Safety operations on medium voltage switchgear

It is important when operating on medium voltage equipment that we follow the safety rules and operating regulations in order to be safe. This paper covers general safe operations on medium voltage equipment and looks at the aspects of switching, isolating, testing and earthing, as well as various types of medium voltage testers and their usage.

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Hazards of operating on electrical equipment

There are five types of hazards associated with the operation of electrical equipment.

- Electrical shock
- Electrical burns
- Fire and explosion
- Heat build up
- Mechanical hazards

Electrical shock

There is no way to tell if an electrical conductor or terminal is alive just by looking at it, it should be tested using an appropriate approved tester. Thereafter it should be made safe in such a manner that it cannot be energised by someone else whilst it is being worked on.

Electrical burns

With medium voltage it is not necessary to touch a conductor or terminal in order to get burned. Air does not normally conduct electricity however, when a person gets too close to an electrical wire that is not properly insulated, the air can break down and form a conducting path between them to earth. Coils and capacitors store electrical energy and release it after power has been turned off and should, therefore, be discharged before work commences.

Fire and explosion

There is great danger of fire and explosion when working with medium voltage equipment, due to the large fault currents that can flow in the system. Oil circuit breakers (OCBs) and oil mini sub stations (MSS) and ring main panels (RMPs) pose a particular threat. Operator errors can also cause faults, livening up a cable, whist the other end is earthed for instance.

Heat build up

Heat can build up in wires. A lightweight extension lead gets hot when used for heavy duty service. Avoid using extension leads at all, if possible. If they must be used, ensure they can carry the current without overheating. Do not string them overhead, across aisles and under mats, where heat can build up and fully extend them.

Mechanical hazards

Electricity is often used to run machinery, rotating machinery and moving parts are always a source of danger, always ensure that guards are in place. Make sure the machine you are working on cannot be turned on without your knowledge.

Electricity

Because there is a serious threat of flashover, shock, arcing, etc. when working in a medium voltage environment, lower voltages tend to be treated with less respect. It must be remembered that a voltage as low as 50 V, with a current of ± 30 mA, can cause asphyxia and/or heart muscle fibrillation.

The biggest danger of electricity is that live and dead apparatus are indistinguishable from each other. Therefore, apparatus must never be assumed dead, always presume it is alive. This can only be ascertained by testing with the appropriate approved tester, or by the presence of a visual earth connection.

Electricity can jump gaps, which means that it is not even necessary to touch a medium voltage conductor in order to get hurt. Merely approaching too close can have fatal results, therefore, it is necessary to maintain close proximity distances.

Close proximity

Close proximity is the minimum distance any part of a person's body or work tool may encroach to any unearthed, bare LV conductor or any unearthed and unscreened MV/HV conductor.

In view of the dangers discussed earlier, it is obvious that work cannot normally be done on live or operational plant.

It is important to understand the meaning of the concept isolate, since isolation is the process where dangerous operational plant is rendered safe for persons to work on.

Even after isolation, a cable, or capacitor, or other similar device can retain a dangerous charge and therefore, they must be regarded as alive until discharged.

The term live is not only used in connection with electrical apparatus, but also to describe a vessel or pipeline under pressure, e.g. a live steam line.

ISITE

The acronym ISITE can be adopted to assist with the correct sequence of switching operations.

I - Identify the correct operating location

I - Identify the correct operating device

S - Switch

I – Isolate

T - Test

E – Earth

- Identify the correct substation/MSS etc.
- Identify the correct circuit breaker/ isolator.
- Switch – open the circuit breaker/ isolator.
- Isolate the circuit breaker by racking out/ down.
- Test – using approved voltage detector.
- Earth – connect effectively to earth using correct method.

Switch

Circuit breakers can be opened in several different ways, remote operation is recommended.

Locally

- Electrically – using open/close switch.
- Mechanically – by pushing trip button.

Rated voltage	Clearance
Up to 11 kV	0,2 m
Exceeding11 kV, but not exceeding 33 kV	0,43 m
Exceeding 33 kV, but not exceeding 132 kV	1,45 m
Exceeding 132 kV, but not exceeding 275 kV	2,35 m

Table 1: Minimum clearance for safe working.

- Some circuit breakers have emergency trip buttons or foot pedals.

Remotely

- Remote operating panel
- Remote operating device
- SCADA (supervisory)

Circuit breakers should be opened remotely, where possible. If operation is to take place locally at the panel, then it is recommended that the appropriate personal protective equipment (PPE) is worn (flash suit).

