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Electrical Safety Testing During Manufacture: A Practical Guide

Helping you ensure the electrical safety of your products. Every. Single. Day.

SEAWARD
TESTED, TRUSTED... WORLDWIDE.

Seaward: Making Your Life Easier and More Efficient

World-Leading Electrical Test Equipment from Seaward

At Seaward we have over three decades of experience in the design and manufacture of innovative electrical safety test equipment. Today, our first-class range of products serves a wide variety of testing and precision measurement applications.

For over 35 years, we have been constantly developing new technology to ensure our electrical safety testers are the benchmark for production line testing. Our test equipment has always been designed with the needs of our customers in mind, ensuring straightforward operation for test operators while offering the power of test sequence configuration and data capture to meet the demands of a modern production environment.

Safety and efficiency in the workplace is of paramount importance, and our testers provide the quick and effective key to aiding in the creation of a safe working environment. That's why a Seaward production tester is backed by a huge range of accessories, including safety beacons, test management software, and fault verification checkers.

Peace of mind is guaranteed for our customers, because they know that help and advice is always available via our technical support team, and our UK on-site calibration team can help minimise the downtime of your equipment when any servicing or repairs are needed. We also have approved service partners available Worldwide.

HAL Series
Comprehensive Hipot Testers

On-board Storage

Large memory for test result storage with the capability to add a product reference for traceability

Test Sequences

Fully configurable automatic test sequences to improve your efficiency reducing user interaction

Full Suite of Tests

The HAL performs many tests including Ground Bond, AC & DC hipot, Insulation Resistance

Fully Compliant

Tests to IEC/EN 60950, IEC/EN 61010, BS EN 60335-1, BS EN 60598 and BS EN 60745, and many others.

The HAL Series combines over 50 years of expertise in ensuring the electrical safety of manufactured electrical products.

These feature packed comprehensive safety testers offer outstanding levels of flexibility and functionality to dramatically improve the quality and productivity of production line safety testing and are ideal for any electrical or lighting manufacturer.

Find out more about the HAL at **seaward.com/HAL**

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Contents

Definition of Terms

Device Under Test (DUT)
The product, or item, that is being subjected to an electrical safety test.

Alternating Current (AC)
A repeated cyclic waveform, where the magnitude of current increases over time to a maximum, drops to zero and then is reversed in the opposite direction. The cycle is measured as how many times it repeats per second in Hertz (Hz). For example, in the UK the AC voltage supplied to the home has 50 Hz as this cycle is repeated 50 times per second. An AC waveform would appear as below.

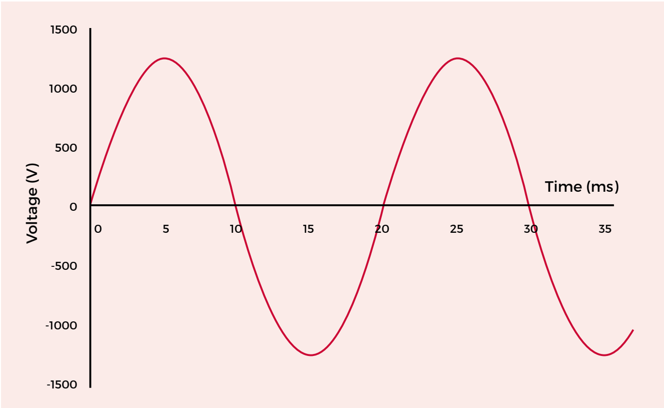

Figure 1. 50Hz AC waveform

Direct Current (DC)
A continuous flow of electric current in one direction, generally positive (+) to negative (-). The polarity of DC current cannot be changed once flowing but the magnitude of the current can be increased. This kind of current is typical of that supplied from a battery.

Conductor
Any material which allows the flow of current, for example line, neutral and earth cables.

Insulation
A material that does not allow a flow of current. Insulation is therefore used to create a barrier between conductive parts and parts what can be touched. Insulation can also be referred to as a dielectric, being designed to isolate two conductive parts.

Breakdown
Complete failure of the product under test's insulation, which results in high levels of current flow.

Flashover
A flashover is an electric discharge over or around the surface of an insulator, and is indicative of failing insulation.

Trip / Trip Current
The level of current flow allowed when performing a dielectric withstand test, once the level has been reached, the test voltage is inhibited and the instrument will issue a fail condition.

Residual Current Device (RCD)
These devices disconnect an electrical circuit when it detects that the current is not balanced between an energized (line) conductor(s) and the return neutral conductor. In normal circumstances, these two wires are expected to carry matching currents, and any difference usually indicates that there is an adverse amount of current flow to earth. RCD devices are designed to trip usually in sub 300ms to reduce the exposure time.

Ground Fault Circuit Interrupter (GFCI)
See RCD definition.

The Benefits of Electrical Safety Testing

Performing electrical safety testing can offer many benefits to a manufacturer of electrical products, in the first instance completion of required tests to prove legislative compliance will allow products to be sold into the market.

With a routine testing schedule in place, a manufacturer can ensure that ultimately the end user will not come to harm when using the product.

This procedure, when combined with a record of the test can help protect against liability claims.

In addition, a comprehensive electrical safety test can highlight poor components, areas for improvement in manufacture and equipment operational status ensuring that the product was working safely and as intended prior to shipping. This can help reduce cost involved in the repair and replacement of expensive, “out of the box” failures.

Introduction to Standards

Legislation, such as the Low Voltage Directive, Machinery / Directives and Medical Directives, demand that safety testing is performed on all electrical products that are manufactured or repaired.

In addition, a number of independent and government product approval agencies require that this testing is performed and that records are kept for each product design and for each product manufactured. These organisations include:

- Underwriters Laboratories (UL)
- Canadian Standards Association (CSA)
- International Electrotechnical Commission (IEC)
- British Standards Institute (BSI)
- German Electrical Engineers Association (VDE)
- Technische Uberwachungs Verein (TUV)
- Japanese Standards Institute (JIS)

Within the European marketplace, these directives must be obeyed for a product to comply with the CE mark regulation. Relevant agency approval must also be attained before a product can display an agency safety marking logo. Without such approvals it can be illegal to offer the products for sale in the relevant territories.

To aid manufacturers to be compliant with such directives and approval, agency requirements, working groups containing industry experts, were created to ensure that a manufacturer could follow a best practice guide to safely design and manufacture their product.

These standards normally group types of product, for example lighting or household appliances, and define the parameters for the electrical safety tests.

In order to make the process of trade across the world easy, many of the standards became harmonized, i.e. proving that the product has been designed and manufactured in accordance with the standards will satisfy all approval agencies and directive requirements. However, there are still some standards in which testing regimes may differ.

Different Test Regimes: Type vs Routine

For a manufacturer of an electrical product, there are two main instances where a product should be subjected to an electrical safety test, these are known as type testing and routine testing.

Type Testing

The type test is performed under laboratory style conditions and is generally performed on a product that is still in prototype phase, this is sometimes referred to as R&D testing. This type of testing is performed to ensure compliance with the relevant standards in order to highlight any defects in the design of the product.

The type test is generally more arduous than a routine test, often subjecting the device under test to pro-longed withstand testing (it is normal for the voltage to be applied for a minute or longer).

