Workbook for unit standard 750 version 8 17 Electrical test instruments

Requirements for a harmful electric shock

A difference in voltage that is sufficient enough to break skin resistance

Prescribed electrical work starts at 50 volts ac. Any voltage above this level increases the ability to force a current through the body

Enough current to cause the heart to stop or breathing to stop or both

RCDs for general use are limit 30mA of shock current or residual current. Where risk is higher usually because skin resistance is lower or the person is more vulnerable to shock, the current is limited to 10mA

A current path that includes the heart

A path across the chest includes the heart, which may cause fibrillation or the lungs which the current may cause to constrict

Enough time

Outlet circuits must operate the protection within 400mS if there is a short circuit fault.

RCDs in general use must operate in 300mS if 30 mA is flowing as residual current.

RCDs in elevated risk situations must operate in 40mS at 10mA of residual current.

A heart cycle is around 400mS with only one part of the heart cycle (the rising T) a fibrillation risk

Harmful electric shocks cause

Fibrillation

Arrested breathing

Burns

Falls or consequential injury

Electrical test instruments

Introduction

The instruments discussed are used to verify isolation, assist diagnosis of faults and verify electrical compliance on low voltage installations and appliances

Instrument class classifications

Test instruments **for use on low voltage**, less than 1000v ac, 230v single phase and 400v 3 phase are divided into 3 classes, (cat II, cat III and cat IV)

These classes are called **"cat rated"**

This mean the category of fault (high transient voltages) that the test instrument is rated to be safe at.

Cat I is not to be used on low voltage circuits. An instrument that has no cat markings printed on it would be Cat I. Don't use it above 50v ac regardless of any high voltage scale that may be displayed on the meter. Look for the cat rating.

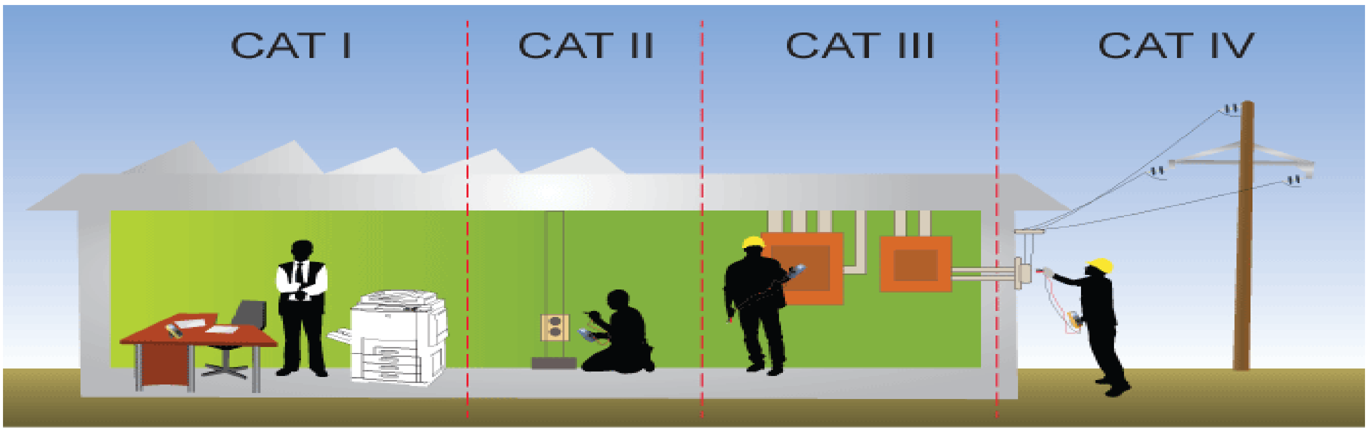
Cat II is safe to use on **appliances** connected to sub circuits and final subcircuits. Final subcircuits are the cables that leave the switchboard that lead out to lighting, outlets and other loads in an installation. These cables and loads are protected by the fuses, circuit breakers and RCDs at that switchboard.

