FIRE PERFORMANCE CABLES UNDER CURRENT OVERLOAD CONDITIONS

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ABSTRACT

Fire performance cables are generally tested to relevant Standards, against fire introduced externally. In this study, the behaviour of fire safety cables was tested during current overload conditions. It was found that a conventional fire-rated cable, in which the conductor is glass-mica taped and insulated with XLPE, can represent a fire hazard, both as an ignition and a fuel source. In contrast, a cable design that relies on a ceramifying insulation proved to increase resistance to self-ignition. Results obtained from Cone calorimeter tests helped to understand the advantages of the ceramifying insulation in gross overload conditions.

KEYWORDS

Fire safety; Current overload; Ceramifying; Cone calorimeter; Heat release rate.

INTRODUCTION

Numerous Standards and regulations were developed to minimize the fire hazard of cables, wiring and electrical components. Nevertheless, it is possible that fires can be initiated due to electrical components failure or faulty installations [1]. Babrauskas [2] identifies three main failure mechanisms that lead to ignition of electrical insulation: (1) arcing, (2) excessive ohmic heating and (3) external heating. He further identifies the causes of excessive ohmic heating: (1) gross overloads, (2) excessive thermal insulation, (3) stray currents and ground faults, (4) overvoltage and (5) poor connections.

Although electric circuits are generally protected from current overloads by circuit breakers and fuses, it is possible that these components fail and allow gross overloads. Rare experimental studies indicate that currents 3 - 7 times the rated load are needed for ignition [3]. Although likelihood of such events is low, the severity of consequences prompted research in case of cables for nuclear power plants [4] and spacecraft [5]. A Report [6] shows that the number of electrical fires can be very significant, even in industrially developed countries where standards and regulations are strictly followed. For example, 984 electrical fires were recorded in Finland in 1995; 72% of them were due to short circuit or ground faults and 5% from overheating.

Fire performance cables are designed to maintain circuit integrity under fire conditions for extended periods of time, providing power for emergency services in buildings, including exit lights, lifts, alarms etc. Such cables are tested according to National or International Standards, where fire conditions are simulated using burners and furnaces.

An example of a severe fire test being AS/NZS 3013:2005, the latest Australian/New Zealand standard for the classification of the fire and mechanical performance of wiring systems, in which the cables are exposed to the ISO 834 heating curve in a gas furnace for 2 hours (reaching 1,050°C), followed by a water spr ay for 3 minutes, while maintaining the full mains circuit voltage. The last thing that customers should expect from such cables is for them to start a fire. Nevertheless, the possibility exists prompting us to compare commercially available fire resistance cables subjected to gross overloads and understand the principles that can improve their safety.

EXPERIMENTAL DETAILS

Samples for current overload testing were cut from single-core cables sourced from suppliers to Australian and Asia-Pacific markets. The details are given in Table 1. It should be noted that all cables were of the same conductor size (16mm^2 copper) and consequently very similar current rating (around approx. 130A). Only one of the conductors was flexible, i.e. 6x32/0.30mm rather than 7/1.70mm PACW. Three out of four cables rely on the glass-mica tape to provide circuit integrity during fire tests, e.g. to AS/NZS 3013:2005, IEC 60331 or BS 6387, while #2 was designed with a 'ceramifying' insulation based on a compound that transforms into a ceramic state during firing [7].

Equipment used for the current overload tests was: - ESAB Machine Division high current transformer with short circuit output current rating of 125 to 5000A RMS in 23 steps; - Crompton 0.001 ohm, 500A continuous rating, current measuring resistor; - Rigol DS1000E digital storage oscilloscope and HP 400E AC Voltmeter. Cable surface temperatures were measured with a Digitech QM7221 Infrared thermometer. All tests were recorded using a Sony HDR-SR8 video camera.
The cables were tested in 600mm lengths which were horizontally suspended between current injecting electrodes. The overload current-time windows used in the tests ranged from 10 minutes to 120 seconds with initial RMS currents of 400 and 1200A, respectively.

Three materials (HFFR sheath, XLPE and Ceramifying insulation) that were available in our lab were compression moulded into 100 x 100 x 3.2 mm sheets and tested in a Cone calorimeter with a heat flux of 50kW/m^2, according to Standard [8]. Bomb calorimeter was used to obtain the HHV values.