Приложение № 6

ПРИЛОЖЕНИЯ КЪМ ПРИЛОЖЕНИЕ № 3

КЪМ ДОГОВОР ЗА ОБЩЕСТВЕНА ПОРЪЧКА ЗА ПОДМЯНА НА МАСЛОНАПЪЛНЕНА КАБЕЛНА ЕЛЕКТРОПРОВОДНА ЛИНИЯ 110 KV „ЕНОС" ОТ ЛИНЕЕН НОЖОВ РАЗЕДИНИТЕЛ 110 KV НА ПС „ДИМИТЪР ДИМИТРОВ" ДО ЛИНЕЕН НОЖОВ РАЗЕДИНИТЕЛ 110 KV В ПС „ХИПОДРУМА

1. КАТАЛОЖНИ ДАННИ КЪМ ПРИЛОЖЕНИЕ № 2;
2. КАТАЛОЖНИ ДАННИ КЪМ ПРИЛОЖЕНИЕ № 3;
3. ПРИЛОЖЕНИЕ № 7;
4. ПРИЛОЖЕНИЕ № 8.

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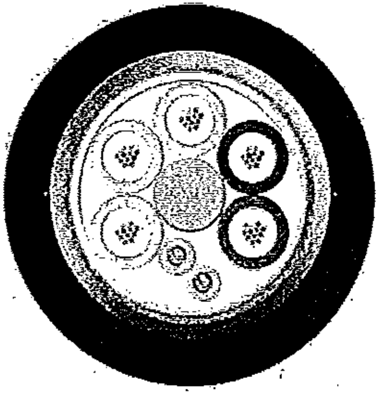
Hybrid cable

A-DSF(ZN)(L)2Y + Cu 0.8

Loose tube construction, jelly filled cable core, watertight, rodent protection, Aluminium-PE-composite-layer sheath, copper pair ø 0,8 mm



tube diameter mm	number of tubes	max. fibers / tube	max. number of fibers	tensile strenght approx. N	weight approx. kg/km	outer diameter approx. mm
2.6	5	12	60	2.000	175	14.5
2.4	6	12	72	2.000	185	[illegible]
2.4	8	12	96	2.500	230	16.8
2.4	[illegible]	12	120	3.000	280	18.6
2.4	12	12	144	3.500	340	20.5
2.8	5	24	120	2.000	180	14.3
2.8	6	24	144	2.000	195	15.0
2.8	8	24	192	2.500	235	16.8
2.8	10	24	240	3.000	290	18.6
2.8	12	24	288	3.500	350	20.5

* at lower number of tubes corresponding blind elements are used

Application
Suited for outdoor use - for fixed laying in cable ducts, conduits or direct burial

Construction
- FRP-central element
- jelly-filled loose tubes + 1 copper pair (Ø 0,8 mm)
- SZ-cabling (if necessary with fillers)
- jelly-filled cable core (petrol jelly)
- strength members (swellable aramid yarns)
- Aluminium-PE-composite-layer-sheath (1,5 mm), UV-resistant, black

Fiber colours
PENGG KABEL standard according to page 87 - or upon customer requirements other color codes (DIN, TIA / EIA-598 (MPO), IEC - see page 87)

Tube colours
PENGG KABEL standard according to page 88 - or upon customer requirements other color codes (DIN, TIA / EIA-598 (MPO), IEC - see page 88)

Standard marking:
double-sinus, phone-sign, meter marking, PENGG KABEL, year of manufacturing - with hot-foil stamping

On request
- construction with 2 cores or 1 quad
- constrution with several copper elements
- dry-filled cable core
- increased tensile strength
- increased sheath thickness
- other sheath colours
- coloured stripes
- HDPE or LDPE sheath
- other marking

Technical data

tensile strength	according to IEC 60794-1-E1 value: see above table
compressive strength (crush)	according to IEC 60794-1-E3 value: 3000 N/10 cm
impact	according to IEC 60794-1-E4 value: 25 Nm
torsion	according to IEC 60794-1-E7 value: 5 cycles ±1 turn
kink, cable	according to IEC 60794-1-E10 value: The cable do not form a kink when a loop is drawn together to a diameter 12 times the cable outer diameter.
kink, tube	according to IEC 60794-1-E16 value: The tube do not kink.
min. bending radius	according to IEC 60794-1-E11 Wert: R = 20 x D (Kabelaußen-)
temperature range	according to IEC 60794-1-F1 storage and transport: -40°C up to +70°C installation: -5°C up to +60°C operation: -25°C up to +70°C
water penetration	according to IEC 60794-1-F5 value: No water on free end.

Hybrid cables

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С Е Р Т И Ф И К А Т

Сертификационният орган
TÜV SÜD Management Service GmbH

удостоверява, че

SÜDKABEL GmbH
Rhenaniastrasse 12-30
68199 Mannheim
Германия

е въвела и прилага система за управление на качеството и околната среда по следните приложения :

Разработване, производство, доставка и монтаж на силови кабели и арматура за силови кабели 10 – 550 kV.

Извършването на одити (Доклад- № 70760382) представи доказателства, че изискванията по :

ISO 9001: 2008
ISO 14001:2004

са изпълнени. Този сертификат е валиден от **2016-03-02** до **2019-02-06**
Регистрационен номер на сертификата № **12 100/104 37712 TMS**

ВЯРНО С ОРИГИНАЛА

"ЕВРОКАБЕЛ" СОФИЯ ООД

Мюнхен, 2016-03-03

Е. Панайотов

ВЯРНО С ОРИГИНАЛА

ООД РУДИН Стара Загора

ZERTIFIKAT ■ CERTIFICATE ■ 認證證書 ■ СЕРТИФИКАТ ■ CERTIFICADO ■ CERTIFICAT

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Management Service

CERTIFICATE

The Certification Body
of TÜV SÜD Management Service GmbH

certifies that

SÜDKABEL

Südkabel GmbH

Rhenaniastrasse 12-30
68199 Mannheim
Germany

has established and applies
a Quality and Environmental Management System
for the following scope of application:

Development, manufacturing, installation
and supply of power cables and power
cable accessories 10 - 550 kV.

Performance of audits (Report No. 70760382)
has furnished proof that the requirements under:

ISO 9001:2015
ISO 14001:2015

are fulfilled.

The certificate is valid from **2016-03-02** until **2019-02-06**.

Certificate Registration No.: **12 100/104 37712 TMS.**

Product Compliance Management
Munich, 2016-03-03

DAkkS
Deutsche Akkreditierungsstelle
D-ZM-14143-01-03
D-ZM-14143-01-04

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Management Service

ZERTIFIKAT ■ CERTIFICATE ■ 認證證書 ■ СЕРТИФИКАТ ■ CERTIFICADO ■ CERTIFICAT

ZERTIFIKAT

Die Zertifizierungsstelle
der TÜV SÜD Management Service GmbH

bescheinigt, dass das Unternehmen

SÜDKABEL

Südkabel GmbH

Rhenaniastrasse 12-30
68199 Mannheim
Deutschland

für den Geltungsbereich

Entwicklung, Produktion, Montage
und Vertrieb von Starkstromkabeln und
Starkstromkabel-Garnituren 10 - 550 kV

ein Qualitäts- und Umweltmanagementsystem
eingeführt hat und anwendet.

Durch Audits, dokumentiert im Auditbericht (Bericht-Nr. 70760382),
wurde der Nachweis erbracht, dass diese Managementsysteme
die Forderungen folgender Normen erfüllen:

ISO 9001:2015
ISO 14001:2015.

Dieses Zertifikat ist gültig vom **2016-03-02** bis **2019-02-06**.

Zertifikat-Registrier-Nr.: **12 100/104 37712 TMS**.

Product Compliance Management
München, 2016-03-03

DAkkS
Deutsche Akkreditierungsstelle
D-ZM-14143-01-03
D-ZM-14143-01-04

Стара Загора

ПРИЛОЖЕН РЕФЕРЕНТЕН СПИСЪК НА SUDKABEL GmbH, Германия

за периода от 1973г. до 2015г.

SÜDKABEL

Reference List of High Voltage **XLPE** Cable Systems from 1973 to 2015

Referenzliste **VPE**-Hochspannungskabelanlagen von 1973 bis 2015

Year Jahr	Customer Kunde	Country Land	Voltage Spannung kV	cross section Querschnitt mm^2		length (core) Aderlänge m
1973	Stadtwerke Karlsruhe	Germany	123	1x 240	Cu	510
1974	Stadtwerke München	Germany	123	1x 240	Cu	99
1975	Bayerische Electrizitäts-Lieferungs-Gesellschaft AG	Germany	123	1x 240	Cu	5.997
1975	Stadtwerke Frankfurt	Germany	123	1x 240	Cu	291
1975	Stadtwerke Karlsruhe	Germany	123	1x 240	Cu	150
1975	Bewag, Berlin	Germany	123	1x 300	Cu	252
1975	Neckarwerke	Germany	123	1x 400	Al	2.262
1975	BBC, Mannheim	Iran	72.5	1x 185	Cu	3.840
1975	BBC, Mannheim	Greece	72.5	1x 300	Cu	786
1975	BBC, Mannheim	Brazil	72.5	1x 400	Cu	510
1976	Isar-Amperwerke	Germany	123	1x 185	Cu	279
1976	Energieversorgung Schwaben	Germany	123	1x 400	Al	136
1976	Compania de Electricidade de Macau	Macau	72.5	1x 150	Cu	25.500
1976	Compania de Electricidade de Macau	Macau	72.5	1x 300	Cu	16.500
1976	Compania de Electricidade de Macau	Macau	72.5	1x 400	Cu	57.000
1976	Dietz, München	Taiwan	72.5	1x 240	Cu	900
1976	FISIPE, Lissabon	Portugal	123	1x 185	Cu	816
1976	BBC, Mannheim	China	123	1x 240	Cu	650
1977	Stadtwerke Neumünster	Germany	72.5	1x 185	Cu	7.185
1977	Stadtwerke Karlsruhe	Germany	123	1x 240	Cu	139
1977	Energieversorgung Schwaben	Germany	123	1x 300	Cu	482
1977	VEW	Germany	123	1x 400	Al	424
1977	BBC, Mannheim	Iran	72.5	1x 185	Cu	180
1977	BBC, Mannheim	Iran	72.5	1x 500	Cu	1.200
1977	EW Helsinki	Finland	123	1x 185	Cu	462
1977	BBC, Mannheim	Abu-Dhabi	145	1x 500	Cu	900
1977	SAG	Abu-Dhabi	145	1x 500	Cu	500
1978	BBC, Baden	Romania	123	1x 240	Cu	6.500
1978	BBC, Baden	Iran	145	1x 150	Cu	1.950
1978	BBC, Mannheim	Pakistan	145	1x 240	Cu	2.502
1978	BBC, Baden	Saudi Arabia	145	1x 300	Cu	3.100
1978	WED	Abu-Dhabi	145	1x 500	Cu	11.267
1979	Stadtwerke Neumünster	Germany	72.5	1x 185	Cu	4.047
1979	Nordwestdeutsche Kraftwerke	Germany	72.5	1x 240	Cu	528
1979	Elektizitätswerke Heilbronn	Germany	72.5	1x 400	Al	378
1979	ICI Wilhelmshaven	Germany	72.5	1x 500	Cu	765
1979	Kraftwerk Laufenburg	Germany	123	1x 185	Cu	389
1979	Neckarwerke	Germany	123	1x 400	Cu	8.403
1979	Energieversorgung Schwaben	Germany	123	1x 630	Cu	1.745
1979	Elektrim Warzaw	Poland	123	1x 150	Cu	16.000
1979	Centrozap, Kattowitz	Poland	123	1x 185	Cu	22.500
1980	Maximilianshütte	Germany	45	1x 240	Cu	914
1980	Kali & Salz	Germany	72.5	1x 240	Cu	140
1980	Energieversorgung Schwaben	Germany	123	1x 240	Cu	7.400

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ООД

SÜDKABEL GmbH
Mannheim, Germany

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Year Jahr	Customer Kunde	Country Land	Voltage Spannung kV	cross section Querschnitt mm^2		length (core) Aderlänge m
1980	Energieversorgung Schwaben	Germany	123	1x 300	Cu	242
1980	Stadtwerke Karlsruhe	Germany	123	1x 240	Cu	151
1980	Nordwestdeutsche Kraftwerke	Germany	123	1x 300	Cu	3.945
1980	Neckarwerke	Germany	123	1x 400	Cu	9.283
1980	BBC, Mannheim	Germany	123	1x 500	Al	7.968
1980	Energieversorgung Schwaben	Germany	123	1x 630	Cu	701
1980	BBC, Mannheim	Chile	123	1x 400	Cu	1.003
1980	Elektrim, Warzaw	Poland	123	1x 400	Cu	10.000
1980	BBC, Mannheim	Irak	145	1x 185	Cu	2.028
1981	Neckarwerke	Germany	123	1x 400	Cu	3.594
1981	Energieversorgung Schwaben	Germany	123	1x 630	Cu	2.223
1981	BBC, Mannheim	Egypt	72.5	1x 240	Cu	1.110
1981	BBC, Mannheim	Philippines	72.5	1x 240	Cu	405
1981	PNEM	Netherlands	123	1x 185	Cu	161
1981	BBC, Mannheim	China	123	1x 300	Cu	6.000
1981	BBC, Mannheim	Chile	123	1x 400	Cu	500
1981	Royal Commission	Saudi Arabia	123	1x 300	Cu	17.130
1981	Royal Commission	Saudi Arabia	123	1x 800	Cu	12.360
1981	BBC, Baden	Saudi Arabia	145	1x 300	Cu	1.100
1981	MECO, München	Abu Dhabi	145	1x 500	Cu	4.074
1981	BBC, Baden	Jordan	145	1x 800	Cu	483
1981	BBC, Mannheim	Philippines	145	1x 240	Cu	1.504
1982	BBC, Mannheim	Germany	123	1x 300	Cu	160
1982	BBC, Mannheim	Germany	123	1x 400	Cu	270
1982	Bewag, Berlin	Germany	123	1x 630	Cu	5.856
1982	BBC, Mannheim	Libya	72.5	1x 500	Cu	1.500
1982	BBC, Baden	Egypt	72.5	1x 630	Cu	3.000
1982	BBC, Mannheim	Libya	72.5	1x 630	Cu	1.750
1982	Elektroexportimport	Romania	123	1x 630	Al	1.200
1982	BBC, Mannheim	Iraq	145	1x 185	Cu	150
1982	BBC, Mannheim	Saudi Arabia	145	1x 300	Cu	2.100
1982	BBC, Mannheim	Pakistan	145	1x 630	Cu	405
1982	BBC, Mannheim	Saudi Arabia	145	1x 630	Cu	8.995
1982	BBC, Baden	Jordan	145	1x 800	Cu	269
1983	Stadtwerke München	Germany	123	1x 240	Cu	163
1983	Stadtwerke Karlsruhe	Germany	123	1x 240	Cu	1.330
1983	Neckarwerke	Germany	123	1x 400	Cu	2.010
1983	Badenwerk	Germany	123	1x 500	Cu	4.722
1983	BBC, Mannheim	Liberia	72.5	1x 300	Cu	540
1983	BBC, Hong Kong	Macau	72.5	1x 300	Cu	320
1983	BBC, Mannheim	Cyprus	72.5	1x 300	Cu	815
1983	BBC, Mannheim	Libya	72.5	1x 400	Cu	5.002
1983	BBC, Mannheim	Egypt	72.5	1x 500	Cu	1.506
1983	BBC, Mannheim	Libya	72.5	1x 500	Cu	2.546

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Year Jahr	Customer Kunde	Country Land	Voltage Spannung kV	cross section Querschnitt mm^2		length (core) Aderlänge m
1983	BBC, Mannheim	Libya	72.5	1x 630	Cu	2.130
1983	BBC, Hong Kong	Macau	72.5	1x 630	Cu	470
1983	BBC, Hong Kong	Macau	72.5	1x 800	Cu	850
1983	Meco, München	Iraq	145	1x 185	Cu	1.260
1983	BBC, Mannheim	Iraq	145	1x 185	Cu	500
1983	BBC, Mannheim	Saudi Arabia	145	1x 240	Cu	3.277
1983	BBC, Mannheim	Abu Dhabi	145	1x 500	Cu	4.944
1983	BBC, Mannheim	Saudi Arabia	145	1x 630	Cu	1.566
1983	NEB, Kuala Lumpur	Malaysia	145	1x 630	Cu	35.730
1984	Energieversorgung Schwaben	Germany	123	1x 300	Cu	1.572
1984	Neckarwerke	Germany	123	1x 400	Cu	7.742
1984	Stadtwerke Mannheim	Germany	123	1x 400	Cu	909
1984	Stadtwerke München	Germany	123	1x 400	Cu	148
1984	BBC, Mannheim	Guinea	72.5	1x 185	Cu	4.446
1984	BBC, Baden	Egypt	72.5	1x 500	Cu	1.800
1984	BBC, Mannheim	Libya	72.5	1x 500	Cu	500
1984	BBC, Mannheim	Indonesia	72,5	1x 800	Cu	1.836
1984	BBC, Mannheim	Bulgaria	123	1x 185	Cu	300
1984	BBC, Mannheim	Venezuela	123	1x 240	Cu	300
1984	BBC, Mannheim	Jordan	145	1x 500	Cu	2.230
1984	SCECO, Riyadh	Saudi Arabia	145	1x 300	Cu	300
1984	SCECO, Riyadh	Saudi Arabia	145	1x 630	Cu	500
1985	Stadtwerke München	Germany	123	1x 240	Cu	265
1985	Bewag, Berlin	Germany	123	1x 630	Cu	1.335
1985	Neckarwerke	Germany	123	1x 400	Cu	8.511
1985	Neckarwerke	Germany	123	1x 800	Cu	1.122
1985	MECO, München	Thailand	72.5	1x 95	Al	4.350
1985	BBC, Mannheim	Syria	72.5	1x 300	Cu	213
1985	Tavanir, Teheran	Iran	72.5	1x 185	Al	2.000
1985	Hellenic Aspropyrgos Refinery	Greece	170	1x 240	Cu	6.040
1985	BBC, Mannheim	Indonesia	170	1x 240	Cu	3.570
1986	Kali & Salz	Germany	72.5	1x 300	Cu	185
1986	Energieversorgung Schwaben	Germany	123	1x 240	Cu	2.265
1986	Kraftwerk Laufenburg	Germany	123	1x 240	Cu	2.925
1986	Neckarwerke Esslingen	Germany	123	1x 400	Cu	14.400
1986	Bewag, Berlin	Germany	123	1x 360	Cu	1.554
1986	Großkraftwerk Mannheim	Germany	123	1x 1600	Cu	186
1986	Neckarwerke	Germany	123	1x 1600	Cu	6.950
1986	BBC, Mannheim	Indonesia	72,5	1x 800	Cu	1.320
1986	NEB Kuala Lumpur	Malaysia	145	1x 400	Cu	85.154
1987	BBC, Mannheim	Germany	72.5	1x 185	Al	1.860
1987	Energieversorgung Schwaben	Germany	123	1x 240	Cu	1.738
1987	Stadtwerke Karlsruhe	Germany	123	1x 240	Cu	200
1987	Stadtwerke Neumünster	Germany	123	1x 240	Cu	6.726

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Year Jahr	Customer Kunde	Country Land	Voltage Spannung kV	cross section Querschnitt mm²		length (core) Aderlänge m
1987	Stadtwerke Karlsruhe	Germany	123	1x 300	Cu	110
1987	Neckarwerke	Germany	123	1x 400	Cu	7.200
1987	PWA Waldhof	Germany	123	1x 400	Cu	1.875
1987	Energieversorgung Schwaben	Germany	123	1x 630	Cu	5.840
1987	Kraftwerk Laufenburg	Germany	123	1x 630	Cu	4.611
1987	Badenwerk	Germany	123	1x 240	Al	600
1987	Electric Power Corp., Rangoon	Burma	72.5	1x 500	Cu	62.200
1987	BBC, Mannheim	Egypt	72.5	1x 300	Cu	250
1987	BBC, Mannheim	Indonesia	72,5	1x 800	Cu	496
1987	SCECO, Jeddha	Saudi Arabia	123	1x 1600	Cu	2.400
1987	BBC, Johannesburg	South Africa	145	1x 500	Cu	1.053
1987	BBC, Johannesburg	South Africa	145	1x 1000	Cu	624
1987	Civilco Contracting Comp., Muscat	Oman	145	1x 1200	Cu	1.300
1987	BBC, Mannheim	Greece	170	1x 400	Cu	320
1987	BBC, Mannheim	Turkey	170	1x 400	Cu	1.254
1988	Bewag, Berlin	Germany	123	1x 630	Cu	3.351
1988	Energieversorgung Schwaben	Germany	123	1x 240	Cu	277
1988	Kraftwerke Mainz-Wiesbaden	Germany	123	1x 500	Cu	930
1988	Neckarwerke	Germany	123	1x 800	Cu	17.872
1988	Badenwerk	Germany	123	1x 240	Al	300
1988	Bayernwerk	Germany	245	1x 800	Cu	429
1988	ABB, Mannheim	USA	123	1x 300	Cu	2.100
1988	ABB, Mannheim	Saudi Arabia	145	1x 300	Cu	570
1989	Badenwerk	Germany	123	1x 240	Cu	578
1989	Neckarwerke	Germany	123	1x 240	Cu	789
1989	Bayernwerk	Germany	123	1x 300	Al	3.442
1989	Neckarwerke	Germany	123	1x 400	Cu	12.418
1989	Badenwerk	Germany	123	1x 500	Cu	1.299
1989	Badenwerk	Germany	123	1x 630	Cu	599
1989	Badenwerk	Germany	123	1x 1000	Cu	1.144
1989	ABB, Mannheim	Italy	72.5	1x 240	Cu	1.500
1989	ABB, Mannheim	Egypt	72.5	1x 300	Cu	8.250
1989	ABB, Mannheim	Egypt	72.5	1x 1200	Cu	430
1989	GAC Nokosia	Cyprus	72.5	1x 300	Cu	900
1989	ABB, Baden	Saudi Arabia	145	1x 300	Cu	646
1989	ABB, Mannheim	Saudi Arabia	145	1x 630	Cu	6.000
1989	ABB, Riyadh	Saudi Arabia	145	1x 1000	Cu	1.200
1989	ABB, North Brunswick	USA	145	1x 240	Cu	230
1990	EW Mittelbaden	Germany	123	1x 185	Cu	8.475
1990	Energieversorgung Schwaben	Germany	123	1x 240	Cu	258
1990	Neckarwerke	Germany	123	1x 240	Cu	299
1990	Badenwerk	Germany	123	1x 400	Cu	1.305
1990	Isar-Amperwerke	Germany	123	1x 400	Cu	61.635
1990	Neckarwerke	Germany	123	1x 400	Cu	3.060

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SÜDKABEL GmbH
Mannheim, Germany

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Reference List of High Voltage **XLPE** Cable Systems from 1973 to 2015
Referenzliste **VPE**-Hochspannungskabelanlagen von 1973 bis 2015

Year Jahr	Customer Kunde	Country Land	Voltage Spannung kV	cross section Querschnitt mm²		length (core) Aderlänge m
1990	Energieversorgung Schwaben	Germany	123	1x 800	Cu	1.124
1990	Bewag, Berlin	Germany	123	1x 240	Al	500
1990	UHDE, Dortmund	Egypt	72.5	1x 300	Cu	1.125
1990	ABB, Hong Kong	China	123	1x 240	Cu	320
1990	China Metallurgical	China	123	1x 240	Cu	800
1990	ABB, North Brunswick	USA	123	1x 240	Al	915
1990	ABB, Mannheim	Dubai	145	1x 300	Cu	1.143
1990	ABB, Baden	Hawaii, USA	123	1x 400	Cu	1.004
1990	ABB, Wien	Austria	123	1x 400	Cu	135
1991	Neckarwerke	Germany	123	1x 240	Cu	1.217
1991	Energieversorgung Schwaben	Germany	123	1x 240	Cu	175
1991	Stadtwerke Heidelberg	Germany	123	1x 240	Cu	131
1991	Neckarwerke	Germany	123	1x 400	Cu	17.284
1991	Großkraftwerk Mannheim	Germany	123	1x 500	Cu	3.771
1991	Bewag, Berlin	Germany	123	1x 630	Cu	175
1991	Energieversorgung Schwaben	Germany	123	1x 800	Cu	219
1991	BASF	Germany	123	1x 800	Cu	412
1991	Neckarwerke	Germany	123	1x 800	Cu	26.912
1991	ABB, Mannheim	Angola	72.5	1x 300	Cu	600
1991	SAE Sadelmi	St. Lucia	72.5	1x 185	Cu	3.293
1991	ABB, Mannheim	Greece	72.5	1x 400	Cu	320
1991	ABB, Monmouth	USA	123	1x 400	Cu	4.723
1991	ABB, Mannheim	Dubai	145	1x 400	Cu	1.000
1991	ABB, Riyadh	Saudi Arabia	145	1x 400	Cu	350
1991	ABB, Kuala Lumpur	Malaysia	145	1x 400	Cu	4.510
1991	Salzburger Aktiengesellschaft	Austria	145	1x 500	Cu	18.280
1991	ABB, Baden	Great Britain	145	1x 800	Cu	750
1991	ABB, Montreal	Canada	170	1x 400	Cu	3.274
1992	Badenwerk	Germany	123	1x 185	Cu	2.140
1992	Großkraftwerk Mannheim	Germany	123	1x 240	Cu	1.035
1992	Neckarwerke	Germany	123	1x 240	Cu	2.015
1992	WEMAG	Germany	123	1x 240	Cu	1.500
1992	Badenwerk	Germany	123	1x 630	Cu	9.096
1992	Neckarwerke	Germany	123	1x 800	Cu	4.612
1992	Badenwerk	Germany	123	1x 1000	Cu	1.245
1992	Neckarwerke	Germany	123	1x 1600	Cu	871
1992	Badenwerk	Germany	245	1x 630	Cu	5.058
1992	ABB, Kuala Lumpur	Malaysia	145	1x 500	Cu	780
1992	ABB, Kuala Lumpur	Malaysia	145	1x 630	Cu	20.978
1992	ABB, Baden	Greece	170	1x 400	Cu	3.000
1992	ABB, Kuala Lumpur	Malaysia	300	1x 800	Al	4.030
1993	Thyssen	Germany	123	1x 240	Al	880
1993	ABB, Mannheim	Germany	123	1x 300	Cu	1.122
1993	Bayernwerk	Germany	123	1x 300	Cu	1.320

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Reference List of High Voltage **XLPE** Cable Systems from 1973 to 2015
Referenzliste **VPE**-Hochspannungskabelanlagen von 1973 bis 2015

Year Jahr	Customer Kunde	Country Land	Voltage Spannung kV	cross section Querschnitt mm^2		length (core) Aderlänge m
1993	ÜW Unterfranken	Germany	123	1x 300	Cu	3.535
1993	Stadtwerke Mannheim	Germany	123	1x 500	Cu	5.982
1993	BASF, Ludwigshafen	Germany	123	1x 630	Cu	1.514
1993	ABB, Cottbus	Germany	123	1x 1000	Cu	10.860
1993	Badenwerk	Germany	123	1x 1200	Cu	480
1993	ABB, Wien	Austria	123	1x 500	Cu	18.576
1993	Energetik, Warzawa	Poland	123	1x 630	Cu	27.000
1993	ABB	Saudi Arabia	145	1x 400	Cu	250
1993	ABB, Kuala Lumpur	Malaysia	145	1x 630	Cu	2.295
1993	ABB	Saudi Arabia	145	1x 1000	Cu	4.060
1993	ABB	Saudi Arabia	145	1x 1200	Cu	18.750
1993	ABB, Mannheim	Pakistan	245	1x 630	Al	11.104
1994	Badenwerk	Germany	123	1x 240	Cu	1.835
1994	ABB, Mannheim	Germany	123	1x 240	Cu	120
1994	Stadtwerke München	Germany	123	1x 240	Cu	675
1994	ÜW Unterfranken	Germany	123	1x 300	Cu	3.303
1994	Thüringer Energie	Germany	123	1x 400	Cu	1.888
1994	Stadtwerke Mannheim	Germany	123	1x 500	Cu	7.041
1994	Bewag, Berlin	Germany	123	1x 630	Cu	7.095
1994	Badenwerk	Germany	123	1x 630	Cu	676
1994	Badenwerk	Germany	123	1x 1200	Cu	1.035
1994	VEBA Kraftwerke Ruhr	Germany	123	1x 1400	Cu	5.403
1994	ABB, Ratingen	Mozambique	72.5	1x 185	Al	270
1994	EAC Nikosia	Cyprus	72.5	1x 300	Cu	1.990
1994	ABB, Mannheim	Indonesia	72.5	1x 800	Cu	588
1994	ABB, Wien	Austria	123	1x 500	Cu	2.508
1994	ELBUD, Warzaw	Poland	145	1x 800	Cu	1.090
1994	ABB	Saudi Arabia	145	1x 400	Cu	600
1994	Deutsche Babcock	Abu Dhabi	145	1x 500	Cu	9.300
1994	ABB	Saudi Arabia	145	1x 1000	Cu	3.600
1995	ABB, Mannheim	Germany	123	1x 185	Cu	3.366
1995	Neckarwerke	Germany	123	1x 240	Cu	1.503
1995	ABB, Mannheim	Germany	123	1x 300	Cu	117
1995	ABB, Nürnberg	Germany	123	1x 300	Cu	640
1995	RWE Energie	Germany	123	1x 300	Cu	4.344
1995	ABB, Dresden	Germany	123	1x 630	Cu	2.703
1995	Preussag Stahl	Germany	123	1x 630	Cu	8.110
1995	Bewag, Berlin	Germany	123	1x 630	Cu	11.844
1995	Neckarwerke	Germany	123	1x 800	Cu	22.243
1995	RWE Energie	Germany	245	1x 630	Cu	15.138
1995	ABB	Saudi Arabia	72.5	1x 1200	Cu	900
1995	MEW Oman	Oman	145	1x 2000	Cu	1.870
1995	ABB, Mannheim	Hungary	123	1x 240	Cu	450
1995	ABB, Halle	Kazakhstan	123	1x 630	Cu	1.070

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Year Jahr	Customer Kunde	Country Land	Voltage Spannung kV	cross section Querschnitt mm²		length (core) Aderlänge m
1995	ABB, Lodz	Poland	123	1x 800	Cu	2.355
1995	Stadtwerke Klagenfurt	Austria	123	1x 240	Cu	255
1995	ABB, Mannheim	Oman	145	1x 240	Cu	2.040
1995	ABB	Saudi Arabia	245	1x 800	Cu	850
1995	TNB, Kuala Lumpur	Malaysia	300	1x 800	Cu	1.920
1996	Stadtwerke Heidelberg	Germany	123	1x 240	Cu	578
1996	Braunschweigische Kohlen-Bergwerke	Germany	123	1x 240	Cu	600
1996	Neckarwerke	Germany	123	1x 300	Cu	1.279
1996	ABB, Mannheim	Germany	123	1x 300	Cu	2.400
1996	Energieversorgung Gera	Germany	123	1x 400	Cu	11.431
1996	BASF	Germany	123	1x 630	Cu	6.235
1996	ABB, Mannheim	Germany	123	1x 800	Cu	3.618
1996	BASF	Germany	123	1x 1600	Cu	5.883
1996	Neckarwerke	Germany	420	1x 800	Al	1.571
1996	ABB, Mannheim	Indonesia	170	1x 300	Cu	18.000
1996	NOK Baden	Switzerland	245	1x 800	Cu	3.435
1996	Sanming	China	123	1x 300	Cu	1.731
1996	ABB for MEW	Kuwait	145	1x 630	Cu	900
1996	ELBUD, Warzaw	Poland	123	1x 630	Cu	2.200
1996	ABB, Baden	Thailand	123	1x 240	Cu	320
1997	Stadtwerke Chemnitz	Germany	123	1x 630	Cu	3.000
1997	Stadtwerke Chemnitz	Germany	123	1x 800	Cu	24.450
1997	VEW Energie	Germany	123	1x 1200	Cu	1.218
1997	Stadtwerke Leipzig	Germany	123	1x 800	Cu	9.246
1997	Stadtwerke Leipzig	Germany	123	1x 800	Cu	2.931
1997	Stadtwerke Leipzig	Germany	123	1x 630	Cu	3.012
1997	SCA, Mannheim	Germany	123	1x 630	Cu	1.875
1997	Stadtwerke Baden-Baden	Germany	123	1x 185	Cu	1.896
1997	Stadtwerke Pforzheim	Germany	123	1x 240	Cu	2.940
1997	Mosenergo, Moscow	Russia	245	1x 1000	Cu	56.450
1997	ABB, Mannheim	Canada	145	1x 240	Cu	5.684
1997	ELBUD, Warzaw	Poland	123	1x 630	Cu	380
1997	ABB, Mannheim	Indonesia	170	1x 630	Cu	765
1997	ABB, Mannheim	Indonesia	170	1x 1000	Cu	1.935
1997	ABB, Mannheim	Abu Dhabi	145	1x 500	Cu	511
1997	ABB, Singapore	Malaysia	300	1x 800	Cu	700
1997	ABB, Mannheim	Philippines	145	1x 300	Cu	1.040
1997	ABB, Mannheim	Philippines	145	1x 1000	Cu	5.580
1997	ABB, Mannheim	Philippines	145	1x 630	Cu	1.280
1998	Bewag, Berlin	Germany	420	1x 1600	Cu	20.290
1998	ABB, Switzerland	Saudi Arabia	245	1x 1600	Cu	924
1998	ABB, Switzerland	Chile	245	1x 1200	Cu	1.500
1998	ABB, Mannheim	Sri Lanka	245	1x 1200	Cu	2.260
1998	ABB, Mannheim	Sri Lanka	245	1x 630	Cu	490

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Year Jahr	Customer Kunde	Country Land	Voltage Spannung kV	cross section Querschnitt mm^2	length (core) Aderlänge m
1998	ABB, Switzerland	Taiwan	170	1x 1200 Cu	2.700
1998	ABB, Mannheim	Indonesia	170	1x 1000 Cu	962
1998	ABB, Mannheim	Canada	170	1x 630 Cu	4.050
1998	ABB, Mannheim	Abu Dhabi	145	1x 500 Cu	275
1998	ABB, Mannheim	Abu Dhabi	145	1x 500 Cu	350
1998	ABB Contracting, Riyadh	Saudi Arabia	145	1x 630 Cu	1.920
1998	MEW, Oman	Oman	145	1x 2000 Cu	495
1998	MEW, Oman	Oman	145	1x 800 Cu	491
1998	ABB, Mannheim	Sri Lanka	145	1x 1200 Cu	2.360
1998	EVS, Stuttgart	Germany	123	1x 500 Cu	3.483
1998	Neckarwerke	Germany	123	1x 400 Cu	9.804
1998	ABB, Dresden	Germany	123	1x 800 Cu	481
1998	Stadtwerke Karlruhe	Germany	123	1x 240 Cu	5.600
1998	ABB, Mannheim	Germany	123	1x 300 Cu	1.500
1998	ELBUD, Warzaw	Poland	123	1x 300 Cu	350
1998	ELBUD, Warzaw	Poland	123	1x 630 Cu	4.665
1998	ABB, Mannheim	Poland	123	1x 630 Cu	90
1998	Elektrobudowa, Katowice	Poland	123	1x 300 Cu	600
1998	Elektrobudowa, Katowice	Poland	123	1x 630 Cu	390
1998	ABB, Mannheim	Russia	123	1x 300 Cu	200
1998	ABB Energo, Prague	Czech Republic	123	1x 800 Cu	550
1998	ABB Energo, Prague	Czech Republic	123	1x 240 Cu	830
1998	ABB Elektro, Bratislava	Slovakia	123	1x 185 Cu	2.750
1999	China National Water Resources Beijing	China	550	1x 800 Cu	2.535
1999	ABB, Riyadh	Saudi Arabia	245	1x 800 Cu	600
1999	ELMÜ, Budapest	Hungary	145	1x 500 Cu	13.730
1999	MEW, Kuwait	Kuwait	145	1x 240 Cu	2.100
1999	ABB Contracting, Riyadh	Saudi Arabia	145	1x 240 Cu	110
1999	ABB, Wien	Austria	123	1x 240 Cu	2.700
1999	ABB, Austria	Austria	123	1x 500 Cu	39.000
1999	ABB, Ukraine	Ukraine	123	1x 240 Cu	1.390
1999	Bewag, Berlin	Germany	123	1x 630 Cu	3.055
1999	NWS, Stuttgart	Germany	123	1x 240 Cu	802
1999	BHN, Bamberg	Germany	123	1x 185 Cu	5.193
1999	ABB, Turgi	Germany	123	1x 240 Cu	1.950
1999	Stadtwerke Augsburg	Germany	123	1x 630 Cu	2.220
1999	ABB, Dresden	Germany	123	1x 500 Cu	350
1999	RWE Energie, Essen	Germany	123	1x 2000 Cu	5.038
1999	RWE Energie, Essen	Germany	123	1x 1600 Cu	4.423
1999	ABB, Kiew	Ukraine	123	1x 240 Cu	1.500
1999	ABB, Ljublijana	Slovenia	123	1x 240 Cu	2.700
1999	NWS, Stuttgart	Germany	123	1x 400 Cu	9.532
1999	Elbud Impex	Egypt	72.5	1x 1600 Cu	1.300
1999	ABB, Mannheim	USA	72.5	1x 185 Cu	1.560

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Year Jahr	Customer Kunde	Country Land	Voltage Spannung kV	cross section Querschnitt mm^2		length (core) Aderlänge m
1999	ABB, Mannheim	USA	72.5	1x 630	Cu	2.280
1999	Adtranz, Frankfurt	Netherlands	50	1x 630	Cu	1.860
1999	Adtranz, Frankfurt	Netherlands	50	1x 400	Cu	1.770
2000	Bewag, Berlin	Germany	420	1x 1600	Cu	17.050
2000	Babcock, Oberhausen	Abu Dhabi	420	1x 1000	Cu	10.329
2000	Babcock, Oberhausen	Abu Dhabi	420	1x 800	Cu	15.543
2000	China National Water Resources Beijing	China	245	1x 500	Cu	2.175
2000	ABB, Switzerland	China	245	1x 400	Cu	4.200
2000	ABB, Mannheim	Taiwan	170	1x 400	Cu	950
2000	Babcock, Oberhausen	Abu Dhabi	145	1x 1000	Cu	2.460
2000	SAOG, Oman	Oman	145	1x 2000	Cu	1.850
2000	ABB, Riyadh	Saudi Arabia	145	1x 1000	Cu	660
2000	EV Potsdam	Germany	123	1x 630	Cu	29.730
2000	BHN, Bamberg	Germany	123	1x 500	Cu	12.905
2000	RWE, Essen	Germany	123	1x 1200	Cu	4.413
2000	Wemag, Schwerin	Germany	123	1x 240	Cu	70
2000	ABB, Prague	Czech Republic	123	1x 240	Cu	6.948
2000	ABB, Prague	Czech Republic	123	1x 300	Cu	110
2000	ABB, Wien	Austria	123	1x 500	Cu	3.915
2000	ELBUD, Warzaw	Poland	123	1x 400	Cu	5.158
2000	ELBUD, Warzaw	Poland	123	1x 300	Cu	6.441
2000	ABB, Mannheim	Philippines	145	1x 300	Cu	160
2000	ABB, Mannheim	Hungary	123	1x 300	Cu	300
2000	ELBUD, Warzaw	Poland	123	1x 630	Cu	360
2000	ABB, Netherland	Singapore	72,5	1x 400	Cu	2.190
2000	ABB, Mannheim	Nigeria	145	1x 630	Cu	4.725
2000	ABB, Mannheim	Nigeria	145	1x 1600	Cu	321
2001	National Grid Company	Great Britain	420	1x 2500	Cu	61.685
2001	Taiwan Power Company	Taiwan	362	1x 2500	Cu	62.060
2001	Alstom, France	Malaysia	300	1x 800	Al	1.750
2001	ABB, Brasilien	Brasil	245	1x 630	Cu	180
2001	ABB, Taiwan	Taiwan	170	1x 400	Cu	2.850
2001	Electricity Authority, Nicosia	Cyprus	145	1x 800	Cu	22.617
2001	ABB, Hanau	Brasil	123	1x 300	Cu	250
2001	ABB, Karlskrona	Sri Lanka	123	1x 1600	Cu	432
2001	ABB, Zürich	Taiwan	170	1x 240	Cu	170
2001	ABB, Mannheim	Taiwan	170	1x 800	Cu	628
2001	ABB, Ljubljana	Slovenia	123	1x 630	Cu	1.560
2001	SOGEX, Oman	Oman	145	1x 800	Cu	65
2001	ELBUD, Warzaw	Poland	123	1x 630	Cu	390
2001	ABB, Mannheim	Germany	123	1x 300	Cu	120
2001	NWS, Stuttgart	Germany	123	1x 800	Cu	5.136
2001	NWS, Stuttgart	Germany	123	1x 800	Cu	1.560
2001	EnBW, Karlsruhe	Germany	123	1x 240	Al	100

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Year Jahr	Customer Kunde	Country Land	Voltage Spannung kV	cross section Querschnitt mm^2		length (core) Aderlänge m
2001	NWS, Stuttgart	Germany	123	1x 800	Cu	10.680
2001	ABB, Mannheim	Germany	123	1x 300	Cu	6.855
2001	ABB, Mannheim	Germany	123	1x 240	Cu	150
2001	ABB, Mannheim	Germany	123	1x 800	Cu	280
2001	ABB, Lehrte	Germany	123	1x 630	Cu	12.600
2001	Stadtwerke München	Germany	123	1x 240	Cu	75
2001	ABB, Mannheim	Egypt	72,5	1x 400	Cu	14.156
2001	ABB, Dresden	Germany	72,5	1x 150	Cu	1.365
2002	Red Electrica, Madrid	Spain	420	1x 2500	Cu	40.160
2002	Tala Hydro Power Authority	Bhutan	420	1x 1200	Cu	8.920
2002	ABB for CEPS, Prague	Czech Republic	420	1x 2500	Cu	1.420
2002	Civil Contracting, Ruwi	Oman	145	1x 2000	Cu	1.500
2002	Civil Contracting, Ruwi	Oman	145	1x 800	Cu	400
2002	Galfar Engineering, Muscat	Oman	145	1x 2000	Cu	2.090
2002	Bahwan Engineering, Ruwi	Oman	145	1x 2000	Cu	3.867
2002	ABB Contracting, Riyadh	Saudi Arabia	145	1x 630	Cu	1.140
2002	Electricity Authority, Nicosia	Cyprus	145	1x 800	Cu	945
2002	ABB, Mannheim	Iraq	145	1x 800	Al	3.600
2002	ABB, Mannheim	Germany	123	1x 300	Cu	100
2002	ABB, Mannheim	Germany	123	1x 300	Cu	465
2002	Stadtwerke Karlsruhe	Germany	123	1x 240	Cu	155
2002	NWS, Stuttgart	Germany	123	1x 800	Cu	3.920
2002	NWS, Stuttgart	Germany	123	1x 800	Cu	3.300
2002	ABB, Mannheim	Algeria	72,5	1x 240	Cu	2.370
2003	AES, Nigeria	Nigeria	145	1x 1600	Cu	270
2003	AES, Nigeria	Nigeria	145	1x 630	Cu	176
2003	National Grid Company	Great Britain	420	1x 2500	Cu	16.313
2004	STEWEAG-STEG, Graz	Austria	123	1x 800	Cu	12.812
2004	Stadtwerke Klagenfurt	Austria	123	1x 500	Cu	1.250
2004	Borealis, Schwechat	Austria	123	1x 185	Cu	4.800
2004	Borealis, Schwechat	Austria	123	1x 630	Cu	356
2004	Stadtwerke Bielefeld	Germany	123	1x 300	Cu	2.959
2004	SAG, Weinheim	Germany	123	1x 300	Cu	1.400
2004	Bewag, Berlin	Germany	123	1x 630	Cu	11.883
2004	Großkraftwerk Mannheim	Germany	123	1x 500	Cu	1.560
2004	Verbund Austrian Hydro Power	Austria	420	1x 800	Al	600
2004	Electricity Authority Nicosia	Cyprus	145	1x 300	Cu	3.000
2004	Electricity Authority Nicosia	Cyprus	145	1x 630	Cu	34.593
2004	Electricity Authority Nicosia	Cyprus	145	1x 630	Cu	28.323
2004	Electricity Authority Nicosia	Cyprus	145	1x 800	Cu	1.000
2004	ETA for ADWEA	UAE	145	1x 800	Cu	12.900
2004	ETA for ADWEA	UAE	145	1x 1200	Cu	42.000
2004	Voith Siemens Hydro for Baglihar P/S	India	420	1x 800	Cu	1.874
2004	Rodax Corporation, Athens	Greece	420	1x 800	Cu	2.150

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Year Jahr	Customer Kunde	Country Land	Voltage Spannung kV	cross section Querschnitt mm²		length (core) Aderlänge m
2004	Reykjavik Energy	Iceland	145	1x 630	Cu	10.050
2004	EnBW, Stuttgart	Germany	123	1x 800	Cu	4.380
2004	Hydropower Station Bureya	Russia	550	1x 800	Cu	2.650
2005	Alstom Power, France	Sudan	550	1x 1200	Cu	3.900
2005	Alstom Power, France	Sudan	550	1x 800	Cu	3.000
2005	Miro, Karlsruhe	Germany	123	1x 240	Cu	3.987
2005	Stadtwerke Erfurt	Germany	123	1x 630	Cu	9.297
2005	Stadtwerke Karlsruhe	Germany	123	1x 240	Cu	1.050
2005	Bewag, Berlin	Germany	123	1x 630	Cu	621
2005	SWU Energie, Ulm	Germany	123	1x 630	Cu	340
2005	Power Projects for Kahramaa	Qatar	72,5	1x 500	Cu	2.220
2005	Power Projects for Kahramaa	Qatar	72,5	1x 500	Cu	1.300
2005	NV Net A/S	Denmark	170	1x 800	Al	16.800
2005	GA Leitungsbau, Hohenwarsleben	Germany	123	1x 630	Cu	2.600
2005	EnBW, Karlsruhe	Germany	123	1x 300	Cu	90
2005	Reykjavik Energy	Iceland	245	1x 400	Al	8.954
2005	Wacker Chemie AG, Burghausen	Germany	123	1x 300	Cu	4.590
2005	Wacker Chemie AG, Burghausen	Germany	123	1x 1000	Cu	3.240
2005	Taiwan Power Company	Taiwan	362	1x 1600	Cu	28.800
2005	Alstom Power, Austria	Turkey	420	1x 800	Al	1.200
2005	Velis, Bulgaria	Bulgaria	123	1x 400	Cu	6.780
2005	RWE, Dortmund	Germany	123	1x 630	Cu	1.020
2005	Electricity Supply Board	Ireland	72,5	1x 630	Cu	20.400
2005	ABB Ltd. Budapest	Hungary	145	1x 500	Cu	6.210
2006	Hydropower Station Bureya	Russia	550	1x 800		2.850
2006	ManWan HPP, China	China	550	1x 800		950
2006	GouPiTan HPP, China	China	550	1x 800		10.050
2006	N1 A/S, Arhus	Denmark	170	1x 1200	Al	39.300
2006	Enertrag AG, Dauerthal	Germany	123	1x 1000	Al	41.562
2006	Verbund Austrian Power Grid	Austria	245	1x 1600	Cu	3.152
2006	EnBW, Karlsruhe	Germany	123	1x 240	Al	200
2006	EnBW, Karlsruhe	Germany	123	1x 800	Cu	3.840
2006	RWE, Dortmund	Germany	123	3x 300	Cu	1.425
2006	RWE, Dortmund	Germany	123	1x 630	Cu	8.022
2006	RWE, Dortmund	Germany	123	1x 630	Cu	9.357
2006	RWE, Dortmund	Germany	245	1x 630	Cu	903
2006	RWE, Dortmund	Germany	420	1x 800	Cu	300
2006	RWE, Dortmund	Germany	123	1x 630	Cu	917
2006	RWE, Dortmund	Germany	123	1x 300	Cu	215
2006	National Grid Electricity Transmission Co.	Great Britain	145	1x 1600	Cu	32.500
2006	Uhde, Dortmund	Qatar	145	1x 800	Cu	11.117
2006	ABB, Mannheim, RasAbuFontas	Qatar	245	1x 400	Cu	2.673
2006	ABB, Mannheim, RasAbuFontas	Qatar	245	1x 630	Cu	3.781
2006	SN Energie, St. Gallen	Switzerland	123	1x 500	Cu	9.618

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Year Jahr	Customer Kunde	Country Land	Voltage Spannung kV	cross section Querschnitt mm^2		length (core) Aderlänge m
2006	Larsen & Toubro, Ruwi	Oman	145	1x 1200	Cu	2.700
2006	Civil Contracting, Ruwi	Oman	145	1x 1200	Cu	2.700
2006	Pfisterer Ixosil, Altdorf	Switzerland	72,5	1x 240	Cu	9.555
2006	ABB, Mannheim	Cuba	145	1x 240	Cu	4.590
2006	ABB, Mannheim	Dom. Rep.	145	1x 800	Cu	1.472
2006	MAN Ferrostaal, Essen	Iran	145	1x 1000	Cu	1.140
2006	Al Hassan, Ruwi	Oman	145	1x 1200	Cu	840
2006	ABB, Kuwait	Kuwait	145	1x 240	Cu	1.950
2006	ABB, Kuwait	Kuwait	145	1x 240	Cu	1.950
2006	ABB, Bratislava	Slovakia	123	1x 185	Al	2.787
2006	SAG, Ergolding	Germany	123	1x 300	Cu	1.623
2006	Siemens, Erlangen	Germany	123	1x 300	Cu	1.477
2006	Pfisterer Ixosil, Altdorf	Switzerland	123	1x 630	Cu	497
2006	EW Altdorf	Switzerland	72,5	1x 240	Cu	1.000
2006	ABB Ltd., Budapest	Hungary	170	1x 400	Cu	451
2006	Centrala Zaopatrzenia, Warzawa	Poland	145	1x 800	Cu	160
2006	ABB, Mannheim	Germany	123	1x 240	Cu	180
2006	AREVA, Mannheim	Germany	123	1x 300	Cu	626
2006	ABB, Prag	Czech Republic	123	1x 300	Cu	272
2006	MOESK, Moscow	Russia	245	1x 1000	Cu	24.244
2006	ABB, Mannheim	Libya	72,5	1x 500	Cu	598
2006	MOESK, Moscow	Russia	245	1x 1200	Cu	7.230
2006	ABB, Mannheim	Qatar	72,5	1x 500	Cu	22.893
2006	ABB, Mannheim	Saudi Arabia	420	1x 630	Cu	6.210
2006	MOESK, Moscow	Russia	245	1x 1200	Cu	26.260
2006	BPMC	Brunei	72,5	1x 500	Cu	2.700
2006	GTE, Mannheim	Germany	145	1x 300	Cu	838
2006	MOESK, Moscow	Russia	245	1x 1200	Cu	23.750
2007	SAG, Langen for Vianden	Luxemburg	245	1x 300	Cu	6.177
2007	SAG, Langen for Vianden	Luxemburg	245	1x 300	Cu	6.295
2007	E.ON Thüringer Energie, Erfurt	Germany	123	1x 630	Cu	2.720
2007	ABB, Mannheim	Germany	123	1x 2500	Cu	975
2007	Vattenfall Europe Berlin	Germany	123	1x 300	Cu	620
2007	Wemag, Schwerin	Germany	123	1x 300	Cu	900
2007	Rheinkraftwerk Albruck-Dogern	Germany	123	1x 240	Al	10.400
2007	Stadtwerke Lübeck	Germany	123	1x 400	Al	17.793
2007	Wacker Chemie Burghausen	Germany	123	1x 1600	Cu	11.740
2007	Landsnet, Reykjavik	Iceland	145	1x 500	Al	8.900
2007	Landsnet, Reykjavik	Iceland	145	1x 630	Cu	5.610
2007	Bechtel & Co. L.L.C	Oman	245	1x 300	Cu	3.829
2007	MOESK, Moscow	Russia	245	1x 1600	Cu	895
2007	MOESK, Moscow	Russia	245	1x 1200	Cu	14.120
2007	EC Energo	Russia	245	1x 1200	Cu	84.325
2007	Siemens, Erlangen	Germany	123	1x 630	Cu	387

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Year Jahr	Customer Kunde	Country Land	Voltage Spannung kV	cross section Querschnitt mm²		length (core) Aderlänge m
2007	MOESK, Moscow	Russia	245	1x 1600	Cu	34.196
2007	Wienstrom	Austria	420	1x 1200	Cu	2.291
2007	Syd Energy via S. Tygesen Energi	Denmark	72,5	1x 630	Al	21.920
2007	ABB, Prague	Czech. Republic	145	1x 300	Cu	690
2007	Federal Grid Company, Moscow	Russia	123	1x 2000	Cu	4.594
2007	Federal Grid Company, Moscow	Russia	123	1x 1600	Cu	1.512
2007	Federal Grid Company, Moscow	Russia	245	1x 1600	Cu	3.237
2007	Shadeed Iron & Steel via L&T	Oman	245	1x 1200	Cu	23.448
2007	ABB, Mannheim	Iraq	420	1x 630	Al	2.205
2007	Pfisterer Ixosil	Switzerland	123	1x 800	Cu	624
2007	National Grid Electricity Transmission Co.	Great Britain	300	1x 1600	Cu	30.821
2007	Pfisterer Ixosil	Switzerland	170	1x 800	Al	360
2007	Wienstrom via ALB, Wien	Austria	123	1x 630	Cu	2.111
2007	Wienstrom via ALB, Wien	Austria	123	1x 1600	Cu	447
2007	Cro-Bar Construction	Ireland	123	1x 630	Al	50.387
2007	Electricity Authority Nicosia	Cyprus	145	1x 800	Cu	8.886
2007	Electricity Authority Nicosia	Cyprus	145	1x 300	Cu	3.000
2007	Electricity Authority Nicosia	Cyprus	145	1x 630	Cu	2.660
2007	ABB, Mannheim	Sri Lanka	245	1x 1000	Al	1.812
2007	NOK via Pfisterer	Switzerland	245	1x 400	Cu	471
2007	ABB, Skovlunde	Denmark	170	1x 1200	Al	150
2007	Teknik Janakuasa	Malaysia	300	1x 800	Al	350
2007	Sipel, Ellange	Luxemburg	72,5	1x 150	Cu	600
2007	Syd Energy via S. Tygesen Energi	Denmark	72,5	1x 400	Al	11.400
2007	Großkraftwerk Mannheim	Germany	123	1x 800	Al	1.088
2007	MOESK, Moscow	Russia	245	1x 1600	Cu	41.775
2008	ADWEA TRANSCO	UAE	145	1x 1200	Cu	52.134
2008	Subgerencia Projectos Generacion	Colombia	550	1x 800	Al	5.235
2008	Reykjavik Energy	Iceland	245	1x 400	Al	6.468
2008	Qatalum via ABB, Mannheim	Qatar	420	1x 2000	Cu	3.840
2008	Qatalum via ABB, Mannheim	Qatar	245	1x 1000	Cu	4.383
2008	N1 via S. Tygesen Energi	Denmark	170	1x 800	Al	22.050
2008	SEWA via Scan Electromech.	UAE	245	1x 800	Cu	3.600
2008	SEWA via Scan Electromech.	UAE	245	1x 1600	Cu	7.200
2008	ABB, Mannheim	Algeria	245	1x 800	Cu	5.100
2008	Electricity Authority of Cyprus	Cyprus	145	1x 800	Cu	54.740
2008	E.ON Thüringer Energie	Germany	123	1x 630	Cu	880
2008	Pfisterer Ixosil	Switzerland	123	1x 800	Cu	314
2008	SAG, Chemnitz	Germany	123	1x 630	Cu	1.635
2008	AES Kilroot Power Limited	Great Britain	300	1x 630	Al	1.250
2008	Goradskije Seti, Tolyatty	Russia	123	1x 630	Cu	7.500
2008	RODAX	Greece	420	1x 800	Cu	200
2008	Kraftwerk Rheinfelden via AREVA, CH	Germany	123	1x 630	Cu	2.300
2008	Kraftwerk Rheinfelden via AREVA, CH	Germany	123	1x 300	Cu	613

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2008	DREWAG, Dresden	Germany	123	1x 630	Cu	2.700
2008	RODAX	Greece	420	1x 800	Al	1.200
2008	Cegelec	Germany	123	1x 400	Cu	2.190
2008	Cegelec	Germany	123	1x 300	Cu	210
2008	ADWEA TRANSCO via RemCon	UAE	145	1x 800	Cu	1.000
2008	ADWEA TRANSCO via RemCon	UAE	145	1x 800	Cu	13.650
2008	ADWEA TRANSCO via RemCon	UAE	145	1x 1200	Cu	5.640
2008	MVV, Mannheim	Germany	123	1x 500	Cu	4.860
2008	MVV, Mannheim	Germany	123	1x 300	Cu	60
2008	Thomsen Anlagenbau GmbH, Göldenitz	Germany	145	1x 300	Cu	165
2008	Thomsen Anlagenbau GmbH, Göldenitz	Germany	145	1x 240	Cu	70
2008	Evonik, Rheinfelden	Germany	123	3x 120	Cu	1.800
2008	RWE , Dortmund	Germany	123	3x 300	Cu	10.464
2008	Großkraftwerk Mannheim	Germany	123	1x 800	Cu	2.954
2008	Großkraftwerk Mannheim	Germany	123	1x 500	Cu	3.213
2008	AREVA, Berlin	Germany	123	1x 240	Cu	2.145
2008	AREVA, Berlin	Germany	123	1x 630	Al	60
2008	Niroo Ramshir (RAMTEC), Teheran	Iran	145	1x 630	Cu	22.000
2008	Niroo Ramshir (RAMTEC), Teheran	Iran	145	1x 630	Cu	4.800
2008	ADWEA TRANSCO via RemCon	UAE	145	1x 1600	Cu	3.150
2008	ADWEA TRANSCO via RemCon	UAE	145	1x 1200	Cu	29.766
2008	BPMC	Brunei	72,5	1x 500	Cu	3.000
2008	E.ON Földgáz Storage, Budapest	Hungary	145	1x 400	Al	2.610
2008	EnBW, Stuttgart	Germany	123	1x 1600	Cu	37
2008	Siemens AG, Erlangen	Germany	245	1x 800	Cu	180
2008	BARD Engineering GmbH, Emden	Germany	170	1x 800	Cu	120
2008	MOESK, Moscow	Russia	245	1x 1200	Cu	2.120
2008	MOESK, Moscow	Russia	245	1x 2000	Cu	7.250
2008	MOESK, Moscow	Russia	245	1x 2000	Cu	10.000
2008	MOESK, Moscow	Russia	245	1x 1600	Cu	27.887
2008	MOESK, Moscow	Russia	245	1x 1000	Cu	1.252
2008	MOESK, Moscow	Russia	245	1x 1200	Cu	25.315
2008	MOESK, Moscow	Russia	245	1x 1200	Cu	9.260
2008	MOESK, Moscow	Russia	123	1x 1600	Cu	9.000
2008	MOESK, Moscow	Russia	123	1x 1600	Cu	500
2008	STATKRAFT, Lilleaker	Norway	420	1x 630	Al	3.030
2008	RWE, Dortmund	Germany	123	1x 800	Cu	32.983
2008	Uhde, Dortmund	Algeria	72,5	1x 630	Cu	7.065
2009	SAG, Chemnitz	Germany	123	1x 800	Cu	1.701
2009	IBERDROLA, Bilbao	Spain	245	1x 500	Al	375
2009	WEMAG , Schwerin	Germany	123	1x 630	Al	990
2009	Pfisterer	Italia	170	1x 800	Al	552
2009	Pfisterer, Altdorf	Switzerland	145	1x 800	Cu	444
2009	Enertrag, Sofia	Bulgaria	123	1x 800	Cu	530

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2009	Wienstrom via ALB, Wien	Austria	245	1x 1200	Cu	495
2009	Wienstrom via ALB, Wien	Austria	420	1x 630	Cu	495
2009	ETS Solutions Limited	Russia	245	1x 1200	Cu	150
2009	ABB Mannheim	Dom. Rep.	145	1x 800	Cu	200
2009	ABB A/S, Fredericia	Denmark	145	1x 300	Cu	350
2009	NBR Nussbaumer & Cie S.A, Halle	Belgium	123	1x 300	Cu	193
2009	Stadtwerke Karlsruhe	Germany	123	1x 300	Cu	139
2009	ABB, Budapest	Hungary	72,5	1x 150	Al	124
2009	IBERDROLA S.A., Bilbao	Spain	245	1x 500	Al	335
2009	BARD Engineering GmbH , Emden	Germany	170	1x 800	Cu	120
2009	SIEMENS AG, Erlangen	Germany	170	1x 800	Cu	180
2009	EnergoServiceProject Ltd. , Moscow	Russia	245	1x 2000	Cu	7.622
2009	Berakas Power Management, Brunei	Brunei	72,5	1x 500	Cu	3.000
2009	Moscow Electrical Utility	Russia	550	1x 800	Cu	600
2009	Moscow Electrical Utility	Russia	245	1x 1600	Cu	67.752
2009	Abu Dhabi Transmission & Despatch Co.	UAE	145	1x 1200	Cu	54.840
2009	Moscow Electrical Utility	Russia	245	1x 1200	Cu	64.150
2009	Dneprosteel	Ukraine	362	1x 800	Al	82.648
2009	Jaiprakash Associates Limited, New Delhi	India	420	1x 2500	Cu	4.785
2009	Jaiprakash Associates Limited, New Delhi	India	420	1x 630	Cu	2.709
2009	Moscow Electrical Utility	Russia	245	1x 1200	Cu	38.000
2009	HELIOPOLIS ELECTRIC CO., Abu Dhabi	UAE	145	1x 1200	Cu	7.815
2009	HELIOPOLIS ELECTRIC CO., Abu Dhabi	UAE	145	1x 800	Cu	6.708
2009	Electricity Authority of Cyprus, Nicosia	Cyprus	145	1x 800	Cu	25.380
2009	ENERCON GMBH, AURICH	Germany	123	1x 630	Al	65.142
2009	Electricity Authority of Cyprus, Nicosia	Cyprus	145	1x 800	Cu	172.434
2009	Moscow Electrical Utility	Russia	245	1x 1200	Cu	13.105
2009	Taneko Oil Refinery	Russia	245	1x 500	Al	22.850
2009	GEM, Sejskaja	Russia	550	1x 800	Cu	7.500
2009	ABB, Mannheim	Libya	245	1x 1600	Cu	4.290
2009	Mapna Europe GmbH , Düsseldorf	Iran	245	1x 1000	Cu	4.488
2009	EUROKABEL OOD , Sofia	Bulgaria	420	1x 630	Cu	3.200
2009	Abu Dhabi Transmission & Despatch Co.	UAE	145	1x 1200	Cu	3.390
2009	Taneko Oil Refinery	Russia	245	1x 500	Al	11.037
2009	Taneko Oil Refinery	Russia	245	1x 500	Al	8.970
2009	E.ON Netz GmbH , Bayreuth	Germany	123	1x 400	Al	31.800
2009	EnBW, Stuttgart via ABB, Mannheim	Germany	123	1x 1000	Cu	1.755
2009	EnBW, Stuttgart via ABB, Mannheim	Germany	123	1x 2500	Cu	936
2009	Abazivnyi Zavod Ilich, St. Petersburg	Russia	123	1x 1200	Cu	1.440
2009	Abazivnyi Zavod Ilich, St. Petersburg	Russia	245	1x 1000	Cu	1.050
2009	TAXON Universal LLP, Cardiff	Kasachstan	123	1x 300	Cu	8.155
2009	Stadtwerke Pforzheim	Germany	123	1x 800	Al	9.765
2009	Union Fenosa, Madrid	Spain	145	1x 500	Cu	2.300
2009	PTD Technology Sdn Bhd	Brunei	72,5	1x 1000	Cu	1.560

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Year Jahr	Customer Kunde	Country Land	Voltage Spannung kV	cross section Querschnitt mm²		length (core) Aderlänge m
2009	Federal Grid Company	Russia	123	1x 2000	Cu	861
2009	BPMC	Brunei	72,5	1x 1000	Cu	1.200
2009	GA Energieanlagenbau GmbH , Fellbach	Germany	123	1x 800	Cu	1.890
2009	ALB, Wien	Austria	123	1x 300	Cu	242
2009	ALB, Wien	Austria	123	1x 400	Cu	1.016
2009	Electroandina S.A , Las Condes- Santiago	Chile	245	1x 1200	Cu	450
2009	EnBW Kraftwerke AG , Heilbronn	Germany	123	1x 400	Cu	2.295
2009	IBERDROLA S.A. , Bilbao	Spain	245	1x 500	Al	1.005
2009	Landsnet , Reykjavik	Iceland	72,5	1x 150	Al	36.270
2009	Electro Consult SRL , Oradea	Romania	123	1x 300	Al	3.150
2009	Lenergo, Saint-Petersburg	Russia	123	1x 1200	Cu	690
2009	Rheinkraftwerk Iffezheim	Germany	123	1x 300	Cu	3.180
2009	Lechwerke AG, Augsburg	Germany	123	1x 630	Cu	1.971
2009	ABB Engg. Technologies Co. , Safat	Kuwait	145	1x 240	Cu	900
2009	Überlandwerk Groß-Gerau	Germany	123	1x 500	Al	1.545
2009	E.ON Thüringer Energie AG , Erfurt	Germany	123	1x 300	Cu	1.410
2009	IBERDROLA S.A. , Bilbao	Spain	245	1x 500	Al	530
2010	National Contracting Co. Ltd, Abu Dhabi	UAE	145	1x 1000	Cu	28.095
2010	Rusgidro	Russia	550	1x 2500	Cu	3.600
2010	TGK-1	Russia	123	1x 400	Cu	2.665
2010	TGK-1	Russia	123	1x 1600	Cu	2.829
2010	TGK-1	Russia	362	1x 630	Cu	4.695
2010	Federal Grid Company	Russia	123	1x 630	Cu	22.190
2010	Abu Dhabi Transmission & Despatch Co.	UAE	145	1x 1000	Cu	6.462
2010	Moscow E. Utility	Russia	362	1x 800	Cu	4.320
2010	EnBW via Leonhard Weiss, Göppingen	Germany	123	1x 1200	Cu	13.128
2010	Moscow E. Utility	Russia	245	1x 1200	Cu	65.407
2010	Federal Grid Company	Russia	245	1x 1400	Cu	4.146
2010	TGK-1	Russia	123	1x 1200	Cu	4.422
2010	Federal Grid Company	Russia	123	1x 1200	Cu	3.145
2010	SSEM Branch Office, Jeddah	Saudi Arabia	420	1x 630	Cu	2.010
2010	Federal Grid Company	Russia	123	1x 1600	Cu	2.060
2010	RWE, Dortmund	Germany	123	1x 300	Cu	3.720
2010	EnBW, Stuttgart	Germany	123	1x 630	Cu	1.467
2010	RWE, Dortmund	Germany	123	1x 300	Cu	1.870
2010	SAG, Essen	Germany	123	1x 300	Cu	330
2010	RWE, Dortmund	Germany	123	1x 400	Al	240
2010	ENERCON, Aurich	Germany	123	1x 630	Al	450
2010	Offshore Ostsee Wind AG, Bremen	Germany	123	1x 400	Al	110
2010	Electricity Authority of Cyprus, Nicosia	Cyprus	145	1x 300	Cu	3.000
2010	Electricity Authority of Cyprus, Nicosia	Cyprus	145	1x 800	Cu	42.360
2010	Vattenfall, Berlin	Germany	123	1x 630	Cu	16.945
2010	Vattenfall, Berlin	Germany	123	1x 800	Cu	921
2010	Abu Dhabi Transmission & Despatch Co.	UAE	145	1x 800	Cu	6.600

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2010	RWE, Dortmund	Germany	123	3x 300	Cu	14.616
2010	Jaiprakash Associates Limited	India	420	1x 2500	Cu	1.152
2010	Jaiprakash Associates Limited	India	420	1x 630	Cu	408
2010	ALDERS LLC, Nicosia	Cyprus	245	1x 2000	Cu	1.380
2010	ALDERS LLC, Nicosia	Cyprus	245	1x 630	Cu	2.430
2010	GEM, Sejskaja	Russia	245	1x 800	Cu	4.311
2010	Federal Grid Company	Russia	123	1x 800	Cu	4.530
2010	ALDERS LLC, Nicosia	Cyprus	123	1x 240	Cu	5.160
2010	50Hertz Transmission, Berlin	Germany	245	1x 2000	Cu	1.863
2010	RWE , Dortmund	Germany	123	3x 300	Cu	5.145
2010	URUK Engineering Co. Ltd., Baghdad	Iraq	145	1x 800	Al	2.601
2010	Moscow E. Utility	Russia	245	1x 1200	Cu	1.575
2010	Federal Grid Company	Russia	245	1x 1000	Cu	1.404
2010	Federal Grid Company	Russia	245	1x 630	Cu	2.690
2010	Union Fenosa, Madrid	Spain	72,5	1x 630	Al	5.139
2010	TGK-2	Russia	362	1x 630	Al	684
2010	Federal Grid Company	Russia	123	1x 1200	Cu	912
2010	Gazprom	Russia	245	1x 400	Cu	1.296
2010	RWE, Dortmund	Germany	123	1x 630	Cu	3.990
2010	Deutsche Bahn via SAG, Weinheim	Germany	484	1x 630	Al	1.200
2010	RemCon Electrical Co. L.L.C.	UAE	245	1x 1200	Cu	360
2010	Gazprom	Russia	123	1x 300	Cu	1.041
2010	Federal Grid Company	Russia	245	1x 2000	Cu	327
2010	Moscow E. Utility	Russia	245	1x 1200	Cu	440
2010	Moscow E. Utility	Russia	245	1x 1200	Cu	342
2010	Thomsen Anlagenbau, Göldenitz	Germany	123	1x 300	Cu	450
2010	AREVA Energietechnik, Berlin	Germany	123	1x 300	Cu	420
2010	ALSTOM GRID Hellas AE	Greece	145	1x 300	Cu	165
2010	ELIN Energietechnik GmbH, Berlin	Germany	123	1x 300	Cu	2.766
2010	EUROKABEL OOD, Sofia	Bulgaria	420	1x 630	Al	3.200
2010	EnBW via Leonhard Weiss, Göppingen	Germany	123	1x 630	Cu	16.665
2010	EnBW via Leonhard Weiss, Göppingen	Germany	123	1x 800	Cu	12.600
2010	EnBW via Leonhard Weiss, Göppingen	Germany	123	1x 800	Cu	7.428
2010	Evonik, Marl	Germany	123	3x 800	Cu	2.679
2010	Vattenfall, Berlin	Germany	123	1x 300	Cu	1.446
2010	Reykjavik Energy	Iceland	245	1x 400	Al	4.422
2010	Continent Projects Technologies Ltd	India	420	1x 630	Al	900
2010	Continent Projects Technologies Ltd	India	420	1x 1600	Cu	1.600
2011	Skolkovo Federal Grid Co.	Russia	550	1x 2500	Cu	69.562
2011	Maaden Aluminium	Saudi Arabia	245	1x 800	Cu	6.065
2011	Maaden Aluminium	Saudi Arabia	245	1x 400	Al	20.660
2011	Maaden Aluminium	Saudi Arabia	245	1x 400	Cu	6.895
2011	SSC ScottishPower	Great Britain	145	1x 1200	Al	13.596
2011	SSC ScottishPower	Great Britain	145	1x 800	Al	26.682

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2011	Electricity Authority of Cyprus, Nicosia	Cyprus	145	1x 800	Cu	13.980
2011	ALDERS LLC	Cyprus	123	1x 300	Cu	8.070
2011	ALDERS LLC	Cyprus	123	1x 2000	Cu	1.185
2011	Vattenfall, Berlin	Germany	123	1x 630	Cu	13.542
2011	EnviaM via SAG, Chemnitz	Germany	123	1x 1600	Al	14.110
2011	DREWAG, Dresden	Germany	123	1x 630	Cu	12.501
2011	Salzgitter Mannesmann, Düsseldorf	Iran	420	1x 630	Al	3.655
2011	SWU Energie, Ulm	Germany	123	1x 240	Al	4.245
2011	SWU Energie, Ulm	Germany	123	1x 800	Al	8.664
2011	Großkraftwerk Mannheim	Germany	123	1x 500	Cu	900
2011	Großkraftwerk Mannheim	Germany	245	1x 2500	Cu	1.476
2011	MVV Energie, Mannheim	Germany	123	1x 630	Cu	6.900
2011	METKA Metal, Athen	Syria	420	1x 630	Cu	1.341
2011	METKA Metal, Athen	Syria	245	1x 1000	Cu	1.896
2011	ABB, Mannheim	Algeria	72,5	1x 800	Cu	4.600
2011	ABB, Mannheim	Algeria	72,5	1x 630	Cu	900
2011	ALDERS LLC	Cyprus	245	1x 1200	Cu	1.840
2011	ALDERS LLC	Cyprus	245	1x 400	Cu	558
2011	Vattenfall, Berlin	Germany	123	1x 630	Cu	5.820
2011	SAG, Langen	Germany	123	1x 1000	Al	8.445
2011	Energo Komplex, Moscow	Russia	245	1x 1200	Cu	2.280
2011	Skolkovo Federal Grid Co.	Russia	550	1x 2500	Cu	880
2011	HYUNDAI, Seoul	UAE	245	1x 1200	Cu	1.370
2011	SAG, Weinheim	Germany	145	1x 1600	Cu	600
2011	SAG, Weinheim	Germany	123	1x 800	Cu	1.238
2011	VSE, Saarbrücken	Germany	123	1x 2500	Cu	951
2011	Landsnet, Reykjavik	Iceland	72,5	1x 300	Al	18.150
2011	CEPCO Jeddah	Saudi Arabia	420	1x 800	Cu	1.200
2011	URUK Engineering Co. Ltd. Baghdad	Iraq	145	1x 800	Al	2.925
2011	Eidsiva Vannkraft AS Lillehammer	Norway	420	1x 630	Al	2.160
2011	Mitsubishi Electric Europe B.V, Croydon	Great Britain	275	1x 2500	Cu	1.085
2011	Abu Dhabi Transmission & Despatch	UAE	145	1x 800	Cu	1.660
2011	STATKRAFT, Lilleaker	Norway	145	1x 400	Al	4.500
2011	ETS Solutions Limited	Romania	420	1x 630	Cu	360
2011	Energo Komplex, Moscow	Russia	245	1x 1200	Cu	1.070
2011	SEWA via Scan Electromechanical	UAE	245	1x 800	Cu	500
2011	CEPCO, Jeddah	Saudi Arabia	245	1x 800	Cu	600
2011	MOESK, Moscow	Russia	245	1x 1200	Cu	780
2011	Federal Grid Company, Moscow	Russia	123	1x 300	Cu	1.540
2011	ALB, Wien	Austria	123	1x 300	Cu	1.755
2011	ALSTOM, Wien	Austria	245	1x 400	Cu	1.095
2011	Energo Komplex, Moscow	Russia	245	1x 1200	Cu	500
2011	Electricity Authority of Cyprus, Nicosia	Cyprus	145	1x 300	Cu	1.200
2011	Großkraftwerk Mannheim	Germany	245	1x 500	Al	1.066

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Year Jahr	Customer Kunde	Country Land	Voltage Spannung kV	cross section Querschnitt mm^2		length (core) Aderlänge m
2011	Centrala Zaopatrzenia, Warschau	Poland	123	1x 630	Cu	1.655
2011	ABB, Baden	Switzerland	245	1x 800	Cu	500
2011	ALSTOM, Oberentfelden	Switzerland	123	1x 630	Cu	426
2011	Pfisterer, Altdorf	Switzerland	123	1x 800	Cu	780
2011	ABB, Mannheim	Germany	123	1x 400	Cu	300
2011	Rheinkraftwerk Iffezheim	Germany	123	1x 300	Cu	2.004
2011	ALSTOM, Wien	Austria	123	1x 300	Cu	260
2011	DREWAG, Dresden	Germany	123	1x 300	Cu	380
2011	Großkraftwerk Mannheim	Germany	123	1x 300	Cu	5.925
2011	Großkraftwerk Mannheim	Germany	123	1x 630	Cu	4.914
2011	Großkraftwerk Mannheim	Germany	123	1x 800	Cu	1.641
2011	Stadtwerke München	Germany	123	1x 300	Cu	310
2011	National Grid Electricity Transmission Co.	Great Britain	420	1x 2500	Cu	198.400
2011	Siemens Gecol	Libya	245	1x 1600	Cu	997
2012	SAG, Chemnitz	Germany	123	1x 300	Cu	130
2012	Civil & Elect. Projects Contg. Co., Jeddah	Saudi Arabia	420	1x 2500	Cu	38.304
2012	Powertech Engineering L.L.C.,Seeb	Oman	145	1x 1200	Cu	1.500
2012	EnBW via Leonhard Weiss, Göppingen	Germany	123	1x 800	Cu	4.707
2012	RemCon Electrical, Abu Dhabi	UAE	145	1x 800	Cu	1.515
2012	Disace Energia, Madrid	Spain	245	1x 500	Al	480
2012	Elsy Trading Limited	Russia	550	1x 2000	Cu	1.350
2012	Civil & Elect. Projects Contg. Co., Jeddah	Saudi Arabia	123	1x 2500	Cu	23.800
2012	DOW U.S.A. , Houston	USA	145	1x 300	Cu	4.371
2012	ESTRALIN AG	Russia	550	1x 2500	Cu	180
2012	Sewoong Plant Co.LTD., Seoul	South Korea	245	1x 500	Cu	300
2012	SAG, Essen	Germany	123	1x 300	Cu	250
2012	Wacker Chemie, München	Germany	123	1x 1600	Cu	2.925
2012	Calik Enerji Sanayi ve Ticaret A.S.	Turkey	420	1x 630	Cu	3.173
2012	Calik Enerji Sanayi ve Ticaret A.S.	Turkey	420	1x 630	Cu	5.824
2012	Landsnet, Reykjavik	Iceland	72,5	1x 150	Al	34.700
2012	ALB, Wien	Austria	123	1x 300	Cu	185
2012	ABB, Mannheim	Dom. Rep.	145	1x 800	Cu	200
2012	ESTRALIN AG	Russia	550	1x 2500	Cu	200
2012	Carillion Utilities Services, Manchester	Great Britain	550	1x 2500	Cu	170
2012	Centrala Zaopatrzenia, Warszawa	Poland	123	1x 800	Cu	1.540
2012	Centrala Zaopatrzenia, Warszawa	Poland	123	1x 300	Cu	210
2012	BASF, Ludwigshafen	Germany	123	1x 2500	Al	12.679
2012	BASF, Ludwigshafen	Germany	245	1x 2500	Cu	16.053
2012	ALSTOM Grid, Nurek	Tajikistan	550	1x 800	Cu	6.337
2012	ALSTOM Grid, Nurek	Tajikistan	550	1x 2500	Cu	1.035
2012	ELSY TRADING	Russia	245	1x 2500	Cu	681
2012	ABB, Mannheim	Germany	123	1x 300	Cu	822
2012	Siemens, Erlangen	Libya	245	1x 1600	Cu	3.491
2012	ELSY TRADING	Russia	123	1x 2500	Cu	2.955

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SÜDKABEL GmbH
Mannheim, Germany

SÜDKABEL

Reference List of High Voltage **XLPE** Cable Systems from 1973 to 2015

Referenzliste **VPE**-Hochspannungskabelanlagen von 1973 bis 2015

Year Jahr	Customer Kunde	Country Land	Voltage Spannung kV	cross section Querschnitt mm^2		length (core) Aderlänge m
2012	ELSY TRADING	Russia	245	1x 1200	Cu	1.551
2012	G & W Electric Ltd, Shanghai(ZJ.)	China	245	1x 400	Cu	800
2012	Landsnet, Reykjavik	Iceland	72,5	1x 150	Al	6.300
2012	Civil & Elect. Projects Contg. Co., Jeddah	Saudi Arabia	245	1x 2000	Cu	3.429
2012	Nordural via Johan Rönning hf	Iceland	245	1x 630	Al	200
2012	SSC Scottish Power, Bellshill	Great Britain	145	1x 1200	Al	48.383
2012	ALSTOM GRID, La Defense Cedex	Iraq	145	1x 800	Al	834
2012	ALSTOM GRID, La Defense Cedex	Iraq	420	1x 630	Al	1.679
2012	ALSTOM Grid, Nurek	Tajikistan	550	1x 2500	Cu	340
2012	ALSTOM Grid, Nurek	Tajikistan	550	1x 800	Cu	500
2012	Fluor Limited, Farnborough	Great Britain	245	1x 400	Cu	31.452
2012	Carillion Utilities Services, Manchester	Great Britain	550	1x 2500	Cu	606
2012	SSC Scottish Power, Bellshill	Great Britain	145	1x 1200	Al	600
2012	ELSY TRADING	Russia	123	1x 1600	Cu	291
2012	ELSY TRADING	Russia	123	1x 300	Cu	624
2012	ELSY TRADING	Russia	123	1x 2500	Cu	1.755
2012	ELSY TRADING	Russia	245	1x 400	Cu	1.317
2012	ELSY TRADING	Russia	245	1x 630	Cu	258
2012	ABB, Mannheim	Dom. Rep.	145	1x 800	Cu	494
2012	TRADE LINKS & SERVICES, Ruwi	Oman	145	1x 1200	Cu	5.985
2012	Alstom Grid, Dubai	UAE	145	1x 800	Al	2.500
2012	Independent Power Transmission, Athen	Greece	420	1x 800	Al	1.748
2012	Thomsen Anlagenbau; Ziesendorf	Germany	123	1x 300	Cu	210
2012	Großkraftwerk Mannheim	Germany	245	1x 630	Cu	410
2013	Civil & Elect. Projects Contg. Co., Jeddah	Saudi Arabia	420	1x 2500	Cu	72.396
2013	ALSTOM India Limited, Mumbai	India	300	1x 400	Cu	2.672
2013	SWM-Versorgungs GmbH, München	Germany	123	1x 630	Cu	100
2013	ELSY TRADING	Russia	123	1x 2000	Cu	6.790
2013	Siemens T & D, Hebburn	Great Britain	420	1x 600	Cu	400
2013	Siemens T & D, Hebburn	Great Britain	420	1x 600	Cu	760
2013	Siemens T & D, Hebburn	Great Britain	420	1x 600	Cu	750
2013	ESTRALIN AG	Russia	550	1x 2500	Cu	431
2013	PPI Pazifik Power Inc., Makati City	India	145	1x 800	Cu	370
2013	Vattenfall, BERLIN	Germany	123	1x 630	Cu	2.910
2013	Siemens, Ljubljana	Slowenia	420	1x 1200	Cu	1.110
2013	Siemens, Ljubljana	Slowenia	123	1x 240	Cu	908
2013	STATKRAFT Energi, Lilleaker	Norway	145	1x 400	Al	1.500
2013	Western Power Distribution, Plymouth	Great Britain	145	1x 1600	Al	4.425
2013	METS, Riyadh	Saudi Arabia	245	1x 2500	Cu	2.700
2013	ABB Schweiz, Baden	Switzerland	245	1x 800	Cu	217
2013	SAG, Chemnitz	Germany	123	1x 300	Cu	1.296
2013	Larsen & Toubro Ltd., Construction, Sharjah	UAE	245	1x 1200	Cu	19.311
2013	Tameo MT OÜ, Tallinn	Estland	72,5	1x 150	Al	315
2013	Thomsen Anlagenbau, Ziesendorf	Germany	145	1x 630	Al	1.850

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Year Jahr	Customer Kunde	Country Land	Voltage Spannung kV	cross section Querschnitt mm^2	length (core) Aderlänge m
2013	Landsnet, Reykjavik	Iceland	72,5	1x 150 Al	3.480
2013	Landsnet, Reykjavik	Iceland	72,5	1x 150 Al	5.040
2013	Thomsen Anlagenbau, Ziesendorf	Germany	123	1x 300 Cu	540
2013	Voith Hydro, Heidenheim	India	420	1x 800 Cu	951
2013	Voith Hydro, Heidenheim	India	420	1x 630 Cu	4.670
2013	Civil & Elect. Projects Contg. Co., Jeddah	Saudi Arabia	420	1x 2500 Cu	1.695
2013	Alstom Grid SAS,Dubai	UAE	245	1x 1600 Cu	1.450
2013	Alstom Grid SAS,Dubai	UAE	145	1x 1200 Cu	60
2013	Larsen & Toubro Ltd., Construction, Sharjah	UAE	245	1x 1200 Cu	3.399
2013	ESTRALIN AG	Russia	550	1x 2500 Cu	610
2013	Morrison Utility Services, Bedfordshire	Great Britain	145	1x 1600 Al	1.500
2013	ABB Schweiz, Baden	Switzerland	300	1x 800 Cu	376
2013	ABB, Ljubljana	Slowenia	123	1x 630 Cu	505
2013	Siemens Sanaysi ve Ticaret A.S., Istanbul	Turkey	145	1x 800 Al	2.500
2013	SWU Netze, Ulm	Germany	123	1x 800 Al	1.650
2013	E.ON Anlagenservice, Gelsenkirchen	Germany	123	1x 800 Al	5.880
2013	Calik Enerji Sanayi ve Ticaret A.S.	Turkey	420	1x 400 Cu	1.350
2013	Thomsen Anlagenbau, Ziesendorf	Germany	123	1x 300 Cu	500
2013	Civil & Elect. Projects Contg. Co., Jeddah	Saudi Arabia	420	1x 2500 Cu	102.627
2013	SIEMENS, Abu Dhabi	UAE	245	1x 1200 Cu	2.050
2013	SIEMENS, Abu Dhabi	UAE	245	1x 1600 Cu	550
2013	Hell GmbH & Co. KG, Krefeld	Germany	72,5	1x 150 Al	240
2013	IKB via ALB, Wien	Austria	123	1x 500 Cu	7.416
2013	Eurokabel ltd., Sofia	Bulgaria	123	1x 1600 Al	1.730
2013	Eurokabel ltd., Sofia	Bulgaria	123	1x 2000 Cu	1.350
2013	Netze BW , Stuttgart	Germany	123	1x 300 Cu	150
2013	Disace Energia, Madrid	Spain	145	1x 500 Cu	500
2013	ELSY TRADING	Russia	362	1x 1600 Cu	4.158
2013	RÖSCH Engineering GmbH, Berlin	Germany	123	1x 300 Cu	1.530
2013	SWM via ENACO, Maisach	Germany	123	3x 400 Cu	12.558
2013	Civil & Elect. Projects Contg. Co., Jeddah	Saudi Arabia	420	1x 1000 Cu	1.000
2013	ELSY TRADING	Russia	550	1x 2500 Cu	12.825
2013	METS, Riyadh	Saudi Arabia	245	1x 2500 Cu	3.044
2013	UNITED ELECTRICAL POWER, Taichung	Taiwan	145	1x 1000 Cu	1.000
2013	Netze BW, Stuttgart	Germany	123	1x 400 Cu	2.422
2014	Punatsangchhu-I Hydroelectric Project Authority	Bhutan	420	1x 1200 Cu	12.252
2014	Punatsangchhu-I Hydroelectric Project Authority	Bhutan	420	1x 630 Cu	2.952
2014	Voith Hydro GmbH & Co. KG, Heidenheim	Germany	420	1x 800 Cu	1.121
2014	METKA Metal Constructions of Greece, Athen	Greece	420	1x 800 Cu	4.695
2014	AEG Industrial Engineering AG,Berlin	Gemany	123	1x 1200 Cu	911
2014	London Array Limited, London	Great Britain	550	1x 2500 Cu	180
2014	Evonik Industries AG, Hanau	Germany	123	3x 800 Al	1.385
2014	Südkabel UK Ltd., London	Great Britain	145	1x 1200 Al	51.978
2014	SIEMENS AG, Erlangen	Germany	245	1x 1600 Cu	551

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Reference List of High Voltage **XLPE** Cable Systems from 1973 to 2015
Referenzliste **VPE**-Hochspannungskabelanlagen von 1973 bis 2015

Year Jahr	Customer Kunde	Country Land	Voltage Spannung kV	cross section Querschnitt mm^2		length (core) Aderlänge m
2014	Landsnet, Reykjavik	Iceland	72,5	1x 185	Al	2.322
2014	ELSY TRADING	Russia	245	1x 2000	Cu	2.740
2014	SAG GmbH, Chemnitz	Germany	123	1x 500	Cu	176
2014	ELSY TRADING	Russia	362	1x 1000	Cu	732
2014	Thomsen Anlagenbau, Ziesendorf	Germany	123	1x 630	Cu	105
2014	China Machinery & Equipment (HK) Co. Ltd,Hongkong	Pakistan	550	1x 800	Al	17.266
2014	METKA Metal Constructions of Greece, Athen	Greece	420	1x 800	Cu	650
2014	ELSY TRADING	Russia	123	1x 2500	Cu	3.054
2014	ELSY TRADING	Russia	245	1x 2000	Cu	5.356
2014	ELSY TRADING	Russia	245	1x 1000	Cu	322
2014	Civil & Elect. Projects Contg. Co., Jeddah	Saudi Arabia	123	1x 2500	Cu	1.500
2014	National Grid Electricity Transmission Co.	Great Britain	420	1x 2500	Cu	430
2014	ALB, Wien	Austria	245	1x 1200	Cu	180
2014	Civil & Elect. Projects Contg. Co., Jeddah	Saudi Arabia	420	1x 2500	Cu	14.700
2014	SAG GmbH, Oberhausen	Germany	123	1x 300	Cu	765
2014	Amprion GmbH, Dortmund	Germany	123	1x 2000	Cu	1.108
2014	ALB, Wien	Austria	123	1x 630	Cu	300
2014	SP Power Systems Limited, Glasgow	Great Britain	145	1x 1200	Al	18.903
2014	MVV Energie AG, Mannheim	Germany	123	1x 500	Al	3.900
2014	Thomsen Anlagenbau, Ziesendorf	Germany	123	1x 1000	Al	28.566
2014	Civil & Elect. Projects Contg. Co., Jeddah	Saudi Arabia	420	1x 2500	Cu	7.978
2014	Amprion GmbH, Dortmund	Germany	123	1x 300	Cu	481
2014	Civil & Elect. Projects Contg. Co., Jeddah	Saudi Arabia	420	1x 2500	Cu	124.321
2014	TRADE LINKS & SERVICES CO.L.L.C., Ruwi	Oman	145	1x 1200	Cu	3.750
2014	FL Smidth A/S, Copenhagen	Denmark	123	1x 300	Cu	125
2014	SAG GmbH, Essen	Germany	123	1x 300	Cu	411
2014	Landsnet, Reykjavik	Iceland	245	1x 500	Al	240
2014	ALB, Wien	Austria	123	1x 300	Cu	210
2015	Amprion, Dortmund	Germany	123	1x 2500	Cu	1.080
2015	Amprion, Dortmund	Germany	123	1x 2500	Cu	1.179
2015	Amprion, Dortmund	Germany	123	1x 300	Cu	343
2015	Amprion, Dortmund	Germany	123	1x 2500	Cu	275
2015	NetzeBW, Stuttgart	Germany	123	1x 300	Cu	90
2015	Westnetz , Dortmund	Germany	123	1x 300	Cu	57
2015	ABB Mannheim	Germany	123	1x 300	Cu	25
2015	SAG Oberhausen	Germany	123	1x 300	Cu	170
2015	SWM Infrastruktur GmbH, München	Germany	123	1x 300	Cu	470
2015	HIGHVOLT PRUEFTECHNIK, Dresden	Germany	123	1x 300	Cu	100
2015	Siemens AG, Erlangen	Germany	123	1x 800	Cu	100
2015	ALB, Wien	Austria	123	1x 630	Cu	270
2015	Leonhard Weiss GmbH & Co. KG,Göppingen	Germany	123	1x 300	Cu	585
2015	Lechwerke AG, Augsburg	Germany	123	1x 300	Cu	570
2015	SAG GmbH , Oberhausen	Germany	123	1x 300	Cu	700
2015	Volker Infra Ltd., Heddeston	Great Britain	145	1x 1000	Al	270

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Reference List of High Voltage **XLPE** Cable Systems from 1973 to 2015
Referenzliste **VPE**-Hochspannungskabelanlagen von 1973 bis 2015

Year Jahr	Customer Kunde	Country Land	Voltage Spannung kV	cross section Querschnitt mm^2		length (core) Aderlänge m
2015	Western Power Distribution, Plymouth	Great Britain	145	1x 1200	Cu	150
2015	SAG GmbH , Oberhausen	Germany	123	1x 1600	Cu	343
2015	Volker Infra Ltd., Heddeston	Great Britain	145	1x 800	Al	1.000
2015	Volker Infra Ltd., Heddeston	Great Britain	145	1x 1000	Al	1.074
2015	ALB, Wien	Austria	420	1x 630	Al	1.320
2015	ELSY TRADING AG, Baar	Switzerland	420	1x 630	Cu	904
2015	Gregory Rowcliffe Milners, London	Great Britain	420	1x 800	Al	1.800
2015	Civil & Elect. Projects Contg. Co. , Jeddah	Saudi Arabia	245	1x 800	Cu	1.500
2015	Siemens AG, Erlangen	Germany	362	1x 800	Cu	564
2015	Siemens AG, Erlangen	Germany	362	1x 2500	Cu	360
2015	TenneT TSO GmbH, Lehrte	Germany	245	1x 1800	Cu	3.141
2015	Omexom Hochspannung GmbH, Walsrode	Polen	245	1x 1400	Cu	1.732
2015	Ka-tek GmbH, Kitzingen	Germany	123	1x 300	Al	14.145
2015	Suchow Elektrotechnik GmbH, Bellheim	Germany	245	1x 400	Al	6.700
2015	Sewoong Plant Co.LTD., Seoul	South Korea	420	1x 630	Cu	2.400
2015	Suchow Elektrotechnik GmbH, Bellheim	Germany	245	1x 1200	Cu	2.085
2015	ANDRITZ HYDRO GmbH, Wien	Austria	245	1x 500	Al	797
2015	ANDRITZ HYDRO GmbH, Wien	Austria	245	1x 1200	Al	7.590
2015	Sindra GmbH & Co. KG, Übach-Palenberg	Germany	123	1x 300	Cu	11.400
2015	NHPC Limited, Faridabad-Haryana	India	420	1x 1000	Cu	2.490
2015	SAG GmbH , Chemnitz	Germany	123	1x 630	Cu	2.688
2015	SAG GmbH , Chemnitz	Germany	123	1x 800	Cu	3.798
2015	Leonhard Weiss GmbH & Co. KG,Göppingen	Germany	123	1x 800	Cu	7.311
2015	Leonhard Weiss GmbH & Co. KG,Göppingen	Germany	123	1x 800	Cu	8.712
2015	Merowe Dam Electricity Company	Sudan	550	1x 800	Cu	1.000
2015	Merowe Dam Electricity Company	Sudan	550	1x 1200	Cu	1.100
2015	JSC «Rogun HPS»	Tadschikistan	550	1x 1000	Cu	4.128
2015	O'Connor Utilities Ltd., Manchaster	Great Britain	145	1x 800	Al	14.829
2015	O'Connor Utilities Ltd., Manchaster	Great Britain	145	1x 1200	Al	3.231
2015	Emirates Electrical Engineering LLC , Dubai	UAE	145	1x 630	Cu	13.116
2015	Petrofac Engineering & Construction, Sharjah	UAE	145	1x 500	Cu	22.830
2015	National Grid Electricity Transmission, Warwick	Great Britain	145	1x 800	Al	26.973
2015	National Grid Electricity Transmission, Warwick	Great Britain	145	1x 2000	Al	19.943
2015	Siemens AG, Offenbach	Egypt	550	1x 1200	Al	19.999
2015	Civil & Elect. Projects Contg. Co., Jeddah	Saudi Arabia	420	1x 2500	Cu	16.758
2015	Civil & Elect. Projects Contg. Co., Jeddah	Saudi Arabia	420	1x 2500	Cu	60.426

Alle Aufträge ab 2004 unter Südkabel GmbH
All orders since 2004 by Südkabel GmbH

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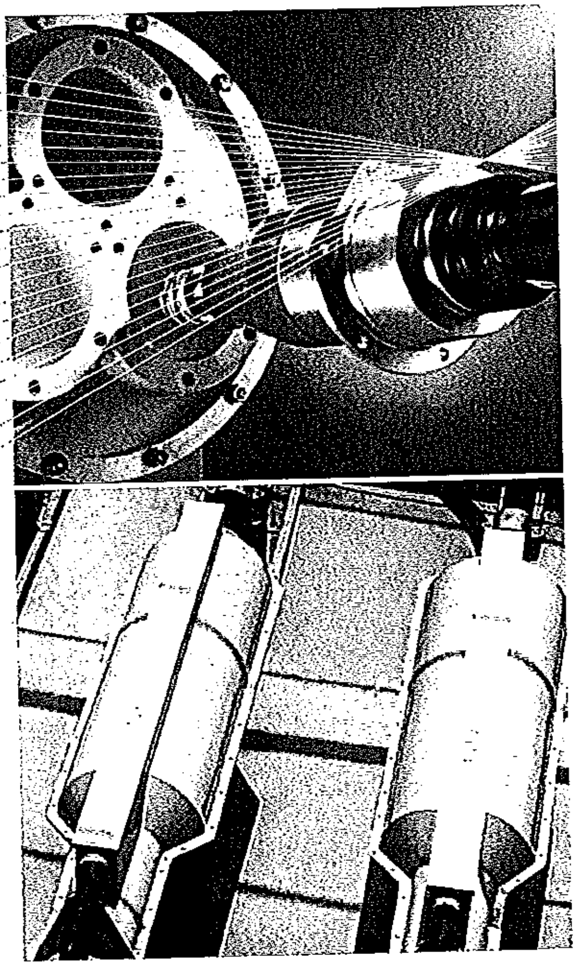
ACCESSORIES FOR XLPE-INSULATED HIGH AND EXTRA-HIGH VOLTAGE CABLES



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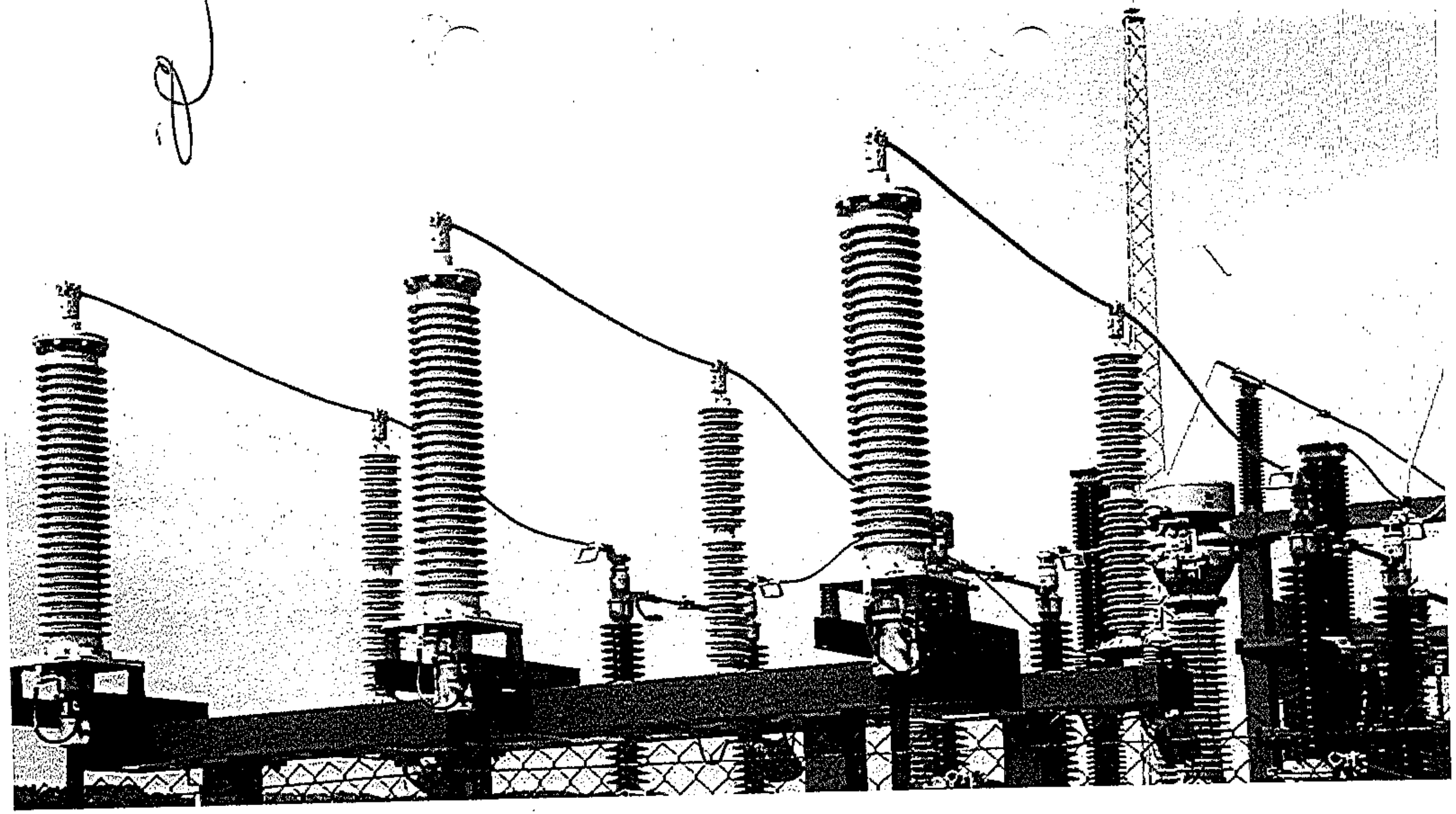

hese are qualities that drive a
100 years. Superior products,
ıanagement are what define us
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ВЯРНО С ОРИГИНАЛА

ООД

Inquiring Minds and the Power of Innovation

Maintaining and improving our knowledge and know-how are important parts of the entrepreneurial culture at Südkabel. The drive to innovate is one of our traditions. Our company is known worldwide as a pioneering specialist for cutting-edge products and technology. Our teams are always on the lookout for new materials, manufacturing or assembly processes that promise better utility and safety. We work hard toward further improving our user-friendly solutions – solutions that meet all our customers' requirements.

Pioneers in XLPE Cable Technology

Ever since the company was founded, our goal has been to provide new solutions that guarantee our customers greater safety and improved procedures. Südkabel established its reputation as a pioneer in XLPE technology when Germany's polymeric-insulated medium-voltage cables were laid in the 1960s. And many more trailblazing innovations followed: the planning and construction of the first 110 kV XLPE cable system in Germany, the first 400 kV XLPE cable system in the European transmission

High-performance technology: Accessories for complex projects

Südkabel accessories are important components for XLPE-insulated high and extra-high voltage cables. Here, too, the development of new products were path-breaking, such as joints for 400 kV XLPE-insulated cables, which in 1995 suceeded in the first world-wide prequalification according to CIGRE (International Council on Large Electric Systems). Our compact terminations are based on this advanced technology. They are excellent examples of how we enhance safe and easy to-install accessories for XLPE-insulated high and extra-high voltage cables. They can be used for almost all types of XLPE-insulated cables with vastly different conductors, screens, sheaths, and armouring. Südkabel accessories can also be installed on EPR insulation up to 170 kV. The optical fibres in screens can be decoupled in all accessories. Accessories for extra-high voltage applications can be supplied with integrated sensors for partial discharge detection. All cable accessories are designed for a long life, the same as expected for energy cables themselves.

Welcome to Sü

Cable access

Built-in terminations _

EHSVS compact termin

and EHTVS (in oil-filled

Outdoor termi

Outdoor terminations fil

Gas-insulated outdoor t

Joints ______

SEHDV(CB) cable joints

Fitting materia

Our Offer ____

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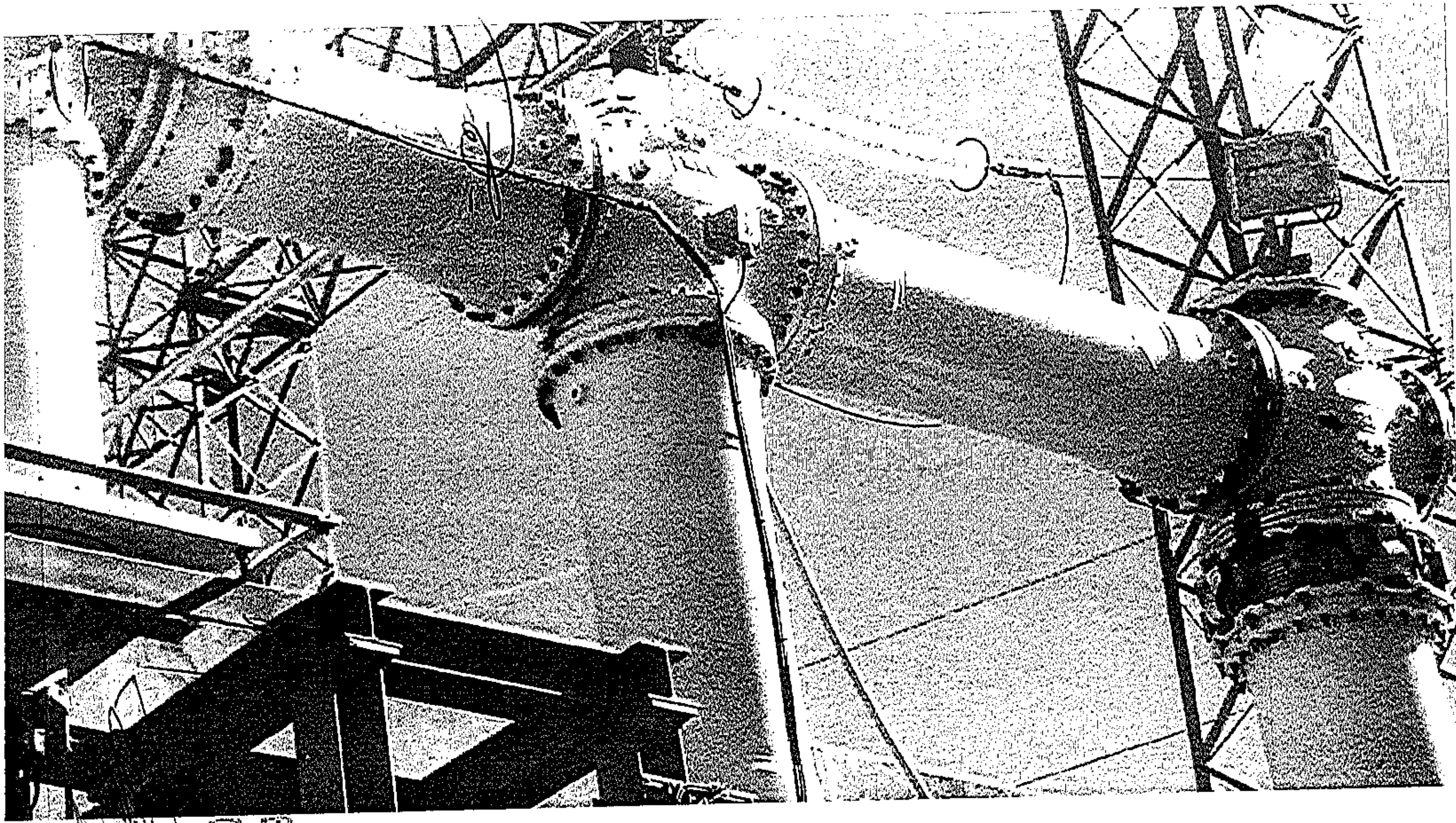

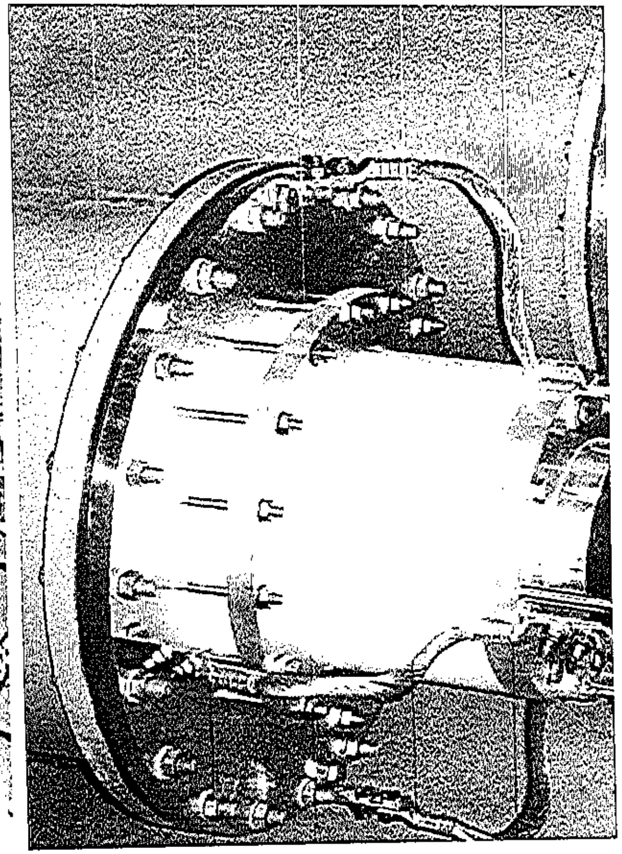

aintenance-free and can be

s the solid insulation contains

n to allow for compact design

nsulator can be pre-installed as
arately from switchgear or
rmination is then simply
socket
d at any position since no
allow for liquid expansion
ost any installation length or

s up to 170 kV at the
itional equipment since for
est adapter is available

ВЯРНО С
ОРИГИНАЛА

ООД

Tests and Test Specifications

- Test specifications for XLPE-insulated high and extra-high voltage cables up to 170 kV are published in DIN VDE 0276-632 and IEC 60840 respectively, and for operating voltages higher than 170 kV in IEC 62067. The compact terminations EHSVS and EHTVS comply with all relevant test specifications
- The values shown in Table 1 (page 7), 'Data sheet for compact terminations', were derived from type and prequalification tests for each compact termination in a single-phase arrangement
- Compact terminations for voltages up to 170 kV were tested in a three-phase enclosure together with the pluggable conductor connection for resistance to lightning impulses (also under reduced operating pressure) and short circuits

For outdoor terminations, Südkabel distinguishes between terminations filled with liquid insulation (EHFV and EHFVC series) and the dry, gas-filled type EHFVCS. The EHFVC is a light-weight, slim-line outdoor termination with a rigid-type composite insulator. We can also produce a variant with a porcelain insulator (EHFV type) for all voltage levels upon request. In both types, the electric field is controlled by means of prefabricated stress cones made of silicone rubber. A balancing volume in the top part of the insulator compensates for temperature-related volume changes in the insulating compound, making for a pressure- and maintenance-free system.

In addition to the composite insulator, the most important component of the dry, gas-filled EHFVCS type is a complete compact termination for controlling the electrical field. This helps shorten on-site installation time since the composite insulator can be supplied pre-assembled.

The Südkabel accessories portf
from 72.5 kV to 550 kV. In 199
provide prefabricated and pre-t
from 245 kV to 550 kV.

All joint types are basically mair
or liquid components. The SEHD
the screens, while the SEHDVCE
for both sides of the screens. S
bonding of cable screens, or for

The joints comply with relevant
IEC 62067). A three-part VMEV(
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and two field control elements r
used to connect two cables wit

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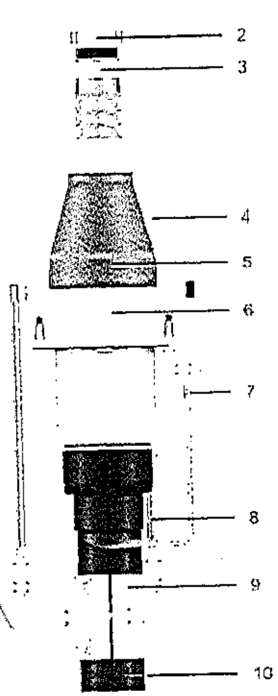
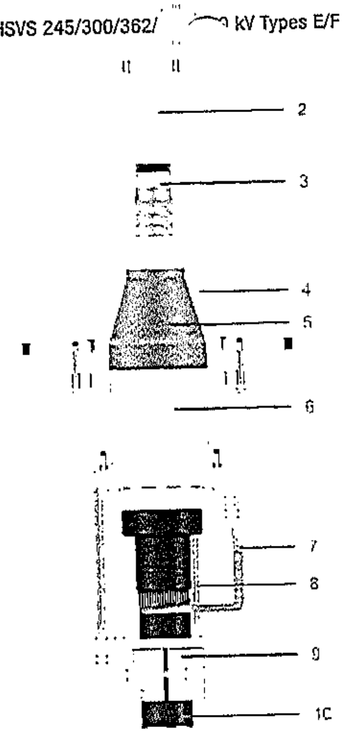
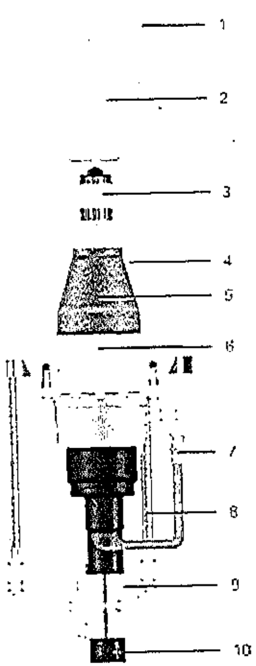
EHSVS 123/145/170 Types A/B



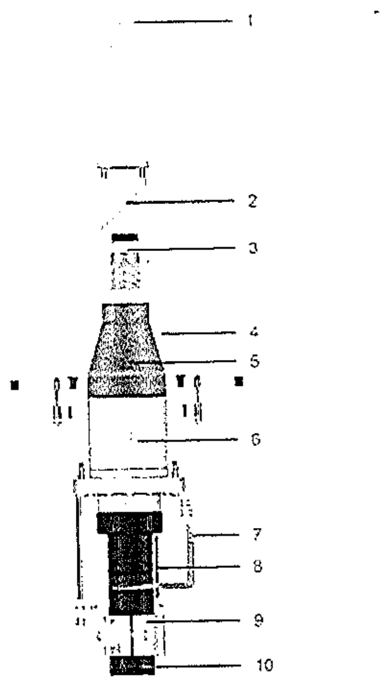
EHSVS 245/300/362/ kV Types E/F



EHTVS 5/123/145 Type D



EHTVS 245/300 Type E



ct

5. Silicone rubber stress cone
6. Inlet with inner spring assembly
7. Screen connection
8. Clamp support
9. Cable clamp
10. XLPE-insulated cable

1. Corona shield
2. Connector
3. Pluggable current contact
4. Epoxy resin insulator
5. Silicone rubber stress cone
6. Inlet with inner spring assembly
7. Screen conı
8. Clamp supp

ВЯРНО С ОРИГИНАЛА

ıse in cable enclosures at

ınce with the interface

ıs A/B are identical, but are

ı made of silicone rubber for
ılator via spring assemblies
ıgs
ər, can generally be used
² up to max. 2500 mm²

Type D

- For voltages from 72.5 kV to 145 kV
- Interface dimensions comply with IEC 62271-209 for voltages from 123 kV to 145 kV
- Like Types A/B, uses a single-phase epoxy resin insulator
- Stress cone made of silicone rubber, with inner spring assembly and pluggable current contact

Types E/F

- For voltages from 245 to 300 kV (Type E) and from 362 to 550 kV (Type F)
- Both variants consist of a pre-assembled stress cone made of silicone rubber for permanent elastic connection with the insulator via spring assemblies
- Design essentially the same as Types A/B
- Single-phase insulator in accordance with the interface dimensions of IEC 62271-209

Highest voltage U_m	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Insulator type	-	G	D/C	A/B	D/C	A/B	A/B	E
In SF_6-enclosure	-	EHSVS	EHSVS	EHSVS	EHSVS	EHSVS	EHSVS	EHSVS
In oil-transformer enclosure	-	EHTVS	EHTVS	EHTVS	EHTVS	EHTVS	EHTVS	EHTVS
Impulse lightning voltage	kV	350	550	550	650	650	750	1050
Switching impulse voltage	kV	-	-	-	-	-	-	-
Normative document	IEC	60840	60840	60840	60840	60840	60840	62067
Cu/Al conductor (min.)	mm²	95	150	150	240	240	240	400
Cu/Al conductor (max.)	mm²	800	800	2500	800	2500	2500	2500
Rated current (max.) *	A	3150	3150	3150	3150	3150	3150	3150
Rated peak current *	kA	100	100	170	100	170	170	170
Rated short-time withstand current *	kA/s	40/3	40/3	50/3 63/1	40/3	50/3 63/1	50/3 63/1	50/3 63/1

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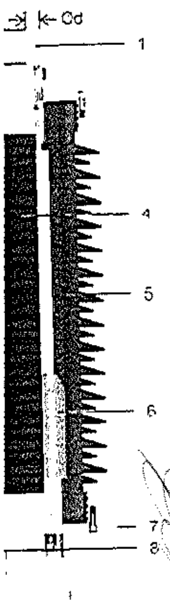
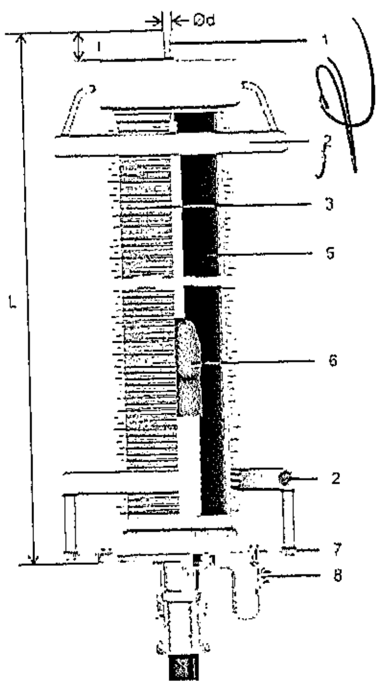
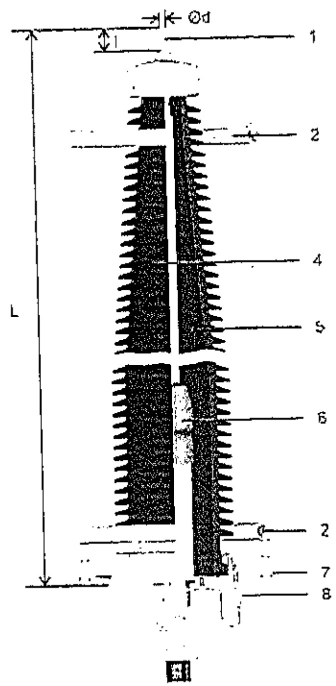
V to 170 kV



EHFVC to 550 kV



E... 50 kV



...nsulation liquid
6. Stress cone
7. Base plate
8. Screen connection

...osite insulator)
...sulator)
... made of fibreglass-reinforced
...t sheds of high-grade silicone
...ss cone made of silicone
...mination
...olyisobutylene)
... fittings (arcing horns)
... special cast-resin

- Meets the requirements of relevant test specifications (e.g. IEC 60840, IEC 62067, IEC 60815)
- Insulators with extended creepage paths for use in highly polluted areas are available
- Cantilever load at conductor bolt dependent on type and length of insulator
- Possible modification of external insulation to correct for atmospheric conditions (for installations at altitudes > 1000 m) by increasing the arcing distance with longer insulators or by using accessories with a higher voltage level
- Short overall height insulator up to a maximum of 30° inclination

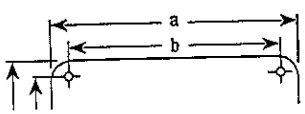
ВЯРНО С ОРИГИНАЛА

ООД ... Загора

High voltage ...						
Variant with composite i...	-	EHFVC	EHFVC	EHFVC	EHFVC	EHFVC
Variant with porcelain insulator	-	EHFV	EHFV	EHFV	EHFV	EHFV
Impulse lightning voltage	kV	350	550	650	750	1050
Switching impulse voltage	kV	-	-	-	-	-
Normative document	IEC	60840 60815	60840 60815	60840 60815	60840 60815	62067 60815
Cu/Al conductor (min.)	mm²	95	150	240	240	400
Cu/Al conductor (max.)	mm²	2500	2500	2500	2500	2500
Rated current (max.) *	A	3150	3150	3150	3150	3150
Rated peak current *	kA	170	170	170	170	170
Rated short-time withstand current *	kA/s	50/3 63/1	50/3 63/1	50/3 63/1	50/3 63/1	50/3 63/1
Standard pollution class	-	≥ d/III heavy	≥ d/III heavy	≥ d/III heavy	≥ d/III heavy	≥ d/III heavy
Length with class d/III (approx.) EHFVC/EHFV [L]	mm	1350/ 1020	1710/ 1490	1980/ 1700	2290/ 1950	2590/ 2540
Weight with class d/III (approx.) EHFVC/EHFV **	kg	80/ -	90/ 175	95/ 195	105/ 235	370/ 470
Base plate dimensions [a]	mm	420	420	420	420	600
Hole distance [b]	mm	345	345	345	345	500
Hole diameter [Ø c]	mm	18	18	18	18	23
Bolt diameter [Ø d] (≤1000 mm²/>1000 mm²)	mm	30/50	30/50	30/50	30/50	30/50
Bolt length [l]	mm	100	100	100	100	100

* Depending on cable conductor cross-section; ** Without cable

Table 2: Data sheet for outdoor terminations filled with liquid plate



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2

3

4

5

6

5. Compact termination
6. Screen connection

ВЯРНО С ОРИГИНАЛА

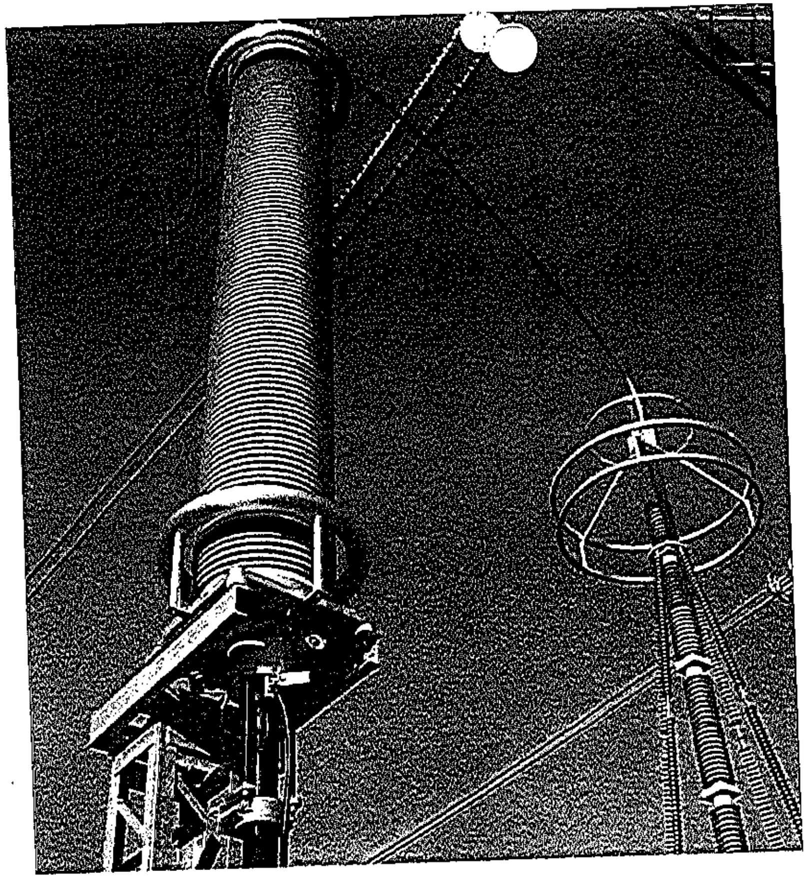
me compared with terminations

ng on shed alignment
mbly

rced plastic support tubing
silicone-rubber
mponent of the electric

fastened to the base plate of

silicone rubber connected to

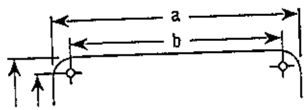


- Filled with high-grade insulating gas
- Optional equipment: flashover protective fittings (arcing horns)
- Meets the requirements of relevant test specifications (e.g. IEC 62067, IEC 60815)
- Insulators with extended creepage paths for use in highly polluted areas
- Cantilever load at conductor bolt dependent on type and length of insulator being used
- Possible modification of external insulation to correct for atmospheric conditions (for installations at altitudes > 1000 m) by increasing the arcing distance with longer insulators or by using higher-voltage accessories
- Also available with optional heating system for use in very low-temperature environments

Highest voltage Um				
Variant with composite In... or	-	EHFVCS	EHFVCS	EHFVCS
Impulse lightning voltage	kV	1050	1050	1175
Switching impulse voltage	kV	-	850	950
Normative document	IEC	62067 60815	62067 60815	62067 60815
Cu/Al conductor (min.)	mm²	400	400	500
Cu/Al conductor (max.)	mm²	2500	2500	2500
Rated current (max.) *	A	3150	3150	3150
Rated peak current *	kA	170	170	170
Rated short-time withstand current *	kA/s	50/3 63/1	50/3 63/1	50/3 63/1
Standard pollution class	-	≥ d/III heavy	≥ d/III heavy	≥ d/III heavy
Length with class d/III (approx.) [L]	mm	3120	3120	3650
Weight with class d/III (approx.) **	kg	350	350	650
Max. longitudinal power effect	kN	2	2	2
Base plate dimensions [a]	mm	600	600	800
Hole distance [b]	mm	500	500	700
Hole diameter [Ø c]	mm	23	23	23
Bolt diameter [Ø d]	mm	60	60	60
Bolt length [l]	mm	100	100	100

* Depending on cable conductor cross-section; ** Without cable

Table 3: Data sheet for gas-filled outdoor terminations



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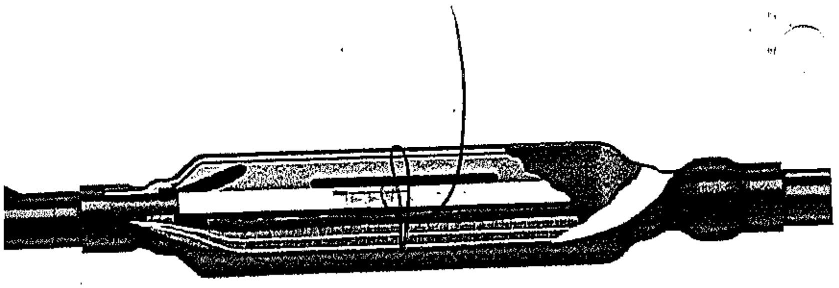

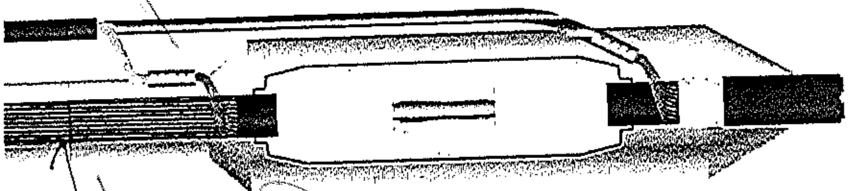

ВЯРНО С ОРИГИНАЛА

lcone-rubber joint allows for

i different cross-sections and

t with one or more heat-
i 170 kV; from 245 kV to

specifications (e.g. IEC 60840,
)67 Annex G)
ion with a cast-resin filling in
il coating (for lead- and
; protective housing
ling in a fibreglass protective
im 245 kV to 550 kV
coating (for lead- and

Alternative for 245 kV – 420 kV

The three-part VMEV(CB) joint can be used as an alternative for voltages from 245 to 420 kV. This joint consists of an epoxy-resin body and two field control elements made of silicone rubber. Südkabel has carried this variation since 1993 in its product range, meaning it can look back on many years of experience with it. This type of joint can also be used to connect cables with two completely different constructions.

Highest voltage Um							
Variant	-	SEHDV(CB)	SEHDV(CB)	SEHDV(CB)	SEHDV(CB)	SEHDV(CB)	S
Impulse lightning voltage	kV	350	550	650	750	1050	
Switching impulse voltage	kV	-	-	-	-		
Impulse lightning voltage screen separation	kV	60	75	75	75	95	
Impulse lightning voltage outer protection	kV	30	37,5	37,5	37,5	47,5	
Direct voltage outer protection	kV	20	20	20	20	20	
Normative document	IEC	60840	60840	60840	60840	62067	
Cu/Al conductor (min.)	mm²	95	150	240	240	400	
Cu/Al conductor (max.)	mm²	2500	2500	2500	2500	2500	
Rated current (max.) *	A	2500	2500	2500	2500	2500	
Rated peak current *	kA	170	170	170	170	170	
Rated short-time withstand current *	kA/s	50/3 63/1	50/3 63/1	50/3 63/1	50/3 63/1	50/3 63/1	
Length insulation body (approx.)	mm	540	680	680	680	740	
Weight of standard-variant (approx.) **	kg	15	30	30	30	50	
Max. longitudinal force effect (in-air installation)	kN	20	20	20	20	20	
Max. longitudinal force effect (in-ground installation)	kN	50	50	50	50	50	

* Depending on cable conductor cross-section; ** Without cable

Table 4: Data sheet for joints, 72.5 – 550 kV

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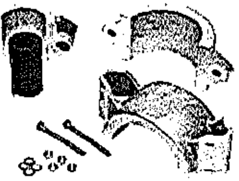

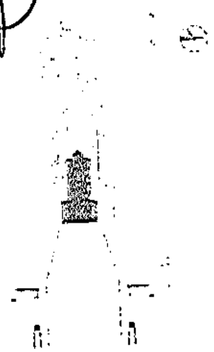

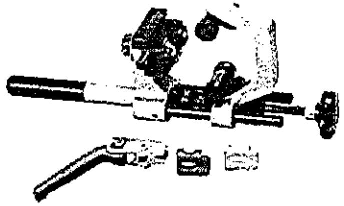

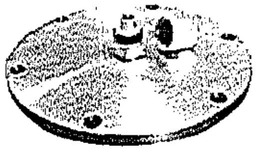

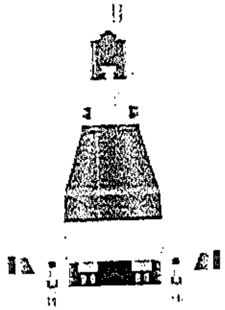

· compact

ırs with compact insulator
voltage)
nsulators installed in

SF_6 test pressures within

3, C/D/G, E and F

or cross-bonding or grounding
atalogue features boxes for
egree IP66), as well as for
ean shafts or directly in the

allable
an be installed in boxes for
l screen bonding
d current-resistant design
) to 63 kA/ 1 s rated short-time

erminations

compact termination top

EHSVSM GIS/transformer dead-ends

- EHSVSM dead-ends for voltage-stable, contact-protected termination of built-in insulators in SF_6 gas-insulated switchgears, or oil-filled transformers without cable connection
- The facility can be operated without pressure monitoring or risk to humans
- Very simple mounting without the need for specialised personnel
- When GIS/transformer dead-ends are removed, the corresponding compact termination can be inserted and the system re-energised
- Suitable for voltages up to max. 2.5 U_0

GIS/transformer connection adapters

In addition to conventional interfaces for compact terminations Südkabel can produce custom variants for almost all types of connector bolts and connector flanges in accordance with IEC 62271-209 and EN 50299.

Installation tools

- Südkabel offers the entire range of specialised installation tools, such as stripping tools, compression tools, cutting tools, etc.

Compact termination insulator

- Adapter to make all available SF_6 gas-insulated switchgears, bushings and transformers compatible with compact terminations from Südkabel
- Installation in all current models, including retroactive installation to use dry compact terminations as a replacement for conventional oil-filled terminations

Bundling tape

- Fibreglass-reinforced black adhesive tape for short circuit-proof

MAB Cable Cleaner

- Cable cleaning fluid for removing installation residues such as dust, oil, or grease particles from cable sheathing and insulation
- Supplied in 0.6 litre containers

Plastic cable clamps

- Fibreglass-reinforced polyamide cable clamps for secure, short circuit-proof mounting of single- and multicore XLPE-insulated cables
- Flame retardant polyamide, dyed black for UV resistance
- Two-part clamps consisting of an upper and a lower section
- Obligatory rubber insert
- Consistent resistance values for temperature ranges encountered in the field
- Mechanical short-circuit stability up to 20 kN
- Can be used for light cables in any type of installation; with heavy cables, use only in horizontal sections

Sheath voltage limiter (SVL)

- For cable screen cross bonding and for single-end screen bonding
- Size of metal-oxide arrestors determined by maximum expected failure voltage (generally max. approx. 10 kV)

Test adapter

- For high-voltage testing of an XLPE-insulated cable system prior to mounting the EHSVS or EHTVS compact terminations in the GIS or transformer
- Component usually includes test cable for test voltage supply
- Supplied with appropriate insulator sockets in a metal jacket tube filled with pressurised SF_6 gas

Protective cover wi
for compact termin

Protective covers are recommer
terminations.

