1. Type — HH-SI 6/12kV 16A FC TB ÜLA 292/56
Order-No.: 67220.0169

2. Reason for test

Temperature-rise tests and power-dissipation measurement

3. Tests performed / measurements

Measurement of temperatures, of voltage drop across fuse-link and power dissipation at different operating currents.

4. Applied standards

IEC 60282-1 1998-01 VDE 0670 Teil 4 Abs. 12 02/98

5. Test-laboratory, period of time

EFEN Prüflabor Eltville, 10/04/2000 – 10/12/2000

6. Arrangement of the equipment

The high-voltage fuse-link is mounted vertically in a fuse-base, with the striker-pin at the top.
The size of bare copper conductors is 25 mm².
Temperatures are measured at the fuse contacts (top and bottom), in the middle of the fuse with thermocouples and are recorded.
The test currents are recorded.

7. Inspection and test sequence

The fuse-link was loaded with test currents I = 8,0 A and I = 16 A

Test current I [A]	Comments
8,0	50% rated current
16	Rated current

Temperatures are measured at the fuse contacts and in the middle of the tube with thermocouples.
Calculation of power dissipation from recorded voltage drop and recorded test current.
Calculation of resistance depending on the currents.

8. Results

Type: HH-SI 6/12kV 16A FC TB ÜLA 292/56
R_{cold}: 107 mΩ

8.1 Temperature rise test

		Temperature			Temperature rise			Informative	
I [A]	$\vartheta_{amb.}$ [°C]	ϑ_{top} [°C]	ϑ_{bottom}	$\vartheta_{perm.}$ [°C]	$\Delta\vartheta_{top}$ [K]	$\Delta\vartheta_{bottom}$ [K]	$\Delta\vartheta_{perm.}$ [K]	ϑ_{center} [°C]	ϑ_{center} [K]
8,0	21	28	26	105	7	5	65	37	16
16	23	48	38	105	25	15	65	85	62

8.2 Power dissipation and resistance of the test object at defined currents.

I [A]	P_d [W]	$U_{fuse-link}$ [V]	R [mΩ]
8	7,5	0,94	118
16	38	2,36	148

9. Evaluation

The product passed the temperature-rise test acc. to IEC 60 282-1 and VDE 0670 Teil 4 respectively.

372 / 23
06/06/2001

EFEN GmbH Prüflabor Test Laboratory Eltville

Test engineer

Head of laboratory

1. Type — HH-SI 6/12kV 20A FC TB ÜLA 292/56
Order-No.: 67220.0209

2. Reason for test

Temperature-rise tests and power-dissipation measurement

3. Tests performed / measurements

Measurement of temperatures, of voltage drop across fuse-link and power dissipation at different operating currents.

4. Applied standards

IEC 60282-1 1998-01 VDE 0670 Teil 4 Abs. 12 02/98

5. Test-laboratory, period of time

EFEN Prüflabor Eltville, 10/24/2000 – 10/30/2000

6. Arrangement of the equipment

The high-voltage fuse-link is mounted vertically in a fuse-base, with the striker-pin at the top.
The size of bare copper conductors is 25 mm².
Temperatures are measured at the fuse contacts (top and bottom), in the middle of the fuse with thermocouples and are recorded.
The test currents are recorded.

7. Inspection and test sequence

The fuse-link was loaded with test currents I = 10 A and I = 20 A

Test current I [A]	Comments
10	50% rated current
20	Rated current

Temperatures are measured at the fuse contacts and in the middle of the tube with thermocouples.
Calculation of power dissipation from recorded voltage drop and recorded test current.
Calculation of resistance depending on the currents.

8. Results

Type: HH-SI 6/12kV 20A FC TB ÜLA 292/56
R_{cold}: 71,4 mΩ

8.1 Temperature rise test

		Temperature			Temperature rise			Informative	
I [A]	$\vartheta_{amb.}$ [°C]	ϑ_{top} [°C]	ϑ_{bottom} [°C]	$\vartheta_{perm.}$ [°C]	$\Delta\vartheta_{top}$ [K]	$\Delta\vartheta_{bottom}$ [K]	$\Delta\vartheta_{perm.}$ [K]	ϑ_{center} [°C]	ϑ_{center} [K]
10	22	28	26	105	6	4	65	37	15
20	23	48	37	105	25	14	65	83	60

8.2 Power dissipation and resistance of the test object at defined currents.

I [A]	P_d [W]	$U_{fuse-link}$ [V]	R [mΩ]
10	7,7	0,772	77,2
20	38	1,91	95,5

9. Evaluation

The product passed the temperature-rise test acc. to IEC 60 282-1 and VDE 0670 Teil 4 respectively.

372 / 23
06/06/2001

EFEN GmbH Prüflabor Test Laboratory Eltville

Test engineer

Head of laboratory

1. Type — HH-SI 6/12kV 25A FC TB ÜLA 292/56
Order-No.: 67220.0259

2. Reason for test

Temperature-rise tests and power-dissipation measurement

3. Tests performed / measurements

Measurement of temperatures, of voltage drop across fuse-link and power dissipation at different operating currents.

4. Applied standards

IEC 60282-1 1998-01 VDE 0670 Teil 4 Abs. 12 02/98

5. Test-laboratory, period of time

EFEN Prüflabor Eltville, 10/24/2000 – 10/30/2000

6. Arrangement of the equipment

The high-voltage fuse-link is mounted vertically in a fuse-base, with the striker-pin at the top.
The size of bare copper conductors is 25 mm².
Temperatures are measured at the fuse contacts (top and bottom), in the middle of the fuse with thermocouples and are recorded.
The test currents are recorded.

7. Inspection and test sequence

The fuse-link was loaded with test currents I = 12,5 A and I = 25 A

Test current I [A]	Comments
12,5	50% rated current
25	Rated current

Temperatures are measured at the fuse contacts and in the middle of the tube with thermocouples.
Calculation of power dissipation from recorded voltage drop and recorded test current.
Calculation of resistance depending on the currents.

8. Results

Type: HH-SI 6/12kV 25A FC TB ÜLA 292/56
R_{cold}: 51,6 mΩ

8.1 Temperature rise test

		Temperature			Temperature rise			Informative	
I [A]	$\vartheta_{amb.}$ [°C]	ϑ_{top} [°C]	ϑ_{bottom}	$\vartheta_{perm.}$ [°C]	$\Delta\vartheta_{top}$ [K]	$\Delta\vartheta_{bottom}$ [K]	$\Delta\vartheta_{perm.}$ [K]	ϑ_{center} [°C]	ϑ_{center} [K]
12,5	22	30	28	105	8	6	65	40	18
25	22	54	41	105	32	19	65	94	72

8.2 Power dissipation and resistance of the test object at defined currents.

I [A]	P_d [W]	$U_{fuse-link}$ [V]	R [mΩ]
12,5	8,9	0,71	56,9
25	45,5	1,82	72,8

9. Evaluation

The product passed the temperature-rise test acc. to IEC 60 282-1 and VDE 0670 Teil 4 respectively.

372 / 23
06/06/2001

EFEN GmbH Prüflabor Test Laboratory Eltville

Test engineer

Head of laboratory

1. Type — HH-SI 6/12kV 31,5A FC TB ÜLA 292/56
Order-No.: 67220.0329

2. Reason for test

Temperature-rise tests and power-dissipation measurement

3. Tests performed / measurements

Measurement of temperatures, of voltage drop across fuse-link and power dissipation at different operating currents.

4. Applied standards

IEC 60282-1 1998-01 VDE 0670 Teil 4 Abs. 12 02/98

5. Test-laboratory, period of time

EFEN Prüflabor Eltville, 10/24/2000 – 10/30/2000

6. Arrangement of the equipment

The high-voltage fuse-link is mounted vertically in a fuse-base, with the striker-pin at the top.
The size of bare copper conductors is 25 mm².
Temperatures are measured at the fuse contacts (top and bottom), in the middle of the fuse with thermocouples and are recorded.
The test currents are recorded.

7. Inspection and test sequence

The fuse-link was loaded with test currents I = 16 A and I = 31,5 A

Test current I [A]	Comments
16	50% rated current
31,5	Rated current

Temperatures are measured at the fuse contacts and in the middle of the tube with thermocouples.
Calculation of power dissipation from recorded voltage drop and recorded test current.
Calculation of resistance depending on the currents.

8. Results

Type: HH-SI 6/12kV 31,5A FC TB ÜLA 292/56
R_{cold}: 42,9 mΩ

8.1 Temperature rise test

		Temperature			Temperature rise			Informative	
I [A]	$\vartheta_{amb.}$ [°C]	ϑ_{top} [°C]	ϑ_{bottom}	$\vartheta_{perm.}$ [°C]	$\Delta\vartheta_{top}$ [K]	$\Delta\vartheta_{bottom}$ [K]	$\Delta\vartheta_{perm.}$ [K]	ϑ_{center} [°C]	ϑ_{center} [K]
16	23	33	29	105	10	6	65	46	23
31,5	20	59	46	105	39	26	65	115	95

8.2 Power dissipation and resistance of the test object at defined currents.

I [A]	P_d [W]	$U_{fuse-link}$ [V]	R [mΩ]
16	12,8	0,78	49,8
31,5	64,4	2,05	65,1

9. Evaluation

The product passed the temperature-rise test acc. to IEC 60 282-1 and VDE 0670 Teil 4 respectively.

372 / 23
06/06/2001

EFEN GmbH Prüflabor Test Laboratory Eltville

Test engineer

Head of laboratory

KEMA

HIGH–POWER LABORATORY
Utrechtseweg 310 – 6812 AR Arnhem – The Netherlands

719–00

REPORT OF PERFORMANCE

CLIENT	EFEN Elektrotechnische Fabrik GmbH, Eltville am Rhein, Germany
MANUFACTURER	EFEN Elektrotechnische Fabrik GmbH, Eltville am Rhein, Germany
APPARATUS	Current limiting fuses
DESIGNATION	HH–SI 6/12kV FC TB 292/56 1 – 2 – 4 – 6.3 – 10 – 16 – 20 – 25 – 31.5 A
SERIAL No.	67220.0010, 67220.0020, 67220.0040, 67220.0060, 67220.0100, 67220.0160, 67220.0200, 67220.0250 and 67220.0320.

RATINGS ASSIGNED BY THE MANUFACTURER

Voltage	12	kV
Current	1 – 2 – 4 – 6.3 – 10 – 16 – 20 – 25 – 31.5	A (1)
Frequency	50	Hz
Breaking capacity at 12 kV	63	kA
Series	1	
Class	Back–up	

(1) The fuse–links 20 – 25 – 31.5 A form a homgeneous series in accordance with Sub–clause 13.3.1 of IEC 60282–1.

The tests have been carried out strictly in accordance with IEC 60282–1, Sub–clause 13 (Test–duty 1).
The apparatus has complied with the relevant requirements.

Date of tests 22nd November 2000

The performance of the apparatus tested and the observations made during the tests have been recorded in the tables with test results and the oscillograms

THIS REPORT CONSISTS OF:

Pages	11
Circuit diagrams	1
Oscillograms	25
Drawings	13
Photographs	4
Evaluation sheet	B70E

KEMA Nederland B.V.

A.L.J. Janssen
Manager High–Power Laboratory

Arnhem, 27th February 2001

E40E

TABLE WITH TEST RESULTS

REPORT 719–00	TYPE OF TESTS REQUESTED: Test–duty 1	TEST CIRCUIT S01	PAGE 9

Condition before tests: Fuse–base new. Photograph 0401304.
Before each test new fuse–link.
Fuse–link mounted vertically in free air.
Distance fuse–link to floor 1.5 m.

Date and test	Fuse–link Type	Fuse–link Rated voltage kV / Rated current A	Resistance before test mΩ / after test MΩ	Test circuit Applied voltage kV	Test circuit Prospective current kA	Commencing of arcing after voltage zero °	Instantaneous current at initiation of arcing peak kA	Cut–off current peak kA	Pre–arcing time ms	Arcing time ms	Total operating time ms	Recovery voltage (1) kV	Switching voltage peak kV	Melt ∫I²t A²s x 10⁶	Total ∫I²t A²s x 10⁶	Energy ∫U x I x t kJ	Condition after test: Fuse–link / Striker; Behaviour during test, Remarks
001122 4019	HH–SI 6/12 FC TB 292/56 67220.0160 001559	12 / 16	105 / > 300	10.6	64.3	48	2.32	2.55	0.10	6.05	6.15	10.5	20.2	182	1140	19.6	cold / operated; Fuse cleared.
001122 4020	HH–SI 6/12 FC TB 292/56 67220.0160 001560	12 / 16	105 / > 300	10.6	64.3	76	2.55	2.93	0.09	4.06	4.15	10.5	26.6	214	1160	13.9	cold / operated; Fuse cleared.
001122 4021	HH–SI 6/12 FC TB 292/56 67220.0160 001561	12 / 16	110 / > 300	10.6	64.3	79	2.70	2.99	0.09	3.64	3.73	10.5	26.8	214	1120	11.9	cold / operated; Fuse cleared.

Remarks: Fuse–base showed no visible change.

(1) Maintained for 15 s.

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E40E

TABLE WITH TEST RESULTS

REPORT 719–00 | TYPE OF TESTS REQUESTED: Test–duty 1 | TEST CIRCUIT S01 | PAGE 10

Condition before tests: Fuse–base in same condition.
Before each test new fuse–link.
Fuse–link mounted vertically in free air.
Distance fuse–link to floor 1.5 m.

Date and test	Fuse–link: Type	Fuse–link: Rated voltage kV / Rated current A	Resistance: before test mΩ / after test MΩ	Test circuit: Applied voltage kV	Test circuit: Prospective current kA	Commencing of arcing after voltage zero °	Instantaneous current at initiation of arcing peak kA	Cut–off current peak kA	Pre–arcing time ms	Arcing time ms	Total operating time ms	Recovery voltage (1) kV	Switching voltage peak kV	Melt ∫I²t A²s x 10⁶	Total ∫I²t A²s x 10⁶	Energy ∫U x I x t kJ	Condition after test: Fuse–link / Striker: Behaviour during test, Remarks
001122 4022	HH–SI 6/12 FC TB 292/56 67220.0200 001566	12 / 20	72 / > 300	10.6	64.3	45	2.98	3.18	0.15	5.67	5.82	10.5	20.0	425	1790	17.3	cold / operated: Fuse cleared.
001122 4023	HH–SI 6/12 FC TB 292/56 67220.0200 001567	12 / 20	70 / > 300	10.6	64.3	77	3.47	3.81	0.11	3.85	3.96	10.5	27.2	440	2300	19.5	cold / operated: Fuse cleared.
001122 4024	HH–SI 6/12 FC TB 292/56 67220.0200 001568	12 / 20	71 / > 300	10.6	64.3	80	3.40	3.75	0.11	2.81	2.92	10.5	28.2	476	2040	12.3	cold / operated: Fuse cleared.

(1) Maintained for 15 s.

Remarks: Fuse–base showed no visible change.

KEMA

E40E

TABLE WITH TEST RESULTS

REPORT 719–00	TYPE OF TESTS REQUESTED: Test–duty 1	TEST CIRCUIT S01	PAGE 11

Condition before tests: Fuse–base in same condition.
Before each test new fuse–link.
Fuse–link mounted vertically in free air.
Distance fuse–link to floor 1.5 m.

Date and test	Fuse–link Type	Fuse–link Rated voltage kV / Rated current A	Resistance before test mΩ / after test MΩ	Test circuit Applied voltage kV	Test circuit Prospective current kA	Commencing of arcing after voltage zero °	Instantaneous current at initiation of arcing peak kA	Cut–off current peak kA	Pre–arcing time ms	Arcing time ms	Total operating time ms	Recovery voltage (1) kV	Switching voltage peak kV	Melt ∫I2t A2s x 10^6	Total ∫I2t A2s x 10^6	Energy ∫U x I x t kJ	Condition after test: Fuse–link / Striker; Behaviour during test, Remarks
001122 4025	HH–SI 6/12 FC TB 292/56 67220.0320 001577	12 / 31.5	41 / > 300	10.6	64.3	47	4.24	4.32	0.21	5.34	5.55	10.5	22.9	1280	3720	20.2	cold / operated; Fuse cleared.
001122 4026	HH–SI 6/12 FC TB 292/56 67220.0320 001578	12 / 31.5	41 / > 300	10.6	64.3	80	4.83	5.20	0.16	4.11	4.27	10.5	28.7	1280	5640	34.8	cold / operated; Fuse cleared.
001122 4027	HH–SI 6/12 FC TB 292/56 67220.0320 001579	12 / 31.5	41 / > 300	10.6	64.3	79	4.83	5.20	0.17	3.70	3.87	10.5	29.9	1310	4730	25.6	cold / operated; Fuse cleared.

Remarks: Fuse–base showed no visible change.
Photograph 0401305.

(1) Maintained for 15 s.

KEMA

FGH
Engineering & Test GmbH
Mannheim-Rheinau, Hallenweg 40

Accredited testing laboratory to DIN EN 45001 for subject

Deutscher Akkreditierungs Rat DAR

DAT-P-103/00-00 High-voltage apparatus switchgear and controlgear

DAT-P-103/00-10 High-voltage cables and accessories

Test Report

No. L 00056

Duly signed copy 1E

Reference: 114-00/829...842, 1034...1045

Apparatus: **Current-limiting fuse-link**

Types:
a) HH-SI 6/12kV 16A FC TB 292/56, Ident-No.: 67220.0160
b) HH-SI 6/12kV 20A FC TB 292/56, Ident-No.: 67220.0200
c) HH-SI 6/12kV 25A FC TB 292/56, Ident-No.: 67220.0250
d) HH-SI 6/12kV 31.5A FC TB 292/56, Ident-No.: 67220.0320

Rated voltage: 12 kV
Rated current: a) 16 A, b) 20 A, c) 25 A, d) 31.5 A
Class: Back-up

Manufacturer: EFEN Elektrotechnische Fabrik GmbH,
Postfach 12 54, D-65344 Eltville, Germany

Customer: EFEN Elektrotechnische Fabrik GmbH,
Postfach 12 54, D-65344 Eltville, Germany

Test Specification: IEC 60282-1 (1998-01), Ed.4.2

Tests performed: Breaking tests:

Test duty 2:
Verification of the operation with prospective current I2 at which current limiting occurs when a high level of energy is stored in the inductance of the circuit.

These fuse-links form a homogenous series, therefore only types a); b) and d) were tested.

Test duty 3:
Verification of the operation at the rated minimum breaking current

Test Results: During the breaking tests performed, the tested fuse-links fully complied with the standard conditions of behaviour with respect to breaking capacity.

Mannheim, October 11, 2000
Hch

FGH Engineering & Test GmbH

FGH Engineering & Test GmbH

Test Engineer:

(Heil)

Place and date of test: LPF Mannheim-Rheinau, September 26, 2000

Number of sheets: 40

FGH Engineering & Test GmbH

No. L 00056 Sheet 13

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	12	16	67220.0160 HH-SI 6/12kV 16A FC TB 292/56

Test-no.	114-00/		1042	1043	1044	1045
Specimen		No.	Adjust-ment test	001380	001382	001383
Resistance		mΩ	-	107	108	109
Test-duty (according to IEC 282-1)			2	2	2	2
Power factor of the test circuit	cos φ		0.11	0.11	0.11	0.011
Prospective breaking current (RMS)		A	574	574	574	573
Making angle after voltage zero		° el	8.6	9.4	8.6	9.0
Pre-arcing / Melting time	t_m	ms		3.47	3.51	3.43
Melting current	I_m	A		530	530	522
Pre-arcing Joule Integral		A^2s		245	246	235
Cut-off / Let through current	i_d	A		606	599	604
Arcing time	t_{LB}	ms		7.03	7.02	7.36
Arcing Joule Integral		A^2s		1270	1240	1450
Arcing time until breaking by the circuit breaker		ms		-	-	-
Max. switching voltage	u_s	kV		20.4	20.4	18.8
Power frequency recovery voltage	U_w	kV	10.50	10.50	10.50	10.48
Maintaining voltage after breaking		s	-	≥60	≥60	≥60
Test result:						
Fuse operated correct		y/n		yes	yes	yes
Switching voltage $u_s \leq$ permissive value		y/n		yes	yes	yes
Current limiting:	($i_d \leq$ Let-through characteristic)	y/n		-	-	-
Requirement for I2:	i_m/I = 0.85...1.06	i_m/I		0.92	0.92	0.91
Emission of flames or sand		y/n		no	no	no
Damages (external)		y/n		no	no	no
Operation of striker correct		y/n		yes	yes	yes

FGH Engineering & Test GmbH

No. L 00056 — Sheet 14

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	12	16	67220.0160 HH-SI 6/12kV 16A FC TB 292/56

Test-no. 114-00/		No.	829	830	831	
Specimen			Adjust-ment test	001384	001385	
Resistance		mΩ	-	109	110	
Test-duty (according to IEC 282-1)			3			
Power factor of the test circuit	cos φ		0.53			
Prospective breaking current (RMS)		A	53.8			
Maintained current with low voltage source	at 54 A at A	s		19.9	16.1	
Time of current-interruption while switching over from low voltage to high voltage circuit		ms		155	155	
Pre-arcing / Melting time	t_m	s		19.9	16.1	
Pre-arcing Joule Integral		kA^2s		57.7	47.0	
Arcing time	t_{LB}	ms		40.7	40.7	
Arcing Joule Integral		A^2s		117	115	
Arcing time until breaking by the circuit breaker		ms		-	-	
Max. switching voltage	u_s	kV		17.9	17.9	
Power frequency recovery voltage	U_w	kV	12.4	12.4	12.4	
Maintaining voltage after breaking		s		≥60	≥60	

Test result:

Fuse operated correct	y/n		yes	yes	
Switching voltage u_s ≤ permissive value	y/n		yes	yes	
Emission of flames or sand	y/n		no	no	
Damages (external)	y/n		no	no	
Operation of striker correct	y/n		yes	yes	

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	12	20	67220.0200 HH-SI 6/12kV 20A FC TB 292/56

