

PPR-1658

Type Test Report
for
Plug-in Switchgear Termination
for $U_m = 145 \text{ kV}$
PHVS-1450P

Tested by: **Felten & Guilleaume Kabelwerke GmbH**

Date: 16.9.02

Pages: 23

Appendix: —



Type Test Report

Plug-in Switchgear Termination for $U_m = 145$ kV **KSEV 145**

1. Purpose

Tyco Electronics requested Felten & Guillaume Kabelwerke GmbH to carry out a type test on the Plug-in Switchgear Termination up to $U_m = 145$ kV. The plug-in component is designed to fit an insulator for $U_m = 72,5$ and 145 kV. Therefore this type test relates to KSEV 72 and KSEV 145 (identical with Tyco: PHVS-1450P-XX/YY).

2. Plug-in Termination

2.1 Description Insulator

The tested dry-type switchgear termination consists of the insulator and the plug-in part, which is fitted to the cable. The insulator is made of epoxy with an embedded electrode. This gas-leak-proof design does not require installation of additional sealing technology. An insulating ring integrated at the insulator base enables the separation of the cable metal screen from earth.

With an adapter on top all requirements of IEC 60859 are met and the insulator can be pre-installed into the switchgear at the manufacturing site. The insulator is factory tested.

2.2 Description Plug-in Part

The plug-in part consists of the conductor connector, the prefabricated and pre-tested stress cone and the appropriate cable gland. The conductor connector is available either in mechanical connection or crimping technology. Multiple contact elements at the top of the connector stud provide the current connection to the embedded electrode of the insulator housing. The rubber electrical stress cone installed onto the cable insulation limits the electrical stress of the cable insulation and the switchgear housing within the design performance.

2.3 Description Cable Gland

A spring loaded compression device including a sealing of the cable oversheath and switchgear housing is part of the cable gland. The compression device exerts forces on the stress cone to provide occurrence perfect electrical interface fit between cone and insulator housing.



The termination is a dry type version of a switchgear termination. The compact dimensions of the maintenance-free design allow multiple connections and disconnections .

3. Test Set-up

For type testing of the 145 kV plug-in termination a test arrangement was installed with a 15 m long 110 kV XLPE cable with copper conductor of 630 mm² conductor cross section (Annex 2), a test termination and the plug-in termination. The switchgear housing was completed with an outdoor/SF₆ bushing. The bushing and the test termination were connected to form a loop and to facilitate conductor heating. The test arrangement and the position of the thermocouples is shown in annex 3.

4. Test Program

The type test was carried out in accordance with VDE 0276, part 632, edition may 1999 and IEC 60840, edition 1988.

Additional tests were carried out following the "Bewag *)-Vorschrift für 110-kV-VPE-Kabel-und deren Garnituren, Ausgabe TKT 04.98": Short duration AC voltage test and a test at the insulating flange at the insulator with DC voltage and impulse voltage. Both versions of the conductor connection (compression and screwing technique) inside the termination were tested with high current following the VDE 0670 T1000, edition 1998.

*) BEWAG = Berliner E- Werke AG

List of type test program:

- Short duration AC voltage test with 275 kV
- Partial test with 1,5 U₀
- Heating cycle voltage test with 2 U₀
- Impulse voltage test with 650 kV
- AC voltage test with 2,5 U₀
- Partial discharge test with 1,5 U₀
- DC voltage test at the insulating flange with 20 kV
- Impulse voltage test at the insulating flange with 37,5 kV
- High current test

5. Test Procedure

5.1 Short Duration Test

The test was successfully carried out with 275 kV for 1 minute (Annex 4).

5.2 Partial Discharge Test

The partial discharge test was carried out with 1,5 U₀ = 114 kV. At a interference level of 1



pC no discharge from the test installation was detected (Annex 5).

5.3 Heating Cycle Voltage Test

The temperature correlation is given in appendix 6 between conductor temperature and temperature at the outer plastic cable sheath.

With a current of 1600 A the conductor temperature of 95 °C was reached after 6 hours. The temperature was maintained within the limits between 95 to 100 °C for 2 hours. A natural cooling period of 16 hours followed the heating period. The temperature of the outer plastic cable sheath is shown in annex 7 to 10.

The cycle of heating and cooling was carried out 20 times. During the whole test a voltage of 2 U_o was applied (annex 11).

No flashover or breakdown did occur.

5.4 Impulse Voltage Test

The test installation was again heated to a temperature 95 to 100 °C (Annex 12).

The test was carried out with ten positive and ten negative impulses with a peak of 650 kV (Annex 13).

The diagrams are shown in annex 14 and 15.

