BOTTER Designs

APPLICATION NOTE 31

# ELCB, GFCI, RCCB, DCDF TESTERS

by Jacques Botte V1.00

## WHY AND WHERE TO USE THEM?

### Terms and Abbreviations

| | |
|---|---|
| ELCB | Earth Leakage Circuit Breaker |
| ELB | Earth Leakage Breaker |
| GFCI | Ground Fault Circuit Interrupter |
| GFI | Ground Fault Interrupter |
| RCCB | Residual Current Circuit Breaker |
| RCB | Residual Current Breaker |
| DCDF | Disjoncteur de Current Differentiel de Fuite |
| DD | Disjoncteur Differentiel |

RCD,.....

Those are only a few abbreviations used in different countries and, by different manufacturers.

### Why to use Them ?

**Ground Fault Circuit Interrupters are used to prevent dangerous and lethal electric shocks to humans and assets.**

**Read Application Note #1**
HIGH VOLTAGE INSULATION METERS
WHY AND WHERE TO USE THEM?

GFCI, ELCB, RCCB, DCDF are required by many electrical code of practice and legislation in areas such as bathrooms, unfinished basements, home, factories, etc...

**The testers are designed to verify accurately their disconnection sensitivity and time.**

GFCI, ELCB, RCCB, DCDF are classified in mainly two types :

- •Instantaneous (trips above a certain fault level = **sensitivity-mA**).
- •Time Delayed / Inverse Time Delayed (Trips after a certain **time delay -S or mS, if** fault current is above a certain level of sensitivity-A or mA)

***Those types of breakers are found everywhere***.

Photos of Instantaneous Domestic ELCBs

Photos Industrials Time Delayed and Inverse Time Delayed ELCBs

**Time / Inverse Time delay Types - Industrial / Domestics 2nd & Third Level Protection**

The specifications are similar for Domestic and Industrial ELCBs.

With the early ELCBs, a magnetic amplifier was used to amplify the earth fault in order to trip the Main Circuit Breaker.

Over the years, new ELCB designs have moved away from magnetic amplifiers to passive devices, then to active semi-conductors types.

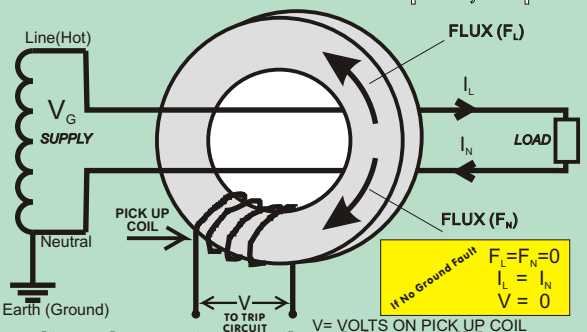
Today, with modern ELCBs designs, many industrial types are programmable and controlled by microprocessor.

The operation of ELCBs was primarily checked by simulating an earth fault equal or greater than the nominal sensitivity of the ELCB and then, checking whether the ELCB tripped.

**It has now become necessary, not only to ensure that tripping takes place, but that ELCBs disconnects at the exact sensitivity and within the correct time, from where a fault occurs.**

### HOW DOES A ELCB WORK ?

If the current leaving the power supply, comes back without taking a grounded path, then the Line and Neutral Currents are equals, no pick up




voltage is created on the pick up coil because no unbalance exist between $I_L$ and $I_N$.

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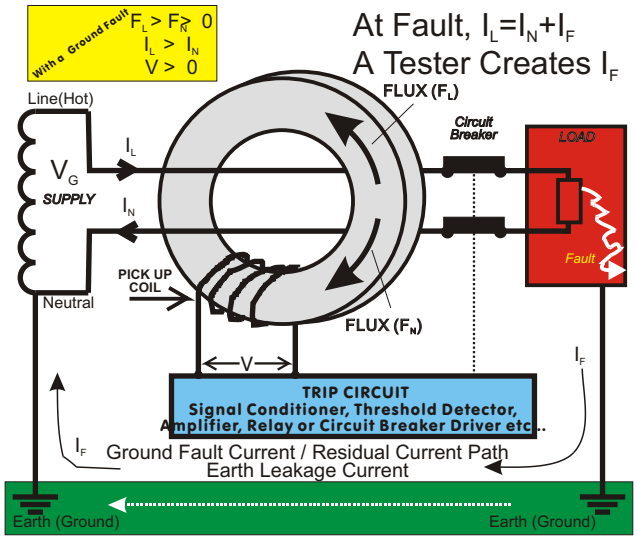


