Lightning protection – where it matters most

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A reliable power distribution grid is essential for reliable power supply. Protection measures for substations and transformer stations, as well as safe working conditions, are essential.

High voltage systems (between 110 000 V and 420 000 V) transport large amounts of energy over great distances and are thus the backbone of power transmission. In this context, uninterrupted supply is a top priority. Due to the increasingly distributed supply of renewable energies, higher requirements are placed on the availability of medium-voltage systems. Voltages from 1 000 V to 30 000 V are used for medium-sized transmission lines up to about 100 km. This so-called medium-voltage (MV) is transformed down from high-voltage in substations. To ensure uninterrupted supply, substations and overhead line networks must be maintained. System failure and surges on the low-voltage (LV) side pose high risks for the connected loads. To be able to use electrical energy in households, it must be transformed down from medium to LV in centrally located transformer stations, before it is distributed to the loads.

In this context, it must be observed that voltages up to 1 000 V are termed 'low-voltage'. To prevent interruption and failure of the electrical energy supply, maintenance and repair work must be performed on the installation. Although these installations and networks frequently need to be disconnected for maintenance and repair, which includes disconnecting, re-connecting and verifying that the installation is dead, it is important to remember that at the moment of reconnecting the system is still live. To prevent accidents, tested high-quality products are indispensable. To minimise the number of fatal electrical accidents, it is mandatory to observe the five safety rules according to EN 50110-1 [1] when working on electrical installations:

- Disconnect completely
- Secure against re-connection
- Verify that the installation is dead
- Carry out earthing and short-circuiting
- Provide protection against adjacent live parts

Protecting personnel in the event of an arc fault

Every day, electrical work is carried out all over the world. The risk that technical defects, maloperation, pollution or foreign matter in the installation can cause arc faults cannot be excluded. An arc flash is part of an arc fault, a type of electrical explosion that results from a low-impedance connection to ground or another voltage phase in an electrical system. The light and heat produced from an arc flash, when supplied with sufficient electrical energy, can cause substantial damage or harm, fire or injury. An arc fault is the most catastrophic event that can occur in an electrical enclosure, with temperatures that can exceed 10 000°C at the arc terminal. The massive energy released in the fault rapidly vaporises the metal conductors involved, blasting molten metal and expanding plasma outward with extraordinary force. The result of the violent event can cause the destruction of equipment involved, fire, and injury, not only to an electrical worker but also to bystanders. There are many methods of protecting personnel from arc flash hazards. These include wearing arc flash personal protective equipment (PPE) or modifying the design and configuration of electrical equipment. The best way to remove the hazards of an arc flash is to de-energise electrical equipment when interacting with it, although de-energising electrical equipment is itself an arc flash hazard. The installation of a modular arc fault protection system for low-voltage distribution boards in transformer stations will protect persons from the effects of an arc fault during live working. The arc fault protection system detects arc faults in an installation and immediately causes a short-circuit, which trips the upstream overcurrent protective devices. Consequently, the incident energy is considerably reduced and the thermal effects of the arc fault significantly limited.

With recent increased awareness of the dangers of arc flash, tremendous progress has been made in protecting workers against the heat energy associated with arc flash, with a major area of improvement being the steps taken to get workers into safer clothing. Arc-fault-tested personal protective equipment consists of a safety helmet with face shield for electricians, protective gloves and a protective suit, which will safeguard against thermal effects. After safety helmets and protective gloves, protective suits and jackets constitute the third most important component for reducing the risk of arc flash injury while working on electrical installations. Whilst the materials used must provide maximum protection and excellent wearing comfort, it is important that they do not continue to burn after the extinction of an arc and also that they do not release any toxic or corrosive elements.

Lightning protection systems for substations and transformer stations

The National Oceanic and Atmospheric Administration (NOAA) reports that, in any single second, there are over 2 000 thunderstorms occurring around the globe. Lightning protection systems protect structures, including substations, from fire or mechanical destruction, and persons in the buildings from injury or even death. A lightning protection system comprises external and internal protection. The external lightning protection system is made up of three elements, i.e. air termination, down conductors and grounding systems. The functions of the external lightning protection are: to channel direct lightning strikes into an air termination system; the safe conduction of the lightning current to the earth by means of a down-conductor system; and the distribution of the lightning current in the earth via an earth-termination system. The function of internal lightning protection is to prevent hazardous sparking inside the building or structure. This is achieved by means of equipotential bonding or a safety distance between the components of the lightning protection system and other conductive elements inside the building or structure.