No breakdown or flashover did occur.

5.5 AC Voltage Test

After the impulse test the test circuit was subjected to an AC voltage of 2,5 U_o = 190 kV for 15 minutes (annex 16).

5.6 Partial Discharge Test

The partial discharge test was carried out with 1,5 U_o = 114 kV. At a interference level of 1 pC no discharge from the test installation was detected (Annex 17).

5.7 DC Voltage Test at the insulating Flange

The insulating flange was tested with a DC voltage of 20 kV for 1 minute (annex 18). The test arrangement passed the test successfully.

5.8 Impulse Voltage Test at the insulating Flange

The impulse voltage test was carried out with ten positive and ten negative impulses with a peak level of each 37,5 kV (annex 19). The test arrangement passed the test successfully.

5.9 High Current Tests

Two complete terminations were installed on a 110 kV cable with a conductor connection in compression and in screwing technique. Both installations were then subjected to a high current test plant. The test were carried out with 50 kA for 1 s , 40 kA for 3 s and with an impulse current of 125 kA for 0,1 s. The test circuit was not damaged dur-



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ing this test (annex 20).

6. Result

The plug-in termination type KSEV-C, version 5.1 has successfully passed all tests according to VDE 0276, part 632, edition may 1999 and IEC 840, edition 1988.

Felten & Guilleaume Kabelwerke GmbH
Development HV Cable Accessories

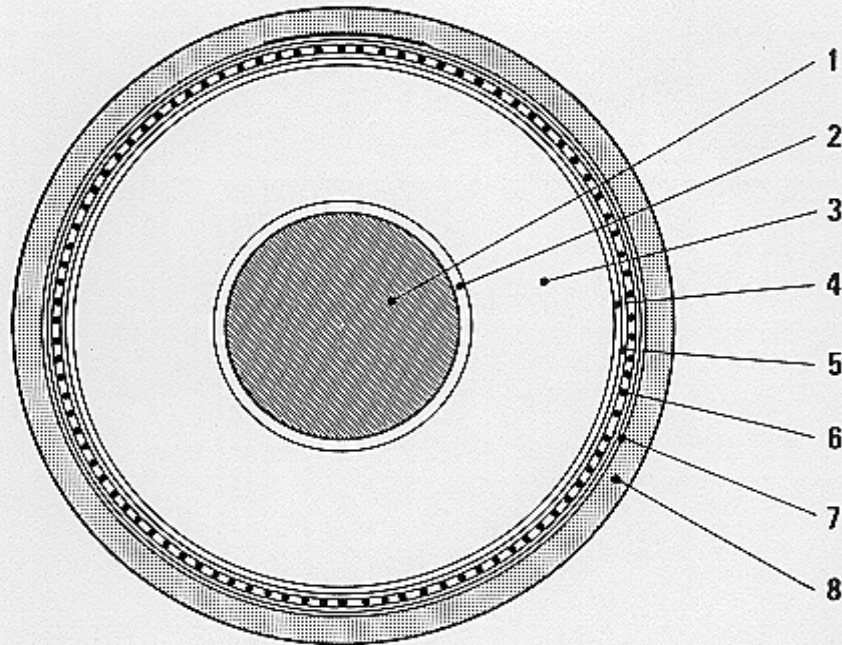
A handwritten signature in blue ink, appearing to read 'Belz'.

Belz

A handwritten signature in blue ink, appearing to read 'Amerpohl'.

Amerpohl

Enclosures



1	conductor size, copper	630 mm ²	
	diameter over conductor	30.0 mm	
2	conductor screen	} triple extruded	
3	XLPE insulation		approx. 1.4 mm
4	insulation screen		18.0 mm
		approx. 1.0 mm	
5	semi-conducting bedding		
6	cross section of copper screen, wires + tape	35 mm ²	
	longitudinally watertight		
7	CWF tape (copper woven fabric tape)		
8	APL sheath consisting of :		
	- coated aluminium tape		
	- PE oversheath, thickness	3.4 mm	
	diameter over completed cable	approx. 83 mm	



