Exploring the Necessity of the Hot Hipot Test

Introduction

In an industry comprised of workers with varying electronics knowledge, a **Hipot test** can seem a daunting task for some. Indeed, many test operators and quality assurance supervisors, having never been trained in electrical engineering, have difficulty understanding the principles and setup of the test itself. Naturally, the mere mention of the more specific Hot Hipot test can bring about feelings of apprehension. Yet the concepts involved with the Hot Hipot test don't have to be entirely elusive to operator and engineer alike. In fact, with a basic understanding of a Hipot test setup it is relatively easy to understand, implement, and perform a Hot Hipot test.

Hipot Test Theory

In order to understand what a Hot Hipot test is and how it is performed, it is first necessary to discuss the theory of the Hipot test itself. The Hipot test, sometimes called a Dielectric Withstand test, is used to verify the strength of the insulation between a product's current-carrying components and its chassis or enclosure. This is done by applying a high voltage from the mains-input lines to the chassis of the product and measuring the resulting leakage current flowing through its insulation. The theory: if a voltage much higher than the product would normally see is applied across the insulation without a breakdown (which results in an excessive amount of leakage current flow), the product will be able to operate safely when run under nominal operating conditions.

The **Hipot tester** is used to indicate whether or not a dielectric breakdown of the insulation has occurred by monitoring the leakage current resulting from the applied test voltage. Even under normal operating conditions, some leakage current will be present in any device under test (DUT), but at minute and safe levels; however, when the insulation breaks down or is damaged an excessive amount flows to the chassis. This can present a substantial shock hazard to anyone that comes into contact with the product.

The Hipot test is so crucial because it is the best way to uncover workmanship and assembly defects in an electrical product that can lead to insulation breakdown. Mistakes during assembly or faulty/damaged components exist to an extent in any manufacturing environment, and the Hipot test can uncover units that are unfit and dangerous to sell. Some of the defects which could result in insulation breakdown include: pinched insulation, pinholes, and poorly crimped wiring. In order to detect for breakdown in electrical products, this test is usually performed during the manufacturing process on 100% of all manufactured units, as well as during routine repair and maintenance.

Hipot Test Specifications

Hipot tests can be performed using either an AC or a DC voltage. Manufacturers may or may not be required to perform a specific type of Hipot test depending on the product and the standard to which it is being tested. Both AC and DC Hipot tests have inherent advantages and disadvantages that become evident depending on the characteristics of the DUT. The following table lists some of the basic advantages of each type of test:

AC Hipot Advantages	DC Hipot Advantages
Slow ramping of the test voltage isn't necessary due to the changing polarity of the applied waveform.	The test can be performed at a much lower current level, saving power and with less risk to the test operator.
It is unnecessary to discharge the DUT after AC testing.	Leakage current measurement is a more accurate representation of the real current.
AC testing stresses the insulation alternately in both polarities.	DC testing is the only option for some circuit components: diodes, capacitors, ect.

These differences between AC and DC waveforms necessitate a variation in Hipot test procedures. Although the test is basically the same, the test operator needs to take into account the relationship between a DC waveform and its equivalent AC waveform. AC waveforms are often listed as RMS (root mean squared). This RMS value, known as the effective value, provides a load with the same amount of energy as a DC waveform of the same voltage: a 25 volt DC source provides the same amount of effective energy as a 25 $volt_{rms}$ AC source.

The actual quantitative value of the RMS AC waveform is much higher at the peaks of the sine wave. In fact, the difference between a peak AC waveform measurement and the RMS measured value is 1.414. The calculation is as follows:

$Volts_{rms} * 1.414 = Volts_{peak}$

Since a Hipot test stresses the insulation of a DUT with a high voltage, the applied test voltage must be the same value whether it is AC or DC. It is unnecessary to worry about the effective RMS value since the energy delivered to the DUT is of no importance; the peak (maximum) voltage is what we are concerned with.