- Protects terminations that a
connected, from mechanica
- Earthing point included

Silumin cable clamp

- Made of non-magnetic alur
- For safe, short circuit-proof
cables
- Available in five basic sizes
- Adaptable to outer cable er
- Fixing material included
- At least 2 clamps in the cer
to ensure correct terminatic
recommended for heavier c

Voltage-proof dead-
terminations

- SF_6 gas-filled, voltage-proo
terminations
- Can be used to test cables
transformer; voltage supplie

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OUR OFFER

Cables

- XLPE-insulated cables from 10 kV to 500 kV

Accessories for medium, high, and extra-high voltage

- Outdoor terminations
- Conventional and compact terminations for SF_6 switchgears and transformers
- Cable joints
- Compact terminations for outer and inner cone systems
- Cable links for medium voltage
- Accessories for electrostatic precipitator cables

Cable systems

- Turnkey XLPE-insulated cable systems up to 500 kV

Overhead line conductors

- Aluminium
- Copper
- Aluminium steel

Services

- Consulting for application-related questions
- Training for installation personnel
- Cable laying and supervision of laying
- Installation of accessories
- Commissioning
- After-sales services

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ВЯРНО С ОРИГИНАЛА

ООД Стара Загора

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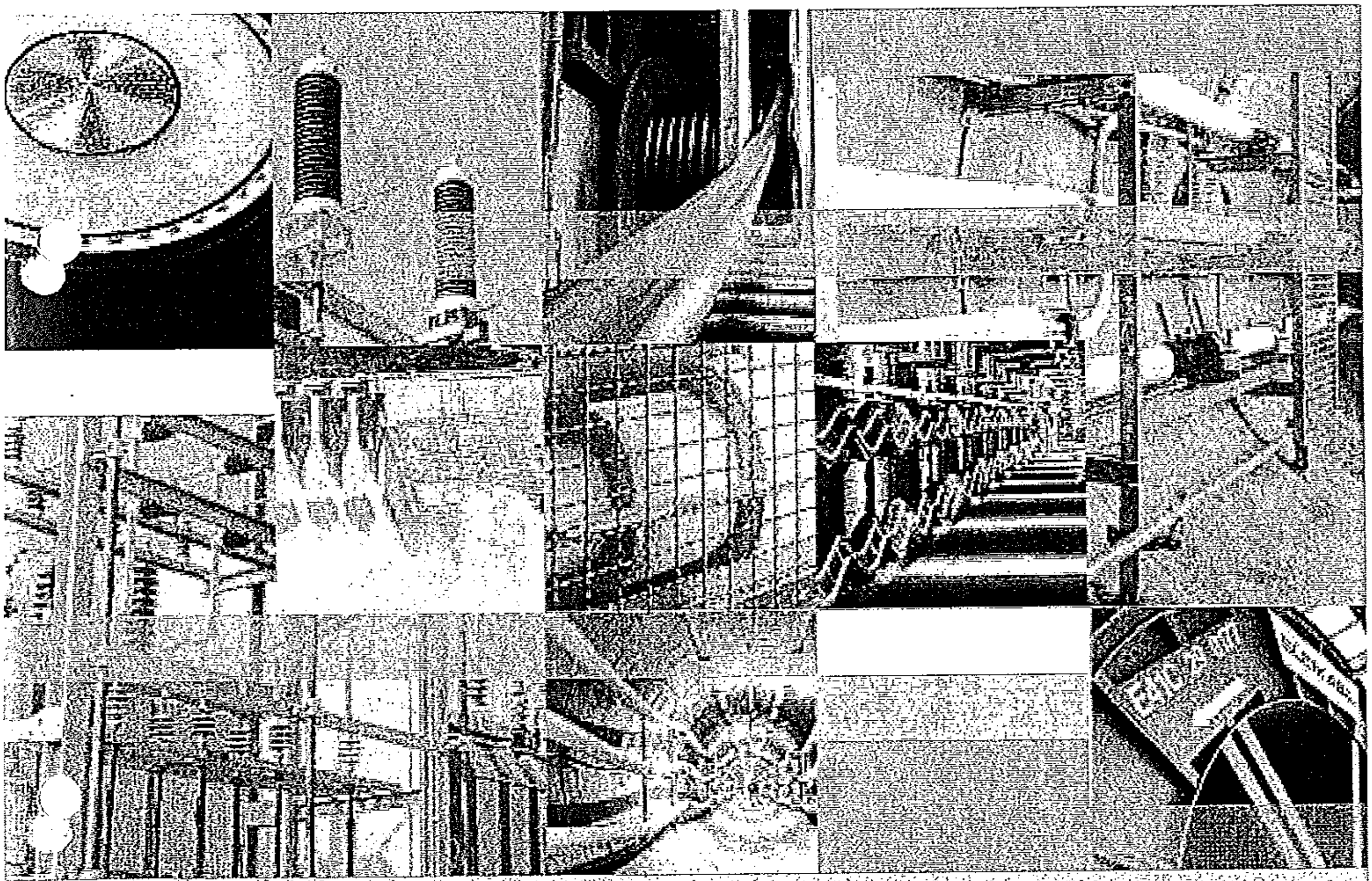
XLPE Power Cable Systems for High and Extra-High Voltages



Kabelsysteme, Kabel und Garnituren
Cable Systems, Cables and Accessories

SÜDKABEL

ВЯРНО С
ОРИГИНАЛА

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XLPE Cable Systems for High and Extra-High Voltages

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Typical Data for High and Extra-High Voltage XLPE Cables	18
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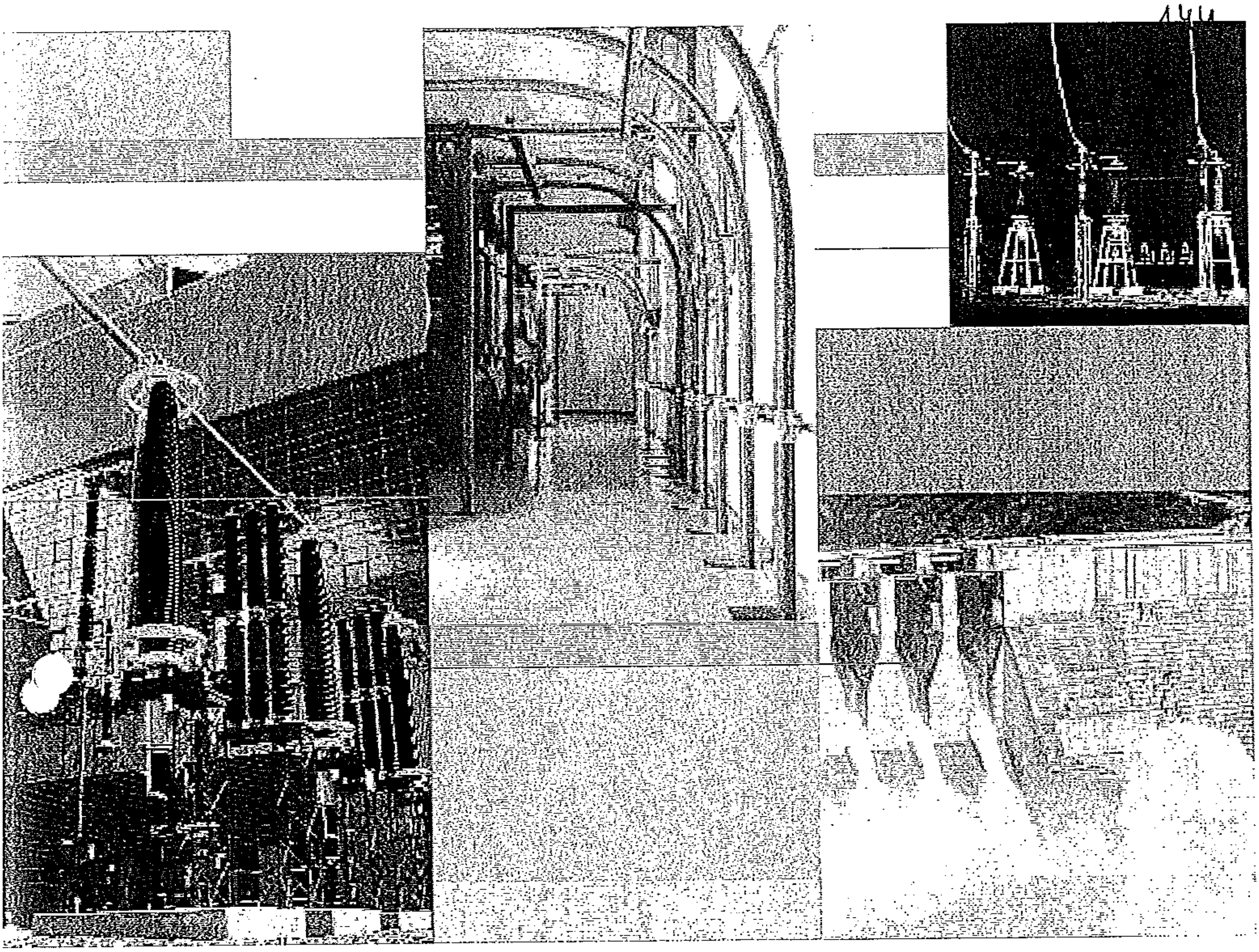
Südkabel – a brief history

Südkabel's first cable factory was initially founded at Mannheim in 1898 as Süddeutsche Kabelwerke (Südkabel). In 1970, Südkabel merged with Rheinische Kabel- und Drahtwerke GmbH (Rheinkabel), Cologne, and from that date onwards the company operated under the name of Kabel- und Lackdrahtfabriken GmbH (Kabel+Draht).
Kabel + Draht was for more than 15 years a wholly owned subsidiary of Brown, Boveri & Cie. (BBC) and after the merger between Asea and BBC to create the ABB Group in 1988, the company's name was changed to ABB Kabel und Draht GmbH.
As from 1997, the power cable operations were handled under the name of ABB Energiekabel GmbH in Mannheim.
Effective 1 January 2004, the company together with all its cable and accessory manufacturing operations in Mannheim, Germany, was taken over by the German Wilms Group - owner of a number of independent companies and cable factories - and from this date onwards it has been trading as Südkabel GmbH.



A Pioneer with Can-do Capabilities Honed over Decades

Professional expertise at the highest voltage level

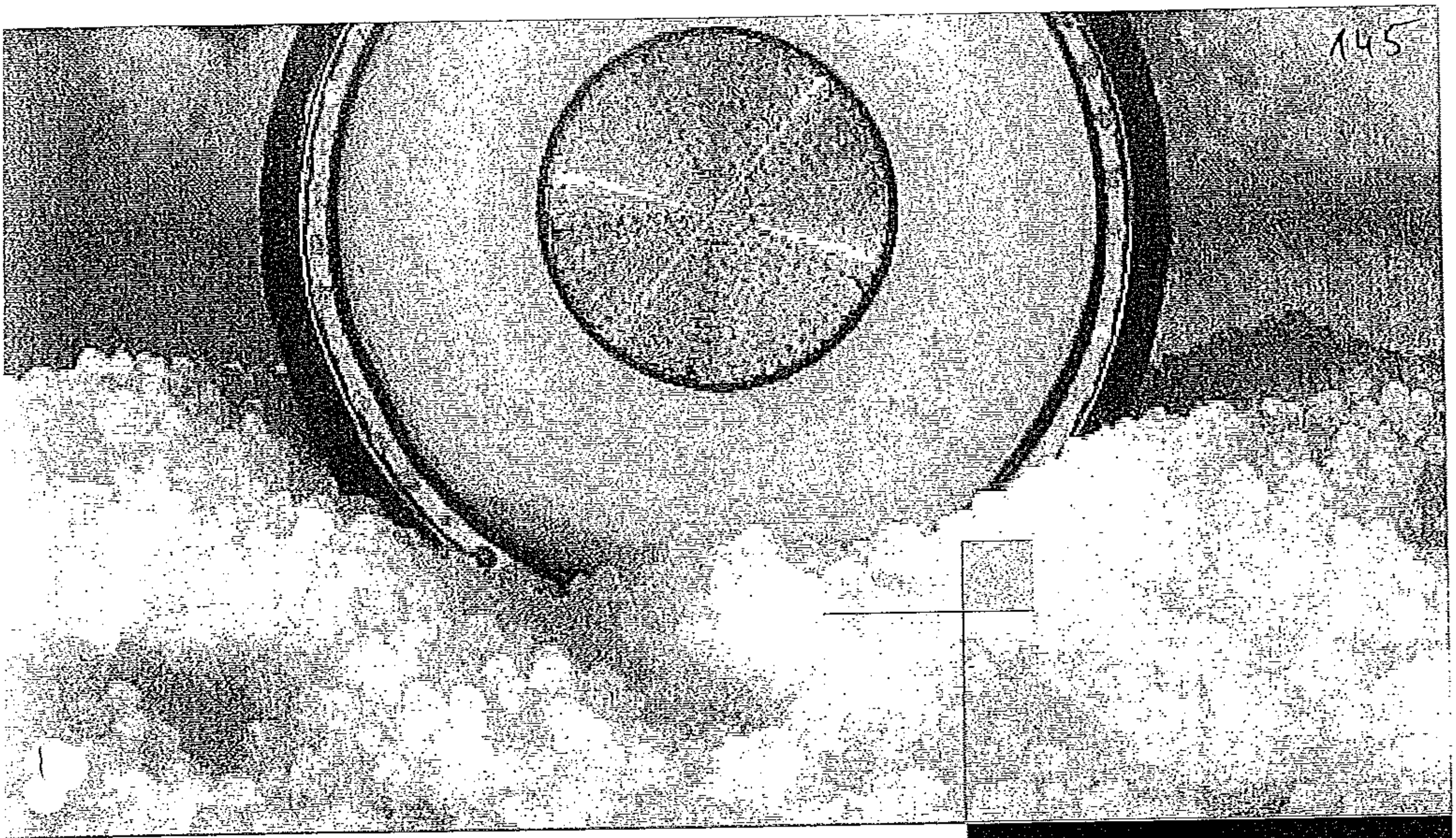
Südkabel is a respected partner for power utilities and the electrical engineering industry the whole world over.
For safe, reliable power transmission and distribution, it offers complete system packages coupled with state-of-the-art production processes, comprehensive service support and a maximum of quality assurance.

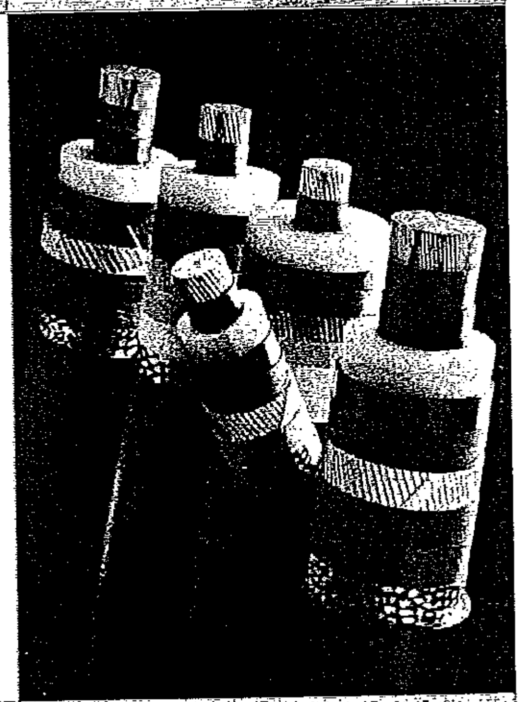
On national and international markets alike, this long-established company, drawing on more than a century of experience in cable production, is acknowledged as a top-ranking vendor of cable systems; its can-do expertise is incorporated in up-to-the-future products whose efficacy has been validated in actual operation.

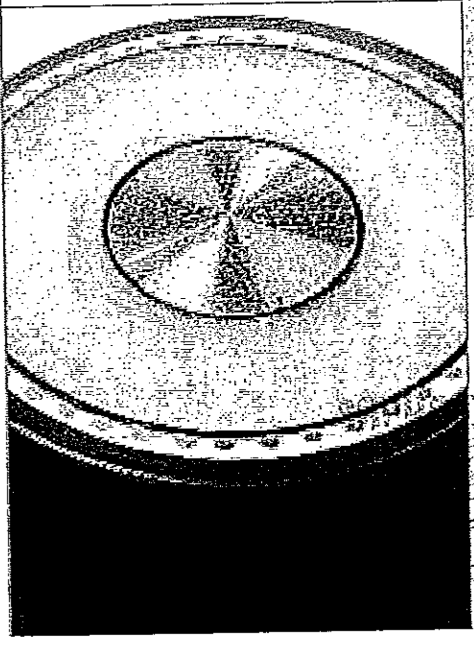
Südkabel – for pathbreaking XLPE technology

Südkabel has set numerous milestones in the field of power transmission cables.
Its pioneering achievements are particularly evident in the field of XLPE technology: it was back in the 1960s that the first solid-dielectric medium-voltage cables were installed in Germany.

Since then, the cable specialists have maintained their path breaking status worldwide - by planning and building the first 123 kV XLPE cable systems in Germany in the early 1970s, Germany's first XLPE insulated 245 kV cable system, the first 420 kV XLPE cable system in the European transmission network, and not least by manufacturing and installing their first 550 kV XLPE cable system in China.







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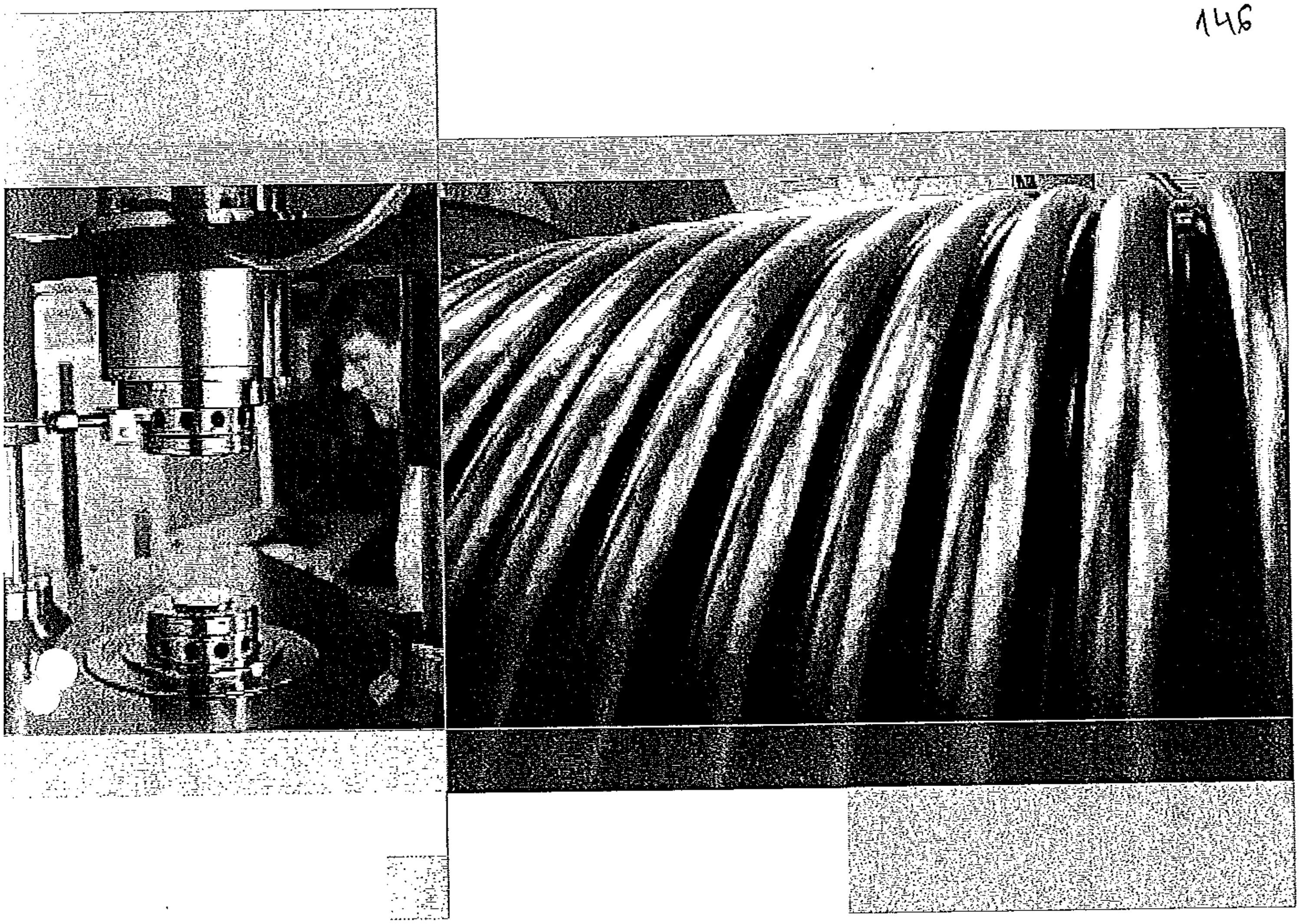


XLPE - The Insulating Material

for High and Extra-High Voltage Cables

The raw material used for the insulation is low-density polyethylene (LDPE). By virtue of its homopolar character, polyethylene has a low relative permittivity, a very low power loss factor and very high dielectric strength.

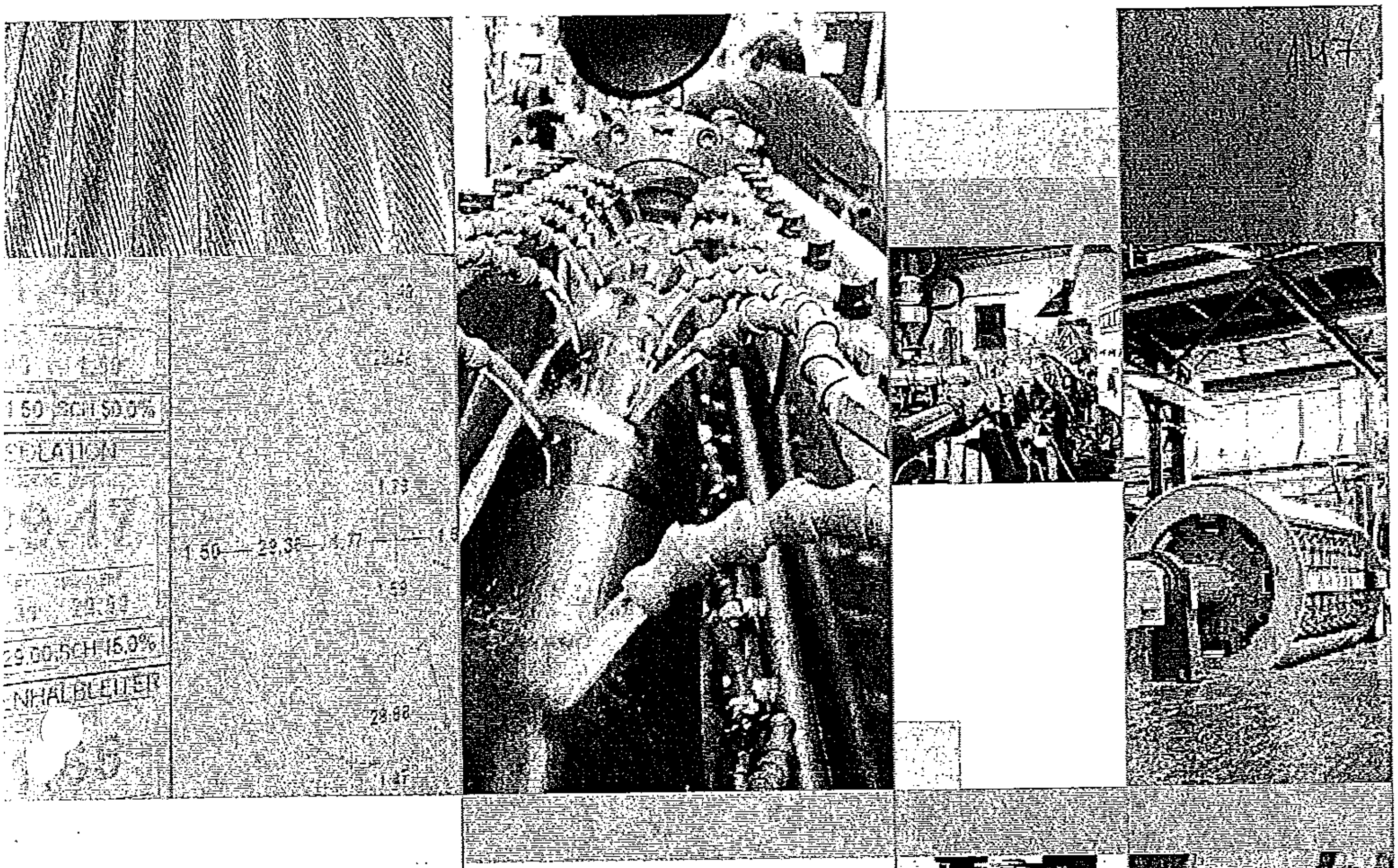
The cross-linking process provides improved mechanical characteristics while not affecting the dielectric properties at all.

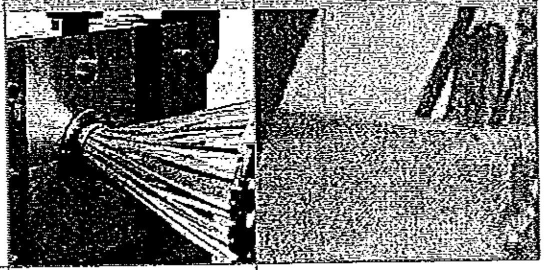
Besides the excellent electrical properties, the mechanical characteristics remain also very good even at high temperatures.

Even at high short-circuit temperatures, XLPE retains good dimensional stability and in this crucial point it is definitely superior to thermoplastic PE.

Thanks to XLPE's high thermal stability, thermal ageing plays practically no role at all, provided the permissible operating conditions are complied with.

Results from extensive long-term studies show, that with the technologies available nowadays the material can be relied upon to cope with very high operating field strengths.





The Design of High Voltage XLPE Cables

The conductor

In high voltage XLPE cables, round, compacted, stranded conductors made of copper or aluminium are used. In order to reduce the skin effect, a segmented conductor design is provided in the case of conductor cross-sectional areas of >1000 sq.mm.

The insulation

For optimised manufacture of the XLPE insulation and the field-limiting inner and outer semi-conductive layers, the cable core is extruded in a triple extrusion head, thus ensuring the smooth interfacing between insulation and semi-conductive layers required for high operating field strength.

The subsequent continuous cross-linking and cooling operation is performed in a tube connected directly to the triple head.
The "dry" cross-linking process and the high pressure inside the tube assure a homogeneous insulation structure for the cable core, without any voids.

The screen

A layer of conductive tapes is applied over the extruded outer semi-conductive layer. The copper-wire screen itself consists of shield wires arranged in a helical configuration and one or more counter-helixes made of copper tapes.
The geometrical cross-section of the copper screen is chosen to suit the short-circuit requirements in each individual application.

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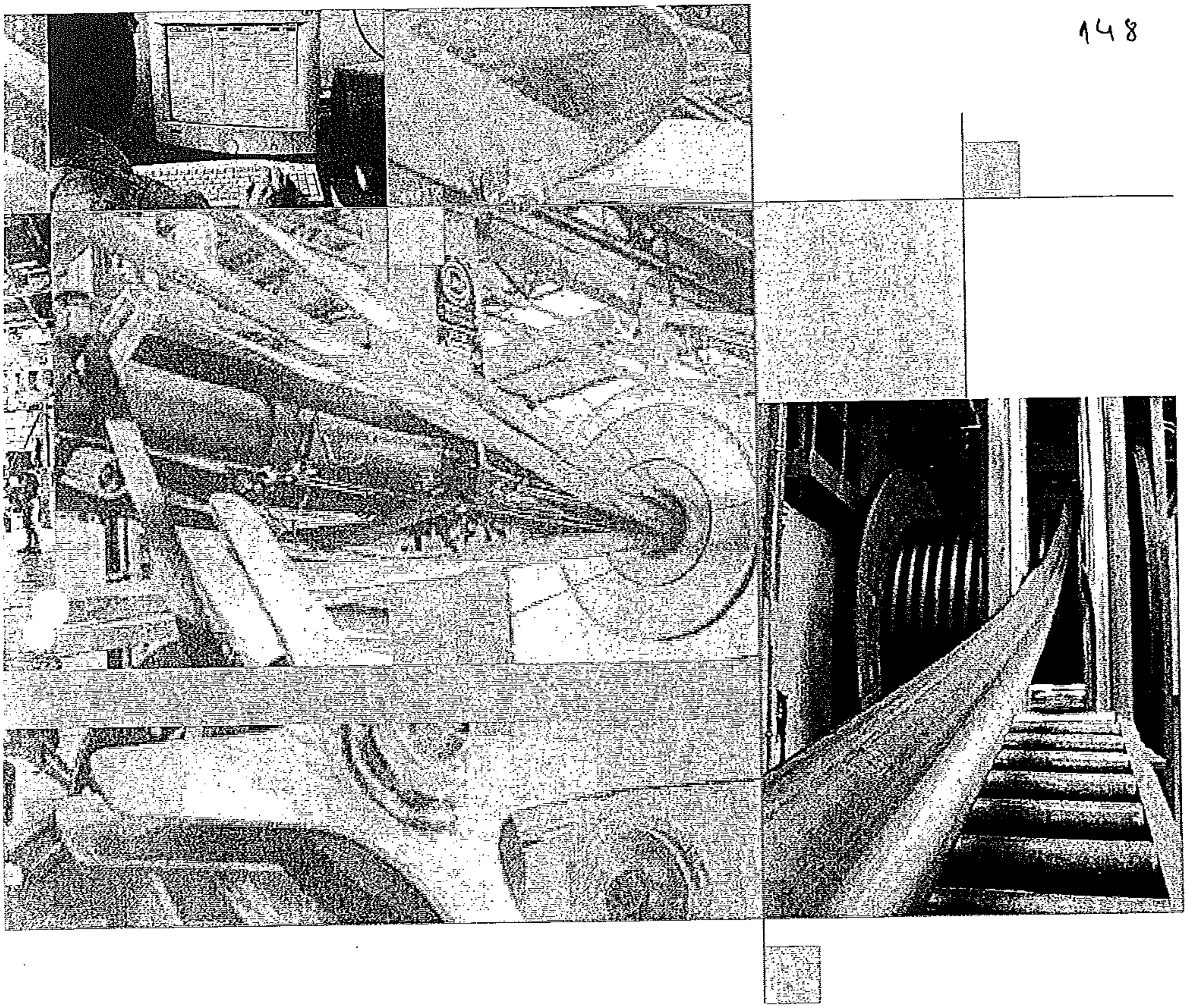


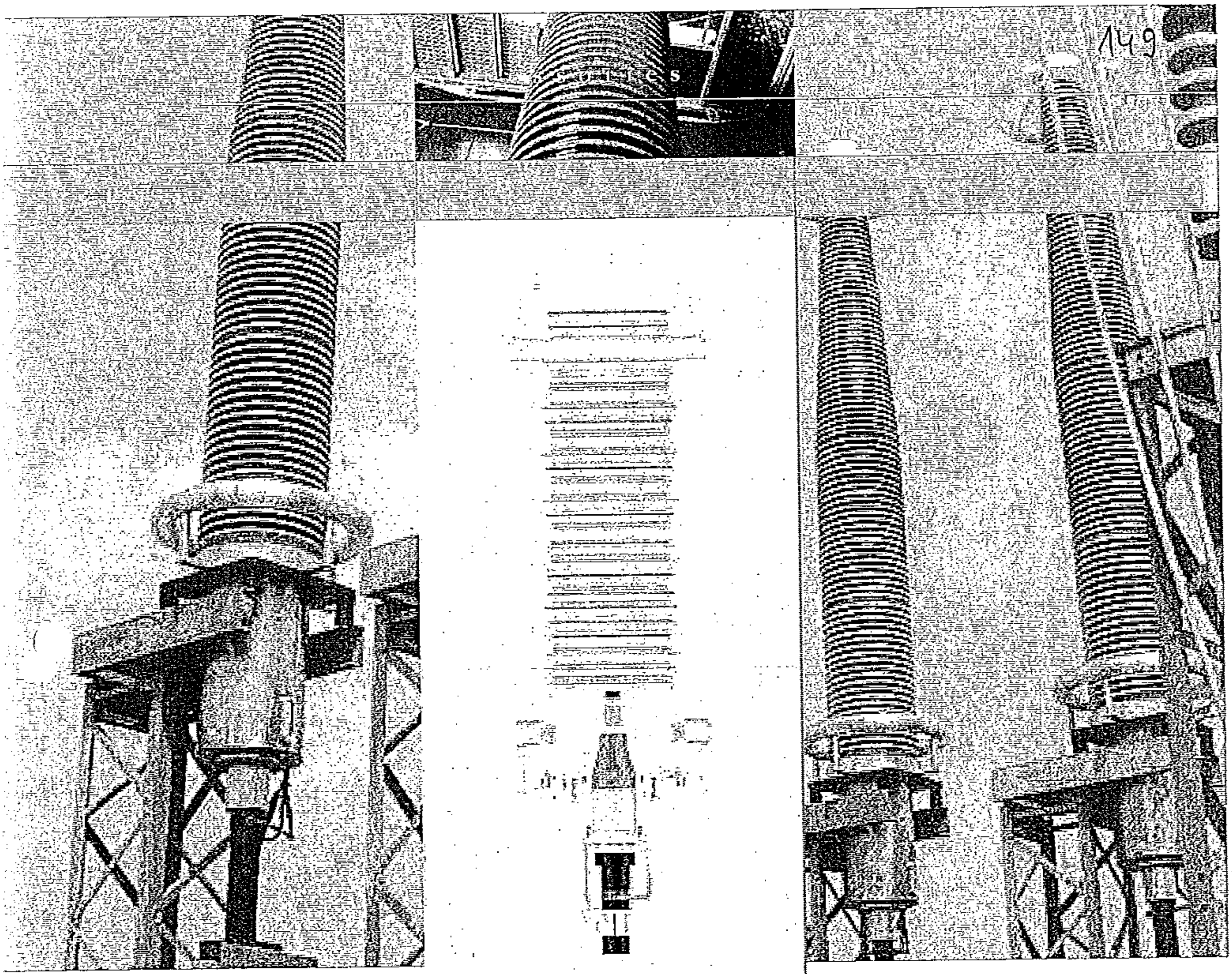
The screen area is in longitudinally watertight design, either filled with a swellable powder or with a swellable substrate provided by inserting textile or nonwoven tapes.
These substances will swell up substantially if they come into contact with water, e.g. following damage to the outer sheath, thus forming a barrier to water in the longitudinal direction.

The outer sheath

To ensure reliable protection against mechanical effects from outside, the high and extra-high voltage XLPE cables are given an outer sheath made of high-density polyethylene (HDPE), which possesses excellent mechanical properties.

With a transversely watertight cable design, protection is provided by a laminated sheath, comprising a longitudinally applied coated aluminium tape, firmly welded to the polyethylene sheath extruded over it.
While the polyethylene provides mechanical protection for the cable, the aluminium tape prevents radial water-vapour diffusion and thus any penetration of moisture into the cable.
As an optional extra, additional flame-retardant and/or semi-conductive layers can be extruded together with the PE outer sheath.

Besides the cable construction described above, other cable designs can also be offered, e.g. with a lead sheath.



Outdoor termination

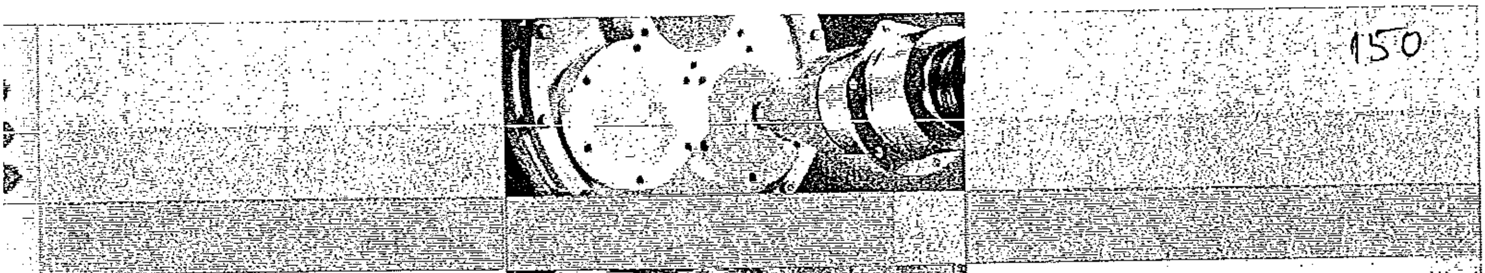
For our extra-high voltage cables with insulation made of cross-linked polyethylene, all commonly used cable accessories are available: outdoor terminations, transformer and SF_6 GIS terminations, and joints. Accessories for XLPE-insulated high and extra-high voltage cables necessitate seamlessly customised compatibility, so Südkabel develops and manufactures these accessories in-house.
The entire range of accessories is matched to the cables with optimum precision - thus providing a maximum of safety under all operating conditions in our customers' power transmission networks.

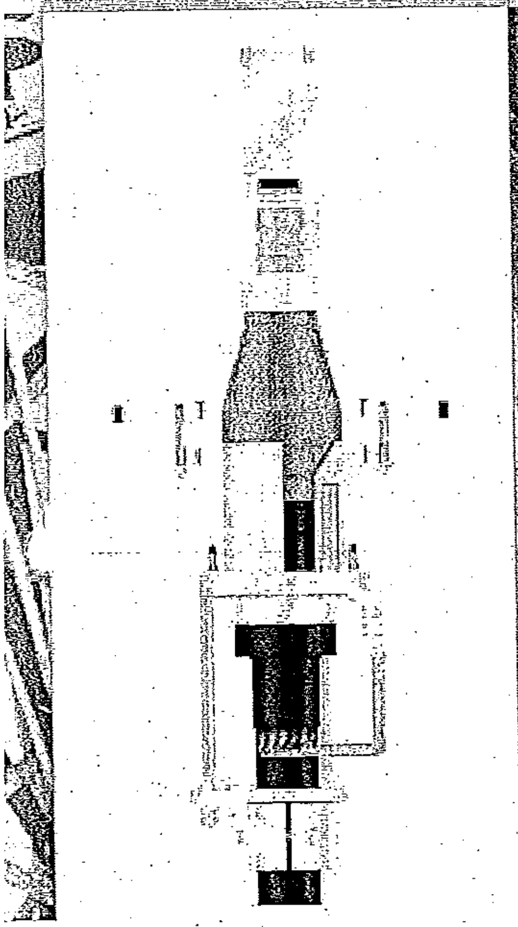
Outdoor terminations

The outdoor terminations are installed with a porcelain or a composite insulator.
The length of the insulator's creepage path is specified to suit the requirements of the particular application concerned. It is usually mounted on a steel support construction using additional post-insulators, providing the necessary potential isolation between the termination's base plate and the earthed supporting structure during sheath testing.

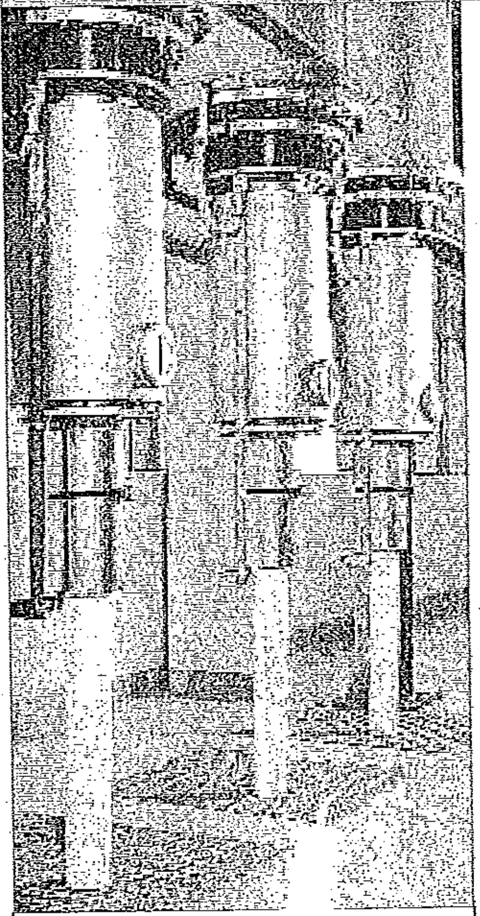
ВЯРНО С
ОРИГИНАЛА

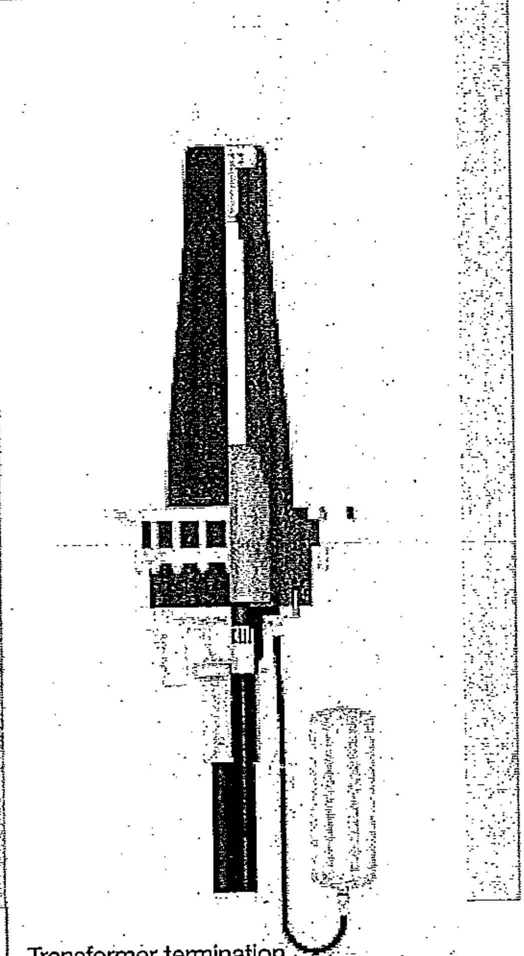
150





SF$_6$-GIS termination





Transformer termination

SF$_6$ GIS terminations

The terminations for SF$_6$-gas-insulated switchgears are installed with an epoxy resin insulator, including an integrated insulating clearance for potential isolation between the switchgear housing and the cable screen/sheath.
The interface dimensions conform to IEC TS 60859 or are agreed between the switchgear and cable system suppliers for the particular application concerned.
Both conventional terminations with a fluid filling in the insulator and plug-in "dry" terminations are available.

The advantage of the plug-in terminations is that the insulator socket can be installed in advance at the switchgear manufacturer's plant, thus obviating the need for additional work with SF$_6$ gas for cable installation on site.
The version with plug-in terminations also enables a cable test to be performed before the plug-in operation, using appropriate test adapters.

Transformer terminations

The transformer terminations feature an insulator made of epoxy resin, with an integrated insulating clearance for potential isolation between the transformer housing and the cable screen/sheath.
The interface dimensions conform to DIN EN 50299 and IEC TS 60859, or are agreed between the transformer and cable suppliers concerned in the particular case involved.
As with the switchgear terminations, both conventional fluid-filled and "dry" plug-in terminations are available for use in transformers.
Using the plug-in terminations in transformers offers comparable advantages to those obtained with the switchgear.

ВЯРНО С
ОРИГИНАЛА

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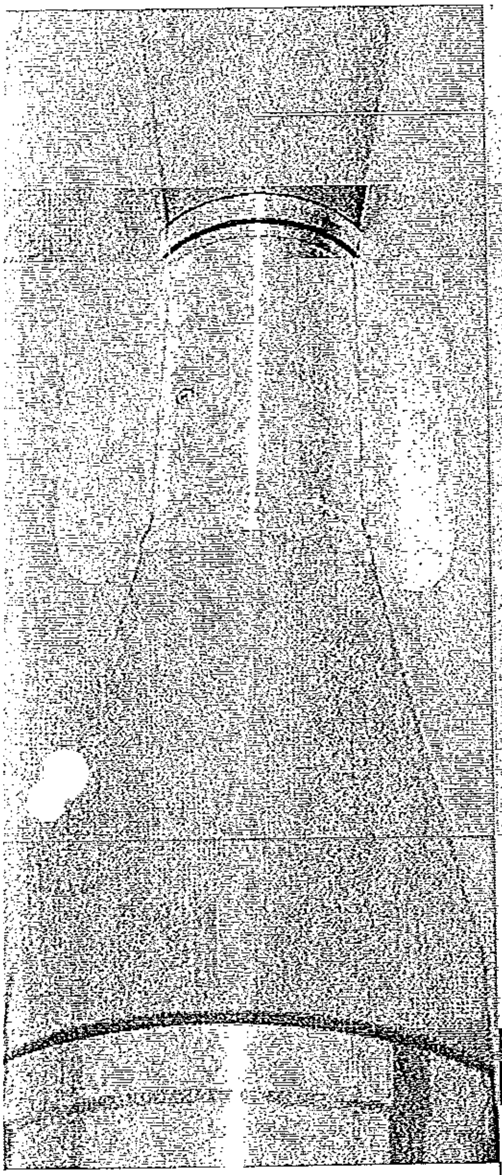
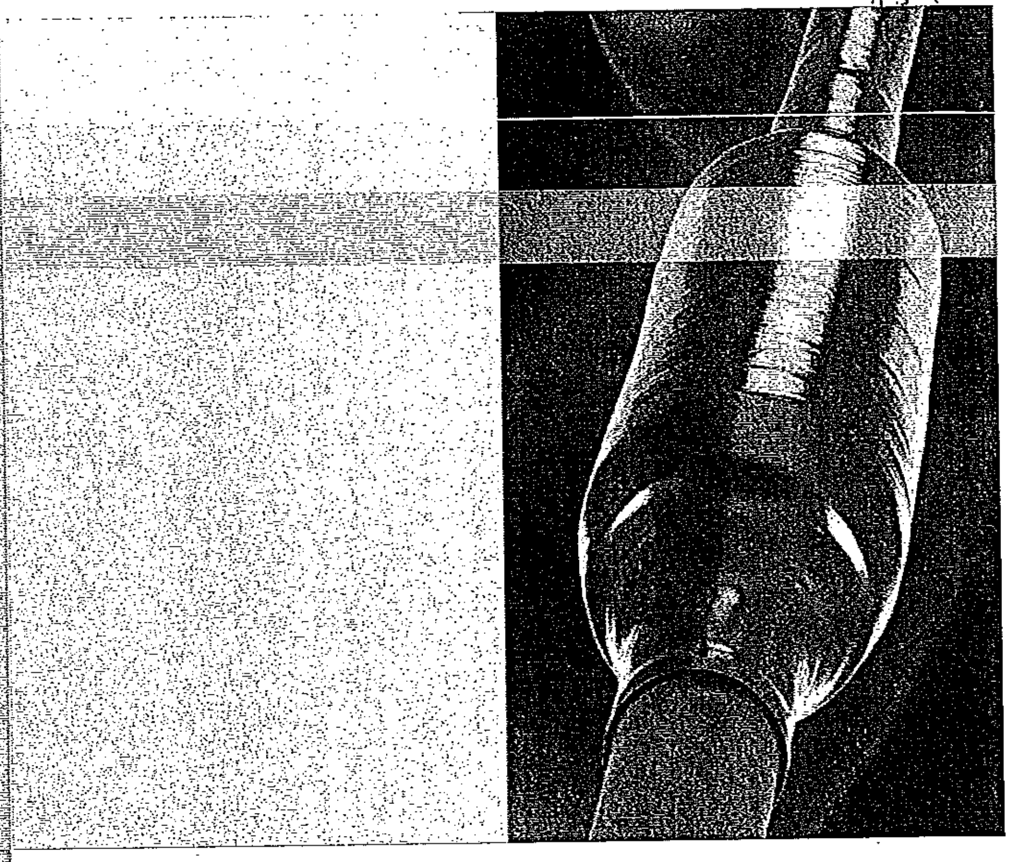
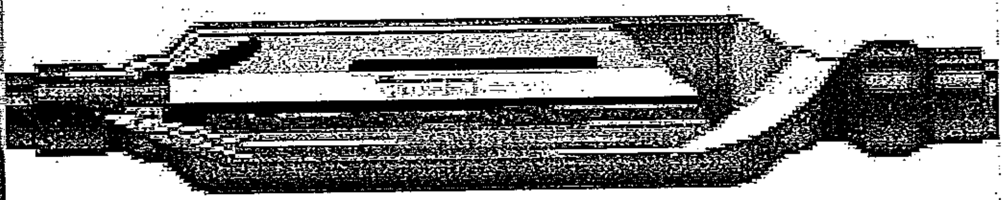






Straight joint

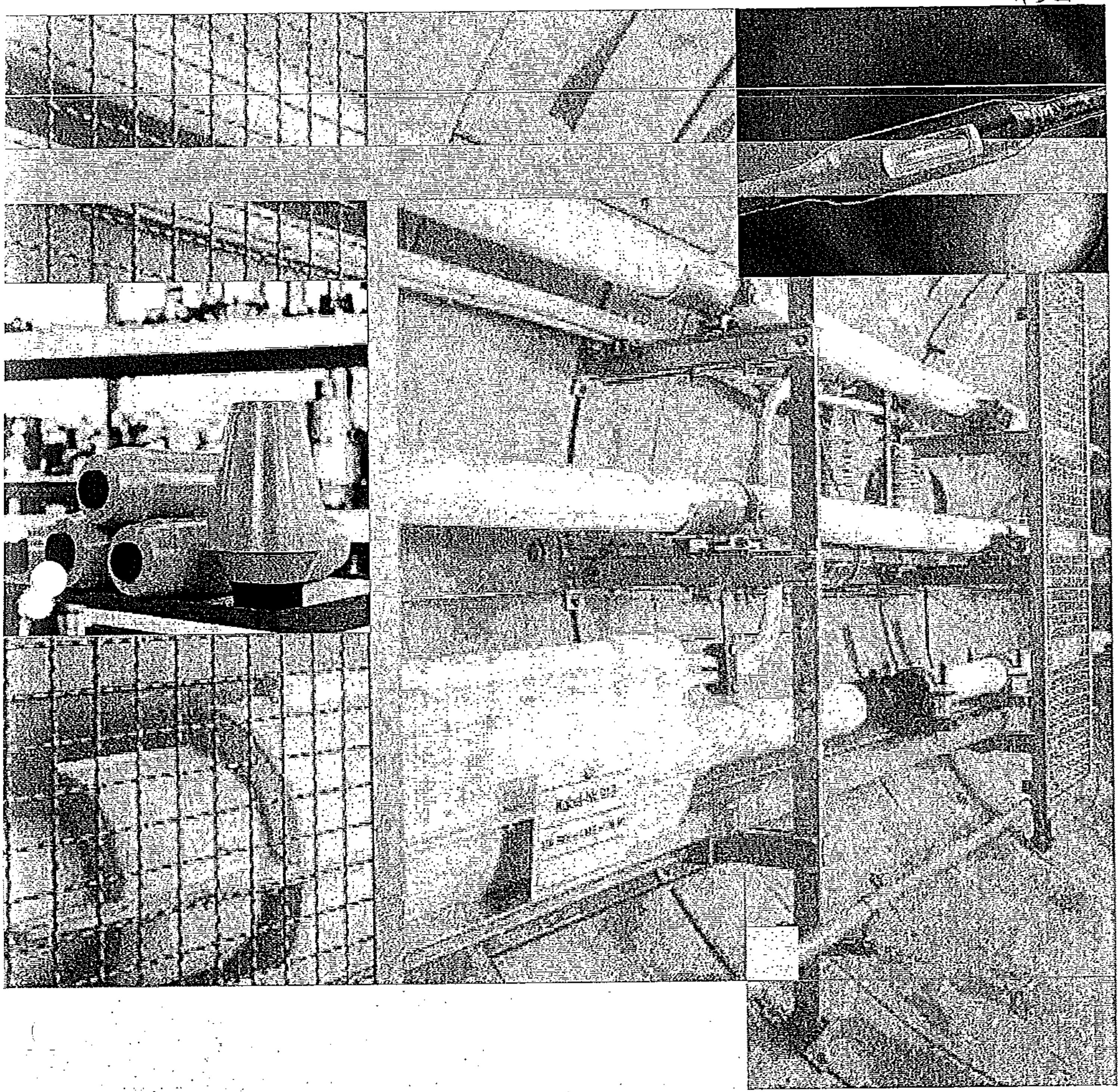
Joints

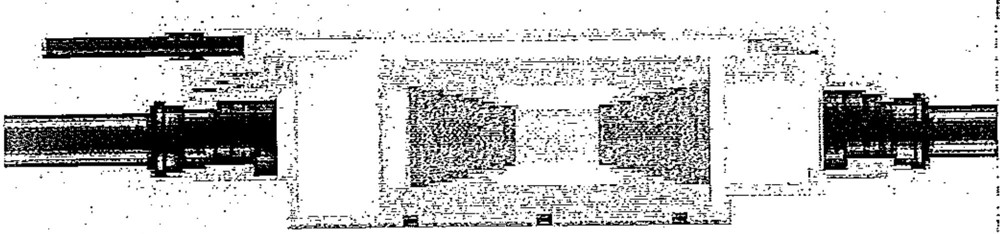
Südkabel offers an extensive program of joints for high and extra-high voltage XLPE cables.
The joints are completely maintenance-free, since they contain no gaseous or liquid constituents ("solid joints").

Both straight-through joints with through connections of the screen and sectionalising joints with potential isolation of the screen on each side of the joint are used.
For better quality assurance of the manufacturing and installation procedures, prefabricated and pretested joints are the preferred solution.

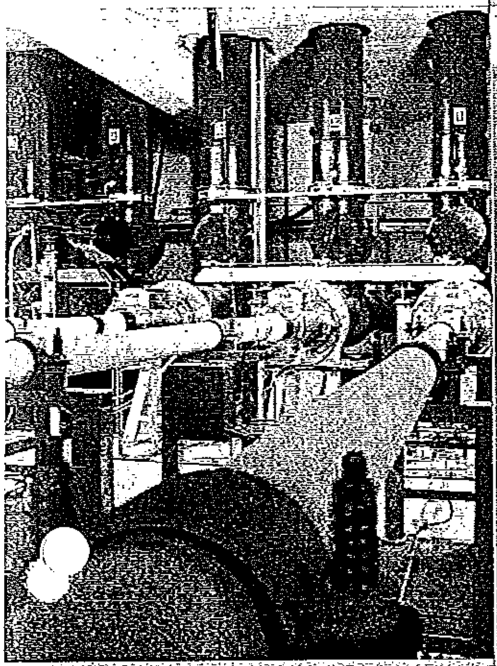
The sectionalising joints are suitable for cross-bonding the screens or for single-sided screen earthing of the individual laying sections.
In 1993, Südkabel was the first company to provide prefabricated, pretested joints in the extra-high voltage levels of 245 kV to 420 kV as well.

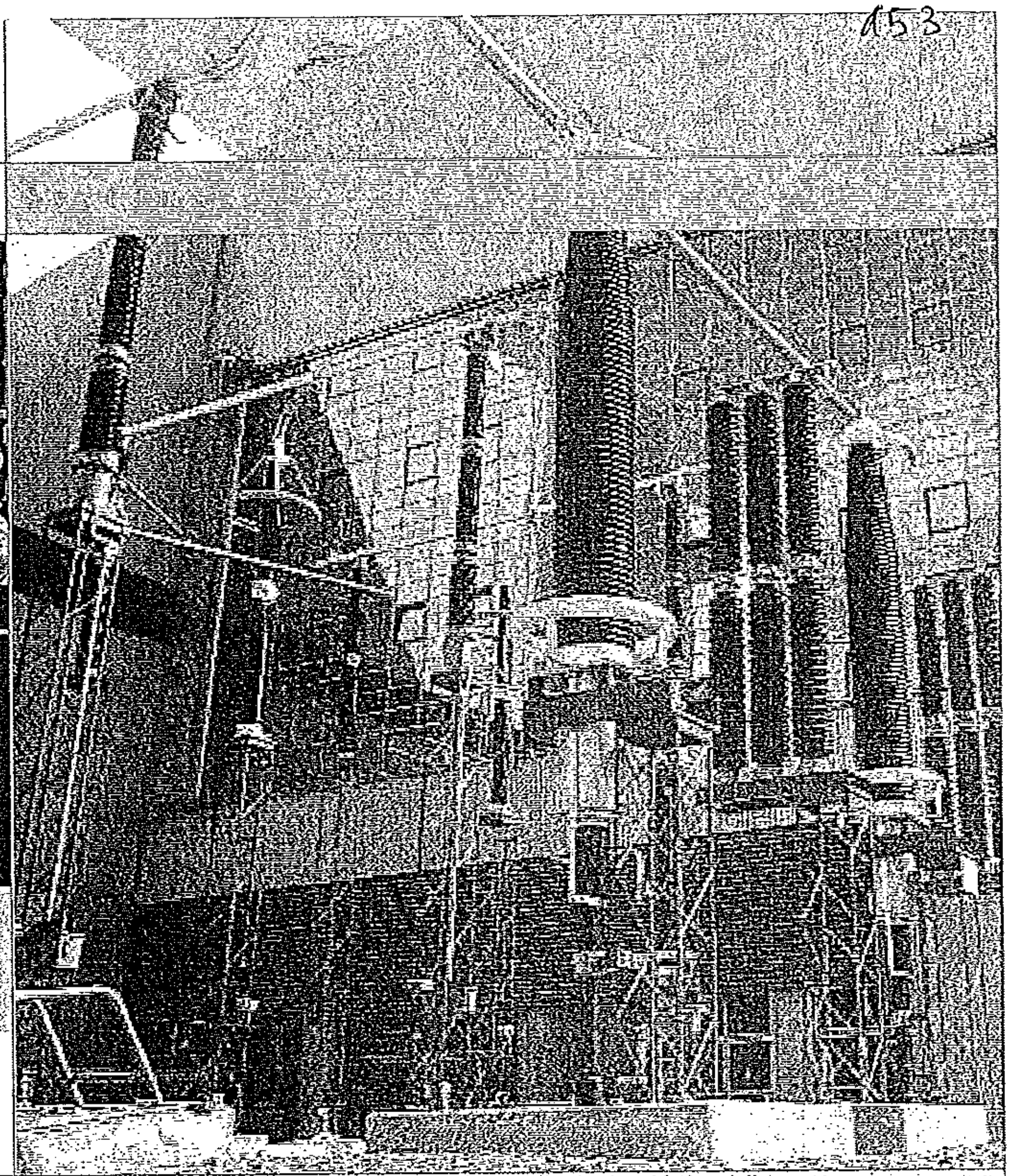
This tripartite joint type has more than proved its outstanding reliability in several projects on the 420 kV voltage level.





Cross-bonding joint





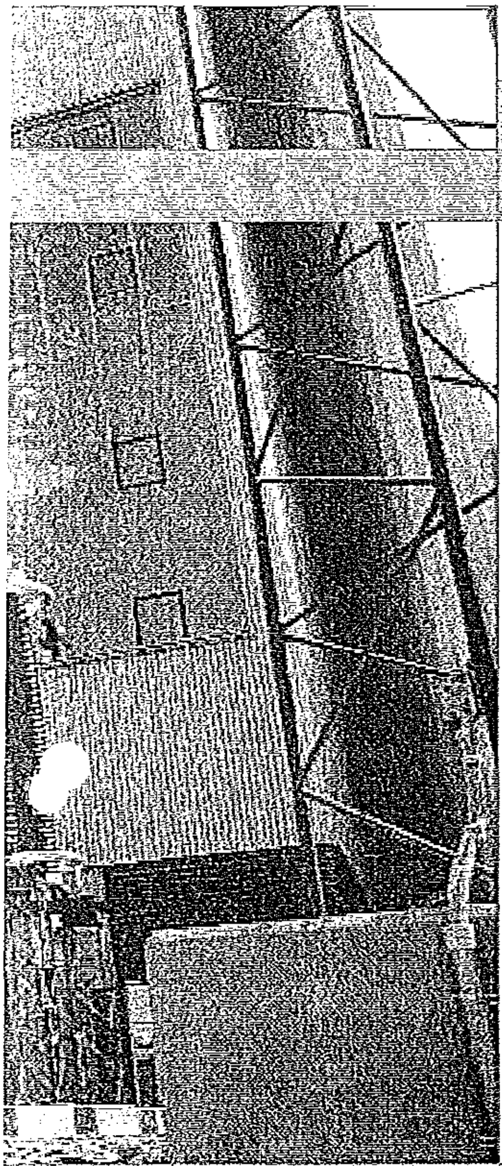
Südkabel possesses decades of experience in designing, laying and installing high and extra-high voltage cable systems.

We design them

We design and build the cable systems to suit our customers' individual requirements.
In challenging projects, our experience and know-how may be invaluable, particularly in the early stages.
It may be in finding the most cost-efficient solution, developing customised designs, optimising the maximum transmittable power, specifying an efficient cooling system, suggesting the correct embedding material or the use of appropriate earthing procedures, e.g. single-point screen grounding or cross-bonding.

We assist you in designing the optimum route, factoring in the health, safety and environmental regulations involved.

ВЯРНО С ОРИГИНАЛА



We lay them

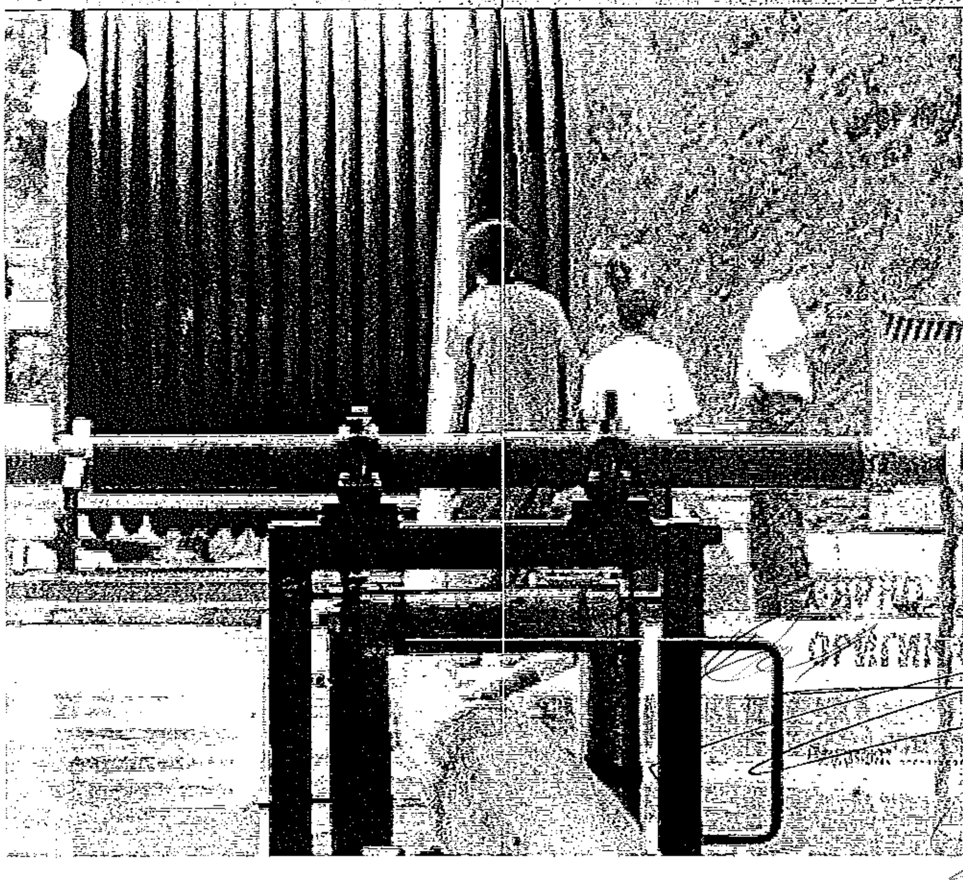
Laying cables of the highest voltage levels requires the use of special laying methods and equipment, plus meticulous preparation.
We calculate the cable pull for each individual case, and minimise the tensile forces involved by using state-of-the-art cable pulling equipment.
The length of the individual laying sections will depend on a multitude of factors, such as the laying conditions in the cable route, the maximum delivery length, restrictions on transportation by land or sea, and the design of the protection against transient over-voltages, using cross-bonding or single-point grounding of the cable screens.
While laying lengths of approx. 500 to 600 m are usually planned, in special cases lengths of well above 1000 m are possible.

We install them

Our accessories are installed by our specially trained fitters, with many years of experience behind them.
An intensive training program for all relevant electrical and mechanical jobs involved, plus annual refresher courses, are all part of the job for our fitters.

We commission them

Before a cable system we have installed is commissioned, it is usually tested in accordance with the relevant test specifications for XLPE high and extra-high voltage cable systems.
These include DC voltage tests on the cable sheath and/or AC voltage tests on the main insulation.
For extra-high voltage systems, particularly, they may be supplemented by partial discharge tests on the accessories installed.



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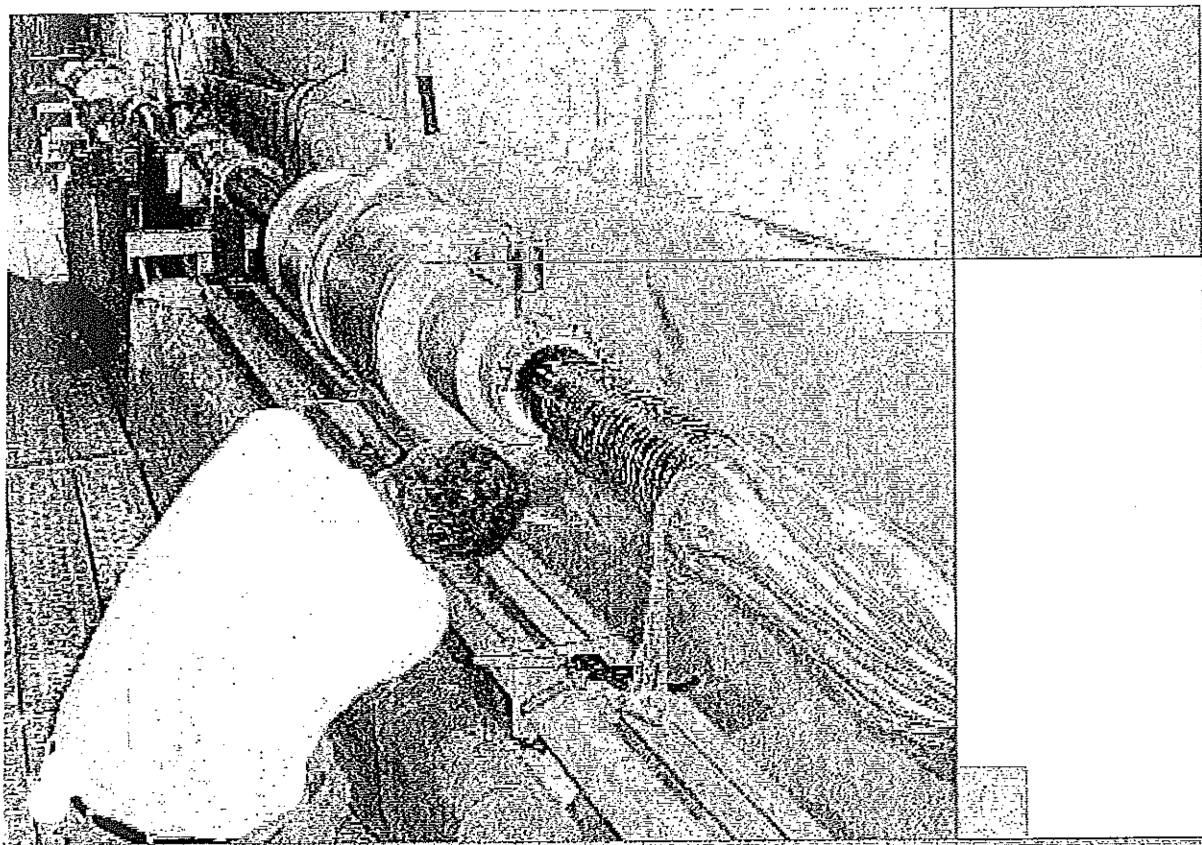

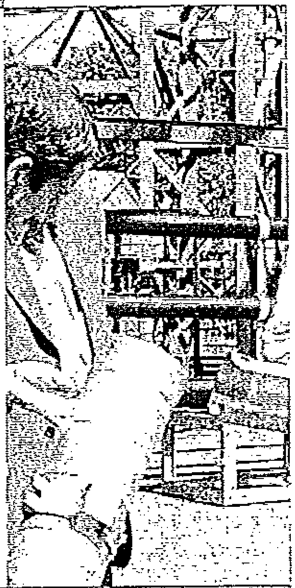

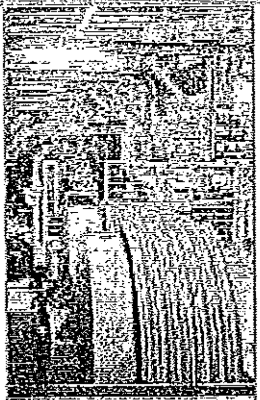

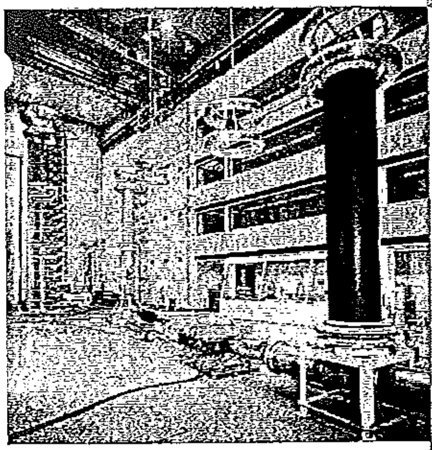

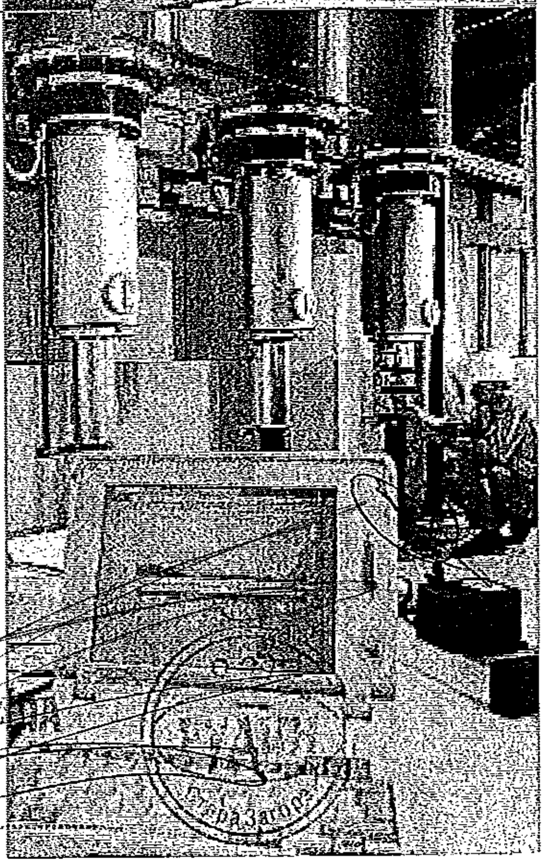

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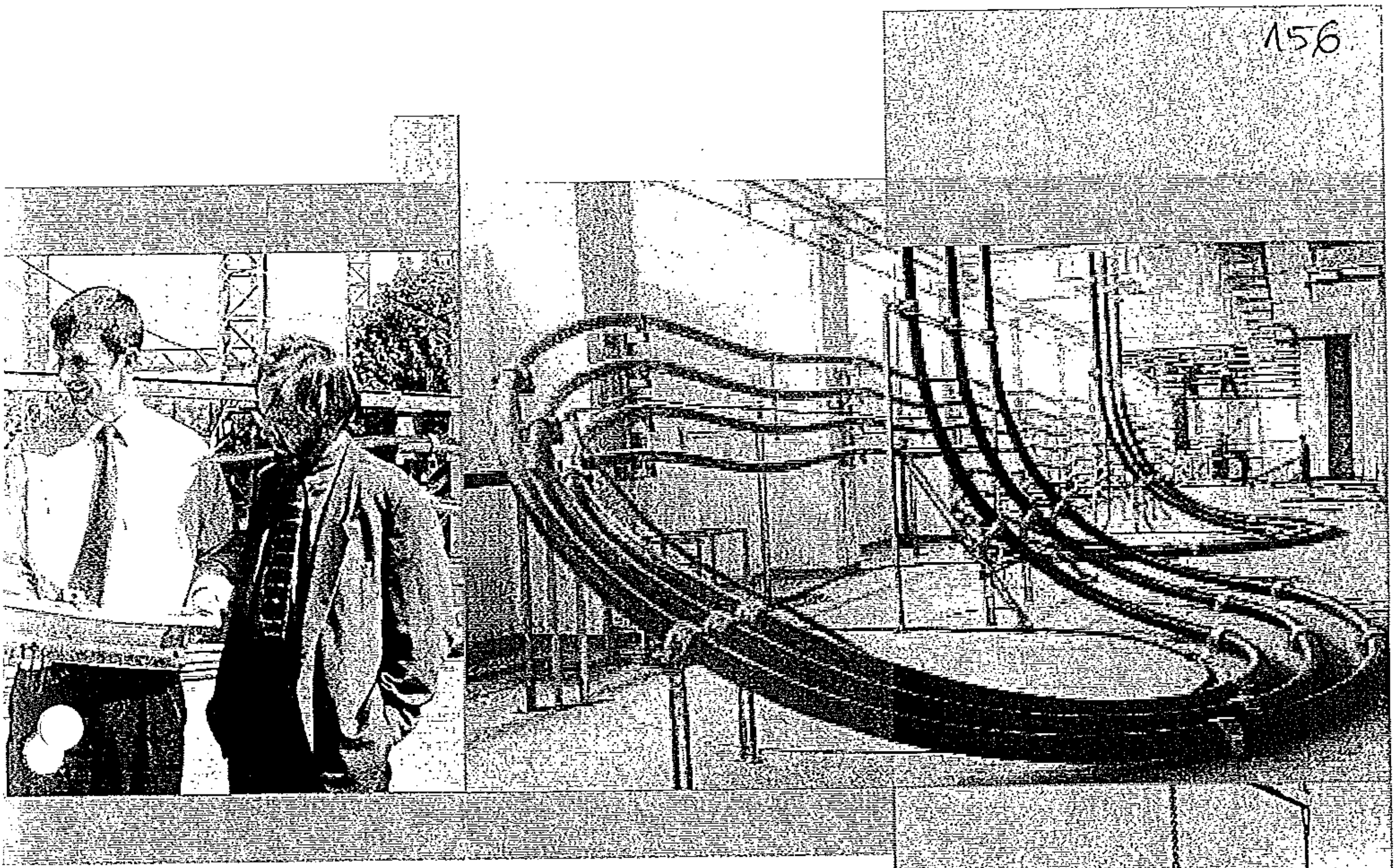
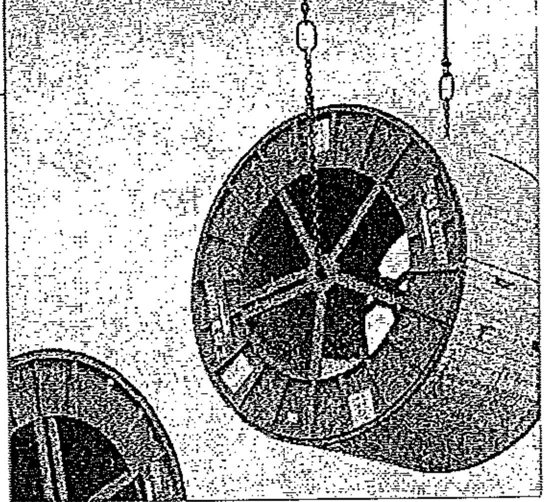


Project

Management



On request, Südkabel offers a complete project management package for the installation of XLPE high and extra-high voltage cable systems.

Our detailed project planning package includes:

- calculating current carrying capacities
- selecting accessories
- transportation to site
- laying the cables
- installing the accessories
- final inspection and testing

In addition, our spectrum of products and services can be extended to include complete site coordination, with planning and execution of the requisite civil engineering work.

ВЯРНО С ОРИГИНАЛА

O u r

Südkabel's trademark is quality.

Our goal is to supply products and services in the highest possible quality, at the time agreed, and conforming to the contractually specified conditions.

A high standard of quality is maintained and continuously improved through the challenge of satisfying our customers' ever-more-stringent requirements.

A free and frank dialogue with our staff, the public and government agencies is high on our list of corporate priorities.

We regard it as an important part of our job to continuously monitor all our production steps and products for eco-compatibility, and to improve them wherever possible.

On request, we provide our customers and the public with all information regarding the eco-relevance of the products we manufacture.

Instructions on correct handling and eco-friendly disposal can be supplied with every product if so desired.

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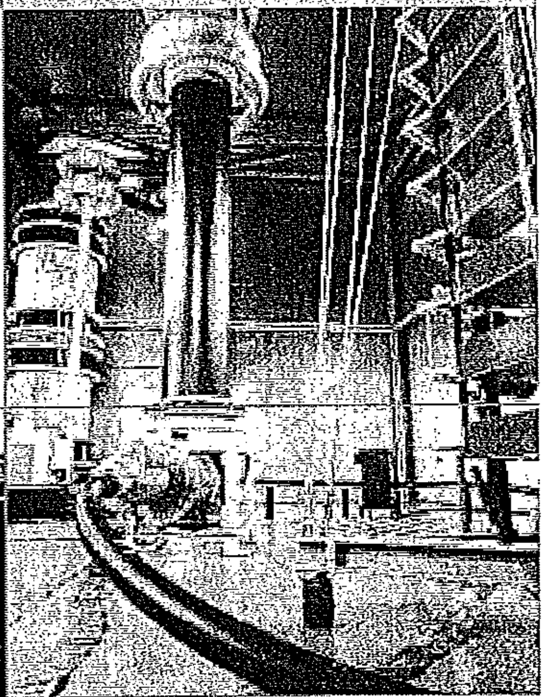
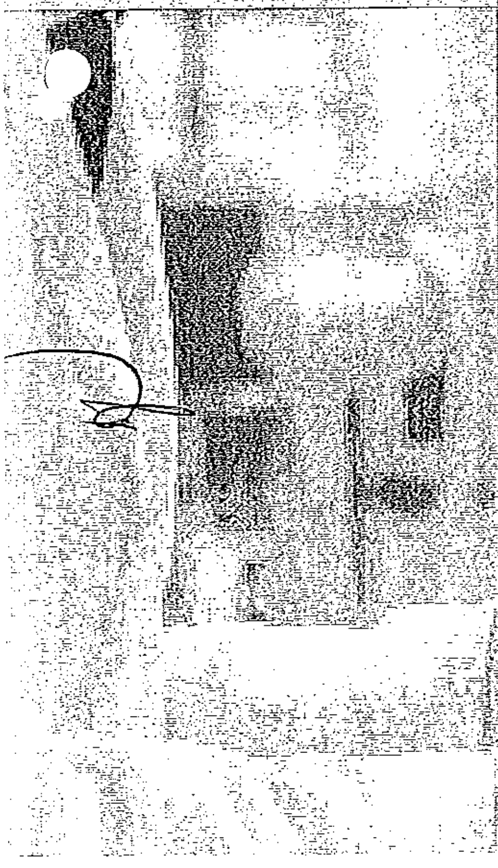
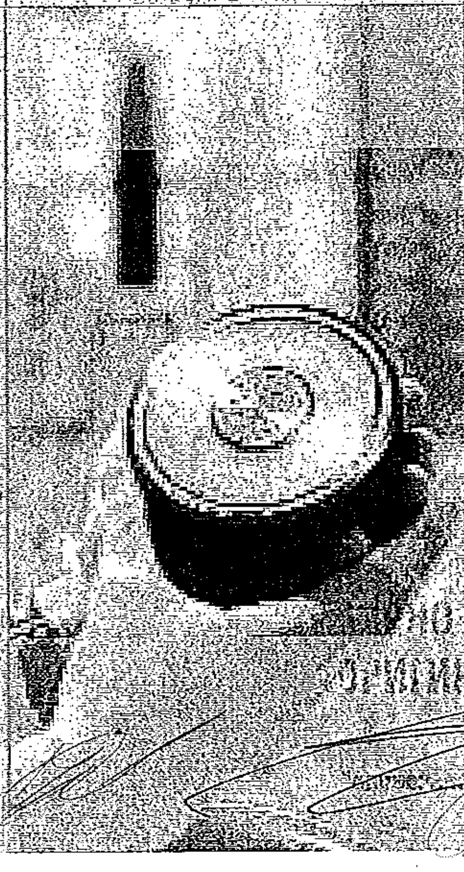
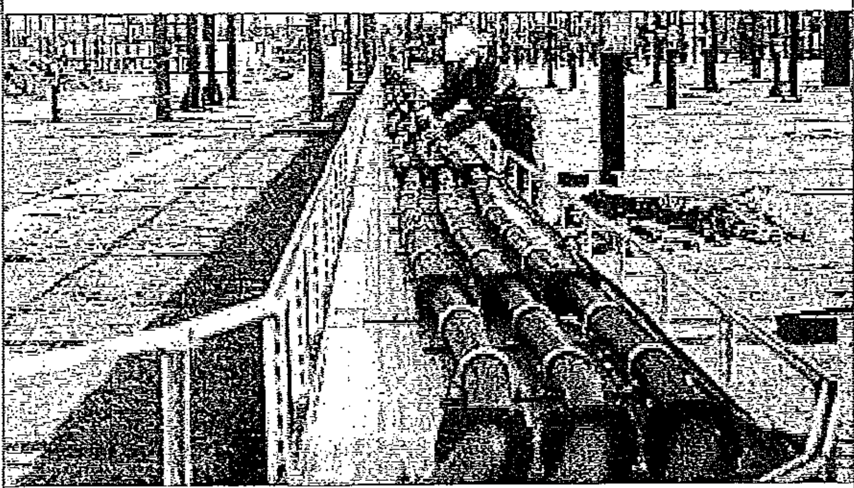






for High and Extra-High Voltage XLPE Cables



The good thermal properties of cross-linked polyethylene permit a continuous conductor temperature of 90 °C.
In the event of a short-circuit, the conductors can briefly withstand a temperature of up to 250 °C.
The cross-sectional area of the conductor is determined in dependence on the transmission capacity specified.
The short-circuit data of the network involved must of course be taken into account. For defining the cross-sectional area of the metallic screen, the single-phase short-circuit current is normally the determining factor.

The maximum permissible conductor temperature and heat transfer to the surroundings limits the maximum transmission capacity.

This means the following conditions have to be factored in:

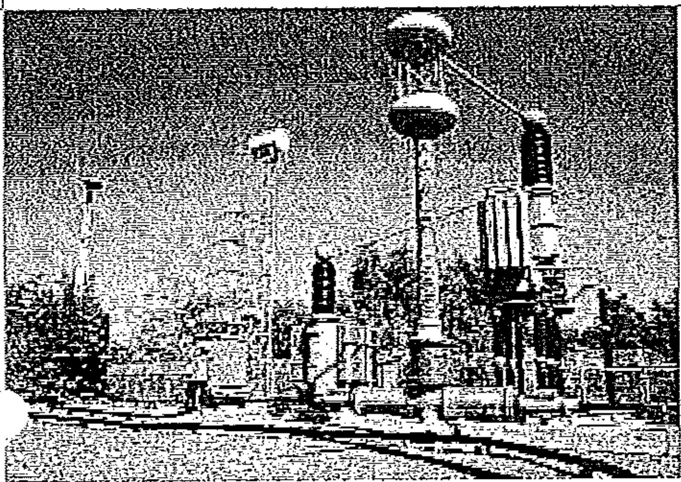
- installation underground, in air or in water
- ambient temperatures
- thermal conductivity of the surroundings
- soil drying out
- cables laid in parallel or with direct or indirect cooling of the cable system involved

High heat losses in the screen due to induced screen currents can be avoided when using single-point screen grounding or the cross-bonding procedure.
Due to the low permittivity and the low power loss factor of XLPE, the dielectric losses of XLPE cables dependent on the operating voltage are very small.

The cable dimensions indicated in following tables are average values and may for technical reasons vary without affecting the functional efficiency of the cable.

cross-section of conductor	diameter of conductor	insulation thickness*)	diameter of core	cross-section of screen	sheath thickness	diameter of cable	weight with Al-conductor
mm²	mm	mm	mm	mm²	mm	mm	kg/m
nominal voltage 60 kV							
95	11.2	9.0	33.0	35	2.5	42	1.8
120	12.6	9.0	34.4	35	2.5	44	1.9
150	14.0	9.0	35.8	35	2.5	45	2.0
185	15.8	9.0	37.6	35	2.6	47	2.2
240	18.0	9.0	39.8	35	2.6	49	2.5
300	20.2	9.0	42.0	35	3.0	52	2.8
400	23.2	9.0	45.0	35	3.0	55	3.2
500	26.2	9.0	48.0	35	3.0	58	3.6
630	30.6	9.0	52.8	35	3.0	63	4.2
800	34.8	9.0	57.0	35	3.4	68	4.9
1000	39.3	9.0	61.5	35	3.4	73	5.7
1200	43.3	9.0	68.5	35	3.8	81	6.9
1400	46.7	9.0	71.9	35	3.8	84	7.6
1600	50.3	9.0	75.5	35	3.8	88	8.4
2000	56.6	9.0	81.8	35	4.0	94	9.8
nominal voltage 110 kV							
150	14.0	15.0	47.8	35	3.0	58	3.0
185	15.8	15.0	49.6	35	3.0	60	3.2
240	18.0	15.0	51.8	35	3.0	62	3.5
300	20.2	15.0	54.0	35	3.4	65	3.9
400	23.2	15.0	57.0	35	3.4	68	4.3
500	26.2	15.0	60.0	35	3.4	71	4.8
630	30.6	15.0	64.8	35	3.8	77	5.6
800	34.8	15.0	69.0	35	3.8	81	6.3
1000	39.3	15.0	73.5	35	3.8	86	7.2
1200	43.3	15.0	80.5	50	4.0	93	8.6
1400	46.7	15.0	83.9	50	4.0	97	9.4
1600	50.3	15.0	87.5	50	4.0	100	10.2
2000	56.6	15.0	93.8	50	4.0	107	11.8
2500	63.3	15.0	100.5	50	4.0	113	13.5

*) Verified by technical experience lower values for the insulation thickness may be offered



weight with Cu-conductor kg/m	conductor resistance Al, 20°C Ω/km	conductor resistance Cu, 20°C Ω/km	capacitance µF/km	charging current/phase at 50 Hz A/km	charging power/system at 50 Hz MVA/km	inductance oo mH/km	inductance ooo mH/km	max. field-strength at cond. at U_0 kV/mm	surge impedance Ω	reduction factor
2.3	0.320	0.193	0.15	1.6	0.17	0.47	0.72	6.1	34.4	0.50
2.7	0.253	0.153	0.16	1.7	0.18	0.46	0.70	5.9	32.1	0.50
3.0	0.206	0.124	0.17	1.8	0.19	0.44	0.68	5.8	30.1	0.50
3.4	0.164	0.0991	0.18	2.0	0.21	0.43	0.65	5.6	27.9	0.50
4.0	0.125	0.0754	0.20	2.1	0.23	0.41	0.63	5.4	25.6	0.50
4.6	0.100	0.0601	0.21	2.4	0.24	0.40	0.60	5.3	23.7	0.50
5.7	0.0778	0.0470	0.24	2.6	0.27	0.38	0.57	5.1	21.5	0.45
6.7	0.0605	0.0366	0.26	2.8	0.29	0.37	0.55	5.0	19.6	0.45
8.1	0.0469	0.0283	0.29	3.2	0.33	0.35	0.52	4.8	17.3	0.45
9.9	0.0367	0.0221	0.32	3.5	0.36	0.34	0.49	4.7	15.7	0.45
12.0	0.0291	0.0176	0.35	3.9	0.41	0.33	0.47	4.6	14.3	0.45
14.4	0.0247	0.0151	0.40	4.3	0.45	0.33	0.45	4.5	12.8	0.40
16.3	0.0212	0.0129	0.42	4.6	0.48	0.33	0.43	4.5	12.0	0.40
18.4	0.0186	0.0113	0.45	4.9	0.51	0.32	0.42	4.5	11.3	0.40
22.2	0.0149	0.0090	0.49	5.3	0.55	0.31	0.40	4.4	10.3	0.40
3.9	0.206	0.124	0.12	2.4	0.46	0.49	0.68	7.6	42.1	0.45
4.4	0.164	0.0991	0.13	2.6	0.50	0.48	0.65	7.3	39.4	0.45
5.0	0.125	0.0754	0.14	2.8	0.53	0.46	0.63	7.0	36.5	0.45
5.7	0.100	0.0601	0.15	3.0	0.57	0.44	0.60	6.7	34.0	0.45
6.8	0.0778	0.0470	0.16	3.2	0.61	0.42	0.57	6.4	31.2	0.45
7.9	0.0605	0.0366	0.18	3.5	0.67	0.41	0.55	6.2	28.8	0.45
9.5	0.0469	0.0283	0.20	3.9	0.74	0.39	0.52	6.0	25.7	0.40
11.3	0.0367	0.0221	0.22	4.3	0.82	0.38	0.49	5.8	23.5	0.40
13.5	0.0291	0.0176	0.23	4.7	0.90	0.37	0.47	5.6	21.5	0.40
16.0	0.0247	0.0151	0.26	5.2	0.99	0.36	0.49	5.5	19.4	0.35
18.2	0.0212	0.0129	0.27	5.5	1.05	0.36	0.48	5.4	18.4	0.35
20.1	0.0186	0.0113	0.29	5.8	1.11	0.35	0.46	5.3	17.4	0.30
24.2	0.0149	0.0090	0.32	6.3	1.20	0.34	0.44	5.2	15.9	0.30
29.1	0.0120	0.0072	0.35	6.9	1.31	0.33	0.42	5.1	14.6	0.30

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for High and Extra-High Voltage XLPE Cables

cross-section of conductor mm²	diameter of conductor mm	insulation thickness*) mm	diameter of core mm	cross-section of screen mm²	sheath thickness mm	diameter of cable mm	weight with Al-conductor kg/m
nominal voltage 132 kV							
240	18.0	16.0	53.8	95	3.4	66	4.4
300	20.2	16.0	56.0	95	3.4	68	4.7
400	23.2	16.0	59.0	95	3.4	71	5.2
500	26.2	16.0	62.0	95	3.4	74	5.7
630	30.6	16.0	66.8	95	3.8	80	6.5
800	34.8	16.0	71.0	95	3.8	84	7.2
1000	39.3	16.0	75.5	95	4.0	89	8.2
1200	43.3	16.0	82.5	95	4.0	96	9.4
1400	46.7	16.0	85.9	95	4.0	100	10.3
1600	50.3	16.0	89.5	95	4.0	103	11.0
2000	56.6	16.0	95.8	95	4.0	109	12.5
2500	63.3	16.0	102.5	95	4.0	116	14.4
nominal voltage 150 kV							
240	18.0	18.0	57.8	95	3.4	70	4.8
300	20.2	18.0	60.0	95	3.4	72	5.1
400	23.2	18.0	63.0	95	3.4	75	5.6
500	26.2	18.0	66.0	95	3.8	79	6.2
630	30.6	18.0	70.8	95	3.8	84	7.0
800	34.8	18.0	75.0	95	4.0	89	7.9
1000	39.3	18.0	79.5	95	4.0	93	8.7
1200	43.3	18.0	86.5	95	4.0	100	10.0
1400	46.7	18.0	89.9	95	4.0	104	10.9
1600	50.3	18.0	93.5	95	4.0	107	11.6
2000	56.6	18.0	99.8	95	4.0	113	13.2
2500	63.3	18.0	106.5	95	4.0	120	15.1
nominal voltage 220 kV							
400	23.2	21.6	70.2	150	3.8	84	7.1
500	26.2	20.5	71.0	150	3.8	85	7.4
630	30.6	19.3	73.4	150	3.8	87	7.8
800	34.8	19.8	78.6	150	4.0	93	8.9
1000	39.3	20.2	83.9	150	4.0	98	9.9
1200	43.3	20.7	91.9	150	4.0	106	11.3
1400	46.7	20.9	95.7	150	4.0	110	12.3
1600	50.3	21.1	99.7	150	4.0	114	13.2
2000	56.6	21.5	106.8	150	4.0	121	15.0
2500	63.3	22.0	114.5	150	4.0	129	17.2

*) Verified by technical experience lower values for the insulation thickness may be offered

Nominal Voltages

weight with Cu-conductor kg/m	conductor resistance Al, 20°C Ω/km	conductor resistance Cu, 20°C Ω/km	capacitance µF/km	charging current/phase at 50 Hz A/km	charging power/system at 50 Hz MVA/km	inductance oo mH/km	inductance ooo mH/km	max. field-strength at cond. at U_0 kV/mm	surge impedance Ω	reduction factor
5.9	0.125	0.0754	0.13	3.2	0.73	0.47	0.67	8.0	38.0	0.25
6.6	0.100	0.0601	0.14	3.4	0.78	0.45	0.65	7.7	35.5	0.25
7.7	0.0778	0.0470	0.16	3.7	0.85	0.43	0.62	7.4	32.6	0.25
8.8	0.0605	0.0366	0.17	4.0	0.91	0.42	0.60	7.1	30.2	0.25
10.4	0.0469	0.0283	0.19	4.5	1.03	0.40	0.56	6.8	26.9	0.25
12.2	0.0367	0.0221	0.21	4.9	1.12	0.39	0.54	6.6	24.7	0.25
14.4	0.0291	0.0176	0.22	5.4	1.23	0.37	0.51	6.4	22.6	0.25
16.9	0.0247	0.0151	0.25	5.9	1.35	0.37	0.49	6.2	20.4	0.25
19.0	0.0212	0.0129	0.26	6.3	1.44	0.36	0.48	6.1	19.4	0.25
21.0	0.0186	0.0113	0.28	6.6	1.51	0.35	0.46	6.1	18.3	0.25
25.0	0.0149	0.0090	0.30	7.2	1.65	0.34	0.44	5.9	16.8	0.20
30.0	0.0120	0.0072	0.33	7.9	1.81	0.33	0.42	5.8	15.4	0.20
6.3	0.125	0.0754	0.12	3.4	0.88	0.48	0.67	8.4	41.0	0.25
7.0	0.100	0.0601	0.13	3.6	0.94	0.46	0.65	8.1	38.4	0.25
8.1	0.0778	0.0470	0.14	3.9	1.01	0.44	0.62	7.8	35.3	0.25
9.3	0.0605	0.0366	0.15	4.2	1.09	0.43	0.60	7.5	32.7	0.25
10.9	0.0469	0.0283	0.17	4.7	1.22	0.41	0.56	7.1	29.3	0.25
12.8	0.0367	0.0221	0.19	5.1	1.33	0.40	0.54	6.9	26.9	0.25
14.9	0.0291	0.0176	0.20	5.6	1.45	0.38	0.51	6.7	24.7	0.25
17.4	0.0247	0.0151	0.23	6.1	1.58	0.38	0.49	6.5	22.4	0.25
19.6	0.0212	0.0129	0.24	6.5	1.69	0.37	0.48	6.4	21.2	0.20
21.6	0.0186	0.0113	0.25	6.8	1.77	0.36	0.46	6.3	20.1	0.20
25.6	0.0149	0.0090	0.27	7.5	1.95	0.35	0.44	6.1	18.4	0.20
30.7	0.0120	0.0072	0.30	8.1	2.10	0.34	0.42	6.0	17.0	0.20
9.6	0.0778	0.0470	0.13	5.1	1.94	0.47	0.62	10.1	39.7	0.15
10.5	0.0605	0.0366	0.14	5.7	2.17	0.44	0.60	10.1	35.7	0.15
11.8	0.0469	0.0283	0.16	6.6	2.51	0.42	0.56	10.0	30.8	0.15
13.8	0.0367	0.0221	0.18	7.0	2.67	0.41	0.54	9.4	28.8	0.15
16.1	0.0291	0.0176	0.19	7.5	2.86	0.39	0.51	9.0	26.9	0.15
18.8	0.0247	0.0151	0.20	8.1	3.09	0.39	0.49	8.5	24.9	0.15
21.0	0.0212	0.0129	0.21	8.5	3.24	0.38	0.48	8.3	23.8	0.15
23.2	0.0186	0.0113	0.22	8.9	3.39	0.37	0.46	8.1	22.7	0.15
27.4	0.0149	0.0090	0.24	9.5	3.62	0.36	0.44	7.8	21.2	0.15
32.8	0.0120	0.0072	0.25	10.1	3.85	0.35	0.42	7.5	19.9	0.15

ВЯРНО С ОРИГИНАЛА

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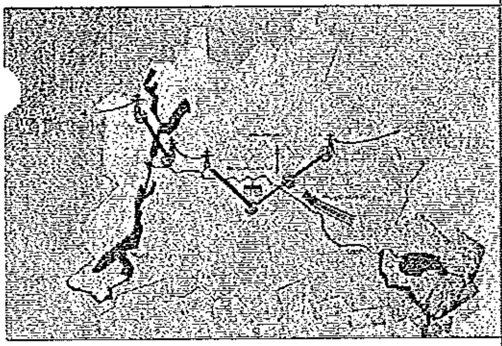
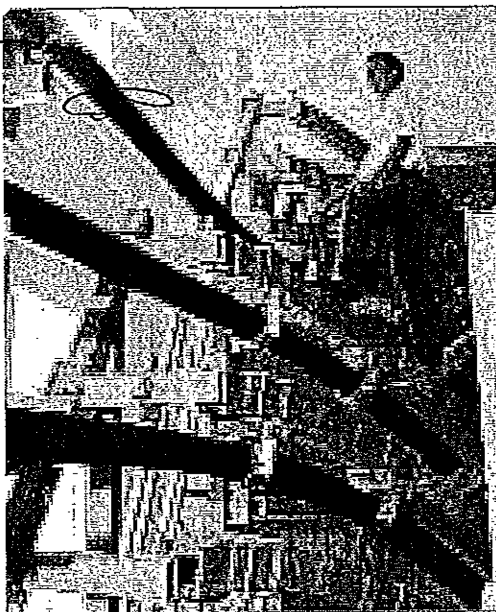
Typical Data

for High and Extra-High Voltage XLPE Cables





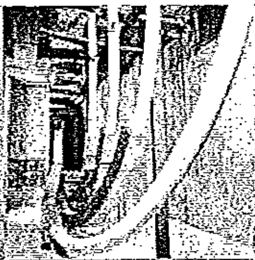
cross-section of conductor mm²	diameter of conductor mm	insulation thickness*) mm	diameter of core mm	cross-section of screen mm²	sheath thickness mm	diameter of cable mm	weight with Al-conductor kg/m
nominal voltage 275 kV							
500	26.2	29.2	88.4	150	4.0	103	9.9
630	30.6	27.0	88.8	150	4.0	103	10.0
800	34.8	25.3	89.6	150	4.0	104	10.4
1000	39.3	24.0	91.5	150	4.0	106	11.0
1200	43.3	22.7	95.9	150	4.0	110	12.0
1400	46.7	22.2	98.3	150	4.0	113	12.8
1600	50.3	21.7	100.9	150	4.0	115	13.4
2000	56.6	21.5	106.8	150	4.0	121	15.0
2500	63.3	22.0	114.5	150	4.0	129	17.2
nominal voltage 345 kV							
630	30.6	26.5	87.8	250	4.0	103	10.9
800	34.8	25.0	89.0	250	4.0	105	11.5
1000	39.3	23.7	90.9	250	4.0	107	12.1
1200	43.3	22.7	95.9	250	4.0	112	13.2
1400	46.7	23.0	99.9	250	4.0	116	14.2
1600	50.3	23.2	103.9	250	4.0	120	15.1
2000	56.6	23.7	112.2	250	4.0	127	17.0
2500	63.3	24.0	118.5	250	4.0	134	19.1
nominal voltage 380 kV							
630	30.6	29.5	93.8	250	4.0	109	11.8
800	34.8	27.6	94.2	250	4.0	110	12.3
1000	39.3	26.2	95.9	250	4.0	112	12.9
1200	43.3	25.4	101.3	250	4.0	117	14.0
1400	46.7	25.8	105.5	250	4.0	121	15.0
1600	50.3	26.1	109.7	250	4.0	125	16.0
2000	56.6	26.7	117.2	250	4.0	133	18.1
2500	63.3	27.0	124.5	250	4.0	140	20.2
nominal voltage 500 kV							
800	34.8	34.0	107.0	250	4.0	123	14.4
1000	39.3	32.0	107.5	250	4.0	123	14.7
1200	43.3	30.0	110.5	250	4.0	126	15.6
1400	46.7	29.0	111.9	250	4.0	128	16.3
1600	50.3	28.0	113.5	250	4.0	129	16.7
2000	56.6	28.5	120.8	250	4.0	136	18.7
2500	63.3	29.0	128.5	250	4.0	144	21.1

*) Verified by technical experience lower values for the insulation thickness may be offered

Nominal Voltages

weight with Cu-conductor kg/m	conductor resistance Al, 20°C Ω/km	conductor resistance Cu, 20°C Ω/km	capacitance μF/km	charging current/phase at 50 Hz A/km	charging power/system at 50 Hz MVA/km	inductance oo (trefoil) mH/km	inductance ooo mH/km	max. field-strength at cond. at U_0 kV/mm	surge impedance Ω	reduction factor
13.0	0.0605	0.0366	0.11	5.7	2.71	0.48	0.60	10.1	44.6	0.15
13.9	0.0469	0.0283	0.13	6.5	3.10	0.45	0.56	9.9	38.5	0.15
15.4	0.0367	0.0221	0.15	7.4	3.52	0.43	0.54	10.0	34.1	0.15
17.3	0.0291	0.0176	0.17	8.3	3.95	0.41	0.51	10.0	30.4	0.15
19.4	0.0247	0.0151	0.19	9.5	4.52	0.40	0.49	10.0	26.6	0.15
21.5	0.0212	0.0129	0.20	10.1	4.81	0.39	0.48	10.0	24.9	0.15
23.3	0.0186	0.0113	0.22	10.9	5.19	0.37	0.46	10.0	23.2	0.15
27.4	0.0149	0.0090	0.24	11.9	5.67	0.36	0.44	9.8	21.2	0.15
32.8	0.0120	0.0072	0.25	12.7	6.05	0.35	0.42	9.4	19.9	0.15
14.8	0.0469	0.0283	0.13	8.3	4.96	0.45	0.56	12.6	38.0	0.10
16.5	0.0367	0.0221	0.15	9.4	5.62	0.43	0.54	12.6	33.8	0.10
18.3	0.0291	0.0176	0.17	10.5	6.27	0.41	0.51	12.6	30.1	0.10
20.6	0.0247	0.0151	0.19	11.9	7.11	0.40	0.49	12.5	26.6	0.10
22.9	0.0212	0.0129	0.20	12.4	7.41	0.39	0.48	12.2	25.5	0.10
25.1	0.0186	0.0113	0.21	12.9	7.71	0.38	0.46	11.9	24.4	0.10
29.4	0.0149	0.0090	0.22	13.8	8.25	0.37	0.44	11.4	22.9	0.10
34.6	0.0120	0.0072	0.24	14.9	8.90	0.36	0.42	11.0	21.3	0.10
15.8	0.0469	0.0283	0.12	8.6	5.66	0.46	0.56	13.0	40.7	0.10
17.2	0.0367	0.0221	0.14	9.6	6.32	0.44	0.54	13.0	36.1	0.10
19.1	0.0291	0.0176	0.16	10.8	7.11	0.42	0.51	12.9	32.3	0.10
21.5	0.0247	0.0151	0.18	12.1	7.96	0.41	0.49	12.7	28.9	0.10
23.7	0.0212	0.0129	0.18	12.5	8.23	0.40	0.48	12.3	27.8	0.10
26.0	0.0186	0.0113	0.19	13.1	8.62	0.39	0.46	12.0	26.7	0.10
30.5	0.0149	0.0090	0.20	13.9	9.15	0.38	0.44	11.5	25.0	0.10
35.8	0.0120	0.0072	0.22	14.9	9.81	0.37	0.42	11.1	23.3	0.10
19.4	0.0367	0.0221	0.12	11.1	9.61	0.46	0.54	15.0	41.3	0.10
21.0	0.0291	0.0176	0.14	12.4	10.74	0.44	0.51	14.9	36.9	0.10
23.1	0.0247	0.0151	0.16	14.1	12.21	0.42	0.49	14.9	32.4	0.10
25.0	0.0212	0.0129	0.17	15.2	13.16	0.41	0.48	14.9	30.2	0.10
26.7	0.0186	0.0113	0.18	16.4	14.20	0.40	0.46	15.0	28.0	0.10
31.1	0.0149	0.0090	0.19	17.5	15.16	0.38	0.44	14.4	26.2	0.10
36.6	0.0120	0.0072	0.21	18.6	16.11	0.37	0.42	13.8	24.6	0.10

ВЕРНО С ОРИГИНАЛА



Südkabel-References

Worldwide

Abu Dhabi

Algeria

Angola

Austria

Bhutan

Botswana

Brazil

Canada

Cayman Islands

Chile

China

Cyprus

Czech Republic

Dubai

Egypt

Finland

Germany

Great Britain

Greece

Guinea

Hungary

Iceland

Indonesia

Iran

Iraq

Italy

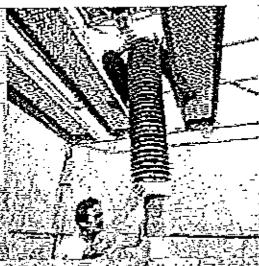
Jordan

Kazakhstan

Kuwait

Liberia

ВІРНО С
ОРИГІНАЛА



Libya

Macao

Malaysia

Mexico

Mozambique

Netherlands

Nigeria

Oman

Pakistan

Philippines

Poland

Portugal

Romania

Russia

Saudi Arabia

Singapore

Slovakia

Slovenia

Spain

Sri Lanka

St Lucia

South Africa

Switzerland

Syria

Taiwan

Thailand

Turkey

United States

Ukraine

Venezuela

ВЯРНО С ОРИГИНАЛА

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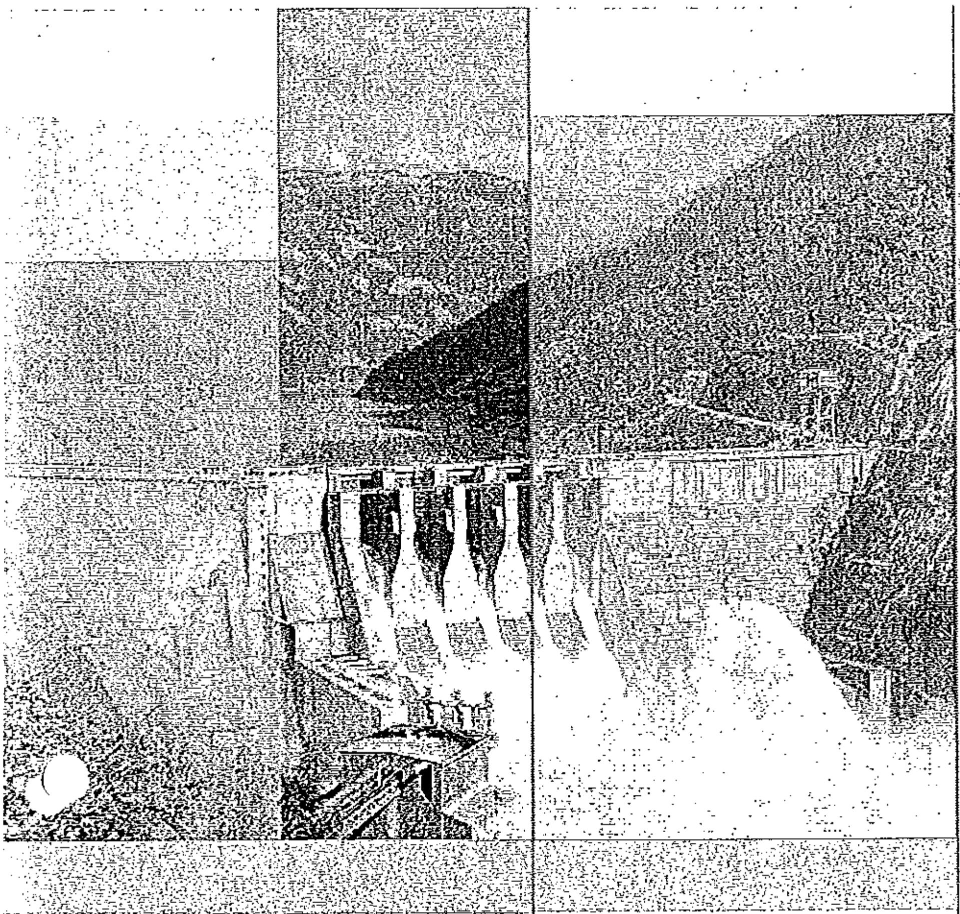


1 9 7 3
First 123 kV XLPE cable system in Germany

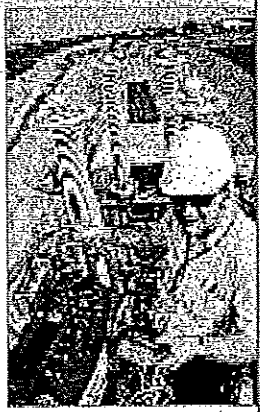
1 9 8 8
Germany´s first 245 kV XLPE cable system

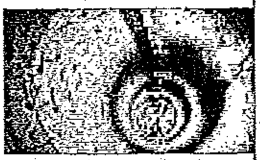
1 9 9 2
Type Test for 420 kV XLPE cable system

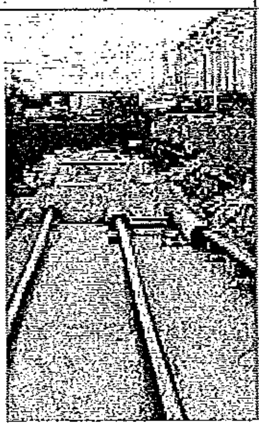
1 9 9 5
Successful pre-qualification testing for 420 kV XLPE cable systems at CESI, Italy

1 9 9 6
Europe's first 420 kV XLPE installation

1 9 9 8
First 420 kV XLPE Cable System including joints in Germany

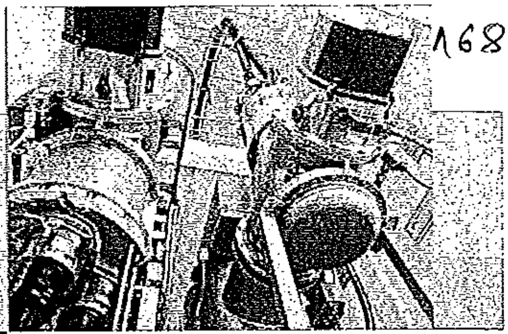


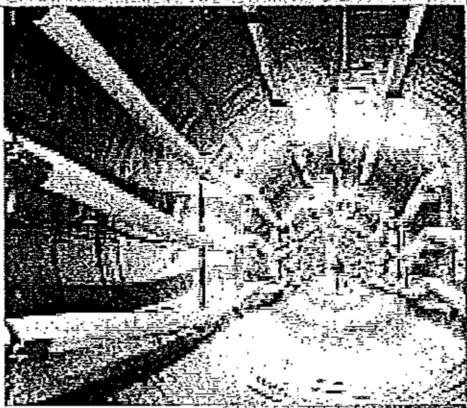




ВЯРНО С
ОРИГИНАЛА

References in High- and Extra High-Voltage Cable Systems

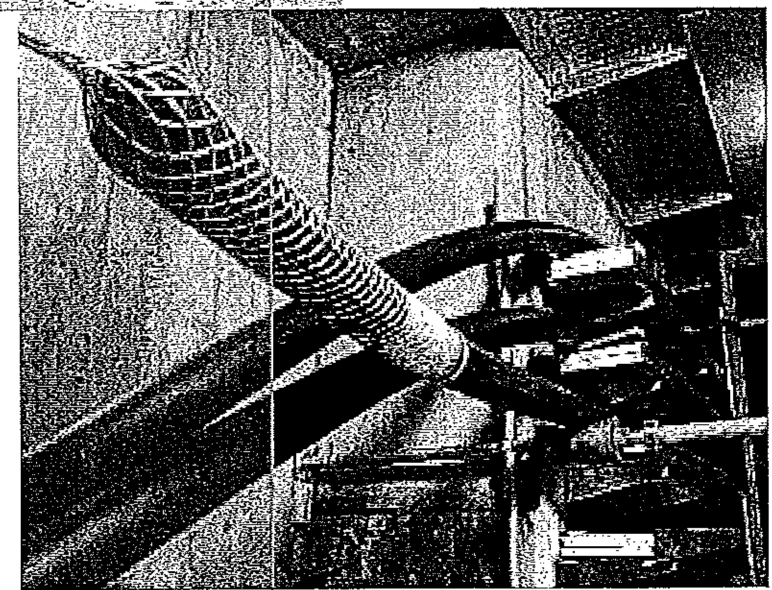




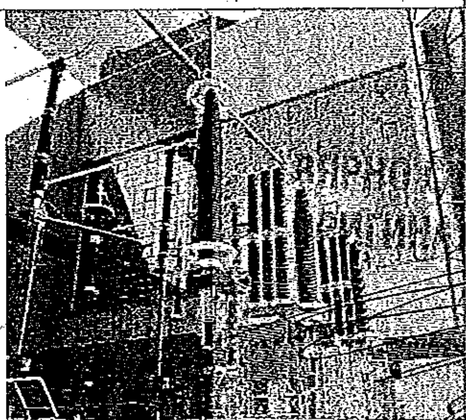
2000
Successful pre-qualification testing for 550 kV XLPE cable systems at FGH, Germany

2001
550 kV XLPE system in China

2001 - 2002
Orders for Extra-High Voltage XLPE Cable Systems with approximately 200 core-km of cable for commissioning during 2003-2004.



Reference lists and brochures describing major completed projects are available as hard-copies.



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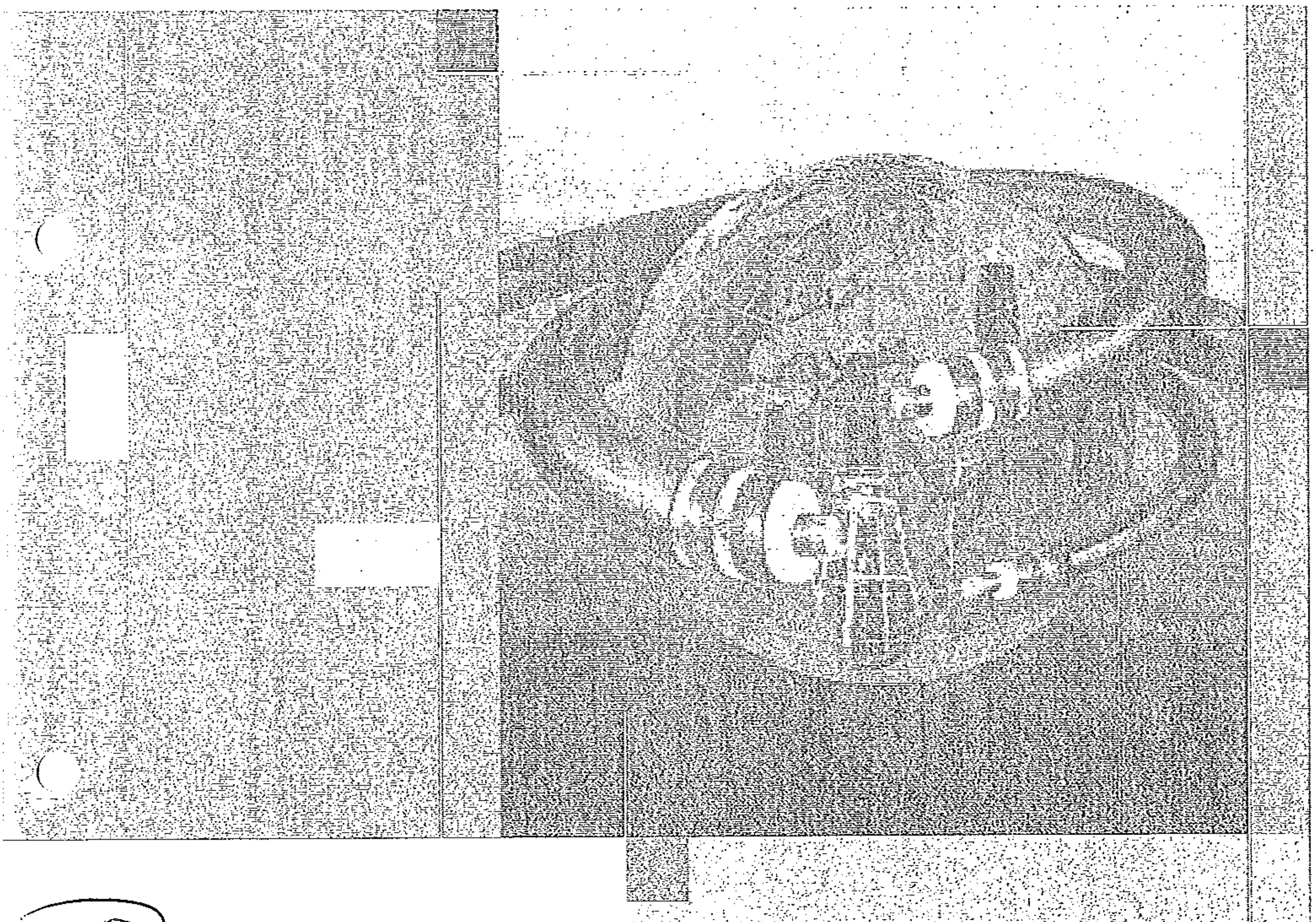
CMYK, Mannheim



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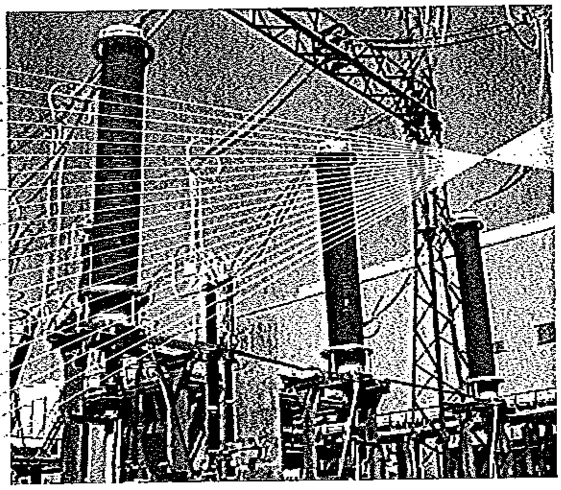
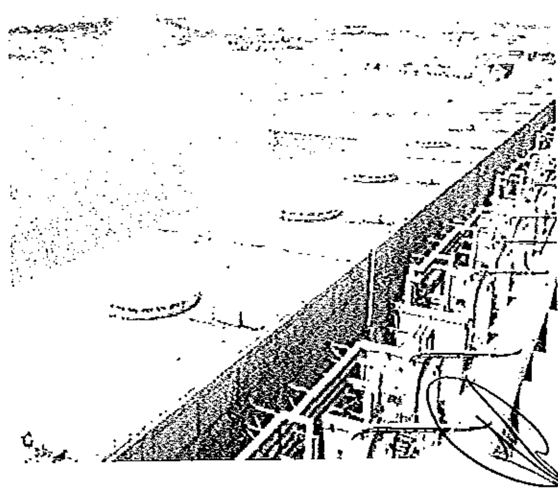
VPE-ISOLIERTE KABEL UND SYSTEME FÜR HOCH- UND HÖCHSTSPANNUNG

XLPE-INSULATED POWER CABLES AND SYSTEMS FOR HIGH AND EXTRA-HIGH VOLTAGES





ВЯРНО С
ОРИГИНАЛА

Kabelsysteme, Kabel und Garnituren
Cable Systems, Cables and Accessories

SÜDKABEL

ООД
Стара Загора

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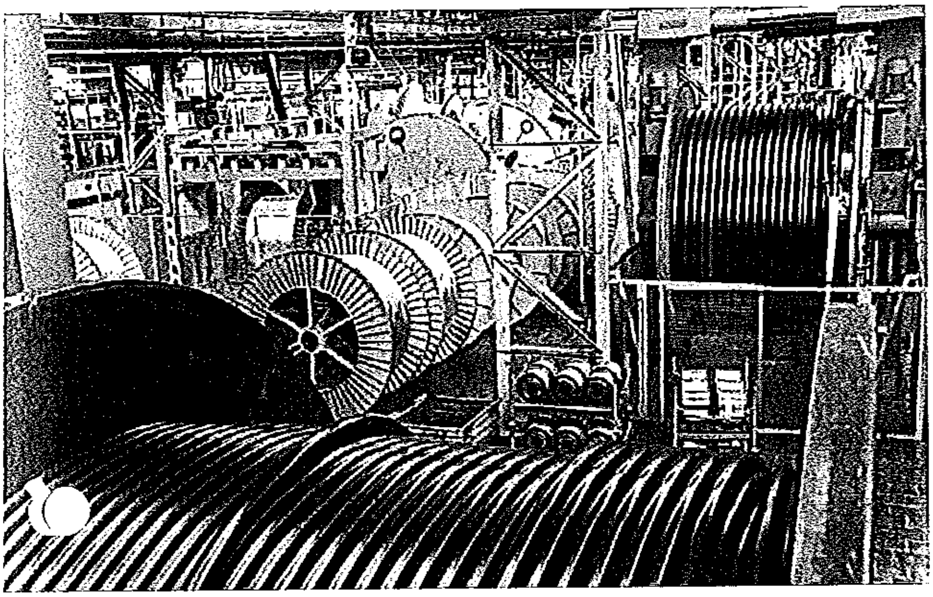
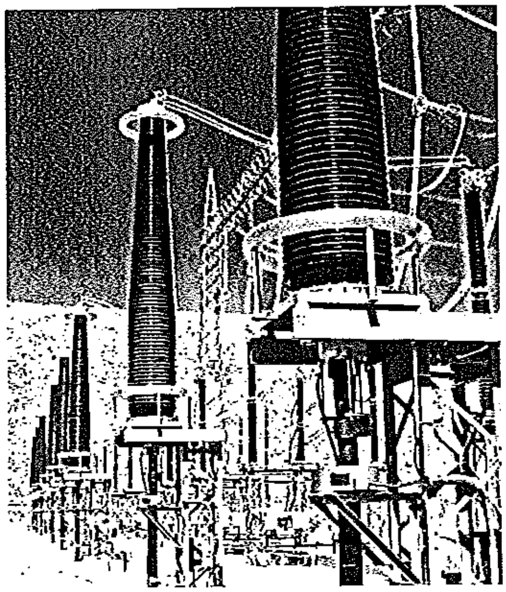
SÜDKABEL – WEGBEREITER DER VPE-TECHNOLOGIE

SÜDKABEL – FOR PATH-BREAKING XLPE TECHNOLOGY





Südkabel hat viele Meilensteine in der Kabeltechnik für die Energieübertragung gesetzt. Pionierarbeit leistete das Unternehmen insbesondere auf dem Gebiet der VPE-Technologie: Bereits in den 60er Jahren wurden in Deutschland die ersten kunststoffisolierten Mittelspannungskabel verlegt.

Seither nimmt Südkabel weltweit eine Vorreiterrolle ein – mit der Projektierung und dem Bau der ersten 110 kV und 220 kV VPE-Kabelanlagen in Deutschland, der ersten 400 kV VPE-Kabelanlage im europäischen Übertragungsnetz und nicht zuletzt durch die Fertigung und Installation der ersten 500 kV VPE-Kabelanlage in China.

Südkabel has set numerous milestones in the field of power transmission with cables. Its pioneering achievements are particularly evident in the field of XLPE technology: it was back in the sixties that the first solid-dielectric medium-voltage cables were installed in Germany.

Since then, the cable specialists have maintained their pathbreaking status worldwide – by planning and building the first 110 kV and 220 kV XLPE-insulated cable systems in Germany in the early seventies, the first 400 kV XLPE-insulated cable system in the European transmission network, and last but not least by manufacturing and installing the first 500 kV XLPE-insulated cable system in China.

KOMPETENZ AUF HÖCHSTEM SPANNUNGSNIVEAU

PROFESSIONAL EXPERTISE AT THE HIGHEST VOLTAGE LEVEL

Südkabel ist ein geschätzter Partner der Energieversorgungsunternehmen und der elektrotechnischen Industrie in der ganzen Welt.
Für die sichere Energieverteilung bietet Südkabel komplette Systemlösungen, gepaart mit modernsten Fertigungsverfahren, umfassenden Dienstleistungen und einem Höchstmaß an Qualitätssicherung.

Auf den nationalen und internationalen Märkten ist das Traditionsunternehmen mit über hundertjähriger Erfahrung in der Produktion von Kabeln, Kabelgarnituren und als Anbieter von Kabelsystemen eine feste Größe. Kompetenz und Know-how fließen ein in zukunftsweisende Produktentwicklungen, die sich in der Praxis bestens bewähren.

Südkabel is a respected partner for power utilities and the electrical engineering industry all over the world.
For safe, reliable power transmission and distribution, it offers complete system packages coupled with state-of-the-art production processes, comprehensive service support and a maximum of quality assurance.

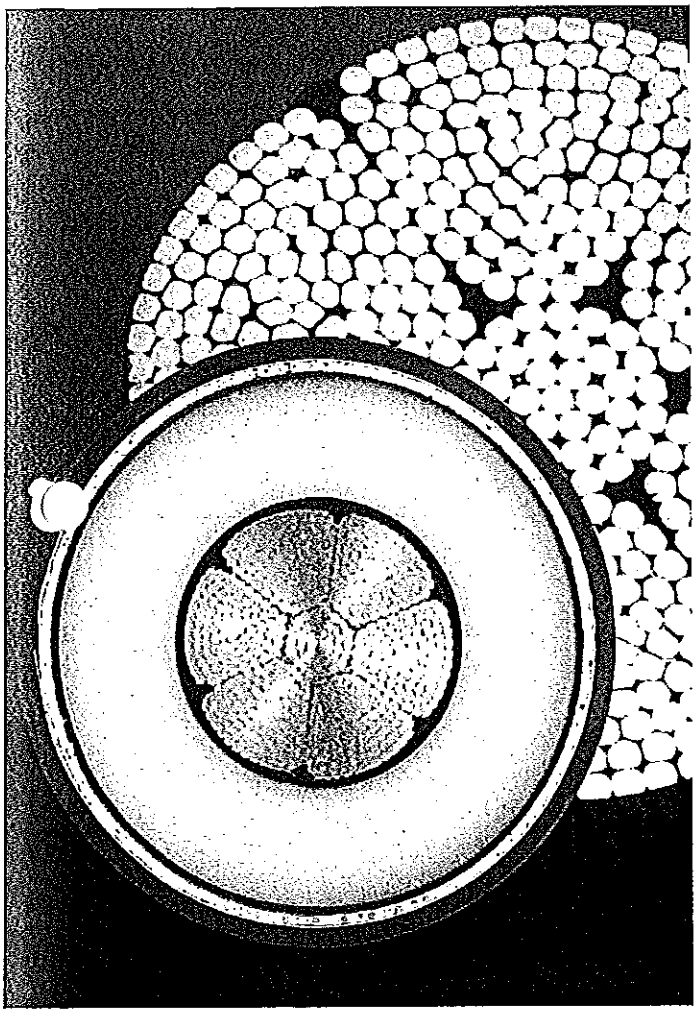
On national and international markets alike, this long-established company, drawing on more than a century of experience in cable and cable accessories production, is acknowledged as a top-ranking vendor of cable systems; its can-do expertise is incorporated in up-to-the-future oriented products whose reliability has been validated in actual operation.

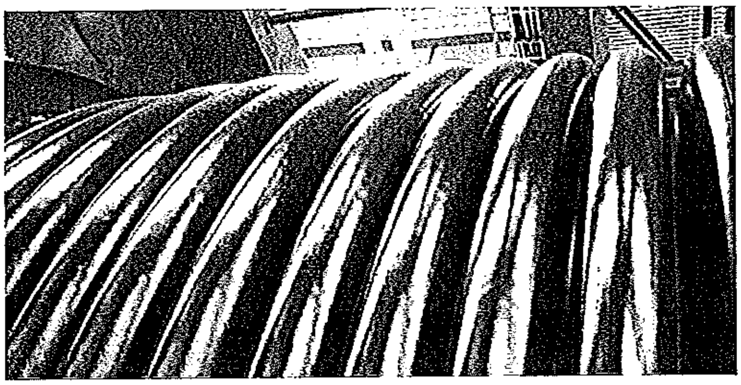
ВЯРНО С ОРИГИНАЛА

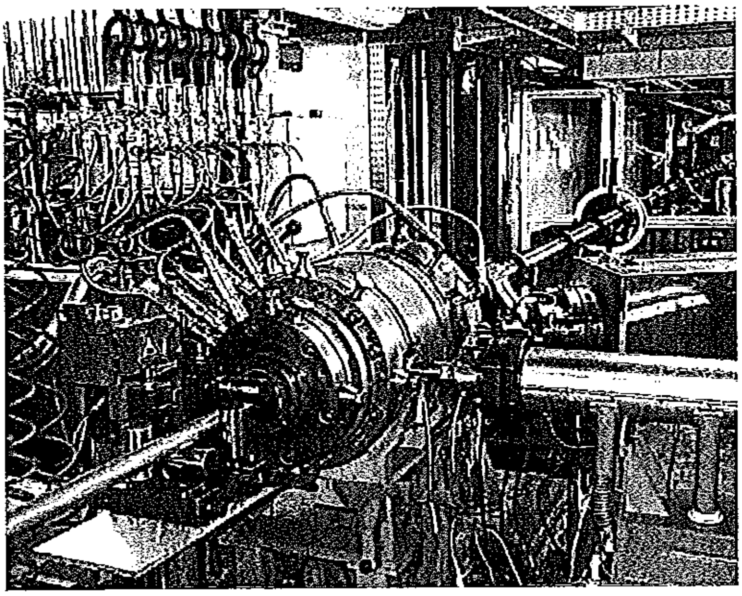
ООД РУДИН Стара Загора

VPE* – DER ISOLIERWERKSTOFF FÜR HOCH- UND HÖCHSTSPANNUNGSKABEL

XLPE – THE INSULATING MATERIAL FOR HIGH- AND EXTRA-HIGH VOLTAGE CABLES*







Als Ausgangsmaterial für die Isolierung wird Polyethylen niedriger Dichte (LDPE) verwendet. Wegen seines unpolaren Charakters hat Polyethylen eine niedrige Dielektrizitätszahl, einen sehr geringen Verlustfaktor und eine sehr hohe elektrische Festigkeit. Die Vernetzung führt zu besseren mechanischen Eigenschaften, die dielektrischen Eigenschaften werden dadurch nicht beeinflusst. Neben den ausgezeichneten elektrischen Eigenschaften bleiben auch die mechanischen Eigenschaften bei hohen Temperaturen gut. Selbst bei hohen Kurzschlusstemperaturen behält VPE eine gute Formbeständigkeit und ist in diesem wesentlichen Punkt dem thermoplastischen PE deutlich überlegen. Wegen der hohen thermischen Beständigkeit des VPE spielt die thermische Alterung unter zulässigen Betriebsbedingungen praktisch keine Rolle. Basierend auf Ergebnissen umfangreicher Langzeituntersuchungen werden sehr hohe Betriebsfeldstärken mit den heute zur Verfügung stehenden Technologien sicher beherrscht.

