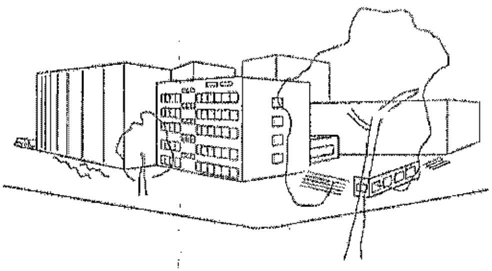
Bereich Hochspannungsprüftechnik
Institut für Elektroenergiesysteme und Hochspannungstechnik



Universität Fridericiana (TH) Karlsruhe
76128 Karlsruhe - Kaiserstraße 12
Telefon (0721) 608 2520 Telefax (0721) 69 52 24

## Test Report No 2010-116

# Type Test of

# Outdoor Terminations Type

# CONTRAX CAE-F 24 kV

Customer: Cellpack GmbH
Carl-Zeiss-Str.20

79761 Waldshut-Tiengen

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

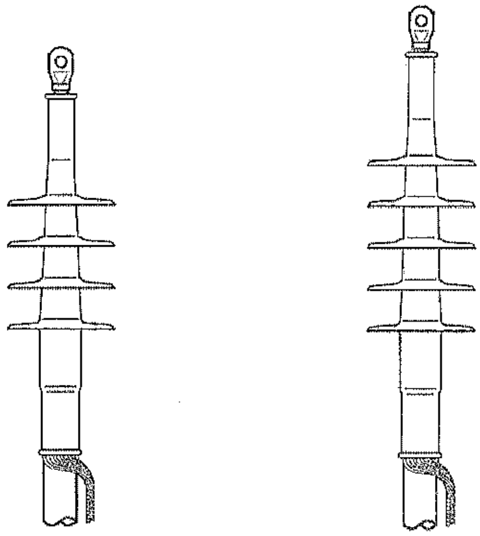
# 1 Purpose of Test

*4 outdoor terminations* for $V_0$ / $V_n$ / $V_m$ = 12,7 / 22 / 24 kV were subjected to a type test corresponding to DIN VDE 0278-629-1: 2009-07 table 4 test sequence A1.

# 2 Miscellaneous Data

| | | |
|---|---|---|
| Test object: | – | *4 outdoor terminations type CONTRAX CAE-F 24 kV*<br>$V_m$ = 24 kV,<br>Installation instruction: 202188/0506/3/6, Figure 2.1 - 2.6<br>Packing list 199196, Figure 2.7<br><br>Type of the cable: The test object was mounted on a single-wire XLPE-cable, type:N2XSY 1x185RM/25 12/20kV, Figure 2.8<br>Cable length termination - termination: 5 m |
| Manufacturer: | | Cellpack GmbH<br>Carl-Zeiss-Str. 20<br>79761 Waldshut-Tiengen |
| Place of test: | | *Institute of Electric Energy Systems and High Voltage Technology* – University of Karlsruhe<br>Kaiserstraße 12 – 76128 Karlsruhe |
| Testing dates: | | Delivery: 23.09.2010<br>Mounting: 23.09.2010<br>Test period: 23.09.2010 – 03.01.2011 |
| Atmospheric conditions: | | Temperature: 19°C – 24°C<br>Air pressure: 980 - 1025 mbar<br>rel. humidity: 35 % – 60 % |
| Representatives: | | *Customer´s representatives*:<br>Dipl.-Ing. C. Reuber<br>*Representatives responsible for the tests*:<br>Dr.-Ing. R. Badent<br>Dr.-Ing. B. Hoferer<br>Mr. O. Müller |

**Medium Voltage** | **CONTRAX**



**CAE-F ...**

**$U_o/U(U_m)$ 6/10(12) kV – 19/33(36) kV**

**Working Instruction**

**CONTRAX single-core outdoor termination**
**for all single-core polymeric cables**
**up to 36 kV**

**202188/0506/3/6**

Prüfgegenstand entspricht der vorgelegten technischen Zeichnung

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CELLPACK
Electrical Products

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Figure 2.1: Installation instruction

**General remarks**

- Check the range and size of the cable and the cable accessories.
- Check the content of the kit as per packing list.
- Thoroughly read the working instructions.

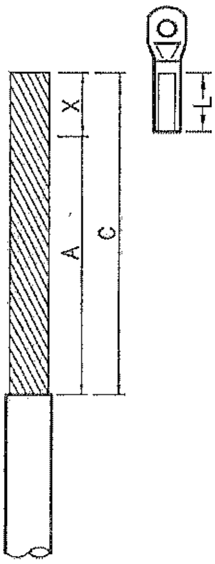
Installation must only be executed by competent personnel.
The manufacturer accepts no liability for breakdowns resulting from incorrect installation.