Routine Testing

Routine testing, or production line testing, is a method of determining that the manufacturing process has not contributed to the safety of the DUT being compromised. It can also highlight potential supplier issues where components are not performing as expected.

Typically, for routine testing, the DUT is subjected to much shorter testing times, usually only for a few seconds. Tests in this category are normally performed on 100% of manufactured product, either on completion of the process or at a stage where further manufacturing processes cannot compromise the electrical safety of the DUT.

Understanding Electric Shock

Electric shock occurs when the human body is exposed to live voltage but there are three main factors that will determine the severity of the shock.

The higher the levels of current flow through the body the worse the shock, the below table highlights the physiological effects on the human body at levels of current exposure. Current, however, is not a danger on its own, a high current also requires enough voltage to be present to cross the skins insulation barrier to cause a problem.

Physiological effect	50Hz AC
Generally not perceptible	0.5mA
Threshold of perception, tingling sensation	1mA
Maximum “let go” current	5mA
Painful, can’t let go	10 - 20mA
Severe pain, muscular contraction, difficulty breathing	30mA
Possible Ventricular Fibrillation after 3s, death possible	0.1A
Skeletal muscle damage – death likely	1.5A

1. **The Path Through the Body**
   The path which the current flows through the body and the organs the current flows through will be a contributing factor in how severe the shock will be. Any situation where the current flows inside the body across the chest would be considered the worst case scenario. For example, right hand to left foot as this scenario has a high chance of effecting the normal function of the heart, which uses electrical signals to maintain its rhythm.

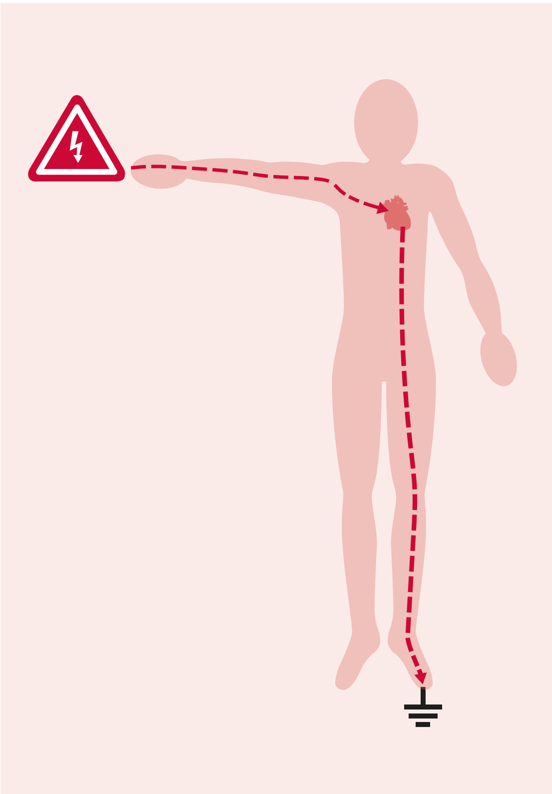

Figure 2- Path which current flows through the body; in this case from right hand to left foot

2. **The Exposure Time**
   The longer the body is exposed to current, the worse the physical damage will be. It is therefore important to consider methods of fast disconnection from the supply. Seaward testers inhibit the test voltage instantly the moment the trip current is reached, but the mains supply should have a method of fast disconnection to add a second layer of protection, such as an RCD.

3. **Competence and Training**
   Most, if not all, standards require that the operator performing the test is a 'competent person'. This phrase is fairly vague and difficult to define. Training and understanding of both the electrical concepts and use of the testing equipment is essential. Seaward recommend initial training for all test operatives and refresher training every two years to ensure operators are kept up to date with best practice and any changes to standards. While no specific training exists that is deemed to ensure an operative is 'competent' a certificate from Seaward is a big step in the right direction.

Electrical Safety Testing Do's and Don'ts

The following are a selection of do's and don'ts when performing electrical safety testing, Further explanation will be included in subsequent sections.

Do's	Don'ts
✔ Do ensure the Item is switched on (where possible) prior to testing	✘ Don't touch the item under test
✔ Do only test in a suitably insulated area	✘ Don't test on ESD flooring/tables
✔ Do wear suitable PPE	✘ Don't allow untrained personnel to enter the test area
✔ Do ensure the test equipment is verified regularly	✘ Don't test whilst wearing ESD clothing
✔ Do visually inspect test leads regularly	

Creating a Safe Working Environment

Along with proper guidance, one of the best ways to prevent an injury caused by electric shock is to create a safe working environment both for the operator and those who work in the vicinity of the test area.

When creating a safe working environment it is key to consider the following:

- How do we protect the test operative?
- How do we protect everyone else?

In order to answer these questions, standards such as EN50191 were created to guide in the creation of safe working environments for electrical testing. For full details please refer to our Guide to Setting Up and Operating Electrical Test Installations, available from **seaward.com/en50191**

There are a number of areas a manufacturer must review and take action if needed.

1. **The Test Bench**
   Consider using a non-conductive material, such as wood or plastic, for the construction of the test bench.

2. **The Test Floor**
   Consider installing rubber matting with a high voltage rating to create a barrier between the operative and ground.

> **Note:** Testing on any ESD surface is not recommended, by design ESD is designed to carry the test voltage to ground, rather than isolating it.

3. **The Test Area**
   Create a prohibition zone around the test area that ensures nobody outside of the test can come into contact with the DUT during testing.

4. **The Test Area Electrical Supply**
   Installation of an RCD (GFCI) protected mains supply to the test area will ensure the power is cut, rapidly, if too much current flows away from the line and neutral conductors. Also ensure that emergency stop buttons (E-Stops) are installed both inside the test area and outside, these can be installed directly in the mains supply to the tester or be connected to the guard switch of your Seaward tester.

5. **Warning Signs and Test Beacons**
   Warning signs should be placed around the test area to ensure untrained personnel are aware of the potential for harm inside the prohibition zone. Signal beacons can also be used to indicate when the test instrument is live (red) and when the instrument is dormant (green). Seaward testers have their own beacons that simply plug in to the rear of the tester and will be activated by the tester when a danger is present.

6. Personal Protective Equipment
Consider equipping test operatives with appropriate PPE for the task, such as protective goggles and high voltage gauntlets to protect in case if accidental contact with live parts. The need for PPE can be mitigated by ensuring your operatives are in a 'safe zone', this can be accomplished by using devices such as a foot switch or fixed two handed switches that can be connected to all Seaward manufacturing testers.

Seaward offer an EN50191 kit to help you keep your staff safe and put you on the path to fully complying with the standard.

When creating a test area there are two main types of test areas that should be considered, and either can be used where practical.

1. Test Station with Automatic Protection Against Direct Contact
This type of installation consists of an enclosure into which the DUT is placed and connected for the test. A lid or door is then closed to create an environment where the DUT cannot be touched during the test procedure. Seaward testers are designed as such that if the door to the enclosure is fitted with switches these can be connected to the safety interlock of the test equipment, opening the door inhibits the test voltage instantly and closing the door can be used as a start condition to maximise efficiency.