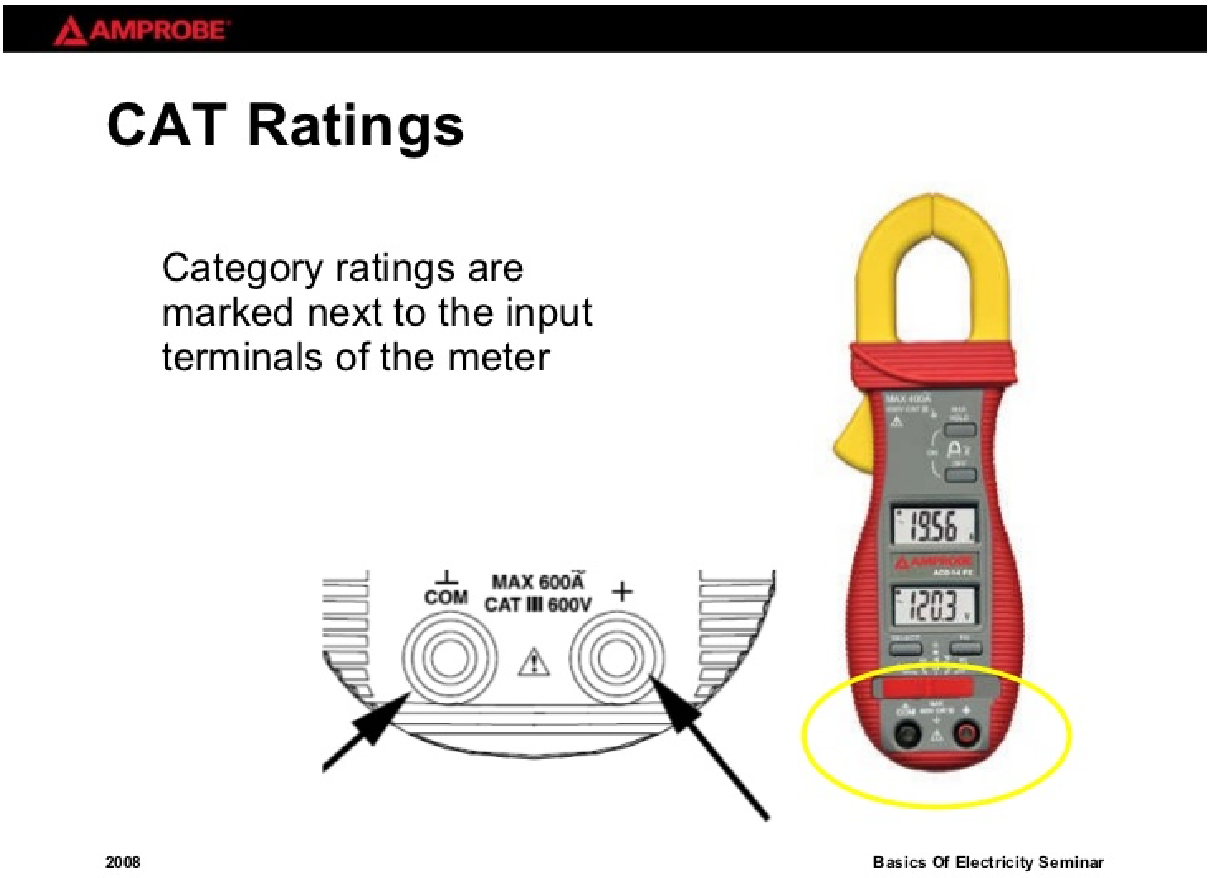
These protective devices therefore limit the consequences of a fault involving you, your meter, the equipment and cables at that location. The subcircuit cable in particular, while low resistance, is still relatively high, compared to the supply resistance that feeds it.

Cat III is safe to use on all subcircuit wiring back to the fuses, circuit breakers and RCDs at that switchboard. A fault at the switch board after the protection will offer protection by those devices. Prior to those subcircuit protection devices a higher cat rating is needed

Cat IV is needed to be safe to interrupt substantial faults on the distribution lines and consumer mains to the switchboard

Each category also has a 600v or 1000v option.





Fuses and leads

It is not just the instrument that is cat rated. The leads must be capable of withstanding the cat rated fault as well. Particular care must be taken to replace a blown fuse with the same performance fuse. Without this, the cat rating fails and the protection level too

Multimeter

A multimeter can be either analogue, where a moving needle displays the value, or a digital meter that usually displays numerals.

Multimeters can display ohms, amps and volts, both for ac and dc applications and over various ranges. Digital options can have auto ranging where the meter chooses the range when it reads.

The **ohmmeter** part of the multimeter uses an on board battery to provide the energy to measure the resistance.

