CERAMIFYING INSULATION MATERIALS FOR FIRE SAFETY CABLES

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ABSTRACT

Traditional fire safe or fire performance cables rely on mechanical supports, like mica/glass tapes or metal sheaths to achieve their fire rating. A new, fully extruded design has been developed in Australia by Olex Australia, in conjunction with the Cooperative Research Centre for Polymers and CSIRO.

The new cables are insulated with a composition that progressively converts from polymer-based to ceramic when subjected to fire. Cables made with these materials have been successfully tested to international Standards (IEC 60331, BS6387 cat C,W,Z) and also the Australian AS/NZS3013, which requires 2 hours in the standard time-temperature regime used in the building industry (1,050 °C, similar to DIN4102 Pt 12), followed by 3 minutes of water-jet spray. This paper includes practical information on the testing process behind this innovative new insulation concept.

KEYWORDS

Fire safety, fire performance, circuit integrity.

INTRODUCTION

Fire in confined spaces, in particular buildings, is a hazard to life and property. There are statistics that indicate that this is a problem in all countries to a greater or lesser extent, hence the need for the many fire standards and codes which seek to regulate the design of buildings, what goes into them, and the subsequent development of the science of fire [1-5].

The presence of increasing numbers of cables in buildings has also led to concerns about the possibility of fire spreading along cables, in particular in vertical risers, and there are a number of tests that are applied to measure the tendency of this to happen (e.g. IEC60332). However, this is not the kind of cable we are addressing with our new insulation material, even though we can also comply with this kind of fire safety. The specific problem addressed by this development is providing a continuing service when there is a fire in a section of an installation. This function is generally known as providing circuit integrity [6,7]. Applicable Standards are IEC60331, DIN 4102 part 12, BS6387, etc. In Australia, the relevant test is AS/NZS3013:2005, and tests to this Standard are the main focus of this paper.

HISTORICAL SOLUTIONS

Originally, cables that satisfied the requirement of circuit integrity were of the type known as metal sheathed, mineral insulated cables (MIMS). These cables were/are difficult to install, compared to standard cables, requiring special equipment and techniques. The finished terminations are also potential sites for moisture ingress, which leads to a loss in insulation resistance and a loss in function of the circuit. The bending radius of these cables is also comparatively large and the cost of the cable and the installation is high.

Work began in the 1970's to develop cables that could still provide circuit integrity, but addressed the shortcomings of the MIMS design. The most satisfactory designs harnessed the mica-glass tapes available from the transformer industry in the form of a wrapped tape over the conductors. This solution addressed many of the shortcomings of the MIMS cable, being more flexible and resistant to moisture and lower cost of cable and installation, but new problems were introduced. The taping process was/is very slow, the tapes themselves are very expensive, there is a risk that the tapes will not be completely removed during installation and the tapes make the cable less flexible and more difficult to install than a standard cable.

Many researchers began exploring the concept of providing a material that could transform from a polymeric to a ceramic structure to overcome the remaining problems arising from use of the mica-glass tape [8,9]. An extrudable material would conceivably be much faster to apply than a tape, and could result in a lower cost solution. This paper shows some of the highlights in the development of cables of this type, focusing on the Australian market.

COMPOSITION DEVELOPMENT

Laboratory preparation of compositions for testing and prototype making is fairly straightforward, but complex and demanding. A "design of experiment" technique is used to generate possible compositions, that are then prepared and tested for key criteria, including ceramic strength and shrinkage. Standard equipment is used, and the compositions must also be suitable for normal insulation and handling requirements, as well as ceramification.

Testing for normal requirements is done before any fire testing. It has been found that due to the activity of copper metal at 1,000 °C, and also the relative coefficients of expansion and contraction of the copper metal, its oxides and the ceramic insulation, that cable prototypes are needed for evaluation of changes to the composition. Electrical resistivity at 1,000 °C is considered particularly important, and through trial and error we have found that we need a minimum of 1 megaohm at this temperature in our lab tests to make advancement to full scale testing worthwhile.