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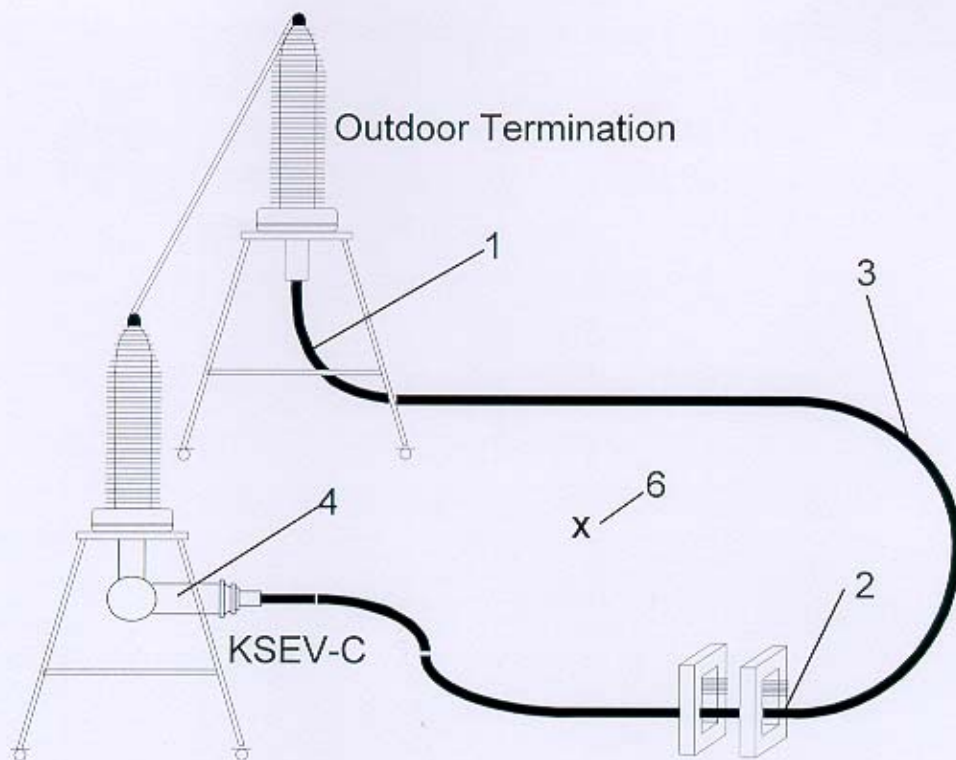
Single Core XLPE Cable
2XS(FL)2Y 1 x 630 RM/35
64 / 110 kV

EHP 8418/2

Scale	: 1 : 1
Drawn	: 23.07.97 <i>ak</i>
Checked	: 23.07.97 <i>ak</i>
Revision	:



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Typetest installation and
Position of the thermocouples

- | | | |
|------------------|---|--|
| Thermocouple No: | 1 | Cable sheath in the near of the outdoor termination |
| | 2 | Cable sheath in the near of the heating transformers |
| | 3 | Cable sheath |
| | 4 | Housing of the switchgear sealing end |
| | 6 | Ambient temperature |

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Test certificate

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AC-Voltage Test

Short duration voltage test

Annex 4

Test : Type Test Plug-in Switchgear Termination for $U_m=145$ kV

Specification : IEC 840, edition 1988

Cable type : N2XS (FL) 2Y 1 x 630 RM / 35 64 / 110 kV

Order No : Length of sample : 15 m

Outdoor-Term. : Test termination Term.-Type : KSEV-C, Version 5.1

Drawing No: ET5 KEW 10208

Switch on		Switch off		Voltage kV	h-counter		Duration of test		Sign
Date	Time	Date	Time		On	Off	h	min	
2.6.98	9.48	2.6.98	9.49	275	0			1	Be

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Partial Discharge Test

Before heating cycle test

Annex 5

Test : Type Test Plug-in Switchgear Termination for $U_m=145$ kV	
Specification : IEC 840, edition 1988	
Cable type : N2XS (FL) 2Y 1 x 630 RM / 35 64 / 110 kV	
Order No :	Length of sample : 15 m
Outdoor Term. : Test termination	Term.-Type : KSEV-C, Version 5.1 Drawing-No: ET5 KEW 10208

Adjustment and calibration of the test circuit

Calibration impulse: 2 pC

- at the cable end remote from the detector 2 pC \pm 10 mm

- at the cable end near the detector _____

Basic interference level < 1 pC \pm 5 mm

Partial discharge measuring

Date	Voltage	Interference level		Partial discharge intensity		Sign
	kV	mm	pC	mm	pC	
2.6.98	114	< 5	< 1	< 5	< 1	Be

