Knowing status of an Earthing Switch in MV Switchgear, contact visibility or positive mechanical indication?

Jean-Marc BIASSE, Schneider Electric – France: jean-marc.biasse@schneider-electric.com
Gang WANG, Schneider Electric – China: gang-jack.wang@schneider-electric.com
Andrea MENGO, Schneider Electric – Italy: andrea.mengo@schneider-electric.com

Abstract
Safety of personnel operating or maintaining MV switchgear is crucial. When work needs to be done on an electrical installation, the equipment must be earthed, since earthing is what ensures the equipotentiality of the working area. Knowing the status of the earthing switch is then critical. The paper critically reviews the different ways to get the information on the status, coming to the conclusion that the positive mechanical indication is the most reliable.

Keywords:
Earthing, switch, mechanical indication, MV switchgear.
When work needs to be done on an MV electrical installation, the equipment must be earthed, since earthing is what ensures the equipotentiality of the working area. Of course, earthing an installation requires the implementation of an operating procedure more complex than the simple switching off of the circuit. Before earthing the installation, it is necessary to make sure that the main circuit is definitely de-energized. To do so, the following operations have to be realized:

- switching off the circuit;
- disconnecting the circuit from the supply;
- checking of the absence of voltage.

Only after having performed these operations, earthing can be done in order to work on the equipment.

Safety means earthing and it is essential to be sure of the link to the earth.

The earthing switch: The safety device

As earthing ensures safety for people in charge of MV switchgear maintenance, the only real device that can be called a safety device is the earthing switch. In MV switchgear, there are two possibilities to connect the main circuit to the earth:

- through an integrated earthing switch in the cubicle;
- by means of a portable device.

Earthing switch with making capability

An integrated earthing switch may have making capability on short-circuits or not. Today, most of the MV integrated earthing switches have making capability and comply with IEC standard 62271-102 [1]. This type of earthing switch is recommended by most of operators and manufacturers. There are many different designs depending on the nature of the MV switchgear, but always a spring gives speed to the moving contacts to achieve the making capability. This making capability is very important because it ensures safety of people in case of closing on short-circuit, for example if the circuit is mistakenly still energized. Figure 1. shows a typical earthing switch of an Air Insulated Switchgear and its mechanism.

Figure 1
Typical earthing switch with its mechanism

Portable earthing and short-circuit device

The portable earthing and short-circuit device is a fully mobile unit that can be brought to an installation and that is used by operators, for example, for additional earthing. For servicing operations, once lock-out/tag-out is done, the work manager installs his own portable earthing unit before doing the maintenance work.

In some regions of the world, for example in North America, the integrated earthing switch is not yet commonly used. Customary operating procedures are different, based on portable devices.
Knowledge of the status of an earthing switch

Knowing the earthing switch status is key for Safety
Remembering that only the earthing switch can provide the equipotentiality of the working area, it is obvious that knowing the status of the earthing switch is critical for safety. The most important thing is to be sure it is in the closed position when it is supposed to ensure equipotentiality. On the other hand, knowing that the earthing switch is in the open position is very important when going back to normal service.

Three ways to know the position of an earthing switch
There are three methods to find out the position of the earthing switch:

- by checking the contacts visually;
- by a mechanical indication system;
- by an electrical auxiliary switch.

IEC standards recognize the visibility of the contacts and the reliable mechanical indication device as the two methods to provide information on the position of the main contacts. This is first expressed in a general way in IEC 62271-1 Common specifications [2] at clause 5.12 Position indication. Then other product standards such as IEC 62271-102 for disconnectors and earthing switches [1] refer to IEC 62271-1 and precise some additional requirements. The electrical auxiliary switch is not considered reliable enough to provide indisputable information on the position of the contacts but it is sometimes requested by some customers to find out the status of the earthing switch remotely.

Practical methods used for position indication

Visibility of contacts
Even if the text of the IEC62271-102 has been unchanged since many years, with the two options presented at the same level of reliability (visibility of contacts and mechanical position indication), there still exists in the minds of some customers a bias in favour of the direct visibility of the main contacts.

Positive mechanical indication
In MV equipment or in GIS, more and more, positive mechanical indication is used to provide the information on the position of the earthing switch (or disconnector). Figure 3, shows a typical MV switch-disconnector including the earthing switch in the same enclosure.
Reliability aspects

Traditional view based on HV designs

It is not difficult to identify the main reasons behind this.
- the traditional disconnector and earthing switch designs adopted for many decades since the beginning of the electrical industry and consisting basically of blades hinged on the top of 3 post insulators engaging fixed contacts over another 3 post insulators located in front of them (Figure 4). With this solution, direct visibility of the gap was the most obvious resort for the safety of the operator. This solution is still the most common in HV equipment;
  - the regulations included in the Work Safety Legislation of some countries. A typical case was Italy where direct visibility of open contacts of disconnectors has been compulsory since 1955 until 1997 before change;
  - the influence of High Voltage world, where most disconnectors and earthing switches are still close to the original concept with imposing contacts moving slowly in the air;
  - the habit of workers on the basis of the above and the naive feeling that nothing can be more reliable than their own eyes.