**CONTRAX single-core outdoor termination type CAE-F ...**

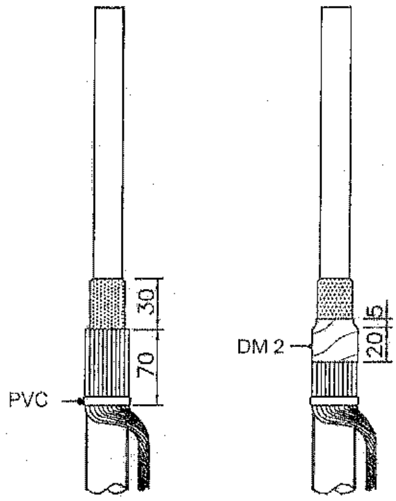
| Voltage | **Wire screen** | | **Tape screen** | |
|---|---|---|---|---|
| | Dimension A | C | Dimension A | C |
| (kV) | mm | mm | mm | mm |
| 6/10(12)kV – 6,35/11(12)kV | 220 | 270 | 230 | 280 |
| 8,7/15(17,5)kV | 220 | 270 | 230 | 280 |
| 12/20(24)kV – 12,7/22(24)kV | 220 | 270 | 230 | 280 |
| 18/30(36)kV – 19733(36)kV | 305 | 380 | 315 | 390 |

**Cable with wire screen:**

1a)




2a)




- Adjust cable to the plant.
- Cut back cable sheath by dim. **A+X.**
  X = length of cable lug shaft (**L**)
  + room to move for crimping:
  5 mm for copper-conductor or
  10 mm for aluminium-conductor.
  **ATTENTION! If X < 50 mm then dimension C !**
- Clean cable sheath.

- Bend back the screened wires and fix them on the cable sheath.
- Carefully remove the outer semi-conductive layer except for **30 mm** (mind a clean cut back edge).
- Wrap sealant tape DM2 onto the wire screen and cover 5 mm of the conductive layer as shown in the drawing.

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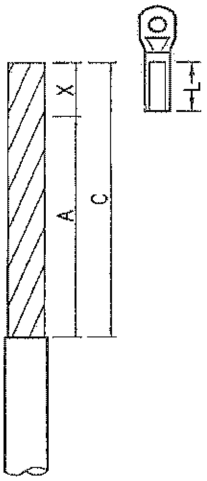
Figure 2.2: Installation instruction

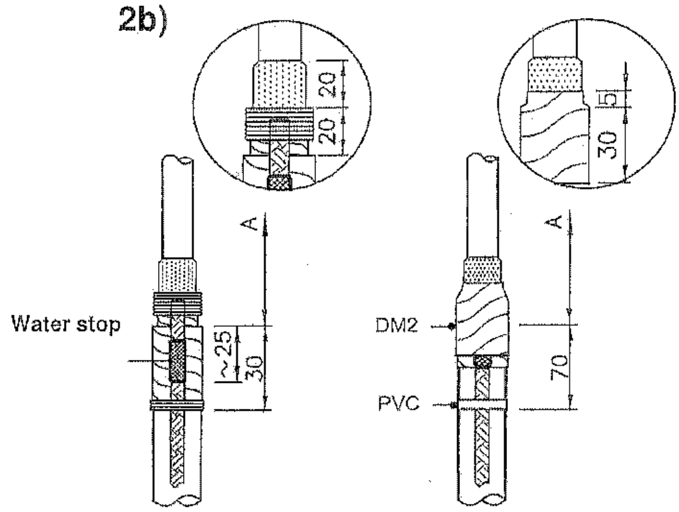
**Cable with tape screen:**

**1b)**



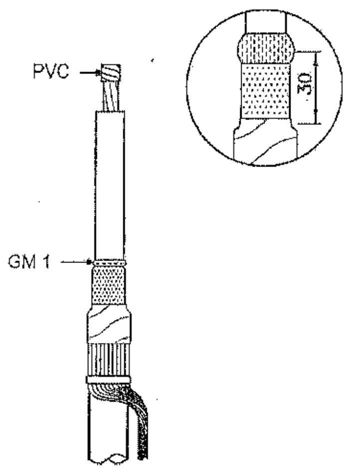

- Adjust cable to the plant.
- Remove cable sheath by dim. **A+X.**
  X = length of cable lug shaft (**L**)
  + room to move for crimping:
  5 mm for copper-conductor or
  10 mm for aluminium-conductor.
  **ATTENTION! If X < 50 mm then dimension C !**
- Clean cable sheath.
- Wrap one layer of sealing tape DM 2 onto the cable sheath.

