Bereich Hochspannungsprüftechnik
Institut für Elektroenergiesysteme und Hochspannungstechnik

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Test Report No. 2014-33

Type Test of
a separable T-Form Connector,
Type CTS 630A 24kV 95-240

Customer: Cellpack GmbH
Carl-Zeiss-Straße. 20
79761 Waldshut-Tiengen

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

1 Purpose of Test

Several separable T-Form Connectors, type CTS 630A 24kV 95-240 for $U_0/U_n/U_m$ = 12,7/22(24) kV were subjected to a type test according to CENELEC HD 629.1 S2 02/2006 + A1:2008, table 7, test sequence D1, D2 and additional tests, position 17, 18, 19 and 21.

2 Miscellaneous Data

Test object:

– Test sequences D1 and D2
4 resp. 3 separable T-Form Connectors,
type CTS 630A 24kV 95-240
Installation instruction 333679, Figure 2.1 – 2.7
KIT Content 342350, Figure 2.8
Type of cable: The test objects were mounted on single core shielded XLPE-cables, type N2XSY 1x185RM/25 12/20 kV Südkabel 2005, Figure 2.9

– Additional tests, Pos 17, 18, 19 and 21
In each case 1 separable T-Form Connector,
type CTS 630A 24kV 95-240
Installation instruction 333679, Figure 2.1 – 2.7
KIT Content 342350, Figure 2.8

Manufacturer:
Cellpack GmbH
Carl-Zeiss-Straße. 20
79761 Waldshut-Tiengen

Place of test:
Institut für Elektroenergiesysteme und
Hochspannungstechnik (IEH)
Karlsruher Institut für Technologie (KIT)
Engesserstr. 11 – 76128 Karlsruhe
Accreditation No.: D-PL-11068-09-00

Testing dates:

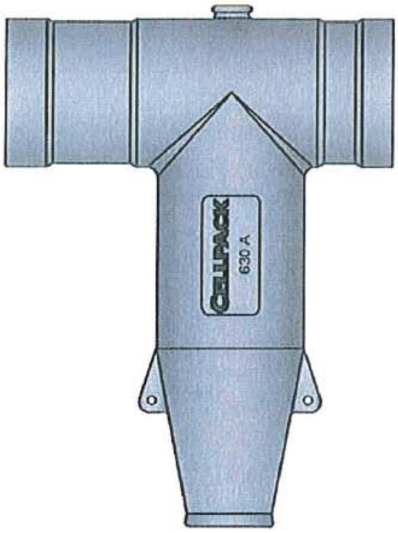
	Delivery:	28.03.2014
	Mounting:	28.03.2014
	Test date:	28.03. – 25.02.2015

Atmospheric conditions:

	Temperature:	18°C - 25°C
	Air pressure:	980 - 1020 mbar
	rel. humidity:	35% - 70%

Representatives	Customer's representatives: Dr.-Ing. I. Ovsyanko Representatives responsible for the tests Dr.-Ing. R. Badent Dr.-Ing. B. Hoferer Mr. O. Müller

Medium Voltage **CELLPLUX**



CTS 630A 24kV 95-240
$U_o/U(U_m)$ 6/10(12) kV – 12,7/22(24) kV

Working Instruction

Separable T-Form Connector
for single-core polymeric cables
up to 24 kV

333679

Prüfgegenstand entspricht der vorgelegten technischen Zeichnung

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CELLPACK
Electrical Products

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Figure 2.1: Installation instruction, T-Form Connector

General remarks:

- Check if the range and size of the accessories is appropriate to the cable.
- Check the content of the kit as per packing list.
- Thoroughly read the working instruction.

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

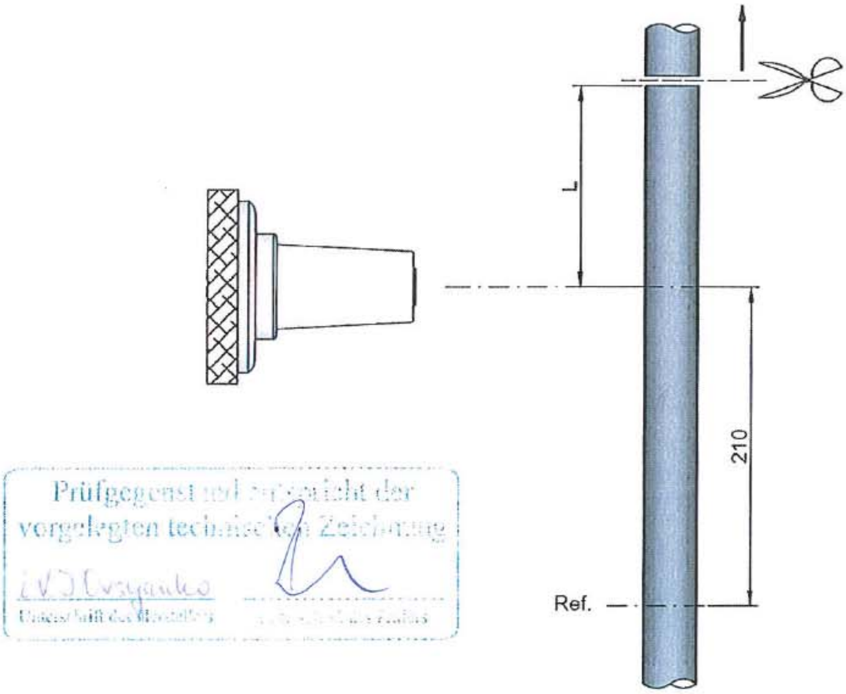
Separable T-Form Connector Type CTS 630A 24kV 95-240

Cross-Section Application

Voltage Uo/U(Um) kV	Cable Cross-Section (*) mm^2
6/10(12) – 6,35/11(12) kV	150 – 240
8,7/15(17,5) kV	120 – 240
12/20(24) – 12,7/22(24) kV	95 – 240

(*) Minimum diameter over cable insulation of 22,0 mm

Adjustment



- Clean thoroughly the cable end up to **1 m**.
- Adjust the cable overhanging in the middle of the bushing by **L = 200 – 500 mm**. Cut-off the excess of cable.
- Make a mark **210 mm** from the centre of the bushing onto the cable sheath (Ref.).

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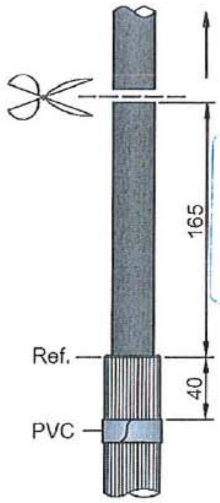
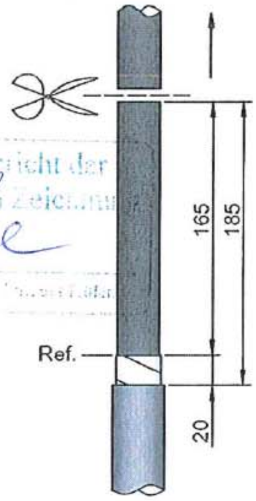
Figure 2.2: Installation instruction, T-Form Connector

1a) Cable with wire screen



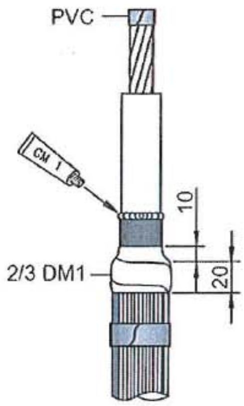
- Remove the cable sheath up to the mark (Ref.).
- Bend back the screen wires of the cable and fix them on the cable sheath with PVC tape.
- Cut off the conductor at the length of **165 mm.**
- Prepare the cable end according to the template (see page 4). Apply the PVC tape. Then check the dimensions.

