

## Glossary of Electrical Safety Terms

### AC

Alternating current: an electric current that has one polarity during one part of the cycle and the opposing polarity during the other part of the cycle. Residential electricity is AC.

### ANSI

American National Standards Institute, an industry association that defines standards for data processing and communication

### Applied Part Leakage Current Test

A line leakage current test that measures the current that would flow from or to applied parts and between applied parts such as sensor and patient leads.

### Arcing

Sparking or “flashing over” caused by a breakdown of electrical insulation.

### Breakdown

Breakdown is the failure of electrical insulation to provide a dielectric barrier to current flow.

### Capacitance

The ratio of charge on either plate of a capacitor to the potential difference (voltage) across the plates. When a voltage is applied, current flows immediately at a high rate and then decays exponentially toward zero as the charge builds up. If an AC voltage is applied, an AC current appears to flow continuously because the polarity of the voltage is reversed at the frequency of the applied voltage. The waveform of this current, however, is displaced in time from the applied voltage by 90°.

### Charging Current

An insulated product exhibits the basic characteristics of a capacitor. Application of a voltage across the insulation causes a current to flow as the capacitor charges. The current instantaneously rises to a high value as voltage is applied then exponentially decays to zero as the DUT becomes fully charged. Charging current decays to zero much faster than dielectric absorption.

### Clearance

Clearance is the shortest distance between two conductors through air or insulating medium.

### Creepage

Creepage is the shortest path along the surface of an insulator or insulating medium that separates two conductors. The insulator or insulation medium cannot be air.

## CSA

Canadian Standards Association

## Current Draw

Current Draw is the mains current consumed by the product or DUT.

## DC

Direct Current: non-reversing polarity. The movement of charge is in one direction. Used to describe both current and voltage. Batteries supply direct current.

## Delay Time

The amount of time an instrument waits before performing a task.

## Dielectric Absorption

Dielectric absorption is the physical phenomenon of insulation appearing to absorb and retain an electrical charge slowly over time. Apply a voltage to a capacitor for an extended period of time and then quickly discharge it to zero voltage. Leave the capacitor open circuited for a period of time then connect a voltmeter to it and measure the residual voltage. The residual voltage is caused by the dielectric absorption of the capacitor.

## Dielectric Strength

The Dielectric Strength of a material is the ratio between the voltage at which breakdown of the insulating material occurs and the distance between the two points subject to the applied voltage.

## Dielectric Withstand Test

This is the most common electrical safety test performed today. A high voltage either AC or DC is applied to determine if a breakdown will occur in the insulation of the DUT. Also referred to as a HIPOT test or Dielectric Withstand test.

## Discharge

Discharge is the act of draining off an electrical charge to ground. Devices that retain charge should be discharged after a DC hipot or IR test.

## Double Insulated

A descriptive term indicating that a product is designed so that a single ground fault cannot cause a dangerous voltage to be applied to any exposed part of the product that a user might touch.

## DUT

Device Under Test — the product being tested.

## Dwell Time

The amount of time the DUT is allowed to stabilize at the test voltage before measurements are performed.

### Earth Continuity Test

A test to verify that all conductive parts of a product that are exposed to user contact are connected to the power line ground. The ground bond test is similar to the ground continuity test. The main difference is that the ground bond test verifies the integrity of the ground connection using a high current AC signal with current level as high as 30Amps. Ground bond provides a better simulation of how a product will perform under an actual fault condition.

### Earth Leakage Current Test

The most important and most common of the line leakage current tests, earth leakage current is basically the current flowing back through the ground conductor on the power cord. It is measured by opening the ground conductor, inserting a circuit with simulated the impedance of the human body and measuring the voltage across part of the circuit with a true RMS voltmeter.

### Enclosure Leakage Current

This Line Leakage Test measures the current that flows through the human body if the enclosure of the DUT were to be touched.

### Electric Current

Electrical current is a flow of electrons (or electron “holes”) through a conducting material, which may be a solid, liquid, or gas; the rate of flow of charge past a given point in an electric circuit. The magnitude of current flow through the conductor is proportional to the magnitude of voltage or electrical potential applied across the conductor and inversely proportional to the resistance (or impedance) of the conductor. Current is expressed in amperes or milliamperes (amperes/1000).

### Fall Time

The amount of time it takes to gradually decrease the voltage to zero potential.

### Frequency

The rate at which a current or voltage reverses polarity and then back again completing a full cycle, measured in Hertz (Hz) or cycles per second.

### GFCI

An acronym for Ground Fault Circuit Interrupter: a safety device that breaks a power circuit as soon as it detects current flow of a certain magnitude through the ground return of a power circuit.

### Ground Fault Interruption (GFI patent pending)

A safety feature designed to protect an operator from inadvertent contact with high voltage. A circuit monitors the current leaving the hipot and returning to the hipot. If an imbalance in current leaving versus returning is detected the high voltage output of the hipot is shut down in less than 2ms.