**2b)**




- Cut back tape screen except for **20 mm.**
- Carefully remove the outer semi-conductive layer except for **20 mm** (mind a clean cut back edge).
- Contact the earthing conductor on the tape screen by means of pressure spring/tinned wire.
- Wrap sealant tape DM2 onto the wire screen and cover 5 mm of the conductive layer as shown in the drawing.

**3)**




- Remove conductor insulation by dimension **X.**
- At the end of the conductor affix a protective wrap of PVC tape.
- Clean insulation with a cleaning cloth.
- For cables with removable semi-conductive layer, apply lubricant and filling material GM1 at the end of the semi-conductive layer.

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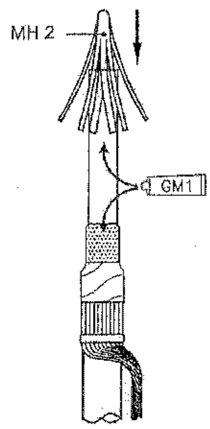
**4)**




- Moisten conductor insulation and semi-conductive layer with lubricant and filling material GM1 (according to the drawing).
- Place the applicator MH2 onto the conductor.

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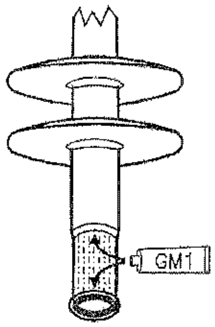
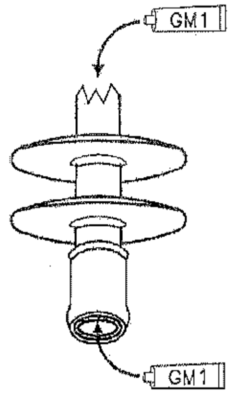
Figure 2.3: Installation instruction

5)



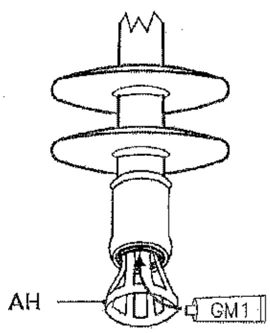

- Grease the lower part of the termination externally with lubricant and filling material GM 1 (evenly spread with your finger).

6)



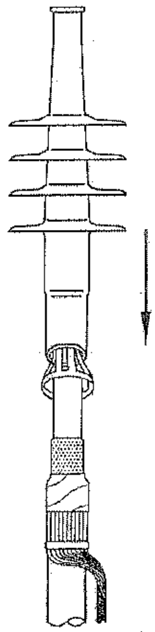

- Bend back the lower part (see drawing).
- Generously moisten the termination inside with lubricant and filling material GM1 (evenly spread with your finger).

7)




- Insert the applicator AH into the termination.

8)



- Slip-on the termination body onto the cable end.
- The internal field control element must lie against the wire or tape screen, respectively.

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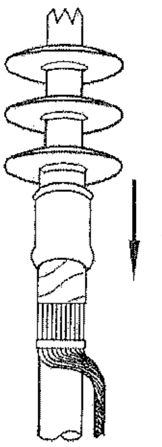
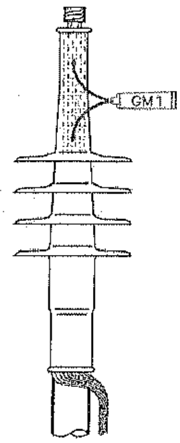
Figure 2.4: Installation instruction

9)



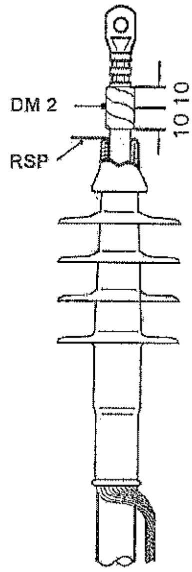
- Remove the applicator AH, pull out the tongues individually.
- Remove the applicator MH2.
- Check for correct fit of the termination, correct it, if necessary.
- Remove excess lubricant.
- Slip back the bent back area.

10)



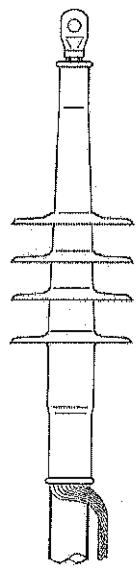

- Moisten the upper part of the termination according to the drawing with lubricant and filling material GM1.