Connecting the meter to a live circuit on this function may cause the fuse to blow in the meter or the circuit protection to operate. A low cat meter may be destroyed. Some meters have a protection circuit warning against wrong connections

The current meter or **ammeter** function passes the circuit current through shunts (low ohm resistors) within the meter and displays the value on the scale.

Diodes are used when choosing ac to change the sample current to dc as the scale only reads dc

The **voltmeter** function is also either ac or dc and also needs to be chosen. Diodes again are used to change ac samples to dc.

Both voltage and current values can only be read on a livened circuit.

Digital meter below

Analogue meter below

Digital multimeter with a built in non-contact voltage tester below

Clip-on ammeter

This type of meter is a non-contact meter. There is no electrical connection to the meter rather the meter reads the value by interpreting the electrostatic field around the conductor. This field is proportional to the current.

The advantage of this type of tester is a live circuit can be measured without interruption and without any live connection. This is both more convenient and safer.

As seen above only one conductor must be read. If both phase and neutral is measured at once the resultant will be zero (equal and opposite cancels the readings). This is also true of DC readings. Most clip-on or finger meters only read ac current.

Clip on ammeters can also incorporate multimeter functions

This type allows the insulated conductor to be inserted into the slot on the left, to take a non- contact reading. Multimeter functions can be chosen on the dial and leads on the left are used to connect to the circuit

Non-contact voltage testers

This type of tester is simply placed close to an insulated or uninsulated conductor and responds to the electrostatic field to indicate a voltage. This will read the presence of voltage without the need for a current to be flowing.

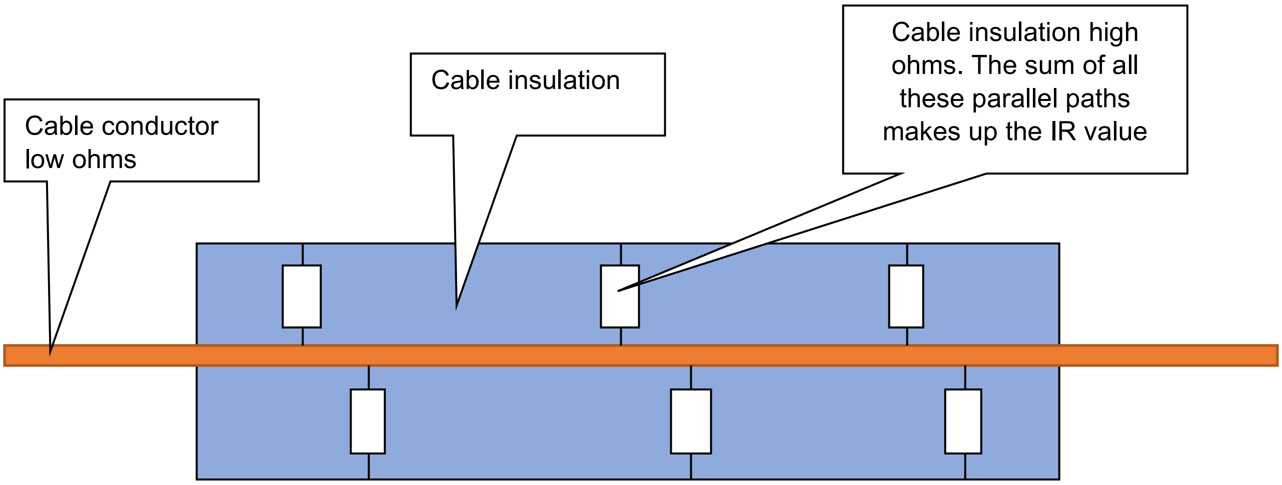
This is a safer method of testing for the presence of voltage but does not give a value. Most indicate at 50 volts or above but some have a dual voltage where 12 to 50 volts indicates differently to above 50 v.

Indication is by illuminated lights, flashing lights, sounds, vibration or combinations of these.

Some are more sensitive than others so care and experience must be employed for correct interpretation. Generally used to detect voltage presence and then confirm isolation with a voltmeter. “Prove - test - prove all combinations”

Insulation resistance tester (IR)

This meter is often referred to as “a megger”, after the manufacturer that first made it. It is actually called an IR tester and measures the resistance of the cable insulation **not** the resistance of the cable conductor.



The longer the cable, the more paths are available for current to leak through the insulation.

The higher the voltage on the conductor, the greater the leakage current.

