

Best Practices for Implementing Effective Fire Suppression Systems for Transformers in Nuclear Plants

As one of the most watched-over industries in the world, nuclear power generating plants are required to abide by an abundance of regulations and standards to ensure that the facility, its employees, the environment and the local population are protected from potential hazards. One of the most ominous threats that every nuclear power generating facility faces is the risk of a fire developing within the plant and the associated consequences. There is no shortage of hazards within these facilities; the possibility for fires to ignite from sources such as lube oil, fuel oil or general combustibles within a warehouse are genuine concerns. However, one of the most common sources for ignition – and unfortunately one of the most dangerous as well – are the plant’s transformers.

How Do Transformer Fires Ignite?

It is no surprise that transformers are inherently high-risk, considering the hundreds of thousands of volts that they transfer on a continuous basis. There are a number of events that can trigger transformer fires, from weather-related incidents to failures stemming from equipment operating beyond its intended service life. While lightning and short circuits in electrical equipment can cause transformer failures, breakdowns in the insulation system are frequently found to be the source of failure. As the insulation material protecting the transformer deteriorates over time from exposure to natural elements, it puts the equipment at risk for failure and subsequently, fires.

What Are the Implications of a Transformer Fire?

Depending on the severity of the fire and the effectiveness of the fire suppression system protecting the area, the consequences of a transformer fire can range from minimal to devastating. Ensuing damage can include the destruction of overhead conductors, buses and cable trays, as well as the potential for more extreme ramifications when oil or other flammable materials are introduced.

It is not uncommon for a transformer to rupture during a failure, which can release oil into the area, amplifying the risk substantially. When oil is emitted from the transformer, it has the potential to spread the fire to other areas of the facility, resulting in broader damage. Additionally, if the water discharge calculations are incorrect or the containment pits are not the appropriate size, it is possible for oil to overflow from the collection basins. This creates environmental concerns and can result in oil infiltrating the water source that is used to deliver water to the fire suppression system, impeding the system’s ability to control the fire. It is critical that all of these



Transformer fires can be extremely volatile and have the potential to destroy not only equipment in the surrounding area but also other areas of the plant when fuels such as oil are introduced.

variables are taken into account when implementing a fire protection system to minimize the risks associated with transformer fires.

What Design Tactics Must be Used to Develop an Effective Fire Protection System for Transformers?

Stringent regulations require fire protection system designers to follow very rigid guidelines when designing a suppression system for transformers. However, integrating these guidelines into the unique environment of an individual plant can be laborious and demands a great deal of expertise. Optimizing the design for the most effective protection, while also adhering to the requirements set forth by the Authority Having Jurisdiction (AHJ), NFPA, insurance requirements and nuclear authorities demands direct knowledge of and experience with the application.

Effective design should begin by utilizing the transformer outline drawings to develop a system that will function within the parameters ascertained from the drawings. It is at this stage that a designer can determine the most efficient piping system to optimize water discharge through the strategic placement of nozzles. Selecting the appropriate nozzle for the application requires sufficient knowledge to make a determination about which nozzle angle and orifice size will be the most effective for the particular design.

Nozzles should be positioned to provide complete water spray impingement on all exterior surfaces without directly enveloping energized bushings or lightning arrestors. Additional considerations such as electrical clearance requirements and future access to coolers and control cabinets should be factored into the design as well, for simplified plant maintenance of the transformer in the future. Designing a deluge releasing system should also involve the same level of forethought to ensure that all potential issues are considered before they impede the effectiveness of the fire protection system or cause a hindrance to plant operations.



To design an effective deluge system for transformers the appropriate nozzles must be selected and placed in strategic positions. Variables such as the electrical clearance requirements and future access must be factored into the design as well.

Exhaustive Pre-Planning, Efficient Installation Practices Allow for Streamlined Work

Beyond the expertise that is required to design an effective fire protection system for a transformer in a nuclear application, it is essential that comprehensive pre-planning is conducted before the installation begins. Plant outages are typically brief, giving the installation crew a very limited timeframe to install the system and perform the appropriate testing. The background work related to access, safety, quality control and material management must be thoroughly arranged to allow for an efficient installation.

Extensive collaboration between Project Managers and Plant Engineering should occur on an ongoing basis to identify pre-outage work and ensure that all parties' expectations are aligned. The contractor and owner should work closely to develop an engineering change package that reflects any and all of the nuances associated with transformer fire protection and the specific

environmental factors of the site. Facets of the project such as determining the location of pipe foundations to suit the transformer foot print and calculating the water discharge in relationship to the size of the containment pits should be addressed comprehensively to minimize any delays that could occur once the outage has begun.

Material management and safety requirements can also present challenges if certain measures are not taken to streamline the process. A detailed pre-fabricated material and parts list can help alleviate logistical issues by making it easier to track materials, meet Foreign Material Exclusion (FME) requirements and control quality assurance. The contractor should have a thorough understanding of the material receipt and related processes to avoid unnecessary interruptions in the installation process. To ensure efficiency, those involved in the installation should complete any safety requirements well before the on-site work begins and a job safety analysis should be conducted to prevent injury during the installation.

Once the on-site work has begun, it is imperative that installation crews adhere to the strategy that has been mapped out in the pre-planning stage of the project. Efficient management of equipment such as aerial lifts and scaffolding saves time and improves workflow. Coordination with other trades performing work on the site is vital to maximizing manpower as well as ensuring the safety of the crew. Transformer areas are inherently congested, leaving little room for installers to perform their work. Installers should have the skill and experience that is required to perform intricate work within tight spaces that present obstructions.

Effective Transformer Fire Protection is More than Just Exemplary Design and Installation

As crucial as competent design and installation methodologies are to the performance of a transformer's fire protection system, the long-term performance of the system relies on ongoing inspection, testing and maintenance (ITM). Developing a comprehensive ITM regimen, which includes detailed documentation of the processes performed, is imperative to ensuring the system will function as intended when it is called upon.

As previously stated, the potential repercussions of an uncontrolled transformer fire can be devastating to a nuclear power plant. For this reason, it is equally important for a fire protection system to be as robust in the years following implementation as it was when it was first implemented. Just as NFPA, insurance and the AHJ requirements dictated the design and installation guidelines for design and installation; an ITM program should be cultivated in accordance with these regulations as well.

Weekly and monthly inspections of specific components, annual trip tests and full flow tests at prescribed intervals can ensure that systems will be fully functional when activated. Other maintenance processes such as draining the oil collection basins after heavy rains can also prevent problems specific to transformers. In nuclear applications, discovering that a fire protection system is not functioning at peak performance after a fire has ignited is too late.



Developing an ongoing inspection, testing and maintenance regimen helps maximize the deluge system's life cycle.