USE OF ELECTRICAL TEST EQUIPMENT

Test equipment is necessary for determining proper set-up, adjustment, operation, and maintenance of electrical systems and control panels.

The following is a general procedure for use of test equipment:

TYPES

VOLTMETERS

For measuring differences of potential (voltage) between two points in an electrical circuit. The instrument is connected in parallel with the circuit being measured. Ranges vary from a few tenths volt to a few thousand volts. Instruments are capable of measuring both A.C. and D.C. voltage.

OHMETERS

For measuring the electrical D.C. ohm resistance of a circuit, circuit part, or component. Calibrated from zero ohms to infinite. Measures either series or parallel resistance.

AMMETERS

Measure magnitude of electrical current flow in an electrical circuit. When measuring D.C. currents, some types must be inserted in series with the circuit. A.C. ammeters are of two types. One requires that it be connected in series with the circuit; the other needs only to be clamped around the current carrying conductor. Ranges are from less than .0005 to over 100 Amperes, depending upon the instrument.

HIGH POTENTIAL TESTERS (HI-POT)

Capable of generating calibrated voltages from zero to several thousand for purpose of testing the integrity of insulation on wiring (usually buried in the earth).

GROUND ROD TESTER

For testing the effectiveness of, and determining the value of resistance of the grounding electrode (rod) circuit in an electrical system. Usually operate by a balanced bridge circuit and has a direct readout of resistance.

CHART RECORDERS

Electrically driven and operated roll chart indicator. Gives a graphic readout of parameters versus time. Units are available for recording voltages, currents, pressures, temperatures, light levels, etc. Some instruments are single channel; others can measure multiple inputs. Useful for monitoring a parameter over a period of time.

Instrument sensitivities and accuracies vary approximate proportional to the quality.

Some instruments combine functions and are capable of measuring different quantities. One is the common VOM, or the volt-ohm- Ammeter.
Mode and range is selected by a switch or switches.

A convenient and versatile instrument is a late model VOM of great sensitivity and range and has a liquid crystal readout, is portable and capable of operating for long periods of time powered by an internal replaceable battery.

PRECAUTIONS

Care must be taken when using test instruments not only for the protection of the instrument and the circuitry under test, but for the protection of the user.

GENERAL RULES:

Always start by starting the range switch at a value higher than that which you reasonably expect to measure. If not, you could damage the instrument.

Make sure your multi-tester is set in the right mode. Trying to measure voltage with the mode set on “AMPS” could destroy the meter and possibly cause harm to the operator. Also, some meters are destroyed by trying to measure voltage if meter is set to measure resistance.

If you have a choice of finding a fault in a circuit with dangerous voltages on it by either testing voltages or measuring resistance, turn off the power and use the latter.

Keep test leads in good condition—No cracked insulation, keep probes sharp, connectors tight.

Do not place the instrument in a place where it may be pulled off and onto the floor or onto other circuitry.

If using an ammeter that requires that it be inserted in series with the measured circuit, turn off the power, make your connections, turn on the power and measure. Repeat procedure when disconnecting the meter.

Clamp-on type ammeters do not require the circuit to be opened for insertion of the meter; safer and faster to use.

When using a HI-POT tester, keep the area clear of those who are not part of the testing.

Always start tests with output control at zero, and the switch in the “OFF” condition. Make sure all equipment grounds are tight, and that the device is connected and used according to manufacturer’s instructions. This device can fry you.

Make sure that the power cannot be turned on to the circuits you are testing unless or until you want it turned on. Stand on a rubber mat; concrete is a good electrical conductor.
Note: above ohmmeter examples assume no other circuits are in parallel with those shown. Erroneous readings will be obtained if this is not the case. To be sure, take resistance readings on a suspected component by either unplugging it, or disconnecting one of its leads.
AMMETERS (SERIES TYPE)

By measuring across an Open controlling switch Meter is in series with Load- O.K.