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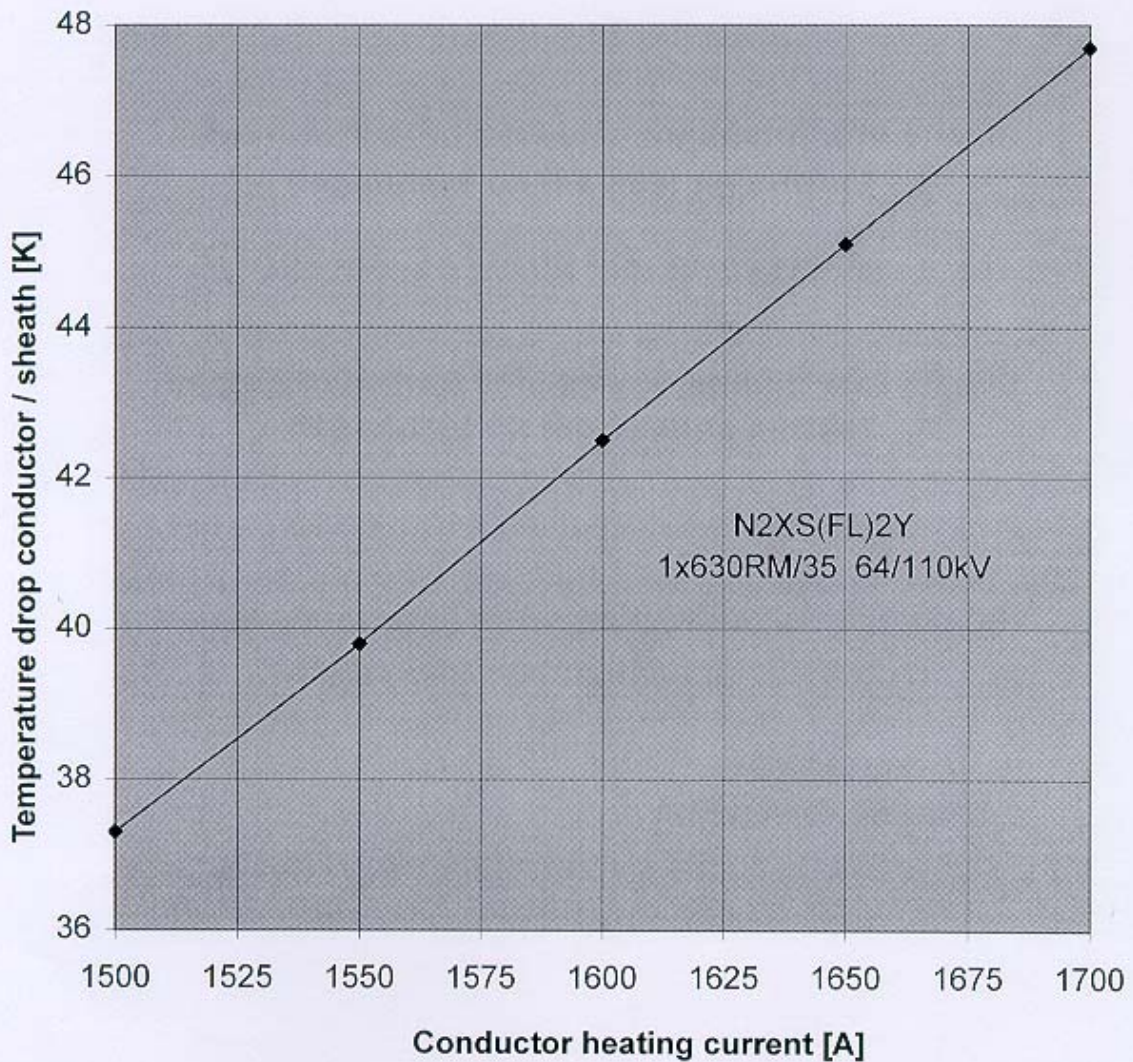


Correlation of the temperature

Annex 6

Test : Type Test Plug-in Switchgear Termination for $U_m=145$ kV	
Specification : IEC 840, edition 1988	
Cable type : N2XS (FL) 2Y 1 x 630 RM / 35 64 / 110 kV	
Order No :	Length of sample : 15 m
Outdoor Term. : Test termination	Term-Type : KSEV-C, Version 5.1 Drawing-No: ET5 KEW 10208