Test-no.	114-00/		1038	1039	1040	1041
Specimen		No.		001394	001395	001396
Resistance		mΩ	-	73.2	74.0	74.2
Test-duty (according to IEC 282-1)			2	2	2	2
Power factor of the test circuit	cos φ		0.11	0.11	0.11	0.11
Prospective breaking current (RMS)		A	765	765	765	765
Making angle after voltage zero		° el	8.3	9.0	8.1	8.1
Pre-arcing / Melting time	t_m	ms		3.67	3.70	3.68
Melting current	i_m	A		757	758	755
Pre-arcing Joule Integral		A^2s		524	528	523
Cut-off / Let through current	i_d	A		855	857	850
Arcing time	t_{LB}	ms		7.20	7.27	7.14
Arcing Joule Integral		A^2s		2790	2920	2690
Arcing time until breaking by the circuit breaker		ms		-	-	-
Max. switching voltage	u_s	kV		18.7	18.3	19.0
Power frequency recovery voltage	U_w	kV	10.53	10.53	10.53	10.53
Maintaining voltage after breaking		s	-	≥60	≥60	≥60
Test result:						
Fuse operated correct		y/n		yes	yes	yes
Switching voltage u_s ≤ permissive value		y/n		yes	yes	yes
Current limiting:	(I_d ≤ Let-through characteristic)	y/n		-	-	-
Requirement for I2:	i_m/I = 0.85...1.06	i_m/I		0.99	0.99	0.99
Emission of flames or sand		y/n		no	no	no
Damages (external)		y/n		no	no	no
Operation of striker correct		y/n		yes	yes	yes

FGH Engineering & Test GmbH

No. L 00056 **Sheet** 16

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	12	20	67220.0200 HH-SI 6/12kV 20A FC TB 292/56

Test-no. 114-00/		832	833	834	
Specimen	No.	Adjust-ment test	001397	001398	
Resistance	mΩ	-	74.6	75.2	
Test-duty (according to IEC 282-1)		3			
Power factor of the test circuit cos φ		0.52			
Prospective breaking current (RMS)	A	72.2			
Maintained current with low voltage source at 72 A / at A	s		200	218	
Time of current-interruption while switching over from low voltage to high voltage circuit	ms		133	140	
Pre-arcing / Melting time t_m	s		200	218	
Pre-arcing Joule Integral	A^2s		-	-	
Arcing time t_{LB}	ms		26.4	23.9	
Arcing Joule Integral	A^2s		117	95.4	
Arcing time until breaking by the circuit breaker	ms		-	-	
Max. switching voltage u_s	kV		20.7	21.7	
Power frequency recovery voltage U_W	kV	12.5	12.5	12.4	
Maintaining voltage after breaking	s		≥60	≥60	
Test result:					
Fuse operated correct	y/n		yes	yes	
Switching voltage $u_s \leq$ permissive value	y/n		yes	yes	
Emission of flames or sand	y/n		no	no	
Damages (external)	y/n		no	no	
Operation of striker correct	y/n		yes	yes	

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	12	25	67220.0250 HH-SI 6/12kV 25A FC TB 292/56

Test-no.	114-00/		836	837	838	
Specimen		No.	Adjust-ment test	001410	001411	
Resistance		mΩ	-	53.1	52.6	
Test-duty (according to IEC 282-1)			3			
Power factor of the test circuit	cos φ		0.50			
Prospective breaking current (RMS)		A	93.3			
Maintained current with low voltage source	at 93 A at A	s		34	51	
Time of current-interruption while switching over from low voltage to high voltage circuit		ms		158	146	
Pre-arcing / Melting time	t_m	s		34	51	
Pre-arcing Joule Integral		A^2s		-	-	
Arcing time	t_{LB}	ms		26.8	23.7	
Arcing Joule Integral		A^2s		205	204	
Arcing time until breaking by the circuit breaker		ms		-	-	
Max. switching voltage	u_s	kV		18.1	18.1	
Power frequency recovery voltage	U_W	kV	12.4	12.5	12.5	
Maintaining voltage after breaking		s		≥60	≥60	
Test result:						
Fuse operated correct		y/n		yes	yes	
Switching voltage $u_s \leq$ permissive value		y/n		yes	yes	
Emission of flames or sand		y/n		no	no	
Damages (external)		y/n		no	no	
Operation of striker correct		y/n		yes	yes	

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	12	31.5	67220.0320 HH-SI 6/12kV 31.5A FC TB 292/56

Test-no. 114-00/			1034	1035	1036	1037
Specimen		No.		001422	001423	001424
Resistance		mΩ		43.3	43.1	43.6
Test-duty (according to IEC 282-1)			2	2	2	2
Power factor of the test circuit	cos φ		0.09	0.09	0.09	0.09
Prospective breaking current (RMS)		kA	1.37	1.38	1.38	1.38
Making angle after voltage zero		° el	8.6	8.3	9.4	9.0
Pre-arcing / Melting time	t_m	ms		3.55	3.52	3.52
Melting current	i_m	kA		1.31	1.31	1.32
Pre-arcing Joule Integral		kA^2s		1.50	1.52	1.53
Cut-off / Let through current	I_d	kA		1.44	1.45	1.43
Arcing time	t_{LB}	ms		6.97	7.16	6.77
Arcing Joule Integral		kA^2s		6.35	7.03	5.70
Arcing time until breaking by the circuit breaker		ms		-	-	-
Max. switching voltage	u_s	kV		22.3	21.3	23.4
Power frequency recovery voltage	U_w	kV	10.49	10.58	10.58	10.58
Maintaining voltage after breaking		s	-	≥60	≥60	≥60
Test result:						
Fuse operated correct		y/n		yes	yes	yes
Switching voltage u_s ≤ permissive value		y/n		yes	yes	yes
Current limiting: (I_d ≤ Let-through characteristic)		y/n		-	-	-
Requirement for I2: i_m/I = 0.85...1.06		i_m/I		0.95	0.95	0.95
Emission of flames or sand		y/n		no	no	no
Damages (external)		y/n		no	no	no
Operation of striker correct		y/n		yes	yes	yes

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	12	31.5	67220.0320 HH-SI 6/12kV 31.5A FC TB 292/56

Test-no. 114-00/			840	841	842	
Specimen		No.	Adjust-ment test	001425	001426	
Resistance		mΩ	-	43.2	42.9	
Test-duty (according to IEC 282-1)			3			
Power factor of the test circuit	cos φ		0.51			
Prospective breaking current (RMS)		A	105			
Maintained current with at 105 A low voltage source at A		s		23.2	22.0	
Time of current-interruption while switching over from low voltage to high voltage circuit		ms		144	150	
Pre-arcing / Melting time	t_m	s		23.2	22.0	
Pre-arcing Joule Integral		kA^2s		254	241	
Arcing time	t_{LB}	ms		34.6	30.9	
Arcing Joule Integral		A^2s		308	350	
Arcing time until breaking by the circuit breaker		ms		-	-	
Max. switching voltage	u_s	kV		18.1	18.1	
Power frequency recovery voltage	U_w	kV	12.5	12.5	12.5	
Maintaining voltage after breaking		s		≥60	≥60	
Test result:						
Fuse operated correct		y/n		yes	yes	
Switching voltage $u_s \leq$ permissive value		y/n		yes	yes	
Emission of flames or sand		y/n		no	no	
Damages (external)		y/n		no	no	
Operation of striker correct		y/n		yes	yes	

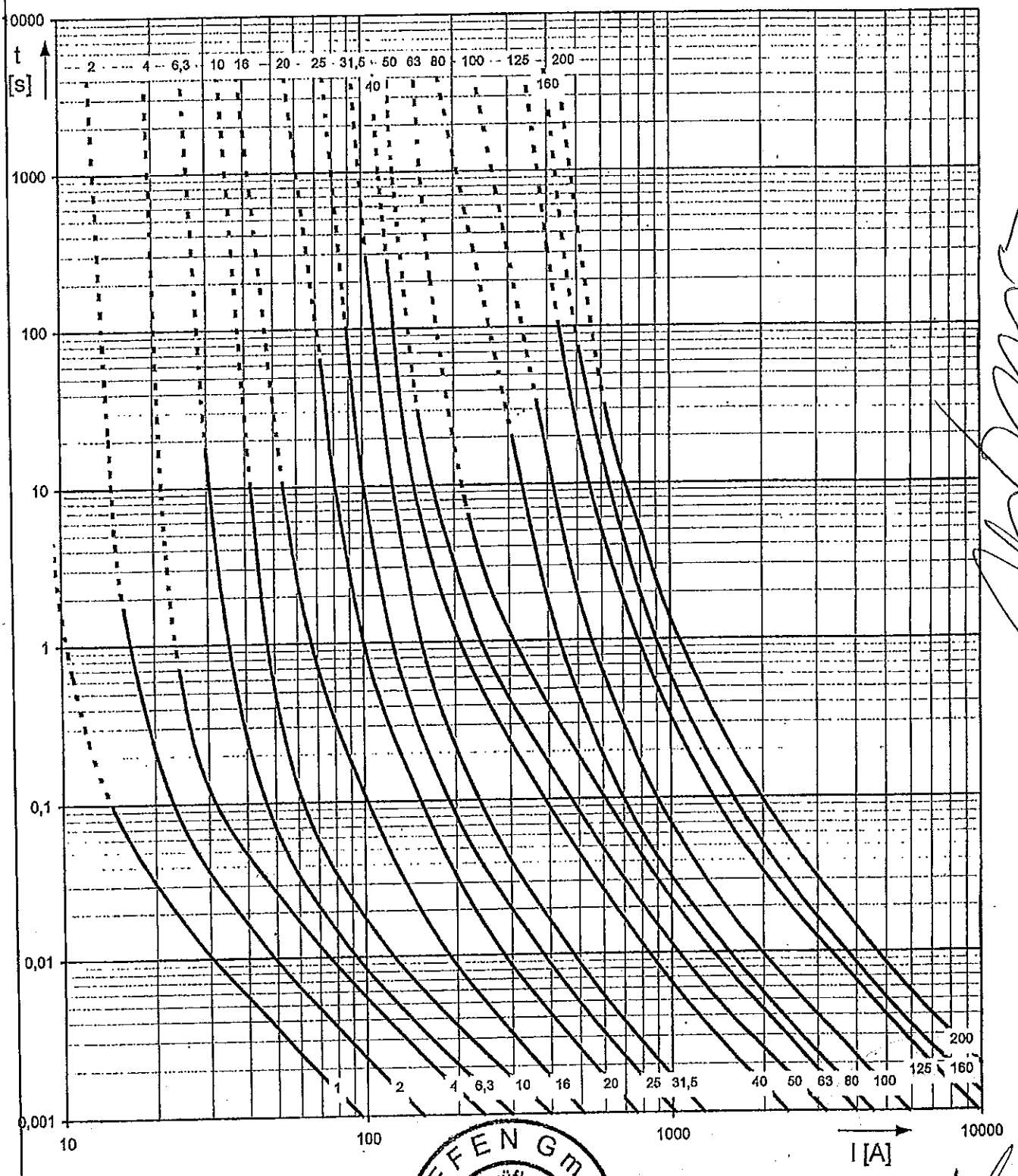
EFEN WICKMANN GRUPPE

Time-current characteristics of H.V. back-up fuse-links with ÜLA (controlled power dissipation)

Lab.-No. 01168

6/12kV 1 A - 200 A acc. to IEC 60282-1 / VDE 0670 Teil 4

Order-No.: 67220.0019 - 67220.2009



EFEN GmbH Prüflabor Test Laboratory Eltville

06.06.2001 / 23

EFEN GmbH

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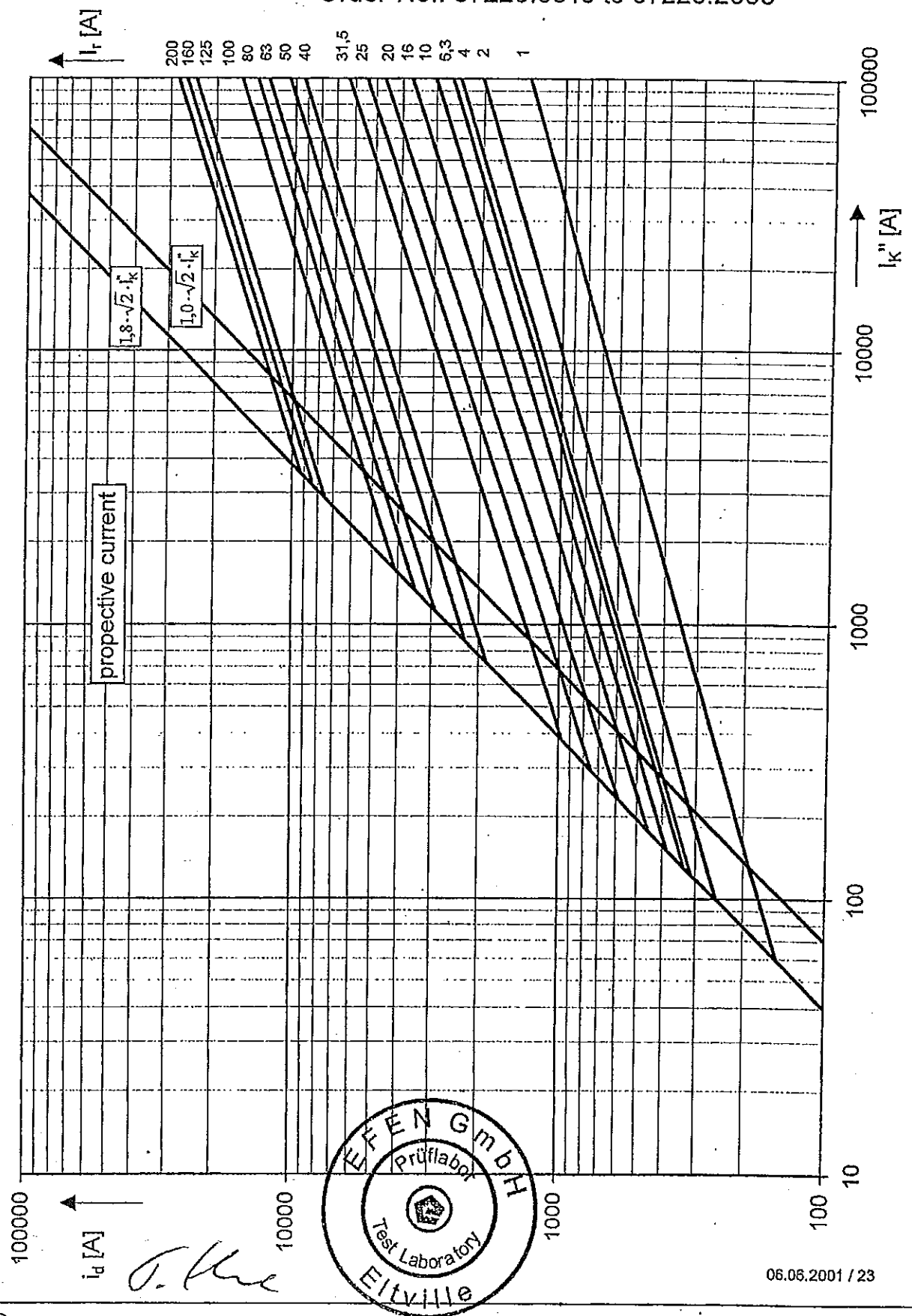
EFEN WICKMANN GRUPPE

Cut-off characteristics of H.V. back-up fuse-links with ÜLA (controlled power dissipation)

Lab.-No. 01170 6/12 kV 1 A - 200 A acc. to IEC 60282-1 / VDE 0670 Teil 4

Order-No.: 67220.0019 to 67220.2009



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1. Type HH – fuse link with striker 81902.0100(3) (duration 30mm)

2. Reason for test

Test of Strikers

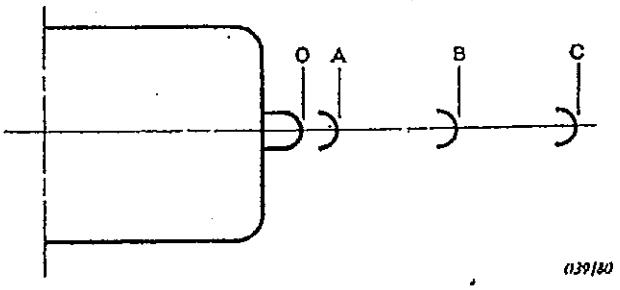
3. Tests performed / measurements

I. measurement of the duration of travel
II. measurement of the force-travel characteristics and calculation of the striker energy actuated by the spring
III. Verification of the withstand force according to applied standard (4)

4. Applied standards

IEC 60282-1 2002-01 VDE 0670 Teil 4 Abs. 12 02/98

4.1 standard in detail regarding strikers



OA – Free travel – No energy output specified.
AB – Further travel during which energy must be delivered.
OB – Minimum actual travel.
OC – Maximum actual travel.
CB – Maximum permitted return travel under withstand force (when applicable).

Type	Energy	Mechanical characteristics					
		Values of		Actual travel		Minimum withstand force	Maximum duration of travel (see note)
		Free travel (OA)*	Further travel during which energy must be delivered (AB)*	Min. (OB)*	Max. (OC)*		
	J	mm	mm	mm	mm	N	ms
Light	0,3 ± 0,25	2	8	10	30	Not applicable	100
Medium	1 ± 0,5	4	16	20	40	20	100
Heavy	2 ± 1	4	6	10	16	40	100

* See figure 12.

NOTE – Duration of travel is defined for actual fuse-links as the time from commencement of arcing to the time when travel OB is reached. For dummy fuses it is the time from application of voltage until travel OB is reached.

5. Test-laboratory, period of time

EFEN laboratory Eltville, 4.12.2003

6. Arrangement of the equipment

I. The tested fuse link is fixed in a fuse-base. An NC (normally closed) switch will be opened if the striker has travelled 30mm. Current, Voltage and the NC switch are recorded by an digital oscilloscope.

II. & III. The force-travel characteristics will be measured by an approved force meter*. For this measurement the striker will be prepared with an scale indicator for measuring the travelled way in mm.

*Zwick Z2.5 / TN1S Material testing device

7. Inspection and test sequence

I. Intact striker circuit is tested with current < 10A and voltage < 15V.
II. Current, voltage and the NC switch are recorded.
III. Force of striker is measured at Positions: 0, 10, und 20mm.
The Position of the Striker is measured at the minimum withstand force of 20N.

8. Results

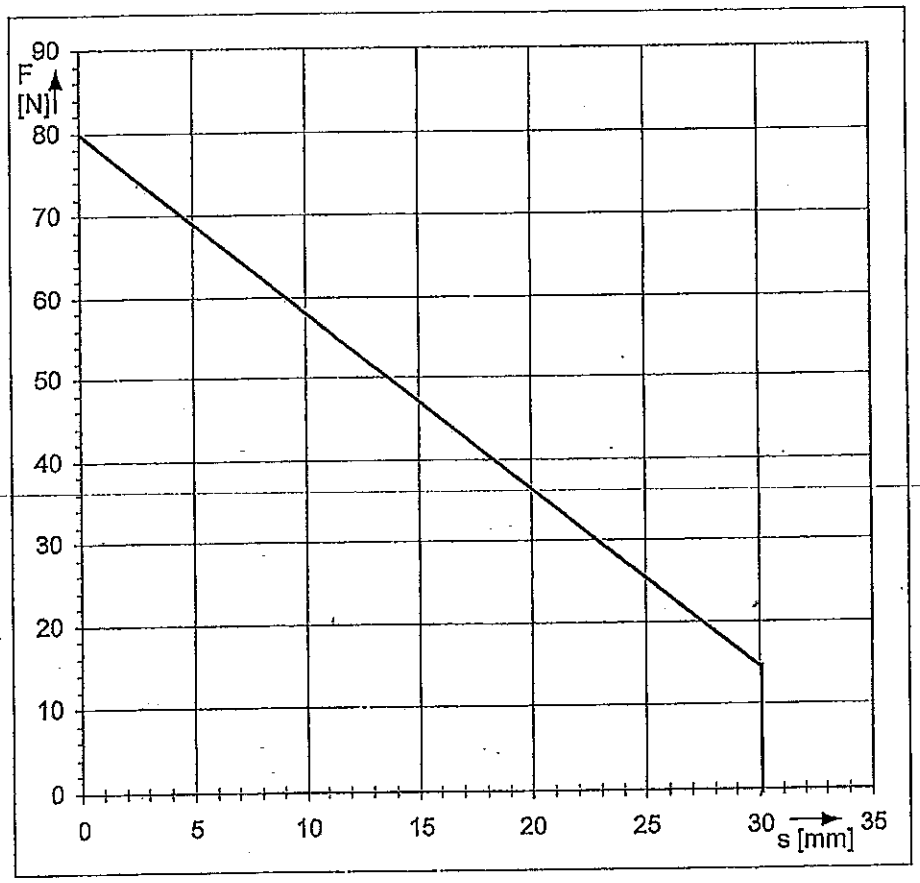
I. measurement of the duration of travel

	duration of travel	Current	Voltage
Sample 1	5 ms	9,9 A	< 15 V
Sample 2	2 ms	11,7 A	< 15 V
Sample 3	4 ms	10 A	< 15 V
Sample 4	6 ms	9,9 A	< 15 V

II. measurement of the force-travel characteristics and calculation of the striker energy

		Sample 1		Sample 2		Sample 3		
Position	Length / mm	Measurem. 1	Measurem. 2	Measurem. 1	Measurem. 2	Measurem. 1	Measurem. 2	Average:
O	0	77	76,8	85,5	81,7	78	78	79,5
A	4	66,5	66,4	67,5	67,4	71,7	69,7	68,2
B	20	37,7	36,1	33,7	33,1	36,2	36,5	35,6
	Energy / J:	0,83	0,82	0,81	0,80	0,86	0,85	0,83

$$Energy = \frac{(F_A + F_B) \times \overline{AB}}{2000} \qquad Energy[J];\ F_A[N];\ F_B[N];\ \overline{AB}[mm];$$



III. Verification of the withstand force of 20N at Position ≥ 20mm

	Measurement	Force / N	Length / mm
Sample 1	1	20	27,4
Sample 1	2	20	27,7
Sample 2	1	20	27,3
Sample 2	2	20	26,9
Sample 3	1	20	28,4
Sample 3	2	20	28,4

9. Evaluation

Type	Energy		Free travel	Further travel during which energy must be delivered	Actual travel			Minimum travel force	
	Actual value	Specified value	$\overline{OA}$	$\overline{AB}$	Actual value	Specified value Min. $\overline{OB}$	Specified value Max. $\overline{OC}$	Actual value	Specified value
	J		mm	mm	mm			N	
Medium	0,83	1±0,5	4	16	30	20	40	35,6	≥20

I. Measured duration of travel < maximum duration of travel (100ms)
II. striker energy is Medium 1J +-0,5 J
III. Verification of the withstand force proofed that the striker has the necessary force.

