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*Reference:* *TSL0104-HJP-R17889*

*Sponsored by:* *Tyco Electronic UK Limited*
*Faraday Road*
*Swindon*
*SN3 5HH*

*Issue Date:* *22nd August 2005*

*Prepared by:* *Hush J Patel (Senior Consultant)*

*Signature:* .....

*Certified by:* *Ben Enina (Technologist)*

*Signature:* .....

# TEST REPORT

## TSL No. R17889

**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. SM0E1**

**"All combustible component parts used in the joint's assembly".**

**Testing to LUL Fire Standard 2-01001-002: Issue A1: Section 5.2.3**



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**Tyco joint kit unique design ref. SMOE 82051**
**"All combustible component parts used in the joint's assembly".**
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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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**CONTENTS**

**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. SMOE 82051**
**"All combustible component parts used in the joint's assembly".**
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## 1. INTRODUCTION

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

The following clients instructions in conjunction with Metronet Rail BCV are:

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

## 2. MATERIAL DESCRIPTION

The description of the material given below has been prepared from information provided by the sponsor of the test. All values quoted are nominal, unless tolerances are given.

| **Transfire Services Limited reference No.** | **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. |
|---|---|---|---|---|---|
| TSL0104/1 | Connector insulation sleeve | WCSM-43/12-280/S | 1895 | Cross linked low density polyethylene with carbon black filler. | WCSM |
| TSL0104/2 | 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 |
| TSL0104/3 | Woven glass sheet with intumescent coating on one side only (Inner facing side) | 'Fireplug Multiwrap' Supplied to Tyco by Complete Fire Protection Ltd (Bristol). | | ' | |
| TSL0104/4 | Securing tape for woven glass sheet | | | Paper-based self-adhesive tape | |

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| | | | | | |
|---|---|---|---|---|---|
| TSL0104/5 | Outer protection sleeve | ZCSM-120/50-1200 | 1360 | Cross linked ethylene vinyl acetate polymer with magnesium hydroxide filler. | ZCSM |
| TSL0104/6 | 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 |

Note: At the request of Metronet Rail BCV, the specimen samples TSL0104/4 and TSL0104/6 were not tested.

## 3. TEST METHOD

Chemical analysis for the the toxic fume emission tests were subcontracted to 4-Rail Services Limited.

### 3.1 TOXIC FUME EMISSION

#### 3.1.1 QUALITATIVE ANALYSIS

The above specimen samples were tested on 11th May 2004, for qualitative elemental analysis using scanning electron microscopy and energy dispersive X-Rays.

#### 3.1.2 QUANTITATIVE ANALYSIS

The above specimen samples were tested on 18th May 2004, for quantitative analysis of Nitrogen, Carbon and Sulphur using Carlo Erba EA1108 Elemental analyser'.

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## 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 TOXIC FUME EMISSION

#### 4.1.1 QUALITATIVE ANALYSIS

The elements detected are given below as seen by Figures 1-4; Page 9-10.

| Sample reference | Elements detected |
|---|---|
| TSL0104/1 | Carbon, Oxygen. |
| TSL0104/2 | Carbon, Oxygen, Sulphur. |
| TSL0104/3 | Carbon, Oxygen, Sodium, Magnesium, Aluminium, Silicon, Phosphorus, Sulphur, Potassium, Calcium, Titanium, Manganese, Iron |
| TSL0104/5 | Carbon, Oxygen, Magnesium, Aluminium, Iron. |

#### 4.1.2 QUANTITATIVE ANALYSIS

| Sample reference | % Nitrogen | % Carbon | % Sulphur |
|---|---|---|---|
| TSL0104/1 | <0.01 | 87.14 | 0.04 |
| TSL0104/2 | 1.77 | 78.37 | 0.21 |
| TSL0104/3 | 0.09 | 28.49 | 0.59 |
| TSL0104/5 | <0.03 | 38.11 | 0.15 |

The above results are expressed as a percentage wt/wt.