11)




- Bend back the upper part and secure it by means of the angle profile RSP.
- Remove the protective layers at the conductor end.
  Install the cable lugs according to the manufacturer's instructions, if necessary, remove fins, and clean.
- Wrap sealing tape DM2 according to the drawing, cover 10 mm of the Insulation and 10 mm of the cable lug.

12)



- Remove the angle profile RSP.
- Slide back the upper part of the of the termination.

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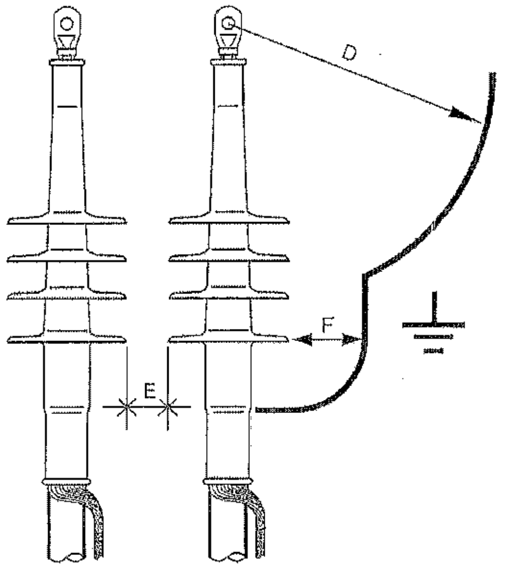
Figure 2.5: Installation instruction

**Minimum clearance:**




| Voltage<br><br><br>(kV) | D<br>Air clearance<br>phase/earth | F<br>Distance<br>sheds/earth<br>(mm) | E<br>Distance between<br>the sheds<br>(mm) |
|---|---|---|---|
| 6/10(12) – 6.35/11(12) | according to | 15 | 10 |
| 8.7/15(17.5) | local | 20 | 15 |
| 12/20(24) – 12.7/22(24) | regulations | 25 | 20 |
| 18/30(36) – 19/33(36) | | 35 | 25 |

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Figure 2.6: Installation instruction

| Packliste 199 196 | Lista de carga | CELLPACK |
|---|---|---|
| Packing list | Elenco da imballaggio | |
| Liste d'emballage | Liste de carga | Electrical Products |

| MEDIUM VOLTAGE | CONTRAX |
|---|---|

**Einleiter-Endverschluß Freiluft**
**Single-core termination outdoor**
**Extrémité unipolaire extérieur**
**Terminal unipolar exterior**
**Terminale unipolare externo**
**Fecho unipolar exterior**

Type **CAE-F 24kV 120-400**
120 – 400 mm²
12/20(24) kV – 12,7/22(24) kV
Isolation ∅ min. 23,1 mm

**Version: 03**

| Pos | | Cont. | Dimension | | | |
|---|---|---|---|---|---|---|
| 1 | | 3 | CAE-<br>3/4S | Endverschluß<br>Termination | Extrémité<br>Terminal | Terminale<br>Fecho |
| 2 | | 9 | DM 2<br>250x25x0,8 | Dichtband rot<br>Sealing tape red | Ruban d'étanchéité rouge<br>Cinta de estanqueidad rojo | Nastro sigillante rosso<br>Fita vedante vermelho |
| 3 | | 3 | GM 1 | Gleit- und Füllmittel<br>Lubrificant and filler | Lubrificant<br>Lubrificante | Lubrificante<br>Deslizante |
| 4 | | 1 | AH2 | Aufschiebehilfe<br>Applicator | Aide de pose<br>Ayuda de montaje | Ausilio d'applicazione<br>Dispositivo auxiliar |
| 5 | | 1 | MH2 | Aufschiebehilfe<br>Applicator | Aide de pose<br>Ayuda de montaje | Ausilio d'applicazione<br>Dispositivo auxiliar |
| 6 | | 3 | RSP | Rollsperre<br>Plastic collar | Arrêt à dérouler<br>Collar plástico | Blocaggio mobile<br>Colar plástico |
| 7 | | 1 | N°028<br>5 m | Isolierband<br>Insulation tape | Ruban isolant<br>Cinta aislante | Nastro isolante<br>Fita isoladora |
| 8 | | 1 | 1 Paar | Handschuhe<br>Gloves | Glands<br>Guante | Guanti |
| 9 | | 1 | SL<br>25x300 | Schmirgelleinen<br>Emery cloth | Toile d'émeri<br>Cinta de esmeril | Smerigliata<br>Tira de Lixa |
| 10 | | 3 | RT | Reinigungstuch<br>Cleaning tissue | Papier impregné de solvant<br>Tela de limpieza | Fazzolettino detergebte<br>Toalhete de limpeza |
| 11 | | 1 | MA-CAE-F<br>D, E, F, ES | Montageanleitung<br>Installation instruction | Instructions de montage<br>Instrucciones de montaje | Istruzioni di montaggio<br>Instruções de montagem |
| 12 | | | | | | |
| 13 | | | | | | |
| 14 | | | | | | |
| 15 | | | | | | |
| 16 | | | | | | |
| 17 | | | | | | |