The striker full fills all Requirements of striker Type medium according to:
IEC 60282-1 2002-01; VDE 0670 Teil 4 Abs. 12 02/98

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2004-03-29

Test engineer

EFEN GmbH Prüflabor Test Laboratory Eltville

Head of Laboratory

EFEN WICKMANN GRUPPE

Type Test Report

Lab.-No. 01158

1. Object

Current-limiting high-voltage fuse-links
Class: Back-up
Striker: "medium"
Type: HH-SI 6/12kV 40A / 50A / 63A FC TB ÜLA 292/56
Ident-No.: 67220.0409 / 67220.0509 / 67220.0639

Rated voltage	6/12 kV		
Rated current	40 A	50 A	63 A
Rated maximum breaking current	63 kA		
Rated frequency	50 Hz		
Rated minimum breaking current	125 A	160 A	230 A

2. Reason for test

Type test according to IEC 60282-1 (VDE 0670 Teil 4): 1998-02

3. Tests performed

3.1 Temperature-rise tests and power-dissipation measurement

Rated current		40 A	50 A	63 A
Test laboratory		EFEN Prüflabor Eltville		
Test result: $\Delta\vartheta_{max}$ [1]		38 K	47 K	55 K
Test result: P_a	at 50% I_r	10,3 W	12,6 W	14,9 W
	at 100% I_r	53,8 W	69,5 W	84,5 W
EFEN Lab-No.		01133	01134	01135
Test passed		Yes	Yes	Yes

[1] permissible temperature rise: 65 K

3.2 Breaking Test: Test Duty 1

Rated current	40 A	50 A	63 A
Test Laboratory / Document No	KEMA / 281-01		
Test circuit applied voltage: U	10,6 kV		
Test circuit prospective current I	64,0 kA		
EFEN Lab-No.	01107		
Test passed	Yes	Hom.	Yes

EFEN GmbH
Postfach 1254 D-65332 Eltville Tel. 0049 (0) 6129 46-0 Fax.46222 e-Mail: efen@efen.com Internet: www.efen.com

3.3 Breaking Test: Test Duty 2

Rated current	40 A	50 A	63 A
Test Laboratory / Document No	FGH / L 01004 1E		
Test circuit applied voltage U	10,51 kV	10,50 kV	10,55 kV
Test circuit prospective current I	2,25 kA	3,48 kA	4,29 kA
EFEN Lab-No.	01069		
Test passed	Yes	Yes	Yes

3.4 Breaking Test: Test Duty 3

Rated current	40 A	50 A	63 A
Test Laboratory / Document No.	FGH / L 01004 1E		
Test circuit applied voltage: U	12,3 kV	12,4 kV	12,4 kV
Test circuit prospective current I	123 A	154 A	222 A
EFEN Lab-No.	01069		
Test passed	Yes	Yes	Yes

3.5 Tests for time-current characteristics
Test Laboratory: EFEN Prüflabor Eltville
EFEN Lab-No: 01168
Test passed

3.6 Cut-off characteristics
EFEN Lab-No: 01170

3.7 Test of strikers
Test result: 0,83 J => Type medium
Test Laboratory: EFEN Prüflabor Eltville
EFEN Lab-No: 03088
Test passed

4. Test results

The products passed the type tests according to IEC 60 282-1 and VDE 0670 Teil 4 respectively at KEMA, FGH and EFEN test laboratories.

All requirements are fulfilled (see 3.).

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2004-11-18

EFEN GmbH Prüflabor Test Laboratory Eltville

Test Engineer

Head of laboratory

EFEN GmbH
Postfach 1254 D-65332 Eltville · Tel. 0049 (0) 6129 46-0 Fax 46222 e-Mail: efen@efen.com Internet: www.efen.com

1. Type — HH-SI 6/12kV 40A FC TB ÜLA 292/56
Order-No.: 67220.0409

2. Reason for test

Temperature-rise tests and power-dissipation measurement

3. Tests performed / measurements

Measurement of temperatures, of voltage drop across fuse-link and power dissipation at different operating currents.

4. Applied standards

IEC 60282-1 1998-01 VDE 0670 Teil 4 Abs. 12 02/98

5. Test-laboratory, period of time

EFEN Prüflabor Eltville, 10/04/2000 – 10/12/2000

6. Arrangement of the equipment

The high-voltage fuse-link is mounted vertically in a fuse-base, with the striker-pin at the top.
The size of bare copper conductors is 50 mm².
Temperatures are measured at the fuse contacts (top and bottom), in the middle of the fuse with thermocouples and are recorded.
The test currents are recorded.

7. Inspection and test sequence

The fuse-link was loaded with test currents I = 20 A and I = 40 A

Test current I [A]	Comments
20	50% rated current
40	Rated current

Temperatures are measured at the fuse contacts and in the middle of the tube with thermocouples.
Calculation of power dissipation from recorded voltage drop and recorded test current.
Calculation of resistance depending on the currents.

8. Results

Type: HH-SI 6/12kV 40A FC TB ÜLA 292/56
R_{cold}: 22,2 mΩ

8.1 Temperature rise test

		Temperature			Temperature rise			Informative	
I [A]	$\vartheta_{amb.}$ [°C]	ϑ_{top} [°C]	ϑ_{bottom} [°C]	$\vartheta_{perm.}$ [°C]	$\Delta\vartheta_{top}$ [K]	$\Delta\vartheta_{bottom}$ [K]	$\Delta\vartheta_{perm.}$ [K]	ϑ_{center} [°C]	ϑ_{center} [K]
20	20	30	26	105	10	6	65	40	20
40	19	57	41	105	38	22	65	102	83

8.2 Power dissipation and resistance of the test object at defined currents.

I [A]	P_d [W]	$U_{fuse-link}$ [V]	R [mΩ]
20	10,3	0,51	25,8
40	53,8	1,34	33,6

9. Evaluation

The product passed the temperature-rise test acc. to IEC 60 282-1 and VDE 0670 Teil 4 respectively.

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06/06/2001

EFEN GmbH Prüflabor Test Laboratory Eltville

Test engineer

Head of laboratory

1. Type — HH-SI 6/12kV 50A FC TB ÜLA 292/56
Order-No.: 67220.0509

2. Reason for test

Temperature-rise tests and power-dissipation measurement

3. Tests performed / measurements

Measurement of temperatures, of voltage drop across fuse-link and power dissipation at different operating currents.

4. Applied standards

IEC 60282-1 1998-01 VDE 0670 Teil 4 Abs. 12 02/98

5. Test-laboratory, period of time

EFEN Prüflabor Eltville, 01/04/2001 – 01/10/2001

6. Arrangement of the equipment

The high-voltage fuse-link is mounted vertically in a fuse-base, with the striker-pin at the top.
The size of bare copper conductors is 50 mm².
Temperatures are measured at the fuse contacts (top and bottom), in the middle of the fuse with thermocouples and are recorded.
The test currents are recorded.

7. Inspection and test sequence

The fuse-link was loaded with test currents I = 25 A and I = 50 A

Test current I [A]	Comments
25	50% rated current
50	Rated current

Temperatures are measured at the fuse contacts and in the middle of the tube with thermocouples.
Calculation of power dissipation from recorded voltage drop and recorded test current.
Calculation of resistance depending on the currents.

8. Results

Type: HH-SI 6/12kV 50A FC TB ÜLA 292/56
R_{cold}: 17,2 mΩ

8.1 Temperature rise test

		Temperature			Temperature rise			Informative	
I [A]	$\vartheta_{amb.}$ [°C]	ϑ_{top} [°C]	ϑ_{bottom} [°C]	$\vartheta_{perm.}$ [°C]	$\Delta\vartheta_{top}$ [K]	$\Delta\vartheta_{bottom}$ [K]	$\Delta\vartheta_{perm.}$ [K]	ϑ_{center} [°C]	ϑ_{center} [K]
25	20	33	28	105	13	8	65	46	26
50	21	68	47	105	47	26	65	123	102

8.2 Power dissipation and resistance of the test object at defined currents.

I [A]	P_d [W]	$U_{fuse-link}$ [V]	R [mΩ]
25	12,6	0,51	20,2
50	69,5	0,95	23,9

9. Evaluation

The product passed the temperature-rise test acc. to IEC 60 282-1 and VDE 0670 Teil 4 respectively.

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06/06/2001

EFEN GmbH Prüflabor Test Laboratory Eltville

Test engineer

Head of laboratory

1. Type — HH-SI 6/12kV 63A FC TB ÜLA 292/56
Order-No.: 67220.0639

2. Reason for test

Temperature-rise tests and power-dissipation measurement

3. Tests performed / measurements

Measurement of temperatures, of voltage drop across fuse-link and power dissipation at different operating currents.

4. Applied standards

IEC 60282-1 1998-01 VDE 0670 Teil 4 Abs. 12 02/98

5. Test-laboratory, period of time

EFEN Prüflabor Eltville, 01/04/2001 - 01/10/2001

6. Arrangement of the equipment

The high-voltage fuse-link is mounted vertically in a fuse-base, with the striker-pin at the top.
The size of bare copper conductors is 50 mm².
Temperatures are measured at the fuse contacts (top and bottom), in the middle of the fuse with thermocouples and are recorded.
The test currents are recorded.

7. Inspection and test sequence

The fuse-link was loaded with test currents I = 31,5 A and I = 63 A

Test current I [A]	Comments
31,5	50% rated current
63	Rated current

Temperatures are measured at the fuse contacts and in the middle of the tube with thermocouples.
Calculation of power dissipation from recorded voltage drop and recorded test current.
Calculation of resistance depending on the currents.

8. Results

Type: HH-SI 6/12kV 63A FC TB ÜLA 292/56
R_{cold}: 12,5 mΩ

8.1 Temperature rise test

		Temperature			Temperature rise			Informative	
I [A]	$\vartheta_{amb.}$ [°C]	ϑ_{top} [°C]	ϑ_{bottom} [°C]	$\vartheta_{perm.}$ [°C]	$\Delta\vartheta_{top}$ [K]	$\Delta\vartheta_{bottom}$ [K]	$\Delta\vartheta_{perm.}$ [K]	ϑ_{center} [°C]	ϑ_{center} [K]
31,5	20	33	27	105	13	7	65	48	28
63	21	76	52	105	55	31	65	133	112

8.2 Power dissipation and resistance of the test object at defined currents.

I [A]	P_d [W]	$U_{fuse-link}$ [V]	R [mΩ]
31,5	14,9	0,47	15,0
63	84,5	1,34	21,3

9. Evaluation

The product passed the temperature-rise test acc. to IEC 60 282-1 and VDE 0670 Teil 4 respectively.

372 / 23
06/06/2001

EFEN GmbH Prüflabor Test Laboratory Eltville

Test engineer

Head of laboratory

KEMA

HIGH–POWER LABORATORY
Utrechtseweg 310 – 6812 AR Arnhem – The Netherlands

281–01

REPORT OF PERFORMANCE

CLIENT	EFEN Elektrotechnische Fabrik GmbH, Eltville am Rhein, Germany
MANUFACTURER	EFEN Elektrotechnische Fabrik GmbH, Eltville am Rhein, Germany
APPARATUS	Current limiting fuses
DESIGNATION	HH–SI 6/12kV FC TB 292/56
SERIAL No.	67220.0400, 67220.0500, 67220.0630, 67220.0800, 67220.1000, 67220.1250, 67220.1600, 67220.2000.

RATINGS ASSIGNED BY THE MANUFACTURER

Voltage		12	kV
Current	40 – 50 – 63 – 80 – 100 –125 – 160 – 200		A (1)
Frequency		50	Hz
Breaking capacity at	12 kV	63	kA
Series		1	
Class		back up	

(1) The fuse–links 40 – 50 – 63 A form a homgeneous series in accordance with Sub–clause 13.3.1 of IEC 60282–1.

The tests have been carried out strictly in accordance with IEC 60282–1.
The apparatus has complied with the relevant requirements.

Date of tests 13th March 2001

The performance of the apparatus tested and the observations made during the tests have been recorded in the tables with test results and the oscillograms

THIS REPORT CONSISTS OF:

Pages	11
Circuit diagrams	1
Oscillograms	23
Drawings	22
Photographs	1
Addition sheet	B70E

KEMA Nederland B.V.

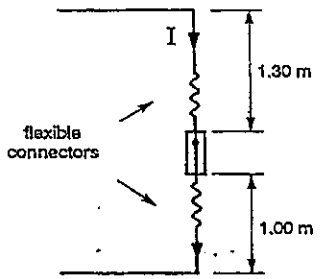
A.L.J. Janssen
Manager High–Power Laboratory

Arnhem, 23rd April 2001

TABLE WITH TEST RESULTS

REPORT 281–01	TYPE OF TESTS REQUESTED: Test duty 1	TEST CIRCUIT S01	PAGE 5

Condition before tests: Fuse–base new. Photograph 1502901.
Before each test new fuse–link.
Fuse–link mounted vertically in free air.
Distance fuse–link to floor 1.5 m.
Supply on top of the fuse–carrier.



Date and test	Fuse–link Type	Fuse–link Rated voltage kV / Rated current A	Resistance before test mΩ / after test MΩ	Test circuit Applied voltage kV	Test circuit Prospective current kA	Commencing of arcing after voltage zero °	Instantaneous current at Initiation of arcing peak kA	Cut–off current peak kA	Pre–arcing time ms	Arcing time ms	Total operating time ms	Recovery voltage (1) kV	Switching voltage peak kV	Melt ∫I²t A²s x 10³	Total ∫I²t A²s x 10³	Energy ∫UIt kJ	Condition after test: Fuse–link / Striker; Behaviour during test, Remarks
010313 5002				5.20	32.0												Checking of the prospective current.
010313 5004				10.6									21.6				Checking of the applied voltage and TRV.
010313 5005	HH–SI 6/12 FC TB 292/56 67220.0400 2138	12 / 40	22.5 / > 300	10.6	64.0	48	6.40	5.48	0.32	6.4	6.72	10.5	20.8	4.44	14.5	79.6	hot / 23 mm; Fuse cleared.
010313 5006	HH–SI 6/12 FC TB 292/56 67220.0400 2139	12 / 40	22.5 / > 300	10.6	64.0	69	7.70	7.40	0.23	5.3	5.53	10.5	26.0	4.67	20.8	97.7	hot / 23 mm; Fuse cleared.
010313 5007	HH–SI 6/12 FC TB 292/56 67220.0400 2140	12 / 40	22.5 / > 300	10.6	64.0	83	7.90	7.60	0.30	4.3	4.60	10.5	27.1	3.84	20.1	83.1	hot / 23 mm; Fuse cleared.

Remarks: Fuse–base showed no visible change.

(1) Maintained for 15 s.

KEMA

E40E

TABLE WITH TEST RESULTS

TEST CIRCUIT S01 | PAGE 6

REPORT 281–01 | TYPE OF TESTS REQUESTED: Test duty 1

Condition before tests: Fuse–base in same condition.
Before each test new fuse–link.
Fuse–link mounted vertically in free air.
Distance fuse–link to floor 1.5 m.

Date and test	Fuse–link Type	Fuse–link Rated voltage kV	Fuse–link Rated current A	Resistance before test mΩ	Resistance after test MΩ	Test circuit Applied voltage kV	Test circuit Prospective current kA	Commencing of arcing after voltage zero °	Instantaneous current at initiation of arcing peak kA	Cut–off current peak kA	Pre–arcing time ms	Arcing time ms	Total operating time ms	Recovery voltage (1) kV	Switching voltage peak kV	Melt ∫I²t A²s x 10³	Total ∫I²t A²s x 10³	Energy ∫UIt kJ	Condition after test: Fuse–link / Striker; Behaviour during test, Remarks
010313 5008	HH–SI 6/12 FC TB 292/56 67220.0630 2152	12	63	13	> 300	10.6	64.0	55	9.70	10.4	0.46	6.0	6.46	10.5	25.4	12.7	50.3	158	hot / 23 mm; Fuse cleared.
010313 5009	HH–SI 6/12 FC TB 292/56 67220.0630 2153	12	63	13	> 300	10.6	64.0	87	10.4	11.4	0.32	4.5	4.82	10.5	27.9	12.7	52.7	133	hot / 23 mm; Fuse cleared.
010313 5010	HH–SI 6/12 FC TB 292/56 67220.0630 2154	12	63	13	> 300	10.6	64.0	88	11.1	11.5	0.42	4.4	4.82	10.5	26.8	13.4	60.3	152	hot / 23 mm; Fuse cleared.

(1) Maintained for 15 s.

Remarks: Fuse–base showed no visible change.

KEMA

FGH
Engineering & Test GmbH
Mannheim-Rheinau, Hallenweg 40

Accredited testing laboratory to DIN EN 45001 for subject
Deutscher Akkreditierungs Rat DAR
DAT-P-103/00-00 High-voltage apparatus switchgear and controlgear
DAT-P-103/00-10 High-voltage cables and accessories

Test Report

No. **L 01004**

Duly signed copy 1E

Reference: 114-00/1089...1096, 1108...1128, 1202...1207

Apparatus: **Current-limiting fuse-link**

Types: a) HH-SI 6/12kV 40A FC TB 292/56, Ident-No.: 67220.0400
b) HH-SI 6/12kV 50A FC TB 292/56, Ident-No.: 67220.0500
c) HH-SI 6/12kV 63A FC TB 292/56, Ident-No.: 67220.0630

Rated voltage: 12 kV
Rated current: a) 40 A, b) 50 A, c) 63 A
Class: Back-up

Manufacturer: EFEN Elektrotechnische Fabrik GmbH,
Postfach 12 54, D-65344 Eltville, Germany

Customer: EFEN Elektrotechnische Fabrik GmbH,
Postfach 12 54, D-65344 Eltville, Germany

Test Specification: IEC 60282-1 (1998-01), Ed.4.2

Tests performed: Breaking tests:

Test duty 2:
Verification of the operation with prospective current I2 at which current limiting occurs when a high level of energy is stored in the inductance of the circuit.

Test duty 3:
Verification of the operation at the rated minimum breaking current

Test Results: During the breaking tests performed, the tested fuse-links fully complied with the standard conditions of behaviour with respect to breaking capacity.