The raw material used for the insulation is low-density polyethylene (LDPE). By virtue of its homopolar character, polyethylene has a low relative permittivity, a very low power loss factor and very high dielectric strength.
The cross-linking process provides improved mechanical characteristics while not affecting the dielectric properties at all.
Besides the excellent electrical properties, the mechanical characteristics remain also very good even at high temperatures. Even at high short-circuit temperatures, XLPE retains good dimensional stability and in this crucial point it is definitely superior to thermoplastic PE.
Thanks to XLPE's high thermal stability, thermal ageing plays practically no role at all, provided the permissible operating conditions are complied with. Results from extensive long-term studies show, that with the technologies available nowadays the material can be relied upon to cope with very high operating field strengths

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* vernetztes Polyethylen

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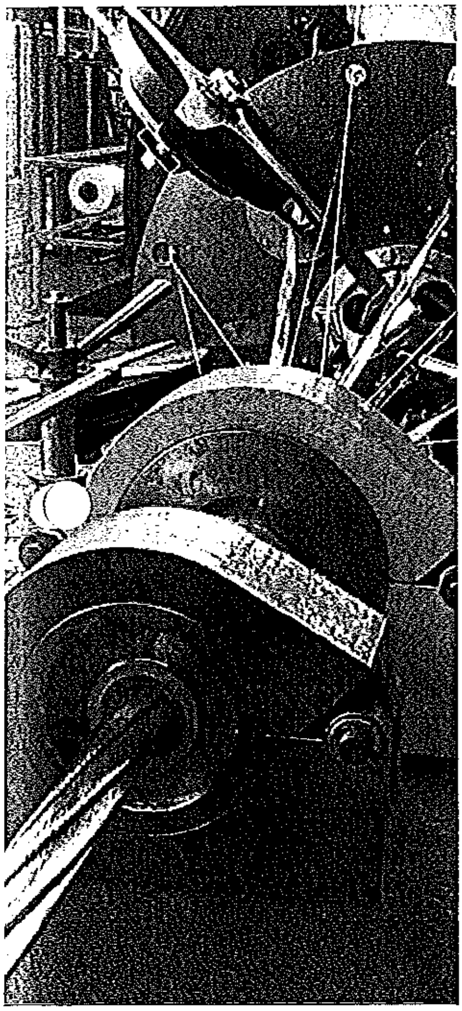
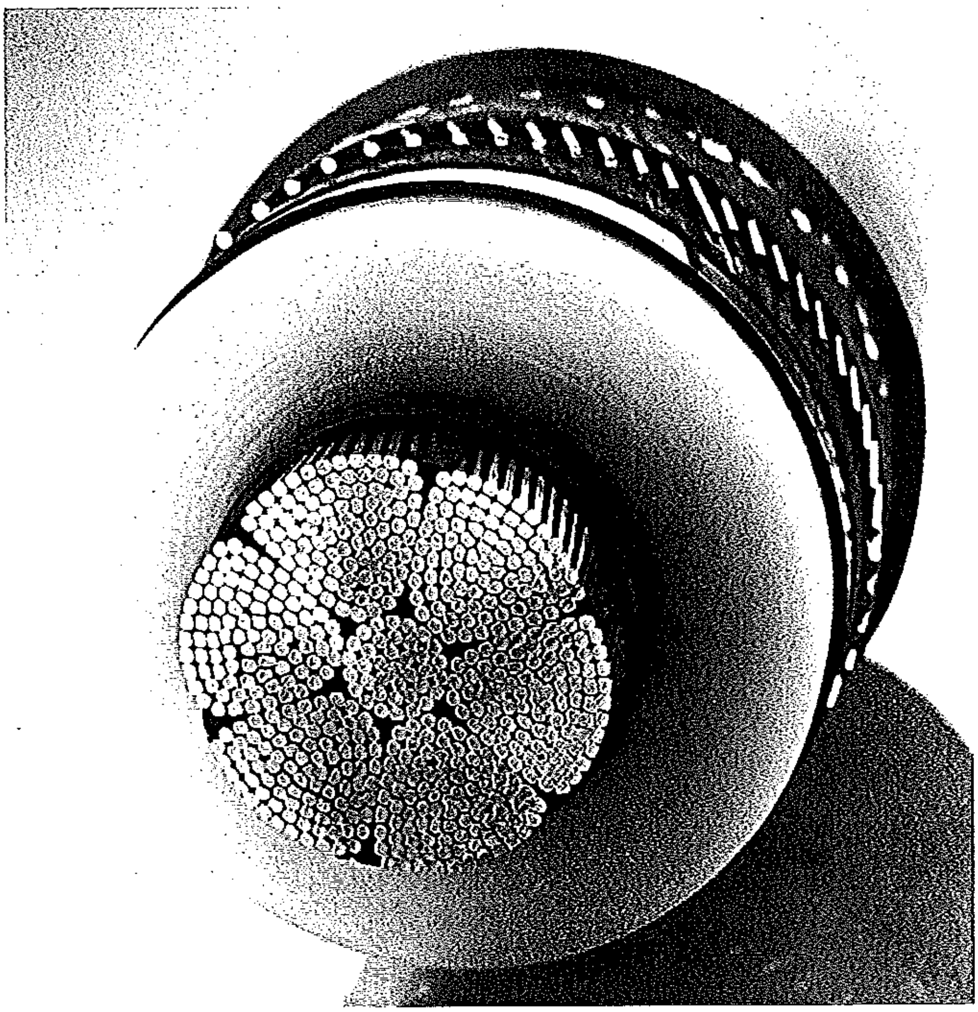
AUFBAU VON VPE-ISOLIERTEN HOCHSPANNUNGSKABELN

THE DESIGN OF HIGH VOLTAGE XLPE-INSULATED CABLES





Der Leiter

(E-isolierten Hochspannungskabeln werden runde, verdichtete, mehrdrähtige Leiter aus Kupfer oder Aluminium eingesetzt. Zur Verringerung des Skin-Effektes ist bei Leiterquerschnitten ab 1.200 mm² eine segmentierte Leiterkonstruktion vorgesehen. Zur Maximierung der Übertragungsleistung können darüber hinaus spezielle Leiterkonstruktionen eingesetzt werden.

The conductor

In high voltage XLPE-insulated cables, round, compacted, stranded conductors made of copper or aluminium are used. In order to reduce the skin effect, a segmented conductor design is provided in case of conductor cross-sectional areas as from 1.200 sqmm and above. To maximize the transmission capacity specially designed segmented conductors can be used.

Die Isolierung

Zur optimalen Aufbringung der Isolierung und der feldbegrenzenden, inneren und äußeren leitfähigen Schichten erfolgt die Extrusion der Kabelader in einem Dreifachspritzkopf. Dadurch wird die für hohe Betriebsfeldstärke erforderliche glatte Grenzschicht zwischen Isolierung und Leitschichten erreicht.
Der anschließende Vernetzungsvorgang findet in einem unmittelbar an den Dreifachkopf angeschlossenen Vernetzungsrohr statt. Das „trockene" Vernetzungsverfahren und der hohe Druck im Vernetzungsrohr gewährleisten eine hohlraumfreie, homogene Isolierungsstruktur der Kabelader.

The insulation

For optimised manufacture of the XLPE insulation and the field-limiting inner and outer semi-conductive layers, the cable core is extruded in a triple extrusion head, thus ensuring the smooth interfacing between insulation and semi-conductive layers required for high operating field strength.
The subsequent continuous cross-linking and cooling operation is performed in a tube connected directly to the triple head. The "dry" cross-linking process and the high pressure inside the tube assure a homogeneous insulation structure for the cable core, without any voids.

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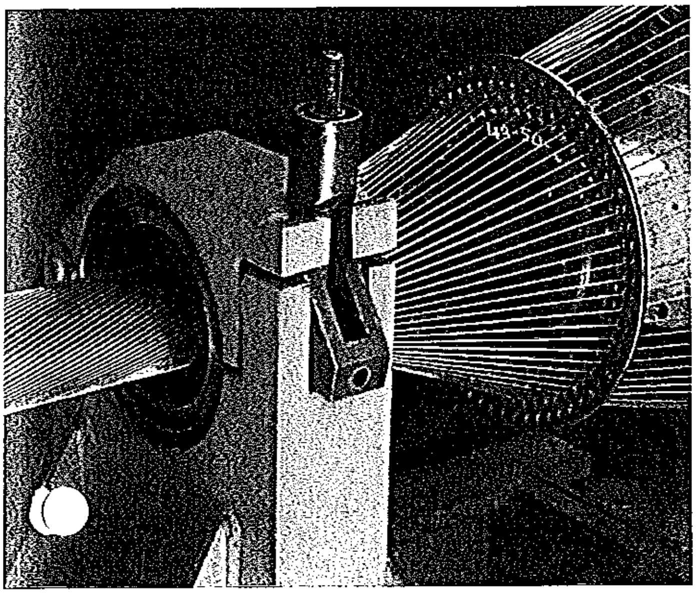

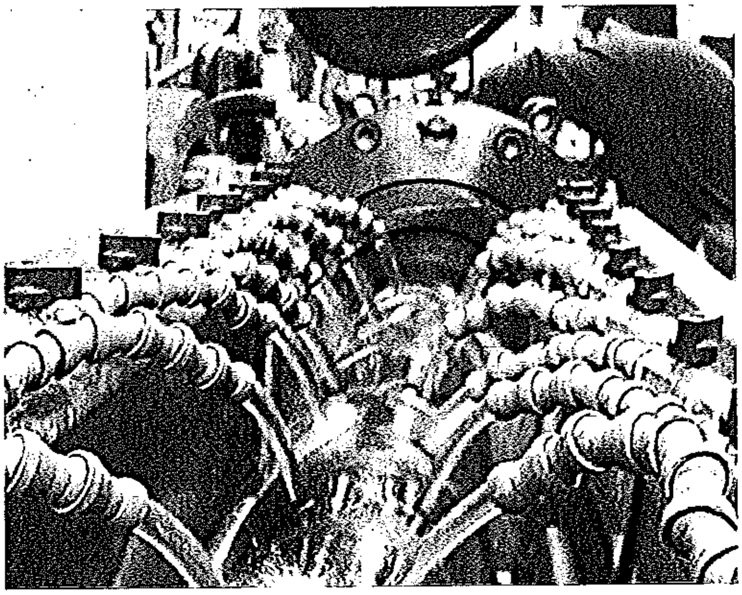

Der Schirm

Über der extrudierten äußeren Leitschicht wird eine Lage aus leitfähigen Bändern aufgebracht.
Der Kupferdrahtschirm selbst besteht aus spiralförmig angeordneten Schirmdrähten und einer oder mehreren Querleitwendeln aus Kupferband.
Der geometrische Querschnitt des Kupferschirms wird entsprechend den Kurzschlussanforderungen im jeweiligen Anwendungsfall festgelegt.
Der Schirmbereich wird längswasserdicht ausgeführt. Dies geschieht durch das Einbringen von Textil- oder Vliesbändern mit einem quellfähigen Substrat. Die quellfähigen Substanzen haben die Eigenschaft bei Berührung mit Wasser, z. B. nach einer Mantelbeschädigung, stark aufzuquellen und bilden auf diese Weise eine Wassersperre in Längsrichtung.

The screen

A layer of conductive tapes is applied over the extruded outer semi-conductive layer.
The copper-wire screen itself consists of shield wires arranged in a helical configuration and one or more counter-helices made of copper tapes
The geometrical cross-section of the copper screen is designed to suit the short-circuit requirements in each individual application. The screen area is in longitudinally watertight design with a swellable substrate provided by inserting textile or nonwoven tapes. These substances will swell up substantially if they come into contact with water, e. g. following damage to the outer sheath, thus forming a barrier to water in the longitudinal direction

Außenmantel

Als zuverlässigen Schutz gegen mechanische äußere Einwirkungen erhalten die VPE-isolierten Hoch- und Höchstspannungskabel einen Außenmantel aus Polyethylen hoher Dichte (HDPE), das hervorragende mechanische Eigenschaften besitzt.
Bei querwasserdichtem Kabelaufbau schützt ein Schichtenmantel, bestehend aus einem längs einlaufenden beschichteten Aluminiumband, das mit dem darüber extrudierten Polyethylenmantel fest verschweißt ist, das Kabel gegen eindringende Feuchtigkeit. Während der HDPE-Mantel das Kabel mechanisch schützt, verhindert das Aluminiumband eine radiale Wasserdampf-Diffusion und somit das Eindringen von Feuchtigkeit in das Kabel. Optional können zusätzliche flammwidrige und/oder leitfähige Schichten zusammen mit dem PE-Außenmantel extrudiert werden.

Ergänzend zum oben beschriebenen Kabelaufbau sind auf Wunsch auch andere Kabelkonstruktionen lieferbar, z. B. mit Bleimantel.

The outer sheath

To ensure reliable protection against mechanical effects from outside, the high and extra-high voltage XLPE-insulated cables are given an outer sheath made of high-density polyethylene (HDPE), which possesses excellent mechanical properties.
With a transversely watertight cable design, protection against ingress of humidity is provided by a laminated sheath, comprising a longitudinally applied coated aluminium tape, firmly welded to the polyethylene sheath extruded over it
While the polyethylene provides mechanical protection for the cable, the aluminium tape prevents radial water-vapour diffusion and thus any penetration of moisture into the cable. As an optional extra, additional flame-retardant and/or semi-conductive layers can be extruded together with the PE outer sheath.

Besides the cable construction described above, other cable designs can also be provided on request, e.g. with a lead sheath.

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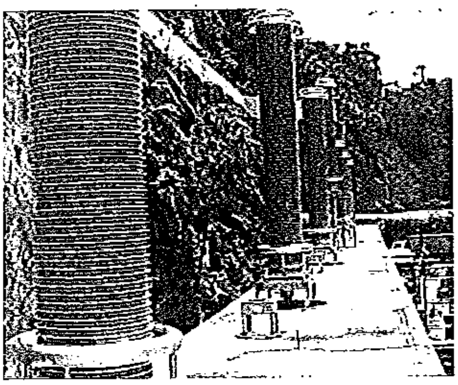

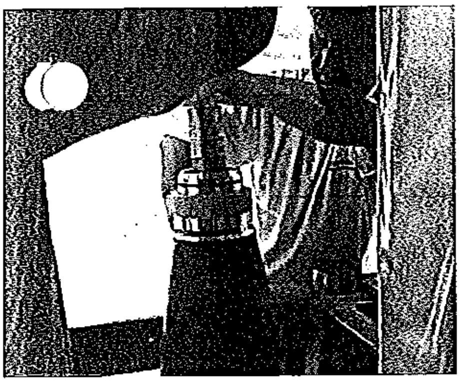

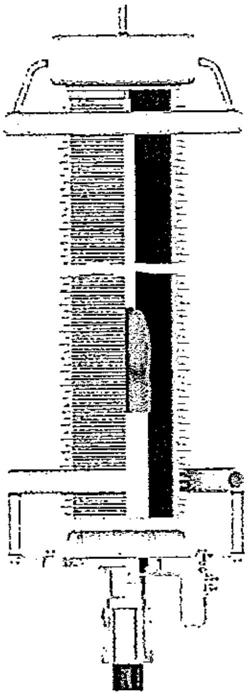

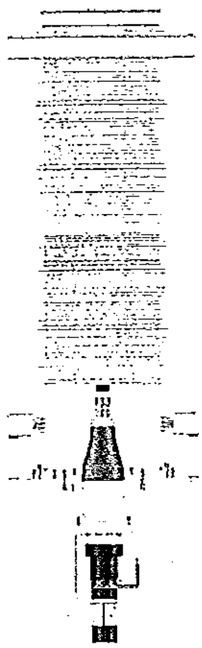

Für Kabel mit Isolierung aus VPE sind alle gängigen Garnituren verfügbar: Freiluft-, Transformator- und SF_6-Endverschlüsse sowie Verbindungsmuffen. Garnituren für VPE-isolierte Hoch- und Höchstspannungskabel sind „Maßarbeit". Deshalb entwickelt und fertigt Südkabel die Garnituren selbst – dies ergibt ein Höchstmaß an Sicherheit bei allen Betriebsbedingungen in den Energieübertragungsnetzen unserer Kunden.

For our cables with XLPE-insulation, all commonly used cable accessories are available: Outdoor terminations, transformer and SF_6 GIS terminations, and joints. Accessories for XLPE-insulated high and extra-high voltage cables require customised compatibility, so Sudkabel develops and manufactures these accessories inhouse – thus providing a maximum of safety under all operating conditions in our customers' power transmission networks.

luftendverschlüsse

Die Freiluftendverschlüsse werden mit Porzellan- oder Verbundisolator ausgeführt. Die Kriechweglänge des Isolators wird entsprechend den Anforderungen im jeweiligen Anwendungsfall festgelegt. Die Aufstellung erfolgt in der Regel auf einem Stahlgerüst gegebenenfalls unter Verwendung zusätzlicher Stützisolatoren, die z. B. für Mantelprüfungen die Potentialtrennung zwischen der Endverschlussgrundplatte und dem geerdeten Traggerüst ermöglichen.

Outdoor terminations

The outdoor terminations are installed with porcelain or composite insulator. The length of the insulator's creepage path is specified to suit the requirements of the particular application concerned. It is usually installed on to a steel support structure, using additional post-insulators where required, providing the necessary potential isolation between the termination's base plate and the earthed supporting structure during sheath testing

ВЯРНО С ОРИГИНАЛА

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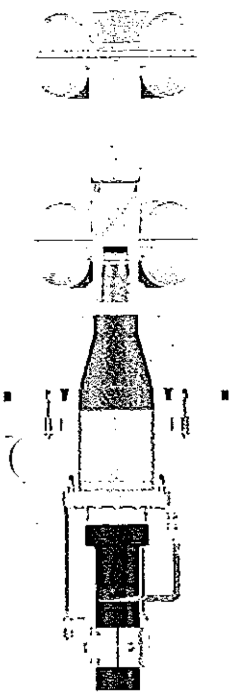

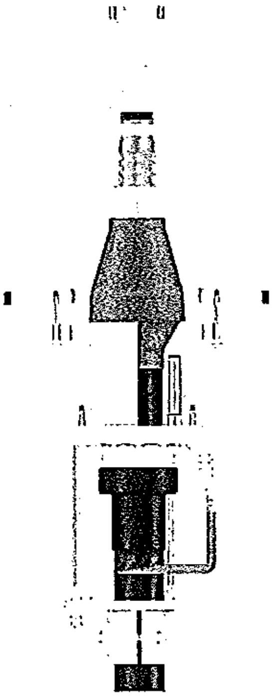

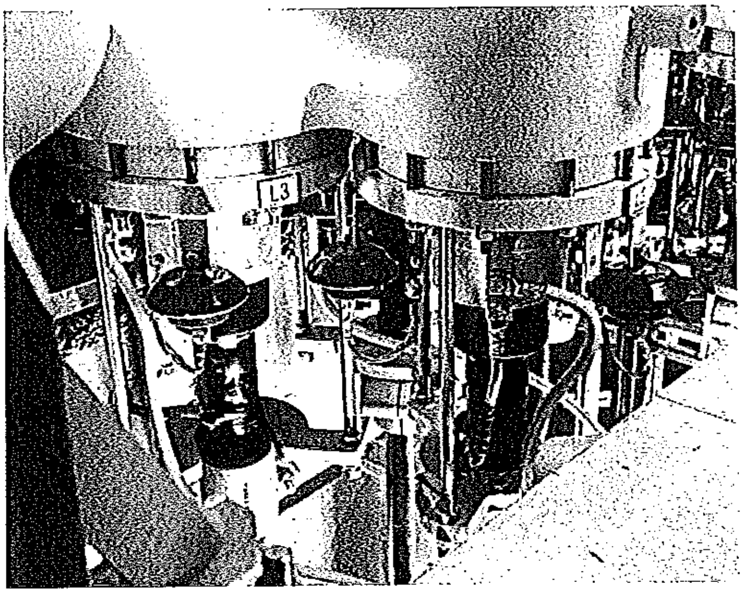

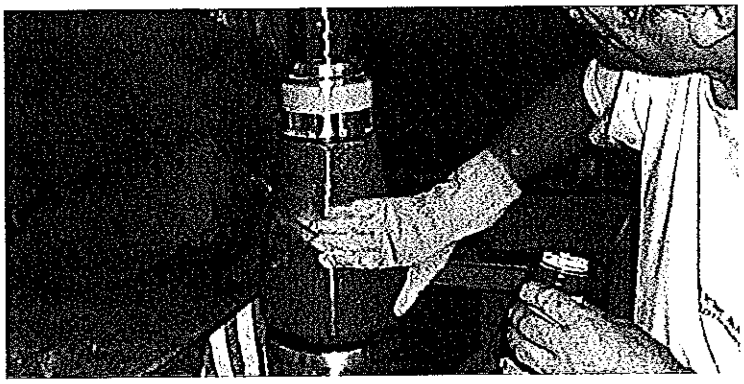

SF_6 GIS-Einbauendverschlüsse

Die Einbauendverschlüsse für SF_6-gasisolierte Schaltanlagen (GIS) werden mit einem Epoxidharz-Isolator ausgeführt, der eine integrierte Isolierstrecke für die Potentialtrennung zwischen Schaltanlagengehäuse und Kabelschirm/-mantel aufweist. Die Anschlussmaße entsprechen IEC 62271-209 oder werden im jeweiligen Anwendungsfall zwischen Schaltanlagen- und Kabelhersteller abgestimmt. Es sind sowohl konventionelle Einbauendverschlüsse mit einer Flüssigkeitsfüllung im Isolator als auch steckbare „trockene" Endverschlüsse verfügbar. Die Steckendverschlüsse haben den Vorteil, dass die Isolatorsteckbuchse bereits im Herstellerwerk der Schaltanlage vormontiert und zusätzliche Handhabung mit SF_6-Gas bei der Kabelmontage vermieden werden kann.

SF_6 GIS terminations

The terminations for SF_6 gas-insulated switchgears (GIS) are installed with an epoxy resin insulator, including an integrated insulating clearance for potential isolation between the switchgear housing and the cable screen/sheath. The interface dimensions conform to IEC 62271-209 or are agreed upon between the switchgear and cable system suppliers for the particular application concerned. Both conventional terminations with a fluid filling in the insulator and plug-in "dry" terminations are available. The advantage of the plug-in terminations is that the insulator socket can be installed in advance at the switchgear manufacturer's plant, thus avoiding additional work with SF_6 gas during cable installation on site.

Transformator-Einbauendverschlüsse

Die Transformator-Einbauendverschlüsse besitzen einen Isolator aus Epoxidharz mit einer integrierten Isolierstrecke für die Potentialtrennung zwischen Transformatorgehäuse und Kabelschirm/-mantel. Die Anschlussabmessungen entsprechen DIN EN 50299 oder werden im jeweiligen Anwendungsfall zwischen Transformator- und Kabelhersteller abgestimmt. Wie bei den Schaltanlagen-Endverschlüssen sind für den Einsatz in Transformatoren sowohl konventionelle Endverschlüsse als auch „trockene" Steckendverschlüsse verfügbar. Die Anwendung der steckbaren Endverschlüsse in Transformatoren bietet vergleichbare Vorteile wie bei den Schaltanlagen.

Transformer terminations

The transformer terminations feature an insulator made of epoxy resin with an integrated insulating clearance for potential isolation between the transformer housing and the cable screen/sheath. The interface dimensions conform to DIN EN 50299 or as agreed upon between the transformer and cable suppliers concerned in the particular case involved. As with the switchgear terminations, both conventional fluid-filled and "dry" plug-in terminations are available. Using the plug-in terminations in transformers offers comparable advantages to those obtained with the switchgear.

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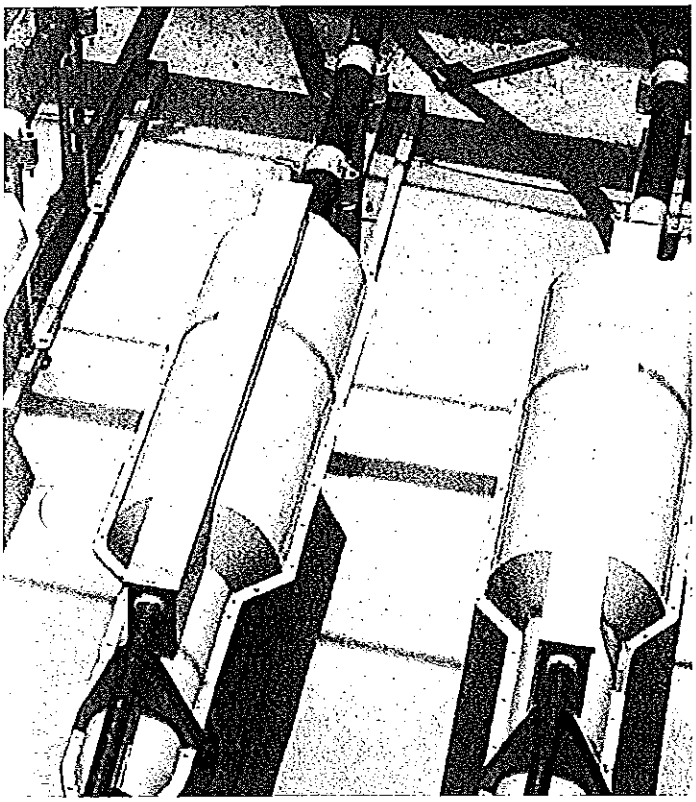

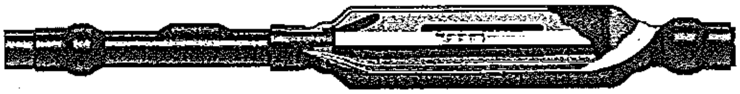

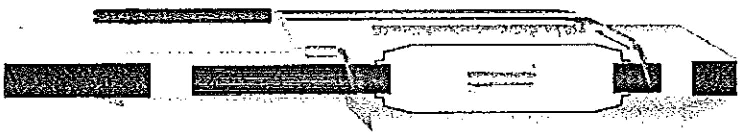

Verbindungsmuffen

Südkabel bietet ein umfangreiches Programm an Verbindungsmuffen für VPE-isolierte Hoch- und Höchstspannungskabel. Die Muffen sind völlig wartungsfrei, da auf gasförmige oder flüssige Bestandteile verzichtet wird („Feststoffmuffen").

Es werden sowohl Verbindungsmuffen mit Durchverbindung des Schirmes als auch Isoliermuffen mit Potentialtrennung der beidseitigen Schirme [illegible]setzt. Die Isoliermuffen sind geeignet für das Auskreuzen der Schirme (Cross-Bonding) oder für einseitige Schirmerdung der einzelnen Legeabschnitte. Als erstes Unternehmen hat Südkabel schon seit 1993 vorgefertigte und vorgeprüfte Verbindungsmuffen auch in den Höchstspannungsebenen 220 kV bis 500 kV geliefert.

Joints

Südkabel offers an extensive program of joints for high and extra-high voltage XLPE-insulated cables. The joints are completely maintenance-free since they contain no gaseous or liquid constituents ("solid joints").

Both straight-through joints with through connections of the screen as well as sectionalising joints with potential insulation of the cable screen at both sides of the joint are used. Insulating joints are designed for cross-bonding of the cable screen or for applications with single bonded cable screens. In 1993, Südkabel was the first company to provide prefabricated and pretested joints in the extra-high voltage levels of 220 kV to 500 kV as well.

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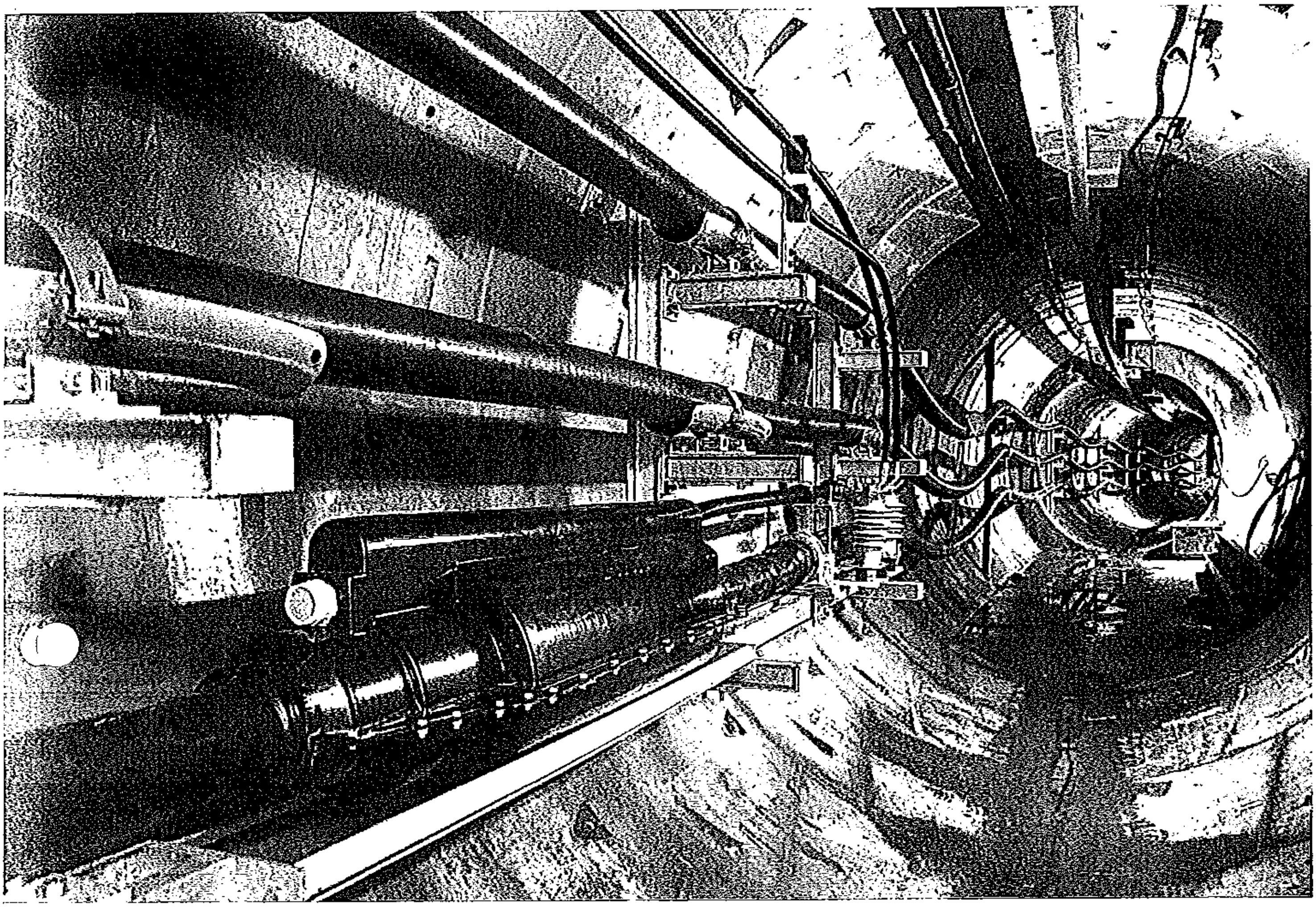

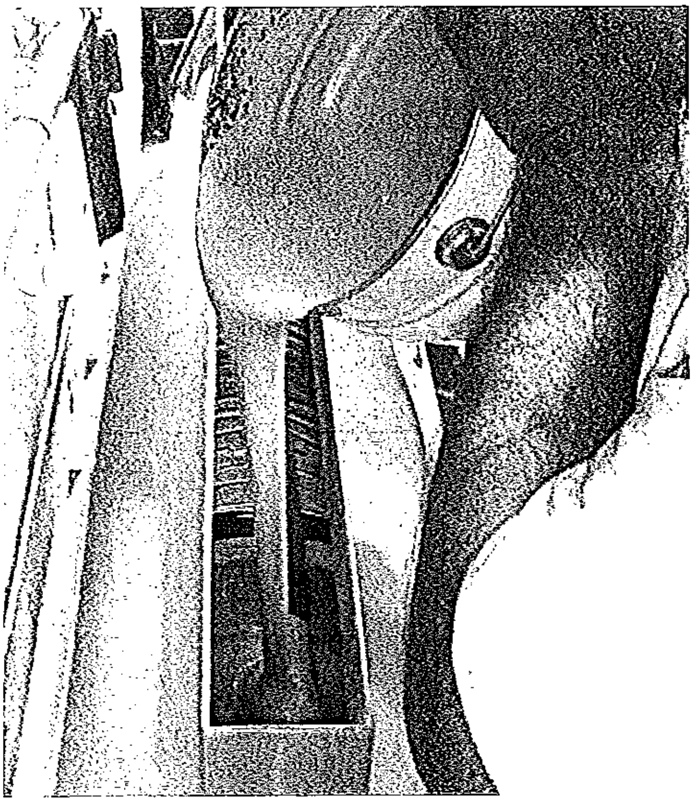

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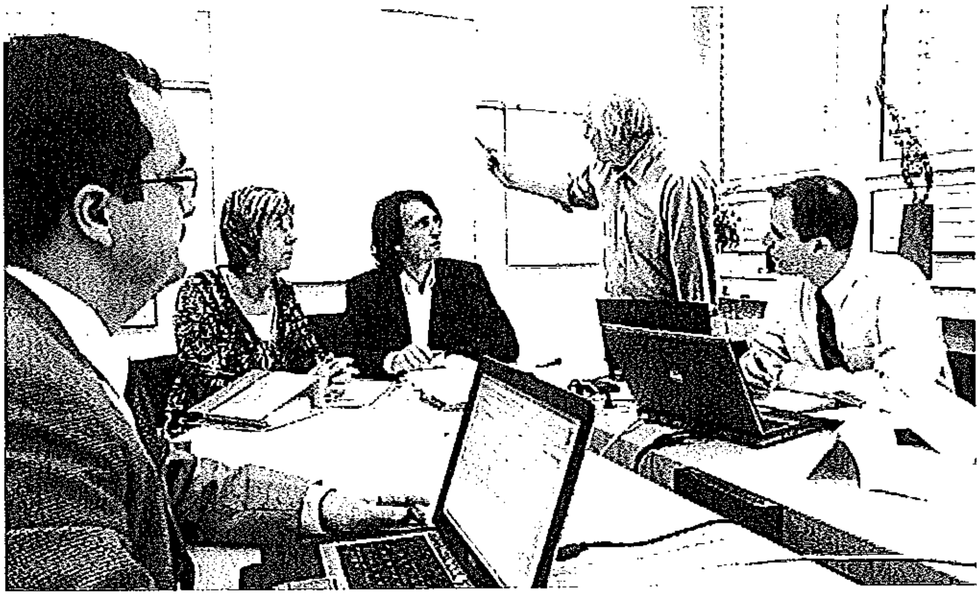


Planung

Wir planen, projektieren und bauen Kabelsysteme nach den Anforderungen unserer Kunden. Vor allem zu Beginn anspruchsvoller Projekte sind unsere langjährigen Erfahrungen und Kenntnisse hilfreich:

- Bei der Suche nach der wirtschaftlichsten Lösung.
- Bei der Entwicklung kundenspezifischer Konstruktionen.
- Bei der Optimierung der maximal übertragbaren Leistung.
- Bei der Festlegung einer effizienten Kühlung, des richtigen Bettungsmaterials oder der Anwendung geeigneter Erdungsverfahren, wie einseitige Schirmerdung oder das Cross-Bonding-Verfahren.
- Bei der Planung des optimalen Trassenverlaufs.
- Bei der Auslegung der Sekundärtechnik, z. B. Erdungseinrichtungsanlagen, Schirmerdung, Temperaturüberwachung der Kabeltrasse, Teilentladungsüberwachung.
- Bei der Einhaltung von Umweltauflagen.

Planning

We plan, design and build cable systems to suit our customers' individual requirements. In challenging projects, our experience and know-how may be invaluable, particularly in the early stages:

- In finding the most cost-efficient solution.
- Developing customised designs.
- Optimising the maximum transmittable power.
- Specifying an efficient cooling system, suggesting the correct embedding material or use of appropriate earthing procedures, e. g. single-point screen earthing or cross-bonding.
- Designing the optimum route.
- Designing of secondary systems, e. g. earthing systems, screen earthing, temperature monitoring of the cable route or partial discharge monitoring
- In the compliance of health, safety and environmental regulations.

Projektmanagement

Auf Wunsch bietet Südkabel das komplette Projektmanagement für VPE-isolierte Hoch- und Höchstspannungskabelanlagen.
Die Durchführung der detaillierten Projektplanung enthält:

- Strombelastbarkeitsberechnungen
- Auswahl der Garnituren
- Transporte zur Baustelle
- Kabellegung
- Garniturenmontage
- Abschlussprüfung
- Inbetriebnahme

Darüber hinaus wird unser Liefer- und Leistungsspektrum optional um die komplette Baustellenkoordination einschließlich Planung und Ausführung der erforderlichen Tiefbauleistungen ergänzt.

Project Management

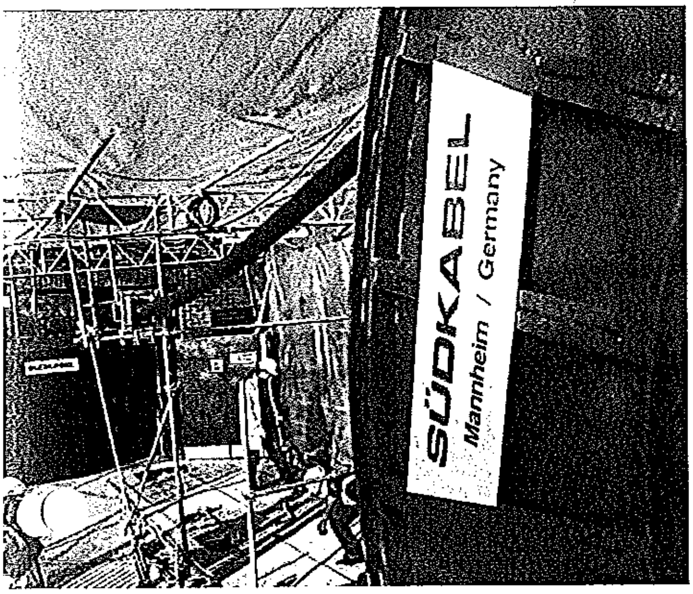
On request, Südkabel offers the complete project management package for the installation of high and extra-high voltage XLPE-insulated cable systems. The implementation of the detailed project planning consists of:

- Calculations of current carrying capacity
- Selecting accessories
- Transportation to site
- Laying the cables
- Installing the accessories
- Final inspection and testing
- Commissioning

In addition, our spectrum of products and services can be extended to include complete site coordination, with design and execution of the required civil works.

ВЯРНО С ОРИГИНАЛА

ООД РУДИМ Стара Загора



Verlegung

Die Legung von Kabeln der höchsten Spannungsebenen erfordert den Einsatz spezieller Legemethoden und -geräte sowie sorgfältige Vorbereitung. Wir berechnen individuell den Kabelzug und reduzieren durch den Einsatz von modernsten Kabelschubgeräten die Zugkräfte auf ein Minimum. Die Festlegung der einzelnen Legeabschnitte hängt von vielen Faktoren ab, wie z. B. Legebedingungen in der Kabeltrasse, maximale Lieferlänge und Einschränkungen beim Transport auf dem Land- oder Seeweg sowie der Auslegung der Schutzeinrichtung gegen transiente Überspannungen beim Auskreuzen oder einseitigen Erden der Kabelschirme. Während Legelängen von ca. 500 bis 600 m üblicherweise projektiert werden, sind in Sonderfällen Längen von weit über 1.000 m möglich.

Laying

Laying cables of the highest voltage levels requires the use of special laying methods and equipment, plus meticulous preparation. We calculate the cable pull for each individual case and minimise the pulling forces involved by using state-of-the-art cable pulling equipment. The length of the individual laying sections will depend on a multitude of factors, such as the laying conditions in the cable route, the maximum delivery length restrictions on transportation by land or sea, and the design of the protection against transient over-voltages, using cross-bonding or single-point earthing of the cable screens. While laying lengths of approx. 500 to 600 m are usually planned, in special cases lengths of well above 1000 m are possible.

Montage

Die Montage unserer Garnituren führen wir mit speziell ausgebildeten Monteuren mit langjähriger Erfahrung durch. Ein intensives Ausbildungsprogramm für alle relevanten elektrischen und mechanischen Vorgänge sowie jährliche Wiederholungskurse sind für unsere Monteure eine Selbstverständlichkeit.

Installation

Our accessories are installed by our specially trained fitters, with many years of experience behind them. An intensive training program for all relevant electrical and mechanical jobs involved, plus annual refresher courses, are all part of the job for our fitters.

Inbetriebnahme

Vor einer Inbetriebnahme werden die von uns installierten Kabelanlagen, in der Regel nach den einschlägigen Prüfvorschriften für VPE-isolierte Hoch- und Höchstspannungskabel, geprüft. Hierzu gehören Gleichspannungsprüfungen am Kabelmantel und/oder Wechselspannungsprüfungen der Hauptisolierung, die gegebenenfalls, insbesondere bei Höchstspannungsanlagen um Teilentladungsprüfungen, an den installierten Garnituren ergänzt werden.

Südkabel kann mit einer eigenen Vorort-Resonanzprüfanlage Spannungen bis 520 kV erzeugen und somit Kabelsysteme bis U_m = 550 kV konform internationaler/nationaler und Kundenspezifikationen prüfen.

Commissioning

Before an installed cable system is commissioned, it is usually tested in accordance with the relevant test specifications for high and extra-high voltage XLPE-insulated cable systems. These include DC voltage tests on the cable sheath and/or AC voltage tests on the main insulation. For extra-high voltage systems, particularly, they may be supplemented by partial discharge tests on the accessories installed.

With its own mobile resonant test system Sudkabel can produce test voltages up to 520 kV. Thus it is possible to test cable systems up to U_m = 550 kV compliant to international/national and clients' specifications.

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UNSERE QUALITÄTSPHILOSOPHIE

OUR QUALITY PHILOSOPHY

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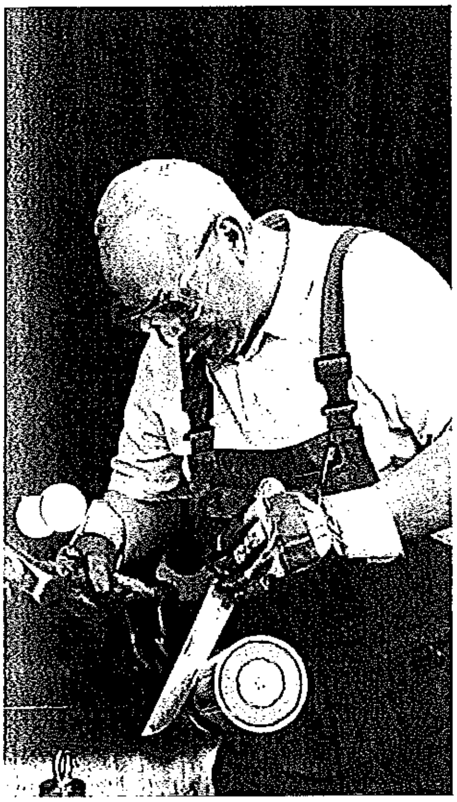
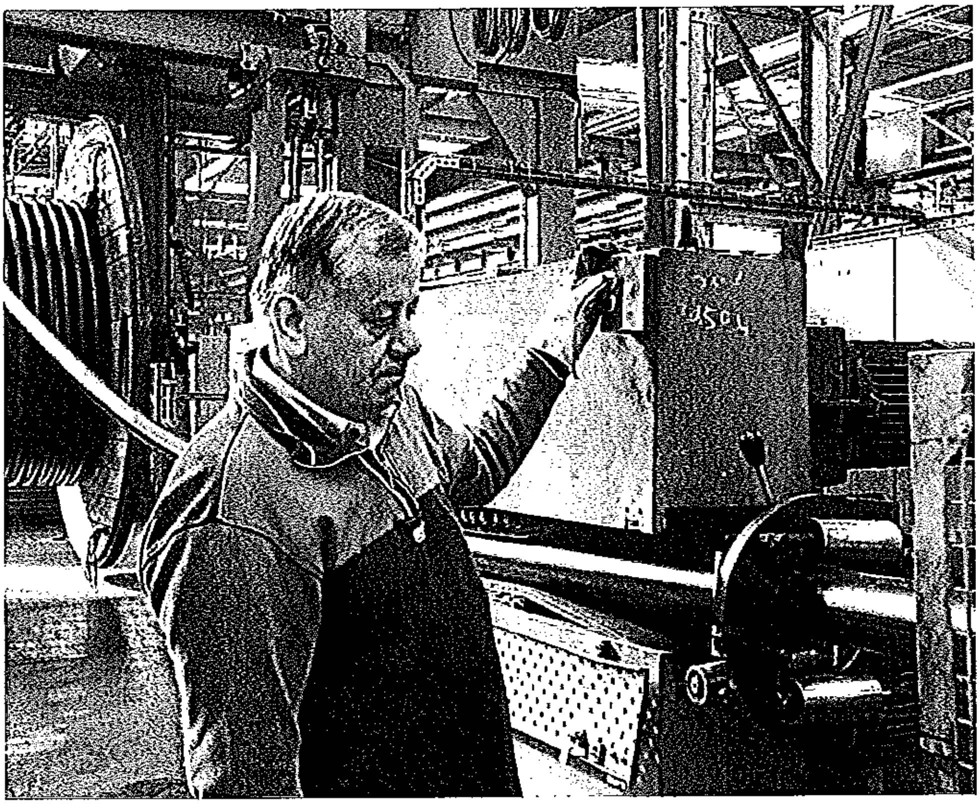




Das Kennzeichen von Südkabel ist Qualität

Unser Ziel ist es, Produkte und Dienstleistungen in der bestmöglichen Qualität, zur vereinbarten Zeit und zu vertraglich festgesetzten Bedingungen zu liefern. Ein hoher Qualitätsmaßstab soll nicht nur die Ansprüche unserer Kunden erfüllen, sondern als Herausforderung angesehen werden, uns ständig zu verbessern und damit auch den steigenden Anforderungen unserer Kunden gerecht zu werden.

(fene Dialog mit Mitarbeitern, Öffentlichkeit und Behörden ist für unser Unternehmen eine wichtige Aufgabe, ebenso die kontinuierliche Überprüfung aller Produktionsschritte und Produkte auf Umweltverträglichkeit.

Wir stellen unseren Kunden und der Öffentlichkeit auf Wunsch alle Informationen über die Umweltrelevanz der hergestellten Produkte zur Verfügung.

Südkabel's trademark is quality

Our goal is to supply products and services in the highest possible quality, at the time agreed, and conforming to the contractually specified conditions. A high standard of quality is maintained and continuously improved through the challenge of satisfying our customers' ever-more-stringent requirements.

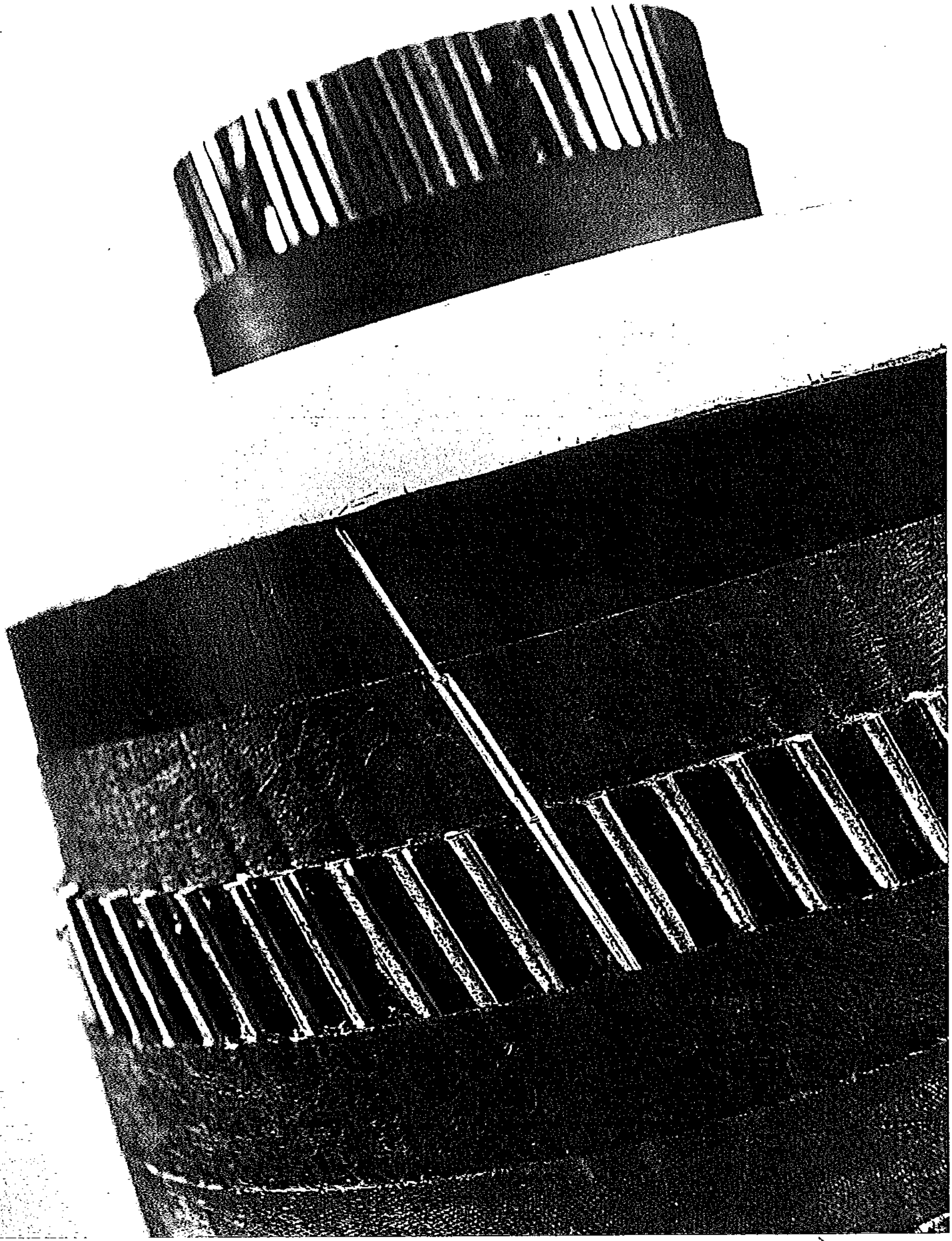
A free and frank dialogue with our staff, the public and government agencies is high on our list of corporate priorities. We regard it as an important part of our job to continuously monitor all our production steps and products for eco-compatibility and to improve them wherever possible.

On request, we provide our customers and the public with all information regarding the eco-relevance of the products we manufacture.

ВЯРНО С ОРИГИНАЛА

Подпис:

ООД РУДИН Стара Загора



ВЯРНО С
ОРИГИНАЛА

РУДИН
Стара Загора

A 83

UNSER ANGEBOT

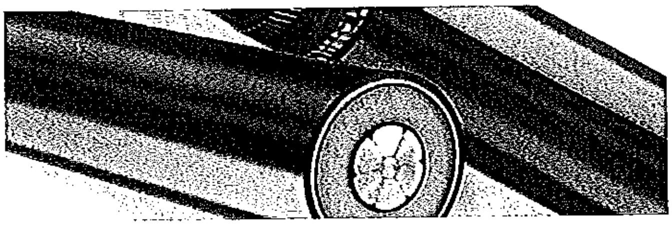
OUR OFFER

Mittel-, Hoch- und Höchstspannung: Wir unterstützen Sie mit kompletten Systemlösungen, einer breit gefächerten Produktpalette und umfassenden Dienstleistungen von allerhöchster Qualität. Damit Sie auch in Zukunft wirtschaftlich und umweltverträglich, sicher und zuverlässig Energie übertragen und verteilen können.

Medium, high and extra-high voltage: we support you with complete system solutions, a wide-ranging portfolio of products and comprehensive services in the highest quality so that you may transmit and distribute energy safely and reliably also in the future in an economic and environmentally friendly way.

Kabel

Cables

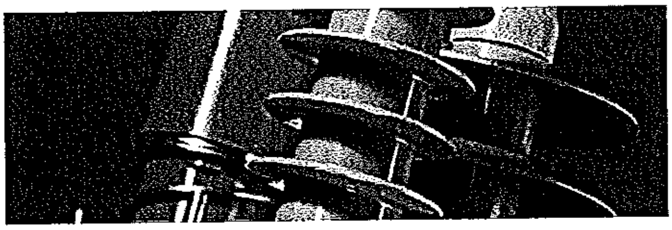


- VPE-isolierte Kabel von 6 kV bis 500 kV

- *XLPE-insulated cables from 6 kV to 500 kV*

Garnituren für Mittel-, Hoch- und Höchstspannung

Accessories for medium, high and extra-high voltage



- Freiluft-Endverschlüsse
- Konventionelle und steckbare Einbauendverschlüsse für SF_6-Schaltanlagen und Transformatoren
- Verbindungsmuffen
- Steckendverschlüsse für Außen- und Innenkonussysteme
- Kabelbrücken für Mittelspannung
- Garnituren für Elektrofilterkabel

- *Outdoor terminations*
- *Conventional and plug-in terminations for SF_6 switchgears and transformers*
- *Cable joints*
- *Plug-in terminations for outer and inner cone systems*
- *Cable links for medium-voltage*
- *Accessories for electrostatic precipitator cables*

ВЯРНО С ОРИГИНАЛА

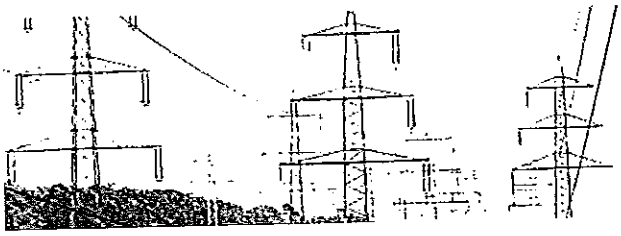
ООД РУДИН Стара Загора

Подпис: ....

Kabelsysteme *Cable systems*

- Schlüsselfertige VPE-Kabelanlagen bis 500 kV
- *Turnkey XLPE-insulated cable systems up to 500 kV*

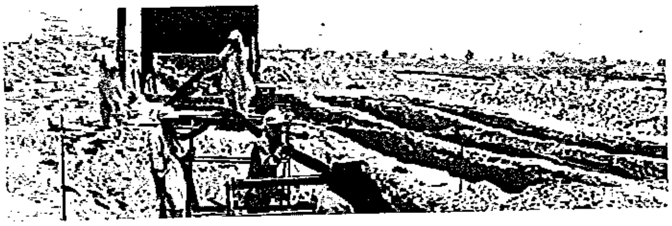
Freileitungsseile *Overhead line conductors*



- Aluminium
- Kupfer
- Aluminium-Stahl

- *Aluminium*
- *Copper*
- *Aluminium-steel*

Dienstleistungen *Services*



- Beratung in anwendungstechnischen Fragen
- Monteurschulungen
- Kabelverlegung und Verlegeaufsicht
- Garniturenmontage
- Inbetriebnahmeprüfung
- Störungsdienst

- *Consulting service on application-related questions*
- *Training for installation personnel*
- *Cable laying and supervision of laying*
- *Installation of accessories*
- *Commissioning*
- *After sales services*

ВЯРНО С ОРИГИНАЛА

ООД РУДИН Стара Загора

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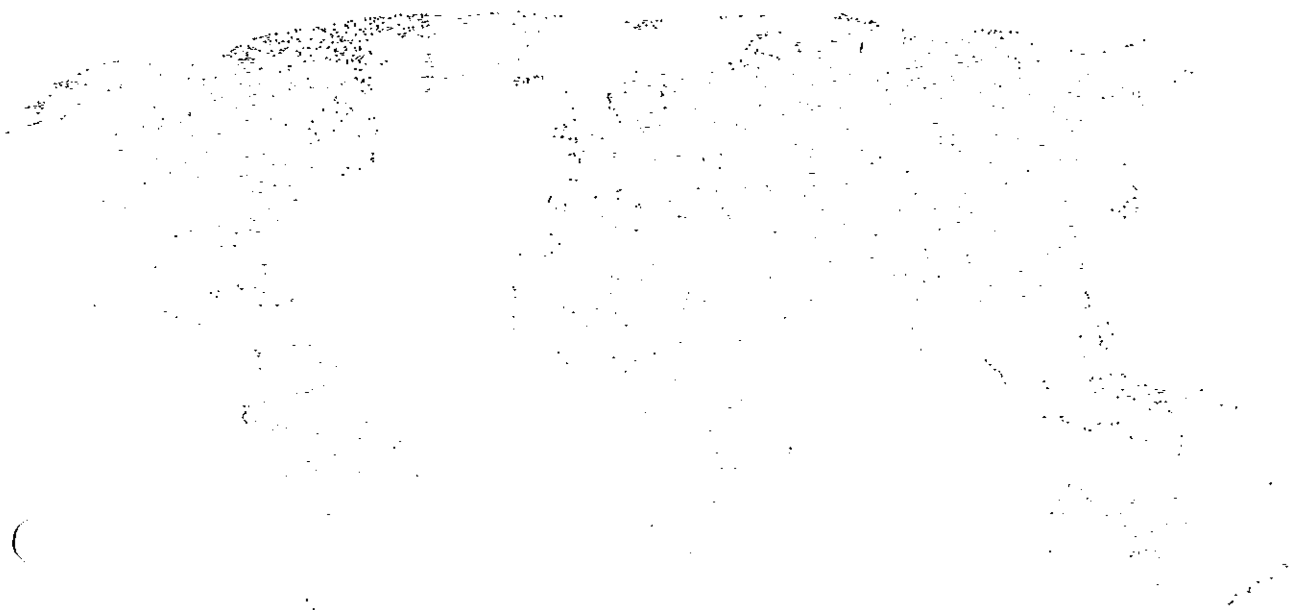

ВЯРНО С
ОРИГИНАЛА

ООД
РУДИН
Стара Загора

Südkabel GmbH

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Tel.: +49 621 8507 01 | Fax: +49 621 8507 294
E-Mail: info@suedkabel.com

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www.suedkabel.com

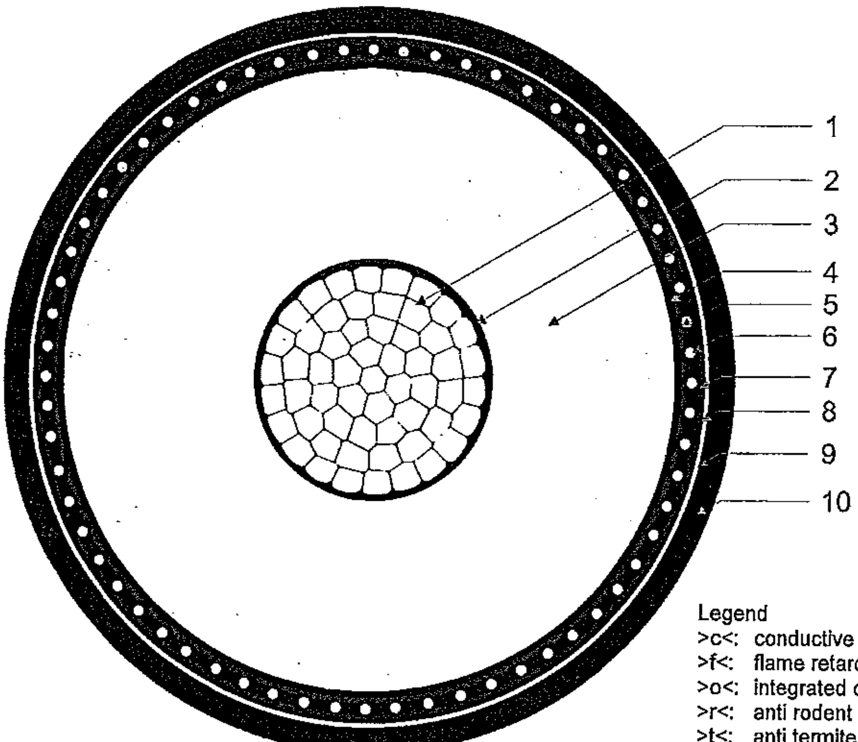
SÜDKABEL

Südkabel 1004-1 1000 D/E

Tech. Document no. KSH-2017-014-K-02

SÜDKABEL

Kabeltyp *cable type* **A2XS(FL)2Y 1x1600 RM/110 64/110 kV >c-r<**



Legend
>c<: conductive
>f<: flame retardant
>o<: integrated optical fiber
>r<: anti rodent repellant
>t<: anti termite repellant
>w<: longitudinally water-proof conductor

(nicht maßstabsgetreu / *not to scale*)
(Änderungen vorbehalten / *subject to change*)

1	Leiter *conductor*	Aluminium, RM *aluminium, RM*	1600 mm²	Durchmesser ca. *diameter approx.*	49.5 mm
2	innere Leitschicht *conductor screen*	leitfähige VPE-Verbindung, Feldstärke: *conductive XLPE-compound, stress:*	4.8 kV/mm	Dicke ca. *thickness approx.*	1.6 mm
3	Isolation *insulation*	VPE *XLPE*		Dicke ca. *thickness approx.*	16.7 mm
4	äußere Leitschicht *insulation screen*	leitfähige VPE-Verbindung, Feldstärke: *conductive XLPE-compound, stress:*	3.0 kV/mm	Dicke ca. *thickness approx.*	1.6 mm
5	Polster *bedding*	Quellband / Krepppapier, halbleitend *swelling tape / crepe paper, semi-conducting*		Dicke ca. *thickness approx.*	0.4 mm
6	Drahtschirm *wire screen*	74 Kupferdrähte *copper wires*	110 mm²	Dicke ca. *thickness approx.*	1.38 mm
7	Polster *bedding*	Quellband / Krepppapier, halbleitend *swelling tape / crepe paper, semi-conducting*		Dicke ca. *thickness approx.*	0.4 mm
8	Polster *bedding*	Gewebeband, halbleitend *fabric tape, semi-conducting*		Dicke ca. *thickness approx.*	0.2 mm
9	Metallmantel *metallic sheath*	Copolymerbeschichtetes Aluminium *copolyper-laminated aluminium*		Dicke ca. *thickness approx.*	0.2 mm
10	Außenmantel *outer sheath*	HDPE, leitfähige Außenschicht mit Nagerschutz *HDPE, outer conductive layer with anti rodent repellant*		Dicke ca. *thickness approx.*	4.3 mm
-	Kabelgewicht *cable weight*	11.5 kg/m		Kabeldurchmesser ca. *cable diameter approx.*	105 mm

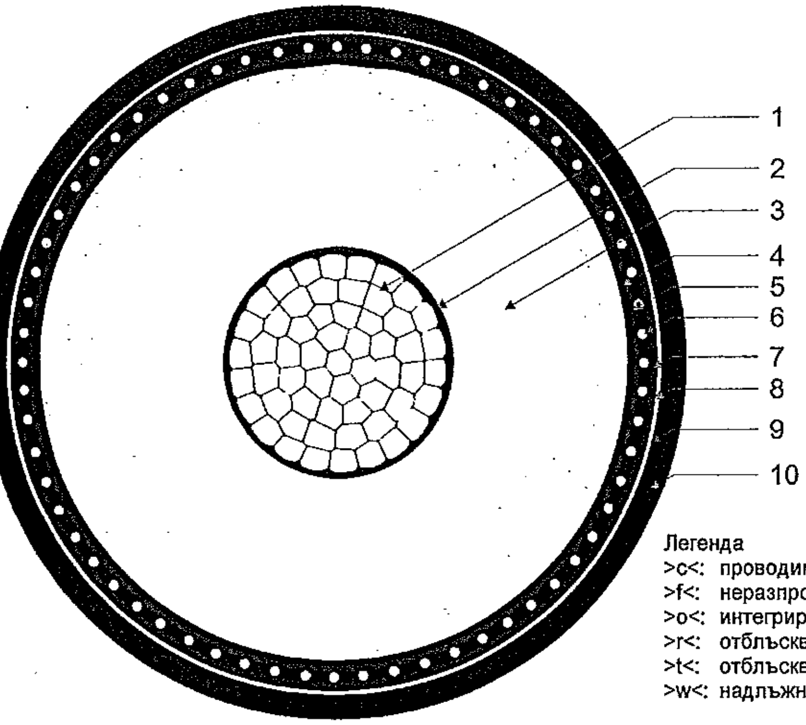
ВЯРНО С ОРИГИНАЛА

ООД Стара Загора

Техн. Документ № Kabel ENOS.docx

SÜDKABEL

Кабел тип *cable type* **A2XS(FL)2Y 1x1600 RM/110 64/110 kV >c-r<**



Легенда
>c<: проводим
>f<: неразпространяващ горенето
>o<: интегрирани оптични влакна
>r<: отблъскващ гризачи
>t<: отблъскващ термити
>w<: надлъжно водонепромокаемо жило

(не отговаря на мащаба / *not to scale*)

1	Жило *conductor*	Алуминиево, RM *aluminium, RM*	1600 mm²	Прибл. диаметър *diameter approx.*	49.5 mm
2	Вътрешен проводим слой *conductor screen*	Проводим XLPE слой, интензитет на полето: *conductive XLPE-compound, stress:*	4.8 kV/mm	Прибл. дебелина *thickness approx.*	1.6 mm
3	Изолация *insulation*	XLPE *XLPE*		Прибл. дебелина. *thickness approx.*	16.7 mm
4	Външен проводим слой *insulation screen*	Проводим XLPE слой, интензитет на полето: *conductive XLPE-compound, stress:*	3.0 kV/mm	Прибл. дебелина *thickness approx.*	1.6 mm
5	Бандаж *bedding*	Набъбваща лента + креп хартия, полупроводима *swelling tape + crepe paper, semi-conducting*		Прибл. дебелина. *thickness approx.*	0.4 mm
6	Екран от телове *wire screen*	74 медни телове *copper wires*	110 mm²	Прибл. дебелина. *thickness approx.*	1.38 mm
7	Бандаж *bedding*	Набъбваща лента + креп хартия, полупроводима *swelling tape + crepe paper, semi-conducting*		Прибл. дебелина *thickness approx.*	0.4 mm
8	Бандаж *bedding*	Текстилна лента, полупроводима *fabric tape, semi-conducting*		Прибл. дебелина *thickness approx.*	0.2 mm
9	Метална обвивка *metallic sheath*	Алуминий, покрит с кополимер *copolyper-laminated aluminium*		Прибл. дебелина *thickness approx.*	0.2 mm
10	Външна обвивка *outer sheath*	HDPE, проводим външен слой, неразпространяващ горенето и отблъскващ гризачи *HDPE, outer flame retardant, conductive layer with anti rodent repellant*		Прибл. дебелина *thickness approx.*	4.3 mm
-	Тегло на кабела *cable weight*	11,5 kg/m		Прибл. диаметър на кабела *cable diameter approx.* (не отговаря на мащаба / *not to scale*)	105 mm

ВЯРНО С ОРИГИНАЛА

ООД ... Стара Загора

Document No: KSH-2017-014-B-02 SÜDKABEL

Customer: Eurokabel Ltd.
Project: ENOS 110kV
Subject: Cable Data Sheet

V1-2-53

Cable Type: NA2XS(FL)2Y 1x1600 RM/110 64/110 kV >c-r<

<u>Cable construction</u>

Round conductor of stranded aluminium wires; triple extruded insulation with field limiting layers of cross-linked polyethylene; bedding tapes; wire screen in longitudinally water-tight embedding; bedding tapes; copolymer coated aluminium tape; Outer sheath of PE with extruded semiconducting layer

Conductor cross-section	1600 mm^2
Insulation thickness approx.	17 mm
Cross section of wire screen (nominal value) (copper)	110 mm^2
Metallic sheath thickness approx.	0,2 mm
Cross-section of metallic sheath approx.	60 mm^2
Outer sheath of PE with a thickness of	4,3 mm
Cable diameter approx.	105 mm

<u>Laying in channel</u>

ambient temperature	20 °C
Thickness of cover 300 mm, Height 1000 mm, Width 1000 mm	
Laying depth (center of system)	1200 mm
Thermal resistivity of soil	1,00 Km/W
Laying in flat formation with a axial phase distance of	300 mm
Crossbonding	

<u>Electrical Data</u>

Nominal voltage U	110 kV
Conductor-earth voltage U_0	64 kV
Max. permissible operating voltage U_{max}	123 kV
Max. permissible transmission rating at nominal voltage	300 MVA
Max. permissible transmission current I_{max} (μ = 1.0)	1575 A
DC-resistance of the conductor at 20 °C	0,0186 Ω/km
AC-resistance of the conductor at 90 °C	0,0271 Ω/km
Field strength at the conductor screen at U_0	4,9 kV/mm
Field strength at the insulation screen at U_0	3,0 kV/mm
Frequency	50 Hz
Capacitance	0,275 µF/km
Charging current per phase	5,5 A/km
Charging power of the system	1045 kVA/km
Operating inductance (mean value)	0,60 mH/km
Screening factor	0,22

System losses at 1575 A	203,5 W/m
Conductor	201,9 W/m
Dielectric	0,6 W/m
Screen	1,0 W/m

Max. conductor short-circuit current (Preload 1575 A) 152,4 kA for 1,0 s leads to 250 °C
Max. screen short-circuit current (initial temperature 67 °C) 27,6 kA for 1,0 s leads to 250 °C

ОРИГИНАЛА

ООД РУДИН Стара Загора

Calculation methods
Conductor: electrical resistance according to IEC 60228
Insulation: Thermal resistivity according to IEC 60287-2-1; 2.1.1.1
Screen: Dielectric losses and capacitance of the cable according to IEC 60287-1-1; 2.2
Screen: Screen losses calculated according to IEC 60287-1-1; 2.3.3
Metallic sheath: Eddy current losses calculated according to IEC 60287-1-1; 2.3.6.1
Below Metallic sheath: Thermal resistivity according to IEC 60287-2-1; 2.1.1.1
Outer sheath: Thermal resistivity according to IEC 60287-2-1; 2.1.1.1
Air in Tunnel: With given max. conductor temperature iteration of load
Thermal resistivity of the inner wall to the ground of a canal or trench according to Heinholt, Stubbe: p 320

Air in Tunnel: Convective therm. resistivity calculated according to Heinholt, S186
Air in Tunnel: Thermal radiation resistivity for cables laid in air calculated according to Heinholt, S186

With given ampacity calculation of conductor temperature
Screen: Calculation of thermally permissible short-circuit currents according to IEC 60949, clauses 2,4 and 6

ВЯРНО С
ОРИГИНАЛА
Подпис:

ООД РУДИН Стара Загора

Данни за кабела

SÜDKABEL
Südkabel GmbH

Клиент: Еврокабел ООД
Проект: ЕНОС

<u>Тип</u>: NA2XS(FL)2Y 1x1600 RM/110 64/110 kV >c-r<

<u>Конструкция на кабела</u>

Кръгъл проводник от усукани алуминиеви жила;

тройно екструдирана изолация със слоеве за ограничаване на полетата от омрежен полиетилен;

бандажни ленти; ширмовка от телове в надлъжно водоблокираща обвивка; бандажни ленти; алуминиева лента, покрита с кополимер; външна обвивка от PE с ектрудиран полупроводим слой

Сечение на жилото	1600 мм2
Дебелина на изолацията (приблизително)	17,0 мм
Сечение на екрана (номинална стойност) (меден)	110 мм2
Дебелина на металната обвивка (приблизително)	0,2 мм
Сечение на металната обвивка (приблизително)	60 мм2
Външна обвивка от PE с дебелина от	4,3 мм
Прибл. диаметър на кебела	105 мм
<u>Полагане в канал</u>	
температура на околната среда	20 °C
Дебелина на капака 300 мм, височина 1000 мм, ширина 1000 мм	
Дълбочина на полагане (център на системата)	1200,0 мм
Топлинно съпротивление на почвата	1,0 Km/W
Успоредно полагане с осово разстояние между фазите	300 мм
Кросбондинг	
<u>Електрически данни</u>	
Номинално напрежение U	110 kV
Напрежение проводник-земя Uo	64 kV
Макс. допустимо работно напрежение U_{max}	123 kV
Макс. допустима преносна мощност при номинално напрежение	300 MVA
Максимален обявен ток I_{max}	1575 A
Съпротивление на тоководещия проводник при 20°C	0,0186 Ω/km
Съпротивление на тоководещия проводник при 90°C	0,0271 Ω/km
Диелектрична якост на проводника при U_0	4,9 kV/мм
Диелектрична якост на екрана на изолацията при U_0	3,0 kV/мм
Честота	50 Hz
Електрически капацитет	0,275 µF/km
Ток на зареждане за фаза	5,5 A/km
Ток на зареждане на системата	1045 kVA/km
Работна индукция (средна стойност)	0,60 mH/km
Редукционен фактор	0,22
Системни загуби при 1575 A	203,5 W/m
Жило	201,90 W/m
Диелектрик	0,60 W/m
Екран	1,00 W/m

Макс ток на късо съединение на жилото (предварително натоварване 1575 A) 152,4 кА за 1,0 сек води до 250 °C

Макс ток на късо съединение на екрана (нач. температура 67 °C)27,6 kA за 1 сек води до 250 ° C

ВЯРНО С ОРИГИНАЛА

ООД РУДИН Стара Загора

Подпис: ....

<u>Методи на изчисление</u>

Жило: електрическо съпротивление по IEC 60228

Изолация: Топлинно съпротивление по IEC 60287-2-1; 2.1.1.1

Екран: диелектрични загуби и капацитет на кабела по IEC 60287-1-1; 2.2

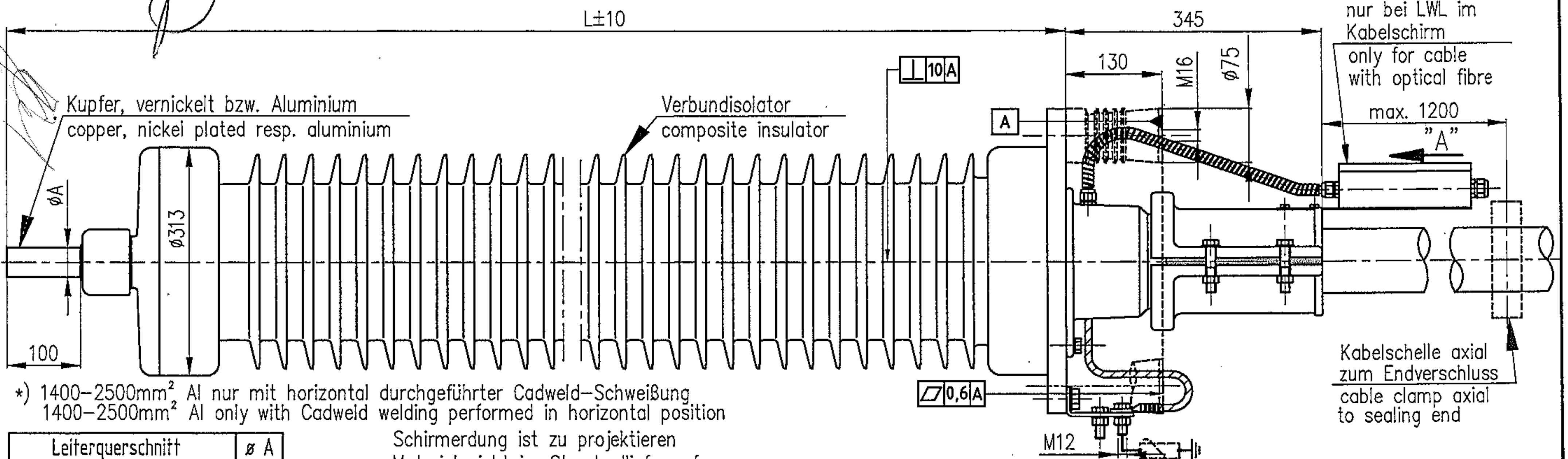
Екран: Загубите са изчислени по IEC 60287-1-1; 2.3.3
Метална обвивка: Загубите са изчислени по IEC 60287-1-1; 2.3.6.1
Долна метална обвивка: Топлинно съпротивление по
IEC 60287-2-1; 2.1.1.1
Външна обвивка: Топлино съпротивление по IEC 60287-2-1; 2.1.1.1
Въздух в тунели: конвекционно топлинно съпротивление изчислено по Heinholt, S186

Въздух в тунели: съпротивление на топлинна радиация за въздушно положени кабели изчислено по Heinholt, S186
С дадено изчисление на допустимото токово
натоварване на температурата на жилото
Екран: Изчисляване на топлинно допустимия ток на късо съединение по IEC 60949, раздели 2,4 и 6

Съставено от: Андре Саламе Дата: 19.01.2016	
Стр. 2 от 2	V1-2-12

ВЯРНО С ОРИГИНАЛА

ООД РУДИН Стара Загора



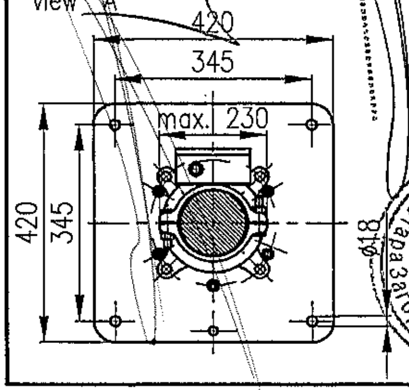
*) 1400–2500mm² Al nur mit horizontal durchgeführter Cadweld–Schweißung
1400–2500mm² Al only with Cadweld welding performed in horizontal position

Leiterquerschnitt cross section	ø A mm
≤ 1000 mm²	30
1200 - 2500 mm² *)	50

Schirmerdung ist zu projektieren
Material nicht im Standardlieferumfang
screen earthing to be engineered
material not in standard scope of supply
Aderdurchmesser: max. 104 mm
diameter over cable core: max. 104 mm
Durchmesser über geschälter Ader: max. 99 mm
diameter over stripped core: max. 99 mm
max. Abweichung von senkrechter Aufstellung 30°
max. deviation from vertical position 30°

Isolator insulator	max. Leiterquerschnitt max. cross section	Kriechweg leakage path	L mm	Gewicht weight	1.5 MML
72.5 kV	2500 mm²	≥ 150 cm	1028	75 kg	11.9 kN
72.5 kV	2500 mm²	≥ 227 cm	1343	80 kg	8.4 kN
123 kV	2000 mm²	≥ 316 cm	1703	90 kg	6.5 kN
145 kV	1800 mm²	≥ 383 cm	1973	95 kg	5.4 kN
170 kV	1400 mm²	≥ 462 cm	2288	105 kg	4.6 kN

Ansicht "A"
view "A"



ВЯРНО С ОРИГИНАЛА
РУДИН ООД Стара Загора

last change: Ø-zeichen bei 18 ergänzt

scale		day	name
%	prepared	02.04.2014	Güllich
resp.dept. ECG	checked	28.04.2014	Stroot
	approved	05.05.2014	Eckert

reference document no.
replacement for
replaced by

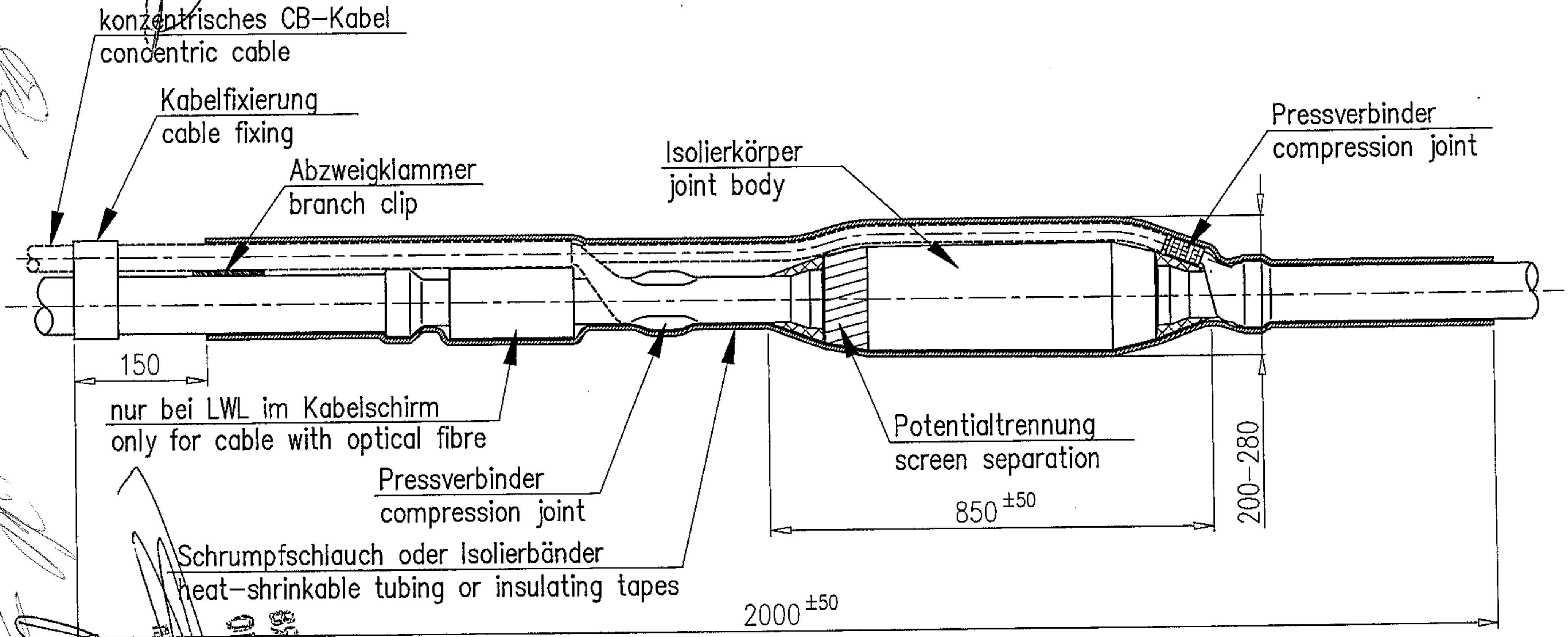
SÜDKABEL
68147 Mannheim
Germany

Freiluftendverschluss EHFVC 72.5/123/145/170
Outdoor Sealing End Type EHFVC 72.5/123/145/170

document no. 0.36.72.5a
rev. 16

design
model GFK Normalschirme
document type OF
format A4

193



Schirmanschluss ist zu projektieren
Material nicht im Standardlieferumfang enthalten

screen connection to be engineered
material not in standard scope of supply

Leiterquerschnitt: max. 2500 mm²
cross-section:

Gewicht: 25–35 Kg
weight:

ВЯРНО С ОРИГИНАЛА

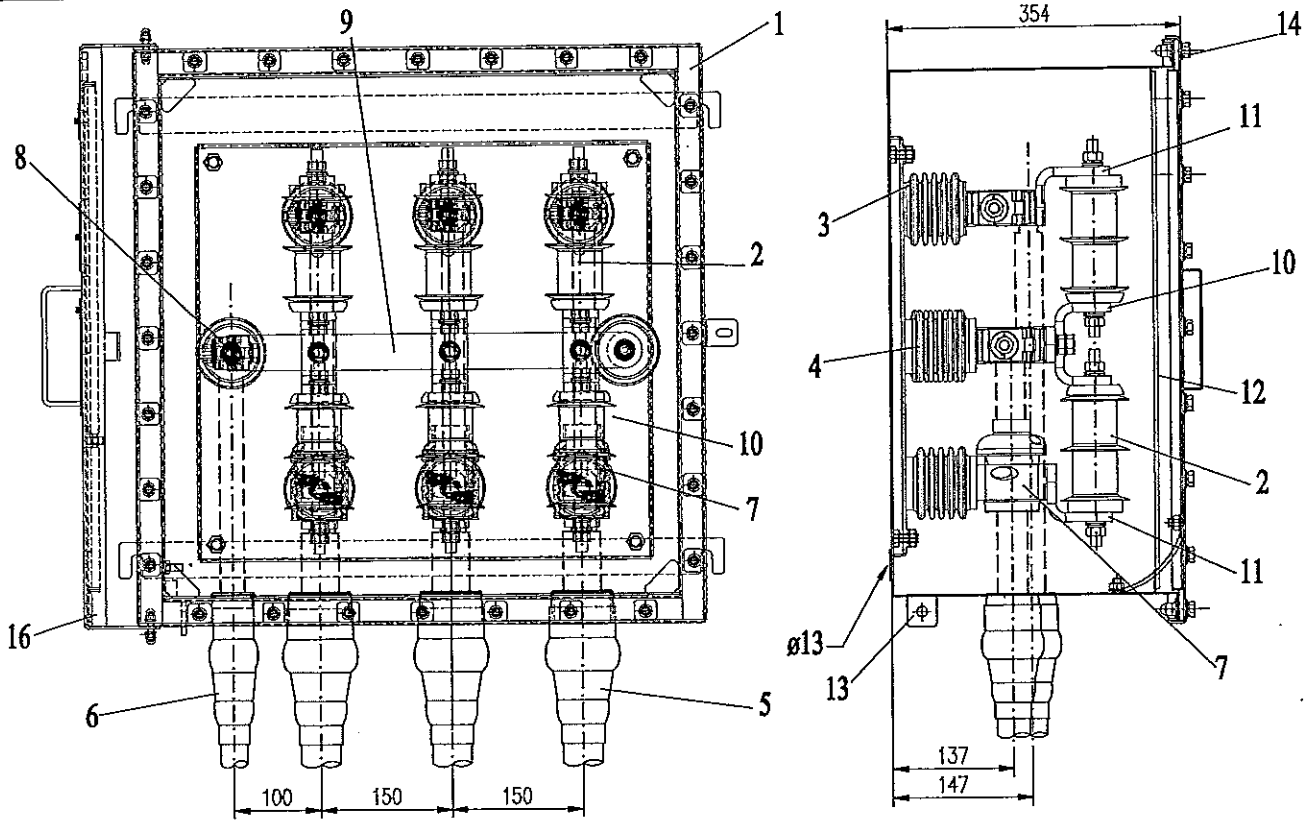
"РУДИН" ООД Стара Загора

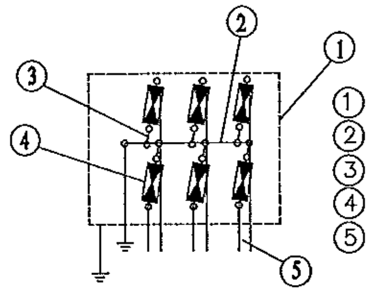
last change:	Ersatz für....., "andere Q-schnitte" entfallen, Spleißkasette ergänzt				
scale %		day	name	The reproduction, dictribution and utilization of this document as well as the communication of its contents to others without express authorization is prohibited. Offenders will be held liable for the payment of damages. All rights reserved in the event of the grant of a patent, utility model or design. © Südkabel GmbH	reference document no.
	prepared	19.11.2013	Weber		replacement for 0.3600.36.9a
resp.dept. ECG	checked	11.12.2013	Stroot		replaced by
	approved	12.12.2013	Eckert		
SÜDKABEL 68147 Mannheim Germany	Isoliermuffe Typ SEHDVCB 123/145/170 Sectionalising Joint Type SEHDVCB 123/145/170				document no. 0.3600.36.1a — rev. 06
	design 1 Koaxialkabel		model Abzweigklammer; LWL opt.		document type OF — format A4

194

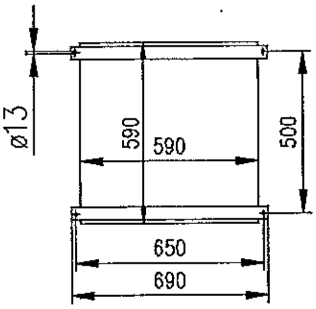
SÜDKABEL

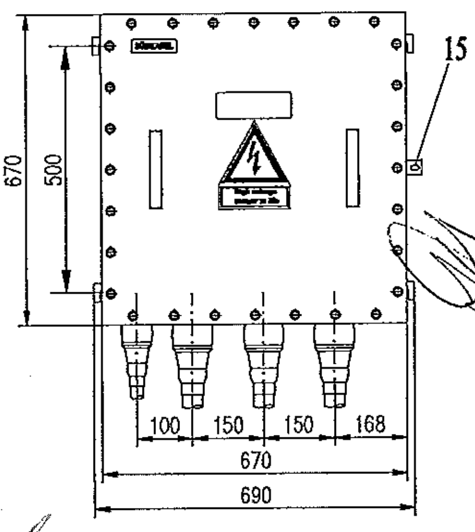
Südkabel GmbH
68199 Mannheim - GERMANY





1. LINK BOX
2. EARTHING BUS BAR
3. DISCONNECTABLE LINKS
4. DISCONNECTABLE S.A.
5. COAX BONDING CABLE





LIST OF MAIN PARTS

Item	Name of parts	Materials
1	CABINET (2 mm)	STAINLESS STEEL
2	SURGE ARRESTER	ZnO
3	SUPPORT INSULATORS (SHORT)	EPOXY
4	SUPPORT INSULATORS (LONG)	EPOXY
5	GLAND FOR COAXIAL CABLE	STAINLESS STEEL
6	GLAND FOR EARTHING CABLE	STAINLESS STEEL
7	FIXING CLAMP	TINNED COPPER
8	CABLE END FIXING CLAMP	TINNED COPPER
9	BUS BARS (10x40)	TINNED COPPER
10	SUPPORT BAR (10x40)	TINNED COPPER
11	SUPPORT BAR (10x40)	TINNED COPPER
12	PROTECTION COVER	PLEXYGLASS
13	BOX EARTHING BAR	STAINLESS STEEL
14	DOOR FIXING BOLTS	STAINLESS STEEL
15	PADLOCK FACILITY	STAINLESS STEEL
16	COVER (3 mm)	STAINLESS STEEL

Specifications

Protection degree	IP68
DC Voltage test	25 kV–5 min.
Short circuit test	50 kA–1 sec.
Internal power arcing	40 kA–0,1 sec.
Impulse voltage between parts	N / A
Impulse voltage against earth	40 kV
*SA rate (Politek–PMSP)	N / A
Bonding cable (Coaxial)	95–400 mm2
**Inner Core Insulation Dia.(Min.–Max.)	ø20–ø36
**Screen Wires Dia.(Min.–Max.)	ø25–ø48
**Outer Dia.(Min.–Max.)	ø30–ø64
Weight	app. 75 Kg.
Volume of Filling compound (optional)	app. 52 Lt.
Colour	RAL 7032

ВЯРНО С ОРИГИНАЛА

*Indicate, if different SA (SVLs) required...
**Indicate, if bonding cable different size...

Rev.	Date	Drawn	Check	Apprv.	
D					
C					
B					
A	07.10.10	F.CASAROLI	S.FRODENZ	S.FRODENZ	Cable gland and sealing, surge arrester support bars, cable fixing system changed

ООД РУДИН Стара Загора

Earthing Link Box 08.04.01 Rev. A

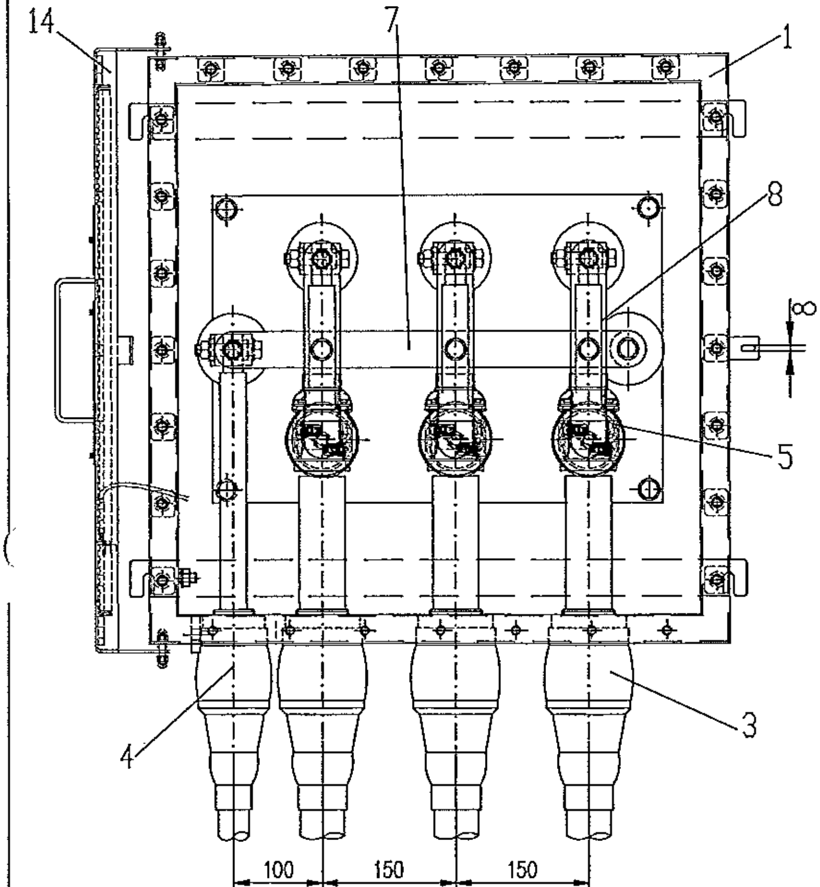
FOR UNDERGROUND TYPE

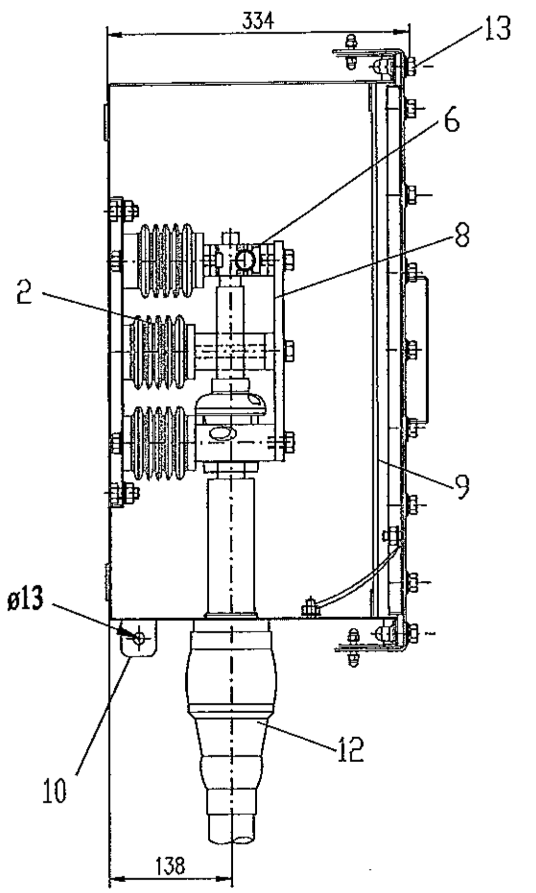
TYPE : O.EKUU-K3U

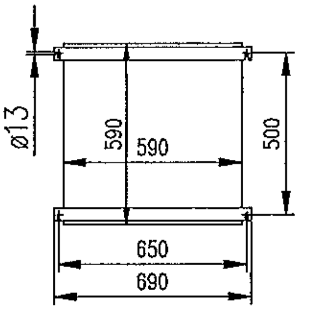
Drawn : 01/04/2008 / F.C.

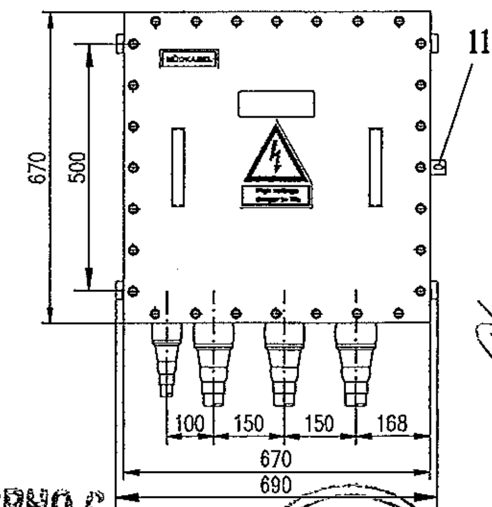
Approved : 01.04.2008 / S.E.

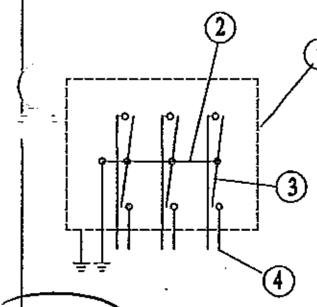
SÜDKABEL Südkabel GmbH
68199 Mannheim - GERMANY











(1) LINK BOX
(2) EARTHING BUS BAR
(3) DISCONNECTABLE BAR
(4) COAXIAL BONDING CABLE

LIST OF MAIN PARTS

Item	Name of parts	Materials
1	CABINET (2 mm)	STAINLESS STEEL
2	SUPPORT INSULATORS	EPOXY
3	GLAND FOR COAXIAL CABLE	STAINLESS STEEL
4	GLAND FOR EARTHING CABLE	STAINLESS STEEL
5	FIXING CLAMP	TINNED COPPER
6	CABLE END FIXING CLAMP	TINNED COPPER
7	EARTHING BUS BAR(10x40)	TINNED COPPER
8	DISCONNECTABLE CROSSING BAR(10x40)	TINNED COPPER
9	PROTECTION COVER	PLEXYGLASS
10	BOX EARTHING BAR	STAINLESS STEEL
11	PADLOCK FACILITY	STAINLESS STEEL
12	HEAT SHRINKABLE TUBE	MWTD
13	DOOR FIXING BOLTS	STAINLESS STEEL
14	COVER (3 mm)	STAINLESS STEEL

Specifications	
Protection degree	IP68
DC Voltage test	25 kV–5 min.
Short circuit test	50 kA–1 sec.
Internal power arcing	40 kA–0,1 sec.
Impulse voltage between parts	N / A
Impulse voltage against earth	40 kV
*SA rate (Poltek–PMSP)	N / A
Bonding cable (Coaxial)	95–400 mm2
**Inner Core Insulation Dia.(Min.–Max.)	ø20–ø36
**Screen Wires Dia.(Min.–Max.)	ø25–ø48
**Outer Dia.(Min.–Max.)	ø30–ø64
Weight	app. 68 Kg.
Volume of Filling compound (optional)	app. 57 Lt.
Colour	RAL 7032

*Indicate, If different SA (SVLs) required...
**Indicate, If bonding cable different size...

ВЯРНО С ОРИГИНАЛА

Rev.	Date	Drawn	Check	Apprv.	
D					
C	21.03.10	F.CABAROGLU	S.ERDENIZ	S.ERDENIZ	Cable gland sealing, earthing cable center dimension changed
B	28.04.08	F.CABAROGLU	S.ERDENIZ	S.ERDENIZ	Box Dimension Changed
A	11.05.07	F.CABAROGLU	S.ERDENIZ	S.ERDENIZ	Padlock Shown, thickness & Dimension mentioned

Earthing Bonding Link Box
FOR UNDERGROUND TYPE
Drw. No : O.EKE-K3U

04.09.07 Rev. C

Drawn : 04.11.2004 / F.C.
Approved : 04.11.2004 / S.E.

ООД РУДИН Стара Загора

Типово изпитание No 2010-47

Типово изпитание на кабелна система 145 kV, състояща се от 2 глави за открит монтаж, съединителна муфа, щепселна глава и XLPE-кабел

Клиент: Südkabel GmbH
Rhenaniastr. 12-30
68147 Mannheim

Поз. 1 Проверка на дебелината на изолацията
Поз. 2 Изпитание за частичен разряд
$\hat{u}/2 = 1{,}75\ U0 = 133$ kV 10 s след това;
$\hat{u}/2 = 1{,}5\ U0 = 114$ kV
няма отчетен разряд
Поз. 3 Изпитване с цикли на загряване
Цикъл на зареждане: 24 ч
8ч зареждане до 95°C - 100 °C температура на жилото със завършек 2ч при 95°C-100°C
16ч охлаждане
Изпитателно напрежение: $\hat{u}/2 = 2{,}0\ U_0 = 174$ kV
Брой на циклите: 20
Поз. 4 Изпитание за частичен разряд
$\hat{u}/2 = 1{,}75\ U_0 = 133$ kV 10 s след това;
$\hat{u}/2 = 1{,}5\ U_0 = 114$ kV
няма отчетен разряд
Поз. 5 Изпитание за частичен разряд при повишена температура
8ч зареждане до 95°C - 100 °C температура на жилото със завършек 2ч при 95°C-100°C
$\hat{u}/2 = 1{,}75\ U_0 = 133$ kV 10 s след това ;
$\hat{u}/2 = 1{,}5\ U_0 = 114$ kV
няма отчетен разряд
Поз. 6 Изпитване с импулсно напрежение при повишена температура
T = 95°C-100°C, със завършек 2h, $\hat{u} = 650$ kV,
10 импулса за всяка полярност
Поз. 7 Издържано променливо напрежение в период на охлаждане
$\hat{u}/2 = 2{,}5\ U0 = 190$ kV, t = 15 min
Поз. 8 Изпитване на кабелите и арматурата

ВЯРНО С ОРИГИНАЛА

ООД РУДИН Стара Загора

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 2010-47

Type Test
of a 145 kV- Cable System

Consisting of
Two Outdoor Terminations, a Straight Joint, Compact Sealing End and XLPE-Cable

Client: Südkabel GmbH
Rhenaniastr. 12-30
68147 Mannheim

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

This report includes 26 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 the tested objects.

1 Purpose of Test

A 145 kV- Cable System consisting of two outdoor terminations, a straight joint, compact sealing end and XLPE-cable was subjected to a type test according to IEC 60840 04/2004 type test on accessories.

2 Miscellaneous Data

Test object: *145 kV - cable system*

- Outdoor Sealing End, type EHFVC 145, 30 Sheds
  Drawing No 0.36.72.8a, dated 08.07.2010, Figure 2.1
- Outdoor Sealing End, type EHFVC 170, 45 Sheds
  Drawing No 0.36.72.8a, dated 08.07.2010, Figure 2.1
- Straight Joint, type: SEHDV 145
  Drawing No 0.3600.35.2a, dated 04.08.2010, Figure 2.2
- GIS Compact Sealing End, type EHSVS 145
  Drawing no: 0.360.01.0a, dated 19.06.2009, Figure 2.3
- 150-kV-XLPE-cable, type 2XS(FL)2Y 1x2500RMS/220 87/150kV, cable 1, Figure 2.4 – 2.5
- 132-kV-XLPE-cable, type 1x2500 RMSCu/XLPE/ corr.Al/PE 76/132/145 kV, cable 2, Figure 2.6

Figure 3.1 shows the mounting of the different accessories on the two cables.

Manufacturer:

Cable 1 and accessories:
Südkabel GmbH
Rhenaniastr. 12-30
68147 Mannheim

Cable 2:
Taihan Electric Wire Co Ltd.
Insong Building 194-15, Hoehyeon-dong 1-ga
Jung-gu, Seoul, Korea

Place of test:

Institute of Electric Energy Systems and High-Voltage Technology – University of Karlsruhe
Kaiserstraße 12 – 76128 Karlsruhe

Testing dates:

Delivery:	26.07.2010
Mounting:	26.07. – 23.08.2010
Test date:	26.08. – 29.09.2010

ВЯРНО С ОРИГИНАЛА

ООД РУАЛИН

Atmospheric conditions:	Temperature:	18°C - 25°C
	Air pressure:	980 - 1020 mbar
	rel. humidity:	30% - 70%

Representatives

Client's representatives
Dipl.-Ing.(FH) A. Jurtschin; Südkabel GmbH
Representatives responsible for the tests
Dr.-Ing. R. Badent
Dr.-Ing. B. Hoferer
Mr. O. Müller

ВЯРНО С ОРИГИНАЛА

ООД РУДИН

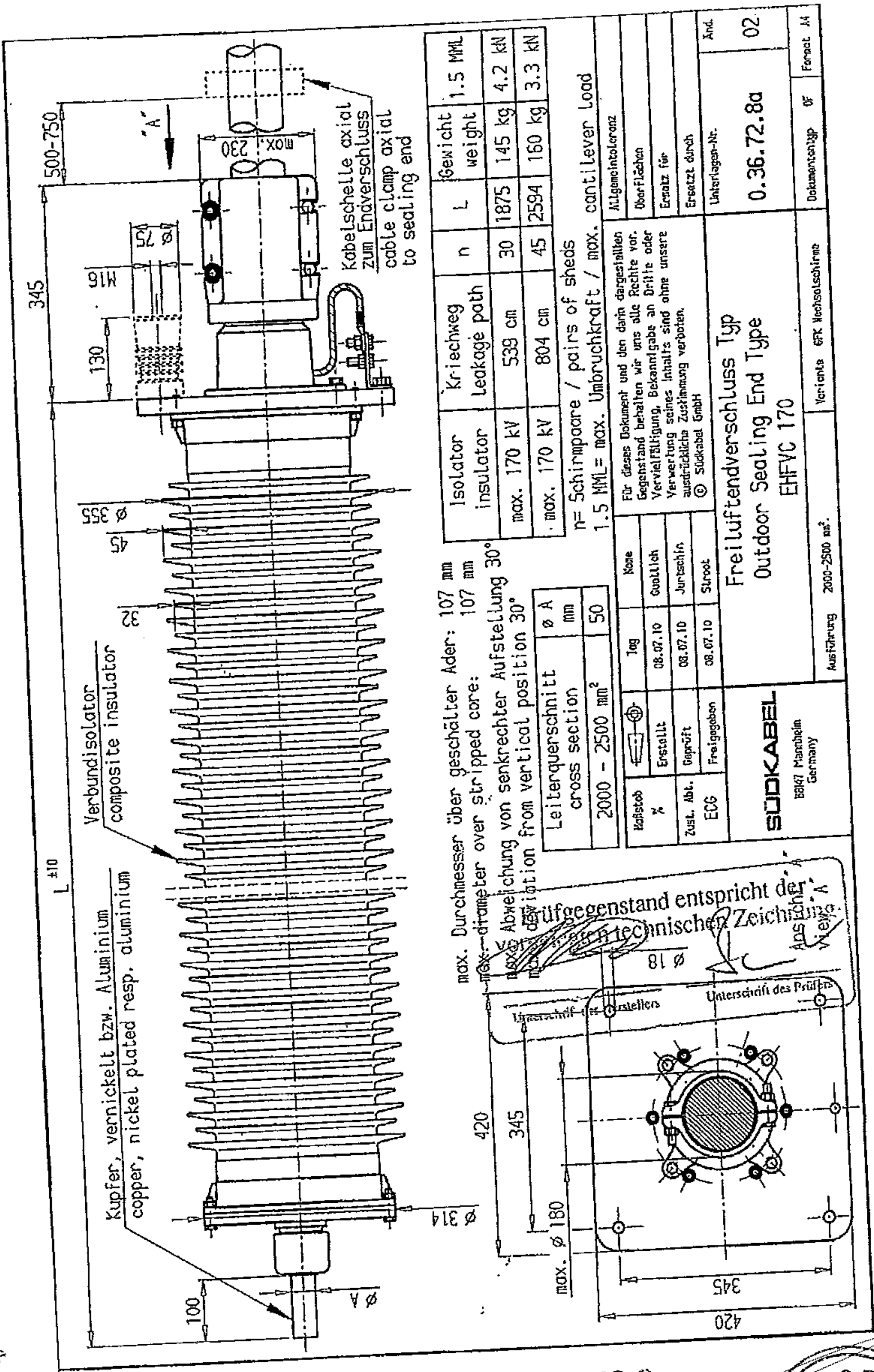


Figure 2.1: Outdoor Sealing End, Type EHFVC

ВЯРНО С ОРИГИНАЛА

ООД РУДИН Стара Загора

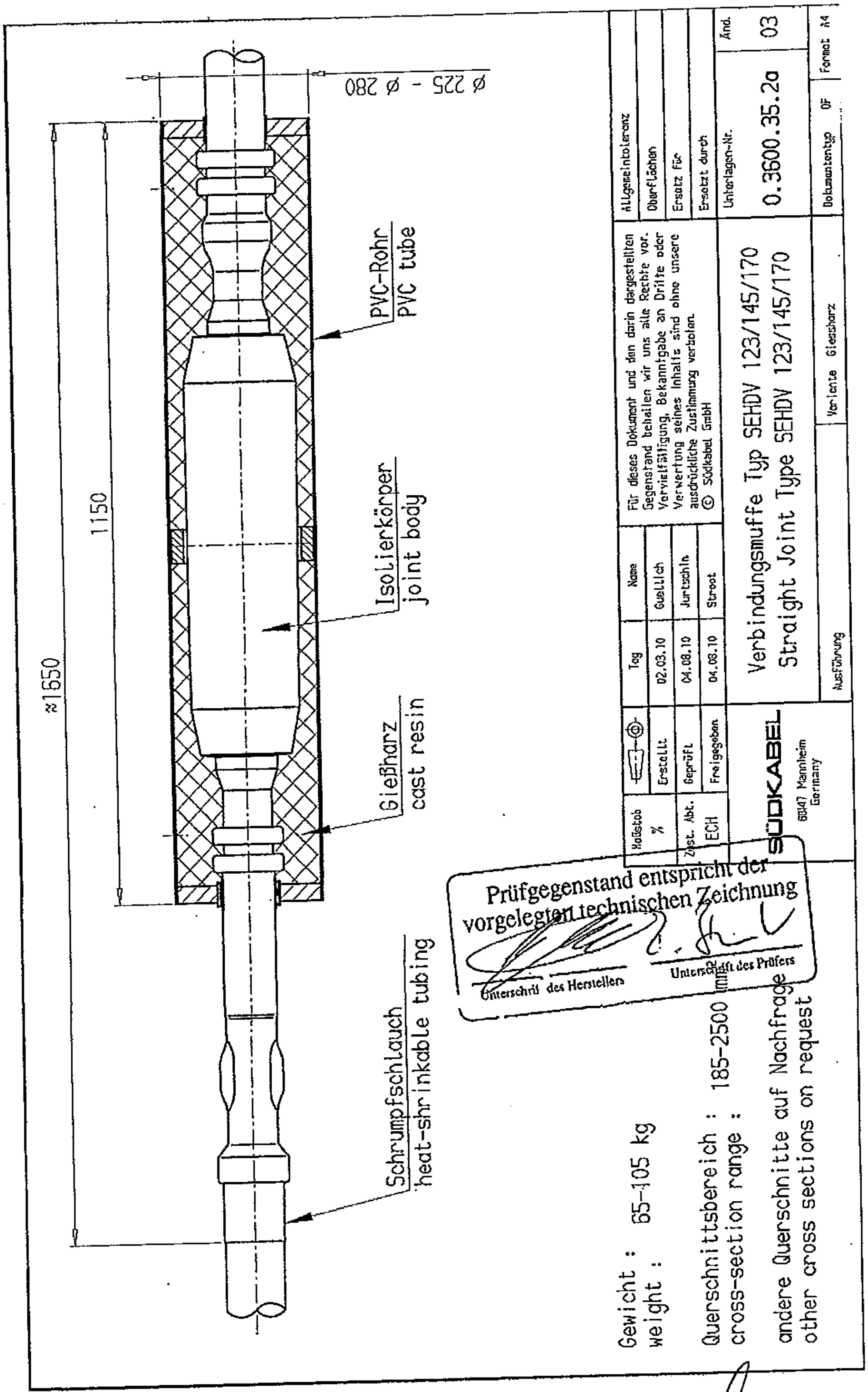


Figure 2.2: Straight Joint, Type SEHDV 145

ВЯРНО С ОРИГИНАЛА

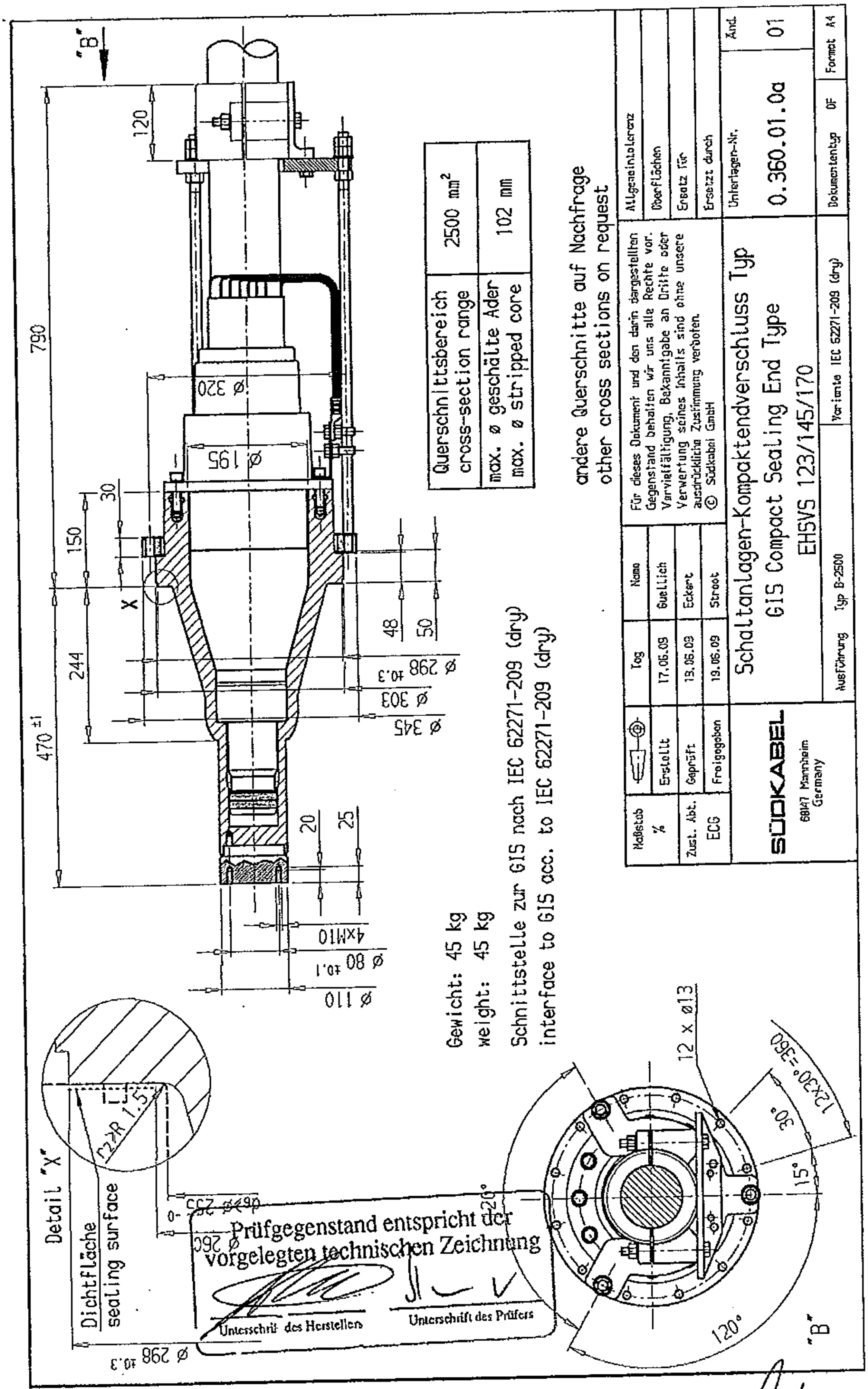


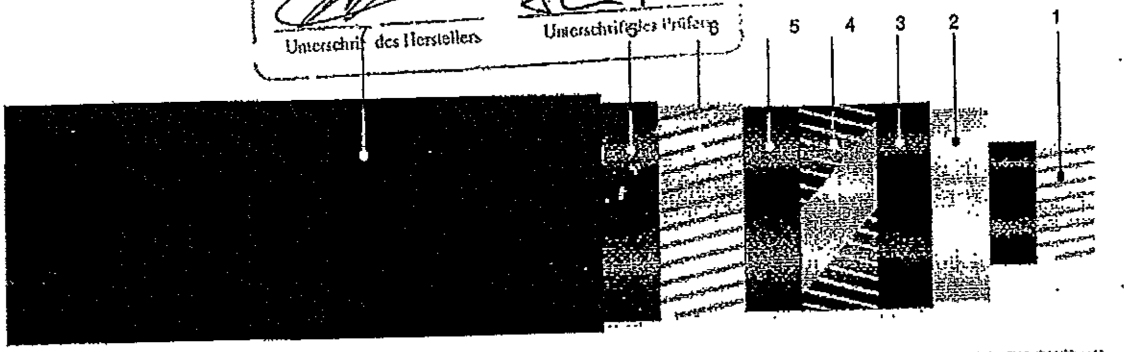
Figure 2.3: GIS Compact Sealing End, Type EHSVS 145

ВЯРНО С ОРИГИНАЛА

Prüfgegenstand entspricht der vorgelegten technischen Zeichnung

Unterschrift des Herstellers — Unterschrift des Prüfers

Cable Data Sheet SÜDKABEL



Kabeltypen

0.	**Name of Cable**	2XS(FL)2Y 1x2500RMS/220 87/150 kV (type no.: 4910576)		
1.	**Conductor**	☐ Al	☑ Cu	
	Cross section	2500 mm²		
	Diameter of conductor	62.3 mm², tolerance according to IEC 60228		
	round, stranded	☐ RM		
	round, segmented, stranded	☑ RMS		
	round, solid	☐ RE		
2.	**Insulation**			
	Type of insulation	☑ XLPE	☐ PE	☐ EPR
	Nominal thickness of insulation	15.2 mm		
	Diameter over insulation	Ø 96.7 mm, tolerance ± 1 mm		
	Voltage level $U_0/U_N/U_m$	87 /	150 /	170 kV
3.	**Insulation screen (conductive layer)**			
	Wall thickness/diameter outer conductor screen	1.6 mm/	99.9 mm, ± 1 mm	
	Type of conductor screen	☐ graphited	☑ fix bonded	
4.	**Screen/metallic sheath**			
	Cross section/wall thickness/diameter	220 mm²/	2.18 mm/Ø	105.3 mm
		☑ copper wire	☐ copper tape	☐ lead sheath
		☐ Al-corrugated sheath		☐ Cu-corrugated sheath
	Optical fibres in screen	☑ no	☐ yes	___ number of tubes
5.	**Laminated sheath**	☐ no	☐ yes	
	Material/wall thickness/diameter	☑ AL	☐ CU	0.2 mm/Ø 106.9 mm
6.	**Armouring**	☑ no	☐ yes	
		☐ round wire	☐ flat wire	☐ tape
	Material/dimension	____ /	____ mm	
7.	**Outer sheath**	☑ PE	☐ PVC	☐ conductive layer
	Overall diameter	Ø 115.3 mm		

Figure 2.4: XLPE-Cable 1, type 2XS(FL)2Y 1x2500RMS/220 87/150kV

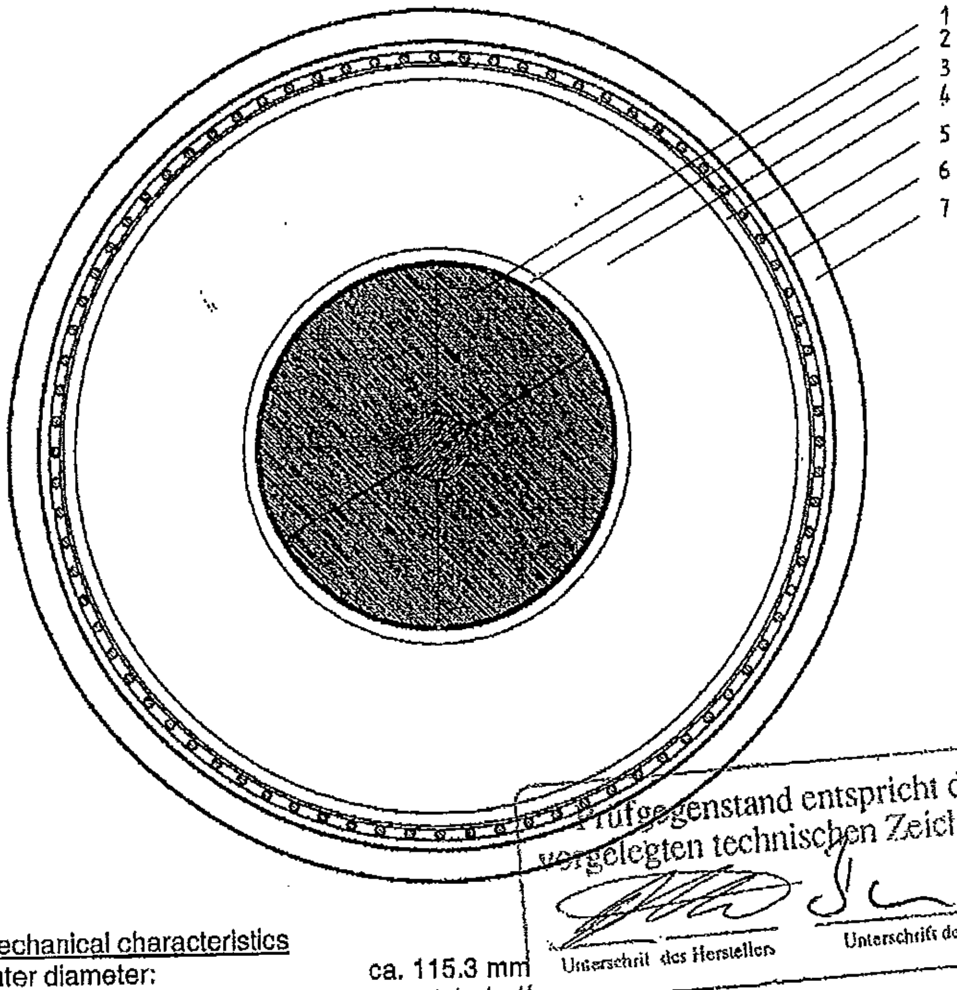
ВЯРНО С ОРИГИНАЛА

ООД РУДИН Стара Загора

Cable type:
2XS(FL)2Y 1x2500RMS/220 87/150 kV
part no.: 4910576

SÜDKABEL
Südkabel GmbH

1. copper (round, stranded, segmented)
2. conductor screen (extruded)
3. XLPE insulation
4. outer conductor screen (extruded)
5. copper screen with longitudinal water-tight embedding of wires
6. aluminium tape
7. PE sheath



Prüfgegenstand entspricht der vorgelegten technischen Zeichnung

Unterschrift des Herstellers   Unterschrift des Prüfers

<u>mechanical characteristics</u>

outer diameter:	ca. 115.3 mm
weight:	ca. 32.1 kg/m

ECG/ Ju date: 20.07.2010	**cable cross section**

Figure 2.5: XLPE-Cable 1, type 2XS(FL)2Y 1x2500RMS/220 87/150kV

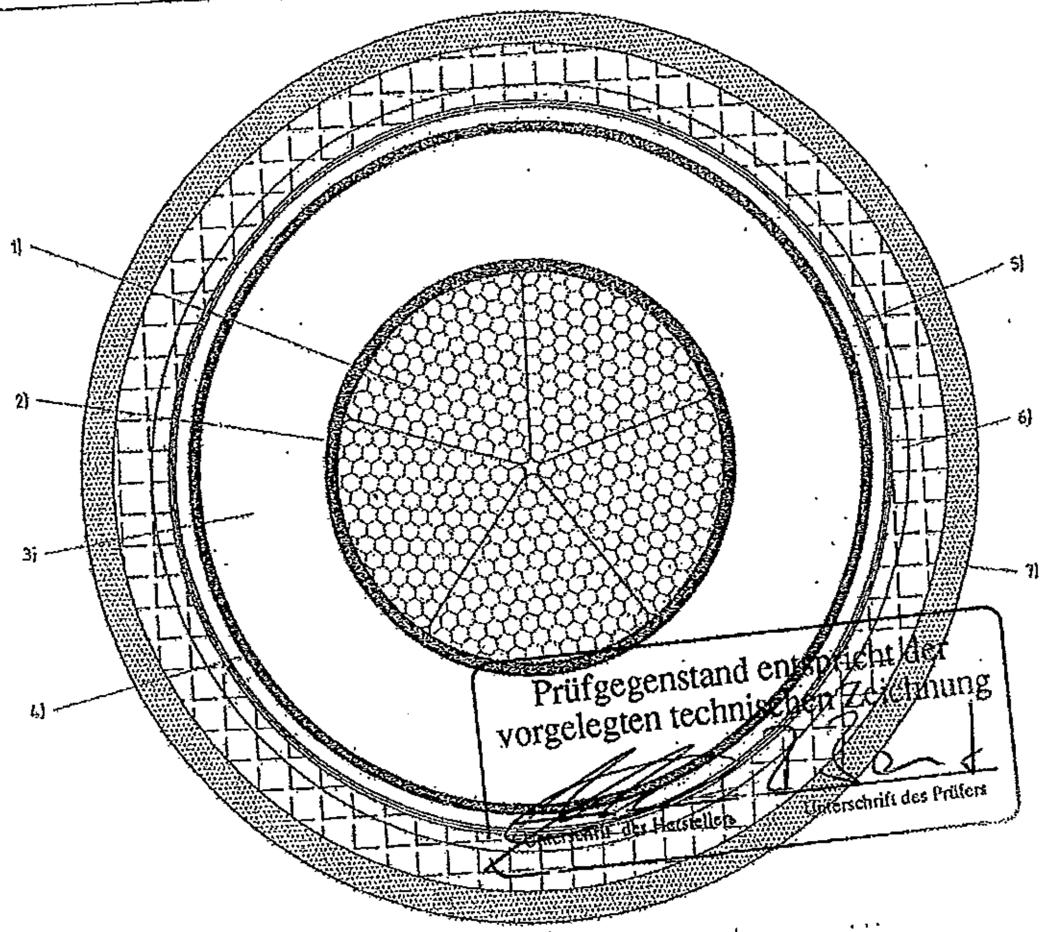
ОРИГИНАЛА

ООД

CROSS SECTION FOR 132kV 2500SQMM SINGLE-CORE POWER CABLE

5-Segmental compacted annealed copper conductor, XLPE insulation, corrugated seamless aluminum sheath and HDPE outer serving

Rated Voltage(Uo/U/Um) : 76/132/145 kV	CONDUCTOR SIZE : 2500 SQMM	SYSTEM FREQUENCY : 50Hz



Prüfgegenstand entspricht der vorgelegten technischen Zeichnung

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ITEM	DESCRIPTION	MATERIAL	THICKNESS	OUTER DIAMETER
1)	CONDUCTOR	ANNEALED COPPER, 5-SEGMENTAL COMPACTED,	-	APPROX. 61.2mm
2)	CONDUCTOR SCREEN	SEMI-CONDUCTIVE COMPOUND	NOM. 15mm	NOM. 65.1mm
3)	INSULATION	XLPE	NOM. 20.0mm MIN. 19.0mm	NOM. 105.1mm
4)	INSULATION SCREEN	SEMI-CONDUCTIVE COMPOUND	NOM. 15mm	NOM. 108.1mm
5)	WATER BLOCKING TAPE	SEMI-CONDUCTING SWELLABLE TAPE	APPROX. 0.5mm	NOM. 113.6mm
6)	METALLIC SHEATH	CORRUGATED ALUMINUM (ANNULAR RING TYPE)	NOM. 2.6mm	NOM. 132.4mm
7)	OUTER SERVING	HDPE with GRAPHITE COATING	NOM. 4.0mm	APPROX. 142.0mm
COMPLETED CABLE		- Test voltage : A.C 190 / 30min - Weight : Approx. 35,5 kg/m - Max. D.C. resistance of conductor at 20°C : 0.0072 ohm/km		
DWG. TXCCA-1322000-0902K02		REV.0	SCALE : N/S	TAIHAN ELECTRIC WIRE CO.,LTD

Figure 2.6: XLPE-Cable 2, type 1x2500 RMSCu/XLPE/ corr.Al/PE 76/132/145 kV.

ВЯРНО С ОРИГИНАЛА

ООД РУАМИ Стара Загора

Подпис:

Tests: Test volume, chronological order and requirements conform to IEC 60840 04-2004 type test on accessories, subclause 14.3.2

Pos. 1 Check on insulation thickness

Pos. 2 Partial Discharge Test
$\hat{u} / \sqrt{2} = 1{,}75\ U_0 = 133$ kV 10 s thereafter ;
$\hat{u} / \sqrt{2} = 1{,}5\ U_0 = 114$ kV
no detectable discharge

Pos. 3 Heating cycle voltage test
Load cycle: 24 h
8h loading up to 95°C - 100 °C conductor temperature with at least 2h at 95°C-100°C
16h cooling
Test voltage: $\hat{u} / \sqrt{2} = 2{,}0\ U_0 = 174$ kV
Number of cycles: 20

Pos. 4 Partial Discharge Test
$\hat{u} / \sqrt{2} = 1{,}75\ U_0 = 133$ kV 10 s thereafter ;
$\hat{u} / \sqrt{2} = 1{,}5\ U_0 = 114$ kV
no detectable discharge

Pos. 5 Partial Discharge Test at elevated temperature
8h loading up to 95°C - 100 °C conductor temperature with at least 2h at 95°C-100°C
$\hat{u} / \sqrt{2} = 1{,}75\ U_0 = 133$ kV 10 s thereafter ;
$\hat{u} / \sqrt{2} = 1{,}5\ U_0 = 114$ kV
no detectable discharge

Pos.6 Lightning impulse voltage test at elevated temperature
T = 95°C-100°C, at least 2h, $\hat{u}$ = 650 kV,
10 impulses each polarity

Pos.7 AC-voltage withstand test during cooling period
$\hat{u} / \sqrt{2} = 2{,}5\ U_0 = 190$ kV, t = 15 min

Pos. 8 Cable and accessory examination

ВЯРНО С ОРИГИНАЛА

ООД Стара Загора

3 Mounting

The cable preparation, assembling and mounting of the cable system was accomplished by technicians of Südkabel GmbH. Fig 3.1 shows the test setup

Scematic installation of cable system

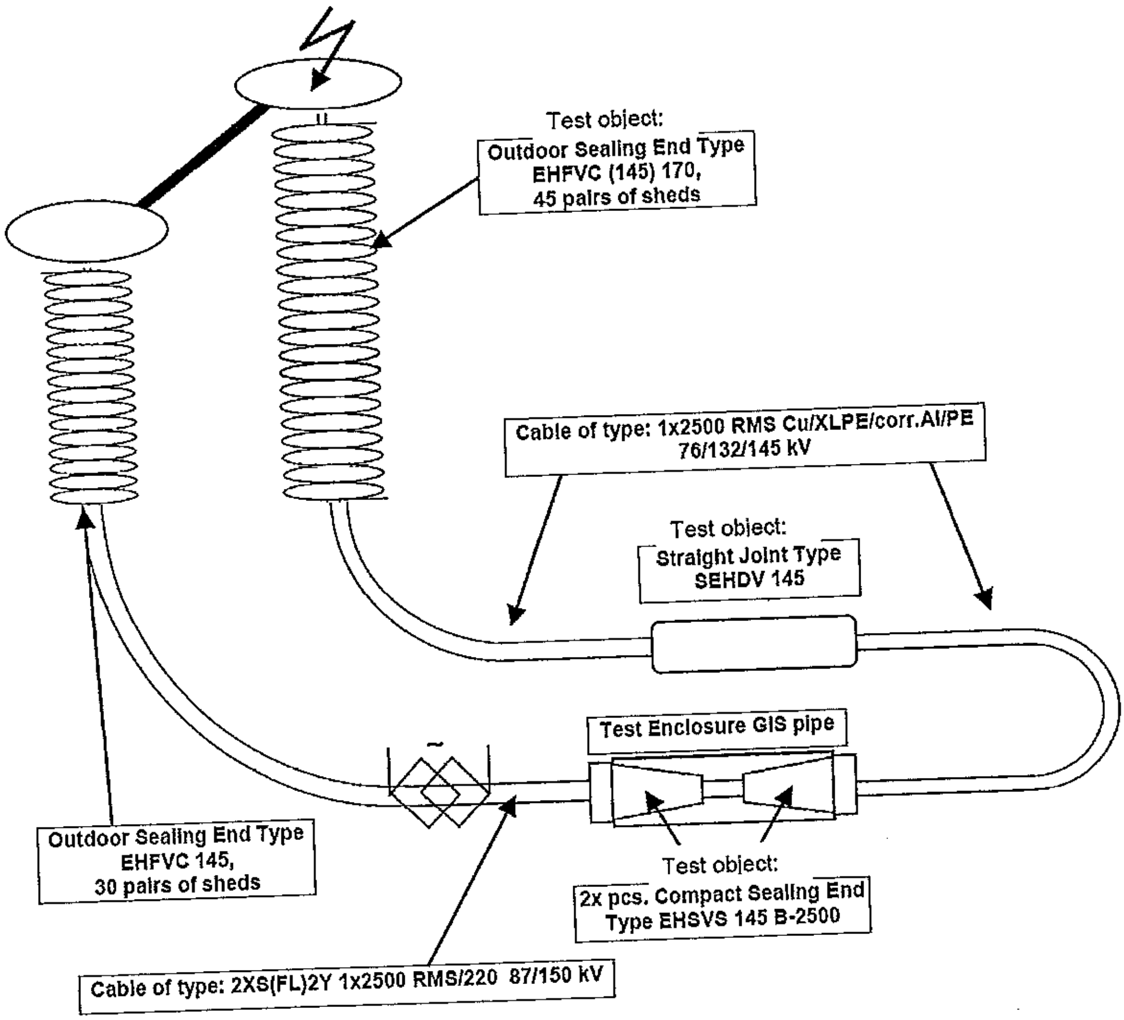

Fig 3.1: Schematic of test setup

ВЯРНО С
ОРИГИНАЛА

ООД РУДИН Стара Загора

Подпис: ....

4 Test Setup

4.1 Check on Insulation Thickness

The insulation thickness was measured as described in IEC 60811-1-1, subclause 8.1. For measuring the insulation thickness a profile projector with a magnification of 10 was used which allowed a reading of 0.001 mm.

4.2 AC Voltage Withstand Test

The test voltage was generated by a 720-kVA transformer. The voltage was measured with a capacitive divider (C_H = 351 pF; ratio = 10.000:1) and a peak voltmeter reading $\hat{u}/\sqrt{2}$. The primary side of the AC-transformer was connected to a motor-generator set consisting of a variable frequency DC motor and a synchronous generator with variable excitation. The generator delivers voltages from 0 ... 500 V with currents up to 1000 A.

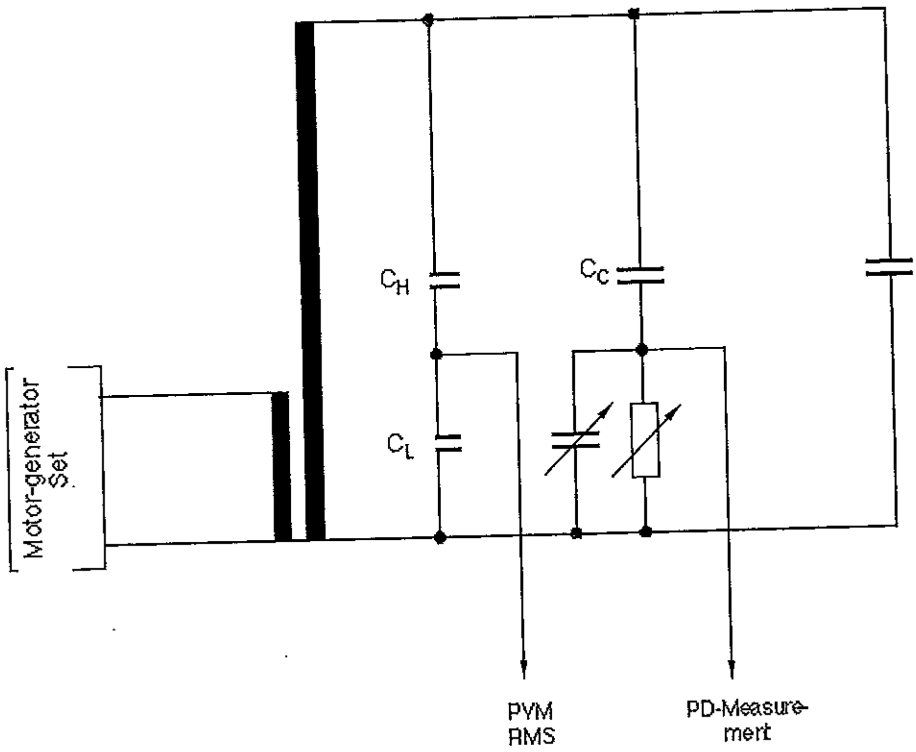

Figure 4.2: Test-setup for AC-voltage withstand test and PD measurement

AC-transformer:	500V/600kV; S_N = 720 kVA
Voltage measurement:	C_H = 351 pF; ratio 10.000:1 uncertainty 3 %
PD measurement:	C_C = 1000 pF; U_N = 800 kV_{rms} uncertainty 5 %

ВЯРНО С ОРИГИНАЛА

ООД Стара Загора

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 133 kV_{rms} was 2,0 pC.

