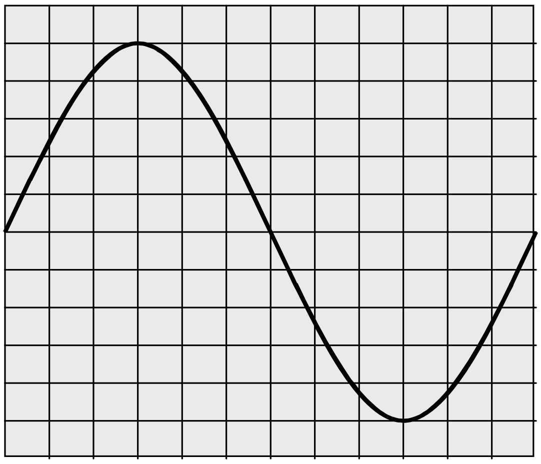

# PPR-3037

Type test report of Raychem Plug In Termination , Type RPIT-631x
Up to 36(42) kV

Type test according to CENELEC HD 629.1 S2 02/2006

Pages:41 (including cover page)

Date: 15 July 2014

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Test Institute:
IEH, Institute of Electrical Energy Systems and High Voltage Technology - University of Karlsruhe, Karlsruhe Germany

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Raychem
from TE Connectivity

Bereich Hochspannungsprüftechnik
Institut für Elektroenergiesysteme und Hochspannungstechnik

Universität Fridericiana (TH) Karlsruhe
76128 Karlsruhe – Kaiserstraße 12
Tel.: +4972160842520 Fax: +49721695224

Test Report No 2012-83

# Type Test of

# Plug-In Terminations, Type RPIT 631x

# up to 36 (42) kV

Customer: TE Connectivity
Finsinger Feld 1
85521 Ottobrunn

Reporter: Dr.-Ing. R. Badent
Dr.-Ing. B. Hoferer

This report includes 40 numbered pages and is only valid with the original signature. Copying of extracts is subject to the written authorization of the test laboratory. The test results concern exclusively to the tested objects.

# 1 Purpose of Test

*4 respectively 3 Plug-In Terminations* for $U_0/U_n/U_m$ = 20,8/36(42) kV were subjected to a type test according to CENELEC HD 629.1 S2 02/2006 table 7, test sequence D1 resp. D2. Two *Plug-In Terminations* for $U_0/U_n/U_m$ = 20,8/36(42) were subjected to additional tests for smallest cable cross section compliance according to CENELEC HD 629.1 S2 02/2006 table 10. Two *Plug-In Terminations* for $U_0/U_n/U_m$ = 20,8/36(42) were subjected to a test according to CENELEC HD 629.1 S2 02/2006, table 7, Pos 20 and 21.

# 2 Miscellaneous Data

Test object:

– Test sequences D1 and D2
7 Plug-In Terminations, type RPIT 6319, $U_m$ = 42 kV,
Installation instruction EPP-2011-6/12 dated 06/2012, Figure 2.1 – 2.6
KIT Content RPIT-6319, Figure 2.7
Type of cable: The test objects were mounted on single core shielded XLPE-cables, SYNERGY CABLES 1x630/ 50mm²-19/33kV Figure 2.8

– Test sequence table 10, smallest cross section
2 Plug-In Terminations, type RPIT 6311, $U_m$ = 42 kV,
Installation instruction EPP-2011-6/12 dated 06/2012, Figure 2.1 – 2.6
KIT Content RPIT-6311, Figure 2.9
Type of cable: The test objects were mounted on single core shielded XLPE-cables, NA2XS2Y 1x95/16mm² 18/30kV Figure 2.10

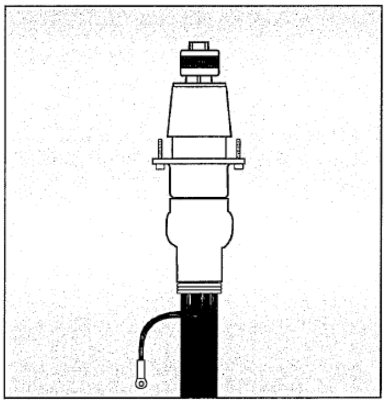
The terminations were mounted on Plug-In Sockets, type RPIS, installation instruction EPP-1333-11/08, dated 08/2011, Fig. 2.11 – 2.14

Manufacturer: TE Connectivity
Finsinger Feld 1
85521 Ottobrunn

| | |
|---|---|
| Place of test: | *Institute of Electric Energy Systems and High Voltage Technology* – University of Karlsruhe<br>Kaiserstraße 12 – 76128 Karlsruhe<br>Accreditation No.: DAT-PL-039/94-03 |
| Place of dynamic short circuit test: | Zkušebnictví, a. s.<br>Podnikatelská 547<br>190 11 Prague 9, Běchovice<br>Czech Republic<br>Accreditation certificate No. 573 /2012 |
| Testing dates: | Delivery: 29.08.2012, resp.12.05.2014<br>Mounting: 29.08.2012, resp.12.05.2014<br>Test period: 29.08.2012 – 03.07.2014 |
| Atmospheric conditions: | Temperature: 18$^{o}$C – 25$^{o}$C<br>Air pressure: 970 - 1040 mbar<br>rel. humidity: 20 % – 70 % |
| Representatives: | *Customer´s representatives*:<br>Dipl.-Ing. N. Schad<br>Dipl.-Ing. G. Sens<br>Dipl.-Ing. Xiangming Quan<br><br>*Representatives responsible for the tests*:<br>Dr.-Ing. R. Badent<br>Dr.-Ing. B. Hoferer<br>Mr. O. Müller |

TE connectivity ENERGY

Raychem
from TE Connectivity



**Installation Instruction**
**EPP-2011-6/12**

**Raychem**
**Plug-In Termination for**
**Inside Cones 1250 A (Size 3)**
**according to EN50181,**
**with / without Test Lead**
**for Single Core Polymeric**
**Insulated Wire Shielded**
**Cable**
**up to 36 / (42) kV**

**Type: RPIT-x31x-xxxx**

**Safety Warning:**
**It is essential to observe the applicable safety regulations for working with high voltage equipment.**
**For precise safety information please contact the responsible authority.**

Prüfgegenstand entspricht der vorgelegten technischen Zeichnung

Unterschrift des Herstellers | Unterschrift des Prüfers

**Tyco Electronics Raychem GmbH**
ein Unternehmen der TE Connectivity Gruppe
TE Energy
Finsinger Feld 1
85521 Ottobrunn/München
Telefon: 089-6089-0
Telefax: 089-6096-345
energy.te.com

Figure 2.1: Installation instruction, Plug-In Termination

## Before Starting

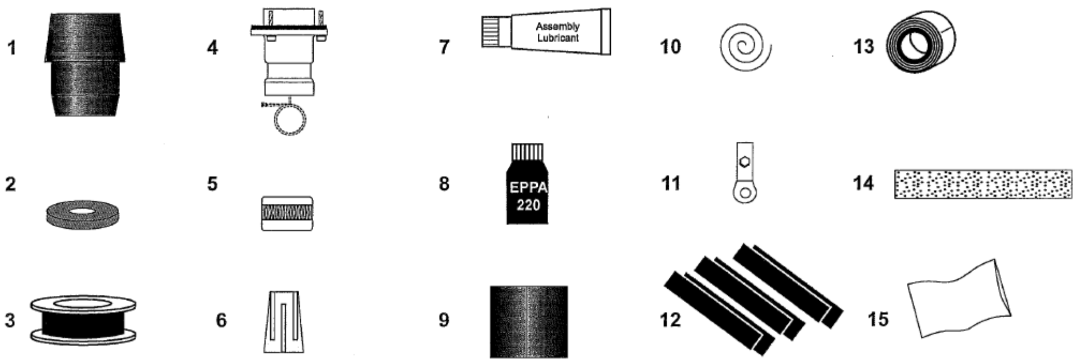
**Check to ensure that the kit you are going to use fits the cable.**

**Refer to the kit label and the title of the installation instruction.**

**Components or working steps may have been improved since you last installed this product.**

**Carefully read and follow the steps in the installation instruction.**

**Kit Contents**




| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1** | 3 x Stress cone | **4** | 3 x Protection cover | **7** | 1 x Assembly lubricant | **10** | 1 x Wire binder | **13** | 1 x PVC-Tape |
| **2** | 3 x Stopper ring | **5** | 3 x Multilam contact ring | **8** | 1 x Conductive paint | **11** | 3 x Earth cable lug | **14** | 1 x Abrasive strip |
| **3** | 1 x Semi conductive tape | **6** | 3 x Conical wedge | **9** | 3 x Sealing sleeve | **12** | 6 x Strips black mastic | **15** | 1 x Paper towel |

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Unterschrift des Herstellers    Unterschrift des Prüfers

The Information contained in these installation instructions is for use only by installers trained to make electrical power installations and is intended to describe the correct method of installation for this product. However, TE Connectivity has no control over the field conditions which influence product installation.
It is the user's responsibility to determine the suitability of the installation method in the user's field conditions. TE Connectivity's only obligations are those in TE Connectivity's standard Conditions of Sale for this product and in no case will TE Connectivity be liable for any other incidental, indirect or consequential damages arising from the use or misuse of the products.
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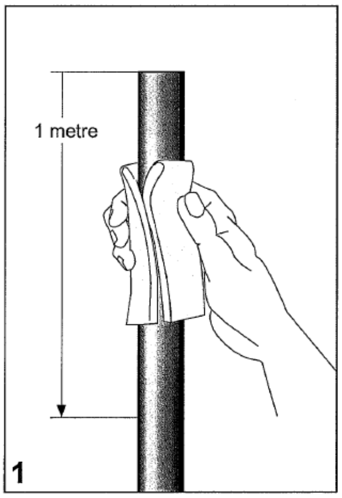
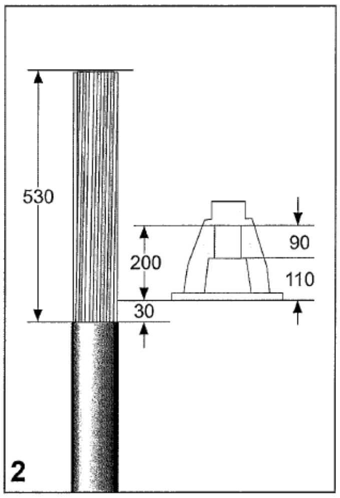
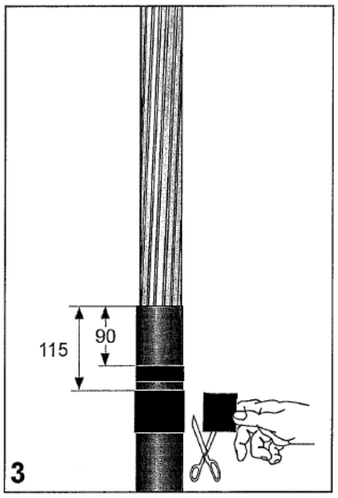
Figure 2.2: Installation instruction, Plug-In Termination

**Cable Preparation**




Clean and degrease the end of the oversheath for a length of 1 metre with solvent wipe.
Ensure that the cable is absolutely straight for 1 m.

