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TEST REPORT

TSL No. R17890

Smoke emission testing

Tyco Electronic UK Ltd.
(Product brand name: Raychem).
600/1000V Heat Shrink cable joint for 4-core 300sqmm SWA cable.
Tyco joint kit unique design ref. SOME 82051.

'Fully assembled joint'
Testing to LUL Fire standard 2-01001-002: Issue A1: Table 2.2: Premises test programmes Category TU/CA & ST/CA
&
M.R.BCV Draft 600/1000V Power joint requirements.

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QUERIES OR FURTHER INFORMATION.

ANY QUERIES OR REQUESTS FOR ADDITIONAL INFORMATION ON THE SUBJECT OF THIS REPORT SHOULD BE ADDRESSED TO THE AUTHOR WHO MAY BE CONTACTED AT THE ADDRESS GIVEN ON THE TITLE PAGE.

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1. INTRODUCTION

Sample specimen of cable joint assembly, referenced SOME 82051, was submitted on 30th April 2004, by Mr I Castle of Tyco Electronics UK Limited, for smoke emission evaluation in accordance with the London Underground Limited Engineering Standard 2-01001-002: Issue A1: 2003.

Following client's instruction apply to this task:

Section Labtest No.:	: BCV-01-082-LB01
Section Task No.:	: BCV- 01/082

2. MATERIAL DESCRIPTION

The description of the material given below was provided by Metronet Rail BCV Limited. All values quoted are nominal, unless tolerances are given.

General details - Fully assembled joint, comprising :-

- 4 cable core conductors crimp connected.
- 4 adhesive lined heat-shrinkable XLPE tubes acting as connector insulations.
- Steel armour case over assembled core, secured with two worm-drive clamps at each end.
- Woven glass sheet wrapping with inner facing side having an intumescent coating, secured in place with a few wraps of paper-based self-adhesive tape.
- Heat-shrinkable sleeve of Tyco compound ref. ZCSM, bonded only at the ends to the cable sheath with butyl mastic containing alumina trihydrate filler.
- Galvanised steel wire mesh tape, applied overall and secured to the cable sheath with steel roll-springs.

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Component details - Fully assembled joint, comprising :-

Item	**Tyco component ref.** As used for the specific item provided in this Type Test joint kit SMOE 82051	**Tyco 'Material code**	**Material description**	**Tyco 'Product reference'** As would apply generally for this item if used in a similar 'Raychem' joint of another size.
Conductor connectors were compression type: Pirelli BT300CS				
Connector insulation sleeve This is a tube with an adhesive on the inside.	WCSM-43/12-280/S	1895	Cross-linked low density polyethylene with carbon black filler	WCSM
adhesive coating on the inside of the WCSM connector insulation sleeve	No separate ref as this is incorporated as part of the insulation sleeve	T2689	Polyamide hot-melt adhesive	Coating code /239
Armour support ring (half-shells), 4 off	EPPA-205-3-72			
Wrap-around steel armour case	EPPA-200-15-900			
Worm-drive armour clamp (4 off)	EPPA-042-1-100			
Protection over worm-drive clamps			Paper-based self-adhesive tape	
Woven glass sheet with intumescent coating on one side only (Inner facing side)	'Fireplug Multiwrap' Supplied to Tyco by Complete Fire Protection Ltd (Bristol).			

Continued.

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Securing tape for woven glass sheet			Paper-based self-adhesive tape	
Outer protection sleeve	ZCSM-120/50-1200	1360	Cross-linked ethylene vinyl acetate polymer with magnesium hydroxide filler	ZCSM
Sealant mastic (Used only at the ends of the outer sleeve to seal it to the cable sheath)		1715	Butyl mastic with alumina trihydrate filler	S1085
Galvanised steel wire mesh tape (A tape wrapping that provides containment of any sleeving material that might fall during a fire)	EXRM-0845-8000			
Steel roll-springs use to secure the galvanised steel wire mesh tape to the cable sheath				

The above specimen sample (Joint assembly) was referenced TSL0104.

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3. TEST METHOD

3.1 SMOKE EMISSION

An ad-hoc smoke emission was carried out on the assembly at positions A and B according to Metronet Rail BCV Limited Lab test instruction 'Lab_inst Iss_A2 SMOE 82051'.

The assembly was tested on 30th April 2004, using the BS EN 50268: 2000.

The overall outer diameter of the joint assembly at positions A and B were 118mm and 101mm respectively.

4. RESULTS

The tests relate to the behaviour of test specimens of the products under particular conditions of test; they are not intended to be the sole criterion for assessing the potential fire hazard of the product in use. In particular, differences in the thickness, orientation or design may significantly affect fire performance and care should be taken to ensure that any differences between the test conditions and application conditions are not adversely significant.

4.1 SMOKE EMISSION

The measured absorbance A_m is calculated in accordance with the Beer-Lambert Law as follows:

$$A_m = \log_{10} (I_o / I_t)$$

Where: I_o = Initial Luminous intensity
I_t = Transmitted Luminous intensity

A_m is converted to Standard absorbance A_o (Figures 1-2; Page 12-13), using the equation:

$$A_o = (A_m \times V) / (n \times L)$$

Where: V = volume of the cube ($27m^3$)
L = optical path length (3m)
N = is the number of units comprising the specimen.

