serious defect of this method is AC voltage source changing and output voltage changing correspondingly. For offset this defect the manufacturer increases test voltage above 20% as testing to compensate the voltage. Another defect is the leakage current value inside transformer it also will affect the voltage value of output. For decreasing the change of voltage value and then increase the output power to 500VA, because the higher of output power and the lower affect on the leakage current value inside transformer. The merit of 500VA design is for more different power products to progress safety test. However partly safety standards have descriptions, if there is voltmeter measuring on output terminal of voltage keeps test voltage on standard value and outside of the limit.

The design of excellent hipot test equipment of nowadays keeps the stable of test voltage by digital design, line regulation and load regulation. The real time test voltage by digital display thus it is over the purpose of 500VA test requirement and reaches more accurate measurement and display. Another one hidden worry of 500VA test equipment is safety consideration for operating personnel, the more power supply and the more danger of operating personnel thus the related precaution and protection circuit will become another important lesson.

3.2 Ground Protection Test

Ground protection consists of two kinds of test method: Ground Continuity test (GC) and Ground Bond test (GB). The purpose of ground protection test is for protecting users from electrical hazards as touching equipment when unsuitable current is created and flows to the earth. Thus, it is necessary to measure if between DUT accessible part and E terminal of power exist over high resistance value or load capacitance insufficiency

The test method of ground continuity is from power terminal to input 1 ampere DC current for confirm the resistance value between two ends lower than 1Ω . Ground bond test is from power terminal to input 25A or 1.5 times rated current, select the higher one (50/60Hz) the standard of resistance values mostly are lower than $100m\Omega$. Various safety standards are with different test multiples, some are 2 multiples of current and have different conditions for setting. For example, when DUT is with 5A/220V rated fuse to select test current value by rated current of fuse.

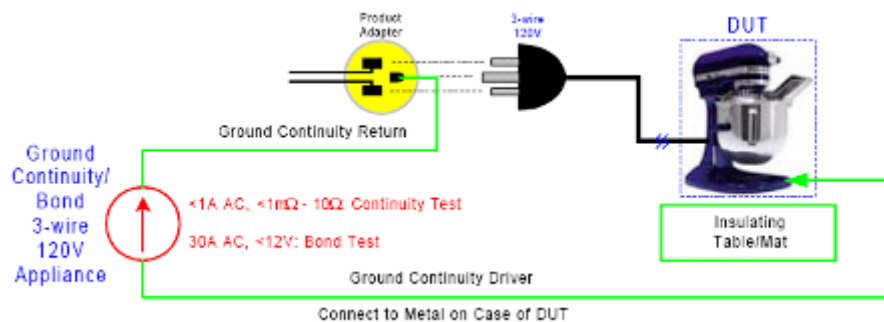


Figure 6 Ground Continuity test (GC)

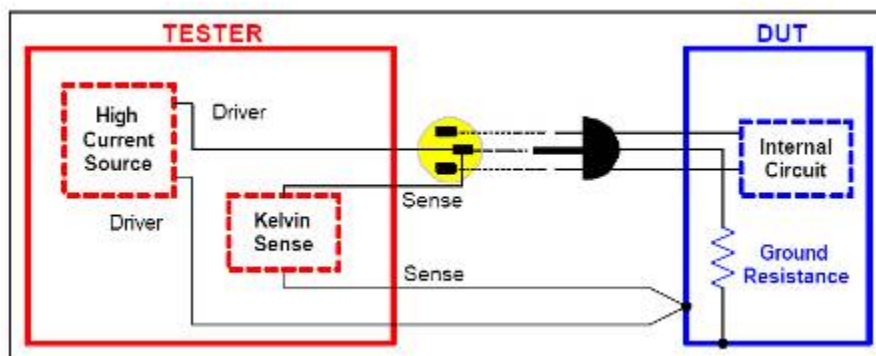


Figure 7 Ground Bond test (GB)

3.3 Insulation Resistance Test

Insulation resistance test and DC withstand test are very similarity, apply DC voltage (50~1000V) to two points of connecting for judging good and no good product. Generally speaking, test voltage is 500V or 1000V the insulation resistance value can't lower than $10M\Omega$. Insulation resistance test is nondestructive test and can detect if insulation is good. In some regulation, do insulation resistance test firstly then withstand test. When insulation resistance test can't pass usually withstand voltage test also can't pass.

The standard insulation resistance test is divided into four steps: Charge, DWELL, Test and Discharge. Charge and discharge are mentioned in previous, all DC related tests are with charge/discharge subjects.