Mannheim, January 11, 2001
Hch

FGH Engineering & Test GmbH

FGH Engineering & Test GmbH

Test Engineer:

(Heil)

Place and date of test: LPF Mannheim-Rheinau, November 30, 2000 and December 12, 2000

Number of sheets: 36

No. L 01004

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	12	40	67220.0400 HH-SI 6/12kV 40A FC TB 292/56

Test-no.	114-00/		1082	1083	1085	1086
Specimen		No.	Adjust-ment test	001584	001586	001587
Resistance		mΩ	-	22.5	22.4	22.6
Test-duty (according to IEC 282-1)			2	2	2	2
Power factor of the test circuit	cos φ		0.09	0.09	0.09	0.09
Prospective breaking current (RMS)		kA	2.25	2.25	2.26	2.26
Making angle after voltage zero		° el	9.0	9.0	9.0	9.0
Pre-arcing / Melting time	t_m	ms		3.74	3.77	3.74
Melting current	i_m	kA		2.36	2.36	2.36
Pre-arcing Joule Integral		kA^2s		5.24	5.23	5.22
Cut-off / Let through current	I_d	kA		2.51	2.54	2.52
Arcing time	t_{LB}	ms		7.00	7.27	7.12
Arcing Joule Integral		kA^2s		18.1	21.7	19.7
Arcing time until breaking by the circuit breaker		ms		-	-	-
Max. switching voltage	u_s	kV		23.2	21.7	22.8
Power frequency recovery voltage	U_w	kV	10.51	10.51	10.54	10.57
Maintaining voltage after breaking		s		60	60	60
Test result:						
Fuse operated correct		y/n		yes	yes	yes
Switching voltage u_s ≤ permissive value		y/n		yes	yes	yes
Current limiting:	(i_d ≤ Let-through characteristic)	y/n		yes	yes	yes
Requirement for I2:	i_m/I = 0.85...1.06	i_m/I		1.05	1.04	1.04
Emission of flames or sand		y/n		no	no	no
Damages (external)		y/n		no	no	no
Operation of striker correct		y/n		yes	yes	yes

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	12	40	67220.0400 HH-SI 6/12kV 40A FC TB 292/56

Test-no. 114-00/		1108	1109	1110	
Specimen	No.	Adjust-ment test	001591	001592	
Resistance	mΩ	-	23.0	22.5	
Test-duty (according to IEC 282-1)		3			
Power factor of the test circuit cos φ		0.49			
Prospective breaking current (RMS)	A	123			
Maintained current with bei 123...125 A low voltage source bei A	min		4:10	5:00	
Time of current-interruption while switching over from low voltage to high voltage circuit	ms		151	158	
Pre-arcing / Melting time t_m	s		250	300	
Pre-arcing Joule Integral	A^2s		-	-	
Arcing time t_{LB}	ms		94.2	57.8	
Arcing Joule Integral	A^2s		1020	746	
Arcing time until breaking by the circuit breaker	ms		-	-	
Max. switching voltage u_s	kV		17.6	17.6	
Power frequency recovery voltage U_w	kV	12.3	12.3	12.3	
Maintaining voltage after breaking	s		60	60	
Test result:					
Fuse operated correct	y/n		yes	yes	
Switching voltage $u_s \leq$ permissive value	y/n		yes	yes	
Emission of flames or sand	y/n		no	no	
Damages (external)	y/n		no	no	
Operation of striker correct	y/n		yes	yes	

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	12	50	67220.0500 HH-SI 6/12kV 50A FC TB 292/56

Test-no. 114-00/			1093	1094	1095	1096
Specimen		No.	Adjust-ment test	001599	001600	001601
Resistance		mΩ	-	18.0	17.9	18.0
Test-duty (according to IEC 282-1)			2	2	2	2
Power factor of the test circuit	cos φ		0.105	0.105	0.105	0.105
Prospective breaking current (RMS)		kA	3.48	3.48	3.48	3.48
Making angle after voltage zero		° el	7.4	6.8	7.2	8.8
Pre-arcing / Melting time	t_m	ms		3.42	3.43	3.36
Melting current	i_m	kA		3.16	3.17	3.16
Pre-arcing Joule Integral		kA^2s		8.56	8.62	8.49
Cut-off / Let through current	i_d	kA		3.33	3.32	3.34
Arcing time	t_{LB}	ms		6.90	6.90	7.05
Arcing Joule Integral		kA^2s		26.3	26.5	29.6
Arcing time until breaking by the circuit breaker		ms		-	-	-
Max. switching voltage	u_s	kV		25.4	25.5	24.2
Power frequency recovery voltage	U_w	kV	10.50	10.50	10.49	10.50
Maintaining voltage after breaking		s		60	60	60
Test result:						
Fuse operated correct		y/n		yes	yes	yes
Switching voltage $u_s \leq$ permissive value		y/n		yes	yes	yes
Current limiting:	($i_d \leq$ Let-through characteristic)	y/n		yes	yes	yes
Requirement for I2:	i_m/I = 0.85...1.06	i_m/I		0.91	0.91	0.91
Emission of flames or sand		y/n		no	no	no
Damages (external)		y/n		no	no	no
Operation of striker correct		y/n		yes	yes	yes

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	12	50	67220.0500 HH-SI 6/12kV 50A FC TB 292/56

Test-no. 114-00/			1126	1127	1128	
Specimen		No.	Adjust-ment test	001735	001736	
Resistance		mΩ	-	17.8	17.8	
Test-duty (according to IEC 282-1)			3			
Power factor of the test circuit	cos φ		0.50			
Prospective breaking current (RMS)		A	154			
Maintained current with at 154 A low voltage source at A		s		30	26	
Time of current-interruption while switching over from low voltage to high voltage circuit		ms		150	142	
Pre-arcing / Melting time	t_m	s		30	26	
Pre-arcing Joule Integral		A^2s		-	-	
Arcing time	t_{LB}	ms		88.1	126	
Arcing Joule Integral		kA^2s		1.70	2.27	
Arcing time until breaking by the circuit breaker		ms		-	-	
Max. switching voltage	u_s	kV		17.9	17.8	
Power frequency recovery voltage	U_W	kV	12.4	12.4	12.3	
Maintaining voltage after breaking		s		60	60	

Test result:

Fuse operated correct	y/n		yes	yes	
Switching voltage $u_s \leq$ permissive value	y/n		yes	yes	
Emission of flames or sand	y/n		no	no	
Damages (external)	y/n		no	no	
Operation of striker correct	y/n		yes	yes	

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	12	63	67220.0630 HH-SI 6/12kV 63A FC TB 292/56

Test-no. 114-00/			1202	1204	1205	1207
Specimen		No.	Adjust-ment test	001741	001742	001745
Resistance		mΩ	-	13.0	13.0	13.0
Test-duty (according to IEC 282-1)			2	2	2	2
Power factor of the test circuit	cos φ		0.095	0.095	0.095	0.095
Prospective breaking current (RMS)		kA	4.29	4.29	4.27	4.27
Making angle after voltage zero		° el	9.0	9.0	9.0	9.0
Pre-arcing / Melting time	t_m	ms		3.60	3.60	3.61
Melting current	i_m	kA		4.21	4.23	4.22
Pre-arcing Joule Integral		kA^2s		16.1	16.4	16.2
Cut-off / Let through current	i_d	kA		4.35	4.34	4.33
Arcing time	t_{LB}	ms		6.89	6.70	6.72
Arcing Joule Integral		kA^2s		47.3	41.9	42.6
Arcing time until breaking by the circuit breaker		ms		-	-	-
Max. switching voltage	u_s	kV		25.4	26.5	26.3
Power frequency recovery voltage	U_w	kV	10.55	10.55	10.51	10.51
Maintaining voltage after breaking		s		60	60	60
Test result:						
Fuse operated correct		y/n		yes	yes	yes
Switching voltage $u_s \leq$ permissive value		y/n		yes	yes	yes
Current limiting:	($i_d \leq$ Let-through characteristic)	y/n		yes	yes	yes
Requirement for I2:	i_m/I = 0.85...1.06	i_m/I		0.98	0.98	0.99
Emission of flames or sand		y/n		no	no	no
Damages (external)		y/n		no	no	no
Operation of striker correct		y/n		yes	yes	yes

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	12	63	67220.0630 HH-SI 6/12kV 63A FC TB 292/56

Test-no. 114-00/			1119	1123	1124	
Specimen		No.	Adjust-ment test	001751	001752	
Resistance		mΩ	-	12.5	12.5	
Test-duty (according to IEC 282-1)			3			
Power factor of the test circuit	cos φ		0.51			
Prospective breaking current (RMS)		A	222			
Maintained current with at 223...224 A low voltage source at A		s		6.03	5.25	
Time of current-interruption while switching over from low voltage to high voltage circuit		ms		147	151	
Pre-arcing / Melting time	t_m	s		6.03	5.25	
Pre-arcing Joule Integral		kA^2s		300	263	
Arcing time	t_{LB}	ms		80.0	118	
Arcing Joule Integral		kA^2s		3.54	4.39	
Arcing time until breaking by the circuit breaker		ms		-	-	
Max. switching voltage	u_s	kV		17.9	17.9	
Power frequency recovery voltage	U_w	kV	12.3	12.4	12.4	
Maintaining voltage after breaking		s		60	60	
Test result:						
Fuse operated correct		y/n		yes	yes	
Switching voltage $u_s \leq$ permissive value		y/n		yes	yes	
Emission of flames or sand		y/n		no	no	
Damages (external)		y/n		no	no	
Operation of striker correct		y/n		yes	yes	

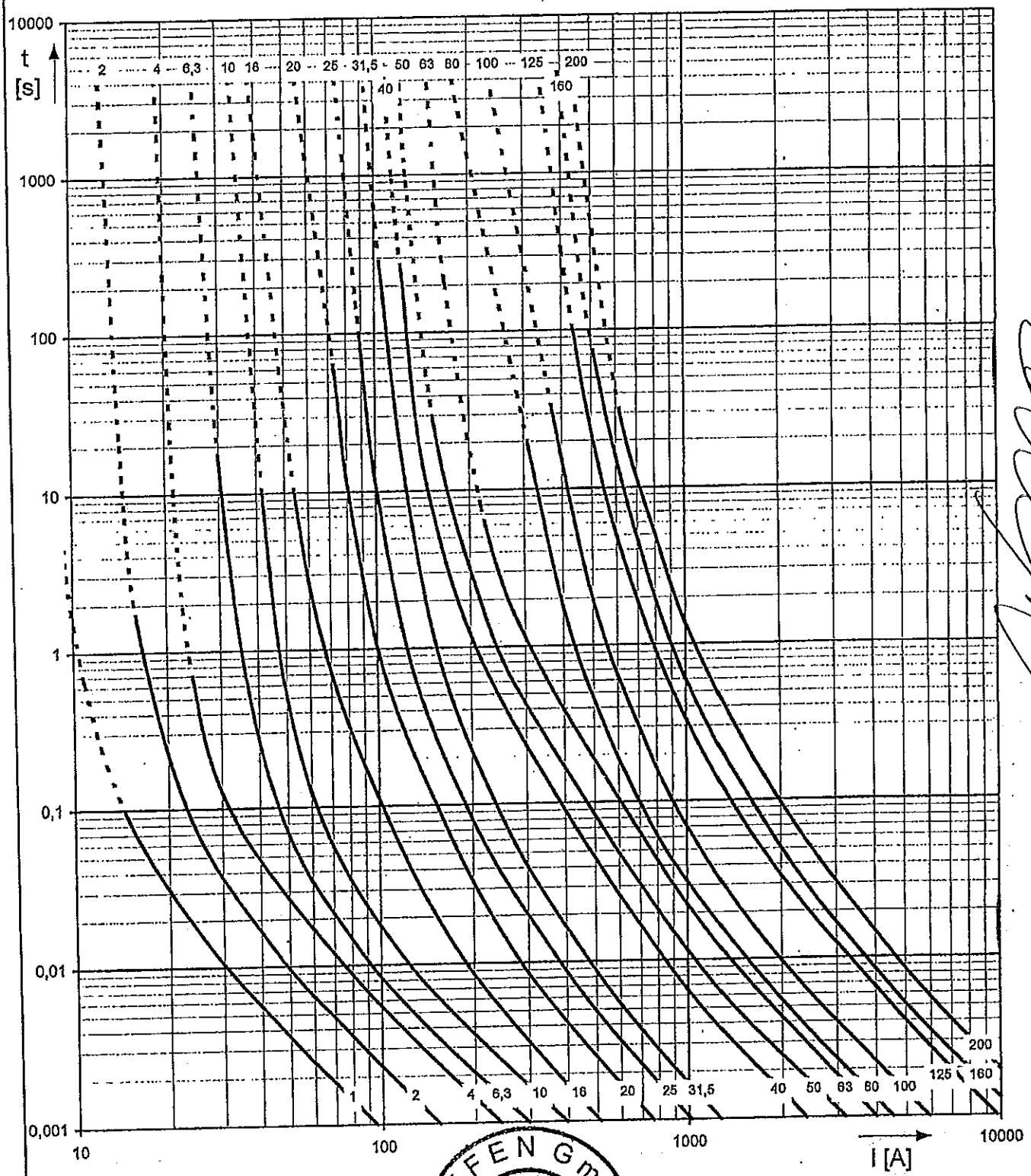
EFEN WICKMANN GRUPPE

Time-current characteristics of H.V. back-up fuse-links with ÜLA (controlled power dissipation)

Lab.-No. 01168

6/12kV 1 A - 200 A acc. to IEC 60282-1 / VDE 0670 Teil 4

Order-No.: 67220.0019 - 67220.2009



EFEN GmbH Prüflabor Test Laboratory Eltville

06.06.2001 / 23

EFEN GmbH

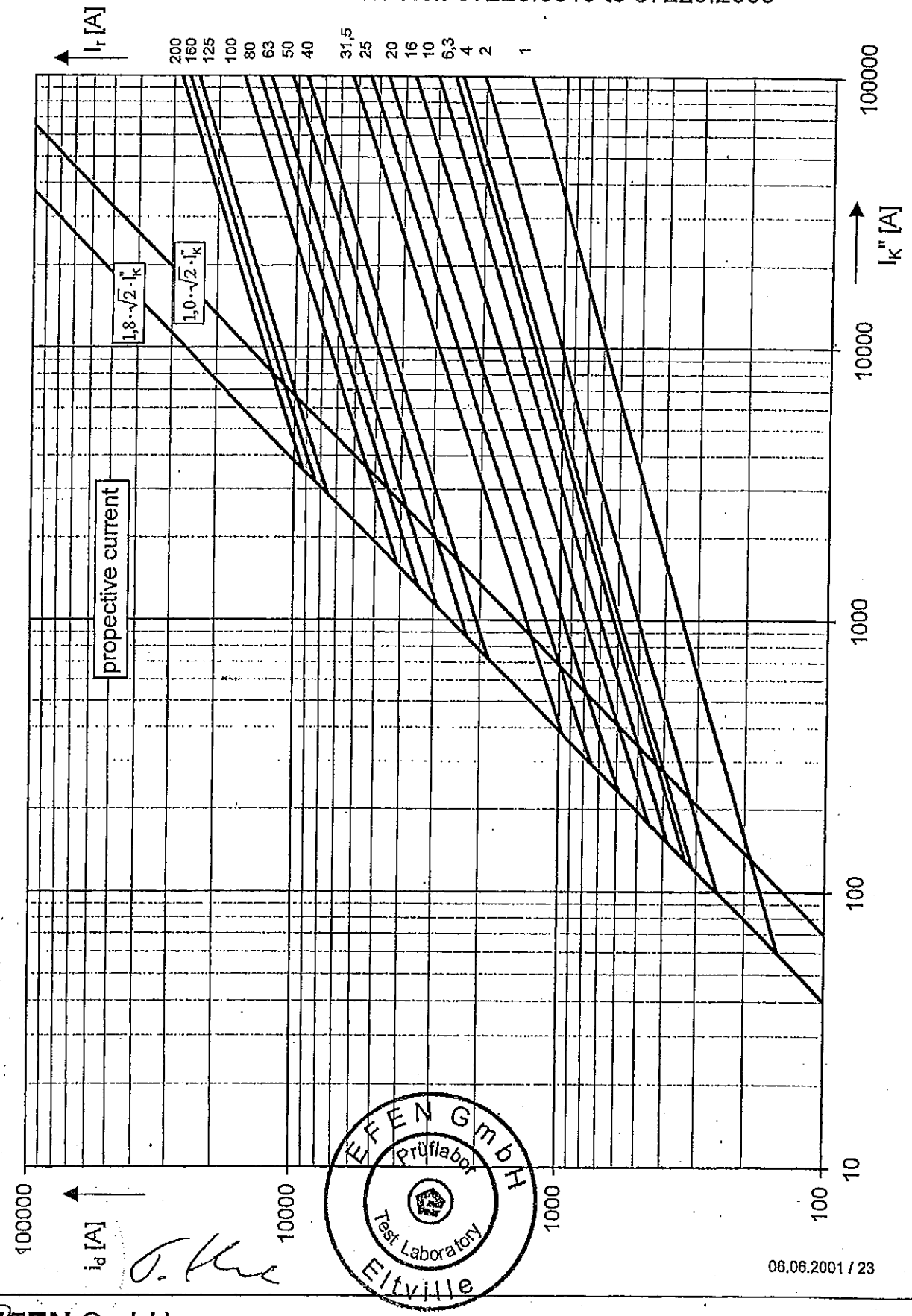
Postfach 1254 · D-65332 Eltville · Tel. 0049 (0) 6123 / 46-0 · Fax 46222 · e-Mail: efen@efen.com · Internet: www.efen.com

EFEN
WICKMANN GRUPPE

Cut-off characteristics of H.V. back-up fuse-links with ÜLA (controlled power dissipation)

Lab.-No. 01170 6/12 kV 1 A - 200 A acc. to IEC 60282-1 / VDE 0670 Teil 4

Order-No.: 67220.0019 to 67220.2009



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Postfach 1254 · D-65332 Eltville · Tel. 00 49 (0) 61 29 46-0 · Fax 4 62 22 · e-Mail: efen@efen.com · Internet: www.efen.com

1. Type HH – fuse link with striker 81902.0100(3) (duration 30mm)

2. Reason for test

Test of Strikers

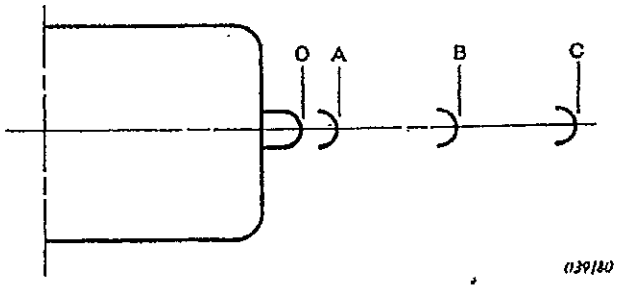
3. Tests performed / measurements

I. measurement of the duration of travel
II. measurement of the force-travel characteristics and calculation of the striker energy actuated by the spring
III. Verification of the withstand force according to applied standard (4)

4. Applied standards

IEC 60282-1 2002-01 VDE 0670 Teil 4 Abs. 12 02/98

4.1 standard in detail regarding strikers



OA – Free travel – No energy output specified.
AB – Further travel during which energy must be delivered.
OB – Minimum actual travel.
OC – Maximum actual travel.
CB – Maximum permitted return travel under withstand force (when applicable).

Type	Energy	Mechanical characteristics					
		Values of		Actual travel		Minimum withstand force	Maximum duration of travel (see note)
		Free travel (OA)*	Further travel during which energy must be delivered (AB)*	Min. (OB)*	Max. (OC)*		
	J	mm	mm	mm	mm	N	ms
Light	0,3 ± 0,25	2	8	10	30	Not applicable	100
Medium	1 ± 0,5	4	16	20	40	20	100
Heavy	2 ± 1	4	6	10	16	40	100

* See figure 12.

NOTE – Duration of travel is defined for actual fuse-links as the time from commencement of arcing to the time when travel OB is reached. For dummy fuses it is the time from application of voltage until travel OB is reached.

5. Test-laboratory, period of time

EFEN laboratory Eltville, 4.12.2003

6. Arrangement of the equipment

I. The tested fuse link is fixed in a fuse-base. An NC (normally closed) switch will be opened if the striker has travelled 30mm. Current, Voltage and the NC switch are recorded by an digital oscilloscope.

II. & III. The force-travel characteristics will be measured by an approved force meter*. For this measurement the striker will be prepared with an scale indicator for measuring the travelled way in mm.

*Zwick Z2.5 / TN1S Material testing device

7. Inspection and test sequence

I. Intact striker circuit is tested with current < 10A and voltage < 15V.
II. Current, voltage and the NC switch are recorded.
III. Force of striker is measured at Positions: 0, 10, und 20mm.
The Position of the Striker is measured at the minimum withstand force of 20N.

8. Results

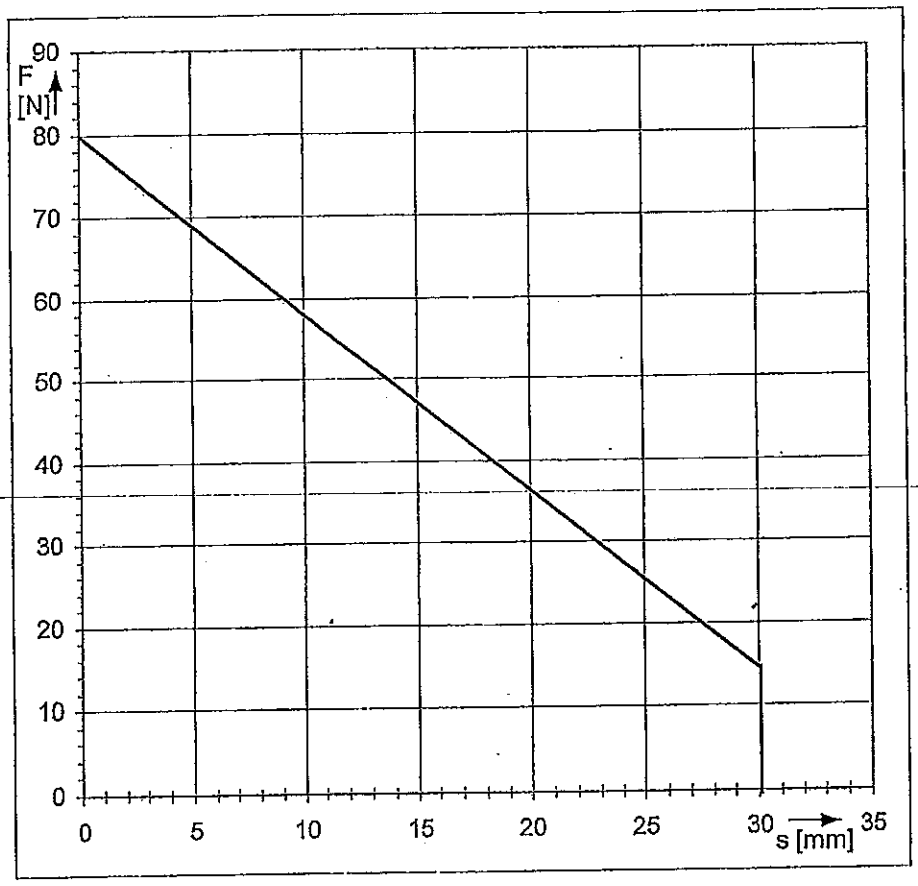
I. measurement of the duration of travel

	duration of travel	Current	Voltage
Sample 1	5 ms	9,9 A	< 15 V
Sample 2	2 ms	11,7 A	< 15 V
Sample 3	4 ms	10 A	< 15 V
Sample 4	6 ms	9,9 A	< 15 V

II. measurement of the force-travel characteristics and calculation of the striker energy

		Sample 1		Sample 2		Sample 3		
Position	Length / mm	Measurem. 1	Measurem. 2	Measurem. 1	Measurem. 2	Measurem. 1	Measurem. 2	Average:
O	0	77	76,8	85,5	81,7	78	78	79,5
A	4	66,5	66,4	67,5	67,4	71,7	69,7	68,2
B	20	37,7	36,1	33,7	33,1	36,2	36,5	35,6
	Energy / J:	0,83	0,82	0,81	0,80	0,86	0,85	0,83

$$Energy = \frac{(F_A + F_B) \times \overline{AB}}{2000} \qquad Energy[J];\ F_A[N];\ F_B[N];\ \overline{AB}[mm];$$



III. Verification of the withstand force of 20N at Position ≥ 20mm

	Measurement	Force / N	Length / mm
Sample 1	1	20	27,4
Sample 1	2	20	27,7
Sample 2	1	20	27,3
Sample 2	2	20	26,9
Sample 3	1	20	28,4
Sample 3	2	20	28,4

9. Evaluation

Type	Energy		Free travel	Further travel during which energy must be delivered	Actual travel			Minimum travel force	
	Actual value	Specified value	$\overline{OA}$	$\overline{AB}$	Actual value	Specified value Min. $\overline{OB}$	Specified value Max. $\overline{OC}$	Actual value	Specified value
	J		mm	mm	mm			N	
Medium	0,83	1±0,5	4	16	30	20	40	35,6	20

I. Measured duration of travel < maximum duration of travel (100ms)
II. striker energy is Medium 1J +-0,5 J
III. Verification of the withstand force proofed that the striker has the necessary force.

