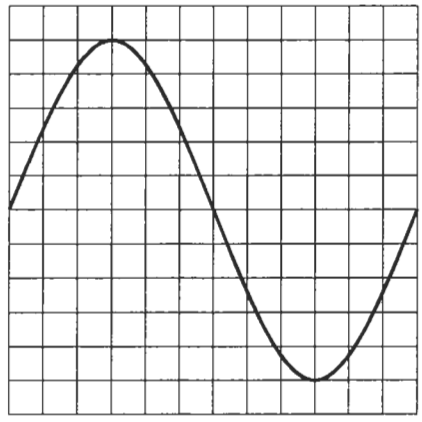

Application Confirmation
of Test Report PPR 1501 as

Generic Qualification of
Raychem Low Voltage Joints to
CENELEC HD 623.

Applicable for joint types:
EPKJ, UAGA, SMOE,
POLJ, GUSJ, TRAJ

Pages: 14
Appendices: PPR 1501

Confirmed by:
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Product Management and Engineering
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Date: 16.06.05

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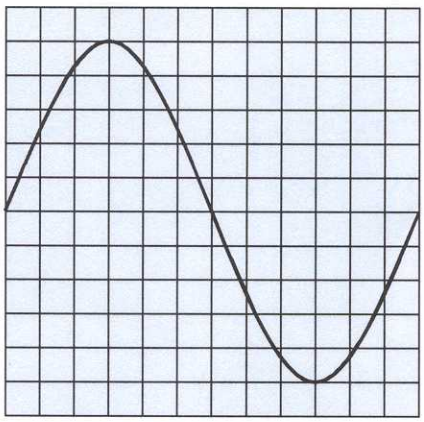

Test Report
PPR 1501

Qualification of
Adhesive /S
(S1323)

Material and
application testing

Pages: 13
Appendices: -

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Contents

1. Purpose:

The tests were carried out to show the reliability of a newly formulated hot melt adhesive for co-extrusion with heat shrink tubing. This included tests of the adhesives material properties as well as tubing tests and application tests (test of the installed accessory). Since there is a huge variety of possible applications, one low voltage joint product line (EPKJ) was selected for the application tests to represent the other products as well.

2. Test Requirements:

PPS 3012/76 (Tyco Energy specification)
CENELEC HD623 S1: 1996
Long term load cycling 7000h
VEW ETK30.0065 (Customer specification)
Internal pressure testing (Tyco Telecom specification)

Several international and internal specifications were used. For materials testing there are a lot of different specifications, summarised in the internal Tyco specification PPS 3012. The application tests on EPKJ were carried out according to CENELEC including some additional tests, for example with increased conductor temperature according to a customer specification of Vereinigte Elektrizitätswerke (VEW), Germany.

3. Conclusion:

All testing showed satisfactory performance of the newly formulated adhesive and the products including it. The relevant test procedures were passed. So the adhesive can be considered to be functional and reliable for electrical power applications.

4. Material Testing

Material testing was carried out according to the internal master specification PPS 3012, the required individual values are documented in the internal specification PPS 3012/76. These test values are only related to the adhesive and independent from the coated product. Requirements and results are summarised in Table1:

Test	Unit	Requirement	Test Result
Density	g/cm³	1.0±0.1	1.05
Softening Point	°C	110±10	111.6
Low Temperature Flexibility	-	4h at -35±3°C no cracking	passed
Adhesive Peel Strength (to various materials)	N/25mm	depending on substrate (see PPS 3012/76)	passed
Shear Strength	MPa	1 min.	1.25
Dielectric Strength	kV/cm	140 min.	331
Volume Resistivity	Ωcm	1 x 10^{11} min.	1.7 x 10^{11}
Water Absorption	%	1.0 max.	0.6
Corrosive Effect	-	16h at 120±2°C	no corrosion

Table 1: Summary of the material tests

5. Application testing with EPKJ Product line

5.1 Test Samples and Components

The new adhesive was mainly developed for the Raychem medium wall and heavy wall heat shrinkable tubing. Apart from general-purpose applications, these tubing are mainly used for low voltage applications as insulation sleeve and as rejacketing sleeve for low, medium and high voltage applications. The LV joint product line EPKJ was chosen to prove the functionality of the sleeves. In this test the sleeves are tested directly on the connector and core insulation, which gives the most severe thermal and mechanical stress for the material.