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The calculated results (rounded up to 3 d.p) are as follows:

Note:
The performance requirements used below are based, as instructed by M.R.BCV, upon the average diameter of the joint over the range covered by the fire source and using this average dimension in place of 'd' in the cable smoke emission 'arc tan' requirements formula. The values for the equivalent 'd' and resulting Ao(ON) and Ao(OFF) have therefore been determined for this joint as follows :-

Test 1 – Fire source at the middle of the joint
Overall diameter at middle of the joint 118mm, since the joint was, for all practical purposes, consistent over the region covered by the fire source tray.
Therefore, based on d = 118mm, this gives a requirement of :-
Ao (ON) 1.04 and Ao (OFF) 1.88

Test 2 – Fire source at one end of the joint (position as selected by M.R.BCV)
Over the range covered by the fire source tray the overall diameter of the joint varied between 80mm at one end of the tray and 122mm at the other end of the tray, giving an average OD of (80 + 122)/2 = 101mm.
Therefore, based on d = 101mm, this gives a requirement of :-
Ao (ON) 1.00 and Ao (OFF) 1.79

	Results Ao(abs) m^2/burn length	**Requirements Ao(abs) m^2/burn length**
Test 1. (Position A on assembly)		
Ao(ON)	1.536	<1.04
Ao(OFF)	2.116	<1.88
$Go_{(10\text{-}14min)}$	0.179	<0.1536
Test 2. (Position B on assembly)		
Ao(ON)	1.366	<1.00
Ao(OFF)	2.096	<1.79
$Go_{(12\text{-}16min)}$	0.121	<0.1366

Note:
Since compliant performance has not been demonstrated, through using the 'General performance method' (i.e. comparing the requirement with the 'equivalent cable diameter'), the client (M.R.BCV) requested that a 'Specific case performance determination' be made based upon the London Underground fire performance standard 2-01001-002-A1: Clauses 3.1.3.1 and 3.1.3.2. which state :-

- A materials installation shall not be responsible for generating smoke which will reduce the specific visibility distance to below 10 metres.
- As far as reasonably practicable the general visibility distance should remain above 10 metres.

Additionally, the client has advised they consider, that the Go parameter is not an appropriate parameter for cable joints and, therefore, the achieved Go performance may be ignored for the purposes of establishing overall smoke test compliance. For completeness of records, the client has asked that this test report includes the reasons for discounting of the Go parameter, as described below.

- the joint itself will only be used with cables that are already authorised designs previously tested for compliance with London Underground's fire performance requirement. Therefore, fire propagation is not being considered beyond the dimensions of the actual joint itself;
- during both smoke emission tests no burning material fall was recorded;
- the original purpose of the Go value was to give an 'indication of possible flaming involvement' of the test item and, by itself, Go was not to be considered an overall failure of the product;
- if a test item fails the Go parameter, it is then required to undergo a large scale flammability test to establish whether flame spread is a hazard or results in burning material fall;
- because the total length of this joint is less than 1.5m (at which point it changes to compliant cable), fire propagation along the joint itself can never exceed the 1.5m limit as described in the large scale flammability test. Therefore, regardless of Go performance achieved, the joint cannot itself act as a means of laterally nor vertically propagating the fire.
- the outermost combustible layer (i.e. the Outer Sleeving 'ZCSM') has been tested as part of this specific joints fire performance evaluation and achieved a flammability oxygen index of 39.6% (see Transfire Services report R17891).

5. CALCULATIONS AND DISCUSSIONS

According to the London Underground Limited Engineering Standard 2-01001-002: Issue A1: December 2003, it is possible to establish the potential smoke emission hazards in terms of Visibility Distances, which are clearly defined in the M1042, Manual of Good Practice. The visibility distances are briefly described as:

- The general visibility distance, D_G, is the distance from an observer to the light source at which objects surrounding the observer can just be seen. It is generally agreed that the illuminance, I_t, necessary for this is 0.5lux.

- The specific visibility distance, D_S, is the distance from an observer to the light source at which the light source itself can just be seen. It is generally agreed that the illuminance, I_t, necessary for this is 0.005lux.

The standard set in the Manual of Good Practice and the London Underground Limited Engineering Standard 2-01001-002: Issue A1: December 2003 are as follows:

Recommendations	D_G > 10 meters
Requirement	D_S > 10 meters

In order to calculate the specific visibility distance, it has to be assumed, that only one cable joint would be involved in a potential fire whose fire region is 1.25m^2. Thus, in a tunnel application which has a dispersal volume of 200m^3, the calculated visibility distances are:

Test 1 - Position A - Fire source at the middle of the joint

D_G > 26.04 meters
D_S > 78.12 meters

Test 2 – Position B - Fire source at one end of the joint

D_G > 29.28 meters
D_S > 87.85 meters

6. CONCLUSION

The testing of a cable joint is considered to be an ad-hoc test since LUL Standard 2-01001-002: Issue A1: December 2003 does not clearly define the smoke emission requirements for such equipment.