**Note:** Cables at cross sections **above 300 mm²** have to be straightened, preferably warmed up for 1 hour with heat blanket like HVIA-CABLE-HEAT-BLANKET.

Position the cable end in line with the bushing centre having an overlap of 500 mm. Mark the oversheath 530 mm below the cable end.
Remove the oversheath over this distance.

Cut off Cu-spiral screening tape flush with end of outer sheath.
Place a marker tape (PVC) according to dimension 90 mm below the oversheath cut as shown in the drawing.
Wrap one turn of sealant tape (black) with no overlap and slight tension at 115 mm below the over sheath cut.
Cut the tape and push ends together.

Bend the shielding wires back onto the oversheath. Ensure flush positioning and avoid crossing the individual wires. Temporarily secure the wires with a tape or binding wire.
Cut the core with a hack saw at dimension 230 mm as shown in the drawing.

**5a. Cable with bonded core screen**
Remove the core screen with appropriate screen cutting tool according to dimension 205 mm given in the drawing.

**5b. Cable with easy strip core screen**
Wrap a few layers of PVC tape over the core screen at dimension 205 mm given in the drawing. Use round file to take away core screen at the edge of the marker tape until the white colour of the insulation becomes visible. Use the depth limiting cutter to cut the core screen and thoroughly remove the screen according to dimension given in the drawing.
**Note:** Do not nick the core screen or insulation.

Cut back the insulation according to dimension 85 mm as shown in the drawing.
Check position of marker tape with dimension 320 mm given in the drawing.
Cover the end of the conductor with two layers of PVC tape as shown.

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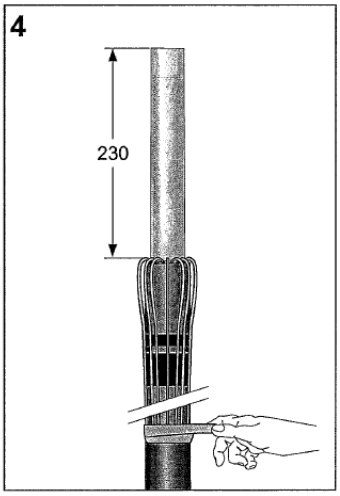
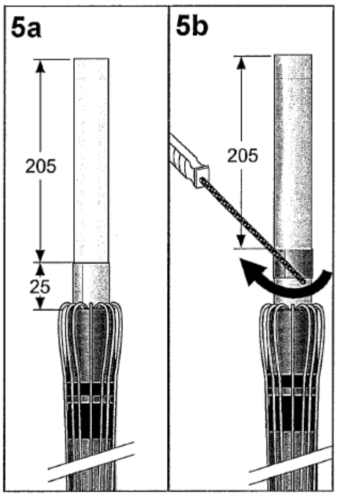
Unterschrift des Herstellers



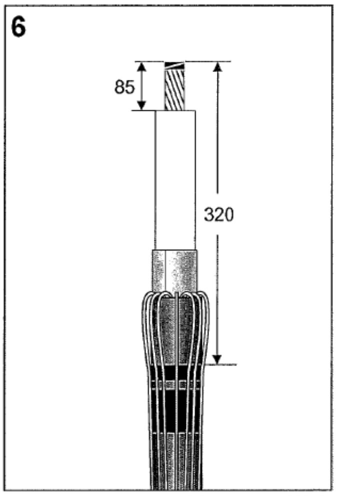




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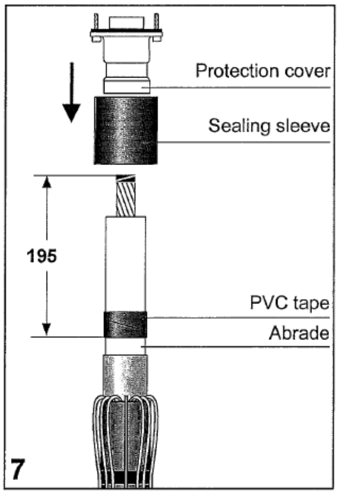
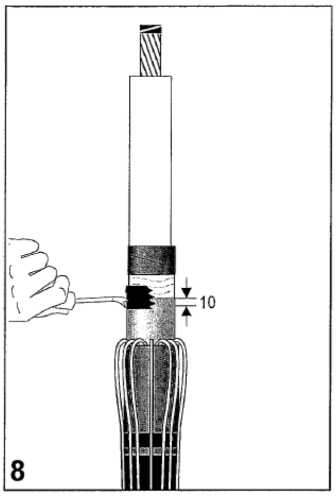
Figure 2.3: Installation instruction, Plug-In Termination

**Core Preparation**




Slide over the exposed cable core the heat shrinkable sealing sleeve followed by the protection cover.
Clean and degrease the core insulation. Apply a PVC-tape (adhesive side up) onto the core insulation at distance 195 mm as shown in the drawing.
Abrade the core insulation between end of core screen and PVC tape with abrasive paper at grit size 400.
Clean abraded area.

Shake the bottle of conductive paint thoroughly.
Apply the conductive paint evenly all around the insulation between core screen end and PVC tape. Cover in addition 10 mm of the adjacent core screen.
Ensure that the conductive paint has dried prior to removal of PVC tape.

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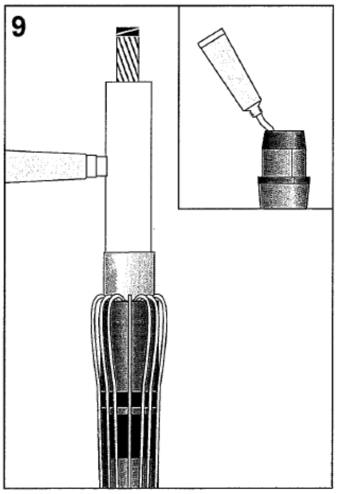
Apply onto the inner surface of the stress cone at the bottom end a 5 cm long sausage of assembly lubricant and spread it evenly over the inner surface. Use one way glove if necessary.
Apply a generous amount of assembly lubricant and spread it evenly onto the bare core insulation with sponge top.

Push the stress cone in one sequence without a twisting movement over the core insulation until 10 mm of insulation become visible at the top end.
Remove the PVC tape at the end of the conductor.



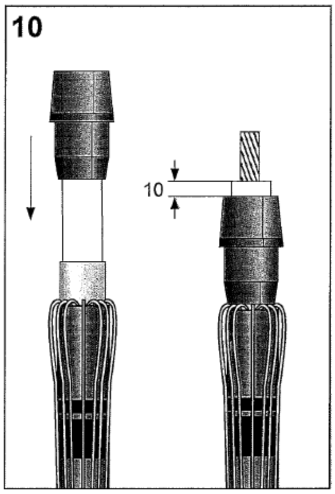




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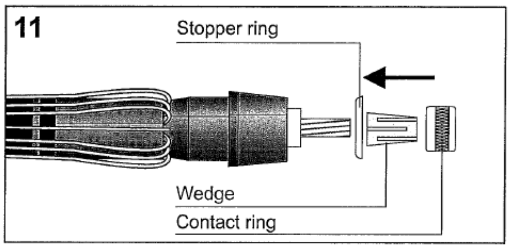
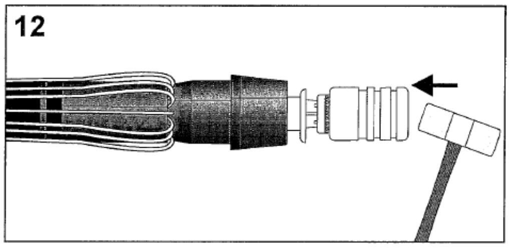
Figure 2.4: Installation instruction, Plug-In Termination

Remove excessive lubricant. Clean and degrease the conductor.
Slide the stopper ring, the wedge and the Multilam contact ring over the conductor as shown in the drawing. Ensure that the stopper ring slides onto the core insulation by approx. 3 mm.



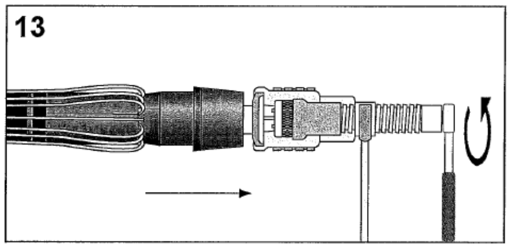

Position the wedge in such a way that it butts against the stopper ring. Ensure that the **thin** end of the wedge exceeds the conductor end by less than 1 mm. Slide the contact ring over the wedge and fix it temporarily with impact device and plastic hammer as shown in drawing. Use appropriate impact device marked with three groves for size 3.




Tighten the contact ring with special compression tool (Type IT-1000-25 or equivalent), spanner and torque wrench at following values:

| Size 3 |
|---|
| Torque: 120 Nm |

Push the stress cone back towards the conductor butting against the stopper ring.




Fill the gap between stress cone end and wire shield with several layers of semi conductive tape until an even level between stress cone end and wire shield is achieved.

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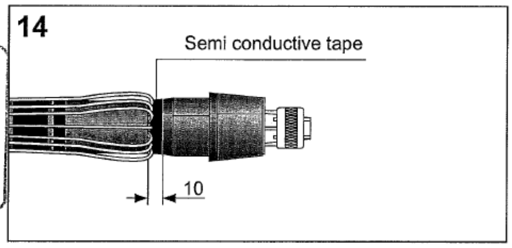
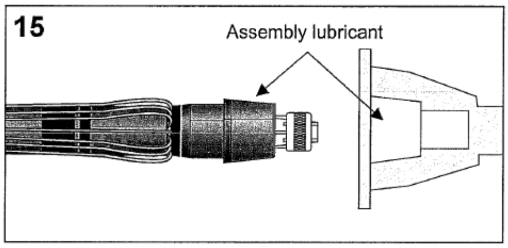



**Inserting the Termination**

Clean and degrease the inner surface of the bushing and the outer surface of the stress cone.
Apply a **thin** layer assembly lubricant onto the inner surface of the bushing as well as on the outer surface of the stress cone.




Insert the cable termination into the bushing and push up the stress cone by hand.
Use tie wrap between plug and bushing as air pressure relief during installation. Remove tie wrap once the part is inserted.