All used sleeves and cable sizes are given in table 2. Some sleeves are coated with the adhesive /172. But these are rejacketing sleeves not having any sealing function when tested according to HD 623 due to a window cut in the sheath to simulate a sheath damage. However, these sleeves are necessary for thermal reasons.

Cable details see 5.2.

#	Type	**Insulation sleeve** Batch No.	**Rejacketing sleeve** Batch No.	**Cable(s)**
1	EPKJ-0228	WCSM-9/3-80/S EC20501-08	WCSM-33/8-250/S EB50852-13	4 x 1.5mm² PVC/PVC
2	similar to EPKJ-0242	WCSM-20/60-170/S EC21431-01	MWTM-50/16-650/S EC71561-19	4 x 35mm² XLPE/PE
3	EPKJ-0256	WCSM-33/8-250/S EB50852-13	WCSM-105/30-800/172 EZ30131-00	4 x 150mm² PVC/PVC
4	EPKJ-0256	WCSM-33/8-250/S EB50852-13	WCSM-105/30-800/172 EZ30131-00	4 x 150mm² XLPE/PVC
5	EPKJ-0917	WCSM-33/8-250/S EB50852-13	WCSM-105/30-800/172 EZ30131-00	4 x 120mm² PILC to 4 x 150mm² PVC/PVC
6	similar to EPKJ-0528	WCSM-20/6-150/U EC21151-07	MWTM-50/16-450/S EC-71561-19	4 x 25mm² PILC
7	EPKJ-0256 (VEW)	WCSM-33/8-250/S EB50852-13	WCSM-105/30-800/172 EZ30131-00	4 x 150mm² XLPE/PVC
8	EPKJ-0256 (long term)	WCSM-33/8-250/S EB50852-13	WCSM-105/30-800/172 EZ30131-00	4 x 150mm² PVC/PVC

Table 2: test samples for application testing

Samples 1 through 6 were tested according to CENELEC HD623, Sample 7 to VEW Werknorm ETK30.0065. Sample 8 was used for a long term load cycling test.

5.2 Cables

A variety of cables was used to test the performance on different sizes and insulation materials. Table 3 gives an overview of the cables in detail.

Type	Conductor	Insulation	Sheath
4 x 1.5mm² NYY	copper, round, solid	PVC	PVC
4 x 35mm² NA2X2Y	aluminium, round, solid	XLPE	XLPE
4 x 150mm² NAYY	aluminium, sector shaped, solid	PVC	PVC
4 x 150mm² NA2XY	aluminium, sector shaped, solid	XLPE	PVC
4 x 25mm² PILC	copper, round, stranded	impregnated paper	lead covered, PVC sheathed
4 x 120mm² PILC	aluminium, sector shaped, stranded	impregnated paper	lead covered, tape armour, jute

Table 3: Cable details

5.3 Installations

The samples were built according to standard Raychem installation instructions. These are EPP-0081-9/93 for plastic or rubber cable joints, EPP-0168-4/94 for the transition joint and EPP-0186-4/94 for the paper cable joint. Installations were done under normal indoor ambient conditions. Installations were made to standard rules without any special treatment of the cables or the sleeves unless mentioned in the installation instruction.

6. Test Programmes Application Testing

6.1 Test programme in accordance with CENELEC HD 623

The following test programme was carried out with samples #1 - #6

Test	HD 623 subclause
AC voltage withstand in air	6.6.4
Insulation resistance in air	6.6.7
AC voltage withstand immersed	6.6.4
Insulation resistance immersed	6.6.7
Load cycling in air	6.6.8
Load cycling in water	6.6.8
AC voltage withstand	6.6.4
Insulation resistance immersed	6.6.7

6.1.1 AC voltage withstand in air

For all samples an AC voltage of 4kV was applied for one minute between the bunched cores and ground. After this an AC voltage of 4kV was applied for one minute between each core in turn and all other cores grounded.