The concept of reliability needs to evolve with modern MV designs

Trying to characterize the evolution in design of MV switchgear in the last 30 years, two basic trends may be identified:
- the reduction of dimensions associated with new breaking technologies (SF6, vacuum), with new insulating materials, with new procedures of design, testing and data analysis (digital simulation, 6sigma, ...);
- the integration of different functions in a same product. Maybe the most current case in MV is the ring-main unit concept and its many applications, which has been made possible, in turn, by the reduction of dimensions mentioned before. The consequence is that, when disconnecting and earthing functions are integrated in a multifunction product, it is often very hard for the designer to provide windows placed in a suitable location for the operator in order to check visually the position of the contacts. The inspection windows are necessarily very small due to the general reduction of dimensions (Figure 5).
The light penetrating inside is dim and a clear understanding of what can be seen highly unlikely as the design is increasingly far from the conventional blade-and-hinge layout and what the observer is seeing more and more lacks any obviousness and definitely needs instructions to be understood. Moreover, different manufacturers have different designs and therefore different instructions on their methods to look at the contacts, which may confuse the operators and mislead them about the real position of the contacts.

An additional problem is the transparency of the inspection windows themselves during the equipment operating life. The window clearness can be impaired in two basic respects:

> first, for gas-insulated equipment, by dust deposits on the inner side of the windows; no
> second, for any type of equipment, by the use of inappropriate solvents in order to clean the accessible side the window. Manufacturers usually provide instructions and recommendations about cleaning agents but experience has proven that often these information get lost in time, cleaning being considered as a minor task for unskilled staff.

For MV switchgear integrating several functions including disconnection and earthing in the same tank, there is an additional difficulty and a possible risk of mistake. Generally, during maintenance operations, the positions to be checked are the open position for a disconnector and the closed position for an earthing switch and all these contacts may be very similar and difficult to distinguish (Figure 6).

It comes naturally to say, at this point, that the prejudice in favour of the visibility of the disconnecting and earthing contacts has definitely outlived its usefulness. Taking into consideration the evolution of the MV switchgear technology and design, for most of the modern available products, direct seeing of contacts is more and more uncertain in normal operations and downright difficult in emergency troubleshooting circumstances such as at night, on holidays, in stormy weather, or when there is a power outage. In these circumstances, it is very uncertain to rely on visible contacts and yet it is precisely in emergencies that it is necessary to quickly determine whether the equipment is in the proper configuration, and not to make mistakes.
The advantages of positive mechanical indication for MV switchgear

A positively driven mechanical indicating system consists of a mechanical kinematic chain made of rigid parts, thus without any spring in the chain. For an earthing switch or a disconnector this kinematic chain includes the movable contact. A high reliability of this mechanical indicating device is necessary, specially to be sure of the closed position of an earthing switch. The reliability is demonstrated by compliance with IEC standard 62271-102 Disconnectors and earthing switches. The testing method, including severe type tests on power kinematic chain and position indicating chain, is described in the complete Annex A of the standard. Forces up to 750 N are applied in different conditions and tests are passed if after the tests the position-indicating device still indicates correctly the position of the moving contact.

Other reasons can further support the choice of mechanical indicators. The status of the earthing switch is directly visible on the front panel. The symbol of the earth position and of a disconnector are standardized and as a consequence the interpretation of the device status, whether disconnector or earthing switch, becomes unambiguously clear at a quick glance for anybody, even from several meters away (Figure 7). These standardized symbols are used by all manufacturers on mimic diagrams.

There is no need for a deep understanding of the device inner layout, no need to rely on the permanent awareness of operators about disconnector or earthing switch contacts. During the last decades, some utilities, by experience, have chosen to introduce preference to the mechanical indication.

In Italy, for example, the mandatory requirement for direct visibility has been canceled in 1997.

In France, EDF changed his position in the 90’s, imposing positive mechanical indication as the preferred and even unique one for some applications. In clause 5.105 Disconnectors and earthing switches of its technical specification HN-64-S-40 October 1995 (24 kV metalenclosed switchgear for public distribution) [3], French utility EDF prohibits the visibility of contacts of disconnectors and of earthing switches as position indication.

Adjustments of standards on position indication requirement

Since edition 2001, the IEC Standard 62271-102 includes Annex A: “Design and testing of position-indicating devices”, intended to establish design requirements and type tests necessary in order to consider the position-indicating devices as reliable. Unfortunately this Standard, while accepting mechanical indicators as reliable if complying with its requirements, still presents them as “alternative to the visible isolating distance” with a wording that betrays a bias in favour of isolating distance visibility. This kind of wording is clearly a reminiscence of the history where standardization activity was driven by HV technology expertise. It is no longer consistent with the MV technological advance of last decades. Progressively, in all product standards, when revised, evolution
of MV switchgear design is taken in account by the maintenance teams in charge and strict equivalence of methods is recognized and implemented [4].

Conclusion

As it has been explained and demonstrated, the most reliable method to know the status of an MV earthing switch or a disconnector in an integrated MV switchgear is to look at a mechanical indicating device on front panel. This brings many advantages, among them standardized format of the information preventing any mistake. For the sake of homogeneity, contact visibility should be totally abandoned in metal-enclosed MV switchgear (i.e. not even taken into account as an option), in order to standardize the operating procedure for the field engineers who should not be requested once to look through the inspection windows and immediately after to rely on a mechanical indicator in order to get the same kind of information for the same type of equipment. This is the way to achieve the best safety conditions for operating staff.

References

[1] IEC 62271-102 Ed 1.1 2012-02, Alternating current disconnectors and earthing switches
[4] IEC 62271-103 Ed 1.0 2011-06, Switches for rated voltage above 1 kV up to and including 52 kV papers for The Green Grid.