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Figure 2.7: Packing list

DIN VDE 0278-629-1 (VDE 0278-629-1):2009-07
HD 629.1 S2:2006 + A1:2008

# Anhang A
(informativ)

## Dokumentation der Prüfkabel (siehe 5.1.1 und 8.2)

Nennspannung $U_0/U$ ($U_m$): 12/20(24) kV

| | | | |
|---|---|---|---|
| Kabelaufbau: | [X] 1-Leiter | [ ] 3-Leiter | [X] einzeln geschirmt |
| | | | [ ] gemeinsam geschirmt |
| Leiteraufbau: | [ ] Al | [X] Cu | |
| | [X] mehrdrähtig | [ ] massiv | |
| | [X] Rundleiter | [ ] Sektorleiter | |
| | [ ] 120 mm² | [ ] 150 mm² | [X] 185 mm² |
| | anderer Querschnitt: | mm² | |
| Kabelisolation: | [X] VPE | | |
| | [ ] EPR | [ ] HEPR | |
| Äußere Leitschicht: | [X] fest extrudiert | [ ] abziehbar | |
| Metallischer Schirm: | [X] Drähte | [ ] Bänder | [ ] extrudiert |
| Armierung: | [ ] Draht | [ ] Band | |
| Außenmantel: | [X] PVC | [ ] PE (Typ ist anzugeben) | |
| Wassersperre, wenn vorhanden: | [ ] im Leiter | [ ] unter Außenmantel | |

Durchmesser:
- Leiter 16,2 mm
- Isolierung 28,3 mm
- äußere Leitschicht 29,1 mm
- Außenmantel 36,5 mm

Kabelbezeichnung: TF Kabel 5
N2XSY 1x185 RM/25 20kV

Figure 2.8: Cable data sheet

Tests: Test volume and requirements conform to DIN VDE 0278-629-1: 2009-07 test sequence A1, table 4. The chronological order was different to DIN VDE 0278-629-1: 2009-07. The AC-voltage withstand test, wet, was performed at the end of the test sequence A1. The PD-test was performed at 2 $V_0$. The tests were carried out in accordance with the test methods described in IEC 61442 03/2005.

**Test sequence A1:**

*Pos. 1.* *DC voltage withstand test*
$V = 6\ V_0 = -76$ kV ; t = 15 min

*Pos. 2.* *AC voltage withstand test*
$\hat{v}/\sqrt{2} = 4{,}5\ V_0 = 57$ kV; t = 5 min

*Pos. 4.* *Partial discharge test*
$\hat{v}/\sqrt{2} = 2{,}0\ V_0 = 25$ kV ; PD = 10 pC

*Pos. 5.* *Impulse voltage withstand test at elevated temperature*
$\hat{v} = 125$ kV; positive and negative polarity each 10 impulses

*Pos. 6.* *Electrical heat cycling in air*
each loading cycle had a 5 hour heating period and a 3 hour no-load cooling period; test voltage: $\hat{v}/\sqrt{2} = 32$ kV
number of cycles: 126

*Pos. 7.* *Immersion Test*
each loading cycle had a 5 hour heating period and a 3 hour no-load cooling period
number of cycles: 10

*Pos. 8.* *Partial discharge test at ambient temperature and elevated temperature*
$\hat{v}/\sqrt{2} = 2{,}0\ V_0 = 25$ kV ; PD = 10 pC

*Pos .12.* *Impulse voltage withstand test,*
$\hat{v} = 125$ kV; positive and negative polarity each 10 impulses

*Pos. 13.* *AC voltage withstand test*
$\hat{v}/\sqrt{2} = 2{,}5\ V_0 = 32$ kV; t = 15 min

*Pos. 3.* *AC voltage withstand test, wet*
$\hat{v}/\sqrt{2} = 4{,}5\ V_0 = 51$ kV; t = 1 min

# 3 Mounting

Final assembling of the terminations was executed in the high-voltage laboratory of the IEH by technicians of Cellpack GmbH.