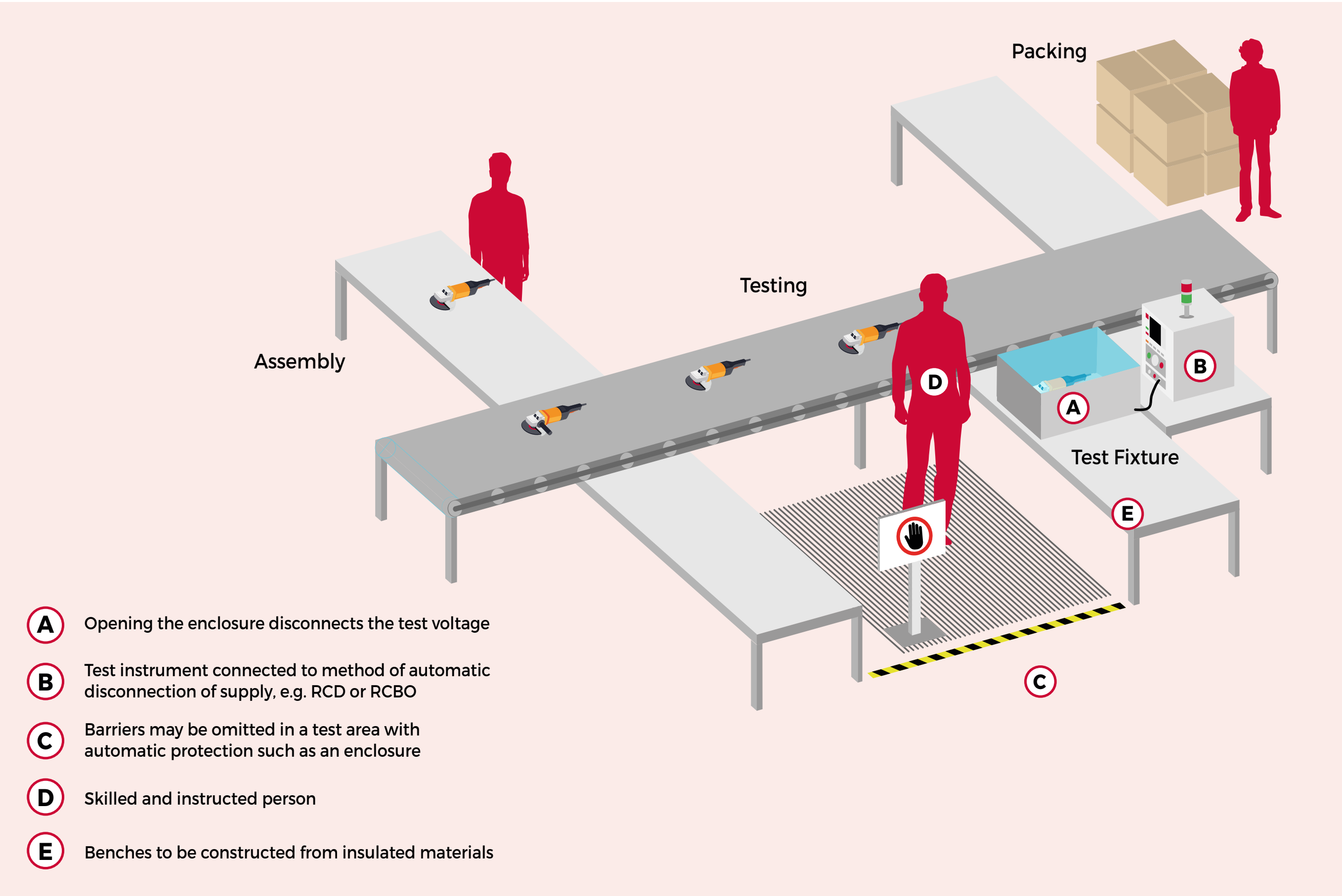

Figure 3 - Test station with automatic protection against direct contact

2. Test Station Without Automatic Protection Against Direct Contact

This type of installation does not have a method for stopping the operative coming into direct contact with the DUT. For this type of installation, careful consideration must be taken to ensure the test area and operator are suitably insulated to prevent the risk of injury.

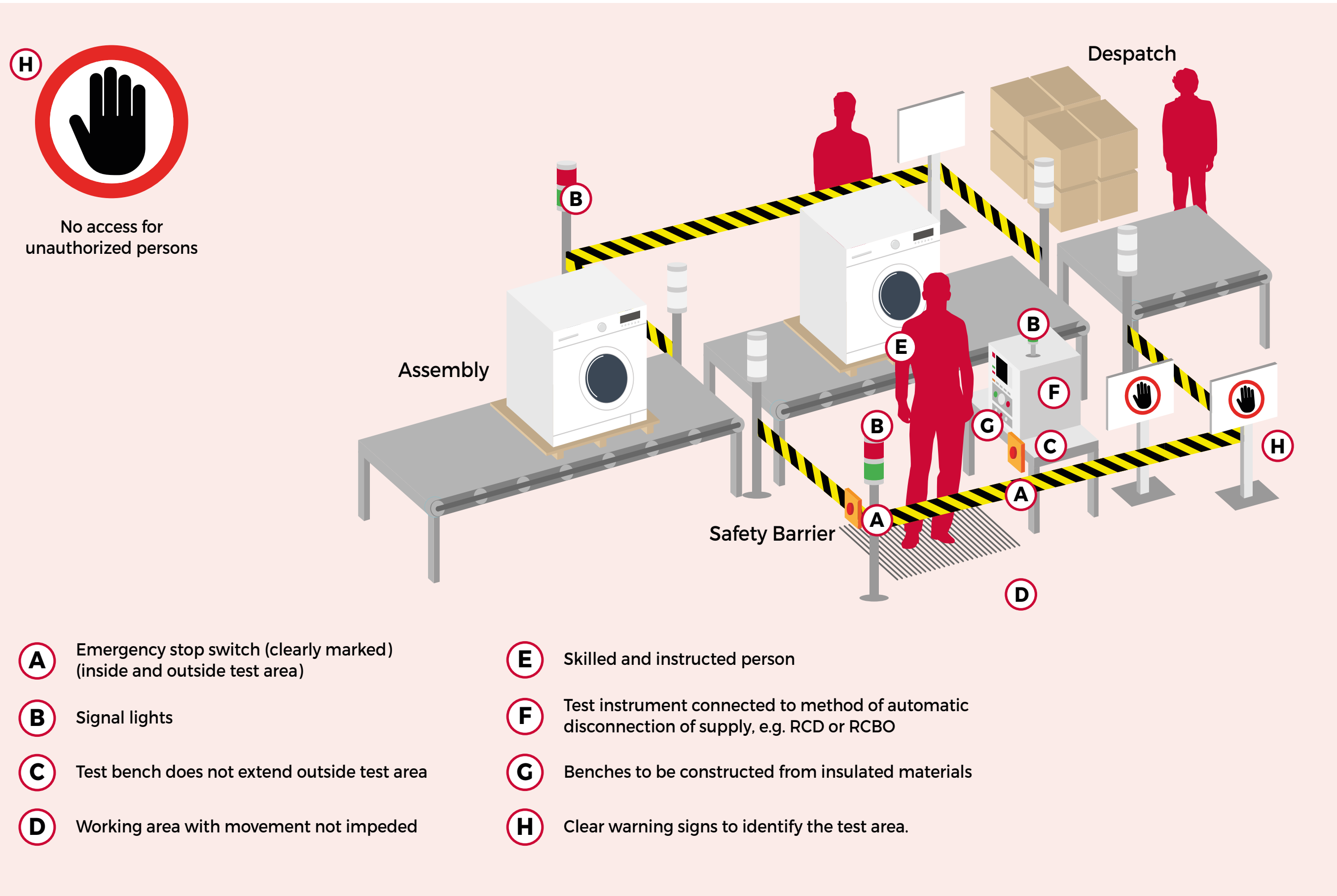

Figure 4 - Test station without automatic protection against direct contact

Definition of Product Classes

Electrical products are typically separated into several different classifications, the most common of which are class I, class II and class III.