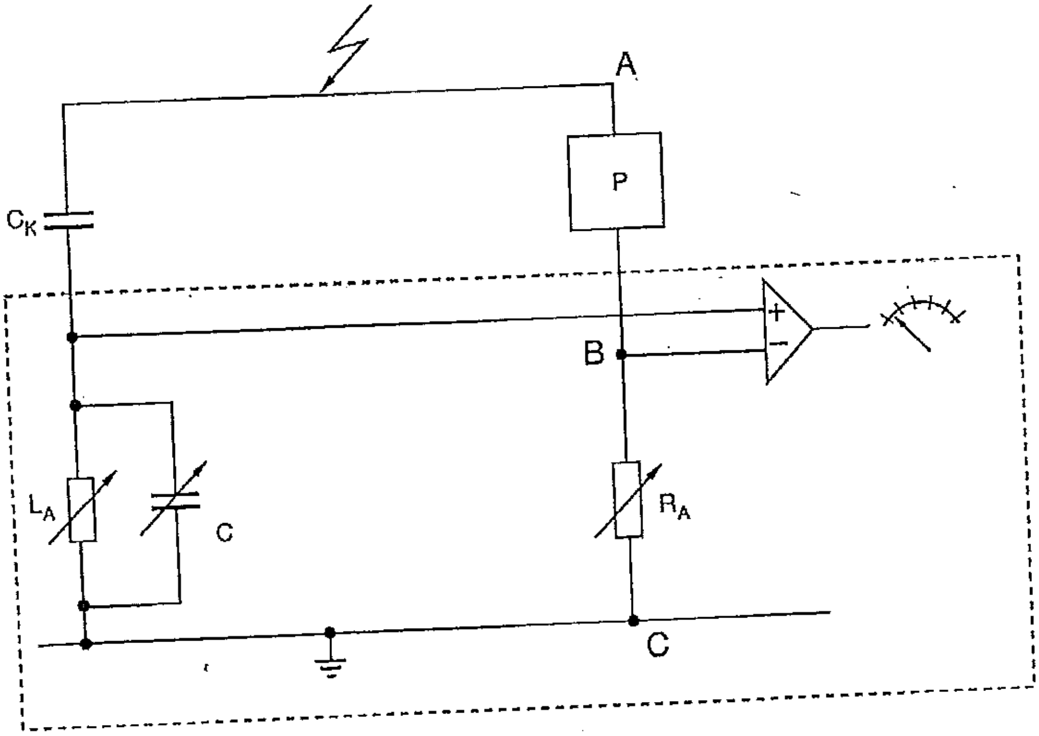

Figure 4.3: Scheme of PD test circuit
TO : Test object
C_C: Coupling Capacitor

For balancing the bridge a calibrating impulse with q_A = 1000 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 = 5 pC, is applied between A and B. Subsequently, the amplifier output of the PD measuring unit is adapted to the applied pulse.

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4.4 Cyclic Current Loading

According to IEC 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 required heating current I was determined via a dummy cable. A 8 m sample of the cable used for the test, was provided with a 1 mm diameter drilling hole down to the center conductor. The temperature was measured with a thermo couple NiCr-Ni. . Two other thermocuples were installed on the conductor of the reference cable 0,5 m away from the middle and 1,0 m away from the middle. The difference between the three readings was less than 1°C. Furthermore two additional thermocouples NiCr-Ni were placed on the outer sheath of the cable, one on the dummy and one on the test loop. Figure 4.4 illustrates the temperature rise at the conductor with a maximum heating current of I = 3900 A, 8h. Current inception was accomplished by two transformers (U_1 = 400 V; U_2 = 20 V) which used the cable as secondary winding. The current was regulated by a control unit and measured by a current transformer, 5000/1, and a digital multimeter. The measurement uncertainty was 1%.

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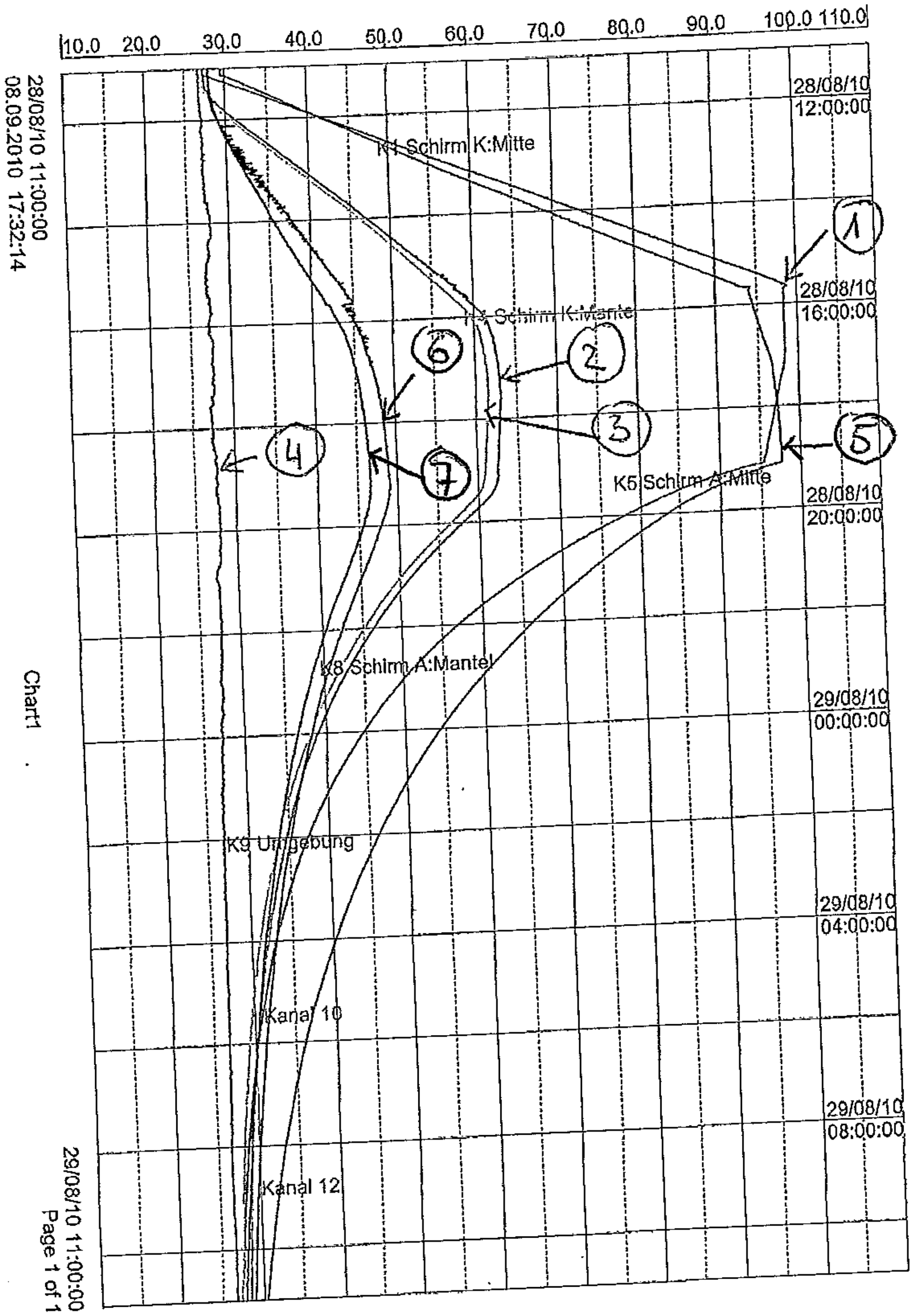

Figure 4.4: Heat cycle I = 2700..3300 A regulated, 8h; I = 0A, 16 h
1: Conductor temperature cable1; 2: Jacket temperature test loop, cable 1
3: Jacket temperature dummy, cable 1; 4: Temperature HV-laboratory
5: Conductor temperature cable 2; 6: Jacket temperature test loop, cable 2
7: Jacket temperature dummy, cable 2

ВЯРНО С ОРИГИНАЛА

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4.5 Lightning Impulse Voltage Test

For lightning impulse testing 8 stages of a Marx generator (Haefely) with a maximum cumulative charging voltage of U = 1600 kV and a maximum impulse energy of E_{max} = 80 kW_s were used. 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.

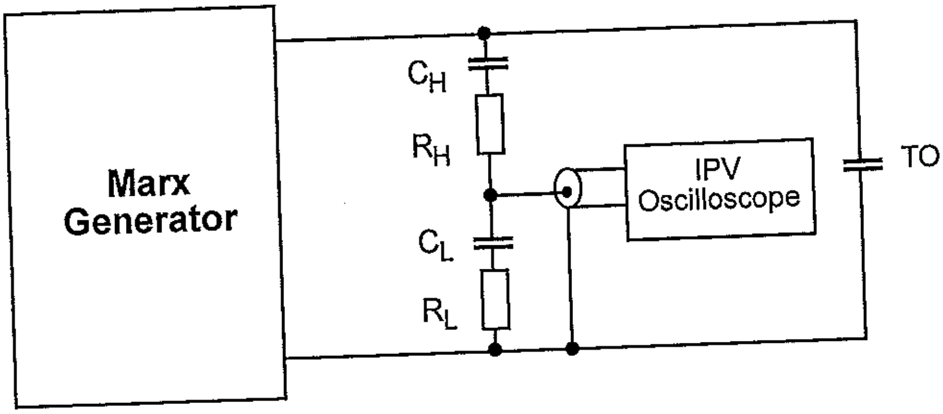

Figure 4.5.1: Scheme of lightning impulse voltage test circuit
C_H: 1200 pF ; R_H = 70 Ω ; ratio: 3215;
IPV: impulse-peak-voltmeter (Haefely) – measurement uncertainty 3%
Oscilloscope: Tektronix TDS 3044B – measurement uncertainty 2%

The waveform parameters were determined at reduced charging voltage. Figure 4.5.2 shows the front time, Figure 4.5.3 the time to half value for positive polarity each. Figure 4.5.4 shows the front time, Figure 4.5.5 the time to half value for negative polarity each.

Positive impulse: :	T_1 = 3,81 µs	T_2 = 55,2 µs
Negative impulse:	T_1 = 3,64 µs	T_2 = 55,4 µs

ВЯРНО С ОРИГИНАЛА

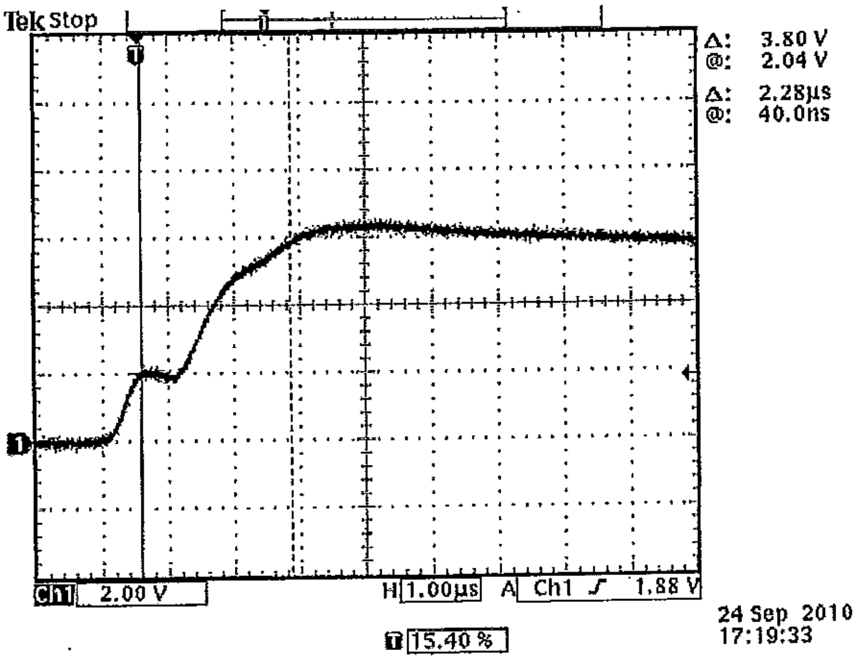

Figure 4.5.2: Front time, positive polarity
horiz.: 1 µs/Div; vert.: 2V/Div; probe 10:1; ratio 3215:1

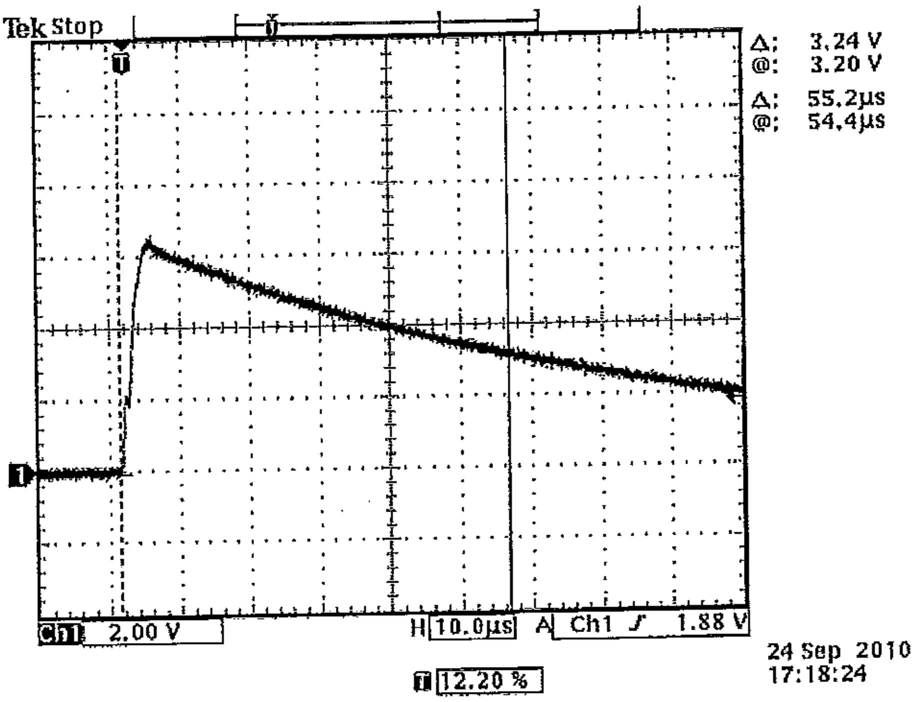

Figure 4.5.3: Time to half value, positive polarity
horiz.: 10 µs/Div; vert.: 2V/Div; probe 10:1; ratio 3215:1

ВЯРНО С ОРИГИНАЛА

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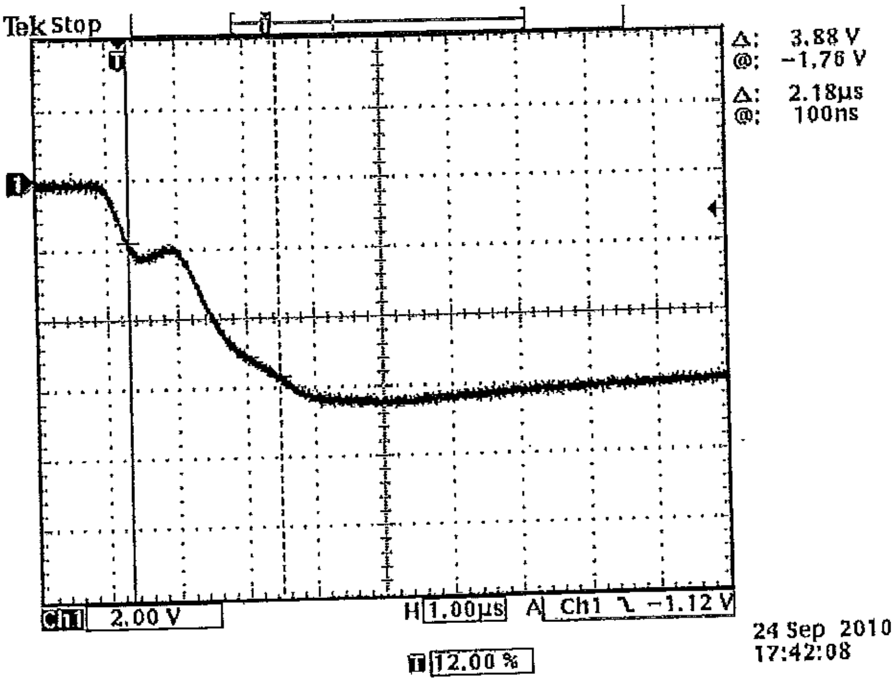

Figure 4.5.4: Front time, negative polarity
horiz.: 1 µs/Div; vert.: 2V/Div; probe 10:1; ratio 3215:1

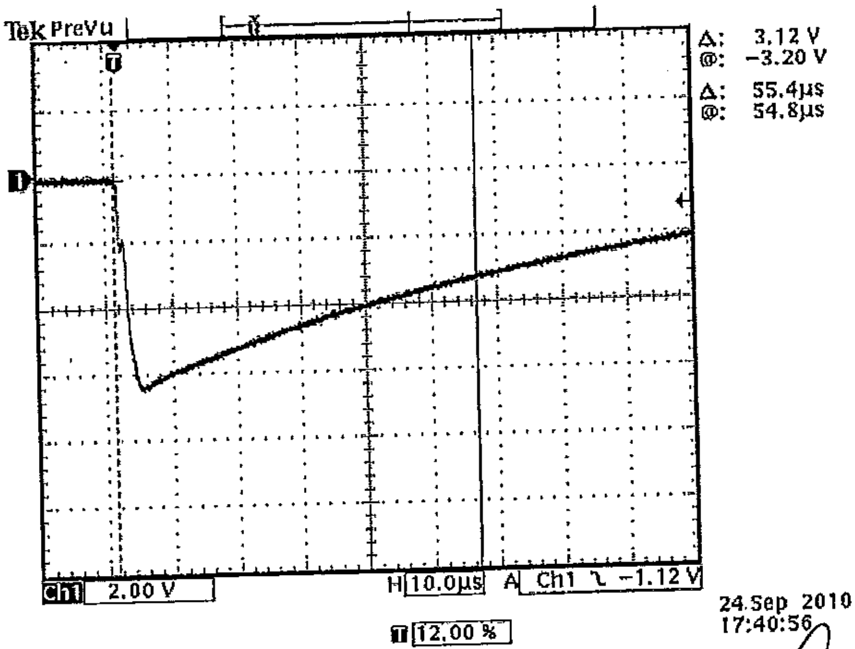

Figure 4.5.5: Time to half value, negative polarity
horiz.: 10 µs/Div; vert.: 2V/Div; probe 10:1; ratio 3215:1

ВЯРНО С ОРИГИНАЛА

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5 Results

5.1 Check on Insulation Thickness

The test was carried out as described in 4.

Test date: 03.08.2010

5.1.1 Cable 1

Nominal value:	15,2 mm
Measured Values:	14,52 mm
	14,65 mm
	15,07 mm
	14,97 mm
	14,08 mm
	14,15 mm
Average Value:	14,57 mm
Result:	The average value is 4,2% lower than the nominal value, so no correction was necessary

5.1.2 Cable 2

Nominal value:	20,0 mm
Measured Values:	19,81 mm
	19,78 mm
	19,42 mm
	19,87 mm
	20,26 mm
	19,99 mm
Average Value:	19,86 mm
Result:	The average value is 0,7% lower than the nominal value, so no correction was necessary

ВЯРНО С ОРИГИНАЛА

5.2 PD-Test

The test was carried out as described in 4.

Test date:	26.08.2010
Calibration pulse:	$q_{cal} = 5$ pC
Background noise level:	2.0 pC
Test voltage:	$\hat{u} / \sqrt{2}$ = 133 kV; t = 10 s, thereafter
	$\hat{u} / \sqrt{2}$ = 114 kV; with pd reading
PD:	no detectable discharges

The test was passed successfully

5.3 Heating cycle voltage test

The test was carried out as described in 4.

Test date:	28.08. – 16.09.2010
Test voltage:	$\hat{u} / \sqrt{2}$ = 174 kV
Heating current:	I = 2700..3300 A regulated, 8h I = 0A, 16 h
Cycle:	8 h heating; 16 h cooling
Number of cycles:	20

Neither breakdown nor flashover occurred.

The test was passed successfully

5.4 PD-Test

The test was carried out as described in 4.

Test date:	21.09.2010
Calibration pulse:	$q_{cal} = 5$ pC
Background noise level:	2.0 pC
Test voltage:	$\hat{u} / \sqrt{2}$ = 133 kV; t = 10 s, thereafter
	$\hat{u} / \sqrt{2}$ = 114 kV; with pd reading
PD:	no detectable discharges

The test was passed successfully

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5.5 PD-Test at elevated temperature

The test was carried out as described in 4.

Test date:	24.09.2010
Calibration pulse:	$q_{cal} = 5$ pC
Background noise level:	2.0 pC
Heating current:	I = 2700..3300 A regulated, 8h
Temperature:	T = 99.5°C
Test voltage:	$\hat{u} / \sqrt{2}$ = 133kV; t = 10 s, thereafter
	$\hat{u} / \sqrt{2}$ = 114 kV; with pd reading
PD:	no detectable discharges

The test was passed successfully

ВЯРНО С
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5.6 Lightning Impulse Voltage Withstand Test at elevated temperature

This test was carried out as described in 4.

Test date:	24.09.2010
Test voltage:	û = 650 kV
Heating current:	I = 2700..3300 A regulated, 8h
Temperature:	T = 99.7°C
Impulse:	1-5µs / 40-60 µs
Number of tests:	10 positive polarity, 10 negative polarity

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

The test was passed successfully

Table 5.6.1 shows the test results with positive polarity, table 5.6.2 with negative polarity.

number	charging voltage / kV	û / kV	Figure	remark
1	30,0	202		front time,
2	30,0	202		time to half value
3	48,3	324		50%
4	67,8	456		70%
5	87,0	585		90%
6	96,7	651	5.6.1	1. 100%
7	96,7	651	5.6.1	2. 100%
8	96,7	651	5.6.1	3. 100%
9	96,7	650	5.6.1	4. 100%
10	96,7	650	5.6.1	5. 100%
11	96,7	651	5.6.2	6. 100%
12	96,7	650	5.6.2	7. 100%
13	96,7	650	5.6.2	8. 100%
14	96,7	650	5.6.2	9. 100%
15	96,7	650	5.6.2	10. 100%

Table 5.6.1: Lightning impulse voltage withstand test, positive polarity

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number	charging voltage / kV	û / kV	Figure	remark
1	- 30,0	- 202		front time,
2	- 30,0	- 202		time to half value
3	- 48,3	- 324		50%
4	- 67,8	- 455		70%
5	- 87,0	- 586		90%
6	- 96,7	- 650	5.6.3	1. 100%
7	- 96,7	- 650	5.6.3	2. 100%
8	- 96,7	- 649	5.6.3	3. 100%
9	- 96,7	- 650	5.6.3	4. 100%
10	- 96,7	- 650	5.6.3	5. 100%
11	- 96,7	- 650	5.6.4	6. 100%
12	- 96,7	- 650	5.6.4	7. 100%
13	- 96,7	- 650	5.6.4	8. 100%
14	- 96,7	- 650	5.6.4	9. 100%
15	- 96,7	- 650	5.6.4	10. 100%

Table 5.6.2: Lightning impulse voltage withstand test, negative polarity

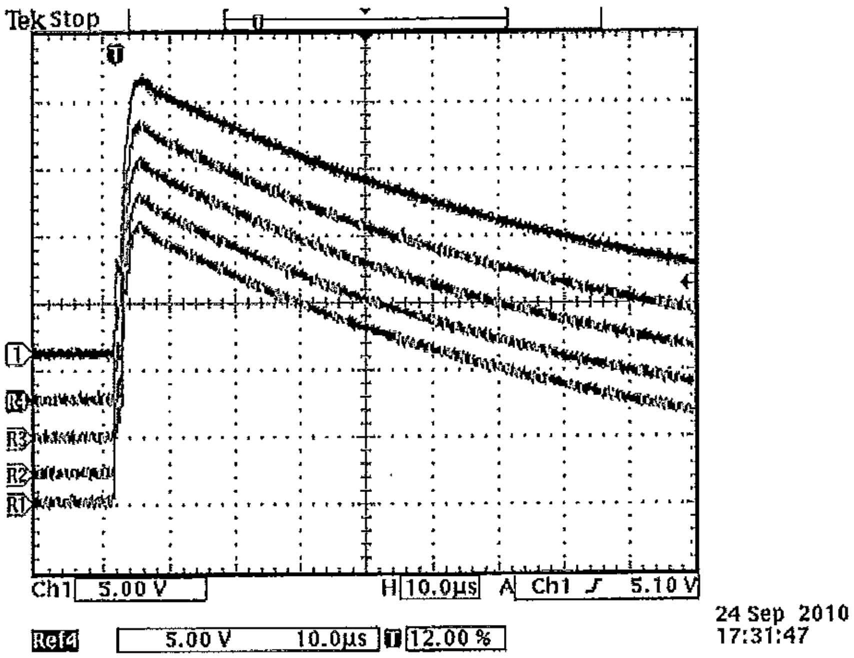

Figure 5.6.1: 100%-stress 1 - 5, positive polarity
Hor.: 10µs/Div; Vert.: 5V/Div; probe 10:1; û = 3215

ВЯРНО С ОРИГИНАЛА

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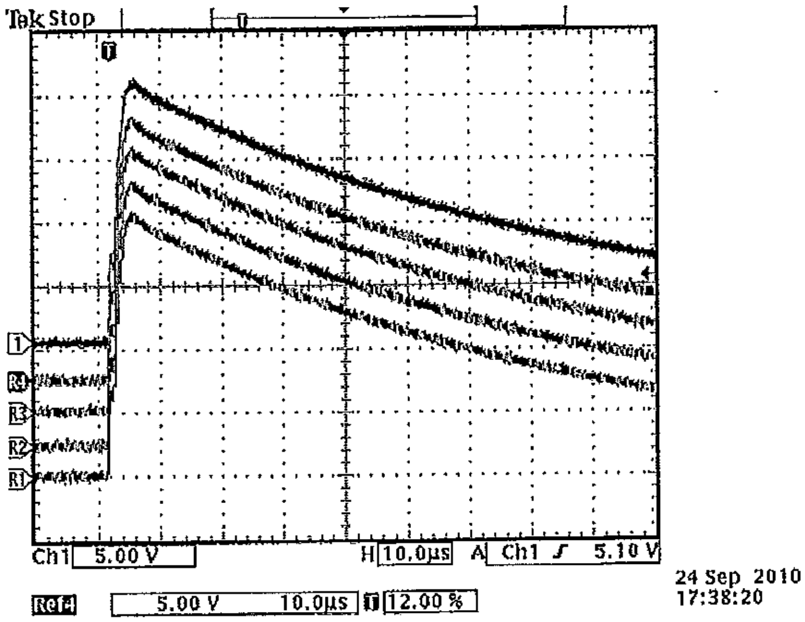

Figure 5.6.2: 100%-stress 6 - 10, positive polarity
Hor.: 10µs/Div; Vert.: 5V/Div; probe 10:1;ü = 3215

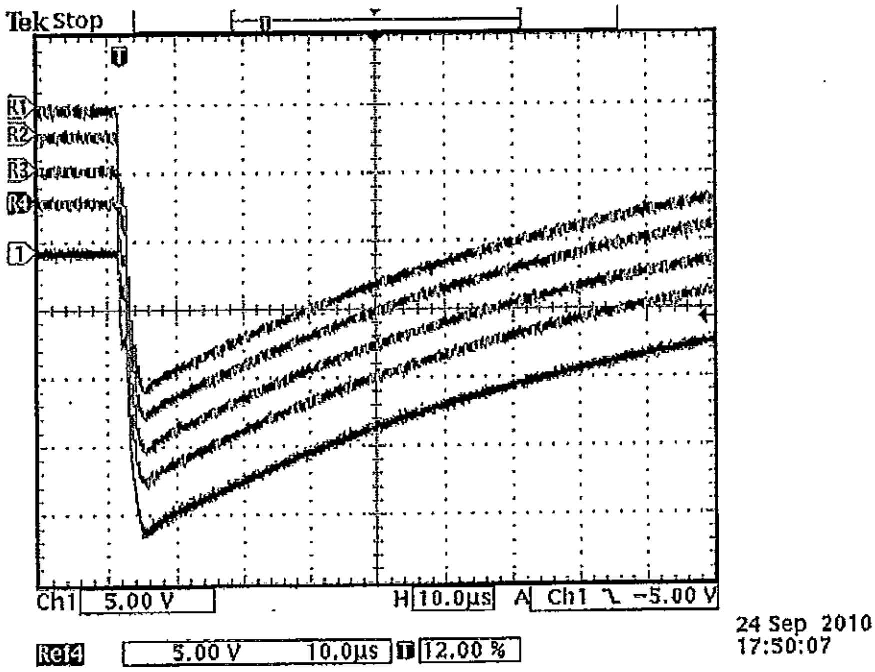

Figure 5.6.3: 100%-stress 1 - 5, negative polarity
Hor.: 10µs/Div; Vert.: 5V/Div; probe 10:1; ü = 3215

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Подпис: ....

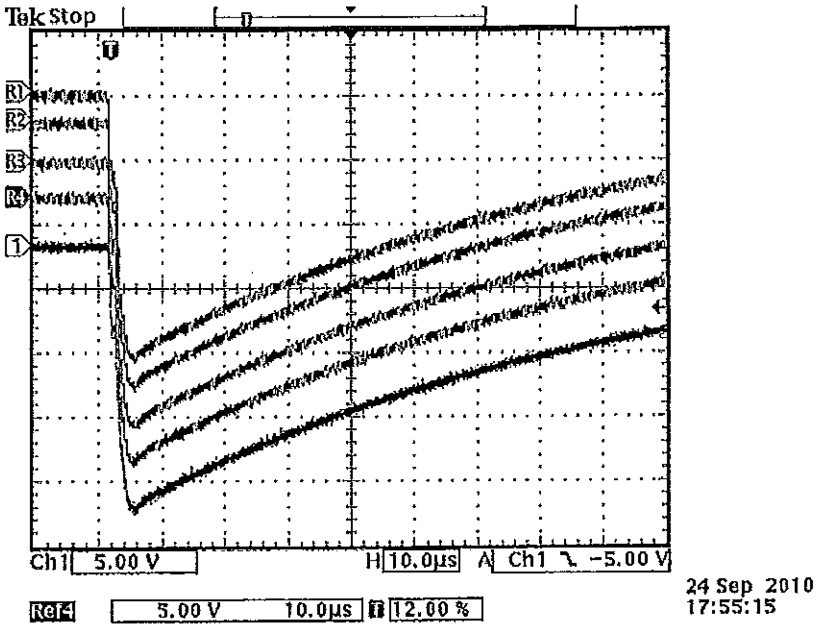

Figure 5.6.4 100%-stress 6 - 10, negative polarity
Hor.: 10µs/Div; Vert.: 5V/Div; probe 10:1; ü = 3215

5.7 AC Voltage Withstand Test during Cooling Period

The test was carried out as described in 4.

Test date:	25.09.2010
Temperature:	26.4°C
Test voltage:	$\hat{u}/\sqrt{2}$ = 190 kV; t = 15 min

Neither breakdown nor flashover occurred.

The test was passed successfully.

5.10 Cable and Accessory Examination

Test date: 27.09. – 29.09.2010

On completion of the electrical tests the XLPE insulation of the cable and the accessories were examined. There was no evidence of electrical activity.

The test was passed successfully.

ВЯРНО С ОРИГИНАЛА

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6 Conclusion

The 145 kV- Cable System consisting of 150kV-XLPE-cable, Outdoor Sealing End type EHFVC, Straight Joint type SEHDV and GIS Compact Sealing End type EHSVS, manufacturer Südkabel GmbH, passed all tests described in Chapter 2 successfully. The test object fulfilled the requirements according IEC 60840 04-2004, type test on accessories.

Karlsruhe, 08.11.2010

Dr.-Ing. R. Badent
Head of Department
„High Voltage Dielectric Testing"

Dr.-Ing. B. Hoferer
Vice-Head of Department
„High Voltage Dielectric Testing"

ВЯРНО С ОРИГИНАЛА

ООД

Стара Загора

Доклад № 17е / H289a (Типово изпитание)

Типово изпитание на кабелна система 123/145 kV,

състояща се от

глава за открит монтаж тип
EHFVC 123/145,

2 щепселни глави за трансформатор тип
EHTVS 123/145 Тип D,

2 съединителни муфи тип
SEHDV 123/145

и 2 различни XLPE-кабела

в съответствие с IEC 60840 и допълнителни тестове по BEWAG, IEEE Std 48-1996 и IEEE Std 404-2000

ВЯРНО С ОРИГИНАЛА

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№	Изпитание	Дата	Стандарт	Изискване	Резултат
1	Издържано променливо напрежение **Продължителност 1 мин** **Изпитат. напрежение 230 kV**	03-05-12	BEWAG	без повреда	**издържан**
2	Изпитване с променливо напрежение **Продължителност 30 мин** **Изпитат. напрежение 160 kV**	03-05-12	-	без повреда	**издържан**
3	Изпитване за частичен разряд **Изпитат. напрежение 160 kV**	03-05-12	BEWAG (2.5 Uo) IEC (1.5 Uo)	< 1 pC < 5 pC	**издържан**
4	Изпитване за частичен разряд **$T_{жилото}$ = 95-100 ˚ C** **Изпитат. напрежение 160 kV**	03-05-12	-	< 5 pC	**издържан**
5	Изпитване с цикли на загряване **20 цикъла на загряване 8/16 ч $T_{жилото}$ = 95-100˚C** **~1350 A променлив ток** **Изпитат. напрежение 160 kV**	03-05-14 - 03-06-03	BEWAG (2.5 Uo) IEC (2.0 Uo)	без повреда	**издържан**
6	Изпитване за частичен разряд **$T_{жилото}$ = 95-100 ˚ C** **Изпитат. напрежение 160 kV**	03-06-03	BEWAG (2.5 Uo)	< 1 pC	**издържан**
7	Изпитване за частичен разряд **Изпитат. напрежение 160 kV**	03-06-04	BEWAG (2.5 Uo)	< 1 pC	**издържан**
8	Изпитване с импулсно напрежение **10 импулса за всяка полярност** (1-5 µs/40-60 µs), **$T_{жилото}$ = 95-100 ˚ C** **Изпитат. напрежение Û = 550 kV**	03-06-04	BEWAG	без повреда	**издържан**
9	Изпитване с променливо напрежение **Продължителност 4 часа** **Изпитат. напрежение 160 kV**	03-06-04	BEWAG (2.5 Uo)	без повреда	**издържан**
10	Изпитване за частичен разряд **$T_{жилото}$ = 95-100 ˚ C** **Изпитат. напрежение 160 kV**	03-06-04	BEWAG (2.5 Uo)	< 1 pC	**издържан**
11	Изпитване за частичен разряд **Изпитат. напрежение 160 kV**	03-06-05	BEWAG (2.5 Uo)	< 1 pC	**издържан**

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12	Изпитване с импулсно напрежение **10 импулса за всяка полярност** (1-5 μs/40-60 μs), **$T_{жилото}$ = 95-100 ˚C** **Изпитат. напрежение Û = 650 kV**	03-06-13	IEC	без повреда	**издържан**
13	Изпитване с променливо напрежение **Продължителност 15 мин** **Изпитат. напрежение 190 kV**	03-06-14	IEC (2.5 Uo)	без повреда	**издържан**
14	Изпитване за частичен разряд **Изпитат. напрежение 190 kV**	03-06-18	-	< 5 pC	**издържан**
15	Издържано променливо напрежение **Продължителност 6 ч** **Изпитат. напрежение 210 kV**	03-07-08	IEEE Std 48-1996	без повреда	**издържан**
16	Издържано променливо напрежение **Продължителност 15 мин** **Изпитат. напрежение 240 kV**	03-07-08	IEEE Std 404-2000	без повреда	**издържан**
17	Издържано променливо напрежение **Продължителност 1 мин** **Изпитат. напрежение 310 kV**	03-07-08	IEEE Std 48-1996	без повреда	**издържан**

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Type Test
of a 123/145 kV - Cable System

consisting of

Outdoor Sealing End Type
EHFVC 123/145,

two Transformer Compact Sealing Ends Type
EHTVS 123/145 Typ D,

two Straight Joints Type
SEHDV 123/145

and two different XLPE-Cables

according to IEC 60840 [1] and additional tests according to BEWAG-Specification [2], IEEE Std 48-1996 [3] and IEEE Std 404-2000 [4]

Summary

The type test of a 123/145 kV - cable system consisting of one outdoor sealing end type EHFVC 123/145 according to drawing O.35.72.5a, two transformer sealing ends type EHTVS 123/145 type D according to drawing O.350.96.0a, two straight joints type SEHDV 123/145 according to drawing O.3500.32.1a and two different XLPE-cables according to IEC 60840 [1] and additional tests according to BEWAG-Specification [2], IEEE Std 48-1996 [3] and IEEE Std 404-2000 [4] were all successfully passed.

The type test was witnessed in the substantial tests for U_m = 123 kV by BEWAG (Berlin) and for U_m = 145 kV by FGH Engineering & Test GmbH (Mannheim).

ABB Energiekabel GmbH
Development Center

(Dr. Kaumanns) (Dipl.-Ing. Weinlein)

FGH Engineering & Test GmbH

[1] Power Cables with extruded insulation and their accessories for rated voltages above 30 kV (U_m = 36 kV) up to 150 kV (U_m = 170 kV) – 1999
[2] Vorschriften für Aufbau und Prüfungen von 110 kV-Kabeln mit Isolierung aus vernetztem Polyethylen und deren Garnituren – TKT 04.98
[3] IEEE Standard Test Procedures and Requirements für Alternating-Current Cable Terminations 2.5 kV Through 765 kV - 1996
[4] IEEE Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500 000 V - 2000

cc: GAM, KSE/KSH, EC/ECH/ECP

ВЯРНО С ОРИГИНАЛА

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Purpose of Test

One outdoor sealing end type EHFVC 123/145 according to drawing O.35.72.5a (see figure 7), two transformer compact sealing ends type EHTVS 123/145, type D according to drawing O.350.96.0a (see figure 8) and two straight joints type SEHDV 123/145 according to drawing O.3500.32.1a (see figure 9) were mounted.
Both transformer compact sealing ends type EHTVS 123/145, type D and one straight joint type SEHDV 123/145 were mounted on a XLPE-cable of type A2XS(FL)2Y 1 x 800 RM/35 64/110 kV (ABB Energiekabel GmbH, part number 4910220, thickness of insulation = 11.0 mm).
The outdoor sealing end type EHFVC 123/145 was mounted on a XLPE-cable of type N2XS(FL)2Y 1 x 630 RM/35 64/110 kV (ABB Energiekabel GmbH, part number 4905220, thickness of insulation = 17.8 mm).
The second straight joint type SEHDV 123/145 connected both cables named above.

Both transformer compact sealing ends were situated in a tube (inside diameter 325 mm) filled with transformer oil (Shell Diala D).

The schematic test installation is detailed in figure 1, the mounting of both EHTVS 123/145, type D into the test housing shows figure 10.

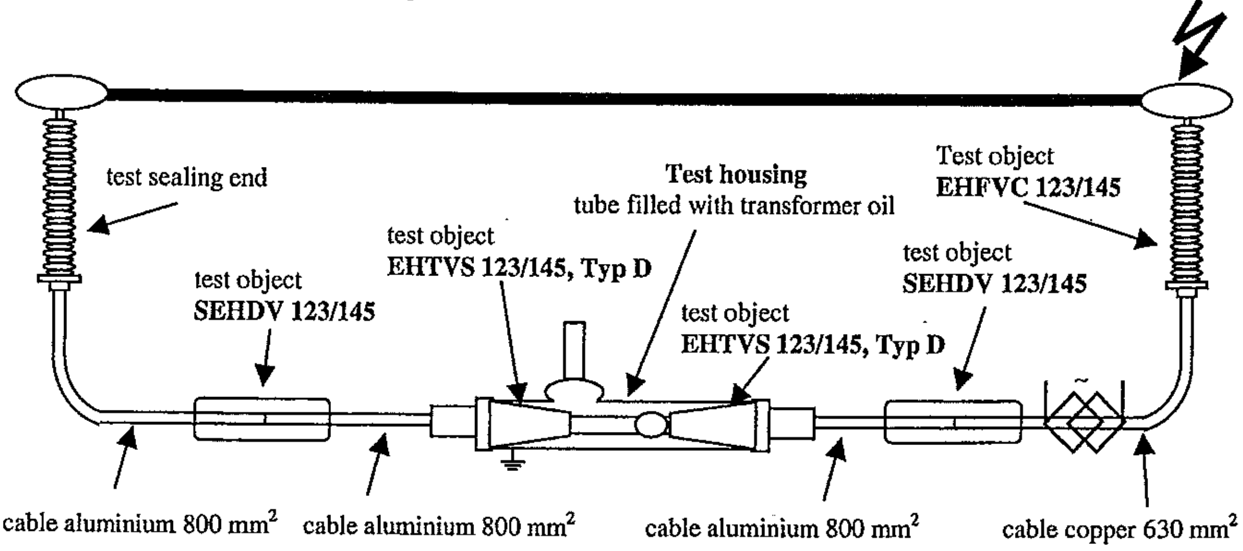

figure 1: schematic installation of type test

Mounting

Preparation of the cable, assembly and mounting of the cable system and the test objects was accomplished by technicians of ABB Energiekabel GmbH.
The test installation contained five test objects.

The outdoor sealing end EHFVC 123/145 was mounted according to installation instruction no. 16104-0, installation drawing MZ00167 and the additional installation instructions no. 65709 and no. 68703-0.

The EHFVC 123/145 was mounted with parts / materials detailed in the assembly drawing TZ00160 and in the additional list of materials no. 1000080.

The transformer compact sealing ends EHTVS 123/145 type D were mounted according to installation instruction no. 15417-0, installation drawing MZ00156 and the additional installation instructions no. 65709 and no. 68703-0.
The EHTVS 123/145, type D were mounted with parts / materials detailed in the assembly drawing TZ00159 and in the additional list of materials no. 9050022.
The corona shield according to DIN EN 50299 draft 10.98 shown in drawing O.350.96.0a-01 (figure 8) was not used in this type test.

The straight joints SEHDV 123/145 were mounted according to installation instruction no. 15508-0, installation drawing MZ00178 and MZ00177 and the additional installation instructions no. 65709, no. 68703-0 and no. 65713-0.
The SEHDV 123/145 were mounted with parts / materials detailed in the assembly drawing TZ00164 and in the additional list of materials no. 1000096.

In both straight joints were used bolted sleeve instead of the conventional hexagonal compressing of the conductor connection.

The core of the aluminium 1x800 cable (11.0 mm thickness of insulation) was stripped off to a diameter of 57.2 mm (equivalent 9.8 mm insulation).

The core of the copper 1x630 cable (18.0 mm thickness of insulation) was stripped off to a diameter of 68.0 mm (equivalent 17.7 mm insulation) for mounting the EHFVC 123/145.

To use a standard insulating body suitable for both stripping diameters this straight joint SEHDV 123/145 connecting the aluminium with the copper cable, the thicker one was stripped off a diameter of 63.4 mm using a special preparation method.

Measuring and Test Equipment

- a.c. transformer: manufacturer ASEA (200 kV, $S_N = 10$ kVA)
- voltage measurement: manufacturer ASEA (test equipment no.. 53-1657-203)
- temperature recorder: manufacturer Yokogawa (test equipment no.. 21-1657-234)
- current transformer: manufacturer Ritz (test equipment no.. 047-1657-224)
- multimeter (Metra-Hit 16 S): manufacturer Gossen (test equipment no.. 42-1657-224)
- PD measurement (calibrator): manufacturer Haefely (test equipment no.. 50-1657-217)
- a.c. cascade transformer: manufacturer Koch+Sterzel (600 kV, $S_N = 300$ kVA)
- voltage measurement: manufacturer MWB (test equipment no.. 53-1657-239)
- impulse generator: manufacturer High Volt (800 kV, W = 80 kJ, used 10 stages)
- peak voltage measurement: manufacturer High Volt (test equipment no.. 53-1657-236)

All test equipment was calibrated.

Tests

The tests followed the specifications in IEC 60840, clause 12 (Type tests on systems, cable and accessories) - issue 1999, the BEWAG-specification, the specifications in IEEE Std 48-1996, clause 8.4.1, table 1, column 5 and 3 (Dielectric tests) and IEEE Std 404-2000, clause 7.8, table 2, column 4 and 5 (High-Voltage Time Test).

The tests were performed in the sequence detailed in table 1.

According to IEC 60840 the insulation class $U_m = 145$ kV ($U_0 = 76$ kV) was tested.
All requirements of the insulation class $U_m = 123$ kV of IEC 60840 and the BEWAG-specification also are included with the tests carried out.

Explicit for insulation class $U_m = 123$ kV the lightning impulse level tests were carried out.
Lightning impulse voltage tests (550 kV, 9th + 10th negative and 9th and 10th positive lightning impulse at $T_{conductor}$= 95 - 100°C) are documented by figure 3 and 4.

Lightning impulse voltage tests for insulation class $U_m = 145$ kV (650 kV, 9th + 10th negative and 9th and 10th positive lightning impulse at $T_{conductor}$= 95 - 100°C) are documented by figure 5 and 6.
The waveform parameters were determined at reduced charging voltage.

Figure 2 shows the 18th heating cycle of the heating cycle voltage test.

Results

The tests and the test results are specified in table 1.

All tests were passed successfully.

No.	Test	Date	Standard	Requirement	Result
01	a.c. withstand voltage test **duration: 1 minute, test voltage: 230 kV**	03-05-12	BEWAG	no breakdown	**passed**
02	a.c. voltage test **duration: 30 minutes, test voltage: 160 kV**	03-05-12	-	no breakdown	**passed**
03	partial discharge test **test voltage: 160 kV**	03-05-12	BEWAG ($2.5 \cdot U_0$) IEC ($1.5 \cdot U_0$)	< 1 pC < 5 pC	**passed** 1)
04	partial discharge test **$T_{conductor}$= 95-100°C, test voltage: 160 kV**	03-05-12	-	< 5 pC	**passed** 1)
05	heating cycle voltage test **20 heating cycles 8/16h, $T_{conductor}$= 95-100°C, ~1350 A alternating current, test voltage: 160 kV**	03-05-14 - 03-06-03	BEWAG ($2.5 \cdot U_0$) IEC ($2.0 \cdot U_0$)	no breakdown	**passed**

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06	partial discharge test **$T_{conductor}$= 95-100°C,** **test voltage: 160 kV**	03-06-03	BEWAG (2.5·U_0)	< 1 pC	passed [1]
07	partial discharge test **test voltage: 160 kV**	03-06-04	BEWAG (2.5·U_0)	< 1 pC	passed [1]
08	impulse voltage test **10 impulses of each polarity (1-5 µs/40-60 µs),** **$T_{conductor}$= 95-100°C** **test voltage: Û = 550 kV**	03-06-04	BEWAG	no breakdown	passed [3]
09	a.c. voltage test **duration: 4 hours,** **test voltage: 160 kV**	03-06-04	BEWAG (2.5·U_0)	no breakdown	passed
10	partial discharge test **$T_{conductor}$= 95-100°C,** **test voltage: 160 kV**	03-06-04	BEWAG (2.5·U_0)	< 1 pC	passed [1), 3)]
11	partial discharge test **test voltage: 160 kV**	03-06-05	BEWAG (2.5·U_0)	< 1 pC	passed [1]
12	impulse voltage test **10 impulses of each polarity (1-5 µs/40-60 µs),** **$T_{conductor}$= 95-100°C** **test voltage: Û = 650 kV**	03-06-13	IEC	no breakdown	passed [3]
13	a.c. voltage test **duration: 15 minutes,** **test voltage: 190 kV**	03-06-14	IEC (2.5·U_0)	no breakdown	passed
14	partial discharge test test voltage: 190 kV	03-06-18	-	< 5 pC	passed [1), 2)]
15	a.c. withstand voltage test **duration: 6 hours,** **test voltage: 210 kV**	03-07-08	IEEE Std 48-1996	no breakdown	passed
16	a.c. withstand voltage test **duration: 15 minutes,** **test voltage: 240 kV**	03-07-08	IEEE Std 404-2000	no breakdown	passed
17	a.c. withstand voltage test **duration: 1 minute,** **test voltage: 310 kV**	03-07-08	IEEE Std 48-1996	no breakdown	passed

note to column 'standard': BEWAG: U_m = 123 kV (U_0 = 64 kV) / IEC: U_m =145 kV (U_0 = 76 kV)
[1)] no detectable PD above the background noise level of 1 pC, calibrating impulse = 2 pC
[2)] external witness of BEWAG (Berlin) Mr. Ulewski present during test
[3)] external witness of FGH Engineering & Test GmbH (Mannheim) Mr. Stolz present during test

table 1: tests and results

The tests were performed under the following atmospheric conditions: temperature = 22°C - 32°C, air pressure: 980 – 1025 mbar, relative humidity 35% - 55%.

Visual Inspection

Having passed all tests the outdoor sealing end type EHFVC 123/145, the transformer compact sealing end type EHTVS 123/145, type D and the straight joints type SEHDV 123/145 were disassembled and the single components were examined.

No changes to the initial states were detected.

Summary

The outdoor sealing end type EHFVC 123/145 (according to drawing O.35.72.5a), the transformer compact sealing end type EHTVS 123/145, type D (according to drawing 350.96.0a) and the straight joint type SEHDV 123/145 (according to drawing O.3500.32.1 have passed all tests according to IEC 60840, clause 12 and the additional tests according to BEWAG-specification, IEEE Std 48-1996 and IEEE Std 404-2000 successfully.

The type test was witnessed in the substantial tests for U_m = 123 kV by BEWAG (Berlin) and for U_m = 145 kV by FGH Engineering & Test GmbH (Mannheim).

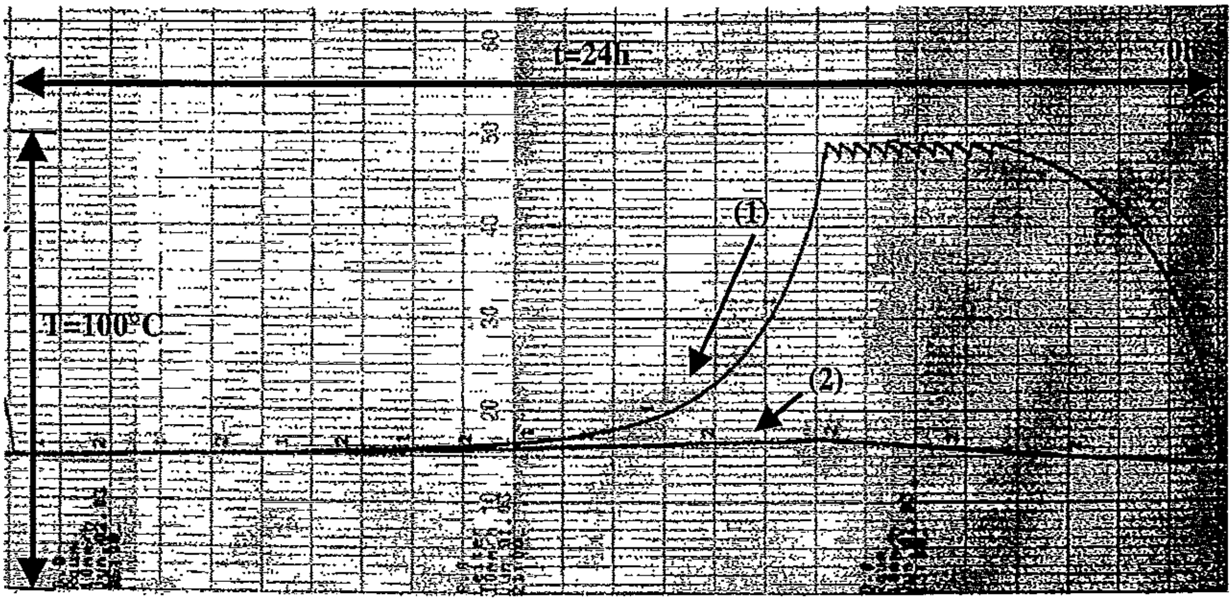

figure 2: 18th heating cycle 8/16h, I = 1350 A (8h, 2h operated in the switching mode), I = 0 A (16h), U= 160 kV curve 1: conductor temperature dummy, curve 2: ambient temperature (scale marks 1h, 20°C)

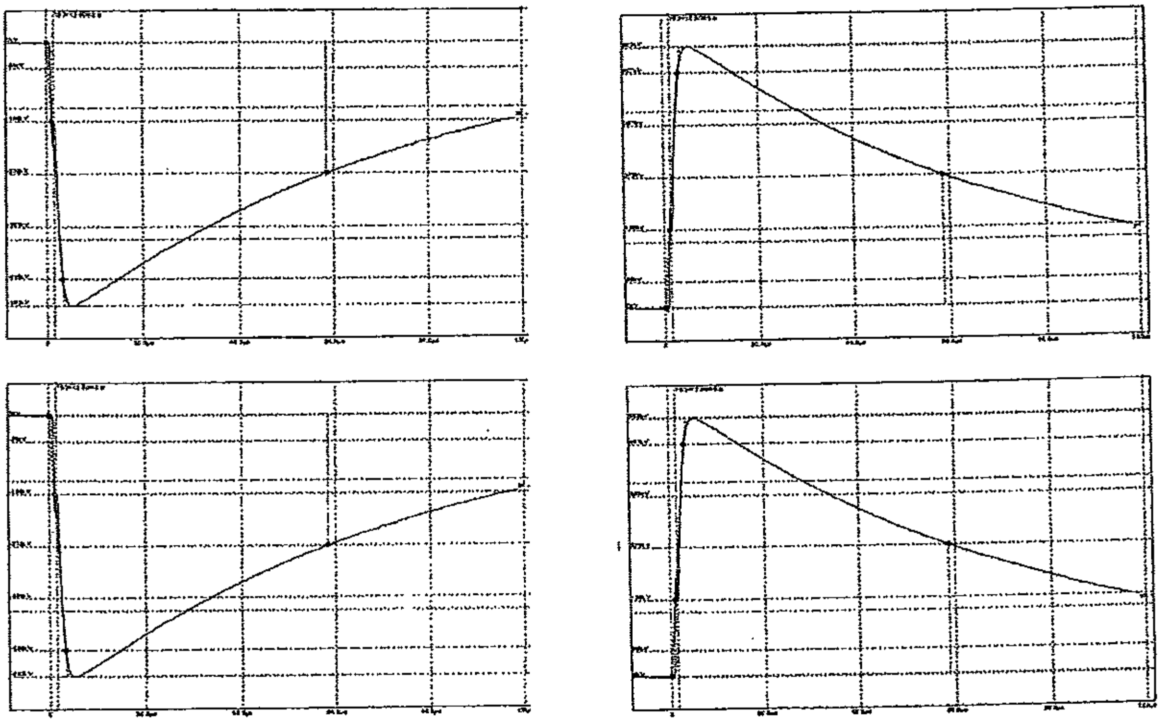

figure 3 and 4: oscillograms impulse lightning test with Û = 550 kV
(pictures show $9^{th} + 10^{th}$ negative and $9^{th} + 10^{th}$ positive impulse)

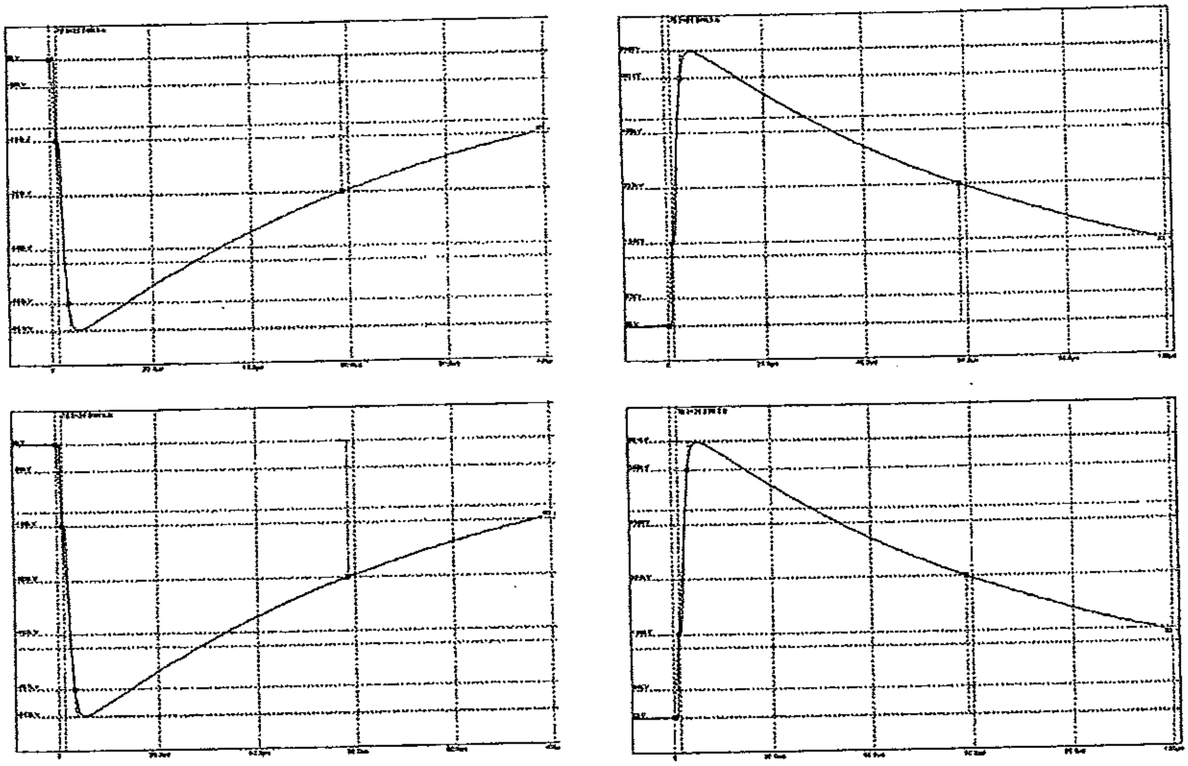

figure 3 and 4: oscillograms impulse lightning test with Û = 650 kV
(pictures show $9^{th} + 10^{th}$ negative and $9^{th} + 10^{th}$ positive impulse)

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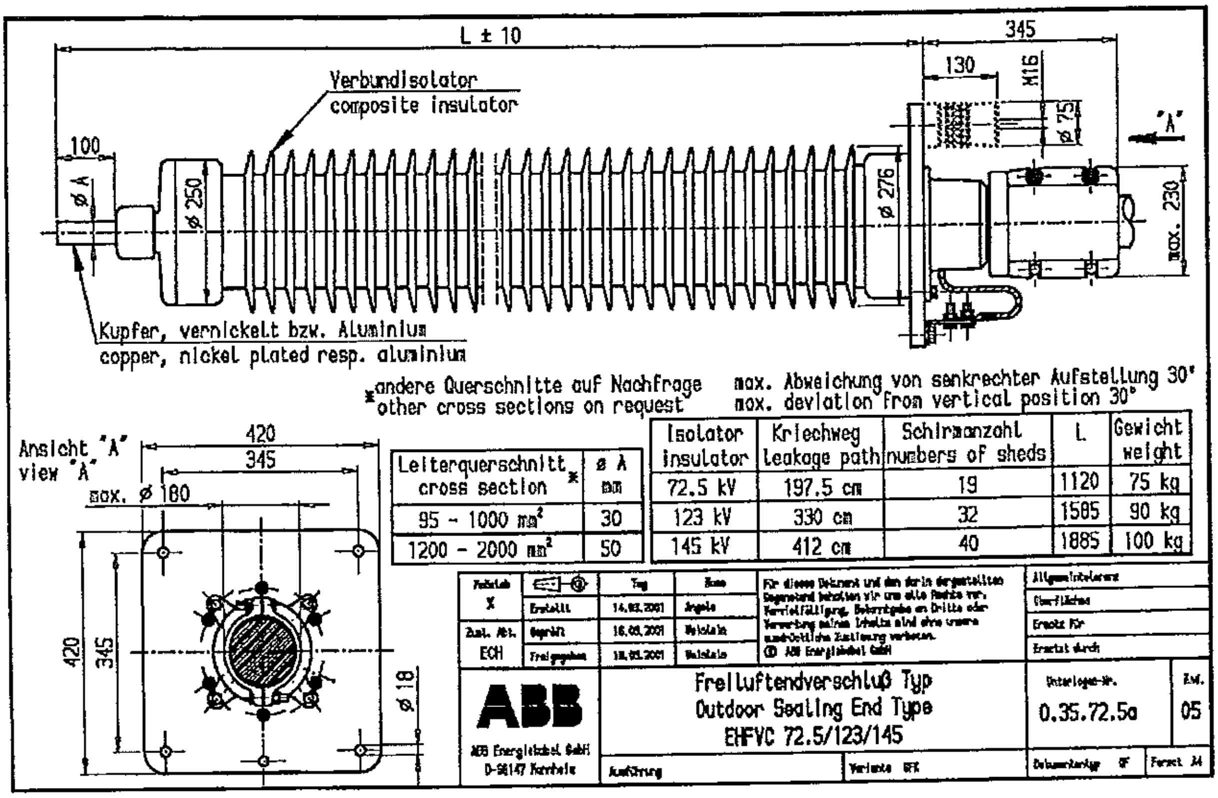

figure 7: drawing O.35.72.5a 'outdoor sealing end type EHFVC 123/145'

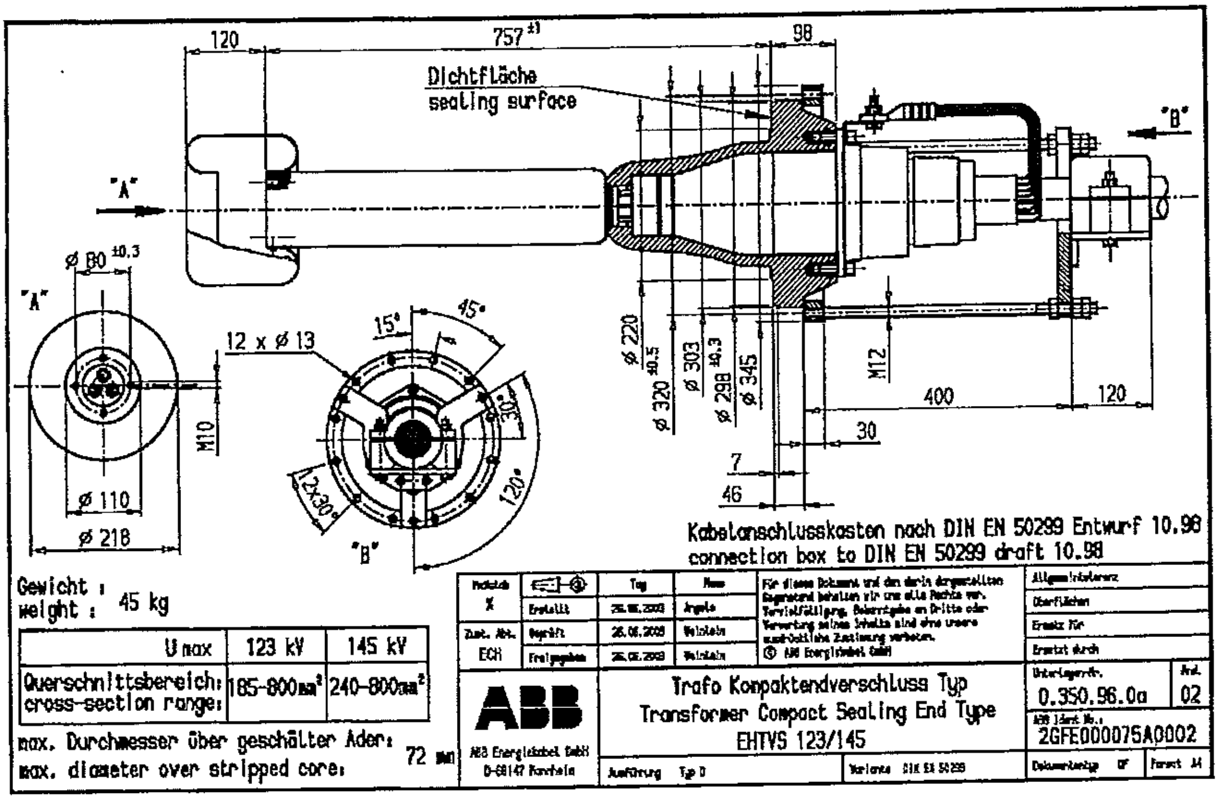

figure 8: drawing O.350.96.0a 'transformer compact sealing end type EHTVS, type D 123/145'

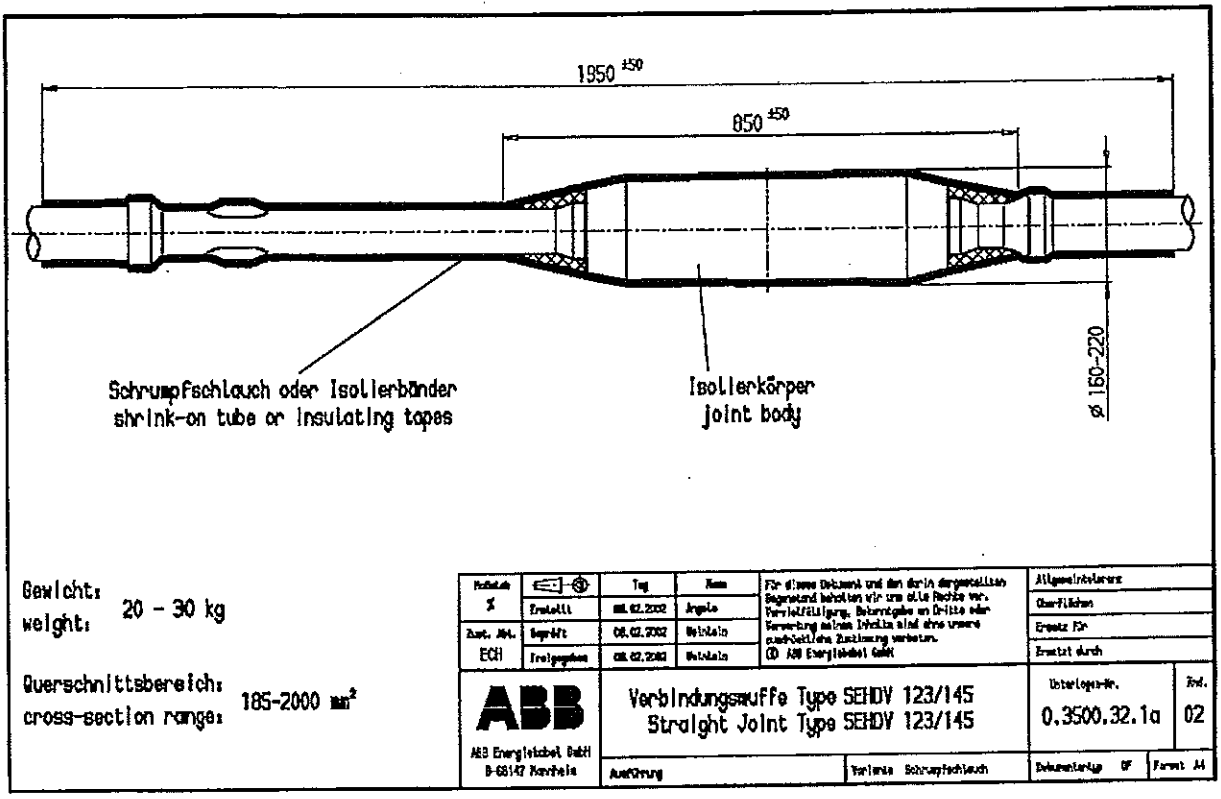

figure 9: drawing O.3500.32.1a 'straight joint type SEHDV 123/145'

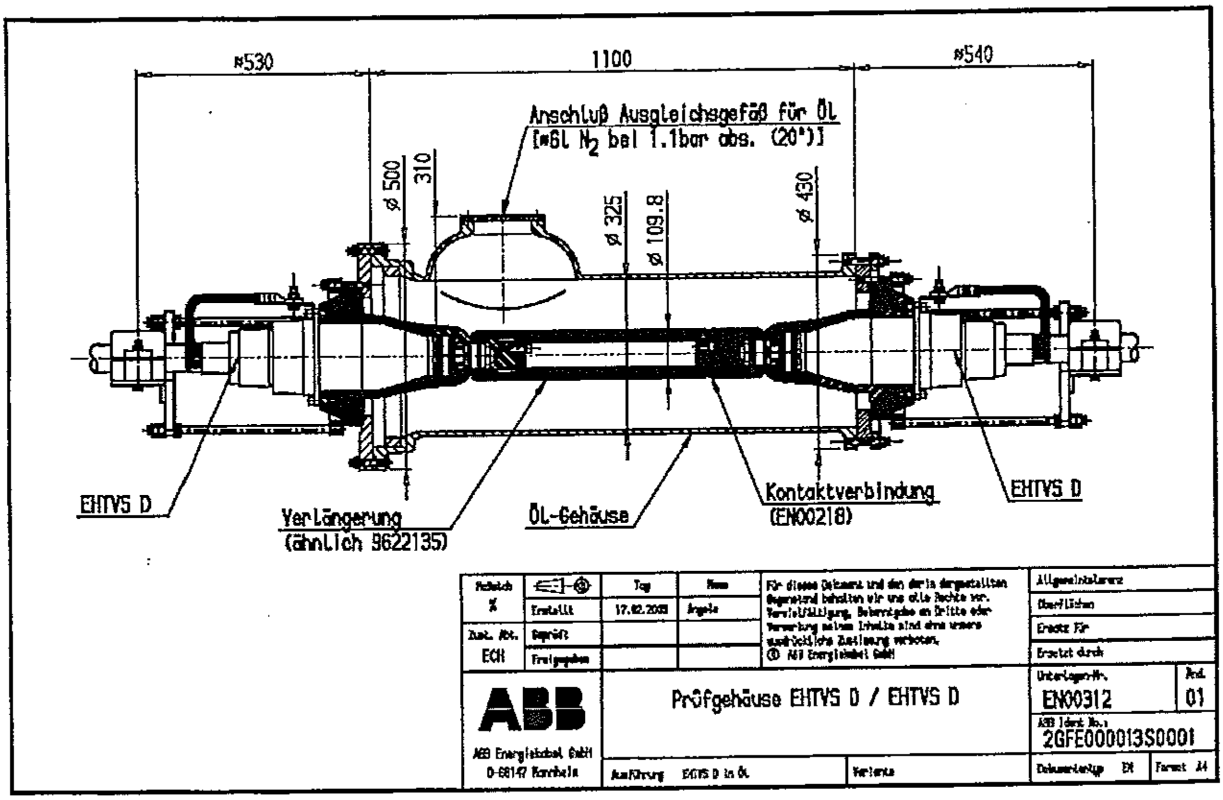

figure 10: test housing EHTVS 123/145 type D with EHTVS 123/145 type D in transformer oil

distribution: customer, EC/ECP/ECG/EQ, KS/KSE/KSH, KSI, QW, VP/VPG/VPK

title: common tests on cables and accessories, with U_m = **123 kV**

1 Routine tests on cables

	Test	Requirements	IEC 60840 Ed. 4.0 (2011-11)	Method
1	Partial discharge test	Applied voltage: 1.5 U_0 = 96 kV (after 10 s 1.75 U_0), Sensitivity: ≤ 10 pC. No detectable discharge.	Chapter 9.2	IEC 60885-3
2	High Voltage test	Applied A.C. voltage and duration: 160 kV / 30 min (2.5 U_0) No breakdown	Chapter 9.3	
3	Electrical test on non-metallic sheath	Spark test during manufacturing AC voltage: max. 15 kV, or a DC voltage test with max. 25 kV **(explicit customer acknowledgement)**	Chapter 9.4	IEC 60229

2 Routine tests on accessories

	Test	Requirements	IEC 60840 Ed. 4.0 (2011-11)	Method
1	Partial discharge test	Applied voltage: 1.5 U_0 = 96 kV (after 10 s 1.75 U_0), Sensitivity: ≤ 5 pC. No detectable discharge.	Chapter 9.2	IEC 60885-3
2	High Voltage test	Applied A.C. voltage and duration: 160 kV / 30 min. (2.5 U_0) No breakdown	Chapter 9.3	

3 Sample tests on cables (according to customer specification)

	Test	Requirements	IEC 60840 Ed. 4.0 (2011-11)	Method
1	Conductor examination		Chapter 10.4	IEC 60228
2	Measurement of electrical resistance of conductor and metallic sheaths	Maximum value according IEC 60228, d.c. resistance measurement corrected on 1 km cable length and 20 °C	Chapter 10.5	
3	Measurements of thickness of insulation and oversheath	Insulation: $t_{min} \geq 0.9 \cdot t_{nom}$ and $(t_{max}-t_{min})/t_{max} \leq 0.15$; Outer jacket: $t_{min} \geq 0.85 \cdot t_{nom} - 0.1$ mm	Chapter 10.6	IEC 60811-1-1 incl. Amendment 1
4	Measurement of thickness of metallic sheath	Lead or Lead alloy sheath: $t_{min} \geq 0.95 \cdot t_{nom} - 0.1$ mm Aluminium sheath: $t_{min} \geq 0.9 \cdot t_{nom} - 0.1$ mm	Chapter 10.7	
5	Measurement of diameters	Core diameter and outer diameter of cable **(explicit customer agreement)**	Chapter 10.8	IEC 60811-1-1 incl. Amendment 1
6	Hot set test for XLPE insulation	Max. elongation under load: 175 % Max. permanent elongation after cooling: 15 %	Chapter 10.9	IEC 60811-2-1 incl. Amendment 1
7	Measurement of cable capacity	Measured value corrected on 1 km length, maximum value: nominal value + 8%	Chapter 10.10	
8	Measurement of HDPE-density	density ≥ 0.94 g/m³	Chapter 10.11	IEC 60811-1-1 incl. Amendment 1
9	Lightning impulse voltage test	10 pos. / 10 neg. impulses at 550 kV, followed by an A.C. voltage test with 160 kV / 15 min.	Chapter 10.12	IEC 60230

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		no breakdown **(explicit customer agreement)**		
10	Water penetration test	No water shall emerge from the ends of the test piece (min length: 6 m) **(explicit customer agreement)**	Chapter 10.13 Chapter 12.5.14 Annex E	
11	Tests on cables with longitudinal metal tape or foil, attached to the oversheath	- visual examination (no cracks or separation) - adhesion strength (5 specimen, min. 0.5 N/mm) - Peel strength (min. 0.5 N/mm)	Chapter 10.14 Chapter 12.5.15	

4 Sample tests on accessories (according to customer specification)

	Test	Requirements	IEC 60840 Ed. 4.0 (2011-11)	Method
1	Inspection against drawings	No deviation against the declared tolerances	Chapter 11.1	

- only for not pre-moulded accessories, number of that type in contract > 50 pieces

	Test	Requirements	IEC 60840 Ed. 4.0 (2011-11)	Method
1	Partial discharge test	Applied voltage: 1.5 U_0 = 96 kV (after 10 s 1.75 U_0), Sensitivity: $\leq$ 5 pC. No detectable discharge.	Chapter 9.2	IEC 60885-3
2	High Voltage test	Applied A.C. voltage and duration: 160 kV / 30 min. (2.5 U_0) No breakdown	Chapter 9.3	

5 Electrical tests after installation

	Test	Requirements	IEC 60840 Ed. 4.0 (2011-11)	Method
1	DC voltage test of the oversheath	Max. value of 10 kV for 1 min. (4 kV per millimetre of specified thickness of extruded oversheath) shall be applied between the metallic screen/sheath and ground No flashover shall occur	Chapter 16.1	IEC 60229 Chapter 5
2	AC voltage test of the insulation	A voltage between conductor and screen shall be applied for 1 h with a voltage according to table 4: 128 kV (Frequency 20 Hz – 300 Hz); alternatively, a voltage of U_0 = 64 kV may be applied for 24 h.	Chapter 16.2	

DAtech немски акредитационен орган Техника от TGA GmbH Участващ в

многостранното спорзаумение на ЕА и ILAC за взаимно признаване
представляван от

НЕМСКИ АКРЕДИТАЦИОНЕН СЪВЕТ (DAR)

АКРЕДИТАЦИЯ

TGA GmbH, представлявана от **DAtech немски акредитационен орган Техника от TGA GmbH** потвърждава, че изпитателната лаборатория

Институт за електроенергийни системи и високоволтова техника (IEH) на университет Карлсруе
Енгесщрасе 11

76128 Карлсруе

има правото по DIN EN ISO/IEC да провежда изпитания в областите

диелектрични и климатични изпитания на електрически устройства и компоненти за електрически системи вкл. кабели и електромагнитна съвместимост (EMC)

съгласно приложения списък със стандарти и спецификации.

Акредитацията е валидна до: **09.07.2019 г.**

Анексът се счита за част от сертификата и обхваща 19 страници.

DAR-регистрационен номер **DAT-PL-11068-09-00**

Франкфурт на Майн, 10.07.2014 г.

Коректността на английския превод потвърдена: Франкфурт на Майн, 10.07.2014г.

Дипл. инж. Р. Егнер

Директор на акредитационния орган

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DAkkS
Deutsche
Akkreditierungsstelle

Deutsche Akkreditierungsstelle GmbH

Entrusted according to Section 8 subsection1 AkkStelleG in connection with Section 1 subsection 1 AkkStelleGBV
Signatory to the Multilateral Agreements of
EA, ILAC and IAF for Mutual Recognition

Accreditation

The Deutsche Akkreditierungsstelle GmbH attests that the testing laboratory

Karlsruher Institut für Technologie (KIT)
Institut für Elektroenergiesysteme und Hochspannungstechnik (IEH)
Engesserstraße 11, 76128 Karlsruhe

is competent under the terms of DIN EN ISO/IEC 17025:2005 to carry out tests in the following fields:

Electromagnetic Compatibility (EMC), High Voltage, Power Cable

The accreditation certificate shall only apply in connection with the notice of accreditation of 10.07.2014 with the accreditation number D-PL-11068-09 and is valid until 09.07.2019. It comprises the cover sheet, the reverse side of the cover sheet and the following annex with a total of 21 pages.

Registration number of the certificate: **D-PL-11068-09-00**

ВЯРНО С
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Frankfurt am Main, 10.07.2014

Dipl.-Ing. (FH) Ralf Egner
Abteilungsleiter

Подпис: ....

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This document is a translation. The definitive version is the original German accreditation certificate.

See notes overleaf.

Deutsche Akkreditierungsstelle GmbH

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ВЯРНО С
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Стара Загора

Указания за полагане на силови кабели ВН и СН с XLPE изолация

1. Приложение

Тези указания са приложими за:

- превоз на кабелите и боравене с тях на обекта
- подготовка на канал
- полагане на кабелите
- боравене с кабелите по време на монтаж
- изпитвания

2. Боравене с кабелите

2.1. Превоз на кабелите и боравене с тях на обекта

2.1.1. Дървената кутия, в която се превозват барабаните, трябва да се провери за възможни повреди при пристигането им на обекта.

2.1.2. Дървената предпазна кутия се отстранява единствено непосредствено преди процедурата по полагане.

2.2. Подготовка на канал

2.2.1. При подготовката на канала вземаме предвид DIN 57 298 част 1, раздел 5.3.5, образец 1990, който гласи, че предпоставка за полагането е кабелно трасе с подходящо разширение за огъване, както и достатъчен брой ролки. Специално внимание трябва да се обърне на предоставянето на достатъчен брой водещи ролки и на това, че радиусите на огъване за изтеглането на кабелите са над минималната стойност.

Допустими радиуси на огъване:

$r \geq 25 \times D_A$ за кабели ВН и $\geq 15 \times D_A$ за кабели СН

с D_A: външен диаметър на кабела.

2.3. Полагане на кабелите

2.3.1. Кабелите трябва да са с температура не по- ниска от -5 С (кабели ВН) съответно -20 С (кабели СН) по време на полагане. Въпреки това кабелите могат да се полагат дори и при по-ниски външни температури, ако са били складирани в отоплени помещения (например 48 часа при 20 С) или затоплени чрез други подходящи методи преди полагане. Трябва да се следи температурата на кабелите преди полагане да не пада под -5 С (кабели ВН) съответно -20 С (кабели СН).

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2.3.2. Изтеглянето на кабелите се осъществява посредством кабелен чорап с дължина от поне 1.5 м. Кабелният край трябва да е изолиран с термосвиваема шапка преди да се монтира чорапът.

2.3.3. Поради факта, че силата на изтегляне се предава пряко на проводника, не трябва да се превишават максималните теглителни сили, посочени по-долу:

Медно жило: 50 N/ mm^2 сечение на жилото
Алуминиево жило: 30 N/ mm^2 сечение на жилото

Препоръчваме да се контролират и отбелязват силите на изтегляне, приложени по време на целия процес.

2.3.4. Ако кабелите трябва да се срежат по време на изтегляне, външната обвивка на кабелния край трябва да е грапава и краищата трябва да се изолират с термосвиваема шапка преди полагане.

2.4. Боравене с кабелите по време на монтаж на арматурата

Приложимите инструкции за монтаж, валидни за арматурата по време на инсталиране, трябва стриктно да се спазват. Изпразването и пълненето на главите трябва да се осъществи според приложимите инструкции за инсталация.

3. Изпитвания

Ако не е уговорено друго, изпитванията трябва да се извършат съгл. DIN VDE 0276, част 632, съответно IEC 60840 за кабели ВН и съгл. DIN VDE 0276, част 620 съответно IEC 60502 за кабели СН.

Забележка:
Трябва да се отдели известно време на обекта за дейността по пълното полагане и инсталация.

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SÜDKABEL

Recommendations for laying of XLPE–Single Core Cables

1. **Steps for laying**
   1. Cable reel
   2. Bends in trench / duct
   3. Cable pulling winch
   4. Cable feeder
   5. Communication
   6. Ways of laying

2. **Cable pulling calculations in general**
   1. Max. allowable pulling force
   2. Radial force in bends
   3. Min. allowable bending radii
   4. Allowable laying temperature
   5. Adhesion coefficient
   6. Calculation of the pulling force
      1. Without elevation difference
      2. With elevation difference

3. **Cable laying in tunnel**

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1. Steps for laying

1.1 Cable reel

The cable slides always from top of the reel. Take care to pull off the cable against the direction it was rolled on.
For laying use a drum trailer or cable jacks with enough load capacity. It must be possible to install a break.
Place the reel with sufficient distance of the trench, to allow a guidance with cable-rollers.

1.2 Bends in trench / duct

For changes in the cable route the placement of cable guiding rollers must be done carefully.
The allowable bending radius must not fall below its minimum value any way (see 2.3).
The cable rollers must be fixed to avoid change of their position during cable laying in any way.
The number of vertical rollers has to be chosen with the aspect, to keep the force in axial direction during the pulling small (minimum is typically 5 rolls for 90° bows).

The design of cable angle rollers is totally different to cable rollers.

1.3 Cable pulling winch

Place the cable pulling winch approx. 10 meters away from the end of the route to secure a perfect roll on of the rope.
Anchor the winch to withstand the pulling force.
The pulling rope must be equipped with a swivel having a predetermined breaking load.
The pulling force has to be observed all the time on its uniformity and has to be recorded with calibrated equipment.
If the maximum allowable pulling force is passed over, the winch has to stop automatically.

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The winch-driver must be able to stop the winch any times required.

1.4 Cable feeder

In case of passing over the maximum allowable pulling force, the use of cable feeders can reduce these forces during laying. The use is recommended in long routes with numerous bends and cables with low allowable pulling force.
Use the cable feeder in front of bends and on the first sector of the route.
Using more than two cable feeders is difficult and needs well trained staff.

1.5 Communication

The works on the cable reel, cable start, cable winch and possibly cable feeders must be well co-ordinated. Therefor a safe communication between the single groups is necessary.
In free area radios with enough range normally are adequate. In a tunnel this doesn't work and telephones are necessary.
The function of the telephones must be checked and safe.

1.6 Ways of laying

By laying with cable pulling winch and / or cable feeders there are four main characteristics which have to be observed:

1. maximum allowable pulling force
2. radial force in bends
3. minimum allowable bending radius
4. laying temperature

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Pull manner	**Cable type**	**Max. allowable pull stress**	**Max. allowable pull force**
With pulling eye on conductor	All cable types	$\sigma = 50\ N/mm^2$ (copper conductor) $\sigma = 30\ N/mm^2$ (aluminium conductor)	$F = \sigma * A$
With cable grip	Plastic insulated cables without metallic sheath and armour	$\sigma = 50\ N/mm^2$ (copper conductor) $\sigma = 30\ N/mm^2$ (aluminium conductor)	$F = \sigma * A$
	All wired armoured cables	$K = 9\ N/mm^2$	$F = K * d^2$
	Cables without pulling proof armour Single-core	$K = 3\ N/mm^2$	$F = K * d^2$

F: maximum allowable pulling force

A: conductor dimensions

s: maximum allowable pulling stress

d: cable diameter

K: maximum allowable pulling stress (depending on the construction of the cable)

Table 1: Maximum allowable pulling forces

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Cable type	Outer protection / outer jacket	Deepest allowable laying temperature
Paper insulated cable	Impregnated jute PVC	+ 5° C + 5° C
PVC – insulated cable	PVC PE	- 5° C - 5° C
XLPE – insulated cable	PVC PE	- 5° C - 5° C

Table 2: Deepest allowable laying temperature

By pulling in the cables into plastic tubes a good greasing will reduce the higher pulling force caused by adhesion. If multiple cables shall be pulled in, the tube must have an adequate radius and it's not allowed to use steel ropes, because they could damage the outer jacket.

In this case it would be better to pull in all cables the same time.

ВЯРНО С ОРИГИНАЛА

ООД РУДИМ Стара Загора

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2. Pulling force calculations

2.1 Maximum allowable pulling force

The maximum allowable pulling force can be calculated with the product of conductor dimensions A and the corresponding allowable stress σ_{zul}:

$$F_{zul} = A * \sigma_{zul} \qquad [F] = 1N$$

For not armoured cables the conductor is used as pulling element. The cable gets connected with the pulling winch by means of a 1.5m long cable grip.

For this pulling variant is valid:

Copper-single-core-cable: $\sigma_{zul} = 50\ N/mm^2$

Aluminium-single-core-cable: $\sigma_{zul} = 30\ N/mm^2$

2.2 Radial force in bends

Laying cables in bends causes radial forces. The radial force per length unit depends on the pulling force F in linear direction, the turn angle α and the circle radius r.
It is:

$$Z_B = [F * \sin \alpha/2] / [r * \pi * \alpha/360°]$$

In area of 0° to 90° it's roughly:

$$\sin \alpha/2 = \pi * \alpha/360° \quad \text{and so} \quad Z_B \approx F/r \qquad [Z_B] = 1\ N/m$$

The mistake due to change of angles less 90° is with before given, simplified formula less than 10 % and good enough for practice.

2.3 Minimum allowable bending radius

The minimum allowable bending radius r_{Bzul} of XLPE single-core-cable is – without take into account of the radial forces – determined with the following formula:

$$r_{Bzul} = 30 * D_A$$

D_A = diameter over outer jacket

For single bend, for example in front of sealing ends, the minimum allowable bending radius can be reduced to:

$$r_{Bmin} = 15 * D_A$$

But only with competent and careful treatment (heating the cable to 30 °C, bending over template).

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2.4 Allowable laying temperature

Don't let the cables get colder than the deepest allowable laying temperature during laying (according to table 2). If the temperature outside is colder, it is necessary to heat the cable by storing it in warm rooms (for example 48 hours with 20 °C) or otherwise heating before laying.

2.5 Adhesion coefficient

The adhesion coefficients μ is dependent on the two gliding materials and the used grease.
Always pull in cables with outer plastic jacket into plastic tubes with grease, because adhesion heating, especially in bends, can cause damages on the outer jacket.

	μ
Pulling in on laying rollers	0,1 – 0,15
Pulling in into plastic tubes	
with grease	0,15 – 0,25
with water	0,2 – 0,3

2.6 Calculation of pulling force on linear routes

2.6.1 Without elevation difference

The pulling force F on the end of the laying route is given with:

$$F = G * l * \mu$$

with
- F = end pull in N
- G = cable weight in N/m
- l = length of route in m
- μ = adhesion coefficient

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2.6.2 With elevation difference

The elevation difference causes, depending on up- or down pulling, a growth or a reduction of the end pull.

The pulling force is given with:

$$F = G * l * (\mu * \cos\beta \pm \sin\beta)$$

with β = angle

$+$ = upward pull

$-$ = downward pull

Up to an angle of $\beta \leq 20°$ (36%) it's simplified valid:

$$F = G * l * \mu \pm G * h$$

with h = elevation difference in m

$+$ = upward pull

$-$ = downward pull

3. Cable laying in tunnel

Before the laying starts it must be proofed with calculations, that the maximum allowable pulling forces will not be passed.

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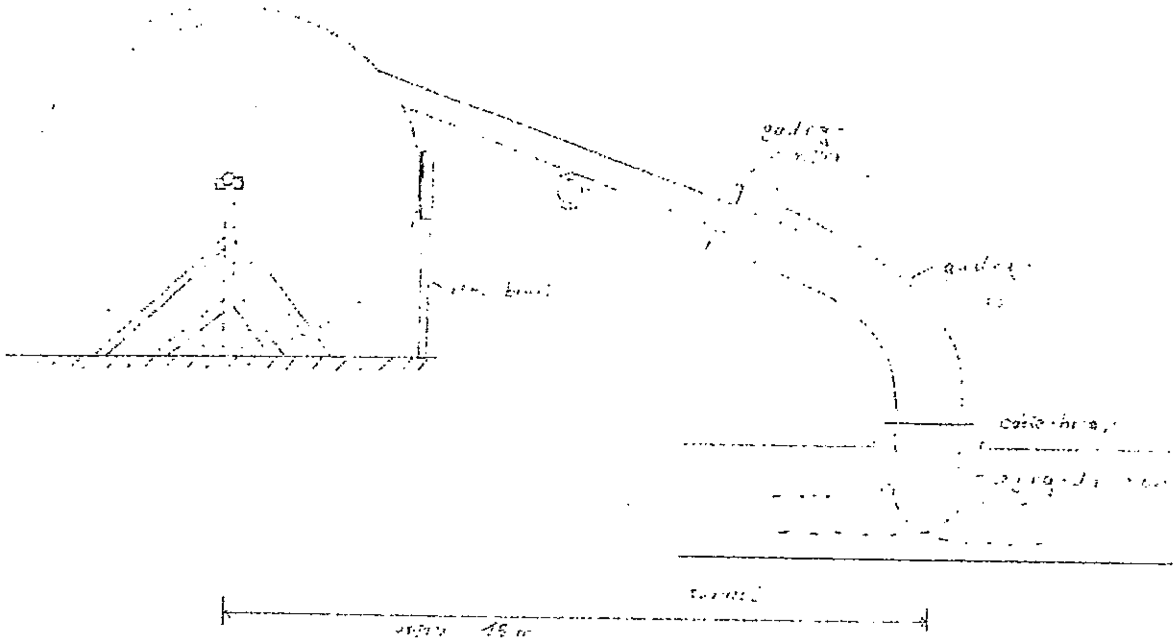

Picture 1: Cable laying

It is meaningful to start the laying with the upper cable.

It is helpful to straighten the first 2 meters, i.e. according to installation instruction 67509.

Place the reel approximately 15m from the tunnel entrance on solid ground.

To give the cable the correct direction, the guidance with a tube on the first meters into the tunnel is useful (see picture 1). If necessary, use a rubber-break to avoid an uncontrolled slipping off of the cable.

The reel must have a break with sufficient breaking power to stop the reel within short time in any case.

The first meters in the tunnel the cable has to be guided with guiding rollers.

If the cable on the reel reaches its end, an adjustable breaking winch with a minimum power of 500 N up to approximately 5000 N has to be installed on the end of the cable. Only after this it is allowed to take off the cable from the reel.

If the cable has reached its final position, it has to be fixed with ropes and chain pulleys. First the pulling end, than the breaking end. After fixing it, the winches can be removed.

The fixing of the cable will be removed just before the installation of the joints. All time before the cable has to be fixed with the ropes.

ВЯРНО С ОРИГИНАЛА

SÜDKABEL

Cable sagging

For adjusting the cable sagging start in the middle of the cable and fix it. Then it can be done in both directions at the same time in the same manner. The fixing ropes and pulleys can be opened step by step but not removed.

ВЯРНО С
ОРИГИНАЛА
Подпис: ....

ООД
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Стара Загора

Südkabel

General Information
on Transportation and Handling of Cable Drums

Our (extra) high-voltage cables will usually be supplied on steel drums being lagged with wooden battens suitable for sea transport. These battens are strong enough to protect the cable against outer mechanical damages, but they are not designed to withstand the total weight of the drum. This means for handling the drums adequate care should be taken to avoid pressure on these wooden protection panels. Drums should always be placed on stable and even ground. To prevent autonomous rolling the use of wooden wedges/bars is recommended.

Due to the heavy weight a suitable crane is to be used to load/unload the drums on/from a trailer. An adequate lifting device (traverse) with slings to be fastened on a steel pipe resp. on special hooks has to be applied. It is absolutely forbidden to lift the cable drums without the traverse because of possible flange damages. Transport of the cables has only to be effected by suitable vehicles (e.g. low-bed/beam trailers equipped for drum transports). On the trailer the drums must be placed in upright position, i.e. with drum axis in horizontal position, and be secured by means of steel chains or polyester webbing straps and wooden wedges, if required.

In case of stowage on flat-racks for container vessels a special base frame made of steel must be provided by the freight carrier to support the drum flanges and to avoid direct contact of the wooden battens with the bottom of the flat-rack.

After arrival of the cable drums at the storage area a careful check of the drums and the wooden battens is compulsory. Any damage shall be reported immediately to the responsible buyer representatives and to Südkabel GmbH.
Each cable drum need to be stored on an even and dry area for admissible load and be blocked against rolling.

ВЯРНО С
ОРИГИНАЛА

ООД
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Стара Загора

Südkabel

Обща информация за транспортиране и боравене с кабелните барабани

Нашите кабели (свръх)високо напрежение обикновено се доставят на стоманени барабани, опаковани в дървена опаковка, предназначена за превоз на товар по вода. Летвите на опаковката са достатъчно здрави, за да защитят кабела от външни механични повреди, но не са направени така, че да могат да издържат цялото тегло на барабана. Това обуславя необходимостта от взимане на адекватни мерки за избягване на натиска върху дървените предпазни панели. Барабаните винаги се поставят върху стабилна и равна повърхност. Препоръчва се използването на дървени клинове/трупчета за предотвратяване на непредвидено търкаляне.

Предвид тежестта на товара товаро-разтоварните дейности на и от ремаркето/платформата се извършват с подходящ за целта кран. Задължително се използва и повдигащо устройство (траверса) със сапани/вериги, които се захващат за стоманена тръба съотв. за специални куки. Абсолютно забранено е повдигане на кабела без траверса, защото могат да се повредят ръбовете. Транспортирането на кабелите се осъществява само с подходящи превозни средства (например ремарке с ниска платформа, оборудвано за транспорт на барабани). Барабаните трябва да се превозват в изправено положение, т.е. оста на барабана да е в хоризонтално положение, и да са обезопасени посредством метални вериги или сапани и дървени клинове, ако е небходимо.

При товарене на „Flat rack" контейнери превозвачът е длъжен да осигури специална стоманена рамка за основа, която да държи краищата и да предотвратява директния контакт на дървените опаковъчни летви с пода на „Flat rack"-a.

След пристигане на мястото за съхранение барабаните задължително се оглеждат внимателно за повреди. Всяка щета се докладва незабавно на упълномощения представител, както и на Südkabel.
Всеки барабан трабва да се съхранява на равно и сухо място и да бъде застопорен против търкаляне.

ВЯРНО С ОРИГИНАЛА

"ЕВРОКАБЕЛ" ООД СОФИЯ

ВЯРНО С ОРИГИНАЛА

ПОДПИС: ....

ООД РУДИН Стара Загора

Specification for transport and details of equipment storage

Sealing and Drumming

Immediately after the factory tests, both ends of each cable end shall be sealed against the ingress of water during transportation, storage and installation.

The cable shall be supplied on non-returnable steel drum with wooden lagging to protect the cable from damage.
The cable shall be tightly wrapped on the cable drum and no turn shall be left loose. A central lifting hole shall be provided for loading and unloading of the drum.

Each drum shall have labels on the outside of each flange. These labels shall bear the following markings, but not limited to them:

- name of the client
- country and port of destination
- contract number and name
- particulars of cable
- gross and net weight

Sealing of Cable Ends

All cables have a PE-oversheath being abrasion and weather resistant. Both cable ends are reliably protected against moisture by using heatshrinkable plastic caps already applied in the factory, immediately after the tests at manufacturer's works. Depending on the type of pulling heads other options are possible.

Transportation of Cable Drums

The cables will be supplied on steel drums being lagged with wooden battens for sea-freight transport. Upon arrival of these cable drums at storage area carefully check that drums and wooden battens are not damaged.

Any damage should be reported immediately to the responsible Buyer representatives and to Südkabel.

Handling of Cable Drums

The drums are adequately protected against mechanical damage during handling and transportation by means of wooden battens. A central lifting hole is provided to accommodate a suitable steel pipe for loading/unloading of drums.

Due to the heavy weight a crane is to be used to load/unload the drums on/from a trailer/low loader. Adequate lifting device (traverse) with suitable slings to be fastened on the steel pipe has to be used.

A special lifting device (traverse) and a suitable steel pipe will be supplied together with the drums. Please make sure that these tools will be together with the drums during the entire transport to the site and will be used at every transfer of the drums.
On the trailer/low loader the drums are to be placed in upright position and to be secured by means of steel chains and wooden wedges.

Transport of the cables has only to be effected by suitable vehicles (e.g. drum trailer, truck, low-bed trailer) and with drum axis being horizontal position.

Before storage the drums are to be investigated whether any damage occurred. Damages are to be reported to the responsible Buyer representatives and to Südkabel. Once the cable drums are stored in an undamaged state in a controlled storage area they shall only be handled and unpacked in the presence of the Südkabel supervisor who will be supervising the cable laying activities.
Testing of the cables on the drum before turnover to the cable laying contractor is not to be performed.

Please also see to pictures annexed hereto.

Transportation and Handling of containers

All contractual goods, except the XLPE cables, are stored adequately in containers which need to be approved by Convention for Safe Containers (CSC) and be released for sea-freight transportation.

Transport of the containers has only to be effected by suitable vehicles, e.g. truck, low-bed trailer. On the trailer/low loader the containers are to be secured by means of steel chains and wooden wedges.

Due to the heavy weight a crane is to be used to load/unload the containers on/from a trailer/low loader. Adequate lifting equipment with suitable steel chains to be fasten on the container has to be used. The centres of gravity are indicated on the containers.

Before storage the containers are to be investigated whether any damage occurred. Damages are to be reported to the responsible Buyer representatives and to Südkabel. Once the containers are stored in an undamaged state in a controlled storage area they shall only be handled and unpacked in the presence of the Südkabel ´s supervisor who will be supervising the installation activities.

Storage of Cable Drums

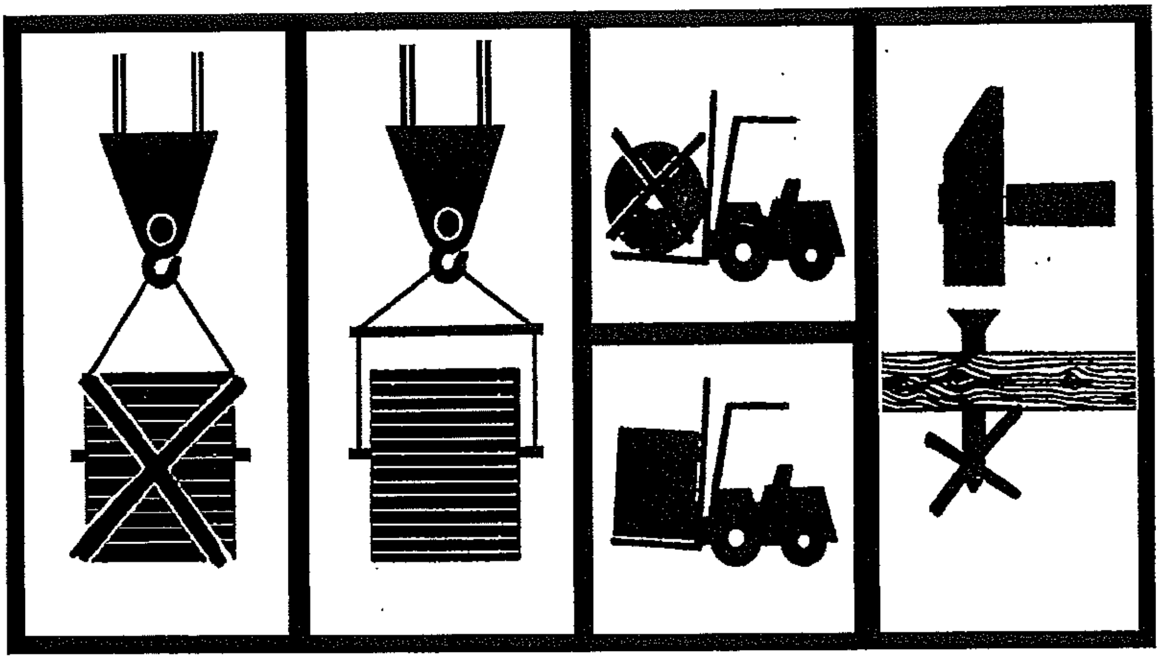
Each cable drum need to be stored on hard and dry surface.

The drums are to be stored in a fenced and 24 hrs. secured yard and should be stored well protected against mechanical damages and UV-radiation.
Damages are to be reported to the responsible Buyer representatives and to Südkabel.

ВЯРНО С ОРИГИНАЛА

ООД Стара Загора

Fig 1 Handling Instructions.



Storage of Accessories

With the cables a number of accessories for the cable sealing ends will be provided shipped in containers. Accessories shall be carefully checked for completeness and for damage of the packing according to the detailed shipping list.
Any damage should be reported immediately to the responsible Buyer representatives and to Südkabel as well.

STORAGE CONDITIONS

- XLPE Cable - no limits

- Accessories
  - indoor
  - controlled temperature
  - dry
  - not in direct sunlight

Описание на превоза и детайлите по съхранение на оборудването

Изолиране и барабани

Непосредствено след заводските изпитания, двата края на всеки кабел ще бъдат изолирани против проникването на вода по време на превоза, съхранението и монтажа.

Кабелът ще бъде доставен на неподлежащ на връщане стоманен барабан в дървена изолационна кутия, която предпазва кабела от повреди. Кабелът ще бъде здраво увит около барабана без да стърчи.

За да може да се натовари и разтовари, барабанът ще има осов напречен отвор, в който се поставя тръба, спомагаща за повдигането.

Всеки барабан ще има етикет на външната част на всеки ръб. Тези етикети ще съдържат следните означения, без да се ограничават само до тях:

- име на клиента
- държава и пристанищна дестинация
- име и телефон за контакт
- подробности по кабела
- брутно и нетно тегло

Изолиране на кабелните краища

Всички кабели имат полиетиленова външна обвивка, която е устойчива на протъркване и атмосферни условия. Двата кабелни края са изпитано защитени против влага-използвани са термосвиваеми пластмасови шапки, поставени още във фабриката непосредствено след работата на производителя. Възможни са други варианти в зависимост от вида на приспособлението за изтегляне при монтаж на кабела.

Превоз на кабелните барабани

Кабелите ще бъдат доставени на стоманени барабани, които ще са опаковани в дървени контейнери, предназначени за превоз на товар по вода. При пристигането им в зоната за съхранение, внимателно проверете и барабаните, и дървените дъски за повреди.

При наличие на повреди, незабавно съобщете на отговарящите представители на купувача, както и на Südkabel.

Как да се борави с кабелните барабани

Барабаните ще са достатъчно защитени срещу механични повреди по време на пренос и превоз посредством дървени дъски. Барабаните ще имат централен осов отвор, който да побере подходяща стоманена тръба, спомагаща за товаренето и разтоварването им.

ВЯРНО С ОРИГИНАЛА

Подпис: ....

ООД РУДИН Стара Загора

Предвид тежкия товар, нужно е да се използва товароподемен кран, за да се натоварят и разтоварят барабаните на и от ремаркето/ платформата.Трябва да се използва съответното устройство за повдигане (траверса) с подходящи сапани/вериги, закрепени на стоманената тръба.

Специалното устройство за повдигане (траверса) и подходящата стоманена тръба ще бъдат доставени заедно с барабаните. Моля проверете дали съоръженията са в наличност заедно с барабаните по време на целия превоз до обекта и също така дали със сигурност са използвани по време на всяко преместване на всеки барабан. Барабаните трябва да са поставени в изправено положение в ремаркето/платформата и да са обезопасени посредством метални вериги и дървени клинове.

Транспортирането на кабелите трябва да се осъществява само с подходящи превозни средства (например ремарке за барабани, камион, ремарке с ниска платформа) като оста на барабана трябва да е в хоризонтално положение.

Преди складиране барабаните трябва да бъдат огледани за повреди. В случаи на повреди да се съобщи на отговарящите представители на купувача, както и на Südkabel. След като барабаните са съхранени в изправно състояние в контролирана зона за съхранение, остава да бъдат обслужени и разопаковани в присъствието на супервайзор от Südkabel, който ще контролира монтажната дейност.

Кабелите няма да бъдат проверявани преди да се предадат на изпълнителя по монтаж на кабели.

Моля, вижте и приложените тук снимки.

Превоз на контейнерите и как да се борави с тях

Всички договорни стоки, освен кабелите с XLPE, са подходящо складирани в контейнери, които трябва да бъдат одобрени от Конвенцията за безопасни контейнери и да са пуснати за товаропревоз по вода.

Превозът на контейнери да се извършва само от подходящи возила, например камион, ремарке с платформа. В ремаркето/ платформата контейнерите трябва да са обезобасени посредством стоманени вериги или дървени клинове.

Предвид тежкия товар, нужно е да се използва товароподемен кран, за да се натоварят и разтоварят контейнерите от и на ремаркето/ платформата. Трябва да се използват подходящи съоръжения за повдигане с подходящи стоманени вериги, закрепени за контейнера. Гравитационните центрове са означени на контейнерите.

Преди складиране проверете контейнерите за повреди.
Повредите да се докладват на отговарящите представители на купувача, както и на Südkabel.

ВЯРНО С ОРИГИНАЛА

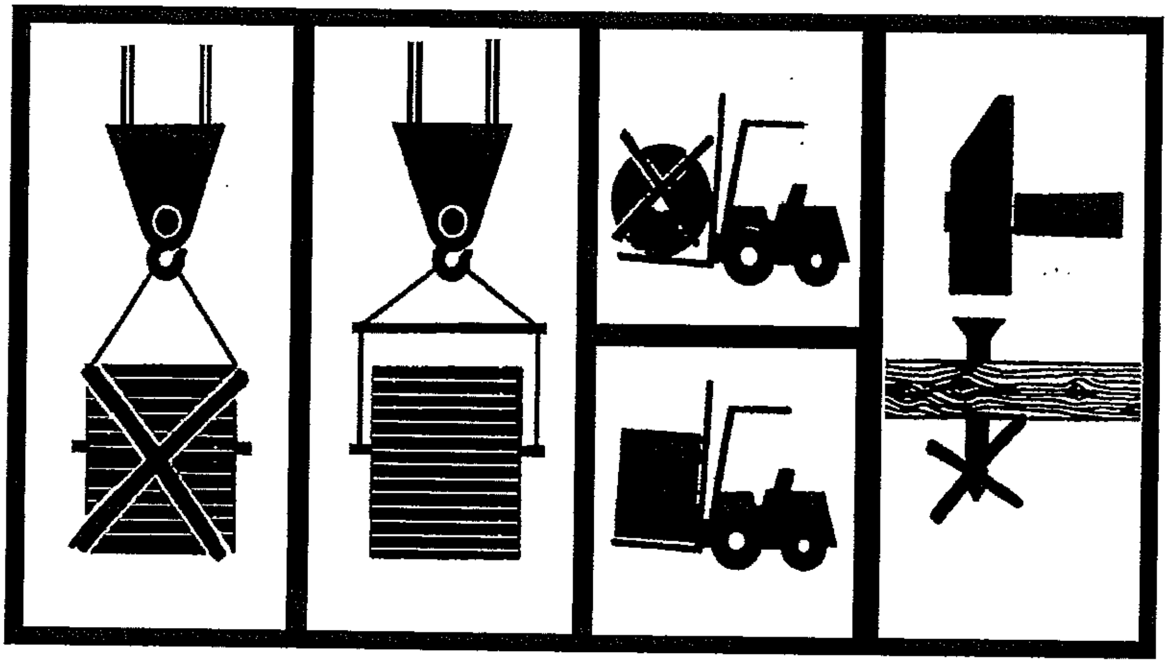
ООД РУДИН Стара Загора

След като контейнерите са складирани в изправност в контролирана зона за съхранение, те ще бъдат обслужени и разопаковани в присъствието на супервайзор от Südkabel, който ще контролира монтажната дейност.

Съхранение на кабелните барабани

Всеки барабан трябва да се съхранява върху твърда и суха повърхност. Барабаните да се съхраняват в ограден и 24 часово охраняем склад и да са добре защитени против механични повреди и UV- радиация.
Повредите да се докладват на отговарящите предствители на купувача, както и на Südkabel.

Фиг. 1 Инструкции за пренасяне



Съхранение на арматурата

Заедно с кабелите в контейнери ще бъде доставена и кабелна арматура. Трябва да се провери внимателно според подробния опаковъчен лист дали арматурата е изцяло в наличност и дали има повреди по опаковането.
Всяка повреда да се докладва незабавно на отговарящите представители на купувача, както и на Südkabel .

Условия за съхранение

- XLPE кабел - без ограничения
- Арматура - на закрито

ВЯРНО С ОРИГИНАЛА
Подпис: ....

ООД РУДИН Стара Загора

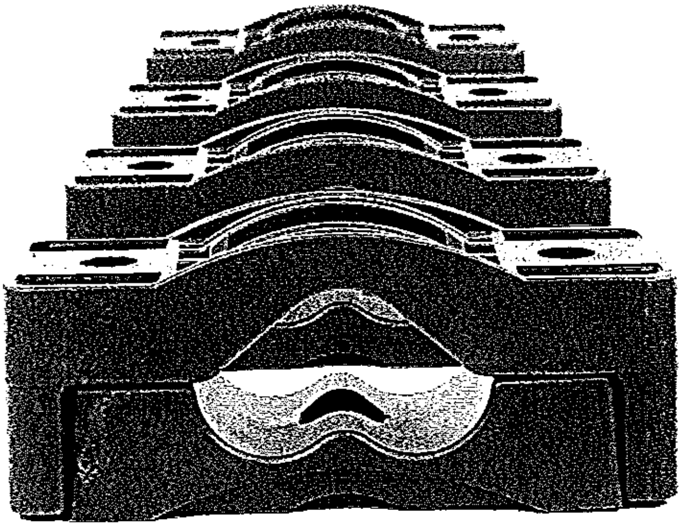
- контролирана температура
- на сухо
- да не се излага на пряка слънчева светлина

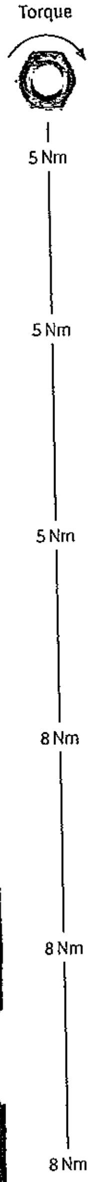
СКОБИ ЗА ЗАКРЕПВАНЕ НА КАБЕЛ

КАТАЛОГ И ТЕСТОВИ ИЗПИТАНИЯ

Dutchclamp®

Cable clamps - Cable blocks





Triple Type 27 - 38

Triple Type 38 - 51

Triple Type 51 - 69

Triple Type 69 - 90

Triple Type 90 - 118

Triple Type 118 - 150

Dutchclamp® Triple cable clamps are specially designed for short-circuit resistant fastening of of cables in trefoil applications. Triple types are available in 6 models and suitable for cables with a diameter from 27 mm to 150 mm.

Dutchclamp® Triple cable clamps are unique in their kind. The surfaces wherein the cables come to lie ensure perfect pressure distribution and maximum grip on the cables without sharp edges. In this way, there is no point load on the cables and the cables are not damaged. The Triple cable clamps are also stackable. Dutchclamp® Triple cable clamps are manufactured from the highest quality glass fibre reinforced polyamide and are therefore ideally suited for installations where high short circuit forces may occur.

The unique raw material used in manufacturing these cable clamps, makes them resistant to corrosion, ozone, frost, heat, oil, acids, salts, aggressive chemicals, UV and nuclear radiation. There is no reduction in force within temperatures from -40° C to + 125°C (momentarily up to 225°C).

Dutchclamp® Triple cable clamps have been tested by, among others, **UL (The Underwriters Laboratories U.S.A)**, **Voltalab** in Grenoble **(Schneider)**, the **Prof. Ir. Damstra laboratory (Eaton) KEMA** and **SGS Brussels** in accordance with the **NEN-EN-IEC 61914:2009** international standard. (All test reports are available upon request).

Dutchclamp® Triple cable clamps are used worldwide and are therefore available from stock. They can also be supplied with appropriate fastening material.

ВЯРНО С ОРИГИНАЛА

ООД

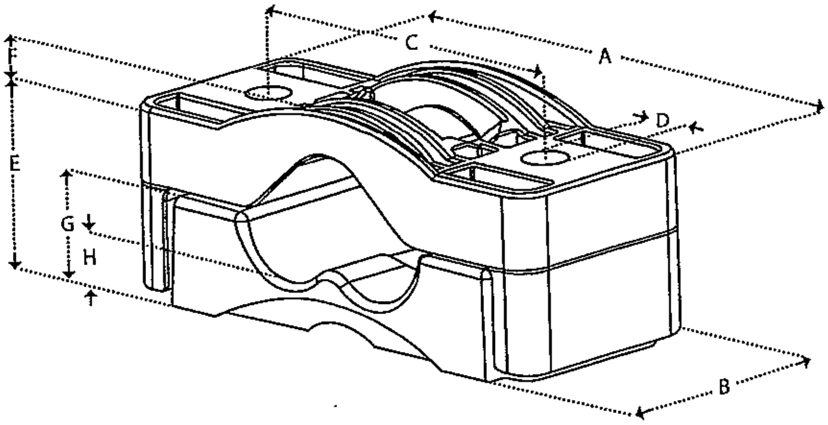
Стара Загора

Dutchclamp®

Cable clamps - Cable blocks

Certified in accordance with the NEN-ENIEC 61914:2009 international safety standard

Dutchclamp has been developing and producing innovative cable clamps and cable blocks for installation of low, medium and high voltage cables since 1982. The clamps have been designed in close collaboration with major energy companies. Dutchclamp is globally renowned for its quality, service and reliability. The Dutchclamp cable clamps and cable blocks are now being successfully used in more than 50 countries around the world.



Dimensions in mm.									
Type	cable ø	A	B	C	D	E	F	G	H
TRIPLE 27 - 38	3x 27 - 38	180	75	125	15.5	63	12	35	16.5
TRIPLE 38 - 51	3x 38 - 51	195	80	145	15.5	84	16	45	20
TRIPLE 51 - 69	3x 51 - 69	220	85	170	15.5	109	21	58	26
TRIPLE 69 - 90	3x 69 - 90	252	90	215	15.5	134	29	72	30
TRIPLE 90 - 118	3x 90 - 118	321	100	270	15.5	180	27	89	33
TRIPLE 118 - 150	3x 118 - 150	400	110	340	15.5	211	37	110	75

e design

By way of the specific unique model, each type of cable clamp provides an exact fit for the required short-circuit resistant installation.

The raw material

Dutchclamp cable clamps are produced from high-quality virgin raw materials, with glass fibre reinforced polyamide as the main ingredient. The Dutchclamp cable clamps are self extinguishing and halogen free.

Robustness

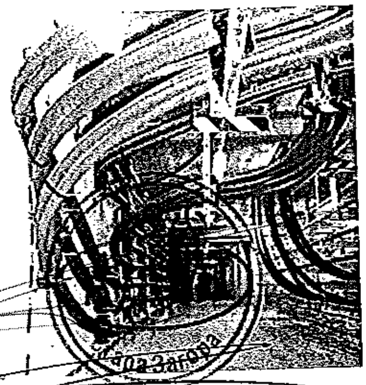
Owing to the unique design combined with the specific composition of the raw materials, these plastic cable lamps are among the strongest in the world. They are specially designed to withstand the enormous forces that occur during short circuiting and have been tested by various laboratories.

Tests

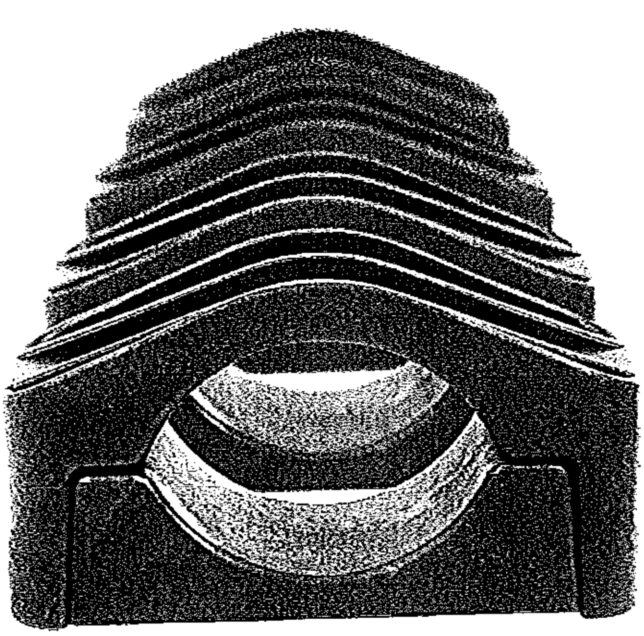
The cable clamps have been tested by, among others, UL (The Underwriters Laboratories U.S.A), Prof. Ir. Damstra Laboratory (Eaton), Volta laboratory in Grenoble (Schneider), KEMA and SGS Brussels, in accordance with the NEN-EN-IEC 61914:2009 international standard. (all test reports are available upon request)

ADVANTAGES

- Resistant to short-circuit currents / forces up to 150 Ka.
- Resistant to oils, fats, aggressive chemicals, frost, heat, UV, ozone, salt, moisture, acids, and nuclear radiation.
- Self-extinguishing V-0 (UL94), Halogen free.
- Temperature range from -40 °C to 125°C. (225°C) momentarily.
- Coloured black.
- No magnetism / conductivity.
- Custom mounting available.
- Fastening materials can be supplied to size.
- No oxidation / corrosion.
- No sharp angles.
- Recyclable.
- Lifetime warranty.
- Very simple installation.
- Available worldwide.
- Stackable.
- Certified in accordance with NEN-EN-IEC 61914:2009



#Dutchclamp®
Cable clamps - Cable blocks



Torque


VHWs h#8:59

8#Qp


VHWs h59:6;

8#Qp


VHWs h69:85#

8#Qp


VHWs h83#8

8#Qp


VHWs h# 8:433

8#Qp


VHWs h433:58

;#Qp


VHWs h68:4: 3

;#Qp

Gxwfkfodp s1#/H#fdeoh#fodp s v#duh#shfldo#ghvljqhg#ru#krogl#fxlwhvlvwdqfhdwxqlqj# rilqj#dq#ru#xolfruhp#hglxp#dqg#klj k#rodj h#fdeohv1#/H#s hv#duh#dyd#doeoh#lq#p rgho#dqg#xlvdeoh#ru#fdeohv#lvk#gldp hwhuv#ur p#8#p p#wr#: 3#p p 1

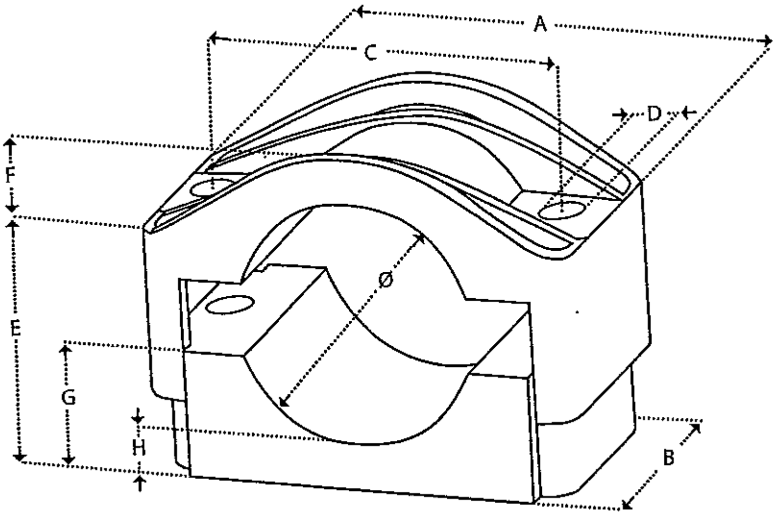
Gxwfkfodp s1#/H#fdeoh#fodp s v#duh#qlt xh#q#khlu#lqg#Wkh#xudfhv#khuh#q#kh#fdeohv# frp h#lq#frqwdfw#zlwk#khuh#v#uhwxuh#glvwulexwlrq#dqg#p d{lp xp#jus#q#kh#fdeohv#lvkrxw# vkdus#hgj hv#q#klvk#d|/#kh#v#wr#q#r lqw#dg#q#kh#fdeohv#dqg#kh#fdeohv#duh#qrw# gdp dj hg1Gxwfkfodp s#/H#fdeoh#fodp s v#duh#p dqxidfwxuhg#ur p#kh#klj khvw#xdd#|#/#j odvv# ileuh#hlqirufhg#r ¢dp lgh#dqg#duh#khuhir uh#ghdo#ixlvhg#ru#lqwhqvlr qv#khuh#hu|#klj k# vkr uwflufxlw#r ufhv#p d|##ffxu1

Wkh#qlt xh#dz#p dwhuldo#vhg#q#p dqxidfwxulqj#kh#fdeoh#fodp s v#p dnhv#khp#hvlvwdqw# wr#frurvlr q/#}r qh/#ru#vwkhdv#lq#iflgv#dov#j uhdvh#khp lfdov#dqg#pxfohdu# radiation. There is no reduction in force within temperatures from -40° C to + 125 ° C. (225 °C p r p hqwdu|,1

Gxwfkfodp s1#/H#fdeoh#fodp s v#kdyh#hhq#whvwhg#e|#/#lp r qj#vkhuv/#KO#Wkh# Xqghuz ulwhuv#Oder udwr uhv#K WO/#kh#ur i1#u#Gdp vwd#der udwr u|#Hdwq/#r odqg# J uhqr eoh#Vfkqhlghu#dqg#J V#Euxvvho#q#fr ugdqfh#z lwk#kh#QHQ#HQ#LHF#94<47=533<# lqwhuqdwlr qdo#wdqgdug1#Dw#vwhs r uwv#duh#dydlodeoh#s r q#ht xhvw1

Gxwfkfodp s1#/H#fdeoh#fodp s v#duh#vhg#z r uog#lgh#dqg#duh#khuhir uh#dydlodeoh#ur p# wrfn1#Wkh|#dq#dov#eh#xss olhg#z lwk#s ur s uldwh#dwdqlqj#p dwhuldo1

Dutchclamp®
Cable clamps - Cable blocks



Certified in accordance with the NEN-ENIEC 61914:2009 international safety standard

Dutchclamp has been developing and producing innovative cable clamps and cable blocks for installation of low, medium and high voltage cables since 1982. The clamps have been designed in close collaboration with major energy companies. Dutchclamp is globally renowned for its quality, service and reliability. The Dutchclamp cable clamps and cable blocks are now being successfully used in more than 50 frxqwulhv#durxqg#wkh#zruog1

Dimensions in mm									
Type	cable ø	A	B	C	D	E	F	G	H
SE 15 - 26	15 - 26	77	45	50	10	26 - 42	4	17	8
SE 26 - 38	26 - 38	92	60	60	12	33 - 49	7	18	7
SE 36 - 52	36 - 52	105	60	75	12	39 - 55	15	23	8
SE 50 - 75	50 - 75	126	60	95	12	46 - 71	22	30	9
SE 75 - 100	75 - 100	200	80	150	15	70 - 95	32	45	10
SE 100 - 135	100 - 135	225	85	175	15	85 - 120	43	58	10
SE 135 - 170	135 - 170	260	90	210	15	133 - 169	62	90	28

Ghvljq

E| #d #i#wkh#vshfliif #xqlt xh#p rghoh#dfk#vsh# i#dedh# fodp s #ru ylgh#dq#hdvlvr uwkh#t xluhg#kr uuf lufxlw# uhvwdqvlqwdeolvr q1

Vkh#dz #p dwhuldo

Gxwfkfodp s#dedh#fodp s#duh#surgxfhg#ur p #kljk0t xdolw| #yluj lq#dz #p dwhuldo/#zklfk#dowr#ehu#hlqir ufhg#r rodp lgh# dv#wkh#p dlq#qj uhglhqw#Wkh#Gxwfkfodp s#dedh#fodp s#duh# vhd#{wlqj xlvklqj #dqg#kdoj hq#uhh1

Ur exwqhvv

Rzlqj #wr#wkh#xqlt xh#ghvlj q#fr p elqhg#zlwk#wkh#vshfliif # fr p sr vlwlr q#i#wkh#dz #p dwhuldo/#wkh#fdeoh#fodp s#duh# p vwlwh#p r qj #wkh#wr qj hvw#q#wkh#z r ugo1#Wkh| #duh# vshfldo#ghvlj qhg#wr#zlwkwdqg#wkh#hqr up r xv#iruf hv# wkdw#ffxu#gxulqj #kr uwfluf xlwlqj #dqg#kdyh#ehhq#whvwhg#e| # ydulr xv#ode r udwr ulhv#

Whvw

Wkh#dedh#fodp s#kdyh#ehhq#whvwhg#e| #dp r qj #rwkhuv#KO -#Wkh#Qhwkhu odqgv/#Oder udwr ulhv#X1V1D/#Eu lwlvk#Gdp wd Oder udwr u| #+Hqjodqg,/#Fr qvxowlqj #dqg#Dqdo| wlfdo#ode r udwr u| #Q|Z#+Vkhqj#Kxdqj /#Fklqd,#dqg#J H#Dehu wkh#qj hqhhuv/#Lqgld#/#Fr qdhvwlqj /#Dqg#JLVD#+Lqgld,#kdv#eh wkh#QHQ0HQ0LHF#94<47=533<#dqg#lqwhuqdwlrqdo#Hw#dqgdugv#Hvwdeolvkhg#eu#wkhp #Wkhvwhv#vkrz#wkh#iroorzlqj

DGYDQWDJHV

|#Uhvlvwdqfh#wr#kr uwflufxlw#fxuuhqw# xs#wr#535#Nd1

|#Uhvlvwdqfh#wr#lqvlgdwlqj j uhwlyh# fkhp lfdov#ru #wkhdwh#XY#}r qh# vdow#p r lvwxuh#dqg#fxflqdu# udgldwlr q1#

|#Vhoi0h{wlqj xlvklqj #XO#XO<7,# Kdoj hq#uhh1

|#Whp shudwxuh#udqj h#ir u#p #073#F#wr# 458#F#558#F#p r p hqwdu| ,1

|#Fr orxuhg#edfn1

|#Qr#p dj qhwlvp #ru#frqgxfwlylw|1

|#Fxvwrp#p rxqwlqj #dydlodeoh1

|#I dvwhqlqj #p dwhuldov#dqg#eh# vxssolhg#wr#W}h1

|#Qr#{lgdwlrq#ru#fruurvlrq1

|#Qr#wkdus#hgjhv1

|#Uhf|foedeoh1

|#Qlfhvp#hz#dudqw|1

|#Yhu|#lp soh#lqwvdoodwlr q1

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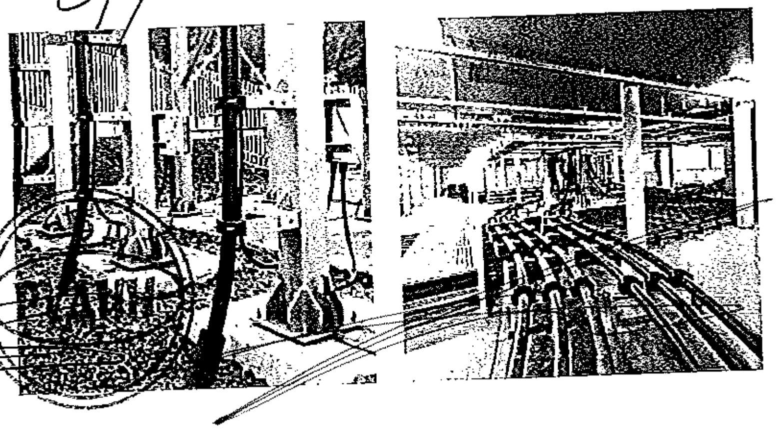

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KEMA

REPORT OF PERFORMANCE TIC 2505-14

OBJECT	Cable clamp
TYPE	Dutchclamp - Cable Clamp SERIAL No. Triple 38-51, Triple 27-38 60/80 kApeak at 80 cm clamp distance
CLIENT	Dutchclamp, Dordrecht, The Netherlands
MANUFACTURER	Dutchclamp, Dordrecht, The Netherlands
TESTED BY	KEMA Nederland B.V., Arnhem, The Netherlands
DATE(S) OF TESTS	3 July 2014
TEST SPECIFICATION	The tests have been carried out in accordance with the client's instructions.

This report applies only to the object tested. The responsibility for conformity of any object having the same type references as that tested rests with the manufacturer.

This report consists of 30 pages in total.

KEMA Nederland B.V.

S.A.M. Verhoeven
Director Testing, Inspections & Certification The Netherlands

Arnhem, 11 August 2014

ВЯРНО С ОРИГИНАЛА

ООД ГУДАЙН Стара Загора

INFORMATION SHEET

1 Certificate

A Certificate contains a record of a series of type tests carried out strictly in accordance with a recognized standard. The equipment tested has fulfilled the requirements of this standard and the relevant ratings assigned by the manufacturer are endorsed by KEMA. The Certificate is applicable only to the equipment tested. KEMA is responsible for the validity and the contents of the Certificate. The responsibility for conformity of any object having the same type references as the one tested rests with the manufacturer. The Certificate contains the essential drawings and a description of the equipment tested.
Detailed rules are given in KEMA's Certification procedure.

2 Report of Performance

A Report of Performance contains a record of one or more tests which have been carried out according to the client's instructions. These tests are not necessarily in accordance with a recognized standard. The test results do not verify ratings of the test object.
KEMA issues three types of Reports of Performance:

2.1 The tests have been carried out strictly in accordance with .... The apparatus has complied with the relevant requirements.

This sentence will appear on the front page of a Report of Performance if the tests have been performed in accordance with a recognized standard, but the series of tests does not completely fulfil the requirements for a Certificate of Compliance (for example, if the number of test duties is not a complete series of type tests). The Report contains verified drawings and a description of the equipment tested. Detailed rules are given in KEMA's Certification procedure. The condition of the test object after the tests is assessed and recorded in the Report.

2.2 The tests have been carried out in accordance with the client's instructions. Test procedure and test parameters were based on ....

This sentence will appear on the front page of a Report of Performance if the number of tests, the test procedure and the test parameters are based on a recognized standard and related to the ratings assigned by the manufacturer. If the apparatus does not pass the tests such behaviour will be mentioned on the front sheet. Verification of the drawings (if submitted) and assessment of the condition after the tests is only done on the client's request.

2.3 The tests have been carried out according to the client's instructions.

This sentence will appear on the front page of a Report of Performance if the tests, test procedure and/or test parameters are not in accordance with a recognized standard.

3 Standards

When reference is made to a standard, and the date of issue is not stated, this applies to the latest issue, including amendments which have been officially published prior to the date of the tests.

4 Official and uncontrolled test documents

The official test documents of KEMA High-Power Laboratory are issued in bound form. Uncontrolled copies may be provided as loose sheets or as a digital file for convenience of reproduction by the client. The copyright has to be respected at all times.

5 Accuracy of measurement

In the table of test results the measured quantities are given in three digits. This method of presentation does not indicate an accuracy. The guaranteed uncertainty in the figures mentioned, taking into account the total measuring system, is less than 5%, unless mentioned otherwise.

ВЯРНО С ОРИГИНАЛА

Подпис: ....

ООД РУДАНИ Ст.Загора

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1 Identification of the object tested ... 4
1.1 Ratings/characteristics of the object tested ... 4
1.2 Description of the object tested ... 4

2 General Information ... 5
2.1 The tests were witnessed by ... 5
2.2 The tests were carried out by ... 5

3 Legend ... 6

4 Summary of tests ... 7

Serial No. Triple 38-51

5 Short-time current test ... 10
5.1 Condition before test ... 10
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6 Short-time current test ... 16
6.1 Condition before test ... 16
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Serial No. Triple 27-38

7 Short-time current test ... 22
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7.4 Test results and oscillograms ... 25
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ВЯРНО С ОРИГИНАЛА

ООД ТРАДИН Стара Загора

version: i

1 IDENTIFICATION OF THE OBJECT TESTED

1.1 Ratings/characteristics of the object tested

Peak withstand current (at 80 cm clamp distance)	60/80 kA

1.2 Description of the object tested

Cable clamp

ВЯРНО С
ОРИГИНАЛА

Подпис: ....