The striker full fills all Requirements of striker Type medium according to:
IEC 60282-1 2002-01; VDE 0670 Teil 4 Abs. 12 02/98

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2004-03-29

Test engineer

EFEN GmbH Prüflabor Test Laboratory Eltville

Head of Laboratory

EFEN WICKMANN GRUPPE

Type Test Report

Lab.-No. 01159

1. Object

Current-limiting high-voltage fuse-links
Class: Back-up
Striker: "medium"
Type: HH-SI 6/12kV 80A / 100A FC TB ÜLA 292/65
Ident-No.: 67220.0809 / 67220.1009

Rated voltage	6/12 kV	
Rated current	80 A	100 A
Rated maximum breaking current	63 kA	
Rated frequency	50 Hz	
Rated minimum breaking current	350 A	500 A

2. Reason for test

Type test according to IEC 60282-1 (VDE 0670 Teil 4): 1998-02

3. Tests performed

3.1 Temperature-rise tests and power-dissipation measurement

Rated current		80 A	100 A
Test laboratory		EFEN Prüflabor Eltville	
Test result: $\Delta\vartheta_{max}$ [1]		56,6 K	74,5 K [2]
Test result: P_a	at 50 % I_r	19,2 W	24,5 W
	at 100 % I_r	114,4 W	156 W
EFEN Lab-No.		01136	01137
Test passed		Yes	Yes

[1] permissible temperature rise: 65 K
[2] derating factor: 0,94

3.2 Breaking Test: Test Duty 1

Rated current	80 A	100 A
Test Laboratory / Document No	KEMA / 281-01	
Test circuit applied voltage: U	10,6 kV	
Test circuit prospective current I	64,0 kA	
EFEN Lab-No.	01107	
Test passed	Yes	Yes

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3.3 Breaking Test: Test Duty 2

Rated current	80 A	100 A
Test Laboratory / Document No	FGH / LV 00042 1E	FGH / LV 98080/1E
Test circuit applied voltage U	10,51 kV	10,55 kV
Test circuit prospective current I	5,05 kA	6,27 kA
EFEN Lab-No.	00088	98108
Test passed	Yes	Yes

3.4 Breaking Test: Test Duty 3

Rated current	80 A	100 A
Test Laboratory / Document No.	FGH / LV 00042 1E	
Test circuit applied voltage: U	12,1 kV	12,4 kV
Test circuit prospective current I	345 A	497 A
EFEN Lab-No.	00088	
Test passed	Yes	Yes

3.5 Tests for time-current characteristics
Test Laboratory: EFEN Prüflabor Eltville
EFEN Lab-No: 01168
Test passed

3.6 Cut-off characteristics
EFEN Lab-No: 01170

3.7 Test of strikers
Test result: 0,83 J => Type medium
Test Laboratory: EFEN Prüflabor Eltville
EFEN Lab-No: 03088
Test passed

4. Test results

The products passed the type tests according to IEC 60 282-1 and VDE 0670 Teil 4 respectively at KEMA, FGH and EFEN test laboratories.

All requirements are fulfilled (see 3.).

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2004-11-18

EFEN GmbH Prüflabor Test Laboratory Eltville

Test Engineer

Head of laboratory

1. Type — HH-SI 6/12kV 80A FC TB ÜLA 292/65
Order-No.: 67220.0809

2. Reason for test

Temperature-rise tests and power-dissipation measurement

3. Tests performed / measurements

Measurement of temperatures, of voltage drop across fuse-link and power dissipation at different operating currents.

4. Applied standards

IEC 60282-1 1998-01 VDE 0670 Teil 4 Abs. 12 02/98

5. Test-laboratory, period of time

EFEN Prüflabor Eltville, 10/21/1998

6. Arrangement of the equipment

The high-voltage fuse-link is mounted vertically in a fuse-base, with the striker-pin at the top.
The size of bare copper conductors is 150 mm².
Temperatures are measured at the fuse contacts (top and bottom), in the middle of the fuse with thermocouples and are recorded.
The test currents are recorded.

7. Inspection and test sequence

The fuse-link was loaded with test currents I = 40 A and I = 80 A

Test current I [A]	Comments
40	50% rated current
80	Rated current

Temperatures are measured at the fuse contacts and in the middle of the tube with thermocouples.
Calculation of power dissipation from recorded voltage drop and recorded test current.
Calculation of resistance depending on the currents.

8. Results

Type: HH-SI 6/12kV 80A FC TB ÜLA 292/65
R_{cold}: 10,7 mΩ

8.1 Temperature rise test

		Temperature			Temperature rise			Informative	
I [A]	$\vartheta_{amb.}$ [°C]	ϑ_{top} [°C]	ϑ_{bottom} [°C]	$\vartheta_{perm.}$ [°C]	$\Delta\vartheta_{top}$ [K]	$\Delta\vartheta_{bottom}$ [K]	$\Delta\vartheta_{perm.}$ [K]	ϑ_{center} [°C]	ϑ_{center} [K]
40	19,1	32,8	28,9	105	13,7	9,8	65	49,0	29,9
80	18,0	74,6	56,0	105	56,6	38,0	65	143,3	125,3

8.2 Power dissipation and resistance of the test object at defined currents.

I [A]	P_d [W]	$U'_{fuse-link}$ [V]	R [mΩ]
40	19,2	0,48	12,0
80	114,4	1,43	18,5

9. Evaluation

The product passed the temperature-rise test acc. to IEC 60 282-1 and VDE 0670 Teil 4 respectively.

372 / 23
06/06/2001

EFEN GmbH Prüflabor Test Laboratory Eltville

Test engineer

Head of laboratory

1. Type — HH-SI 6/12kV 100A FC TB ÜLA 292/65
Order-No.: 67220.1009

2. Reason for test

Temperature-rise tests and power-dissipation measurement

3. Tests performed / measurements

Measurement of temperatures, of voltage drop across fuse-link and power dissipation at different operating currents.

4. Applied standards

IEC 60282-1 1998-01 VDE 0670 Teil 4 Abs. 12 02/98

5. Test-laboratory, period of time

EFEN Prüflabor Eltville, 12/01/1998

6. Arrangement of the equipment

The high-voltage fuse-link is mounted vertically in a fuse-base, with the striker-pin at the top.
The size of bare copper conductors is 150 mm².
Temperatures are measured at the fuse contacts (top and bottom), in the middle of the fuse with thermocouples and are recorded.
The test currents are recorded.

7. Inspection and test sequence

The fuse-link was loaded with test currents I = 50 A and I = 100 A

Test current I [A]	Comments
50	50% rated current
100	Rated current

Temperatures are measured at the fuse contacts and in the middle of the tube with thermocouples.
Calculation of power dissipation from recorded voltage drop and recorded test current.
Calculation of resistance depending on the currents.

8. Results

Type: HH-SI 6/12kV 100A FC TB ÜLA 292/65
R_{cold}: 8,50 mΩ

8.1 Temperature rise test

		Temperature			Temperature rise			Informative	
I [A]	$\vartheta_{amb.}$ [°C]	ϑ_{top} [°C]	ϑ_{bottom} [°C]	$\vartheta_{perm.}$ [°C]	$\Delta\vartheta_{top}$ [K]	$\Delta\vartheta_{bottom}$ [K]	$\Delta\vartheta_{perm.}$ [K]	ϑ_{center} [°C]	ϑ_{center} [K]
50	21,9	39,5	33,6	105	17,6	11,7	65	57,1	35,2
100	22,6	97,1	70,1	105	74,5	47,5	65	175,1	152,5

8.2 Power dissipation and resistance of the test object at defined currents.

I [A]	P_d [W]	$U_{fuse-link}$ [V]	R [mΩ]
50	24,50	0,49	9,80
100	156,00	1,56	15,60

9. Evaluation

The limits for temperature (105 °C) and temperature-rise (65 K) for components and materials are followed according to the IEC standard up to 94 A. A derating factor of 0,94 has to be applied with reference to rated current.

372 / 23
06/06/2001

EFEN GmbH Prüflabor Test Laboratory Eltville

Test engineer

Head of laboratory

KEMA

HIGH-POWER LABORATORY
Utrechtseweg 310 – 6812 AR Arnhem – The Netherlands

281-01

REPORT OF PERFORMANCE

CLIENT	EFEN Elektrotechnische Fabrik GmbH, Eltville am Rhein, Germany
MANUFACTURER	EFEN Elektrotechnische Fabrik GmbH, Eltville am Rhein, Germany
APPARATUS	Current limiting fuses
DESIGNATION	HH-SI 6/12kV FC TB 292/56
SERIAL No.	67220.0400, 67220.0500, 67220.0630, 67220.0800, 67220.1000, 67220.1250, 67220.1600, 67220.2000.

RATINGS ASSIGNED BY THE MANUFACTURER

Voltage	12	kV
Current	40 – 50 – 63 – 80 – 100 –125 – 160 – 200	A (1)
Frequency	50	Hz
Breaking capacity at 12 kV	63	kA
Series	1	
Class	back up	

(1) The fuse-links 40 – 50 – 63 A form a homgeneous series in accordance with Sub-clause 13.3.1 of IEC 60282-1.

The tests have been carried out strictly in accordance with IEC 60282-1.
The apparatus has compiled with the relevant requirements.

Date of tests 13th March 2001

The performance of the apparatus tested and the observations made during the tests have been recorded in the tables with test results and the oscillograms

THIS REPORT CONSISTS OF:

Pages	11
Circuit diagrams	1
Oscillograms	23
awings	22
graphs	1
on sheet	B70E

KEMA Nederland B.V.

A.L.J. Janssen
Manager High-Power Laboratory

Arnhem, 23rd April 2001

E40E

TABLE WITH TEST RESULTS

REPORT 281–01	TYPE OF TESTS REQUESTED: Test duty 1	TEST CIRCUIT S01	PAGE 7

Condition before tests: Fuse–base in same condition.
Before each test new fuse–link.
Fuse–link mounted vertically in free air.
Distance fuse–link to floor 1.5 m.

Date and test	Fuse–link Type	Fuse–link Rated voltage kV / Rated current A	Resistance before test mΩ / after test MΩ	Test circuit Applied voltage kV	Test circuit Prospective current kA	Commencing of arcing after voltage zero °	Instantaneous current at initiation of arcing peak kA	Cut–off current peak kA	Pre–arcing time ms	Arcing time ms	Total operating time ms	Recovery voltage (1) kV	Switching voltage peak kV	Melt ∫I²t A²s x 10³	Total ∫I²t A²s x 10³	Energy ∫UIt kJ	Condition after test: Fuse–link / Striker; Behaviour during test, Remarks
010313 5011	HH–SI 6/12 FC TB 292/65 67220.0800 1905	12 / 80	10 / > 300	10.6	64.0	60	11.6	12.1	0.51	6.0	6.51	10.5	27.5	16.7	94.3	248	hot / 23 mm; Fuse cleared.
010313 5012	HH–SI 6/12 FC TB 292/65 67220.0800 1906	12 / 80	10 / > 300	10.6	64.0	88	12.5	13.0	0.38	4.4	4.78	10.5	29.4	17.3	84.0	187	hot / 23 mm; Fuse cleared.
010313 5013	HH–SI 6/12 FC TB 292/65 67220.0800 1907	12 / 80	10 / > 300	10.6	64.0	84	12.1	12.9	0.42	4.8	5.22	10.5	29.3	17.9	86.3	202	hot / 23 mm; Fuse cleared.

Remarks: Fuse–base showed no visible change.

(1) Maintained for 15 s.

KEMA

E40e

TABLE WITH TEST RESULTS

REPORT 281–01	TYPE OF TESTS REQUESTED: Test duty 1	TEST CIRCUIT S01	PAGE 8

Condition before tests: Fuse–base in same condition.
Before each test new fuse–link.
Fuse–link mounted vertically in free air.
Distance fuse–link to floor 1.5 m.

Date and test	Fuse–link Type	Fuse–link Rated voltage kV / Rated current A	Resistance before test mΩ / after test MΩ	Test circuit Applied voltage kV	Test circuit Prospective current kA	Commencing of arcing after voltage zero °	Instantaneous current at initiation of arcing peak kA	Cut–off current peak kA	Pre–arcing time ms	Arcing time ms	Total operating time ms	Recovery voltage (1) kV	Switching voltage peak kV	Melt ∫I²t A²s x 10³	Total ∫I²t A²s x 10³	Energy ∫UIt kJ	Condition after test: Fuse–link / Striker; Behaviour during test, Remarks
																	hot / 23 mm
010313 5014	HH–SI 6/12 FC TB 292/65 67220.1000 1920	12 / 100	6.9 / > 300	10.6	64.0	51	13.0	13.3	0.58	6.6	7.18	10.5	26.5	28.8	126	286	Fuse cleared.
																	hot / 23 mm
010313 5015	HH–SI 6/12 FC TB 292/65 67220.1000 1921	12 / 100	6.9 / > 300	10.6	64.0	85	14.6	15.2	0.45	4.9	5.35	10.5	29.0	31.0	142	275	Fuse cleared.
																	hot / 23 mm
010313 5016	HH–SI 6/12 FC TB 292/65 67220.1000 1922	12 / 100	7.0 / > 300	10.6	64.0	85	14.6	15.0	0.46	4.8	5.26	10.5	30.1	29.2	123	240	Fuse cleared.

Remarks: Fuse–base showed no visible change.

(1) Maintained for 15 s.

KEMA

FORSCHUNGSGEMEINSCHAFT FÜR
ELEKTRISCHE ANLAGEN UND STROMWIRTSCHAFT E.V.

Mannheim-Rheinau, Hallenweg 40

FGH

Accredited testing laboratory to DIN EN 45001 for subject

Deutscher Akkreditierungs Rat DAR

DAT-P-020/92-01	High-voltage apparatus switchgear and controlgear
DAT-P-020/92-12	High-voltage cables and accessories
DAT-P-020/92-21	Voltage quality flicker

Test Report

No. LV 00042

Duly signed copy 1E

Reference: 114-98/596...605
114-99/294...298
114-00/050...052

Apparatus: Current-limiting fuse-link

Types: a) HH-SI 6/12kV 63A FC TB 292/65, Ident-No.: 67220.0630
b) HH-SI 6/12kV 80A FC TB 292/65, Ident-No.: 67220.0800
c) HH-SI 6/12kV 100A FC TB 292/65, Ident-No.: 67220.1000

Rated voltage: 12 kV
Rated current: a) 63 A, b) 80 A, c) 100 A
Class: Back-up

Manufacturer: EFEN Elektrotechnische Fabrik GmbH,
Postfach 12 54, D-65344 Eltville, Germany

Customer: EFEN Elektrotechnische Fabrik GmbH,
Postfach 12 54, D-65344 Eltville, Germany

Test Specification: IEC 282-1, fourth edition, 1994

Tests performed: Breaking tests:

Test duty 2 with type b):
Verification of the operation with prospective current I2 at which current limiting occurs when a high level of energy is stored in the inductance of the circuit.

Test duty 3 with types a), b), c):
Verification of the operation at the rated minimum breaking current
a) I3 = 221 A,
b) I3 = 345 A,
c) I3 = 497 A.

Test Results: During the breaking tests performed, the tested fuse-links fully complied with the standard conditions of behaviour with respect to breaking capacity.

Mannheim, May 5, 2000
Hch

Forschungsgem. für Elektrische Anlagen und Stromwirtschaft e.V. * FGH

FORSCHUNGSGEMEINSCHAFT FÜR
ELEKTRISCHE ANLAGEN UND STROMWIRTSCHAFT E.V.

Test Engineer

i.V. 9/5/3

(Heit / Schaefer)

Place and date of test: LVF Mannheim-Rheinau, 01/12/98, 07/12/98, 08/12/99, 26/01/00

Number of sheets: 28

No. LV 00042

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	12	80	HH-SI 6/12kV 80A FC TB 292/65 Ident.-No.: 67220.0800

Test-no. 114-99/			294	296	297	298
Specimen		No.	Adjustment test	991077	991078	991079
Resistance		mΩ	-	10.8	10.4	10.7
Test-duty (according to IEC 282-1)			2			
Power factor of the test circuit	cos φ		0.083			
Prospective breaking current (RMS)		kA	5.05	5.05	5.05	5.05
Making angle after voltage zero		° el	8.1	7.6	8.5	7.7
Pre-arcing / Melting time	t_m	ms		3.67	3.69	3.67
Melting current	i_m	kA		4.90	5.05	4.96
Pre-arcing Joule Integral		kA^2s		21.4	23.3	22.2
Cut-off / Let through current	i_d	kA		5.20	5.32	5.24
Arcing time	t_{LB}	ms		7.12	7.20	6.95
Arcing Joule Integral		kA^2s		73.1	85.2	67.6
Arcing time until breaking by the circuit breaker		ms		-	-	-
Max. switching voltage	u_S	kV		25.9	24.9	27.0
Power frequency recovery voltage	U_W	kV	10.51	10.50	10.51	10.51
Maintaining voltage after breaking		s		> 60	> 60	> 60
Test result:						
Fuse operated correct		y/n		y	y	y
Switching voltage u_s ≤ permissive value		y/n		y	y	y
Current limiting:	(I_d ≤ Let-through characteristic)	y/n		-	-	-
Requirement for I2:	i_m/I = 0.85...1.06	i_m/I		0.97	1.00	0.98
Emission of flames or sand		y/n		n	n	n
Damages (external)		y/n		n	n	n
Operation of striker correct		y/n		y	y	y

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	12	80	HH-SI 6/12kV 80A FC TB 292/65 Ident.-No.: 67220.0800

Test-no. 114-98/			602	604	605	
Specimen		No.	Adjustment test	99401	99401a	
Resistance		mΩ	-	10.5	10.6	
Test-duty (according to IEC 282-1)			3			
Power factor of the test circuit	cos φ		0.50			
Prospective breaking current (RMS)		A	345			
Maintained current with low voltage source at A at A		s		-	-	
Time of current-interruption while switching over from low voltage to high voltage circuit		ms		-	-	
Melting time	t_m	s		1.68	2.22	
Pre-arcing Joule Integral		kA^2s		202	268	
Arcing time	t_{LB}	ms		23	21	
Arcing Joule Integral		kA^2s		2.05	1.56	
Arcing time until breaking by the circuit breaker		s		-	-	
Max. switching voltage	u_S	kV		17.4	17.4	
Power frequency recovery voltage	U_W	kV	12.1	12.1	12.1	
Maintaining voltage after breaking		s		60	60	
Test result:						
Fuse operated correct		y/n		y	y	
Switching voltage $u_S \leq$ permissive value		y/n		y	y	
Emission of flames or sand		y/n		n	n	
Damages (external)		y/n		n	n	
Operation of striker correct		y/n		y	y	

FORSCHUNGSGEMEINSCHAFT FÜR
HOCHSPANNUNGS- UND HOCHSTROMTECHNIK E.V.

Mannheim-Rheinau, Hallenweg 40

FGH

Accredited testing laboratory to DIN EN 45001 for subject

Deutscher Akkreditierungs Rat DAR

DAT-P-020/92-01	High-voltage apparatus, switchgear and controlgear
DAT-P-020/92-12	High-voltage cables and accessories
DAT-P-020/92-21	Voltage quality flicker

Test Report

No.: LV 98080/1E

Reference: 114-98/126-144

Apparatus: Current-limiting fuse-links, with striker

Types:	HH-SI 6/12kV 63A FC TB 292/65	Order-no.:	67220.0630
	HH-SI 6/12kV 100A FC TB 292/65	Order-no.:	67220.1000
	HH-SI 6/12kV 160A FC TB 292/88	Order-no.:	67220.1600
Rated voltage:	12 kV		
Rated currents:	63 A, 100 A, 160 A		
Classification:	Back-up		

Manufacturer: EFEN Elektrotechnische Fabrik GmbH,
Postfach 12 54, D-65332 Eltville, Germany

Customer: EFEN Elektrotechnische Fabrik GmbH,
Postfach 12 54, D-65332 Eltville, Germany

Test Specification: IEC 282-1, fourth edition, 1994

Tests performed: Breaking tests
Test duty 2: Verification of the operation with prospective current I2 at which current limitation occurs when a high level of energy is stored in the inductance of the circuit.

Test Results: During the performed tests the fuse-links fully complied with the standard conditions of behaviour with respect to breaking capacity.

Mannheim, November 18, 1998
Wa

Forschungsgem. f. Hochspannungs- u. Hochstromtechnik e.V.

FORSCHUNGSGEMEINSCHAFT FÜR
HOCHSPANNUNGS- UND HOCHSTROMTECHNIK E.V.

i.V. i.V.

