CHAPTER

8

FIRE EMISSIONS FROM ONSHORE AND OFFSHORE ELECTRICAL CABLES

Miss Hasimawaty Mat Kiah, Kevin O' Neill,
Gordon Andrews, and Herodotus Phylaktou

8.1 INTRODUCTION

When individuals are exposed to smoke, fumes, and toxic substances emitted during fires, the evidence of health risks and dangers becomes apparent. These harmful byproducts of combustion can lead to respiratory failure, hypoxia, and skin issues, sometimes resulting in fatality. Identifying the composition of cable materials in substations can be difficult due to the increasing use of synthetic materials with various polymeric compounds and flame retardants. This poses concerns, especially when considering the installation of up to 50 km of cable in modern substations. The most crucial factor in assessing fire hazards is the heat release rate (HRR), as stated by Babrauskas and Peacock (1992), Jain et al. (2023), and Janssens (2018). During hazard identifications (HAZIDs), fire loads from hydrocarbon fluids are often prioritised due to their volatility. Nonetheless, studies indicate that cables featuring ethylene propylene rubber (EPR) or cross-linked polyethylene (XLPE) insulations display analogous properties. The heat of combustion for XLPE cables stands at 46 MJ/kg, which is on par with the hydrocarbon mineral oil commonly utilised in transformers (Sundstrom, 2006). This realisation highlights a significant problem in the industry today. The release of volatiles from non-halogenated cables during fully developed fires is often overlooked. European and British cable standards do not require testing of cables for all potentially toxic gas emissions during fire scenarios. Current cable fire resistance testing methods primarily focus on fire propagation rates rather than assessing toxicity (Sundstrom, 2006).

In the United States (US), halogenated cables containing hydrogen chloride (HCl) are promoted due to their inherent flame-retardant properties. However, in Europe and the United Kingdom (UK), environmental policies prioritise reducing the release of acidic gases, including HCl, produced by polyvinyl chloride (PVC) cables. Consequently, non-halogenated cables, known as LSOH (Low Smoke Zero Halogen), are commonly used. Recent research on PVC cable materials suggests that HCl is not the primary concern (Al-Sayegh et al., 2015). Instead, toxic gases like acrolein, found in non-halogenated cable insulations, pose a significantly higher hazard even at lower concentrations. Therefore, PVC cable is included for comparison purposes against commonly used cables in both onshore and offshore substations.

This research focuses on electrical cables frequently installed within offshore and onshore substations to emphasise the risks and improve fire safety strategies, ultimately promoting safer designs.

8.2 ROLE AND IMPORTANCE OF CABLES

The function of cables is to facilitate the flow of electrical charge, conveyed through electrons within the copper core. This flow of charge inevitably generates heat, which can become a significant factor in fire incidents. The heat production can escalate when there is a fault current or when the cable is overloaded. These scenarios often act as the main ignition source for fires.

As the design current and distance increase, the earth loop impedance and fault current also increase, leading to changes in the cross-sectional area

(CSA) of the cable. This change affects not only the electrical characteristics but also the insulation level and the amount of heat generated. It is essential that the materials used for cable insulation and sheathing exhibit appropriate electrical and mechanical characteristics.

Insulation primarily serves to protect the copper conductors, reduce energy loss, and additionally acts as a protective shield for the cable, guarding it against external factors and potential interference. These characteristics play a vital role in the cable selection process, as external factors can cause issues like insulation cracking, corrosion, and general degradation, ultimately increasing the risk of cable fires.

Considering the environmental impact and personnel safety, it is essential to carefully assess the benefits and drawbacks of installing systems that require significant amounts of cabling. This evaluation should encompass factors such as the potential for insulation damage, the risk of fire incidents, and the overall safety implications for both the environment and personnel involved.

8.3 SIMULATION OF FIRE SCENARIO

The experimental study is designed to replicate fire scenarios that occur within substations when HVAC (heating, ventilation, and air conditioning) units are shut down in response to confirmed fires. The objective is to simulate fires with limited ventilation to assess current testing practices for materials. To achieve this, the study employs ISO 5660-1:2015, which utilises the cone calorimeter and Fourier Transform Infrared (FTIR) analyser. The cone calorimeter and FTIR analyser are instrumental tools employed for assessing a wide array of parameters. These measurements encompass heat release rates, rates of mass loss, effective heat of combustion, ignition time, flame extinguishment time, oxygen consumption rates, and the identification of combustion by-products.

Thermo Flash EA 2000 elemental analyser (CHNS) analysis serves as a method for acquiring elemental data from materials. To perform this analysis, cable insulation is first transformed into a powdered form