ООД
РУДИН
Стара Загора

2 GENERAL INFORMATION

2.1 The tests were witnessed by

Name	Company
van der Waal, M.	Dutchclamp,
de Waard, B.	Dordrecht, The Netherlands

2.2 The tests were carried out by

Name	Company
Dobbe, N.	KEMA Nederland B.V.,
Ursino, F.	Arnhem, The Netherlands

ВЯРНО С ОРИГИНАЛА

Подпис:

ООД РУДИМ Стара Загора

3 LEGEND

Phase indications

If more than one phase is recorded on oscillogram, the phases are indicated by the digits 1, 2 and 3. These phases 1, 2 and 3 correspond to the phase values in the columns of the accompanying table, respectively from left to right.

Explanation of the letter symbols and abbreviations on the oscillograms

pu	Per unit (the reference length of one unit is represented by the black bar on the oscillogram)
I1TO	Current through test object
I2TO	Current through test object
I3TO	Current through test object
Itank	Tank current test object
U1TO	Voltage across test object
U2TO	Voltage across test object
U3TO	Voltage across test object

ВЯРНО С ОРИГИНАЛА

Подпис:

ООД Стара Загора

4 SUMMARY OF TESTS

Short-time current test								
Test no.			140703 6002					
Peak value of current	R	kA	60,0					
	S	kA	-45,2					
	T	kA	-48,5					
Symmetrical current, beginning	R	kA	22,9					
	S	kA	23,5					
	T	kA	23,5					
Symmetrical current, middle	R	kA	22,0					
	S	kA	22,5					
	T	kA	22,6					
Symmetrical current, end	R	kA	21,5					
	S	kA	22,1					
	T	kA	22,2					
Symmetrical current, average	R	kA	22,4					
	S	kA	22,9					
	T	kA	22,9					
Average current, three phase		kA	22,7					
Current duration	R	s	1,04					
	S	s	1,04					
	T	s	1,04					
Thermal equivalent			20 kA during 1,30 s					

REMARKS	
140703-6002	No visible disturbance.

ВЯРНО С ОРИГИНАЛА

ООД РУДИН Стара Загора

Подпис: ....

Short-time current test								
Test no.			140703 6003					
Peak value of current	R	kA	80,2					
	S	kA	-60,5					
	T	kA	-67,2					
Symmetrical current, beginning	R	kA	31,4					
	S	kA	32,1					
	T	kA	33,0					
Symmetrical current, middle	R	kA	30,7					
	S	kA	31,3					
	T	kA	31,7					
Symmetrical current, end	R	kA	27,6					
	S	kA	27,6					
	T	kA	24,9					
Symmetrical current, average	R	kA	30,9					
	S	kA	31,6					
	T	kA	29,8					
Average current, three phase		kA	30,8					
Current duration	R	s	1,05					
	S	s	1,05					
	T	s	1,05					
Thermal equivalent			30 kA during 1,10 s					

REMARKS	
140703-6003	Heavy emission of flames and gas due to breakdown of cable connection to the supply system. Cable clamps not affected.

ВЯРНО С
ОРИГИНАЛА
Подпис:

ООД
Стара Загора

Short-time current test								
Test no.			140703 6004					
Peak value of current	R	kA	76,6					
	S	kA	-59,3					
	T	kA	-63,8					
Symmetrical current, beginning	R	kA	32,3					
	S	kA	33,0					
	T	kA	32,0					
Symmetrical current, middle	R	kA	30,5					
	S	kA	31,3					
	T	kA	31,0					
Symmetrical current, end	R	kA	31,0					
	S	kA	30,8					
	T	kA	30,6					
Symmetrical current, average	R	kA	31,2					
	S	kA	31,7					
	T	kA	31,2					
Average current, three phase		kA	31,4					
Current duration	R	s	0,518					
	S	s	0,518					
	T	s	0,518					
Thermal equivalent			30 kA during 0,560 s					

REMARKS	
140703-6004	Heavy emission of flames and gas due to breakdown of cable connection to the supply system. Cable clamps not affected.

ВЯРНО С ОРИГИНАЛА

Подпис: ....

ООД РУДИН Стара Загора

5 SHORT-TIME CURRENT TEST

Standard and date

Standard	-
Test date(s)	3 July 2014

5.1 Condition before test

Cable clamp (Serial No. Triple 38-51) new.
Supply to left side of cables.
Short-circuit on right side of cables.

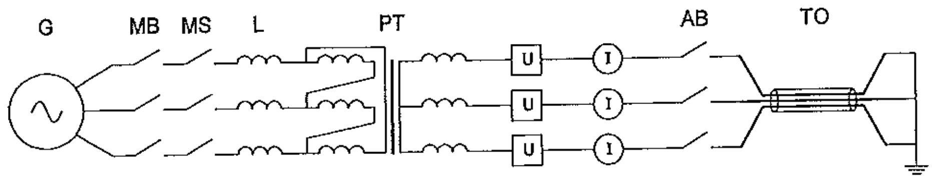
Length of cable used for testing: 8 m.
Three cables used, having a diameter of 50 mm.
Distance between two consecutive cable clamps: 80 cm.
Distance between the cable cores: 50 mm.
Cables in trefoil formation.

ВЯРНО С ОРИГИНАЛА

Подпис: ....

ООД РУАЛИ Стара Загора

5.2 Test circuit S01



G	= Generator	TO	= Test Object	U	= Voltage Measurement to earth
MB	= Master Breaker	L	= Reactor	I	= Current Measurement
MS	= Make Switch				
PT	= Power Transformer				

Supply		
Power	MVA	41
Frequency	Hz	50
Phase(s)		3
Voltage	kV	1,2
Current	kA	20
Impedance	Ω	0,035
Power factor		< 0,1
Neutral		not earthed

Load	
Short-circuit point	earthed

ВЯРНО С ОРИГИНАЛА

Подпис: ....

ООД РУДИМ Стара Загора

Remarks: -

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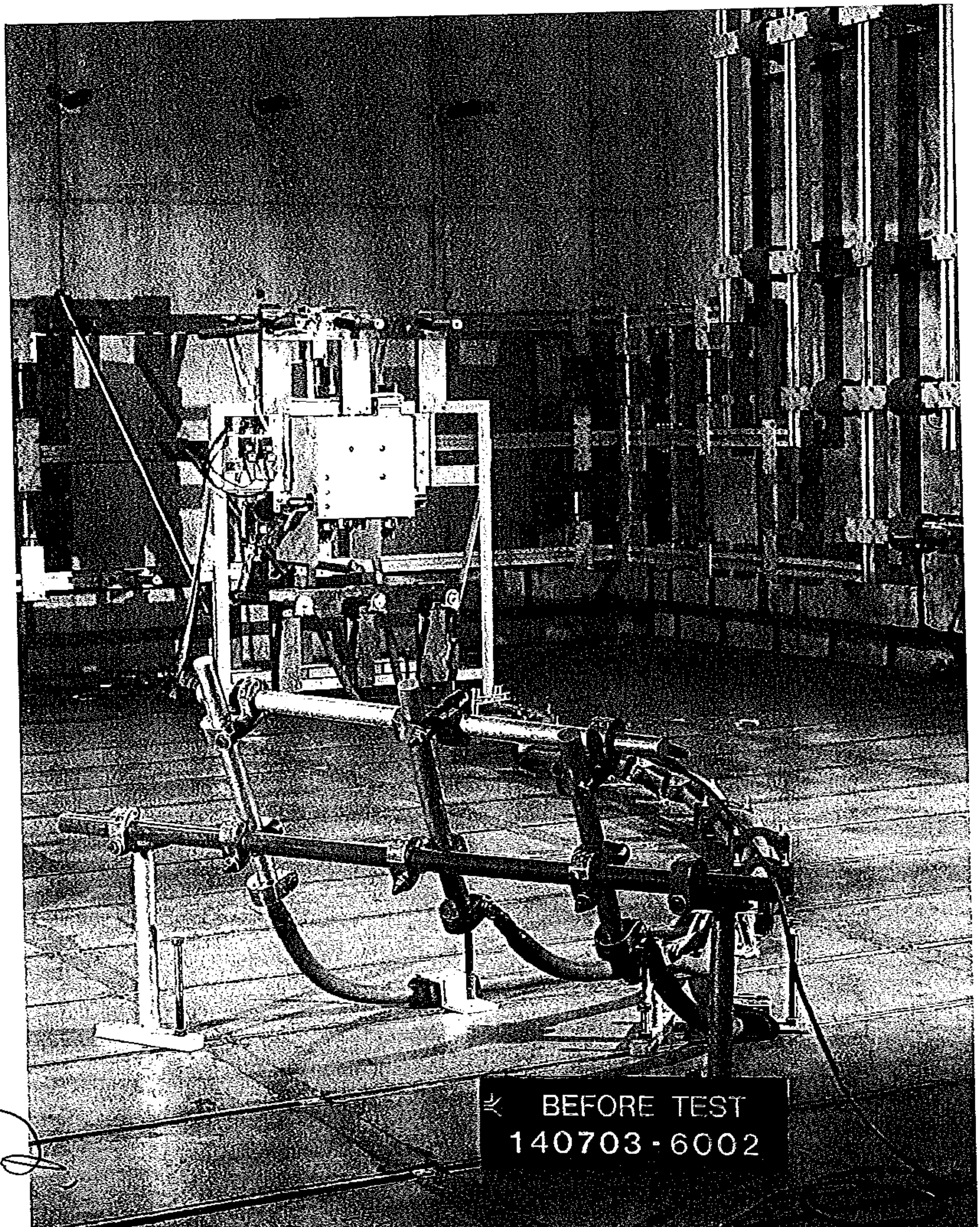
5.3 Photograph before test



ВЯРНО С
ОРИГИНАЛА
ООД
РУАЛМ
Стара Загора

5.4 Test results and oscillograms

Overview of test numbers
140703-6002

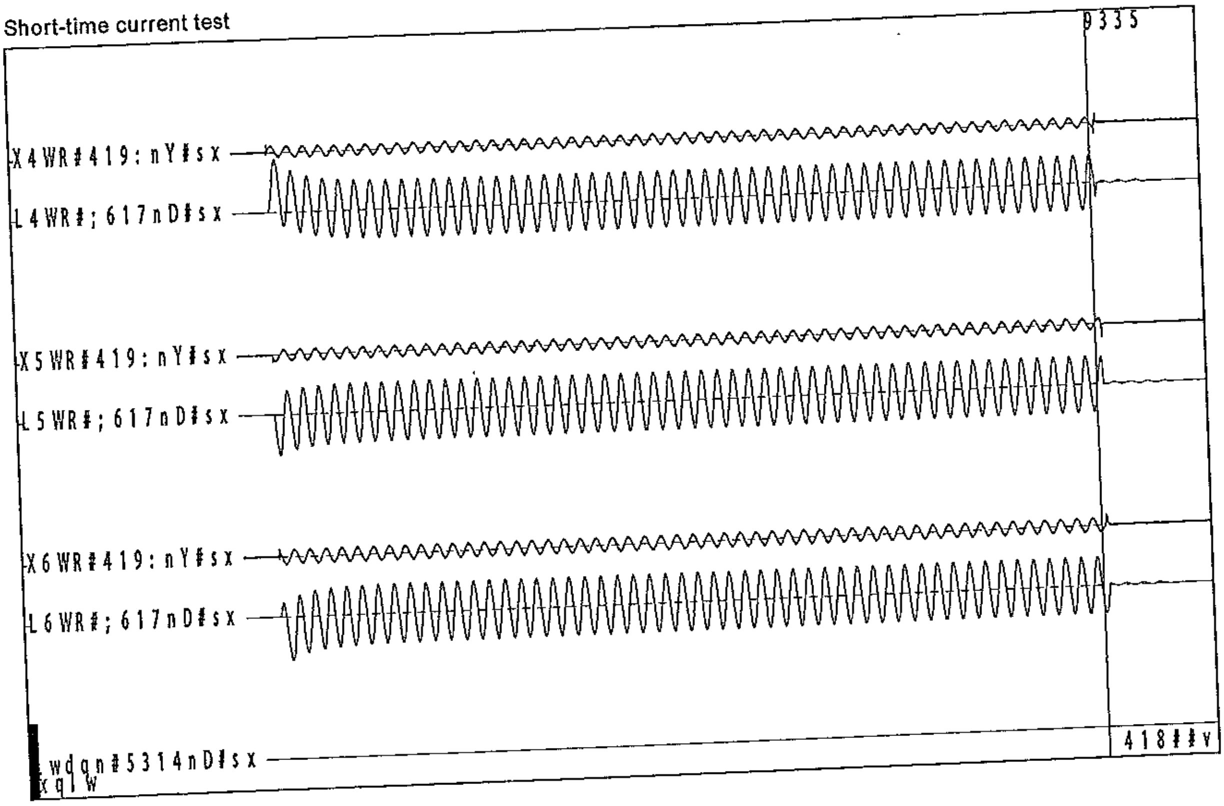
Remarks
-

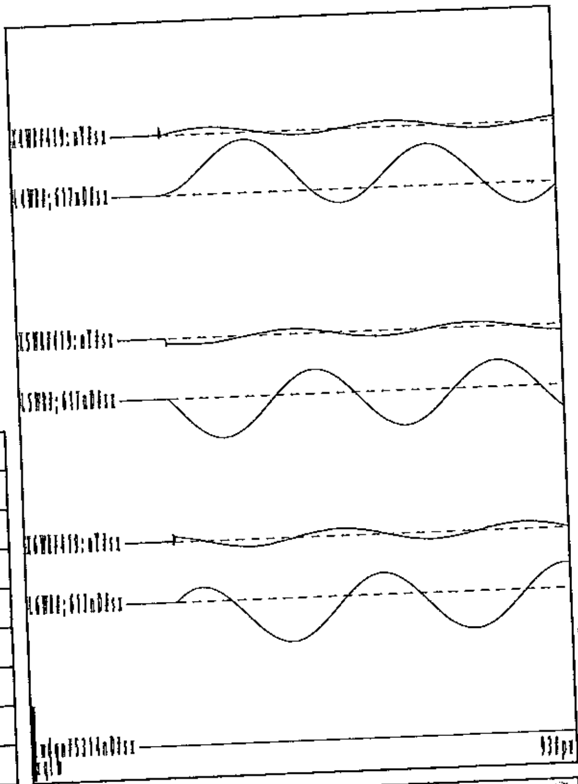
ВЯРНО С
ОРИГИНАЛА

Подпис: ....

ООД
РУДНИК
Стара Загора

Short-time current test





Test number: 140703-6002

Phase		R	S	T
Peak value of current	kA	60,0	-45,2	-48,5
Symmetrical current, beginning	kA	22,9	23,5	23,5
Symmetrical current, middle	kA	22,0	22,5	22,6
Symmetrical current, end	kA	21,5	22,1	22,2
Symmetrical current, average	kA	22,4	22,9	22,9
Average current, three phase	kA	22,7		
Current duration	s	1,04	1,04	1,04
Thermal equivalent		20 kA during 1,30 s		

Remarks: No visible disturbance.

ВЯРНО С ОРИГИНАЛА

ООД Стара Загора

Подпис: ....

5.5 Condition / inspection after test

No cracks observed in cable clamps.

ВЯРНО С
ОРИГИНАЛА

Подпис: ....

Стара Загора

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6 SHORT-TIME CURRENT TEST

Standard and date

Standard	-
Test date(s)	3 July 2014

6.1 Condition before test

Cable clamp (Serial No. Triple 38-51) in same condition.
Supply to left side of cables.
Short-circuit on right side of cables

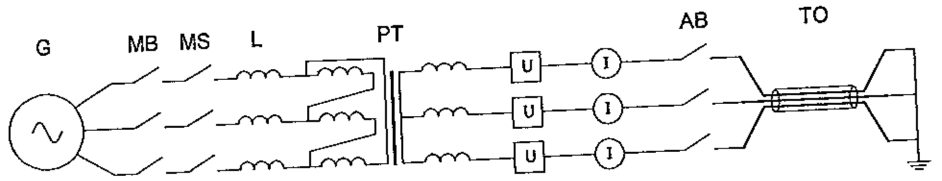
Length of cable used for testing: 8 m.
Three cables used, having a diameter of 50 mm.
Distance between two consecutive cable clamps: 80 cm.
Distance between the cable cores: 50 mm.
Cables in trefoil formation.

ВЯРНО С ОРИГИНАЛА

Подпис: ....

ООД РУДАН Стара Загора

6.2 Test circuit S02



G	= Generator	TO	= Test Object	U	= Voltage Measurement to earth
MB	= Master Breaker	L	= Reactor	I	= Current Measurement
MS	= Make Switch				
PT	= Power Transformer				

Supply		
Power	MVA	41
Frequency	Hz	50
Phase(s)		3
Voltage	kV	1,7
Current	kA	30
Impedance	Ω	0,035
Power factor		< 0,1
Neutral		not earthed

Load	
Short-circuit point	earthed

ВЯРНО С ОРИГИНАЛА

Подпис: ....

ООД

Стара Загора

Remarks:

6.3 Test results and oscillograms

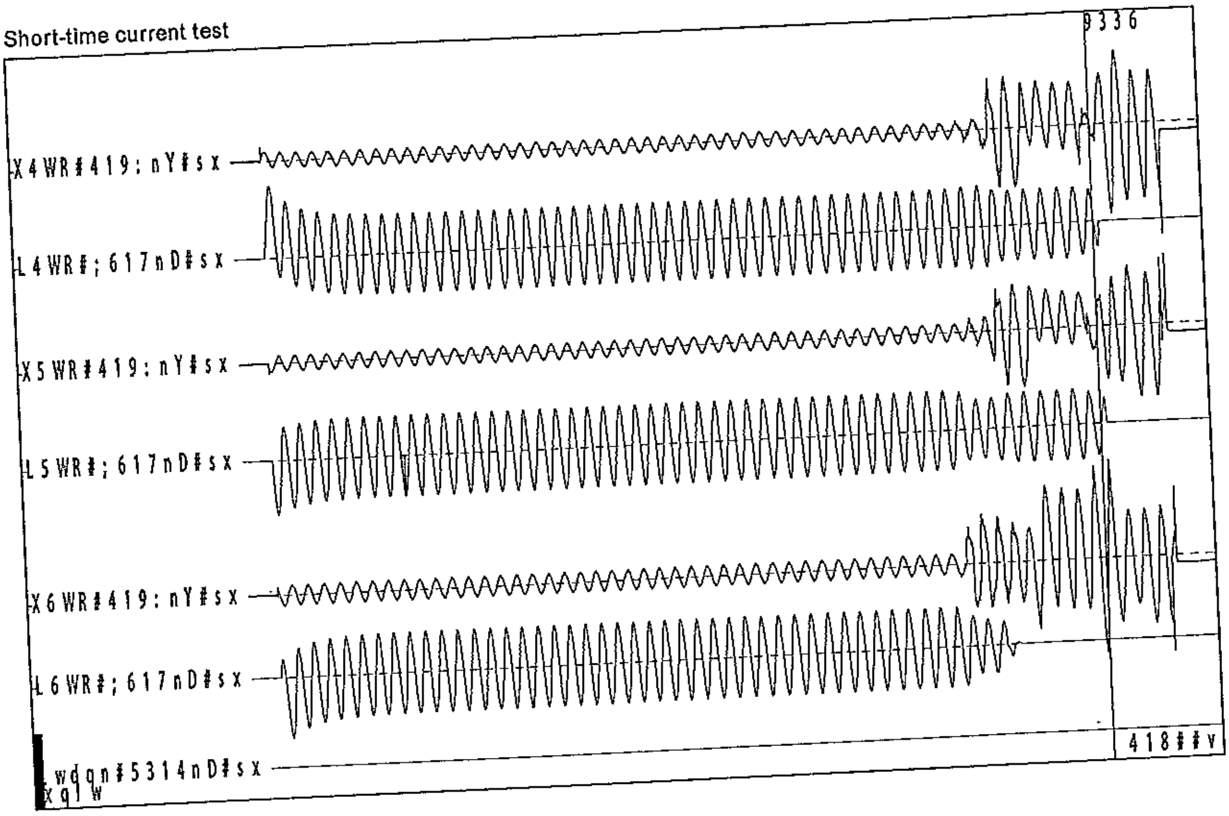
Overview of test numbers
140703-6003

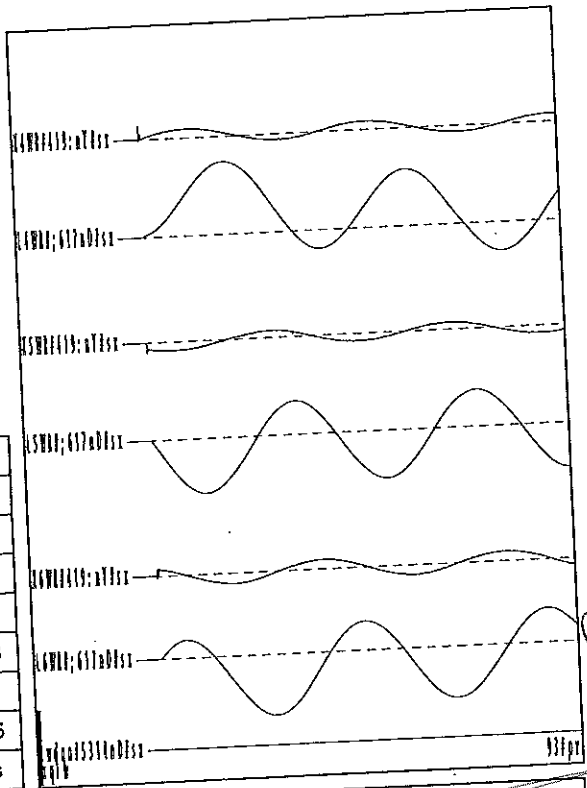
Remarks
-

ВЯРНО С
ОРИГИНАЛА
Подпис: ....

ООД
РУДИН
Стара Загора

Short-time current test





Test number: 140703-6003

		R	S	T
Phase				
Peak value of current	kA	80,2	-60,5	-67,2
Symmetrical current, beginning	kA	31,4	32,1	33,0
Symmetrical current, middle	kA	30,7	31,3	31,7
Symmetrical current, end	kA	27,6	27,6	24,9
Symmetrical current, average	kA	30,9	31,6	29,8
Average current, three phase	kA	30,8		
Current duration	s	1,05	1,05	1,05
Thermal equivalent		30 kA during 1,10 s		

Remarks: Heavy emission of flames and gas due to breakdown of cable connection to the supply system. Cable clamps not affected.

ВЯРНО С ОРИГИНАЛА

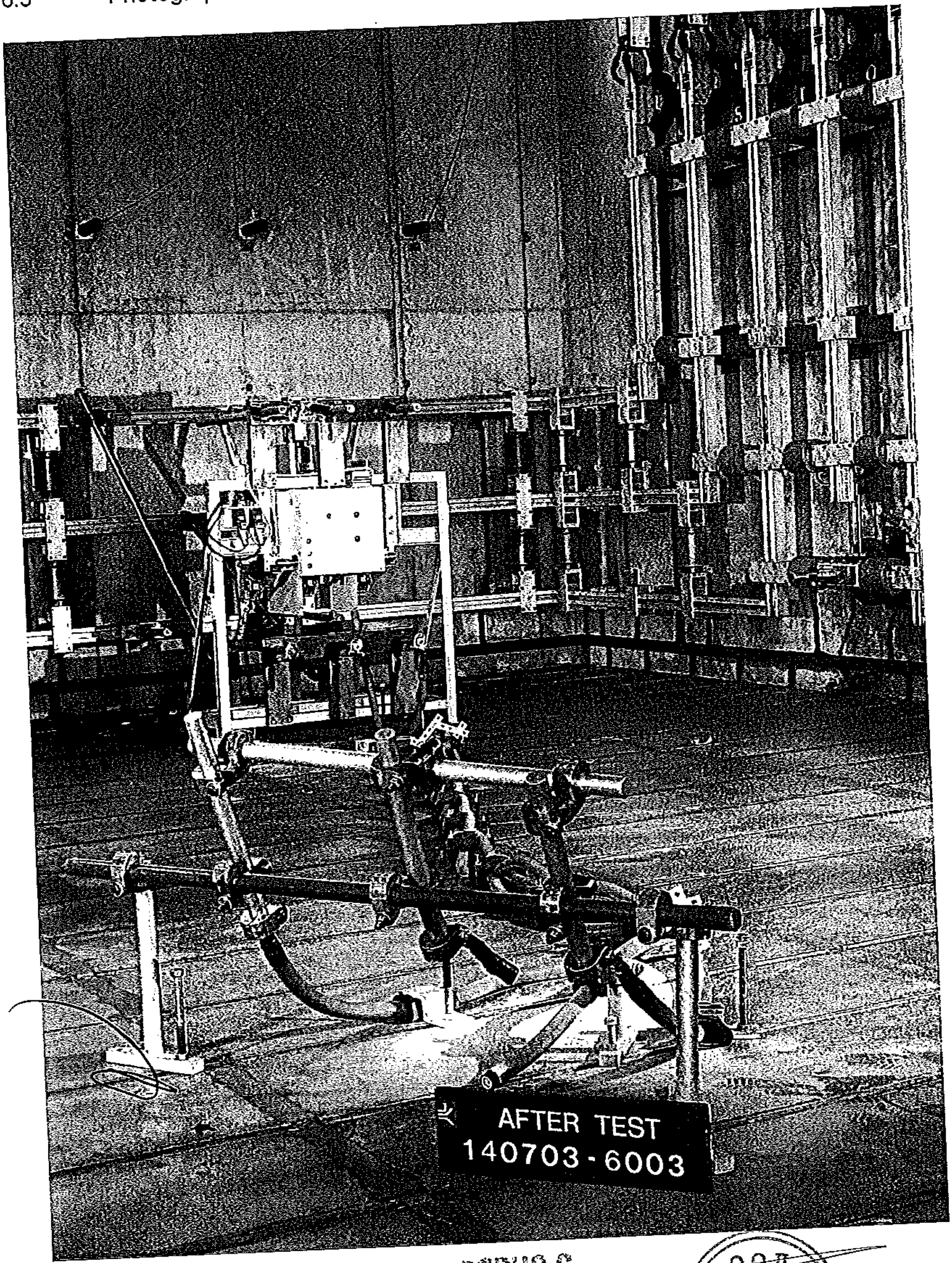
ООД РУДИН Стара Загора

Подпис: ....

6.4 Condition / inspection after test

No cracks observed in cable clamps.

6.5 Photograph after test



ВЯРНО С ОРИГИНАЛА

Подпис: ....

ООД

Стара Загора

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7 SHORT-TIME CURRENT TEST

Standard and date

Standard	-
Test date(s)	3 July 2014

7.1 Condition before test

Cable clamp (Serial No. Triple 27-38) new.
Supply to left side of cables.
Short-circuit on right side of cables.

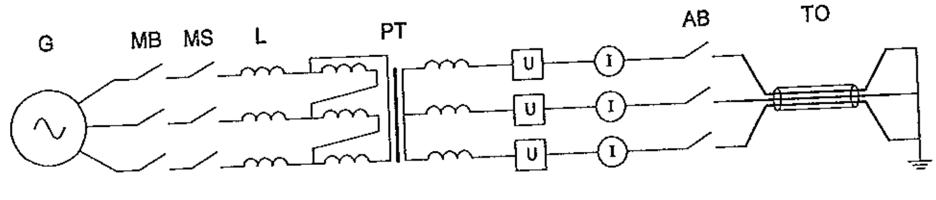
Length of cable used for testing: 8 m.
Three cables used, having a diameter of 38 mm.
Distance between two consecutive cable clamps: 80 cm.
Distance between the cable cores: 38 mm.
Cables in trefoil formation.

ВЯРНО С
ОРИГИНАЛА

Подпис: ....

Стара Загора

7.2 Test circuit S02



G	= Generator	TO	= Test Object	U	= Voltage Measurement to earth
MB	= Master Breaker	L	= Reactor	I	= Current Measurement
MS	= Make Switch				
PT	= Power Transformer				

Supply		
Power	MVA	41
Frequency	Hz	50
Phase(s)		3
Voltage	kV	1,7
Current	kA	30
Impedance	Ω	0,035
Power factor		< 0,1
Neutral		not earthed

Load	
Short-circuit point	earthed

ВЯРНО С ОРИГИНАЛА

ООД

Стара Загора

Remarks: -

Version: 1

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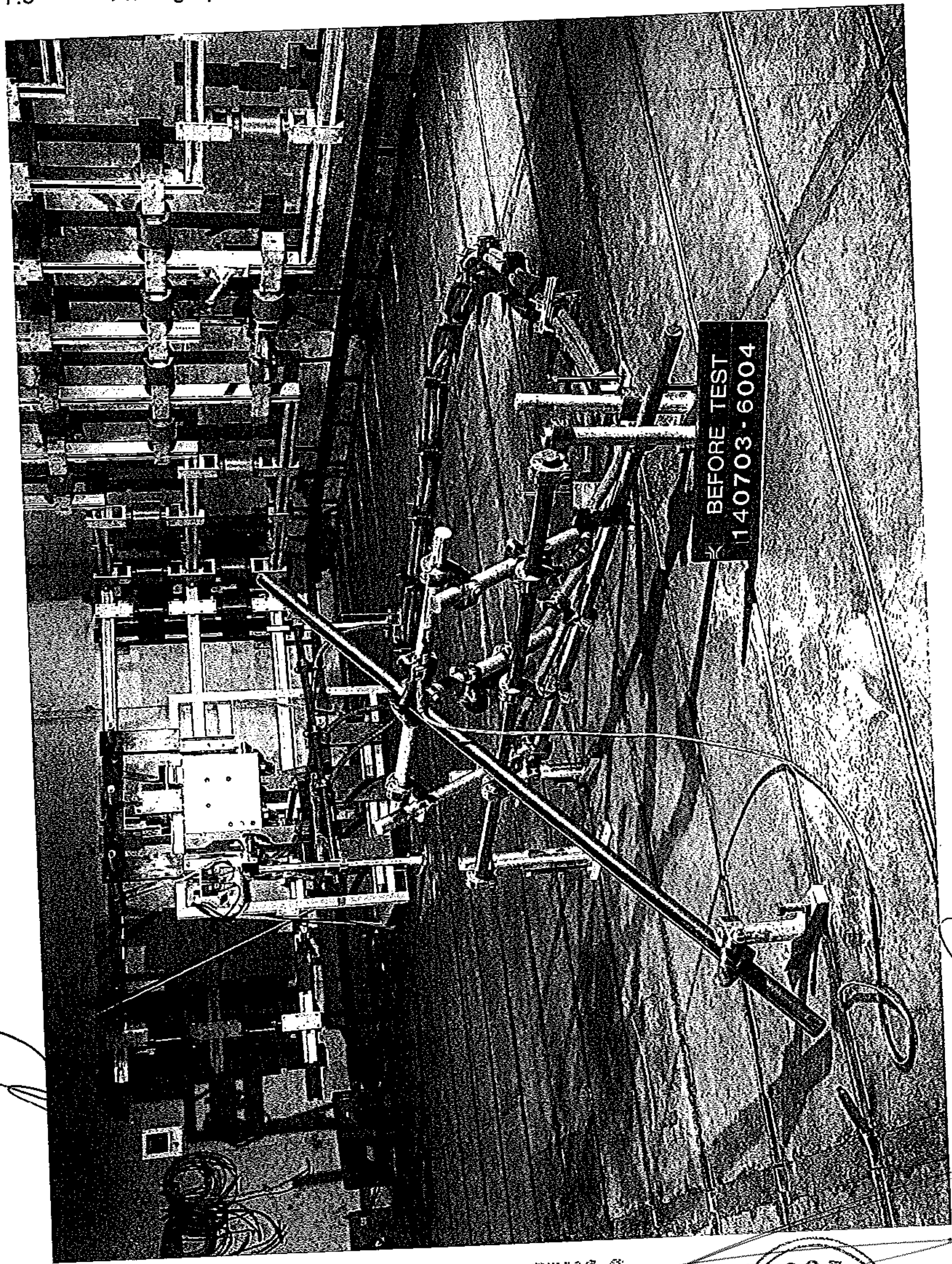
7.3 Photograph before test



ВЯРНО С
ОРИГИНАЛА
Подпис:

ООД
Стара Загора

7.4 Test results and oscillograms

Overview of test numbers

140703-6004

Remarks

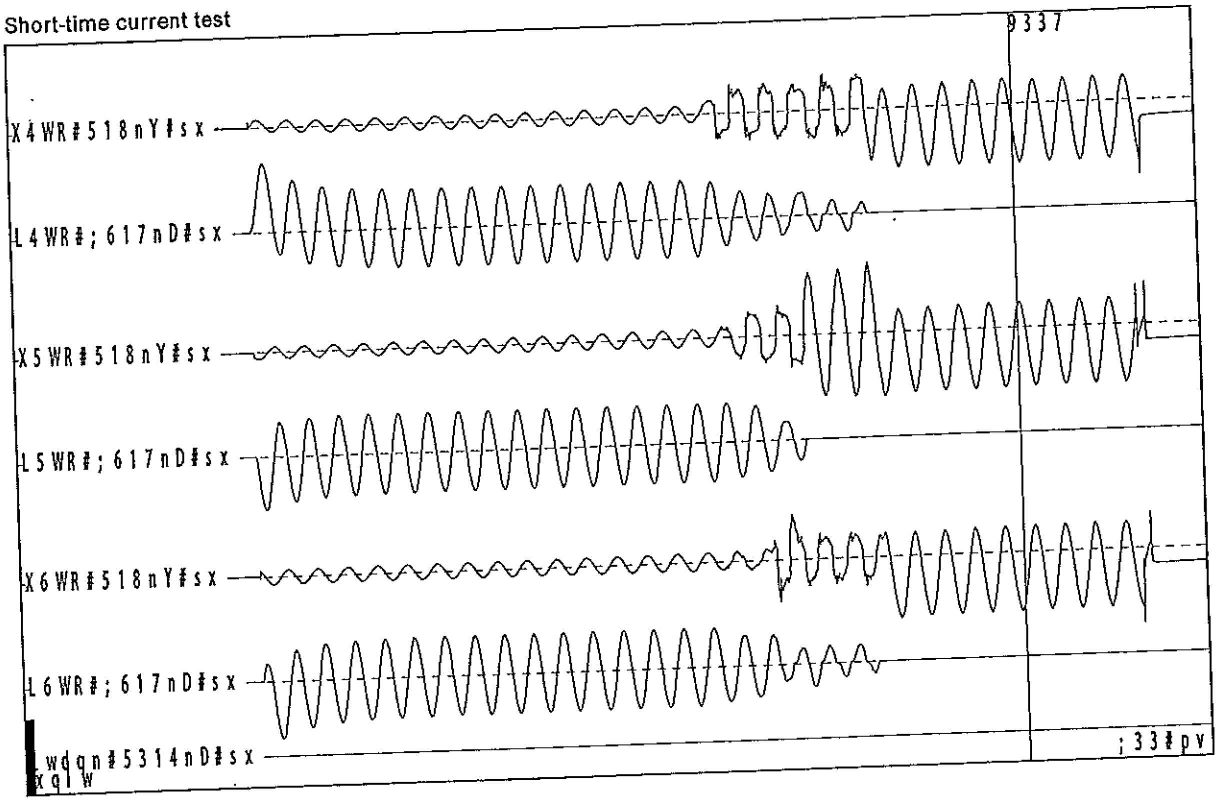
-

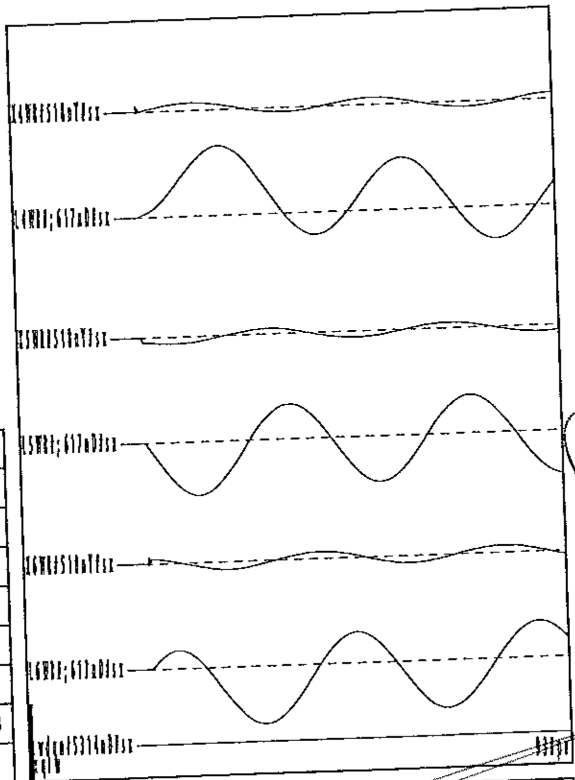
ВЯРНО С ОРИГИНАЛА

Подпис: ....

РУДИН ООД Стара Загора

Short-time current test





Test number: 140703-6004

Phase		R	S	T
Peak value of current	kA	76,6	-59,3	-63,8
Symmetrical current, beginning	kA	32,3	33,0	32,0
Symmetrical current, middle	kA	30,5	31,3	31,0
Symmetrical current, end	kA	31,0	30,8	30,6
Symmetrical current, average	kA	31,2	31,7	31,2
Average current, three phase	kA	31,4		
Current duration	s	0,518	0,518	0,518
Thermal equivalent		30 kA during 0,560 s		

Remarks:	Heavy emission of flames and gas due to breakdown of cable connection to the supply system. Cable clamps not affected.

ВЯРНО С ОРИГИНАЛА

7.5 Condition / inspection after test

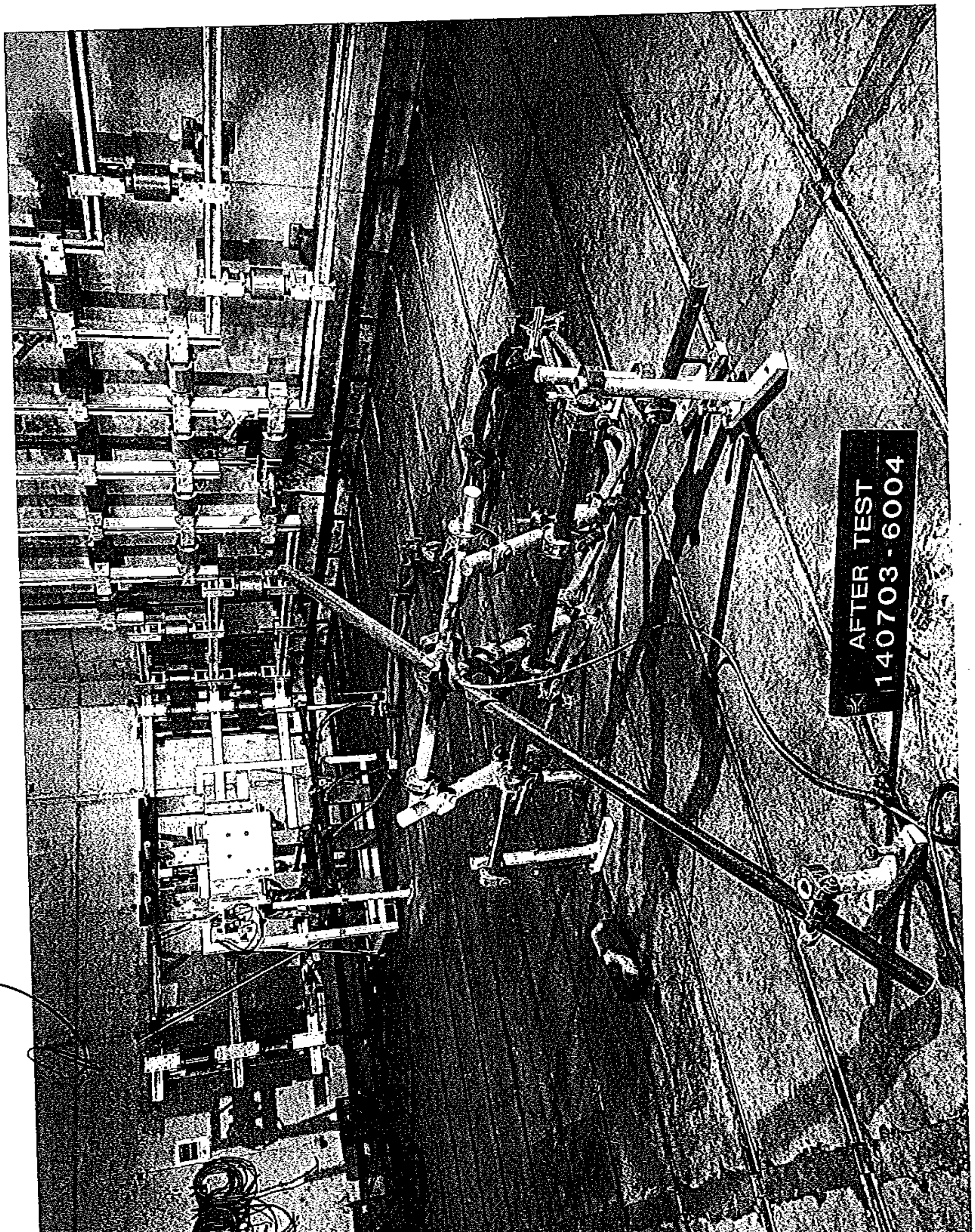
No cracks observed in cable clamps.

ВЯРНО С
ОРИГИНАЛА

Подпис: ....

Стара Загора

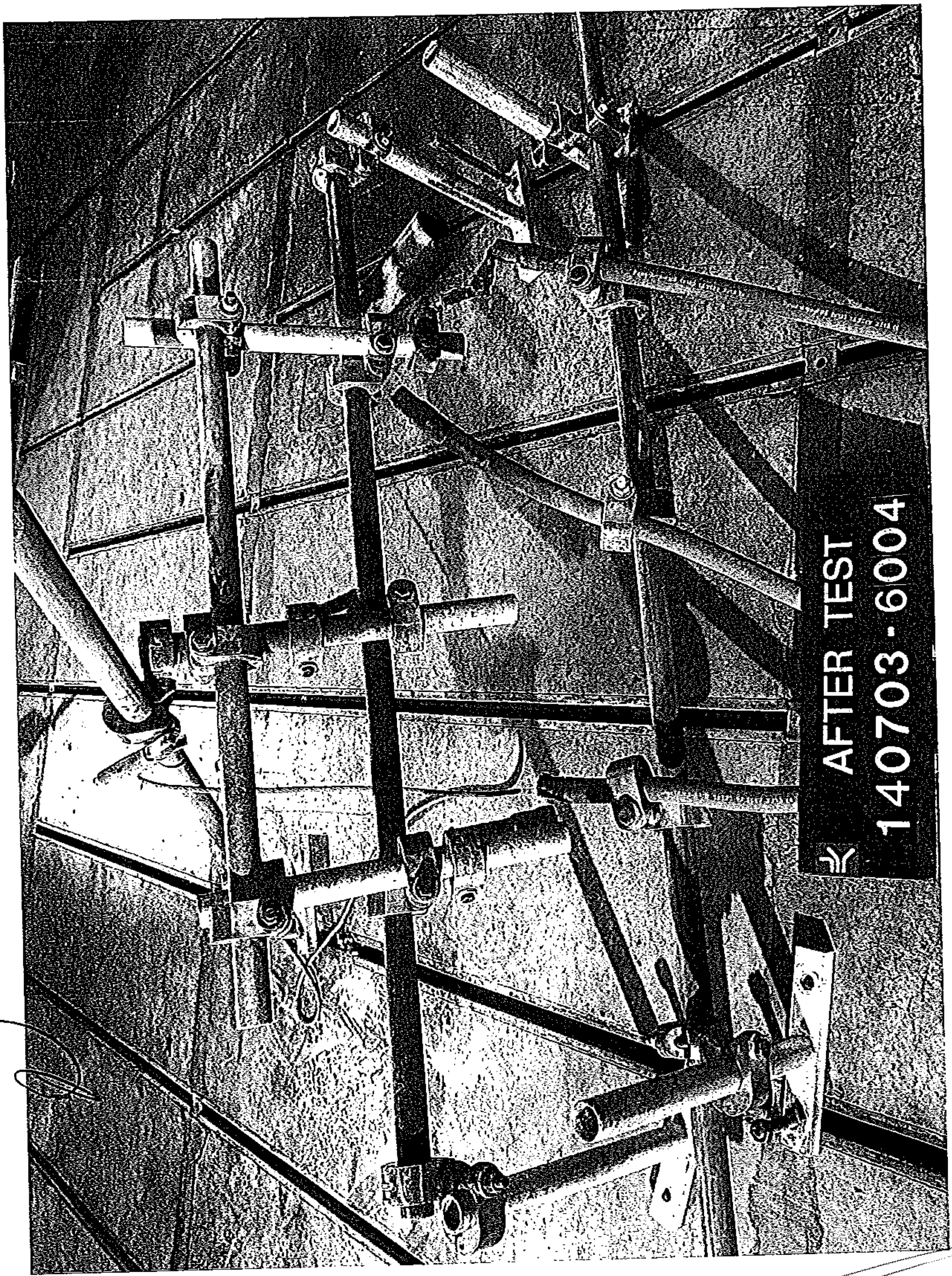
7.6 Photographs after test



Вярно с
оригинала

Подпис:

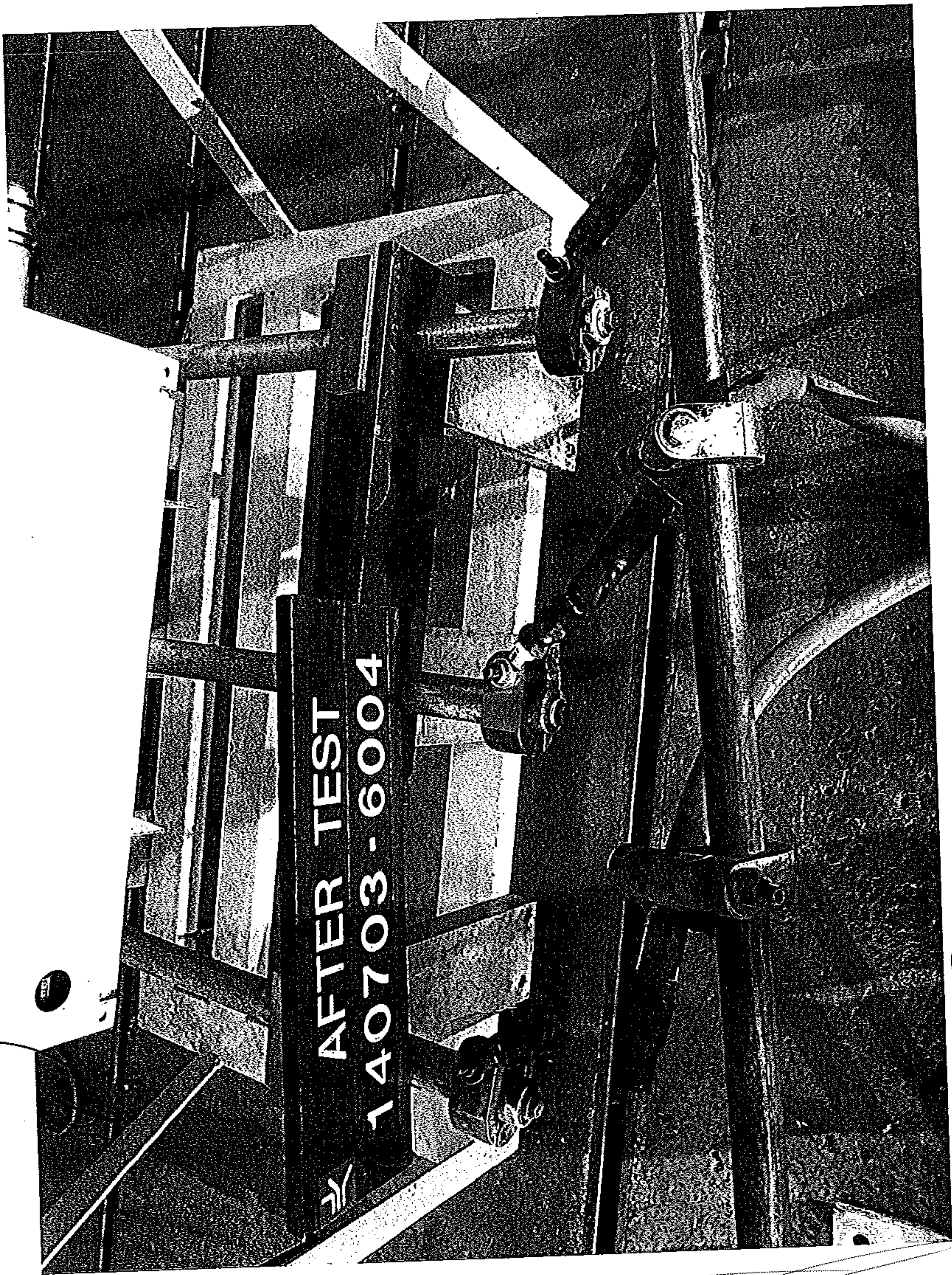
ООД
Стара Загора



ВЯРНО С
ОРИГИНАЛА

Подпис: ....

ООД
Стара Загора



ВЯРНО С
ОРИГИНАЛА

ООД
Стара Загора

Reference: 18564C

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CERTIFICATE OF CONFORMITY

Product: Cable cleats

Tested by request of

Dutchclamp
Egstraat, 1
PO Box 9078
3319 LA DORDRECHT
Netherlands

Manufactured at (name and place)

Dutchclamp
Egstraat, 1
PO Box 9078
3319 LA DORDRECHT
Netherlands

Trade mark (if any): DUTCHCLAMP

Model/Type Ref: See appendix

Ratings and principal characteristics: See appendix

Additional information (if any):

Samples of the products have been tested and found to be in conformity with :

EN 61914:2009, IEC 61914:2009

as shown in the test report 591965.01

This Certificate of Conformity is the result of testing a sample of the product submitted, in accordance with the provisions of the relevant specific standard. It does not imply an assessment of the whole production. Conformity of the produced products with the specimen tested remains on the full responsibility of the manufacturer.

Brussels, 17/10/2013

C. LANA,
Certification Manager.

SGS Belgium NV - Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. D
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

ВЯРНО С
ОРИГИНАЛА
Подпис:

005-PROD

Südkabel GmbH · 68147 Mannheim · GERMANY

SÜDKABEL

Person in charge
Andre Salame
Department
Kabelsysteme Hochspannung
Phone
+49 (0)621 8507-449
Fax

Mobile
+49 (0)173 2598-556
E-Mail
Andre.Salame@suedkabel.com

To whom it may concern

Your ref. Your letter dated

Our ref.
2017-KSH-014-D-03

Date 2017-01-17

Declaration

from

Südkabel GmbH, Rhenaniastrasse 12-30, 68199 Mannheim

Manufacturer of cables, cable terminations and cable joints

Project: Replacing the oil-filled cable line 110 kV Line "ENOS" from linear knife disconnectors 110 kV of Substation "Dimitar Dimitrov" to a straight knife disconnectors 110 kV of Substation "Hipodruma".

We herewith confirm that

1. Delivery:
The delivery time for our cables and accessories according to the quantities and conditions in our Quotation KSH 2017-014 on the basis EX-Works Mannheim amounts 70 days. Receipt of technical approval, commercially clear order, advance payment and final delivery lengths is preconditioned. Delivery times are to be firmly agreed at time of order.

2. Defects liability
The defects liability for our cables and accessories according to the quantities and conditions in our Quotation KSH 2017-014 amounts 60 months after installation, latest 72 months after notification of readiness for delivery.
For defects liability reasons the installation works of the accessories delivered by Südkabel have to be performed under Südkabel supervision or by Südkabel trained and certified people.

With kind regards
Südkabel GmbH

SÜDKABEL GmbH
Rhenaniastraße 12-30
68199 Mannheim

i.A.
Andre Salame
Project Manager

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Да послужи където е необходимо

Декларация

от

Зюдкабел ГмбХ, Ренаниащрасе 12-30, 68199 Манхайм

Производител на кабели, кабелни глави и муфи

Проект: Подмяна на маслонапълнена кабелна електропроводна линия 110 kV „Енос" от линеен ножов разединител 110 kV на ПС „Димитър Димитров" до линеен ножов разединител 110 kV в ПС „Хиподрума"

С настоящия документ потвърждаваме, че

1. Доставка:
   Срокът на доставка на произведените от нас кабели и кабелна арматура в съответствие с количествата и условията от оферта KSH 2017-014 франко Манхайм е 70 дни. Задължително условие е да сме получили техническо одобрение, търговски ясна поръчка, авансово плащане и точните доставни дължини. Срокът ще се съгласува окончателно по време на извършване на поръчката.

2. Гаранционен срок
   Гаранционният срок на нашите кабели и кабелна арматура в съответствие с количествата и условията от оферта KSH 2017-014 е 60 месеца след извършване на монтажа, но не повече от 72 месеца от обявяването на готовност за доставка.
   За да бъде гаранцията валидна, монтажът на арматурата, доставяна от Зюдкабел, трябва да бъде извършен под супервизия от страна на Зюдкабел или от сертифицирани от Зюдкабел монтажници.

С уважение
Зюдкабел ГмбХ

Андре Саламе
Мениджър проекти

ВЯРНО С ОРИГИНАЛА

ООД ТУДИМ Стара Загора

Подпис: ....

ПРИЛОЖЕНИЕ №8

Списък на типовите изпитания на устройствата от серията 670 и в частност RED670 съгласно съответните приложими международни стандарти

Таблица 17: Електромагнитна съвместимост

Тест/изпитване	Стойности при типови изпитания	Референтен стандарт
1 MHz бързо смущение	2.5 kV	IEC 60255-26
100 kHz бавно затихващо смущение с осцилираща вълна	2.5 kV	IEC 61000-4-18, клас III
Изпитания при смущение с кръгова вълна, 100 kHz	2-4 kV	IEC 61000-4-12, клас IV
Изпитания за издръжливост при смущения от пренапрежения	2.5 kV, осцилиращо 4.0 kV, бърз преходен процес	IEEE/ANSI C37.90.1
Електростатичен разряд Директно приложение Индиректно проложение	15 kV въздушен разряд 8 kV контактен разряд 8 kV контактен разряд	IEC 60255-26 IEC 61000-4-2, клас IV
Електростатичен разряд Директно приложение Индиректно проложение	15 kV въздушен разряд 8 kV контактен разряд 8 kV контактен разряд	IEEE/ANSI C37.90.1
Бързо преходно смущение	4 kV	IEC 60255-26, зона A
Изпитание при смущения от пренапрежение	2-4 kV, 1.2/50 ms голяма енергия	IEC 60255-26, зона A
Изпитание при смущения с промишлена честота	150-300 V, 50 Hz	IEC 60255-26, зона A
Изпитание за проведено смущение от общ вид	15 Hz-150 kHz	IEC 61000-4-16, клас IV
Изпитания при смущения с магнитно поле с промишлена честота	1000 A/m, 3 s 100 A/m, продължително	IEC 61000-4-8, клас V
Изпитание при смущения с пулсиращо магнитно поле	1000 A/m	IEC 61000–4–9, клас V
Изпитание при смущения от затихващо осцилиращо магнитно поле	100 A/m	IEC 61000-4-10, клас V
Излъчвания на електромагнитно поле с радио честоти	20 V/m, 80-1000 MHz 1.4-2.7 GHz	IEC 60255-26
Излъчвания на електромагнитно поле с радио честоти	20 V/m 80-1000 MHz	IEEE/ANSI C37.90.2
Проведено смущение на електромагнитно поле	10 V, 0.15-80 MHz	IEC 60255-26
Радио смущения	30-5000 MHz	IEC 60255-26
Радио смущения	30-5000 MHz	IEEE/ANSI C63.4, FCC
Проведени емисии	0.15-30 MHz	IEC 60255-26

ВЯРНО С ОРИГИНАЛА

Таблица 18: Изолация

Тест/изпитване	Стойности при типови изпитания	Референтен стандарт
Диелектрични изпитания	2.0 kV AC, 1 мин.	IEC 60255-27 ANSI C37.90
Изпитания с импулсно напрежение	5 kV, 1.2/50 ms, 0.5 J	
Изолационно съпротивление	>100 MОм при 500 VDC	

Таблица 19: Изпитания за околна среда

Тест/изпитване	Стойности при типови изпитания	Референтен стандарт
Работа при студ	Тест Ad за 16 часа при -25°C	IEC 60068-2-1
Изпитание при съхранение на студ	Тест Ab за 16 часа при -40°C	IEC 60068-2-1
Изпитание при работа на суха топлина	Тест Bd за 16 часа при +70°C	IEC 60068-2-2
Изпитание при съхранение на суха топлина	Тест Bb за 16 часа при +85°C	IEC 60068-2-2
Изпитание при промяна на температурата	Тест Nb за 5 цикъла при условия от -25°C до +70°C	IEC 60068-2-14
Изпитание при влажна топлина, стабилно състояние	Тест Ca за 10 дни при условия +40°C и влажност 93%	IEC 60068-2-78
Изпитание при влажна топлина, цикличен тест	Тест Db за 6 цикъла при условия от +25 до +55°C и влажност 93 до 95% (1 цикъл = 24 часа)	IEC 60068-2-30

Таблица 20: CE съответствие

Тест/изпитване	Референтен стандарт
Смущения	EN 60255–26
Излъчване	EN 60255–26
Директива ниско напрежение	EN 60255–27

Таблица 21: Механични тестове

Тест/изпитване	Стойности при типови изпитания	Референтен стандарт
Тест за реакция при вибрации	клас II	IEC 60255-21-1
Тест за износване при вибрации	клас I	IEC 60255-21-1
Тест за реакция удар	клас I	IEC 60255-21-2
Тест за издържане на удар	клас I	IEC 60255-21-2
Тест при друсане	клас I	IEC 60255-21-2
Сеизмични изпитания	клас II	IEC 60255-21-3

ВЯРНО С ОРИГИНАЛА

Подпис: ....

ООД РУДИН Стара Загора

Списък на типовите изпитания на устройствата от серията 650 и в частност REQ650 и REC650 съгласно съответните приложими международни стандарти

Таблица 17: Електромагнитна съвместимост

Тест/изпитване	Стойности при типови изпитания	Референтен стандарт
Изпитания при 100kHZ и 1 MHz бързо смущение • Общ/обикновен режим • Диференциален режим	 2.5 kV 2.5 kV	IEC 61000-4-18, клас III IEC 60255-22-1 ANSI C37.90.1-2012
Електростатичен разряд • Контактен разряд • Въздушен разряд	 8 kV 15 kV	IEC 61000-4-2, клас III IEC 60255-22-6 ANSI C37.90.3-2001
Изпитания при смущения с радио честота • Проведени, общ режим • Излъчени, ампл.-модулирани	 10 V (emf), f=150kHz...80MHz 20 V/m (rms), f=150kHz...1000MHz и f=1.4...2.7 GHz	IEC 61000-4-6, клас III IEC 60255-22-6 IEC 61000-4-3, клас III IEC 60255-22-3 ANSI C37.90.2-2004
Изпитания за издръжливост при смущения от бързи преходни процеси • Комуникационни портове • Други портове	4 kV 4 kV	IEC 61000-4-4 IEC 60255-22-4, клас A ANSI C37.90.1-2012
Изпитания при смущения от пренапрежения • Комуникация • Други портове • Захранващ блок	 1kV фаза към земя 2kV фаза към земя, 1kV фаза към фаза 4kV фаза към земя, 2kV фаза към фаза	IEC 61000-4-5 IEC 60255-22-5
Изпитания за въздействие на магнитно поле с промишлена честота (50Hz) • 3 s • непрекъснато	 1000A/m 100 A/m	IEC 61000-4-8 ниво 5
Изпитания при смущения с пулсиращо магнитно поле	1000A/m	IEC 61000-4-9 ниво 5
Изпитания със затихващо осцилиращо магнитно поле	100 A/m, 100kHz и 1MHz	IEC 61000-4-10 ниво 5
Изпитания при смущения с промишлена честота • общ режим • диференциален режим	 300 V rms 150 V rms	IEC 60255-27-7 клас A IEC 61000-4-16
Изпитания при срив в напрежението DC	Пропадане: 40%/200 ms 70%/500 ms Прекъсвания:	IEC 60255-11 IEC 61000-4-11

ВЯРНО С ОРИГИНАЛА

Подпис: ....

ООД РУДИН Стара Загора

	0-50ms; без рестартиране 0 ... ∞ s: правилно поведение при изчезване на напрежението	
Изпитания при срив в напрежението AC	Пропадане: 40% 10/12 периода при 50/60Hz 70% 10/12 периода при 50/60Hz Прекъсвания: 0 - 50ms; без рестартиране 0 ... ∞ s: правилно поведение при изчезване на напрежението	IEC 60255-11 IEC 61000-4-11
Изпитания при електромагнитни емисии • Проведени радиочестоти емисия (основни клеми) 0.15 ...0.50 MHz 0.5 ... 30 MHz • Излъчени радиочестоти емисия IEC 30 ...230 MHz 230 ... 1000 MHz	 < 79 dB(μV) квази пик < 66 dB(μV) средно < 73 dB(μV) квази пик < 60 dB(μV) средно < 40 dB(μV) квази пик, измерено на разстояние 10м. < 47 dB(μV) квази пик, измерено на разстояние 10м.	EN 55011, клас A IEC 60255-25 ANSI C63.4, FCC

Таблица 16: Изолация

Тест/изпитване	Стойности при типови изпитания	Референтен стандарт
Диелектрични изпитания • Изпитвателни напрежения	2kV, 50Hz, 1 мин. 1kV, 50Hz, 1 мин. комуникация	IEC 60255-27 ANSI C37.90-2005
Изпитания с импулсно напрежение • Изпитвателни напрежения	5 kV еднополярни импулси, вълна с форма 1.2/50 ms, източник с енергия 0.5 J 1 kV еднополярни импулси, вълна с форма 1.2/50 ms, източник с енергия 0.5 J комуникации	IEC 60255-27 ANSI C37.90-2005
Измерване на изолационното съпротивление • Изпитвателни напрежения	>100 MΩ при 500 VDC	IEC 60255-27 ANSI C37.90-2005
Напрежение на защитното заземяване • Изпитвателни напрежения	<0.2 Ω (60сек.)	IEC 60255-27

ВЯРНО С
ОРИГИНАЛА

ООД РУДИН Стара Загора

Подпис:

Таблица 17: Механични тестове

Тест/изпитване	Референтен стандарт	Стойности при типови изпитания
Тест за реакция при вибрации	IEC 60255-21-1	клас II
Тест за износване при вибрации	IEC 60255-21-1	клас I
Тест за реакция удар	IEC 60255-21-2	клас I
Тест за издържане на удар	IEC 60255-21-2	клас I
Тест при друсане	IEC 60255-21-2	клас I
Сеизмични изпитания	IEC 60255-21-3	клас II

Таблица 18: Продуктова безопасност

Тест/изпитване	Референтен стандарт
Директива НН	2006/95/ЕС
Стандарт	EN 60255–27 (2005)

Таблица 19: Съответствие по електромагнитна съвместимост

Тест/изпитване	Референтен стандарт
Директива НН	2004/95/ЕС
Стандарт	EN 60255–27 (2005)

ВЯРНО С ОРИГИНАЛА

Подпис: ....

ООД РУДИН Стара Загора

Power and productivity
for a better world™

Whomever

From Krister Hagman
Business area ABB Grid Automation Products
Phone direct +4621321462
Fax direct
E-Mail krister.hagman@se.abb.com
Cc
Reference No 1MRG026182
Page 1/1
Date 2017-01-17

Certification

Dear Sir/Madam

We hereby confirm that the Relion® 670 series version 2.1 and Relion® 650 series version 2.1 Protection and Control IEDs are fully based on the Relion® 670 series version 2.0 hardware platform. All tests performed on the Relion® 670 series version 2.0 hardware are valid also for the Relion® 670 and Relion® 650 series version 2.1.

We can confirm that the conformance test certificate below, for the Relion® 670 series version 2.0, is valid for the Relion® 670 and Relion® 650 series version 2.1.

1323-15, KEMA Type Test Certificate of Environmental Performance, 670-series, Ver. 2.0

We also confirm that conformance tests on protocols like IEC 61850 edition 2, DNP 3.0 and IEC 60870-5-103 have been performed by DNV GL.

Krister Hagman
Global Product Manager Relion® 650 series

Joseph Menezes
Global Product Manager Relion® 670 series

ABB
Grid Automation Products

ВЯРНО С
ОРИГИНАЛА

Postal address:
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Grid Automation Products
SE-721 59 Västerås
Sweden
www.abb.com/protection-control

Visiting address:
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Phone: +46 (0)21 32 50 00
Fax: +46 (0)21 14 69 18

Reg. no:
556029-7029
VAT no:
SE556029702901

Reg. office
Västerås, Sweden

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DNV·GL

KEMA TYPE TEST CERTIFICATE OF ENVIRONMENTAL PERFORMANCE

ABB AB

Västerås, Sweden

has successfully passed the type test sequence on a

protection relay family

Type: 670-series, Ver. 2.0
Rating: operating range -25 - 70 °C - mechanical class 1 -
EMC emission class A

The test object passed the specification of test duties of

IEC 60255-1, IEEE C37.90.1, C37.90.2 and C37.90.3

The test results are recorded in Certificate No.

1323-15

This Certificate was issued on 10 November 2015

KEMA Nederland B.V.

J.P. Fonteijne
Executive Vice President
KEMA Laboratories

KEMA Laboratories

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UCA International Users Group

SVC

1KHL050078

IEC 61850 Conformance Certificate Level B[1]

Issued to: ABB AB SA Products S-721 59 Västeras Sweden	*For the product:* REC670 Bay Control Firmware version 2.1 S/N T1537006

Issued by: ABB Switzerland Ltd, Power Systems, SVC Baden

The server product has not been shown to be non-conforming to:

IEC 61850 First Edition Parts 6, 7-1, 7-2, 7-3, 7-4 and 8-1

Communication networks and systems in substations

The conformance test has been performed according to IEC 61850-10, the UCA International Users Group Server Device Test Procedures version 2.3 with TPCL[2] version 1.8, the product's protocol, model and technical issue implementation conformance statements: " 1MRG021055_ABB 650 & 670 Series version 2.1 Ed.1 - PICS", "1MRG021087 ABB 670 and 650 series version 2.1 Ed1 - MICS", "1MRG021063_ABB 650 & 670 Series version 2.1 Ed.1 – TICS" and the extra information for testing: "1MRG021064_ABB 650 & 670 Series version 2.1 Ed.1 – PIXIT".

The following IEC 61850 conformance blocks have been tested with a positive result (number of relevant and executed test cases / total number of test cases):

1	Basic Exchange (20/24)	9a	GOOSE Publish (9/12)
2	Data Sets (3/6)	9b	GOOSE Subscribe (11/11)
3	Substitution (4/4)	12a	Direct Control (7/11)
4	Setting Group Selection (3/3)	12d	Enhanced SBO Control (14/19)
5	Unbuffered Reporting (16/19)	13	Time Synchronization (4/5)
6	Buffered Reporting (24/28)	14	File Transfer (6/7)

This Certificate includes a summary of the test results as carried out at the SVC Baden in Switzerland with UniCAsim 61850 version 4.29.03 with test suite 3.29.00 and UniCA Analyzer 5.27.04. This document has been issued for information purposes only, and the original paper copy of the SVC Baden report: No. 1KHL050077 will prevail.
The test has been carried out on one single specimen of the product as referred above and submitted to SVC Baden by ABB AB, SA Products. The manufacturer's production process has not been assessed. This certificate does not imply that SVC Baden has approved any product other than the specimen tested.

Baden, 2015-12-17

S. Gerspach Certification Manager	C. Zehnder Test engineer

1 Level B - Tester with ISO 9001 Quality System
2 TPCL - Test procedures change list

ABB Switzerland Ltd
Power Systems, System Verification and Validation Center, SVC Baden
Bruggerstrasser 72, CH-5400 Baden

ABB

ВЯРНО С ОРИГИНАЛА

ООД РУДИН Стара Загора

UCA International Users Group

SVC IEC 61850

1KHL050078

Applicable Test Procedures from the UCA International Users Group Device Test Procedures version 2.3 with TPCL version 1.8

Conformance Block		Mandatory	Conditional
1	Basic Exchange	Ass1, Ass2, Ass3, AssN2, AssN4, AssN5 Srv1, Srv2, Srv3, Srv4, Srv5, SrvN1abcd, SrvN4	AssN3, Srv6, Srv7, Srv8, SrvN1e, SrvN1f, SrvN3
2	Data Sets	Dset1, Dset10a, DsetN1ae	
3	Substitution	Sub1, Sub2, Sub3, SubN1	
4	Setting Group Selection	Sg1, SgN1a, Sg3	
5	Unbuffered Reports	Rp1, Rp2, Rp3, Rp4, Rp9, Rp15, RpN1, RpN2, RpN3, RpN4, RpN8	Rp5, Rp8, Rp10, Rp11, Rp12,
6	Buffered Reports	Br1, Br2, Br3, Br4, Br9, Br15, Br20, Br21, Br22, Br25, Br26, Br27, Br28 BrN1, BrN2, BrN3, BrN4, BrN5, BrN8	Br5, Br8, Br10, Br11, Br12
9a	GOOSE publish	Gop2, Gop3, Gop4, Gop9, Gop10a	Gop1, Gop7, Gop10b, GopN2
9b	GOOSE subscribe	Gos1a, Gos2, Gos3, GosN1, GosN2, GosN3, GosN4, GosN5, GosN6	Gos1b, Gos4
12a	Direct Control	CtlN3, CtlN8, DOns1	Ctl2, Ctl7, CtlN10, CtlN11
12d	Enhanced SBO control	Ctl3, CtlN1, CtlN2, CtlN3, CtlN4, CtlN9 SBOes1, SBOes2, SBOes3	Ctl2, Ctl7, CtlN6, CtlN10, CtlN11,
13	Time Synchronization	Tm1, Tm2,	Tm3, TmN1
14	File Transfer	Ft1, Ft2ab, Ft4, FtN1ab	Ft2c, FtN1c

All configuration file and data model tests have been successfully performed for the product variants using the same hardware and software version:

- REB650 Busbar Protection
- REC650 Bay Control
- RED650 Line Differential Protection
- REL650 Line Distance Protection
- REQ650 Breaker Protection
- RET650 Transformer Protection
- REB670 Busbar Protection
- RED670 Line Differential Protection
- REG670 Generator Protection
- REL670 Line Distance Protection
- RES670 Phasor Measurement
- RET670 Transformer Protection

ВЯРНО С ОРИГИНАЛА

ABB Switzerland Ltd
Power Systems, System Verification and Validation Center, SVC Baden
Bruggerstrasser 72, CH-5400 Baden

Подпис:

РУДИН ООД Стара Загора

ABB

UCA International Users Group

IEC 61850 Certificate Level A[1]

No. 10004038-OPE/INC 15-2826

Issued to:
ABB AB
SA Products
S-721 59 Västerås
Sweden

For the server product:
REC670 Bay Control
Software version: 2.1.0.23
S/N: REC670 2.1.0.16

The server product has not been shown to be non-conforming to:

IEC 61850 Edition 2 Parts 6, 7-1, 7-2, 7-3, 7-4 and 8-1

Communication networks and systems for power utility automation

The conformance test has been performed according to IEC 61850-10 Edition 2, the UCA International Users Group Edition 2 Server Test Procedures version 1.0 with TPCL[2] 1.0.2 with product's protocol, model and technical issue implementation conformance statements: "Protocol Implementation Conformance Statement for the IEC 61850 interface in ABB 650 and 670 series version 2.1 - IEC 61850 Edition 2, 1MRG021052", "Model Implementation Conformance Statement for the IEC 61850 Ed2 interface in ABB 650 and 670 series version 2.1, 1MRG021098" and "TISSUES Implementation Conformance Statement for the IEC 61850 Ed2 interface in ABB 650 and 670 series version 2.1, 1MRG021051" and the extra information for testing: "Protocol Implementation eXtra Information for Testing (PIXIT) for the IEC 61850 interface in ABB 650 and 670 series version 2.1 - IEC 61850 Edition 2, 1MRG021053".

The following IEC 61850 conformance blocks have been tested with a positive result (number of relevant and executed test cases / total number of test cases):

1	Basic Exchange (22/26)	9a	GOOSE Publish (8/13)
2	Data Sets (4/7)	9b	GOOSE Subscribe (13/14)
3	Substitution (3/3)	12a	Direct Control (12/18)
4	Setting Group Selection (4/4)	12d	Enhanced SBO Control (19/28)
4+	Setting Group Definition (12/13)	13	Time Synchronization (6/7)
5	Unbuffered Reporting (17/20)	14	File Transfer (7/8)
6	Buffered Reporting (25/29)	15	Service Tracking (12/17)

This certificate includes a summary of the test results as carried out at ABB in Sweden with UniCA 61850 Client Simulator 4.29.03 with test suite Ed2 3.29.05 and UniCA 61850 Analyzer 5.29.02. This document has been issued for information purposes only, and the original paper copy of the DNV GL verification report No. 74108086-OPE/INC 15-2824 will prevail.

The test has been carried out on one single specimen of the product as referred above and submitted to DNV GL by ABB. The manufacturer's production process has not been assessed. This certificate does not imply that DNV GL has approved any product other than the specimen tested.

Arnhem, October 1, 2015

M. Adriaensen
Head of Department
Operational Excellence

Issued by:
DNV·GL
DNV KEMA is now DNV GL

R. Schimmel
Verification Manager

[1] Level A - Independent test lab with certified ISO 9001 Quality System
[2] TPCL - Test procedures change list

ОРИГИНАЛА

ООД
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Стара Загора

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UCA International Users Group

IEC 61850 Certificate Level A No. 10004038-OPE/INC 15-2826

Applicable Test Procedures from the UCA International Users Group Edition 2 Server Test Procedures version 1.0 with TPCL 1.0.2

Conformance Block	Mandatory	Conditional
1: Basic Exchange	sAss1, sAss2, sAss3, sAssN2, sAssN3, sAssN4, sAssN5, sSrv1, sSrv2, sSrv3, sSrv4, sSrv5, sSrvN1abcd, sSrvN4	sSrv6, sSrv8, sSrv11, sSrv12, sSrv13, sSrvN1e, sSrvN1f, sSrvN3
2: Data Sets	sDs1, sDs10a, sDsN1ae	sDs15
3: Substitution	sSub1, sSub2, sSub3	
4: Setting Group Selection	sSg1, sSg3, sSgN1	sSg11
4+: Setting Group Definition	sSg2, sSg4, sSg7, sSg8, sSg10, sSg12, sSgN2, sSgN3, sSgN4, sSgN5	sSg5, sSg9
5: Unbuffered Reporting	sRp1, sRp2, sRp3, sRp4, sRp9, sRp14, sRpN1, sRpN2, sRpN3, sRpN4, sRpN8	sRp5, sRp8, sRp10, sRp11, sRp12, sRp13
6: Buffered Reporting	sBr1, sBr2, sBr3, sBr4, sBr9, sBr14, sBr20, sBr21, sBr22, sBr25, sBr26, sBr27, sBr28, sBrN1, sBrN2, sBrN3, sBrN4, sBrN5, sBrN8	sBr5, sBr8, sBr10, sBr11, sBr12, sBr13
9a: GOOSE publish	sGop2a, sGop3, sGop4, sGop7, sGop9, sGop10, sGop11	sGop1
9b: GOOSE subscribe	sGos1, sGos2, sGos3, sGos5, sGos6a, sGos7, sGosN1, sGosN2, sGosN3, sGosN4, sGosN5, sGosN6	sGos6b
12a: Direct control	sCtl5, sCtl10, sDOns1, sDOns2	sCtl7, sCtl13, sCtl15, sCtl16, sCtl17, sCtl18, sCtl19, sCtl21
12d: Enhanced SBO Control	sCtl5, sCtl8, sCtl9, sCtl10, sCtl11, sCtl25, sSBOes1, sSBOes2, sSBOes6, sSBOes8	sCtl4, sCtl6, sCtl7, sCtl15, sCtl16, sCtl17, sCtl18, sCtl19, sCtl26
13: Time sync	sTm1, sTm2, sTmN1	sTm3, sTm4, sTm5
14: File transfer	sFt1, sFt2ab, sFt4, sFt5, sFtN1ab	sFt2c, sFtN1c
15: Service tracking		sTrk1, sTrk2, sTrk4, sTrk7, sTrk8, sTrk9, sTrk10, sTrk11, sTrk12, sTrk13, sTrk14, sTrk17

All configuration file and data model tests have been successfully performed for the product variants using the same communication hardware and software version:

- REB650 Busbar Protection
- REC650 Bay Control
- RED650 Line Differential Protection
- REL650 Line Distance Protection
- REQ650 Breaker Protection
- RET650 Transformer Protection
- REB670 Busbar Protection
- RED670 Line Differential Protection
- REG670 Generator Protection
- REL670 Line Distance Protection
- RER670 Railway Protection
- RES670 Phasor Measurement
- RET670 Transformer Protection

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ATTESTATION OF CONFORMITY

No. 10004038-OPE/INC 15-3092

Issued to:
ABB
SA Products
Nätverksgatan 3, B391, Finnslätten
721 59 Västeras
Sweden

For the client system:
REL 670
Type: Slave station
Product version 2.1.0
Firmware version 2.1.0.17

With the implemented communication protocol:

IEC 60870-5-103 (IS 1998)

Companion Standard for the informative interface of protection equipment and the ABB Relion 650 and 670 series version 2.1 IEC 60870-5-103, Interoperability, dated August 28, 2015.

The product has not been shown to be non-conforming to the specified protocol standard, including the interface requirements.

End-to-End data element tests for the information and control points as described in manufacturer Protocol Implementation Conformance Statement (PICS) have been performed on the product's protocol implementation. Functional tests in controlled mode are performed for the following levels:

• *Station initialization in Unbalanced mode* • *Cyclic data transmission* • *Acquisition of events* • *General Interrogation*	• *General command* • *Clock synchronisation* • *Transmission of Disturbance records* • *Test mode and local parameter setting*

The test campaign did not reveal any errors in the product's protocol implementation.

This Attestation is granted on account of tests made at location of ABB in Västerås, Sweden and performed with UnIECIm version 3.0.3 (2014) running CS103 Test Suite version CS103MasterNormal 2.4. The results, including remarks and limitations, are laid down in our report no. 10004038-OPE/INC 15-3086.

The tests have been carried out on one single specimen of the product, submitted by ABB. The Attestation does not include an assessment of the manufacturer's production. Conformity of his production with the specimen tested by DNV GL is not the responsibility of DNV GL.

Arnhem, November 18, 2015

Issued by:

DNV·GL

DNV KEMA is now DNV GL

P. Cioci
Head of Section
Operational Excellence

G. Webber
Test Consultant

IMPORTANT: Remarks apply to this implementation. See the resulting report for full details. Publication of this document is allowed. Publication in total or in part and/or reproduction in whatsoever way of the contents of the above mentioned report(s) is not allowed unless permission has been explicitly given either in the report(s) or by previous letter

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332

ABB AB
Substation Automation Products

Postal Address
SE-721 59 Västerås / Sweden

Telephone +46 21 32 50 00
Fax +46 21 14 69 18

Declaration of Conformity

ABB

Document identity
1MRK 000 612-110

Revision A

Declaration

We ABB AB, Substation Automation Products, SE-721 59 Västerås, Sweden, declare under our sole responsibility that the family of apparatus:

Line Differential Protection	**Type:** **RED670, Ver. 2.1** **acc. to Product Guide** **1MRK 505341-BEN**

to which this declaration relates is in conformity with the following directives

Directive	**EMC Directive 2014/30/EU** **Low Voltage Directive 2014/35/EU**

Our internal quality control system ensures compliance between the manufactured products and the technical documentation.

Year of affixed CE-marking	**2015**

Application of the objects

The family is intended for use in the industrial environment and to protect high voltage or high power apparatus, and thus normally used in a harsh electromagnetic environment near high voltage apparatus.

References

Standards	**EN 60 255-26: 2013** **EN 60 255-27: 2014**

Authorisation

Signed by	Joseph Menezes, PM	Date 2016-03-30

ВЯРНО С ОРИГИНАЛА

ООД РУДИН Ст. Загора

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Part of product	Sheet
Designations for 1/2x19" casing with 1 TRM slot	2
Power supply module	3
Line data communication module	4
Transformer input module	5
Binary input module	6
Binary output module	7

Prepared	2014-04-14	Jill Eriksson	Title Connection diagram RED670 A31X00 Single breaker, 3 phase tripping
Approved	2015-09-04	Patrik Nyback	
Project			ABB AB

Doc.des. Doc.kind Ref.des. =Xn.Qn
Resp.dept. Rev.ind. A Lang. en
Doc.No. 1MRK002803-DA Sheet 1 Cont. 2

Based on: Rev Rev. Note Date Name

ВЯРНО С ОРИГИНАЛА

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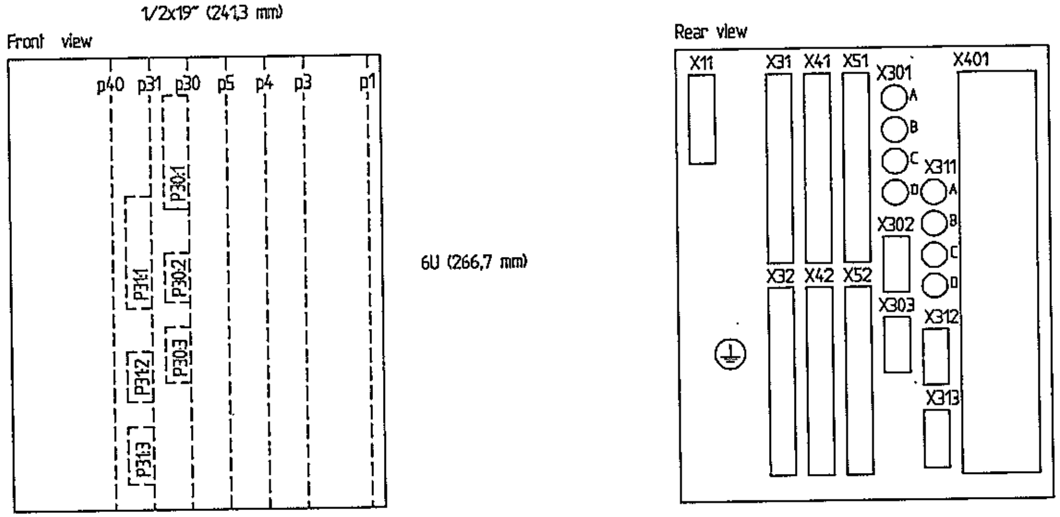
Designations for 1/2x19" casing with 1 TRM slot



ВЯРНО С ОРИГИНАЛА

Prepared 2014-04-14 Jili Eriksson	Title Connection diagram RED670 A31X00 Single breaker, 3 phase tripping	Doc.des. Doc.kind	Ref.des. =Xn.Qn
Approved 2015-09-04 Patrik Nyback		Resp.dept.	Rev.ind. A Lang.
Based on	Project	ABB ABB AB	Doc.No. 1MRK002803-DA	Sheet 2 Cont. 3
Rev Rev. Note Date Name			

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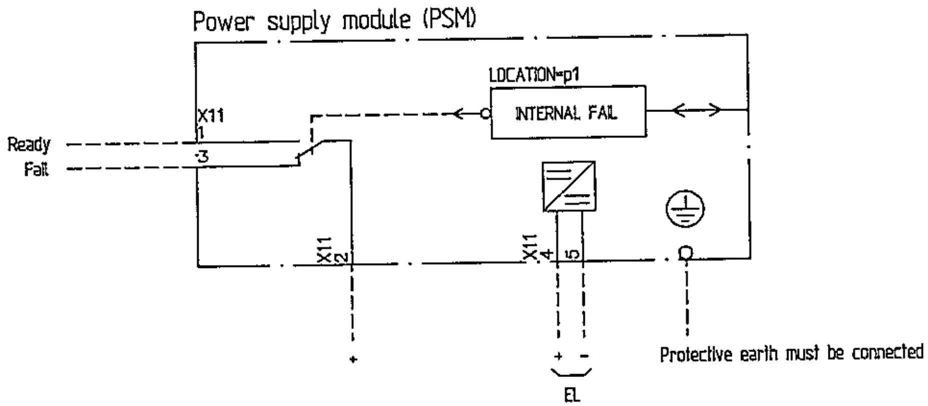

Based on			Prepared 2014-04-14 Jill Eriksson	Title Connection diagram RED670 A31X00 Single breaker, 3 phase tripping	Doc.des. Doc.kind Ref.des. Xn.Qn
			Approved 2015-09-04 Patrik Nyback		Resp.dept. Rev.Ind. A Lang.
			Project	ABB ABB AB	Doc.No. 1MRK002803-DA Sheet 3 Cont. 4
Rev	Rev. Note	Date	Name		

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ООД РУАН Стара Загора

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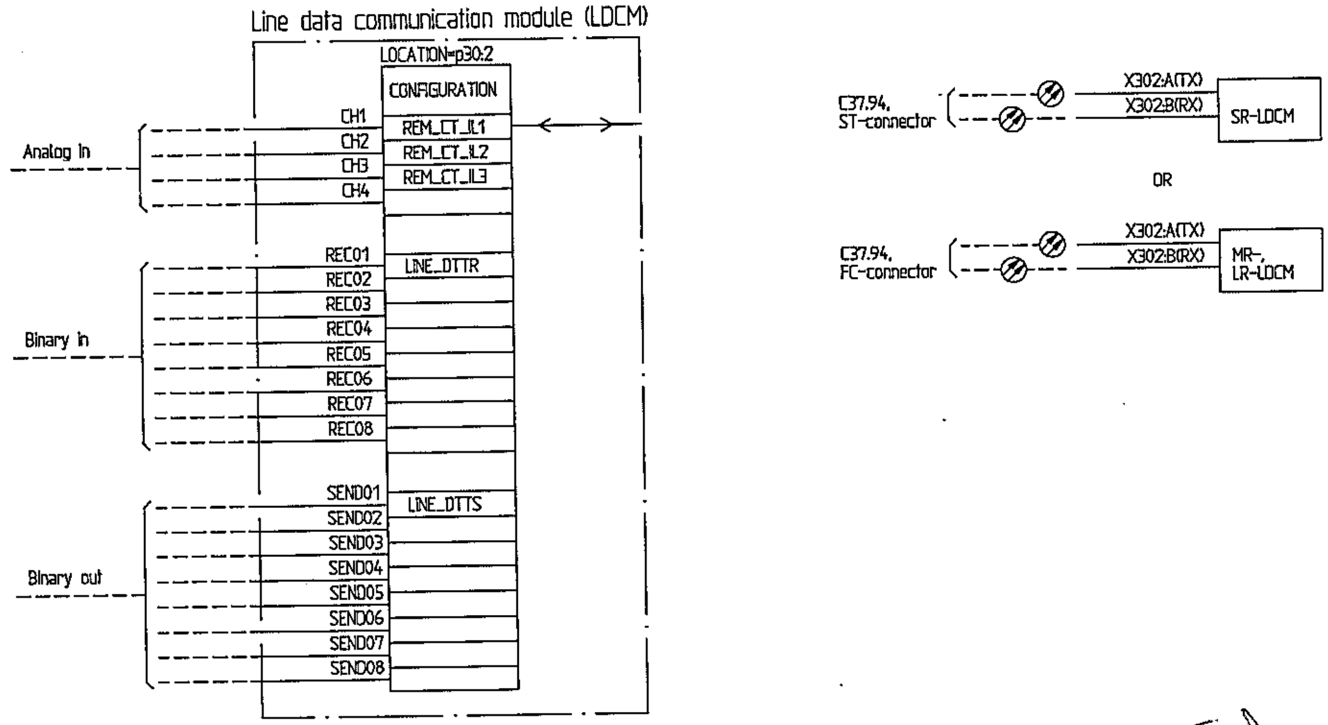
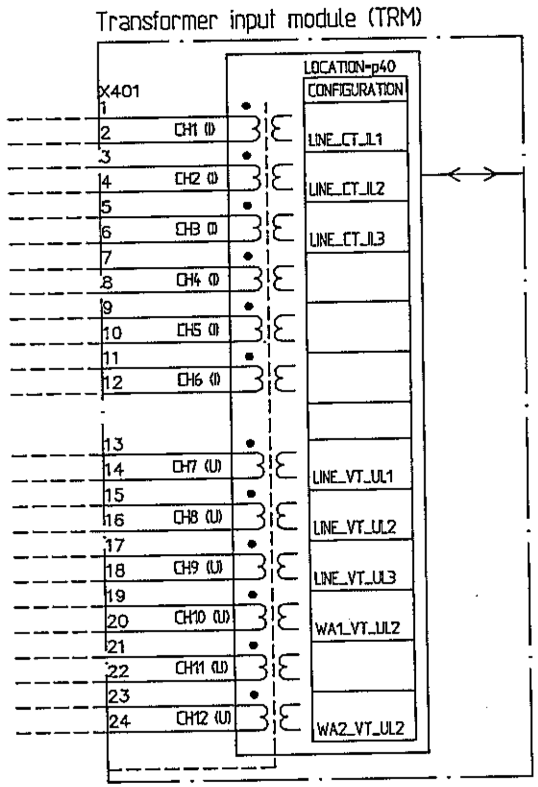


Prepared 2014-04-14	Jill Eriksson	Title Connection diagram RED670 A31X00 Single breaker, 3 phase tripping	Doc.des. / Doc.kind / Ref.des. Xn.Qn
Approved 2015-09-04	Patrik Nyback		Resp.dept. / Rev.Ind. A / Lang.
Project		ABB / ABB AB	Doc.No. 1MRK002803-DA / Sheet 4 / Cont. 5

Rev | Rev. Note | Date | Name | Based on



ВЯРНО С
ОРИГИНАЛА

Based on			
Rev	Rev. Note	Date	Name

Prepared	2014-04-14	Jill Eriksson
Approved	2015-09-04	Patrik Nyback
Project		

Title Connection diagram
RED670 A31X00
Single breaker, 3 phase tripping

ABB

ABB AB

Doc.des.	Doc.kind	Ref.des. Xn.Qn	
Resp.dept.		Rev.ind. A	Lang.
Doc.No. 1MRK002803-DA			Sheet 5
			Cont. 6

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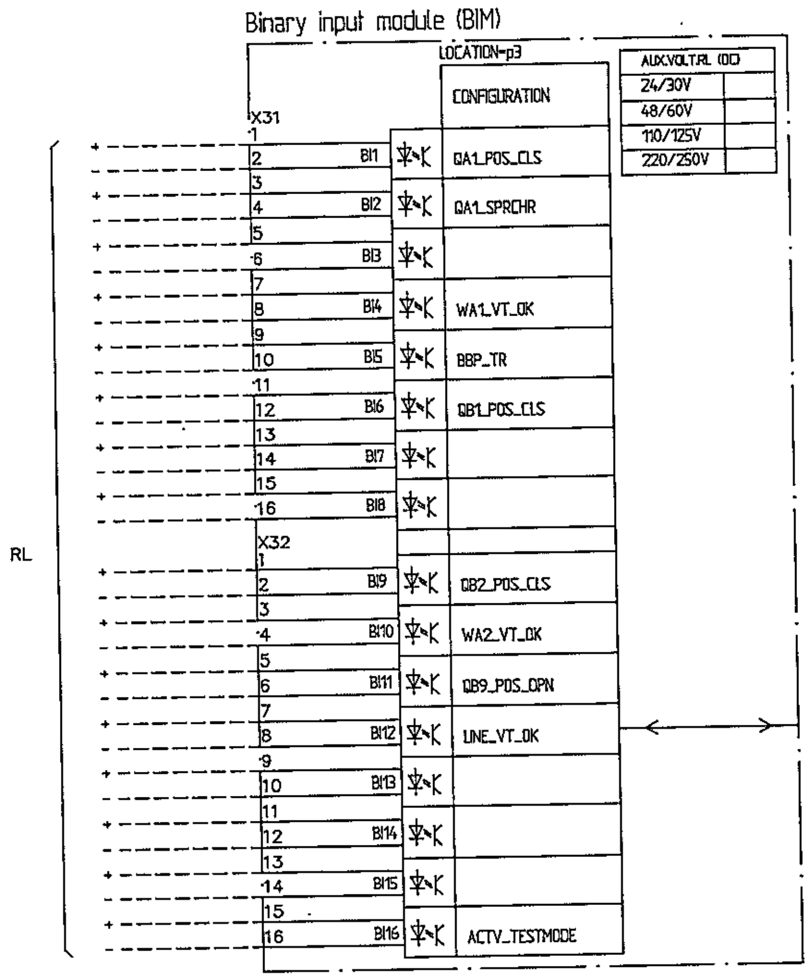

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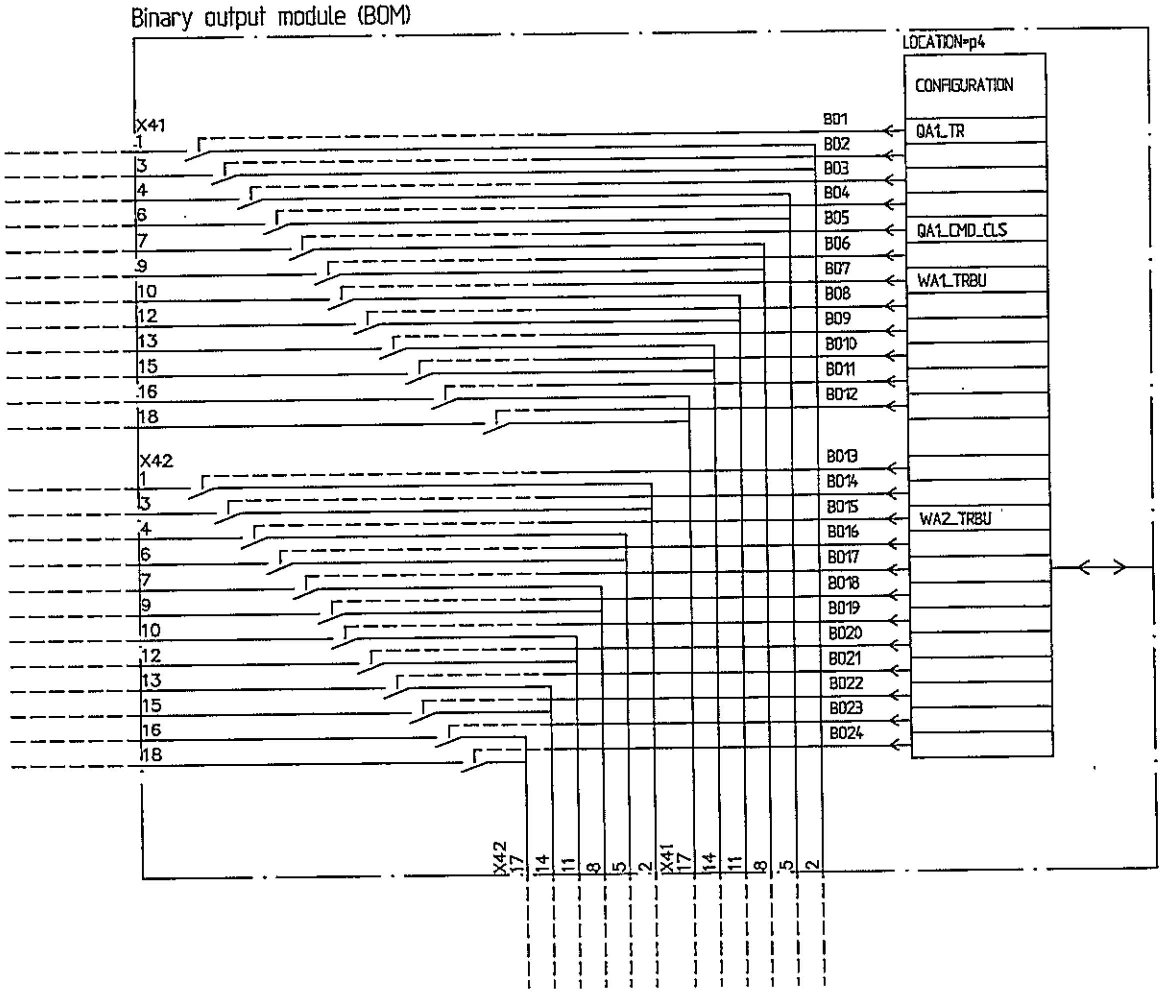
Prepared 2014-04-14 Jill Eriksson	Title Connection diagram RED670 A31X00 Single breaker, 3 phase tripping	Doc.des. Doc.kind	Ref.des. Xn.Qn
Approved 2015-09-04 Patrik Nyback		Resp.dept.	Rev.ind. A Lang.
Project	ABB ABB AB	Doc.No. 1MRK002803-DA	Sheet 6 Cont. 7

Rev	Rev. Note	Date	Name
Based on			



Prepared 2014-04-14 Jill Eriksson	Title Connection diagram RED670 3Ph/1CB) A31X00 Single breaker, 3 phase tripping	Doc.des. Doc.kind	Ref.des. Xn.Qn
Approved 2015-09-04 Patrik Nyback		Resp.dept.	Rev.Ind. A Lang.
Project	ABB ABB AB	Doc.No. 1MRK002803-DA	Sheet 7 Cont. –
Based on	Rev. Rev.-Note	Date	Name

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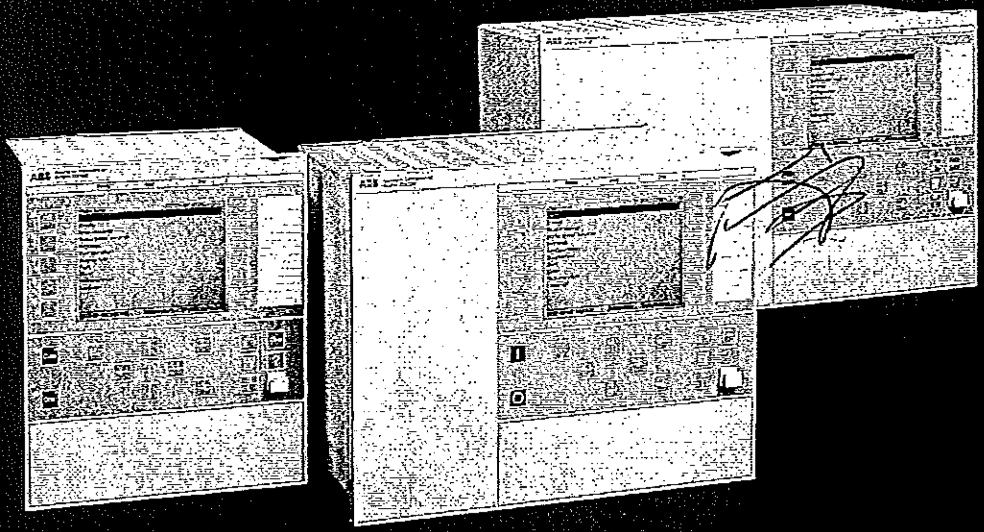

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Line differential protection RED670 2.1 IEC
Type test certificate

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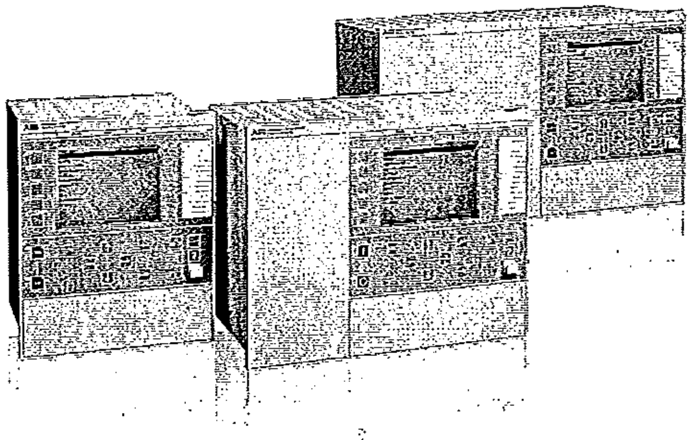

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Product version: 2.1

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Disclaimer

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Conformity

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2006/95/EC). This conformity is the result of tests conducted by ABB in accordance with the product standard EN 60255-26 for the EMC directive, and with the product standards EN 60255-1 and EN 60255-27 for the low voltage directive. The product is designed in accordance with the international standards of the IEC 60255 series.

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Section 1 General

1.1 Type test data

This document certifies that the product described below is in accordance with, and conforms to the data stated in this Type Test Certificate and corresponding data in the Type Test Report and Product Guide.

The product has been tested according to relevant parts of the standards stated below.

Product/Type	Line differential protection IED Type RED670 v2.1
Product Guide	1MRK 505 346-BEN
User's Manuals	1MRK 500 123-UEN 1MRK 505 343-UEN 1MRK 505 344-UEN 1MRK 505 345-UEN 1MRK 514 024-UEN
Function	Line differential protection
Manufactured by	ABB AB, Sweden
Author/department	Rune Östlund, TP/TD
Date of Issue	2015-09-15
Approved by	ABB AB Product Manager Joseph Menezes
Standards	IEC 60068, IEC 60255, IEC 60529, IEC 60870, IEC 61000, IEC 61810, IEC 61850, ANSI C37.90, ANSI C37.99, ANSI C37.112, ANSI C63.4, SS 4351503

1.2 Definitions

Reference value

The specified value of an influencing factor to which are referred the characteristics of the equipment.

Nominal range

The range of values of an influencing quantity (factor) within which, under specified conditions, the equipment meets the specified requirements.

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Operative range

The range of values of a given energizing quantity for which the equipment, under specified conditions, is able to perform its intended functions according to the specified requirements.

Section 2 Energizing quantities, rated values and limits

2.1 Analog inputs

Table 1: TRM - Energizing quantities, rated values and limits for protection transformer modules

Quantity	Rated value	Nominal range
Current	I_r = 1 or 5 A	(0.2-40) × I_r
Operative range	(0-100) x I_r	
Permissive overload	4 × I_r cont. 100 × I_r for 1 s *)	
Burden	< 150 mVA at I_r = 5 A < 20 mVA at I_r = 1 A	
Ac voltage	U_r = 110 V	0.5–288 V
Operative range	(0–340) V	
Permissive overload	420 V cont. 450 V 10 s	
Burden	< 20 mVA at 110 V	
Frequency	f_r = 50/60 Hz	±5%
*) max. 350 A for 1 s when COMBITEST test switch is included.		

Table 2: TRM - Energizing quantities, rated values and limits for measuring transformer modules

Quantity	Rated value	Nominal range
Current	I_r = 1 or 5 A	(0-1.8) × I_r at I_r = 1 A (0-1.6) × I_r at I_r = 5 A
Permissive overload	1.1 × I_r cont. 1.8 × I_r for 30 min at I_r = 1 A 1.6 × I_r for 30 min at I_r = 5 A	
Burden	< 350 mVA at I_r = 5 A < 200 mVA at I_r = 1 A	
Ac voltage	U_r = 110 V	0.5–288 V
Operative range	(0–340) V	
Permissive overload	420 V cont. 450 V 10 s	
Burden	< 20 mVA at 110 V	
Frequency	f_r = 50/60 Hz	±5%

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Table 3: MIM - mA input module

Quantity:	Rated value:	Nominal range:
Input resistance	R_{in} = 194 Ohm	-
Input range	±5, ±10, ±20mA 0-5, 0-10, 0-20, 4-20mA	-
Power consumption each mA-board each mA input	 ≤ 2 W ≤ 0.1 W	-

Table 4: OEM - Optical ethernet module

Quantity	Rated value
Number of channels	1 or 2 (port A, B for IEC 61850-8-1 / IEEE C37.118 and port C, D for IEC 61850-9-2LE / IEEE C37.118) 1 or 2 (port A, B for IEC 61850-8-1 / IEEE C37.118)
Standard	IEEE 802.3u 100BASE-FX
Type of fiber	62.5/125 µm multimode fibre
Wave length	1300 nm
Optical connector	Type ST
Communication speed	Fast Ethernet 100 Mbit/s

2.2 Auxiliary DC voltage

Table 5: PSM - Power supply module

Quantity	Rated value	Nominal range
Auxiliary dc voltage, EL (input)	EL = (24 - 60) V EL = (90 - 250) V	EL ±20% EL ±20%
Power consumption	50 W typically	-
Auxiliary DC power in-rush	< 10 A during 0.1 s	-

2.3 Binary inputs and outputs

Table 6: BIM - Binary input module

Quantity	Rated value	Nominal range
Binary inputs	16	-
DC voltage, RL	24/30 V 48/60 V 110/125 V 220/250 V	RL ±20% RL ±20% RL ±20% RL ±20%
Power consumption 24/30 V, 50mA 48/60 V, 50mA 110/125 V, 50mA 220/250 V, 50mA 220/250 V, 110mA	 max. 0.05 W/input max. 0.1 W/input max. 0.2 W/input max. 0.4 W/input max. 0.5 W/input	-
Counter input frequency	10 pulses/s max	-
Oscillating signal discriminator	Blocking settable 1–40 Hz Release settable 1–30 Hz	
Debounce filter	Settable 1–20ms	

Maximum 176 binary input channels may be activated simultaneously with influencing factors within nominal range.

Table 7: BIM - Binary input module with enhanced pulse counting capabilities

Quantity	Rated value	Nominal range
Binary inputs	16	-
DC voltage, RL	24/30 V 48/60 V 110/125 V 220/250 V	RL ±20% RL ±20% RL ±20% RL ±20%
Power consumption 24/30 V 48/60 V 110/125 V 220/250 V	 max. 0.05 W/input max. 0.1 W/input max. 0.2 W/input max. 0.4 W/input	-
Counter input frequency	10 pulses/s max	-
Balanced counter input frequency	40 pulses/s max	-
Oscillating signal discriminator	Blocking settable 1–40 Hz Release settable 1–30 Hz	
Debounce filter	Settable 1-20 ms	

Maximum 176 binary input channels may be activated simultaneously with influencing factors within nominal range.

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Table 8: IOM - Binary input/output module

Quantity	Rated value	Nominal range
Binary inputs	8	-
DC voltage, RL	24/30 V 48/60 V 110/125 V 220/250 V	RL ±20% RL ±20% RL ±20% RL ±20%
Power consumption 24/30 V, 50 mA 48/60 V, 50 mA 110/125 V, 50 mA 220/250 V, 50 mA 220/250 V, 110 mA	 max. 0.05 W/input max. 0.1 W/input max. 0.2 W/input max. 0.4 W/input max. 0.5 W/input	-
Counter input frequency	10 pulses/s max	
Oscillating signal discriminator	Blocking settable 1-40 Hz Release settable 1-30 Hz	
Debounce filter	Settable 1-20 ms	

Maximum 176 binary input channels may be activated simultaneously with influencing factors within nominal range.

Table 9: IOM - Binary input/output module contact data (reference standard: IEC 61810-2)

Function or quantity	Trip and signal relays	Fast signal relays (parallel reed relay)
Binary outputs	10	2
Max system voltage	250 V AC, DC	250 V DC
Test voltage across open contact, 1 min	1000 V rms	800 V DC
Current carrying capacity Per relay, continuous Per relay, 1 s Per process connector pin, continuous	 8 A 10 A 12 A	 8 A 10 A 12 A
Making capacity at inductive load with L/R>10 ms 0.2 s 1.0 s	 30 A 10 A	 0.4 A 0.4 A
Making capacity at resistive load 0.2 s 1.0 s	 30 A 10 A	220–250 V/0.4 A 110–125 V/0.4 A 48–60 V/0.2 A 24–30 V/0.1 A
Breaking capacity for AC, cos φ > 0.4	250 V/8.0 A	250 V/8.0 A
Breaking capacity for DC with L/R < 40 ms	48 V/1 A 110 V/0.4 A 125 V/0.35 A 220 V/0.2 A 250 V/0.15 A	48 V/1 A 110 V/0.4 A 125 V/0.35 A 220 V/0.2 A 250 V/0.15 A
Maximum capacitive load	-	10 nF

Maximum 72 outputs may be activated simultaneously with influencing factors within nominal range. After 6 ms an additional 24 outputs may be activated. The activation time for the 96 outputs must not exceed 200 ms. 48 outputs can be activated during 1 s. Continued activation is possible with respect to current consumption but after 5 minutes the temperature rise will adversely affect the hardware life. Maximum two relays per BOM/IOM/SOM should be activated continuously due to power dissipation.

Table 10: IOM with MOV and IOM 220/250 V, 110mA - contact data (reference standard: IEC 61810-2)

Function or quantity	Trip and Signal relays	Fast signal relays (parallel reed relay)
Binary outputs	IOM: 10	IOM: 2
Max system voltage	250 V AC, DC	250 V DC
Test voltage across open contact, 1 min	250 V rms	250 V rms
Current carrying capacity Per relay, continuous Per relay, 1 s Per process connector pin, continuous	 8 A 10 A 12 A	 8 A 10 A 12 A
Making capacity at inductive loadwith L/R>10 ms 0.2 s 1.0 s	 30 A 10 A	 0.4 A 0.4 A
Making capacity at resistive load 0.2 s 1.0 s	 30 A 10 A	220–250 V/0.4 A 110–125 V/0.4 A 48–60 V/0.2 A 24–30 V/0.1 A
Breaking capacity for AC, cos φ>0.4	250 V/8.0 A	250 V/8.0 A
Breaking capacity for DC with L/R < 40 ms	48 V/1 A 110 V/0.4 A 220 V/0.2 A 250 V/0.15 A	48 V/1 A 110 V/0.4 A 220 V/0.2 A 250 V/0.15 A
Maximum capacitive load	-	10 nF

Maximum 72 outputs may be activated simultaneously with influencing factors within nominal range. After 6 ms an additional 24 outputs may be activated. The activation time for the 96 outputs must not exceed 200 ms. 48 outputs can be activated during 1 s. Continued activation is possible with respect to current consumption but after 5 minutes the temperature rise will adversely affect the hardware life. Maximum two relays per BOM/IOM/SOM should be activated continuously due to power dissipation.

Table 11: SOM - Static Output Module (reference standard: IEC 61810-2): Static binary outputs

Function of quantity	Static binary output trip	
Rated voltage	48 - 60 VDC	110 - 250 VDC
Number of outputs	6	6
Impedance open state	~300 kΩ	~810 kΩ
Test voltage across open contact, 1 min	No galvanic separation	No galvanic separation
Current carrying capacity: Continuous 1.0s	 5A 10A	 5A 10A
Making capacity at capacitive load with the maximum capacitance of 0.2 μF : 0.2s 1.0s	 30A 10A	 30A 10A
Breaking capacity for DC with L/R ≤ 40ms	48V / 1A 60V / 0.75A	110V / 0.4A 125V / 0.35A 220V / 0.2A 250V / 0.15A
Operating time	<1ms	<1ms

Table 12: SOM - Static Output module data (reference standard: IEC 61810-2): Electromechanical relay outputs

Function of quantity	Trip and signal relays
Max system voltage	250V AC/DC
Number of outputs	6
Test voltage across open contact, 1 min	1000V rms
Current carrying capacity: Continuous 1.0s	 8A 10A
Making capacity at capacitive load with the maximum capacitance of 0.2 μF: 0.2s 1.0s	 30A 10A
Breaking capacity for DC with L/R ≤ 40ms	48V / 1A 110V / 0.4A 125V / 0.35A 220V / 0.2A 250V / 0.15A

Maximum 72 outputs may be activated simultaneously with influencing factors within nominal range. After 6 ms an additional 24 outputs may be activated. The activation time for the 96 outputs must not exceed 200 ms. 48 outputs can be activated during 1 s. Continued activation is possible with respect to current consumption but after 5 minutes the temperature rise will adversely affect the hardware life. Maximum two relays per BOM/IOM/SOM should be activated continuously due to power dissipation.

Table 13: BOM - Binary output module contact data (reference standard: IEC 61810-2)

Function or quantity	Trip and Signal relays
Binary outputs	24
Max system voltage	250 V AC, DC
Test voltage across open contact, 1 min	1000 V rms
Current carrying capacity Per relay, continuous Per relay, 1 s Per process connector pin, continuous	 8 A 10 A 12 A
Making capacity at inductive load with L/R>10 ms 0.2 s 1.0 s	 30 A 10 A
Breaking capacity for AC, cos φ>0.4	250 V/8.0 A
Breaking capacity for DC with L/R < 40 ms	48 V/1 A 110 V/0.4 A 125 V/0.35 A 220 V/0.2 A 250 V/0.15 A

Maximum 72 outputs may be activated simultaneously with influencing factors within nominal range. After 6 ms an additional 24 outputs may be activated. The activation time for the 96 outputs must not exceed 200 ms. 48 outputs can be activated during 1 s. Continued activation is possible with respect to current consumption but after 5 minutes the temperature rise will adversely affect the hardware life. Maximum two relays per BOM/IOM/SOM should be activated continuously due to power dissipation.

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2.4 Influencing factors

Table 14: Temperature and humidity influence

Parameter	Reference value	Nominal range	Influence
Ambient temperature, operate value	+20°C	-10 °C to +55°C	0.02% / °C
Relative humidity Operative range	10%-90% 0%-95%	10%-90%	-
Storage temperature	-	-40 °C to +70 °C	-

Table 15: Auxiliary DC supply voltage influence on functionality during operation

Dependence on		Reference value	Within nominal range	Influence
Ripple, in DC auxiliary voltage Operative range		max. 2% Full wave rectified	15% of EL	0.01% / %
Auxiliary voltage dependence, operate value			±20% of EL	0.01% / %
Interrupted auxiliary DC voltage			24-60 V DC ± 20% 90-250 V DC ±20%	
	Interruption interval 0–50 ms			No restart
	0–∞ s			Correct behaviour at power down
	Restart time			<300 s

Table 16: Frequency influence (reference standard: IEC 60255–1)

Dependence on	Within nominal range	Influence
Frequency dependence, operate value	f_r ±2.5 Hz for 50 Hz f_r ±3.0 Hz for 60 Hz	±1.0% / Hz
Frequency dependence for distance protection operate value	f_r ±2.5 Hz for 50 Hz f_r ±3.0 Hz for 60 Hz	±2.0% / Hz
Harmonic frequency dependence (20% content)	2nd, 3rd and 5th harmonic of f_r	±2.0%
Harmonic frequency dependence for distance protection (10% content)	2nd, 3rd and 5th harmonic of f_r	±10.0%
Harmonic frequency dependence for high impedance differential protection (10% content)	2nd, 3rd and 5th harmonic of f_r	±10.0%
Harmonic frequency dependence for overcurrent protection	2nd, 3rd and 5th harmonic of f_r	±3.0% / Hz

Section 3 Type tests according to standards

Table 17: Electromagnetic compatibility

Test	Type test values	Reference standards
1 MHz burst disturbance	2.5 kV	IEC 60255-26
100 kHz slow damped oscillatory wave immunity test	2.5 kV	IEC 61000-4-18, Class III
Ring wave immunity test, 100 kHz	2-4 kV	IEC 61000-4-12, Class IV
Surge withstand capability test	2.5 kV, oscillatory 4.0 kV, fast transient	IEEE/ANSI C37.90.1
Electrostatic discharge Direct application Indirect application	15 kV air discharge 8 kV contact discharge 8 kV contact discharge	IEC 60255-26 IEC 61000-4-2, Class IV
Electrostatic discharge Direct application Indirect application	15 kV air discharge 8 kV contact discharge 8 kV contact discharge	IEEE/ANSI C37.90.1
Fast transient disturbance	4 kV	IEC 60255-26, Zone A
Surge immunity test	2-4 kV, 1.2/50 μs high energy	IEC 60255-26, Zone A
Power frequency immunity test	150-300 V, 50 Hz	IEC 60255-26, Zone A
Conducted common mode immunity test	15 Hz-150 kHz	IEC 61000-4-16, Class IV
Power frequency magnetic field test	1000 A/m, 3 s 100 A/m, cont.	IEC 61000-4-8, Class V
Pulse magnetic field immunity test	1000 A/m	IEC 61000–4–9, Class V
Damped oscillatory magnetic field test	100 A/m	IEC 61000-4-10, Class V
Radiated electromagnetic field disturbance	20 V/m, 80-1000 MHz 1.4-2.7 GHz	IEC 60255-26
Radiated electromagnetic field disturbance	20 V/m 80-1000 MHz	IEEE/ANSI C37.90.2
Conducted electromagnetic field disturbance	10 V, 0.15-80 MHz	IEC 60255-26
Radiated emission	30-5000 MHz	IEC 60255-26
Radiated emission	30-5000 MHz	IEEE/ANSI C63.4, FCC
Conducted emission	0.15-30 MHz	IEC 60255-26

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Table 18: Insulation

Test	Type test values	Reference standard
Dielectric test	2.0 kV AC, 1 min.	IEC 60255-27 ANSI C37.90
Impulse voltage test	5 kV, 1.2/50 μs, 0.5 J	
Insulation resistance	>100 MΩ at 500 VDC	

Table 19: Environmental tests

Test	Type test value	Reference standard
Cold operation test	Test Ad for 16 h at -25°C	IEC 60068-2-1
Cold storage test	Test Ab for 16 h at -40°C	IEC 60068-2-1
Dry heat operation test	Test Bd for 16 h at +70°C	IEC 60068-2-2
Dry heat storage test	Test Bb for 16 h at +85°C	IEC 60068-2-2
Change of temperature test	Test Nb for 5 cycles at -25°C to +70°C	IEC 60068-2-14
Damp heat test, steady state	Test Ca for 10 days at +40°C and humidity 93%	IEC 60068-2-78
Damp heat test, cyclic	Test Db for 6 cycles at +25 to +55°C and humidity 93 to 95% (1 cycle = 24 hours)	IEC 60068-2-30

Table 20: CE compliance

Test	According to
Immunity	EN 60255–26
Emissivity	EN 60255–26
Low voltage directive	EN 60255–27

Table 21: Mechanical tests

Test	Type test values	Reference standards
Vibration response test	Class II	IEC 60255-21-1
Vibration endurance test	Class I	IEC 60255-21-1
Shock response test	Class I	IEC 60255-21-2
Shock withstand test	Class I	IEC 60255-21-2
Bump test	Class I	IEC 60255-21-2
Seismic test	Class II	IEC 60255-21-3

Section 4 Control

Table 22: Synchronizing, synchrocheck and energizing check SESRSYN)

Function	Range or value	Accuracy
Phase shift, $\varphi_{line} - \varphi_{bus}$	(-180 to 180) degrees	-
Voltage high limit for synchronizing and synchrocheck	(50.0-120.0)% of UBase	±0.5% of U_r at $U \leq U_r$ ±0.5% of U at $U > U_r$
Reset ratio, synchrocheck	> 95%	-
Frequency difference limit between bus and line for synchrocheck	(0.003-1.000) Hz	±2.5 mHz
Phase angle difference limit between bus and line for synchrocheck	(5.0-90.0) degrees	±2.0 degrees
Voltage difference limit between bus and line for synchronizing and synchrocheck	(0.02-0.5) p.u	±0.5% of U_r
Time delay output for synchrocheck when angle difference between bus and line jumps from "PhaseDiff" + 2 degrees to "PhaseDiff" - 2 degrees	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Frequency difference minimum limit for synchronizing	(0.003-0.250) Hz	±2.5 mHz
Frequency difference maximum limit for synchronizing	(0.050-0.500) Hz	±2.5 mHz
Breaker closing pulse duration	(0.050-60.000) s	±0.2% or ±15 ms whichever is greater
tMaxSynch, which resets synchronizing function if no close has been made before set time	(0.000-6000.00) s	±0.2% or ±35 ms whichever is greater
Minimum time to accept synchronizing conditions	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Voltage high limit for energizing check	(50.0-120.0)% of UBase	±0.5% of U_r at $U \leq U_r$ ±0.5% of U at $U > U_r$
Reset ratio, voltage high limit	> 95%	-
Voltage low limit for energizing check	(10.0-80.0)% of UBase	±0.5% of U_r
Reset ratio, voltage low limit	< 105%	-
Maximum voltage for energizing	(50.0-180.0)% of UBase	±0.5% of U_r at $U \leq U_r$ ±0.5% of U at $U > U_r$
Table continues on next page		

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Function	Range or value	Accuracy
Time delay for energizing check when voltage jumps from 0 to 90% of Urated	(0.000-60.000) s	±0.2% or ±100 ms whichever is greater
Operate time for synchrocheck function when angle difference between bus and line jumps from "PhaseDiff" + 2 degrees to "PhaseDiff" - 2 degrees	Min. = 15 ms Max. = 30 ms	-
Operate time for energizing function when voltage jumps from 0 to 90% of Urated	Min. = 70 ms Max. = 90 ms	-

Table 23: *Autorecloser SMBRREC*

Function	Range or value	Accuracy
Number of autoreclosing shots	1 - 5	-
Autoreclosing open time: shot 1 - t1 1Ph shot 1 - t1 2Ph shot 1 - t1 3PhHS shot 1 - t1 3Ph	(0.000-120.000) s	±0.2% or ±35 ms whichever is greater
shot 2 - t2 3Ph shot 3 - t3 3Ph shot 4 - t4 3Ph shot 5 - t5 3Ph	(0.00-6000.00) s	±0.2% or ±35 ms whichever is greater
Extended autorecloser open time	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Minimum time CB must be closed before AR becomes ready for autoreclosing cycle	(0.00-6000.00) s	±0.2% or ±35 ms whichever is greater
Maximum operate pulse duration	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Reclaim time	(0.00-6000.00) s	±0.2% or ±15 ms whichever is greater
Circuit breaker closing pulse length	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Wait for master release	(0.00-6000.00) s	±0.2% or ±15 ms whichever is greater
Inhibit reset time	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater
Autorecloser maximum wait time for sync	(0.00-6000.00) s	±0.2% or ±45 ms whichever is greater
CB check time before unsuccessful	(0.00-6000.00) s	±0.2% or ±45 ms whichever is greater
Wait time after close command before proceeding to next shot	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater

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Section 5 Differential protection

Table 24: *1Ph High impedance differential protection HZPDIF*

Function	Range or value	Accuracy
Operate voltage	(10-900) V I=U/R	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Reset ratio	>95% at (30-900) V	-
Maximum continuous power	U>Trip^2/SeriesResistor ≤200 W	-
Operate time at 0 to 10 x U_d	Min. = 5 ms Max. = 15 ms	
Reset time at 10 to 0 x U_d	Min. = 75 ms Max. = 95 ms	
Critical impulse time	2 ms typically at 0 to 10 x U_d	-
Operate time at 0 to 2 x U_d	Min. = 25 ms Max. = 35 ms	
Reset time at 2 to 0 x U_d	Min. = 50 ms Max. = 70 ms	
Critical impulse time	15 ms typically at 0 to 2 x U_d	-

Table 25: *Line differential protection L3CPDIF,L6CPDIF,LT3CPDIF,LT6CPDIF*

Function	Range or value	Accuracy
*Minimum operate current	(20-200)% of *IBase*	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
SlopeSection2	(10.0-50.0)%	-
SlopeSection3	(30.0-100.0)%	-
EndSection 1	(20–150)% of *IBase*	-
EndSection 2	(100–1000)% of *IBase*	-
*Unrestrained limit function	(100–5000)% of *IBase*	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
*Second harmonic blocking	(5.0–100.0)% of fundamental	±1.0% of I_r Note: fundamental magnitude = 100% of I_r
*Fifth harmonic blocking	(5.0–100.0)% of fundamental	±2.0% of I_r Note: fundamental magnitude = 100% of I_r
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Function	Range or value	Accuracy
*Inverse characteristics, see table 136, 137 and table 137	16 curve types	See table 136, 137 and table 138
Critical impulse time	2ms typically at 0 to 10 x I_d	-
Charging current compensation	On/Off	-
LT3CPDIF and LT6CPDIF:		
*Operate time, restrained function at 0 to 10 x I_d	Min. = 25 ms Max. = 35 ms	-
*Reset time, restrained function at 10 to 0 x I_d	Min. = 5 ms Max. = 15 ms	-
*Operate time, unrestrained function at 0 to 10 x I_d	Min. = 5 ms Max. = 15 ms	-
*Reset time, unrestrained function at 10 to 0 x I_d	Min. = 15 ms Max. = 25 ms	-
L3CPDIF and L6CPDIF:		
*Operate time, restrained function at 0 to 10 x I_d	Min. = 10 ms Max. = 25 ms	-
*Reset time, restrained function at 10 to 0 x I_d	Min. = 15 ms Max. = 25 ms	-
*Operate time, unrestrained function at 0 to 10 x I_d	Min. = 5 ms Max. = 15 ms	-
*Reset time, unrestrained function at 10 to 0 x I_d	Min. = 15 ms Max. = 25 ms	-
**Note: Data valid for a single IED with two local current input groups*		

Table 26: Additional security logic for differential protection LDRGFC

Function	Range or value	Accuracy
Operate current, zero sequence current	(1-100)% of IBase	±1.0% of I_r
Operate current, low current operation	(1-100)% of IBase	±1.0% of I_r
Operate voltage, phase to neutral	(1-100)% of UBase	±0.5% of U_r
Operate voltage, phase to phase	(1-100)% of UBase	±0.5% of U_r
Independent time delay, zero sequence current at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±40 ms whichever is greater
Independent time delay, low current operation at 2 x I_{set} to 0	(0.000-60.000) s	±0.2% or ± 40 ms whichever is greater
Independent time delay, low voltage operation at 2 x U_{set} to 0	(0.000-60.000) s	±0.2% or ±40 ms whichever is greater
Reset time delay for startup signal at 0 to 2 x U_{set}	(0.000-60.000) s	±0.2% or ±40 ms whichever is greater

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Section 6 Impedance protection

Table 27: Distance measuring zone, Quad ZMQPDIS

Function	Range or value	Accuracy
Number of zones	Max 5 with selectable direction	-
Minimum operate residual current, zone 1	(5-1000)% of IBase	-
Minimum operate current, phase-to-phase and phase-to-earth	(10-1000)% of IBase	-
Positive sequence reactance	(0.10-3000.00) Ω/ phase	±2.0% static accuracy ±2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Positive sequence resistance	(0.01-1000.00) Ω/ phase	
Zero sequence reactance	(0.10-9000.00) Ω/ phase	
Zero sequence resistance	(0.01-3000.00) Ω/ phase	
Fault resistance, phase-to-earth	(0.10-9000.00) Ω/loop	
Fault resistance, phase-to-phase	(0.10-3000.00) Ω/loop	
Dynamic overreach	<5% at 85 degrees measured with CVT's and 0.5<SIR<30	-
Definite time delay Ph-Ph and Ph-E operation	(0.000-60.000) s	±0.2% or ±40 ms whichever is greater
Operate time	25 ms typically	IEC 60255-121
Reset ratio	105% typically	-
Reset time at 0.1 to 2 x Zreach	Min. = 20 ms Max. = 35 ms	-

Table 28: Distance measuring zone, quadrilateral characteristic for series compensated lines ZMCPDIS, ZMCAPDIS

Function	Range or value	Accuracy
Number of zones	Max 5 with selectable direction	-
Minimum operate residual current, zone 1	(5-1000)% of *IBase*	-
Minimum operate current, Ph-Ph and Ph-E	(10-1000)% of *IBase*	-
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Function	Range or value	Accuracy
Positive sequence reactance	(0.10-3000.00) Ω/phase	±2.0% static accuracy ±2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Positive sequence resistance	(0.10-1000.00) Ω/phase	
Zero sequence reactance	(0.01-9000.00) Ω/phase	
Zero sequence resistance	(0.01-3000.00) Ω/phase	
Fault resistance, Ph-E	(0.10-9000.00) Ω/loop	
Fault resistance, Ph-Ph	(0.10-3000.00) Ω/loop	
Dynamic overreach	<5% at 85 degrees measured with CCVT's and 0.5<SIR<30	-
Definite time delay Ph-Ph and Ph-E operation	(0.000-60.000) s	±0.2% or ± 35 ms whichever is greater
Operate time	25 ms typically	IEC 60255-121
Reset ratio	105% typically	-
Reset time at 0.1 to 2 x Zreach	Min. = 20 ms Max. = 35 ms	-

Table 29: ***Phase selection, quadrilateral characteristic with fixed angle FDPSPDIS***

Function	Range or value	Accuracy
Minimum operate current	(5-500)% of *IBase*	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Reactive reach, positive sequence	(0.50–3000.00) Ω/phase	±2.5% static accuracy ±2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Resistive reach, positive sequence	(0.10–1000.00) Ω/phase	
Reactive reach, zero sequence	(0.50–9000.00) Ω/phase	
Resistive reach, zero sequence	(0.50–3000.00) Ω/phase	
Fault resistance, phase-to-earth faults, forward and reverse	(1.00–9000.00) Ω/loop	
Fault resistance, phase-to-phase faults, forward and reverse	(0.50–3000.00) Ω/loop	
Load encroachment criteria: Load resistance, forward and reverse Safety load impedance angle	(1.00–3000.00) Ω/phase (5-70) degrees	
Reset ratio	105% typically	-

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Table 30: Full-scheme distance protection, Mho characteristic ZMHPDIS

Function	Range or value	Accuracy
Number of zones, Ph-E	Max 5 with selectable direction	-
Minimum operate current	(10–30)% of IBase	-
Positive sequence impedance, Ph-E loop	(0.005–3000.000) Ω/phase	±2.0% static accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: 85 degrees
Positive sequence impedance angle, Ph-E loop	(10–90) degrees	
Reverse reach, Ph-E loop (Magnitude)	(0.005–3000.000) Ω/phase	
Magnitude of earth return compensation factor KN	(0.00–3.00)	
Angle for earth compensation factor KN	(-180–180) degrees	
Dynamic overreach	<5% at 85 degrees measured with CVT's and 0.5<SIR<30	-
Definite time delay Ph-Ph and Ph-E operation	(0.000-60.000) s	±0.2% or ±60 ms whichever is greater
Operate time	22 ms typically	IEC 60255-121
Reset ratio	105% typically	-
Reset time at 0.5 to 1.5 x Zreach	Min. = 30 ms Max. = 45 ms	-

Table 31: High speed distance protection ZMFPDIS, ZMFCPDIS

Function	Range or value	Accuracy
Number of zones	3 selectable directions, 3 fixed directions	-
Minimum operate current, Ph-Ph and Ph-E	(5-6000)% of IBase	±1.0% of I_r at I ≤ I_r ±1.0% of I at I > I_r
Positive sequence reactance reach, Ph-E and Ph-Ph loop	(0.01 - 3000.00) ohm/ phase	±2.0% of static accuracy ±2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: At 0 degrees and 85 degrees
Positive sequence resistance reach, Ph-E and Ph-Ph loop	(0.00 - 1000.00) ohm/ phase	
Zero sequence reactance reach	(0.01 - 9000.00) ohm/p	
Zero sequence resistive reach	(0.00 - 3000.00) ohm/p	
Fault resistance reach, Ph-E and Ph-Ph	(0.01 -9000.00) ohm/l	
Dynamic overreach	< 5% at 85 degrees measured with CVTs and 0.5 < SIR < 30	
Definite time delay to trip, Ph-E and Ph-Ph operation	(0.000-60.000) s	±2.0% or ±35 ms whichever is greater
Operate time	16 ms typically	IEC 60255-121
Reset time at 0.1 to 2 x Zreach	Min. = 20 ms Max. = 35 ms	-
Reset ratio	105% typically	-

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Table 32: ***Full-scheme distance protection, quadrilateral for earth faults ZMMPDIS***

Function	Range or value	Accuracy
Number of zones	Max 5 with selectable direction	-
Minimum operate current	(10-30)% of *IBase*	-
Positive sequence reactance	(0.50-3000.00) Ω/phase	±2.0% static accuracy ±2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Positive sequence resistance	(0.10-1000.00) Ω/phase	
Zero sequence reactance	(0.50-9000.00) Ω/phase	
Zero sequence resistance	(0.50-3000.00) Ω/phase	
Fault resistance, Ph-E	(1.00-9000.00) Ω/loop	
Dynamic overreach	<5% at 85 degrees measured with CCVT's and 0.5<SIR<30	-
Definite time delay Ph-Ph and Ph-E operation	(0.000-60.000) s	±0.2% or ±40 ms whichever is greater
Operate time	25 ms typically	IEC 60255-121
Reset ratio	105% typically	-
Reset time at 0.1 to 2 x Zreach	Min. = 20 ms Max. = 35 ms	-

Table 33: ***Faulty phase identification with load encroachment FMPSPDIS***

Function	Range or value	Accuracy
Load encroachment criteria: Load resistance, forward and reverse	(1.00–3000.00) Ω/phase (5–70) degrees	±2.0% static accuracy Conditions: Voltage range: (0.1–1.1) x U_r Current range: (0.5–30) x I_r Angle: at 0 degrees and 85 degrees

Table 34: ***Distance measuring zone, quadrilateral characteristic, separate settings ZMRPDIS, ZMRAPDIS***