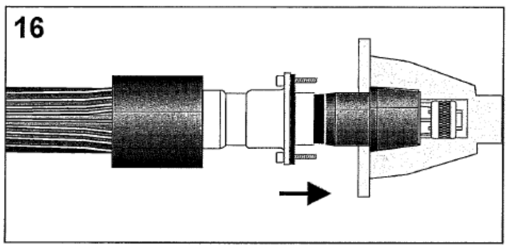



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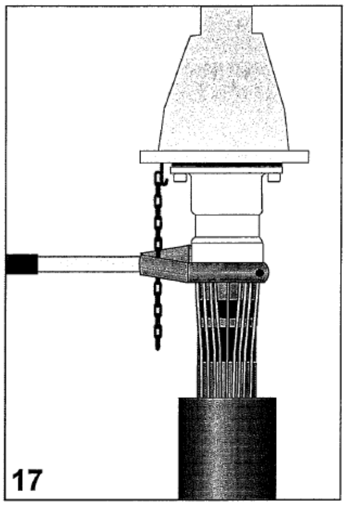
Figure 2.5: Installation instruction, Plug-In Termination




**For Size 3**
If M 12 threaded connection exists for system:

**a.** Screw chain into front eye.

**b.** Hook assembly lever into chain.

**c.** Press the protection cover against the outside flange of the switch gear using the assembly lever.

Prüfgegenstand entspricht der vorgelegten technischen Zeichnung

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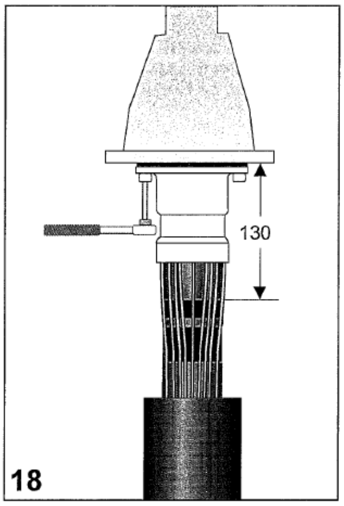
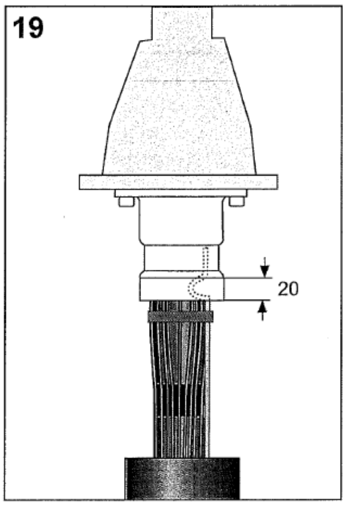
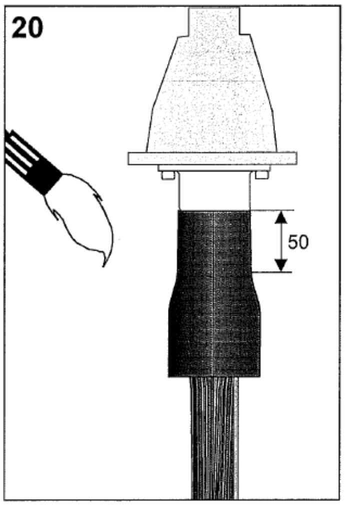



Lift up the cable protection cover and position the screws to the mating threading. Tighten the screws alternately and finally at a torque of 10 Nm.
Shake and push up the cable and turn the insertion into a complete state. Ensure that the cable stays in its position by external means / holding devices. Check the actual dimension 130 mm as shown in drawing. Take care of corrective steps if necessary.

Remove the PVC marker.
Push up the test lead (if any) with slack inside the protection cover by 20 mm. Secure the test lead with a PVC tape and add at the expected end of the heath shrink sleeve a 30 mm wide protection wrap.




Slide the sealing sleeve over the end of the protection cover by 50 mm.
Start shrinking the sleeve from the top end towards the bottom as shown in the drawing.
Stop for a minute once the first 50 mm are recovered. Then continue to recover the sleeve evenly all around the circumference.




Fix the shielding wires with a wire binder (four layers) at the end of the heat shrinkable tubing. Gather the wires together and form an earth lead. Install at the end of the shielding wires the connection lug supplied.
**Perform connection to ground.**

**Plug in termination completed.**

**Please dispose of all waste according to environmental regulations.**

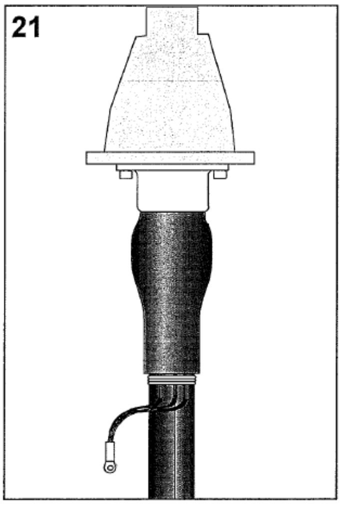



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Figure 2.6: Installation instruction, Plug-In Termination

TE connectivity ENERGY

## RPIT-6319

36 (42) kV Inner cone terminations with voltage tap for single core XLPE insulated cables with wire shield and without armour. Cross-section: 1 x 630 mm²

| QTY | x | DESCRIPTION | APPLICATION |
|---|---|---|---|
| 3 | x | RPIT-SCN3-44-VD | STRESS CONE ADAPTER |
| 3 | x | EXRM-2021-SR3-3454 | STOPPER RING |
| 3 | x | EXRM-1937-WG3-32.5 | WEDGE |
| 3 | x | RPIT-PCB3-VD | BRONZE PROTECTION COVER WITH VD |
| 3 | x | EXRM-1942-CR3 | CONTACT RING |
| 1 | x | EPPA-019-1-4500 | CONDUCTIVE TAPE |
| 1 | x | EPPA-029-3-5000 | TINNED COPPER WIRE |
| 1 | x | EPPA-064-60 | ASSEMBLY LUBRICANT |
| 1 | x | EPPA-202-2 | PVC TAPE (BLACK) |
| 1 | x | EPPA-203-54-1000 | ABRASIVE TAPE (GRIT 400) |
| 1 | x | EPPA-220(C40) | CONDUCTIVE PAINT |
| 3 | x | HEL-2070.1-Z-AK | CABLE SHIELD LUG |
| 1 | x | HO19-PAPIER-HAND-TUCH | PAPER TOWEL |
| 3 | x | MWTM-115/34-200/S | SEALING SLEEVE |
| 6 | x | S1061-1-300 | SEALING MASTIC |
| 1 | x | EPP-2011-6/12 | INSTALLATION INSTRUCTION |

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Figure 2.7: KIT Content, test sequences D1 and D2

TE connectivity ENERGY

**Annex A**
(informative)

**Identification of test cable (XLPE insulated) used with RPIT - 6319**

| | | | |
|---|---|---|---|
| Rated voltage $U_0/U$ ($U_m$): | 20,8/36 (42) kV | | |
| Construction: | ☒ 1-core | ☐ 3-core | ☒ Individually shield |
| | | | ☐ Overall shield |
| Conductor: | ☒ Al | ☐ Cu | |
| | ☒ Stranded | ☐ Solid | |
| | ☒ Circular | ☐ Shaped | |
| | ☒ 630 mm$^2$ | ☐ | |
| Insulation: | ☒ XLPE | | |
| | ☐ EPR | ☐ HEPR | |
| Insulation screen: | ☒ Bonded | ☐ Strippable | |
| Metallic shield: | ☒ Wire | ☐ Tape | ☐ Polylam |
| Shield : | ☐ Al | ☒ Cu | Section: 35 mm² |
| Armour: | ☐ Wire | ☐ Tape | |
| Oversheath: | ☐ PVC | ☒ PE (state type) | |
| Water blocking, if any: | ☐ In conductor | ☒ Under oversheath | |
| Cable dimensions: | Conductor diameter above: | 31,0 mm | |
| | Insulation thickness: | 8,0 mm | |
| | Diameter over insulation: | 48,6 mm | |
| | Oversheath diameter above: | 58,0 mm | |
| Cable marking: | SYNERGY CABLES 1X630/50 mm²-19/33 kV – year of manufacture – manufacture order – length mark | | |

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Figure 2.8: Cable data sheet, test sequences D1 and D2

TE connectivity ENERGY

## RPIT-6311

36 (42) kV Inner cone terminations with voltage tap for single core XLPE insulated cables with wire shield and without armour. Cross-section: 1 x 95 mm²

| QTY | x | DESCRIPTION | APPLICATION |
|---|---|---|---|
| 3 | x | RPIT-SCN3-25-VD | STRESS CONE ADAPTER |
| 3 | x | EXRM-2021-SR3-1335 | STOPPER RING |
| 3 | x | EXRM-1937-WG3-12 | WEDGE |
| 3 | x | RPIT-PCB3-VD | BRONZE PROTECTION COVER WITH VD |
| 3 | x | EXRM-1942-CR3 | CONTACT RING |
| 1 | x | EPPA-019-1-4500 | CONDUCTIVE TAPE |
| 1 | x | EPPA-029-3-5000 | TINNED COPPER WIRE |
| 1 | x | EPPA-064-60 | ASSEMBLY LUBRICANT |
| 1 | x | EPPA-202-2 | PVC TAPE (BLACK) |
| 1 | x | EPPA-203-54-1000 | ABRASIVE TAPE (GRIT 400) |
| 1 | x | EPPA-220(C40) | CONDUCTIVE PAINT |
| 3 | x | HEL-2070.1-Z-AK | CABLE SHIELD LUG |
| 1 | x | HO19-PAPIER-HAND-TUCH | PAPER TOWEL |
| 3 | x | MWTM-115/34-200/S | SEALING SLEEVE |
| 6 | x | S1061-1-300 | SEALING MASTIC |
| 1 | x | EPP-2011-6/12 | INSTALLATION INSTRUCTION |

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Figure 2.9: KIT Content, table 10 test