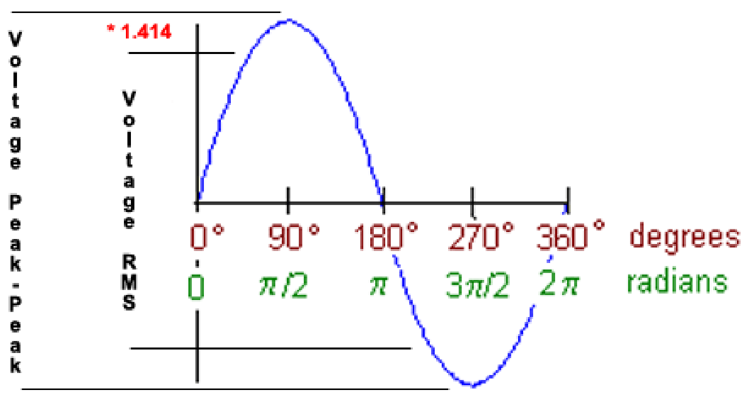

Figure 1.0: Peak vs. RMS Measurement of a Sinusoid

A good rule of thumb for determining the test voltage during an AC Hipot test is to multiply the nominal input voltage (usually from a wall outlet given as an RMS voltage) by 2 and add 1000 volts.

AC Hipot test voltage = Nominal input voltage * 2 + 1000

For a DC test use the following procedure to assure that the DC voltage is the same value as the peak of the AC waveform: multiply the calculated AC voltage by 1.414.

DC Hipot test voltage = AC Hipot test voltage * 1.414

By performing this operation, the DC voltage is applied at the same level as the peak of the AC voltage waveform.

The amount of time high voltage must be applied during testing is also specified in many safety agency standards. The most common test durations are 1 second for production tests and 1 minute for design tests. Further, agencies such as UL require that Hipot testers meet certain output voltage regulation specifications to ensure that the DUT is stressed at the correct voltage. Contact your local safety agency for more information about test duration and voltage requirements.

Hipot Test Procedure

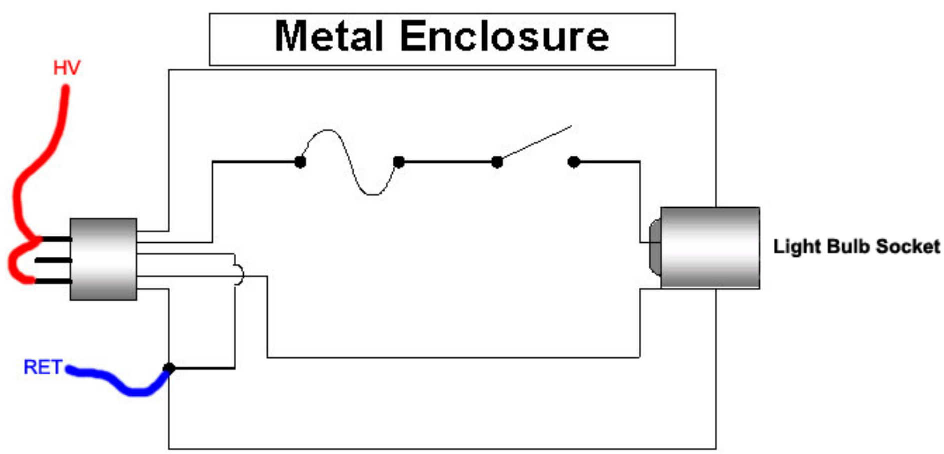

Figure 2.0: Hipot Test Connection Diagram

The Hipot test is set up by connecting the two output leads of the tester to the device under test. Follow the steps below to ensure that your tester is properly connected.

1.) For products terminated in a three-pronged line cord (known as Class I products) or a two-pronged line cord (known as Class II products), connect the hot lead of the Hipot tester to both the line and the neutral inputs to the DUT.

2.) Place the DUT's power switch to the ON position.
3.) Connect the return lead of the Hipot tester to the metal chassis or enclosure of a Class I DUT.
4.) For a Class II product, connect the return lead of the tester to a piece of aluminum foil that is wrapped around the chassis of the DUT. The aluminum foil is necessary to create a conductive material around the insulation which comprises the chassis of a Class II product.

*By connecting the tester in this way, all of the internal current-carrying conductors are raised to the same potential with respect to the chassis. This connection scheme ensures that the high voltage waveform is applied directly across the insulation of the product.