Temperature drop between conductor and sheath dependent on the heating current



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Test certificate



Heating Cycle Test

Heating protocol

Annex 7

Test : Type Test Plug-in Switchgear Termination for $U_m=145$ kV

Specification : IEC 840, edition 1988

Cable type : N2XS (FL) 2Y 1 x 630 RM / 35 64 / 110 kV

Order No : Length of sample : 15 m

Outdoor Term. : Test termination Term.-Type : KSEV-C, Version 5.1

Drawing-No: ET5 KEW 10208

		Sheath temperature at the thermocouple					Ambient-temperature			
Date	Time	Current A	1 °C	2 °C	3 °C	4 °C	6 °C	Heating cycle No	Sign	
5.6.98	7.00	0	21	21	21	21	21	1.	Be	
5.6.98	13.00	1600	55	43	52	34	23		Be	
5.6.98	15.00	1600	57	45	54	35	24		Be	
6.6.98	7.00	0	23	23	23	23	23	2.	Be	
6.6.98	13.00	1600	54	43	52	34	23		Be	
6.6.98	15.00	1600	56	44	53	35	23		Be	
7.6.98	7.00	0	23	23	23	23	23	3.	Be	
7.6.98	13.00	1600	54	42	51	31	22		Be	
7.6.98	15.00	1600	56	43	52	33	21		Be	
8.6.98	7.00	0	22	22	22	22	22	4.	Be	
8.6.98	13.00	1600	52	42	51	31	21		Be	
8.6.98	15.00	1600	53	43	52	32	21		Be	
9.6.98	7.00	0	22	22	22	22	22	5.	Be	
9.6.98	13.00	1600	52	42	50	31	22		Be	
9.6.98	15.00	1600	53	43	51	32	22		Be	
10.6.98	7.00	0	22	22	22	22	22	6.	Be	
10.6.98	13.00	1600	53	42	50	31	22		Be	
10.6.98	15.00	1600	54	43	51	32	22		Be	

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Test certificate



Heating Cycle Test
Heating protocol

Annex 8

Test :	Type Test Plug-in Switchgear Termination for $U_m=145$ kV
Specification :	IEC 840, edition 1988
Cable type :	N2XS (FL) 2Y 1 x 630 RM / 35 64 / 110 kV
Order No :	Length of sample : 15 m
Outdoor Term. :	Test termination
	Term.-Type : KSEV-C, Version 5.1
	Drawing-No: ET5 KEW 10208

		Sheath temperature at the thermocouple					Ambient-temperature			
		Current	1	2	3	4	6	Heating cycle		
Date	Time	A	°C	°C	°C	°C	°C	No	Sign	
11.6.98	7.00	0	21	21	21	21	21	7.	Be	
11.6.98	13.00	1600	54	43	51	32	22		Be	
11.6.98	15.00	1600	55	44	52	33	22		Be	
12.6.98	7.00	0	20	20	20	20	20	8.	Be	
12.6.98	13.00	1600	52	41	50	30	20		Be	
12.6.98	15.00	1600	54	42	51	31	20		Be	
13.6.98	7.00	0	19	19	19	19	19	9.	Be	
13.6.98	13.00	1600	53	41	50	31	20		Be	
13.6.98	15.00	1600	54	42	50	32	20		Be	
14.6.98	7.00	0	19	19	19	19	19	10.	Be	
14.6.98	13.00	1600	52	40	50	31	19		Be	
14.6.98	15.00	1600	53	41	50	32	19		Be	
15.6.98	7.00	0	20	20	20	20	20	11.	Be	
15.6.98	13.00	1600	52	41	50	31	20		Be	
15.6.98	15.00	1600	53	42	51	32	20		Be	
16.6.98	7.00	0	20	20	20	20	20	12.	Be	
16.6.98	13.00	1600	52	41	50	30	20		Be	
16.6.98	15.00	1600	53	42	51	31	20		Be	

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Test certificate



Heating Cycle Test

Heating protocol

Annex 9

Test : Type Test Plug-in Switchgear Termination for $U_m=145$ kV

Specification : IEC 840, edition 1988

Cable type : N2XS (FL) 2Y 1 x 630 RM / 35 64 / 110 kV

Order No : Length of sample : 15 m

Outdoor Term. : Test termination Term.-Type : KSEV-C, Version 5.1

Drawing-No: ET5 KEW 10208

		Sheath temperature at the thermocouple					Ambient-temperature			
		Current	1	2	3	4	6	Heating cycle		
Date	Time	A	°C	°C	°C	°C	°C	No	Sign	
17.6.98	7.00	0	20	20	20	20	20	13.	Be	
17.6.98	13.00	1600	52	41	50	29	20		Be	
17.6.98	15.00	1600	53	42	50	30	20		Be	
18.6.98	7.00	0	20	20	20	20	20	14.	Be	
18.6.98	13.00	1600	51	40	48	29	19		Be	
18.6.98	15.00	1600	52	41	49	30	19		Be	
19.6.98	7.00	0	20	20	20	20	20	15.	Be	
19.6.98	13.00	1600	54	42	50	31	21		Be	
19.6.98	15.00	1600	55	43	51	32	22		Be	
20.6.98	7.00	0	21	21	21	21	20	16.	Be	
20.6.98	13.00	1600	55	42	52	34	23		Be	
20.6.98	15.00	1600	57	44	53	35	23		Be	
21.6.98	7.00	0	23	23	23	23	23	17.	Be	
21.6.98	13.00	1600	54	43	51	32	23		Be	
21.6.98	15.00	1600	56	44	52	33	23		Be	
22.6.98	7.00	0	23	23	23	23	22	18.	Be	
22.6.98	13.00	1600	54	43	51	33	22		Be	
22.6.98	15.00	1600	55	44	52	34	22		Be	