3.4 Leakage Current Test

The current is brimmed over as flowing through insulation impedance we called it leakage current, contact by human body and the current through human body flow to Earth then electrical damage is occurred. The difference between leakage current test, withstanding voltage test and grounding protection test is equipment testing under running status. The leakage current adds a human body simulation impedance circuit in testing, it can simulate the quantity of leakage current through human body under real condition.

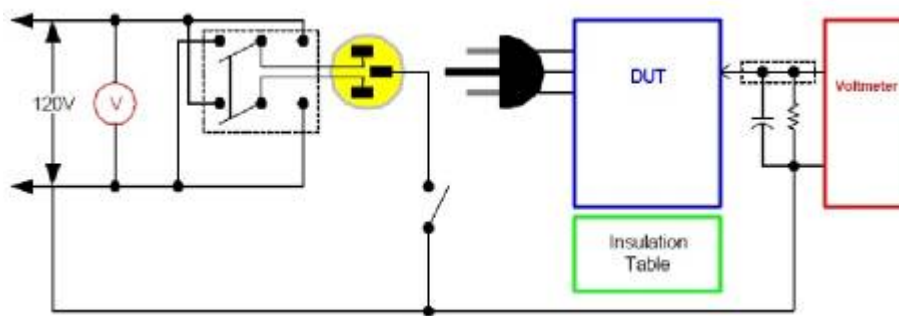


Figure 8 Earth Leakage Current (IEC60601-1)

Whatever national standard regulation or region standard regulation, the standard of leakage current is different by the insulation types of products. “CLASS I, II, III” are mainly in consideration of the insulation system of product which derived from IEC system, brief descriptions are as below:

- CLASS I indicates anti-shock protection of product not only depends on basic insulation but also includes grounding method.
- CLASS II indicates anti-shock protection of product not only depends on basic insulation but also includes additional precaution. For example double or reinforce insulation but without grounding or installation condition for relying precaution.
- CLASS III indicates anti-shock protection of product depends on power voltage is safety extra-low voltage (SELV) and it don't generate danger voltage.

“CLASS2” consider about current and energy are derived from Canadian Electrical Code Part I. The circuit voltage is divided into four ranges of 0-20 V, 20-30 V, 30-60 V and 60-150 V. Every range has concrete current and energy quantity requirement. If the circuit confirms as CLASS 2 users can decrease a lot of accessory requirements for using this circuit to reach the purpose of saving cost. Apply to product standards of CAN/CSA C22.2 No.223 (ELV, CLASS 2 output power adapter) and CAN/CSA C22.2 No.950 (computer information product) concretely. For reaching the requirement of CLASS2 circuit users can adopt the following methods to limit current of circuit.

- By using the resistance of transformer to limit (after short circuit for one minute the current down to below requirement value).
- By using overcurrent protection device to limit (use appropriate specification fuse to cut circuit).
- By using electronic circuit protection method to limit (auto limit the current below regulation value under normal or abnormal status).

IEC60601-1 divides into two types of CLASS I and CLASS II.

- CLASS I: Apply basic insulation mode for avoiding the damage of electrical, it is a plug of three-wire (power terminal). Connecting the inductive outer components by Protect Earth, lead the mostly leakage current to earth. Thus, the majority of CLASS I product, the allowable value of leakage current is higher. If the protect earth is fixed mode and the limit of leakage current is also difference.