Class I equipment is constructed in such a way that protection against electric shock does not rely on basic insulation alone. In addition to basic insulation around live internal parts, exposed conductive parts are connected to the protective conductor in the fixed wiring of the electrical installation.

Class I equipment relies upon a connection to the protective conductor to prevent exposed conductive parts becoming live in the event of a failure in the basic insulation. In simple terms this means that the earth cable takes any current leakage to the casing of the equipment to ground rather than the person touching it becoming the conductor.

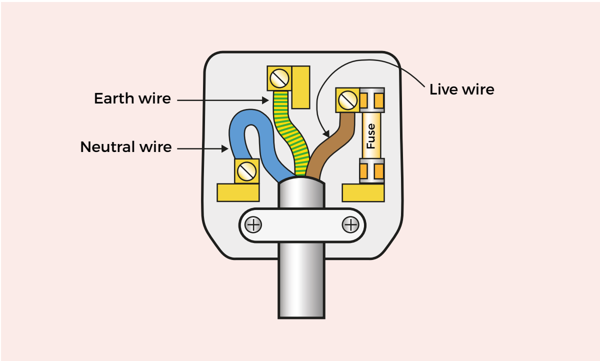

Figure 5 - A typical Class I plug

Class II equipment relies upon sufficient insulation between the live parts and exposed conductive parts to prevent shock in the event of a failure in the basic insulation.

In addition to basic insulation around live internal parts, supplementary insulation is provided. There is no provision for a connection of exposed connective parts to a protective conductor, (earth wire), so this layer of supplementary insulation ensures that the current does not leak out from the internal circuitry. Such equipment is often described as "double insulated" and should carry the symbol as shown below.

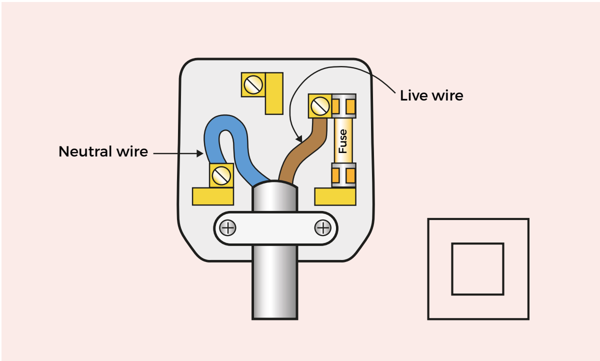

Figure 6 - Class 2 plug and double insulated symbol

Class III equipment is equipment in which protection against electric shock relies on a supply from a separated extra-low voltage source (SELV). In a SELV supply the voltage is less than 50Vrms and no exposed conductive parts are connected to the protective conductor.

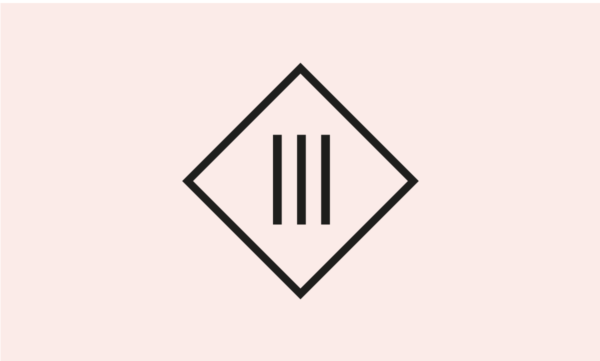

Figure 7 - Class III symbol

Definition of Test

Earth (Ground) Testing

The aim of any earth test is to prove that a path exists between exposed conductive parts and the main earth terminal, (or pin if supplied on a plug). The mains earth is vital to ensure the majority of any fault current in a Class 1 piece of equipment is safely transferred to the protective conductor in the building's mains supply.

There are two types of testing that are usually performed to check for the presence of a protective earth.

Earth (Ground) Continuity

The earth continuity test is usually performed using a low current source, typically in the order of a few hundred milliohms and is designed to prove a connection between the main earth terminal and accessible metal parts of the product. This is normally performed as a measure of the resistance but can be used with a simple beeper to prove the connection exists.

This test does not give a measure of the quality of the connection, nor does it prove under fault conditions that the earth cable would carry the fault current to the protective earthing of the building.

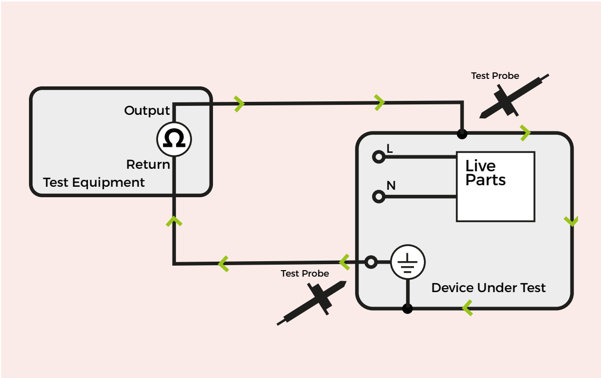

Figure 8 - Earth Continuity Measurement Diagram

Earth (Ground) Bond

The earth bond test is used to verify the integrity of earth connection by measuring the resistance of the circuit. This test is performed using a high current source, which varies according to the standard used but typically greater than 10A is used.

This test is performed in the same way as the continuity test previously discussed, but can be used to give a measure of how the connection will perform in the event a fault condition occurs. This test is required by most manufacturing standards.

Test Method

The test instrument will require connection to the DUT in two places, at the point where the mains supply enters the product, (mains supply terminal or plug), and any accessible conductive parts usually by method of test probe or clip. It should be noted that multiple tests may need to be performed to ensure that parts attached to the main earthing point via earth straps are suitably connected.

The test current is then applied from a known voltage source, and the voltage drop across the connection point is measured in order to calculate the resistance of the earth. As shown in the diagram below.

What is a Good Test?

A 'good test' means that the product has passed by meeting the criteria defined in the particular standard the DUT is being tested to.

For earth testing, typically a reading of less than 0.1Ohms is expected, although this can vary by standard and by the amount of mains cable supplied with the product, the more cable in the circuit the higher the resistance will be.

However, in all cases a good test will be where the resistance measured is less than the defined limit. This is often defined as a limit of 0.1Ohms+R where R is the resistance of the mains cable.