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REQUIREMENTS

The Engineering Standard states that "For unrestricted use of a material, covered by Standard 2-01001-002: Issue A1: December 2003, neither it nor its constituents shall have deliberately incorporated by selection, addition or modification any significant amounts of organically bound halogens, nitrogen, sulphur or phosphorus; typical chemical groups proscribed are:-

C-X (where X = Halogen)
C-N
C-P
C-O-P
C-S
C-O-S

Trace levels of such chemical groups are acceptable – the criterion for "trace level" shall be that the summation of the weight for weight percentage of the chemical group divided by the atomic weight for the group shall not exceed 0.015. i.e.

The Toxicity Index is given by

$$\sum \frac{w/w\%\ of\ \ Chemical\ Group}{Atomic\ weight\ of\ \ Group} \leq 0.015$$

For each material the toxicity index was calculated to 4 decimal places, as shown below:

| TSL Sample ref. | Calculation | Resulting toxicity index |
|---|---|---|
| TSL0104/1: | (0.04 ÷ 32) | 0.0013 |
| TSL0104/2: | (1.77 ÷ 14) + (0.21 ÷ 32) | 0.133 |
| TSL0104/3: | (0.09 ÷ 14) + (0.59 + 32) | 0.0248 |
| TSL0104/5: | (0.15 ÷ 32) | 0.0047 |
| Total: | Samples 1+2+3+5 | 0.1638 |

The combined toxicity index is: 0.164, (to three decimal places)
(Note: At the request of M.R.BCV, the specimen samples TSL0104/4 and TSL0104/6 were not tested).

The toxicity index for the combined materials and, in particular, for the materials referenced TSL0104/2 and TSL0104/3 is significantly greater than the toxicity for the trace levels (0.015) as stated in London Underground standard 2-01001-002: Issue A1: December 2003 due to the presence of nitrogen and sulphur content above the permitted limits. However, with respect to Section 3.1.4 of this standard, these test results can be reassessed with the interpretation that toxic fume emission levels should be below IDLH (Immediately Dangerous to Life or Health) levels. Hence, it is possible

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to calculate the potential toxic hazard presented by the combination of materials, constituting the sample (i.e. samples TSL0104/1, 2, 3 & 5 combined).

REASSESSMENT BASED ON M1042

The following reassessment has been conducted using the principals and methods described in London Underground document M1042 "Manual of Good Practice: Fire Safety of Materials used in the Underground" (referenced in Section 2.3 of standard 2-01001-002 issue A1),

In order to reassess the potential toxic fume hazards, the following assumptions would need to be made:

*The dispersal volume in which the product is installed is 200m$^3$ for Tunnel.*

*The material is the sole contributor to the fire atmosphere.*

*All of the nitrogen and sulphur in the material(s) would convert to hydrogen cyanide and sulphur dioxide i.e. 100% conversion of nitrogen to hydrogen cyanide and sulphur to sulphur dioxide respectively.*

*Size of Fire region is 0.5m$^2$for tunnel locations.*

Hence, the expected concentrations of hydrogen cyanide is calculated, according to "Users Guide to the LUL Code of Practice - Fire Safety of Materials Used in the Underground - Issue 1; 1994" and the Manual of Good Practice M1042, which gives the following expected concentrations of hydrogen cyanide and sulphur dioxide,

| **Toxic Gas** | **Concentration (ppm) in Location RS/SU/v & p (Rolling Stock/Surface/Verticle & Prone)** | | |
|---|---|---|---|
| | TSL0104/2 | TSL0104/3 | TSL0104/5 |
| HCN | 2.27 | 1.93 | - |
| $SO_2$ | 0.12 | 5.53 | 2.25 |

The total expected toxicity, $T_x$, is given by the equation:

$$T_{Total} = \sum \frac{C_N}{H_N}$$

Where, $C_N$ = Concentration of any one toxic species, and
$H_N$ = IDLH for value for that toxic species.

The calculated values and the requirements are:

| Location | Total expected toxicity, $T_{x.}$ | Requirements |
|---|---|---|
| RS/SU/v & p | 0.163 | <1.0 |

## 5. CONCLUSION

The London Underground Limited Engineering Standard 2-01001-002: Issue A1: December 2003 criterion for toxic fume emission is a summation toxicity index value of less than 1.0. The specimen samples described in section 2.0 of this report give a summation toxicity index value of 0.163. Thus, the specimen samples comply with the toxic fume emission requirements.