TE connectivity ENERGY

**Annex A**
(informative)

**Identification of test cable (XLPE insulated) used with RPIT - 6311**

| | | | |
|---|---|---|---|
| Rated voltage $U_0/U$ ($U_m$): | 20,8/36 (42) kV | | |
| Construction: | ☒ 1-core | ☐ 3-core | ☒ Individually shield |
| | | | ☐ Overall shield |
| Conductor: | ☒ Al | ☐ Cu | |
| | ☒ Stranded | ☐ Solid | |
| | ☒ Circular | ☐ Shaped | |
| | ☒ 95 mm² | ☐ | ☐ |
| Insulation: | ☒ XLPE | | |
| | ☐ EPR | ☐ HEPR | |
| Insulation screen: | ☒ Bonded | ☐ Strippable | |
| Metallic shield: | ☒ Wire | ☐ Tape | ☐ Polylam |
| Shield : | ☐ Al | ☒ Cu | Section: 16 mm² |
| Armour: | ☐ Wire | ☐ Tape | |
| Oversheath: | ☐ PVC | ☒ PE (state type) | |
| Water blocking, if any: | ☐ In conductor | ☒ Under oversheath | |
| Cable dimensions: | Conductor diameter above: | 11,6 mm | |
| | Insulation thickness: | 8,0 mm | |
| | Diameter over insulation: | 29,4 mm | |
| | Oversheath diameter above: | 37,8 mm | |
| Cable marking: | NEXANS; NA2XS2Y 1X95/16 mm²-18/30 kV – year of manufacture – manufacture order – length mark | | |

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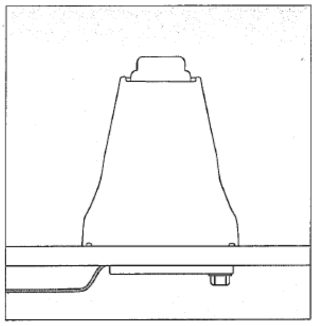
Figure 2.10: Cable data sheet, table 10 test

**Energy Division**

**Tyco Electronics**



**Installation Instruction**
**EPP-1333-11/08**

**Raychem**
**Plug In Sockets and**
**Insulating cap for**
**Inside Cones 800 A (Size 2)**
**and 1250 A (Size 3) in**
**Accordance to EN50181 for**
**use with oil or gas insulated**
**Switchgear**
**up to 36/(42) kV**

**Type: RPIS-2-IS & RPIS-3-IS**
**RPIC-2 & RPIC-3**

**Safety Warning:**

**It is essential to observe the applicable safety regulations for working with high voltage equipment.**
**For precise safety information please contact the responsible authority.**

Prüfgegenstand entspricht der vorgelegten technischen Zeichnung
Unterschrift des Herstellers — Unterschrift des Prüfers

**Tyco Electronics Raychem GmbH**
**Energy Division**
Finsinger Feld 1
85521 Ottobrunn/Germany
0049-89-6089-0 tel
0049-89-6089-345 fax
http://energy.tycoelectronics.com

Figure 2.11: Installation instruction Plug-In Sockets

## Before Starting

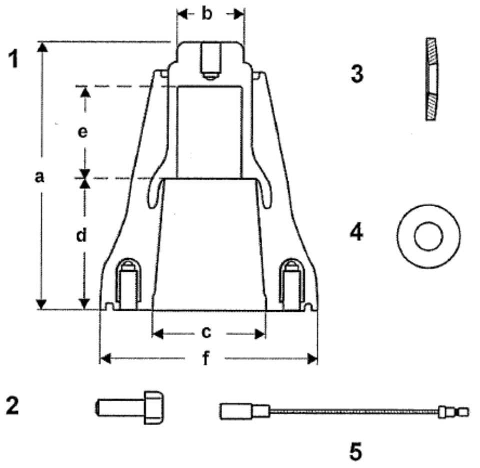
**Check to ensure that the kit you are going to use fits the cable.**

**Refer to the kit label and the title of the installation instruction.**

**Components or work steps may have been improved since you last installed this product.**

**Carefully read and follow the steps in the installation instruction.**

**Kit Contents RPIS**




**1** 3 x Plug in Socket

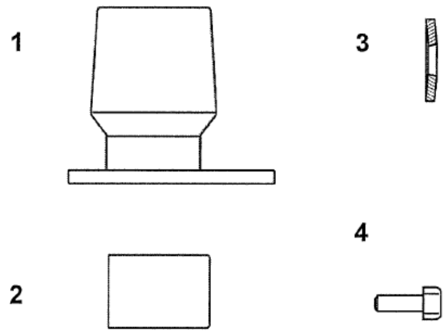
**2** Screw –M8x20
Size 2: 9pc
Size 3: 18 pc

**3** Conical spring washer M8
Size 2: 9pc
Size 3: 18 pc

**4** 3 x Sealing ring

**5** 3 x Test lead (optional)

**Kit Contents RPIC**




**1** 3 x Insulating plug

**2** 3 x Stopper

**3** 9 x Conical Spring washer M8

**4** 9 x Screw - M8x35

Prüfgegenstand entspricht der vorgelegten technischen Zeichnung

Unterschrift des Kunden    Unterschrift des Prüfers

**Table 1 - Main dimensions of plug in socket**

| Size | a (mm) | b (mm) | c (mm) | d (mm) | e (mm) | f (mm) |
|---|---|---|---|---|---|---|
| **2** | 140 | 50 | 69.5 | 69 | (48) | 136 |
| **3** | 217.5 | 58 | 92.5 | 97.5 | (90) | 163 |

The Information contained in these installation instructions is for use only by installers trained to make electrical power installations and is intended to describe the correct method of installation for this product. However, Tyco Electronics has no control over the field conditions which influence product installation.
It is the user's responsibility to determine the suitability of the installation method in the user's field conditions. Tyco Electronics' only obligations are those in Tyco Electronics' standard Conditions of Sale for this product and in no case will Tyco Electronics be liable for any other incidental, indirect or consequential damages arising from the use or misuse of the products.
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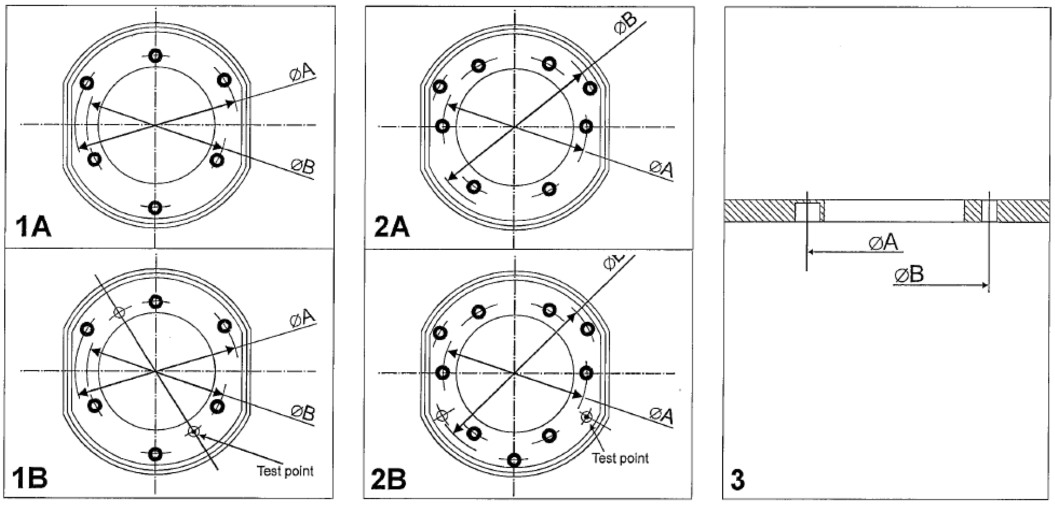
Figure 2.12: Installation instruction Plug-In Sockets

**Installation of Plug in Socket**




**Front view of plug in socket size 2**
**A** Product without test point
**B** Product with test point

**Front view of plug in socket size 3**
**A** Product without test point
**B** Product with test point

Side view of base plate.
**Note**: Base plate is integral component of switchgear.

| Dimensions interface type 2 | | |
|---|---|---|
| ø A | For bushing installation | ø 108 |
| ø B | For cable termination | ø 102 |

| Dimensions interface type 3 | | |
|---|---|---|
| ø A | For bushing installation | ø 113 |
| ø B | For cable termination | ø 130 |

Prüfgegenstand entspricht der vorgelegten technischen Zeichnung
Unterschrift des Herstellers
Unterschrift des Prüfers

Clean the outer and inner surface of the plug in socket as well as the outer surface of the base plate. With a clean cloth and solvent (alcohol). Do the same with the sealing ring.

Position the plug-in socket and the sealing ring at the predetermined location within the switchgear.
Align the screw holes of the plug in socket with the fixing holes of the base plate.

Tighten the hexagon screws alternately and firmly at a torque of 10 Nm. Follow the pattern as shown in detail **a** for size 2 or detail **b** for size 3.

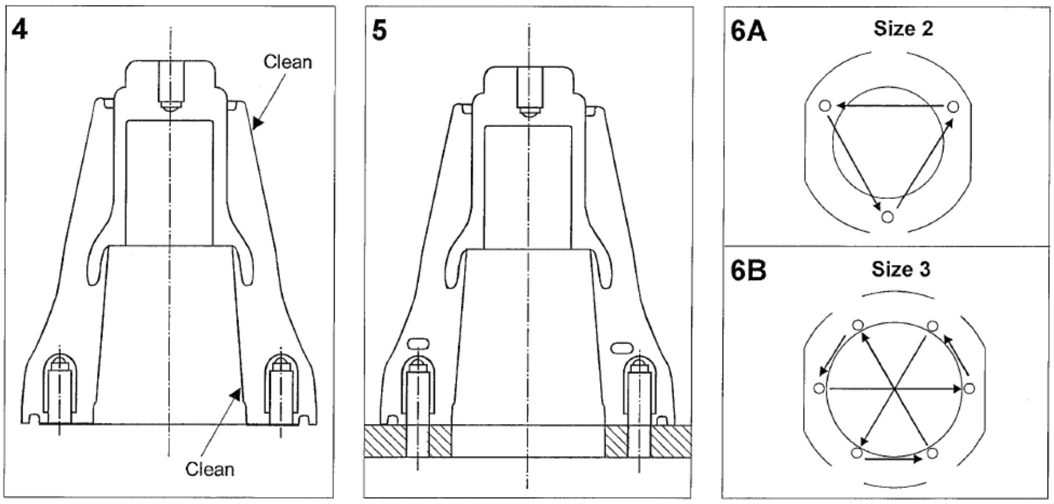



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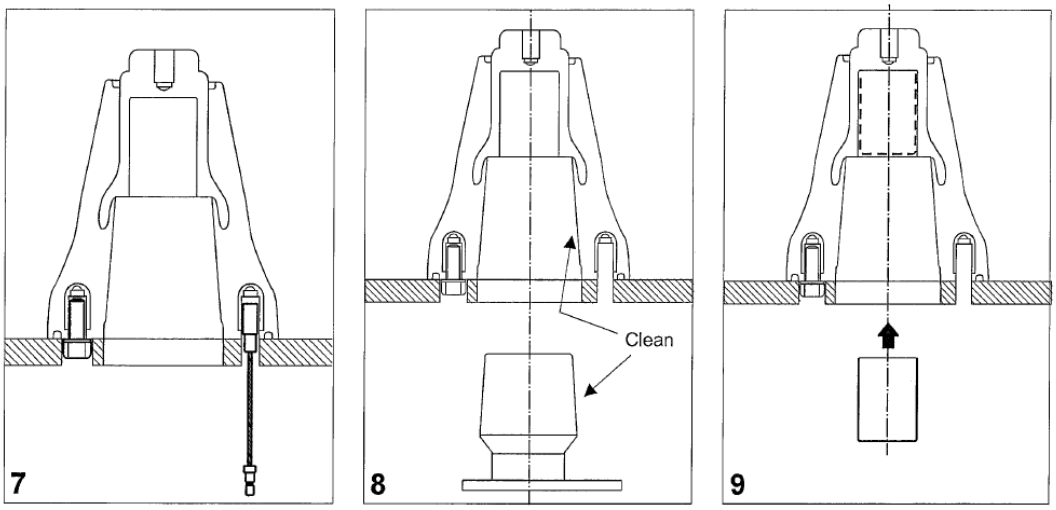
Figure 2.13: Installation instruction Plug-In Sockets

**Insertion of test point drawer** **Installation of Insulating cap**




Insert the optional test point drawer lead at the test point entry as shown in detail **b** of picture 1 for size 2 or picture 2 for size 3.

