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Lightning protection

Nuclear facilities

Lightning is a natural phenomenon that can have more or less significant impact on nuclear facilities. However, these consequences can be avoided with suitable protection against lightning. There are three practical problems:

- How to avoid that lightning does not cause an environmental contamination hazard?
- How to protect nuclear facilities against direct impacts, including basic safety installations?
- How to protect the electrical installation against indirect effects and guarantee the functionality of sensitive equipment?

CEA Cadarache

1. Studies of scenarios contained in the safety report

Lightning which strikes a building can result in damage to its structure, its occupants and property, including equipment failures, especially electrical and electronic equipment. Damages and failures may also extend outside of the structures or even involve environment outside the facility limits. This extension is based on the characteristics of the structure and of the lightning impulse.

Nuclear facilities have the particularity to create potentially a risk of radioactive contamination to the environment and people that can be in and around the facility.

Compared to a non-nuclear industrial facility, the feared scenarios are the release of radioactive material related to loss of a static or dynamic containment barrier. Therefore, it is necessary to examine the safety report and the effect of lightning on the safety functions. The analysis is based on scenarios where lightning can be a triggering or aggravating factor taking into account the direct and indirect effects of lightning.

<u>Scenarios related to the direct effects:</u>

- fire linked to a direct lightning strike on the structure,
- loss of containment may be created by a direct impact mechanically damaging part of the building structure,
- an effluent or radioactive waste spread linked to a lightning strike during a transfer.

<u>Scenarios related to indirect effects:</u>

- electrical fires related to indirect effects of lightning,
- loss of containment due to the loss of power of the nuclear ventilation,
- hydrogen explosion issued by radiolysis, triggered by indirect effects of lightning,
- loss of power, resulting in a loss of monitoring or loss of control of the facility,
- deterioration or loss of Major Safety Equipment (EIS) and Risk Management Equipment (MMR).

La Hague

To prevent that such scenarios occur when lightning strike a structure, SEFTIM is working with the nuclear industry and research centers to define appropriate solutions. This approach is one of the major factors of the Lightning Risk Analysis.

2. Protection against direct effects for nuclear facilities

- **Protection against direct lightning effects :** there are different solutions depending on the type of structure and the level of risk estimated by the Lightning Risk Analysis.
  - Using a lightning rod adapted to the protection of roof elements, small buildings, chimneys and vents,
  - Using an isolated lightning protection system when there are a lot of equipment on the roof or when we want to avoid a sparkover between lightning protection system and the structure (to protect the containment barrier, in presence of asbestos, ...)

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- Using stretched wires when the roof can not be used as a natural lightning protection component for structural reasons and / or nuclear risk.
- These capture devices are connected to natural down conductors (case of a metal structure) or dedicated conductors and a lightning earth interconnected to the electrical earth loop of the structure.

CEN Mâamora MAROC

➢ **High frequency evaluation of lightning earthing system:** on some nuclear facilities, it is sometimes difficult to plan long-term work due to the presence of significant radioactivity. To avoid excessive work of grounding, it is sometimes possible to control the state of the earthing system by using high frequency impedance measurements in different points distributed along the building perimeter, as suggested in the IEC 62305-3 standard.

This allows validating the presence of the earthing system, its shape and state, without performing earthwork. These measures also determine if the earthing system can be used in whole or in part, or if it needs to be complemented by additional electrodes. Globally, these measures and their interpretation, have to assess the ability of the earthing system to facilitate the flow of lightning currents and check if its electrical characteristic is compatible with people and facility safety in and near structures. These measures also help to design more accurately surge protective devices.

➢ **Protections of the basic safety installations :** in 2011, the Fukushima nuclear plant accident in Japan is a major accident in the nuclear industry in the world. Following this event it became necessary to take into account basic safety installations that have to withstand natural stresses more severe than usual: earthquake, tidal wave, flood ... Obviously lightning is one of those natural stresses. Lightning impulses different from standardized lightning impulses must then be considered taking into account CIGRE distributions (report published in August 2013) and experience feedback.

➢ **To reduce the risk of contamination**, it is necessary to use a storm detection device coupled with a shutdown of certain risky activities such as:

- radioactive effluent unloading,
- transfer of radioactive waste,
- transfer of nuclear combustible ...

CEA Marcoule

3. Protection against indirect effects of nuclear installations

➢ **For protection against indirect effects of lightning**, it is necessary to install surge protective devices (SPDs) Type 1+2 with low voltage protection levels on the power normal / emergency lines and data lines connected in and out to the building. These SPDs Type 1+2 provide equipotential bonding and help to protect the electrical installations. It is often necessary to install additionally Type 2 SPDs near the Major Safety Equipment (EIS) and Risk Management Equipment (MMR) to provide better protection of sensitive equipment (ventilation, fire monitoring, radiation monitoring, remote alarm panel, emergency call, fixed or mobile power generators ...)