An insulation resistance tester generates 500VDC and by regulation must maintain close to that voltage throughout the test.

Where cable conductor has a constant resistance as voltage is applied.

A cable’s insulation resistance reduces as higher voltages are applied.

Any fault that may occur at service peak voltages will be revealed at this higher test level.

Long lengths of large cables and power transformers have a high capacitive effect. AC would charge and discharge them like a capacitor and alter the test value.

DC charges them up and then tests at that voltage for a more accurate value.

An ohmmeter cannot be used to test insulation as the voltage levels are only around 9 volts and will not stress the insulation.

The 500v DC required to test insulation above the 325V peak for 230v AC circuits can damage electronic devices not designed for such stress.

For this reason insulation testing is carried out with phase and neutral shorted to one lead of the tester and earth to the second lead.

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The 500 volt output can be increased to 1000 volts for three phase tests. The higher voltage is more appropriate for the 565 volt peak of 400 volt rms.

The 500 volt output can also be decreased to 250 volts if delicate electronics is at risk of damage

Most IR testers also incorporate a low ohm function for testing main earths or earth leads at a greater accuracy than a multimeter.

500 volt dual IR and low ohm tester

Below analogue insulation tester

Earth loop impedance testing

Three areas of verification converge on the use of earth loop impedance testing.

1) The requirement for disconnection of socket outlets within 400mS as outlined in AS/NZS 3000 1.5.5.3(d) protection by automatic disconnection of supply disconnection times

2) The requirement for the breaking capacity of any short circuit protective devices (circuit breakers or fuses) to be greater than the prospective short circuit current at the point where the device is installed

3) Verification that the protective earthing conductor is effective

RCDs in general use are required to operate within 300mS to protect people from electrocution. This is based on sound data from the international shock standards.

If RCDs are protecting the circuit involved there is no requirement to use an ELZ tester.

There is still however the question of the MCB or fuse breaking capacity to ascertain.

In summary an ELZ test will firstly verify if a socket outlet will disconnect before someone is shocked to the point of fibrillation if connected to a short circuit fault. Less than 400mS.

This test is typically carried out at the furthermost socket outlet to check for the disconnection time's worst case.

And secondly to verify if the protective device will withstand the short circuit current.

This test is typically carried out at the switchboard to check the kA rating of the protective device.

Using an earth loop impedance tester is an easy method, providing the installation is supplied with electricity.

The tester displays the ohm value of the subcircuit being tested. This value is then compared to table 8.1 section 8.3.9.3 AS/NZS 3000. The size and type of MCB or fuse is a factor on this table. If the value on the tester is lower than the appropriate value on the table then the protection at that point will operate within 400mS if a phase to frame or phase to neutral fault occurs.

Protective device rating A	Circuit-breakers Type B	Circuit-breakers Type C	Circuit-breakers Type D	Fuses	
	Disconnection times				
	0.4 s			0.4 s	5 s
	Maximum earth fault-loop impedance Z_s Ω				
6	9.58	5.11	3.07	11.50	15.33
10	5.75	3.07	1.84	6.39	9.20
16	3.59	1.92	1.15	3.07	5.00
20	2.88	1.53	0.92	2.09	3.59
25	2.30	1.23	0.74	1.64	2.71
32	1.80	0.96	0.58	1.28	2.19
40	1.44	0.77	0.46	0.96	1.64
50	1.15	0.61	0.37	0.72	1.28
63	0.91	0.49	0.29	0.55	0.94
80	0.72	0.38	0.23	0.38	0.68
100	0.58	0.31	0.18	0.27	0.48
125	0.46	0.25	0.15	0.21	0.43
160	0.36	0.19	0.12	0.16	0.30
200	0.29	0.15	0.09	0.13	0.23