Clean the inner and outer surface of the bushing and lubricate the inner surface with assembly lubricant. Do the same with outer surface of the insulating plug.

Insert the cylindrical part (stopper) of the insulating cap in the connection area of the Socket.


Align the screw holes of the covering cap with the fixing holes of the base plate.
Tighten the hexagon screws alternately and firmly at a torque of 10 Nm.
**Installation of insulating cap completed.**

Place a venting string at one side of the conical inner surface.

Insert the insulating plug whilst removing gradually the venting string during insertion procedure.

**Please dispose of all waste according to environmental regulations.**

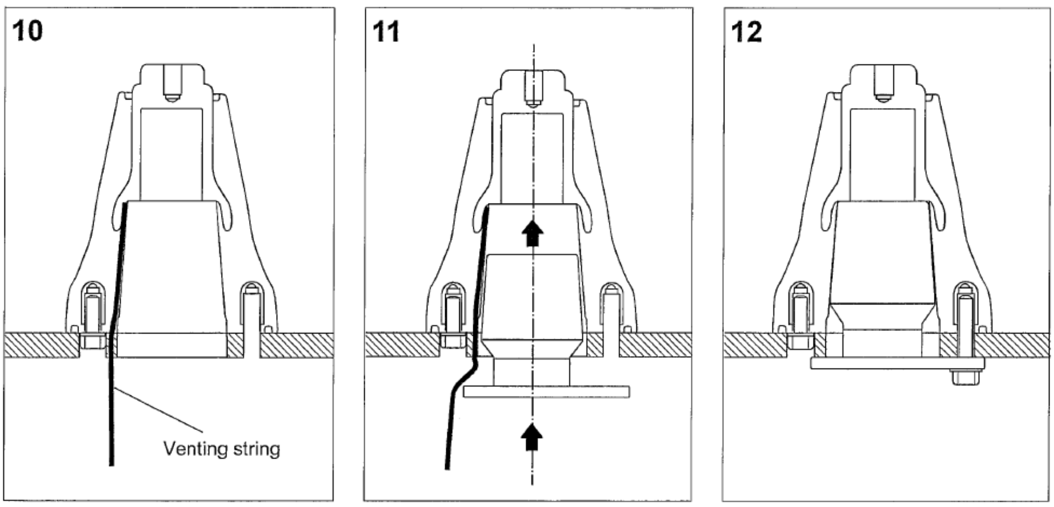



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Figure 2.14: Installation instruction Plug-In Sockets

Tests: Test volume, chronological order and requirements conform to CENELEC HD 629.1 S2 02/2006 test sequence D1 and D2, table 7 and table 10. The PD-test was performed at 2 $U_0$. The tests were carried out in accordance with the test methods described in IEC 61442 03/2005.

**Test sequence D1:**

*Pos.1.* *DC voltage withstand test*
$U = 6\ U_0 = -125$ kV ; t = 15 min

*Pos. 2.* *AC voltage withstand test*
$\hat{u}/\sqrt{2} = 4{,}5\ U_0 = 93{,}5$ kV; t = 5 min

*Pos. 3.* *Partial discharge test*
$\hat{u}/\sqrt{2} = 2{,}0\ U_0 = 42$ kV ; PD ≤ 10 pC

*Pos. 4.* *Impulse voltage withstand test at elevated temperature*
$\hat{u} = 200$ kV; positive and negative polarity each 10 impulses

*Pos. 5.* *Electrical heat cycling in air*
each loading cycle had a 5 hour heating period and a 3 hour no-load cooling period; test voltage: $\hat{u}/\sqrt{2} = 52$ kV
Number of cycles: 63

*Pos. 6.* *Electrical heat cycling in water*
each loading cycle had a 5 hour heating period and a 3 hour no-load cooling period; test voltage: $\hat{u}/\sqrt{2} = 52$ kV
Water height: 1,0 m Number of cycles: 63

*Pos. 10.* *Disconnection / Connection*
5 complete operations

*Pos. 11.* *Partial discharge test at ambient temperature and elevated temperature*
$\hat{u}/\sqrt{2} = 2{,}0\ U_0 = 42$ kV ; PD ≤ 10 pC

*Pos .12.* *Impulse voltage withstand test,*
$\hat{u} = 200$ kV; positive and negative polarity each 10 impulses

*Pos. 13.* *AC voltage withstand test*
$\hat{u}/\sqrt{2} = 2{,}5\ U_0 = 52$ kV; t = 15 min

*Pos. 16.* *Examination*

**Test sequence D2:**

*Pos.1.* *DC voltage withstand test*
$U = 6\ U_0 = -125$ kV ; t =15 min

*Pos. 2.* *AC voltage withstand test*
$\hat{u}/\sqrt{2} = 4{,}5\ U_0 = 93{,}5$ kV; t = 5 min

*Pos. 8.* *Thermal short circuit test, conductor*
$\theta_{Sc} = 250°C$; 2 stresses

*Pos. 9.* *Dynamic short circuit test*
$\hat{i} = 125$ kA; 1 stress

*Pos. 10.* *Disconnection / Connection*
5 complete operations

*Pos .12.* *Impulse voltage withstand test,*
$\hat{u} = 200$ kV; positive and negative polarity each 10 impulses

*Pos. 13.* *AC voltage withstand test*
$\hat{u}/\sqrt{2} = 2{,}5\ U_0 = 52$ kV; t = 15 min

*Pos. 16.* *Examination*

**Additional tests for smallest cable cross section compliance:**

*Pos.1.* *DC voltage withstand test*
$U = 6\ U_0 = -125$ kV ; t = 15 min

*Pos. 2.* *AC voltage withstand test*
$\hat{u}/\sqrt{2} = 4{,}5\ U_0 = 93{,}5$ kV; t = 5 min

*Pos. 3.* *Partial discharge test*
$\hat{u}/\sqrt{2} = 2{,}0\ U_0 = 42$ kV ; PD ≤ 10 pC

*Pos. 4.* *Impulse voltage withstand test at ambient temperature*
$\hat{u} = 200$ kV; positive and negative polarity each 10 impulses

*Pos. 5.* *Electrical heat cycling in air*
each loading cycle had a 5 hour heating period and a 3 hour no-load cooling period; test voltage: $\hat{u}/\sqrt{2} = 52$ kV
number of cycles: 10

*Pos. 6.* *Partial discharge test at ambient temperature and elevated temperature*
$\hat{u} / \sqrt{2} = 2{,}0 \ U_0 = 42$ kV ; PD ≤ 10 pC

*Pos. 7.* *AC voltage withstand test*
$\hat{u} / \sqrt{2} = 2{,}5 \ U_0 = 52$ kV; t = 15 min

*Pos. 8.* *Examination*

**Additional tests according table 7:**

*Pos. 20.* *Operating force test*
F < 900 N

*Pos. 21.* *Capacitive test point performance*

# 3 Mounting

Final assembling of the terminations was executed in the high-voltage laboratory of the IEH by technicians of TE Connectivity. For performing the high voltage tests, the sockets were mounted in aluminium alloy tubes (inner diameter = 400 mm, length = 500 mm), which have been filled with $SF_6$, pressure = 0,15 $MPa_{abs}$.

# 4 Test Setups

## 4.1 DC Voltage Withstand Test

The DC-voltage was generated according to Figure 4.1. The voltage measurement was carried out with an ohmic-capacitive divider (ratio 2000:1). The measurement uncertainty was 3%.

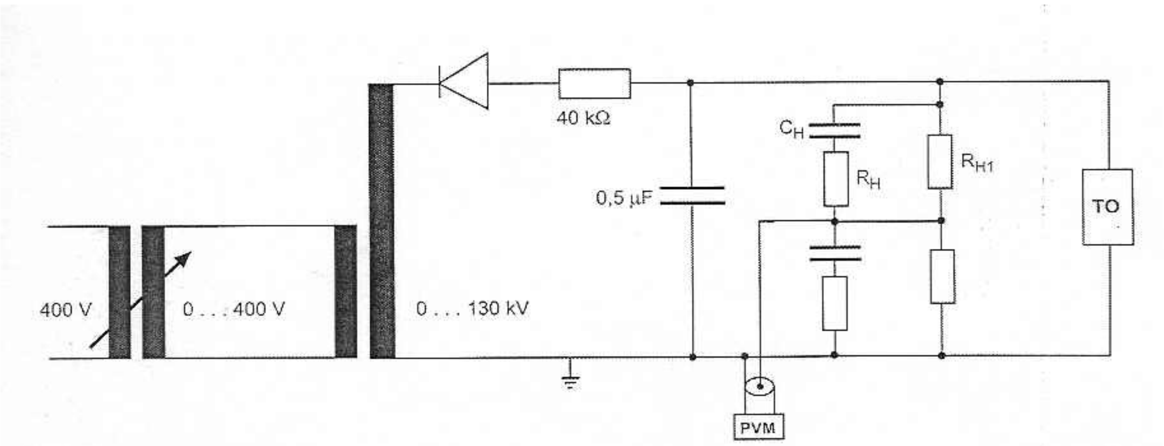


Figure 4.1: Scheme of DC voltage test circuit.
$R_H$ = 3,6 kΩ, $R_{H1}$ = 360 MΩ, $C_H$ = 180 pF, ratio 2.000:1, PVM: Peak Voltmeter, measurement uncertainty 3%
TO: Test object

## 4.2 AC Voltage Withstand Test

The test voltage was generated by an 60-kVA transformer. The voltage measurement was carried out with a capacitive divider ($C_H$ = 180 pF; ratio = 2.000) and a peak voltmeter calibration $\hat{u} / \sqrt{2}$ .