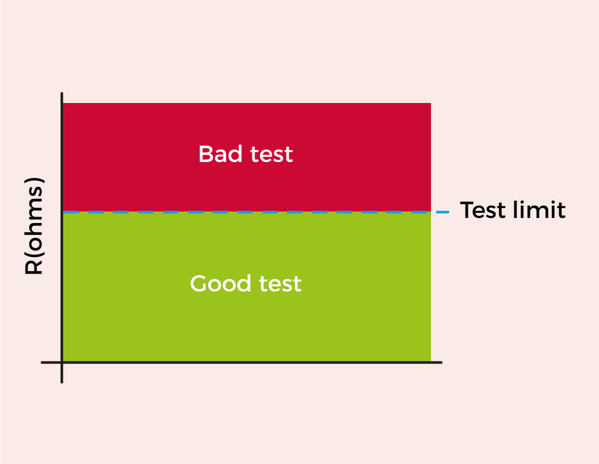

Figure 9 - Earth test - Pass or Fail?

Dielectric Strength

The dielectric strength test, (or flash / hipot / dielectric withstand as the test is also commonly known), is performed to stress the insulation of a product under test. It is used to detect any breakdown in the insulating properties of the item under test.

This breakdown can manifest in the form of cracks or tiny holes in the insulating materials, incorrectly wired items, or gaps and clearances between conductive parts and earth that are not sufficient. These failures could be indicative of problems with the manufacturing processes, incorrect or faulty components or wear and tear when routine withstand testing is performed. This test is where the greatest potential for injury is present, great care should be taken during this test and the DUT should never be touched.

AC or DC Dielectric Withstand Testing

Many standards will allow testing to be performed at either AC or DC voltages. As previously mentioned, the idea of the test is to stress the insulation, during an AC test the stress on the product is at its highest when the test voltage reaches the height of its waveform in both the positive and negative cycle.

An as example an AC test voltage of 1000Vrms will have voltage peaks of 1414V, or 1.414 times the test voltage.

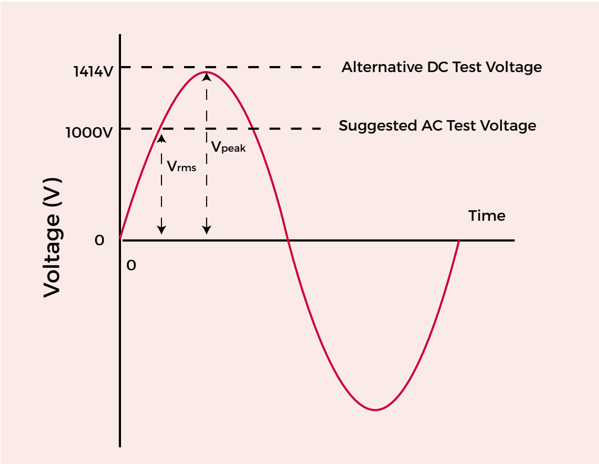

Figure 10 - Example AC Waveform showing AC and DC test voltages

As a DC test voltage does not fluctuate on a sinusoidal waveform we must ensure the test stresses the insulation as much as the peak value of an AC test. Therefore when choosing to perform a DC dielectric strength test, the test voltage should be the recommended AC test voltage multiplied by 1.414.

For example, a typical recommendation that an AC strength test is performed at 1500Vrms, would equate to an equivalent DC test voltage of 2121V.

Whilst there is no clear definition for when either method should be performed, it is typical, but not exclusive, to perform an AC test on AC powered equipment and DC test on DC powered equipment. Both test types have a place within a modern production line test environment and the decision of which to use will depend on many factors including the application and the type of equipment.

Capacitance

When deciding which version of the test to use, we firstly must consider any capacitance in the test circuit. Many products are now being fitted with mains filtering capacitors to comply with the EMC directive, and traditionally could be removed from the circuit prior to testing, this of course can involve time consuming activities bypassing the circuit. In addition, this is not the only source of capacitance within a circuit, any conductors that are adjacent to one another and have a voltage difference between them will generate capacitance.

So why is capacitance an issue? Within an AC circuit the voltage is constantly changing as the waveform progresses from peak to peak, this change in voltage will create a charge between the two conductors which will start a flow of current. This current flow, (reactive current or capacitive leakage), can be much greater than the actual leakage current being tested for, which could result in unexpected failures. Another side effect of this is that the pass limit, (and ultimately the voltage cut out), could be increased to 'zero out' this leakage to compensate, which could fall into unsafe levels of current for the operator.

However performing a hipot test with a DC voltage will only create such current flow during the initial charging, (voltage ramp), phase, after which the voltage is stabilised to its final value and no reactive current will flow, leaving only a true measure of the leakage current.

This can also mean that failure limits set when performing a DC hipot test can generally be much lower than that of an equivalent AC test, which can offer safety benefits to the test operative.

Ramp Time and Discharge

When performing a DC hipot test, it is necessary to charge the equipment under test, this charging is performed in the act of gradually increasing (ramping) the test voltage to its final value. It is important to note that the ramp time should not be included as part of the test time. Similarly, at the end of the test, it is important that the item under test is discharged in order to protect the operator from a shock. This could significantly increase the test time. Be aware that not all testers will have a discharge or ramp down function to ensure the product is safe on completion of testing; Seaward testers have this function as default.

AC testing however, does not have the same time constraints, as by its very nature, the test voltage is constantly increasing and decreasing, creating a natural ramp of the test voltage. Typically no ramping of the test voltage to a final value is required, unless stated / recommended in the product standard. And as the voltage is continually changing, no charge is stored between the conductors and no discharge is required after test, meaning that no ramp up or ramp down times are usually required for an AC test.

Polarity

AC hipot testing will test the product in both polarities, due to the cyclic nature of the waveform. However DC testing will only perform the test in one direction, this could be overcome by simply swapping the lead connections and performing the test again, however this will add onto the overall test time.

	Advantages	Disadvantages
AC Hipot Testing	• Overall test times can be much shorter when performing an AC test, slow ramping of the test voltage is not required due to the fact that the waveform is constantly changing polarity. • It is not necessary to discharge the DUT on completion of an AC test, again decreasing the overall test time. • It can be considered as a better test of the DUT due the fact that the insulation is stressed in both polarities due to the AC waveform.	• Total leakage current is measured, both the true leakage and reactive elements due to capacitance in the circuit. This may require the use of instruments with larger transformers in order to measure the higher currents present in the test circuit. • Higher limits may need to be applied which could be more problematic to the operator if exposed.
DC Hipot Testing	• The leakage current measured is a better representation of the true leakage of the DUT as the capacitance is charged after the ramp time, as such is it a better test for products with large capacitance. • The pass limit can be set at much lower values, which means the trip would react at far safer levels for the operator, should they become exposed to the test voltage.	• Overall test times are slower due to the need to ramp the test voltage to its final value. In certain circumstances this can be significantly longer than the actual test time. • The DUT must be discharged at the end of the test, this again may add to the test time but importantly can be a safety concern for the operator. • Only stresses the insulation in one polarity as opposed to both when using an AC waveform.