1b) Cable with tape screen



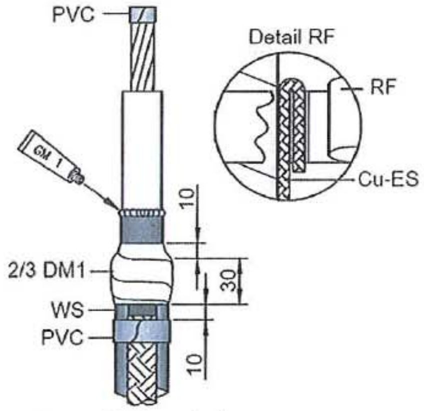
- Remove the cable sheath up to the mark (Ref.) + additional **20 mm.**
- Cut the cable according to the drawing.
- Remove carefully the tape screen up to **20 mm.**
- Prepare the cable end according to the template (see page 4). Apply the PVC tape. Then check the dimensions.

2a) Cable with wire screen



- Clean the cable insulation.
- Wrap 2/3 of the length of sealing tape DM1 **10mm** on to the semi-conductive layer and **20mm** on to the wire screen (stretch 50%).
- Apply at and around the cut edge of the semi-conductive layer lubricant and filling agent GM1 (forming a ring).

2b) Cable with tape screen



- Clean the cable insulation.
- Fix the flat Cu-braid tape Cu-ES with the pressure spring RF on to the tape screen (order the earthing kit separately).
- Wrap 2/3 of the length of sealing tape DM1 **10mm** on to the semi-conductive layer and **30mm** on to the RF and Cu-ES up to the water stop WS (stretch 50%).
- Apply at and around the cut edge of the semi-conductive layer lubricant and filling agent GM1 (forming a ring).

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Figure 2.3: Installation instruction, T-Form Connector

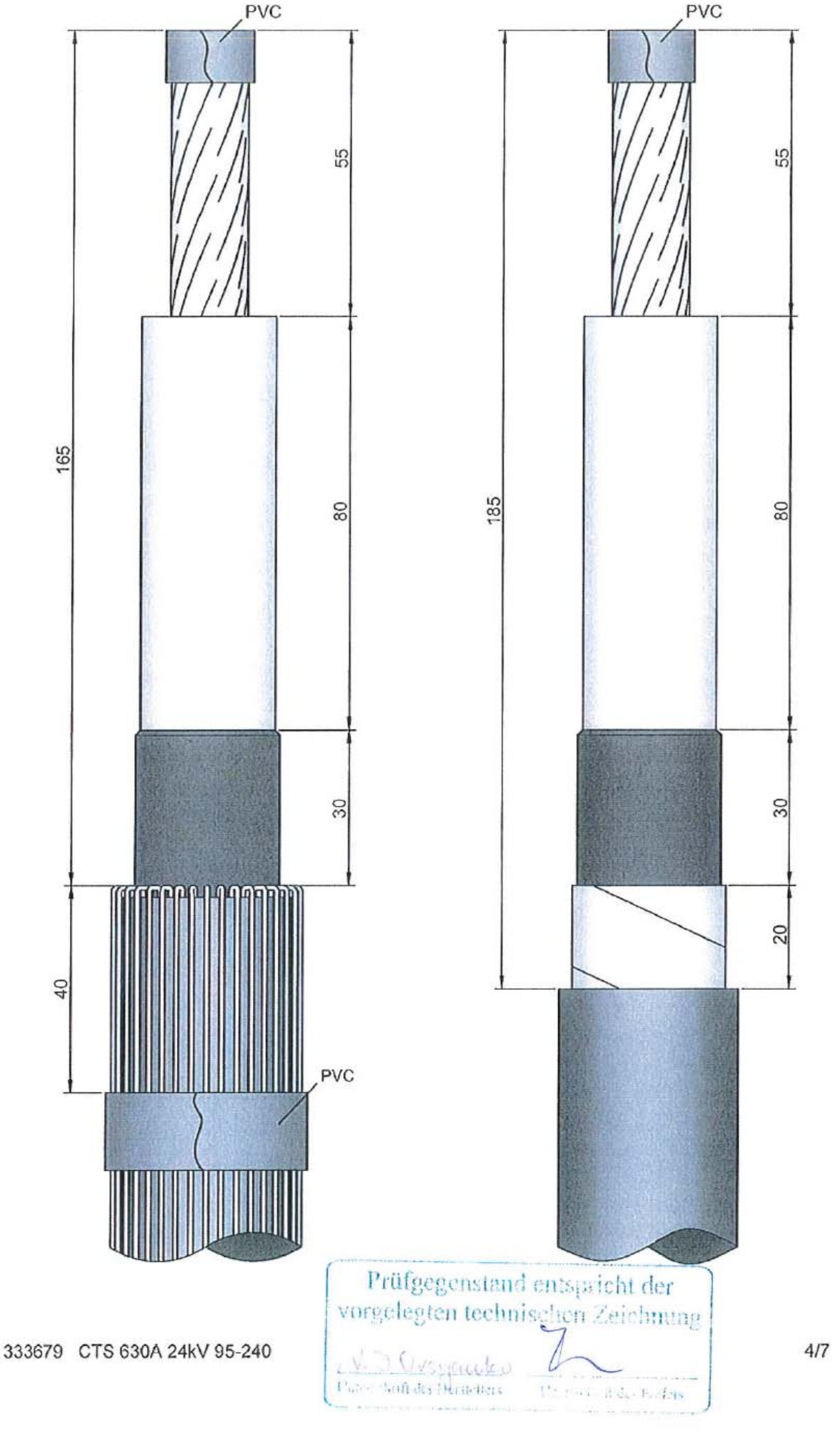
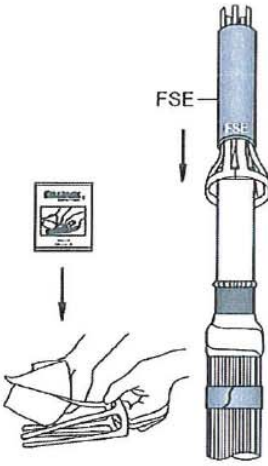


Figure 2.4: Installation instruction, T-Form Connector

3)

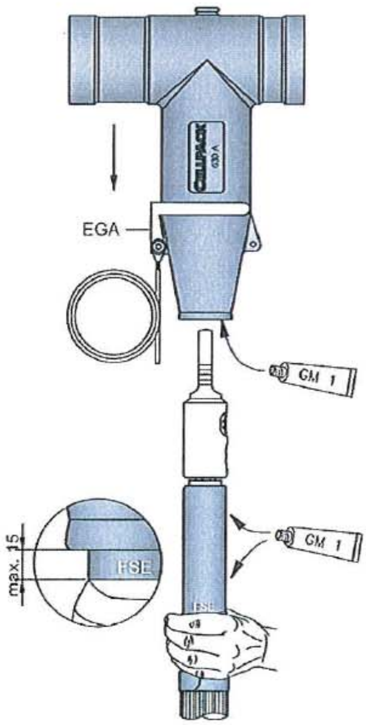


- Grease the tongues of the applicator AH with the silicon towel.
- Insert the applicator AH into the stress control element FSE and slip it onto the cable up to the sealing tape.
- Remove the applicator AH by pulling out the tongues one by one.
- Adjust the position of the stress control element FSE by turning it slightly (Fig. 4).