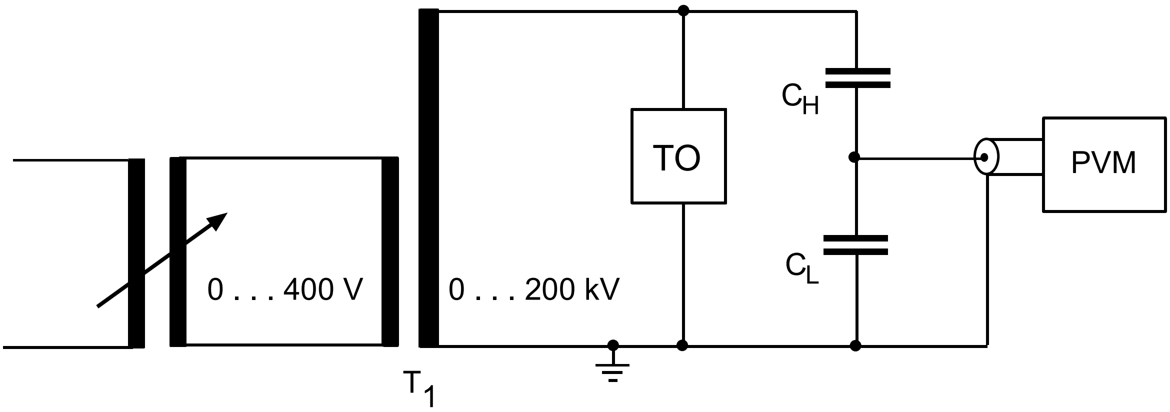


Figure 4.2: Scheme of AC test circuit
$T_1$ : transformer 400V / 200000V ; 60 kVA ; $u_K$ = 3,5 % ; 50 Hz
$C_H$: 180 pF ; ratio 2000:1 ; PVM : Peak-Voltmeter
TO: Test object; measurement uncertainty 3 %

## 4.3 Partial Discharge Test

The PD-measurement was performed with an analog bridge according to *Kreuger*, Figure 4.3. External PDs producing common mode signals at the detector are rejected by the differential amplifier. Internal PDs represent differential mode signals and are amplified. The background noise level at 42 $kV_{rms}$ was 0,7 pC.

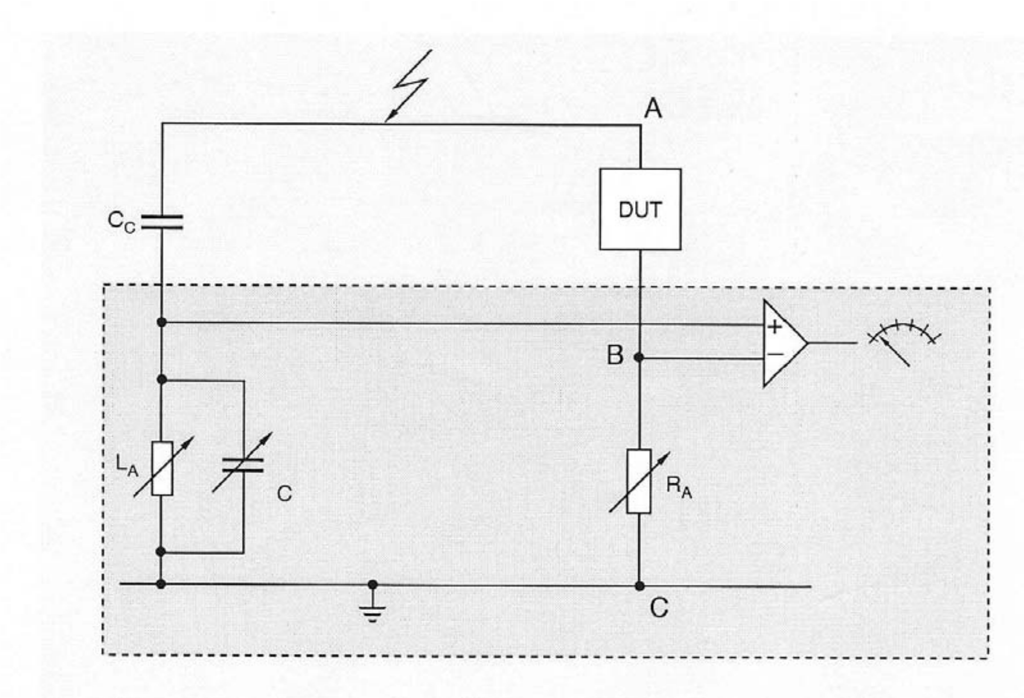


Figure 4.3: Scheme of PD test circuit
$C_C$: Coupling capacitor
DUT: Device under test

For balancing the bridge a calibrating impulse with $q_A$ = 100 pC is applied between the terminals A (high-voltage) and C (ground) and the amplifier output is minimized. A pulse between the terminals A and C corresponds to an external PD. For the calibration a PD pulse, $q_A$ = 10 pC, is applied between A and B. Subsequently, the amplifier output of the PD measuring unit is adapted to the applied pulse.

Starting from zero the AC-voltage was steadily raised up to 47,2 kV and kept constant for 60 s, then slowly reduced to 42 kV including PD-reading

## 4.4 Impulse Voltage Withstand Test

For impulse testing a two-stage Marx generator (Haefely) was used with a maximum cumulative charging voltage of U = 400 kV and a maximum impulse energy of $E_{max}$ = 20 kWs. At this test, the capacity of the energy storage capacitor was $C_S$ = 0.25 µF. The crest value of the impulse voltage was measured by a damped capacitive divider and a subsequent impulse peak voltmeter (Haefely). The front time and the time to half value were evaluated from the oscillographs.

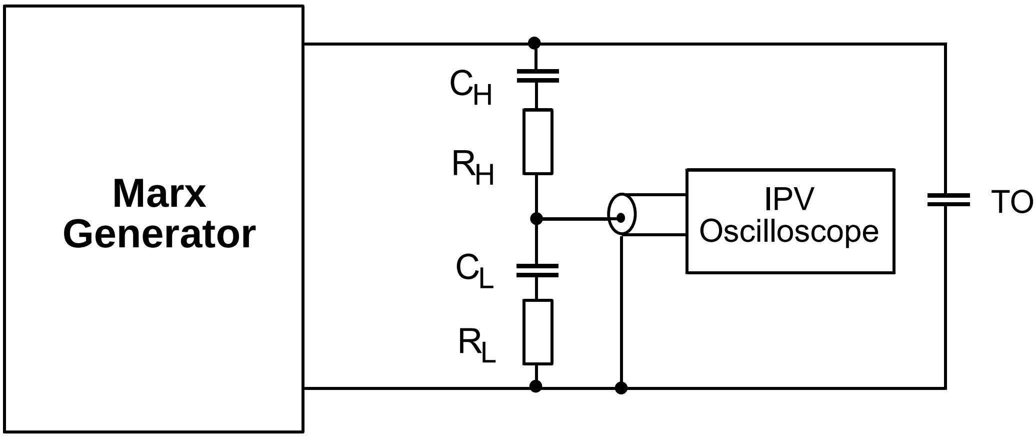


Figure 4.4: Scheme of impulse voltage test circuit
$C_H$: 1200 pF ; $R_H$ = 70 Ω ; ratio: 30780;
IPV: impulse-peak-voltmeter – measurement uncertainty 3%
Oscilloscope: Tektronix TDS 3044B – measurement uncertainty 2%

The waveform parameters were determined at reduced charging voltage.

Positive impulse: $T_1$ = 2,61 µs $T_2$ = 52,0 µs

Negative impulse: $T_1$ = 2,64 µs $T_2$ = 51,8 µs

## 4.5 Electrical Heat Cycling in Air

The test objects must be heated by a current which provides the permitted service temperature of the tested cable plus 5 K - 10 K, that means 95°C - 100°C, for XLPE-cable. The heating current I was determined with a dummy cable. The same cable as used for the test, with a length of 3 m, was drilled with a diameter of 0.8 mm up to the conductor. The temperature was measured with a thermo couple NiCr-Ni. The measurement uncertainty was ± 2K

The maximum possible heating current for the test sequence D1 (Al 630) was 1500 A. However, the steady state current during temperature stabilisation was much lower, app. 1250 A. Current inception was accomplished by a transformer ($U_1$ = 400 V; $U_2$ = 10 V) which used the cable as secondary winding. The current was regulated by a control unit and measured by a current transformer, 1500/5, and a digital multimeter. The measurement uncertainty was 1%.

The maximum possible heating current for the test for smallest cable cross section compliance (Cu95) was 600 A. However, the steady state current during temperature stabilisation was much lower, app. 480 A. Current inception was accomplished by a transformer ($U_1$ = 400 V; $U_2$ = 8 V) which used the cable as secondary winding. The current was regulated by a control unit and measured by a current transformer, 1500/5, and a digital multimeter. The measurement uncertainty was 1%.

## 4.6 Electrical Heat Cycling in Water

The test objects were placed in a pressure tank, which was filled with water, so that the test objects were completely covered with water. The conductivity of the water at 20°C was 63 mS/m. The top of the tank was then pressurized with air. The air pressure was 0,11 $MPa_{abs}$, corresponding to a water height of 1,0 m.

## 4.7 Thermal Short Circuit Current Test

According IEC 986 for Al with q = 630 mm$^2$ $I^2t = 5764 \cdot 10^6$ A$^2$s with $\theta_{sc}$ = 250°C and $\theta_i$ = 20°C. That means $I_K$(1s) = 75,92 kA. The short-circuit current during test was $I_K$ = 34,93 kA, resulting in a short-circuit duration of $t_K$ = 4,75 s. The test object was tested with two thermal short-circuit currents. Between two tests the specimen cooled down to ambient temperature. The current was measured with Rogowski current transducer, type CWT600B (sensitivity 50mV / kA) connected to a digital storage oscilloscope (Tektronix DPO 4034). The measurement uncertainty was 2%.