Surge and lightning protection for electrical and electronic systems

A lightning protection system, according to International Electrotechnical Commission (IEC) 62305-3, protects persons and material assets
of value in the buildings. It does not protect the electrical and electronic systems, but it is precisely such systems – in the form of building management, telecommunications, control and security systems – that are rapidly becoming common in all areas of residential and functional buildings. Whilst owners or operators place high demands on the permanent availability and reliability of these systems, few developers seem to appreciate the fact that they are critically susceptible to externally and internally generated voltage transients and surges, especially those produced by lightning. Lightning up to a kilometre away can cause damage to sensitive electrical and electronic equipment. At these distances, the induced voltages can be as high as 200 V per metre of cable, which is more than enough to cause damage to equipment. Even equipment connected via cabling within a building can be damaged as a result of the high electromagnetic induction that occurs under lightning conditions. Lightning damage falls into two main categories; primary and secondary effects. Primary effects are those resulting from direct lightning strikes, which are a major cause of fire, instant destruction of property, electrocution injury and death. Even though it is one of the most common natural phenomena known to man, there has been no practical method developed to prevent lightning strikes or to avoid damage caused by a direct hit. The most prevalent technology for dealing with lightning is to divert the strike energy to a properly grounded lightning rod or cabling system. The external lightning protection on a building is only there to act as a preferential point of strike and offers a controlled discharge path to earth, thus preventing structural damage to the building. A common misconception is that if the building has external lightning protection, or if there is a high mast in the area, the equipment will not be damaged. It must be borne in mind that a single earth-termination system for all the various electrical systems is preferable. This earth-termination system must be connected to the equipotential bonding (MEBB – Main Equipotential Bonding Bar). Secondary effects are approximately a thousand times more likely to occur than primary effects. These are the damage caused to sensitive electronic devices, electrical networks and systems. Approximately 24 out of 100 cases of damage to electronic equipment are caused by surges. Plus, with the advent of Surface Mount Technology (SMT), sensitivity to lightning and overvoltage damage has increased exponentially. Lighting does not have to strike a facility directly to do real damage. Protection currently in place may be fine for normal surges caused by load switching and utility transients, but will not be effective against lightning. It may even put system equipment at greater risk by providing a pathway through sensitive equipment. Electronic equipment can be protected from the potentially destructive effects of high-voltage transients. Protective devices, known by a variety of names (including lightning barriers, surge arrestors, lightning protection units and so on) are available. The correct names, accepted internationally, are Surge Protection Device (SPD), or Transient Voltage Surge Suppressor (TVSS). These terms are used to describe electrical devices typically installed in power distribution panels, process control systems, communications systems and other heavy-duty industrial systems, for the purpose of protecting against electrical surges and spikes, including those caused by lightning. Surge protection devices should ideally operate instantaneously to divert a surge current to ground with no residual common-mode voltage presented at the equipment terminals. Once the surge current has subsided, the SPD should automatically restore normal operation and reset to a state ready to receive the next surge. Ideally, the SPD/TVSS should be built within a corrosion-resistant stainless steel threaded pipe.

**Conclusion**

Today, microprocessors and integrated circuits are hard at work processing digital data, controlling critical systems and communicating information through ever-expanding global networks. These now common components have dramatically lowered system costs while increasing the power and flexibility of modern electronic systems in a manner unimaginable just a few years ago. Whilst our buildings are protected, the guarding of these sensitive devices is often overlooked. The devices are critical to the running of our homes and businesses and also incredibly susceptible to both externally and internally generated voltage transients and surges, especially those produced by lightning. According to the International Social Security Association and national regulations in the country of use, arc fault protection shall be taken into account for risk assessment. If there is an arc fault risk, employers must ensure that suitable PPE is provided to their employees and that it is used. PPE must be tested and approved by an accredited certification body.

**Reference**