APPLICATION NOTE

Advances in Modern Instrument Controls: The Evolution of Insulation Tester Equipment

The original design of electrical test instrumentation was often focused on taking a measurement and little else. A lot of the operation and interpretation was left to the operator. This was fine for people who liked the challenge or had experience. But it could be tough on apprentices, new hires, and those who were simply handed the instrument with no training.

Constant improvement in instrumentation has addressed these problems by adding to the capabilities of the instrument. Some are for convenience, some safety and some the advancement in technology over the years that helps standardize testing and provide more accurate results. A prime example is that of insulation testers. Let's examine some of the key improvements in features and functions, and what they mean to the operator.

Some control styles are still appropriate

For field work, test instrument panels are best fitted with selector switches. This may seem old school to those who like modern devices, but while membrane switches work well for R&D work in a laboratory or shop, for field work the selector switch is more practical and produces less error. Remember, when working in the field, the operator's hands may be full or they may be wearing gloves. Although membrane switches are useful, they can be unresponsive or easily jump to the wrong option under these conditions.

Another variable is that the operator may be distracted or called away, then have to re-establish where he or she is with regard to the options. A selector switch is robust, stands up well to rough field conditions, is easy to operate and readily shows what position it is in. Most important, it only requires a glance for a distracted operator to re-establish what the selected test conditions are.

Changes in function and mode switches

Let's take a look at two selectors that are staples of insulation testers: function switches and mode switches.

Function switch

Function switches on old instruments were limited to a discrete number of test voltages plus a continuity test, and possibly a kilohm range and/or a voltage check. The selector may have a flexible test voltage position. With this, the operator is able to set almost any test voltage across the whole range of the instrument. This could possibly be done in increments as tight as 1 V. If you need to test 600V wiring, it's no problem using an older tester.

In addition, there is no need to make a choice between 500 V or 1 kV. The instrument can be set at precisely 600 V. This enables standards conformances to be met precisely rather than approximately, and greatly reduces controversy and disputes with customers, clients and oversight authorities. It also facilitates careful observation of the reaction of insulation to gradual increase in voltage by small increments, similar to a “tip up” test in high-potting, but without the destructive potential.

Another position not found on old testers is Setup. Typically, if you go there you can then use arrow keys to scroll through every function that the operator can influence. First-time users will usually want to ignore this key, but once fundamental operation has become familiar, the setup menu affords options to make the testing quicker, and more precise. These available options are expanding all the time.

Modern mode and function switches on insulation tester

Generally, horizontal arrow keys scroll through the options and up/down keys select values. Press a lock button and the selection becomes a permanent feature of the instrument until changed. Test time and pass/fail measurement beepers can be set. You may be able to select high or low test currents for continuity tests on either building-wiring or sensitive equipment.

Convenience functions like backlight timer and sleep timer can be set to the operator’s convenience and battery conservation. A terminal lockout voltage may be set whereby the tester will not engage if external voltage is present on the system or item being tested. This is a vital safety feature for both the operator and the instrument, and can be adjusted against the operating parameters of the system. When testing point-to-point around a system, a REL mode enables the operator to enter a base value and then view the difference between the base value and every subsequent measurement.

Dedicated models for telecom/datacom applications afford additional convenience features. The capacitance per length of the tested cable can be set and then measured. The tester automatically converts the measurement to the length of the circuit and displays that. Some advanced testers will also have a button that rotates the measurement among tip, ring and ground. Three test leads can be connected and the three combinations…tip to ring, tip to ground, ring to ground…can be measured by merely pressing a button, with no need to change leads.

Mode switch

The other selector is the mode switch. This gives the operator the option of selecting a standard insulation resistance (IR) test, a timed insulation resistance test (IRt), a Polarization Index (PI)

test, a Dielectric Absorption ratio (DAR) test, a Dielectric Discharge (DD) test, a Step Voltage (SV), and a Ramp test.

Let's explore what each of these tests does.

Testing modes on insulation testers

When using an old tester, most tests need to be performed manually. The operator did each step individually and results were hand written on record cards. Of the above tests, the dielectric discharge and ramp tests cannot be performed manually at all, while the others required a lot more involvement, time and possible error by the operator.

Insulation Resistance Test

With a modern tester, the time that the resistance test is to run is a 'set and forget'. The operator can set the test then perform another task, like working on something else or taking a break. The test will run continuously for the prescribed time, terminate automatically and all data will be retained.

Polarization Index Test

The polarization index is a reading taken at one minute divided into the reading at ten minutes. Modern testers may provide the ability to adjust these times for convenience, although any other interval cannot properly be termed a PI. The resultant ratio is a figure of merit that frees the operator from having to interpret resistance readings, which can range from Megohm to Tera-ohm values.

Results of Polarization Index test on MIT1025 10kV insulation tester

In strong insulation, the tester measures mostly charging currents, which are part of the insulation structure. As they charge, they diminish, and readings go up. Deteriorated insulation, by contrast, will pass leakage current to ground, lowering the reading. If the PI is low, it means the tester has measured a comparatively large amount of leakage current and the automatically calculated figure of merit will alert the operator.

Dielectric Absorption Ratio Test

DAR is just PI with shorter time intervals; 30 seconds divided into a minute or one minute into three. The principle and results are the same as for PI, but are an accommodation to newer insulating materials that do not have as long a time signature due to composition of enormous cross-linked polymeric materials. The DAR time can be adjusted. The shortened time will often provide a measurement that a PI will over-range before the 10-minute mark, thereby providing no figure of merit as there is no second number into which to divide the one-minute reading.

Dielectric Discharge Test

DD is a complex test that cannot be performed manually. Unlike all the others, it measures the DIS-charge current after the test item has been fully charged in an insulation test and then the test voltage terminated. This is called relaxation current, where the structure of the insulating material reverts to its more random pattern once the dc voltage gradient of the test has been removed. Like PI and DAR, it calculates a figure of merit. Its prime function is to alert the operator to a faulted layer between perfectly good layers of a multi-layered insulation.

Step Voltage Test

Rather than applying a steady test voltage, step voltage increases it automatically in regular steps. Typically, the operator enters the top voltage and the tester automatically divides this into five one-minute intervals. This could be done manually with a watch and turning up the selector switch, but an automated SV has numerous advantages. As the voltage increases, the resistance should essentially hold. Deteriorated insulation…especially old, dry and brittle…will pass increasingly more current as smaller cracks and other imperfections are exploited, and so the resistance will drop notably with each step.

Ramp Test

The Ramp Test is a sophisticated SV, where the test increases steadily one volt at a time instead of by quantum leaps. It helps to have a practiced eye to interpret a ramp test, but one hopes to see a smooth and steadily rising resistance curve versus time. Deviations from smooth curve can give the experienced operator valuable insight into the nature of insulation damage and deterioration.

Advances of modern insulation testers

With these advanced capabilities, a modern full-featured insulation tester provides much more information more quickly, accurately, and reliably than older single-function testers. Gone are the days of manual timing, record keeping and fewer available tests. While modern insulation testers still require training to use them properly and accurately interpret results, advances in controls technology has helped drastically reduce human error in testing.

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