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**Figure 1: X-ray spectrum for Connector Insulation sleeve.**
**Laboratory sample reference: TSL0104/1**

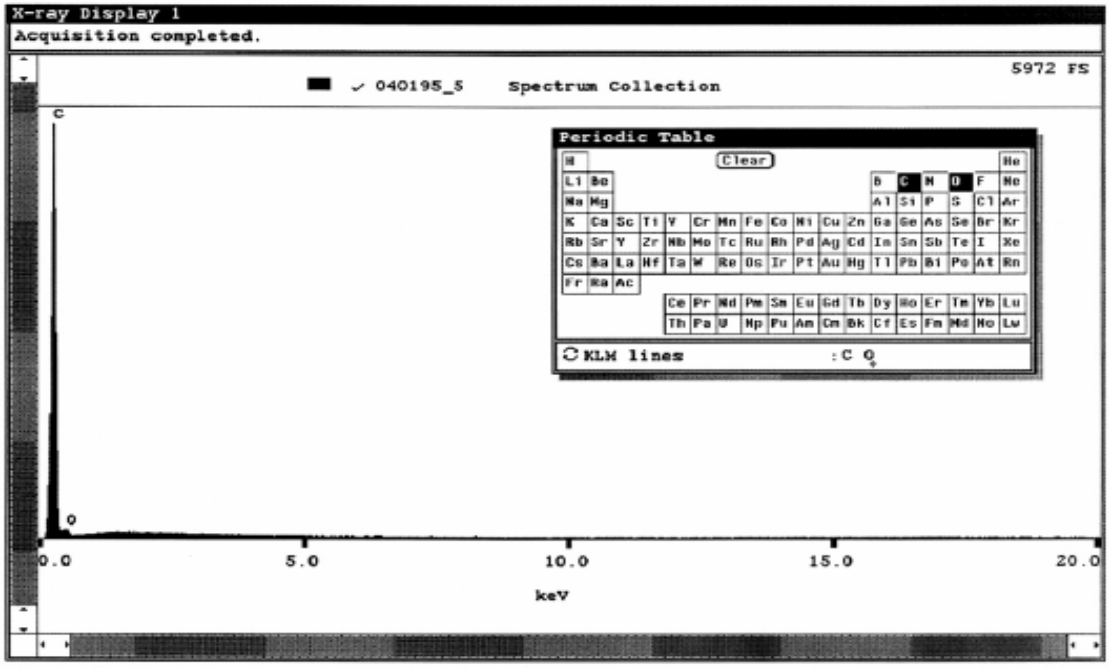


**Figure 2: X-ray spectrum for Polyamide hot-melt adhesive.**
**Laboratory sample reference: TSL0104/2**

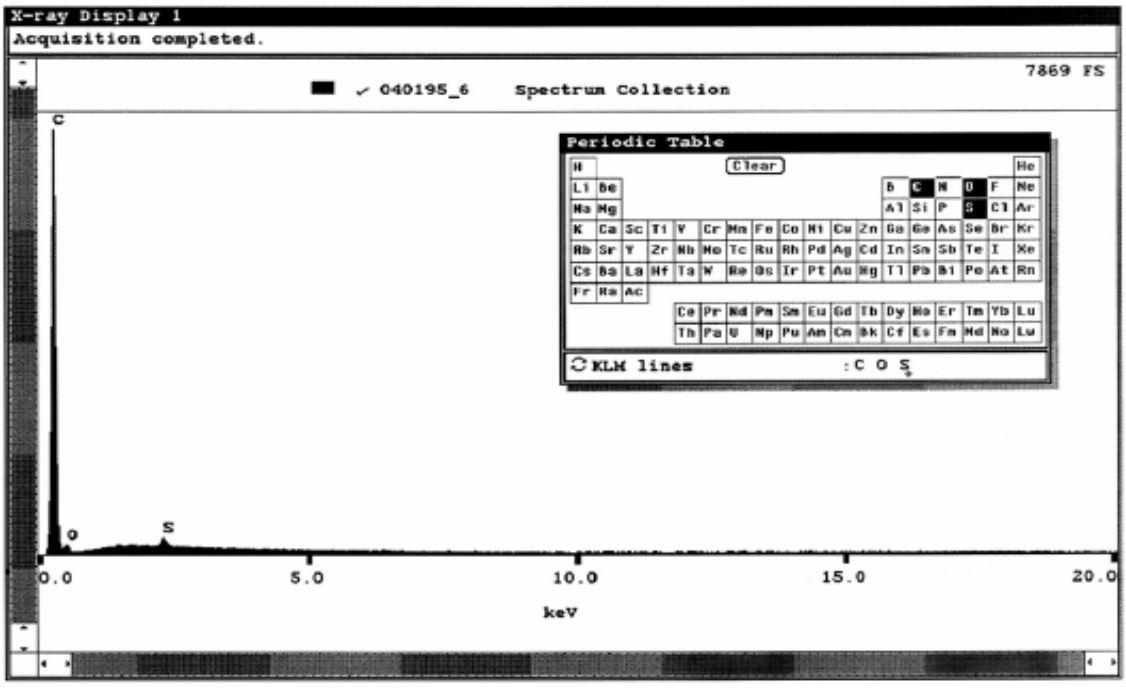