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Test certificate



Impulse Voltage Test
Heating protocol

Annex 12

Test : Type Test Plug-in Switchgear Termination for U_m=145 kV

Specification : IEC 840, edition 1988

Cable type : N2XS (FL) 2Y 1 x 630 RM / 35 64 / 110 kV

Order No : Length of sample : 15 m

Outdoor Term. : Test termination Term.-Type : KSEV-C, Version 5.1

Drawing-No: ET5 KEW 10208

		Sheath temperature at the thermocouple					Ambient-temperature			
		Current	1	2	3	4		6	Heating cycle	
Date	Time	A	°C	°C	°C	°C	°C	°C	No	Sign
17.7.98	2.00	0	21	21	21	21		21		Be
17.7.98	8.00	1600	55	43	52	33		21		Be
17.7.98	10.00	1600	57	45	53	34		22		Be

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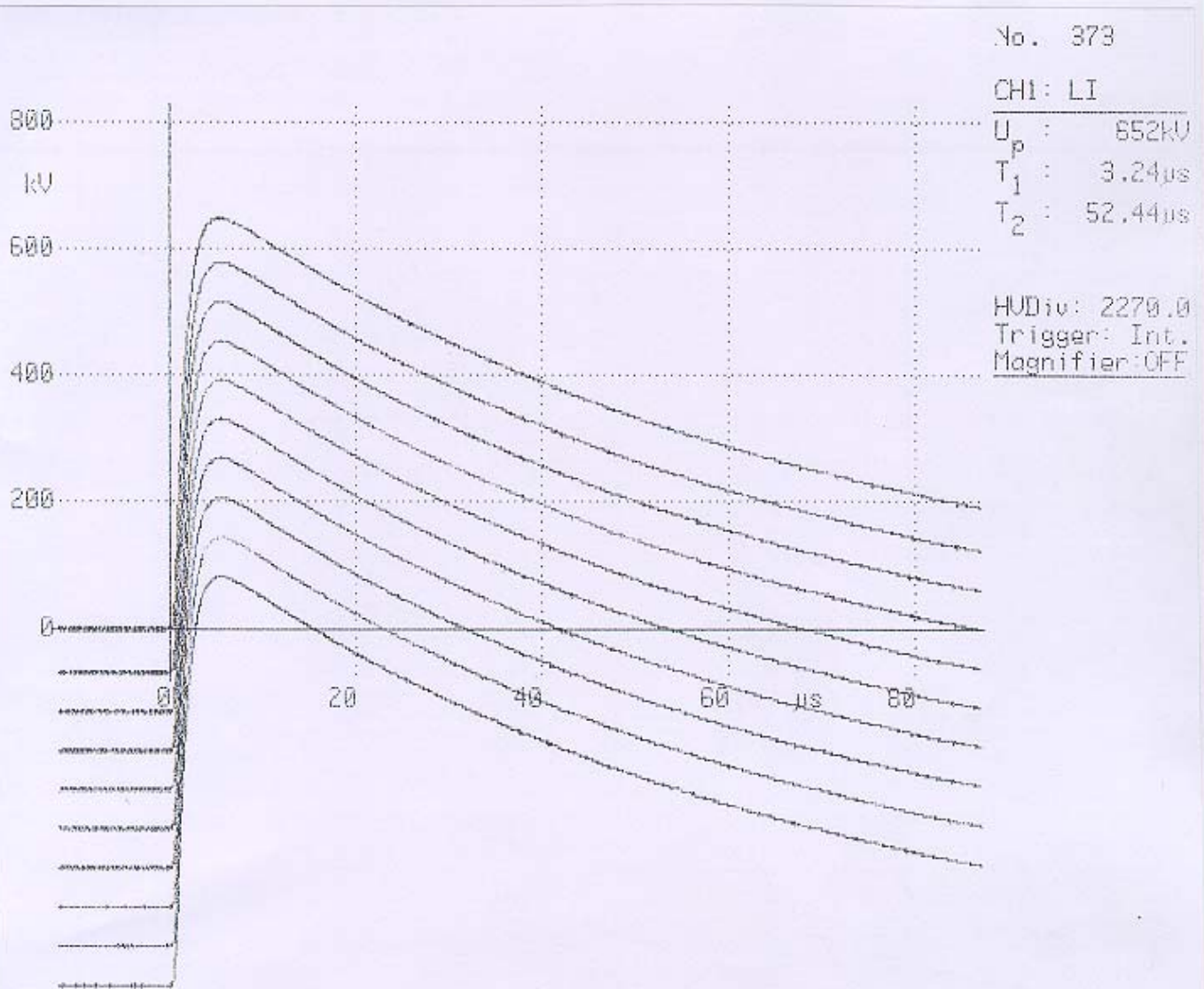