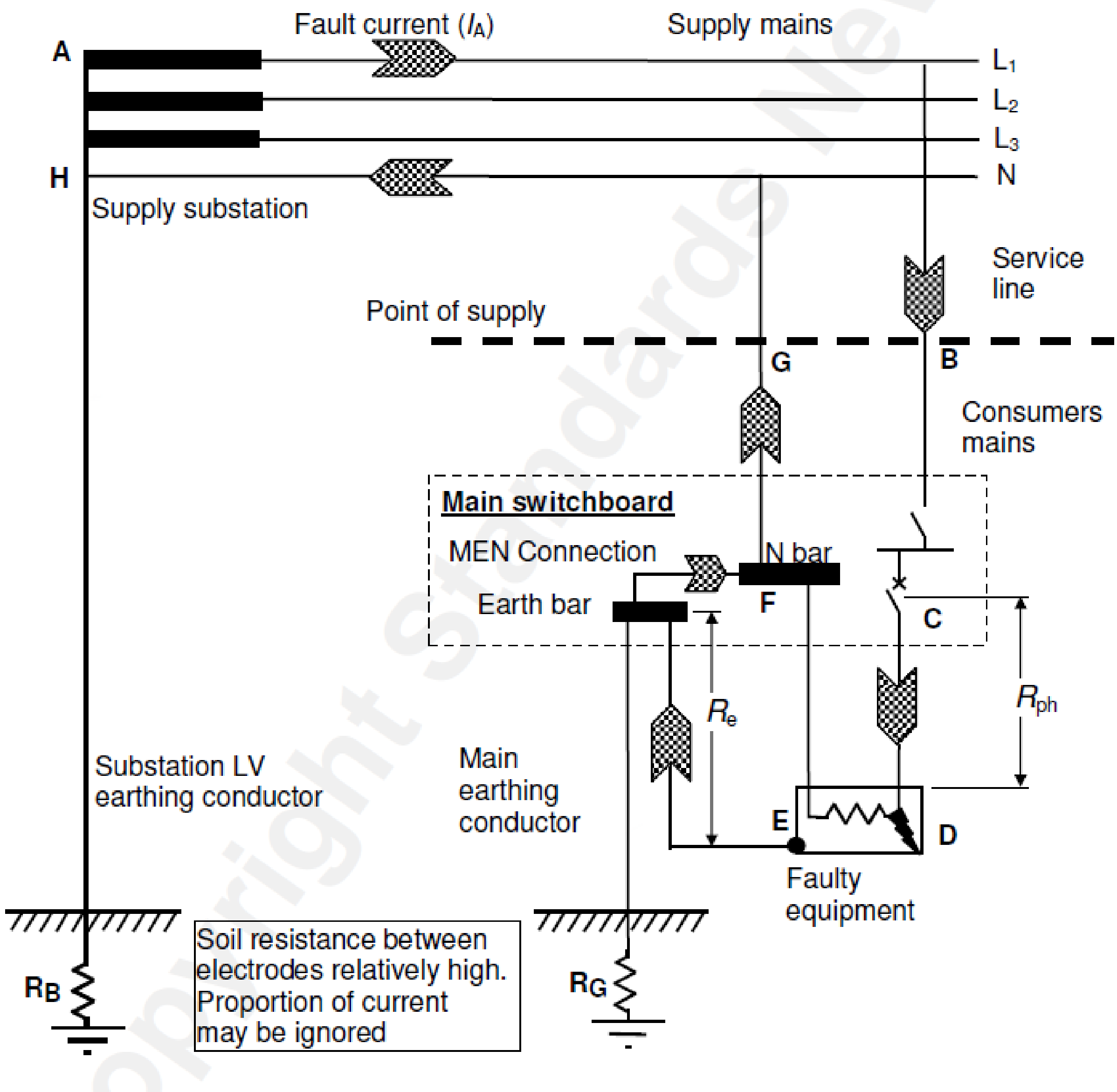
A high current test checks all the connection points along this path, showing a higher impedance reading than expected if any connections are high resistance.

A low current test has the advantage of testing the loop while not tripping if an RCD is protecting the subcircuit, but doesn't check poor connections as well as a high current test

The loop test path follows the subcircuit earth back to the earth bar, across the MEN link to the neutral bar. The main neutral (PEN conductor), service line neutral and back to the star point of the supply transformer.

Through the transformer windings, along the service line active and consumer main to the main switchboard.

The path is then completed through the metering, main switch, protection and subcircuit active.



RCD testing

RCDs can be tested by pushing the test button on the front of the RCD. This should trip the RCD. This is a basic test and does not confirm trip time.

A better way and sometimes mandated method is to use an **RCD tester**.

An RCD tester measures the tripping time and the tripping current that the RCD will operate at.

The RCD tester can be used for both common RCDs in NZ of

- **30mA for 300mS** for general use or
- 10mA for 300mS for rest homes and child care
- 10mA for 40mS for high risk use

To use the tester, the RCD is firstly plugged in and reset for a portable RCD. The RCD tester is then plugged into the RCD and then can be tested

For a switchboard mounted RCD, the RCD is switched on and a socket outlet that is protected by that RCD is used to connect the RCD tester.