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**Figure 3: X-ray spectrum for Fireplug Multiwrap.**
**Laboratory sample reference: TSL0104/3**

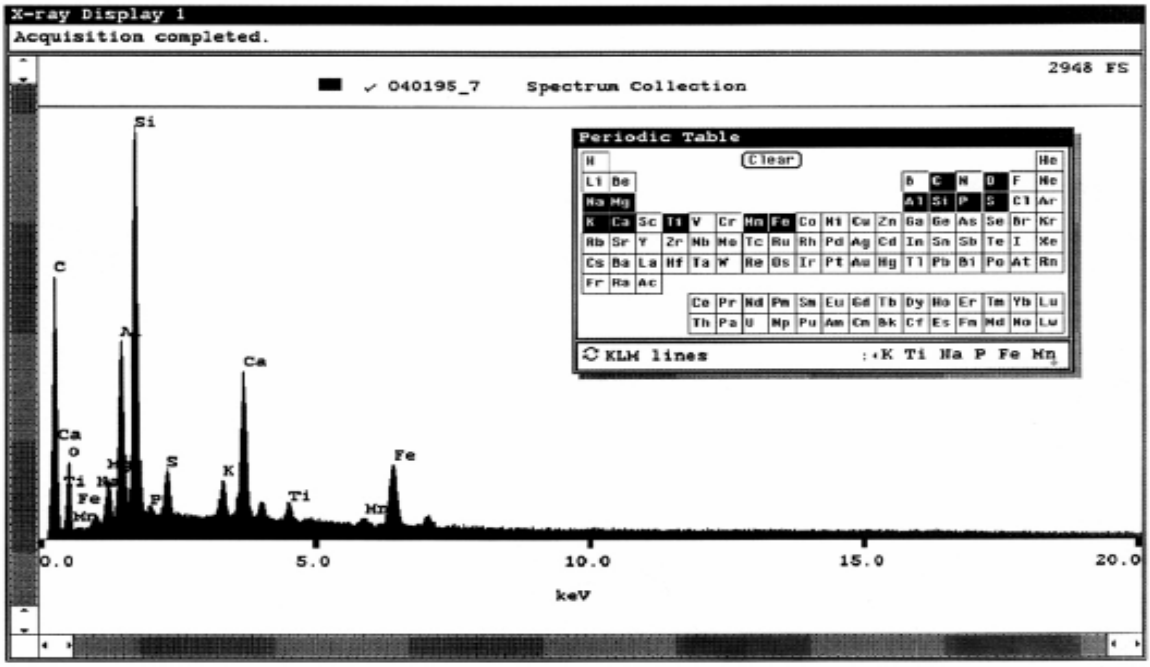


**Figure 4: X-ray spectrum for Outer protection sleeve, referenced ZCSM-120/50-1200.**
**Laboratory sample reference: TSL0104/5**