In Fig. 8A no reading is obtained because closed switch shorts out meter.

Do Not measure across the load. The low resistance of the meter will draw very large currents. (B)
Rods should be about 20 feet apart in and in a straight line with each other.

See Instrument instruction manual for calibration and use.

**RECORDING INSTRUMENTS**

Connections are made in the same manner as show for voltmeters, ohmmeters, or ammeters. If the instrument is capable of monitoring more than one parameter, a mode switch must be set prior to hookup.
HI-POT TESTS

This test normally done by licensed electricians or test specialists after continuity and insulation tests have been performed on the wires or cables.

Criteria for testing depends upon the type of wire insulation, and the conductor size. Test voltages and method are described in job specifications.

Purpose of this test is to detect breakdown of wiring insulation through holes or cracks in insulation due to damage or manufacturing defects.

A graph leakage current versus D.C. test voltage is included here to represent a typical curve obtained by this test.

Basically, a high D.C. voltage is applied between the conductor and ground; the voltage gradually increased at a definite rate of time and held at a maximum for a specified length of time.
GROUND LOOP IMPEDANCE TESTER
them to the test anywhere in the world.

<table>
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<tr>
<th><strong>8022B Handheld DMM</strong></th>
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<th><strong>8024B Handheld DMM</strong></th>
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**8021B Handheld DMM**
All of the functions of the 8022B with the high-speed continuity beeper.
$149

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KEITHLY CLAMP ON AMMETER PROBE

Set range for best accuracy

Clamp probe around single conductor
Control Cable Insulation Resistance Test

Make measurements with digital type ohmmeter with a 10,000 megohm minimum scale range, Fluke 8020A or equivalent. Limit test voltage to 10 volts D.C. (Fluke meets this requirement).

Procedure:

1. (a) Disconnect all cable conductors and shields at both ends.
   (b) This cable has two shields which should be tied together and treated as one shield for testing purposes. Scrape off plastic coating when connecting shields together.

2. Drive a 5-foot ground rod near cable end test point.

3. Set a voltmeter to the 200 D.C. millivolt range (on Fluke meter press the bottom gray button in, all others out). Place test leads in the center and right hand test jacks. (SEE METER SETUP “A”).

4. Measure the voltage between the shield and ground rod, and record. (Fig. 1) The voltage should be less than .01 volts, (ten millivolts). If the voltage is more than .01 volts, this indicates cracks or cuts in the outer cable insulation, which must be repaired before the remaining tests are performed. If the measured voltage is less than .01, proceed to the next step.

5. Set meter on the 200 nanoseimens range (on Fluke meter press the upper two gray buttons and the lower white button in, all others out). Place test leads in the center and right hand test jacks. (SEE METER SETUP “B”)

Note: to convert nanoseimens to megohms, use the following formula:

\[
\text{Megohms} = \frac{1000}{\text{Reading}}
\]

Reading = 1.0 Then megohms = 1000/1.0 = 1000
Or use conversion charts supplied with Fluke meter.

6. Measure and record insulation resistance between:
   a. Each conductor and every other conductor. (FIG. 2)
   b. Each conductor and cable shield. (FIG.3)
   c. Each conductor to the ground rod. (FIG.4)
   d. Cable shield to the ground rod. (FIG.5)

All individual resistance measurements shall exceed 5,280 KFTM. (kilofeet-Megohms).
KFTM. (Insulation Resistance) =
Length of cable in kilofeet x measured resistance in megaohms.
1 kilofoot (KFT) = 1000 ft.

Example:

Cable length = 2,641 feet (2.640 KFT)
Measured resistance of cable shield to ground rod = 2,400 megohms.

So, Insulation Resistance (KFTM) =

(2.640) KFT. X (2,400) megohms = 6,335 KFTM.

This is acceptable, as it exceeds the minimum of 5,280 Kilofeet –Megohm specification.