## Ground

Ground is the base reference from which voltages are measured. It is nominally the same potential as the earth. Ground is also the side of a circuit that is at the same potential as the base reference.

## Ground Bond Test

A test to verify that all conductive parts of a product that are exposed to user contact are connected to the power line ground. The ground bond test is similar to the ground continuity test. The main difference is that the ground bond test verifies the integrity of the ground connection using a high current AC signal with current level as high as 30Amps. Ground bond provides a better simulation of how a product will perform under an actual fault condition.

## Ground Continuity Test

A test to verify that all conductive parts of a product that are exposed to user contact are connected to the power line ground. GC Test normally performed with a low current DC signal that checks to ensure the ground connection has a resistance of  $<1\Omega$ .

## Hertz

The unit of measure of frequency, equivalent to cycles per second.

## High Limit

The high limit is the upper value for a test to be considered a PASS. If the measured value is higher than the high limit the test is considered a FAIL. In hipot, leakage current and ground bond tests a high limit is required.

## Hipot Tester

A hipot tester is an instrument for testing dielectric strength using a high potential (voltage); hence, the term "hipot".

## IEEE

Institute of Electrical and Electronic Engineers: The IEEE society is a professional association of engineers.

## IEEE 488

General Purpose Interface Bus (GPIB): an industry standard definition of a parallel bus connection for the purpose of communicating data between devices.

## Impedance

This a term used with alternating current circuits to describe the "AC resistance" to the flow of current through a circuit when an AC voltage is applied across the terminals of that circuit. Impedance is a complex quantity composed of real (in phase with voltage) and reactive (out of phase by  $90^\circ$ ) components. Impedance is calculated as Voltage/Current.

### Imaginary Component

An imaginary component is the component of an AC voltage, current, or impedance that is 90° out of phase with the "real" or in phase component. Reactive components are associated with capacitive or inductive circuits.

### Insulation

The protection against unwanted flow of current through a path, as between a circuit of a product and the ground reference. Materials that prevent current flow are referred to as insulators or dielectrics.

### Insulation Resistance

Characteristic of an insulating material that being subject to voltage, indicates a resistance such that the value of leakage current which flows through it stays within acceptable limits.

### Interlock

An interlock is a device or arrangement by means of which the functioning of one part is controlled by the functioning of another, for safety purposes.

### ISO 9000

A Quality Assurance standard written by the International Standards Organization: ISO9000 is a philosophy by which companies document their internal processes and organization to insure that products and services that are being provided meet customer expectations.

### Kelvin Connection

A Kelvin connection is a circuit configuration that automatically compensates for measurement errors caused by resistance of leads between a tester and the point of measurement on a DUT.

**Leakage current** definitions can be tricky since manufacturers use different words to explain the same conditions. Leakage current is the residual flow of current after HIGH voltage (greater than normal operating voltage) has been applied to the device under test. This is the current measured in a Hipot test.

**Line leakage** current is that measured at a NORMAL operating voltage. The device under test is powered by normal operating voltage, turned on and the line leakage is measured across a circuit that simulates the impedance of the human body. Ground that circuit and you are measuring the **Earth leakage** current. The ground connector is open, a circuit that simulates the impedance of the human body is inserted and the voltage is measured across it.

**Enclosure leakage** is that line leakage current measured by connecting the circuit that simulates the impedance of the human body to any exposed metal on the chassis of the device under test. This simulates someone touching the enclosure/chassis of the device under test. Is that enclosure protectively grounded?

**Applied Part (Patient) leakage** is that line leakage measured from or between applied parts of the device under test such as the current that might flow from patient leads and sensors on a medical device.

### Load

The total resistance or impedance of all circuits and devices connected to a voltage source.

### Low Limit

The low limit is the lower value for a test to be considered a PASS. If the measured value is lower than the low limit the test is considered a FAIL. In insulation resistance mode a low limit is required.

### Megohmmeter

An instrument designed to measure high values of resistance using a DC voltage usually greater than 50 V DC.

### Milliohmmeter

An instrument designed to measure low values of resistance using a DC current or voltage.

### Mode

Mode is the test that is to be performed such as AC Hipot (WAC), DC Hipot (WDC), Insulation Resistance (IR), Ground Bond (GR) or Leakage Current (LC).

### NIST

NIST is an acronym for the National Institute of Standards and Technology. It is an agency of the U.S. Government that sets standards for physical measurements and references; formerly called the National Bureau of Standards.

### NRTL

NRTL is an acronym for a Nationally Recognized Testing Laboratory, such as Underwriters Laboratories (UL), Factory Mutual (FM), or Canadian Standards Association (CSA).