Test Method

Typically, a dielectric strength test is performed by shorting all mains conductors and applying a voltage in the region of twice the operating voltage plus 1000V. The earth conductor acts as a return to the instrument and any current flow is measured. When performing tests on a class II piece of equipment, a probe or clip is connected to exposed conductive parts on the device to act as a channel for any flow of current to return to the instrument. See below images.

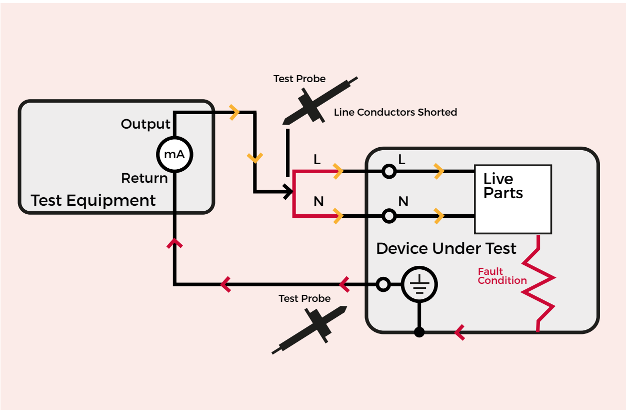

Figure 11 - Flash Measurement Diagram Class I

It is important to note that the mains power switch must be in the on position to ensure the test is performed correctly. Where this is not possible, certain standards will require that the switch is bypassed or removed from the circuit for testing purposes.

If a digital switch is present that requires mains power to be available before it can be activated, or if there is no way of engaging a physical switch in the 'on' position, this test will not test the whole circuit.

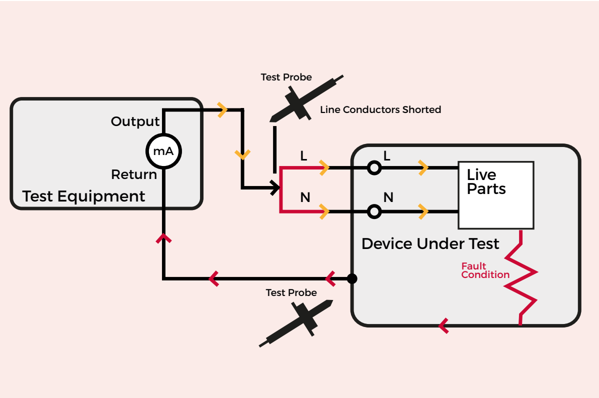

Figure 12 - Flash Measurement Diagram Class II

Seaward's range of manufacturing testers are capable of performing an alternative to flash testing that applies mains power to the DUT and measures the leakage. This test allows an operator to activate digital power switches and perform the leakage test correctly on the whole life circuit. This test is detailed later in this document.

What is a Good Test?

Many standards will state the following, "no breakdown or flash over shall occur". This would suggest that the item can be deemed to have failed if a sharp and sudden increase in current flow were to occur. For manufacturers it is important to consider the potential safety risk should a breakdown occur, it is therefore recommended that a suitable level of current flow is chosen to act as a fail threshold, i.e. if the current is greater than the threshold the test shall fail.

In this instance, it is recommended that the manufacturer samples a number of products to determine an average level for the normal amount of current flowing at the test voltage. From here it would be possible to decide on a safe level that will not cause nuisance tripping due to normal variations. For example average current plus 20%.

Certain standard however will suggest a limit for the current flow, 5mA, is fairly typical in BS EN Standards (e.g. 60598, 60335).

The test is deemed good providing that the measured current flow does not exceed the limit, either during the ramping phase or the test phase.

Seaward testers also allow for a minimum current limit to be included. During a properly connected dielectric strength test a small current will flow through the DUT and any test cables or jigs. If, for any reason, the circuit is interrupted, this current flow will not exist. Broken test leads, a faulty test output, or even the product not being in the ON position could be the issue. If a low limit was not included, a current flow of 0mA would be considered a good test, even though the DUT may not have been subjected to the test correctly. The minimum current judgement should not be made until the test instrument has completed the ramp up phase.

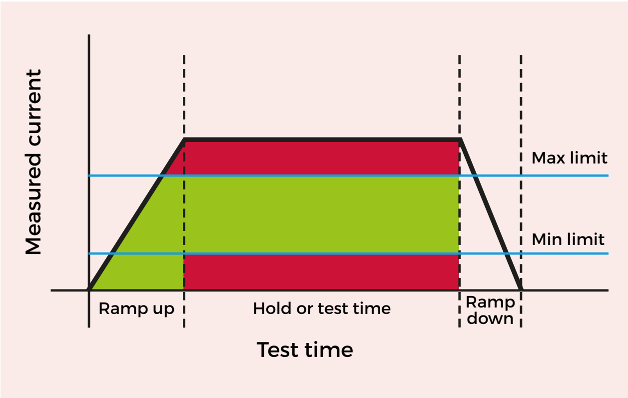

Figure 13 - Flash test - Pass or Fail?

Insulation Resistance

The purpose of the insulation resistance test is to provide a measure of the quality of the insulating materials. This test measures the total resistance between two points that are separated by an insulator.

Although not commonly required as part of a production line test, the insulation resistance measurement can be useful for ongoing maintenance tests on equipment to detect where the insulation is degrading over time, therefore preventing costly repairs or operator accidents before they occur.

The insulation resistance test can be a substitute for a dielectric withstand test in certain standards, particularly where the higher voltages would prove to be detrimental to the product under test. For example EN-60598-1 recommends either a 1500Vac withstand test or a 500Vdc insulation resistance test.

Test Method

An insulation resistance test is performed in much the same way as a dielectric withstand test by shorting all mains conductors and applying a test voltage, usually in the region of 100-1000V, dependent upon the standard being followed.

The earth conductor acts as a return to the instrument, and any current flow is measured and a resistance displayed. When performing tests on a class II piece of equipment, a probe or clip is connected to exposed conductive parts on the device to act as a channel for any flow of current to return to the instrument. As is the case with a DC hipot, it may be necessary to ramp the test voltage to the desired level. See below images.

It is important to note that the mains power switch should be in the 'on' position, to ensure the test is performed correctly. Where this is not possible certain standards will require that either the switch is bypassed or removed from the circuit for testing purposes, or that an alternative test is used.

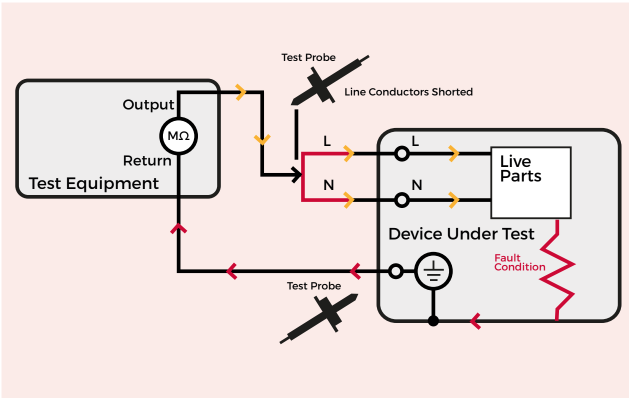

Figure 14 - Insulation Measurement Diagram Class I

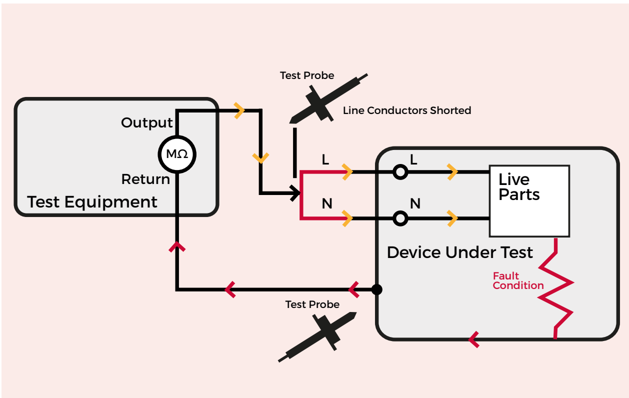

Figure 15- Insulation Measurement Diagram Class II

What is a Good Test?