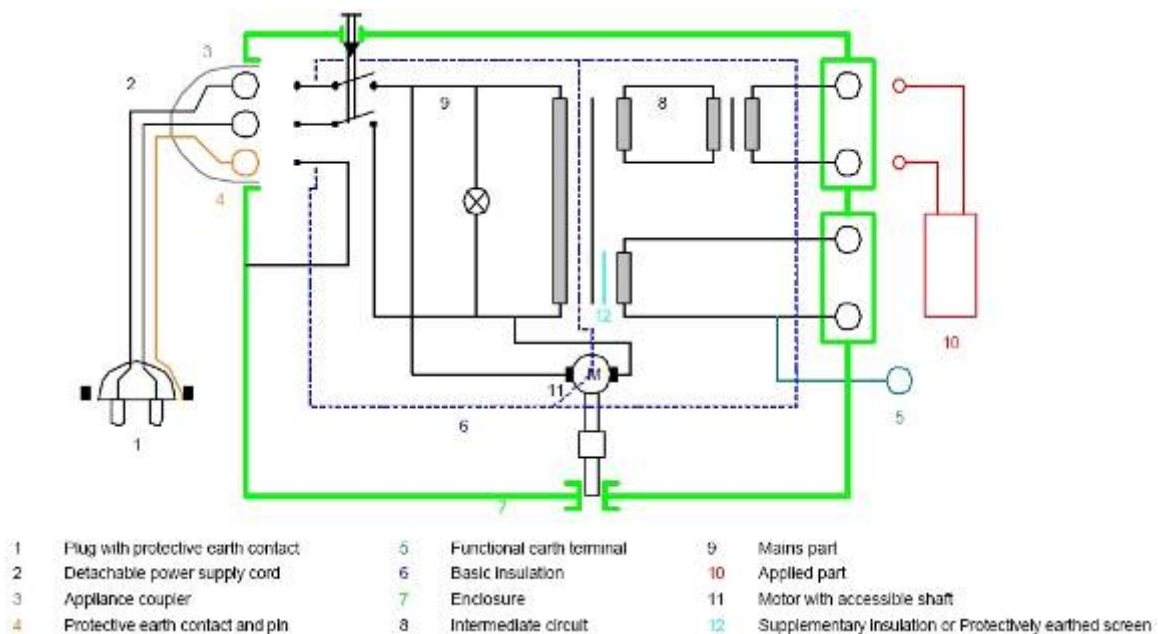


Figure 9 CLASS I equipment

- CLASS II: This is a product of two-wire power terminal. Because there is no protect earth can expel the leakage current out, so except for the basic insulation to add supplemental insulation, double insulation or reinforce insulation. Moreover, the allowable value of leakage current is stricter.

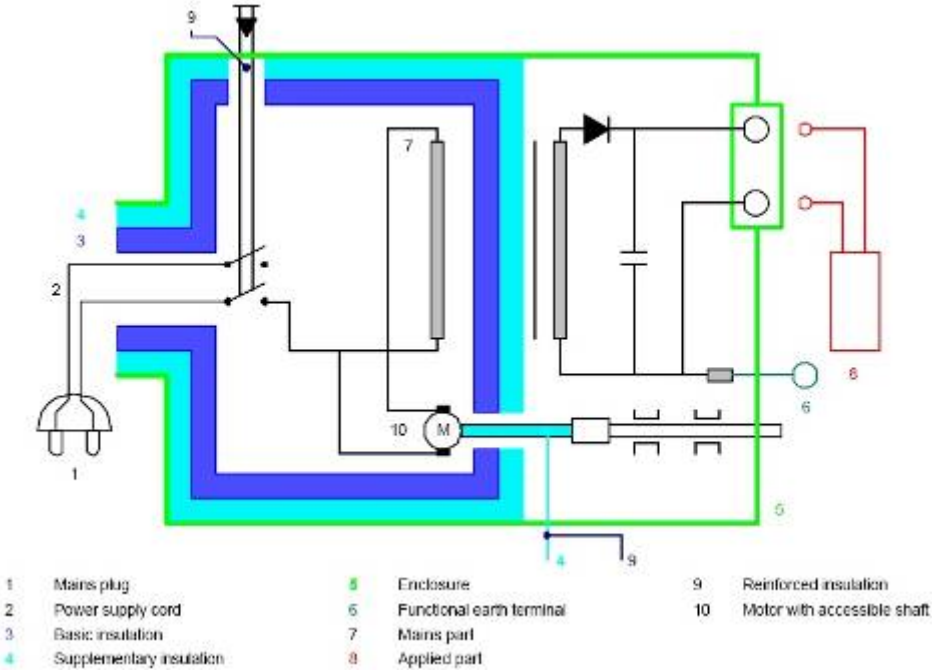


Figure 10 CLASS II equipment

The leakage current testing is for protecting users safety, IEC 479-1(the effect of current to human being and livestock – the general effect) through voltage, current, frequency and human body impedance alternative test and comparison to know human body impedance is about 61MΩ under the voltage of 25V, thus mostly of human body simulation circuit standard is by 50MΩ. When the contact voltage is more than about AC 50V, total impedance of human body has great change (43MΩ). The influence of leakage current to human body is different by various using methods and environments.

The leakage current with different test mode by various safeties and different leakage current standard by various test point. The most often seen is that the current flows through DUT to E terminal of power, the human body touches E terminal of product will cause induction we called it earth leakage current. When earth leakage current is testing input 110% rated voltage to add human simulation circuit and judge if the current value of flowing through human simulation circuit is over the limit value of leakage current. In addition, there are Patient Leakage Current, Patient Auxiliary Leakage Current and etc leakage tests.