4)

- Remove the PVC tape from the tip end of the conductor.
- Install the shear-head screw cable lug according to the separate instruction. Tighten the screws alternately with an appropriate tool till the shear head breaks. Mind the sequence indicated on the drawing.
- Please note that the tapped hole of the cable lug is in line with the bushing axle.
- Clean thoroughly the surface of the stress control element FSE.

5)



- Install the earthing set EGA to the T-Connector body.
- Grease the T-Connector body inside and the surface of the stress control element FSE with lubricant and filling agent GM1.
- The contact parts shouldn't be greased.
- Hold the stress control element FSE in right position and slip the T-Connector body on to the conductor until the tapped hole of the cable lug is centred inside the T-Connector body. Check the right position of the FSE according to the detail drawing.
- Remove remaining lubricant and filling material GM1. Use cleaning tissue.

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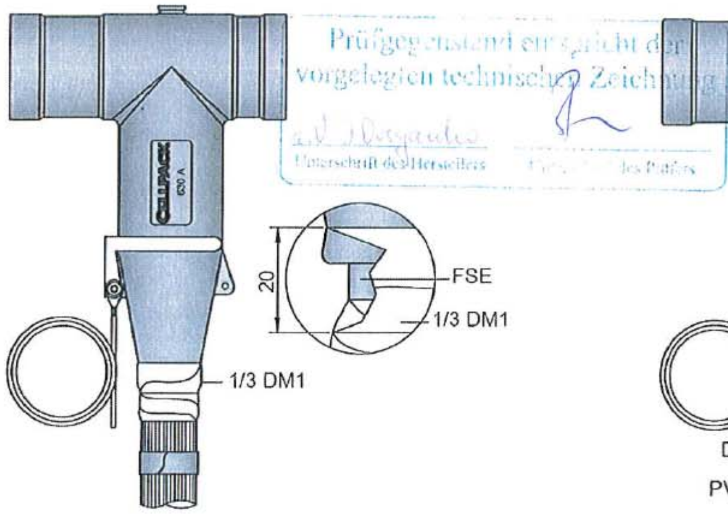
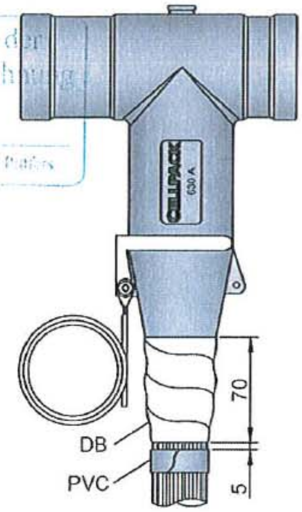
Figure 2.5: Installation instruction, T-Form Connector

6)

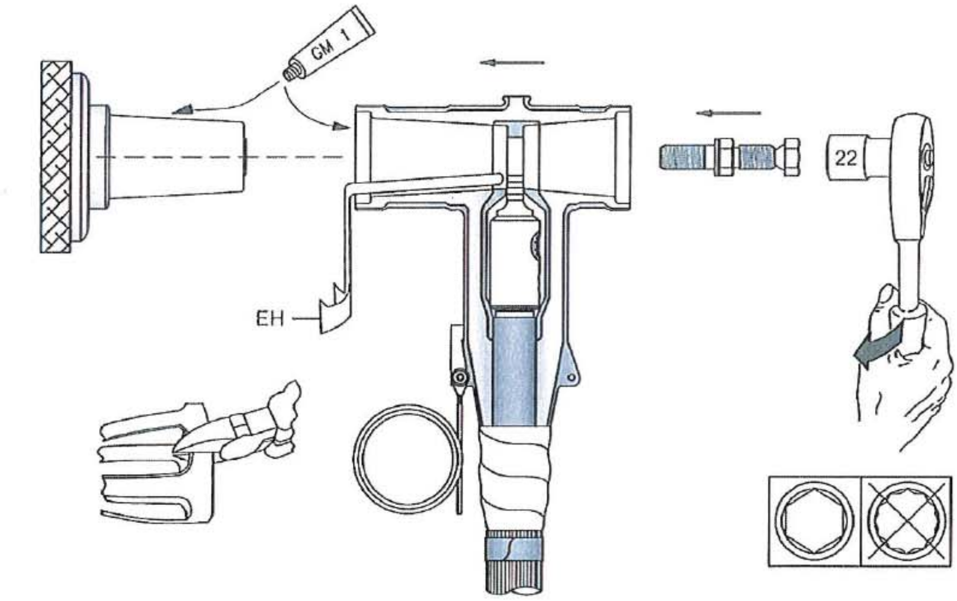


7)



- Wrap the remaining **1/3** of sealing tape DM1 between the end of the T-Connector body and the sealing area.
- Wrap the sealing tape black DB adhesive side inwards according to the drawing (stretch 20%).

8)



- Grease the surface of the bushing and inside of the T-Connector body with lubricant and filling agent GM1.
- Cut out a tongue from the applicator AH (air decompression device EH).
- Insert the decompression device EH into the T-Connector body and mark the right depth.
- Attach the T-Connector straight on to the bushing and screw the contact screw manually.
- Tighten the contact screw with an appropriate tool till the shear head breaks (min. 50Nm).

Attention: In case of re-connecting of the plugs use additional reconnecting set ZS-CTS.