# 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%.

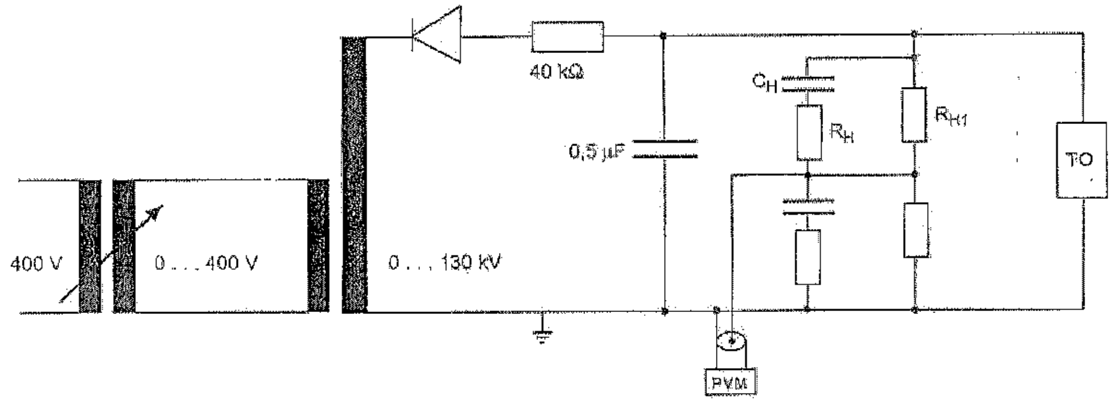


Figure 4.1: Scheme of DC voltage test circuit.
$R_H$ = 3,6 kΩ, $R_{H1}$ = 360 MΩ, $C_H$ = 180 pF, ratio 2.000:1, PVM: Peak Voltmeter TO: Test object, measurement uncertainty 3%

## 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 $\hat{v} / \sqrt{2}$ .

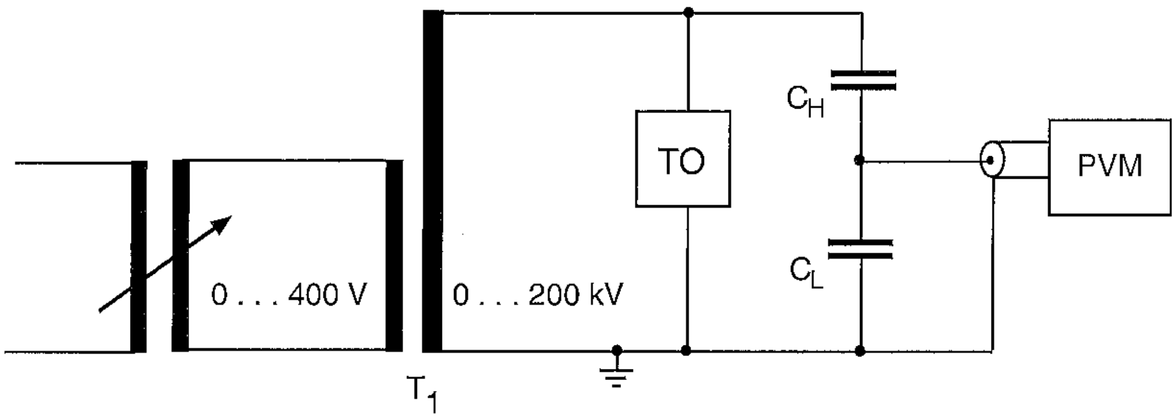


Figure 4.2: Scheme of AC test circuit
$T_1$ : transformer 400V / 200000V ; 60 kVA ; $v_K$ = 3,5 % ; 50 Hz
$C_H$: 180 pF ; RATIO 2000:1 ; PVM : Peak-Voltmeter
TO: Test object; measurement uncertainty 3 %

## 4.3 AC Voltage Withstand Test, wet

The test was carried out according HD 588.1, chapter 9.1. The terminations were sprayed with water of prescribed resistivity and temperature ($\rho$ = 100±15 Ωm, T = 20°C ± 15 °C) falling on it as droplets, whereby the vertical and horizontal components of the spray intensity had been approximately equal.

The intensities were measured with divided collecting vessel having openings of 225 $cm^2$ on horizontal and on vertical alternatively, the vertical opening facing the spray.

During the measuring period (60s) the collecting vessel was slowly moved over the whole measuring zone.