4. Test Equipment and Operating Safety

4.1 Test Environment

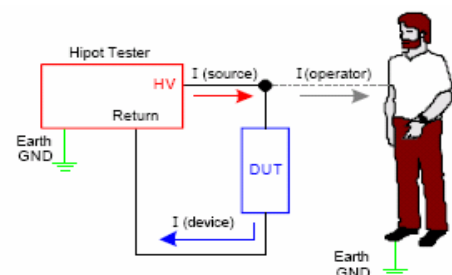
In Europe, the safety for manufacturers and test personnel of laboratory had performed for many years. The manufacturers and test personnel of electronic appliances, technology product, household appliances, mechanical tool or miscellaneous equipment, there is chapter to regulate in various safety regulations. The contents of UL, IEC and EN include grounding status of test area marking (personnel, instrument and DUT position), equipment marking (marked with “dangerous” specifically or the item in testing), equipment worktable and etc and electrical insulation capability of various test equipment (IEC 61010).

These articles are just appended to various regulations users can't manage them unitarily, thus European Community had issued EN50191 appropriate for EC on 2000. We can feel Europe pay much attention to local test personnel, this standard became the superior standard in European Community on October 1, 2002. The current domestic standards conflict with EN50191 will be withdrawn. The standard of EN50191: 2000 are mainly to regulate five types of test workstation: Test workstation with auto protection function, test workstation without auto protection function, test laboratory, experiment worktable and temporary test workstation.

The standard of EN50191 requests factory test area should be separated from the general work area and channel by barrier to protect non-testing personnel from touching dangerous test area. The distance and height of barrier are different by various test voltage. Only personnel with the test technical can work in the test area and set warning mark and signal LED for display the condition of test area to protect the safety of test personnel by the method of fixture or remote control.

In high voltage test area or equipment in testing its operating voltage is above 1000 volt, this standard is still with additional regulation. If the workstation connection is by other methods or isolation is by rack then to judge the standard by the entire condition (the mainly judgment of safety standard is by accessible and exposed parts).

EN50191 also indicates that test equipment is equipped with auto interrupt device so that develops into Ground Fault Interrupt (GFI) function. When the current meter detect the difference between the value and actual test current over high, this device can cut the power transiently for protecting human body safety. It is not only accordingly to the safety standard but also more safeguards for test personnel.



4.2 Test Equipment

Almost all of DUTs are equipped with capacitance and occurred charge condition when DC tests. For avoiding test personnel electrical hazard is occurred, it is necessary to discharge to regulation voltage value when test is ended. However, the higher of capacitance and the

longer of discharge time it affects the smooth of production directly. The excellent safety test equipment is equipped with reliable and fast discharge circuit for the manufacturers bring the efficiency of economy.

Like as the general electrical products the output protection of test equipment also needs to focus on IEC 379-1 to decrease the energy after discharge to AC 50V for guarding the users' safety. The excellent safety test equipment will offer interlock function or remote control interface to optional accessory or fixture for operator away from high voltage area to avoid the hazards when operating equipment.

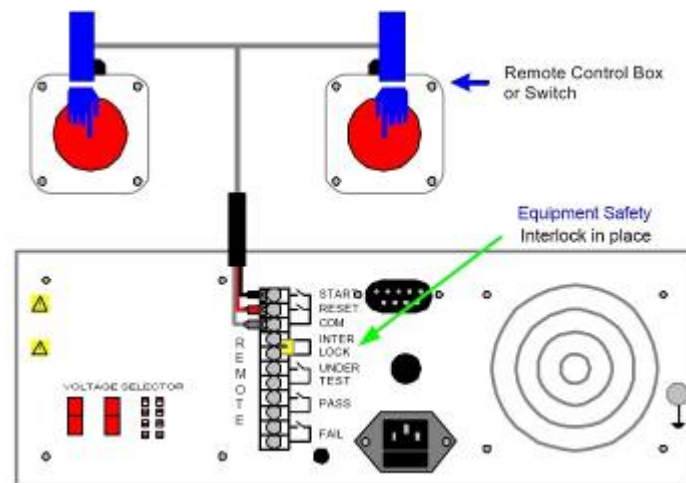


Figure 11 Remote Control Fixture

4.3 Test Connection

It may occur DUT no contact or bad contact condition during test procedure, especially in production line of emphasizing efficiency occurs more easily. The DUTs which are no contact, bad contact, test line damage or short circuit will judge no good product as good product or damage the equipment then cause the unnecessary risk cost. Thus, a lot of safety test equipment will judge if there is bad contact by low limit or high limit of current, this method interference factor too much so can't judge effectively. The excellent safety test equipment filter short circuit DUT or judge circuit bad contact by more accurate judgment method to save the production cost of manufacturers.