Requirement: no breakdown.

Results: All samples passed.

6.6.2 Insulation resistance in air

The insulation resistance was measured between each core in turn. The insulation resistance was measured at 500 Volts D.C.

Requirement: R_{ins}>50MΩ

Results: All samples passed.

6.6.3 AC voltage withstand immersed

The samples were immersed in water in such a way, that the waterhead over the cable was more than 1m. For all samples an AC voltage of 4kV was applied for one minute between the bunched cores and water. After this an AC voltage of 4kV was applied for one minute between each core in turn and water and all other cores grounded.

Requirement: no breakdown.

Results: All samples passed.

6.6.4 Insulation resistance immersed

The samples were still immersed in water. The insulation resistance was measured between each core and water as well as between each core in turn. The insulation resistance was measured at 500 Volts D.C.

Requirement: R_{ins}>50 MΩ

Results: All samples passed.

6.6.5 Load cycling in air

For load cycling the cores of each sample were connected in series. The samples were connected to a current transformer controlled by a temperature regulator (except for #1, which was supplied with a constant current).

The test loops were subjected to 63 load cycles under ambient conditions. Each cycle lasted eight hours, consisting of a three hours temperature raising period, a two hours period of constant temperature depending on the rated cable temperature and a three hours cooling period without any heating current. Temperature was measured directly in the core crutch of the cable, about 500mm from the cable end. Table 4 is an overview of the test temperatures

#	type	core insulation	rated core temperature	test temperature / remarks
1	straight joint	PVC	70°C	constant current 20A
2	straight joint	XLPE	90°C	95°C
3	straight joint	PVC	70°C	75°C
4	straight joint	XLPE	90°C	95°C
5	transition joint	PVC/paper	70°C / 80°C	75°C / measured on PVC side
6	straight joint	paper	80°C	85°C

Table 4: Load cycling details

6.6.6 Load cycling in water

For the immersed load cycling on each sample the oversheath was removed together with any bedding and filler material for a length of about 75mm close to the joint area. The samples were immersed in water in such a way, that the waterhead over the oversheath cutback was 1m.

For load cycling all samples were again connected to the current transformer controlled by the temperature regulator (except #1). The test loops were subjected to 63 load cycles as mentioned above. Temperature was measured again in the core crutch but outside the water, as described in the CENELEC specification.

6.6.7 AC voltage withstand

The samples were still immersed in water. For all samples an AC voltage of 4kV was applied for one minute between the bunched cores and water. After this an AC voltage of 4kV was applied for one minute between each core in turn and water and all other cores grounded.

Requirement: no breakdown.

Results: All samples passed.

6.6.8 Insulation resistance immersed

The samples were still immersed in water. The insulation resistance was again measured between each core and water as well as between each core in turn. The insulation resistance was measured at 500 Volts D.C.

Requirement: R_{ins}>50 MΩ

Results: All samples passed.

6.2 Test programme in accordance with VEW Werknorm

Sample #7 was tested to the customer specification VEW ETK30.0065. This is basically a CENELEC test and two weeks additional load cycling with increased core temperatures.

The following test sequence was carried out:

- AC voltage withstand immersed
- Insulation resistance immersed
- 63 Load cycles in air @ 95°C conductor temperature
- 63 Load cycles in water @ 95°C conductor temperature
- 21 Load cycles in air @ 115°C conductor temperature
- 21 Load cycles in water @ 115°C conductor temperature
- AC voltage withstand
- Insulation resistance immersed

All tests were carried out in the same way and under the same conditions as the above-mentioned CENELEC test. This test shows the reliability of the tubing material as well as the adhesive even for increased conductor temperatures, for example in an emergency overloading the cable.