The test works the same for both RCD types.

Selecting different tests

Firstly half the rated residual current is selected and the test button pressed. The result should be that the RCD does not trip.

Secondly the full rated residual current is selected (ie 30mA) and the test button pressed. The result must be that the RCD does trip. It must trip in less than 300mS for a 30 mA RCD. This value will be displayed on the RCD tester screen.

Thirdly after resetting the RCD, 5 times the full rated residual current is selected and the test button pressed. The result must be that the RCD does trip. It must trip in less time than the full rated test. This new value will be displayed on the RCD tester screen.

Fourthly a ramp test is selected after the reset button is pressed. Time is not a factor on this part of RCD testing. A set of increasing residual current faults are applied to the RCD until it finally trips. This value will be displayed on the RCD tester screen, and must be less than the rated residual current for that RCD.

Portable RCD

Fixed switch board mount RCD

Thermal test instruments

Thermal test instruments are becoming increasingly used to detect an increase in temperature where if would not be expected.

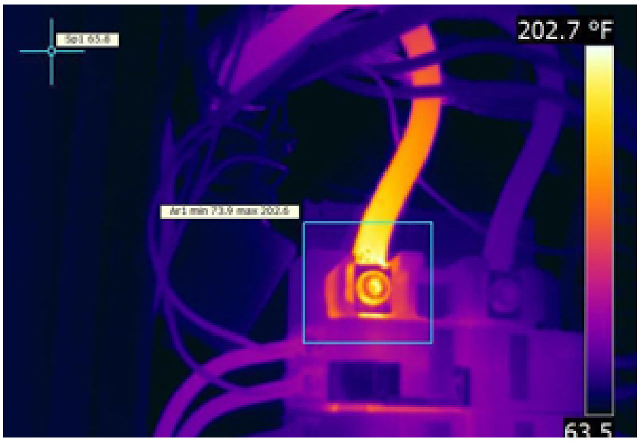
This can be due to poor connections or damage in fittings, connectors or cables.

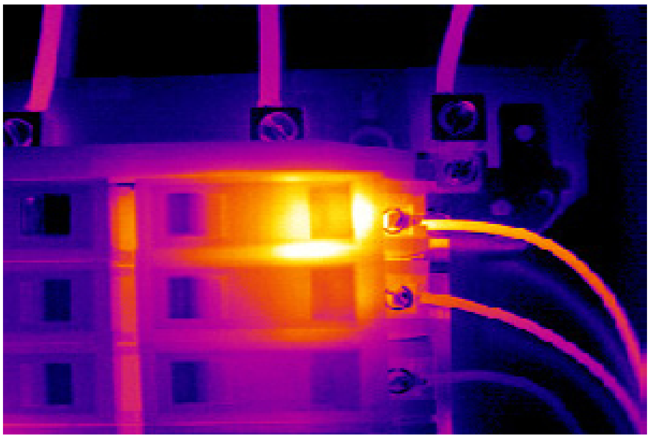
Fault finding overloaded cables, poorly terminated connections and failing switches or contacts is a feature of this equipment

Switch boards can be scanned when commissioned and fully loaded. It is becoming increasingly common to use this type of equipment as part of a maintenance program

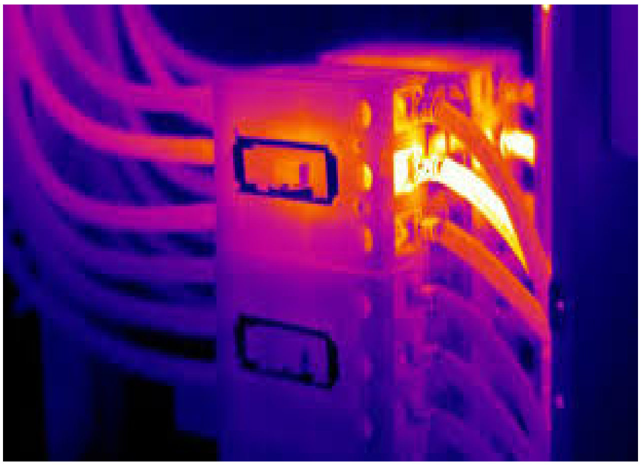
Infrared and visible images are fused together and displayed onto a screen.