Nevertheless, the Specific Visibility Distance was calculated (reference to the Standard 2-01001-002, Section 3.1 and 3.2). The cable joint assembly was found to be compliant according to the principles of assessment with the standard.

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OBSERVATIONS

SAMPLE REFERENCE TSL0104

TEST 1 – Position A – fire source at the middle of the joint.

Time (min.sec)	Observations
0.00 – 25.50	Nothing significant (No burning material fall occurred)
25.50	Fuel source consumed
25.50-40.00	Nothing significant (No burning material fall occurred)

TEST 2 – Position B – Fire source at one end of the joint

Time (min.sec)	Observations
0.00 – 26.00	Nothing significant (No burning material fall occurred)
26.00	Fuel source consumed
26.00-40.00	Nothing significant (No burning material fall occurred)

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Figure 1: Variation of Absorbance (Ao) with Time of cable joint assembly

TEST 1 – Position A – Fire source at the middle of the joint

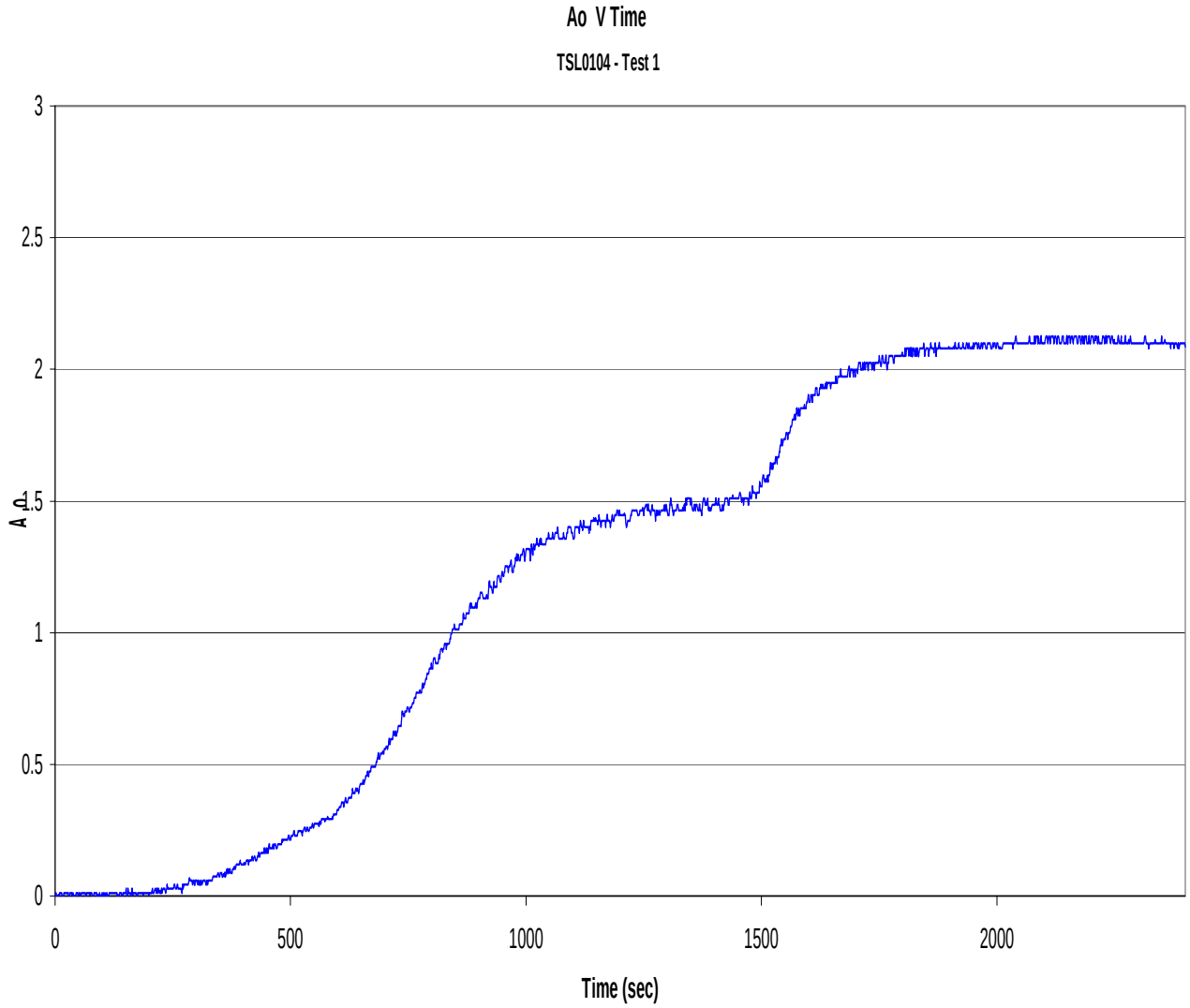

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Figure 2: Variation of Absorbance (Ao) with Time of cable joint assembly.

TEST 2 - Position B – Fire source at one end of the cable joint