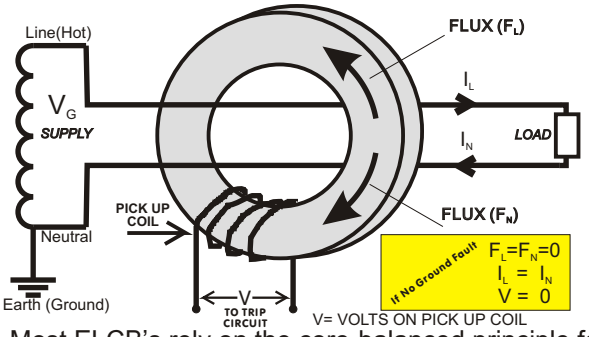

Most ELCB testers rely for their operation on the simulation of a earth fault by connecting a variable resistor between Line(Hot) and Earth(Ground).
But, due to the power dissipation, this become difficult in industrial environment which has a higher system voltage (550V to 1000V Line to Line).
Resistive testers have the disadvantage of having their fault current proportional to the voltage, therefore, as unstable, as the voltage.
In Industrial environment, sensitivities are much higher than in domestic environement.
You will find ELCBs from as little as 20mA, to 30/125/250/375/500/1000mA and some time even higher!

Old TopTronic Testers Produced since 1991 (Now discontinued and replaced by SEW's Testers)

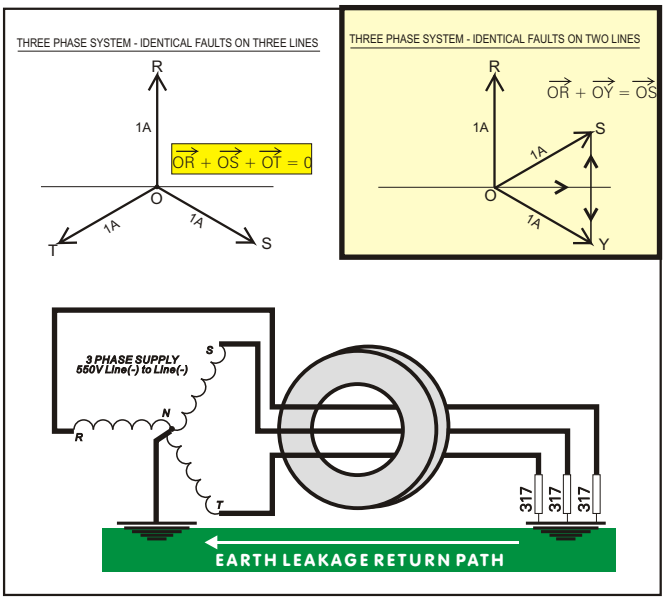
Photos of old TEL2, TEL3, TEL4, TEL5, TEL6, TEL8, TEL9, TEL9R ETC...

***The ironic situation has in fact evolved where authorities requires tests to be done to ascertain the sensitivity and time disconnection of the ELCBs and no testers have been available to execute those tests.***
***With the emergence of the new SEW range of Domestic and Industrial ELCB Testers, this status quo no longer exist.***

## ELCB - HOW IT WORK ?




Most ELCB's rely on the core-balanced principle for their operation.
The current carrying conductors pass through a high permeability core. The vector sum of the fluxes produced in the core by these conductors is Zero if no earth fault is present.
***When an earth fault is present, the out-of-balance flux generates a voltage in the pick-up coil which in turn is used to trip (open) the circuit breaker.***
In a three phase system, if each line has an earth fault of exactly the same amplitude, the ELCB will not see any leakage current and will not trip.




For example, assume that we have a 550V system (550Vac Line to Line) which has 317Vac Line to Earth and that a 317 (the choice of 317 is purely for ease of calculation) resistor is connected from each line to earth.
The earth effectively constitues the star-point of this network with the earth-return path constituting the neutral.
Because we have a balanced load, no current will flow in the earth-return path and the ELCB will not trip because it will not see any fault or any leakage current.
**This example illustrate that in three phase systems, caution must be exercised in simulating faults from the line to earth while the load is connected.**