Impulse Voltage Test

Annex 14

Test : Type Test Plug-in Switchgear Termination for $U_m=145$ kV

Specification : IEC 840, edition 1988



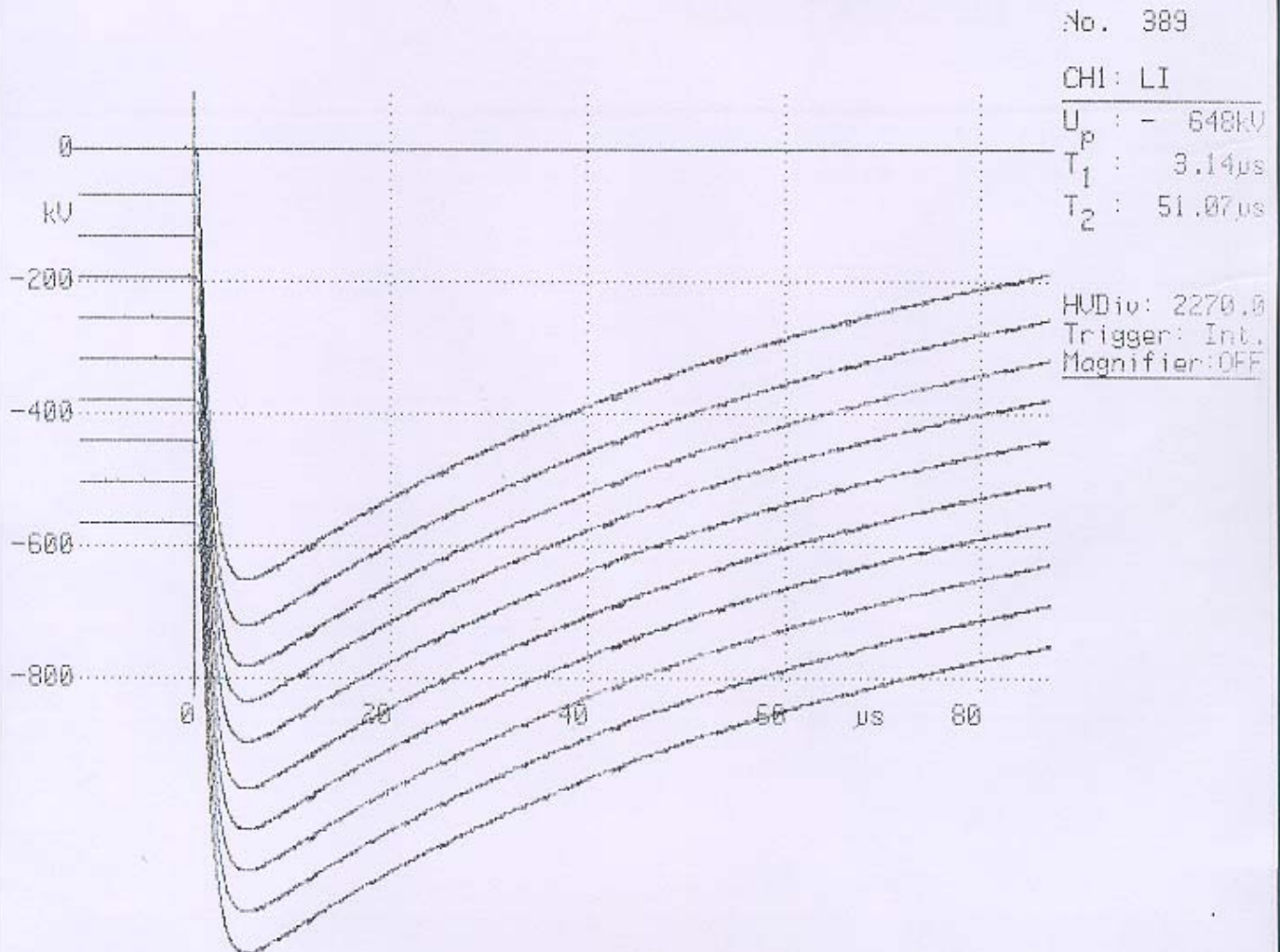


Impulse Voltage Test

Annex 15

Test : Type Test Plug-in Switchgear Termination for $U_m=145$ kV

Specification : IEC 840, edition 1988





AC-Voltage Test
After Impulse voltage test

Annex 16

Test : Type Test Plug-in Switchgear Termination for U_m=145 kV

Specification : IEC 840, edition 1988

Cable type : N2XS (FL) 2Y 1 x 630 RM / 35 64 / 110 kV

Order No :