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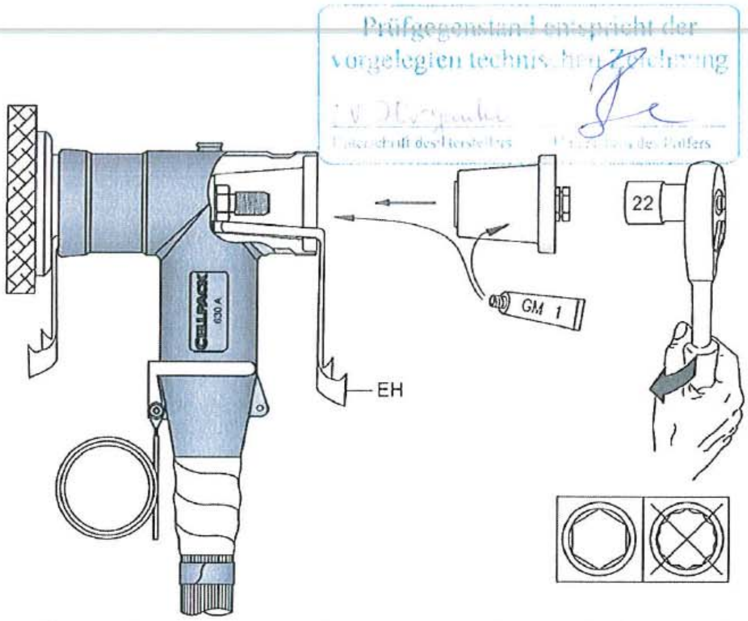
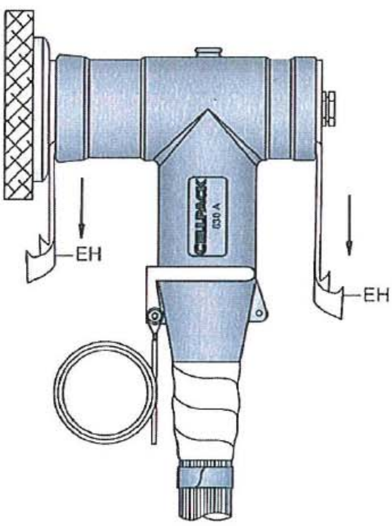
Figure 2.6: Installation instruction, T-Form Connector

9)



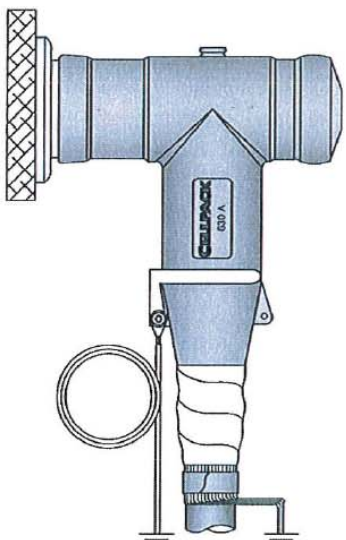
- Grease the T-Connector body inside and the insulating plug with lubricant and filling agent GM1.
- Cut out the second tongue from the applicator AH (air decompression device EH).
- Insert the decompression device EH into the T-Connector body and mark the right depth.
- Screw the insulating plug into the T-Connector body manually. Tighten the insulating plug with an appropriate tool **up to the stop** (max. 30Nm).

10)



- Pull out gently the air decompression devices EH.
- Remove remaining of lubricant and filling agent GM1. Use cleaning tissue.

11)



- Insert the conductive protection cup over the T-Connector body. Please note a good contact between measuring point and the cap.
- Ground the earthing set EGA.
- Further earthing measurements have to be carried out according to local regulations.

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Figure 2.7: Installation instruction, T-Form Connector

Art.-Nr.:342350 — Packliste / Packing list / Liste d'emballage — Lista de carga / Paklijst / Lista kompletacyjna

CELLPACK Electrical Products

MEDIUM VOLTAGE | **CELLPLUX**

T-Steckanschluss
Connecteur Séparable en T
T-Stekker aansluiting

T-Form Connector
Terminal Enchufable en T
Głowica konektorowa typu T

Type: CTS 630A 24kV 95-240
Interface Type C

12/20(24)kV - 12,7/22(24)kV 95-240 mm²
8,7/15(17,5)kV 120-240 mm²
6/10(12)kV - 6,35/11(12)kV 150-240 mm²

Isolation min. Ø: 22,0 mm

1/1

Pos.		pc.	Dimension			
1		3	CTS 630A 24kV	Steckanschluß Connecteur séparable Stekkeraansluiting	Plug-in connector Cuerpo de Conector Głowica konektorowa	
2		3	CTS 630A	Schraubisolierstöpsel Connecteur isolé Schroefisolatiestop	Insulated plug Enchufe aislado Zatyczka izolacyjna	
3		3	FSE 20	Feldsteuerelement Elément répartiteur de champ Veldstuurelement	Field control element Elemento de control de campo Element sterujący	FSE-Set
4		3	AH3	Aufschiebehilfe Dispositif d'enfilage Opschuifhulpstuk	Applicator Aplicador Aplikator	
5		3	CTS 630A C95-240	Schraubkabelschuh + Anschlussbolzen Cosse à visser+ vis de contact Schroef kabelschoen met contactbouten	Screw cable lug with connecting bolt Terminal de cable con perno de conexión Końcówka śrubowa z śrubą mocującą	
6		3	EGA Set	Erdungs-Set Kit de mise à la terre Aardingkits	Earthing-kit Conjuntos de puesta a tierra Zestaw uziemiający	
7		3	DM1 25x200mm	Dichtband grau Ruban d'étanchéité gris Dichtband grijs	Sealing tape grey Cinta de estanqueidad gris Taśma uszczelniająca szara	
8		3	DB 50x350mm	Dichtband schwarz Ruban d'étanchéité noir Dichtband zwart	Sealing tape black Cinta de estanqueidad negra Taśma uszczelniająca czarna	
9		1	Nr.128 5m	Isolierband Ruban isolant Isolatieband PVC	Insulation tape Cinta aislante Taśma izolacyjna	ZK 9
10		4	GM1	Gleit- und Füllmittel Lubrifiant Glij- en vulmiddel	Lubrificant and filler Agente de deslizamiento y relleno Smar uszczelniający	
11	RT	6	RT	Reinigungstuch Lingette nettoyante Reinigingsdoek	Cleaning tissue Toalla de Limpieza Chusteczka czyszcząca	
12	ST	3	ST	Tuch mit Silikonöl Lingette siliconée Siliconedoek	Tissue with silicon oil Toalla siliconada Chusteczka z olejem sil.	
13		3	SHS	Schutzhandschuhe Gants Handschoenen	Gloves Guantes Rękawiczki	
14		6	MA	Montageanleitung Instructions de montage Montagehandleiding	Working instruction Instrucciones de montaje Instrukcja montażu	

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Figure 2.8: KIT Content, T-Form Connector

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): kV

Kabelaufbau: ☒ 1-Leiter ☐ 3-Leiter ☐ einzeln geschirmt ☐ gemeinsam geschirmt

Leiteraufbau: ☐ Al ☒ Cu
☒ mehrdrähtig ☐ massiv
☒ Rundleiter ☐ Sektorleiter
☐ 120 mm^2 ☐ 150 mm^2 ☒ 185 mm^2
anderer Querschnitt: mm^2

Kabelisolation: ☒ VPE
☐ EPR ☐ HEPR

Äußere Leitschicht: ☒ fest extrudiert ☐ abziehbar

Metallischer Schirm: ☒ Drähte ☐ Bänder ☐ extrudiert

Armierung: ☐ Draht ☐ Band

Außenmantel: ☒ PVC ☐ PE (Typ ist anzugeben)

Wassersperre, wenn vorhanden: ☐ im Leiter ☐ unter Außenmantel

Durchmesser:
- Leiter 16 mm
- Isolierung 28 mm
- äußere Leitschicht 29,6 mm
- Außenmantel 37,5 mm

Kabelbezeichnung:

N2XSY 1x185 RM/25 12/20kV Südkabel/2005

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i.A. J. Ovsyanko
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Figure 2.9: Cable data Sheet

Tests: Test volume, chronological order and requirements conform to CENELEC HD 629.1 S2 02/2006 + A1:2008, table 7, test sequence D1, D2, Pos. 17, 18, 19 and 21. 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
$U = 6\ U_0 = -76$ kV ; $t = 15$ min

Pos. 2. AC voltage withstand test
$\hat{u}/\sqrt{2} = 4{,}5\ U_0 = 57$ kV; $t = 5$ min

Pos. 3. Partial discharge test
$\hat{u}/\sqrt{2} = 2{,}0\ U_0 = 25$ kV ; PD ≤ 10 pC

Pos. 4. Impulse voltage withstand test at elevated temperature
$\hat{u} = 125$ 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: $\hat{u}/\sqrt{2} = 32$ 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: $\hat{u}/\sqrt{2} = 32$ 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
$\hat{u}/\sqrt{2} = 2{,}0\ U_0 = 25$ kV ; PD ≤ 10 pC

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

Pos. 13. AC voltage withstand test
$\hat{u}/\sqrt{2} = 2{,}5\ U_0 = 32$ kV; $t = 15$ min

Pos. 16. Examination

Test sequence D2:

Pos.1. DC voltage withstand test
$U = 6\ U_0 = -76$ kV; t =15 min

Pos. 2. AC voltage withstand test
$\hat{u}/\sqrt{2} = 4{,}5\ U_0 = 57$ kV; t = 5 min

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

Pos. 10. Disconnection / Connection
5 complete operations

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

Pos. 13. AC voltage withstand test
$\hat{u}/\sqrt{2} = 2{,}5\ U_0 = 32$ kV; t = 15 min

Pos. 16. Examination

Additional tests according table 7:

Pos. 17. Screen resistance measurement
R max 5000 Ω

Pos. 18. Leakage current measurement
max 0,5 mA at U_m (= 24 kV)

Pos. 19. Screen fault current initiation
Unearthed / impedance earthed system

Pos. 21. Capacitive test point performance

3 Mounting

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

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%.

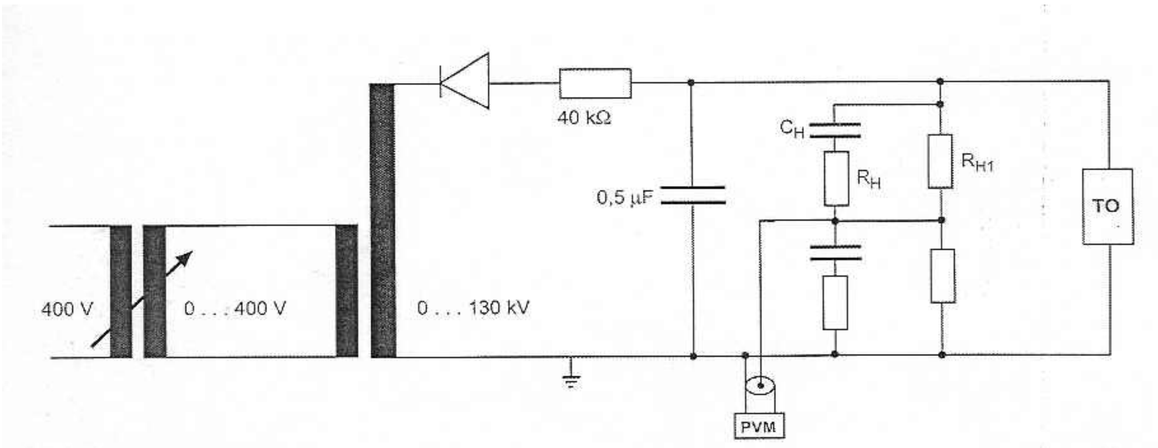

Figure 4.1: Scheme of DC voltage test circuit.
R_H = 3,6 kΩ, R_{H1} = 360 MΩ, C_H = 180 pF, ratio 2.000:1,
PVM: Peak Voltmeter, measurement uncertainty 3%
TO: Test object

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 $\hat{u} / \sqrt{2}$.

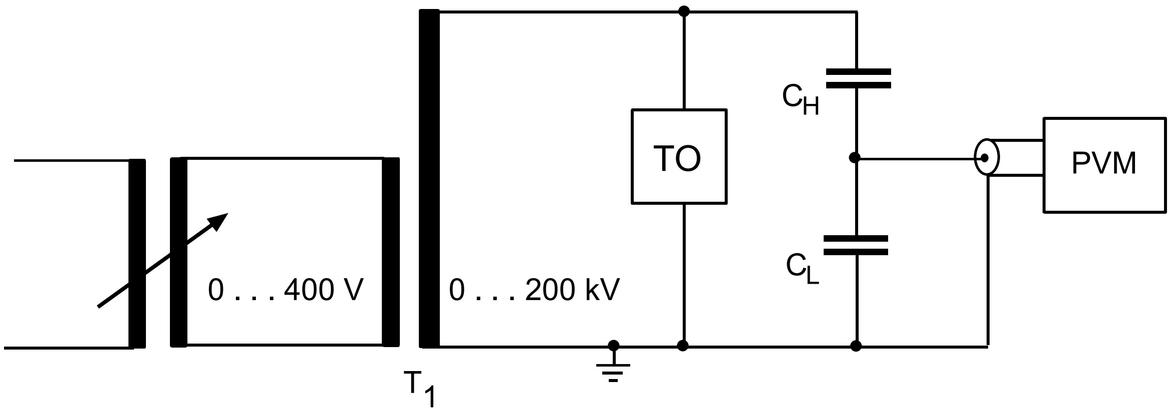

Figure 4.2: Scheme of AC test circuit
T_1 : transformer 400V / 200000V ; 60 kVA ; u_K = 3,5 % ; 50 Hz
C_H: 180 pF ; ratio 2000:1 ; PVM : Peak-Voltmeter
TO: Test object; measurement uncertainty 3 %

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 25 kV_{rms} was 0,8 pC.