Hipot Test Shortcomings

The Hipot test has long been considered the most important electrical safety test; as such it is usually specified by safety agencies to be performed on all consumer and industrial products terminated in three- or two-pronged line cords. Historically this test has been effective on the gamut of electrical products due to a dependence on

single-pole relays and mechanical switches. Yet products that operate off of a 220 volt input often incorporate double-pole relays that open both sides (line and neutral) of the input line. Further, with the dawn of the digital age we now find that many products incorporate electronic switches. Often these switches and relays cannot be closed manually without powering-up the product under test. In these cases a standard Hipot test becomes ineffective.

With both sides of the line open the Hipot tester cannot energize all the current-carrying conductors within the DUT and the test results become invalid. The only way to perform a valid Hipot test on products that contain these types of relays or electronic switches is to energize the product while the Hipot test is being performed. Yet in order to Hipot test a powered product, special steps must be taken since under normal conditions the line and neutral inputs of the DUT would be shorted together. This modified setup is commonly called a "Hot Hipot test."

Hot Hipot Test Procedure

A Hot Hipot test is performed in the same fashion as a standard Hipot test. The primary difference is the addition of 1 piece of equipment, an isolation transformer. This transformer is used to isolate the input power to the DUT from earth ground. Without the use of this type of transformer, the chassis of the DUT, which is usually grounded, would be directly connected to the return of the Hipot tester (which is also referenced at or near ground potential). The return of the Hipot tester usually sees current in the milliamp range; however, without an isolation transformer the Hipot tester could be exposed to several amps of line current flowing back through its return. This could cause damage to the tester as well as create a possible shock or fire hazard during a Hot Hipot test.

The isolation transformer creates the necessary isolation between the input lines of the DUT and the Hipot tester. Of course, an AC test voltage is necessary for this test since DC waveforms don't work with transformers. It is also important to verify that the isolation transformer is rated to handle the applied Hipot test voltage; this will prevent damage to the transformer.

1.) In order to set up the test correctly, the primary side of the isolation transformer should be plugged into the power source used to provide the input power to the device under test.
2.) The secondary side of the transformer should then be connected to the input of the DUT.
3.) Once connected, the Hipot tester may then be plugged into a standard wall outlet.
4.) The hot lead of the Hipot tester should then be connected to the output of the secondary side of the isolation transformer. By doing this, you are connecting the hot lead of the Hipot in between the isolation transformer output and the line side input of the DUT.
5.) The return lead of the Hipot tester should then be connected to the chassis of the DUT.
6.) Once the setup is completed, you may turn on the Hipot tester and the DUT.
7.) Perform the test as you would a standard Hipot test.

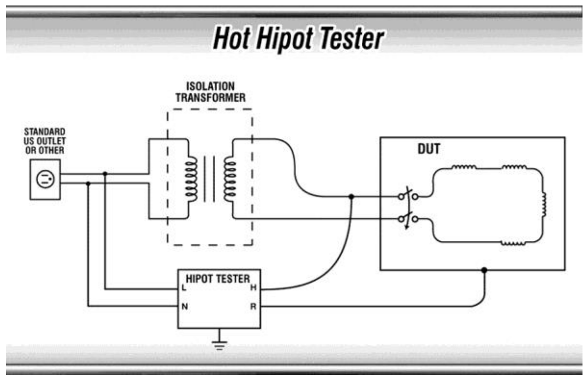

Figure 3.0: Hot Hipot Test Connection Diagram

Summary

With the advancement of the electronics industry Hot Hipot testing is becoming more and more common during routine production line testing. Products that were once operated solely through the use of mechanical relays and switches are now being controlled via electronic circuits that can only be energized while the product is running. Still other products that use 220 volt inputs contain relays that open both sides of the line, rendering a standard Hipot test ineffective. Whatever the reason, a working knowledge of the Hot Hipot test makes good sense of anyone working in the quality assurance or safety testing fields.

Although the Hot Hipot test has long been considered a mysterious and complex safety test, in actuality it isn't much more difficult to perform than a standard Hipot test. With an understanding of the basic test procedure involved in performing a Hipot test and possession of the right equipment, a Hot Hipot test can be performed safely and efficiently. Paying attention to careful setup and implementation, a test operator, quality assurance supervisor, or engineer alike can feel comfortable performing a Hot Hipot test on a variety of products.