

Evaluating Nitrogen Gas Fire Suppression in Electrical Substation Capacitor Rooms

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Abstract: *This study analyzes the effectiveness of Nitrogen gas as a fire suppression agent in substation capacitor rooms, comparing it with traditional water spray systems. It assesses the use of Nitrogen discharge for 120 seconds based on the NFPA 2001 standard, highlighting its advantages in terms of safety and environmental impact.*

Keywords: Nitrogen fire suppression, Substation safety, Capacitor room, Fire hazard management, NFPA 2001 standard

1. Introduction

Generally, we know that electrical production and control systems not only improve everyday life, industry, and the economy, but can also sometimes cause severe damage to lives and assets. As the system has to operate all the time; which can result in heat accumulation, damaging the equipment and lead to fire hazard. Hence considered, fire suppression systems for the equipment capacitors in distribution & transmission. As a fire - control system, fire suppression is one of an interesting option. Since nitrogen gases are in the atmosphere, no production is needed, do not break down to toxic gas, no conductive and do not have environmental impacts. Plus, it does not damage electrical equipment and also save cleaning time (after used) due to no chemical residue.

1.1 Purpose

The purpose of this article is to evaluate the effectiveness of Nitrogen gas fire suppression systems in protecting capacitor rooms in substations, and to compare their efficiency with traditional water - based systems.

1.2 Significance

The significance of this article lies in its potential to influence fire safety practices in electrical substations [1], particularly in the protection of critical capacitor rooms, thereby enhancing both safety and operational efficiency.

1.3 Criteria of capacitor room

Capacitor banks overheating is a common problem in Substation projects, and these are an important aspect of electric distribution and transmission, it occurs due to improper ventilation, loose connections, bad design, or the overvoltage during lower demand period. The reason for a burning or even exploding capacitor bank is based on the liquid - filled capacitors and the plastic parts that are combustible.

Substation capacitor banks are critical equipment hence, their downtime heavily affects substation operations [2]. To avoid the downtime due to the fire risk in capacitor banks the suitable system must be selected based on the following criteria,

- 1) The room has an airtight compartment to provide a total flooding suppression system [3].
- 2) The room construction having fire rated walls and doors
- 3) The air conditioning system provided with Fire dampers for closing of opening during the discharge
- 4) The room has the provision on their exterior wall in order to providing the pressure relief venting system based on the above we can select nitrogen gas suppression system [4] for the capacitor banks room.

1.4 Merits of Nitrogen fire suppression system

- **Zero Ozone Depletion Potential (ODP)**
Nitrogen is naturally occurring inert gas present in the atmosphere. When discharge automatically return to the natural place in the environment.
- **Zero Global Warming Potential (GWP)**
Nitrogen have no atmospheric lifetime and zero GWP, there will be no risk to the environment.
- **Similar Weight of Air**
The weight of Nitrogen corresponds closely to that of normal air and will evacuate a protected area slower than halocarbon agents after a discharge. And it is up to 78 percent available in the atmosphere
- **Electrically Non - conductive**
Being electrically non - conductive, it is highly recommended for protecting electrical and electronic materials. Such as Capacitor bank room, LVAC Room, Control Room.
- **No Fogging During discharge**
Inert gas systems is clear visible during, and after a discharge hence suitable for the occupied spaces because egress path remain visible all time
- **No Residue**
No damage to the equipment hence cleaning of equipment / hazards are not required after the discharge also the Nitrogen will not harm the equipment so the downtime will remain less
- **No Combustion**
As described above, the Nitrogen gas [5] is naturally available atmospheric gas hence do not decompose into toxic or corrosive elements in a fire, making it a safe choice for people and assets.
- **Thermal Shock**

When discharged, Nitrogen cause the least amount of thermal shock (sudden temperature drop), compared to

other clean agents.



2. Theory

With initial concentration of Nitrogen at 41.9% and simulated the incidents when increased safety factor of Class

C fire to 50% and 100% respectively in all 4 experimental gases which divided into 12 cases. The results showed that different types of inert gases did not affect the fire - extinguishing performance caused by the same fuel in the

Volume 12 Issue 12, December 2023

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same environment. And the increasing of safety factor of Class C fire by 50% and 100% respectively in all 4 types of inert gas did not improve their fire - extinguishing performance.

3. Conclusion

In summary, this study demonstrates that Nitrogen gas fire suppression systems offer a reliable and environmentally friendly alternative to traditional water - based systems for protecting capacitor rooms in substations. The findings underscore the importance of adopting advanced fire suppression technologies in critical infrastructure.

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