For measuring the water conductivity a sample was taken after the nozzles.

Before starting the test, the test object was prewetted for at least 15 minutes.

## 4.4 Partial Discharge Test

The PD-measurement was performed with an analog bridge according to *Kreuger*, Figure 4.4. 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 25 $kV_{rms}$ was 1.0 pC.

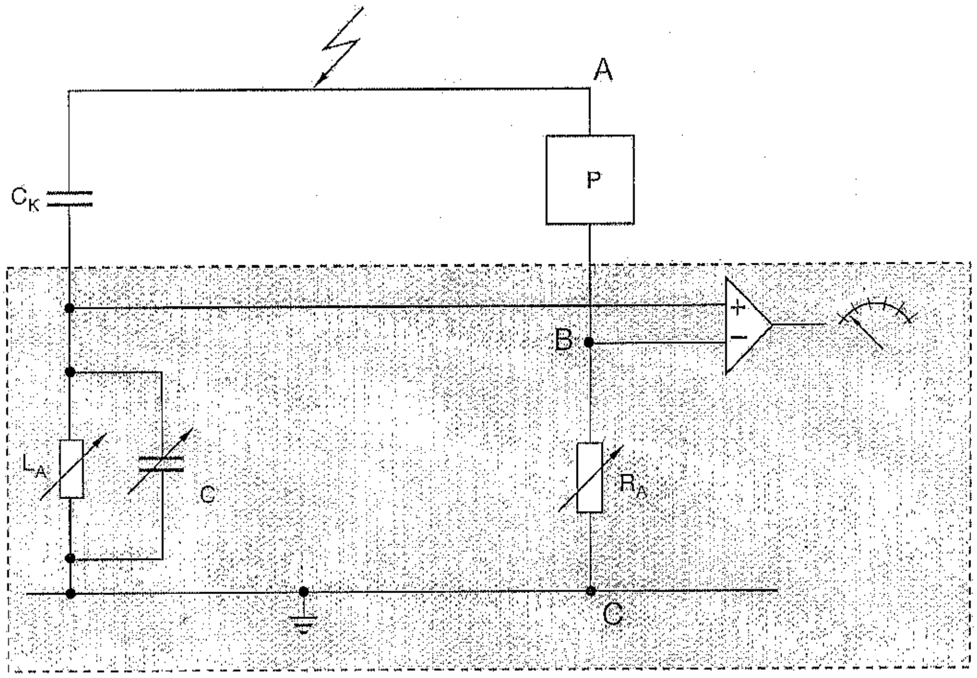


Figure 4.4: Scheme of PD test circuit
TO1: Test object 1
TO2: Test object 2

For balancing the bridge a calibrating impulse with $q_A$ = 10.000 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 28.1 kV and kept constant for 60 s, then slowly reduced to 25 kV including pd-reading.

## 4.5 Impulse Voltage Withstand Test

For impulse testing was used a two-stage Marx generator (Haefely) with a maximum cumulative charging voltage of V = 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.

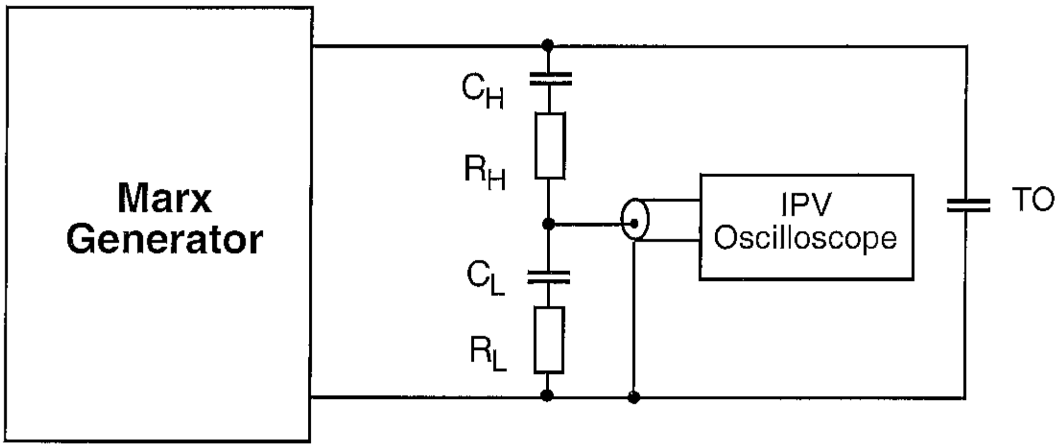


Figure 4.5: Scheme of impulse voltage test circuit
$C_H$: 1200 pF ; $R_H$ = 70 Ω ; ratio: 3215;
IPV: impulse-peak-voltmeter (Haefely) – measurement uncertainty 3%
Oscilloscope: Tektronix TDS 3044B – measurement uncertainty 2%