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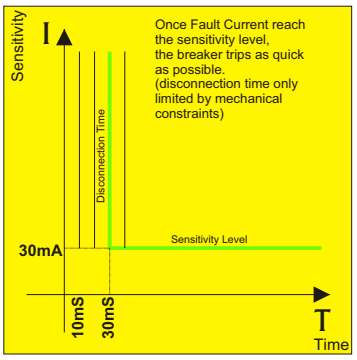
# TYPES OF ELCB's AVAILABLE

**Active or Passive ELCB's ?**

In active devices, an external source is required to trip the breaker.
With passive units, sufficient energy is derived from the fault for tripping the breaker.
Industrial ELCB's are generally of the active type since, even if sufficient energy can be taken from the fault to trip the breaker's contact, an external source is normally necessary to trip a main circuit breaker, usually, via a "shunt" trip.

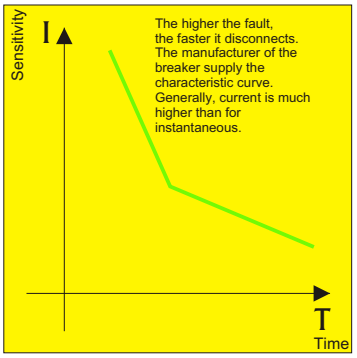
## Instantaneous ELCB's

Once the threshold has been reached, the breaker trips instantaneously (normally within ±10 to 40mS).



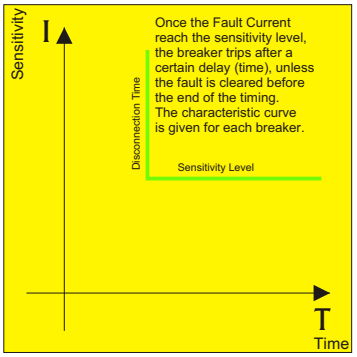

## Inverse Time-Delay ELCB's

The tripping time is inversely proportional to the fault current.



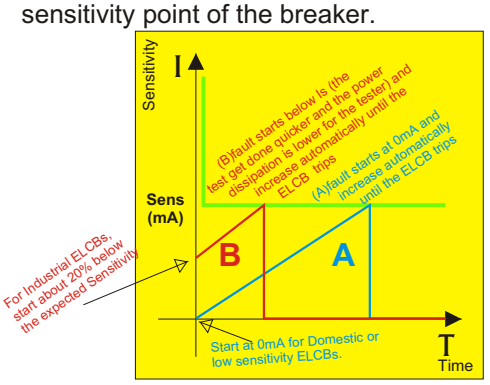

## Fixed Time-Delay ELCB's

With Time delay, once the threshold has been reached, regardless of the amplitude of the fault, a fixed time elapses before tripping occurs.
( provided the fault is not removed before the time delay has elapsed).



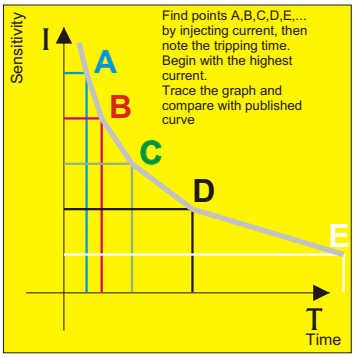

## How to Test Instantaneous ELCB's

To save time and limit the power dissipation in the testers, the starting current can be close to the sensitivity point of the breaker.




## How to Test Inverse Time-Delay ELCB's

A few points on the curve need to be checked and compared with the published curve of the breaker.




## How to Test Fixed Time-Delay ELCB's

Delay must be found by injecting at least twice the rating tripping current noted on the ELCB.
To find the sensitivity, test a bit higher, then a bit lower than the curve and narrow the test around the published information.

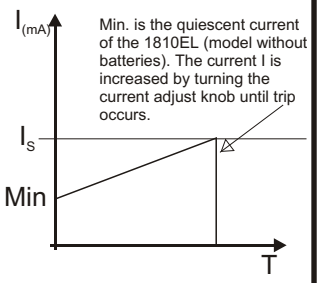
# TEST REQUIREMENTS

## TESTING INSTANTANEOUS ELCBs

A gradually increasing earth fault is injected between Line (Hot) and Earth (Ground) until tripping occurs.
While this increasing fault is injected, the current is monitored by an Ammeter which give the sensitivity of the ELCB (mA).

Analog models let you increase the injected fault current by turning the knob clockwise until the ELCB trips.
No “HOLD” facility is available on this type of instrument. The user must watch the Ammeter while turning the knob.