4.4 Training and Operation Notice Item for Personnel

All personnel of operating test equipment need to accept basic electronic theory training to realize the effect of current on human body and how to avoid electrical shock, familiar with test environment and precaution for emergency condition occurred. Some test equipments are with interlock function to prevent improper operation. When the personnel realize the previous described items then to explain operation procedure and test purpose about the condition of no good product and test fail occurred. Since the safety tests mostly are high voltage or mass current test, the test personnel should be pay attention to the below items particularly.

- Don't put down or take off the DUT except for confirm the warning LED on equipment indicates no output status.
- Don't touch DUT or test equipment during test period.
- When the test personnel using connection cable or fixture for connecting, earth wire is the first priority.
- Don't touch the high voltage output terminal whether the equipment is in testing or not, the personnel only can touch the part of insulation.
- Use the test equipment is with interlock function possibly.
- Confirm all connection points are connected exactly.
- Keep the neat and clean of test environment and avoid the tangled of test wire.
- Follows Standard Operation Procedure (SOP) to operate.
- Confirm the various setting values before testing and check if ruined on test cable.
- It is necessary to turn off power after the test is completed, DUT needs to wait discharge over.

5. Safety Test Equipment

5.1 How to Select the Correct Safety Test Equipment

The first step to select safety test equipment is to realize your basic requirement, it may be the safety standard your company product need to accord. The test is for promoting product function requirement and consideration of cost and efficiency. The excellent safety test equipment is not only in accordance with related safety standard of test equipment but also reach correct and efficiency test for test item, test output range and requirement of various products. The below table introduce the general often seen test function and other additional tests and functions.

General Test Function		
Withstanding test	Almost all of electrical products need to pass this test.	
Ground bond test	Includes information product, medical equipment, audio, video equipment, test equipment, household appliances and etc.	
Ground continuity test	Includes heater, dryer, cooking appliance and etc.	
Insulation resistance test	Heater, motor and etc.	
Leakage current test	Mainly is medical equipment.	
Additional Test and Function		
Operation	Detection and Judgment	Others
Programmable output	Current detection range and resolution higher	Calibration and related technical service.
Programmable charge/discharge time	Voltage compensation function	Fixture function connection
Be able to save and call used test procedure	ARC detection function	Adaptable for various manufacture environment
Operation easily user-friendly	Hardware protection function	With audio/video warning
Front panel interlock function	GFI human body protection function	Interlock
Continuity test, long period test	Bad contact judgment	With the judgment of bad contact or connection.
	Transmission interface	

Table 2 The General Test Function and Other Additional Tests and Functions

5.2 Auxiliary Accessory, Fixture and Software

Auxiliary accessory, fixture and software control of laboratory, production line can promote test efficiency, like as high voltage gun, air power equipment and remote control box can direct control trigger by interface of test equipment or control by interlock. It is not only decrease electrical shock to personnel but also increase the efficiency of production line automation.



6. Industry Application

6.1 Transformer Test

The withstanding voltage test of transformer includes the withstanding voltage of primary and secondary, the withstanding voltage of primary and ground, the withstanding voltage of secondary and ground, layer short circuit test of primary and secondary coils and leakage current test of primary, secondary and ground. If the transformer is with several primary or secondary coils, test procedure will be very complicated. Thus the personnel of research department should be notice if transformer meets to the related regulation of safety standard in the beginning of product design and also need to consider about test efficiency and cost in producing

For example this transformer need to accord with the regulation of medical equipment if it is using on the medical equipment. The safety test of medical equipment includes low leakage current test and withstanding test different from other product safety. Its test voltage is up to 4KV and need to test mutually for all test points. Meanwhile, the first important choice to save cost is safety test equipment with scan function. Transformer is also with several special safety standards, refer the below table.

Standard	Description
UL 506	Standard for Specialty Transformers
UL 1411	Standard for Transformers and Motor Transformers for Use in Audio-, Radio-, and Television-Type Appliances
UL 1876	Standard for Isolating Signal and Feedback Transformers for Use in Electronic Equipment

Table 3 Transformer Special Safety Standard

6.2 Generator/Motor Test

The insulation resistance test standards of generator and motor are different by various reference temperatures. The curve diagram of temperature and resistance is appended in the standard. In addition, motor also belongs to a kind of winding equipment, it need to progress withstanding, layer short circuit and DCR test in various coils.

6.3 Component Test

Component test application includes capacitance, coil, core, choke and EMI FILTER all need to pass withstanding test.