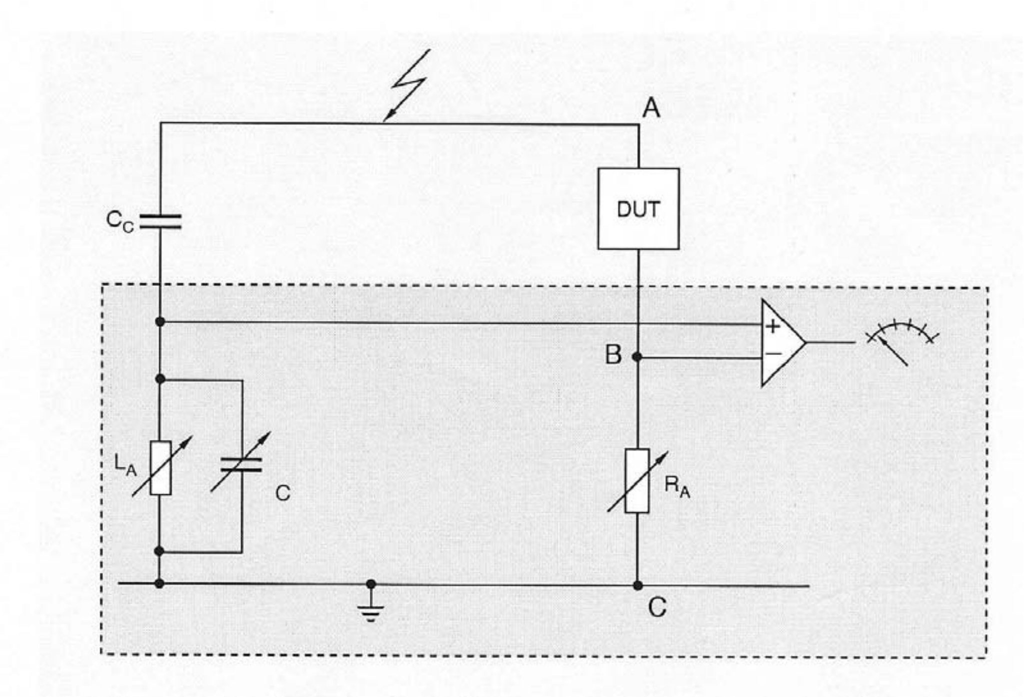

Figure 4.3: Scheme of PD test circuit
C_C: Coupling capacitor
DUT: Device under test

For balancing the bridge a calibrating impulse with q_A = 100 pC is applied bet-ween 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 (= 2,25 U_0) and kept constant for 10 s, then slowly reduced to 25 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. The front time and the time to half value were evaluated from the oscillographs.

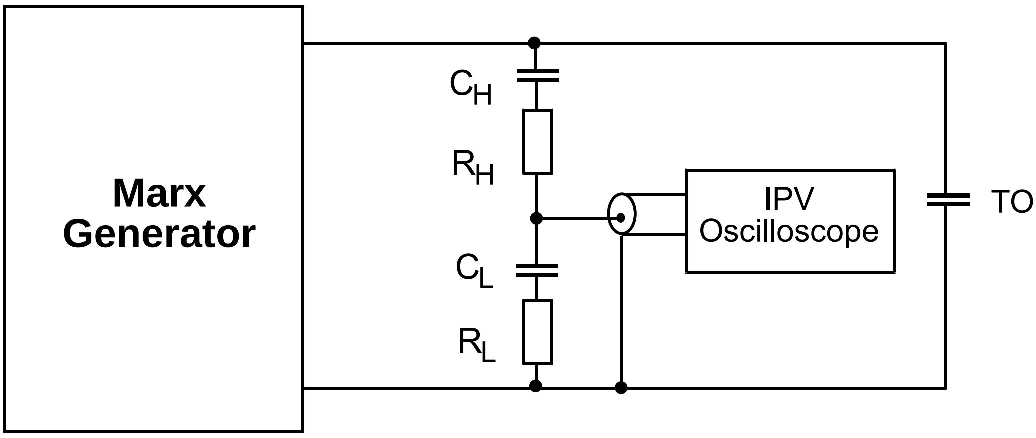

Figure 4.4: Scheme of impulse voltage test circuit
C_H: 1200 pF ; R_H = 70 Ω ; ratio: 30780;
IPV: impulse-peak-voltmeter – measurement uncertainty 3%
Oscilloscope: Tektronix TDS 3044B – measurement uncertainty 2%

The waveform parameters were determined at reduced charging voltage.

Positive impulse:	T_1 = 2,47 µs	T_2 = 51,5 µs
Negative impulse:	T_1 = 2,47 µs	T_2 = 51,0 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 heating current for the test sequence D1 (Cu185) was 850 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%.

4.6 Electrical Heat Cycling in Water

The test objects were placed in a tank, which was filled with water, so that the test objects were completely covered with water. The water height above the test objects was 1000 mm. The conductivity of the water at 20°C was 63 mS/m.

4.7 Thermal Short Circuit Current Test, Conductor

According IEC 61442 03/2005 for Cu with q = 185 mm^2, the permitted limit integral is I^2t = 1126 $(kA)^2s$ with θ_{sc} = 250°C and θ_i = 20°C.

Figure 4.7.1 illustrates the test setup. Via a vacuum circuit-breaker (SW) the 165 V - tapping of a 800 kVA - transformer is directly applied to two test objects. The current is measured by means of a Rogowski current transducer Type CWT600B (Sensitivity 0,05mV/A). The output signal of the current transformer is recorded by a digital measuring and controlling system (DIABLO), which switches also the circuit breaker "On" resp. "Off". The command variable of the controller was the limit integral $\int i^2 dt$. This controller measures on-line the current vs time, calculates from these values the $\int i^2 dt$ and switch off the current after reaching the specified value. The measurement uncertainty was 2%.

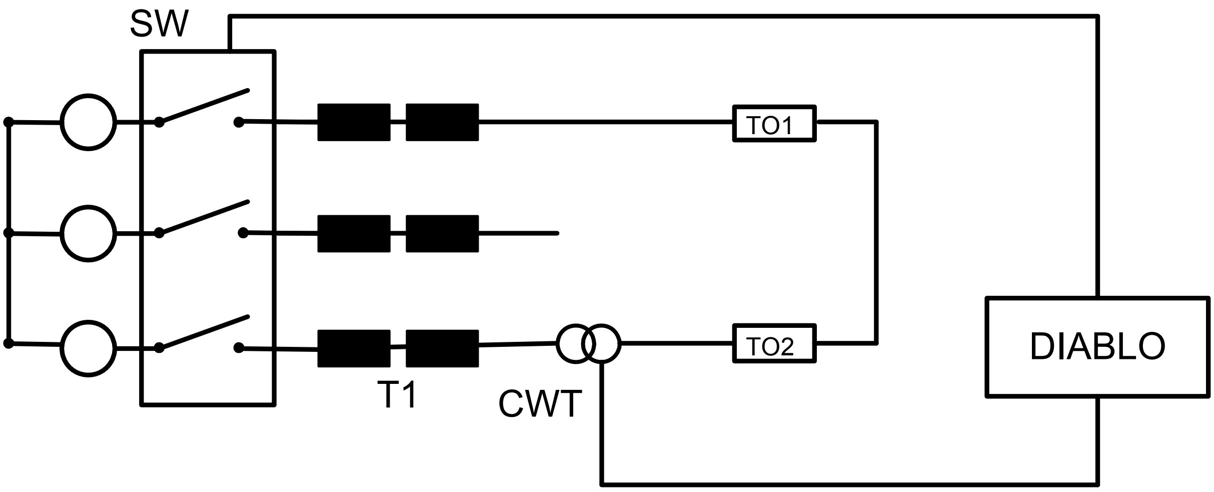

Figure 4.7.1: Test setup

T1:	High Current Transformer, 20kV/165V
SW:	Vacuum Circuit Breaker
CWT:	Rogowski Sensor 50mV / kA
DIABLO:	Control and Measuring Unit, Uncertainty 3%
TO1, TO2:	Test Objects

4.8 Screen Resistance Measurement

For measuring the screen resistance, silver painted electrodes were installed at each end of the connector. The resistance between the electrodes was then measured with a digital multimeter at ambient temperature.