Photo of 1810EL




Min. is the quiescent current of the 1810EL (model without batteries). The current I is increased by turning the current adjust knob until trip occurs.

The standard 230Vac model 1810EL is without batteries and, has a quiescent current of about 10mA. However, it can be operated with batteries and therefore has no quiescent current.
Contact the factory, should you requires the 1810EL with batteries, or to operate on 110Vac.

Digital models, automatically, start the increasing current at the dialed starting current, then slowly increase the fault current until the ELCB trips.

Photos of 1811EL, 2820EL, 2821EL, 6220EL

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TOGETHER,
WE CAN MAKE THE DIFFERENCE

## Testing Inverse Time-Delay ELCB’s

A given fault current is injected between Line and Earth and the tripping time noted.
The result is compared to the published curve for that ELCB.

No analog testers are available for this purpose.
Digital testers let you dial the constant current on the keypad or on the rotary dial.
When the tester starts it’s test sequence, it measures the open circuit voltage (Line to Earth) before current is injected and memorizes it.
Then, wait for the correct phase angle to start injecting the constant current.
The timer is automatically started when the current starts and automatically stopped when the ELCB trips.
Those values are held on the display.

Photos of 6220EL and 2820EL

The correct operation of an inverse time-delay ELCB may only easily be ascertained if the caracteristic curve of the ELCB is to hand.
The operation of the ELCB is nest assecced by checking the tripping time at the minimum of two points on either side of the knee.

## Testing Time-Delay ELCB's

Two tests need to be done:

**1- checking the time delay**

It is checked first by introducing a fault current of at least twice the nominal sensitivity of the ELCB (three times is preferred), so that you can be far away from the knee.

The trip time should be noted.

**2- checking the sensitivity**

The checking of the knee need to be done by making some tests around the value of the knee (lower and higher than the knee), 0.5IS, 0.8IS, IS, 1.2IS, 1.5IS.

In general, the knee is not sharp and a few test points will give the knee accurately.

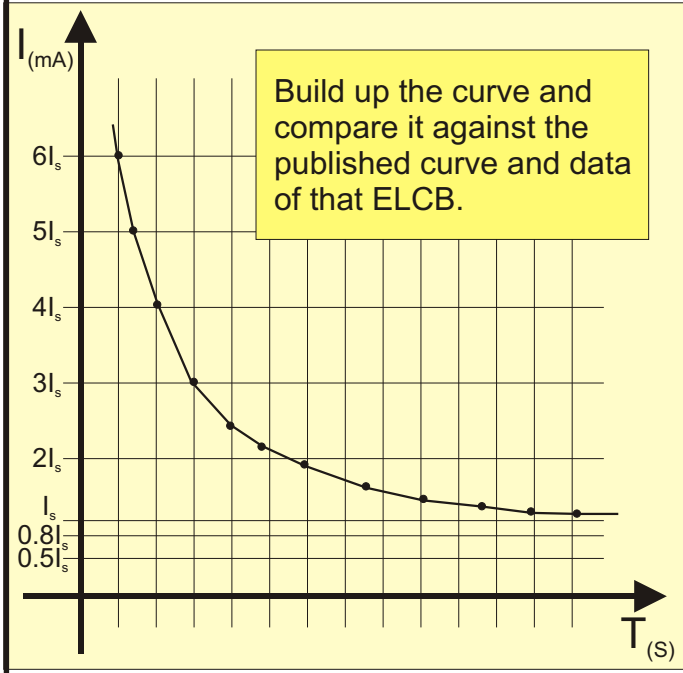


Photo of 2820EL

Designed for Heavy Duty Industrial Applications


Designed for Heavy Duty Industrial Applications

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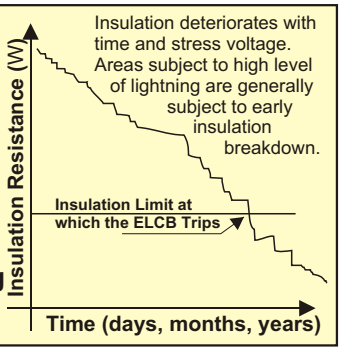
## Causes of Earth Leakage Problems

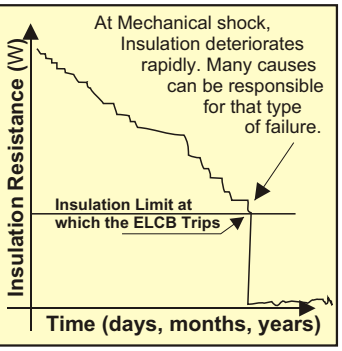
### Insulation

**Insulation deteriorates with time, stress, U.V., temperature, humidity, etc...**
**It's generally a slow process that is mainly responsible for the increase in the standing leakage current.**