Test Engineer: (Schaefer)

Place and date of test: LVF Mannheim-Rheinau, April 14 and 15, 1998

Number of sheets: 26

No. LV 98080 Sheet 16

BREAKING TESTS - HIGH-VOLTAGE FUSES

tested fuse: U_N: 6/12 kV I_N: 100 A Type: 67220.1000
HH-SI 6/12kV 100A FC TB 292/65

Test-No. 114-98/				130	131	132	133
Specimen			No.	Adjust-ment test	98490	98491	98492
Resistance			mΩ	-	8.3	8.2	8.3
Test-duty (according to IEC 282-1. 1994)				2			
Power factor of the test circuit		cos φ		0.026			
Prospective	breaking current	I	kA	6.27			
	peak current	i_s		16.8			
Making angle after voltage zero			° el	13	13	13	13
Pre-arcing / Melting time		t_m	ms		3.4	3.4	3.4
Melting current		i_m	kA		6.42	6.33	6.30
Pre-arcing Joule Integral			kA^2s		36.8	35.4	35.2
i_m/I (for test-duty 2: i_m/I = 0.85...1.06)					1.02	1.01	1.00
Cut-off / Let through current		i_d	kA		6.80	6.81	6.70
Arcing time		t_{LB}	ms		7.1	7.3	7.2
Arcing Joule Integral			kA^2s		143	158	155
Max. switching voltage		u_s	kV		26.9	25.9	25.6
Power frequency recovery voltage		U_w	kV	10.55	10.55	10.54	10.53
Maintaining voltage after breaking			s		60	60	60
Fuse operated correct (yes / no)					yes	yes	yes
Emission of flames or sand					no	no	no
Damages (external)					no	no	no
Operation of striker correct					yes	yes	yes

No. LV 00042

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	12	100	67220.1000 HH-SI 6/12kV 100A FC TB 292/65

Test-no. 114-00/			50	51	52	
Specimen		No.	Adjustment test	991080	991081	
Resistance		mΩ	-	8.6	8.6	
Test-duty (according to IEC 282-1)			3			
Power factor of the test circuit	cos φ		0.50			
Prospective breaking current (RMS)		A	497	496	498	
Maintained current with low voltage source	at A at A	min		-	-	
Time of current-interruption while switching over from low voltage to high voltage circuit		ms		-	-	
Melting time	t_m	ms		782	795	
Pre-arcing Joule Integral		kA^2s		192	198	
Arcing time	t_{LB}	ms		7	16	
Arcing Joule Integral		kA^2s		1.95	3.66	
Arcing time until breaking by the circuit breaker		ms		-	-	
Max. switching voltage	u_S	kV		17.7	17.9	
Power frequency recovery voltage	U_W	kV	12.4	12.3	12.4	
Maintaining voltage after breaking		s		60	60	
Test result:						
Fuse operated correct		y/n		y	y	
Switching voltage $u_S \leq$ permissive value		y/n		y	y	
Emission of flames or sand		y/n		n	n	
Damages (external)		y/n		n	n	
Operation of striker correct		y/n		y	y	

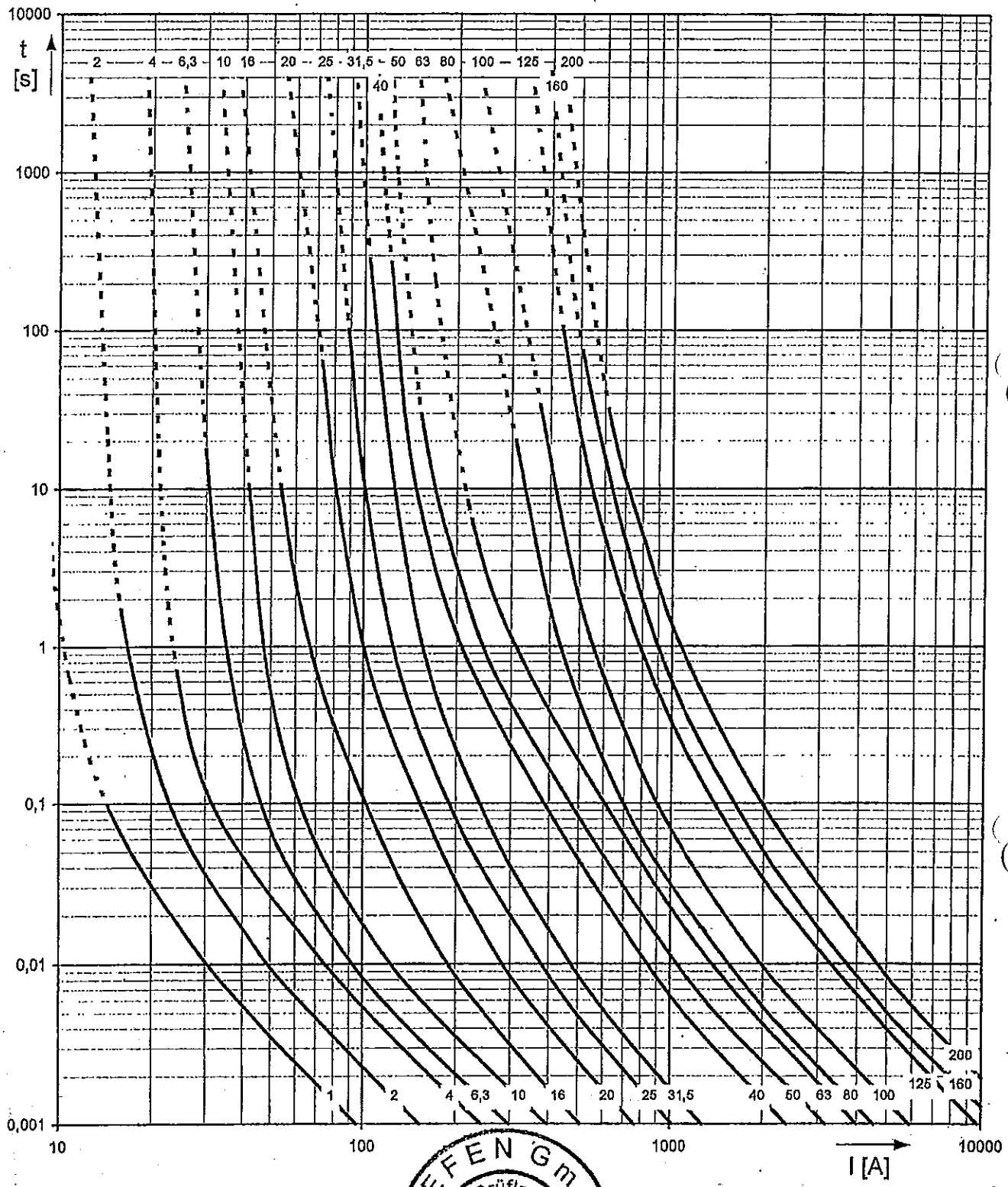
EFEN WICKMANN GRUPPE

Time-current characteristics of H.V. back-up fuse-links with ÜLA (controlled power dissipation)

Lab.-No. 01168

6/12kV 1 A - 200 A acc. to IEC 60282-1 / VDE 0670 Teil 4

Order-No.: 67220.0019 - 67220.2009



EFEN GmbH Prüflabor Test Laboratory Eltville

06.06.2001 / 23

EFEN GmbH

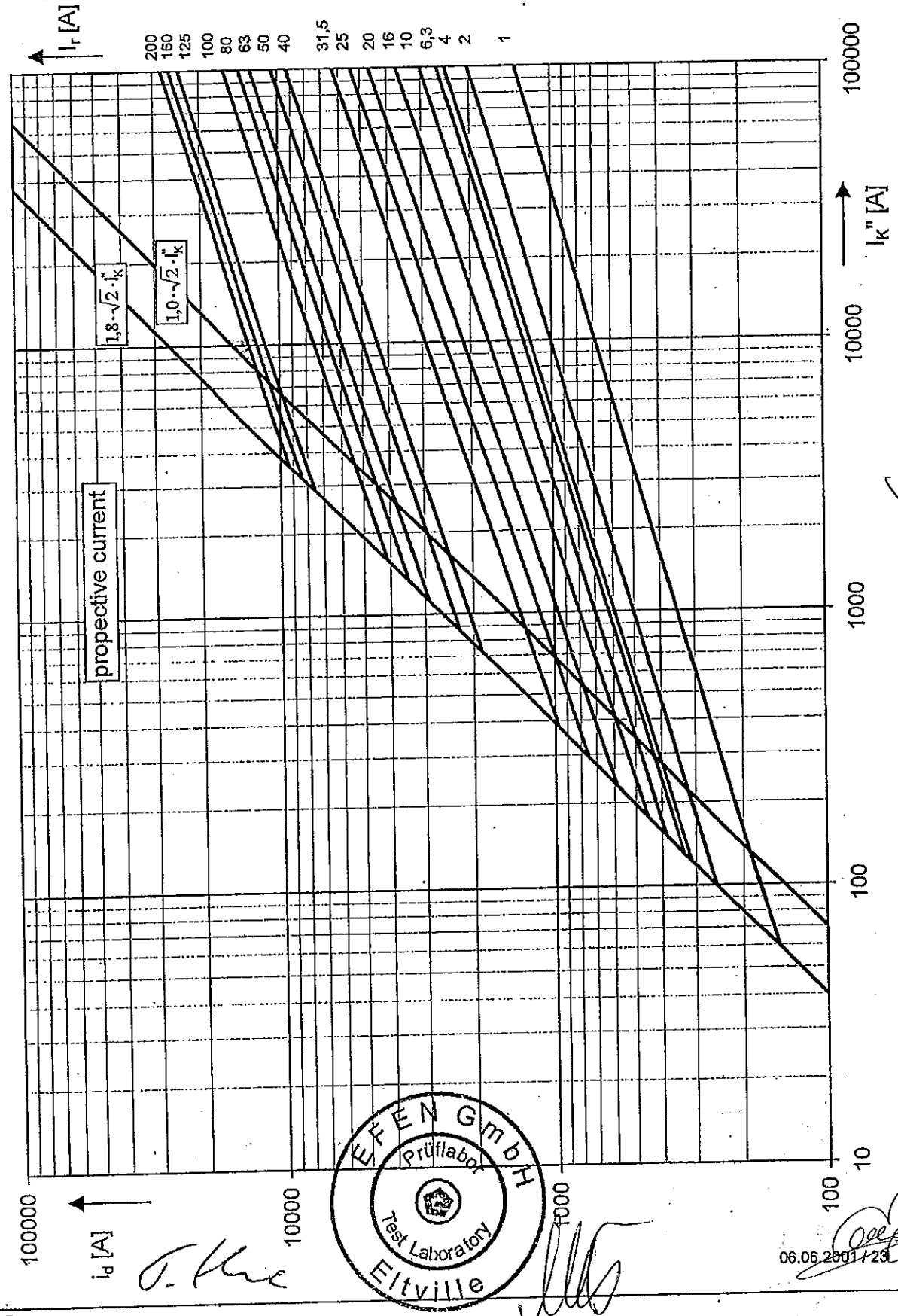
Postfach 1254 · D-65332 Eltville · Tel. 0049 (0) 6129 46-0 · Fax 46222 · e-Mail: efen@efen.com · Internet: www.efen.com

EFEN
WICKMANN GRUPPE

Cut-off characteristics of H.V. back-up fuse-links with ÜLA (controlled power dissipation)

Lab.-No. 01170 6/12 kV 1 A - 200 A acc. to IEC 60282-1 / VDE 0670 Teil 4

Order-No.: 67220.0019 to 67220.2009



EFEN GmbH
Postfach 1254 · D-65332 Eltville · Tel. 00 49 (0) 61 29 46-0 · Fax 46 22 · e-Mail: efen@efen.com · Internet: www.efen.com

1. Type HH – fuse link with striker 81902.0100(3) (duration 30mm)

2. Reason for test

Test of Strikers

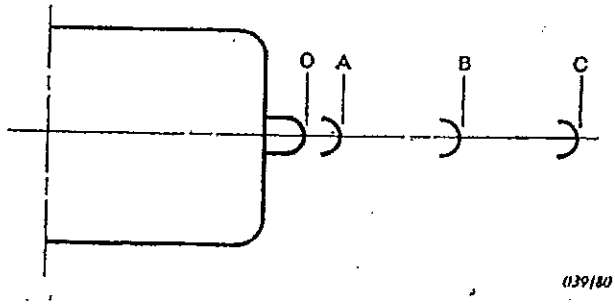
3. Tests performed / measurements

I. measurement of the duration of travel
II. measurement of the force-travel characteristics and calculation of the striker energy actuated by the spring
III. Verification of the withstand force according to applied standard (4)

4. Applied standards

IEC 60282-1 2002-01 VDE 0670 Teil 4 Abs. 12 02/98

4.1 standard in detail regarding strikers



OA – Free travel – No energy output specified.
AB – Further travel during which energy must be delivered.
OB – Minimum actual travel.
OC – Maximum actual travel.
CB – Maximum permitted return travel under withstand force (when applicable).

Type	Energy	Mechanical characteristics					
		Values of		Actual travel		Minimum withstand force	Maximum duration of travel (see note)
		Free travel (OA)*	Further travel during which energy must be delivered (AB)*	Min. (OB)*	Max. (OC)*		
	J	mm	mm	mm	mm	N	ms
Light	0,3 ± 0,25	2	8	10	30	Not applicable	100
Medium	1 ± 0,5	4	16	20	40	20	100
Heavy	2 ± 1	4	6	10	16	40	100

* See figure 12.

NOTE – Duration of travel is defined for actual fuse-links as the time from commencement of arcing to the time when travel OB is reached. For dummy fuses it is the time from application of voltage until travel OB is reached.

5. Test-laboratory, period of time

EFEN laboratory Eltville, 4.12.2003

6. Arrangement of the equipment

I. The tested fuse link is fixed in a fuse-base. An NC (normally closed) switch will be opened if the striker has travelled 30mm. Current, Voltage and the NC switch are recorded by an digital oscilloscope.

II. & III. The force-travel characteristics will be measured by an approved force meter*. For this measurement the striker will be prepared with an scale indicator for measuring the travelled way in mm.

*Zwick Z2.5 / TN1S Material testing device

7. Inspection and test sequence

I. Intact striker circuit is tested with current < 10A and voltage < 15V.
II. Current, voltage and the NC switch are recorded.
III. Force of striker is measured at Positions: 0, 10, und 20mm.
The Position of the Striker is measured at the minimum withstand force of 20N.

8. Results

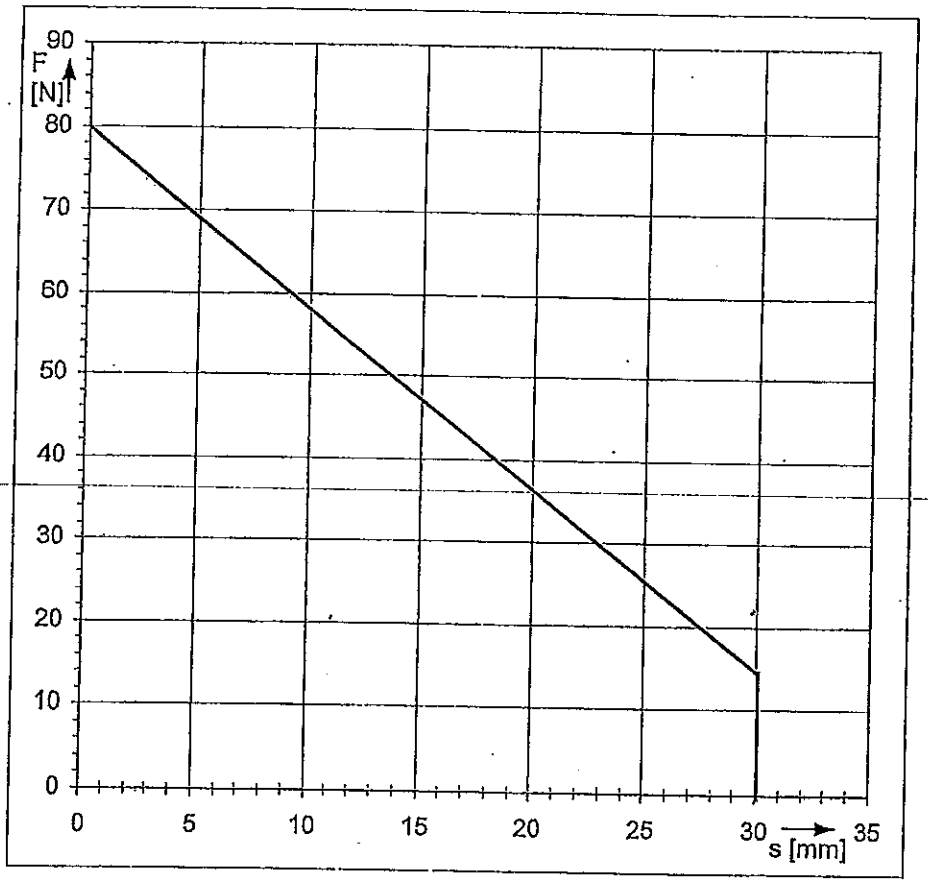
I. measurement of the duration of travel

	duration of travel	Current	Voltage
Sample 1	5 ms	9,9 A	< 15 V
Sample 2	2 ms	11,7 A	< 15 V
Sample 3	4 ms	10 A	< 15 V
Sample 4	6 ms	9,9 A	< 15 V

II. measurement of the force-travel characteristics and calculation of the striker energy

		Sample 1		Sample 2		Sample 3		
Position	Length / mm	Measurem. 1	Measurem. 2	Measurem. 1	Measurem. 2	Measurem. 1	Measurem. 2	Average:
O	0	77	76,8	85,5	81,7	78	78	79,5
A	4	66,5	66,4	67,5	67,4	71,7	69,7	68,2
B	20	37,7	36,1	33,7	33,1	36,2	36,5	35,6
	Energy / J:	0,83	0,82	0,81	0,80	0,86	0,85	0,83

$$Energy = \frac{(F_A + F_B) \times \overline{AB}}{2000} \qquad Energy[J];\ F_A[N];\ F_B[N];\ \overline{AB}[mm];$$



III. Verification of the withstand force of 20N at Position ≥ 20mm

	Measurement	Force / N	Length / mm
Sample 1	1	20	27,4
Sample 1	2	20	27,7
Sample 2	1	20	27,3
Sample 2	2	20	26,9
Sample 3	1	20	28,4
Sample 3	2	20	28,4

9. Evaluation

Type	Energy		Free travel	Further travel during which energy must be delivered	Actual travel			Minimum travel force	
	Actual value	Specified value	$\overline{OA}$	$\overline{AB}$	Actual value	Specified value Min. $\overline{OB}$	Specified value Max. $\overline{OC}$	Actual value	Specified value
	J		mm	mm	mm			N	
Medium	0,83	1±0,5	4	16	30	20	40	35,6	20

I. Measured duration of travel < maximum duration of travel (100ms)
II. striker energy is Medium 1J +-0,5 J
III. Verification of the withstand force proofed that the striker has the necessary force.

The striker full fills all Requirements of striker Type medium according to:
IEC 60282-1 2002-01; VDE 0670 Teil 4 Abs. 12 02/98

370 / 65

2004-03-29

Test engineer

EFEN GmbH Prüflabor Test Laboratory Eltville

Head of Laboratory

Приложение № 5.3.

EFEN WICKMANN GRUPPE

Type Test Report

Lab.-No. 01163

1. Object

Current-limiting high-voltage fuse-links
Class: Back-up
Striker: "medium"
Type: HH-SI 10/24kV 1A / 2A / 4A FC TB ÜLA 442/56
Ident-No.: 67240.0019 / 67240.0029 / 67240.0049

Rated voltage	10/24 kV		
Rated current	1 A	2 A	4 A
Rated maximum breaking current	63 kA		
Rated frequency	50 Hz		
Rated minimum breaking current	14 A	16 A	23 A

2. Reason for test

Type test according to IEC 60282-1 (VDE 0670 Teil 4): 1998-02

3. Tests performed

3.1 Temperature-rise tests and power-dissipation measurement

Rated current		1 A	2 A	4 A
Test laboratory		EFEN Prüflabor Eltville		
Test result: $\Delta\vartheta_{max}$ [1]		1 K	2 K	6 K
Test result: P_a	At 50% I_r	0,54 W	0,81 W	2,31 W
	At 100% I_r	2,17 W	3,32 W	9,70 W
EFEN Lab-No.		01141	01142	01143
Test passed		Yes	Yes	Yes

[1] permissible temperature rise: 65 K

3.2 Breaking Test: Test Duty 1

Rated current	1 A	2 A	4 A
Test Laboratory / Document No	KEMA / 720-00		
Test circuit applied voltage: U	21 kV		
Test circuit prospective current I	63 kA		
EFEN Lab-No.	01072		
Test passed	Yes	Yes	Yes

EFEN GmbH
Postfach 1254 D-65332 Eltville Tel. 0049 (0) 6129 46-0 Fax 46222 e-Mail: efen@efen.com Internet: www.efen.com

3.3 Breaking Test: Test Duty 2

Rated current	1 A	2 A	4 A
Test Laboratory / Document No	FGH / L 00038 1E		
Test circuit applied voltage U	20,98 kV	20,96 kV	21,00 kV
Test circuit prospective current I	103 A	173 A	246 A
EFEN Lab-No.	00183		
Test passed	Yes	Yes	Yes

3.4 Breaking Test: Test Duty 3

Rated current	1 A	2 A	4 A
Test Laboratory / Document No.	FGH / L 00038 1E		
Test circuit applied voltage: U	24,1 kV	24,74 kV	24,3 kV
Test circuit prospective current I	13,7 A	15,1 A	23,2 A
EFEN Lab-No.	00183		
Test passed	Yes	Yes	Yes

3.5 Tests for time-current characteristics
Test Laboratory: EFEN Prüflabor Eltville
EFEN Lab-No: 01169
Test passed

3.6 Cut-off characteristics
EFEN Lab-No: 01171

3.7 Test of strikers
Test result: 0,83 J => Type medium
Test Laboratory: EFEN Prüflabor Eltville
EFEN Lab-No: 03088
Test passed

4. Test results

The products passed the type tests according to IEC 60 282-1 and VDE 0670 Teil 4 respectively at KEMA, FGH and EFEN test laboratories.

All requirements are fulfilled (see 3.).

370 / 65

2004-11-18

EFEN GmbH Prüflabor Test Laboratory Eltville

Test Engineer

Head of laboratory

1. Type — HH-SI 10/24kV 1A FC TB ÜLA 442/56
Order-No.: 67240.0019

2. Reason for test

Temperature-rise tests and power-dissipation measurement

3. Tests performed / measurements

Measurement of temperatures, of voltage drop across fuse-link and power dissipation at different operating currents.