Control Cable Continuity Test

Make measurements which digital type ohmmeter with a 10,000 megohm minimum scale range,
Fluke 8020A or equivalent. Limit test voltage to 10 volts D.C. (Fluke Meets this requirement).

Procedure: (Figure 6)

Disconnect all cable conductors at both ends.
Short both conductors of each pair together at one end of cable.
Set ammeter to measure resistance in the expected range, and measure the resistance of each pair
in the control cable at the opposite end, and record.
(SEE METER SETUP “C”)

The resistance of any pair should not exceed 38 ohms for each 1000 feet of #22 AWG. CU.
Control cable tested.

Acceptable measured pair resistance =

(Cable length in feet) divided by 1000 x (38 ohms/1000 feet)

Example:

Cable length = 1,255 feet
Measured resistance = 45 ohms.

So: (1,255/1000) x (38) = 47.69 ohms. (acceptable maximum)

Actual measured resistance = 45 ohms and is acceptable because this is less than maximum
specified resistance allowable.

Control Cable Installation Precautions

For control cable protection, cable should be surrounded by at least 6 inches of fine sand. Care
must be taken to prevent damage to the cable or insulation by falling rocks, sharp shovels or other
tools, crushing by heavy equipment or machinery. A puncture in the insulation most surely will cause cable failure sooner or later.

The insulation thickness is only “.045” and a small puncture of the insulation will allow moisture and contaminants to contact the shield material, causing electrolysis which will eventually destroy the shield of the cable. More and more moisture enters over a period of time and finally the cable has to be replaced.

Specifications require that an insulation cut or puncture fault without damage to the shield or conductors be encased in a poured resin type splice container (without splicing).
FIG. 1

CONTROL CABLE INSULATION RESISTANCE TEST
(SHIELD TO GROUND VOLTAGE)

SET METER AS SHOWN IN PICTURE "A"

FIG. 3

CONTROL CABLE INSULATION RESISTANCE TEST
(BETWEEN EACH CONDUCTOR & CABLE SHIELD)

SET METER AS SHOWN IN PICTURE "B"
CONTROL CABLE INSULATION RESISTANCE TEST
(BETWEEN EACH CONDUCTOR & EVERY OTHER CONDUCTOR)
SET METER AS SHOWN IN PICTURE "B"

(a) CONNECT ONE LEAD TO "A", AND MEASURE WITH THE OTHER LEAD AT THE REMAINING CONDUCTORS IN SUCCESSION.

(b) MOVE THE COMMON LEAD TO "B", MEASURE AT REMAINING CONDUCTORS (EXCEPT "A" WHICH HAS ALREADY BEEN CHECKED).

(c) MOVE THE COMMON LEAD TO "C" AND REPEAT (EXCEPT FOR "A AND B" WHICH HAVE ALREADY BEEN CHECKED).

(d) CONTINUE PROCEDURE UNTIL ALL WIRES HAVE BEEN CHECKED.
FIG. 4
CONTROL CABLE INSULATION RESISTANCE TEST
(BETWEEN EACH CONDUCTOR & GROUND ROD)
SET METER AS SHOWN IN PICTURE "B"

FIG. 5
CONTROL CABLE INSULATION RESISTANCE TEST
(BETWEEN CABLE SHIELD & GROUND ROD)
SET METER AS SHOWN IN PICTURE "B"
CONTROL CABLE CONTINUITY TEST

SET METER AS SHOWN IN PICTURE "C"
CONTROL CABLE
INSULATION RESISTANCE TEST

(A) D.C. VOLTAGE

(B) RESISTANCE
(NANOE/MENS)

LEADS

LEADS
MODEL 168J KEITHLEY MEASURES AMPS AND READS OUT .1XAMP READING IN VOLTS. MOVE DECIMAL POINT 1 TO RIGHT TO OBTAIN CURRENT READING.
EXAMPLE: 1.35 ON METER = 13.5 AMPS.