Length of sample : 15 m

Outdoor-Term. : Test termination

Term.-Type : KSEV-C, Version 5.1

Drawing No: ET5 KEW 10208

Switch on		Switch off		Voltage kV	h-counter		Duration of test		Sign
Date	Time	Date	Time		On	Off	h	min	
17.7.98	12.00	17.7.98	12.15	190	0	0.25		15	Be

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Partial Discharge Test

After Impulse voltage test

Annex 17

Test : Type Test Plug-in Switchgear Termination for $U_m=145$ kV

Specification : IEC 840, edition 1988

Cable type : N2XS (FL) 2Y 1 x 630 RM / 35 64 / 110 kV

Order No : Length of sample : 15 m

Outdoor Term. : Test termination Term.-Type : KSEV-C, Version 5.1

Drawing-No: ET5 KEW 10208

Adjustment and calibration of the test circuit

Calibration impulse: 2 pC

- at the cable end remote from the detector 2 pC \pm 10 mm

- at the cable end near the detector _____

Basic interference level < 1 pC \pm 5 mm

Partial discharge measuring

Date	Voltage kV	Interference level		Partial discharge intensity		Sign
		mm	pC	mm	pC	
20.7.98	114	<5	<1	<5	<1	Be

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DC-Voltage Test

At the insulating flange

Annex 18

Test : Type Test Plug-in Switchgear Termination for $U_m=145\text{ kV}$

Specification : IEC 840, edition 1988

Cable type : N2XS (FL) 2Y 1 x 630 RM / 35 64 / 110 kV

Order No :

Length of sample : 15 m

Outdoor-Term. : Test termination

Term.-Type : KSEV-C, Version 5.1

Drawing No: ET5 KEW 10208

Switch on		Switch off		Voltage kV	h-counter		Duration of test		Sign
Date	Time	Date	Time		On	Off	h	min	
22.7.98	8.10	22.7.98	8.11	20	0			1	Be

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Test certificate

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Impulse Voltage Test

At the insulating flange

Annex 19

Test : Type Test Plug-in Switchgear Termination for $U_m=145$ kV

Specification : IEC 840, edition 1988

Cable type : N2XS (FL) 2Y 1 x 630 RM / 35 64 / 110 kV

Order No :	Length of sample : 15 m
-------------------	--------------------------------

Outdoor Term. : Test termination

Term.-Type : KSEV-C, Version 5.1

Drawing-No: ET5 KEW 10208

Conductor temperature : °C

Date	Charge voltage kV	Impulses number	Impulses counted	Impulse voltage kV	Polarity	Remarks	Sign
22.7.98	20	1		22,8	+		Be
	30	2		33,2	+		
	31,6	3		35	+		
	33,6	4-13	10	37,5	+		
	16	14		15	-		
	21	15		24,2	-		
	26	16		30,5	-		
	33,9	17-26	10	37,5	-		

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Prüfbericht

PB- 8000--068-001

Auftrag Nr.: 9900224

Auftraggeber: Felten & Guillaume Kabelwerke GmbH
Schanzenstr.24
D-51063 Köln

Hersteller: siehe Auftraggeber

Prüfgegenstand: Kompaktendverschluß

Typbezeichnung: 1. Prüfling: Zeichnung 3.7 6501-01
2. Prüfling: Zeichnung 3.7 6501-02

Herstelldatum: .1999


Prüfspezifikation: in Anlehnung an VDE0670T1000:1998

Durchgeführte Prüfungen: Hochstromprüfungen
1) I_{cw}=40kA, 1sek; I_{pk}=100kA, 100msek
2) I_{cw}=50kA, 1sek; I_{pk}=125kA, 100msek
3) I_{cw}=40kA, 3sek

Prüfergebnis: bestanden

Seitenzahl gesamt: 89 (1 Deckblatt, 86 Dokumentationsseiten, 2 Anlagen)

Ausstelldatum: 16.03.1999



Leiter Prüflaboratorium Bonn



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