### Ohm's Law

Ohm's Law is the fundamental physical law of electrical circuits that describes the relations between voltage, current, and impedance (or resistance). For DC circuits, Ohm's Law states that  $\text{Current} = \text{Voltage} / \text{Resistance}$ . For AC circuits,  $\text{Current} = \text{Voltage} / \text{Impedance}$ . Stated conversely,  $\text{Voltage} = \text{Current} \times \text{Resistance}$  (DC) or  $\text{Current} \times \text{Impedance}$  (AC). The difference between the DC resistance and AC impedance is that AC circuits must deal with phase and time relationships and DC circuits do not.

### Ohms

An ohm is the unit of measure of resistance and impedance, derived from Ohm's Law.

### Offset

Offset is an automatic zeroing function to correct for leakage currents or additional resistance due to test leads or fixtures. An offset is performed by making a measurement at the programmed test settings, calculating the difference between the leakage current or resistance measured and the ideal current or resistance and then subtracting this difference from all future measurements.

### OSHA

OSHA is an acronym for the Occupational Safety and Hazards Administration, an agency of the U.S. Government that regulates industrial safety.

### Phase

The time relationships between alternating voltages, currents and impedances. Usually expressed as complex vectors with “real” (in-phase) and “reactive” (out of phase) components.

### Polarization

A term used to describe a “one way” limitation on the insertion of a plug into a receptacle for a corded product. A polarized plug can be inserted in only one orientation and cannot be reversed.

### Potential

Electrical potential is a term equivalent to “voltage”.

### Prefixes

The prefixes for Multiple Scientific Engineering Symbols are:

1000000000000000 =  $10^{15}$  = Peta P

1000000000000 =  $10^{12}$  = Tera T

1000000000 =  $10^9$  = Giga G

1000000 =  $10^6$  = Mega M

1000 =  $10^3$  = Kilo k

0.001 =  $10^{-3}$  = milli m

0.000001 =  $10^{-6}$  = micro  $\mu$

0.000000001 =  $10^{-9}$  = nano n

0.0000000000001 =  $10^{-12}$  = pico p

0.000000000000001 =  $10^{-15}$  = femto f

**Example:     Microsecond**

A microsecond is one millionth of a second.

### Ramp Time

Ramp Time is the gradual increase of voltage from zero potential over a period of time.

### Reactive Component

A reactive component is the component of an AC voltage, current, or impedance that is 90° out of phase with the "real" or in phase component. Reactive components are associated with capacitive or inductive circuits.

### Real Component

A real component is the component of an AC voltage, current, or impedance that is in phase with the "real" component. Real components are associated with purely resistive circuits.

### Regulation

When applied to electrical circuits, regulation refers to the variation in output voltage that occurs when the input voltage changes or when the connected load changes. When applied to test laboratories and agencies, regulation refers to the control exercised by these entities over test specifications and rules.

### Resistance

Resistance is the electrical characteristic that impedes the flow of current through a circuit to which voltage has been applied. Ohm's Law calculates Resistance = Voltage/Current (for DC circuits). For AC circuits, it is the in-phase or "real" component of impedance. The unit of resistance is the ohm ( $\Omega$ ).

### RS232

An industry standard definition for a serial line communication link or port.

### Scanner

An electronic device designed to switch or matrix signals.

### SCC

The SCC is the Standards Council of Canada, an agency of the Canadian Government analogous to OSHA in the United States.

### Spikes

A spike is a large momentary deviation from normal of a voltage or current waveform.

### Stabilization Time

The time required for a transient disturbance to decay to a steady state value.

### Step

Most electrical safety testers can perform tests in a sequence. The step number indicates in which order the tests will be performed. For example if step 1 is a ground bond test, step 2 an AC hipot and step 3 an insulation resistance measurement then when a test is started the electrical safety tester will perform a ground bond test followed by an AC hipot then an insulation resistance measurement.



## T - Z

### Test Time

- Ramp:** The period of time for the voltage to climb to the programmed level.  
**Dwell:** The period of time for the voltage to settle at the programmed level. (a.k.a.: [delay](#))  
**Test:** The period of time that the voltage is applied to the DUT.  
**Fall:** The period of time for the voltage to decrease back to 0.

### Type Test

A one-time test intended to verify adequacy of the design of a product to meet a safety standard.

### UL

Underwriters Laboratories, Inc., an NRTL located in Illinois.

### Voltage

The electrical potential applied to a circuit.

### Waveform

The instantaneous value of a variable such as voltage or current plotted against time.

### X (Reactance)

Reactance is the imaginary component of Impedance.

### Y (Admittance)

Admittance is the reciprocal of Impedance.  $Y = 1/Z$

### Z (Impedance)

Impedance is the sum of alternating current oppositions (capacitive reactance, inductive reactance and resistance).  $Z = R + jX$

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