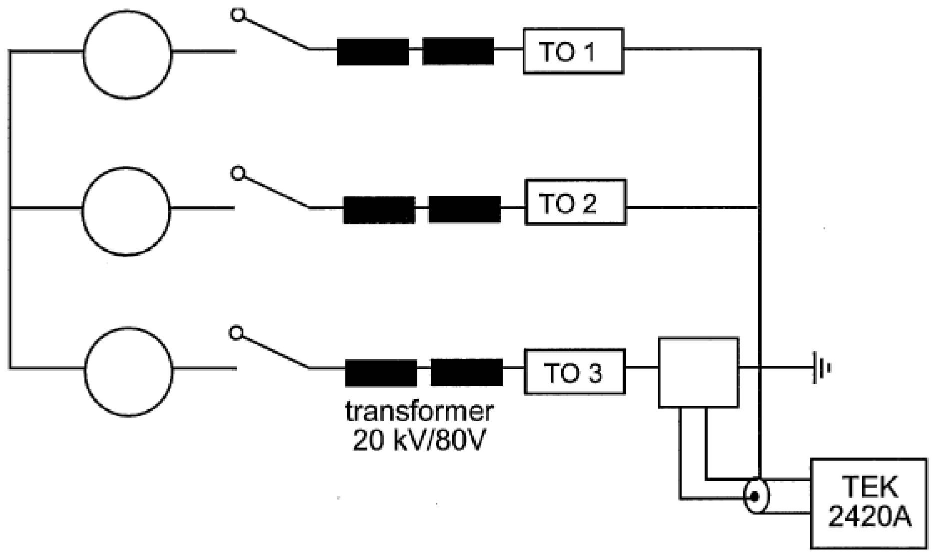


Figure 4.7.1: Scheme of thermal short-circuit current test.

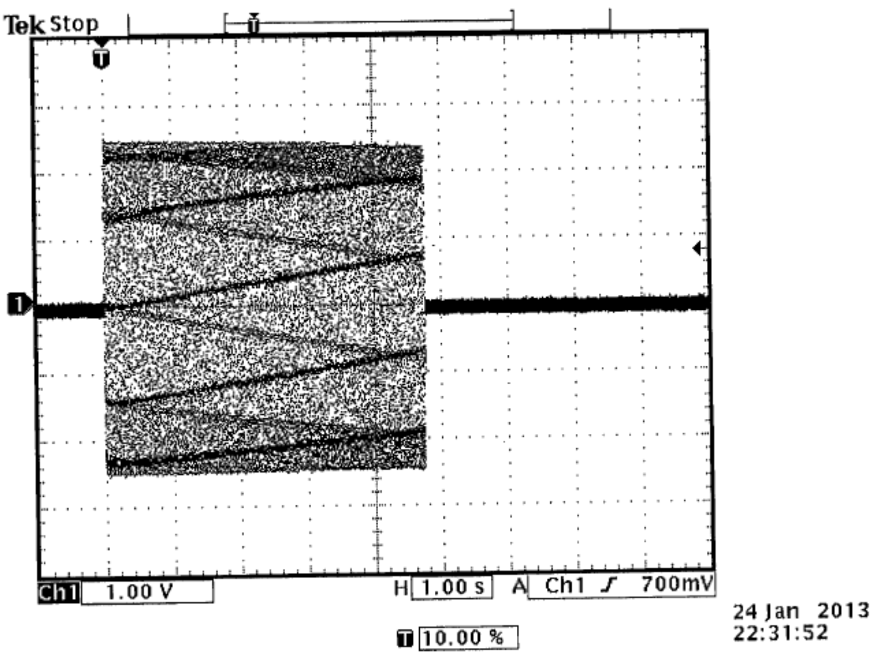


Figure 4.7.2: Short circuit current
Hor: 1 s/Div; Vert: 20 kA/DIV

## 4.8 Dynamic Short Circuit Current Test

For dynamic short circuit current testing, three separable connectors were mounted in bushings. The bushings were mounted on a steel plate. On the other side of the bushings, a short circuit bar was mounted. The other end of the cables was connected to the short circuit generator. The whole setup was fixed in an aluminium rack. Figure 4.8 shows the schematic of the dynamic short circuit current test.

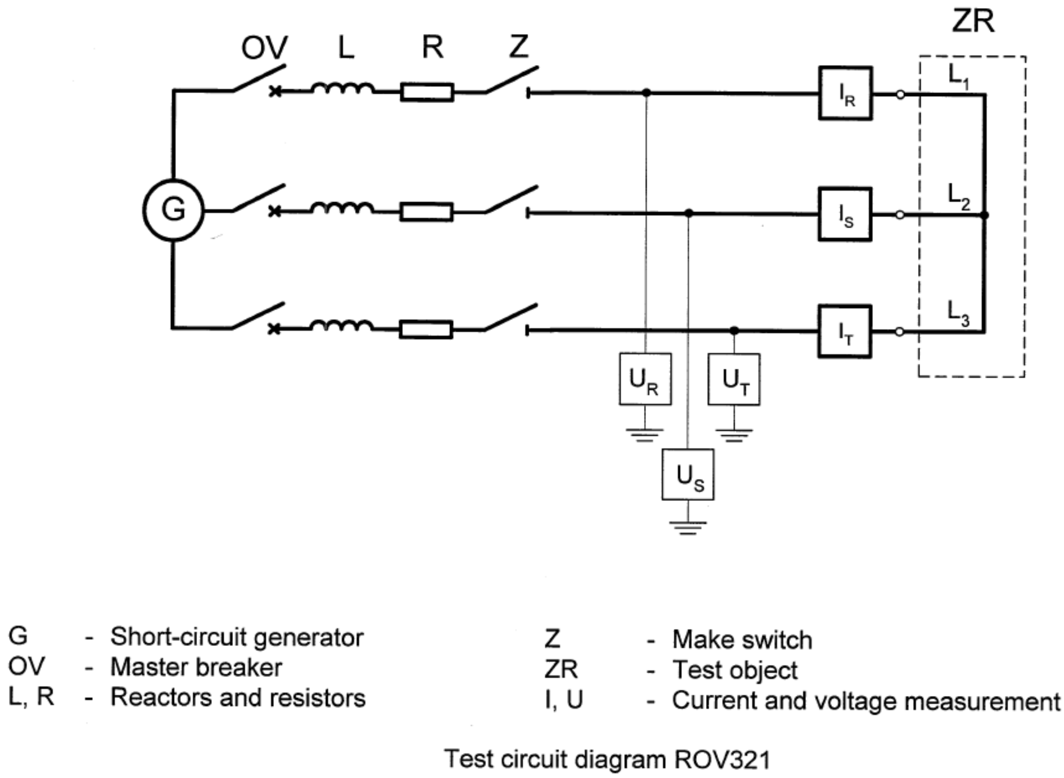


Figure 4.8: Dynamic short circuit current test

## 4.9 Operating Force Test

For measuring the operating force, one separable connector with app. 1m of cable was mounted on a rack. A pulling device consisting of a spring and load cell was also mounted on the rack, allowing operation along the axis of the separable connector and mating bushing interface. The complete rack was placed in a climate chamber. The temperature was lowered to (-20 ± 2)°C and kept constant for at least 12h. Thereafter, the connector was pulled out of the socket and the operation force was measured.

## 4.10 Capacitive Test Point Performance

One separable connector was installed on a cable and the outer screen was earthed. The connector was not mounted in a bushing. The cable length was as short as possible, app 0,5m.
The capacitances were measured with a bridge.

# 5 Results

## 5.1 Test Sequence D1

### 5.1.1 DC Voltage Withstand Test

This test was carried out as described in 4.

Test date: 12.05.2014

Test voltage: U = - 125 kV ; t = 15 min

With each test object neither flashover nor breakdown occurred at the test objects during the DC voltage withstand test.

***The test was passed successfully.***

### 5.1.2 AC Voltage Withstand Test

This test was carried out as described in 4.

Test date: 12.05.2014

Test voltage: $\hat{u}/\sqrt{2}$ = 93,5 kV , t = 5 min

With each test object neither flashover nor breakdown occurred at the test objects during the AC voltage withstand test.

***The test was passed successfully.***

### 5.1.3 Partial Discharge Test

This test was carried out as described in 4.

Test date: 12.05.2014

Voltage: $\hat{u}/\sqrt{2}$ = 47,2 kV , t = 60 s thereafter
$\hat{u}/\sqrt{2}$ = 42 kV with pd reading

PD magnitude (42 kV): < 10 pC

***The test was passed successfully.***

### 5.1.4 Lightning Impulse Voltage Withstand Test at elevated Temperature

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 13.05.2014 |
| Test voltage: | û = 200 kV |
| Maximum heating current: | I = 1500 A regulated; t = 5 h |
| Impulse: | 1-5 / 50 µs |
| Number of tests: | 10 positive polarity, 10 negative polarity |

Neither flashover nor breakdown occurred at the test objects during all lightning impulse voltage withstand tests.

***The test was passed successfully.***

### 5.1.5 Electrical Heat Cycling in Air

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 14.05 – 04.06.2014 |
| Test voltage: | $\hat{u} / \sqrt{2}$ = 52 kV |
| Maximum heating current: | I = 1500 A regulated |
| Cycle: | 5 h heating; 3 h cooling |
| Number of cycles: | 63 |

Neither flashover nor breakdown occurred.

***The test was passed successfully.***

### 5.1.6 Electrical Heat Cycling in Water

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 06.06 – 28.06.2014 |
| Test voltage: | $\hat{u}/\sqrt{2}$ = 52 kV |
| Maximum heating current: | I = 1500 A regulated |
| Height of water: | 1 m above the test object |
| Cycle: | 5 h heating; 3 h cooling |
| Number of cycles: | 63 |

Neither flashover nor breakdown occurred.

***The test was passed successfully.***

### 5.1.7 Disconnection / Connection

| | |
|---|---|
| Test date: | 30.06.2014 |
| No. of operations: | 5 |

After 5 complete operations, there was no visible damage to the contacts.

***The test was passed successfully.***

### 5.1.8 Partial Discharge Test

#### 5.1.8.1 Partial Discharge Test at ambient Temperature

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 01.07.2014 |
| Voltage: | $\hat{u}/\sqrt{2}$ = 47,2 kV , t = 60 s thereafter<br>$\hat{u}/\sqrt{2}$ = 42 kV with pd reading |
| PD magnitude (42 kV): | < 10 pC |

***The test was passed successfully.***

#### 5.1.8.2 Partial Discharge Test at elevated Temperature

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 02.07.2014 |
| Maximum heating current: | I = 1500 A regulated, t = 5 h |
| Voltage: | $\hat{u}/\sqrt{2}$ = 47,2 kV , t = 60 s thereafter<br>$\hat{u}/\sqrt{2}$ = 42 kV with pd reading |
| PD magnitude (42 kV): | < 10 pC |

***The test was passed successfully.***

### 5.1.9 Impulse Voltage Withstand Test

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 02.07.2014 |
| Test voltage: | $\hat{u}$ = 200 kV |
| Impulse: | 1-5 / 50 µs |
| Number of tests: | 10 positive polarity, 10 negative polarity |

Neither flashover nor breakdown occurred at the test objects during all lightning impulse voltage withstand tests.