Function	Range or value	Accuracy
Number of zones	Max 5 with selectable direction	-
Minimum operate residual current, zone 1	(5-1000)% of IBase	-
Minimum operate current, phase-to-phase and phase-to-earth	(10-1000)% of IBase	-
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Function	Range or value	Accuracy
Positive sequence reactance	(0.10-3000.00) Ω/ phase	±2.0% static accuracy ±2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Positive sequence resistance	(0.01-1000.00) Ω/ phase	
Zero sequence reactance	(0.10-9000.00) Ω/ phase	
Zero sequence resistance	(0.01-3000.00) Ω/ phase	
Fault resistance, phase-to-earth	(0.10-9000.00) Ω/loop	
Fault resistance, phase-to-phase	(0.10-3000.00) Ω/loop	
Dynamic overreach	<5% at 85 degrees measured with CVT's and 0.5<SIR<30	-
Definite time delay phase-phase and phase-earth operation	(0.000-60.000) s	±0.2% or ±40 ms whichever is greater
Operate time	25 ms typically	IEC 60255-121
Reset ratio	105% typically	-
Reset time at 0.1 to 2 x Zreach	Min. = 20 ms Max. = 35 ms	-

Table 35: Phase selection with load encroachment, quadrilateral characteristic FRPSPDIS

Function	Range or value	Accuracy
Minimum operate current	(5-500)% of IBase	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Reactive reach, positive sequence	(0.50–3000.00) Ω/phase	±2.0% static accuracy ±2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Resistive reach, positive sequence	(0.10–1000.00) Ω/phase	
Reactive reach, zero sequence	(0.50–9000.00) Ω/phase	
Resistive reach, zero sequence	(0.50–3000.00) Ω/phase	
Fault resistance, Ph-E faults, forward and reverse	(1.00–9000.00) Ω/loop	
Fault resistance, Ph-Ph faults, forward and reverse	(0.50–3000.00) Ω/loop	
Load encroachment criteria: Load resistance, forward and reverse Safety load impedance angle	(1.00–3000.00) Ω/phase (5-70) degrees	
Reset ratio	105% typically	-

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Table 36: Power swing detection ZMRPSB

Function	Range or value	Accuracy
Reactive reach	(0.10-3000.00) Ω/phase	±2.0% static accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Resistive reach	(0.10–1000.00) Ω/loop	
Power swing detection operate time	(0.000-60.000) s	±0.2% or ±10 ms whichever is greater
Second swing reclaim operate time	(0.000-60.000) s	±0.2% or ±20 ms whichever is greater
Minimum operate current	(5-30)% of IBase	±1.0% of I_r

Table 37: Automatic switch onto fault logic ZCVPSOF

Parameter	Range or value	Accuracy
Operate voltage, detection of dead line	(1–100)% of *UBase*	±0.5% of U_r
Operate current, detection of dead line	(1–100)% of *IBase*	±1.0% of I_r
Time delay to operate for the switch onto fault function	(0.03-120.00) s	±0.2% or ±20 ms whichever is greater
Time delay for UI detection	(0.000-60.000) s	±0.2% or ±20 ms whichever is greater
Delay time for activation of dead line detection	(0.000-60.000) s	±0.2% or ±20 ms whichever is greater
Drop-off delay time of switch onto fault function	(0.000-60.000) s	±0.2% or ±30 ms whichever is greater

Table 38: Power swing logic PSLPSCH

Function	Range or value	Accuracy
Permitted maximum operating time difference between higher and lower zone	(0.000 — 60.0000) s	±0,2% or ±15 ms whichever is greater
Delay for operation of underreach zone with detected difference in operating time	(0.000 — 60.0000) s	±0,2% or ±15 ms whichever is greater
Conditional timer for sending the CS at power swings	(0.000 — 60.0000) s	±0,2% or ±15 ms whichever is greater
Conditional timer for tripping at power swings	(0.000 — 60.0000) s	±0,2% or ±15 ms whichever is greater
Timer for blocking the overreaching zones trip	(0.000 — 60.0000) s	±0,2% or ±15 ms whichever is greater

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Table 39: Out-of-step protection OOSPPAM

Function	Range or value	Accuracy
Impedance reach	(0.00 - 1000.00)% of Zbase	±2.0% of $U_r/(\sqrt{3} \cdot I_r)$
Rotor start angle	(90.0 - 130.0) degrees	±5.0 degrees
Rotor trip angle	(15.0 - 90.0) degrees	±5.0 degrees
Zone 1 and Zone 2 trip counters	(1 - 20)	-

Table 40: Pole slip protection PSPPPAM

Function	Range or value	Accuracy
Impedance reach	(0.00 - 1000.00)% of Zbase	±2.0% of U_r/I_r
Zone 1 and Zone 2 trip counters	(1 - 20)	-

Table 41: Phase preference logic PPLPHIZ

Function	Range or value	Accuracy
Operate value, phase-to-phase and phase-to-neutral undervoltage	(1 - 100)% of UBase	±0.5% of U_r
Reset ratio, undervoltage	< 105%	-
Operate value, residual voltage	(5 - 300)% of UBase	±0.5% of U_r at $U \leq U_r$ ±0.5% of U at $U > U_r$
Reset ratio, residual voltage	> 95%	-
Operate value, residual current	(10 - 200)% of IBase	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Reset ratio, residual current	> 95%	-
Independent time delay for residual current at 0 to 2 x I_{set}	(0.000 - 60.000) s	±0.2% or ±25 ms whichever is greater
Independent time delay for residual voltage at 0.8 to 1.2 x U_{set}	(0.000 - 60.000) s	±0.2% or ±25 ms whichever is greater
Independent dropoff-delay for residual voltage at 1.2 to 0.8 x U_{set}	(0.000 - 60.000) s	±0.2% or ±25 ms whichever is greater
Operating mode	No Filter, NoPref Cyclic: 1231c, 1321c Acyclic: 123a, 132a, 213a, 231a, 312a, 321a	

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Section 7 Current protection

Table 42: Instantaneous phase overcurrent protection PHPIOC

Function	Range or value	Accuracy
Operate current	(5-2500)% of IBase	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Reset ratio	> 95% at (50–2500)% of IBase	-
Operate time at 0 to 2 x I_{set}	Min. = 15 ms Max. = 25 ms	-
Reset time at 2 to 0 x I_{set}	Min. = 15 ms Max. = 25 ms	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Operate time at 0 to 10 x I_{set}	Min. = 5ms Max. = 15ms	-
Reset time at 10 to 0 x I_{set}	Min. = 25ms Max. = 40 ms	-
Critical impulse time	2 ms typically at 0 to 10 x I_{set}	-
Dynamic overreach	< 5% at τ = 100 ms	-

Table 43: Four-step phase overcurrent protection OC4PTOC

Function	Setting range	Accuracy
Operate current, step 1 - 4	(5-2500)% of *IBase*	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Reset ratio	> 95% at (50–2500)% of *IBase*	-
Minimum operate current, step 1 - 4	(1-10000)% of *IBase*	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Relay characteristic angle (RCA)	(40.0–65.0) degrees	±2.0 degrees
Relay operating angle (ROA)	(40.0–89.0) degrees	±2.0 degrees
Second harmonic blocking	(5–100)% of fundamental	±2.0% of I_r
Independent time delay at 0 to 2 x I_{set}, step 1 - 4	(0.000-60.000) s	±0.2 % or ±35 ms whichever is greater
Minimum operate time for inverse curves , step 1 - 4	(0.000-60.000) s	±0.2 % or ±35 ms whichever is greater
Inverse time characteristics, see table 136, table 137 and table 138	16 curve types	See table 136, table 137 and table 138
Operate time, start non-directional at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
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Function	Setting range	Accuracy
Reset time, start non-directional at 2 to 0 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start non-directional at 0 to 10 x I_{set}	Min. = 5 ms Max. = 20 ms	-
Reset time, start non-directional at 10 to 0 x I_{set}	Min. = 20 ms Max. = 35 ms	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-

Table 44: Instantaneous residual overcurrent protection EFPIOC

Function	Range or value	Accuracy
Operate current	(5-2500)% of lBase	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Reset ratio	> 95% at (50–2500)% of IBase	-
Operate time at 0 to 2 x I_{set}	Min. = 15 ms Max. = 25 ms	-
Reset time at 2 to 0 x I_{set}	Min. = 15 ms Max. = 25 ms	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Operate time at 0 to 10 x I_{set}	Min. = 5 ms Max. = 15 ms	-
Reset time at 10 to 0 x I_{set}	Min. = 25 ms Max. = 35 ms	-
Critical impulse time	2 ms typically at 0 to 10 x I_{set}	-
Dynamic overreach	< 5% at τ = 100 ms	-

Table 45: Four step residual overcurrent protection EF4PTOC technical data

Function	Range or value	Accuracy
Operate current, step 1 - 4	(1-2500)% of *IBase*	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Reset ratio	> 95% at (10-2500)% of *IBase*	-
Relay characteristic angle (RCA)	(-180 to 180) degrees	±2.0 degrees
Operate current for directional release	(1–100)% of *IBase*	For RCA ±60 degrees: ±2.5% of I_r at $I \le I_r$ ±2.5% of I at $I > I_r$
Independent time delay at 0 to 2 x I_{set}, step 1 - 4	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Minimum operate time for inverse curves, step 1 - 4	(0.000 - 60.000) s	±0.2% or ±35 ms whichever is greater

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Function	Range or value	Accuracy
Inverse time characteristics, see Table 136, Table 137 and Table 138	16 curve types	See Table 136, Table 137 and Table 138
Second harmonic blocking	(5–100)% of fundamental	±2.0% of I_r
Minimum polarizing voltage	(1–100)% of *UBase*	±0.5% of U_r
Minimum polarizing current	(2-100)% of *IBase*	±1.0% of I_r
Real part of source Z used for current polarization	(0.50-1000.00) Ω/phase	-
Imaginary part of source Z used for current polarization	(0.50–3000.00) Ω/phase	-
Operate time, start non-directional at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start non-directional at 2 to 0 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start non-directional at 0 to 10 x I_{set}	Min. = 5 ms Max. = 20 ms	-
Reset time, start non-directional at 10 to 0 x I_{set}	Min. = 20 ms Max. = 35 ms	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-

Table 46: Four step negative sequence overcurrent protection NS4PTOC

Function	Range or value	Accuracy
Operate current, step 1 - 4	(1-2500)% of *IBase*	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Reset ratio	> 95% at (10-2500)% of *IBase*	-
Independent time delay at 0 to 2 x I_{set}, step 1 - 4	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Minimum operate time for inverse curves, step 1 - 4	(0.000 - 60.000) s	±0.2% or ±35 ms whichever is greater
Inverse time characteristics, see table 136, table 137 and table 138	16 curve types	See table 136, table 137 and table 138
Minimum operate current, step 1 - 4	(1.00 - 10000.00)% of *IBase*	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Relay characteristic angle (RCA)	(-180 to 180) degrees	±2.0 degrees
Operate current for directional release	(1–100)% of *IBase*	For RCA ±60 degrees: ±2.5% of I_r at $I \le I_r$ ±2.5% of I at $I > I_r$
Minimum polarizing voltage	(1–100)% of *UBase*	±0.5% of U_r
Minimum polarizing current	(2-100)% of *IBase*	±1.0% of I_r
Real part of negative sequence source impedance used for current polarization	(0.50-1000.00) Ω/phase	-

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Function	Range or value	Accuracy
Imaginary part of negative sequence source impedance used for current polarization	(0.50–3000.00) Ω/phase	-
Operate time, start non-directional at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start non-directional at 2 to 0 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start non-directional at 0 to 10 x I_{set}	Min. = 5 ms Max. = 20 ms	-
Reset time, start non-directional at 10 to 0 x I_{set}	Min. = 20 ms Max. = 35 ms	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-
Transient overreach	<10% at τ = 100 ms	-

Table 47: Sensitive directional residual overcurrent and power protection SDEPSDE

Function	Range or value	Accuracy
Operate level for $3I_0 \cdot \cos\varphi$ directional residual overcurrent	(0.25-200.00)% of *IBase*	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Operate level for $3I_0 \cdot 3U_0 \cos\varphi$ directional residual power	(0.25-200.00)% of *SBase*	±1.0% of S_r at $S \le S_r$ ±1.0% of S at $S > S_r$
Operate level for $3I_0$ and φ residual overcurrent	(0.25-200.00)% of *IBase*	±1.0% of I_r at $\le I_r$ ±1.0% of I at $I > I_r$
Operate level for non-directional overcurrent	(1.00-400.00)% of *IBase*	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Operate level for non-directional residual overvoltage	(1.00-200.00)% of *UBase*	±0.5% of U_r at $U \le U_r$ ±0.5% of U at $U > U_r$
Residual release current for all directional modes	(0.25-200.00)% of *IBase*	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Residual release voltage for all directional modes	(1.00-300.00)% of *UBase*	±0.5% of U_r at $U \le U_r$ ±0.5% of U at $U > U_r$
Operate time for non-directional residual overcurrent at 0 to 2 x Iset	Min. = 40 ms Max. = 65 ms	
Reset time for non-directional residual overcurrent at 2 to 0 x Iset	Min. = 40 ms Max. = 65 ms	
Operate time for directional residual overcurrent at 0 to 2 x Iset	Min. = 110 ms Max. = 160 ms	
Reset time for directional residual overcurrent at 2 to 0 x Iset	Min. = 20 ms Max. = 60 ms	

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Function	Range or value	Accuracy
Independent time delay for non-directional residual overvoltage at 0.8 to 1.2 x Uset	(0.000 – 60.000) s	±0.2% or ± 75 ms whichever is greater
Independent time delay for non-directional residual overcurrent at 0 to 2 x Iset	(0.000 – 60.000) s	±0.2% or ± 75 ms whichever is greater
Independent time delay for directional residual overcurrent at 0 to 2 x Iset	(0.000 – 60.000) s	±0.2% or ± 170 ms whichever is greater
Inverse characteristics, see table 142, table 143 and table 144	16 curve types	See table 142, table 143 and table 144
Relay characteristic angle (RCADir)	(-179 to 180) degrees	±2.0 degrees
Relay operate angle (ROADir)	(0 to 90) degrees	±2.0 degrees

Table 48: Thermal overload protection, one time constant LCPTTR/LFPTTR

Function	Range or value	Accuracy
Reference current	(2-400)% of IBase	±1.0% of I_r
Reference temperature	(0-300)°C, (0 - 600)°F	±1.0°C, ±2.0°F
Operate time: $$t = \tau \ln \left[\frac{I^2 - I_p^2}{I^2 - I_p^2 - \frac{T_{Trip} - T_{Amb}}{T_{ref}} \cdot I_{ref}^2} \right]$$ (Equation 1) T_{Trip}= set operate temperature T_{Amb} = ambient temperature T_{ref} = temperature rise above ambient at I_{ref} I_{ref} = reference load current I = actual measured current I_p = load current before overload occurs	Time constant τ = (1–1000) minutes	IEC 60255-149, ±5.0% or ±200 ms whichever is greater
Alarm temperature	(0-200)°C, (0-400)°F	±2.0°C, ±4.0°F
Operate temperature	(0-300)°C, (0-600)°F	±2.0°C, ±4.0°F
Reset level temperature	(0-300)°C, (0-600)°F	±2.0°C, ±4.0°F

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Table 49: Breaker failure protection CCRBRF

Function	Range or value	Accuracy
Operate phase current	(5-200)% of *IBase*	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Reset ratio, phase current	> 95%	-
Operate residual current	(2-200)% of *IBase*	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Reset ratio, residual current	> 95%	-
Phase current level for blocking of contact function	(5-200)% of *IBase*	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate time for current detection	10 ms typically	-
Reset time for current detection	15 ms maximum	-
Time delay for re-trip at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Time delay for back-up trip at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Time delay for back-up trip at multi-phase start at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±20 ms whichever is greater
Additional time delay for a second back-up trip at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±20 ms whichever is greater
Time delay for alarm for faulty circuit breaker	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater

Table 50: Stub protection STBPTOC

Function	Range or value	Accuracy
Operating current	(5-2500)% of *IBase*	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Reset ratio	> 95% at (50-2500)% of *IBase*	-
Independent time delay at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±30 ms whichever is greater
Operate time, start at 0 to 2 x I_{set}	Min. = 10 ms Max. = 20 ms	-
Reset time, start at 2 to 0 x I_{set}	Min. = 10 ms Max. = 20 ms	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-

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Table 51: Pole discordance protection CCPDSC

Function	Range or value	Accuracy
Operate current	(0–100)% of *IBase*	±1.0% of I_r
Independent time delay between trip condition and trip signal	(0.000-60.000) s	±0.2% or ± 25 ms whichever is greater

Table 52: Directional underpower protection GUPPDUP

Function	Range or value	Accuracy
Power level for Step 1 and Step 2	(0.0–500.0)% of *SBase*	±1.0% of S_r at $S \le S_r$ ±1.0% of S at $S > S_r$ where $S_r = 1.732 \cdot U_r \cdot I_r$
Characteristic angle for Step 1 and Step 2	(-180.0–180.0) degrees	±2.0 degrees
Independent time delay to operate for Step 1 and Step 2 at 2 to 0.5 x S_r and *k=0.000*	(0.01-6000.00) s	±0.2% or ±40 ms whichever is greater

Table 53: Directional overpower protection GOPPDOP

Function	Range or value	Accuracy
Power level for Step 1 and Step 2	(0.0–500.0)% of SBase	±1.0% of S_r at $S \le S_r$ ±1.0% of S at $S > S_r$
Characteristic angle for Step 1 and Step 2	(-180.0–180.0) degrees	±2.0 degrees
Operate time, start at 0.5 to 2 x S_r and *k=0.000*	Min. =10 ms Max. = 25 ms	
Reset time, start at 2 to 0.5 x S_r and *k=0.000*	Min. = 35 ms Max. = 55 ms	
Independent time delay to operate for Step 1 and Step 2 at 0.5 to 2 x S_r and *k=0.000*	(0.01-6000.00) s	±0.2% or ±40 ms whichever is greater

Table 54: Broken conductor check BRCPTOC

Function	Range or value	Accuracy
Minimum phase current for operation	(5–100)% of *IBase*	±1.0% of I_r
Unbalance current operation	(50–90)% of maximum current	±1.0% of I_r
Independent operate time delay	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater
Independent reset time delay	(0.010-60.000) s	±0.2% or ±30 ms whichever is greater
Start time at current change from I_r to 0	Min. = 25 ms Max. = 35 ms	-
Reset time at current change from 0 to I_r	Min. = 5 ms Max. = 20 ms	-

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Table 55: Voltage-restrained time overcurrent protection VRPVOC

Function	Range or value	Accuracy
Start overcurrent	(2.0 - 5000.0)% of IBase	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Reset ratio, overcurrent	> 95%	-
Operate time, start overcurrent at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start overcurrent at 2 to 0 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start overcurrent at 0 to 10 x I_{set}	Min. = 5 ms Max. = 20 ms	-
Reset time, start overcurrent at 10 to 0 x I_{set}	Min. = 20 ms Max. = 35 ms	-
Independent time delay to operate at 0 to 2 x I_{set}	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Inverse time characteristics, see tables 136 and 137	13 curve types	See tables 136 and 137
Minimum operate time for inverse time characteristics	(0.00 - 60.00) s	±0.2% or ±35 ms whichever is greater
High voltage limit, voltage dependent operation	(30.0 - 100.0)% of UBase	±1.0% of U_r
Start undervoltage	(2.0 - 100.0)% of UBase	±0.5% of U_r
Reset ratio, undervoltage	< 105%	-
Operate time start undervoltage at 2 to 0 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time start undervoltage at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Independent time delay to operate, undervoltage at 2 to 0 x U_{set}	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Internal low voltage blocking	(0.0 - 5.0)% of UBase	±0.25% of U_r
Overcurrent: Critical impulse time Impulse margin time	 10 ms typically at 0 to 2 x I_{set} 15 ms typically	-
Undervoltage: Critical impulse time Impulse margin time	 10ms typically at 2 to 0 x U_{set} 15 ms typically	-

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Section 8 Voltage protection

Table 56: Two step undervoltage protection UV2PTUV

Function	Range or value	Accuracy
Operate voltage, low and high step	(1.0–100.0)% of *UBase*	±0.5% of U_r
Absolute hysteresis	(0.0–50.0)% of *UBase*	±0.5% of U_r
Internal blocking level, step 1 and step 2	(1–50)% of *UBase*	±0.5% of U_r
Inverse time characteristics for step 1 and step 2, see table 140	-	See table 140
Definite time delay, step 1 at 1.2 to 0 x U_{set}	(0.00-6000.00) s	±0.2% or ±40ms whichever is greater
Definite time delay, step 2 at 1.2 to 0 x U_{set}	(0.000-60.000) s	±0.2% or ±40ms whichever is greater
Minimum operate time, inverse characteristics	(0.000–60.000) s	±0.5% or ±40ms whichever is greater
Operate time, start at 2 to 0 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start at 1.2 to 0 x U_{set}	Min. = 5 ms Max. = 25 ms	-
Reset time, start at 0 to 1.2 x U_{set}	Min. = 15 ms Max. = 35 ms	-
Critical impulse time	5 ms typically at 1.2 to 0 x U_{set}	-
Impulse margin time	15 ms typically	-

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Table 57: Two step overvoltage protection OV2PTOV

Function	Range or value	Accuracy
Operate voltage, step 1 and 2	(1.0-200.0)% of *UBase*	±0.5% of U_r at $U \le U_r$ ±0.5% of U at $U > U_r$
Absolute hysteresis	(0.0–50.0)% of *UBase*	±0.5% of U_r at $U \le U_r$ ±0.5% of U at $U > U_r$
Inverse time characteristics for steps 1 and 2, see table 139	-	See table 139
Definite time delay, low step (step 1) at 0 to 1.2 x U_{set}	(0.00 - 6000.00) s	±0.2% or ±45 ms whichever is greater
Definite time delay, high step (step 2) at 0 to 1.2 x U_{set}	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater
Minimum operate time, Inverse characteristics	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater
Operate time, start at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 2 to 0 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start at 0 to 1.2 x U_{set}	Min. = 20 ms Max. = 35 ms	-
Reset time, start at 1.2 to 0 x U_{set}	Min. = 5 ms Max. = 25 ms	-
Critical impulse time	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time	15 ms typically	-

Table 58: Two step residual overvoltage protection ROV2PTOV

Function	Range or value	Accuracy
Operate voltage, step 1 and step 2	(1.0-200.0)% of *UBase*	± 0.5% of U_r at $U \le U_r$ ± 0.5% of U at $U > U_r$
Absolute hysteresis	(0.0–50.0)% of *UBase*	± 0.5% of U_r at $U \le U_r$ ± 0.5% of U at $U > U_r$
Inverse time characteristics for low and high step, see table 141	-	See table 141
Definite time delay low step (step 1) at 0 to 1.2 x U_{set}	(0.00–6000.00) s	± 0.2% or ± 45 ms whichever is greater .
Table continues on next page		

Function	Range or value	Accuracy
Definite time delay high step (step 2) at 0 to 1.2 x U_{set}	(0.000–60.000) s	± 0.2% or ± 45 ms whichever is greater
Minimum operate time	(0.000-60.000) s	± 0.2% or ± 45 ms whichever is greater
Operate time, start at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 2 to 0 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start at 0 to 1.2 x U_{set}	Min. = 20 ms Max. = 35 ms	-
Reset time, start at 1.2 to 0 x U_{set}	Min. = 5 ms Max. = 25 ms	-
Critical impulse time	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time	15 ms typically	-

Table 59: Overexcitation protection OEXPVPH

Function	Range or value	Accuracy
Operate value, start	(100–180)% of (*UBase*/f_{rated})	±0.5% of U
Operate value, alarm	(50–120)% of start level	±0.5% of U_r at U ≤ U_r ±0.5% of U at U > U_r
Operate value, high level	(100–200)% of (*UBase*/f_{rated})	±0.5% of U
Curve type	IEEE or customer defined $IEEE: t = \frac{(0.18 \cdot k)}{(M-1)^2}$ (Equation 2) where M = (E/f)/(Ur/fr)	±5.0 % or ±45 ms, whichever is greater
Minimum time delay for inverse function	(0.000–60.000) s	±1.0% or ±45 ms, whichever is greater
Maximum time delay for inverse function	(0.00–9000.00) s	±1.0% or ±45 ms, whichever is greater
Alarm time delay	(0.00–9000.00)	±1.0% or ±45 ms, whichever is greater

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Table 60: *Voltage differential protection VDCPTOV*

Function	Range or value	Accuracy
Voltage difference for alarm and trip	(2.0–100.0) % of *UBase*	±0.5% of U_r
Under voltage level	(1.0–100.0) % of *UBase*	±0.5% of U_r
Independent time delay for voltage differential alarm at 0.8 to 1.2 x UDAlarm	(0.000–60.000)s	±0.2% or ±40 ms whichever is greater
Independent time delay for voltage differential trip at 0.8 to 1.2 x UDTrip	(0.000–60.000)s	±0.2% or ±40 ms whichever is greater
Independent time delay for voltage differential reset at 1.2 to 0.8 x UDTrip	(0.000–60.000)s	±0.2% or ±40 ms whichever is greater

Table 61: *Loss of voltage check LOVPTUV*

Function	Range or value	Accuracy
Operate voltage	(1–100)% of UBase	±0.5% of U_r
Pulse timer when disconnecting all three phases	(0.050–60.000) s	±0.2% or ±15 ms whichever is greater
Time delay for enabling the functions after restoration	(0.000–60.000) s	±0.2% or ±35 ms whichever is greater
Operate time delay when disconnecting all three phases	(0.000–60.000) s	±0.2% or ±35 ms whichever is greater
Time delay to block when all three phase voltages are not low	(0.000–60.000) s	±0.2% or ±35 ms whichever is greater

Table 62: *Radial feeder protection PAPGAPC*

Function	Range or value	Accuracy
Residual current detection	(10 - 150)% of IBase	±1.0% of Ir at I ≤ Ir ±1.0% of I at I > Ir
Reset ratio	>95% at (50 - 150)% of IBase	-
Operate time, residual current detection at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Independent time delay to operate, residual current detection at 0 to 2 x I_{set}	(0.000 - 60.000) s	±0.2% or ±40 ms whichever is greater
Voltage based phase selection	(30 - 100)% of UBase	±1.0% of U_r
Reset ratio	<115%	-
Operate time, voltage based phase selection at 1.2 to 0.8 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Independent time delay to operate, voltage based phase selection at 1.2 to 0.8 x U_{set}	(0.000 – 60.000) s	±0.2% or ±40 ms whichever is greater

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Section 9 Frequency protection

Table 63: Underfrequency protection SAPTUF

Function	Range or value		Accuracy
Operate value, start function, at symmetrical three phase voltage	(35.00-75.00) Hz		±2.0 mHz
Operate time, start at f_{set} + 0.02 Hz to f_{set} - 0.02 Hz	fn = 50 Hz	Min. = 80 ms	-
		Max. = 95 ms	
	fn = 60 Hz	Min. = 65 ms	
		Max. = 80 ms	
Reset time, start at f_{set} - 0.02 Hz to f_{set} + 0.02 Hz	Min. = 15 ms Max. = 30 ms		-
Operate time, definite time function at f_{set} + 0.02 Hz to f_{set} - 0.02 Hz	(0.000-60.000)s		±0.2% or ±100 ms whichever is greater
Reset time, definite time function at f_{set} - 0.02 Hz to f_{set} + 0.02 Hz	(0.000-60.000)s		±0.2% or ±120 ms whichever is greater
Voltage dependent time delay	Settings: UNom=(50-150)% of U_{base} UMin=(50-150)% of U_{base} Exponent=0.0-5.0 tMax=(0.010–60.000)s tMin=(0.010–60.000)s		±1.0% or ±120 ms whichever is greater

$$t = \left[\frac{U - UMin}{UNom - UMin} \right]^{Exponent} \cdot (tMax - tMin) + tMin$$

(Equation 3)

$U=U_{measured}$

Table 64: Overfrequency protection SAPTOF

Function	Range or value		Accuracy
Operate value, start function at symmetrical three-phase voltage	(35.00-90.00) Hz		±2.0 mHz
Operate time, start at f_{set} -0.02 Hz to f_{set} +0.02 Hz	fn = 50Hz	Min. = 80 ms Max. = 95 ms	-
	fn = 60 Hz	Min. = 65 ms Max. = 80 ms	

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Function	Range or value	Accuracy
Reset time, start at f_{set} +0.02 Hz to f_{set} -0.02 Hz	Min. = 15 ms Max. = 30 ms	-
Operate time, definite time function at f_{set} -0.02 Hz to f_{set} +0.02 Hz	(0.000-60.000)s	±0.2% ±100 ms whichever is greater
Reset time, definite time function at f_{set} +0.02 Hz to f_{set} -0.02 Hz	(0.000-60.000)s	±0.2% ±120 ms, whichever is greater

Table 65: ***Rate-of-change frequency protection SAPFRC***

Function	Range or value	Accuracy
Operate value, start function	(-10.00-10.00) Hz/s	±10.0 mHz/s
Operate value, restore enable frequency	(45.00-65.00) Hz	±2.0 mHz
Definite restore time delay	(0.000-60.000) s	±0.2% or ±100 ms whichever is greater
Definite time delay for frequency gradient trip	(0.200-60.000) s	±0.2% or ±120 ms whichever is greater
Definite reset time delay	(0.000-60.000) s	±0.2% or ±250 ms whichever is greater

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Section 10 Multipurpose protection

Table 66: General current and voltage protection CVGAPC

Function	Range or value	Accuracy
Measuring current input	phase1, phase2, phase3, PosSeq, -NegSeq, -3*ZeroSeq, MaxPh, MinPh, UnbalancePh, phase1-phase2, phase2-phase3, phase3-phase1, MaxPh-Ph, MinPh-Ph, UnbalancePh-Ph	-
Measuring voltage input	phase1, phase2, phase3, PosSeq, -NegSeq, -3*ZeroSeq, MaxPh, MinPh, UnbalancePh, phase1-phase2, phase2-phase3, phase3-phase1, MaxPh-Ph, MinPh-Ph, UnbalancePh-Ph	-
Start overcurrent, step 1 - 2	(2 - 5000)% of IBase	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Start undercurrent, step 1 - 2	(2 - 150)% of IBase	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Independent time delay, overcurrent at 0 to 2 x I_{set}, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Independent time delay, undercurrent at 2 to 0 x I_{set}, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Overcurrent (non-directional): Start time at 0 to 2 x I_{set} Reset time at 2 to 0 x I_{set} Start time at 0 to 10 x I_{set} Reset time at 10 to 0 x I_{set}	 Min. = 15 ms Max. = 30 ms Min. = 15 ms Max. = 30 ms Min. = 5 ms Max. = 20 ms Min. = 20 ms Max. = 35 ms	 - - - -
Undercurrent: Start time at 2 to 0 x I_{set} Reset time at 0 to 2 x I_{set}	 Min. = 15 ms Max. = 30 ms Min. = 15 ms Max. = 30 ms	 - -
Overcurrent: Inverse time characteristics, see table 136, 137 and table 138	16 curve types	See table 136, 137 and table 138
Overcurrent:		

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Function	Range or value	Accuracy
Minimum operate time for inverse curves, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Voltage level where voltage memory takes over	(0.0 - 5.0)% of UBase	±0.5% of U_r
Start overvoltage, step 1 - 2	(2.0 - 200.0)% of UBase	±0.5% of U_r at $U \le U_r$ ±0.5% of U at $U > U_r$
Start undervoltage, step 1 - 2	(2.0 - 150.0)% of UBase	±0.5% of U_r at $U \le U_r$ ±0.5% of U at $U > U_r$
Independent time delay, overvoltage at 0.8 to 1.2 x U_{set}, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Independent time delay, undervoltage at 1.2 to 0.8 x U_{set}, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Overvoltage: Start time at 0.8 to 1.2 x U_{set} Reset time at 1.2 to 0.8 x U_{set}	 Min. = 15 ms Max. = 30 ms Min. = 15 ms Max. = 30 ms	 - -
Undervoltage: Start time at 1.2 to 0.8 x U_{set} Reset time at 1.2 to 0.8 x U_{set}	 Min. = 15 ms Max. = 30 ms Min. = 15 ms Max. = 30 ms	 - -
Overvoltage: Inverse time characteristics, see table 139	4 curve types	See table 139
Undervoltage: Inverse time characteristics, see table 140	3 curve types	See table 140
High and low voltage limit, voltage dependent operation, step 1 - 2	(1.0 - 200.0)% of UBase	±1.0% of U_r at $U \le U_r$ ±1.0% of U at $U > U_r$
Directional function	Settable: NonDir, forward and reverse	-
Relay characteristic angle	(-180 to +180) degrees	±2.0 degrees
Relay operate angle	(1 to 90) degrees	±2.0 degrees
Reset ratio, overcurrent	> 95%	-
Reset ratio, undercurrent	< 105%	-
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Function	Range or value	Accuracy
Reset ratio, overvoltage	> 95%	-
Reset ratio, undervoltage	< 105%	-
Overcurrent:		
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-
Undercurrent:		
Critical impulse time	10 ms typically at 2 to 0 x I_{set}	-
Impulse margin time	15 ms typically	-
Overvoltage:		
Critical impulse time	10 ms typically at 0.8 to 1.2 x U_{set}	-
Impulse margin time	15 ms typically	-
Undervoltage:		
Critical impulse time	10 ms typically at 1.2 to 0.8 x U_{set}	-
Impulse margin time	15 ms typically	-

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Section 11 Secondary system supervision

Table 67: Current circuit supervision CCSSPVC

Function	Range or value	Accuracy
Operate current	(10-200)% of IBase	±10.0% of I_r at $I \le I_r$ ±10.0% of I at $I > I_r$
Reset ratio, Operate current	>90%	
Block current	(20-500)% of IBase	±5.0% of I_r at $I \le I_r$ ±5.0% of I at $I > I_r$
Reset ratio, Block current	>90% at (50-500)% of IBase	

Table 68: Fuse failure supervision FUFSPVC

Function	Range or value	Accuracy
Operate voltage, zero sequence	(1-100)% of UBase	±0.5% of U_r
Operate current, zero sequence	(1–100)% of IBase	±0.5% of I_r
Operate voltage, negative sequence	(1-100)% of UBase	±0.5% of U_r
Operate current, negative sequence	(1–100)% of IBase	±0.5% of I_r
Operate voltage change level	(1-100)% of UBase	±10.0% of U_r
Operate current change level	(1–100)% of IBase	±10.0% of I_r
Operate phase voltage	(1-100)% of UBase	±0.5% of U_r
Operate phase current	(1–100)% of IBase	±0.5% of I_r
Operate phase dead line voltage	(1-100)% of UBase	±0.5% of U_r
Operate phase dead line current	(1–100)% of IBase	±0.5% of I_r
Operate time, start, 1 ph, at 1 to 0 x U_r	Min. = 10 ms Max. = 25 ms	-
Reset time, start, 1 ph, at 0 to 1 x U_r	Min. = 15 ms Max. = 30 ms	-

Table 69: Fuse failure supervision VDSPVC

Function	Range or value	Accuracy
Operate value, block of main fuse failure	(10.0-80.0)% of UBase	±0.5% of Ur
Reset ratio	<110%	
Operate time, block of main fuse failure at 1 to 0 x U_r	Min. = 5 ms Max. = 15 ms	–
Reset time, block of main fuse failure at 0 to 1 x U_r	Min. = 15 ms Max. = 30 ms	–
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Function	Range or value	Accuracy
Operate value, alarm for pilot fuse failure	(10.0-80.0)% of UBase	±0.5% of Ur
Reset ratio	<110%	–
Operate time, alarm for pilot fuse failure at 1 to 0 x U_r	Min. = 5 ms Max. = 15 ms	–
Reset time, alarm for pilot fuse failure at 0 to 1 x U_r	Min. = 15 ms Max. = 30 ms	–

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Section 12 Scheme communication

Table 70: Scheme communication logic for distance or overcurrent protection ZCPSCH

Function	Range or value	Accuracy
Scheme type	Off Intertrip Permissive UR Permissive OR Blocking DeltaBlocking	-
Operate voltage, Delta U	(0–100)% of UBase	±5.0% of ΔU
Operate current, Delta I	(0–200)% of IBase	±5.0% of ΔI
Operate zero sequence voltage, Delta 3U0	(0–100)% of UBase	±10.0% of Δ3U0
Operate zero sequence current, Delta 3I0	(0–200)% of IBase	±10.0% of Δ3I0
Co-ordination time for blocking communication scheme	(0.000-60.000) s	±0.5% ±10 ms
Minimum duration of a carrier send signal	(0.000-60.000) s	±0.5% ±10 ms
Security timer for loss of guard signal detection	(0.000-60.000) s	±0.5% ±10 ms
Operation mode of unblocking logic	Off NoRestart Restart	-

Table 71: Phase segregated scheme communication logic for distance protection ZC1PPSCH

Function	Range or value	Accuracy
Scheme type	Intertrip Permissive UR Permissive OR Blocking	-
Co-ordination time for blocking communication scheme	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Minimum duration of a carrier send signal	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater

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Table 72: ***Current reversal and weak-end infeed logic for phase segregated communication ZC1WPSCH***

Function	Range or value	Accuracy
Detection level phase to neutral voltage	(10-90)% of UBase	±0.5% of U_r
Detection level phase to phase voltage	(10-90)% of UBase	±0.5% of U_r
Reset ratio	<105% at (20-90)% of UBase	-
Operate time for current reversal	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Delay time for current reversal	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Coordination time for weak-end infeed logic	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater

Table 73: ***Scheme communication logic for residual overcurrent protection ECPSCH***

Function	Range or value	Accuracy
Scheme type	Permissive Underreaching Permissive Overreaching Blocking	-
Communication scheme coordination time	(0.000-60.000) s	±0.2% or ±20 ms whichever is greater

Table 74: ***Current reversal and weak-end infeed logic for residual overcurrent protection ECRWPSCH***

Function	Range or value	Accuracy
Operate mode of WEI logic	Off Echo Echo & Trip	-
Operate voltage 3U0 for WEI trip	(5-70)% of UBase	±0.5% of U_r
Operate time for current reversal logic	(0.000-60.000) s	±0.2% or ±30 ms whichever is greater
Delay time for current reversal	(0.000-60.000) s	±0.2% or ±30 ms whichever is greater
Coordination time for weak-end infeed logic	(0.000–60.000) s	±0.2% or ±30 ms whichever is greater

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12.1 Direct transfer trip

Table 75: Low active power and power factor protection LAPPGAPC

Function	Range or value	Accuracy
Operate value, low active power	(2.0-100.0)% of SBase	±1.0% of S_r
Reset ratio, low active power	<105%	-
Operate value, low power factor	0.00-1.00	±0.02
Independent time delay to operate for low active power at 1.2 to 0.8 x P_{set}	(0.000-60.000) s	±0.2% or ±40 ms whichever is greater
Independent time delay to operate for low power factor at 1.2 to 0.8 x PF_{set}	(0.000-60.000) s	±0.2% or ±40 ms whichever is greater
Critical impulse time, low active power	10 ms typically at 1.2 to 0.8 x P_{set}	-
Impulse margin time, low active power	10 ms typically	-

Table 76: Compensated over- and undervoltage protection COUVGAPC

Function	Range or value	Accuracy
Operate value, undervoltage	(1-100)% of UBase	±0,5% of U_r
Absolute hysteresis	(0.00–50.0)% of UBase	±0.5% of U_r at $U \leq U_r$ ±0.5% of U at $U > U_r$
Critical impulse time, undervoltage	10 ms typically at 1.2 to 0.8x U_{set}	-
Impulse margin time, undervoltage	15 ms typically	-
Operate value, overvoltage	(1-200)% of UBase	±0.5% of U_r at $U \leq U_r$ ± 0.5% of U at $U>U_r$
Critical impulse time, overvoltage	10 ms typically at 0.8 to 1.2 x U_{set}	-
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Function	Range or value	Accuracy
Impulse margin time, overvoltage	15 ms typically	-
Independent time delay for undervoltage functionality at 1.2 to 0.8 x U_{set}	(0.000-60.000) s	±0.2% or ±40 ms whichever is greater
Independent time delay for overvoltage functionality at 0.8 to 1.2 x U_{set}	(0.000-60.000) s	±0.2% or ±40 ms whichever is greater

Table 77: Sudden change in current variation SCCVPTOC

Function	Range or value	Accuracy
Operate value, overcurrent	(5-100)% of IBase	±2.0% of I_r
Hold time for operate signal at 0 to 2 x Iset	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater

Table 78: Carrier receive logic LCCRPTRC

Function	Range or value	Accuracy
Operation mode	1 Out Of 2 2 Out Of 2	-
Independent time delay	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater

Table 79: Negative sequence overvoltage protection LCNSPTOV

Function	Range or value	Accuracy
Operate value, negative sequence overvoltage	(1-200)% of UBase	±0.5% of U_r at $U \leq U_r$ ±0.5% of U at $U > U_r$
Reset ratio, negative sequence overvoltage	>95% at (10–200)% of UBase	-
Operate time, start at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 2 to 0 x U_{set}	Min. = 15 ms Max. = 30 ms	-
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Function	Range or value	Accuracy
Critical impulse time, negative sequence overvoltage	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time, negative sequence overvoltage	15 ms typically	-
Independent time delay to operate at 0 to 1.2 x U_{set}	(0.000-120.000) s	±0.2% or ±40 ms whichever is greater

Table 80: Zero sequence overvoltage protection LCZSPTOV

Function	Range or value	Accuracy
Operate value, zero sequence overvoltage	(1-200)% of UBase	±0.5% of U_r at $U \le U_r$ ±0.5% of U at $U > U_r$
Reset ratio, zero sequence overvoltage	>95% at (10–200)% of UBase	-
Operate time, start at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 2 to 0 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Critical impulse time, zero sequence overvoltage	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time, zero sequence overvoltage	15 ms typically	-
Independent time delay to operate at 0 to 1.2 x U_{set}	(0.000-120.000) s	±0.2% or ±40 ms whichever is greater

Table 81: Negative sequence overcurrent protection LCNSPTOC

Function	Range or value	Accuracy
Operate value, negative sequence overcurrent	(3 - 2500)% of IBase	±1.0% of Ir at $I \le I_r$ ±1.0% of I at $I > I_r$
Reset ratio, negative sequence overcurrent	>95% at (50–2500)% of IBase	-
Operate time, start at 0 to 2 x I_{set}	Min. = 15 ms Max. = 25 ms	-
Reset time, start at 2 to 0 x I_{set}	Min. = 15 ms Max. = 25 ms	-
Operate time, start at 0 to 10 x I_{set}	Min. = 10 ms Max. = 20 ms	-
Reset time, start at 10 to 0 x I_{set}	Min. = 20 ms Max. = 35 ms	-

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Function	Range or value	Accuracy
Critical impulse time, negative sequence overcurrent	10 ms typically at 0 to 2 x I_{set} 2 ms typically at 0 to 10 x I_{set}	-
Impulse margin time, negative sequence overcurrent	15 ms typically	-
Independent time delay at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±35 ms, whichever is greater
Transient overreach, start function	<5% at τ = 100 ms	-

Table 82: Zero sequence overcurrent protection LCZSPTOC

Function	Range or value	Accuracy
Operate value, zero sequence overcurrent	(3-2500)% of IBase	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Reset ratio, zero sequence overcurrent	>95% at (50–2500)% of IBase	-
Operate time, start at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 2 to 0 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start at 0 to 10 x I_{set}	Min. = 10 ms Max. = 20 ms	-
Reset time, start at 10 to 0 x I_{set}	Min. = 20 ms Max. = 35 ms	-
Critical impulse time, zero sequence overcurrent	10 ms typically at 0 to 2 x I_{set} 2 ms typically at 0 to 10 x I_{set}	-
Impulse margin time, zero sequence overcurrent	15 ms typically	-
Independent time delay at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater

Table 83: Three phase overcurrent LCP3PTOC

Function	Range or value	Accuracy
Operate value, overcurrent	(5-2500)% of IBase	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Reset ratio, overcurrent	> 95% at (50-2500)% of IBase	-
Start time at 0 to 2 x I_{set}	Min. = 10 ms Max. = 25 ms	-
Reset time at 2 to 0 x I_{set}	Min. = 20 ms Max. = 35 ms	-
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Function	Range or value	Accuracy
Critical impulse time, overcurrent	5 ms typically at 0 to 2 x I_{set} 2 ms typically at 0 to 10 x I_{set}	-
Impulse margin time, overcurrent	10 ms typically	-
Independent time delay to operate at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±30 ms whichever is greater

Table 84: Three phase undercurrent LCP3PTUC

Function	Range or value	Accuracy
Operate value, undercurrent	(1.00-100.00)% of IBase	±1.0% of I_r
Reset ratio, undercurrent	< 105% at (50.00-100.00)% of IBase	-
Start time at 2 to 0 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time at 0 to 2 x I_{set}	Min. = 10 ms Max. = 25 ms	-
Critical impulse time, undercurrent	10 ms typically at 2 to 0 x I_{set}	-
Impulse margin time, undercurrent	10 ms typically	-
Independent time delay to operate at 2 to 0 x I_{set}	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater

Section 13 Logic

Table 85: Tripping logic common 3-phase output SMPPTRC

Function	Range or value	Accuracy
Trip action	3-ph, 1/3-ph, 1/2/3-ph	-
Minimum trip pulse length	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
3-pole trip delay	(0.020-0.500) s	±0.2% or ±15 ms whichever is greater
Evolving fault delay	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater

Table 86: Number of PULSETIMER instances

Logic block	Quantity with cycle time			Range or Value	Accuracy
	3 ms	8 ms	100 ms		
PULSETIMER	10	10	20	(0.000–90000.000) s	±0.5% ±10 ms

Table 87: Number of TIMERSET instances

Logic block	Quantity with cycle time			Range or Value	Accuracy
	3 ms	8 ms	100 ms		
TIMERSET	15	15	30	(0.000–90000.000) s	±0.5% ±10 ms

Table 88: Number of PULSETIMERQT instances

Logic block	Quantity with cycle time			Range or Value	Accuracy
	3 ms	8 ms	100 ms		
PULSETIMERQT	-	10	30	(0.000–90000.000) s	±0.5% ±10 ms

Table 89: Number of TIMERSETQT instances

Logic block	Quantity with cycle time			Range or Value	Accuracy
	3 ms	8 ms	100 ms		
TIMERSETQT	-	10	30	(0.000–90000.000) s	±0.5% ±10 ms

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Table 90: Elapsed time integrator with limit transgression and overflow supervision TEIGAPC

Function	Cycle time (ms)	Range or value	Accuracy
Elapsed time integration	3	0 ~ 999999.9 s	±0.2% or ±20 ms whichever is greater
	8	0 ~ 999999.9 s	±0.2% or ±100 ms whichever is greater
	100	0 ~ 999999.9 s	±0.2% or ±250 ms whichever is greater

Table 91: Number of TEIGAPC instances

Function	Quantity with cycle time		
	3 ms	8 ms	100 ms
TEIGAPC	4	4	4

Table 92: Comparator for real input REALCOMP

Function	Accuracy
Operate value, EqualBandHigh and EqualBandLow	±0.5% of set value
Reset value, EqualBandHigh	> 0.1% of set RefPrefix
Reset value, EqualBandLow	< 0.1% of set RefPrefix

Table 93: Number of REALCOMP instances

Function	Quantity with cycle time		
	3 ms	8 ms	100 ms
REALCOMP	4	4	4

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Section 14 Monitoring

Table 94: Measurements CVMMXN

Function	Range or value	Accuracy
Frequency	$(0.95\text{-}1.05) \times f_r$	±2.0 mHz
Voltage	(10 to 300) V	±0.3% of U at U≤ 50 V ±0.2% of U at U> 50 V
Current	$(0.1\text{-}4.0) \times I_r$	±0.8% of I at $0.1 \times I_r < I < 0.2 \times I_r$ ± 0.5% of I at $0.2 \times I_r < I < 0.5 \times I_r$ ±0.2% of I at $0.5 \times I_r < I < 4.0 \times I_r$
Active power, P	(10 to 300) V $(0.1\text{-}4.0) \times I_r$	±0.5% of S_r at $S \leq 0.5 \times S_r$ ±0.5% of S at $S > 0.5 \times S_r$
	(100 to 220) V $(0.5\text{-}2.0) \times I_r$ cos φ< 0.7	±0.2% of P
Reactive power, Q	(10 to 300) V $(0.1\text{-}4.0) \times I_r$	±0.5% of S_r at $S \leq 0.5 \times S_r$ ±0.5% of S at $S > 0.5 \times S_r$
	(100 to 220) V $(0.5\text{-}2.0) \times I_r$ cos φ> 0.7	±0.2% of Q
Apparent power, S	(10 to 300) V $(0.1\text{-}4.0) \times I_r$	±0.5% of S_r at $S \leq 0.5 \times S_r$ ±0.5% of S at $S > 0.5 \times S_r$
	(100 to 220) V $(0.5\text{-}2.0) \times I_r$	±0.2% of S
Power factor, cos (φ)	(10 to 300) V $(0.1\text{-}4.0) \times I_r$	<0.02
	(100 to 220) V $(0.5\text{-}2.0) \times I_r$	<0.01

Table 95: Phase current measurement CMMXU

Function	Range or value	Accuracy
Current at symmetrical load	$(0.1\text{-}4.0) \times I_r$	±0.3% of I_r at $I \leq 0.5 \times I_r$ ±0.3% of I at $I > 0.5 \times I_r$
Phase angle at symmetrical load	$(0.1\text{-}4.0) \times I_r$	±1.0 degrees at $0.1 \times I_r < I \leq 0.5 \times I_r$ ±0.5 degrees at $0.5 \times I_r < I \leq 4.0 \times I_r$

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Table 96: *Phase-phase voltage measurement VMMXU*

Function	Range or value	Accuracy
Voltage	(10 to 300) V	±0.5% of U at U ≤ 50 V ±0.2% of U at U > 50 V
Phase angle	(10 to 300) V	±0.5 degrees at U ≤ 50 V ±0.2 degrees at U > 50 V

Table 97: *Phase-neutral voltage measurement VNMMXU*

Function	Range or value	Accuracy
Voltage	(5 to 175) V	±0.5% of U at U ≤ 50 V ±0.2% of U at U > 50 V
Phase angle	(5 to 175) V	±0.5 degrees at U ≤ 50 V ±0.2 degrees at U > 50 V

Table 98: *Current sequence component measurement CMSQI*

Function	Range or value	Accuracy
Current positive sequence, I1 Three phase settings	(0.1–4.0) × I_r	±0.3% of I_r at I ≤ 0.5 × I_r ±0.3% of I at I > 0.5 × I_r
Current zero sequence, 3I0 Three phase settings	(0.1–1.0) × I_r	±0.3% of I_r at I ≤ 0.5 × I_r ±0.3% of I at I > 0.5 × I_r
Current negative sequence, I2 Three phase settings	(0.1–1.0) × I_r	±0.3% of I_r at I ≤ 0.5 × I_r ±0.3% of I at I > 0.5 × I_r
Phase angle	(0.1–4.0) × I_r	±1.0 degrees at 0.1 × I_r < I ≤ 0.5 × I_r ±0.5 degrees at 0.5 × I_r < I ≤ 4.0 × I_r

Table 99: *Voltage sequence measurement VMSQI*

Function	Range or value	Accuracy
Voltage positive sequence, U1	(10 to 300) V	±0.5% of U at U ≤ 50 V ±0.2% of U at U > 50 V
Voltage zero sequence, 3U0	(10 to 300) V	±0.5% of U at U ≤ 50 V ±0.2% of U at U > 50 V
Voltage negative sequence, U2	(10 to 300) V	±0.5% of U at U ≤ 50 V ±0.2% of U at U > 50 V
Phase angle	(10 to 300) V	±0.5 degrees at U ≤ 50 V ±0.2 degrees at U > 50 V

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Table 100: Supervision of mA input signals

Function	Range or value	Accuracy
mA measuring function	±5, ±10, ±20 mA 0-5, 0-10, 0-20, 4-20 mA	±0.1 % of set value ±0.005 mA
Max current of transducer to input	(-20.00 to +20.00) mA	
Min current of transducer to input	(-20.00 to +20.00) mA	
Alarm level for input	(-20.00 to +20.00) mA	
Warning level for input	(-20.00 to +20.00) mA	
Alarm hysteresis for input	(0.0-20.0) mA	

Table 101: Insulation gas monitoring function SSIMG

Function	Range or value	Accuracy
Pressure alarm level	1.00-100.00	±10.0% of set value
Pressure lockout level	1.00-100.00	±10.0% of set value
Temperature alarm level	-40.00-200.00	±2.5% of set value
Temperature lockout level	-40.00-200.00	±2.5% of set value
Time delay for pressure alarm	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Reset time delay for pressure alarm	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Time delay for pressure lockout	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Time delay for temperature alarm	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Reset time delay for temperature alarm	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Time delay for temperature lockout	(0.000-60.000) s	±0.2% or ±250ms whichever is greater

Table 102: Insulation liquid monitoring function SSIML

Function	Range or value	Accuracy
Oil alarm level	1.00-100.00	±10.0% of set value
Oil lockout level	1.00-100.00	±10.0% of set value
Temperature alarm level	-40.00-200.00	±2.5% of set value
Temperature lockout level	-40.00-200.00	±2.5% of set value
Time delay for oil alarm	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Reset time delay for oil alarm	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Time delay for oil lockout	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
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Function	Range or value	Accuracy
Time delay for temperature alarm	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Reset time delay for temperature alarm	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Time delay for temperature lockout	(0.000-60.000) s	±0.2% or ±250ms whichever is greater

Table 103: *Breaker monitoring SSCBR*

Function	Range or value	Accuracy
Alarm level for open and close travel time	(0 – 200) ms	±3 ms
Alarm level for number of operations	(0 – 9999)	-
Independent time delay for spring charging time alarm	(0.00 – 60.00) s	±0.2% or ±30 ms whichever is greater
Independent time delay for gas pressure alarm	(0.00 – 60.00) s	±0.2% or ±30 ms whichever is greater
Independent time delay for gas pressure lockout	(0.00 – 60.00) s	±0.2% or ±30 ms whichever is greater
CB Contact Travel Time, opening and closing		±3 ms
Remaining Life of CB		±2 operations
Accumulated Energy		±1.0% or ±0.5 whichever is greater

Table 104: *Disturbance report DRPRDRE*

Function	Range or value	Accuracy
Pre-fault time	(0.05–9.90) s	-
Post-fault time	(0.1–10.0) s	-
Limit time	(0.5–10.0) s	-
Maximum number of recordings	100, first in - first out	-
Time tagging resolution	1 ms	See table ""
Maximum number of analog inputs	30 + 10 (external + internally derived)	-
Maximum number of binary inputs	96	-
Maximum number of phasors in the Trip Value recorder per recording	30	-
Maximum number of indications in a disturbance report	96	-
Maximum number of events in the Event recording per recording	150	-
Maximum number of events in the Event list	1000, first in - first out	-

Table continues on next page

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Function	Range or value	Accuracy
Maximum total recording time (3.4 s recording time and maximum number of channels, typical value)	340 seconds (100 recordings) at 50 Hz, 280 seconds (80 recordings) at 60 Hz	-
Sampling rate	1 kHz at 50 Hz 1.2 kHz at 60 Hz	-
Recording bandwidth	(5-300) Hz	-

Table 105: Fault locator LMBRFLO

Function	Value or range	Accuracy
Reactive and resistive reach	(0.001-1500.000) Ω/phase	±2.0% static accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r
Phase selection	According to input signals	-
Maximum number of fault locations	100	-

Table 106: Event list

Function		Value
Buffer capacity	Maximum number of events in the list	1000
Resolution		1 ms
Accuracy		Depending on time synchronizing

Table 107: Indications

Function		Value
Buffer capacity	Maximum number of indications presented for single disturbance	96
	Maximum number of recorded disturbances	100

Table 108: Event recorder

Function		Value
Buffer capacity	Maximum number of events in disturbance report	150
	Maximum number of disturbance reports	100
Resolution		1 ms
Accuracy		Depending on time synchronizing

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Table 109: *Trip value recorder*

Function		Value
Buffer capacity	Maximum number of analog inputs	30
	Maximum number of disturbance reports	100

Table 110: *Disturbance recorder*

Function		Value
Buffer capacity	Maximum number of analog inputs	40
	Maximum number of binary inputs	96
	Maximum number of disturbance reports	100
Maximum total recording time (3.4 s recording time and maximum number of channels, typical value)		340 seconds (100 recordings) at 50 Hz 280 seconds (80 recordings) at 60 Hz

Table 111: *Limit counter L4UFCNT*

Function	Range or value	Accuracy
Counter value	0-65535	-
Max. count up speed	30 pulses/s (50% duty cycle)	-

Table 112: *Running hour-meter TEILGAPC*

Function	Range or value	Accuracy
Time limit for alarm supervision, tAlarm	(0 - 99999.9) hours	±0.1% of set value
Time limit for warning supervision, tWarning	(0 - 99999.9) hours	±0.1% of set value
Time limit for overflow supervision	Fixed to 99999.9 hours	±0.1%

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Section 15 Station communication

Table 113: IEC 61850-9-2 communication protocol

Function	Value
Protocol	IEC 61850-9-2
Communication speed for the IEDs	100BASE-FX

Table 114: LON communication protocol

Function	Value
Protocol	LON
Communication speed	1.25 Mbit/s

Table 115: SPA communication protocol

Function	Value
Protocol	SPA
Communication speed	300, 1200, 2400, 4800, 9600, 19200 or 38400 Bd
Slave number	1 to 899

Table 116: Ethernet communication

Function	Value
Protocol	Ethernet, TCP/IP
Communication speed	10/100 Mbit/s
Connectors	RJ45 shielded Ethernet connection

Table 117: IEC 60870-5-103 communication protocol

Function	Value
Protocol	IEC 60870-5-103
Communication speed	9600, 19200 Bd

Table 118: DNP 3.0 TCP/IP communication

Function	Value
Protocol	UDP, TCP/IP, Ethernet
Communication speed	100 Mbit/s
Connectors	RJ45 shielded Ethernet connection, Optical type ST Ethernet connection

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Table 119: DNP 3.0 serial communication EIA-485

Function	Value
Protocol	DNP 3.0
Communication speed	300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600 or 115200 Bd

Table 120: SLM – LON port

Quantity	Range or value
Optical connector	Glass fiber: type ST Plastic fiber: type HFBR snap-in
Fiber, optical budget	Glass fiber: 11 dB (1000m/3000 ft typically *) Plastic fiber: 7 dB (10m/35ft typically *)
Fiber diameter	Glass fiber: 62.5/125 μm Plastic fiber: 1 mm
*) depending on optical budget calculation	

Table 121: SLM – SPA/IEC 60870-5-103/DNP3 port

Quantity	Range or value
Optical connector	Glass fiber: type ST Plastic fiber: type HFBR snap-in
Fiber, optical budget	Glass fiber: 11 dB (1000m/3000ft m typically *) Plastic fiber: 7 dB (25m/80ft m typically *)
Fiber diameter	Glass fiber: 62.5/125 μm Plastic fiber: 1 mm
*) depending on optical budget calculation	

Table 122: Galvanic X.21 line data communication module (X.21-LDCM)

Quantity	Range or value
Connector, X.21	Micro D-sub, 15-pole male, 1.27 mm (0.050") pitch
Connector, ground selection	2 pole screw terminal
Standard	CCITT X21
Communication speed	64 kbit/s
Insulation	1 kV
Maximum cable length	100 m

Table 123: Galvanic RS485 communication module

Quantity	Range or value
Communication speed External connectors	2400–19200 bauds RS-485 6-pole connector Soft ground 2-pole connector

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Table 124: IEC 62439-3 Edition 1 and Edition 2 parallel redundancy protocol

Function	Value
Communication speed	100 Base-FX

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Section 16 Remote communication

Table 125: Line data communication module

Characteristic	Range or value		
Type of LDCM	Short range (SR)	Medium range (MR)	Long range (LR)
Type of fiber	Graded-index multimode 62.5/125 µm	Singlemode 9/125 µm	Singlemode 9/125 µm
Peak Emission Wave length Nominal Maximum Minimum	 820 nm 865 nm 792 nm	 1310 nm 1330 nm 1290 nm	 1550 nm 1580 nm 1520 nm
Optical budget Graded-index multimode 62.5/125 µm, Graded-index multimode 50/125 µm	13 dB (typical distance about 3 km/2 mile *) 9 dB (typical distance about 2 km/1 mile *)	22 dB (typical distance 80 km/50 mile *)	26 dB (typical distance 110 km/68 mile *)
Optical connector	Type ST	Type FC/PC	Type FC/PC
Protocol	C37.94	C37.94 implementation **)	C37.94 implementation **)
Data transmission	Synchronous	Synchronous	Synchronous
Transmission rate / Data rate	2 Mb/s / 64 kbit/s	2 Mb/s / 64 kbit/s	2 Mb/s / 64 kbit/s
Clock source	Internal or derived from received signal	Internal or derived from received signal	Internal or derived from received signal
*) depending on optical budget calculation **) C37.94 originally defined just for multimode; using same header, configuration and data format as C37.94			

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Section 17 Hardware

17.1 IED

Table 126: Case

Material	Steel sheet
Front plate	Steel sheet profile with cut-out for HMI
Surface treatment	Aluzink preplated steel
Finish	Light grey (RAL 7035)

Table 127: Water and dust protection level according to IEC 60529

Front	IP40 (IP54 with sealing strip)
Sides, top and bottom	IP20
Rear side	IP20 with screw compression type IP10 with ring lug terminals

Table 128: Weight

Case size	Weight
6U, 1/2 x 19"	≤ 10 kg/22 lb
6U, 3/4 x 19"	≤ 15 kg/33 lb
6U, 1/1 x 19"	≤ 18 kg/40 lb

17.2 Electrical safety

Table 129: Electrical safety according to IEC 60255-27

Equipment class	I (protective earthed)
Overvoltage category	III
Pollution degree	2 (normally only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be expected)

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17.3 Connection system

Table 130: CT and VT circuit connectors

Connector type	Rated voltage and current	Maximum conductor area
Screw compression type	250 V AC, 20 A	4 mm^2 (AWG12) 2 x 2.5 mm^2 (2 x AWG14)
Terminal blocks suitable for ring lug terminals	250 V AC, 20 A	4 mm^2 (AWG12)

Table 131: Auxiliary power supply and binary I/O connectors

Connector type	Rated voltage	Maximum conductor area
Screw compression type	250 V AC	2.5 mm^2 (AWG14) 2 × 1 mm^2 (2 x AWG18)
Terminal blocks suitable for ring lug terminals	300 V AC	3 mm^2 (AWG14)

Because of limitations of space, when ring lug terminal is ordered for Binary I/O connections, one blank slot is necessary between two adjacent IO cards. Please refer to the ordering particulars for details.

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Section 18 Basic IED functions

Table 132: Self supervision with internal event list

Data	Value
Recording manner	Continuous, event controlled
List size	40 events, first in-first out

Table 133: GPS time synchronization module (GTM)

Function	Range or value	Accuracy
Receiver	–	±1µs relative UTC
Time to reliable time reference with antenna in new position or after power loss longer than 1 month	<30 minutes	–
Time to reliable time reference after a power loss longer than 48 hours	<15 minutes	–
Time to reliable time reference after a power loss shorter than 48 hours	<5 minutes	–

Table 134: GPS – Antenna and cable

Function	Value
Max antenna cable attenuation	26 db @ 1.6 GHz
Antenna cable impedance	50 ohm
Lightning protection	Must be provided externally
Antenna cable connector	SMA in receiver end TNC in antenna end
Accuracy	+/-1µs

Table 135: IRIG-B

Quantity	Rated value
Number of channels IRIG-B	1
Number of optical channels	1
Electrical connector:	
Electrical connector IRIG-B	BNC
Pulse-width modulated	5 Vpp
Amplitude modulated – low level – high level	 1-3 Vpp 3 x low level, max 9 Vpp
Supported formats	IRIG-B 00x, IRIG-B 12x
Accuracy	+/-10µs for IRIG-B 00x and +/-100µs for IRIG-B 12x
Table continues on next page	

Quantity	Rated value
Input impedance	100 k ohm
Optical connector:	
Optical connector IRIG-B	Type ST
Type of fibre	62.5/125 µm multimode fibre
Supported formats	IRIG-B 00x
Accuracy	+/- 1µs

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Section 19 Inverse characteristics

Table 136: ANSI Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $t = \left(\frac{A}{\left(I^{P} - 1\right)} + B \right) \cdot k + tDef$ Reset characteristic: $t = \frac{t_r}{\left(I^{2} - 1\right)} \cdot k$ $I = I_{measured}/I_{set}$	$0.10 \leq k \leq 3.00$ $1.5 \times I_{set} \leq I \leq 20 \times I_{set}$	ANSI/IEEE C37.112 , ±2.0% or ±40 ms whichever is greater
ANSI Extremely Inverse	A=28.2, B=0.1217, P=2.0 , tr=29.1	
ANSI Very inverse	A=19.61, B=0.491, P=2.0 , tr=21.6	
ANSI Normal Inverse	A=0.0086, B=0.0185, P=0.02, tr=0.46	
ANSI Moderately Inverse	A=0.0515, B=0.1140, P=0.02, tr=4.85	
ANSI Long Time Extremely Inverse	A=64.07, B=0.250, P=2.0, tr=30	
ANSI Long Time Very Inverse	A=28.55, B=0.712, P=2.0, tr=13.46	
ANSI Long Time Inverse	A=0.086, B=0.185, P=0.02, tr=4.6	

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Table 137: IEC Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $$t = \left(\frac{A}{\left(I^{P} - 1 \right)} \right) \cdot k$$ $I = I_{measured}/I_{set}$	$0.10 \le k \le 3.00$ $1.5 \times I_{set} \le I \le 20 \times I_{set}$	IEC 60255-151, ±2.0% or ±40 ms whichever is greater
IEC Normal Inverse	A=0.14, P=0.02	
IEC Very inverse	A=13.5, P=1.0	
IEC Inverse	A=0.14, P=0.02	
IEC Extremely inverse	A=80.0, P=2.0	
IEC Short time inverse	A=0.05, P=0.04	
IEC Long time inverse	A=120, P=1.0	
Programmable characteristic Operate characteristic: $$t = \left(\frac{A}{\left(I^{P} - C \right)} + B \right) \cdot k$$ Reset characteristic: $$t = \frac{TR}{\left(I^{PR} - CR \right)} \cdot k$$ $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01 A=(0.005-200.000) in steps of 0.001 B=(0.00-20.00) in steps of 0.01 C=(0.1-10.0) in steps of 0.1 P=(0.005-3.000) in steps of 0.001 TR=(0.005-100.000) in steps of 0.001 CR=(0.1-10.0) in steps of 0.1 PR=(0.005-3.000) in steps of 0.001	

Table 138: RI and RD type inverse time characteristics

Function	Range or value	Accuracy
RI type inverse characteristic $$t = \frac{1}{0.339 - \frac{0.236}{I}} \cdot k$$ $I = I_{measured}/I_{set}$	$0.10 \le k \le 3.00$ $1.5 \times I_{set} \le I \le 20 \times I_{set}$	IEC 60255-151, ±2.0% or ±40 ms whichever is greater
RD type logarithmic inverse characteristic $$t = 5.8 - \left(1.35 \cdot \ln \frac{I}{k} \right)$$ $I = I_{measured}/I_{set}$		

Table 139: Inverse time characteristics for overvoltage protection

Function	Range or value	Accuracy
Type A curve: $$t = \frac{k}{\left(\frac{U - U>}{U>}\right)}$$ U> = U_{set} U = $U_{measured}$	k = (0.05-1.10) in steps of 0.01	±5.0% or ±45 ms whichever is greater
Type B curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{2.0}} + 0.035$$	k = (0.05-1.10) in steps of 0.01	
Type C curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{3.0}} + 0.035$$	k = (0.05-1.10) in steps of 0.01	
Programmable curve: $$t = \frac{k \cdot A}{\left(B \cdot \frac{U - U>}{U>} - C\right)^{P}} + D$$	k = (0.05-1.10) in steps of 0.01 A = (0.005-200.000) in steps of 0.001 B = (0.50-100.00) in steps of 0.01 C = (0.0-1.0) in steps of 0.1 D = (0.000-60.000) in steps of 0.001 P = (0.000-3.000) in steps of 0.001	

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Table 140: Inverse time characteristics for undervoltage protection

Function	Range or value	Accuracy
Type A curve: $$t = \frac{k}{\left(\frac{U< - U}{U<}\right)}$$ $U< = U_{set}$ $U = U_{measured}$	k = (0.05-1.10) in steps of 0.01	±5.0% or ±45 ms whichever is greater
Type B curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U< - U}{U<} - 0.5\right)^{2.0}} + 0.055$$ $U< = U_{set}$ $U = U_{measured}$	k = (0.05-1.10) in steps of 0.01	
Programmable curve: $$t = \left[\frac{k \cdot A}{\left(B \cdot \frac{U< - U}{U<} - C\right)^{P}}\right] + D$$ $U< = U_{set}$ $U = U_{measured}$	k = (0.05-1.10) in steps of 0.01 A = (0.005-200.000) in steps of 0.001 B = (0.50-100.00) in steps of 0.01 C = (0.0-1.0) in steps of 0.1 D = (0.000-60.000) in steps of 0.001 P = (0.000-3.000) in steps of 0.001	

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Table 141: Inverse time characteristics for residual overvoltage protection

Function	Range or value	Accuracy
Type A curve: $$t = \frac{k}{\left(\frac{U - U>}{U>}\right)}$$ U> = U_{set} U = $U_{measured}$	k = (0.05-1.10) in steps of 0.01	±5.0% or ±45 ms whichever is greater
Type B curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{2.0}} + 0.035$$	k = (0.05-1.10) in steps of 0.01	
Type C curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{3.0}} + 0.035$$	k = (0.05-1.10) in steps of 0.01	
Programmable curve: $$t = \frac{k \cdot A}{\left(B \cdot \frac{U - U>}{U>} - C\right)^{P}} + D$$	k = (0.05-1.10) in steps of 0.01 A = (0.005-200.000) in steps of 0.001 B = (0.50-100.00) in steps of 0.01 C = (0.0-1.0) in steps of 0.1 D = (0.000-60.000) in steps of 0.001 P = (0.000-3.000) in steps of 0.001	

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Table 142: ANSI Inverse time characteristics for Sensitive directional residual overcurrent and power protection

Function	Range or value	Accuracy
Operating characteristic: $$t = \left(\frac{A}{\left(I^{P} - 1\right)} + B \right) \cdot k + tDef$$ Reset characteristic: $$t = \frac{t_r}{\left(I^{2} - 1\right)} \cdot k$$ $I = I_{measured}/I_{set}$	$0.10 \le k \le 2.00$ $1.5 \times I_{set} \le I \le 20 \times I_{set}$	ANSI/IEEE C37.112 , ±5.0% or ±160 ms whichever is greater
ANSI Extremely Inverse	A=28.2, B=0.1217, P=2.0 , tr=29.1	
ANSI Very inverse	A=19.61, B=0.491, P=2.0 , tr=21.6	
ANSI Normal Inverse	A=0.0086, B=0.0185, P=0.02, tr=0.46	
ANSI Moderately Inverse	A=0.0515, B=0.1140, P=0.02, tr=4.85	
ANSI Long Time Extremely Inverse	A=64.07, B=0.250, P=2.0, tr=30	
ANSI Long Time Very Inverse	A=28.55, B=0.712, P=2.0, tr=13.46	
ANSI Long Time Inverse	A=0.086, B=0.185, P=0.02, tr=4.6	

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Table 143: IEC Inverse time characteristics for Sensitive directional residual overcurrent and power protection

Function	Range or value	Accuracy
Operating characteristic: $$t = \left(\frac{A}{\left(I^{P} - 1 \right)} \right) \cdot k$$ $I = I_{measured}/I_{set}$	$0.10 \le k \le 2.00$ $1.5 \times I_{set} \le I \le 20 \times I_{set}$	IEC 60255-151, ±5.0% or ±160 ms whichever is greater
IEC Normal Inverse	A=0.14, P=0.02	
IEC Very inverse	A=13.5, P=1.0	
IEC Inverse	A=0.14, P=0.02	
IEC Extremely inverse	A=80.0, P=2.0	
IEC Short time inverse	A=0.05, P=0.04	
IEC Long time inverse	A=120, P=1.0	
Programmable characteristic Operate characteristic: $$t = \left(\frac{A}{\left(I^{P} - C \right)} + B \right) \cdot k$$ Reset characteristic: $$t = \frac{TR}{\left(I^{PR} - CR \right)} \cdot k$$ $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01 A=(0.005-200.000) in steps of 0.001 B=(0.00-20.00) in steps of 0.01 C=(0.1-10.0) in steps of 0.1 P=(0.005-3.000) in steps of 0.001 TR=(0.005-100.000) in steps of 0.001 CR=(0.1-10.0) in steps of 0.1 PR=(0.005-3.000) in steps of 0.001	

The parameter setting *Characterist1 and 4/Reserved* shall not be used, since this parameter setting is for future use and not implemented yet.

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Table 144: RI and RD type inverse time characteristics for Sensitive directional residual overcurrent and power protection

Function	Range or value	Accuracy
RI type inverse characteristic $t = \dfrac{1}{0.339 - \dfrac{0.236}{I}} \cdot k$ $I = I_{measured}/I_{set}$	$0.10 \leq k \leq 2.00$ $1.5 \times I_{set} \leq I \leq 20 \times I_{set}$	IEC 60255-151, ±5.0% or ±160 ms whichever is greater
RD type logarithmic inverse characteristic $t = 5.8 - \left(1.35 \cdot \ln \dfrac{I}{k}\right)$ $I = I_{measured}/I_{set}$		

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ATTESTATION OF CONFORMITY

No. 74104021-MOC/INC 13-0780

Issued to:
ABB
SA Products
Nätverksgatan 3, B391, Finnslätten
721 59 Västerås, Sweden

for the product:
REL 650
Type: Slave station
Product version 1.3.0
Firmware version 1.3.0.13

With the implemented communication protocol:

IEC 60870-5-103 (IS 1998)

Companion Standard for the informative interface of protection equipment and the ABB 650 series version 1.3 IEC 60870-5-103 Interoperability document, dated January 28, 2013.

The product has not been shown to be non-conforming to the specified protocol standard, including the interface requirements.

End-to-End data element tests for the information and control points as described in manufacturer Protocol Implementation Conformance Statement (PICS) have been performed on the product's protocol implementation. Functional tests in controlled mode are performed for the following levels:

• *Station initialization in Unbalanced mode* • *Cyclic data transmission* • *Acquisition of events* • *General Interrogation*	• *Clock synchronisation* • *Transmission of Disturbance records* • *Test mode and local parameter setting*

The test campaign did not reveal any errors in the product's protocol implementation.

This Attestation is granted on account of tests made at location of ABB in Västerås, Sweden and performed with UnIECim version 3.0.1 (November 2012) running CS103 Test Suite version CS103MasterNormal 2.4. The results, including remarks and limitations, are laid down in our report no. 74104021-MOC/INC 13-0781.

The tests have been carried out on one single specimen of the product, submitted by ABB. The Attestation does not include an assessment of the manufacturer's production. Conformity of his production with the specimen tested by DNV KEMA is not the responsibility of DNV KEMA.

Arnhem, February 15, 2013

M. Adriaensen
Intelligent Networks and Communication

P.H.S. Ermens
Test Consultant

IMPORTANT: Remarks apply to this implementation. See the resulting report for full details
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KEMA

Type test Certificate of complete type tests

ABB AB

Västeras, Sweden

has successfully passed the type test sequence on a

REL650, Ver. 1.3 Line protection

Type: 650 series Ver. 1.3

Rating: 24-250 V (DC) – 100-240 V (AC) –1/5 A – 100/220 V – 50/60 Hz

The test object passed the required clauses of

IEC 60255-1

ANSI IEEE C37.90

The test results are recorded in Certificate No.

TIC 1037-13

This Certificate is issued on 13 November 2013

KEMA Nederland B.V.

S.A.M. Verhoeven

Director Testing, Inspections & Certification The Netherlands

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Experience you can trust.

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Substation Automation Products

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Declaration of Conformity

Document identity
1MRK 000 612-95

Revision B

Declaration

We ABB AB, Substation Automation Products, SE-721 59 Västerås, Sweden, declare under our sole responsibility that the family of apparatus:

Breaker protection	**Type:** **REQ650** **acc. to Product Guide** **1MRK 505294-BEN, -BUS**

to which this declaration relates is in conformity with the following directives

Directive	**EMC Directive 2014/30/EU** **Low Voltage Directive 2014/35/EU**

Our internal quality control system ensures compliance between the manufactured products and the technical documentation.

Year of affixed CE-marking	**2013**

Application of the objects

The family is intended for use in the industrial environment and to protect high voltage or high power apparatus, and thus normally used in a harsh electromagnetic environment near high voltage apparatus.

References

Standards	**EN 60 255-26: 2013** **EN 60 255-27: 2014**

Authorisation

Signed by	Krister Hagman, PM — 30/3-2016 Date

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Подпис ....

Стара Загора

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Based on			Prepared	2013-01-24	Agneta Rydh	Title Connection Diagram REQ650 (3Ph/1CB/1BB) A01A ANSI symbols	Doc.des.	Doc.kind	Ref.des.	
			Approved	2013-01-29	Patrik Nyback		Resp.dept.	PSTP/TPLA	Rev.ind.	Lang. en
			Project			ABB — ABB AB	Doc.No. 1MRK006502-LD			Sheet 1
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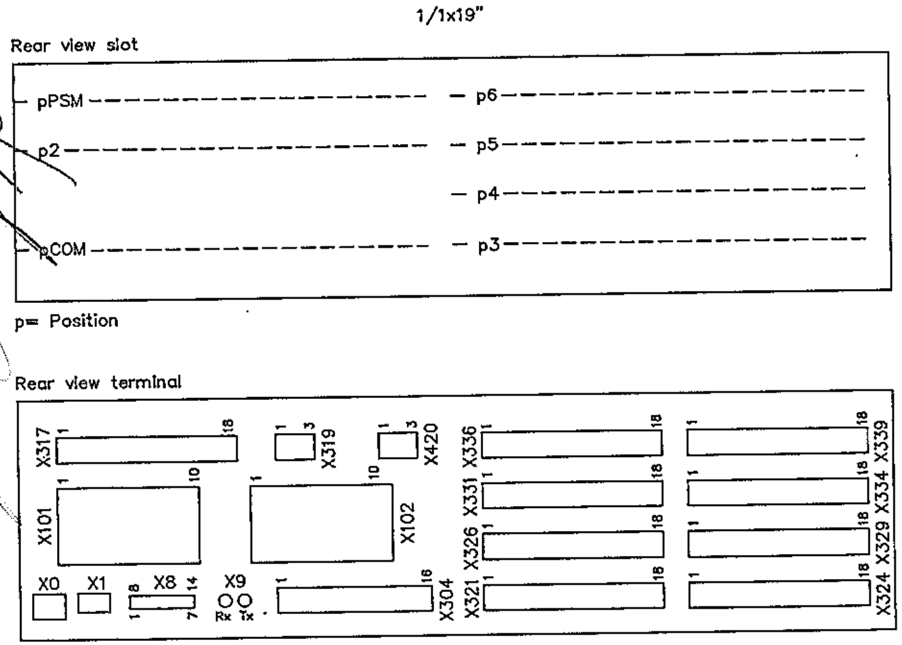

Designation for 3U, 1/1x19" casing with 1 TRM

Module	Slot	Terminal
COM05	pCOM	X0, X1, X8, X9, X304
TRM01	p2	X101, X102
PSM01 PSM02 PSM03	pPSM	X317. X319, X420
BIO01	p3	X321, X324
BIO01	p4	X326, X329
BIO01	p5	X331, X334
BIO01	p6	X336, X339

Compression or ringlug terminals

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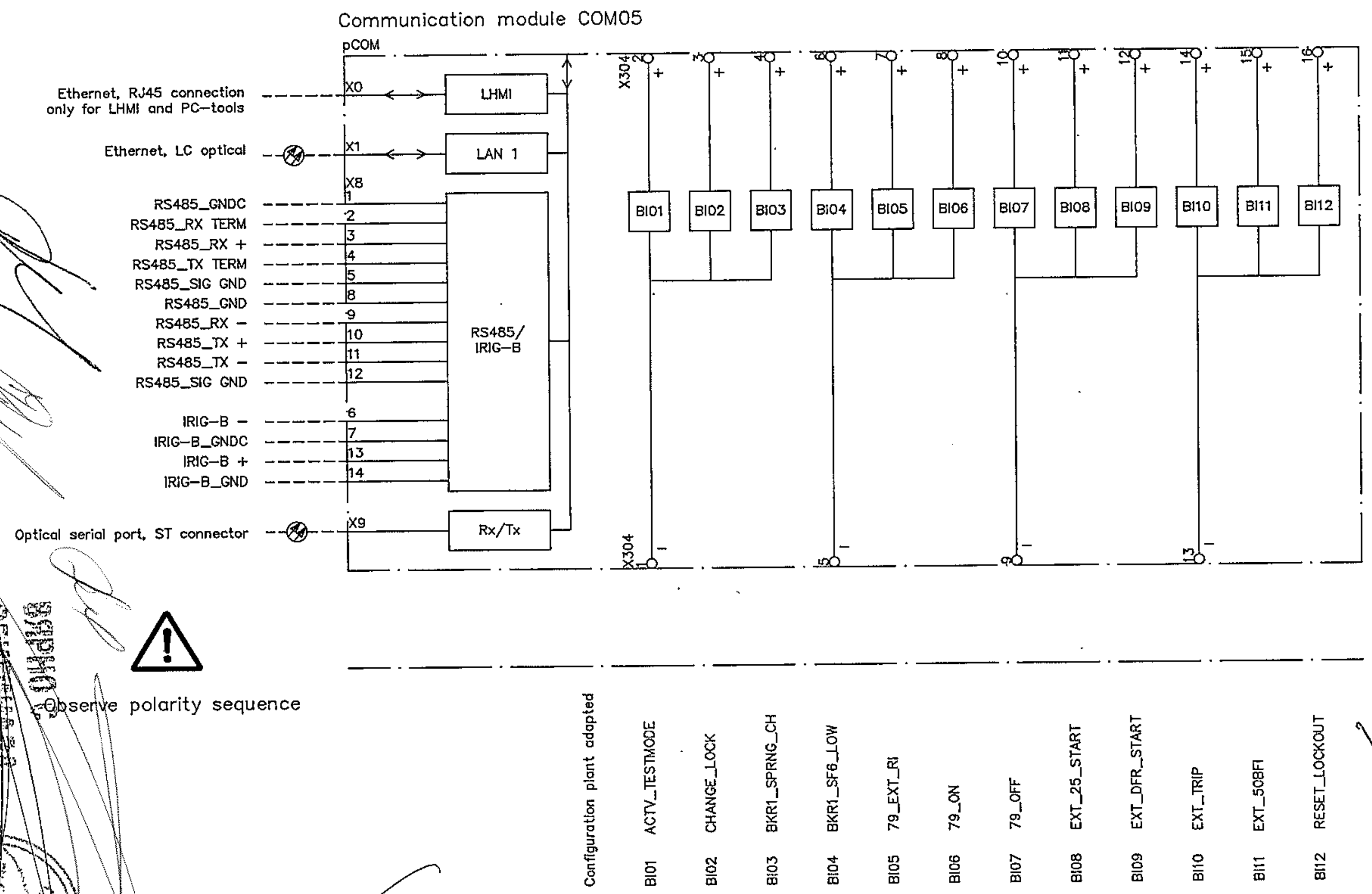

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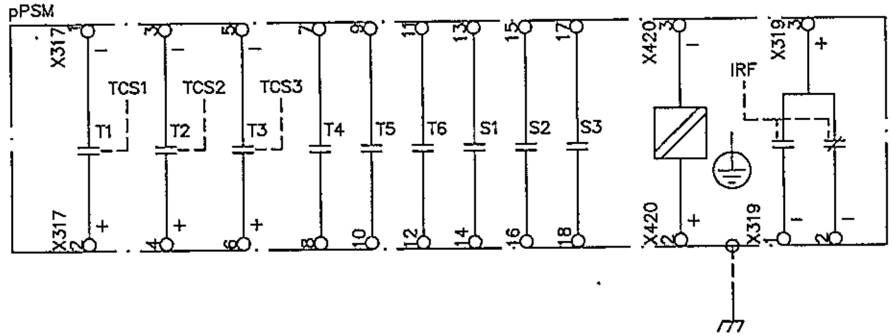
Power supply module PSM01 24–30 VDC



Observe polarity sequence

Configuration plant adapted

T1 BKR1_TRIP

T2 SPARE

T3 SPARE

T4 AUTO_SC_OK

T5 MAN_SC_OK

T6 GENERAL_ALARM

S1 SPARE

S2 SPARE

S3 GENERAL_TRIP

Auxiliary supply EL

Protective earth

Normal

Fail

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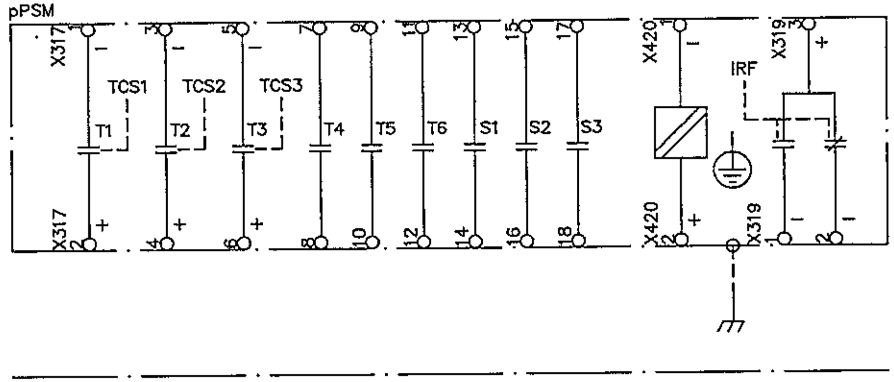
Power supply module PSM02 48–125 VDC



Observe polarity sequence

Configuration plant adapted

T1 BKR1_TRIP

T2 SPARE

T3 SPARE

T4 AUTO_SC_OK

T5 MAN_SC_OK

T6 GENERAL_ALARM

S1 SPARE

S2 SPARE

S3 GENERAL_TRIP

Auxiliary supply EL

Protective earth

Normal

Fail

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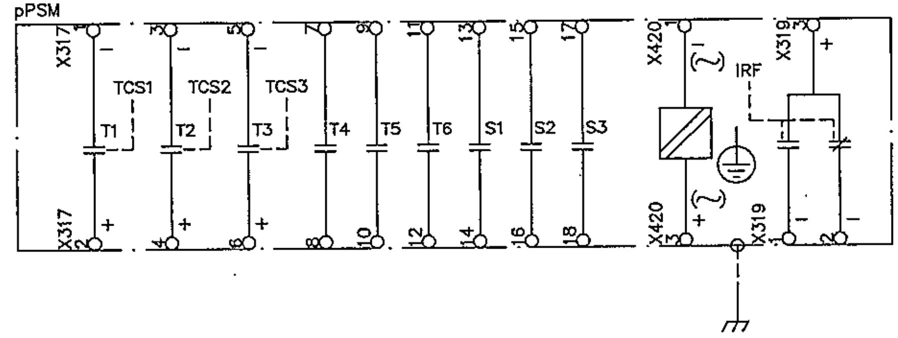
Power supply module PSM03 110–250 VDC, 100–240 VAC



Observe polarity sequence

Configuration plant adapted

T1 BKR1_TRIP

T2 SPARE

T3 SPARE

T4 AUTO_SC_OK

T5 MAN_SC_OK

T6 GENERAL_ALARM

S1 SPARE

S2 SPARE

S3 GENERAL_TRIP

Auxiliary supply EL

Protective earth

Normal

Fail

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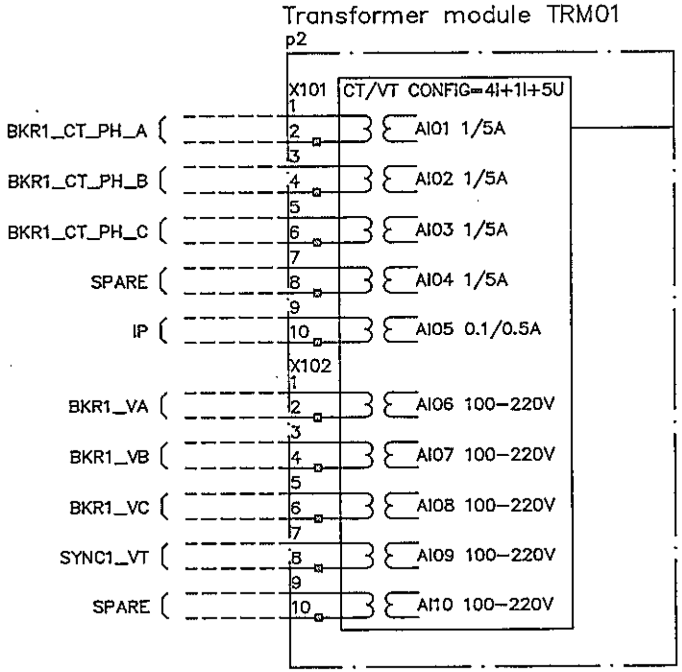

▫ Indicates polarity mark. Note that internal polarity can be adjusted by setting of analog input CT neutral direction and or on SMAI pre-processing function blocks.

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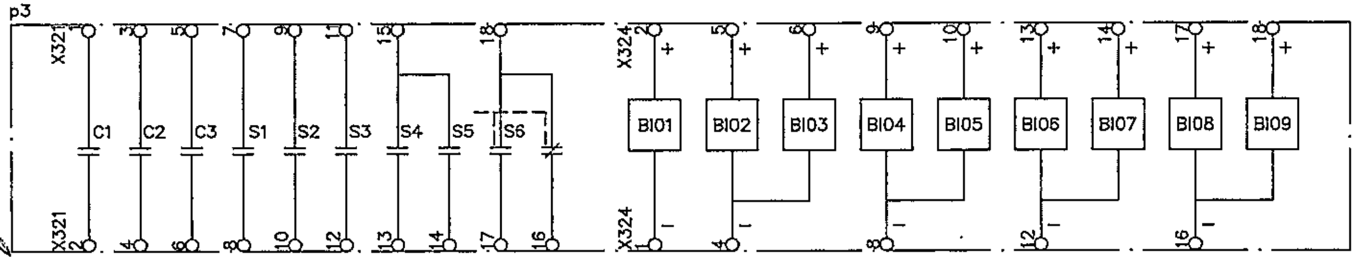
Binary input/output module BIO01



Observe polarity sequence

Configuration plant adapted

C1	SPARE
C2	TRIP_3PH
C3	79_CLOSE
S1	3PH_RI
S2	79_INPRG
S3	50BF_TRIP
S4	SPARE
S5	BAT_SUPRV_AL
S6	BKR1_LOCKOUT
BI01	BKR1_VT_OK
BI02	SYNC1_VT_OK
BI03	SPARE
BI04	BKR1_52b
BI05	BKR1_52a
BI06	189_52b
BI07	189_52a
BI08	989_52b
BI09	989_52a

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	Approved 2013-01-29	Patrik Nyback	
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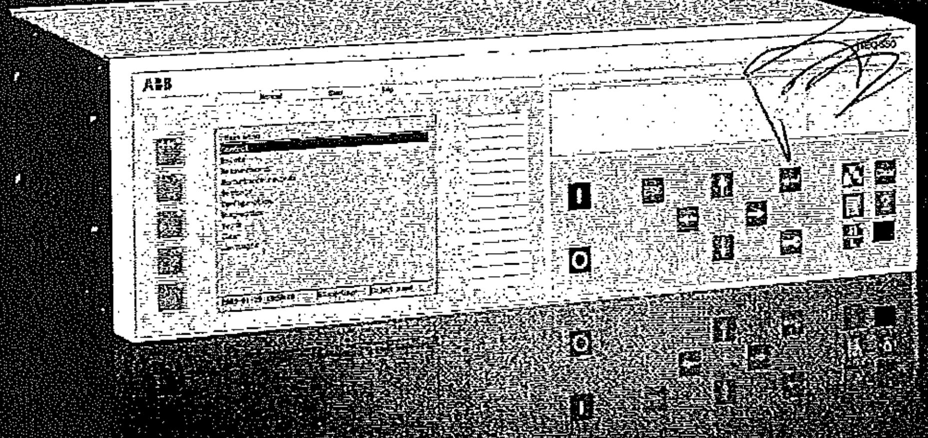

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Breaker protection REQ650
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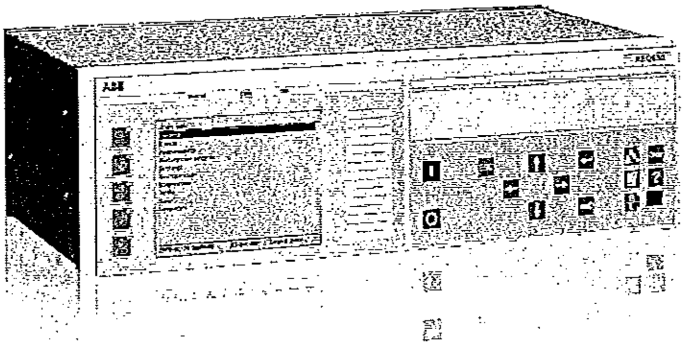

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Issued: October 2016
Revision: A
Product version: 1.3

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Disclaimer

The data, examples and diagrams in this manual are included solely for the concept or product description and are not to be deemed as a statement of guaranteed properties. All persons responsible for applying the equipment addressed in this manual must satisfy themselves that each intended application is suitable and acceptable, including that any applicable safety or other operational requirements are complied with. In particular, any risks in applications where a system failure and/or product failure would create a risk for harm to property or persons (including but not limited to personal injuries or death) shall be the sole responsibility of the person or entity applying the equipment, and those so responsible are hereby requested to ensure that all measures are taken to exclude or mitigate such risks.

This document has been carefully checked by ABB but deviations cannot be completely ruled out. In case any errors are detected, the reader is kindly requested to notify the manufacturer. Other than under explicit contractual commitments, in no event shall ABB be responsible or liable for any loss or damage resulting from the use of this manual or the application of the equipment.

Conformity

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2006/95/EC). This conformity is the result of tests conducted by ABB in accordance with the product standards EN 50263 and EN 60255-26 for the EMC directive, and with the product standards EN 60255-1 and EN 60255-27 for the low voltage directive. The product is designed in accordance with the international standards of the IEC 60255 series.

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Section 1 General

1.1 Type test data

This document certifies that the product described below is in accordance with, and conforms to the data stated in this Type Test Certificate and corresponding data in the Type Test Report and Product Guide.

The product has been tested according to relevant parts of the standards stated below.

Product/Type	Breaker protection IED Type REQ 650 V1.3
Product Guide	1MRK505294-BEN
User's Manuals	1MRK505291-UEN 1MRK505292-UEN 1MRK505293-UEN 1MRK500096-UEN 1MRK514016-UEN
Function	Breaker protection
Manufactured by	ABB AB, Sweden
Author/department	Rune Östlund, TP/TD
Date of issue	2013-03-22
Approved by	ABB AB Product Manager Joseph Menezes
Standards	IEC 60255, IEC 61000, IEC 60068, IEC 60529, IEC 61810, IEC 61850, IEC 60870, IEC 62439, ANSI C37.90, ANSI C37.112, ANSI C63.4
References	Type Test Specification 1MRK001502-238 Type test Report 1MRK001503-609

1.2 Definitions

Reference value

The specified value of an influencing factor to which are referred the characteristics of the equipment.

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Nominal range

The range of values of an influencing quantity (factor) within which, under specified conditions, the equipment meets the specified requirements.

Operative range

The range of values of a given energizing quantity for which the equipment, under specified conditions, is able to perform its intended functions according to the specified requirements.

1.3 Presumptions for technical data

The technical data stated in this document are only valid under the following circumstances:

- CT and VT ratios in the IED are set in accordance with the associated main instrument transformers. Note that for functions which measure an analogue signal which do not have corresponding primary quantity, the 1:1 ratio shall be set for the used analogue inputs on the IED, For example, HZPDIF.
- Parameter IBase used by the tested function is set equal to the rated CT primary current.
- Parameter UBase used by the tested function is set equal to the rated primary phase-to-phase voltage.
- Parameter SBase used by the tested function is set equal to sqrt(3)* IBase* UBase for three-phase power system.

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Section 2 Energizing quantities, rated values and limits

2.1 Analog inputs

Table 1: TRM — Energizing quantities, rated values and limits for transformer inputs

Description	Value	
Current inputs		
Rated current I_r	0.1 or 0.5 A[1]	1 or 5 A[2]
Operating range	0 – 50 A	0 – 500 A
Thermal withstand	100 A for 1 s 20 A for 10 s 8 A for 1 min 4 A continuously	500 A for 1 s *) 100 A for 10 s 40 A for 1 min 20 A continuously
Dynamic withstand	250 A one half wave	1250 A one half wave
Burden	< 1 mVA at I_r = 0.1 A < 20 mVA at I_r = 0.5 A	< 10 mVA at I_r = 1 A < 200 mVA at I_r = 5 A
*) max. 350 A for 1 s when COMBITEST test switch is included.		
Voltage inputs**)		
Rated voltage U_r	100 or 220 V	
Operating range	0 – 420 V	
Thermal withstand	450 V for 10 s 420 V continuously	
Burden	< 50 mVA at 100 V < 200 mVA at 220 V	
**) all values for individual voltage inputs		
Note! All current and voltage data are specified as RMS values at rated frequency		

1) Residual current
2) Phase currents or residual current

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2.2 Auxiliary AC and DC voltage

Table 2: Power supply

Description	PSM01	PSM02	PSM03
U_{aux}nominal	24, 30V DC	48, 60, 110, 125 V DC	100, 110, 120, 220, 240 V AC, 50 and 60 Hz
			110, 125, 220, 250 V DC
U_{aux}variation	80...120% of U_n (19.2...36 V DC)	80...120% of U_n (38.4...150 V DC)	80...110% of U_n (80...264 V AC)
			80...120% of U_n (88...300 V DC)
Maximum load of auxiliary voltage supply	35 W for DC 40 VA for AC		
Ripple in the DC auxiliary voltage	Max 15% of the DC value (at frequency of 100 and 120 Hz)		
Maximum interruption time in the auxiliary DC voltage without resetting the IED	50 ms at U_{aux}		
Resolution of the voltage measurement in PSM module	1 bit represents 0,5 V (+/- 1 VDC)	1 bit represents 1 V (+/- 1 VDC)	1 bit represents 2 V (+/- 1 VDC)

2.3 Binary inputs and outputs

Table 3: Binary inputs

Description	Value
Operating range	Maximum input voltage 300 V DC
Rated voltage	24...250 V DC
Current drain	1.6...1.8 mA
Power consumption/input	<0.38 W
Threshold voltage	15...221 V DC (parametrizable in the range in steps of 1% of the rated voltage)

Table 4: Signal output and IRF output

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	5 A
Make and carry for 3.0 s	10 A
Make and carry 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at U< 48/110/220 V DC	≤0.5 A/≤0.1 A/≤0.04 A

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Table 5: Power output relays without TCS function

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	8 A
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at U< 48/110/220 V DC	≤1 A/≤0.3 A/≤0.1 A

Table 6: Power output relays with TCS function

Description	Value
Rated voltage	250 V DC
Continuous contact carry	8 A
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at U< 48/110/220 V DC	≤1 A/≤0.3 A/≤0.1 A
Control voltage range	20...250 V DC
Current drain through the supervision circuit	~1.0 mA
Minimum voltage over the TCS contact	20 V DC

Table 7: Ethernet interfaces

Ethernet interface	Protocol	Cable	Data transfer rate
100BASE-TX	-	CAT 6 S/FTP or better	100 MBits/s
100BASE-FX	TCP/IP protocol	Fibre-optic cable with LC connector	100 MBits/s

Table 8: Fibre-optic communication link

Wave length	Fibre type	Connector	Permitted path attenuation[1]	Distance
1300 nm	MM 62.5/125 μm glass fibre core	LC	<8 dB	2 km

1) Maximum allowed attenuation caused by connectors and cable together

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Table 9: X8/IRIG-B and EIA-485 interface

Type	Protocol	Cable
Tension clamp connection	IRIG-B	Shielded twisted pair cable Recommended: CAT 5, Belden RS-485 (9841-9844) or Alpha Wire (Alpha 6222-6230)
Tension clamp connection	IEC 68070–5–103 DNP3.0	Shielded twisted pair cable Recommended: DESCAFLEX RD-H(ST)H-2x2x0.22mm^2, Belden 9729, Belden 9829

Table 10: IRIG-B

Type	Value	Accuracy
Input impedance	430 Ohm	-
Minimum input voltage HIGH	4.3 V	-
Maximum input voltage LOW	0.8 V	-

Table 11: EIA-485 interface

Type	Value	Conditions
Minimum differential driver output voltage	1.5 V	–
Maximum output current	60 mA	-
Minimum differential receiver input voltage	0.2 V	-
Supported bit rates	300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200	-
Maximum number of 650 IEDs supported on the same bus	32	-
Max. cable length	925 m (3000 ft)	Cable: AWG24 or better, stub lines shall be avoided

Table 12: Serial rear interface

Type	Counter connector
Serial port (X9)	Optical serial port, type ST for IEC 60870-5-103 and DNP serial

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Table 13: Optical serial port (X9)

Wave length	Fibre type	Connector	Permitted path attenuation[1]
820 nm	MM 62,5/125 µm glass fibre core	ST	6.8 dB (approx. 1700m length with 4 db / km fibre attenuation)
820 nm	MM 50/125 µm glass fibre core	ST	2.4 dB (approx. 600m length with 4 db / km fibre attenuation)

1) Maximum allowed attenuation caused by fibre

2.4 Influencing factors

2.4.1 Enclosure class

Table 14: Environmental tests

Description		Type test value	Reference
Cold tests	operation	96 h at -25°C 16 h at -40°C	IEC 60068-2-1/ANSI C37.90-2005 (chapter 4)
	storage	96 h at -40°C	
Dry heat tests	operation	16 h at +70°C	IEC 60068-2-2/ANSI C37.90-2005 (chapter 4)
	storage	96 h at +85°C	
Damp heat tests	steady state	240 h at +40°C humidity 93%	IEC 60068-2-78
	cyclic	6 cycles at +25 to +55°C humidity 93...95%	IEC 60068-2-30

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Section 3 Type tests according to standards

Table 15: Electromagnetic compatibility tests

Description	Type test value	Reference
100 kHz and 1 MHz burst disturbance test		IEC 61000-4-18, level 3 IEC 60255-22-1 ANSI C37.90.1-2012
• Common mode	2.5 kV	
• Differential mode	2.5 kV	
Electrostatic discharge test		IEC 61000-4-2, level 4 IEC 60255-22-2 ANSI C37.90.3-2001
• Contact discharge	8 kV	
• Air discharge	15 kV	
Radio frequency interference tests		
• Conducted, common mode	10 V (emf), f=150 kHz...80 MHz	IEC 61000-4-6 , level 3 IEC 60255-22-6
• Radiated, amplitude-modulated	20 V/m (rms), f=80...1000 MHz and f=1.4...2.7 GHz	IEC 61000-4-3, level 3 IEC 60255-22-3 ANSI C37.90.2-2004
Fast transient disturbance tests		IEC 61000-4-4 IEC 60255-22-4, class A ANSI C37.90.1-2012
• Communication ports	4 kV	
• Other ports	4 kV	
Surge immunity test		IEC 61000-4-5 IEC 60255-22-5
• Communication	1 kV line-to-earth	
• Other ports	2 kV line-to-earth, 1 kV line-to-line	
• Power supply	4 kV line-to-earth, 2 kV line-to-line	
Power frequency (50 Hz) magnetic field		IEC 61000-4-8, level 5
• 3 s	1000 A/m	
• Continuous	100 A/m	

Table continues on next page

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Description	Type test value	Reference
Pulse magnetic field immunity test	1000A/m	IEC 61000–4–9, level 5
Damped oscillatory magnetic field	100A/m, 100 kHz and 1MHz	IEC 6100–4–10, level 5
Power frequency immunity test		IEC 60255-22-7, class A IEC 61000-4-16
• Common mode	300 V rms	
• Differential mode	150 V rms	
Voltage dips and short interruptionsc on DC power supply	Dips: 40%/200 ms 70%/500 ms Interruptions: 0-50 ms: No restart 0...∞ s : Correct behaviour at power down	IEC 60255-11 IEC 61000-4-11
Voltage dips and interruptions on AC power supply	Dips: 40% 10/12 cycles at 50/60 Hz 70% 25/30 cycles at 50/60 Hz Interruptions: 0–50 ms: No restart 0...∞ s: Correct behaviour at power down	IEC 60255–11 IEC 61000–4–11
Electromagnetic emission tests		EN 55011, class A IEC 60255-25 ANSI C63.4, FCC
• Conducted, RF-emission (mains terminal)		
0.15...0.50 MHz	< 79 dB(µV) quasi peak < 66 dB(µV) average	
0.5...30 MHz	< 73 dB(µV) quasi peak < 60 dB(µV) average	
• Radiated RF-emission, IEC		
30...230 MHz	< 40 dB(µV/m) quasi peak, measured at 10 m distance	
230...1000 MHz	< 47 dB(µV/m) quasi peak, measured at 10 m distance	

Table 16: Insulation tests

Description	Type test value	Reference
Dielectric tests:		IEC 60255-5 ANSI C37.90-2005
• Test voltage	2 kV, 50 Hz, 1 min 1 kV, 50 Hz, 1 min, communication	
Impulse voltage test:		IEC 60255-5 ANSI C37.90-2005

Table continues on next page

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Description	Type test value	Reference
• Test voltage	5 kV, unipolar impulses, waveform 1.2/50 μs, source energy 0.5 J 1 kV, unipolar impulses, waveform 1.2/50 μs, source energy 0.5 J, communication	
Insulation resistance measurements • Isolation resistance	>100 MΩ, 500 V DC	IEC 60255-5 ANSI C37.90-2005
Protective bonding resistance • Resistance	<0.1 Ω (60 s)	IEC 60255-27

Table 17: Mechanical tests

Description	Reference	Requirement
Vibration response tests (sinusoidal)	IEC 60255-21-1	Class 1
Vibration endurance test	IEC60255-21-1	Class 1
Shock response test	IEC 60255-21-2	Class 1
Shock withstand test	IEC 60255-21-2	Class 1
Bump test	IEC 60255-21-2	Class 1
Seismic test	IEC 60255-21-3	Class 2

3.1 Product safety

Table 18: Product safety

Description	Reference
LV directive	2006/95/EC
Standard	EN 60255-27 (2005)

3.2 EMC compliance

Table 19: EMC compliance

Description	Reference
EMC directive	2004/108/EC
Standard	EN 50263 (2000) EN 60255-26 (2007)

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Section 4 Current protection

Table 20: Instantaneous phase overcurrent protection, 3-phase output PHPIOC

Function	Range or value	Accuracy
Operate current	(5-2500)% of IBase	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate time	20 ms typically at 0 to 2 x I_{set}	-
Reset time	30 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Operate time	10 ms typically at 0 to 5 x I_{set}	-
Reset time	40 ms typically at 5 to 0 x I_{set}	-
Critical impulse time	2 ms typically at 0 to 5 x I_{set}	-
Dynamic overreach	< 5% at τ = 100 ms	-

Table 21: Instantaneous phase overcurrent protection, phase segregated output SPTPIOC

Function	Range or value	Accuracy
Operate current	(5-2500)% of IBase	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate time	20 ms typically at 0 to 2 x I_{set}	-
Reset time	30 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Operate time	10 ms typically at 0 to 5 x I_{set}	-
Reset time	40 ms typically at 5 to 0 x I_{set}	-
Critical impulse time	2 ms typically at 0 to 5 x I_{set}	-
Dynamic overreach	< 5% at τ = 100 ms	-

Table 22: Four step phase overcurrent protection, 3-phase output OC4PTOC

Function	Setting range	Accuracy
Operate current	(5-2500)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95% at (50–2500)% of *IBase*	-
Min. operating current	(5-10000)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
2nd harmonic blocking	(5–100)% of fundamental	± 2.0% of I_r
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Function	Setting range	Accuracy
Independent time delay	(0.000-60.000) s	± 0.5% ±25 ms
Minimum operate time for inverse characteristics	(0.000-60.000) s	± 0.5% ±25 ms
Inverse characteristics, see table 74, table 75 and table 76	15 curve types	1) ANSI/IEEE C37.112 IEC 60255–151 ±3% or ±40 ms $0.10 \leq k \leq 3.00$ $1.5 \times I_{set} \leq I \leq 20 \times I_{set}$
Operate time, nondirectional start function	25 ms typically at 0 to 2 x I_{set}	-
Reset time, nondirectional start function	35 ms typically at 2 to 0 x I_{set}	-
Operate time, directional start function	50 ms typically at 0 to 2 x I_{set}	-
Reset time, directional start function	35 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-
1) **Note:** Timing accuracy only valid when 2nd harmonic blocking is turned off		

Table 23: Four step phase overcurrent protection, phase segregated output OC4SPTOC

Function	Setting range	Accuracy
Operate current	(5-2500)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Min. operating current	(5-10000)% of *IBase*	± 1.0% of I_r at $I < I_r$ ±1.0% of I at $I > I_r$
Independent time delay	(0.000-60.000) s	± 0.5% ± 25 ms
Minimum operate time for inverse characteristics	(0.000-60.000) s	± 0.5% ± 25 ms
Inverse characteristics, see table 74, table 75 and table 76	15 curve types	1) ANSI/IEEE C37.112 IEC 60255–151 ±3% or ±40 ms $0.10 \leq k \leq 3.00$ $1.5 \times I_{set} \leq I \leq 20 \times I_{set}$
Operate time, nondirectional start function	25 ms typically at 0 to 2 x I_{set}	-
Reset time, nondirectional start function	35 ms typically at 2 to 0 x I_{set}	-
Operate time, directional start function	50 ms typically at 0 to 2 x I_{set}	-
Reset time, directional start function	35 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-
1) **Note:** Timing accuracy only valid when 2nd harmonic blocking is turned off.		

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Table 24: Instantaneous residual overcurrent protection EFPIOC

Function	Range or value	Accuracy
Operate current	(1-2500)% of IBase	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate time	20 ms typically at 0 to 2 x I_{set}	-
Reset time	30 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Operate time	10 ms typically at 0 to 5x I_{set}	-
Reset time	40 ms typically at 5 to 0x I_{set}	-
Critical impulse time	2 ms typically at 0 to 5 x I_{set}	-
Dynamic overreach	< 5% at τ = 100 ms	-

Table 25: Four step residual overcurrent protection EF4PTOC

Function	Range or value	Accuracy
Operate current	(1-2500)% of *IBase*	± 1.0% of I_r at $I < I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate current for directional comparison, Zero sequence	(1–100)% of *IBase*	± 2.0% of I_r
Operate current for directional comparison, Negative sequence	(1–100)% of *IBase*	± 2.0% of I_r
Min. operating current	(1-10000)% of *IBase*	± 1.0% of I_r at $I < I_r$ ± 1.0% of I at $I > I_r$
Minimum operate time for inverse characteristics	(0.000-60.000) s	± 0.5% ± 25 ms
Timers	(0.000-60.000) s	± 0.5% ±25 ms
Inverse characteristics, see table 74, table 75 and table 76	15 curve types	1) ANSI/IEEE C37.112 IEC 60255–151 ±3% or ±40 ms $0.10 \leq k \leq 3.00$ $1.5 \times I_{set} \leq I \leq 20 \times I_{set}$
Minimum polarizing voltage, Zero sequence	(1–100)% of *UBase*	± 0.5% of U_r
Minimum polarizing voltage, Negative sequence	(1–100)% of *UBase*	± 0.5% of U_r
Minimum polarizing current, Zero sequence	(2–100)% of *IBase*	±1.0% of I_r
Minimum polarizing current, Negative sequence	(2–100)% of *IBase*	±1.0% of I_r
Real part of source Z used for current polarization	(0.50-1000.00) Ω/phase	-
Imaginary part of source Z used for current polarization	(0.50–3000.00) Ω/phase	-

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Function	Range or value	Accuracy
Operate time, non-directional start function	30 ms typically at 0.5 to 2 x I_{set}	-
Reset time, non-directional start function	30 ms typically at 2 to 0.5 x I_{set}	-
Operate time, directional start function	30 ms typically at 0,5 to 2 x I_N	-
Reset time, directional start function	30 ms typically at 2 to 0,5 x I_N	-
[1] **Note:** Timing accuracy only valid when 2nd harmonic blocking is turned off.		

Table 26: Sensitive directional residual overcurrent and power protection SDEPSDE

Function	Range or value	Accuracy
Operate level for $3I_0 \cdot \cos\varphi$ directional residual overcurrent	(0.25-200.00)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$ At low setting: (0.25-1.00)% of I_r: ±0.05% of I_r (1.00-5.00)% of I_r: ±0.1% of I_r
Operate level for $3I_0 \cdot 3U_0 \cdot \cos\varphi$ directional residual power	(0.25-200.00)% of *SBase*	± 2.0% of S_r at $S \le S_r$ ± 2.0% of S at $S > S_r$ At low setting: (0.25-5.00)% of *SBase* ± 10% of set value
Operate level for $3I_0$ and φ residual overcurrent	(0.25-200.00)% of *IBase*	± 1.0% of I_r at $\le I_r$ ± 1.0% of I at $I > I_r$ At low setting: (0.25-1.00)% of I_r: ±0.05% of I_r (1.00-5.00)% of I_r: ±0.1% of I_r
Operate level for non-directional overcurrent	(1.00-400.00)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$ At low setting <5% of I_r: ±0.1% of I_r
Operate level for non-directional residual overvoltage	(1.00-200.00)% of *UBase*	± 0.5% of U_r at $U \le U_r$ ± 0.5% of U at $U > U_r$
Residual release current for all directional modes	(0.25-200.00)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$ At low setting: (0.25-1.00)% of I_r: ±0.05% of I_r (1.00-5.00)% of I_r: ±0.1% of I_r
Residual release voltage for all directional modes	(1.00 - 300.00)% of *UBase*	± 0.5% of U_r at $U \le U_r$ ± 0.5% of U at $U > U_r$
Reset ratio	> 95%	-
Timers	(0.000-60.000) s	± 0.5% ±25 ms
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Function	Range or value	Accuracy
Inverse characteristics, see table 74, table 75 and table 76	15 curve types	ANSI/IEEE C37.112 IEC 60255–151 ±3.0% or±90 ms $0.10 \leq k \leq 3.00$ $1.5 \times I_{set} \leq I \leq 20 \times I_{set}$
Relay characteristic angle RCA	(-179 to 180) degrees	± 2.0 degrees
Relay open angle ROA	(0-90) degrees	± 2.0 degrees
Operate time, non-directional residual over current	60 ms typically at 0 to 2 x I_{set}	60 ms typically at 0 to 2 x 1_{set}
Reset time, non-directional residual over current	65 ms typically at 2 to 0 x I_{set}	65 ms typically at 2 to 0 x 1_{set}
Operate time, non-directional residual overvoltage	45 ms typically at 0.8 to 1.5 x U_{set}	45 ms typically at 0.8 to 1.5 x U_{set}
Reset time, non-directional residual overvoltage	85 ms typically at 1.2 to 0.8 x U_{set}	85 ms typically at 1.2 to 0.8 x U_{set}
Operate time, directional residual over current	140 ms typically at 0.5 to 2 x I_{set}	-
Reset time, directional residual over current	85 ms typically at 2 to 0.5 x I_{set}	-
Critical impulse time non-directional residual over current	35 ms typically at 0 to 2 x I_{set}	-
Impulse margin time non-directional residual over current	25 ms typically	-

Table 27: Thermal overload protection, one time constant LCPTTR/LFPTTR

Function	Range or value	Accuracy
Reference current	(0-400)% of *IBase*	± 1.0% of I_r
Reference temperature	(0-300)°C, (0 - 600)°F	±2.0°C, ±2.0°F
Operate time: $$t = \tau \cdot ln\left(\frac{I^2 - I_p^2}{I^2 - I_{ref}^2}\right)$$ (Equation 1) I = actual measured current I_p = load current before overload occurs I_{ref} = reference load current	Time constant τ = (0–1000) minutes	IEC 60255-8, ±5% + 200 ms
Alarm temperature	(0-200)°C, (0-400)°F	± 2.0°C ± 2.0°F
Trip temperature	(0-300)°C, (0-600)°F	± 2.0°C ± 2.0°F
Reset level temperature	(0-300)°C, (0-600)°F	± 2.0°C ± 2.0°F

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Table 28: ***Breaker failure protection, 3-phase activation and output CCRBRF***

Function	Range or value	Accuracy
Operate phase current	(5-200)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio, phase current	> 95%	-
Operate residual current	(2-200)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio, residual current	> 95%	-
Phase current level for blocking of contact function	(5-200)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Timers	(0.000-60.000) s	± 0.5% ±10 ms
Operate time for current detection	20 ms typically	-
Reset time for current detection	10 ms maximum	-

Table 29: ***Breaker failure protection, phase segregated activation and output CSPRBRF***

Function	Range or value	Accuracy
Operate phase current	(5-200)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio, phase current	> 95%	-
Operate residual current	(2-200)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio, residual current	> 95%	-
Phase current level for blocking of contact function	(5-200)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Timers	(0.000-60.000) s	± 0.5% ±10 ms
Operate time for current detection	20 ms typically	-
Reset time for current detection	10 ms maximum	-

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Table 30: Stub protection STBPTOC

Function	Range or value	Accuracy
Operating current	(1-2500)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate time	20 ms typically at 0 to 2 x I_{set}	-
Reset time	30 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-

Table 31: Pole discordance protection CCRPLD

Function	Range or value	Accuracy
Operate value, current asymmetry level	(0-100) %	± 1.0% of I_r
Reset ratio	>95%	-
Time delay	(0.000-60.000) s	± 0.5% ± 25 ms

Table 32: Broken conductor check BRCPTOC

Function	Range or value	Accuracy
Minimum phase current for operation	(5–100)% of *IBase*	± 1.0% of I_r
Unbalance current operation	(50-90)% of maximum current	± 2.0% of I_r
Timer	(0.00-60.000) s	± 0.5% ± 25 ms
Operate time for start function	35 ms typically	-
Reset time for start function	30 ms typically	-
Critical impulse time	15 ms typically	-
Impulse margin time	10 ms typically	-

Table 33: Directional over/underpower protection GOPPDOP, GUPPDUP

Function	Range or value	Accuracy
Power level	(0.0–500.0)% of *SBase*	± 1.0% of S_r at $S < S_r$ ± 1.0% of S at $S > S_r$
	(1.0-2.0)% of *SBase*	< ± 50% of set value
	(2.0-10)% of *SBase*	< ± 20% of set value
Characteristic angle	(-180.0–180.0) degrees	2 degrees
Timers	(0.010 - 6000.000) s	± 0.5% ± 25 ms

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Table 34: ***Negative sequence based overcurrent function DNSPTOC***

Function	Range or value	Accuracy
Operate current	(2.0 - 200.0) % of *IBase*	± 1.0% of I_r at $I < I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95 %	-
Low polarizing voltage level	(0.0 - 5.0) % of *UBase*	< ± 0.5% of U_r
Relay characteristic angle	(-180 - 180) degrees	± 2.0 degrees
Relay operate angle	(1 - 90) degrees	± 2.0 degrees
Timers	(0.00 - 6000.00) s	± 0.5% ± 25 ms
Operate time, non-directional	30 ms typically at 0 to 2 x I_{set} 20 ms typically at 0 to 10 x I_{set}	-
Reset time, non-directional	40 ms typically at 2 to 0 x I_{set}	-
Operate time, directional	30 ms typically at 0 to 2 x I_{set} 20 ms typically at 0 to 10 x I_{set}	-
Reset time, directional	40 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set} 2 ms typically at 0 to 10 x I_{set}	-
Impulse margin time	15 ms typically	-
Dynamic overreach	< 10% at t = 300 ms	-

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Section 5 Voltage protection

Table 35: Two step undervoltage protection UV2PTUV

Function	Range or value	Accuracy
Operate voltage, low and high step	(1–100)% of *UBase*	± 0.5% of U_r
Reset ratio	<102%	-
Inverse time characteristics for low and high step, see table 78	-	See table 78
Definite time delay, step 1	(0.00 - 6000.00) s	± 0.5% ± 25 ms
Definite time delays, step 2	(0.000-60.000) s	± 0.5% ±25 ms
Minimum operate time, inverse characteristics	(0.000–60.000) s	± 0.5% ± 25 ms
Operate time, start function	30 ms typically at 1.2 to 0.5U_{set}	-
Reset time, start function	40 ms typically at 0.5 to 1.2 xU_{set}	-
Critical impulse time	10 ms typically at 1.2 to 0.8 x U_{set}	-
Impulse margin time	15 ms typically	-

Table 36: Two step overvoltage protection OV2PTOV

Function	Range or value	Accuracy
Operate voltage, step 1 and 2	(1-200)% of *UBase*	± 0.5% of U_r at $U < U_r$ ± 0.5% of U at $U > U_r$
Reset ratio	>98%	-
Inverse time characteristics for steps 1 and 2, see table 77	-	See table 77
Definite time delay, step 1	(0.00 - 6000.00) s	± 0.5% ± 25 ms
Definite time delays, step 2	(0.000-60.000) s	± 0.5% ± 25 ms
Minimum operate time, Inverse characteristics	(0.000-60.000) s	± 0.5% ± 25 ms
Operate time, start function	30 ms typically at 0 to 2 x U_{set}	-

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Function	Range or value	Accuracy
Reset time, start function	40 ms typically at 2 to 0 x U_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time	15 ms typically	-

Table 37: Two step residual overvoltage protection ROV2PTOV

Function	Range or value	Accuracy
Operate voltage, step 1	(1-200)% of *UBase*	± 0.5% of U_r at $U < U_r$ ± 0.5% of U at $U > U_r$
Operate voltage, step 2	(1–100)% of *UBase*	± 0.5% of U_r at $U < U_r$ ± 0.5% of U at $U > U_r$
Reset ratio	> 98%	-
Inverse time characteristics for low and high step, see table 79	-	See table 79
Definite time setting, step 1	(0.00–6000.00) s	± 0.5% ± 25 ms
Definite time setting, step 2	(0.000-60.000) s	± 0.5% ± 25 ms
Minimum operate time for step 1 inverse characteristic	(0.000-60.000) s	± 0.5% ± 25 ms
Operate time, start function	30 ms typically at 0 to 2 x U_{set}	-
Reset time, start function	40 ms typically at 2 to 0 x U_{set}	-
Critical impulse time	10 ms typically at 0 to 1.2 xU_{set}	-
Impulse margin time	15 ms typically	-

Table 38: Loss of voltage check LOVPTUV

Function	Range or value	Accuracy
Operate voltage	(0–100)% of UBase	± 0.5% of U_r
Reset ratio	<105%	-
Pulse timer	(0.050–60.000) s	± 0.5% ± 25 ms
Timers	(0.000–60.000) s	± 0.5% ± 25 ms

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Section 6 Frequency protection

Table 39: Under frequency protection SAPTUF

Function	Range or value	Accuracy
Operate value, start function	(35.00-75.00) Hz	± 2.0 mHz at symmetrical three-phase voltage
Operate value, restore frequency	(45 - 65) Hz	± 2.0 mHz
Reset ratio	<1.001	-
Operate time, start function	At 50 Hz: 200 ms typically at f_{set} +0.5 Hz to f_{set} -0.5 Hz At 60 Hz: 170 ms typically at f_{set} +0.5 Hz to f_{set} -0.5 Hz	-
Reset time, start function	At 50 Hz: 60 ms typically at f_{set} -0.5 Hz to f_{set} +0.5 Hz At 60 Hz: 50 ms typically at f_{set} -0.5 Hz to f_{set} +0.5 Hz	-
Operate time delay	(0.000-60.000)s	<250 ms
Restore time delay	(0.000-60.000)s	<150 ms

Table 40: Overfrequency protection SAPTOF

Function	Range or value	Accuracy
Operate value, start function	(35.00-75.00) Hz	± 2.0 mHz at symmetrical three-phase voltage
Reset ratio	>0.999	-
Operate time, start function	At 50 Hz: 200 ms typically at f_{set} -0.5 Hz to f_{set} +0.5 Hz At 60 Hz: 170 ms typically at f_{set} -0.5 Hz to f_{set} +0.5 Hz	-
Reset time, start function	At 50 and 60 Hz: 55 ms typically at f_{set} +0.5 Hz to f_{set}-0.5 Hz	-
Timer	(0.000-60.000)s	<250 ms

Table 41: Rate-of-change frequency protection SAPFRC

Function	Range or value	Accuracy
Operate value, start function	(-10.00-10.00) Hz/s	± 10.0 mHz/s
Operate value, restore enable frequency	(45.00 - 65.00) Hz	± 2.0 mHz
Timers	(0.000 - 60.000) s	<130 ms
Operate time, start function	At 50 Hz: 100 ms typically At 60 Hz: 80 ms typically	-

Section 7 Secondary system supervision

Table 42: Current circuit supervision CCSRDIF

Function	Range or value	Accuracy
Operate current	(5-200)% of I_r	± 10.0% of I_r at $I \leq I_r$ ± 10.0% of I at $I > I_r$
Block current	(5-500)% of I_r	± 5.0% of I_r at $I \leq I_r$ ± 5.0% of I at $I > I_r$

Table 43: Fuse failure supervision SDDRFUF

Function	Range or value	Accuracy
Operate voltage, zero sequence	(1-100)% of UBase	± 1.0% of U_r
Operate current, zero sequence	(1–100)% of IBase	± 1.0% of I_r
Operate voltage, negative sequence	(1–100)% of UBase	± 0.5% of U_r
Operate current, negative sequence	(1–100)% of IBase	± 1.0% of I_r
Operate voltage change level	(1–100)% of UBase	± 5.0% of U_r
Operate current change level	(1–100)% of IBase	± 5.0% of I_r
Operate phase voltage	(1-100)% of UBase	± 0.5% of U_r
Operate phase current	(1-100)% of IBase	± 1.0% of I_r
Operate phase dead line voltage	(1-100)% of UBase	± 0.5% of U_r
Operate phase dead line current	(1-100)% of IBase	± 1.0% of I_r

Table 44: Breaker close/trip circuit monitoring TCSSCBR

Function	Range or value	Accuracy
Operate time delay	(0.020 - 300.000) s	± 0,5% ± 110 ms

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Section 8 Control

Table 45: Synchronizing, synchrocheck and energizing check SESRSYN

Function	Range or value	Accuracy
Phase shift, $\varphi_{line} - \varphi_{bus}$	(-180 to 180) degrees	-
Voltage ratio, U_{bus}/U_{line}	0.500 - 2.000	-
Reset ratio, synchrocheck	> 95%	-
Frequency difference limit between bus and line for synchrocheck	(0.003-1.000) Hz	± 2.0 mHz
Phase angle difference limit between bus and line for synchrocheck	(5.0-90.0) degrees	± 2.0 degrees
Voltage difference limit between bus and line for synchronizing and synchrocheck	0.03-0.50 p.u	± 0.5% of U_r
Time delay output for synchrocheck	(0.000-60.000) s	± 0.5% ± 25 ms
Frequency difference minimum limit for synchronizing	(0.003-0.250) Hz	± 2.0 mHz
Frequency difference maximum limit for synchronizing	(0.050-0.500) Hz	± 2.0 mHz
Maximum allowed frequency rate of change	(0.000-0.500) Hz/s	± 10.0 mHz/s
Closing time of the breaker	(0.000-60.000) s	± 0.5% ± 25 ms
Breaker closing pulse duration	(0.050-60.000) s	± 0.5% ± 25 ms
tMaxSynch, which resets synchronizing function if no close has been made before set time	(0.000-60.000) s	± 0.5% ± 25 ms
Minimum time to accept synchronizing conditions	(0.000-60.000) s	± 0.5% ± 25 ms
Time delay output for energizing check	(0.000-60.000) s	± 0.5% ± 25 ms
Operate time for synchrocheck function	40 ms typically	-
Operate time for energizing function	100 ms typically	-

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Table 46: Autorecloser for 3-phase operation SMBRREC

Function	Range or value	Accuracy
Number of autoreclosing shots	1 - 5	-
Autoreclosing open time: shot 1 - t1 3Ph	(0.000-60.000) s	± 0.5% ± 25 ms
shot 2 - t2 3Ph shot 3 - t3 3Ph shot 4 - t4 3Ph shot 5 - t5 3Ph	(0.00-6000.00) s	
Autorecloser maximum wait time for sync	(0.00-6000.00) s	
Maximum trip pulse duration	(0.000-60.000) s	
Inhibit reset time	(0.000-60.000) s	
Reclaim time	(0.00-6000.00) s	
Minimum time CB must be closed before AR becomes ready for autoreclosing cycle	(0.00-6000.00) s	
CB check time before unsuccessful	(0.00-6000.00) s	
Wait for master release	(0.00-6000.00) s	
Wait time after close command before proceeding to next shot	(0.000-60.000) s	

Table 47: Autorecloser for 1/3-phase operation STBRREC

Function	Range or value	Accuracy
Number of autoreclosing shots	1-5	-
Autoreclosing open time: Shot 1 - t1 3Ph Shot 1 - t1 1Ph	(0.000-60.000) s	± 0.5% ± 25 ms
shot 2 - t2 3Ph shot 3 - t3 3Ph shot 4 - t4 3Ph shot 5 - t5 3Ph	(0.00-6000.00) s	
Autorecloser maximum wait time for sync	(0.00-6000.00) s	
Open time extension for long trip time	(0.000-60.000) s	
Maximum trip pulse duration	(0.000-60.000) s	
Inhibit reset time	(0.000-60.000) s	
Reclaim time	(0.00-6000.00) s	
Minimum time CB must be closed before AR becomes ready for autoreclosing cycle	(0.00-6000.00) s	
CB check time before unsuccessful	(0.00-6000.00) s	
Wait for master release	(0.00-6000.00) s	
Wait time after close command before proceeding to next shot	(0.000-60.000) s	

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Section 9 Logic

Table 48: Tripping logic common 3-phase output SMPPTRC

Function	Range or value	Accuracy
Trip action	3-ph	-
Timers	(0.000-60.000) s	± 0.5% ± 10 ms

Table 49: Tripping logic phase segregated output SPTPTRC

Function	Range or value	Accuracy
Trip action	3-Ph, 1/3-Ph	-
Timers	(0.000-60.000) s	± 0.5% ± 10 ms

Table 50: Configurable logic blocks

Logic block	Quantity with cycle time			Range or value	Accuracy
	5 ms	20 ms	100 ms		
AND	60	60	160	-	-
OR	60	60	160	-	-
XOR	10	10	20	-	-
INVERTER	30	30	80	-	-
SRMEMORY	10	10	20	-	-
RSMEMORY	10	10	20	-	-
GATE	10	10	20	-	-
PULSETIMER	10	10	20	(0.000–90000.000) s	± 0.5% ± 25 ms for 20 ms cycle time
TIMERSET	10	10	20	(0.000–90000.000) s	± 0.5% ± 25 ms for 20 ms cycle time
LOOPDELAY	10	10	20		

Table 51: Configurable logic Q/T

Logic block	Quantity with cycle time		Range or value	Accuracy
	20 ms	100 ms		
ANDQT	20	100	-	-
ORQT	20	100	-	-
XORQT	10	30	-	-
INVERTERQT	20	100	-	-
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Logic block	Quantity with cycle time		Range or value	Accuracy
	20 ms	100 ms		
RSMEMORYQT	10	30	-	-
SRMEMORYQT	15	10	-	-
PULSETIMERQT	10	30	(0.000–90000.000) s	± 0.5% ± 25 ms for 20 ms cycle time
TIMERSETQT	10	30	(0.000–90000.000) s	± 0.5% ± 25 ms for 20 ms cycle time
INVALIDQT	6	6	-	-
INDCOMBSPQT	10	10	-	-
INDEXTSPQT	10	10	-	-

Table 52: Elapsed time integrator with limit transgression and overflow supervision TEIGGIO

Function	Cycle time (ms)	Range or value	Accuracy
Elapsed time integration	5	0 ~ 999999.9 s	±0.05% or ±0.01 s
	20	0 ~ 999999.9 s	±0.05% or ±0.04 s
	100	0 ~ 999999.9 s	±0.05% or ±0.2 s

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Section 10 Monitoring

Table 53: *Technical data covering measurement functions: CVMMXN, CMMXU, VMMXU, CMSQI, VMSQI, VNMMXU*

Function	Range or value	Accuracy
Voltage	(0.1-1.5) $\times U_r$	$\pm$ 0.5% of U_r at $U \leq U_r$ $\pm$ 0.5% of U at $U > U_r$
Connected current	(0.2-4.0) $\times I_r$	$\pm$ 0.5% of I_r at $I \leq I_r$ $\pm$ 0.5% of I at $I > I_r$
Active power, P	$0.1 \times U_r < U < 1.5 \times U_r$ $0.2 \times I_r < I < 4.0 \times I_r$	$\pm$ 1.0% of S_r at $S \leq S_r$ $\pm$ 1.0% of S at $S > S_r$
Reactive power, Q	$0.1 \times U_r < U < 1.5 \times U_r$ $0.2 \times I_r < I < 4.0 \times I_r$	$\pm$ 1.0% of S_r at $S \leq S_r$ $\pm$ 1.0% of S at $S > S_r$
Apparent power, S	$0.1 \times U_r < U < 1.5 \times U_r$ $0.2 \times I_r < I < 4.0 \times I_r$	$\pm$ 1.0% of S_r at $S \leq S_r$ $\pm$ 1.0% of S at $S > S_r$
Apparent power, S Three phase settings	cos phi = 1	$\pm$ 0.5% of S at $S > S_r$ $\pm$ 0.5% of S_r at $S \leq S_r$
Power factor, cos (φ)	$0.1 \times U_r < U < 1.5 \times U_r$ $0.2 \times I_r < I < 4.0 \times I_r$	< 0.02

Table 54: *Event counter CNTGGIO*

Function	Range or value	Accuracy
Counter value	0-100000	-
Max. count up speed	10 pulses/s (50% duty cycle)	-

Table 55: *Limit counter L4UFCNT*

Function	Range or value	Accuracy
Counter value	0-65535	-
Max. count up speed	5-160 pulses/s	-

Table 56: *Disturbance report DRPRDRE*

Function	Range or value	Accuracy
Current recording	-	$\pm$ 1,0% of I_r at $I \leq I_r$ $\pm$ 1,0% of I at I > Ir
Voltage recording	-	$\pm$ 1,0% of U_r at $U \leq U_r$ $\pm$ 1,0% of U at $U > U_r$
Pre-fault time	(0.05–3.00) s	-
Post-fault time	(0.1–10.0) s	-

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Function	Range or value	Accuracy
Limit time	(0.5–8.0) s	-
Maximum number of recordings	100, first in - first out	-
Time tagging resolution	1 ms	See time synchronization technical data
Maximum number of analog inputs	30 + 10 (external + internally derived)	-
Maximum number of binary inputs	96	-
Maximum number of phasors in the Trip Value recorder per recording	30	-
Maximum number of indications in a disturbance report	96	-
Maximum number of events in the Event recording per recording	150	-
Maximum number of events in the Event list	1000, first in - first out	-
Maximum total recording time (3.4 s recording time and maximum number of channels, typical value)	340 seconds (100 recordings) at 50 Hz, 280 seconds (80 recordings) at 60 Hz	-
Sampling rate	1 kHz at 50 Hz 1.2 kHz at 60 Hz	-
Recording bandwidth	(5-300) Hz	-

Table 57: Event list DRPRDRE

Function		Value
Buffer capacity	Maximum number of events in the list	1000
Resolution		1 ms
Accuracy		Depending on time synchronizing

Table 58: Indications DRPRDRE

Function		Value
Buffer capacity	Maximum number of indications presented for single disturbance	96
	Maximum number of recorded disturbances	100

Table 59: Event recorder DRPRDRE

Function		Value
Buffer capacity	Maximum number of events in disturbance report	150
	Maximum number of disturbance reports	100
Resolution		1 ms
Accuracy		Depending on time synchronizing

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Table 60: *Trip value recorder DRPRDRE*

Function		Value
Buffer capacity	Maximum number of analog inputs	30
	Maximum number of disturbance reports	100

Table 61: *Disturbance recorder DRPRDRE*

Function		Value
Buffer capacity	Maximum number of analog inputs	40
	Maximum number of binary inputs	96
	Maximum number of disturbance reports	100
Maximum total recording time (3.4 s recording time and maximum number of channels, typical value)		340 seconds (100 recordings) at 50 Hz 280 seconds (80 recordings) at 60 Hz

Table 62: *Station battery supervision SPVNZBAT*

Function	Range or value	Accuracy
Lower limit for the battery terminal voltage	(60-140) % of Ubat	± 1.0% of set battery voltage
Reset ratio, lower limit	<105 %	-
Upper limit for the battery terminal voltage	(60-140) % of Ubat	± 1.0% of set battery voltage
Reset ratio, upper limit	>95 %	-
Timers	(0.000-60.000) s	± 0.5% ± 110 ms
Battery rated voltage	20-250V	-

Table 63: *Insulation gas monitoring function SSIMG*

Function	Range or value	Accuracy
Timers	(0.000-60.000) s	± 0.5% ± 110 ms

Table 64: *Insulation liquid monitoring function SSIML*

Function	Range or value	Accuracy
Timers	(0.000-60.000) s	± 0.5% ± 110 ms

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Section 11 Metering

Table 66: Pulse counter PCGGIO

Function	Setting range	Accuracy
Cycle time for report of counter value	(1–3600) s	-

Table 67: Function for energy calculation and demand handling ETPMMTR

Function	Range or value	Accuracy
Energy metering	MWh Export/Import, MVArh Export/Import	Input from MMXU. No extra error at steady load

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Section 12 Station communication

Table 68: Communication protocol

Function	Value
Protocol TCP/IP Communication speed for the IEDs	Ethernet 100 Mbit/s
Protocol Communication speed for the IEDs	IEC 61850–8–1 100BASE-FX
Protocol Communication speed for the IEDs	DNP3.0/TCP 100BASE-FX
Protocol, serial Communication speed for the IEDs	IEC 60870–5–103 9600 or 19200 Bd
Protocol, serial Communication speed for the IEDs	DNP3.0 300–115200 Bd

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Section 13 Hardware

13.1 IED

13.1.1 Enclosure class

13.1.1.1 Ingress protection

Table 69: Ingress protection

Description	Value
IED front	IP 54
IED rear	IP 20
IED sides	IP 40
IED top	IP 40
IED bottom	IP 20

13.1.2 Dimensions

Table 70: Dimensions of the IED - 3U full 19" rack

Description	Value
Width	444 mm (17.48 inches)
Height	132 mm (5.20 inches), 3U
Depth	249.5 mm (9.82 inches)
Weight box	10 kg (<22.04 lbs)

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Section 14 Basic IED functions

Table 71: Self supervision with internal event list

Data	Value
Recording manner	Continuous, event controlled
List size	40 events, first in-first out

Table 72: Time synchronization, time tagging

Function	Value
Time tagging resolution, events and sampled measurement values	1 ms
Time tagging error with synchronization once/min (minute pulse synchronization), events and sampled measurement values	± 1.0 ms typically
Time tagging error with SNTP synchronization, sampled measurement values	± 1.0 ms typically

Table 73: X4/IRIG-B interface

Type	Protocol	Cable
Tension clamp connection	IRIG-B	Shielded twisted pair cable Recommended: CAT 5, Belden RS-485 (9841-9844) or Alpha Wire (Alpha 6222-6230)

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Section 15 Inverse characteristics

15.1 Inverse time characteristics

Table 74: ANSI Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $t = \left(\frac{A}{\left(I^P - 1\right)} + B \right) \cdot k + tDef$ $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01	-
ANSI Extremely Inverse	A=28.2, B=0.1217, P=2.0	
ANSI Very inverse	A=19.61, B=0.491, P=2.0	
ANSI Normal Inverse	A=0.0086, B=0.0185, P=0.02, tr=0.46	
ANSI Moderately Inverse	A=0.0515, B=0.1140, P=0.02	
ANSI Long Time Extremely Inverse	A=64.07, B=0.250, P=2.0	
ANSI Long Time Very Inverse	A=28.55, B=0.712, P=2.0	
ANSI Long Time Inverse	A=0.086, B=0.185, P=0.02	

Table 75: IEC Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $t = \left(\frac{A}{\left(I^P - 1\right)} \right) \cdot k$ $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01	-
IEC Normal Inverse	A=0.14, P=0.02	
IEC Very inverse	A=13.5, P=1.0	
IEC Inverse	A=0.14, P=0.02	
IEC Extremely inverse	A=80.0, P=2.0	
IEC Short time inverse	A=0.05, P=0.04	
IEC Long time inverse	A=120, P=1.0	

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The parameter setting *Characterist1 and 4/Reserved* shall not be used, since this parameter setting is for future use and not implemented yet.