Mini sub stations (MSS) and ring main panels (RMP) are opened manually using the appropriate operating handle. The "T" off to the transformer can be supplied with a circuit breaker or fuses and opened by pushing a button on the front of the unit. They can also be supplied with an electrical remote operating device, the same as a circuit breaker.

Isolate

Isolution mains physically disconnecting the apparatus from all possible sources of electrical potential by:

- Opening and/or removing of fuses.
- Opening of links.
- Withdrawal of truck type switchgear.
- Lock off and apply danger tags.

Security at points of isolation: All points of isolation should be locked off by the application of a personal lock to prevent inadvertent operation of the mains or apparatus.

Danger tags: The use of danger tags is an essential part of the isolation process. Danger tags should be applied at the switch or control gear which has been isolated, in order to enable persons to work on electrical apparatus or conductors safely, by notifying persons that work is being conducted on that piece of apparatus.

Authorised person: A person recommended by the electrical engineer or his nominee and appointed in writing by the designated person to carry out switching, isolating, testing and earthing on electrical mains and apparatus, in liaison with and under the instruction of a control officer and to issue work permits in respect of such mains and apparatus.

Isolation procedure

The authorised person shall carry out the necessary isolations, using personal locks, according to the rules and regulations. Thereafter, carry out safety tests using an appropriate approved tester to ensure that the mains and/or apparatus are dead and apply danger tags at all control points.

Control point: A position on the system where a main and/or apparatus can be switched, isolated, and earthed.

When isolating, the equipment must be isolated, from all possible sources of energy, not just electricity. Therefore, we must consider the following sources of hazardous energy and hazardous substances.

Hazardous energy: Electrical, pneumatic, hydraulic, stored (springs, batteries), potential (by virtue of position), heat (hot water, steam), radiation.

Hazardous substances: Gases, vapours, liquids, dusts with the potential to cause injury or illness, e.g. toxic, corrosive, flammable.

All plant and equipment must have written procedures for isolation; these procedures will set out a step by step account of how the system, plant or equipment is to be isolated and kept safe.

In the case of electrical isolation, a test for voltage must be carried out with an appropriate approved tester, to ensure that the mains and/or apparatus are dead.

Summary

The authorised person performs the isolation according to the rules and regulations. Control points must be locked off using personal locks. Danger tags must be applied to all points of isolation.

The locking of control points and application of danger tags is essential for a safe isolation, and isolation will not be deemed complete until those requirements are met.

Locking off of live shutters

All live shutters should be locked off with the personal lock. Cable shutters should be classed as live shutters, as the cable could be back fed, e.g. open point on a ring, therefore, both bus bar and cable shutters should be locked off.

Test

Before applying earthing equipment, the conductor must first be tested to prove it dead. Before using any approved medium voltage equipment it should be physically inspected for defects. When testing medium voltage the three point test should be adopted, test the tester on a known live source or a test box supplied by the manufacturer, test all three phases and retest the tester.

There are several types of voltage testers on the market and they all have specific uses:

Voltage detector (live tester): Used for testing the presence of voltage. A live tester is one that has to touch the conductor under test in order to determine if it is live or dead (it is recommended that one with audible and visual annunciation is used). These live testers are manufactured in two different types – S and L. S type for use on switchgear. L type for use on overhead lines.

Phase comparator/phasing sticks (live tester): Used to test that circuits are in phase with each other. A phase comparator should be used for phase comparison and not voltage detection.

Phasing in of ring feeds

It is essential to phase in medium voltage equipment prior to energising cable circuits, to ensure the correct phase rotation when cable systems are maintained and extended. Electrical phasing should be conducted when:

- New equipment is installed, which necessitates breaking into a ring feed, e.g. new substations.
- After the repair to any cable which forms part of a ring feed.
- Whenever a cable which forms part of a ring feed is terminated.
- An existing cable (to be returned to service) is being joined and/or terminated.

Voltage detector (proximity tester): Used on overhead lines. This tester does not have to come into contact with the conductor under test to determine if it is live or dead, it detects the magnetic field and therefore only works on bare and unscreened conductors.

There are no test facilities to test the cable is dead before earthing on an MSS/RMP, however, most modern units are supplied with LEDs, indicating if the cable is live or dead and these should be used as a guideline when operating. They also have the facility for doing electrical phasing on the front of the unit, using a multimeter. MSS/RMPs do have test points, however these are for testing the cable once it has been earthed and therefore access can only be gained to them once the cable has been earthed.

Earthed

Connected to the general mass of earth in such a manner as to ensure at all times an immediate safe discharge of electricity.