The insulation resistance is the only test performed where the pass limit is a minimum value, i.e. the measured resistance must be no lower than the limit. It is typical for a product with good insulation to read over the scale of the test instrument.

Where a standard does include an insulation resistance test, it is common for a value in the region of 1 – 2MΩ to be specified for the minimum test limit. Any measurement below this value would be deemed a failure.

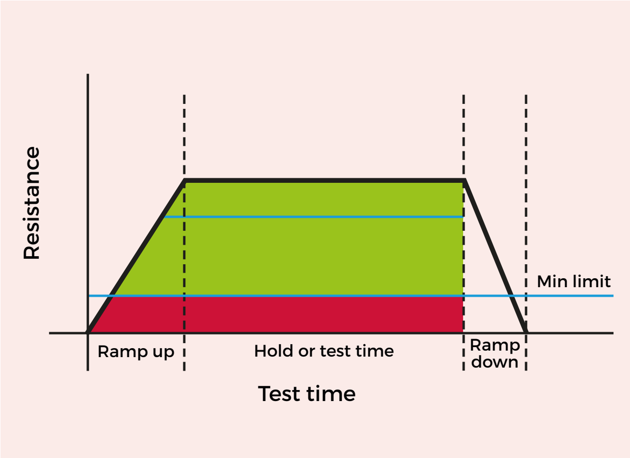

Figure 16 - Insulation resistance test - Pass or Fail?

Leakage Current Test

Leakage testing is performed on a DUT whilst mains power is applied. It is therefore, important to note that the unit will become operational and precautions should be taken to ensure injury is prevented, (for example, ensure the product is not tested with sharp implements attached, or that items which produce heat can be safely handled afterwards).

The aim of a leakage test is primarily the same as that of a dielectric withstand test, it measures the amount of leakage current flow to earth or the enclosure of the DUT. Leakage tests are not normally required for production line testing, the dielectric withstand test is a much better measure of the strength of the insulation, but leakage tests do form part of the requirements for production line testing of medical devices. However this test does feature in many type test requirements.

Test Method

There are a number methods for performing mains leakage testing, these are earth leakage, touch / enclosure leakage and for medical equipment, patient leakage, and patient auxiliary current. The differences in the test methods define how a person could come into contact with the DUT.

For example a touch current measurement simulates the current a human would be exposed to if they came into contact with the enclosure of the product whilst in operation.

During this test the DUT will be powered under normal operating conditions, although some standards require greater than the operating voltage. For protective earth conductor current, the measurement is either taken by direct measurement of the current flowing on the earth conductor, or via a differential method, where the difference in the line and neutral conductors is measured, giving the total leakage away from the appliance.

Touch, or enclosure leakage, uses a probe to simulate contact from a human hand. Any current flow through the probe is channelled through a body model within the test instrument to determine the likely current flow through a human being to earth. The body model used may vary between standards.

It is also common in medical testing to add in fault conditions when performing this test, such as disconnecting the earth cable or reversing the mains supply.

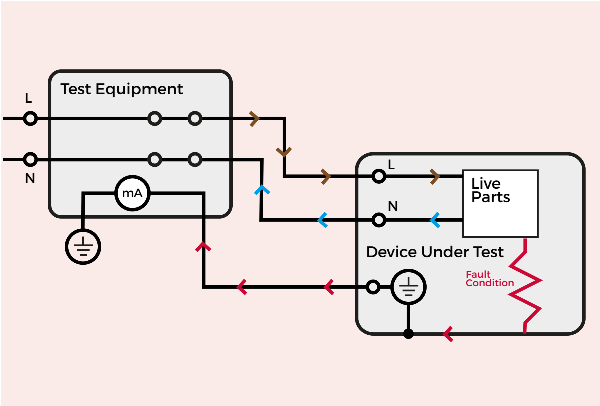

Figure 17 - Protective Earth Conductor Current Measurement Diagram

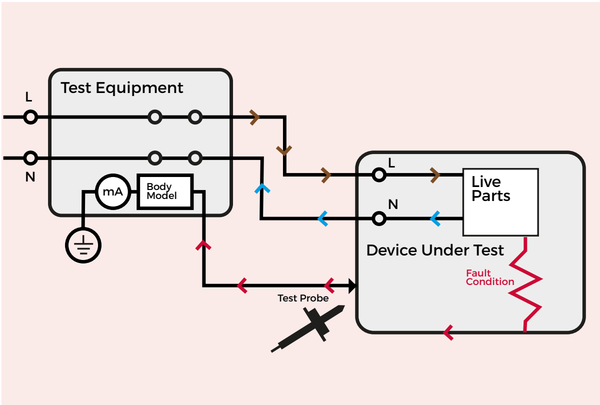

Figure 18 - Touch Leakage Measurement Diagram

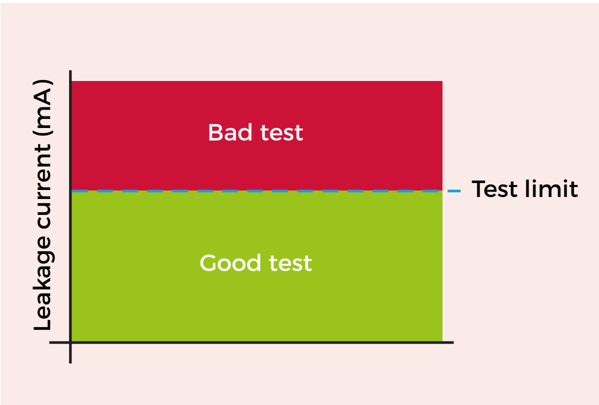

Figure 19 - Leakage test - Pass or Fail?

What is a Good Test?

A pass judgment will be made if the leakage value measured is below the criteria defined within the standard. For tests where parts which connect to medical patients, this level could be as low as 10μA, and any touch current measurement will normally have a pass limit less than the currents that are perceptible to human beings.

For protective conductor current tests, it is typical that the current flowing in the earth cable should be less than 3.5mA – 5mA.

Instrument Verification

As part of any electrical safety testing regime it is recommended that the equipment is subjected to a routine check of it's electrical test functions.

This check should normally be performed as a minimum on a daily basis, but it is recommended to perform a risk assessment, taking into account the throughput of products through the instrument to determine the verification frequency.

If, for any reason, a fault was to occur with the test instrument or test fixtures, a number of products could have been incorrectly tested.