The waveform parameters were determined at reduced charging voltage.

| | | |
|---|---|---|
| Positive impulse: | $T_1$ = 3.07 µs | $T_2$ = 49.6 µs |
| Negative impulse: | $T_1$ = 2.87 µs | $T_2$ = 49.4 µs |

## 4.6 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 heating current for this test was 760 A. Current inception was accomplished by a transformer ($V_1$ = 400 V; $V_2$ = 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%.

## 4.7 Immersion Test

The test objects were placed in a tank and filled with water. The water surface was 30 mm above each part of the test object. The test objects were placed in the tank in opposite direction at ambient temperature, so that the test objects including the sealing was completely in water. The conductivity of the water at 20°C was 63 mS/m.

# 5 Results

## 5.1 Test Sequence A1

### 5.1.1 DC Voltage Withstand Test

This test was carried out as described in 4.

Test date: 24.09.2010

Test voltage: V = - 76 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: 24.09.2010

Test voltage: $\hat{v}/\sqrt{2}$ = 57 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: 24.09.2010

Voltage: $\hat{v}/\sqrt{2}$ = 28.1 kV , t = 60 s thereafter
$\hat{v}/\sqrt{2}$ = 25 kV with pd reading

PD magnitude (25 kV): < 10 pC

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

### 5.1.4 Impulse Voltage Withstand Test at elevated temperature

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 24.09.2010 |
| Test voltage: | $\hat{v}$ = 125 kV |
| Maximum heating current: | I = 760 A; 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: | 30.09. – 18.11.2010 |
| Test voltage: | $\hat{v}/\sqrt{2}$ = 32 kV |
| Maximum heating current: | I = 760 A |
| Cycle: | 5 h heating; 3 h cooling |
| Number of cycles: | 126 |

Neither flashover nor breakdown occurred.

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

### 5.1.6 Immersion

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 14.12. – 18.12.2010 |
| Conductivity: | 63 mS/m |
| Maximum heating current: | I = 760 A |
| Cycle: | 5 h heating; 3 h cooling |
| Number of cycles: | 10 |
| Height of water: | 30 mm above the test object |

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

## 5.1.7 Partial Discharge Test

### 5.1.7.1 Partial Discharge Test at ambient temperature

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 21.12.1010 |
| Voltage: | $\hat{v}/\sqrt{2}$ = 28.1 kV , t = 60 s, thereafter<br>◊ $/\sqrt{2}$ = 25 kV , with pd reading |
| PD magnitude (25 kV): | < 10 pC |

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

### 5.1.7.2 Partial Discharge Test at elevated temperature

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 22.12.2010 |
| Maximum heating current: | I = 760 A, 5h |
| Voltage: | $\hat{v}/\sqrt{2}$ = 28.1 kV , t = 60 s, thereafter<br>◊ $/\sqrt{2}$ = 25 kV , with pd reading |
| PD magnitude (25 kV): | < 10 pC |

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

## 5.1.8 Impulse Voltage Withstand Test

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 27.12.2010 |
| Test voltage: | $\hat{v}$ = 125 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.***

### 5.1.9 AC Voltage Withstand Test

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 27.12.2010 |
| Test voltage: | $\hat{v}/\sqrt{2}$ = 32 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.***

### 5.1.10 AC Voltage Withstand Test, wet

This test was carried out as described in 4.

| | |
|---|---|
| Test date: | 03.01.2011 |
| Amount of water: | vertical: 1.80 mm/min<br>horizontal: 1.80 mm/min |
| Conductivity: | $\sigma$ = 103 µS/cm ($\hat{=}$ 97.1 Ωm) |
| Pre-wetting time: | 15 min |
| Test voltage: | $\hat{v}/\sqrt{2}$ = 51 kV , t = 1 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.***

# 6 Conclusion

The outdoor termination type CONTRAX CAE-F 24 kV (Cellpack GmbH) passed all tests described in clause 2 successfully. The test object fulfilled the requirements corresponding DIN VDE 0278-629-1: 2009-07, Table 4, test sequences A1.

Karlsruhe, 15.01.2011

Dr.-Ing. R. Badent
Bereichsleiter HPT

Dr.-Ing. B. Hoferer
stellv. Bereichsleiter HPT

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