6.4 Non-electronic Product Test

Non-electronic product test includes withstanding and insulation resistance test of wire, nonwoven and etc.

6.5 Appliance Product Test

Appliance product includes household appliance, information product and video/audio appliance. These products contact with end consumer frequently, thus test items include withstanding test, ground resistance test and leakage current test. The safety standard often seen lists in appendix A.

6.6 Medical Equipment Test

The safety standard of medical equipment is the strictest standard. Because medical equipment contact with patient for long time so occurred percentage of electrical shock and level of damage are higher. Therefore, leakage current test detailed divides into three items of ground, patient and patient auxiliary leakage current except for withstanding and ground resistance tests. The standard of leakage current is stricter than the general appliances.

7. Best Appliance for Safety Test

7.1 Full Function Safety Analyzer - Chroma 19032

The 19032 is a 5 in 1 Production Safety Analyzer. It can perform AC/DC Hipot, insulation resistance, grounding resistance and dynamic leakage current (option) 5 safety test functions for electronic products. The dynamic leakage current scan device can be connected externally or built in to 19032. It can support leakage current test of information product, medical equipment and etc. It is capable of measuring the complicate safety requirements with easy installation and operation, and is the finest electronic safety analyzer to increase production test efficiency. Model 19032 has Twin-Port™ to minimize the test time greatly; along with the super large screen display and intelligent operation mode, 19032 is the most powerful single unit for electronic safety analyzer.

- Five instruments in one: AC Hipot, DC Hipot, insulation resistance, ground bond and dynamic leakage current (Option)
- Meet UL, CSA, TUV, VDE, CE safety test requirements
- Twin-Port™ function (Patent)
- Programmable output voltage to 5kV AC and 6kV DC and trip current programmable to 40mA AC and 12mA DC.
- Insulation resistance to 50GΩ/1000V DC
- Ground bond up to 30A (Option up to 40A)
- Open/Short Check
- Password protected front panel lockout
- Storage of 50 tests setups with 100 steps per setup
- Optional dynamic HV leakage current auto scanning (A190305/A190306/A190307)
- Standard RS-232 interface, optional GPIB, PRINTER, SCANNER interface



7.2 Wound Component Scanner – 19035

Chroma 19035 is a production safety tester designed for test requirements of motor, transformer and heater related wound components. Mostly wound components have multiple winding such as three-phase motor, double-wound transformer and etc, and wound component using wound component pulse tester for HV winding to detect winding insulation no good.

- Four instruments in one: AC Hipot, DC Hipot, insulation resistance, DC resistance
- Meet UL, CSA, TUV, VDE, CE safety test requirements
- Programmable output voltage to 5kV AC and 6kV DC and trip current programmable to 30mA AC and 10mA DC
- Insulation resistance to 50GΩ/5KV DC
- Built-in 8 channel scanner
- ARC detection
- Open/Short Check (OSC)
- Storage of 20 tests setups with 50 steps per setup
- Standard RS-232 interface and optional GPIB interface
- Capable of connecting wound component pulse tester



7.3 Multiple Function and Scan Hipot Tester – Chroma

1905x

The Chroma Hipot Tester 19050 series provide 3 models for choice. The 19052 for AC/DC/IR Hipot testing and insulation resistance (IR) measurements, the 19053 which combines both AC and DC Hipot tests and IR measurements with 8HV scan channel capability into a single compact unit, and the 19054 which combines both AC and DC Hipot tests and IR measurements with 4HV scan channel capability into a single compact unit.

- 3 in 1 Tester: AC, DC, IR
- Meet UL, CSA, TUV, VDE, CE safety test requirements (19052/19054)
- Programmable output voltage to 5kV AC and 6kV DC and trip current programmable to 30mA AC and 10mA DC
- Insulation resistance to 50G Ω /1000V DC
- Built-in HV scanner (19053/8 channel, 19054/4 channel)
- ARC detection
- Open/Short Check
- Storage of 50 tests setups with 100 steps per setup
- Fast cutoff time: 0.4ms, fast discharge time: 0.2sec
- Optional transformer test fixture (19053)
- Standard RS-232 interface and optional GPIB, PRINTER interface



7.4 Easy to Use Hipot Tester – Chroma 1907x

Chroma 19070 series are the smallest Hipot Testers currently available in the world. Its super mini size is easy to carry and the large LCD display is suitable for viewing measurement results. These sophisticated Hipot Testers are most applicable to safety test for electronic components.