The worst case scenario would be where the instrument trip function, (i.e. the point at which it issues a failure condition), does not work and items are passed incorrectly. It is therefore common to use a fault simulator to create failure conditions so that the instrument trips and fails the simulation.

Seaward fault simulators are designed so that once a certain voltage is achieved, the current flow will be at a known level. For example, at 1000V the fault simulator will have a current flow of 6mA. The test instrument would therefore be set to ramp to a voltage of 1000V, the pass limit could be set to 5mA. A timed ramp up of the test voltage is normally used, as soon as the current hits 5mA the tester should stop the test under failure conditions.

It is also recommended that any test lead from the tester and any leads and connections within the test jig are routinely inspected for any signs of damage / wear and tear. Stop use immediately and replace test leads if inner conductors are visible.

Standard Examples

		Earth (Ground) Bond		
Standard	**Application**	**Current (A)**	**Limit (Ω)**	**Time (s)**
BS EN 60598 - 1	Luminaires	10	0.5	1
UL 1598	Luminaires	Not Specified	0.1	Not Specified
BS EN 60335 - 1	Household Electrical Appliances	10	0.1 - 0.2	Not Specified
UL 60335 - 1	Household Electrical Appliances	40	0.1 - 0.2	Not Specified
BS EN 60950 - 1	Information Technology	10 - 25	0.1	1 - 4
UL 60950 - 1	Information Technology	No Values Specified (Continuity)		
BS EN 61010 - 1	Laboratory, Control and Test & Measurement Equipment	No Values Specified (Continuity)		
UL 61010 - 1	Laboratory, Control and Test & Measurement Equipment	No Values Specified (Continuity)		
BS EN 62911	Audio, Video and Information Technology Equipment	10 - 25	0.1	1 - 4
BS EN 62841 - 1	Electric Motor Hand-held, Transportable tool and lawn / Garden Machinery	10	0.3 (Plus 0.12 for each additional 5m of cable)	Not Specified

		Dielectric Withstand				
Standard	**Application**	**Voltage (AC)**	**Voltage (DC)**	**Limit (mA)**	**Ramp Req'd**	**Time (s)**
BS EN 60598 - 1	Luminaires	400 - 1500	600 - 2250	5		1
UL 1598	Luminaires	1200	N/S	No Breakdown		
BS EN 60335 - 1	Household Electrical Appliances	400 - 2500	600 - 3750	5 - 30		1
UL 60335 - 1	Household Electrical Appliances	400 - 2500	600 - 3750	5 - 30		1
BS EN 60950 - 1	Information Technology	1500 - 2500	2120 - 3540	No Breakdown	✓	1 - 4
UL 60950 - 1	Information Technology	1000 - 3000	1414 - 4242	No Breakdown	✓	1 - 6
BS EN 61010 - 1	Laboratory, Control and Test & Measurement Equipment	840 - 5300	1200 - 7500	No Breakdown	✓	2
UL 61010 - 1	Laboratory, Control and Test & Measurement Equipment	840 - 11940	1200 - 7500	No Breakdown	✓	2
BS EN 62911	Audio, Video and Information Technology Equipment	1500 - 2500	2120 - 3540	No Breakdown	✓	1 - 4
BS EN 62841 - 1	Electric Motor Hand-held, Transportable tool and lawn / Garden Machinery	1000 - 2500	1414 - 3535	5		3s (or 1s if test voltage increased by 20%)

		Insulation Resistance		
Standard	**Application**	**Voltage (DC)**	**Minimum Limit (MΩ)**	**Time (s)**
BS EN 60598 - 1	Luminaires	100 - 500	2	1
UL 1598		Not Specified		
BS EN 60335 - 1	Household Electrical Appliances	Not Specified		
UL 60335 - 1		Not Specified		
BS EN 60950 - 1	Information Technology	Not Specified		
UL 60950 - 1		Not Specified		
BS EN 61010 - 1	Laboratory, Control and Test & Measurement Equipment	Not Specified		
UL 61010 - 1		Not Specified		
BS EN 62911	Audio, Video and Information Technology Equipment	Not Specified		
BS EN 62841 - 1	Electric Motor Hand-held, Transportable tool and lawn / Garden Machinery	Not Specified		

		Powered Leakage			
Standard	**Application**	**Voltage**	**Limit (mA)**	**Time (s)**	**Functional Test**
BS EN 60598 - 1	Luminaires	Not Specified			✓
UL 1598		Not Specified			
BS EN 60335 - 1	Household Electrical Appliances	Not Specified			✓
UL 60335 - 1		Not Specified			
BS EN 60950 - 1	Information Technology	Not Specified			
UL 60950 - 1		Not Specified			
BS EN 61010 - 1	Laboratory, Control and Test & Measurement Equipment	Not Specified			
UL 61010 - 1		Not Specified			
BS EN 62911	Audio, Video and Information Technology Equipment	Not Specified			
BS EN 62841 - 1	Electric Motor Hand-held, Transportable tool and lawn / Garden Machinery	Not Specified			✓

Considering a New Safety Tester?

When considering the purchase of a new electrical safety tester, we would recommend asking the following questions.

Which test do I need to perform, or which tests am I likely to perform in the future?

The current product range you manufacture might not have a requirement for an earth bond test, for example, but what if the future product designs do? The likelihood would mean replacing the unit prematurely, or adding a separate, single function unit which could add a level of complexity or separate connections, slowing the overall test process.

What are the test voltages / currents that I need to perform and what leakage current levels do I need?

Some instruments may have fixed test outputs, which can be very simple to set up initially, however, they do not provide much in the way of flexibility should your testing requirements change. A test instrument with configurable voltages and test currents will provide a future proof solution.

Do I require the ability to programme test sequences?

Having the ability to program the instrument with test sequences, gives a level of control to the production line. Sequences ensure uniform testing by controlling pass limits / test times and the order performed. This gives the manufacturer peace of mind that the DUT's are always tested to the same specification. It is common in many test areas that the operator scans a barcode to set up the correct test sequence, often by part number, this removes the need for the operator to make a decision on which test is the correct one. These sequences can usually be protected by a password to ensure they cannot be inadvertently altered.

Do I require test result storage?

The ability to store test results, particularly against a serial number, can be extremely useful for a manufacturer and a key addition to any quality management system. The results can provide protection from liability claims, as well as giving information with regards to throughput. Collecting this information is done automatically by most Seaward testers, so no additional time is added to the test process.

We Are Here for You, Every Step of The Way

For more information, or to speak to one of our expert advisors who are on hand to help you with any queries you have about our products, please visit **seaward.com**

Consultation

Our team of specialists are on hand to help you with your testing needs. Call us today to discuss your requirements and how the HAL Series can help you with your electrical safety testing.

Product Selection

Once we have an understanding of your testing requirements we can assist you in selecting the right HAL and any other accessories you may need to test efficiently and effectively.

Training

Our team of professional trainers are on hand to provide bespoke training to fit any company's needs. Get the most from your HAL tester with one of our training packages.

Service & Support

We have a dedicated service centre at our head office in Peterlee, County Durham and a team of on-site calibration and service engineers who can help you with your HAL when needed.

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