Table 76: RI and RD type inverse time characteristics

Function	Range or value	Accuracy
RI type inverse characteristic $$t = \frac{1}{0.339 - \frac{0.236}{I}} \cdot k$$ $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01	
RD type logarithmic inverse characteristic $$t = 5.8 - \left(1.35 \cdot \ln \frac{I}{k}\right)$$ $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01	

Table 77: Inverse time characteristics for overvoltage protection

Function	Range or value	Accuracy
Type A curve: $$t = \frac{k}{\left(\frac{U - U>}{U>}\right)}$$ $U> = U_{set}$ $U = U_{measured}$	k = (0.05-1.10) in steps of 0.01	±5% +60 ms
Type B curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{2.0} - 0.035}$$	k = (0.05-1.10) in steps of 0.01	
Type C curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{3.0} - 0.035}$$	k = (0.05-1.10) in steps of 0.01	

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Table 78: Inverse time characteristics for undervoltage protection

Function	Range or value	Accuracy
Type A curve: $$t = \frac{k}{\left(\frac{U< - U}{U<}\right)}$$ $U< = U_{set}$ $U = UV_{measured}$	k = (0.05-1.10) in steps of 0.01	±5% +60 ms
Type B curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U< - U}{U<} - 0.5\right)^{2.0}} + 0.055$$ $U< = U_{set}$ $U = U_{measured}$	k = (0.05-1.10) in steps of 0.01	

Table 79: Inverse time characteristics for residual overvoltage protection

Function	Range or value	Accuracy
Type A curve: $$t = \frac{k}{\left(\frac{U - U>}{U>}\right)}$$ $U> = U_{set}$ $U = U_{measured}$	k = (0.05-1.10) in steps of 0.01	±5% +70 ms
Type B curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{2.0} - 0.035}$$	k = (0.05-1.10) in steps of 0.01	
Type C curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{3.0} - 0.035}$$	k = (0.05-1.10) in steps of 0.01	

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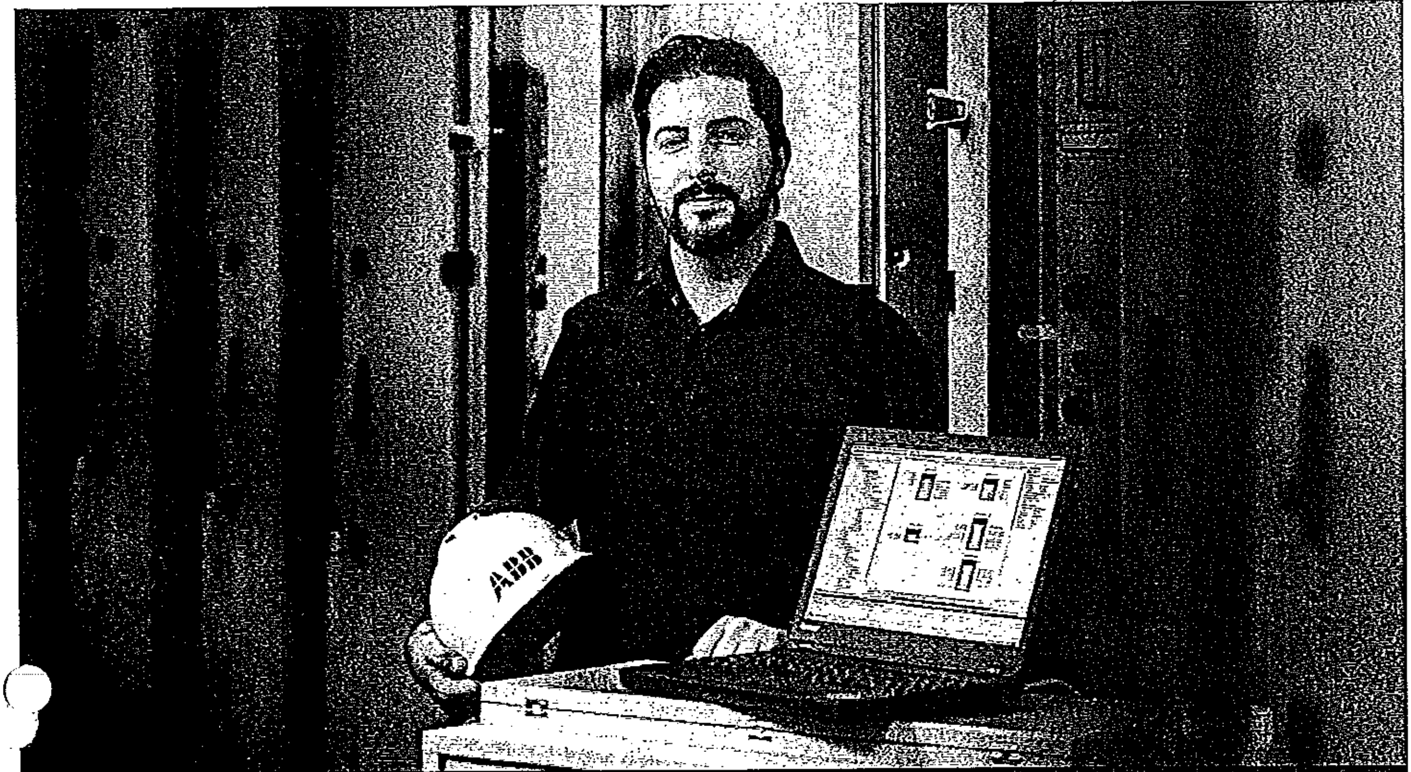

Protection and Control IED Manager PCM600
Product Guide

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1. Description

The Protection and Control IED Manager PCM600 tool provides versatile functionalities for the entire life-cycle of all Relion® protection and control IED applications, at all voltage levels. This easy-to-handle tool helps the user to manage your protection and control equipment all the way from application and communication configuration to disturbance handling, including automatic disturbance reporting.

Designed to communicate, PCM600 interacts with intelligent electronic devices (IEDs) over the fast and reliable TCP/IP via corporate LAN or WAN, or alternatively directly through the communication port at the front of the IED. PCM600 tool is able to read and write all configuration and setting data of an IED with a single command.

The user interface, workflow and the IEC 61850-based data model in PCM600 are designed according to the same philosophy as the Relion® protection and control IEDs, ensuring smooth and seamless integration between the tool and the IEDs.

PCM600 has been designed from the beginning with the IEC 61850 standard in mind. All the functionality is modeled in a way that it reflects the IEC 61850 configuration directly during the engineering. Multivendor product and system interoperability is guaranteed with an independently verified IEC 61850 Edition 2 certificate.

PCM600 also secures the projects and data created with earlier versions of the PCM600 tool, which enables full backwards compatibility.

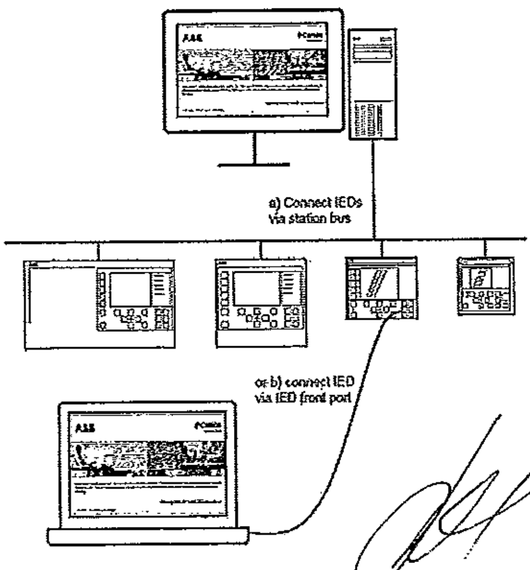

Figure 1. PCM600 connected locally or remotely to IEDs

2. Project explorer

The project explorer can be used to navigate to the used IEDs within a project / substation and furthermore within an IED to navigate to the different functionality of an IED. The user is able to create a plant structure with a substation, voltage levels, bays and IEDs.

New IEDs can also be created by use of IED templates. This enables the reuse of existing IED configurations. IEDs, bays, voltage levels or a whole substation can be copied and pasted in the plant structure. Selection of a specific IED in the project explorer gives access to the IED's tools. The function of importing and exporting descriptions of IEC 61850 substation configurations, configured devices and device functionality allows information to be shared with other engineering and system integration tools. By using the filtering feature of the project explorer the user can filter information of other tools according to the selection made.

3. Parameter setting

The parameter setting of PCM600 enables viewing and setting IED parameters offline (stored in the tool) and online (stored in both the tool and the IED). The parameters can be read from the IED to PCM600 or written from PCM600 to the IED while the IED is in service. In addition, the parameters can be exported and imported for test sets in the XRIO format (for example, Omicron Test Universe) or in the CSV format to be easily read and reused.

The parameter setting function can be used in two different modes. The normal mode allows a quick viewing and changing of the most commonly used parameters, whereas the advanced mode unveils all parameters that can be set.

PCM600 further offers a filtering function that allows the viewing of all IED parameters or the parameters related to a specific function block. In addition, it can be chosen to only view parameters that have been changed or parameters with values deviating from the IED's setting. Changed parameters with different values in the tool and in the IED are clearly indicated.

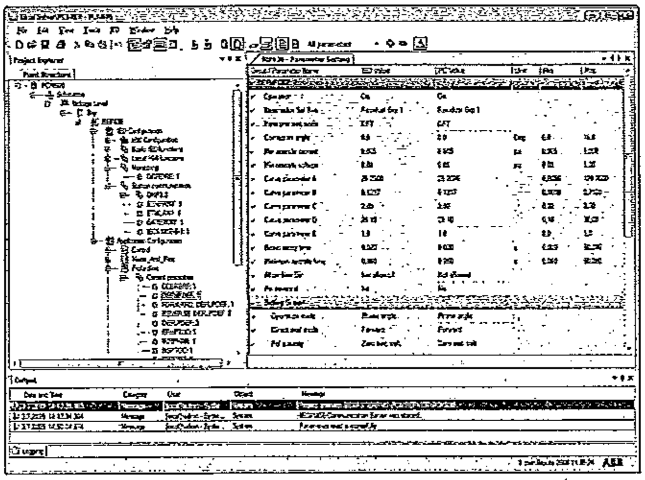

Figure 2. Parameter setting view

The graphical representation of the distance protection function supports in the visual verification of the parameter setting of the distance protection function.

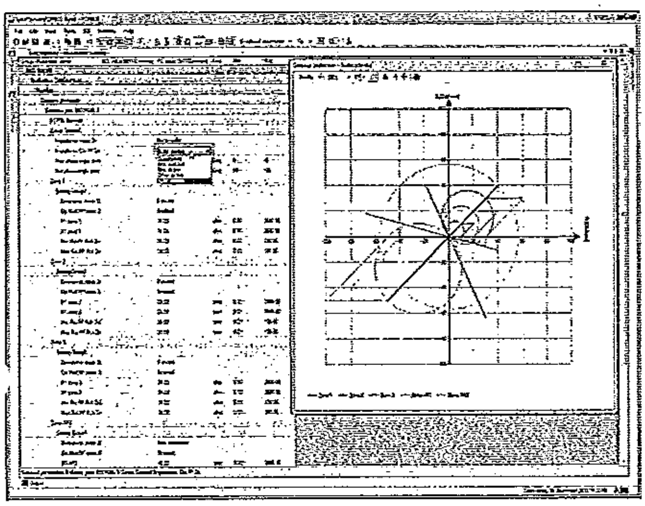

Figure 3. Graphical representation of the distance protection function

4. Graphical application configuration

The graphical application configuration functionality offers powerful ways to create, adapt and modify application configurations, which also can be made as templates for later re-use. PCM600 also enables presentation of the whole signal flow from input to output. It also assists the user during the creation of application configuration through colour indications of the function blocks to ensure that the mandatory inputs have been correctly connected. Before writing the configuration to an IED, the tool offers validation of the complete IED configuration which ensures that the configuration does not contain errors.

Additionally, the user can compare the configuration in the tool to the one in the IED. Further, the signal status on-line monitoring functionality helps to verify the real-time processes in the IED, which is extremely useful for troubleshooting.

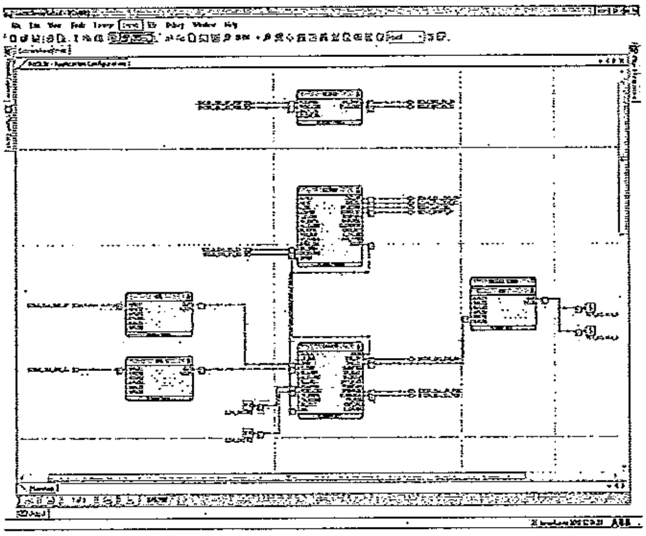

Figure 4. Application configuration, Online monitoring

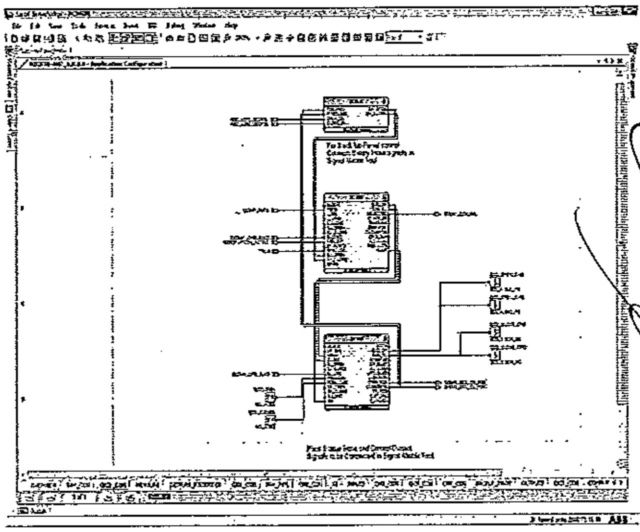

Figure 5. Application configuration, visual indication of the configuration

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5. Signal matrix

The graphical signal matrix of PCM600 allows connecting efficiently CTs, VTs, binary input and output signals to the configuration. The configuration can also be changed from here. The tool can also be used for connecting the LEDs on the IED as well as for connection of the GOOSE signals between the IEDs.

Once the IEDs have been configured and parameterized, PCM600 enables the configuration of the horizontal bay-to-bay communication for station-wide interlocking and sends the complete IED description to a system engineering tool.

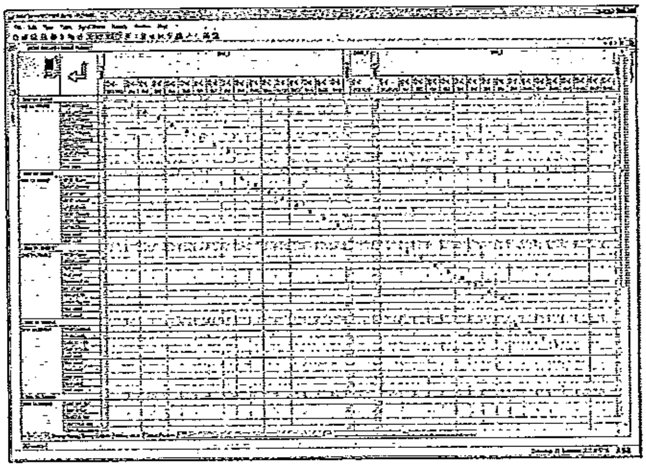

Figure 6. Signal matrix tool view

6. Graphical display editor

The graphical display editor is used for configuring the display of an IED. The graphical display consists of one or more pages. A display page contains the drawing area where the actual display configuration is made. A display is configured by dragging predefined graphical symbols from a library to the drawing area. The directed link tool can be used to draw connections between symbols. Every symbol type has a corresponding representation in both the ANSI and the IEC symbol palettes. Symbols can be connected to the application configuration.

The graphical display editor also supports the reuse of display page templates made for other IEDs.

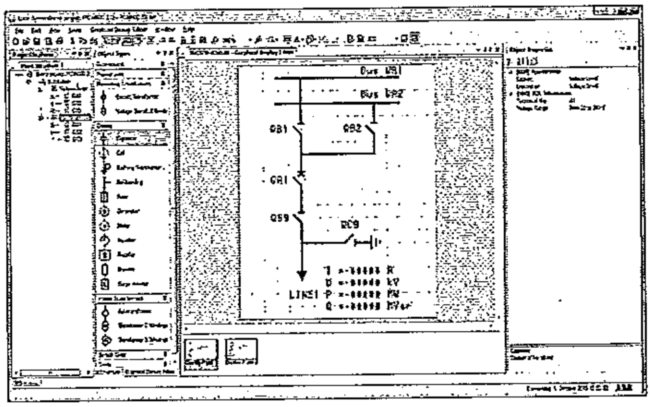

Figure 7. Graphical display editor, configuring the display of an IED

7. Hardware configuration

The hardware configuration can be used to get a quick overview of an IED and to add or change hardware modules. It is possible to view the front and back of the IED including card information and their slot position. Furthermore it is possible to compare the hardware configuration used in the tool to the actual one in the IED.

8. IED configuration comparison

IED comparison is used for comparing configurations of two IEDs of the same kind. Comparison can be made offline regardless of the IEDs being in the same PCM600 project or not. Additionally, the configuration of an IED can be compared to a loose PCMI file. When connected to the IED, it is possible to compare the configurations between the IED and the PCM600 online. A report of the differences between the two different IED configurations is provided as a result of the comparison.

9. IED summary

IED summary functionality can be used to document and view a quick snapshot of all the protection and control IEDs on the substation. PCM600 can collect all the important identification information from the IEDs and illustrate them in a user-friendly browser. IED summary result can be printed for documentation directly from the tool.

10. Signal monitoring

The signal monitoring function provides the user with online information about the measured values and displays the status of binary input and output signals of an IED. Furthermore, PCM600 facilitates commissioning and testing of physical connections via the signal monitoring tool (forcing of signals).

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11. Event viewer
The event viewer of PCM600 enables viewing the IED sequence of events information including timestamps. The event log facilitates detailed post-fault analyses of faults and disturbances. Event viewer additionally enables reading the security events from the IED.

12. Disturbance handling
PCM600 offers effective handling and monitoring of disturbance records from the IEDs. The disturbance files stored in the standard COMTRADE format allow the user to view the disturbance record using Wavewin™ software or any commercially available disturbance analyzer supporting the COMTRADE format. If required, the report layout and contents can be adapted to user-specific needs.

By means of the task scheduler of PCM600, the records can be set to be automatically read from the IED. The task scheduler is an independent process and does not require PCM600 to be activated. After receiving the file, PCM600 automatically creates a disturbance report, which can immediately be forwarded to subscribers by e-mail. Such a notification shortens the time from disturbance detection to corrective action.

13. Communication management
The Communication Management tool is used to configure different communication protocols for an IED. DNP3, IEC 60870-5-101/103/104 or Modbus® are the communication protocols that can be engineered. Depending on the used protocol, the tool provides different views and capabilities to support in the selection or mapping of communication signals.

14. IEC 61850 configuration
The IEC 61850 configuration tool of PCM600 provides the viewing or engineering of the dataset and dataflow configuration for a vertical or horizontal IEC 61850 communication.

In the view mode, the tool supports the viewing of the IEC 61850 configuration, whereas in the engineering mode it is possible to configure IEC 61850 datasets and dataflow for the horizontal and vertical communication.

Table 1. Recommendations for using the IEC 61850 configuration tools

	IEC 61850 tools in a Substation automation system (SAS)	
	No external tool	**IET600 or 3rd party system tool**
ABB Relion IEDs	Engineering mode 1)	View mode 2)
ABB and 3rd party IEDs	View mode 2)	View mode 2)

1) Engineering mode of IEC 61850 configuration tool of PCM600 is recommended for simple applications. Advanced applications require an IEC 61850 system tool like IET600 and view mode.
2) View mode of IEC 61850 configuration tool of PCM600 for the transparancy of IEC 61850 configuration made by an external IEC 61850 system tool like IET600.

15. Connectivity packages
PCM600 incorporates ABB's connectivity package concept, which simplifies protection engineering and reduces the risk of errors. The connectivity packages can be downloaded and installed using the PCM600 Update Manager tool. Furthermore, the IED connectivity packages for the 670 and 650 series are also available on a separate IED Connectivity Package DVD that is delivered with the IEDs, whereas the IED connectivity packages for the 630, 620, 615, 611 and 610 series, RIO600, SAM600, REX521, RE_54_, SPACOM and REF 542plus can be downloaded from the www.abb.com/substationautomation portal.

16. User management
PCM600 tool supports access management both for the tool and the IEDs. The user accounts in PCM600 can be linked to Windows user accounts or be defined as separate user accounts for PCM600. The user management feature allows the administrator to create user groups with different access rights and profiles.

The access management for the IEDs can be enabled or disabled with the IED user management tool in PCM600. PCM600 also includes functionality to activate central account management on IEDs, and manage certificates on the IEDs.

17. Project configuration data management
PCM600 offers functionality for managing configuration data of projects. Complete substation configurations can be exported and imported for long term archiving or for sharing between different engineers. All the configuration data on a workstation can be backed up with a simple manual operation or as scheduled automatic backup functionality.

18. Integrated help menus
All the necessary instructions for using the tool are integrated in PCM600. Context sensitive help menus and tool tips provide the user with information about the selected tools. The IED documentation and guides available from the connectivity package can be directly accessed from the help menus.

19. Data transfer

PCM600 offers improved data transfer between the IEDs and the IED management tool. The IEDs can be accessed remotely using the TCP/IP protocol via a local area network (LAN) and standard Ethernet cables, a secured wide area network (WAN), a secured wireless network (WLAN) or, locally, using the IEDs' front communication port.

20. System requirements

Table 2. Hardware requirements

Hardware	Minimum	Recommended
CPU	1.5 GHz	2.4 GHz
RAM	2 GB	4 GB
Free hard disk space	4 GB	8 GB
Monitor	1024 × 768	1280 × 1024
Ethernet port	Required	Required

Table 3. Supported operating systems

Operating system	Version
Microsoft Windows Server 2008 R2 (64-bit)	-
Microsoft Windows Server 2012 R2 (64-bit)	-
Microsoft Windows Vista (32-bit)	SP2
Microsoft Windows 7 (32-bit/64-bit)	SP1
Microsoft Windows 8 (32-bit/64-bit)	-
Microsoft Windows 8.1 (32-bit/64-bit)	-
Windows 10 (32-bit/64-bit)	-

Table 4. Communication

Protocols
TCP/IP via LAN or WLAN
Serial Port (RS-232) or USB/RS-232 converter if SPA-based communication is used
Opto/electrical (RS-232) cable for front communication if SPA-based communication is used

21. Ordering data

To order the protection and control IED manager PCM600, use the ordering data in the ordering code table.

Table 5. Ordering code

Product name	Order code
PCM600 2.8	PCM600-28

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22. Document revision history

Document revision/date	Product version	History
A/2007-12-20	2.0	First release
B/2008-05-30	2.0 SP1	Content updated
C/2009-03-03	2.0 SP2	Content updated
D/2009-07-06	2.1	Content updated to correspond to the product version
E/2009-11-23	2.2	Content updated to correspond to the product version
F/2010-05-28	2.3	Content updated to correspond to the product version
G/2011-04-08	2.4	Content updated to correspond to the product version
H/2013-01-10	2.5	Content updated to correspond to the product version
K/2013-12-10	2.6	Content updated to correspond to the product version
L/2015-11-20	2.7	Content updated to correspond to the product version
M/2016-09-29	2.8	Content updated to correspond to the product version

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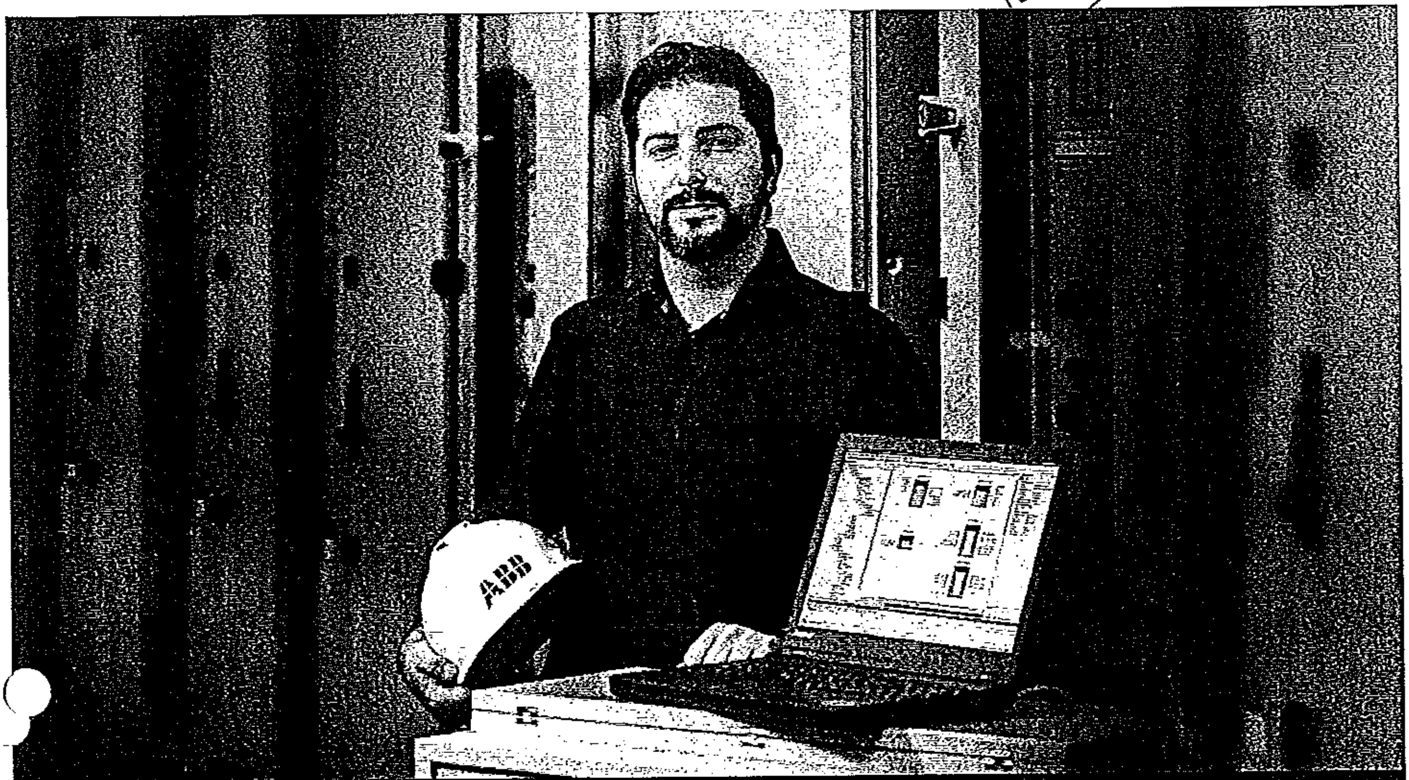

Protection and Control IED Manager PCM600
Getting Started Guide

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Disclaimer

This product has been designed to be connected and communicate data and information via a network interface which should be connected to a secure network. It is the sole responsibility of the person or entity responsible for network administration to ensure a secure connection to the network and to take the necessary measures (such as, but not limited to, installation of firewalls, application of authentication measures, encryption of data, installation of anti virus programs, etc.) to protect the product and the network, its system and interface included, against any kind of security breaches, unauthorized access, interference, intrusion, leakage and/or theft of data or information. ABB is not liable for any such damages and/or losses.

This document has been carefully checked by ABB but deviations cannot be completely ruled out. In case any errors are detected, the reader is kindly requested to notify the manufacturer. Other than under explicit contractual commitments, in no event shall ABB be responsible or liable for any loss or damage resulting from the use of this manual or the application of the equipment.

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Section 1 Introduction

1.1 This manual

The getting started guide provides basic instructions on how to use PCM600. The manual provides instructions for typical use cases in operation and field, as well as for use cases in engineering and commissioning. The purpose of the manual is to describe the PCM600 tool functionality, and it can be seen as a complementary manual to the application-related instructions, such as the relay-specific operation or engineering manuals.

1.2 Intended audience

This manual addresses new users as well as not frequent users of PCM600, providing an easy start or refresh on using the tool. By presenting the typical PCM600 use cases, this manual offers quick assistance to operators and field personnel as well as engineering and commissioning personnel.

1.3 Product documentation

1.3.1 Product documentation set

The cyber security deployment guideline describes the process for handling cyber security when engineering and monitoring protection and control IEDs. The cyber security deployment guideline provides information on how to secure the engineering environment on which the IED is installed. The guideline can be used as a technical reference during the engineering phase, installation and commissioning phase, and during normal service. See also all IED-related cyber security deployment guidelines.

The getting started guide provides basic instructions on how to use PCM600. The manual provides instructions for typical use cases in operation and field, as well as for use cases in engineering and commissioning. The purpose of the manual is to describe the PCM600 tool functionality, and it can be seen as a complementary manual to the application-related instructions, such as the relay-specific operation or engineering manuals.

The online help contains instructions on how to use the software.

1.3.2 Document revision history

Document revision/date	Product version	History
A/2013-04-11	2.5	First release
B/2016-09-29	2.8	Content updated

1.3.3 Related documentation

Name of the document	Document ID
PCM600 Online Help	Available as online help in PCM600

1.3.4 Symbols and conventions

1.3.4.1 Symbols

The caution icon indicates important information or warning related to the concept discussed in the text. It might indicate the presence of a hazard which could result in corruption of software or damage to equipment or property.

The information icon alerts the reader of important facts and conditions.

The tip icon indicates advice on, for example, how to design your project or how to use a certain function.

Operation of damaged equipment could, under certain operational conditions, result in degraded process performance leading to information or property loss. Therefore, comply fully with all notices.

1.3.4.2 Document conventions

A particular convention may not be used in this manual.

- Abbreviations and acronyms are spelled out in the glossary. The glossary also contains definitions of important terms.
- Menu paths are presented in bold.
  Select **Main menu/Settings**.
- Menu, tab, button, list and box names as well as window or dialog box titles are presented in bold.
  On the **File** menu, click **New Project**.
  Right-click the **MainApp** tab and select **Copy** from the shortcut menu.

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Click **OK** to start the comparing.

- Shortcut keys are presented in uppercase letters.
  A page can also be added pressing the shortcut keys CTRL+SHIFT+P.
- Command prompt commands are shown in Courier font.
  Type `ping <devices_IP_address>/t` and wait for at least one minute to see if there are any communication breaks.

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Section 2 Overview

2.1 Protection and Control IED Manager PCM600

PCM600 provides versatile functionalities for the entire life cycle of the protection and control IEDs in transmission and distribution applications.

- Planning
- Engineering
- Commissioning
- Operation and disturbance handling
- Functional analysis

With the individual tool components, it is possible to perform different tasks and functions and control the whole substation.

PCM600 is compliant with IEC 61850, which simplifies the IED engineering and enables information exchange with other IEC 61850 compliant tools. The hierarchical presentation model that reflects the real system topology enables efficient viewing and editing of the power system information.

Some features and functions are product-specific and not available for all the products.

2.1.1 User interface

The initial view of the PCM600 interface is divided into different windows.

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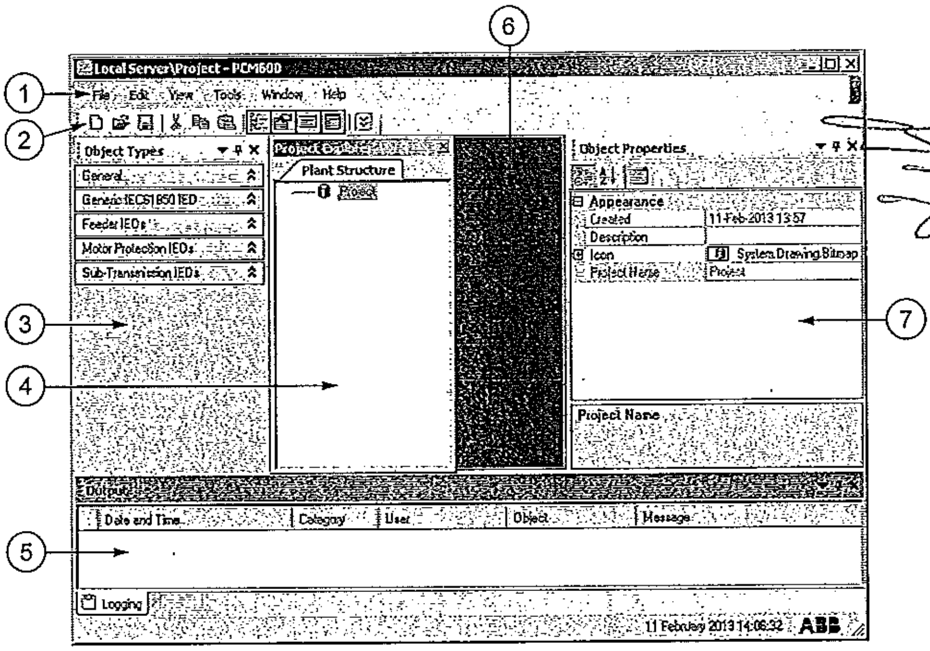

Figure 1: PCM600 interface

1 Menu bar
2 Toolbar
3 **Object Types** window
4 **Project Explorer** window
5 **Output** window
6 Tool window
7 **Object Properties** window

The menu bar and toolbar contents vary depending on the active object and tool.

The **Object Types** window shows all the available objects for the selected IED. The object list content depends on the IED type and the related connectivity package. Before the objects are shown on the list, the objects must be imported from the connectivity package to PCM600 by using Upload Manager.

The **Project Explorer** window is used to navigate to the used IEDs within a project/ substation and to different functions within an IED. A plant structure with a substation, voltage levels, bays and IEDs can be created in **Project Explorer**. All the configuration work, such as communication configuration, can be done via this structure by using the configuration wizard.

The tool window is the working space, where all the tools are opened.

The **Object Properties** window shows the properties of the selected object. The name of the object can be changed in this window.

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The **Output** window shows log information about the PCM600 events.

2.1.2 Tool components

The availability of the tool components depends on the selected IED and the installed connectivity packages.

Table 1: Tool components in PCM600

Tool component	Description
Update Manager	Update Manager is used for downloading updates and managing the current installation of PCM600 and connectivity packages.
Project Explorer	Project Explorer is used for navigating, creating a plant structure, importing and exporting IED configurations, accessing and filtering the content of other tool components.
(Graphical) Application Configuration	Application Configuration is used for configuring the IEDs.
Parameter Setting	Parameter Setting is used for parameterizing the IEDs and viewing the parameter data for the selected node.
Signal Matrix	Signal Matrix is used to create connections between source and target objects in an IED configuration.
Signal Monitoring	Signal Monitoring is used for monitoring online the measured values and the status of the binary input and output signals of an IED and for commissioning and testing physical connections.
Disturbance Handling	Disturbance Handling is used for uploading and processing the disturbance files located in a specific IED, for viewing and processing the disturbance recording data and creating reports.
Event Viewer	Event Viewer displays the actual events stored in an IED.
Graphical Display Editor	Graphical Display Editor is used for configuring the graphical display of an IED.
Hardware Configuration	Hardware Configuration is used for viewing, adding and changing the hardware modules of an IED and for troubleshooting the IED hardware configuration.
Communication Management	Communication Management is used for configuring communication protocols for an IED and for mapping IED signals and outputs.
IEC 61850 Configuration	IEC 61850 Configuration is used for viewing the IEC 61850 data flow configuration and for engineering the dataflow between the IEDs and IEC 61850 clients.
IED Compare	IED Compare is used for comparing the IED configuration of two same type of IEDs.

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2.2 Connectivity packages

A connectivity package is a software component that enables PCM600 or other ABB tools to communicate with an IED. It includes all the data used to describe the IED, for example, a list of the existing parameters, the data format used, the units, the setting range, the access rights and visibility of the parameter.

Connectivity packages are downloaded via PCM600 Update Manager, and their content depends on the functions supported by the IED.

2.2.1 Tool components in connectivity packages

Two types of tools are available for performing tasks and functions in a PCM600 project.

- PCM600 tools
- IED specific tools included in the connectivity packages

The PCM600 tool documentation is included in the PCM600 online help. The IED specific tool documentation is included in the related IED documentation.

Some features and functions are product-specific and not available for all the products.

2.3 PCM600 and IED connectivity package compatibility

It is recommended to use the latest version of PCM600 and the latest version of the connectivity package available in Update Manager. More information on the compatibility between the versions of the IED, connectivity package and PCM600 is found in the IED documentation.

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Section 3 Getting started

3.1 Installing PCM600

Download PCM600 from ABB Software Library and install the software following the instruction in the installation wizard. PCM600 is also available on CD.

3.2 Using Update Manager

Update Manager is used for managing the current installation of PCM600 and connectivity packages, for notifying about available updates and for downloading the updates.

1. On the taskbar, click the **Start** button, and point to **All Programs**, point to **ABB**, and then click **Update Manager**.
2. From the list in the upper left corner, select the content to be shown in the **Update Manager** window.
   - Select **Manage Connectivity Packages** to display the current configuration of PCM600 and select the connectivity packages to be used.
   - Select **Software Updates** to display updates like PCM600 product updates, connectivity packages and other general updates like add-ons, service packs and hotfixes. Download and install the needed updates.
   - Select **Export Software Packages** to display all the available PCM600 add-ons, hotfixes and connectivity packages. From this view it is possible to download the needed updates and export to another location/removable disk.
3. Click **Close** to close Update Manager.

3.3 Installing connectivity packages

1. Download the connectivity package using Update Manager.
2. When the download is completed, click the **Install** button to start the installation.
3. Follow the steps in the installation wizard to install the connectivity package. If the **Download and Install** option is used, Update Manager will first download all the selected packages and then automatically install all of them.
4. Restart PCM600.

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The directory where Update Manager downloads all the packages can be defined in the Settings view. Note that the connectivity packages are still installed on the Program Files directory on the same drive where Windows is installed. The installer needs to be run manually, if the connectivity packages need to be installed on some other directory.

3.4 Activating connectivity packages

The latest connectivity package is activated automatically by default. If wanted, older connectivity packages can also be activated in Update Manager. It is recommended to use the latest version of the connectivity package. The latest PCM600 and connectivity packages are backward compatible with older IED versions.

1. On the taskbar, click the **Start** button, and point to **All Programs**, point to **ABB**, and then click **Update Manager**.
2. Select **Manage Connectivity Packages** from the left navigation bar.
3. Under the tool version to be configured, select the connectivity package version to be used and click **Close**.
4. Restart PCM600.
   Restart is required to initialize the activated connectivity packages.

3.5 Downloading IED preconfigurations and documentation

Preconfigurations are available for some of the IED series. For downloading the preconfigurations, see the IED-specific documentation. The preconfiguration .pcmi files are available on the connectivity package DVD under the user documentation folder, or the files can be downloaded by using the Update Manager.

Enabling preconfiguration and documentation downloading can be done on the Settings view of Update Manager.

1. On the taskbar, click the **Start** button, and point to **All Programs**, point to **ABB**, and then click **Update Manager**.
2. Click **Settings** in the left navigation bar.
3. Check the documentation and preconfiguration options.
   Available documentation and preconfiguration packages are now available on **Software Updates** view.
4. To view the documentation for the IED, right-click the IED in **Plant Structure** and point to **Documentation**. Select the needed document from the list.

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3.6 Installing language add-on packages

Install both the language add-ons for PCM600 and the language add-ons for the IED connectivity packages.

1. On the taskbar, click the **Start** button, and point to **All Programs**, point to **ABB**, and then click **Update Manager**.
2. Click **Settings** in the left navigation bar to enable the preferred languages.
3. From the list in the upper left corner, select **Show All Available Updates**.
4. Select the correct language add-on file and click **Download and Install**.

3.7 Selecting the system language

To change from the default language to another language, install first the language add-on packages. Different Connectivity Packages have different language add-ons available.

1. On the PCM600 menu bar, point to **Tools** and click **Options**.
2. Click **System Settings**.
3. Select the PCM600 and IED languages and click **OK**.
   - **PCM600 Language** defines which language is used in the user interface of PCM600.
   - **Default IED Configuration Language** determines the language of the IED specific content of newly created IEDs. The drop-down list contains all the languages supported by all the active connectivity packages. If the used connectivity package does not support the selected language, English is used. The IED's language can be later changed using the IED shortcut menu **Configuration Language**.

3.8 Installing software packages on a computer that is not connected to the Internet

1. To install software packages needed for PCM600 on an offline computer, first use a computer connected to the Internet.
   1.1. Open Update Manager and select **Export Software Packages**.
   1.2. Select the desired packages and click **Download and Export**.
   1.3. Select folder to export packages on removable disk or network.
2. After download and export, connect the removable disk or network to offline computer.

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2.1. Open Update Manager and select **Settings**.
2.2. Choose **Other source(local/removable disk/network)** and specify folder location under **Directory path**.
2.3. Select **Software Updates** or **Get Connectivity Packages**, and click **Install available packages.**

3.9 Customizing PCM600 menus

The **Tools** menu, the **Project Explorer** shortcut menu and the **Options** dialog box can be customized by defining which tools and tool functions are visible. Tools and functionality that are not needed can be hidden.

1. On the **Tools** menu, click **Options** and then click **Customized Menus.**
2. On the **Tools** tab, select the tools and functions to be shown in the menus. Plus (+) sign before the tool name indicates that the tool has functions for which the visibility can be separately defined. Clicking the plus sign shows the tool functions.
3. On the **Options** tab, select the items to be visible in the **Options** dialog box.
4. On the **Miscellaneous** tab, define the visibility of miscellaneous menu items.

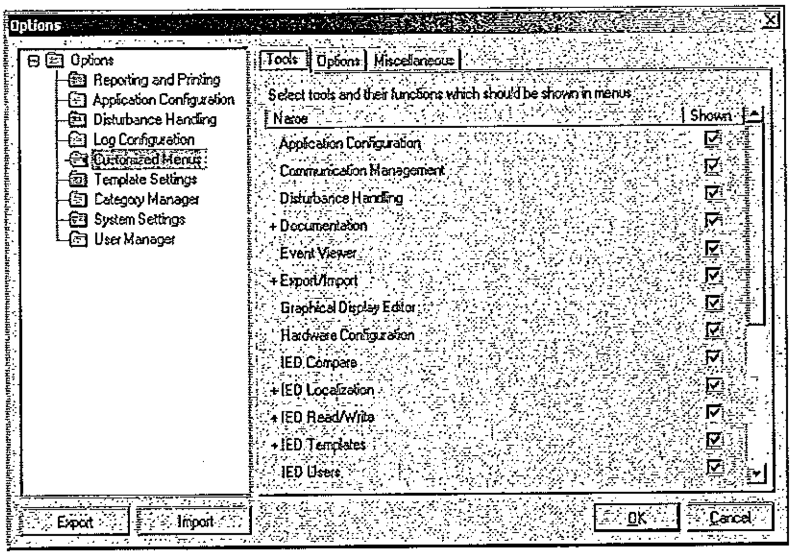

Figure 2: Options for customized menus

Customized menus can be enabled or disabled either using the toolbar button or the **View** menu. When **Customized Menus** is disabled, all functionality is visible in the menus.

The customized menu settings can be exported and imported for reuse.

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3.10 Managing users

3.10.1 Managing PCM600 users

3.10.1.1 Creating user categories

The user management is based on the users and the user categories. The users have a user account for PCM600. Each user account is mapped to one user category, which defines the permission to access certain functions. There are three default user categories.

- System Engineer acts as an administrator for the system and has full rights to perform any function and can define the user accounts.
- Operator can perform certain simple tasks and has read-only access to certain functionality of PCM600.
- Application Engineer can access most of the functions and has read and write access to the IED engineering functionality.

The members of the System Engineer user category can create new user categories. The name of the user category must be unique. Privileges can be defined by a tool component for new user categories. For example, a user category can be defined to have either read or read/write access in Signal Matrix.

1. On the menu bar, click **Tools** and select **Options** to start the user management.
2. Select the **Category Manager** folder.
3. Click **Add New Category** to open the **Add New Category** dialog.
4. Type the name for the new user category.
5. Specify the rights to perform different functions under the **Functions And Rights** field.
6. Select **OK** to save the definition.

3.10.1.2 Creating users

The user authentication can be enabled or disabled in **Tools /Options /System settings**. When the user authentication is disabled, all the users get full rights to operate.

The authentication method can be defined to be PCM600 authentication or Windows authentication. The Windows authentication uses the current user's Windows account to determine if the user is allowed to log in to PCM600. The PCM600 authentication uses user name and password specified in the user management of PCM600.

Create a new user to PCM600 and define the user information.

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- User name (mandatory)
- Real name of the user
- User category

The Windows account can be used to log in automatically. Multiple Windows account names can be used for a single PCM600 account. The Windows account names are separated by a semicolon (;). These Windows account names are only used for login, if the administrator has enabled the Windows authentication.

1. On the menu bar, click **Tools** and select **Options** to start the user management.
2. Select the **User Manager** folder.
   The default **Real Name** is System Administrator and makes it easier to find the user.
3. Click **Add New User** in the **User Profile** field.
   The **Add New User** dialog is displayed.
4. Type **User Name** and select **User Category** from the drop-down list.
   The user name must be at least three characters long.
5. Click **OK** to confirm.
   The new user is created.

The new user name has to be a member of a user category to have permission to PCM600 functions.

3.10.2 Managing IED users

The IED User Management tool component is used for editing user profiles, group memberships and group access rights for the IED functions and operations. The availability of the tool functionalities depends on whether the IED has a full user management control built in or not. For more information on IED-specific functions, see the corresponding IED documentation.

1. Right-click an IED in **Plant Structure** and then click **IED Users**.
2. In the **IED Users** tool window, edit the settings available for the IED.

3.10.2.1 Enabling communication to the IED

For some IEDs, when remote authentication is enabled, some changes are required in PCM600 to get the communication between the IED and PCM600 to work.

1. In **Plant Structure**, click the IED.
2. In the **Object Properties** window, change the values.

- For **Is Authentication Disabled**, select **False**.
- For **Is Password used**, select **True**.
- For **Password**, write the password.

For information on resolving communication problems, see Troubleshooting communication problems.

3.11 Reporting

The contents of each tool component can be viewed and printed.

- On the menu bar, click **File**, and then click either **Print** or **Print Review**.

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Section 4 Use cases for operation and field

4.1 Using Project Explorer

4.1.1 Exporting projects

1. Open the project management by selecting **File/Open/Manage Project**.
2. Select the project from the **Currently available projects** box.
3. Right-click the project to open the shortcut menu.
4. Select **Export Project** from the shortcut menu to open the **Create target file for the project export** dialog.
5. Browse the target location and type the name for the exported file.

Exporting a project enables you to transfer project data between the based systems via different media, for instance in CD-ROM. The source and target computers do not have to be connected to the same network, thus data between two stand-alone computers can be transferred.

All project related data is compressed and saved to one file, which is named and located according to the definitions.

4.1.2 Importing projects

Importing a project enables transferring project data between the based systems via different media, for instance in CD-ROM. The source and target computers do not have to be connected to the same network, thus data between two stand alone computers can be transferred.

1. On the **File** menu, click **Open/Manage Project** to open the project management.
2. Right-click **Projects on my computer**.
3. On the shortcut menu, click **Import** to open the **Import project** dialog.
4. Browse the location and type the name for the imported file.

A new project is created containing all data from the imported file.

4.2 Setting up communication to IEDs

When adding IEDs to the object tree in **Plant Structure**, **Configuration Wizard** assists in building the communication structure needed for the tool components to communicate with the IEDs. When required, communication settings can also be defined manually in the **Object Properties** window.

1. In **Plant Structure**, click an IED to see the settings in the **Object Properties** window.
2. In **Object Properties**, set the communication properties.
   The IED **IP Address** in the PCM600 project has to match the IP address of the physical IED.

4.2.1 Setting the technical key

1. Right-click an IED in **Plant Structure.**
2. On the shortcut menu, click **Set Technical Key in IED.**
   A dialog box opens to inform about the technical key concept.
3. Click **OK.**
   The technical key is read from the IED and the **Set Technical Key** dialog box opens.
4. In **Set Technical Key** dialog box, select the techical key to be used.
   Select one of the given alternatives.
   - Use the existing technical key in the IED.
   - Use the existing technical key defined for the IED object in PCM600.
   - Set a user-defined technical key, which changes the technical key for both the physical IED and the IED object in PCM600

The maximum length of the technical key is 20 characters. The key must begin with an alphabetic character (A-Z, a-z), but the remaining characters can be alphanumerics or the underscore (A-Z, a-z, 0-9,_).

5. Click **OK** to confirm the selection.

The technical key must be unique within the same project. An error message is displayed if the same value is already given to another IED object in the PCM600 project.

4.2.2 Troubleshooting communication problems

- When starting troubleshooting, keep the **PCM600 Output** window open for notifications.

Table 2: Remedies to communication problems

Problem	Action
Is the network cable connected?	• Check the cables. • Check that the cables are connected to correct communication ports.
Is the IED responding to any communication?	• Open the command prompt. • Type `ping <devices_IP_address>/-t` and wait for at least one minute to see if there are any communication breaks. • If the ping does not work, check the communication settings: IP gateway, IP addresses, subnet masks and firewalls.
Is the IP address unique in the subnetwork?	• Unplug the communication cable from the IED and ping the IP address. • If there is a response to the ping, find the device with the same IP address from the network and remove it.
Is the SCL technical key correct?	If the technical key is not correct, a message is displayed in the PCM600 **Output** window. • Select the IED from the PCM600 tree structure and run **Set Technical Key.**
Are the communicating devices in the same subnetwork?	• Verify the PC and IED communication addresses and subnet masks.
Is the communication port set correctly?	• Select the IED from the PCM600 tree structure and check the **Communication Port** setting from the shortcut menu. • Verify that the IP address in the **Object Properties** window is correct.
Was PCM600 first connected to one relay with a certain IP address, and the cable then switched to another relay with the same IP address, and the communication is not working any more?	Windows creates an ARP table containing MAC address and IP address pairs. Clearing this table helps to get communication working when the pairs no longer match. Every relay communication card has a unique MAC address. However, for example in 615 series, the front port IP address is fixed. This can create a mismatched ARP table when several relays are used. Windows also refreshes the ARP table automatically, but this can take several minutes. • Click the **Start** button, write `cmd` in the search box and press ENTER to open the command prompt. • Type `arp -d` and press ENTER to clear the ARP table. If this command is not recognized or allowed, open the command prompt as an administrator.
Are there several PCM600 processes running simultaneously on the same PC?	Only one PCM600 process can communicate at a time. • Stop other PCM600 instances while communicating with the IED.
Is the parameter communication working?	• Open the parameter settings and try to read parameters. If the parameter setting works and if there is no other communication, the problem can be in the firewall settings.
Is the IED communication reserved by other clients?	• Determine the maximum amount of simultaneous clients. In the IEC 61850 communication, this can be seen in the device's SCL file. In some IEDs, the used clients from the IED can be checked manually from the WHMI. • Isolate the IED from other communication devices to make sure that the clients are not reserving the communication. • Try to communicate with the IED directly from the front port when the rear port cable is disconnected.
Does the communication work with other software than PCM600?	• If the IED supports the IEC 61850 communication, try to communicate with the IED with a third-party client. If the communication fails, check the network configuration.
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Problem	Action
Does the communication work with the Windows Administrator rights?	Sometimes the communication configuration is updated wrongly with or without the administrator rights in the Windows Vista and Windows 7 operating systems. • If UAC is enabled, run PCM600 using the administrator account.
Does rebooting the IED help resolve the communication issues?	It is possible that the communication is occasionally reserved in the IED. • Reboot the IED.
Can multiple tools be used simultaneously to configure the IED?	In some cases, when two users access the same IED at the same time, the communication fails.
Can data be read from the IED by using multiple tools at the same time?	Some IEDs do not support the reading of disturbance recording simultaneously from two clients.
Is the IED under heavy load?	Operations in the IED can have a high priority and consume most of the IED resources. This can break the communication with PCM600. An example of a resource-exhausting operation is the storing of a disturbance recording. • Ensure that there are no ongoing processes in the IED and try to communicate again.
Are there multiple devices with the same MAC in the same network?	• Try to communicate with a device directly from the front port when the rear port cable is disconnected.
Are the external network devices working properly?	Sometimes routers, switches and media converters can malfunction. • Try to communicate with a device directly from the front port when the rear port cable is disconnected.

Is the communication time-out too short?	• In the **Object Properties** window, select the value **Fixed with High Latency** for **Connection Type**. The **Time-out** property becomes visible.
	• Define the time-out for long-delay networks.
	    • PCM communication uses the time-out value specified by the user.
	    • When selecting **Fixed**, the default time-out is used.

Does Online Configuration Wizard or reading configuration fail?	• Make sure that your personal firewall allows inbound FTP connections. Reading configuration files from certain IEDs requires the possibility for inbound FTP connections.
Is uploading recordings for REF615 Ver.5.1 with the scheduler interrupted and the error message "Could not connect to FTP server in IED" shown?	The secure connection to the IED has not been "trusted forever" before using the scheduler. • Click **Trust forever**, when a security warning appears while uploading manually from the Disturbance Handling tool. The recordings are then uploaded.

4.3 Using Read from IED and Write to IED

4.3.1 Reading a configuration from an IED

Ensure the IED is online and the communication parameters are correct.

1. In **Plant Structure**, right-click the IED.
2. Select **Read from IED** from the shortcut menu.
3. Click **Yes** to confirm. Clicking **No** cancels the operation.

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The configuration is read from the IED.

4.3.2 Writing a configuration to an IED

Ensure the IED is online and the communication parameters are correct. Writing the configuration to a wrong IED can result in data loss.

1. In **Plant Structure**, right-click the IED.
2. Select **Write to IED** from the shortcut menu.
3. Click **Yes** to confirm. Clicking **No** cancels the operation.

The whole configuration is written to the IED.

The common writing from PCM600 to IED overwrites any parameter changes made locally using the LHMI.

4.4 Using Parameter Setting

Parameter Setting is used for parameterizing the IED units.

1. In **Plant Structure**, select an IED or a function.
2. On the **Tools** menu, click **Parameter Setting.**
   Parameter Setting opens in the tool window and displays parameter data for the selected node. The content of the list displayed depends on the selected level in **Plant Structure.** Settings can be sorted into two groups.
   - Configuration parameters that specify the operation mode of an application function or the IED, and are normally configured only once.
   - Setting parameters that can be changed in the IED at runtime.

   To see the actual IED values, read them from the IED.

3. On the menu bar, click **View** and modify the parameter setting sheet view.
   - Click **Browse options**, and select **Display selected node + child nodes** or **Display only selected node.**

   Depending on the selected node in **Plant Structure**, the view can contain all the parameters of an IED or only the parameters of a specific function.

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- Click **Parameter layer**, and select **Basic parameters** or **Advanced parameters**.
- Click **Setting group presentation**, and select **Vertical** or **Horizontal**.
- Click **Parameter filter**, and select which parameters are to be shown.
- Click **Group options**, and expand or collapse the selected group and its child groups.
- Select **Column autosize** to autosize columns according to their content.

4. On the **View** menu, select **Parameter warnings** to enable displaying parameter warnings.
Warnings are displayed in the **Output** window in certain situations.
    - Modifying a parameter affects other parameters.
    - Parameter reading or writing fails for some parameter.

To find a parameter, press the shortcut keys CTRL+F.

4.4.1 Setting parameters

1. In the **Parameter Setting** sheet, locate the correct parameter, and click the **PC Value** cell.
2. Enter the new value.
Parameter Setting supports several parameter types.
    - Numerical
    - SingleChoice
    - String
    - Date/Time
    - MultiChoice

    Parameter Setting checks that the given value is valid. The old value is shown as a tool tip in the status bar. If the new value is valid, it is shown in bold font. If the value is not valid, an error message is displayed describing the error and correct format for the parameter.
    If the changed parameter affects one or more other parameters and the parameter warnings are on, the dependencies are displayed in the **Output** window.
3. On the toolbar, click the Save button to save the change.

4.4.2 Writing parameters to an IED

In Parameter Setting, parameters can be written to an IED.

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1. In **Plant Structure**, select an IED.
2. On the menu bar, click **IED** and select **Write parameters to IED**.
3. In the **Write Parameters to IED** window, select the **Parameter range** and the **Parameter options**.
4. Select **Read back** check box, if the parameters must be read back after writing.
5. Click **OK**.

In Parameter Setting, only the parameters are written to the IED, not the whole configuration.

If the writing of a single parameter fails, an error message is displayed. Continue by choosing one of the given options.

- Click **Retry** to write the parameter again.
- Click **Skip** to skip the parameter.
- Click **Skip all** to continue the writing of parameters and skip automatically the possible parameters that fail.
- Click **Cancel** to end the writing procedure.

Locked parameters are not written to IED before unlocking them. The locked parameters must first be unlocked by right-clicking the **PC value** field and selecting **Unlock parameter**.

4.4.3 Copying parameter values

In Parameter Setting, parameter values can be copied from one or several parameters to other/s. The copied parameter or parameter group has to be of the same type as the target parameter or group.

1. Select the parameter value or values.
   - For copying a single value, select the PC Value cell of a parameter.
   - For copying multiple values, select a parameter group header (indicated with a blue color) from the setting sheet. All parameters belonging to the selected group are marked with check marks.
2. On the **Edit** menu, click **Copy**.
3. Select the place to paste the parameter value or values.
   - To paste a single parameter value, select a parameter on the setting sheet.
   - To paste multiple parameter values, select a parameter group header on the setting sheet.
4. On the **Edit** menu, click **Paste**.

4.4.4 Copying setting group values

In Parameter Setting, parameter values can be copied from one setting group to another.

1. On the **Edit** menu, click **Copy/paste setting group**.
2. Select the groups in the **Source group** box and the **Target group** box, and click **OK**.
   All parameters currently visible in the setting sheet are copied from the source group to the target group.

4.4.5 Collapsing and expanding parameter groups

- To collapse or expand a single group, double-click the parameter group header in the setting sheet.
- Collapse or expand the selected group and it's child groups.
  - On the menu, select **View/Group options/Expand selected group + child groups** to expand the groups.
  - On the menu, select **View/Group options/Collapse selected group + child groups** to collapse the groups.
- On the toolbar, click the corresponding toolbar buttons.

4.4.6 Finding parameters

Search parameters in Parameter Setting with the **Find parameter** function.

1. On the **Edit** menu, click **Find parameter**.
2. In the **Find Parameter** dialog box, enter the find string and column where to find from.
3. Click **Find Next** to find the parameter.

4.4.7 Exporting parameters

Parameters can be exported from an IED in any level of the Plant Structure.

1. Click the Export parameters toolbar button or on the **File** menu, select **Export parameters**.
2. In the **Export** dialog box, define the export options.
   - File name
   - Path or location
   - File type (xrio, csv, txt)
3. Click **Save**.

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4.4.8 Importing parameters

An exported parameter file contains all the IED functions which have parameters. In the import phase, the functions to be imported from the file can be defined.

Parameters can be imported in an IED in any level of the Plant Structure as a whole or partially.

1. Select the node from the tree structure in **Plant Structure** to import the parameters.
   To import all the parameters, select the IED node. To import the parameters related to a subnode, select the subnode by expanding the IED node.
2. Click the Import parameters toolbar button, or on the **File** menu select **Import parameters.**
3. Define the location of the import file.
   The import file must be in .xrio or .csv format.
4. Click **Open**, and in the **Open** dialog box, select the functions containing the parameters required for importing.
   All the functions are selected by default.
5. Click **OK.**

If a revision mismatch occurs between the source function in the import file and the target function in the PCM600 tool, the function is displayed in red font and it is not selected. The function can be selected and imported but all parameters may not be updated in the target function.

4.5 Using IED Compare

IED Compare is used to compare the configurations of two IEDs of the same type. The configurations to be compared can be stored in PCM600, IED or pcmi file. The result of the comparison is a report listing the differences in the IED configurations.

1. In **Plant Structure**, click **Substation, Voltage level, Bay** or **IED.**
2. On the **Tools** menu, click **IED Compare** to start the tool.
3. In the **IED Compare** tool window, select the online or offline comparison type from the given options.
4. Select the comparison objects from the **Select IED** tree and click **Compare.**
   The comparison report shows differences in the configuration of any two IEDs. The results are grouped to Hardware, Application, Display, GOOSE and Parameter(s) configuration differences.
5. Click **Save** to save the report.
   The report can be saved as Excel or as PDF.

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The online comparison depends on the Connectivity Package and the IED's capability to read the selected configuration and parameters.

4.6 Using Disturbance Handling

Disturbance Handling is used for uploading and processing the disturbance files gathered by a specific IED, for viewing and processing the disturbance recording data and for creating reports.

1. In **Plant Structure**, click an IED.
2. On the **Tools** menu, click **Disturbance Handling**.
   Disturbance Handling opens in the tool window.
3. On the **Tools** menu, click **Options**, and then in the tree structure on the left, click **Disturbance Handling** to set the Disturbance Handling preferences.
   - Click the **General** tab and define where the recordings are stored and which tool to use for opening the recordings.
   - Click the **Column Preferences** tab and define the visibility, width and order of the columns in the Disturbance Handling tool window.
   - Click the **Email Settings** tab and define the options for sending the report via email.

   Click **OK** to confirm settings.
4. On the PCM600 toolbar, select the recording filter to define which recordings are shown in the window.

4.6.1 Reading recordings

The **Read Recordings from IED** operation uploads the selected COMTRADE recordings to the recordings folder in the local computer. On a successful read operation, the computer icon in the first column is enabled indicating that the recording is available locally in the computer for analysis.

The read operation is performed based on the IED's capability. If the IED is not capable of reading the subset of recordings, all the recordings are read. If no recordings are selected, all the recordings are read.

- On the PCM600 menu bar, select **IED/IED Recordings/Read Recordings from IED.**
- Click the **Read Recordings from IED** toolbar button.
- Right-click the **Disturbance Handling** window and select **Read Recordings from IED** in the shortcut menu.
- Double-click the IED recording.

The recordings with the IED icon enabled in the first column can only be read.

If a recording is already read in the local computer, a warning appears asking if the recording should be overwritten.

4.7 Using Event Viewer

Event Viewer displays the actual or history events stored in the IED. These events can be sorted and filtered for easier examination, or they can be printed or exported to a file.

1. In **Plant Structure,** click and IED.
2. On the **Tools** menu, click **Event Viewer.**
   The **Event Viewer** window containing two tabs opens.
   - **IED events** tab contains all events in a table format, the newest event on top.
   - **Security events** tab contains security events in a read-only format, the newest security event on top.

4.7.1 Filtering event data

Filtering allows reducing the amount of the displayed event data.

1. On the main menu, select **Event Viewer** and click **Filter On/Off.**
   A drop-down list box including the column's values is shown for each header.
2. Select a value from the column's drop-down list box to display events that have the selected value.
   Filters can be selected for several columns which enables combining the filter conditions over these columns.
   - To use more advanced filtering options, select **Custom filter** from the drop-down list box of each column. The **Custom Filter for Event List Column** dialog box is shown where you can select filtering options for the selected column. Click **OK** to apply the filtering conditions. Advanced filtering can be selected for several columns which enables combining the filter conditions over these columns.
   - To turn off the filter condition on a specific column, select **No filter** from the column's drop-down list box.
3. To turn off all the filters, select **Event Viewer** on the main menu, and click **Filter On/Off** again.

The drop-down list boxes below the column headers disappear.

When closing Event Viewer, the filter settings are stored and applied when opening Event Viewer the next time.

4.7.2 Printing events

You can print the events that are currently displayed in Event Viewer. You need to have a printer installed on the computer.

1. On the **File** menu, click **Print.**
    - Preview the data to be printed by clicking **Print Preview.**
    - Click **Print Options** to select the columns to print. The **Print Options** menu is available only when Event Viewer contains both the IED events and Security events data.
2. In the **Print** dialog box, select the wanted options and click **OK.**

The **Print** and **Print Preview** functions are not available if no events are shown in the Event Viewer display, or if the default printer is not defined.

4.7.3 Exporting events to Excel file

Filtered events can be exported to an Excel file. Exporting to Excel file can be useful, for example, when the events of two IEDs need to be compared.

1. In Event Viewer, filter the event data for an IED.
2. Select **Reports** on the main menu and click **Export To Excel File.**
3. Select the file destination and click **OK.**

The event data is exported to the selected destination in Excel format.

To export events to Excel file, you can also click the **Export to Excel File** button in the toolbar.

4.8 Using Signal Monitoring

1. In the **Plant Structure,** select an IED.
2. On the menu bar, click **Tools** and select **Signal Monitoring.**

Signal Monitoring opens in the tool window.

3. On the menu bar, point to **IED** to select the monitoring option.
   - Click **Read Latest Values From IED** to read the values and update the view manually.
   - Click **Toggle Continuous Reading** to update the view automatically when new values are received.
   - Click **Toggle Continuous Reading** again to turn it off and click **Forcing Session** to test the function of the IED.
4. To close Signal Monitoring, right-click the **Signal Monitoring** tab on top of the tool window, and then click **Close**.

Section 5 Use cases for engineering and commissioning

5.1 Using Project Explorer

Plant Structure is the default view in **Project Explorer**.

- On the menu bar, click **View** and then click **Project Explorer**.
  The **Project Explorer** window is opened and closed with the selection.

5.1.1 Creating new projects

1. On the **File** menu, click **New Project**.
2. Type the name of the project in the **Project name** box.
3. Type the optional description for the project in the **Description** box.
4. Click **Create** to create a new project to the default location.

5.1.2 Building the plant structure

1. Create IED group or substation level objects.
   1.1. In **Plant Structure**, right-click a project and select **New/ General** and then select **IED Group** or **Substation**.
   1.2. Rename the IED group or substation by the name or identification used in the grid. Right-click the level and select **Rename**.
2. Create voltage level objects.
   2.1. In **Plant Structure**, right-click a substation and select **New/ General/ Voltage Level**.
   2.2. Rename the voltage level by right-clicking the level and selecting **Rename**.
3. Create bay level objects.
   3.1. In **Plant Structure**, right-click a voltage level and select **New/ General/ Bay**.
   3.2. Rename the bay object by right-clicking the object and selecting **Rename**.

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Objects can also be renamed by selecting the object and pressing F2.

5.1.3 Moving objects in the project tree

The drag-and-drop operation follows the typical windows principles.

- In **Plant Structure**, move an object in the project tree by dragging.

5.1.4 Creating IEDs

1. Select and add the IED in one of the alternative ways.
   - On the **View** menu, click **Object Types** and select the IED from the **Object Types** window, and drag it under the bay in **Plant structure**.
   - Right-click the bay in **Plant Structure**, and from the shortcut menu, point to **New** and select **Create from template**.
   - Right-click a bay object in **Plant Structure**, and on the shortcut menu, point to **New** and select the IED to be added.
2. In the **Configuration Wizard**, select the configuration mode and click **Next**.
   - Select **Online configuration** when the IED is already connected to PCM600.
   - Select **Offline Configuration** when the IED is not available or is not connected to PCM600.
3. Set up the IED following the steps in the **Configuration Wizard**.
   The available steps and settings depend on the IED.
   - Communication protocol
   - Port and IP address
   - IED version
   - Housing type
   - Display type
   - Order code
4. Click **Finish** to confirm the configuration.

5.1.5 Creating IEDs from templates

IEDs in **Plant Structure** can be exported to templates that can be used to create new IEDs including the IED application configuration, graphical display configuration, communication mappings and parameters.

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1. In **Plant Structure**, right-click a bay and then select **New /Create from Template.**
2. Select the IED from the list of the available object types.
3. Click the icon on the right column in the list of available templates.
   The **Template Properties** dialog box opens.
4. Check the template information and click **Close** to close the window.
5. In the **Create New Object from Template** dialog box, click **Create** to insert the IED in the bay.
6. Set up the IED following the steps in **Configuration Wizard.**
   The steps and settings available depend on the IED.

After a template IED has been imported, the IP address, the **Caption** in **IED Object Properties** and the technical key that corresponds to the physical IED have to be changed.

5.1.6 Copying and pasting IEDs

1. In the **Plant Structure**, right-click the IED to be copied.
2. On the shortcut menu, click **Copy**.
3. Right-click the object level in **Plant Structure**, for example a bay, where the copied IED is to be inserted.
4. In the shortcut menu, click **Paste**.
   The IED is now visible in the object tree.

Complete Bays or Voltage Levels can also be copied and pasted.

The keyboard shortcuts CTRL+C and CTRL+V can also be used for copying an pasting.

5.1.7 Importing IEDs

A new IED object can be imported to a project in **Plant Structure** by importing an IED (.pcmi) file.

An IED file can only be imported when a bay or an IED group is selected in the plant structure.

1. In **Plant Structure**, right-click the bay and then click **Import**.
2. Select the IED file to be imported and click **Open**.
   After importing, the IED object is created in the plant structure.

After importing the IED file, change the IP address, the name and the technical key that correspond to the physical IED from the **Object Properties** window.

5.1.8 Importing preconfigured IEDs

A preconfigured IED includes all information related to the IED object in PCM600. Preconfigurations are bound to a specific hardware configuration. The License Update tool is needed to ensure that the configuration is compatible with the ordered device.

1. In **Plant Structure**, right-click an IED group or a bay and select **Import**.
2. Select the preconfiguration file saved in .pcmi format and click **Open**.
   The preconfiguration file is imported to the **Plant Structure**.
3. If needed, modify the configuration using the Application Configuration tool.
4. Write the configuration data to the IED by right-clicking the IED in **Plant Structure** and selecting **Write to IED**.
   - Click **Yes** to write the configuration data to IED.
   - Click **No** to cancel the operation.

You can rename the preconfigured IED in the **Plant Structure** by selecting the IED and pressing F2.

The ordered default configurations are not locked, and can be used as a base for other configurations providing that all the needed hardware and software options are available.

5.1.9 Exporting IEDs

1. In the **Plant Structure**, right-click the IED and then click **Export**.
   The **Information** dialog box is displayed with the supported file types and their descriptions.
2. Click **OK** to open the **Export** dialog box.
3. Write the file name, select the file type **IED File (*.pcmi)** and click **Save**.
   The IED file contains the whole IED configuration.

5.2 Using graphical Application Configuration

The graphical Application Configuration is used to create and modify application configurations for IEDs, that is, to define how the IEDs function.

1. In **Plant Structure**, select an IED.
2. On the **Tools** menu, click **Application Configuration**.
   Application Configuration opens in the tool window.
3. Create or modify the application configuration.
   - Organize into main applications over the needed amount of pages.
   - Insert function blocks, hardware channels and variables.
   - Make connections.
4. Click the Save button on the toolbar to save the configuration.
   The changes are shown in the **Plant Structure**.

When both Application Configuration and Parameter Setting are open for the same IED, the Parameter Setting view is synchronized with the view of Application configuration. If a function block is selected in Application Configuration, the same function block is shown in focus in the Parameter Setting window too, and vice versa.

5.2.1 Inserting main applications

A main application is the drawing area for creating or editing the application configuration. The main application can contain several pages. A configuration always has one default main application.

- On the **Insert** menu, click **MainApplication**.
- Click the Insert MainApplication button on the toolbar.

A new main application is created with the default name MainAppX, where X is a sequential number.

5.2.2 Copying main applications

The main application can be copied and pasted either within the same IED Configuration, or to a different IED Configuration with the same capabilities.

1. In **Application Configuration**, right-click the **MainApp** tab and select **Copy** from the shortcut menu.
2. Right-click the tab after which the main application has to be inserted and select **Paste** from the shortcut menu.

Function blocks, channels and other graphical symbols in the main application are pasted on a new **MainApp** tab.

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5.2.3 Deleting main applications

1. In **Application Configuration**, right-click the **MainApp** tab and select **Delete** from the shortcut menu.
   If **Application Configuration** has only one **MainApp**, the delete option is not available.
2. To confirm the deletion, click **Yes**.

The main application is deleted.

5.2.4 Inserting pages

1. In the Application Configuration tool window, click the **MainApp** tab.
2. Scroll to the page after which the new page is to be added.
3. On the **Insert** menu, click **Page**.

A page can also be added using the shortcut menu, or pressing the shortcut keys CTRL +SHIFT+P.

5.2.5 Inserting variables

Input and output variables represent connections in the configuration.

1. On the **Insert** menu, point to **Variable**.
2. Select **Input** or **Output**.
3. Click the Application Configuration window to insert the variable.
   The variable is inserted with its default name.

Variables can also be inserted using a shortcut menu in Application Configuration, the View Variable List button on the toolbar or the shortcut keys CTRL+SHIFT+V.

5.2.6 Inserting function blocks

A function block can be inserted only in the configuration mode of Application Configuration.

1. On the **Insert** menu, click **FunctionBlock**.
2. Click in the **Application Configuration** window.
   The **Insert Function Block** dialog opens.
3. Select the function block and click **Insert**.
4. Enter the function block data and click **Assign**.

If the automatic mode is selected for the execution order from the PCM600 toolbar, the cycle time, execution order and instance number are automatically assigned. Otherwise, set them manually before assigning.

Function blocks can also be inserted in the drawing area by dragging, using the shortcut menu in Application Configuration, or by using the shortcut keys CTRL+SHIFT+F.

5.2.7 Renaming main applications and objects

Main applications and objects in the Application Configuration can be renamed in the **Object Properties** window.

1. Select the item to be renamed.
   - To rename a main application, click a **MainApp** tab.
   - To rename an object, click the object in the Application Configuration tool window.

   The data of the selected item is shown in the **Object Properties** window.
2. Enter the new name in the **Name** or **User Defined Name** field.
   The field cannot be left empty. If the maximum length is exceeded or unallowed characters are used, an error message is shown.
3. Click the Save button on the toolbar to save the new name.

Objects can also be renamed by right-clicking a function block in Application Configuration and selecting **Set User Defined Name**, or by pressing F2.

5.2.8 Finding application objects

In Application Configuration you can search and locate function blocks, variables, hardware channels, text, signals, comments or graphical objects.

1. On the menu bar, select **Edit** and click **Find.**
   - To use a simple search function, type in the text box search words, such as symbol name, and click **Find Next.**
   - To use an advanced search function, click **Find Options**, define the more detailed searching options and click **Find**. The search results are shown on Search Results field. Click an item on the list to locate it.

The finding function can also be started by pressing the shortcut keys CTRL+F.

5.2.9 Connecting signals

5.2.9.1 Connecting by dragging

1. Point to the graphical symbol of the signal or channel so that the hand cursor appears.
2. Drag the source signal or channel to the target.

5.2.9.2 Connecting using variables

With the variables, connections can be represented within a page and across pages or worksheets.

1. Right-click the function block signal or channel, and then click **Connect**.
2. Connect to a variable.
    - Click **New** to add a new variable.
    - Click **Existing Variable**, and in the **Variable** list, select the variable and click **Select**.

The Variable list can also be opened using the shortcut keys CTRL +SHIFT+V.

A connection to an existing or a new variable can also be created by selecting the signals and pressing the shorcut keys CTRL+SHIFT+E or CTRL+SHIFT+N.

5.2.10 Deleting objects and unconnected variables

The **Delete Option** dialog box allows deleting main applications, pages, Application Configuration symbols and unconnected variables from the configuration.

1. On the menu bar, click **Edit** and select **Delete Option**.
   The **Delete Option** dialog box opens.
2. Select the check box next to the item to be deleted.
    - To delete the unconnected variables from the configuration, select the **Delete all unconnected variables from the configuration** check box.
3. Click **Delete**.
4. To confirm the deletion, click **Yes**.

The selected items are deleted from the configuration.

5.2.11 Grouping symbols

In the configuration mode, the group feature allows combining the selected symbols to a single object.

1. Select the desired symbols.
2. Right-click any of the selected symbols and select **Group**.
   The symbols are highlighted in blue, indicating that they are grouped.

To exclude an element from a group, right-click the element, and in the shortcut menu, select **Exclude from Group**.

To ungroup the grouped symbols, right-click the group and select **Ungroup**.

5.2.12 Aligning and spacing symbols

The symbols can be aligned and spaced in Application Configuration.

1. Use the mouse to select the symbols.
   To select several symbols, hold down the CTRL key while selecting.
   The primary selected symbol is outlined with red color, and the secondary selected symbols are outlined with blue color.
2. On the menu bar, select **Format/Format Symbols**, point and click the wanted option.
   - Point to **Align** and select **Left/Right/Horizontal/Top/Bottom/Vertical** to arrange the symbols in relation to the primary selected symbol.
   - Point to **Align** and select **Detect overlapping FunctionBlocks** to find the overlapping function blocks in the configuration. The pages containing overlapping function blocks are listed on the **Output** window. To locate a page, double-click an item on the list.
   - Point to **Align** and select **Align overlapping FunctionBlocks** to align the overlapping function blocks in the configuration.
   - Point to **Horizontal Spacing** and select **Make Equal** to arrange the selected symbols horizontally with equal spaces between them.
   - Point to **Vertical Spacing** and select **Make Equal** to arrange the selected symbols vertically with equal spaces between them.

5.2.13 Locking and unlocking applications, pages, variables and function blocks

Application Configuration enables locking and unlocking applications, pages, variables and function blocks. Locking an application prevents creating or deleting

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graphical symbols and connections, moving graphical symbols and deleting main applications. Locking a page prevents inserting, deleting and moving the graphical symbols on the page. Locking a variable prevents moving, renaming and deleting the variable. Locking a function block prevents operations such as cutting, copying, pasting, moving and deleting the function block.

1. Select the item to be locked.
    - To lock a main application, click the main application tab.
    - To lock a page, go to the page.
    - To lock a variable, select the variable.
    - To lock a function block, select the function block.
2. In the **Object Properties** window set the value of the **Locked** field to **True.**
3. To unlock, set the value of the **Locked** field to **False.**
   A password is required for unlocking a main application. The password is set in **Tools/Options/Application Configuration.**

Locking and unlocking is also possible by right-clicking the particular item, and selecting **Lock** or **Unlock** from the shortcut menu.

5.2.14 Monitoring signal and channel values

The signal and channel values of a configuration can be continuously monitored in the online monitoring mode of Application Configuration. To online monitor the application configuration, the complete IED configuration must first be written to the IED.

1. On the toolbar, click the Work online button to start online monitoring.
   When the IED does not support online monitoring, the button is disabled.

   Only when the application configuration in the IED and PCM600 are the same, the online monitoring starts.

2. On the toolbar, click the Watch window button.
   Use the watch window to monitor certain signals in a separate window. A signal can be added to the watch window by right-clicking the function block signal in Application Configuration, and then selecting **Add to watch window** from the shortcut menu.
3. On the toolbar, click the Work Offline button to stop online monitoring.

The Work online function is not supported if the split window is enabled.

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5.2.15 Validating application configuration

Validating the application configuration enables detecting any errors that can prevent downloading the configuration to the IED.

- On the menu bar, select **IED** and click **Validate Configuration.**

The configuration is validated and the errors and warnings are listed in the **Output** window. To navigate to the problem area in the configuration, double-click the particular error or warning message.

5.2.16 Comparing application configuration

The existing application configuration in PCM600 and the configuration in the IED can be compared.

1. On the **IED** menu, click **Compare Configuration.**
   The function blocks can be compared based on their execution order and cycle time.
2. Click **OK** to start the comparing.

A report is created about the differences in function blocks. Also the missing blocks and connections are listed.

5.2.17 Working with templates

5.2.17.1 Creating main application templates

Main application configurations can be saved as templates and reused.

1. Click the **MainApp** tab to select the main application to be saved as a template.
2. On the **File** menu, select **MainApplication Template Manager.**
   The **MainApplication Template Manager** dialog box opens. The **IED type** combo box displays the current IED type.
   To save the a template in a custom location, clear the check box to select the destination.
3. Enter the template name and description and click **Save** to save the template.

The templates only have application configuration-related information, not parameters or communication-related information.

5.2.17.2 Inserting main applications from templates

Main application templates can be inserted into any configuration in Application Configuration.

1. On the **Insert** menu, click **MainApplication Template Manager.**
2. Select the template in the **Existing Templates** box and click **Insert.**
   The program also shows template migration details and allows managing hardware channels and variables.
3. Click **Close** to close the **MainApplication Template Manager** dialog box.

A new main application is created with the content of the template file.

5.2.18 Application Configuration shortcut keys

Table 3: Application Configuration shortcut keys

Shortcut key	Function
Page selected	
SHIFT+RIGHT ARROW	Backward navigation of the selected variables
SHIFT+LEFT ARROW	Forward navigation of the selected variables
CTRL+TAB	Go to the next main application
CTRL+SHIFT+TAB	Go to the previous main application
RIGHT ARROW	Move the selected objects to the right
LEFT ARROW	Move the selected objects to the left
UP ARROW	Move the selected objects up
DOWN ARROW	Move the selected objects down
CTRL+F	Open the **Find** dialog box
CTRL+SHIFT+V	Open the **Variable List** dialog box
CTRL+SHIFT+P	Insert a page
CTRL+SHIFT+D	Delete a page
PAGE UP	Scroll up the page
PAGE DOWN	Scroll down the page
CTRL+G	Open the **Go To Page** dialog box
CTRL+SHIFT+F	Insert a function block
CTRL+SHIFT+H	Insert a hardware channel
CTRL+P	Print worksheets or pages
CTRL+Z	Undo operation
CTRL+Y	Redo operation
DELETE	Delete the selected objects
CTRL+C	Copy the selected objects
CTRL+V	Paste the copied objects
CTRL+A	Select all objects

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Shortcut key	Function
CTRL+X	Cut the selected objects
CTRL+S	Save the application configuration
F1	Open the PCM600 online help
CTRL+SHIFT+L	Lock a page
CTRL+SHIFT+U	Unlock a page
Application key	Open the shortcut menu of the page
Connection selected	
F1	Open the PCM600 online help
Function block selected	
F1	Open the PCM600 online help
F2	Set the user-defined name for the function block
CTRL+R	Replace the function block
CTRL+SHIFT+M	Manage signals for the function block
CTRL+SHIFT+L	Lock the function block
CTRL+SHIFT+U	Unlock the function block
Application key	Open the shortcut menu of the function block
Hardware channel selected	
F1	Open the PCM600 online help
F2	Set the user-defined name for the hardware channel
Application key	Open the shortcut menu of the hardware channel
Picture selected	
F1	Open the PCM600 online help
Application key	Open the shortcut menu of the picture
Signal selected	
F2	Set the user-defined name for the signal
CTRL+SHIFT+N	Insert new variable (on selection of signal)
CTRL+SHIFT+E	Insert existing variable (on selection of signal)
Application key	Open the shortcut menu of the signal
Text selected	
F1	Open the PCM600 online help
Application key	Open the shortcut menu of the text
Variable selected	
F1	Open the PCM600 online help
F2	Set the user-defined name for the variable
CTRL+SHIFT+L	Lock the variable
CTRL+SHIFT+U	Unlock the variable
Application key	Open the shortcut menu of the variable

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5.3 Using Signal Matrix

The Signal Matrix tool is used for making connections between the physical input and output signals and function blocks, as well as for engineering the GOOSE signal inputs. After the connections are made, the matrix can be exported to an Excel sheet for easier verification.

1. In **Plant Structure**, select an IED.
2. On the **Tools** menu, click **Signal Matrix**.
   Signal Matrix opens in the tool window. Depending on the IED, there is a separate sheet for each possible combination.
3. Click the tab on the status bar to open the correct sheet.
4. Create connections between source and target objects in the IED configuration.
   - White cells are available for configuration.
   - Cells shaded in light red are not available for configuration.
   - Light blue cells are available for configuration, but the corresponding target object already has a connection with some other source object in the grid. In this case, the behaviour of the connection depends on whether or not glue logic is enabled in the grid.
     - If glue logic is not enabled, the existing connection is removed.
     - If glue logic is enabled, Signal Matrix attempts to combine the new source object with the existing source object using glue logic, and connect the output to the target object.
5. Click the Save button on the toolbar to save the connection changes.

Some of the Signal Matrix grids, such as binary inputs, binary outputs and function grids, support glue logic. Normally, only one source object can be connected to a target object. Glue logic enables connecting several source objects to the same target object: the outputs of multiple source objects are connected to the inputs of a simple boolean logic function, and the output of the boolean function is connected to the target object. The available boolean logic functions are AND and OR.

5.3.1 Connecting binary inputs

1. Click the **Binary Inputs** tab in the tool window.
   The availability and the appearance of the grid depend on the IED.
2. Create or delete connections between physical input channels and binary input signals.

- Double-left-click an empty cell to create a direct connection. The selected cell is marked with "X."
- Double-right-click an empty cell to create a connection with an inverter. The selected cell is marked with "I."
- Double-left-click or double-right-click a cell with a symbol X or I to remove a connection.

The **Binary Inputs** grid supports glue logic. This means that several optocoupler input channels can be connected to the same binary input signal.

3. Click the Save button on the toolbar to save the connection changes.

5.3.2 Connecting binary outputs

1. Click the **Binary Outputs** tab in the tool window.
   The availability and the appearance of the grid depend on the IED.
2. Create or delete connections between physical output channels and binary output signals.
   - Double-left-click an empty cell to create a direct connection. The selected cell is marked with "X."
   - Double-right-click an empty cell to create a connection with an inverter. The selected cell is marked with "I."
   - Double-left-click or double-right-click a cell with a symbol X or I to remove a connection.

   The **Binary Outputs** grid supports glue logic. This means that several binary output signals can be connected to the same output relay contact channel.
3. Click the Save button on the toolbar to save the connection changes.

5.3.3 Connecting analog input channels

1. Click the **Analog Inputs** tab in the tool window.
   The availability and the appearance of the grid depend on the IED.
2. Create or delete connections between current and voltage channels and the input signals of current and voltage function blocks.
   - Double-click an empty cell to create a connection.
   - Double-click a cell with a symbol X to delete a connection.

   Several analog input signals can be connected to the same physical analog input channel. But once an analog input signal is connected to a physical analog input channel, it cannot be connected to another physical analog input channel.
3. Click the Save button on the toolbar to save the connection changes.

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5.3.4 Connecting analog output channels

1. Click the **Analog Outputs** tab in the tool window.
   The availability and the appearance of the grid depend on the IED.
2. Create or delete connections between analog output signals and current and voltage channels.
   - Double-click an empty cell to create a connection.
   - Double-click a cell with a symbol X to delete a connection.

   Several analog output signals can be connected to the same physical analog output channel. But once an analog output signal is connected to a physical analog output channel, it cannot be connected to another physical analog output channel.
3. Click the Save button on the toolbar to save the connection changes.

5.3.5 Connecting GOOSE receive signals

The GOOSE receive input signals are those signals that are communicated to one IED from another IED using the IEC 61850 GOOSE communication mechanism.

1. Click the **GOOSE** tab in the tool window.
   The availability and the appearance of the grid depend on the IED.
2. Create or delete connections between GOOSE receive signals and input signals.
   - Double-click an empty cell to create a connection.
   - Double-click a cell with a symbol X to delete a connection.

   The Signal Matrix connection rules prevent incompatible connections. Incompatible connection cells are disabled and shown in red.
3. Click the Save button on the toolbar to save the connection changes.

5.4 Using Graphical Display Editor

Graphical Display Editor is used for drawing the single-line diagram shown on the graphical display of the IED. The diagram with its components corresponds to the actual configuration.

1. In **Plant Structure**, select an IED.
2. On the **Tools** menu, click **Graphical Display Editor**.
   The presentation is empty when no page exists for the IED. If standard configurations are used, a default single-line diagram presentation is displayed.
3. In the **Symbol Library** box, select either IEC or ANSI.

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The symbols in the display pages and in the symbol library are changed.
4. On the toolbar, activate the **Snap to grid** and **Show grid** functions.
5. Create the single-line diagram.

5.4.1 Creating single-line diagrams

1. Add primary equipment to the display page by dragging from the **Symbol Library**.
   - Rotate the symbols with the Rotate left and Rotate right buttons on the toolbar.
   - Select the size in the **Symbol Size** box.
2. Add junction symbols for connections.
3. Connect the symbols where necessary.
   3.1. Point to the symbol's connection point.
   3.2. Drag the connection from the source connection port to the target connection port.
   A connection line between the source and target connection ports is drawn.
4. Modify the symbol properties in the **Object Properties** window.
   4.1. Click an object in the **Display Page**.
   4.2. In the **Object Properties** window, modify the properties, such as, naming the symbol and placing the name.
5. Relate dynamic symbols to their source data.
   5.1. Right-click the symbol and then click **Select Input Signal**.
   5.2. Select the signal from the list.
6. Set the tab order of controllable objects in the **Object Properties** window.
   The tab order defines the order in which the controllable objects are selected when the **Select** button is pressed on the IED.
7. Click the Save button on the toolbar to save the diagram.

5.4.2 Exporting a template

Single-line diagrams created in Graphical Display Editor can be exported as templates and reused.

1. Create a single-line diagram in the **Graphical Display Editor** tool.
2. On the menu bar, point to **Graphical Display Editor** and select **Export Display Pages as a Template**, or on the **File** menu, point to **Display Editor Template** and click **Export**.
3. Once the display page is selected, click **Export**.
   The **File save** dialog box appears.
4. Browse the location to export the template and provide the file name.

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By default, single-line diagram templates are saved in the drive where PCM600 is installed <Drive:> \PCMDataBases\GDE\Templates \<IED type folder>.

5.4.3 Importing a template

In Graphical Display Editor, an exported single-line diagram template can be imported to another IED.

1. On the menu bar, point to **Graphical Display Editor** and select **Import Display Pages from Template** or on the **File** menu, point to **Display Editor Template** and click **Import**.
   The **Import GDE Template** window appears with two sections, **List of Templates** and **Display Pages Preview**.
2. Click **Browse** to select the template files.
   The templates available in the folder appear in the **List of Templates** section.
3. Select a template file to preview the display pages available in the template file.
4. Once the display pages are selected, click **Import** to import the display page.

Multiple pages can be selected for the **Import** function.

5.5 Using IEC 61850 Configuration

The IEC 61850 Configuration tool is used for GOOSE and client-server data flow engineering between IEDs in a substation.

1. In **Plant Structure**, right-click **Substation, Voltage Level, Bay, IED Group** or **IED**, and then select **IEC 61850 Configuration.**
2. On the toolbar, select the configuration mode.
   - GOOSE Communication
   - Client-Server Communication

   Different parts of the IEC 61850 configuration can be edited depending on the selected configuration mode.
3. Click one of the tabs on bottom of the tool window to select the type of the configured data.
   - Data Sets
   - GOOSE Controls
   - Inputs
   - Report Controls

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The type of the data available depends on the current configuration mode.

5.5.1 Sending and receiving data

In the Data Sets, GOOSE Controls, Report Controls and Sampled Value Controls tabs, it is possible to configure the sending or receiving of data. A check mark in the matrix means that the data on the row is sent to or received by the client in the column.

- To send or receive data, select a check box in the mapping matrix.
- To send data to all receivers, right-click the data to be sent and select **Send to All**.
- To receive all data, right-click a receiver and select **Receive All**.
- To receive the same data as another IED, right-click a receiver, select **Receive Same Data As** and select an access point from the pop-up menu.

When sending or receiving a data set, the corresponding control block is created automatically on the sending IED if it does not exist yet. When sending or receiving GOOSE or sampled value data, the inputs corresponding to the sent or received data set are created automatically on the receiving IED.

5.5.2 Creating new objects

New objects can be created in the Data Sets, GOOSE Controls, Report Controls, Sampled Value Controls and Subnetworks tabs.

- Create new objects in the **Data Sets, GOOSE Controls, Report Controls** or **Sampled Value Controls** tab.
  1. Open the dialog box for creating a new object in one of the alternative ways.
     - On the **Edit** menu, click **New**.
     - Click the New button on the PCM600 toolbar.
     - Press CTRL+ALT+N.
  2. Create a new object.
     - 2.1. In the tree on the left, select the logical node where to create the new object.
     - 2.2. Type or select the required information in the fields on the right.
     - 2.3. Click **OK** or press ENTER to create the object.
- Create new objects in the **Subnetworks** tab.
  1. Open the dialog box for creating a new object in one of the alternative ways.

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- On the **Edit** menu, click **New**.
- Click the New button on the PCM600 toolbar.
- Press CTRL+ALT+N.

2. Create a new subnetwork.
   2.1. Enter a unique subnetwork name in the **Name** box (mandatory).
   2.2. Type a description in the **Description** box (optional).
   2.3. Click **OK** or press ENTER to create the object.

5.5.3 Editing data set entries

- Open the data set editor window in the **Data Sets** tab in one of the alternative ways.
  - Select the data set, and on the **Edit** menu, click **Details.**
  - Click the Details button on the PCM600 toolbar.
  - Right-click the data set and select **Details.**
  - Select the data set and click the Browse button of the **Entries** property in the **Object Properties** window.
  - Double-click the data set.
- Right-click a control block and select **Data Set Details** to open the data set editor window in the **GOOSE Controls, Report Controls** or **Sampled Value Controls** tab.
- Select the data.
  1. Select a logical device in the LD list.
  2. Select a logical node in the LN list.
     Logical nodes can be searched by entering the logical node name or part of it into the text field above the logical node list.
  3. Select a data object in the DO list.
  4. Select one or more functional constraints in the FC list or select one or more data attributes in the DA list.
- Append the selected data at the end of the **Data Set Entries** list by clicking the **Append** button or by pressing CTRL+ALT+A.
- Insert the selected data into the **Data Set Entries** list.
  1. Select the location to insert the data.
  2. Click **Insert** or press CTRL+ALT+I.
- Remove the entries from the **Data Set Entries** list.
  1. Select the entries to be removed.
  2. Click **Remove** or press DELETE.
- Move the entries up or down in the **Data Set Entries** list.
  1. Select the entry to be moved.
  2. Click **Up** or **Down** or press CTRL+ALT+UP ARROW or CTRL+ALT +DOWN ARROW.
- Click **OK** or press ENTER to apply the changes.

The current number and the maximum number of entries allowed in data set are displayed on top of the Data Set Entries list. How the current number of entries is calculated depends on the IEC 61850 edition of the IED. On IEC 61850 Edition 1 IEDs, one row in the Data Set Entries list can mean more than one entry depending on what kind of data it is. On IEC 61850 Edition 2 IEDs, one row in the Data Set Entries list means always one entry regardless of what kind of data it is.

Example: DR.RDRE1.RcdMade (ST) data is added to the Data Set Entries list. On Edition 1 IEDs this data means three entries because data object RcdMade contains three data attributes of ST type and the current number of entries is increased by three. On Edition 2 IEDs this data means only one entry and the current number of entries is increased by one.

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Section 6 Glossary

ANSI	American National Standards Institute
ARP	Address Resolution Protocol
DA	Data attribute
DO	Data object
FC	Functional constraint
FTP	File transfer protocol
GOOSE	Generic Object-Oriented Substation Event
IEC	International Electrotechnical Commission
IEC 61850	International standard for substation communication and modeling
IED	Intelligent electronic device (protection and control relay)
LD	Logical device
LHMI	Local human-machine interface
LN	Logical node
MAC	Media access control
PC	1. Personal computer 2. Polycarbonate
PCM600	Protection and Control IED Manager
SCL	XML-based substation description configuration language defined by IEC 61850
UAC	User Account Control
WHMI	Web human-machine interface

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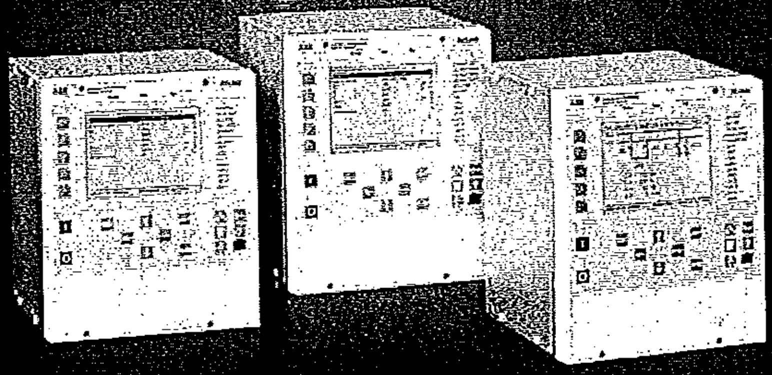

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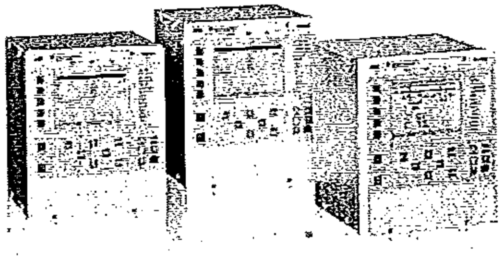

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http://www.abb.com/substationautomation

Опровержение

Данните, примерите и диаграмите в това ръководство са показани само за да дадат по-добра представа при описанието на продукта и не трябва да се приемат за гарантирано състояние. Всички служители, които са отговорни за прилагането на това ръководство трябва да са сигурни, че приложението е подходящо и приемливо, включително, и че всички мерки за сигурност и останалите необходими мерки са взети под внимание. В частност всички рискове по прилагането, в които настъпва системна нередност или риск от повреда на собственост или лица (в това число и не само лични наранявания или смърт), трябва да бъдат единствено отговорност на обекта или субекта прилагащ оборудването. Тези отговорности са изискани по този начин, за да се осигури минимален риск при провеждане на измервания.

Този документ е внимателно проверен от ABB, но немогат да бъдат напълно изключени неточности. Във всеки случай най учтиво Ви молим да уведомите производителя за всички открити грешки. В никакъв случай ABB не носи отговорност или задължения за всички повреди или загуби на оборудване в следствие на употребата на това ръководство за работа, освен при изрични договорни условия.

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ОРИГИНАЛА

Подпис: ....

ООД
Стара Загора

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Съответствие

Този продукт съответства на директивата на съвета на Европейския комитет за изпълнение на законите на държавите членки свързани с електромагнитната съвместимост (EMC Directive 2004/108/EC) и засягащи електрическото оборудване за употреба в определени граници на напрежението (Low-voltage directive 2006/95/EC). Съответствието е в резултат на изпитвания проведени от ABB според стандартите EN 50263 и EN 60255-26 за директивата за ниско напрежение. Устройството е проектирано съгласно международните стандарти IEC 60255.

ВЯРНО С ОРИГИНАЛА

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Безопасност

На изходите може да се появи опасно напрежение, дори и след изключване на външното захранване.

Невнимание може да доведе до смърт, телесни повреди или значителни имуществени щети.

Инсталацията може да се извършва само от квалифициран персонал.

Трябва да бъдат спазвани всички национални и местни норми за безопасност.

Рамката на уреда трябва да бъде заземена.

Всеки път трябва да се вземат мерки срещу неволно изключване, когато се правят промени в устройството.

Уреда съдържа чувствителни на електростатичен разряд компоненти. Поради това трябва да се избягва ненужно докосване на електронни компоненти.

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Глава 1 Представяне

1.1 Това ръководство

Това ръководство съдържа инструкции за работа с устройството (IED - Intelligent Electronic Device) след инсталирането му. Това ръководство съдържа инструкции за наблюдение, управление и настройка на устройството. В ръководството е обяснено също как да се откриват нередности и как да се преглеждат изчислени и измерени данни за определяне на повредата.

1.2 За кого е предназначено

Това ръководство е адресирано до оператора, който работи ежедневно с устройството.

Операторът трябва да бъде обучен и трябва да има основни понятия за работа с защитното оборудване. Това ръководство съдържа термини и изрази, обикновено използвани за описване на такъв вид оборудване.

ВЯРНО С ОРИГИНАЛА

Подпис:

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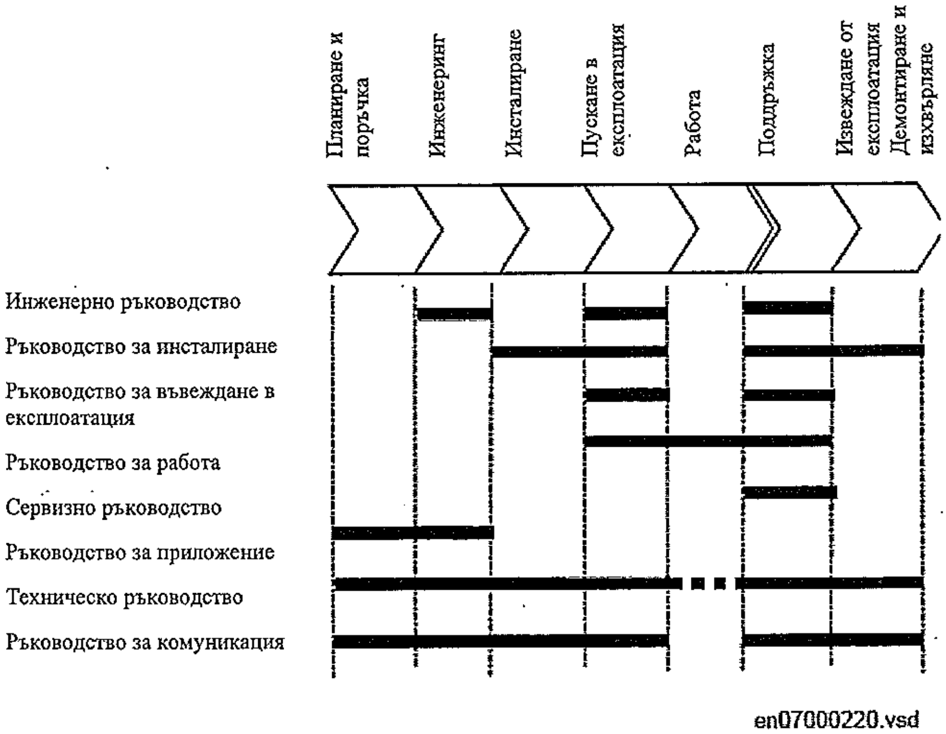
Стара Загора

1.3 Документация за продукта

1.3.1 Окомплектоване на документи



Фиг. 1 Предназначение на ръководствата

Инженерното ръководство съдържа инструкции за използване на различни инструменти в PCM600. Ръководството съдържа инструкции за настройване на PCM600 и поместването на устройството в структурата на проекта. Ръководството също така препоръчва последователност за инженеринг на функции за защита и контрол, LHMI функции както и инженеринг на комуникацията отговаряща на EC 60870-5-103, IEC 61850 и DNP3.

Ръководството за инсталиране съдържа инструкции за инсталиране на устройството. Ръководството осигурява процедури за монтаж и инсталация. Главите са подредени в хронологичен ред, който трябва да се спазва при инсталиране на устройството.

Ръководството за въвеждане в експлоатация съдържа инструкции за въвеждане в експлоатация на устройството. Ръководството може да се ползва и от ремонтен и поддържащ персонал за съдействие по време на тестове. Това ръководство съдържа процедури за проверяване на външната свързаност и захранването на устройството, настройки на параметрите и конфигурацията както и проверка на настройките чрез вторично въвеждане. Ръководството описва процесът на тестване на устройство във подстанция което не е въведено в експлоатация. Главите са подредени в хронологичен ред, който трябва да се спазва при въвеждане на устройството в експлоатация.

Ръководството за работа съдържа инструкции за работа с устройството след неговото въвеждане в експлоатация. Ръководството осигурява инструкции за наблюдение, управление и настройване на устройството. В ръководството е обяснено също как да се откриват нередности и как да се преглеждат изчислени и измерени данни за определяне на повредата.

Сервизното ръководство съдържа инструкции за ремонт и поддръжка на устройството. Това ръководство осигурява и процедури за дезактивиране, извеждане от експлоатация и изхвърляне на устройството.

Ръководството за приложение съдържа описание на приложението и настройки подредени по функции. Ръководството може да се използва за да се разбере кога и по каква причина се използват определени защитни функции. Това ръководство може да се използва и за изчисляване на настройки.

Техническото ръководство съдържа описание за приложение и функционалност и в него са изброени блокове, логически диаграми, входни и изходни сигнали, настройки на параметри и технически данни, сортирани по функция. Ръководството може да се използва за техническа референция по време на инженерната фаза, инсталирането и пускането в експлоатация и дори и при нормална работа на устройството.

Ръководството за комуникация описва протокола за комуникация подържан от устройството. Наръчникът се концентрира върху конкретни реализации на доставчика.

Сервизното ръководство все още не е налично.

1.3.2 История на ревизиите на документа

Дата	Версия на продукта	История
Февруари 2011	1.1	Първо издание

1.3.3 Свързани документи

Документи отнасящи се до REB650	Идентификационен номер
Ръководство за приложение	1MRK 505 262-UEN
Техническо ръководство	1MRK 505 263-UEN
Ръководство за въвеждане в експлоатация	1MRK 505 264-UEN
Ръководство на клиента	1MRK 505 265-BEN
Сертификат за типово изпитване	1MRK 505 265-TEN

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Документи отнасящи се до REL650	Идентификационен номер
Ръководство за приложение	1MRK 506 325-UEN
Техническо ръководство	1MRK 506 326-UEN
Ръководство за въвеждане в експлоатация	1MRK 506 327-UEN
Ръководство на клиента	1MRK 506 328-BEN
Сертификат за типово изпитване	1MRK 506 328-TEN

Документи отнасящи се до RET650	Идентификационен номер
Ръководство за приложение	1MRK 504 124-UEN
Техническо ръководство	1MRK 504 125-UEN
Ръководство за въвеждане в експлоатация	1MRK 504 126-UEN
Ръководство на клиента	1MRK 504 127-BEN
Сертификат за типово изпитване	1MRK 504 127-TEN

Документи отнасящи се до REC650	Идентификационен номер
Ръководство за приложение	1MRK 511 246-UEN
Техническо ръководство	1MRK 511 247-UEN
Ръководство за въвеждане в експлоатация	1MRK 511 248-UEN
Ръководство на клиента	1MRK 511 249-BEN
Сертификат за типово изпитване	1MRK 511 249-TEN

Документи отнасящи се до REG650	Идентификационен номер
Ръководство за приложение	1MRK 502 033-UEN
Техническо ръководство	1MRK 502 034-UEN
Ръководство за въвеждане в експлоатация	1MRK 502 035-UEN
Ръководство на клиента	1MRK 502 036-BEN
Сертификат за типово изпитване	1MRK 502 036-TEN
Земна защита за ротор с модули RXTTE4 и REG670	1MRG 001 910

Документи отнасящи се до REQ650	Идентификационен номер
Ръководство за приложение	1MRK 505 266-UEN
Техническо ръководство	1MRK 505 267-UEN
Ръководство за въвеждане в експлоатация	1MRK 505 268-UEN
Ръководство на клиента	1MRK 505 269-BEN
Сертификат за типово изпитване	1MRK 505 269-TEN

Ръководства за серия 650	Идентификационен номер
Ръководство за комуникационен протокол, DNP3	1MRK 511 241-UEN
Ръководство за комуникационен протокол, IEC 61850	1MRK 511 242-UEN

ВЯРНО С ОРИГИНАЛА

Ръководства за серия 650	Идентификационен номер
Ръководство за комуникационен протокол, IEC60870-5-103	1MRK 511 243-UEN
Ръководство със списък на точките, DNP3	1MRK 511 244-UEN
Инженерно ръководство	1MRK 511 245-UEN
Ръководство за работа	1MRK 500 093-UEN
Ръководство за инсталиране	1MRK 514 014-UEN

1.4 Символи и условности

1.4.1 Символи за безопасност

Този знак показва наличие на опасност от поразяване с електрически ток.

Този знак показва наличие на опасност от нараняване.

Този знак показва важна информация или предупреждение за идеите описани в текста. Той може да показва наличие на опасност, която може да причини Софтуерни грешки или повреда на оборудване или имущество.

Този знак обръща внимание на читателя за важни факти и състояния.

Този знак показва съвет, например как да направите свой собствен проект или как да използвате определени функции.

Въпреки че предупрежденията са свързани с лични наранявания, е необходимо да се разбере, че при определени условия работата с повредено оборудване може да доведе до понижена функционалност, която от своя страна може да доведе до лични наранявания или смърт. Ето защо трябва да се спазват стриктно всички предупредителни надписи.

1.4.2 Общи положения

Общи положения използвани в ръководствата на устройството. Някои положения може да не са разгледани в това ръководство.

- Съкращенията и абревиатурите в това ръководство са изнесени в краткия речник в края. Речникът съдържа също и определения и важни термини.
- Навигацията с бутони в менюто LHMI е представена с помощта на картинки например:
  За навигация между опции, се използва и .
- Пътят до менютата HMI е представен с удебелени букви, например: Избирате **Main menu/Settings.**
- LHMI съобщенията са показани в шрифт Courier, например:
  За да запазите промените в постоянната памет , изберете `Yes` и натиснете .
- Имената на параметрите са в наклонен шрифт, например:
  Функцията може да бъде включена или изключена със настройката *Operation*.
- Символът ^ поставен пред името на входен или изходен сигнал показва, че операторът може дефинира собствено име на сигнала в PCM600.
- Символът * поставен след името на входен или изходен сигнал показва, че сигнала трябва да бъде свързан към друг функционален блок за постигане на функционална конфигурация.

1.4.3 Функции включени в устройства серия 650

Таблица 1: Основни функции

IEC 61860 / Име на функцията	ANSI	Описание на функцията
Диференциална защита		
T2WPDIF	87T	Трансформаторна диференциална защита, две намотки
T3WPDIF	87T	Трансформаторна диференциална защита, три намотки
REFPDIF	87N	Нискоимпедансна земна защита
HZPDIF	87	Високоимпедансна диференциална защита
GENPDIF	87G	Генераторна диференциална защита
Импедансна защита		
ZQDPDIS	21	Дистанционна защита с пет зони, четири-зонална характеристика
FDPSPDIS	21	Избор на фаза, четири-зонална характеристика
ZMOPDIS	21	Дистанционна защита с характеристика на съпротивлението, която не минава през началото на координатната система (MHO)
FMPSPDIS	21	Идентификация за повредена фаза
ZDNRDIR	21	Посочна импедансна с четири-зонална характеристика и MHO

Таблицата продължава на следващата страница

IEC 61860 / Име на функцията	ANSI	Описание на функцията
PPLPHIZ		Преферентна логика на фаза
ZMRPSB	68	Посока на мощността
ZCVPSOF		Автоматичен ключ при неизправност, токова или напреженова
ZGPDIS	21G	Защита при нисък импеданс за генератори и трансформатори
LEXPDIS	40	Загуба на възбуждане
OOSPPAM	13	Защита за асинхронен ход
LEPDIS		Претоварване

Таблица 2: Допълнителни защитни функции

IEC 61860 / Име на функцията	ANSI	Описание на функцията
Токова защита		
PHPIOC	50	Внезапна максималнотокова защита
SPTPIOC	50	Внезапна максималнотокова защита
OC4PTOC	51/67	Четиристъпална максималнотокова защита
OC4SPTOC	51/67	Четиристъпална максималнотокова защита
EF4PTOC	50N	Внезапна остатъчна максималнотокова защита
EF4SPTOC	51N/67N	Внезапна четиристъпална остатъчна максималнотокова защита
SDEPPSDE	67N	Чувствителна посочна остатъчна максималнотокова и напреженова защита
UC2PTUS	37	Закъснителна двустъпална минималнотокова защита
LPTTR	26	Защита от термично претоварване с една времева константа
TRPTTR	49	Защита от термично претоварване с две времеви константи
CCRBRF	50BF	Защита за повреда в прекъсвача
CSPRBRF	50BF	Защита за повреда в прекъсвача
STBPTOC	50STB	Токова отсечка
CCRPLD	52PD	Защита от несъответствие на полюси
BRCPTOC	46	Проверка за прекъснат проводник
GUPPDUP	37	Защита по минимална мощност
GUPPDOP	32	Защита по максимална мощност
DNSPTOC	46	Максималнотокова защита за ток с отрицателна последователност
AEGGAPC	50AE	Защита за инцидентно захранване на синхронен генератор
NS2PTOC	46I2	Максималнотокова защита за ток с отрицателна последователност за машини
VR2PVOC	51V	Максималнотокова защита с ограничено напрежение
Напреженова защита		
UV2PTUV	27	Двустъпална минимално напреженова защита
OV2PTOV	59	Двустъпална максимално напреженова защита
ROV2PTOV	59N	Двустъпална остатъчна максимално напреженова защита
OEXPVPH	24	Защита от превъзбуждане

Таблицата продължава на следващата страница

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Подпис: ....

IEC 61860 / Име на функцията	ANSI	Описание на функцията
LOVPTUV	27	Проверка за загуба на напрежението
STEFPHIZ	64	100% статорна земна защита, базирана на 3-ти хармоник
Честотна защита		
SAPTUF	81	Функция ниска честота
SAPTOF	81	Функция висока честота
SAPFRC	81	Скорост на промяната на честотата

Таблица 3: Функции за управление и наблюдение.

IEC 61860 / Име на функцията	**ANSI**	**Описание на функцията**
Управление		
SESRSYN	25	Проверка за синхронизъм, проверка за захранванер, синхронизиране
SMBRREC	79	АПВ
STBRREC	79	АПВ
SCILO	3	Логически възли за заключване
BB_ES	3	Заключване на заземител на шинна система
A1A2_BS	3	Заключване на секционен прекъсвач
A1A2_DC	3	Заключване на секционен разединител
ABC_BC	3	Заключване за куплунг
BH_CONN	3	Заключване за 1 ½ прекъсвач
BH_LINE_A	3	Заключване за 1 ½ прекъсвач
BH_LINE_B	3	Заключване за 1 ½ прекъсвач
DB_BUS_A	3	Заключване за двоен прекъсвач
DB_BUS_B	3	Заключване за двоен прекъсвач
DB_LINE	3	Заключване за двоен прекъсвач
ABC_LINE	3	Заключване за извод
AB_TRAFO	3	Заключване на трансформаторен извод
SCSWI		Превключващ контролер
SXCBR		Прекъсвач
SXSWI		Превключвател
POS_EVAL		Оценка на индикатор за позиция
SELGGIO		Избор за освобождаване
QCBAY		Управление на шкаф
LOCREM		Поддържане позициите на LR-ключ
LOCREMCTRL		LHMI контрол на PSTO
TR8ATTCC	90	Автоматично управление на напрежението на янсенов регулатор, паралелно
TCMYLTC	84	Управление на янсенов регулатор и наблюдение, 6 двоични входа
SLGGIO		Логически ключ за избор на функция и LHMI презентация
Таблицата продължава на следващата страница		

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IEC 61860 / Име на функцията	ANSI	Описание на функцията
VSGGIO		Избор на разширение за малък прекъсвач
DPGGIO		IEC61850 двуточкова функция на обща входно-изходна комуникация
SPC8GGIO		Едноточково общо управление на 8 сигнала
AUTOBITS		Automation Bits, функция за управление на DNP3.0
I103CMD		Функционални команди за IEC60870-5-103
I103EDCMD		IED команди за IEC60870-5-103
I103USRCMD		Функционални команди дефинирани от потребителя за IEC60870-5-103
I103GENCMD		Функционални команди общи за IEC60870-5-103
I103POSCMD		IED команди със позиция и избор за IEC60870-5-103
Вторично системно наблюдение		
CCSRDIF	87	Следене на токови вериги
SDDRFUF		Следене за прекъснат предпазител
TCSSCBR		Следене на състояние на прекъсвач
Логически		
SMPPTRC	94	Логика за изключване
SPTPTRC	94	Логика за изключване
TMAGGIO		Логика на изключваща матрица
OR		Програмируеми логически блокове, OR
INVERTER		Програмируеми логически блокове, Inverter
PULSETIMER		Програмируеми логически блокове, PULSETIMER
GATE		Програмируеми логически блокове, Controllable gate
XOR		Програмируеми логически блокове, exclusive OR
LOOPDELEY		Програмируеми логически блокове, loop delay
TimeSet		Програмируеми логически блокове, timer
AND		Програмируеми логически блокове, AND
SRMEMORY		Програмируеми логически блокове, set-reset memory
RSMEMORY		Програмируеми логически блокове, reset-set memory
ANDQT		Програмируема логика Q/T, ANDQT
ORQT		Програмируема логика Q/T, ORQT
INVERTERQT		Програмируема логика Q/T,INVERTERQT
XORQT		Програмируема логика Q/T, XORQT
SRMEMORYQT		Програмируема логика Q/T, set reset със памет
RSMEMORYQT		Програмируема логика Q/T, reset-set със памет
TIMERSETQT		Програмируема логика Q/T, settable timer
PULSETIMERQT		Програмируема логика Q/T, pulse timer
INVALIDQT		Програмируема логика Q/T,INVALIDQT
INDCOMBSPQT		Програмируема логика Q/T, single-indication signal combining
INDEXTSPQT		Програмируема логика Q/T, single indication signal extractor
FXDSIGN		Фиксиран по сигнал функционален блок
Таблицата продължава на следващата страница		

IEC 61860 / Име на функцията	ANSI	Описание на функцията
B16I		Преобразуване от 16 булеви към цели числа
B16IFCVI		Преобразуване от 16 булеви към цели числа с показване на логични връзки
IB16A		Преобразуване от цели в 11 булеви числа
IB16FCVB		Преобразуване от цели в 11 булеви числа с показване на логични връзки
Мониторинг		
CVMMXN		Измервания
CMMXU		Измерване токът на фаза
VMMXU		Измерване на напрежението между две фази
CMXQI		Измерване на компонентите на последователност на тока
VMSQI		Измерване на последователност на напрежението
VNMMXU		Измерване на напрежението между фаза и неутрала
AISVBAS		Функционален блок за представяне на сервизни стойности на аналогови входове
TM_P_P2		Функционален блок за представяне на сервизни стойности на основните аналогови входове 600TRM
AM_P_P4		Функционален блок за представяне на сервизни стойности на основните аналогови входове 600AIM
TM_S_P2		Функционален блок за представяне на сервизни стойности на вторичните аналогови входове 600TRM
AM_S_P4		Функционален блок за представяне на сервизни стойности на вторичните аналогови входове 600AIM
CNTGGIO		Контролер на събитията
DRPRDRE		Доклад за нередности
AxRADR		Аналогови входни сигнали
BxRBDR		Цифрови входни сигнали
SPGGIO		IEC61850 входно-изходни функции за обща комуникация
SP16GGIO		IEC61850 входно-изходни функции за обща комуникация, 16 входа
MVGGIO		IEC61850 входно-изходни функции за обща комуникация
MVEXP		Блок за разширение за измерената стойност
LMBRFLO		Локатор за нередност
SPVNZBAT		Следене батерия на станцията
SSIMG	63	Функция за следене на газова изолация
SSIML	71	Функция за следене на течна изолация
SSCBR		Следене на състоянието на прекъсвач
I103MEAS		Измервания по IEC60870-5-103
I103MEASUSR		Измервания на предварително дефинирани сигнали по IEC60870-5-103
I103AR		Състояние „auto-recloser" по IEC60870-5-103
I103EF		Състояние земно съединение по IEC60870-5-103
I103FLTROT		Състояние неизправна защита по IEC60870-5-103
I103IED		Състояние на IED по IEC60870-5-103

IEC 61860 / Име на функцията	ANSI	Описание на функцията
I103SUPERV		Състояние на наблюдението по IEC60870-5-103
I103USRDEF		Състояние на предварително дефинирани сигнали по IEC60870-5-103
Измерване		
PCGGIO		Логика за импулсен брояч
ETPMMTR		Функция за изчисление на енергията и управление на търсенето

Таблица 4: Създаден да комуникира

IEC 61860 / Име на функцията	ANSI	Описание на функцията
Комуникация на станцията		
IEC61850-8-1		Комуникационен протокол IEC6161850
DNPGN CH1TCP CH2TCP CH3TCP CH4TCP MST1TCP MST2TCP MST3TCP MST4TCP		DNP3.0 за TCP/IP комуникационен протокол
DNPFREC		DNP3.0 запис на нередности за TCP/IP комуникационен протокол
IED61870-5-103		IEC60870-5-103 серийна комуникация през COM02
GOOSEINTLKRCV		Хоризонтална комуникация през GOOSE за заключване
GOOSEBINRCV		GOOSE binary receive
GOOSEVCTRCONF		GOOSE VCTR конфигурация за изпращане и получаване
VCTRSEND		Блок за изпращане на управление на напрежението за GOOSE
GOOSEVCTRRCV		Блок за получаване на управление на напрежението за GOOSE
ETHFRNT ETHLAN1 GATEWAY		Мрежова конфигурация на порт отпред, LAN1 порт и gateway
GOOSEDPRCV		Функционален блок GOOSE за получаване на стойности на двойна точка
GOOSEINTRCV		Функционален блок GOOSE за получаване на стойност цяло число
GOOSEMVRCV		Функционален блок GOOSE за получаване на измерена стойност
GOOSESPRCV		Функционален блок GOOSE за получаване на стойност на единична точка
Схемна комуникация		
ZCPSCH	85	Комуникационна логика за разстояние или максимално-токова защита
ZCRWPSCH	85	Логика за смяна на посоката или недостатъчен ток за дистанционна защита
ZCWSPSCH	85	Логика за смяна на посоката или недостатъчен ток за дистанционна защита
ZCLCPLAL		Логика за локално ускорение
ECPSCH	85	Комуникационна логика за максимално-токова защита за остатъчен ток
ECRWPSCH	85	Логика при обратна полярност или недостатъчен ток за МТЗ за остатъчен ток

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Таблица 5: Основни IED функции

IEC 61860 / Име на функцията		Описание на функцията
Основни функции включени във всички продукти		
INTERRSIG		Самонаблюдение със вътрешен списък на събитията
SELFSUPEVLST		Самонаблюдение със вътрешен списък на събитията
TIMESYNCHGEN		Време синхронизация
SNTP		Време синхронизация
DTSBEGIN		Време синхронизация
DTSEND		Време синхронизация
TIMEZONE		Време синхронизация
IRIG-B		Време синхронизация
SETGPRS		Група настройка за поддържане
ACTVGPR		Групи настройка на параметър
TESTMODE		Функционалност на тестов режим
CHNGLCK		Промяна на функцията за заключване
ATHSTAT		Статус на правомощие
ATHCHCK		Проверка на правомощие
TERMINALID		IED идентификатори
PRODINF		Информация за продукта
PRIMVAL		Основни системни стойности
SMAI_20_1 – SMAI_20_12		Сигнална матрица за аналогови входове
3PHSUM		Блок за сумиране, 3 фази
GBASSVAL		Общи основни стойности за настройки
DOSFRNT		Отказ за работа, контрол на цикли за преден порт
DOSLAN1		Отказ за работа, контрол на цикли за LAN1 порт
DOSSCKT		Отказ за работа, управление на пренос

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Глава 2 Въздействие върху околната среда

2.1 Устойчиво развитие

Устойчивостта е взета под внимание още със започването на създаването на устройството, заедно с екологично производство, дълъг живот на работа, експлоатационна надеждност и извеждане от употреба.

Изборът на материали и доставчици е направен според директивата на Европейският съюз RoHS (2002/95/EC). Тази директива ограничава използването на следните вредни вещества:

Таблица 6: Максимална концентрация на плътност на хомогенния материал

Вещество	Предложена максимална концентрация
Олово – Pb	0,1%
Живак – Hg	0,1%
Кадмий – Cd	0,01%
Шест-валентен хром Cr (VI)	0,1%
Полибромирани бифенили – PBB	0,1%
Полибромирани дифенили етери - PBDE	0,1%

Интензивни изпитвания по време на проектиране и производството осигуряват експлоатационна надеждност и дълъг живот. Освен това дългият живот е подсигурен с поддръжка, ремонт и възможност за снабдяване с резервни части.

Проектирането и производството са извършени в сертифицирана екологична система. Ефективността на тази система се оценява системно от външен контролен орган. Ние спазваме екологичните норми и регулации без изключение за да оценим тяхното влияние върху нашите продукти и процеси.

2.2 Изхвърляне на устройството

Определенията и наредбите за вредни материали са специфични за всяка страна и се променят при промяна на познанието за тях. Материалите използвани в това устройство са типични за Електрическите и електронните устройства.

Всички части използвани в този продукт подлежат на рециклиране. Когато изхвърляте устройството или части от него се свържете с местна компания за сметосъбиране на електрически и електронни отпадъци. Те могат да сортират материалите и да ги изхвърлят според местните наредби и изисквания.

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Таблица 7: Материали в частите на устройството

IED	Части	Материали
Устройство	Метални плочи,части и болтчета	Желязо
	Пластмасови части	PC[1)], LPC[2)]
	LHMI дисплей	Различни
Опаковка	Кутия	Картон
Допълнителни	Ръководства	Хартия

1) Поликарбонат
2) Течно-кристален полимер

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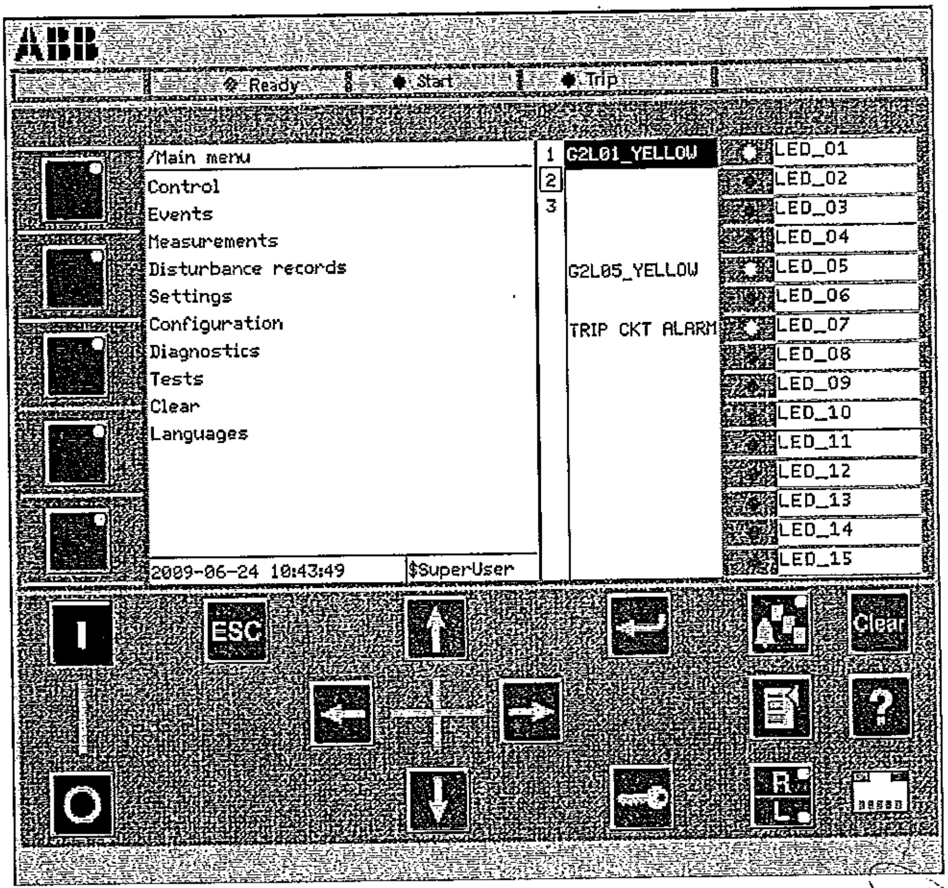
Глава 3 Общ преглед на серия 650

3.1 Локален HMI



Фигура 2: Локален интерфейс човек-машина

LHMI на IED съдържа следните елементи

- Дисплей (LCD)
- Бутони
- Светодиодни индикатори
- Комуникационен порт

LHMI се използва за настройване, мониторинг и управление.