4. Applied standards

IEC 60282-1 1998-01 VDE 0670 Teil 4 Abs. 12 02/98

5. Test-laboratory, period of time

EFEN Prüflabor Eltville, 09/04/2000 – 09/08/2000

6. Arrangement of the equipment

The high-voltage fuse-link is mounted vertically in a fuse-base, with the striker-pin at the top.
The size of bare copper conductors is 25 mm².
Temperatures are measured at the fuse contacts (top and bottom), in the middle of the fuse with thermocouples and are recorded.
The test currents are recorded.

7. Inspection and test sequence

The fuse-link was loaded with test currents I = 0,5 A and I = 1,0 A

Test current I [A]	Comments
0,5	50% rated current
1,0	Rated current

Temperatures are measured at the fuse contacts and in the middle of the tube with thermocouples.
Calculation of power dissipation from recorded voltage drop and recorded test current.
Calculation of resistance depending on the currents.

8. Results

Type: HH-SI 10/24kV 1A FC TB ÜLA 442/56
R_{cold}: 2103 mΩ

8.1 Temperature rise test

		Temperature			Temperature rise			Informative	
I [A]	$\vartheta_{amb.}$ [°C]	ϑ_{top} [°C]	ϑ_{bottom} [°C]	$\vartheta_{perm.}$ [°C]	$\Delta\vartheta_{top}$ [K]	$\Delta\vartheta_{bottom}$ [K]	$\Delta\vartheta_{perm.}$ [K]	ϑ_{center} [°C]	ϑ_{center} [K]
0,5	21	22	21	105	1	0	65	22	1
1	21	22	22	105	1	1	65	24	3

8.2 Power dissipation and resistance of the test object at defined currents.

I [A]	P_d [W]	$U_{fuse-link}$ [V]	R [mΩ]
0,5	0,54	1,06	2160
1	2,17	2,17	2170

9. Evaluation

The product passed the temperature-rise test acc. to IEC 60 282-1 and VDE 0670 Teil 4 respectively.

372 / 23
07/06/2001

EFEN GmbH Prüflabor Test Laboratory Eltville

Test engineer

Head of laboratory

Lab.-No. 01142

1. Type — HH-SI 10/24kV 2A FC TB ÜLA 442/56
Order-No.: 67240.0029

2. Reason for test

Temperature-rise tests and power-dissipation measurement

3. Tests performed / measurements

Measurement of temperatures, of voltage drop across fuse-link and power dissipation at different operating currents.

4. Applied standards

IEC 60282-1 1998-01 VDE 0670 Teil 4 Abs. 12 02/98

5. Test-laboratory, period of time

EFEN Prüflabor Eltville, 09/04/2000 – 09/08/2000

6. Arrangement of the equipment

The high-voltage fuse-link is mounted vertically in a fuse-base, with the striker-pin at the top.
The size of bare copper conductors is 25 mm².
Temperatures are measured at the fuse contacts (top and bottom), in the middle of the fuse with thermocouples and are recorded.
The test currents are recorded.

7. Inspection and test sequence

The fuse-link was loaded with test currents I = 1,0 A and I = 2,0 A

Test current I [A]	Comments
1	50% rated current
2	Rated current

Temperatures are measured at the fuse contacts and in the middle of the tube with thermocouples.
Calculation of power dissipation from recorded voltage drop and recorded test current.
Calculation of resistance depending on the currents.

8. Results

Type: HH-SI 10/24kV 2A FC TB ÜLA 442/56
R_{cold}: 797 mΩ

8.1 Temperature rise test

		Temperature			Temperature rise			Informative	
I [A]	$\vartheta_{amb.}$ [°C]	ϑ_{top} [°C]	ϑ_{bottom}	$\vartheta_{perm.}$ [°C]	$\Delta\vartheta_{top}$ [K]	$\Delta\vartheta_{bottom}$ [K]	$\Delta\vartheta_{perm.}$ [K]	ϑ_{center} [°C]	ϑ_{center} [K]
1	21	21	21	105	0	0	65	22	1
2	21	23	22	105	2	1	65	26	5

8.2 Power dissipation and resistance of the test object at defined currents.

I [A]	P_d [W]	$U_{fuse-link}$ [V]	R [mΩ]
1	0,81	0,81	797
2	3,32	1,66	830

9. Evaluation

The product passed the temperature-rise test acc. to IEC 60 282-1 and VDE 0670 Teil 4 respectively.

372 / 23
07/06/2001

EFEN GmbH Prüflabor Test Laboratory Eltville

Test engineer

Head of laboratory

1. Type — HH-SI 10/24kV 4A FC TB ÜLA 442/56
Order-No.: 67240.0049

2. Reason for test

Temperature-rise tests and power-dissipation measurement

3. Tests performed / measurements

Measurement of temperatures, of voltage drop across fuse-link and power dissipation at different operating currents.

4. Applied standards

IEC 60282-1 1998-01 VDE 0670 Teil 4 Abs. 12 02/98

5. Test-laboratory, period of time

EFEN Prüflabor Eltville, 09/04/2000 – 09/08/2000

6. Arrangement of the equipment

The high-voltage fuse-link is mounted vertically in a fuse-base, with the striker-pin at the top.
The size of bare copper conductors is 25 mm².
Temperatures are measured at the fuse contacts (top and bottom), in the middle of the fuse with thermocouples and are recorded.
The test currents are recorded.

7. Inspection and test sequence

The fuse-link was loaded with test currents I = 2,0 A and I = 4,0 A

Test current I [A]	Comments
2	50% rated current
4	Rated current

Temperatures are measured at the fuse contacts and in the middle of the tube with thermocouples.
Calculation of power dissipation from recorded voltage drop and recorded test current.
Calculation of resistance depending on the currents.

8. Results

Type: HH-SI 10/24kV 4A FC TB ÜLA 442/56
R_{cold}: 587 mΩ

8.1 Temperature rise test

		Temperature			Temperature rise			Informative	
I [A]	$\vartheta_{amb.}$ [°C]	ϑ_{top} [°C]	ϑ_{bottom} [°C]	$\vartheta_{perm.}$ [°C]	$\Delta\vartheta_{top}$ [K]	$\Delta\vartheta_{bottom}$ [K]	$\Delta\vartheta_{perm.}$ [K]	ϑ_{center} [°C]	ϑ_{center} [K]
2	21	23	22	105	2	1	65	25	4
4	21	27	25	105	6	4	65	34	13

8.2 Power dissipation and resistance of the test object at defined currents.

I [A]	P_d [W]	$U_{fuse-link}$ [V]	R [mΩ]
2	2,31	1,15	580
4	9,70	2,42	606

9. Evaluation

The product passed the temperature-rise test acc. to IEC 60 282-1 and VDE 0670 Teil 4 respectively.

372 / 23
07/06/2001

EFEN GmbH Prüflabor Test Laboratory Eltville

Test engineer

Head of laboratory

KEMA
HIGH-POWER LABORATORY
Utrechtseweg 310 – 6812 AR Arnhem – The Netherlands

720-00

REPORT OF PERFORMANCE

CLIENT	EFEN Elektrotechnische Fabrik GmbH, Eltville am Rhein, Germany
MANUFACTURER	EFEN Elektrotechnische Fabrik GmbH, Eltville am Rhein, Germany
APPARATUS	Current limiting fuses
DESIGNATION	HH-SI 10/24kV FC TB 442/56 1 – 2 – 4 – 6.3 – 10 – 16 – 20 – 25 – 31.5 – 40 – 50 – 63 A – 80 A
SERIAL No.	67240.0010, 67240.0020, 67240.0040, 67240.0060, 67240.0100, 67240.0160, 67240.0200, 67240.0250, 67240.0320, 67240.0400, 67240.0500, 67240.0630 and 67240.0800.

RATINGS ASSIGNED BY THE MANUFACTURER

Voltage	24	kV
Current	1 – 2 – 4 – 6.3 – 10 – 16 – 20 – 25 – 31.5 – 40 – 50 – 63 – 80	A (1)
Frequency	50	Hz
Breaking capacity at 24 kV	63	kA
Series	1	
Class	Back-up	

(1) The fuse-links 20 – 25 – 31.5 A and 40 – 50 – 63 A form a homgeneous series in accordance with Sub-clause 13.3.1 of IEC 60282-1.

The tests have been carried out strictly in accordance with IEC 60282-1, Sub-clause 13 (Test-duty 1).
The apparatus has complied with the relevant requirements.

Date of tests 22nd November 2000 and 13th March 2001

The performance of the apparatus tested and the observations made during the tests have been recorded in the tables with test results and the oscillograms

THIS REPORT CONSISTS OF:

Pages	15
Circuit diagrams	1
Oscillograms	36
Drawings	19
Photographs	5
Information sheet	B70E

KEMA Nederland B.V.

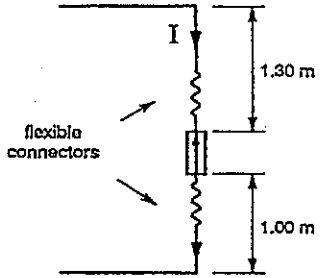
A.L.J. Janssen
Manager High-Power Laboratory

Arnhem, 27th February 2001

TABLE WITH TEST RESULTS

REPORT 720–00	TYPE OF TESTS REQUESTED: Test–duty 1	TEST CIRCUIT S02	PAGE 5

Condition before tests: Fuse–base new. Photograph 0401306.
Before each test new fuse–link.
Fuse–link mounted vertically in free air.
Distance fuse–link to floor 1.5 m.
Supply to top of the fuse–carrier.



Date and test	Fuse–link Type	Fuse–link Rated voltage kV / Rated current A	Resistance before test mΩ / after test MΩ	Test circuit Applied voltage kV	Test circuit Prospective current kA	Commencing of arcing after voltage zero °	Instantaneous current at initiation of arcing peak kA	Cut–off current peak kA	Pre–arcing time ms	Arcing time ms	Total operating time ms	Recovery voltage (1) kV	Switching voltage peak kV	Melt ∫I²t A²s x 10⁶	Total ∫I²t A²s x 10⁶	Energy ∫UIt kJ	Condition after test: Fuse–link / Striker; Behaviour during test; Remarks
001122 4033				10.6	31.9												Checking of the prospective current and applied voltage.
001122 4035	HH–SI 10/24 FC TB 442/56 67240.0010 001624	24 / 1	2200 / > 300	21.0	63.0	45	0.96	0.95	0.01	0.46	0.47	21.0	35.5	4.9	87.5	2.5	cold / operated; Fuse cleared.
001122 4036	HH–SI 10/24 FC TB 442/56 67240.0010 001625	24 / 1	2200 / > 300	21.0	63.0	80	1.18	1.24	0.01	0.55	0.56	21.0	51.1	3.9	103	3.39	cold / operated; Fuse cleared.
001122 4037	HH–SI 10/24 FC TB 442/56 67240.0010 001626	24 / 1	2200 / > 300	21.0	63.0	83	1.14	1.25	0.01	0.55	0.56	21.0	51.0	9.2	103	3.44	cold / operated; Fuse cleared.

Remarks: Fuse–base showed no visible change.

(1) Maintained for 15 s.

KEMA

TABLE WITH TEST RESULTS

REPORT 720–00	TYPE OF TESTS REQUESTED: Test–duty 1	TEST CIRCUIT S02	PAGE 6

Condition before tests: Fuse–base in same condition.
Before each test new fuse–link.
Fuse–link mounted vertically in free air.
Distance fuse–link to floor 1.5 m.

Date and test	Fuse–link Type	Fuse–link Rated voltage kV / Rated current A	Resistance before test m Ω / after test MΩ	Test circuit Applied voltage kV	Test circuit Prospective current kA	Commencing of arcing after voltage zero °	Instantaneous current at initiation of arcing peak kA	Cut–off current peak kA	Pre–arcing time ms	Arcing time ms	Total operating time ms	Recovery voltage (1) kV	Switching voltage peak kV	Melt ∫I²t A2s x 10⁶	Total ∫I²t A2s x 10⁶	Energy ∫UIt kJ	Condition after test: Fuse–link / Striker; Behaviour during test, Remarks
001122 4038	HH–SI 10/24 FC TB 442/56 67240.0020 001631	24 / 2	790 / > 300	21.0	63.0	46	1.53	1.53	0.05	0.58	0.58	21.0	44.0	18	201	3.76	cold / operated; Fuse cleared.
001122 4039	HH–SI 10/24 FC TB 442/56 67240.0020 001632	24 / 2	785 / > 300	21.0	63.0	85	1.48	1.93	0.05	4.14	4.19	21.0	58.2	40	295	19.3	cold / operated; Fuse cleared.
001122 4040	HH–SI 10/24 FC TB 442/56 67240.0020 001633	24 / 2	785 / > 300	21.0	63.0	84	1.55	1.95	0.05	4.04	4.09	21.0	57.8	41	266	16.6	cold / operated; Fuse cleared.

Remarks: Fuse–base showed no visible change.

(1) Maintained for 15 s.

KEMA

TABLE WITH TEST RESULTS

REPORT 720–00	TYPE OF TESTS REQUESTED: Test–duty 1	TEST CIRCUIT S02	PAGE 7

Condition before tests: Fuse–base in same condition.
Before each test new fuse–link.
Fuse–link mounted vertically in free air.
Distance fuse–link to floor 1.5 m.

Date and test	Fuse–link Type	Fuse–link Rated voltage kV / Rated current A	Resistance before test mΩ / after test MΩ	Test circuit Applied voltage kV	Test circuit Prospective current kA	Commencing of arcing after voltage zero °	Instantaneous current at initiation of arcing peak kA	Cut–off current peak kA	Pre–arcing time ms	Arcing time ms	Total operating time ms	Recovery voltage (1) kV	Switching voltage peak kV	Melt ∫I²t A²s x 10⁶	Total ∫I²t A²s x 10⁶	Energy ∫UIt kJ	Condition after test: Fuse–link / Striker; Behaviour during test, Remarks
001122 4041	HH–SI 10/24 FC TB 442/56 67240.0040 001638	24 / 4	535 / > 300	21.0	63.0	48	1.70	1.90	0.06	0.53	0.59	21.0	51.0	51	311	4.45	cold / operated; Fuse cleared.
001122 4042	HH–SI 10/24 FC TB 442/56 67240.0040 001639	24 / 4	534 / > 300	21.0	63.0	82	1.84	2.19	0.06	4.02	4.08	21.0	63.3	70	419	20.0	cold / operated; Fuse cleared.
001122 4043	HH–SI 10/24 FC TB 442/56 67240.0040 001640	24 / 4	535 / > 300	21.0	63.0	82	1.77	2.19	0.07	4.10	4.17	21.0	62.9	81	416	19.8	cold / operated; Fuse cleared.

Remarks: Fuse–base showed no visible change.

(1) Maintained for 15 s.

KEMA

FGH
Engineering & Test GmbH
Mannheim-Rheinau, Hallenweg 40

Accredited testing laboratory to DIN EN 45001 for subject

Deutscher Akkreditierungs Rat DAR

DAT-P-103/00-00 High-voltage apparatus switchgear and controlgear

DAT-P-103/00-10 High-voltage cables and accessories

Test Report

No. L 00038

Duly signed copy 1E

Reference: 114-00/332...342, 370...373, 418...425, 549...569, 707...709

Apparatus: **Current-limiting fuse-link**

Types:
a) HH-SI 10/24kV 1A FC TB 442/56, Ident-No.: 67240.0010
b) HH-SI 10/24kV 2A FC TB 442/56, Ident-No.: 67240.0020
c) HH-SI 10/24kV 4A FC TB 442/56, Ident-No.: 67240.0040
d) HH-SI 10/24kV 6,3A FC TB 442/56, Ident-No.: 67240.0060
e) HH-SI 10/24kV 10A FC TB 442/56, Ident-No.: 67240.0100

Rated voltage: 24 kV
Rated current: a) 1 A, b) 2 A, c) 4 A, d) 6.3 A, e) 10 A
Class: Back-up

Manufacturer: EFEN Elektrotechnische Fabrik GmbH,
Postfach 12 54, D-65344 Eltville, Germany

Customer: EFEN Elektrotechnische Fabrik GmbH,
Postfach 12 54, D-65344 Eltville, Germany

Test Specification: IEC 60282-1 (1998-01), Ed.4.2

Tests performed: Breaking tests:

Test duty 2:
Verification of the operation with prospective current I2 at which current limiting occurs when a high level of energy is stored in the inductance of the circuit.

Test duty 3:
Verification of the operation at the rated minimum breaking current.

Test Results: During the breaking tests performed, the tested fuse-links fully complied with the standard conditions of behaviour with respect to breaking capacity.

Mannheim, September 6, 2000
Wa

FGH Engineering & Test GmbH

FGH Engineering & Test GmbH

Test Engineer:

(Heil)

Place and date of test: LPF Mannheim-Rheinau, May 29-30, and July 1-20, and August 23, 2000

Number of sheets: 50

FGH Engineering & Test GmbH

No. L 00038

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	24	1	67240.0010 HH-SI 10/24kV 1A FC TB 442/56

Test-no.	114-00/		332	336	337	338
Specimen		No.	Adjust-ment test	00558	00559	00560
Resistance		mΩ	-	2130	2110	2110
Test-duty (according to IEC 282-1)			2	2	2	2
Power factor of the test circuit	cos φ		0.133	0.133	0.133	0.133
Prospective breaking current (RMS)		A	102	103	103	102
Making angle after voltage zero		° el		11	11	11
Pre-arcing / Melting time	t_m	ms		3.60	3.73	3.73
Melting current	i_m	A		98.9	103	102
Pre-arcing Joule Integral		A^2s		9.20	10.2	10.2
Cut-off / Let through current	i_d	A		180	171	169
Arcing time	t_{LB}	ms		7.63	6.48	7.37
Arcing Joule Integral		A^2s		105	75.4	89.9
Arcing time until breaking by the circuit breaker		ms		-	-	-
Max. switching voltage	u_s	kV		71.5	83.2	75.8
Power frequency recovery voltage	U_w	kV	20.98	21.15	21.21	20.94
Maintaining voltage after breaking		s	-	>60	>60	>60

Test result:

Fuse operated correct	y/n		yes	yes	yes
Switching voltage $u_s \leq$ permissive value	y/n		yes	yes	yes
Current limiting: ($i_d \leq$ Let-through characteristic)	y/n		-	-	-
Requirement for I2: i_m/I = 0.85...1.06	i_m/I		0.96	1.00	1.00
Emission of flames or sand	y/n		no	no	no
Damages (external)	y/n		no	no	no
Operation of striker correct	y/n		yes	yes	yes

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	24	1	67240.0010 HH-SI 10/24kV 1A FC TB 442/56

Test-no. 114-00/			549	550	551	
Specimen		No.	Adjust-ment test	00721	00722	
Resistance		mΩ	-	2130	2150	
Test-duty (according to IEC 282-1)			3			
Power factor of the test circuit	cos φ		0.52			
Prospective breaking current (RMS)		A	14.1	13.7	13.7	
Maintained current with low voltage source	at A at A			-	-	
Time of current-interruption while switching over from low voltage to high voltage circuit		ms		-	-	
Pre-arcing / Melting time	t_m	s		0.59	0.53	
Pre-arcing Joule Integral		A^2s		113	103	
Arcing time	t_{LB}	ms		64.5	291	
Arcing Joule Integral		A^2s		6.86	49.6	
Arcing time until breaking by the circuit breaker		ms		-	-	
Max. switching voltage	u_s	kV		36.3	36.5	
Power frequency recovery voltage	U_w	kV	24.3	24.1	24.0	
Maintaining voltage after breaking		s		>60	>60	
Test result:						
Fuse operated correct		y/n		yes	yes	
Switching voltage $u_s \leq$ permissive value		y/n		yes	yes	
Emission of flames or sand		y/n		no	no	
Damages (external)		y/n		no	no	
Operation of striker correct		y/n		yes	yes	

Test-no. 550: low resolution in measuring Uw

No. L 00038

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	24	2	67240.0020 HH-SI 10/24kV 2A FC TB 442/56

Test-no.	114-00/		339	340	341	342
Specimen		No.	Adjust-ment test	00574	00575	00576
Resistance		mΩ	-	812	808	804
Test-duty (according to IEC 282-1)			2	2	2	2
Power factor of the test circuit	cos φ		0.11	0.11	0.11	0.11
Prospective breaking current (RMS)		A	173	173	173	173
Making angle after voltage zero		° el	16.2	9	9	9
Pre-arcing / Melting time	t_m	ms		3.73	3.71	3.75
Melting current	i_m	A		169	170	168
Pre-arcing Joule Integral		A^2s		27.0	27.1	26.4
Cut-off / Let through current	i_d	A		277	276	277
Arcing time	t_{LB}	ms		8.23	7.99	8.05
Arcing Joule Integral		A^2s		336	312	316
Arcing time until breaking by the circuit breaker		ms		-	-	-
Max. switching voltage	u_s	kV	-	39.2	41.7	41.7
Power frequency recovery voltage	U_w	kV	20.94	20.96	20.96	20.96
Maintaining voltage after breaking		s	-	>60	>60	>60
Test result:						
Fuse operated correct		y/n		yes	yes	yes
Switching voltage $u_s \leq$ permissive value		y/n		yes	yes	yes
Current limiting:	($i_d \leq$ Let-through characteristic)	y/n		-	-	-
Requirement for I2:	i_m/I = 0.85...1.06	i_m/I		0.98	0.98	0.97
Emission of flames or sand		y/n		no	no	no
Damages (external)		y/n		no	no	no
Operation of striker correct		y/n		yes	yes	yes

No. L 00038

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	24	2	67240.0020 HH-SI 10/24kV 2A FC TB 442/56