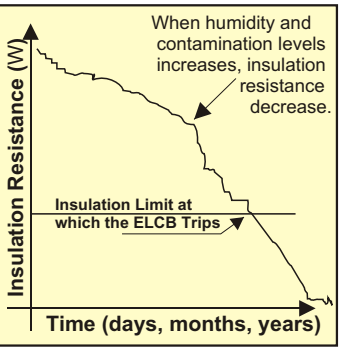

### Mechanical Shock

**Generally, change in insulation is large (touching the chassis) or quickly increasing (something is burning) or material has changed (compressed)**



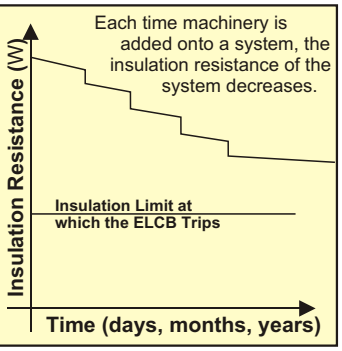

### Contamination

**Wind, sand, dust, humidity, oil, water, petrol, etc...can all contribute to contamination and retains matters which decrease the resistance of the insulation material**




### Increase in Standing Leakage

**Adding new machinery will increase the Standing Leakage Current and will reduce the Insulation Resistance of the total system.**



In most countries, the legislation makes a difference between ***Domestic*** and ***Industrial*** users.

Those differences are mainly single phase versus three phases, low current versus high current, low voltage versus high voltage, low power versus high power and acceptance of the duration of electricity cuts when disconnection is due to a fault.

**Most countries have a policy for testing periodically, all the ground fault circuit interrupters.**

In some countries, this is better enforced than in others, but generally, there is an increased acknoledgement for the need of electrical safety.

***Domestics GFCI.***

Those items are in each houses, all around the world.

Different countries have different limits for those items, for example, here, in South Africa, the sensitivity is 20 to 30mA. The maximum response time is generally specified.

Domestics GFCI are used to prevent dangerous and lethal electric shocks to humans. (Please have a look at my Apllication notes #1 on High Voltage Insulation Meters for effects of current on heart)

Domestic GFCI are required by many electrical codes, for example, for houses, bathrooms, garages, work and construction sites, even boats and outdoors.

In general, they are required in areas where current is more likely to pass through your body, should something go wrong (bad insulation for example).

Domestics ELCBs can detect as little as a few milliamps and disconnect the circuit from the fault.

you are probably familiar with the domestic GFCI which has a reset button and a test button on it.

***Why Time Delayed ?***

Just imagine a building with 30 floors.

Each floor has about, says, 50 offices blocks, each one with a different company operating in it.

Each company, on each floor has a domestic GFCI for protection. (this building has now 1800 domestics GFCI)

Now, what protects the all things ?????

If one of the 1800 GFCIs was having a fault, do you think that it would be acceptable to disconnect the 1800 companies in that building ?

The fault could be just a bad wiring, a mistake, or else(a short circuit for example between Live(Hot) and a Grounded part).

By having a time delayed circuit breaker in the building, the all building would not be disconnected, should a fault occurs.

Take an example, if a domestic GFCI is having a fault on one floor, this domestic GFCI would disconnects quickly.

But because the main building has a time delayed Earth Leakage Circuit Breaker, the main circuit breaker will give enough time to the small domestic GFCI to disconnect.

Should the domestic GFCI not work within the time delay, then, the main Indutrial Time Delayed Circuit Breaker, will trips the all building!!!!

**Time delayed are used to differentiate faults.**

For example; each floor could have a, say 30mA, 2 Secondes, as the Main ELCB, and each company, on each floor could have a domestic instantaneous ELCB of 30mA.

The main building could have an Industrial Time Delayed ELCB of 500mA 10 Secondes,....

**Because the fault which tripped the breaker is not equal to the breaker's sensitivity and is not equal to the breaker's maximum permissible disconnection current. The fault could be anything from a short circuit to the sensitivity of the ELCB.**

In the worst case, only the floor where the fault is created, is shutdown. In the best case, only the company where the fault is, is shutdown.