- Compact size Hipot tester
- Three instruments in one: AC Hipot, DC Hipot, Insulation Resistance (19073)
- Meet UL, CSA, TUV, VDE, CE safety test requirements
- Fast cut-off: 0.4 ms, fast discharge: within 0.2 sec
- Open/Short Check (OSC)
- Provide reliable and stable test results
- Storage of 10 Tests Setups with 100 Steps per setup
- Compatible with the model 19572 Ground Bond Tester



7.5 Ground Bond Tester – Chroma 19572

The 19572 is an instrument dedicated to measure the grounding resistance within the range of 10~510mΩ and AC current output up to 45A. Its compact and easy to operate feature is most suitable for the grounding test in production line. By supplying high reliability and stability test results with built-in resistance compensate function; it is an economical and useful grounding tester.

- High performance AC current output: 45 A
- Wide resistance measurement range: 10 ~ 510mΩ
- Meet UL, CSA, TUV, VDE, CE safety test requirements
- Compact size and easy to operate
- Provide reliable and stable test results
- Built-in resistance compensation function
- Standard RS-232 interface
- Compatible with the model 19070 series Hipot Tester



7.6 High Power Hipot Tester – 9012

The 9012 is a High Power Hipot Tester that combines AC Hipot, DC Hipot, and insulation resistance three functions to one. It has ARC detection and safety protection functions as well as 50 sets of memory with 10 steps in each to reduce the repetitive operation settings and enhance the test speed. Being useful to the fundamental components factory, SPS production and quality assurance, it is an economical and practical Hipot tester and meet the test regulation of EN60065.

- 3 in 1 Tester : AC, DC, IR
- Meet UL, CSA, TUV, VDE, CE safety test requirements
- DC Output: 6kV / 20mA, AC Output: 5kV / 100mA
- ARC Detection Function
- Fast cut-off time: 0.4 ms, fast discharge time: within 0.2 sec
- 50 internal instrument setups with 10 steps per setup
- Programmable voltage ramp time
- Standard RS-232 interface and optional GPIB, RS422, PRINTER, SCANNER Interface



7.7 10KV, 20KV Hipot Tester – 9056, 9056-20KV

The 9055/9056/9056-20kV are the Hipot Testers in super high voltage series. It is suitable for electronic products hi-pot test with super high voltage output. 9055 and 9056 are able to supply 10kV and 12kV/10mA output power, while 9056-20kV can supply super output power up to 20kV/5mA. Working with the optional 8 sets high voltage scanner box (A190301), it can perform super high voltage transformer safety test and is the best selection for super high voltage output safety test.

- Programmable output voltage to 10kV ac (9055 only)
- Programmable output voltage to 12kV dc (9056 only) and 20kV dc (9056-20kV only)
- 50 internal instrument setups with 10 steps per setup
- Key lock & test data protection
- Optional 8 channels scanner (AC: 5kV max.)
- Standard RS-232 interface
- Optional GPIB, SCANNER, RS-422, PRINTER Interface

7.8 Hipot Calibrator – 9102

The 9102 Hipot Calibrator can simulate multiple loads and apply to various safety measurement parameters which consists AC/DC voltage, current, grounding resistance and insulation resistance. It can reduce manufacturers a great deal of regular calibration fee.

- Adequate for versatile testers
- Precise designed standard calibration kit
- Compact size and easy to operate
- Standard GPIB interface



Appendix A

Safety Information Website

UL	www.ul.com	American Underwriters Laboratories Recognized Administration
ANSI	www.ansi.org	American National Standards Institute
BSI	www.bsi.org.uk	British Standards
CENELEC	www.cenelec.org	European Committee for Electrotechnical
CSA	www.csa.ca	Canadian Standards Association
VDE	www.vde.de	Germany Electronic Electrical Information Association
IEC	www.iec.ch	International Electrotechnical Commission
JSA	www.jsa.or.jp	Japanese Standards Association
IEEE	www.ieee.org	American Institute of Electrical and Electronics Engineers, Inc.
ISO	www.iso.ch	International Organization for Standardization
OSHA	www.osha.gov	American Occupational Safety & Health Administration
TUV	www.tuv.com	German TUV Recognized Administration
CCC	www.cccn.org.cn	People's Republic of China Enforced Product Recognized Center
NSSN	www.nssn.org	National Resource for Global Standards
BSMI	www.bsmi.gov.tw	Bureau of Standards, Metrology & Inspection, MOEA, R.O.C
Chroma	www.chromaate.com	Chroma ATE INC.