Results:

- AC voltage withstand 4kV for one minute immersed in water at one meter depth:

  No breakdown

- Insulation resistance immersed, measured at 500V DC:

  All cores R_{ins}>50 MΩ

- 63 Load cycles in air @ 95°C conductor temperature:

  passed

- 63 Load cycles in water @ 95°C conductor temperature. Samples were immersed in water at one meter depth:

  passed

- 21 Load cycles in air @ 115C conductor temperature. The sample was heated with a constant current to avoid connector overload. The temperature was recorded.

  passed

- 21 Load cycles in water @ 115°C conductor temperature. Same as above, but immersed in 1m water depth.

  passed

- AC voltage withstand:

  passed

- Insulation resistance immersed:

  passed

6.3 Long term load cycling

One joint EPKJ-0256 from an earlier test series was kept immersed in the waterbath and load cycled. After about 7000h load cycling the insulation resistance was measured and an AC voltage test was done.

Following is the test sequence and results:

Pretesting:

30 load cycles in air @ 75°C conductor temperature:	no damage
Insulation resistance in water:	R_{ins}>50 MΩ
63 load cycles in water @ 75°C conductor temperature:	no damage
Insulation resistance in water:	R_{ins}>50 MΩ
AC Voltage withstand 6kV/15minutes:	no breakdown
AC Voltage withstand 4kV/1minute:	no breakdown

Long term load cycling:

Additional load cycles in water @ 75°C conductor temperature started January 12th 2000 and stopped on October 30th, 2000. Considering some smaller undocumented breaks (e.g. cleaning the waterbath), a number of 850 load cycles can be guaranteed. This gives an overall load cycling time of over 7000 hours.

Results:

- No visible damage of the joint
- Insulation resistance in water, measured at 500V DC: all cores R_{ins}>50 MΩ
- AC Voltage withstand 4kV AC phase to ground and phase to phase for one minute: no breakdown

7. Internal pressure testing

At the Tyco Electronics Telecom plant in Kessel-Lo, Belgium, tests on three sizes of MWTM tubing were carried out according to the special needs of pressurised telecom cables.

On some cable the oversheath was cut open (repair) or a splice was built. The cable was pressurised with an internal pressure of 40±2kPa and after 15min the tightness was tested. After this, the samples were put into a climate chamber. In the chamber 10 cycles were carried out from -30±2°C to +60±2°C while the pressure was regulated 40±2kPa. The duration of one cycle was 12h. Requirement was tightness for all cycles.

Table 5 shows the tested tubing and cable sizes in detail:

#	Sleeve	Batch No.	Type	Cable Dia.
1	MWTM 35/15-A/S	EC 20521	repair	12,0mm
2			repair	21,5mm
3			repair	32,0mm
4			splice	21,5mm
5			splice	12.0mm
6	MWTM 70/26-A/S	EC 70481	repair	31,0mm
7			repair	42,0mm
8			repair	58,0mm
9			splice	31,0mm
10			splice	55,0mm
11	MWTM 115/34-A/S	EC 70417	repair	42,0mm
12			repair	70,0mm
13			repair	75,0mm
14			splice	42,0mm
15			splice	75,0mm

table 5: Samples for internal pressure testing

Results:

Tightness test 40kPa / 15min: all samples passed

Thermal cycling: 10 cycles -30°C to +60°C @ 40kPa all samples passed

8. Equipment and Environmental Conditions

Equipment used for measurements:

Insulation resistance meter: BBC Metriso 5000 (Ry-E0033)
AC current meter LEM HEME LH2040 (Ry-E0048)
AC voltage breakdown detector: Schuntermann & Benninghoven P1000 (Ry-E0010)
Temperature Regulators: Eurotherm A70915
Temperature Recorder: Siemens Multireg

Environmental condition during installation and test:
Air temperature: 18°C … 26°C

Tests were carried out in between December 1999 and January 2001