The colour displayed is an indication of the temperature range at that part of the image. A targeting cross displays the temperature at that place.





An overloaded cable or a poor connection **A failing contact in a relay**



Thermal imaging camera **an overloaded cable or poor connection**

Incorrect use of test equipment

Incorrect use of test equipment can result in electric shock, flash over burns, eye damage or blindness, damaged equipment.

Select the cat rated instrument suitable for the testing task you are about to perform. This includes the leads and probes that must all the testing to be carried out safely. You may need to check the protection of the meter if it is not your own or from a trusted source.

Do you need gloves and eye protection.

Voltmeters are connected in parallel with the load or across the supply.

Ammeters are connected in series with the load in one conductor.

Ohmmeters are connected in series with the circuit and only on un-livened circuits

Common errors include

1. **Connecting an ohmmeter to a live circuit**. This could lead to a damaged meter, blown fuses or ultimately a flashover.

2. **Connecting a wired ammeter across a supply**. This will have similar but greater consequences to an ohmmeter. The lower ohm value on amps will give a greater fault current. Hopefully the circuit protection and / or meter protection will operate quickly

3. **Connecting a voltmeter in series with the load.** This will cause the voltmeter to read the supply voltage but cause the circuit to fail to operate. This can be misleading and result in a hazard.

4. **Connecting an IR tester to a live circuit** may cause a similar result to connecting on ohmmeter to a live circuit

5. **Broken or open circuit test leads.** This could fail to read on alive circuit resulting in a shock hazard. Prove – test – prove should identify this situation

6. **Blown meter or test lead fuse.** This also could fail to read on alive circuit resulting in a shock hazard. Prove – test – prove should identify this situation

Many modern meters have built in protection that indicates when a wrong function is being applied. Auto ranging also assists errors in reading and selection.

In conclusion, use the highest cat rated test equipment. Keep the instrument and leads in good condition and understand how it is operated and connected. Using a confirming instrument and the prove – test – prove method of testing will reduce errors with interpretation or shock hazards

EE3104 Test meters assignment

Student name

750 Test meters assignment

Name..

1) What is the minimum cat rating that an electrician would use on 230 volt work?

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2) What is the minimum cat rating that an electrician would use to work on an outside domestic meter board?

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3) Define a transient voltage

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4) List 3 methods of protection that lower the risk of shock on subcircuit wiring and fitting

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5) Where are cat ratings usually shown on meters?

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6) What needs to be assured when replacing blown fuses in meters?

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7) Define the difference between an analogue meter and a digital meter

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8) Explain the difference between meter functions and meter scales

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9) List two live tests that a multimeter can safely perform

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10) What is the difference between a clip-on ammeter and the other type of ammeter?

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11) Describe 3 actions you would take to obtain a reading using a clip-on ammeter

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12) Can a clip-on ammeter also be a multimeter?

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13) Can a voltstick detect if current is not flowing?

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14) List two disadvantages of testing for voltage with a non-contact voltage tester

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15) List ways that a non-contact voltage tester may indicate that a voltage is present

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16) What is another name for a megger?

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17) What is an advantage of a voltstick over a voltmeter?

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18) What voltage are IR tests performed at?

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19) Why is that voltage used?

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20) Why is DC used for an IR test and not ac when the circuit will be used on ac circuits when livened?

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21) List the 3 things that an earth loop impedance can test for

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22) Where is the ELZ test taken to confirm a 400mS disconnection time?

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23) Where in the circuit is the ELZ test carried out to confirm the kA rating for fault current?

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24) Where is the table found to confirm the impedance value to confirm that the circuit will trip within 400mS with an ELZ test?

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25) What is the rationale behind choosing either a high current or low current test with an ELZ tester?

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26) Why is the ground not part of the ELZ fault path?

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27) List four things that an RCD tester tests for

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28) What are the values for a general use RCD?

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29) List 3 things a thermal imaging camera can detect while scanning electrical equipment for maintenance or diagnostic purposes

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30) What two ways can a thermal imaging camera display temperatures?

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31) List 4 bad outcomes from incorrect use of electrical test equipment

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32) How are voltmeters connected to an electrical circuit?

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33) How are wired ammeters connected to an electrical circuit?

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34) What will happen if a wired ammeter is connected across the supply to measure current drawn by a load?

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35) Named your assignment?