The prepared connector was then placed in a climate chamber and stored at 120°C for 168 h (7 days).

The resistance measurement was then repeated at ambient temperature.

4.9 Leakage Current Measurement

For leakage current measurement, a connector was mounted on a cable and connected to its mating bushing. A metal foil (50 x 50 mm²) was fixed without any gaps on the outer screen of the bushing as far as possible from the earthing points.
The metal foil was connected with a milliammeter and in series with a 2000 Ω-Resistor earthed. The leakage current was then measured with an AC voltage of U_m, applied between conductor and earth.

4.10 Screen Fault Current Initiation

Prior to the test a faulting wire of approx. 0,2mm was placed in the area of the connecting bolt through a drilled hole. The wire was coonnected with the inner and outer screens and did not protrude beyond the outer screen surface.

The test voltage was generated by a 630 kVA-transformer. A capacitor was connected in series to the test object resulting in a short circuit current of 10 A at test voltage U_0, Figure 4.11. The sequence of test was:

1.) Voltage switched on for 1s
2.) Voltage switched off for 2 min
3.) Voltage switched on for 2 min
4.) Voltage switched off for 2 min
5.) Voltage switched on for 1 min
6.) Voltage switched off

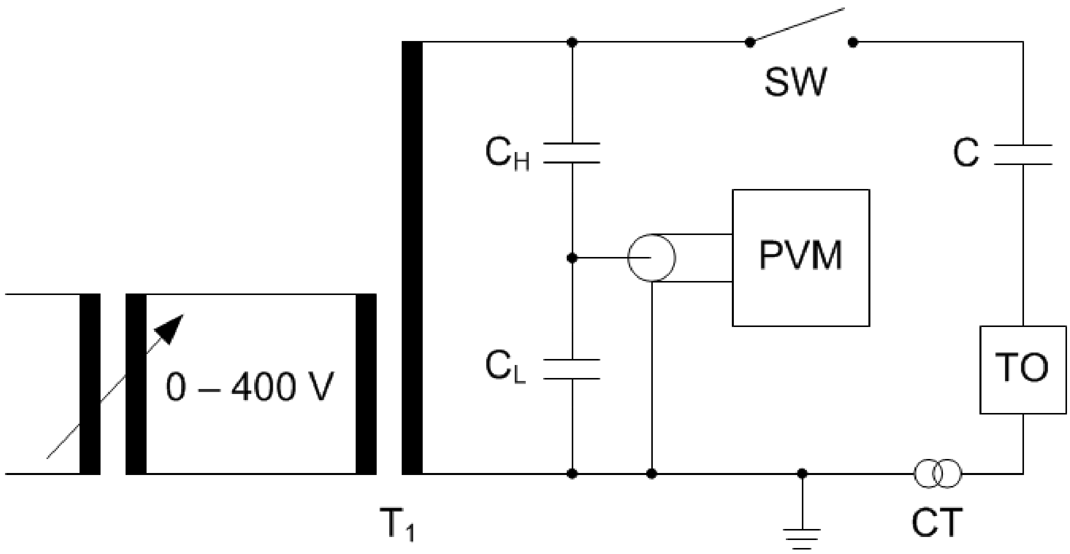

Figure 4.10: Scheme of AC test circuit
T1: Transformer 400V/20000V; 630 kVA
C_H: 300 pF; C_L: 300 nF; PVM: Peak Voltmeter
C: Current limiting capacitance
TO: Test object
CT: Current transformer

4.11 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:	28.03.2014
Test voltage:	U = - 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:	28.03.2014
Test voltage:	$\hat{u}/\sqrt{2}$ = 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:	28.03.2014
Test voltage:	$\hat{u}/\sqrt{2}$ = 28,1 kV ; t = 10 s, thereafter
	$\hat{u}/\sqrt{2}$ = 25 kV with PD-reading
PD magnitude (25 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:	07.04.2014
Test voltage:	$\hat{u}$ = 125 kV
Max. heating current:	I = 850 A, regulated; t = 5 h
Temperature:	T = 97,2 °C
Impulse:	1-5 / 50 µs
Number of tests:	10 positive polarity, 10 negative polarity

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

The test was passed successfully.

5.1.5 Electrical Heat Cycling in Air

This test was carried out as described in 4.

Test date:	08.04. – 30.04.2014
Test voltage:	$\hat{u}/\sqrt{2}$ = 32 kV
Max. heating current:	I = 850 A, regulated; t = 5 h
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:	30.04. – 22.05.2014
Test voltage:	$\hat{u}/\sqrt{2}$ = 32 kV
Max. heating current:	I = 850 A, regulated; t = 5 h
Height of Water:	1000 mm
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:	26.05.2014
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:	27.05.2014
Test voltage:	$\hat{u}/\sqrt{2}$ = 28,1 kV ; t = 10 s, thereafter
	$\hat{u}/\sqrt{2}$ = 25 kV with PD-reading
PD magnitude (25 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:	27.05.2014
Test voltage:	$\hat{u}/\sqrt{2}$ = 28,1 kV ; t = 10 s, thereafter
	$\hat{u}/\sqrt{2}$ = 25 kV with PD-reading
Max. heating current:	I = 850 A, regulated; t = 5 h
Temperature:	T = 97,1 °C
PD magnitude (25 kV):	< 10 pC

The test was passed successfully.

5.1.9 Lightning Impulse Voltage Withstand Test

This test was carried out as described in 4.

Test date:	27.05.2014
Test voltage:	û = 125 kV
Impulse:	1-5 / 50 µs
Number of tests:	10 positive polarity, 10 negative polarity

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

The test was passed successfully.

5.1.10 AC Voltage Withstand Test

This test was carried out as described in 4.

Test date:	27.05.2014
Test voltage:	$\hat{u}/\sqrt{2}$ = 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.

5.1.11 Accessory Examination (For information only)

Test date: 03.06.2014

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: 02.01.2015
Test voltage: U = - 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.

5.2.2 AC Voltage Withstand Test

This test was carried out as described in 4.

Test date: 10.01.2015
Test voltage: $\hat{u}/\sqrt{2}$ = 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.

5.2.3 Short Circuit Current Test, Conductor

This test was carried out as described in 4.

Test date:	21.01.2015
Number of SCC:	2
Time between two stresses:	2h

Table 5.2.3. shows all parameters of each short circuit current test.