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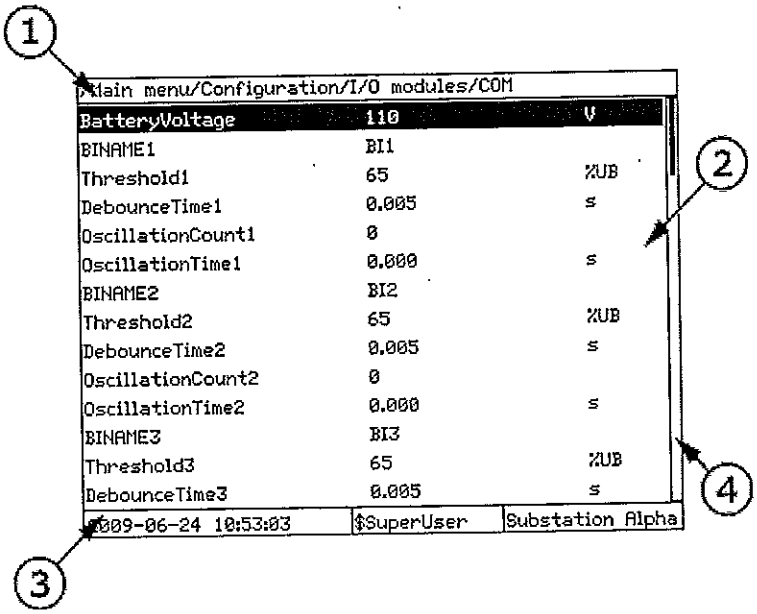
3.1.1 Дисплей

LHMI включва графичен монохромен дисплей с разделителна способност 320 x 240 пиксела. Размерът на символите може да варира. Количеството символи и редове събиращи се на дисплея зависи от размерът на символите и какво точно се вижда на него.

Изгледа на дисплея се разделя на четири основни полета.



Фигура 3: Оформление на екрана

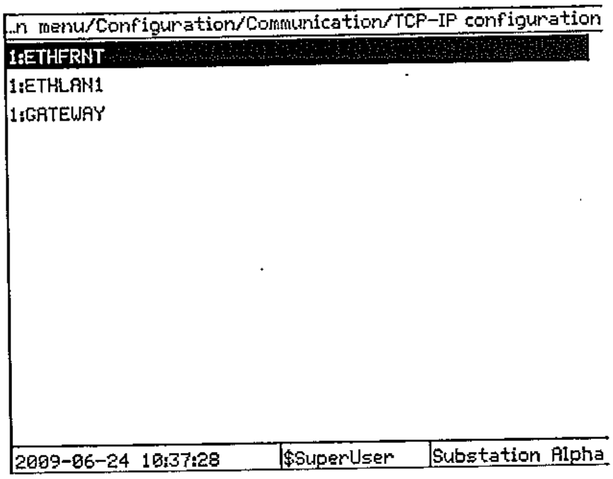
1 Път

2 Съдържание

3 Статус

4 Плъзгач (появява се когато има нужда от него)

- Пътят показва текущото положение в структурата на менюто. Ако пътят е твърде дълъг за да се покаже, той се прекъсва от началото и това се отбелязва с точки.
- Съдържанието показва съдържанието на менюто.
- Полето за статус показва текущо време, потребителят, който в момента го ползва и идентификационен стринг, който може да се зададе през LHMI или с PCM600.
- Ако текст, изображение или друго не се събират на екрана, се появява вертикален плъзгач вдясно. Прекъсвания се показват с три точки.

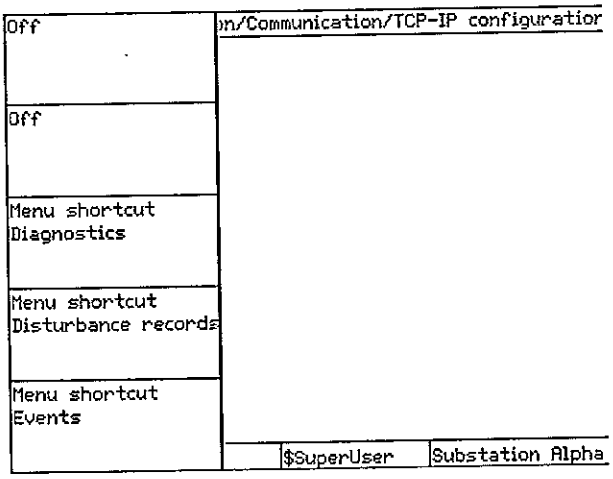


Фигура 4: Прекъснат път

Номерът преди функцията, например `1:ETHFRNT`, показва пореден номер.

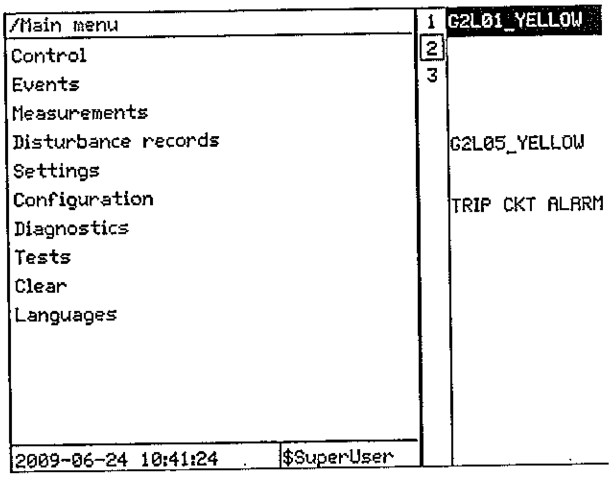
Екрана се опреснява циклично или на базата на промени в изходните данни като параметри или събития.

При посочване панелът с бутони с функции показва възможните действия. Всяка функция има светодиоден индикатор, който може да бъде използван като обратна връзка за съответната функция. Светодиодът е свързан с съответния сигнал с PCM600.



Фигура 5: Панел с бутони за функции

При необходимост към сигналния светодиод се показва пояснителен тест.



Фигура 6:.Панел със сигналите на светодиодите

Бутоните с функции и сигналните светодиоди не могат да се видят едновременно. Всеки от панелите се показва чрез натискане на един от бутоните или от бутона „Multipage". Натискането на бутона „ESC" изчиства панелът от екрана. И двата панела имат динамично променяща се ширина, която зависи от дължината на етикета на стринга, който панелът съдържа.

3.1.2 Светодиоди

LHMI включва три защитни индикации над екрана: Готов, Старт и Прекъсване.

Също така от предната страна на LHMI има матрица с 15 програмируеми светодиода. Всеки светодиод може да представя три състояния със съответните цветове: зелен жълт и червен. Сигналните текстове свързани с цветовете на светодиодите се разделят на три страници и могат да бъдат прегледани със бутонът „Multipage". Физически $15^{-те}$ светодиода от една група, могат да показват 45 различни сигнала. Общо 135 сигнала могат да бъдат представени тъй като има 3 групи по 15 светодиода. Светодиодите могат да се конфигурират със PCM600 и начинът на работа може да бъде избиран със LHMI от PCM600.

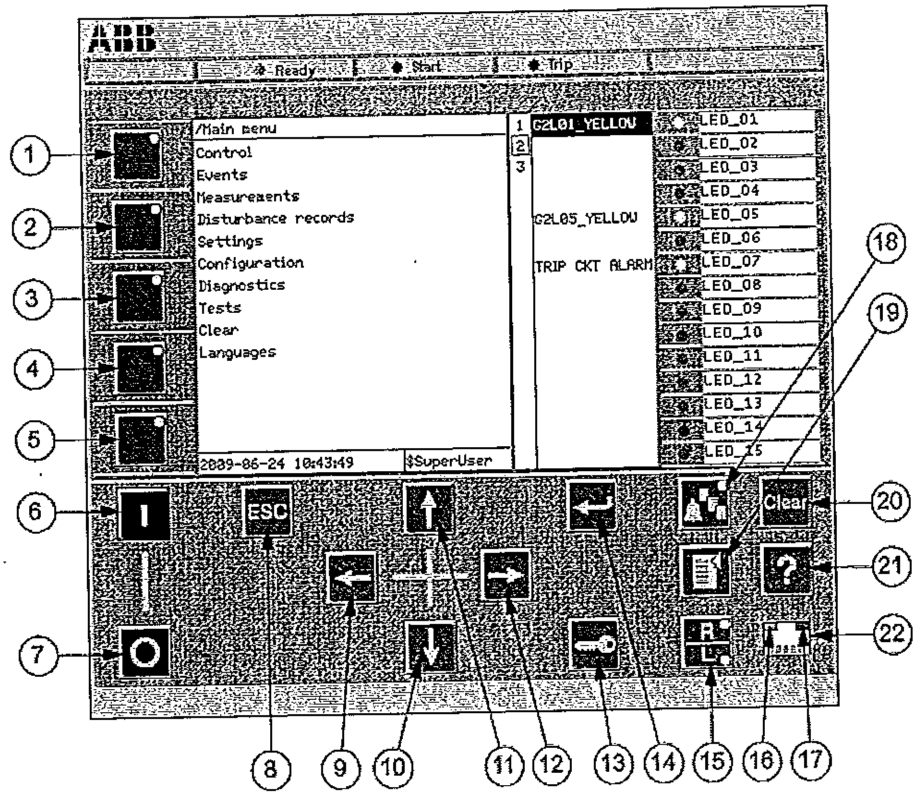
3.1.3 Клавиатура

LHMI клавиатурата съдържа бутони, които се използват за навигация на различни изгледи от менюто. Със бутоните могат да се избират команди за отваряне и затваряне на един основен обект, например прекъсвач, разединител или заземител. Бутоните се използват и за потвърждение на сигнали, индикации за изчистване, дават упътвания и превключват от местно на дистанционно управление.

Също така клавиатурата съдържа програмируеми бутони които могат да бъдат конфигурирани като кратък път към меню или бутони за управление.

ВЯРНО С ОРИГИНАЛА

Подпис:



Фигура 7: LHMI клавиатура със управление на обекти, навигация и бутони за управление и RJ45 комуникационен порт

1..5	Бутони
6	Затваряне
7	Отваряне
8	Излизане
9	Наляво
10	Надолу
11	Нагоре
12	Надясно
13	Ключ
14	Влизане
15	Дистанционно/Местно
16	Индикация за свързаност
17	Не се използва
18	Бутон „Multipage“
19	Меню
20	Изчистване
21	Помощ
22	Комуникационен порт

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Управление на обекти

Ако управлението на устройството е нагласено на местно с бутонът R/L, то може да се управлява посредством бутоните за управление.

Обекта за управление се избира от еднолинейната схема.

Таблица 8: Бутони за управление на обект

Име	Обяснение
Затваряне	Затваря обекта
Отваряне	Отваря обекта

Навигация

Бутоните със стрелки се използват за навигация. За преглеждане на информацията по-надолу натиснете бутона със стрелка надолу няколко пъти или го задръжте натиснат продължително време.

Таблица 9: Бутони за навигация

Име	Обяснение
Излизане	• Напускане на настройки без запазване на промените. • Прекратяване на конкретни действия. • Настройване на контраста на екрана в комбинация с и . • Промяна на езикът в комбинация с и . • Стартиране на тест на екрана в комбинация с . • Изтриване на символ в комбинация с при промяна на стринг • Вмъкване на интервал в комбинация с при промяна на стринг.
Влизане	• Влизане в режим за настройване на параметър. • Потвърждаване на нова стойност на параметър. • Потвърждаване на избор в менюта и панел със сигнали.
Нагоре Надолу	• Придвижване нагоре и надолу в менюта. • Избиране на обект в SLD. • Придвижване нагоре и надолу в менюта и панел със сигнали. • Избиране на символи от параметър при настройване на нови стойности.
Наляво Надясно	• Придвижване наляво и надясно в менюта. • Избиране на страница в SLD. • Промяна на активен символ на параметър при въвеждане на нова стойност.
Ключ	• Активиране на процедурата за упълномощаване , когато операторът не е влязъл в системата. • Излизане от системата, когато операторът е влязъл.

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Команди

Име	Обяснение
Меню	• Придвижване към Основното меню, ако текущото положение е в друго меню. • Придвижване към нормален изглед, ако текущото състояние е в основното меню.
R/L	Промяна на позицията за управление (дистанционно или местно) на устройството. • Когато светодиодът R свети, дистанционния контрол е възможен а местен – не. • Когато светодиодът L свети, местния контрол е възможен, а дистанционния - не. • Когато никой от светодиодите не свети и двата вида управление е невъзможен.
Изчистване	• Активира изгледа Изчистване/Зануляване.
Помощ	• Показва помощно меню
„Multipage“	• Отваря панелът със сигналите и служи за избиране на сигнализация от този изглед на екрана.

Функционални Бутони

Таблица 11: Функционални бутони

Име	Обяснение
Функционален Бутон	Като се изключи дефинираната функция: Изключване, кратък път до меню или цифрово управление.

3.1.4 Местна функционалност на HMI

3.1.4.1 Индикации за защита и известяване

Защитни индикатори

Защитните светодиодни индикатори са Готовност, Старт и Прекъсване.

Необходимо е да се настрои записването на нередности за да заработят светодиодите за Старт и Прекъсване.

Таблица 12: Светодиод за Готовност (зелен)

Статус	Обяснение
Не свети	Изключено е външното поддържащо захранване.
Свети	Нормална работа.
Мига	Интернет проблем.

ВЯРНО С ОРИГИНАЛА

Таблица 13: Светодиод за Старт (Жълт)

Статус	Обяснение
Не свети	Нормална работа.
Свети	Функция на защитата е стартирана и е показано съобщение. Функцията старт е изпълнена и трябва да се изчисти чрез комуникация или с натискане на бутона Clear.
Мига	Мигащ светодиод има по висок приоритет от светещ. Устройството е в тестов режим защитните функции не работят. Индикацията изчезва когато устройството престане да бъде в тестов режим и защитните функции заработят.

Таблица 14: Светодиод за Прекъсване (червен)

Статус	Обяснение
Не свети	Нормална работа.
Свети	Защитна функция е прекъсната и се показва съобщение. Индикацията за прекъсване стои и трябва да бъде изчистена чрез комуникация или с натискане на бутона Clear.

Индикации за известяване

Петнайсетте програмируеми светодиода се използват за известяване. На единичен сигнал се свързан с един от светодиодните блокове може да се присъедини определен цвят, при конфигурирането на устройството .

Таблица 15: Индикации за известяване

Статус	Обяснение
Не свети	Нормална работа. Няма сигнали.
Свети	• Follow-S sequence: Сигналът за активиране е включен. • LachedColl-S sequence: Сигналът за активиране е включен или изключен, а индикацията не е потвърдена. • LachedAsk-F-S sequence: Индикацията е потвърдена, но сигналът за активиране е все още включен. • LachedAsk-S-F sequence: Сигналът за активиране е включен или изключен, а индикацията не е потвърдена. • LachedReset-S sequence: Сигналът за активиране е включен или изключен, а индикацията не е потвърдена.
Мига	• Follow-F sequence: Сигналът за активиране е включен. • LachedAsk-F-S sequence: Сигналът за активиране е включен или изключен, а индикацията не е потвърдена. • LachedAsk-S-F sequence: Индикацията е потвърдена, но сигналът за активиране е все още включен.

Индикации за известяване за REB650

Таблица 16: Конфигурация на група за известяване 1 в REB650 (A03)

Група за известяване 1	Цвят светодиод	Етикет
GRP1_LED1	Червен	Z1 TRIP
GRP1_LED2	Червен	Z2 TRIP
GRP1_LED3	Червен	Z3 TRIP
GRP1_LED4	Червен	BUS1 U TRIP
GRP1_LED5	Червен	BUS2 U TRIP
GRP1_LED6	Червен	OC EF NS TRIP
GRP1_LED7	Червен	PD TRIP
GRP1_LED8	-	-
GRP1_LED9	-	-
GRP1_LED10	-	-
GRP1_LED11	-	-
GRP1_LED12	-	-
GRP1_LED13	-	-
GRP1_LED14	-	-
GRP1_LED15	-	-

Таблица 17: Конфигурация на група за известяване 2 в REB650 (A03)

Група за известяване 2	Цвят светодиод	Етикет
GRP2_LED1	Жълт	Z1 ALARM
GRP2_LED2	Жълт	Z2 ALARM
GRP2_LED3	Жълт	Z3 ALARM
GRP2_LED4	Жълт	BUS1 U START
GRP2_LED5	Жълт	BUS2 U START
GRP2_LED6	Жълт	OC4 EF NS START
GRP2_LED7	Жълт	OCCRPLD START
GRP2_LED8	-	-
GRP2_LED9	-	-
GRP2_LED10	-	-
GRP2_LED11	-	-
GRP2_LED12	-	-
GRP2_LED13	-	-
GRP2_LED14	-	-
GRP2_LED15	Червен	-

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Таблица 18: Конфигурация на група за известяване 3 в REB650 (A03)

Група за известяване 3	Цвят светодиод	Етикет
GRP3_LED1- GRP3_LED14	-	-
GRP3_LED15	Червен	BAT SUP ALARM

Индикации за известяване за REC650

Таблица 19: Конфигурация на група за известяване 1 в REC650 (A02)

Група за известяване 1	Цвят светодиод	Етикет
GRP1_LED1	Червен	GENERAL TRIP
GRP1_LED2	Червен	CB FAIL TRIP
GRP1_LED3	Червен	50/51 OC TRIP
GRP1_LED4	Червен	51N EF TRIP
GRP1_LED5	Червен	59 OV TRIP
GRP1_LED6	Червен	52 PD TRIP
GRP1_LED7	Червен	EXTERNAL TRIP
GRP1_LED8	Червен	LOCKOUT TRIP
GRP1_LED9	-	-
GRP1_LED10	-	-
GRP1_LED11	-	-
GRP1_LED12	-	-
GRP1_LED13	-	-
GRP1_LED14	-	-
GRP1_LED15	-	-

Таблица 20: Конфигурация на група за известяване 2 в REC650 (A02)

Група за известяване 2	Цвят светодиод	Етикет
GRP2_LED1	Жълт	GENERAL START
GRP2_LED2	-	-
GRP2_LED3	Жълт	51 OC START
GRP2_LED4	Жълт	51N EF START
GRP2_LED5	Жълт	59 OV START
GRP2_LED6	Жълт	52 PD START
GRP2_LED7	-	-
GRP2_LED8	-	-
GRP2_LED9	-	-
GRP2_LED10	-	-
GRP2_LED11	-	-
GRP2_LED12	-	-
GRP2_LED13	-	-

Таблицата продължава на следващата страница

Група за известяване 2	Цвят светодиод	Етикет
GRP2_LED14	-	-
GRP2_LED15	-	-

Таблица 21: Конфигурация на група за известяване 3 в REC650 (A02)

Група за известяване 3	Цвят светодиод	Етикет
GRP3_LED1- GRP3_LED9	-	-
GRP3_LED10	Жълт	SELECT IN BAY
GRP3_LED11	Жълт	EXT RESERV
GRP3_LED12	Жълт	SYNCHRONIZING INPR
GRP3_LED13	Жълт	CB SUPV ALARM
GRP3_LED14	Жълт	TCS ALARM
GRP3_LED15	Червен	BAT SUP ALARM
	Жълт	BAT SUP START

Индикации за известяване за REG650

Таблица 22: Конфигурация на група за известяване 1 в REG650 (B05)

Група за известяване 1	Цвят светодиод	Етикет
GRP1_LED1	Червен	DIFF PROT TRIP
GRP1_LED2	Червен	STATOR EF TRIP
GRP1_LED3	Червен	ROTOR EF TRIP
GRP1_LED4	Червен	EF PROT TRIP
GRP1_LED5	Червен	VOLT PROT TRIP
GRP1_LED6	Червен	FREQ PROT TRIP
GRP1_LED7	Червен	GEN PROT TRIP
GRP1_LED8	Червен	GEN BU PROT TRIP
GRP1_LED9	Червен	AUX TRF PROT TRIP
GRP1_LED10	Червен	STEPUP TRF TRIP
GRP1_LED11	Червен	PLD TRIP
GRP1_LED12	Червен	CB FAIL TRIP
GRP1_LED13	Червен	EXTERNAL TRIP
GRP1_LED14	Жълт	P&Q ALARM
GRP1_LED15	Жълт	VOLT ALARM

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Таблица 23: Конфигурация на група за известяване 2 в REG650 (B05)

Група за известяване 2	Цвят светодиод	Етикет
GRP2_LED1	Жълт	DIFF PROT START
GRP2_LED2	Жълт	STATOR EF START
GRP2_LED3	Жълт	ROTOR EF START
GRP2_LED4	Жълт	EF PROT START
GRP2_LED5	Жълт	VOLT PROT START
GRP2_LED6	Жълт	FREQ PROT START
GRP2_LED7	Жълт	GEN PROT START
GRP2_LED8	Жълт	GEN BU PROT START
GRP2_LED9	Жълт	AUX TRF PROT START
GRP2_LED10	Жълт	STEPUP TRF START
GRP2_LED11	Жълт	PLD START
GRP2_LED12	Жълт	GEN UNDEREXCITED
GRP2_LED13	Жълт	FREQ ALARM
GRP2_LED14	Жълт	PF ALARM
GRP2_LED15	Жълт	FUSE FAIL ALARM

Таблица 24: Конфигурация на група за известяване 3 в REL650 (A05)

Група за известяване 3	Цвят светодиод	Етикет
GRP3_LED1-GRP3_LED11	-	-
GRP3_LED12	Жълт	GEN CB TCS ALARM
GRP3_LED13	Жълт	FIELD CB TCS ALARM
GRP3_LED14	Жълт	TURBINE TCS ALARM
GRP3_LED15	Червен	BAT SUP ALARM
	Жълт	BAT SUP START

Индикации за известяване за REL650

Таблица 25: Конфигурация на група за известяване 1 в REL650 (A05)

Група за известяване 1	Цвят светодиод	Етикет
GRP1_LED1	Червен	DIST PROT TRIP
GRP1_LED2	Червен	OC PROT TRIP
GRP1_LED3	Червен	EF PROT TRIP
GRP1_LED4	Червен	CARRIER AID TRIP
GRP1_LED5	Червен	VOLT PROT TRIP
GRP1_LED6	-	-
GRP1_LED7	-	-
GRP1_LED8	-	-
GRP1_LED9	Жълт	BRC ALARM

Таблицата продължава на следващата страница

Група за известяване 1	Цвят светодиод	Етикет
GRP1_LED10	-	-
GRP1_LED11	-	-
GRP1_LED12	-	-
GRP1_LED13	-	-
GRP1_LED14	-	-
GRP1_LED15	-	-

Таблица 26: Конфигурация на група за известяване 2 в REL650 (A05)

Група за известяване 2	Цвят светодиод	Етикет
GRP2_LED1	Жълт	GEN START ZQ
GRP2_LED2	Жълт	GEN START OC
GRP2_LED3	Жълт	GEN START EF
GRP2_LED4	-	-
GRP2_LED5	Жълт	GEN START OV
GRP2_LED6	Жълт	GEN START L1
GRP2_LED7	Жълт	GEN START L2
GRP2_LED8	Жълт	GEN START L3
GRP2_LED9	-	-
GRP2_LED10	-	-
GRP2_LED11	-	-
GRP2_LED12	-	-
GRP2_LED13	-	-
GRP2_LED14	-	-
GRP2_LED15	-	-

Таблица 27: Конфигурация на група за известяване 3 в REL650 (A05)

Група за известяване 3	Цвят светодиод	Етикет
GRP3_LED1- GRP3_LED9	-	-
GRP3_LED10	Жълт	Z BLOCK
GRP3_LED11	Жълт	U BLOCK
GRP3_LED12	-	-
GRP3_LED13	Жълт	CB SUPV ALARM
GRP3_LED14	Жълт	TCS ALARM
GRP3_LED15	Червен	BAT SUP ALARM
	Жълт	BAT SUP START

ВЯРНО С ОРИГИНАЛА

Индикации за известяване за REQ650

Таблица 28: *Конфигурация на група за известяване 1 в REQ650 (B11)*

Група за известяване 1	Цвят светодиод	Етикет
GRP1_LED1	Червен	GENERAL TRIP L1
GRP1_LED2	Червен	GENERAL TRIP L2
GRP1_LED3	Червен	GENERAL TRIP L3
GRP1_LED4	Червен	CB FAIL TRIP
GRP1_LED5	Червен	50/51 OC TRIP
GRP1_LED6	Червен	51N/67N EF TRIP
GRP1_LED7	Червен	59 OV TRIP
GRP1_LED8	Червен	52 PD TRIP
GRP1_LED9	Червен	46 BRC TRIP
GRP1_LED10	Червен	26 THOL TRIP
GRP1_LED11	Червен	EXTERNAL TRIP
GRP1_LED12	Червен	TRIP LOCKOUT
GRP1_LED13	-	-
GRP1_LED14	-	-
GRP1_LED15	-	-

Таблица 29: *Конфигурация на група за известяване 2 в REQ650 (B11)*

Група за известяване 2	Цвят светодиод	Етикет
GRP2_LED1	Червен	GENERAL START L1
GRP2_LED2	Жълт	GENERAL START L2
GRP2_LED3	Жълт	GENERAL START L3
GRP2_LED4	-	-
GRP2_LED5	Жълт	51 OC START
GRP2_LED6	Жълт	51N/67N EF START
GRP2_LED7	Жълт	59 OV START
GRP2_LED8	Жълт	52 PD START
GRP2_LED9	Жълт	46 BRC START
GRP2_LED10	Жълт	26 THOL START
GRP2_LED11	-	-
GRP2_LED12	-	-
GRP2_LED13	-	-
GRP2_LED14	-	-
GRP2_LED15	-	-

Таблица 30: Конфигурация на група за известяване 3 в REQ650 (B11)

Група за известяване 3	Цвят светодиод	Етикет
GRP3_LED1- GRP3_LED9	-	-
GRP3_LED10	Жълт	26 THOL ALARM
GRP3_LED11	-	-
GRP3_LED12	Жълт	SYNCH IN PROG
GRP3_LED13	Жълт	CB SUPERV ALARM
GRP3_LED14	Жълт	TRIP CCT ALARM
GRP3_LED15	Червен	STAT BATT ALARM
	Жълт	STAT BATT START

Индикации за известяване за RET650

Таблица 31: Конфигурация на група за известяване 1 в RET650 (A07)

Група за известяване 1	Цвят светодиод	Етикет
GRP1_LED1	Червен	T1 CURRENT TRIP
GRP1_LED2	Червен	T1 VOLTAGE TRIP
GRP1_LED3	Жълт	T1 POSERRAL
GRP1_LED4	Жълт	T1 CMDERRAL
GRP1_LED5	Жълт	T1 TCERRAL
GRP1_LED6	Жълт	T1 CONVERR
GRP1_LED7	Жълт	T1 HIDIFPOS
GRP1_LED8	Жълт	T1 INVALPOS
GRP1_LED9	Зелен	T1 UGTUPPDB
GRP1_LED10	Зелен	T1 ULTLOWDB
GRP1_LED11	Зелен	T1 TIMERON
GRP1_LED12	Зелен	T1 URAISE
GRP1_LED13	Зелен	T1 ULOWER
GRP1_LED14	Зелен	T1 CTRL MAN
GRP1_LED15	Зелен	T1 CTRL AUTO

Таблица 32: Конфигурация на група за известяване 2 в RET650 (A07)

Група за известяване 2	Цвят светодиод	Етикет
GRP2_LED1	Червен	T2 CURRENT TRIP
GRP2_LED2	Червен	T2 VOLTAGE TRIP
GRP2_LED3	Жълт	T2 POSERRAL
GRP2_LED4	Жълт	T2 CMDERRAL
GRP2_LED5	Жълт	T2 TCERRAL
GRP2_LED6	Жълт	T2 CONVERR
GRP2_LED7	Жълт	T2 HIDIFPOS

Таблицата продължава на следващата страница

Група за известяване 2	Цвят светодиод	Етикет

GRP2_LED8	Жълт	T2 INVALPOS
GRP2_LED9	Зелен	T2 UGTUPPDB
GRP2_LED10	Зелен	T2 ULTLOWDB
GRP2_LED11	Зелен	T2 TIMERON
GRP2_LED12	Зелен	T2 URAISE
GRP2_LED13	Зелен	T2 ULOWER
GRP2_LED14	Зелен	T2 CTRL MAN
GRP2_LED15	Зелен	T2 CTRL AUTO

Таблица 33: Конфигурация на група за известяване 3 в RET650 (A07)

Група за известяване 3	Цвят светодиод	Етикет
GRP3_LED1- GRP3_LED12	-	-
GRP3_LED13	Жълт	TRIP CKT1 ALARM
GRP3_LED14	Жълт	TRIP CKT2 ALARM
GRP3_LED15	Червен	ST BAT ALARM
	Жълт	ST BAT START

3.1.4.2 Управление на параметър

LHMI се използва за достъп до параметрите на устройството. Три вида параметри могат да бъдат четени и записвани.

- Числени стойности
- Стрингови стойности
- Изброени стойности

Числените стойности са представени или в целочислен формат или във формат с десетична запетая със минимална и максимална стойност. Всеки стринг може да се променя символ по символ. Изброените стойности имат предварително дефинирани избираеми стойности.

3.1.4.3 Комуникация от предния панел

Порта RJ-45 в LHMI разрешава комуникация от предния панел.

- Зеления светодиод на порта на предния панел светва когато се включи успешно кабел за комуникация.

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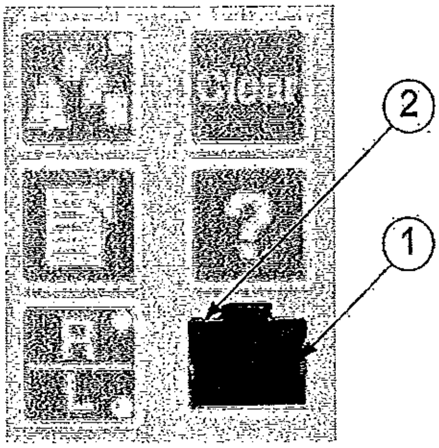

Фигура 8: Комуникационен порт RJ-45 и зелен светодиод

1 RJ-45 конектор

2 Зелен светодиод

Когато се свърже компютър към устройството със „crossed-over" кабел, DHCP сървъра дава IP адрес на компютъра ако е включена функцията *DHCPServer* = *On*. IP адресът от предния панел по подразбиране е 10.1.150.3.

Не свързвайте устройството в LAN мрежа. Свържете се само с компютър със PCM600 към предния порт.

3.1.4.4 Еднолинейна схема

Еднолинейна схема се използва за наблюдение и/или управление. Показва се графично изображение на схемата конфигурирана със PCM600.

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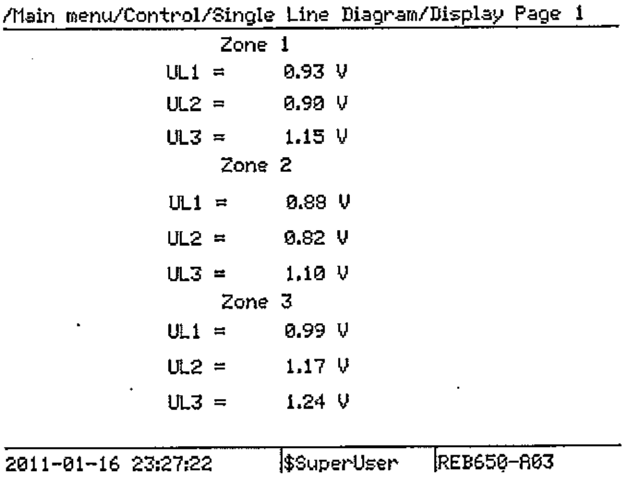
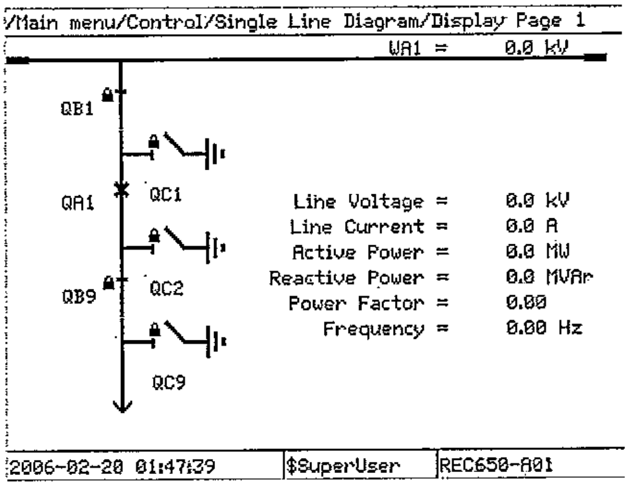
Еднолинейна схема за REB650



Фигура 9: Еднолинейна схема за REB650 (A03)

Еднолинейна схема за REC650



Фигура 10: Еднолинейна схема за REB650 (A01)

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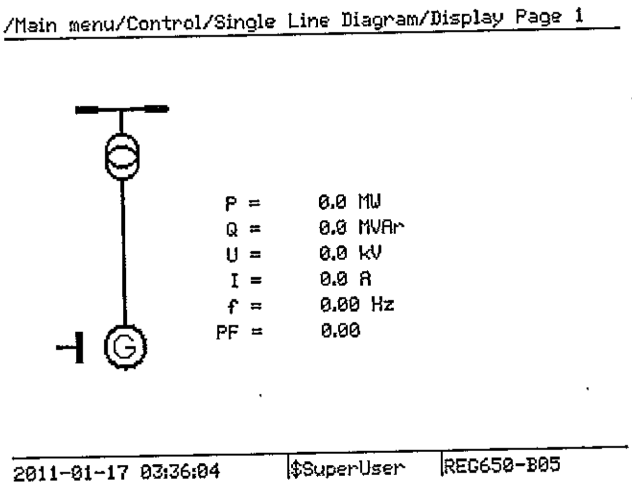
Еднолинейна схема за REG650



Фигура 11: Еднолинейна схема за REG650 (B05)

Еднолинейна схема за REL650

/Main menu/Control/Single Line Diagram/Line Measurement

Line Voltage =	0.0 kV
Line Current =	0.0 A
Active Power =	0.0 MW
Reactive Power =	0.0 MVAr
Power Factor =	0.00
Frequency =	0.00 Hz

2011-01-25 01:37:03	$SuperUser	REL650-A01

Фигура 12: Еднолинейна схема за REL650 (A01)

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Еднолинейна схема за REQ650

/Main menu/Control/Single Line Diagram/Display Page 1

Line Voltage =	0.0 kV
Line Current =	0.0 A
Active Power =	0.0 MW
Reactive Power =	0.0 MVAr
Power Factor =	0.00
Frequency =	0.00 Hz

2010-12-29 01:06:39 | $SuperUser | REQ650-A11

Фигура 13: Еднолинейна схема за REQ650 (A11)

Еднолинейна схема за RET650

/Main menu/Control/Single Line Diagram/W2 Measurands

W2 Voltage =	0.0 kV
W2 Current =	0.0 A
W2 Active Power =	0.0 MW
W2 Reactive Power =	0.0 MVAr
W2 Power Factor =	0.00
W2 Frequency =	0.00 Hz

2011-01-26 15:13:06 | $SuperUser | RET650-A01

Фигура 14: Еднолинейна схема за RET650 (A01)

3.2 Правоспособност

Има възможност за създаване на категории потребители и да се редактират само с PCM600. Един потребител може да принадлежи на една или повече категории.

Вярно с оригинала

При доставка на устройството потребителя има пълен достъп докато не е се създадат профили със PCM600. Влизане в потребителски профил не е нужно за HMI.

Таблица 34: Предварително дефинирани категории потребители.

Категория	Потребителски права
SystemOperator	Управление през LHMI, без байпас
ProtectionEngineer	Всички настройки
DesignEngineer	Конфигурация на приложение
UserAdministrator	Потребителска и администраторска парола

Всички промени във потребителските настройки предизвикват рестартиране на устройството.

3.3 Комуникация

Устройството поддържа комуникационни протоколи по IEC 61850-8-1, IEC 60870-5-103 и DNP3 през TCP/IP.

Цялата операционна информация и управление са възможни през тези протоколи. Достъпът до файловете с нередности е също възможен през всички мрежово базирани приложения в стандартния COMMTRADE формат. Устройството може да изпраща цифрови сигнали до други устройства (така наречената хоризонтална комуникация) използвайки IEC 61850-8-1 GOOSE (Generic Object Oriented Substation Event) профил. Цифровите GOOSE съобщения, например могат да бъдат използвани за защита и вътрешно заключващи схеми. Устройството отговаря на изискванията за производителност на GOOSE за приложения за прекъсване в подстанции, както е дефинирано и в стандарта IEC61850. Освен това устройството поддържа получаване и изпращане на аналогови стойности чрез GOOSE съобщения. Аналоговите съобщения GOOSE позволяват бърз трансфер на стойности през шините на станцията, като по този начин улесняват споделянето на входни стойности RTD, както и стойности на околната температура на други устройства. Устройството с други IEC 61850 съвместими устройства, инструменти и системи и едновременно докладва събития на пет различни потребителя на IEC61850 станция. За системи използващи DNP3 през TCP/IP, събития могат да се изпращат на четири различни потребителя. Системи използващи IEC60870-5-103 устройства могат да се свържат към една главна станция със лъчева топология.

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Всички връзки за комуникация с изключение на предния панел са разположени във вградения комуникационен модул. Устройството е свързано към мрежово базирана комуникационна система през RJ-45 конектор (10/100BASE-FX).

IEC 60870-5-103 е възможно през оптичен сериен порт, където е възможно използването на сериен оптичен кабел (ST connector).

Устройството поддържа SNTP, DNP3 и IRIG-B методи за синхронизация по време със резолюция 1ms.

IEC 60870-5-103 има резолюция за отброяване на времето от ± 5ms.

Устройството поддържа следните методи за синхронизация по време с резолюция 1 ms :

Мрежово базирани:

- SNTP (simple networktime protocol)
- DNP3

Със специално свързване за синхронизация

- IRIG-B

3.4 Инструмент PCM600

Мениджърът за защита и управление PCM600 предоставя всички необходими функции за работа през всички стадии на живот на устройството.

- Планиране
- Инженеринг
- Пускане в експлоатация
- Експлоатация и овладяване на нередности
- Функционален анализ

С отделните компоненти на инструмента могат да се изпълняват различни задачи и функции и да се управлява цяла подстанция. PCM600 може да работи с много различни видове топологии, в зависимост от нуждите на клиента.

За повече информация, вижте документацията на PCM600.

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3.4.1 Пакети за свързване

Пакетите за свързване са набор от софтуер и информация свързана със специфични системи за защита и управление и инструменти за свързване към IED. Пакетите за свързване се използват за създаване на структурни конфигурации в PCM600. Най-новите PCM600 и пакетите за свързване са съвместими със старите IED.

Мениджърът за подновяване е инструмент който помага за дефинирането правилната версия на пакета за свързване за различните системни продукти и инструменти. Мениджърът за подновяване е включен във продуктите за свързаност.

В допълнение пакетът за свързване съдържа описание на вътрешните параметри на устройството и техните свойства (като формат на данните, единици, обхват, видимост и права за достъп) както и софтуер, който адаптира специфичния интерфейс на устройството и инструментите. Такъв е например случаят с четене на доклада с нередности отговарящ на COMTRADE. Обяснителният текст може да бъде превеждан на различни езици.

3.4.2 Пакет за свързване на PCM600 и IED

- Protection and Control IED Manager PCM600 Ver. 2.3 + Hotfix or later
- ABB 650 Series IED Connectivity Package Ver. 1.1 or later
- ABB REB650 1.1.0 Module Ver. 1.0 or later
- ABB REC650 1.1.0 Module Ver. 1.0 or later
- ABB REG650 1.1.0 Module Ver. 1.0 or later
- ABB REL650 1.1.0 Module Ver. 1.0 or later
- ABB REQ650 1.1.0 Module Ver. 1.0 or later
- ABB RET650 1.1.0 Module Ver. 1.0 or later

Изтегляне на пакети за свързване от интернет сайта на ABB http://www.abb.com/substationautomation

3.5 Указания за защита срещу неоторизиран достъп

3.5.1 За указанията за защита срещу неоторизиран достъп

Насоките са сигурност описват процедурите с пароли и ниво на достъп в системата.

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Има различни нива на потребители които имат различен достъп в различните менюта и инструменти на IED. Предварително дефинираните видове потребители са показани в таблицата по-долу.

Трябва да се уверите че потребителят влязъл в системата има съответните права за въвеждане на данни в устройството от PCM600. За повече информация относно потребителските права за въвеждане на настройки се обърнете към главата Конфигурация на системните функции в ръководството за работа с PCM600.

Значение на символите използвани в таблицата по-долу:

- R=Read (Четене)
- W=Write (Запис)
- - = Нямате право на достъп

Таблица 35: Предварително дефинирани видове потребители

Права за достъп	Guest	Super User	SPA Guest	System Operator	Protection Engineer	Design Engineer	User Administrator
Основни настройки (промяна настройки за група, настройки за управление, ограничено наблюдение)	R	R/W	R	R/W	R/W	R/W	R
Настройки за напреднали (например настройки за защита)	R	R/W	R	R	R/W	R/W	R
Основни възможности за управление (управление на процес, без байпас)	R	R/W	R/W	R/W	R/W	R/W	R
Разширен контрол (управление на процес включващо стартиране с вътрешно заключване)	R	R/W	R/W	R/W	R/W	R/W	R
Поддържане на основни команди (Например изчистване на светодиоди, ръчно стартиране)	R	R/W	R	R/W	R/W	R/W	R
Поддържане на разширени команди (Например доклад с нередности)	R	R/W	R	R	R/W	R/W	R
Основни възможности за конфигуриране (Входно изходна конфигурация в SMT)	R	R/W	R	R	R	R/W	R
Разширени възможности за конфигуриране (Конфигуриране на приложения включващо SMT, GDE и CMT)	R	R/W	R	R	R	R/W	R
Зареждане на файлове (Зареждане на база данни от XML-файл)	-	R/W	-	-	-	R/W	R/W
Дъмпинг на файлове (дъмпинг на база данни към XML-файл)	-	R/W	-	-	-	R/W	R/W
Трансфер на файлове (FTP трансфер на файлове)	-	R/W	-	R/W	R/W	R/W	R/W
Трансфер на файлове (ограничен) (FTP трансфер на файлове)	R	R/W	R	R/W	R/W	R/W	R/W
Достъп на нормален потребител до база данни	R	R/W	R	R/W	R/W	R/W	R/W
Потребителска администрация (Мениджмънт на потребителите – FTP трансфер на файлове)	R	R/W	R	R	R	R	R/W

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Потребител в IED може да се създаде или изтрие и промени само със Мениджърът за потребители във PCM600. Потребител може да влезе или излезе от системата през HMI на IED и ням групи потребители които могат да се дефинират през HMI.

Само символите A – Z, a – z и 0 – 9 трябва да се използват в имената на потребителите и паролите.

Поне един потребител трябва да се намира в групата на администраторите за да е възможно създаването на други потребители през PCM600 в IED.

3.5.2 Насоки за сигурност на интернет портовете

Насоките за сигурност не могат да предложат конкретни продукти за подсигуряване на системата. Това трябва да се реши за конкретен проект, изисквания и съществуваща инфраструктура. Подходящото външно оборудване може да отдели устройствата или устройства които комбинират защитна стена, рутер и сигурна VPN функционалност.

За настройване на защитната стена за интернет се използва таблицата по-долу. Портовете са подредени по азбучен ред. Колонката Статус по подразбиране показва дали порта е отворен или затворен по подразбиране. Всички портове, които са затворени по подразбиране се отварят при конфигуриране.

Порт	Протокол	Статус по подразбиране	Услуга	Забележка
21	TCP	отворен	FTP	Протокол за трансфер на файлове
67	UDP	отворен	DHCP	Само порт на предния панел
102	TCP	отворен	IEC61850	MMS комуникация
7001	TCP	отворен	SPA	Собствен за PCM600
2100	TCP	отворен	ODBC	Собствен за PCM600
20 000	TCP	затворен	DNP3	Само DNP3 DNP комуникация
20 000	UDP	затворен	DNP3	Само DNP3 DNP комуникация

Серия 650 поддържа два мрежови протокола за комуникация. Тези протоколи са IEC61850, и DNP3/TCP. Тези протоколи за комуникация са възможни по конфигурация. Това означава че интернет порта е затворен и не се използва ако конфигурацията на серия 650 не включва комуникационната линия на протокола. Ако протокола е конфигуриран да отговаря на интернет протокол тогава порта е винаги отворен.

Виж техническото ръководство на серия 650 и документация за настройване на протокол за серия 650.

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Подпис: ....

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Съществуват някои ограничения и зависимости:

- Порт за интернет протокол използван за трансфер на файлове (по подразбиране порт 21) е фиксиран и неможе да се променя.
- Порт за интернет протокол използван за DHCP (по подразбиране порт 67) между IED и компютър е фиксиран и неможе да се променя.
- Порт за интернет протокол използван за IEC61850 (по подразбиране порт 102) е фиксиран и неможе да се променя.
- Порт за интернет протокол използван за DNP3 са програмируеми. Комуникационния протокол DNP3 може да работи под UDP (по подразбиране порт 20 000) или TCP (по подразбиране порт 20 000). Във настройките се дефинира кой вид комуникация се използва. Само един вид може да се използва за съответната конфигурация.

Два порта се използват от PCM600; за конфигуриране и настройка на параметрите на порта за интернет протокол се използва подходящ ODBC протокол (по подразбиране порт 2100), който е фиксиран и неможе да се променя. За следене на събитията и команди за изчистване се използва подходящ порт протокол за интернет SPA (port 7001), който е фиксиран и неможе да се променя.

Тези затруднения в сигурността са приемливи в ограничени локални мрежи. За по големи мрежи с връзка с интернет, комуникацията на серия 650 трябва да се защити срещу недобронамерен достъп. Тази защита трябва да се поддържа от външни устройства осигуряващи сигурна VPN връзка.

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Глава 4 Използване на HMI

4.1 Използване на локалния HMI

При първоначален достъп, не се изисква входяща парола и операторът има пълен достъп до създаването на потребители и пароли с PCM600, след което те се записват в IED.

Действия, изискващи парола са например: команди, променящи се стойности на параметрите и нулиране на индикации. Четенето на информация на LHMI винаги се допуска без парола.

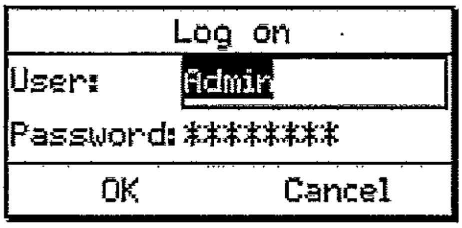
Политиките за контрол на достъпа налагат обезпечаване на сигурността чрез използването на пароли, но в случай на спешни действия, използването на пароли може да доведе до забавяне. Когато се налага изискванията за сигурност да бъдат изпълнени, двата фактора трябва сериозно да бъдат обмислени.

Не изключвайте допълнителното захранване на IED преди направените промените да се запишат.

IED разполага с система за ограничаване на броя на записите за определен период от време, с цел предотвратяване износването на флаш паметта. Поради това запазването на промените може да отнеме до един час. Промените няма да се приемат, ако се прекъсне допълнителното захранване, преди те да бъдат записани.

4.1.1 Влизане

1. Натиснете за да стартирате процедурата по влизане. Процедурата за влизане се стартира автоматично, когато се извършва операция защитена с парола.
2. Изберете потребителско име от менюто.

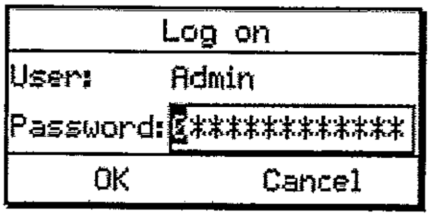


Фигура 15: Избор на потребителско име

3. При подканване въведете парола, цифра по цифра и изберете OK

- Промяната на въвежданата цифра става с и
- Въведете избрания знак с и

Чрез вертикалните стрелки също така могат да бъдат избрани главни и малки букви.



Фигура 16: Въвеждане на парола

В паролата големите и малките букви не са еквивалентни.

4. Натиснете за да потвърдите или за да отмените процедурата

   Ако влизането е неуспешно на дисплея се изписва съобщение.

Фигура 17: Съобщение за грешка, показващо грешна парола

Диалоговият прозорец за влизане ще се отвори, ако операцията изисква друго ниво на права на потребителя.

Влизането с парола е възможно след като даден потребителя е създаден и записан в IED. Ако няма създаден потребител, при опит за влизане на дисплея ще се покаже съответното съобщение.

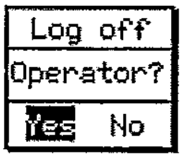
Фигура 18: Не е дефиниран потребител

ВЯРНО С ОРИГИНАЛА

4.1.2 Излизане

Потребителят автоматично излиза след загасване на дисплея. IED се връща към състояние, при които е разрешено само четене. Възможно е и ръчно излизане.

1. Натиснете .
2. За да потвърдите излизането, изберете Yes и натиснете .



Фигура 19: Излизане

- За да отмените излизането, натиснете .

4.1.3 Включване осветлението на дисплея

Нормално осветлението на дисплея е изключено, при включване то се включва.

- За да включите осветлението, натиснете произволен бутон на LHMI. Осветлението ще се включи и панела е готов за операции.

Ако панелът не се използва за определен период от време, осветлението му се изключва. След като загасне осветлението, потребителят автоматично излиза от текущото потребителско ниво. Фабричната настройка за изчакване е 60 минути.

Дисплеят се връща към изглед по подразбиране и всички непотвърдени операции са отменени.

Можете да промените времето за изчакване от **Main menu/ Configuration/HMIScreen/1:SCREEN/DisplayTimeout.**

4.1.4 Избор на локална или отдалечена употреба

Начина на използване на IED се променя с бутона R/L. При локална позиция, чрез LHMI може да бъде управлявано първичното оборудване, като например прекъсвачи или разединители. При позиция дистанционно управление, операции са възможни само от контролен център, който е с по-високо ниво.

- Натиснете
  - Когато L свети, локалния контрол е разрешен, а дистанционния забранен.
  - Когато R свети, дистанционното управление е разрешено, а местното забранено.
  - Когато светодиодите не светят и двете позиции са забранени.

ВЯРНО С ОРИГИНАЛА

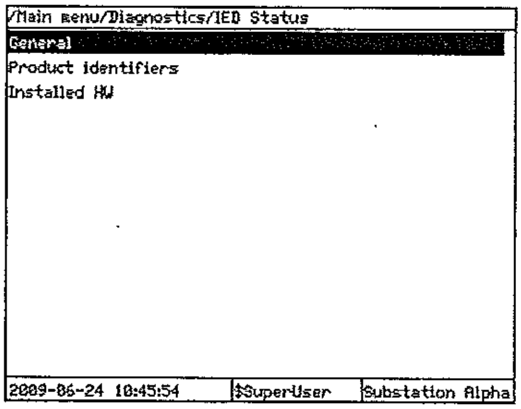
Управлението не може да бъде едновременно местно и дистанционно, но може да бъде забранено, когато нито една от позициите не е активна.

За да управлявате IED, влезте с подходящи потребителски права.

4.1.5 Идентифициране на устройството

В IED има информация за устройството, като например версия и сериен номер.

1. Изберете **Main menu/Diagnostics/IED Status/Product identifiers.**
2. Изберете подменю с и .

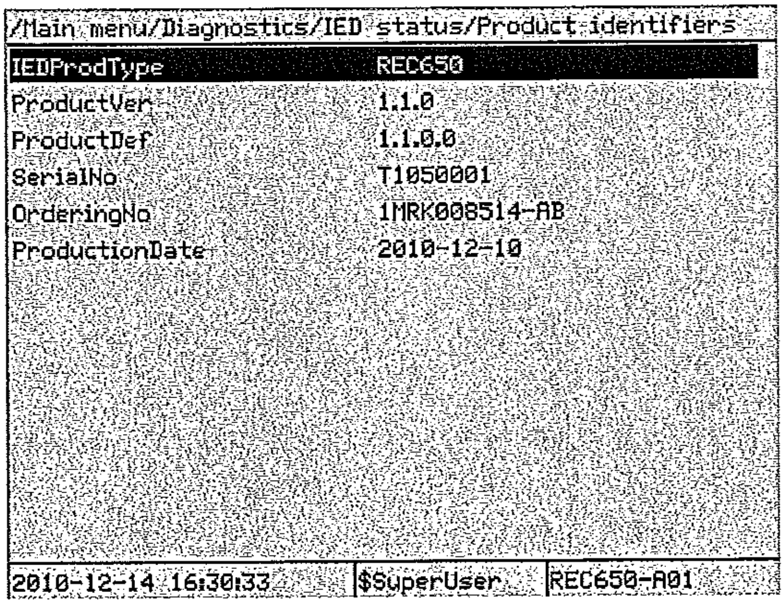


Фигура 20: Избор на подменю

3. Влезте в подменюто с .
4. Изберете информация с и .

ВЯРНО С ОРИГИНАЛА

Подпис:



IEC10000336-1-en

Фигура 21: Информация за IED

4.1.6 Регулиране на контраст на дисплея

За оптимална четливост контрастна на дисплея може да се настрои.

- За да увеличите контраста натиснете едновременно и .
- За да намалите контраста натиснете едновременно и .

При промяна с клавишите на HMI контраста на дисплея не се запаметява. При отпадане на помощното захранване, контраста на дисплея се връща на стойност зададена от параметъра *ContrastLevel.*

За постоянно промяна на контраста задайте параметър *ContrastLevel* чрез **Main menu/Configuration/HMI/Screen/ 1:SCREEN**

4.1.7 Промяна на езика на локалния HMI

1. Изберете **Main menu/Languages/1:LANGUAGE** и натиснете
2. Сменяйте езика използвайки и .
3. Натиснете за да потвърдите избора.
4. Запомнете промените.

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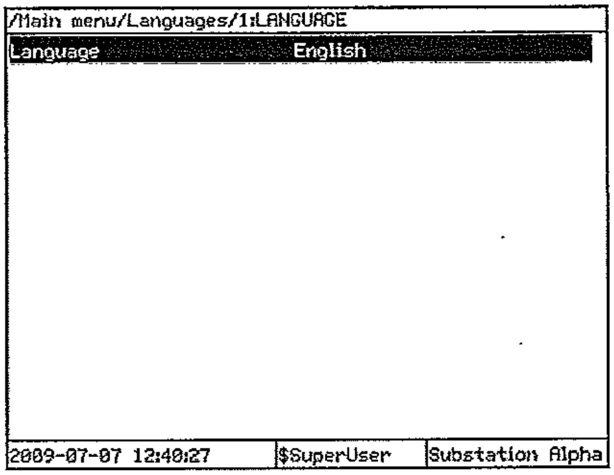

Фигура 22: *Смяна на езика на LHMI*

За да смените езика по-кратък начин, натиснете и или едновременно навсякъде в менюто.

4.1.8 Движение в менюто

Придвижване в менютата и промяна изгледа на екрана с клавиатурата.

- За избор на главното меню или изглед по подразбиране, натиснете .
- За движение на горе и на долу в менюто, натиснете или .
- За движение на долу в дървовидно меню, натиснете .
- За движение на горе в дървовидно меню, натиснете .
- За влизане на режим на настройка, натиснете .
- За излизане от режим на настройка, без записване, натиснете .

4.1.8.1 Структура на менюто

Главното меню съдържа основни групи, които са разделени в по-подробни подменюта.

- Control / Управление
- Events / Събития
- Measurements / Измервания
- Disturbance records / Записи при смущения
- Settings / Настройки
- Configuration / Конфигурация
- Diagnostics / Диагностика

ВЯРНО С ОРИГИНАЛА

ООД

- Tests / Изпитвания
- Clear / Изчистване
- Languages / Езици

4.1.8.2 Превъртане на дисплея

Ако менюто съдържа повече редове, отколкото могат да бъдат показани на дисплея в дясно се показва лента за превъртане.

/Main menu/Configuration/I/O modules/COM		
BatteryVoltage	110	V
BINAME1	BI1	
Threshold1	65	%UB
DebounceTime1	0.005	s
OscillationCount1	0	
OscillationTime1	0.000	s
BINAME2	BI2	
Threshold2	65	%UB
DebounceTime2	0.005	s
OscillationCount2	0	
OscillationTime2	0.000	s
BINAME3	BI3	
Threshold3	65	%UB
DebounceTime3	0.005	s
2009-06-24 10:53:03	$SuperUser	Substation Alpha

Фигура 23: Лента за превъртане в дясно

- За да превъртите изгледа нагоре, натиснете .
- За да превъртите изгледа надолу, натиснете .
- За да прескочите от последния ред към първия ред, натиснете отново .
    - Натиснете за да прескочите от първия ред към последния.

4.1.8.3 Промяна на изгледа по подразбиране

По подразбиране на дисплея е главното меню.

1. Изберете **Main menu/Configuration/HMI/Screen/1:SCREEN** и натиснете .
2. Сменете изгледа по подразбиране с или .
3. Натиснете за да потвърдите избора.

4.1.9 Използване на функционалните бутони

Функционалните бутони могат да бъдат конфигурирани като бързо меню или като бутони за управление. Бутоните са активни, само когато функционалния бутон панела е видим.

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ООД Стара Загора

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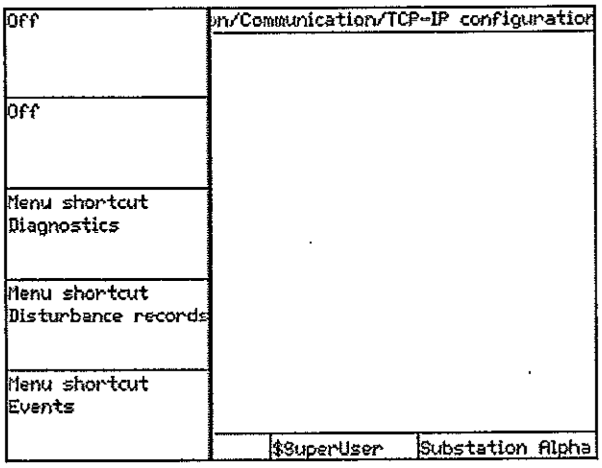
1. Натиснете произволен бутон, за да активирате бутон панела.
   При първото натискане на бутон само се активира панела.



Фигура 24: Функционален бутон панел

2. Натиснете желания функционален бутон
   - Натиснете желания бутон, за да преминете към определен елемент от менюто.
     Менюто се отваря веднага след натискане на бутона.
   - Натиснете желания бутон за не по-малко от 0,5 сек. за да стартира командата. Действието се приема веднъж.
     За да повторите действието, натиснете бутона отново. Ако бутона е натиснат по-малко от 0,5 сек, не се извършва команда.
3. Натиснете ESC за излизане от функционалния бутон панел.

   Панела също се затваря след натискане на бутон конфигуриран за тази цел.

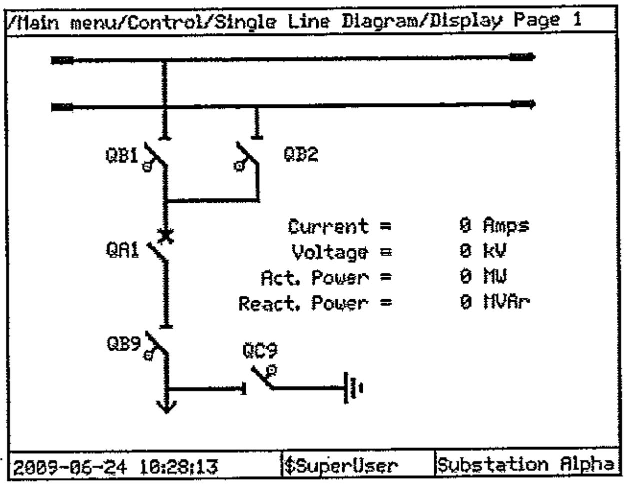
Функционалните бутони са конфигурирани с PCM600.

За повече информация, вижте документацията на PCM600.

4.1.10 Използване на еднолинейната схема

Еднолинейната диаграма е направена с PCM600.

1. Изберете **Main menu/Control/Single line diagram.**
   Показва се изглед на еднолинейната схема.



Фигура 25: Пример на еднолинейна схема

2. Изберете обект с или .

   Избора на обект се показва с квадратни граници, като с помощта на или може да бъде сменен.
   Превключваните обекти могат да имат допълнителни икони, които показват състоянието на обекта.

   - = Превключвания обект е в състояние на замяна.
   - = Превключвания обект е вътрешно заключен.

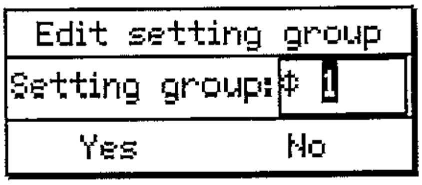
3. Натиснете за да изберете отваряне или за затваряне на обекта.
4. Потвърдете операцията в диалоговия прозорец, който се отваря.
5. За предвижване измежду схемата, натиснете или .

   Изберете еднолинейната схема като изглед по подразбиране в **Main menu /Configuration/HMI/Screen/1:SCREEN/DefaultScreen.**

4.1.11 Преглед на стойностите за настройка

1. Изберете **Select Main menu/Settings/IED Settings**, и натиснете .

2. Натиснете и след това за да активирате избора на номер на групата за настройка.

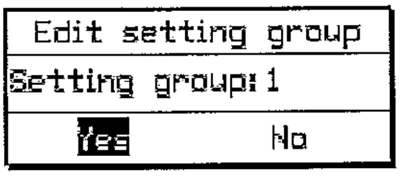


Фигура 26: Избор на номер на групата за настройка

3. Натиснете или за да изберете номер на групата за настройка.

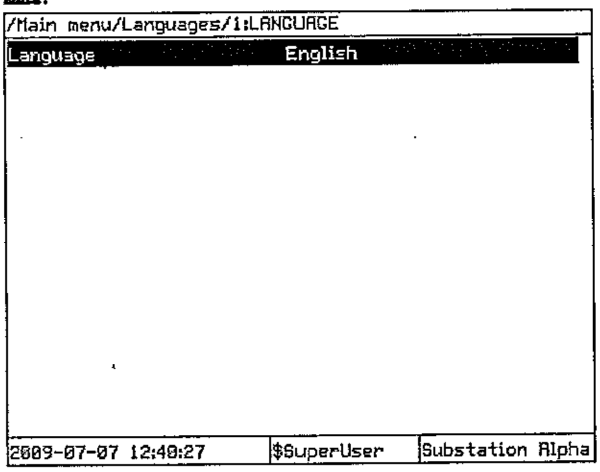
4. Натиснете за да потвърдите избора на групата за настройка и за да се върнете към диалоговия прозорец за смяна на групата.
5. Натиснете за да изберете Yes и да видите стойностите на групата за настройка.

   • Натиснете или за да изберете No и за да излезете.



Фигура 27: Избор на група за настройка

6. За да прегледате настройки, превъртете списъка с или , за избор настройка натиснете . За да се върнете обратно, натиснете .



Фигура 28: Алтернативни настройки в избраната група

Съдържанието на списъка зависи от предварителната конфигурация или от функциите зададени с PCM600.

4.1.12 Редактиране на стойностите

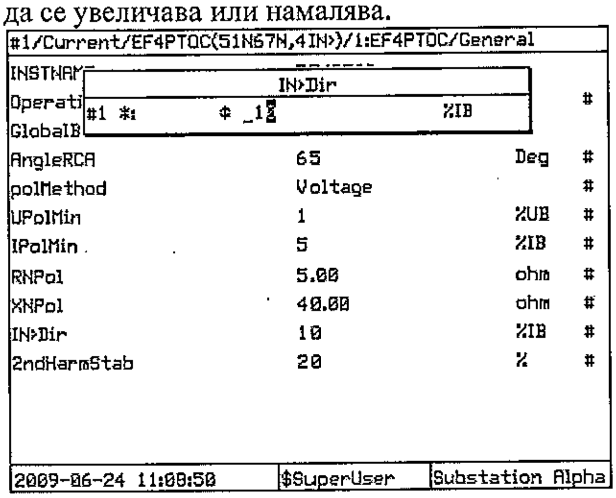
• За да редактирате стойности, влезте с подходящи потребителски права.
  Ако потребителските права не отговарят се отваря диалоговия прозорец за влизане.

4.1.12.1 Редактиране на числови стойности

1. Изберете **Select Main menu/Settings** и след това настройка.

   Активна е последната цифра на стойността.

- Когато има символ ↑ в предната част на стойността, тя може да бъде само увеличена.
- Когато символът е ↓, стойността може да бъде само намалявана.
- Когато символът в предната част на стойност е ↕, стойността може да се увеличава или намалява.



Фигура 29: Последната цифра е активна и може да се променя

2. Натиснете за да увеличите или за да намалите стойността на активната цифра.
   Едно натискане увеличава или намалява стойността с определена стъпка. За цели стойности, промяната е 1, 10, 100 или 1000 (...) в зависимост от активното цифра. За десетични стойности, промяната може да бъде 0.1, 0.01, 0.001 (...) в зависимост от активното цифра.

   Параметрите немогат да се променят под стойността на стъпката.

3. Натиснете или за да преместите курсора на друга цифра.

4. За да изберете минималната или максималната стойност, изберете съответната стрелка пред стойността.
   - За да зададете максимална стойност, натиснете .
   - За да зададете минимална стойност, натиснете .

   След натискане на , предишната стойност може да бъде възстановена чрез натискане веднъж и обратно. При друго натискане на или се задава най-ниска или най-висока граница на стойността. Пред стойността има символ ↕, когато е показана предишна стойност.

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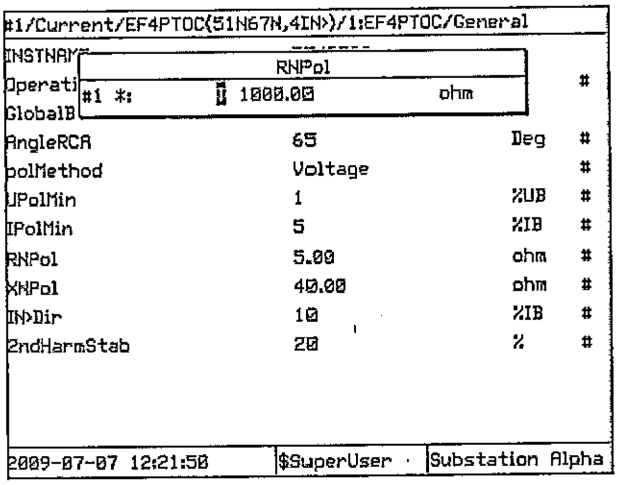


Фигура 30: Възстановяване на предишна стойност

4.1.12.2 Редактиране на стойности в ред

1. Стартирайте режим настройки и изберете настройка.
   При редактиране на редови стойности, курсорът се премества в първия знак.
2. Натиснете или за да промените стойността на активна цифра.

   Едно натискане променя стойността с една стъпка.
3. Натиснете или за да преместите курсора към друга цифра.
   - За да вмъкнете символа или интервал, натиснете едновременно и .
   - За да изтриете символ, натиснете едновременно и .

PCM600 подържа уникален код за всеки знак.

4.1.12.3 Редактиране на изброените стойности

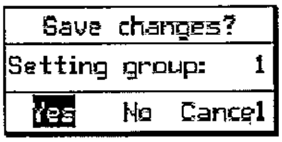
1. Стартирайте режим настройки и изберете настройка.
   При редактиране на изброена стойност, избраната стойност е обърната.
2. Натиснете или за да промените стойността на активна величина.
   Едно натискане променя стойността с една стъпка в специфичния параметричен ред.

4.1.13 Записване на настройките

Променливите стойности се съхраняват в енергонезависима флаш памет. Повечето промени се приемат веднага след записването им, но някои промени се нуждаят от рестартиране на приложението. Стойностите съхранени във флаш паметта остават в сила след рестартиране.

1. Натиснете за да потвърдите всякакви промени.

2. Натиснете за да се придвижите на горе в дървовидно меню или за да влезите в основното меню.



Фигура 31: Потвърждаване на настройките

- За да излезете без да записвате промените, изберете No и натиснете .
- За отказване на записването, изберете Cancel и натиснете .

Натискането на Cancel в прозореца *Запазване на промените* затваря само този диалогов прозорец, но IED устройството остава в режим на редактиране. Приетите промени не се губят и потребителят може да продължи с промяна на настройките. За да излезете от режима на настройка, изберете No или Yes в диалоговия прозорец *Запазване на промените*.

След промяна на параметри, отбелязани с тях !, IED устройството се рестартира автоматично за да влязат промените в сила.

4.1.14 Изчистване и приемане

Бутонът Clear/Изчистване се използва за нулиране, потвърждаване или изчистване на всички съобщения и индикации, включително светодиоди и затворени изходи както и регистри и записи. Натиснете бутона Clear/Изчистване за да стартирате менюто и изберете желаната функция изчистване или рестартиране. Събития и сигнали за тревога на светодиодите, също се изчистват с бутон Clear/Изчистване.

1. Натиснете за да се активира менюто за изчистване.

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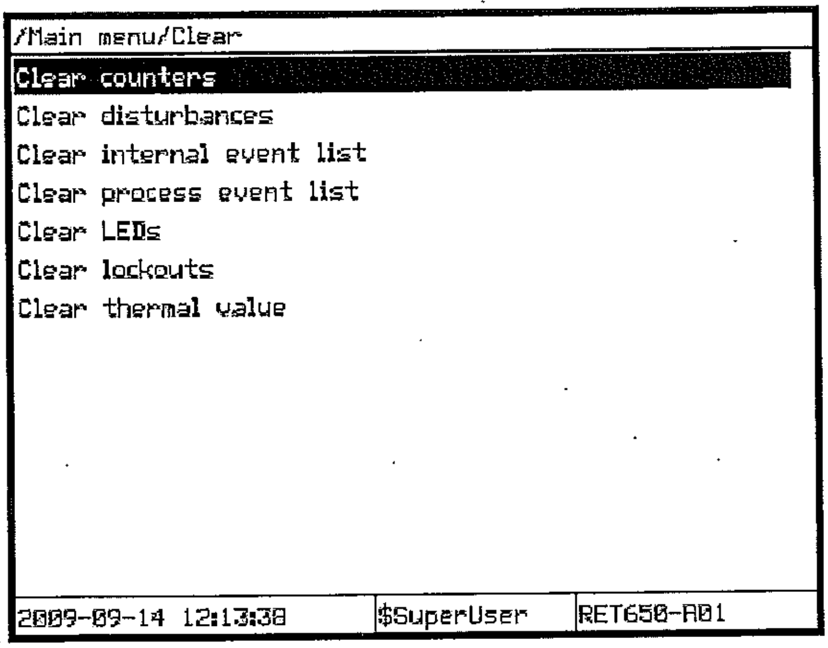

Фигура 32: *Меню изчистване*

Съдържанието на менюто за изчистване зависи от направената конфигурация с PCM600.

2. Изберете елемента за изчистване с или .

3. Натиснете , изберете O K за да потвърдите избора или Cancel за отказване на избора и след това натиснете .

4. Повторете стъпки 2 и 3 за да изчистите други елементи.

4.1.15 Използване на локалната помощ на HMI

1. Натиснете за да се отвори менюто за помощ.
2. Превъртайте текста с или , ако текста не се побира на дисплея.
3. За да излезете от менюто, натиснете .
   Диалоговият прозорец на помощното меню също се затваря при изтичане на определено време.

Глава 5 Работа с IED

5.1 Нормална работа

Основните операции при нормална работа с устройството са наблюдение и процедури за проверка.

- Наблюдение на измерените стойности.
- Проверка на състоянието на обектите.
- Проверка на функционалните настройки на параметрите.
- Проверка на събития и аларми.

Всички основни операции могат да бъдат изпълнени с LHMI или PCM600.

За повече информация, вижте документацията на PCM600.

5.2 Идентификация на смущение

Смущенията и предизвикалите ги причини могат да бъдат установени с LED индикатори: Готовност, Старт и Изключване. По време на нормална работа при готовност LED свети в зелено.

За да работят LED, записаните смущения трябва да бъдат определени в следната конфигурация.

Таблица 36 Идентификация на смущенията

LED	Състояние	Обяснение
LED Старт	Постоянно жълт	Защитата е стартирана
LED Изключване	Постоянно червен	Защитата е заработила

Действията, които трябва да бъдат направени за определяне на смущението:

- Проверка на сигнализацията на LED.
- Прочитане на събитията.
- Проверка на записаните повреди.
- Анализ на записаните смущения.

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Документирайте смущението преди да изтриете информацията от устройството IED.

Само оторизиран и квалифициран персонал трябва да анализира грешките и да предприеме съответните действия. В противен случай записаните смущения могат да бъдат загубени.

5.2.1 Пускане на записа при смущение

Записите при смущения се стартират от IED приложенията обикновено при повреда. Записи могат да се направят ръчно или периодично. Ръчния старт на запис мигновено генерира протокол. Използвайте тази функция за да получите картина на наблюдаваните сигнал.

5.2.2 Анализ на записаните смущения

IED натрупва записи на събитията, които са нагласени да се стартират при определени смущения. Данните се събират и съхраняват за по-късно разглеждане и анализ. Записаните данните от смущения могат да се четат и анализират с PCM600.

За повече информация, вижте документацията на PCM600.

5.2.3 Протокол от смущение

PCM600 може да бъде използвана за създаване на протоколи от записаните събития.

За повече информация, вижте документацията на PCM600.

5.2.4 Вътрешни IED грешки

The IED self-supervision handles internal run-time fault situations. Основният признак при вътрешна грешка е мигащ в зелено светодиод Ready LED.

Вътрешните грешки могат да бъдат разделени на хардуерни, изпълнение или в операционната система и комуникационни. По-нататъшните действия зависят от причината за грешката.

Вярно с оригинала

Серия 650
Наръчник за работа

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Само оторизиран и квалифициран персонал трябва да анализира грешките и вземе решение за по-нататъшни действия.

При събития IED записва статуса на IED.

Документирайте всички записани данни от IED преди възстановяване на изключващи и IED локаут функции.

5.3 Определяне параметрите на IED

Параметрите на IED са зададени чрез LHNI или PCM600.

Параметрите трябва да бъдат изчислени в съответствие с условията на електрическата мрежа и електрическите характеристики на защитеното оборудване. Настройките на IED трябва да бъдат проверени преди да се свържи към системата.

Документирайте всички промени на параметричните настройки.

За повече информация, вижте документацията на PCM600.

Не изключвайте допълнителното захранване на IED преди направените промените, на пример зададените параметри или местно/дистанционно управление да се запишат.

IED разполага с механизъм за ограничаване на броя на записите за определен период от време, с цел предотвратяване износването на флаш паметта. Поради това запазването на промените може да отнеме до един час. Промените няма да се приемат, ако се прекъсне допълнителното захранване, преди те да бъдат записани.

5.3.1 Функционални настройки на IED

Настройки могат да се редактират една по една, предвижвайки се към отделните стойности, например чрез LHMI. Преди редактиране на определена стойност трябва да се знаят стойностите в другите групи за настройка.

Новите стойности са активирани след приключване на редактирането на стойностите в групата. Потребителят може да приеме или да откаже редактираните стойности.

ВЯРНО С ОРИГИНАЛА

ООД

Стара Загора

5.3.2 Настройки на IED при особени работни условия

Настройките на IED могат да бъдат съставени за различни условия на работа, чрез определяне на различни стойности на различните групи за настройки. Активната група за настройка може да бъде променена от приложението на IED или ръчно чрез LHMI или PCM600.

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Глава 6 Работни процедури

6.1 Мониторинг

6.1.1 Индикации

Работата на IED може да бъдат наблюдавана чрез три различни индикации на LHMI.

- Три светодиодни индикатора LED с фиксирана функционалност: Готови, Старт и Изключване.
- 15 програмируеми трицветни светодиодни LED сигнала, които могат да покажат 45 виртуални светодиодни състояния.
    - Текстовете за всяко включено или изключено състояние на светодиодната индикация, могат да бъдат програмирани с PCM600 и чрез LHMI. Текстовете се показват на LHMI.
- Автоматично съобщение на дисплея.

6.1.1.1 Използване на автоматично показване на съобщения

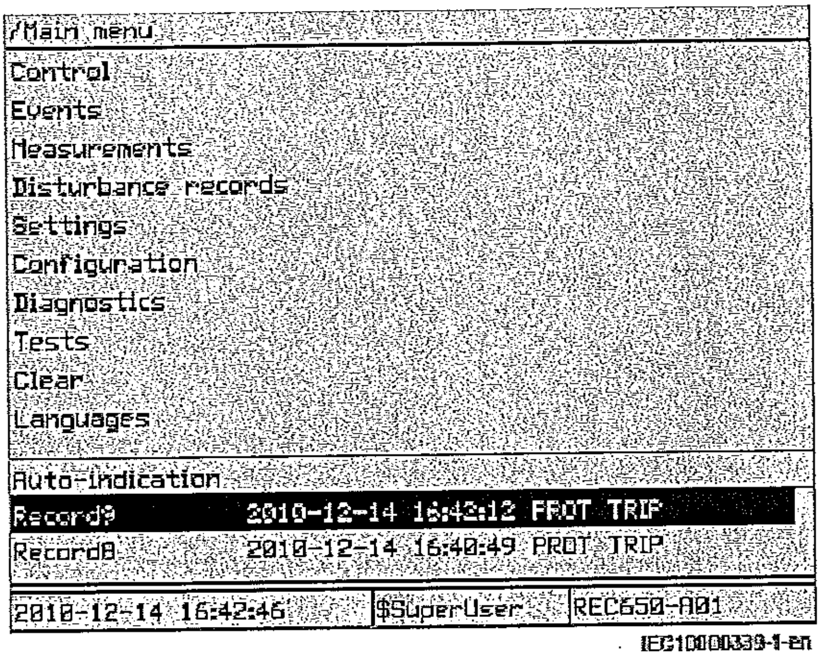
Автоматичните съобщения се показват в диалогов прозорец, когато се задейства запис на смущение. Диалоговия прозорец показва списък на текущите записи от смущения един по един. За да прегледате диалоговия прозорец, използвайте ↑ и ↓.

За да активирате функцията автоматично показване на съобщение, функцията запис при смущение трябва да е активирана и правилни конфигурирана.
Също така проверете дали настройката **Main menu/ Configuration/HMI/Screen/1:SCREEN1/AutoIndicationDRP** е на позиция On.

1. Прочетете автоматичното съобщение в диалоговия прозорец

   Съобщението съдържа същата информация, която е налице и в записа от смущенията.

2. Натиснете → за да видите по-подробна информация.
3. Натиснете ESC за да излезете от автоматичното съобщение без да го изчиствате или натиснете Clear за да активирате прозорец Изчистване и да изтриете съобщението.



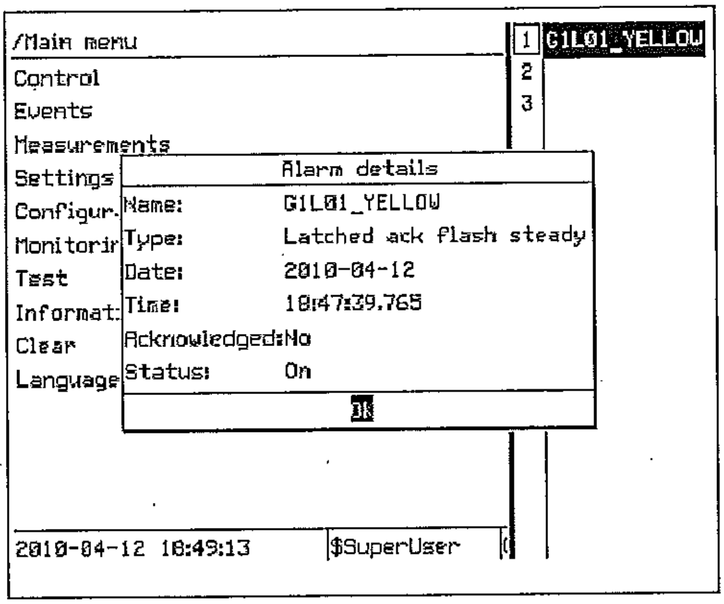
IEC10000339-1-en

Фигура 33: Автоматично показване на съобщение

6.1.1.2 Данни от мониторинга при сигнал за тревога

Активните сигнали за тревога са посочени чрез сигналните светодиоди LED и светодиод на бутона много страници. Сигналите за тревога са конфигурирани с PCM600. Вида и информацията зависят от приложената конфигурация.

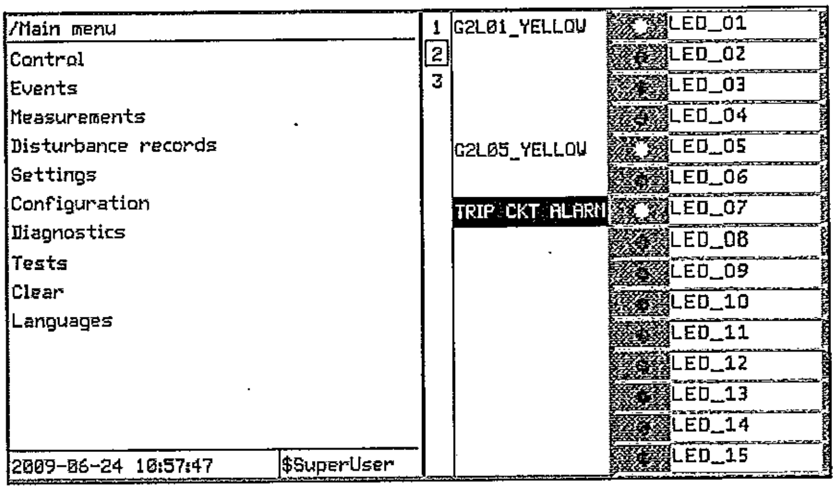
1. Натиснете за да отворите прозореца на сигналите за тревога
2. Натиснете или за да движите между активните сигнали в страницата или натиснете за да превключите между страниците.
3. Натиснете за да отворите диалогов прозорец, който показва по-подробна информация относно избрания сигнал за тревога.



Фигура 34: Подробности за сигнала

Натиснете или за да излезете от диалоговия прозорец.

4. Натиснете за да излезете от прозореца сигнал за тревога.
5. Натиснете за да активирате прозорец Изчистване и да изтриете сигналите за тревога.



Фигура 35: Данни за сигнала

6.1.1.3 Мониторинг на вътрешна грешка на IED

Мигащ в зелено светодиод показва вътрешна IED грешка. Съобщенията за грешка се намират в менюто на LHMI.

ВЯРНО С ОРИГИНАЛА

1. Изберете **Main menu/Diagnostics/Internal events** или **IED status** за да прегледате последната грешка.
2. Натиснете или за да превъртите прозореца.

/Main menu/Diagnostics/IED status/General

Item	Status
Internal fail	Off
Internal warning	Off
Time synch	Ready
Real time clock	Ready
Application	Ready
Runtime execution	Ready
IEC61850	Ready
DNP3	Ready
TRM2	Ready
BIO3	Ready
BIO4	Ready
COM1	Ready
PSM1	Ready
BIO5	Ready

2009-06-24 10:26:42 | $SuperUser | Substation Alpha

Фигура 36: Показване на грешка

Вътрешният списък на събития не се актуализира динамично. За да актуализирате списъка, излезте от меню **Internal events** и след това го изберете отново.

6.1.1.4 Мониторинг условия мониторинг данни

1. Изберете **Main menu/Diagnostics/IED status/General.**
2. Натиснете или за да превъртите прозореца.

С PCM600 потребителят може да картографира изходните сигнали от мониторинга на състоянието свързани с функционалните блокове до съответните предназначения.

6.1.2 Измерени и изчислени стойности

Всички величини показват моментно измерена стойност, някои включват стойности изчислени за определен период от време.

6.1.2.1 Измерени стойности

Измерените стойности могат да бъдат достъпни чрез LHMI.

6.1.2.2 Използване на локалния HMI за мониторинг

1. Изберете **Main menu/Measurements** за преглед на измерените и изчислените стойности.
   Показва се списък на основните измервания от IED.
2. Превъртайте изгледа с и .

6.1.3 Записани данни

IED е снабден с интелигентна и гъвкава функционалност, която събира различни видове данни. Записаните данни дават съществена информация при анализ на повредата.

- Записи при смущения
- Събития

6.1.3.1 Създаване на записи от смущения

Обикновено записите при смущения се стартират от приложенията на IED, но също могат да се стартират и ръчно.

Задайте DRRDRE *Операция* "On" чрез LHMI или PCM600.

1. Изберете **Main menu/Disturbance records.**
2. Изберете **Manual Trig** с и .
3. Изберете за да осъществите ръчно пускане.

/Main menu/Disturbance records		
Record66	2009-05-08 00:17:47	TC_ALARM_3
Record65	2009-05-08 00:17:44	SPR_CHR_ALM
Record64	2009-05-07 23:56:02	TC_ALARM_3
Record63	2009-05-07 23:55:59	SPR_CHR_ALM
Record62	2009-05-07 22:29:14	TC_ALARM_1
Record61	2009-05-07 22:29:11	SPR_CHR_ALM
Record60	2009-05-07 22:23:43	TC_ALARM_1
Record59	2009-05-07 22:23:40	SPR_CHR_ALM
Record58	2009-05-07 21:57:04	TC_ALARM_1
Record57	2009-05-07 21:57:01	SPR_CHR_ALM
Record56	2009-05-07 21:54:34	TC_ALARM_1
Record55	2009-05-07 21:54:31	SPR_CHR_ALM
Record54	2009-05-07 21:50:51	TC_ALARM_1
Record53	2009-05-07 21:50:48	SPR_CHR_ALM
Manual trig		
2009-05-08 00:57:16	Guest	Feeder

Фигура 37: Ръчно пускане

ВЯРНО С
ОРИГИНАЛА

Записът на смущение е пуснат.

6.1.3.2 Мониторинг на данни записани при смущение

Прочетете по отделно записите при смущение от IED със софтуера PCM600 за да прегледате записаните данни.

1. Изберете **Main menu/Disturbance records.**
   Всички записи са показани.
2. Превъртайте прозореца с и .

/Main menu/Disturbance records			
Record66	2009-05-08	00:17:47	TC_ALARM_3
Record65	2009-05-08	00:17:44	SPR_CHR_ALM
Record64	2009-05-07	23:56:02	TC_ALARM_3
Record63	2009-05-07	23:55:59	SPR_CHR_ALM
Record62	2009-05-07	22:29:14	TC_ALARM_1
Record61	2009-05-07	22:29:11	SPR_CHR_ALM
Record60	2009-05-07	22:23:43	TC_ALARM_1
Record59	2009-05-07	22:23:40	SPR_CHR_ALM
Record58	2009-05-07	21:57:04	TC_ALARM_1
Record57	2009-05-07	21:57:01	SPR_CHR_ALM
Record56	2009-05-07	21:54:34	TC_ALARM_1
Record55	2009-05-07	21:54:31	SPR_CHR_ALM
Record54	2009-05-07	21:50:51	TC_ALARM_1
Record53	2009-05-07	21:50:48	SPR_CHR_ALM
Manual trig			
2009-05-08 00:59:12	Guest	Feeder	

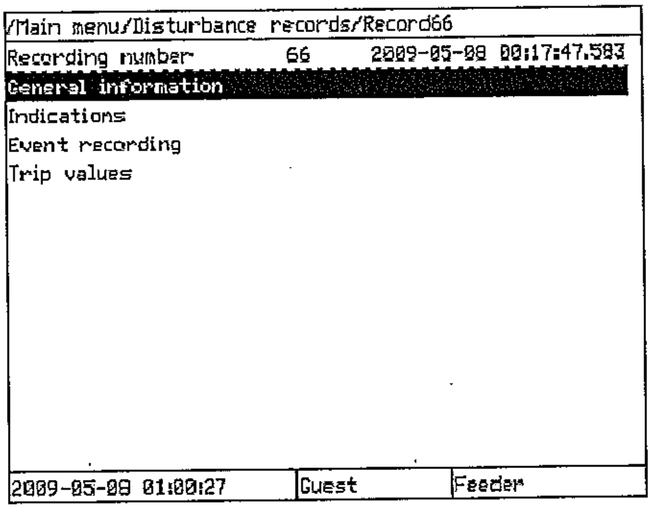
Фигура 38: Мониторинг на записите от смущения чрез LHMI

3. За да видите определен запис, натиснете .

   Показва се списък с подробни категории.

ВЯРНО С ОРИГИНАЛА

Подпис: ....



Фигура 39: Категории на данни на записите при смущения

4. За да изберете категория и да видите съдържанието ѝ, натиснете или и след това .

6.1.3.3 Управление и четене на записаните данни при смущение

Записаните данни при смущение могат да бъдат управлявани и четени с PCM600.

За повече информация, вижте документацията на PCM600.

6.1.3.4 Мониторинг на събития

Групата event\събитие съдържа списък от събития, породени от приложената конфигурация. Събитията са групирани по ден и всяко събитие е на един ред. Изберете последователността на събитията в **Main menu/Configuration/HMI/Screen/1:SCREEN/EvListSrtOrder.**

1. Изберете **Main menu/Events.**
2. Натиснете за да отворите листа със събития.

   Събитията са групирани по дата.

   Показани са време, канал, име на сигнала и стойност на събитието.
3. Натиснете или за да превъртате прозореца.

ВЯРНО С ОРИГИНАЛА

Подпис:

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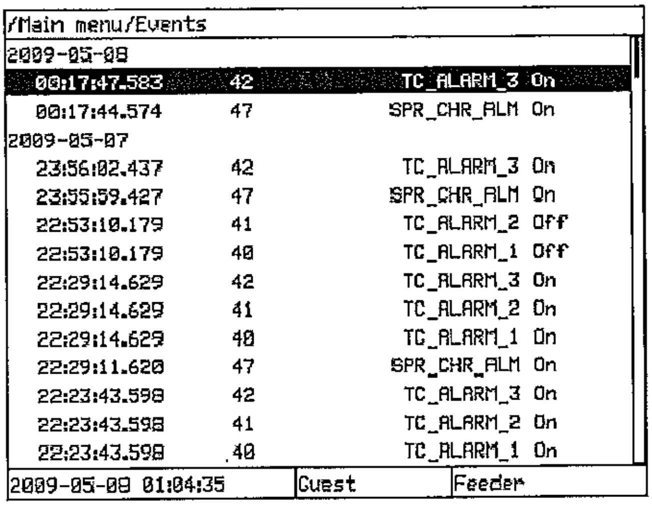

Фигура 40: Мониторинг на събития

Списък на събития не се актуализира динамично. За да актуализирате списъка, излезте от меню Events и след това го изберете отново.

6.1.4 Дистанционен мониторинг

IED подържа подробен дистанционен мониторинг.

6.1.4.1 Мониторинг на IED дистанционно

Използвайте PCM600 за да работите дистанционно IED.

- Прочетете записите при поддръжка и регистрираната версия.
- Анализирайте данните от записа при смущение.
- Създайте регистри от смущението.
- Наблюдавайте IED стойностите.

За повече информация, вижте документацията на PCM600.

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6.2 Управление

6.2.1 Управление на прекъсвачи и разединители

Първичното оборудване може да бъде управлявано чрез LHMI с бутоните Open/Отворен и Close/Затворен, когато IED е настроен в режим на местно управление и потребителя има право на достъп до операциите за управление.

1. Изберете **Main menu/Control/Single line diagram.**

   SLD показва всички управляеми обекти.

2. Изберете обект с или .

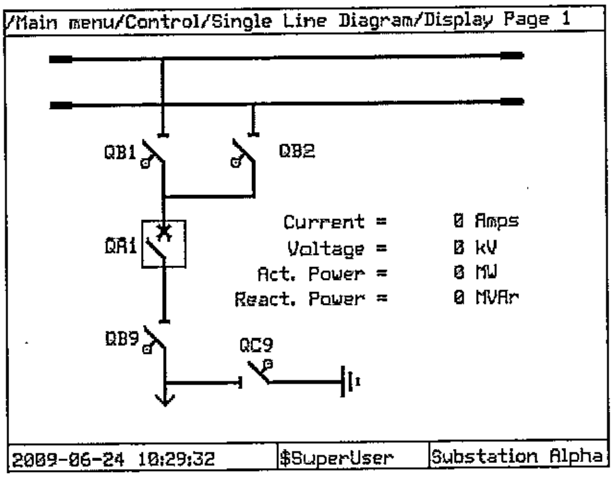
   Изборът на обект е показан с квадратна граница, която се премества при използването на или .

   Превключваните обекти могат да имат допълнителни икони, които показват състоянието им.

   Превключеният обект е в състояние на замяна.

   Превключеният обект е вътрешно заключен.

3. Натиснете за да изберете отваряне или за затваряне на обекта.



Фигура 41: Избор на обект

4. Натиснете за да потвърдите операцията.

ВЯРНО С ОРИГИНАЛА

ООД РУДИН Стара Загора

Подпис:

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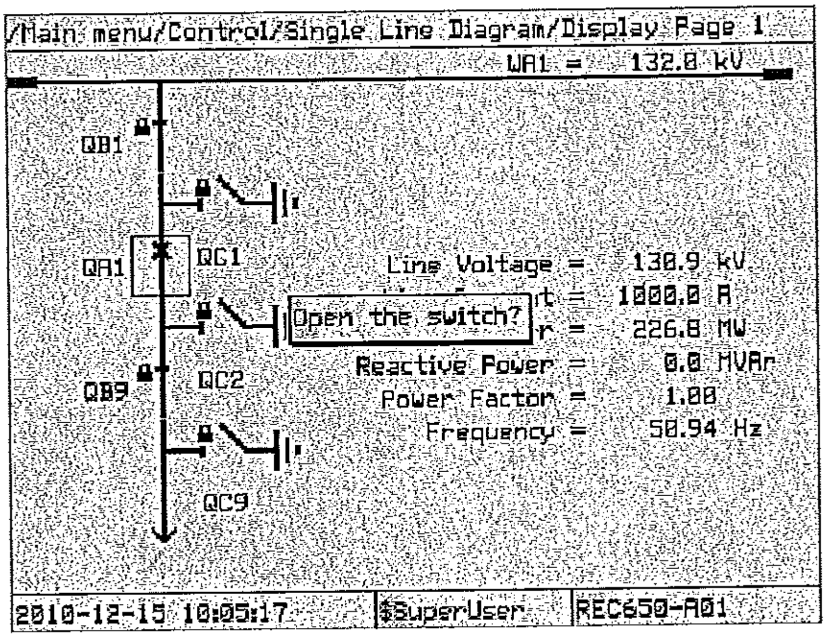


IEC10000340-1-en

Фигура 42: Затваряне на прекъсвач

- Натиснете за да отмените операцията.

5. Натиснете или за предвижване между страниците на еднолинейната схема.

Времето между избора на обект и даването на команда за управление е ограничено от регулируемо изчакване [(зададена от параметъра *tSelect*, за всеки обект)]. Когато обектът е избран, командата за управление трябва да бъде дадена в рамките на това време.

6.3 Възстановяване на началното състояние на IED

6.3.1 Изчистване и потвърждаване чрез локалния HMI

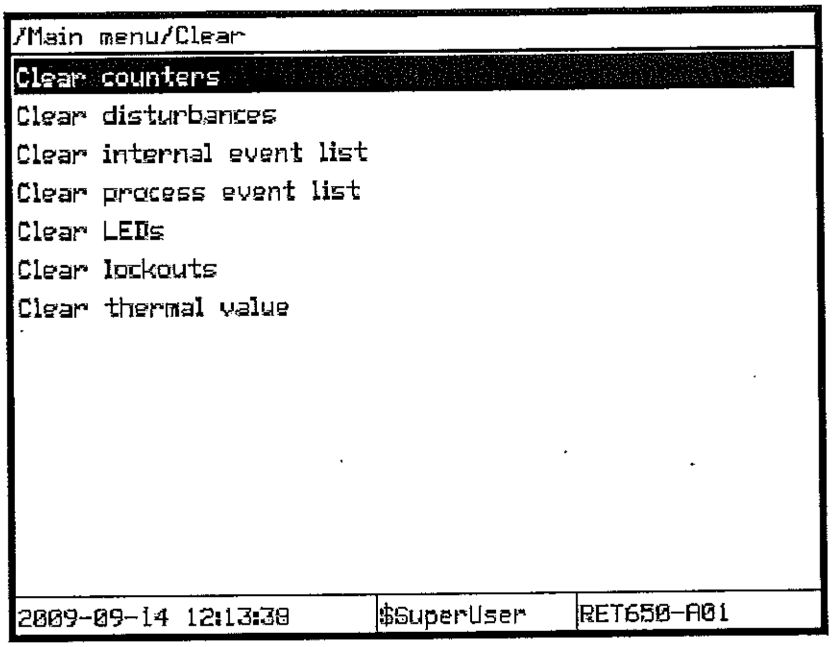
Използвайте бутон Clear/Изчистване за нулиране, потвърждаване или изчистване всички съобщения и индикации, включително светодиоди и затворени изходи, както и регистри и записи. Натискането на бутон Clear/Изчистване активира изглед за избор на функция. Събития и сигнали за тревога на светодиодите, също се изчистват с бутон Clear/Изчистване.

1. Натиснете за да се активира менюто за изчистване

Показани са всички елементи, които могат да бъдат изчистени.

01

ВЯРНО С ОРИГИНАЛА



Фигура 43: Изглед изчистване

Съдържанието на менюто Clear/Изчистване зависи от конфигурацията, оформена с PCM600.

2. Изберете елемент за изчистване с или .
3. Натиснете , изберете OK за потвърждаване на изора или Cancel за да отмените избора.
4. За да изчистите и други елементи, повторете стъпките

6.4 Променяне функционалността на IED

6.4.1 Определяне на групи за настройка

Не изключвайте допълнителното захранване на IED преди направените промените, на пример зададените параметри или местно/дистанционно управление да се запишат.

IED разполага с механизъм за ограничаване на броя на записите за определен период от време, с цел предотвратяване износването на флаш паметта. Поради това запазването на промените може да отнеме до един час. Промените няма да се приемат, ако се прекъсне допълнителното захранване, преди те да бъдат записани.

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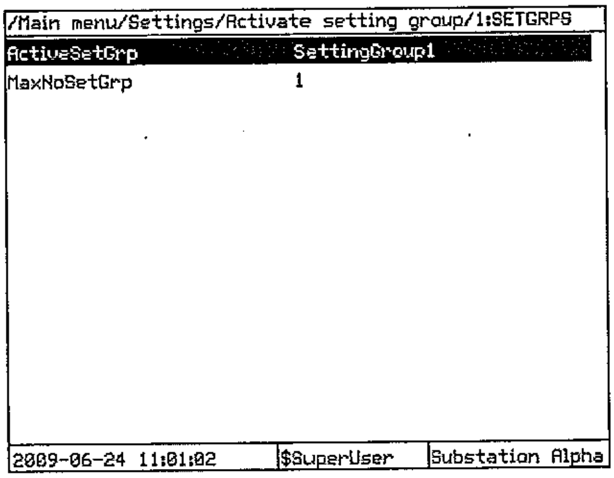
6.4.1.1 Стартиране на група за настройка

Настройки на IED са предварително планирани за различни работни условия чрез изчисляване на стойностите за различните групи за настройка. Активната група за настройка може да бъде променена от приложението на IED или ръчно от менюто.

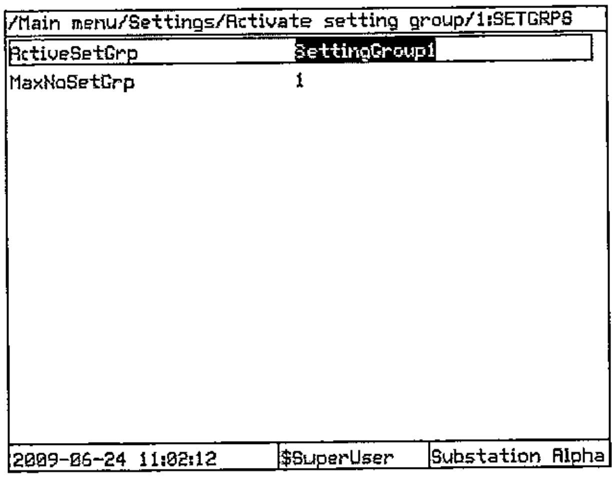
1. Изберете **Main menu/Settings/Activate setting group/1:SETGRPS** и натиснете .



Фигура 44: Активна група за настройка

2. Изберете групата за настройка с или .

3. Натиснете за потвърждаване избора или за отмяна.



Фигура 45: Избиране на активна група за настройка

4. Съхранете настройките

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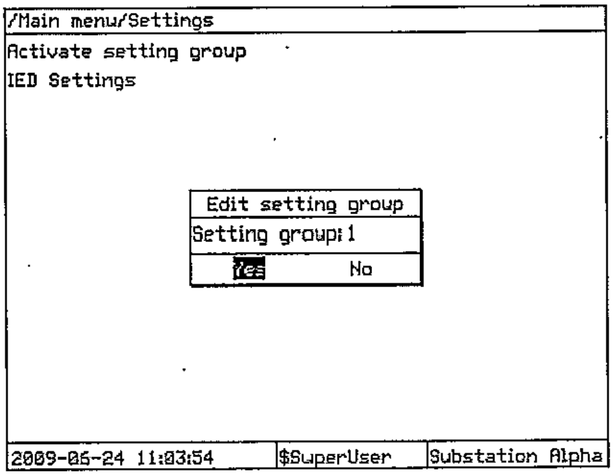
Незабравяйте да документирате направените промени.

6.4.1.2 Преглеждане и редактиране на стойностите на групите

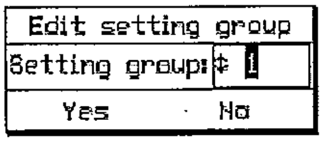
1. Изберете **Main menu/Settings/IED setting** и натиснете .

   Групата за настройка 1 е групата на подразбиране за редактиране.



Фигура 46: Избиране на група за редактиране

2. Натиснете върху реда Setting group в диалоговия прозорец, за да активирате режима на избиране.
3. Изберете желаната група за настройки с или и натиснете .



Фигура 47: Смяна на групата за настройка

4. Изберете Yes в диалоговия прозорец, и натиснете за да продължите.
   Текущата група за настройки е показана в ляво на заглавието.
5. Изберете категорията на функцията за прилагане в списъка с или и натиснете за да видите функционалните блокове в тази категория.
   Категориите налични в списъка, зависят от конфигурацията оформена с PCM600.

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```
#1
Impedance
Current
Voltage
Frequency
Secondary system supervision
Control
Scheme communication
Logic
Monitoring
Metering

2009-06-24 11:05:03 | $SuperUser | Substation Alpha
```

Фигура 48: Избиране на категория функция

6. За да разгледате функционалните блокове, превъртете списъка с и .
   Наличните функционални блокове зависят от конфигурацията на приложението. За да се върнете обратно към списъка, натиснете .
7. За да изберете функционален блок, натиснете .

#1/Current/EF4PTOC(51N67N,4IN>)/1:EF4PTOC/General

INSTNAME	EF4PTOC		
Operation	Off		#
GlobalBaseSel	1		
AngleRCA	65	Deg	#
polMethod	Voltage		#
UPolMin	1	%UB	#
IPolMin	5	%IB	#
RNPol	5.00	ohm	#
XNPol	40.00	ohm	#
IN>Dir	10	%IB	#
2ndHarmStab	20	%	#

2009-06-24 11:06:57 | $SuperUser | Substation Alpha

Фигура 49: Функционален блок за настройки

Знака # в дясно показва, че параметър принадлежи към група за настройка.

8. За да разгледате настройките, превъртете списъка с и .
9. За да редактирате избрана настройка, натиснете .
   - Параметърът е активен за редактиране, в случай че не е част от група за настройка.
   - В случай на параметър от група за настройка, диалоговия прозорец за редактиране показва стойността на съответната настройка във всички налични групи за настройка, но потребителят може да редактира само стойността в избраната

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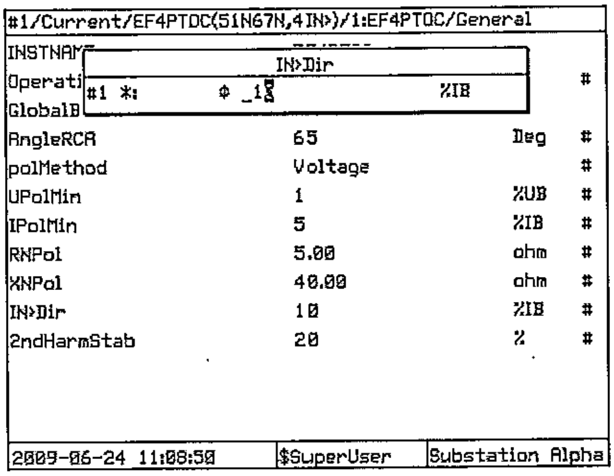
група за настройка. Активната група за настройка е маркирана със звездичка *.



Фигура 50: *Промяна на стойност*

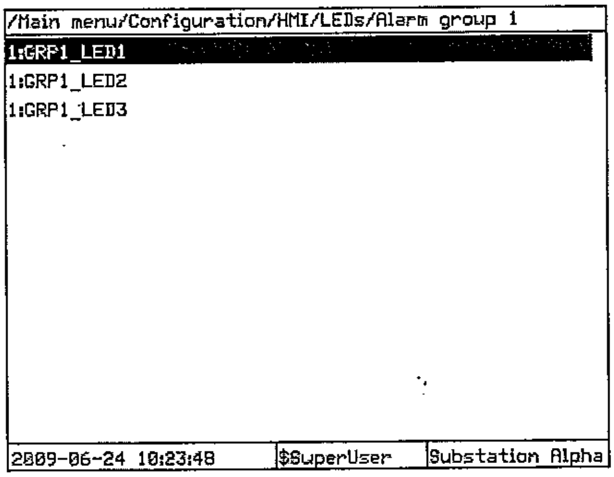
10. Натиснете или за да промените стойността.

11. Потвърдете промените с

6.4.2 Активиране на светодиодите

За да активирате светодиоди, те трябва да бъдат конфигурирани с PCM600.

1. Изберете **Main menu/Configuration/HMI/LEDs** и натиснете .



Фигура 51: *Сигнални групи*

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Списъкът може да съдържа максимум три групи сигнали за тревога. Броят на групите зависи от количеството светодиодите в употреба.

2. Изберете сигнал за тревога с ↑ или ↓ и натиснете ↵.
3. Изберете светодиод при сигнал за тревога с ↑ или ↓.
4. Натиснете ↵ за да потвърдите избора и да промените режима на светодиодната сигнализация за тревога.
5. Натиснете ↑ или ↓ за да промените стойността и ↵ за да потвърдите избора.

За повече информация вижте документацията на PCM600

ВЯРНО С ОРИГИНАЛА

ООД РУАЙН Стара Загора

Глава 7 Установяване на повреда

7.1 Проследяване на повреда

7.1.1 Установяване на хардуерни грешки

1. Проверете модула с грешка.
   - Проверете основното положение на светодиодите в **Main menu /Diagnostics/IED status/General** за повреден хардуерен модул
   - Проверете историята на промените в списъка за вътрешно събитие в **Main menu/Diagnostics/Internal Events.**
2. Прегледайте визуално IED.
   - Прегледайте визуално IED за причинена физическа грешка.
   - Ако неможете да откриете явни физически щети, свържете се с ABB за действия по поправка или заменяне.
3. Проверете дали грешката е външна или вътрешна.
   - Проверете дали грешката не е причинена от външен източник.
   - Извадете проводниците от IED и тествайте входящите и изходящите операции с външно тестово устройство.
   - Ако проблем остане се свържете с ABB за действия по ремонт или заменяне.

7.1.2 Установяване на грешки при изпълнение

1. Проверете грешката от вътрешния списък на събития на IED **Main menu/Diagnostics/IEDstatus/General.**
2. Рестартирайте IED и проверете отново в контрол на събитията дали грешката е изчистена.
3. В случай, че няма промяна се свържете с ABB за коригиращи действия.

7.1.3 Установяване на комуникационни грешки

Обикновено комуникационните грешки са комуникационни прекъсвания или съобщение за грешки при синхронизация дължащи се на разпадане на комуникационната връзка.

- Проверете комуникационния статус на IEC61850 и DNP3 в списъка за вътрешни събития **Main menu/Diagnostics/IED Status/General.**
- В случай, че грешките с вътрешен произход на IED, продължават да съществуват, като например повреден елемент се свържете с ABB за действия по ремонт или заменяне.

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7.1.3.1 Проверка на комуникационната работна връзка

Продукта има няколко различни комуникационни връзки. Първо проверете дали всички комуникационни портове са включени.

1. Проверете предния комуникационен порт RJ-45.
   1.1. Проверете дали допълнителния (uplink) светодиод свети с постоянна зелена светлина. Допълнителният светодиод се намира на LHMI над комуникационния порт RJ-45 вляво. Портът се използва за директна електрическа комуникация с компютър чрез кръстосан Етернет кабел.
   1.2. Проверете комуникационния статус на предния порт чрез LHMI в **Main menu/Test/ Function status/Communication/ 1:DOSFRNT/Outputs**. Проверете дали стойността на *LINKUP* е 1, това означава, че комуникацията работи. Когато стойността е 0, няма връзка.

   Задния порт конектор X0 се използва за свързване на външен HMI към IED. Ако стойността на *LINKUP* за предния порт е 0 няма да има връзка чрез порт X0. Не използвайте задния порт X0, ако IED е оборудван с LHMI.
2. Проверете комуникационния статус на задния порт X1 чрез LHMI в **Main menu/Test/ Function status/Communication/1:DOSLAN1/ Outputs**. Портът за комуникация X1, на задната страна на IED е за оптичен Етернет чрез LC конектор или електрически чрез RJ-45 конектор IEC 61850-8-1.
   - Проверете дали стойността на *LINKUP* е 1, това означава, че комуникацията работи. Когато стойността е 0, няма връзка.

7.1.3.2 Проверка на времето за синхронизация

- Изберете **Main menu/Diagnostics/IED status/General** и проверете статуса на времето за синхронизация на **Time Synch**. Стойността на *Time synch* е *Ready* когато синхронизацията е в изправност. Имайте предвид, че източникът за синхронизация на времето трябва да бъде активиран. В противен случай стойността е винаги *Ready*.

7.1.4 Стартиране на дисплей тест

За да стартирате теста използвате бутоните или менюто.

- Изберете **Main menu/Tests/LED test**.
- Натиснете или едновременно и .

Всички светодиодите се тестват, като ги включите едновременно. На дисплея се показва набор от цветове, така че да се активират всички пиксели. След теста, дисплеят се връща към нормално състояние.

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7.2 Показване на съобщения

7.2.1 Вътрешни грешки

Когато нагласен светодиод показва вътрешна повреда чрез мигане, съобщението за повредата е в списъка с вътрешни събития в менюто на LHMI **Main menu/Diagnostics/Internal events**. Съобщението включва дата, час, описание и състоянието на сигнала за повреда. Вътрешният списък на събития не се актуализира динамично. Той се актуализира чрез излизане от менюто **Internal events** и избирането му отново. Текущото състояние на вътрешните сигнали за повреда също могат да бъдат проверени чрез LHMI в **Main menu /Diagnostics/IED status**.

В зависимост от тежестта на повредата се предприемат различни действия. След като се установи, че повредата е постоянна, IED остава в режим на вътрешна повреда. Когато е в положение на повреда IED продължава да извършва вътрешни тестове.

При поява на повреда, трябва да се запише съобщение за неизправност и да се заяви, при поръчка на сервиз.

Таблица 37: Индикации при вътрешна грешка

Показание на повреда	Допълнителна информация
Internal Fault / Вътрешна повреда Real Time Clock Error / Грешка реално време на часовника	Хардуер грешка с часовник за реално време.
Internal Fault / Вътрешна повреда Runtime Exec. Error / Грешка Exec. при изпълнение	Едно или повече от приложенията не работят правилно.
Internal Fault / Вътрешна повреда SW Watchdog Error / Грешка Watchdog	Този сигнал ще се активира при претоварване на входа за повече от 5 мин.
Internal Fault / Вътрешна повреда Runtime App Error / Грешка App при изпълнение	Едно или повече от приложенията не са в очаквано състояние.
Internal Fault / Вътрешна повреда File System Error / Грешка на системен файл	Възникнала е грешка в системен файл.
Internal Fault / Вътрешна повреда TRM-Error / TRM-Грешка	Възникнала е грешка в TRM карта. Показва се номер в края на индикацията за повреда.
Internal Fault / Вътрешна повреда COM-Error / COM-Грешка	Възникнала е грешка в COM карта. Показва се номер в края на индикацията за повреда.
Internal Fault / Вътрешна повреда PSM-Error / PSM-Грешка	Възникнала е грешка в PSM карта. Показва се номер в края на индикацията за повреда.

7.2.2 Предупреждения

Предупредителното съобщение, свързано с повредата се намира в списъка с вътрешни събития в менюто на LHMI **Main menu/ Diagnostics/Internal events**. Съобщението включва дата, час, описание и състоянието на сигнала за повреда. Текущото състояние на вътрешните сигнали за повреда също могат да бъдат проверени чрез LHMI в **Main menu/Diagnostics/IED status/General.**

При поява на повреда, запишете съобщение посочващо повредата и заявете при поръчка на сервиз.

Таблица 38: Индикации при предупреждение

Индикация при предупреждение	Допълнителна информация
Warning/Предупреждение IEC 61850 Error/Грешка IEC 61850	Не успех при някои дейности IEC 61850 като четене на конфигурираш файл, стартиране и др.
Warning/Предупреждение DNP3 Error/ Грешка DNP3	Грешка в DNP3 комуникацията.

7.2.3 Допълнителни индикации

При допълнителните съобщения не активирате вътрешна повреда или предупреждение.

Съобщенията, са изброени в менюто LHMI под списъка със събития. Данни за състоянието на сигнал се намират под статуса на IED и в списъка с вътрешни събития.

Таблица 39: Допълнителни индикации

Индикация при предупреждение	Допълнителна информация
Time Synch Error/ Грешка при синхронизация	Източника за синхронизация на времето е изгубен или системното време се е нулирало.
BATTERY1 Error/ Грешка батерия 1	Прекъснато е допълнителното захранване.
Settings Changed/ Променени настройки	Променени са настройките.
Setting Groups Changed/ Променени групи за настройка	Променена е група за настройка

7.3 Корекционни процедури

7.3.1 Смяна и настройване на паролата

Паролата може да бъде зададена само с PCM600.

За повече информация, вижте документацията на PCM600.

7.3.2 Установяване на проблеми при употреба на IED

Отидете на подходящо меню в LHMI за идентифициране на възможни проблеми.

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- Проверете дали функцията е on.
- Проверете дали правилната група настройки (от 1 до 4) е активирана.
- Проверете блокировката.
- Проверете режима.
- Проверете измерената стойност.
- Проверете връзката с записващите функции изключване и смущение.
- Проверете настройките на канала.

7.3.2.1 Преглеждане на електрическата инсталация

Физическа проверка на кабелните връзки, често разкрива лоша връзка на фазните токове или напрежения. Все пак, дори връзките на фазния тока или напрежение към клемите на IED да са както трябва, погрешна полярност на един или повече измервателни трансформатори може да предизвика проблеми.

- Проверете измервания ток или напрежение и техните фази от **Main menu/Measurements/Analog primary values** or **Analog secondary voltages**.
- Проверете дали фазната информация и поредността на фазите е правилна.
- Ако е необходимо поправете проводниците.
    - Променете параметъра *Negation* в **Configuration/Analog modules/3PhaseAnalogGroup/1:SMAI_20_n** (n= броят на използваните SMAI).

      Промяна параметъра *Negation* не се препоръчва без нужните умения.

    - Променете параметъра в PCM600, вижте документацията на PCM600.
- Проверете действителното състояние на бинарните входове.
    - В LHMI, изберете **Main menu/Tests/Binary input values/Binary input modules**. След това отидете на панела с действителния бинарен вход.
    - Проверете действителното състояние на бинарните входове чрез PCM600, вижте документацията на PCM600.
- Измервателните изходни контакти използват метода пад на напрежението при прилагане на най-малкия товар на контакта, определен в техническата документация за изходните релета. Например 100 mA при 24 V AC/DC.

  Изходните релета, особено мощностните са проектирани да прекъсват голям ток. Поради това, върху повърхността на контактите може да се появи слой с високо съпротивление. Да не се съди за правилното функциониране на контактната проводимостта/ съпротивление, чрез измерване с обикновен ръчен омметър.

ВЯРНО С ОРИГИНАЛА

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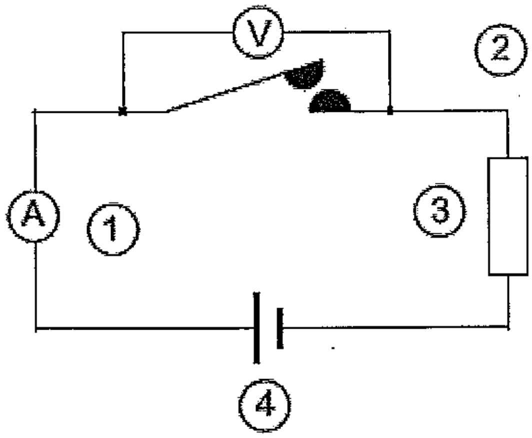
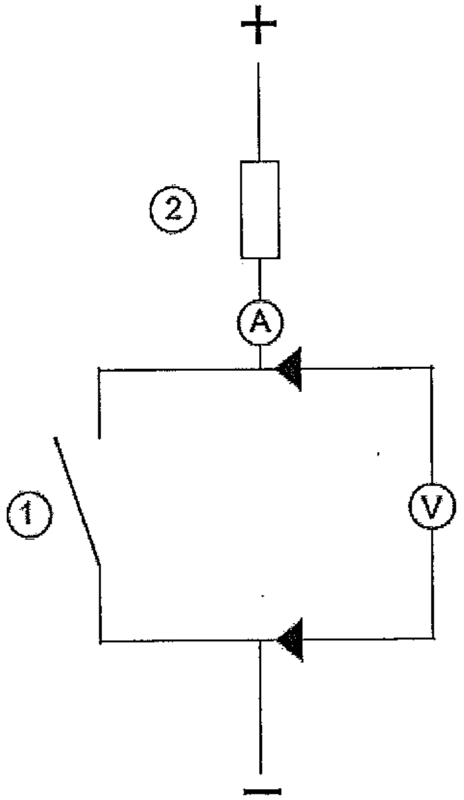


Фигура 52: Тестване на изходните контакти по метода пад на напрежението

1. Токов контакт
2. Контакт с пад на напрежението
3. Товар
4. Захранващо напрежение

ВЯРНО С ОРИГИНАЛА

Подпис:



Фигура 53: Тестване на изключващ контакт

1. Изпитван контакт
2. Съпротивление за ограничаване на тока

- За да проверите състоянието на изходните вериги пуснете изходното реле чрез LHMI, изберете **Main menu/Tests/Binary output values/Binary output modules** и след това отидете на панела с действителния бинарен изход.
- Тествайте и променете състоянието на релето ръчно.
  1. За да настроете IED в режим на тестване, изберете **Main menu/Tests/IEDtestmode1:TESTMODE/TestMode** и поставете параметъра на *On*.
  2. За да задействате или да принудите изходното реле да работи, изберете и след това отидете до панела с действителните бинарни изходи на релето за задействане/принуждаване.
  3. Изберете Bon_PO за да се задейства/принуди и използвайте или за да задействате действителното изходно реле. Всеки Bon_PO е представен с два сигнала. Първият сигнал в LHMI е действителна стойност 1 или 0 на изхода, а в PCM600 светъл или замъглен диод.

ВЯРНО С ОРИГИНАЛА

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Подпис:

Вторият сигнал е положение Normal/Нормален или Forced/Претоварен. Положение Forced/Претоварен се постига само когато BO е поставен на *Forced* или се оперира на LHMI.

След завършването на тези тестове поставете параметъра *TestMode* на *Off*. Светодиода за стартиране спира да мига, когато релето вече не е в режим на тестване.

Първоначално високото съпротивление на контакта не води до проблеми, тъй като то се намалява бързо от фритоване и термично разрушаване на слоевете т. н. ефект на електрическо почистване, поради което съпротивлението на контакта е в границите на милиомове mOhm. В резултат на това практически цялото напрежение е приложено върху товара.

ВЯРНО С ОРИГИНАЛА

ООД

Глава 8 Речник

AC	Променлив ток
ACT	Инструмент за конфигуриране на приложения с PCM600
A/D converter	Аналогов към цифров преобразовател
ADBs	Супервизия на амплитуда на нечувствителен участък от лентата
AI	Аналогов вход
ANSI	Американския национален институт по стандартизация
AR	Устройство за автоматично повторно включване
ASCT	Токов трансформатор с помощно сумиране
ASD	Адаптивни откриване на сигнали
AWG	Американски стандарт за диаметъра на проводници
BI	Бинарен вход
BOS	Статус на бинарните изходи
BR	Външно бистабилно реле
BS	Английски стандарт
CAN	Комуникационен протокол. ISO стандарт (ISO 11898) за серийна комуникация
CB	Прекъсвач
CCITT	Консултативен комитет за международна телеграфия и телефония. Организация за стандарти, спонсорирана от Обединените Нации в рамките на Международния телекомуникационен съюз.
CCVT	Капацитивно свързан напреженов трансформатор
Class C	Защитен токов трансформатор определен клас по IEEE/ANSI
CMPPS	Комбинирани мега импулси за секунда
CMT	Инструмент за управление на комуникацията в PCM600
CO cycle	Цикъл включване-изключване
Codirectional	Начин на предаване G.703 по балансирана линия. Включва две усукани двойки позволяващи пренос на данни в двете посоки.
COMTRADE	Стандартен формат съгласно IEC 60255-24
Contra-directional	Начин на предаване G.703 по балансирана линия. Включва четири усукани двойки, две се използва за пренос на данни в двете посоки и две за сигнали от таймер.
CPU	Централен процесор

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CR	Получаване на носител
CRC	Цикличен управление чрез излишък
CROB	Контролен на изходен блок на реле
CS	Изпращане на носител
CT	Токов трансформатор
CVT	Капацитивен напреженов трансформатор
DAR	Автоматично повторно включване със задържане по време
DARPA	Правителствена агенция към министерството на отбраната на САЩ, занимаваща се с развитието на новите технологии (Разработели протокола TCP/IP и др.)
DBDL	Обезточена шина и линия
DBLL	Обезточена шина, захранена линия
DC	Постоянен ток
DFC	Контрол на потока на данни
DFT	Дискретна трансформации на Фурие
DHCP	Протокол за динамично конфигуриране на хостове
DIP-ключ	Малък превключвател, монтиран върху електронна платка
DI	Цифров вход
DLLB	Обезточена линия, захранена шина (под напрежение)
DNP	Разпределен мрежови протокол по стандарт IEEE/ANSI 1379-2000
DR	Регистратор на повреди
DRAM	Динамична памет с произволен достъп
DRH	Обработка на отчета за смущения
DSP	Процесор за цифрова обработка на сигнали
DTT	Директен пренос на изключваща схема
EHV мрежа	Мрежа Свръх високо напрежение
EIA	Сдружение на отраслите от електронната промишленост
EMC	Електромагнитна съвместимост
EMF	Електродвижещо напрежение
EMI	Електромагнитна интерференция
EnFP	Последна защита на повредата
EPA	Повишени експлоатационни качества на архитектурата
ESD	Електростатичен разряд
FCB	Контрол на потока на битове; Брой битове в прозорец
FOX 20	20 канална модулна телекомуникационна

Вярно с оригинала

Подпис:

ООД Стара Загора

	система за говор, данни и защитни сигнали
FOX 512/515	Мултиплексор на достъпа
FOX 6Plus	Компактен мултиплексор с разделяне по време за пренос на цифрови данни по оптични влакна с до седем дуплексни канала
G.703	Електрическо и функционално описание на цифрови линии, използвани от локални телефонни компании. Използва се за балансирани и небалансирани линии
GCM	Комуникационен интерфейс с приемащ модул на GPS
GDE	Графичен дисплей редактор в PCM600
GI	Основна запитваща команда
GIS	Разпределително устройство с газова изолация
GOOSE	Общо обектно-ориентирано събитие на подстанция
GPS	Глобална система за позициониране
HDLC протокол	Протокол за управление на каналното предаване на данни от високо ниво, базиран на стандарта HDLC
HFBR вид конектор	Конектор с гъвкаво оптично влакно
HMI	Интерфейс човек-машина
HSAR	Автоматично повторно включване с висока скорост
HV	Високо напрежение
HVDC	Високо напрежение с постоянен ток
IDBS	Интегриране на наблюдение със зона на нечувствителност
IEC	Международна електротехническа комисия
IEC 60044-6	IEC стандарт, Измервателни трансформатори – Част 6: Изисквания за защита на токови трансформатори от въздействието на преходни процеси
IEC 61850	Стандарт за автоматизация на подстанции
IEEE	Институт на инженерите по електротехника и електроника
IEEE 802.12	Стандарт за мрежова технология, който осигурява 100 Mbits/s по кабел с усукана двойка или оптично влакно
IEEE P1386.1	Стандарт за PCI Мецанина карта (PMC) за локални шинни модули. Справки към CMC (IEEE P1386, обща мецанин карта) стандарта за механиката и PCI спецификациите от PCI SIG (Група със специален интерес) в областта на електродвижещото напрежение (EMF).
IED	Интелигентно електронно устройство
I-GIS	Интелигентно разпределително устройство с газова изолация
Instance/Инстанция	При няколко повторения на една и съща функция в IED, те се посочват като инстанция

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	на функцията. Една инстанция на функция може да е идентична с друга от същия вид, но в потребителския интерфейс на IED ще има различен номер. Понякога думата „инстанция“ се дефинира като определено количество информация, показваща вида й. В IED инстанция на функцията представя вида й.
IP	1. Интернет протокол. Мрежов слой на комплекта TCP/IP протоколи, широко използван в Етернет мрежи. IP е без връзка, най-продуктивен протокол за обмен на пакети. Той осигурява маршрутизиране на пакетите, фрагментиране и повторно събиране на пакетите през слоя на свързващото ниво. 2. Индекс за защита съгласно IEC стандарт
IP 20	Индекс на защита от проникване, ниво 20
IP 40	Индекс на защита от проникване, ниво 40
IP 54	Индекс на защита от проникване, ниво 54
IRF	Вътрешно неуспял сигнал
IRIG-B	Междуведомствена група по измервателни средства формат B стандарт 200
ITU	Международен съюз по телекомуникации
LAN	Локална мрежа
LIB 520	Софтуерен модул за високо напрежение
LCD	Дисплей с течни кристали
LDD	Локален детектор
LED	Светодиод
MCB	Миниатюрен прекъсвач
MCM	Мецанин носещ модул
MVB	Многофункционална шина. Стандартизирана комуникационна серийна шина.
NCC	Национален център за управление
OCO цикъл	Цикъл изключване-включване-изключване
OCP	Максимално токова защита
OLTC	Регулатор на напрежението под товар
OV	Пренапрежение
Overreach/ Извън обхват	Термин, използван за описание на начина, по който сработва релето при настъпване на авария. Например, едно дистанционно реле достига извън обхват, когато импедансът достигнал до него е по-малък от явния импеданс на повредата, приложен към точката на баланс, т.е. зададения обхват. Релето "вижда" повредата, но може би не е трябвало да я е видяло.

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PCI	Свързани периферни устройства на централния процесор
PCM	Импулсно-кодова модулация
PCM600	Мениджър за защита и управление IED 600
PC-MIP	Стандарт за Мецанин карта
PISA	Интерфейс за сензори и задвижващи механизми
PMC	PCI Мецанин карта
POR	Позволяващ извън обхват
POTT	Позволяващ извън обхват пренос на изключване
Process bus/ шина	Bus или LAN използвани на ниво процесор, в близост до измервания и/или управлявания компонент
PSM	Захранващ модул
PST	Инструмент за настройка на параметри в PCM600
PT коефициент	Коефициент на трансформация
PUTT	Разрешаващ трансфер на изключващ сигнал със съкратена зона
RASC	Реле за проверка на синхронизация, COMBIFLEX
RCA	Ъглова характеристика на реле
RFPP	Съпротивление при междуфазно съединение
RFPE	Съпротивление при фазно съединение
RISC	Компютър с намален набор от инструкции
RMS стойност	Ефективна стойност
RS422	Балансиран сериен интерфейс за пренос на цифрова информация от точка до точка
RS485	Серийна връзка съгласно EIA стандарт RS485
RTC	Часовник в реално време
RTU	Отдалечен терминал за събиране на информация
SA	Автоматизация на подстанция
SBO	Избери преди изпълнение
SC	Ключ или бутон за включване
SCS	Система за управление на станция
SCADA	Система за мониторинг и контрол
SCT	Инструмент за конфигуриране на системата съгласно IEC 61850
SDU	Блок данни на услуга
SMA конектор	Суб-миниатюрна версия А, А едножилен конектор с постоянен импеданс
SMT	Инструмент за матричен сигнал в PCM600

SMS	Система за мониторинг на станция
SNTP	Обикновен протокол за мрежово време – използва се за синхронизиране часовници на компютрите в локални мрежи. Това намалява изискването за наличие на точни хардуерни часовници във всяка вградена в мрежата система. Всеки вграден възел може да се синхронизира с дистанционен часовник, като така се осигурява необходимата точност.
SRY	Ключ за готовност на прекъсвача
ST	Ключ или бутон за изключване
Starpoint/Звездна точка	Неутралата на трансформатор или генератор
SVC	Статична VAr компенсация
TC	Изключваща бобина
TCS	Наблюдение на изключващата мрежа
TCP	Протокол за управление на обменна на информация. Най-често използван в Етернет и Интернет.
TCP/IP	Протокол за управление на трансфера по интернет протокола. Де факто стандартните Етернет протоколи, вградени в 4.2BSD Unix. TCP/IP, са разработени от DARPA за работа в интернет и обхващат протоколи както от мрежовия слой, така и от транспортния. Докато TCP и IP определят два протокола на специфични протоколни слоеве, TCP/IP често се използват за определение на целия пакет протоколи на Министерството на Отбраната на САЩ, изграден на базата на последните и включващ Telnet, FTP, UDP и RDP.
TNC конектор	Neill Concelman, Вид едножилен BNC конектор с постоянен импеданс
TPZ, TPY, TPX, TPS	Класове токови трансформатори съгласно IEC
UMT	Потребителски инструмент за управление
Underreach/Под обхват	Термин, използван за описание на начина, по който сработва релето при настъпване на авария. Например, едно дистанционно реле не достига обхвата, когато импедансът, достигнал до него, е по-голям от явния импеданс на повредата, приложен към точката на баланс, т.е. зададения обхват. Релето “не вижда” повредата, но може би е трябвало да я види. Виж също и „извън обхват”.
U/I-PISA	Компоненти на процесорния интерфейс, които доставят стойностите на измереното напрежение и ток
UTC	Координирано универсално време. Координирана времева скала, поддържана от Международното бюро по мерки и теглилки (BIPM), която оформя основата на координираното разпространение на стандартни честоти и времеви сигнали. UTC произлиза от

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Международното атомно време (TAI) чрез добавка на цяло число за "коригиращи секунди", за да се синхронизира с универсално време 1 (UT1), като по този начин се отчита ексцентричната орбита на Земята, наклона на земната ос (23.5 градуса), но и неправилното въртене на Земята, на което се базира UT1. Координираното универсално време се изразява чрез 24-часовият часовник и използва Григорианския календар. Използва се за навигация на самолети и кораби, известно е по военното си име, "Zulu time". Със "Zulu" във фонетичната азбука се обозначава "Z", което пък обозначава географска дължина нула.

UV	Поднапрежение
WEI	Логика на захранване на неустойчив край
VT	Напреженов трансформатор
X.21	Цифров интерфейс за сигнализация, първоначално използван в оборудването за телекомуникация
$3I_O$	Три пъти тока с нулева последователност. Често се нарича остатъчен или ток в мястото на земно съединение
$3U_O$	Три пъти напрежението с нулева последователност. Често се нарича остатъчно напрежение или напрежение в неутралата

ВЯРНО С ОРИГИНАЛА

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