Comparative study of circuit integrity cable designs and materials for Australian/New Zealand market

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ABSTRACT

In addition to an IEC derived burner test (AS/NZS 1660.5.5), fire-performance cables in Australia have to pass the more severe furnace and water spray AS/NZS 3013 test for Electrical installations – wiring systems. It was noticed that cables that rely on glass-mica tapes (GMT) to provide fire barrier often failed the test. In recent years, insulation materials that transform into ceramic during fire have emerged, bringing an advantage of more efficient manufacturing and installation. The importance of fire safety prompted us to conduct a systematic study of both types of circuit integrity cables and understand factors that may improve their performance.

KEYWORDS

Circuit integrity, fire resistant, mica tape, ceramifiable.

INTRODUCTION

Circuit integrity cables are designed to provide uninterrupted power supply to important services in the event of fire, to allow for safer evacuation and fire-fighting effort. They have to be tested and qualified to applicable Standards, in which a fire situation is being simulated by burners or furnaces. Additionally, water spray or shock can be applied. A common example of a burner test is IEC 60331-11, which requires maintaining the supplied current at rated voltage for a specified time, while exposed to a flame of controlled temperature of 750°C. The Australian/New Zealand equivalent of this test is AS/NZS 1660.5.5 and in combination with other performance requirements, it allows classification as CI-1, 2 or 3 to AS/NZS 4507. However, the test conditions are not as severe as those expected in fully developed building fire.

Consequently, a more severe test was introduced for classification of the fire and mechanical performance of wiring system elements – AS/NZS 3013. The fire test is conducted using a horizontal furnace complying with the requirements of AS 1530.40 (ISO 834 - equivalent, “cellulosic” heating curve) at nominal voltage. After the fire stage (120min) of the test, the cables are further exposed to a water spray (180s), while monitoring the circuit integrity, which is different from DIN 4102 (no water spray) and UL 2196 (water hose, power off). If all circuits of a tested specimen maintain integrity, it receives WS5XW qualification (where WS means ‘wiring system’, numeral 5 is for 120min fire resistance, X can be replaced by a number describing level of mechanical protection and W is for water spray). Other qualifications are possible, e.g. WS4X stands for 90min fire resistance, no water spray. However, industry has settled on a rating of “WS52W”, 2 hours furnace, moderate resistance to cutting and impact and 180 seconds water spray as a “standard” requirement.

The most common technology that provides circuit integrity has been the application of glass-mica tape (GMT) for over 40 years [1,2]. In the last couple of decades, new insulation materials that transform into ceramic during fire were developed. First ceramifiable compositions were based on silicone rubber [3,4]. Further development had delivered polyolefin based insulation materials, both cross-linkable and thermoplastic [5,6]. These ceramifying compounds bring the advantage of easier manufacturing and installation. Nevertheless, the old GMT technology is still commonly used.

When supplying cables to AU/NZ market, it is important to consider the requirement to achieve AS/NZS 3013 qualification. Many suppliers had faced a situation that mica taped “fire-resistant cables” compliant with AS/NZS 1660.5.5 / IEC 60331 fail the AS/NZS 3013 test. It has been understood that furnace based tests are more severe compared to burner based tests [7], but no systematic study could be found that correlates cable designs and materials to the outcome of AS/NZS 3013 fire testing. In this paper we will present analysis of data collected from fire-testing both mica-taped and ceramifiable cables and attempt to identify the factors that determine the test outcome.

EXPERIMENTAL

Cables selected for fire testing to AS/NZS 3013 were 1C (single core) 35mm^2 with flexible conductor (Class 5 or 6, plain annealed copper to AS/NZS 1125). The insulation, sheathing and fire-barrier materials are described in Table 1. The cables were sourced from various manufacturers and they all complied with AS/NZS 5000.1. The cables were installed on galvanised steel trays as trefoils, following the procedure described in AS/NZS 3013. Typical set-up is shown in Fig. 1. The tests were conducted at Exova Warringtonfire, South Dandenong, Australia.

SEM analysis of fire barrier insulation was conducted at CSIRO, Clayton, Australia. The samples for this work were prepared by extruding a 1mm thick proprietary INFIT™ Ceramifiable® material on a 1.5mm^2 solid plain annealed copper wire (PACW) using a Brabender lab-extruder. They were fired in a muffle furnace at 1,050°C for 30min.

The insulation resistance (IR) at high temperature was measured between two twisted 1.5mm^2 cores placed in a tube furnace that was programmed to follow ISO 834 curve, using a Hioki insulation tester.

RESULTS AND DISCUSSION

Fire testing to AS/NZS 3013

Seventeen 1C 35mm^2 cables were sourced and tested to AS/NZS 3013. A usual set-up includes other types and sizes of cables (Fig 1), i.e. multicores with or without earth, as defined by the standard.