No.	Test ojbects	$I_{SC\ rms}$ / kA	t_{SC} / s	∫i²dt / (kA)²s	Calculated Temp. θ_{SC} in °C	Figure
1	all	22,64	2,243	1140	254	5.2.3.1
2	all	22,80	2,193	1140	254	5.2.3.1

Table 5.2.4: Short circuit current test objects

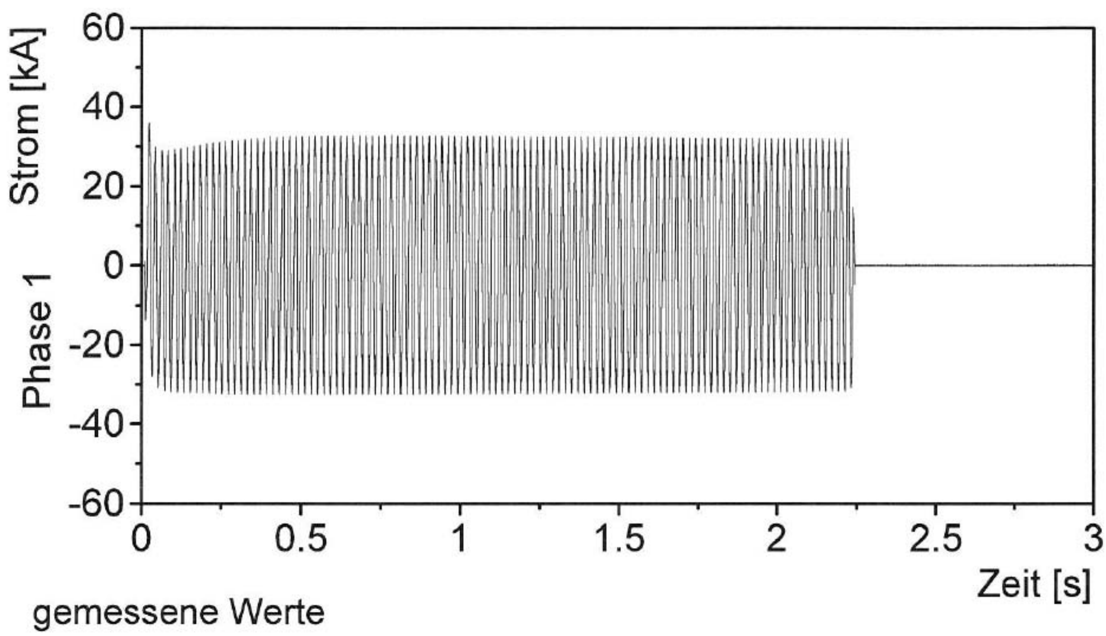

Figure 5.2.3.1 1st short circuit current test

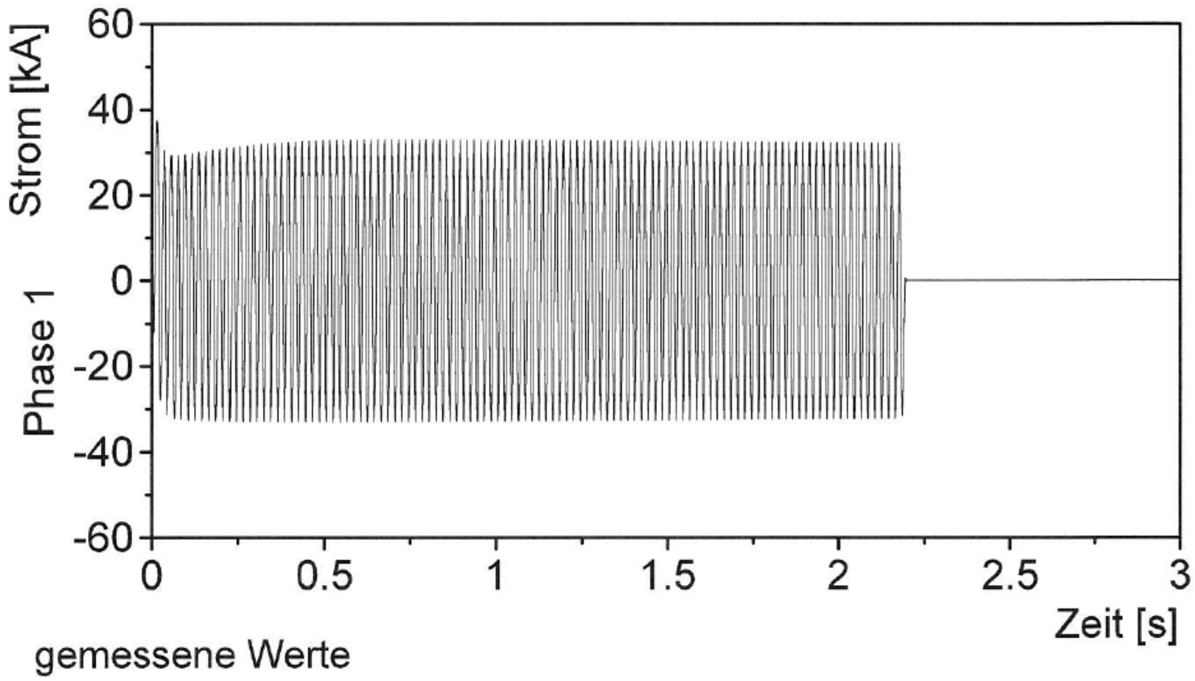

Figure 5.2.3.2 2nd short circuit current test

The test was passed successfully.

5.2.4 Disconnection / Connection

Test date:	11.02.2015
No. of operations:	5

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

The test was passed successfully.

5.2.5 Lightning Impulse Voltage Withstand Test

This test was carried out as described in 4.

Test date:	12.02.2015
Test voltage:	û = 125 kV
Impulse:	1-5 / 50 µs
Number of tests:	10 positive polarity, 10 negative polarity

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

The test was passed successfully.

5.2.6 AC Voltage Withstand Test

This test was carried out as described in 4.

Test date:	12.02.2015
Test voltage:	$\hat{u}/\sqrt{2}$ = 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.

5.2.7 Accessory Examination (For information only)

Test date: 22.02.2015

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

5.3.1 Screen Resistance Measurement

This test was carried out as described in 4.

Test date:	14.01. – 26.01.2015
Initial Resistance:	R = 158 Ω
Ageing:	120°C; 168h
Final Resistance:	R = 95 Ω

Requirement: R < 5 kΩ

The test was passed successfully.

5.3.2 Leakage Current Measurement

This test was carried out as described in 4.

Test date:	26.01.2015
Voltage:	$\hat{u}/\sqrt{2}$ = 24 kV
Leakage current:	I = 0,55 µA

Requirement: max 0,5 mA

The test was passed successfully.

5.3.3 Screen Fault Current Initiation

This test was carried out as described in 4.

Test date:	11.02.2015
Voltage:	$\hat{u}/\sqrt{2}$ = 12 kV
Short circuit current:	I = 10 A

The fault current was flowing continously

The test was passed successfully.

5.3.4 Capacitive Test Point Performance

This test was carried out as described in 4.

Test date:	28.01.2015
Capacitance C_{tc}:	C = 6,5 pF
Capacitance C_{te}:	C = 8,5 pF
Ratio:	C_{te}/ C_{tc} = 1,31
Requirements:	$C_{tc} > 1$ pF
	$C_{te}/ C_{tc} < 12$

The test was passed successfully.

6 Conclusion

The T-Form Connector, Type CTS 630A 24kV 95-240 for $U_0/U_n/U_m$ = 12,7/22(24) kV, manufactured by Cellpack GmbH, passed all tests described in Chapter 2 success-fully. The test object fulfilled the requirements according to CENELEC HD 629.1 S2 02/2006 + A1:2008, table 7, test sequence D1, D2 and additional tests, position 17, 18, 19 and 21.

Karlsruhe, 26.03.2015

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