Appendix B

General Electrical Safety Test Standard (Actual Standard Mainly by Regulation)

Safety Standard		Hipot Test			Grounding Resistance Test			
Product Type	Regulation No.	Test Voltage (Product Voltage 250VAC)	MAX. CURRENT (Amps)	Test Time (sec)	TEST CURRENT	VOLTAGE HIGH LIMIT	Max. Resistance Value (ohm)	Test Time (sec)
Information Product	UL 1950	1500VAC or 2121VDC	No Flashover or Breakdown				0.1	60
	CSA C22.2 No.950	1500VAC or 2121VDC	No Flashover or Breakdown				0.1	12
	EN 60950	1500VAC or 2121VDC	No Flashover or Breakdown				0.1	12
Medical Equipment	UL 2601-1	1500VAC or 2121VDC	No Flashover or Breakdown				0.1	5
	CSA C22.2 No.601.1	1500VAC or 2121VDC	No Flashover or Breakdown				0.1	5
	EN 60601-1	1500VAC or 2121VDC	No Flashover or Breakdown				0.1	5
	UL 544	1000+2*VAC (V<240)	No Flashover or Breakdown	60	25A	6VAC	0.1	5
		1000+240VAC	No Flashover or Breakdown	1				
	CSA C22.2 No.125	1500VAC or 2121VDC	No Flashover or Breakdown			12VAC or DC	0.1	12
Video/Audio Equipment	UL 1492	1080VAC or 1530VDC	No Flashover or Breakdown			12VAC	0.1	
	CSA C22.2 No.1	1000VAC or 1414VDC	No Flashover or Breakdown			12VAC or DC	0.1	12
	EN 60065	2120Vpk	No Flashover or Breakdown	60				
	CSA E65-94	2120Vpk	No Flashover or Breakdown	60	20A	12VAC	0.1	
	UL 6500	2120Vpk	No Flashover or Breakdown	60				
Equipment for Laboratory	UL 3101-1	1350VAC or 1900VDC	No Flashover or Breakdown	60	25A	12VAC or DC	0.1	60
Measurement Equipment	UL 3111-1	1350VAC or 1900VDC	No Flashover or Breakdown	60	25A	12VAC or DC	0.1	60
Laboratory Control, Measurement Equipment	CSA C22.2 No.1010-1	1350VAC or 1900VDC	No Flashover or Breakdown	60	25A	12VAC or DC	0.1	60
	EN 61010-1	1350VAC or 1900VDC	No Flashover or Breakdown	60	25A	12VAC or DC	0.1	60
Industry Control	CSA C22.2 No.14	1000V+2* Max rated V	No Flashover or Breakdown	60	30A	12VAC or DC	0.1	60
Household Appliances	EN60335-1	1000VAC	No Flashover or Breakdown	60	25A	12VAC or DC	0.1	60
Motor Household Food Process Appliance	UL 982	1000VAC for <1.2hp	No Flashover or Breakdown	60				
		or 1200VAC		1				
		1000VAC+2*rated V for <1/2hp	No Flashover or Breakdown	60				

Safety Standard		Hipot Test			Grounding Resistance Test			
Product Type	Regulation No.	Test Voltage (Product Voltage 250VAC)	MAX. CURRENT (Amps)	Test Time (sec)	TEST CURRENT	VOLTAGE HIGH LIMIT	Max. Resistance Value (ohm)	Test Time (sec)
		or 1200VAC+2*rated V for <1/2hp		1				
		Electric knives and wand mixers 2250VAC	No Flashover or Breakdown	60				
		or 2500VAC	No Flashover or Breakdown	1				
	CSA C22.2 No.195	1000VAC	No Flashover or Breakdown	60	30A	12VAC or DC	0.1	12
Cooking and Liquid Heater	CSA C22.2 No.64	1000VAC	No Flashover or Breakdown	60	30A	12VAC or DC	0.1	12
Portable Appliance	CSA C22.2 No.71.1	1000VAC+2*rated V	No Flashover or Breakdown	60	30A	12VAC or DC	0.1	12
Electronic Motor	UL 1004	1000VAC for <1.2hp	No Flashover or Breakdown	60				
		or 1200VAC		1				
		1000VAC+2*rated V for <1/2hp	No Flashover or Breakdown	60				
		or 200VAC+2*rated V for <1/2hp		1				
Cooking and Food Process Appliance	UL 1026	1000VAC	No Flashover or Breakdown	60	GC test on production line.			
		or 1200VAC		1				
Vacuum Cleaner	UL 1017	1000VAC for <1.2hp	No Flashover or Breakdown	60	GC test on production line.			
		or 1200VAC		1				
		1000VAC+2*rated V for <1/2hp	No Flashover or Breakdown	60				
		or 1200VAC+2*rated V for <1/2hp		1				

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