***The test was passed successfully.***

### 5.1.10 AC Voltage Withstand Test

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 02.07.2014 |
| Test voltage: | $\hat{u}/\sqrt{2}$ = 52 kV , t = 15 min |

With each test object neither flashover nor breakdown occurred at the test objects during the AC voltage withstand test.

***The test was passed successfully.***

### 5.1.11 Accessory Examination (For information only)

Test date: 03.07.2014

On completion of the electrical tests, the accessories were examined.

There was no cracking in the filling media, tape or tube components. There was no moisture path bridging a primary seal. There was no corrosion, no tracking and no erosion. There was no leakage of any insulating material.

## 5.2 Test Sequence D2

### 5.2.1 DC Voltage Withstand Test

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 15.12.2012 |
| Test voltage: | U = - 125 kV ; t = 15 min |

With each test object neither flashover nor breakdown occurred at the test objects during the DC voltage withstand test.

***The test was passed successfully.***

### 5.2.2 AC Voltage Withstand Test

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 15.12.2012 |
| Test voltage: | $\hat{u} / \sqrt{2}$ = 93,5 kV , t = 5 min |

With each test object neither flashover nor breakdown occurred at the test objects during the AC voltage withstand test.

***The test was passed successfully.***

### 5.2.3 Thermal Short Circuit Current Test, Conductor

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 24.01. – 25.01.2013 |
| Current: | $I_K$ = 34,93 kA |
| | $t_K$ = 4,75 s |
| Number of stresses: | 2 |
| Time between stresses: | 2h |

***The test was passed successfully.***

## 5.2.4 Dynamic Short Circuit Current Test

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 29.01.2013 |
| Current: | Î = 126,4 kA |
| | $t_K$ = 40 ms |
| Number of stresses: | 1 |

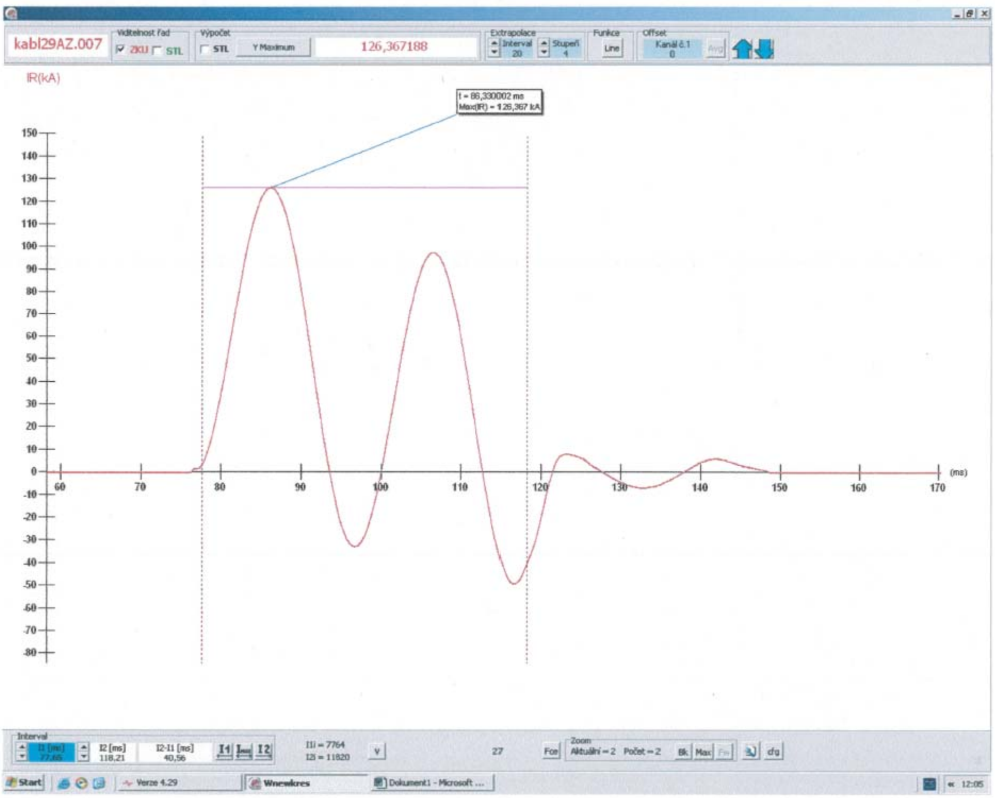


Figure 5.2.4: Dynamic short circuit current

***The test was passed successfully.***

## 5.2.5 Disconnection / Connection

| | |
|---|---|
| Test date: | 28.02.2013 |
| No. of operations: | 5 |

After 5 complete operations, there was no visible damage to the contacts.

***The test was passed successfully.***

### 5.2.6 Impulse Voltage Withstand Test

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 28.02.2013 |
| Test voltage | $\hat{u}$ = 200 kV |
| Impulse: | 1-5 / 50 µs |
| number of tests: | 10 positive polarity, 10 negative polarity |

Neither flashover nor breakdown occurred at the test objects during all lightning impulse voltage withstand tests.

***The test was passed successfully.***

### 5.2.7 AC Voltage Withstand Test

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 28.02.2013 |
| Test voltage: | $\hat{u}/\sqrt{2}$ = 52 kV , t = 15 min |

With each test object neither flashover nor breakdown occurred at the test objects during the AC voltage withstand test.

***The test was passed successfully.***

### 5.2.8 Accessory Examination (For information only)

| | |
|---|---|
| Test date: | 28.02.2013 |

On completion of the electrical tests, the accessories were examined.

There was no cracking in the filling media, tape or tube components. There was no moisture path bridging a primary seal. There was no corrosion, no tracking and no erosion. There was no leakage of any insulating material.

## 5.3 Additional tests for smallest cable cross section compliance

### 5.3.1 DC Voltage Withstand Test

This test was carried out as described in 4.

Test date: 29.08.2012

Test voltage: U = - 125 kV ; t = 15 min

With each test object neither flashover nor breakdown occurred at the test objects during the DC voltage withstand test.

***The test was passed successfully.***

### 5.3.2 AC Voltage Withstand Test

This test was carried out as described in 4.

Test date: 29.08.2012

Test voltage: $\hat{u}/\sqrt{2}$ = 93,5 kV , t = 5 min

With each test object neither flashover nor breakdown occurred at the test objects during the AC voltage withstand test.

***The test was passed successfully.***

### 5.3.3 Partial Discharge Test

This test was carried out as described in 4.

Test date: 30.08.2012

Voltage: $\hat{u}/\sqrt{2}$ = 47,2 kV , t = 60 s thereafter
$\hat{u}/\sqrt{2}$ = 42 kV with pd reading

PD magnitude (42 kV): < 10 pC

***The test was passed successfully.***

### 5.3.4 Lightning Impulse Voltage Withstand Test

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 30.08.2012 |
| Test voltage: | û = 200 kV |
| Impulse: | 1-5 / 50 µs |
| Number of tests: | 10 positive polarity, 10 negative polarity |

Neither flashover nor breakdown occurred at the test objects during all lightning impulse voltage withstand tests.

***The test was passed successfully.***

### 5.3.5 Electrical Heat Cycling in Air

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 10.09.2012 – 14.09.2012 |
| Test voltage: | $\hat{u}/\sqrt{2}$ = 52 kV |
| Maximum heating current: | I = 600 A regulated |
| Cycle: | 5 h heating; 3 h cooling |
| Number of cycles: | 10 |

Neither flashover nor breakdown occurred.

***The test was passed successfully.***

### 5.3.6 Partial Discharge Test

#### 5.3.6.1 Partial Discharge Test at ambient Temperature

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 31.10.2012 |
| Voltage: | $\hat{u}/\sqrt{2}$ = 47,2 kV , t = 60 s thereafter<br>$\hat{u}/\sqrt{2}$ = 42 kV with pd reading |

PD magnitude (42 kV): < 10 pC

***The test was passed successfully.***

#### 5.3.6.2 Partial Discharge Test at elevated Temperature

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 31.10.2012 |
| Maximum heating current: | I = 600 A regulated, t = 5 h |
| Voltage: | $\hat{u}/\sqrt{2}$ = 47,2 kV , t = 60 s thereafter<br>$\hat{u}/\sqrt{2}$ = 42 kV with pd reading |
| PD magnitude (42 kV): | < 10 pC |

***The test was passed successfully.***

### 5.3.7 AC Voltage Withstand Test

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 31.10.2012 |
| Test voltage: | $\hat{u}/\sqrt{2}$ = 52 kV , t = 15 min |

With each test object neither flashover nor breakdown occurred at the test objects during the AC voltage withstand test.

***The test was passed successfully.***

### 5.3.8 Accessory Examination (For information only)

Test date: 31.10.2012

On completion of the electrical tests, the accessories were examined.

There was no cracking in the filling media, tape or tube components. There was no moisture path bridging a primary seal. There was no corrosion, no tracking and no erosion. There was no leakage of any insulating material.

## 5.4 Additional Tests

### 5.4.1 Operation Force Test

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 04.03.2013 |
| Temperature: | - 20,9°C |
| Force: | 531 N |

Requirement: $F < 900$ N

**The test was passed successfully.**

### 5.4.2 Capacitive Test Point Performance

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 04.03.2013 |
| Capacitance $C_{tc}$: | C = 60,01 pF |
| Capacitance $C_{te}$: | C = 71,37 pF |
| Ratio: | $C_{te}/ C_{tc} = 1,18$ |

Requirements: $C_{tc} > 1$ pF
$C_{te}/ C_{tc} < 12$

***The test was passed successfully.***

# 6 Conclusion

The Plug-In Termination type RPIT 631x for 20,8/36/42kV, manufacturer TE Connectivity passed all tests described in clause 2 successfully. The test object fulfilled the requirements according CENELEC HD 629.1 S2 02/2006, Table 7, test sequences D1, D2, Pos 20, Pos 21 and the tests according table 10.

Karlsruhe, 03.07.2014

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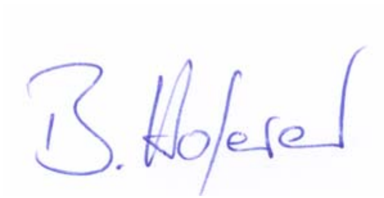

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