There are several different types of earthing methods: integral earthing, earthing carriage, earthing truck, and portable earths.

Integral earthing is designed into the circuit breaker and no external attachments have to be applied to the circuit in order to earth it.

There is no electrical tripping in the earth position on a circuit breaker that has integral earthing, so the manual trip button must be locked off.

Earthing carriages are usually used to earth bus bars and use the circuit breaker that has been racked out.

Earthing trucks are usually used to earth the circuit and rack into the circuit once the circuit breaker has been removed.

Portable earths are usually used on overhead lines, or as working earths when work is being carried out remotely from where the control point earths have been applied, e.g. at capacitor banks.

On MSS/RMPs there are test points on the two ring legs, they are used for testing the cable, e.g. megger tests. These test points are only accessible once the circuit has been earthed and the action of opening the test lever removes the earth off the circuit. It is, therefore, essential when earthing a MSS/RMP that the test point is locked off, as well as the earth point on the unit.

Earthing bus bars

When earthing a bus bar all possible sources of supply must be isolated.

Therefore:

- All remote ends should be switched, isolated, locked off and danger tags applied.
- All local circuit breakers should be switched, isolated, locked off and danger tags applied.
- Test with an approved voltage detector.
- Apply a minimum of one earth.

Portable earthing equipment

Application of portable earthing equipment:

- The mains and/or apparatus to be earthed should be tested with an approved voltage detector to ensure that it is dead.
- Check the condition of the portable earths.
- Securely connect the flexible lead to an earth bar or earth conductor FIRST.
- Using an earth or link stick touch each phase of the mains and/or apparatus to be earthed.
- Clamp onto each phase.
- When removing the portable earths the earth connection should be removed last.

Care must be taken to ensure good tight connections.

It is the authorised person's responsibility to ensure that all portable earths are removed before energising the circuit.

Interlocs

All circuit breakers and MSS/RMPs have mechanical interlocks, for example, you cannot rack a circuit breaker out if it is closed, you will not be able to place an earth on an RMP unless it has been opened first. However, they are not interlocked with each other and it is possible to earth a live cable. To this end, the correct oprating procedure must be followed and the authorised person should ask himself, before operating, what effect will the operation I perform have on the rest of the system – for every action there is a reaction! The following is a list of some of the things to consider before operating:

Switch (open)

- Will any supply be lost? If so, can I reroute the supply (shift open point on the ring, or shift load onto another circuit).
- If load has been shared with another circuit, ensure that that circuit can carry the combined load.
- If load has been shared with another circuit, ensure that that circuit has picked up load before opening the circuit breaker.
- Once the circuit breaker has been opened, check the other circuit has picked up the full load.
- Can the circuit breaker be opened remotely, if not what PPE is required?
- On a MSS/RMP the LEDs can be used to see if supply is lost to other circuits and to check if the circuit is dead.

Isolate

- Have all three phases on the circuit breaker opened?
- Before racking out/down a circuit breaker, it is good practice to check all three phases are no longer drawing load, this can be done by using the ammeter selector switch, if one is fitted.

Test

- Is the tester appropriate for use on the system? e.g. correct type and voltage rating.
- Is the tester in good condition?
- There are no test facilities (NTF) on a MSS/RMP prior to earthing.

Earth

- Is the other side of the circuit opened and isolated or earthed?

When reinstating the circuit

Remove earths

- There is no electrical tripping in the earth position on a circuit breaker, so the circuit breaker has to be tripped manually.

Close

- Has the earth been removed at the remote end?
- Has the remote end been made safe? e.g. has the area been checked after work that there no tools have been left in the working area. Have personnel been warned it is no longer safe to work in the area. Have portable working earths been removed etc.
- Has the remote end been secured? e.g. has it been isolated and locked off?

Work permits

Written authorisation for work to be carried out on electrical mains and/or apparatus.

Once the circuit has been made safe for work as above, the authorised person will issue a medium voltage work permit for work to be performed on the isolated mains and/or apparatus. It is important when issuing a work permit the following interaction with the person in charge is carried out:

- Give explicit instructions to the person in charge of the work regarding the work to be performed and the safe limits of the workplace and ensure that this is understood.
- Show the person in charge the control points and allow him/her to place their personal lock at the control point.
- Earth or prove the mains/apparatus dead at the worksite.

When receiving the work permit back at the workplace from the person in charge, the authorised person is responsible for obtaining confirmation that all persons are clear of the mains and/or apparatus and that all personal working earths applied during the work have been removed.