Test-no. 114-00/		553	556	558	
Specimen	No.	Adjust-ment test	00733	00735	
Resistance	mΩ	-	812	804	
Test-duty (according to IEC 282-1)		3			
Power factor of the test circuit cos φ		0.53			
Prospective breaking current (RMS)	A	15.1			
Maintained current with low voltage source at 15.2 A at 15.6 A	s		7.84	21.4	
Time of current-interruption while switching over from low voltage to high voltage circuit	ms		100	90	
Pre-arcing / Melting time t_m	s		7.84	21.4	
Pre-arcing Joule Integral	A^2s		1810	5210	
Arcing time t_{LB}	ms		399	360	
Arcing Joule Integral	A^2s		93.8	85.1	
Arcing time until breaking by the circuit breaker	ms		-	-	
Max. switching voltage u_s	kV		36.1	35.4	
Power frequency recovery voltage U_w	kV	23.8	24.7	24.7	
Maintaining voltage after breaking	s		>60	>60	
Test result:					
Fuse operated correct	y/n		yes	yes	
Switching voltage $u_s \leq$ permissive value	y/n		yes	yes	
Emission of flames or sand	y/n		no	no	
Damages (external)	y/n		no	no	
Operation of striker correct	y/n		yes	yes	

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	24	4	67240.0040 HH-SI 10/24kV 4A FC TB 442/56

Test-no.	114-00/		417	419	420	421
Specimen		No.	Adjust-ment test	00801	00802	00803
Resistance		mΩ	-	562	537	542
Test-duty (according to IEC 282-1)			2	2	2	2
Power factor of the test circuit	cos φ		0.101	0.101	0.101	0.101
Prospective breaking current (RMS)		A	246	247	246	245
Making angle after voltage zero		° el	8.1	10.6	10.6	10.6
Pre-arcing / Melting time	t_m	ms		3.54	3.49	3.48
Melting current	i_m	A		233	231	229
Pre-arcing Joule Integral		A^2s		48.1	46.5	45.6
Cut-off / Let through current	i_d	A		352	340	343
Arcing time	t_{LB}	ms		7.89	7.40	7.65
Arcing Joule Integral		A^2s		494	405	450
Arcing time until breaking by the circuit breaker		ms		-	-	-
Max. switching voltage	u_s	kV	-	45.5	57.0	54.5
Power frequency recovery voltage	U_w	kV	21.00	21.10	20.96	20.94
Maintaining voltage after breaking		s	-	>60	>60	>60
Test result:						
Fuse operated correct		y/n		yes	yes	yes
Switching voltage $u_s \leq$ permissive value		y/n		yes	yes	yes
Current limiting:	($i_d \leq$ Let-through characteristic)	y/n		-	-	-
Requirement for I2:	i_m/I = 0.85...1.06	i_m/I		0.93	0.94	0.93
Emission of flames or sand		y/n		no	no	no
Damages (external)		y/n		no	no	no
Operation of striker correct		y/n		yes	yes	yes

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	24	4	67240.0040 HH-SI 10/24kV 4A FC TB 442/56

Test-no. 114-00/		No.	707	708	709	
Specimen			Adjust-ment test	001066	001067	
Resistance		mΩ	-	544	547	
Test-duty (according to IEC 282-1)			3			
Power factor of the test circuit	cos φ		0.50			
Prospective breaking current (RMS)		A	23.2			
Maintained current with low voltage source	at 23.2 A at 23.4 A	s		0.454	0.644	
Time of current-interruption while switching over from low voltage to high voltage circuit		ms		98	97	
Pre-arcing / Melting time	t_m	ms		454	644	
Pre-arcing Joule Integral		A^2s		241	350	
Arcing time	t_{LB}	ms		121	141	
Arcing Joule Integral		A^2s		65.8	76.2	
Arcing time until breaking by the circuit breaker		ms		-	-	
Max. switching voltage	u_s	kV		35.3	35.5	
Power frequency recovery voltage	U_w	kV	24.3	24.3	24.4	
Maintaining voltage after breaking		s		>60	>60	
Test result:						
Fuse operated correct		y/n		yes	yes	
Switching voltage $u_s \leq$ permissive value		y/n		yes	yes	
Emission of flames or sand		y/n		no	no	
Damages (external)		y/n		no	no	
Operation of striker correct		y/n		yes	yes	

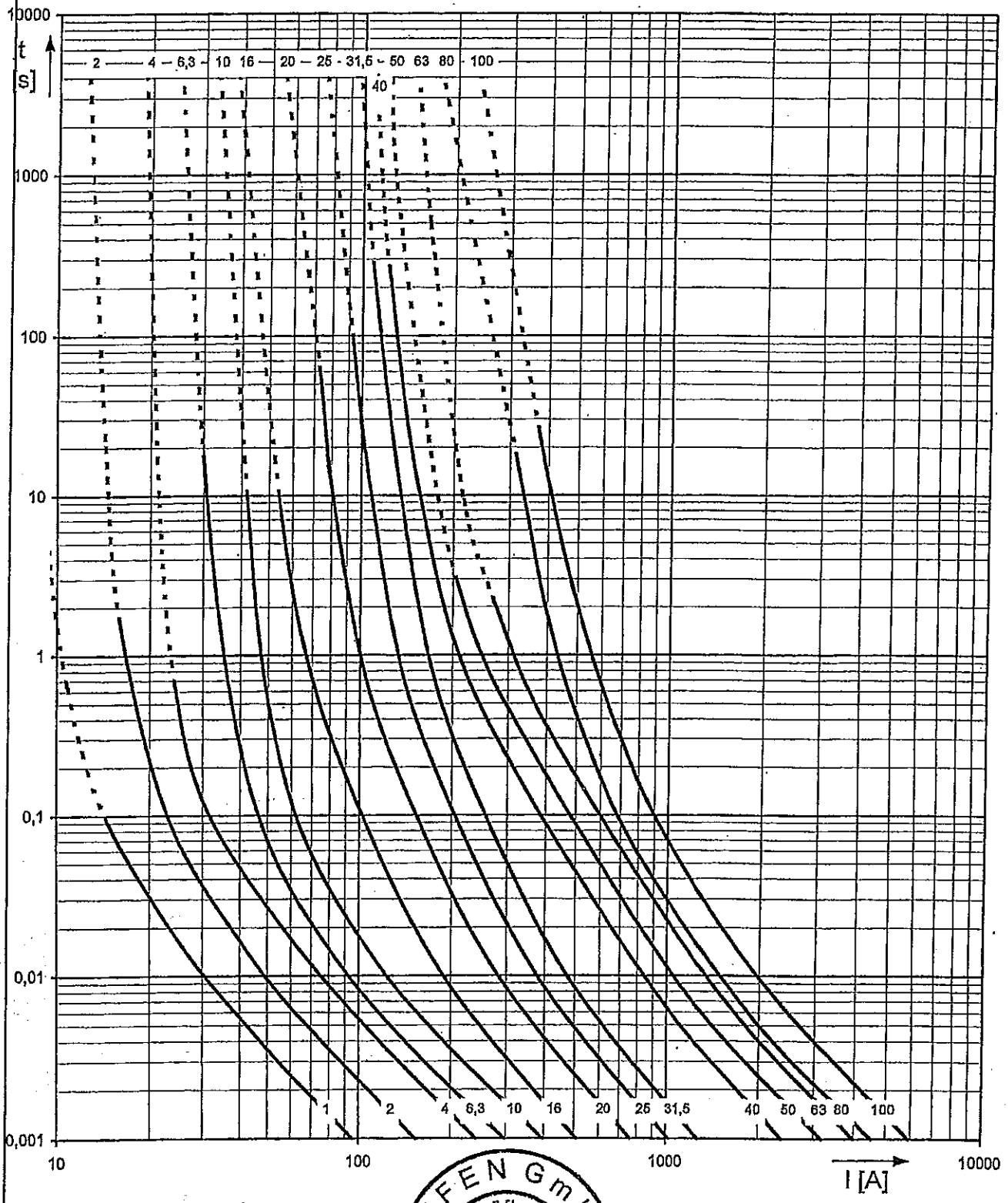
EFEN WICKMANN GRUPPE

Time-current characteristics of H.V. back-up fuse-links with ÜLA (controlled power dissipation)

Lab.-No. 01169

10/24 kV 1 A - 100 A acc. to IEC 60282-1 / VDE 0670 Teil 4

Order-No.: 67240.0019 - 67240.1009



EFEN GmbH Prüflabor Test Laboratory Eltville

06.06.2001 / 23

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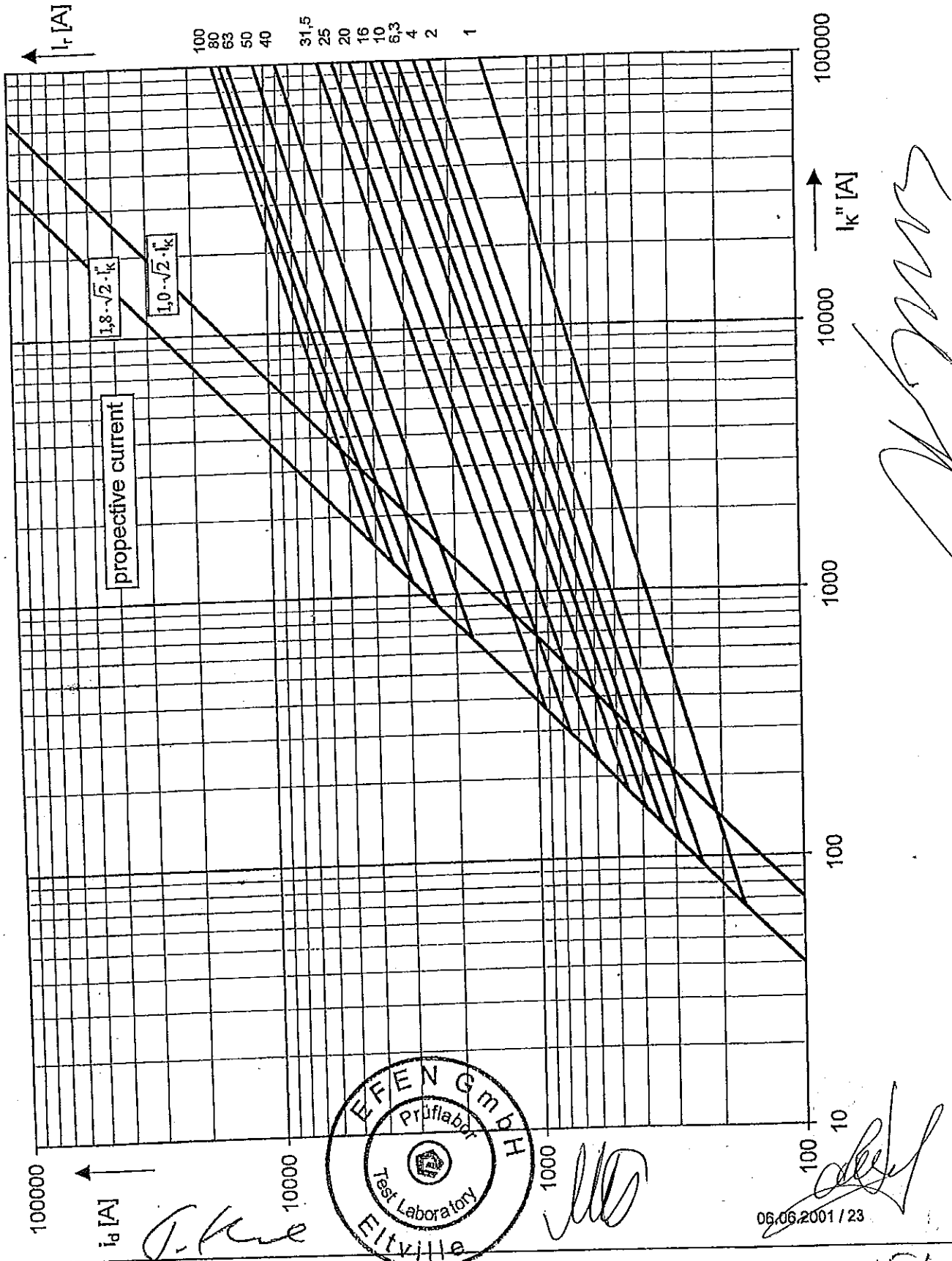
EFEN WICKMANN GRUPPE

Cut-off characteristics of H.V. back-up fuse-links with ÜLA (controlled power dissipation)

Lab.-No. 01171 10/24 kV 1 A - 100 A acc. to IEC 60282-1 / VDE 0670 Teil 4

Order-No.: 67240.0019 to 67240.1009



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1. Type HH – fuse link with striker 81902.0100(3) (duration 30mm)

2. Reason for test

Test of Strikers

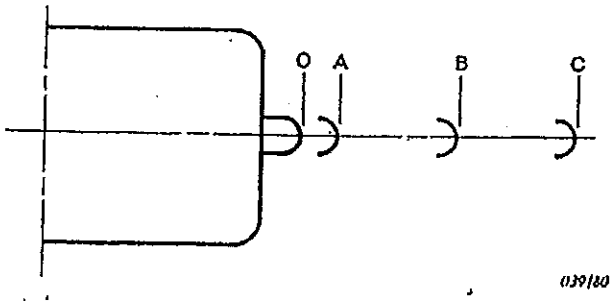
3. Tests performed / measurements

I. measurement of the duration of travel
II. measurement of the force-travel characteristics and calculation of the striker energy actuated by the spring
III. Verification of the withstand force according to applied standard (4)

4. Applied standards

IEC 60282-1 2002-01 VDE 0670 Teil 4 Abs. 12 02/98

4.1 standard in detail regarding strikers



OA – Free travel – No energy output specified.
AB – Further travel during which energy must be delivered.
OB – Minimum actual travel.
OC – Maximum actual travel.
CB – Maximum permitted return travel under withstand force (when applicable).

Type	Energy	Mechanical characteristics					
		Values of		Actual travel		Minimum withstand force	Maximum duration of travel (see note)
		Free travel (OA)*	Further travel during which energy must be delivered (AB)*	Min. (OB)*	Max. (OC)*		
	J	mm	mm	mm	mm	N	ms
Light	0,3 ± 0,25	2	8	10	30	Not applicable	100
Medium	1 ± 0,5	4	16	20	40	20	100
Heavy	2 ± 1	4	6	10	16	40	100

* See figure 12.

NOTE – Duration of travel is defined for actual fuse-links as the time from commencement of arcing to the time when travel OB is reached. For dummy fuses it is the time from application of voltage until travel OB is reached.

5. Test-laboratory, period of time

EFEN laboratory Eltville, 4.12.2003

6. Arrangement of the equipment

I. The tested fuse link is fixed in a fuse-base. An NC (normally closed) switch will be opened if the striker has travelled 30mm. Current, Voltage and the NC switch are recorded by an digital oscilloscope.

II. & III. The force-travel characteristics will be measured by an approved force meter*. For this measurement the striker will be prepared with an scale indicator for measuring the travelled way in mm.

*Zwick Z2.5 / TN1S Material testing device

7. Inspection and test sequence

I. Intact striker circuit is tested with current < 10A and voltage < 15V.
II. Current, voltage and the NC switch are recorded.
III. Force of striker is measured at Positions: 0, 10, und 20mm.
The Position of the Striker is measured at the minimum withstand force of 20N.

8. Results

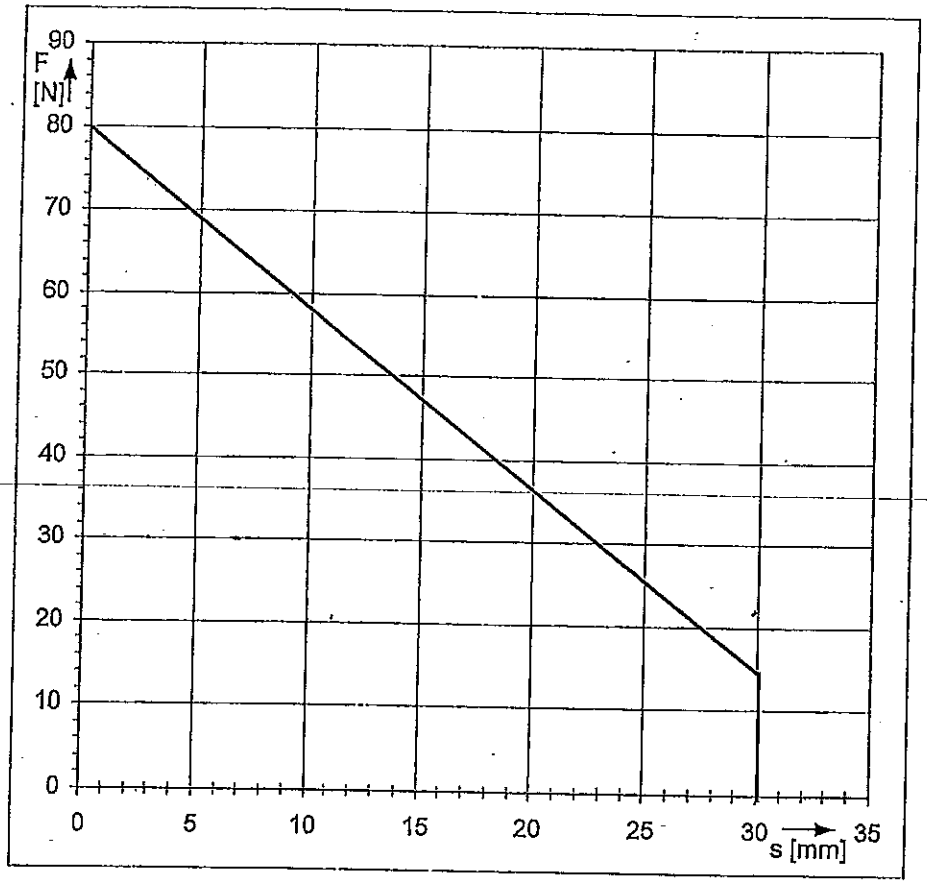
I. measurement of the duration of travel

	duration of travel	Current	Voltage
Sample 1	5 ms	9,9 A	< 15 V
Sample 2	2 ms	11,7 A	< 15 V
Sample 3	4 ms	10 A	< 15 V
Sample 4	6 ms	9,9 A	< 15 V

II. measurement of the force-travel characteristics and calculation of the striker energy

		Sample 1		Sample 2		Sample 3		
Position	Length / mm	Measurem. 1	Measurem. 2	Measurem. 1	Measurem. 2	Measurem. 1	Measurem. 2	Average:
O	0	77	76,8	85,5	81,7	78	78	79,5
A	4	66,5	66,4	67,5	67,4	71,7	69,7	68,2
B	20	37,7	36,1	33,7	33,1	36,2	36,5	35,6
	Energy / J:	0,83	0,82	0,81	0,80	0,86	0,85	0,83

$$Energy = \frac{(F_A + F_B) \times \overline{AB}}{2000} \qquad Energy[J];\ F_A[N];\ F_B[N];\ \overline{AB}[mm];$$



III. Verification of the withstand force of 20N at Position ≥ 20mm

	Measurement	Force / N	Length / mm
Sample 1	1	20	27,4
Sample 1	2	20	27,7
Sample 2	1	20	27,3
Sample 2	2	20	26,9
Sample 3	1	20	28,4
Sample 3	2	20	28,4

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9. Evaluation

Type	Energy		Free travel	Further travel during which energy must be delivered	Actual travel			Minimum travel force	
	Actual value	Specified value	$\overline{OA}$	$\overline{AB}$	Actual value	Specified value Min. $\overline{OB}$	Specified value Max. $\overline{OC}$	Actual value	Specified value
	J		mm	mm	mm			N	
Medium	0,83	1±0,5	4	16	30	20	40	35,6	20

I. Measured duration of travel < maximum duration of travel (100ms)
II. striker energy is Medium 1J +-0,5 J
III. Verification of the withstand force proofed that the striker has the necessary force.

The striker full fills all Requirements of striker Type medium according to:
IEC 60282-1 2002-01; VDE 0670 Teil 4 Abs. 12 02/98

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2004-03-29

Test engineer

EFEN GmbH Prüflabor Test Laboratory Eltville

Head of Laboratory

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EFEN WICKMANN GRUPPE

Type Test Report

Lab.-No. 01164

1. Object

Current-limiting high-voltage fuse-links
Class: Back-up
Striker: "medium"
Type: HH-SI 10/24kV 6,3A / 10A FC TB ÜLA 442/56
Ident-No.: 67240.0069 / 67240.0109

Rated voltage	10/24 kV	
Rated current	6,3 A	10 A
Rated maximum breaking current	63 kA	
Rated frequency	50 Hz	
Rated minimum breaking current	30 A	43 A

2. Reason for test

Type test according to IEC 60282-1 (VDE 0670 Teil 4): 1998-02

3. Tests performed

3.1 Temperature-rise tests and power-dissipation measurement

Rated current		6,3 A	10 A
Test laboratory		EFEN Prüflabor Eltville	
Test result: $\Delta\vartheta_{max}$ [1]		8 K	13 K
Test result: P_a	at 50 % I_r	3,05 W	5,87 W
	at 100% I_r	13,1 W	26,2 W
EFEN Lab-No.		01144	01145
Test passed		Yes	Yes

[1] permissible temperature rise: 65 K

3.2 Breaking Test: Test Duty 1

Rated current	6,3 A	10 A
Test Laboratory / Document No	KEMA / 720-00	
Test circuit applied voltage: U	21 kV	
Test circuit prospective current I	63 kA	
EFEN Lab-No.	01072	
Test passed	Yes	Yes

3.3 Breaking Test: Test Duty 2

Rated current	6,3 A	10 A
Test Laboratory / Document No	FGH / L 00038 1E	
Test circuit applied voltage U	21,11 kV	20,96 kV
Test circuit prospective current I	319 A	424 A
EFEN Lab-No.	00183	
Test passed	Yes	Yes

3.4 Breaking Test: Test Duty 3

Rated current	6,3 A	10 A
Test Laboratory / Document No.	FGH / L 00038 1E	
Test circuit applied voltage: U	25,0 kV	24,9 kV
Test circuit prospective current I	29,3 A	42,1 A
EFEN Lab-No.	00183	
Test passed	Yes	Yes

3.5 Tests for time-current characteristics
Test Laboratory: EFEN Prüflabor Eltville
EFEN Lab-No: 01169
Test passed

3.6 Cut-off characteristics
EFEN Lab-No: 01171

3.7 Test of strikers
Test result: 0,83 J => Type medium
Test Laboratory: EFEN Prüflabor Eltville
EFEN Lab-No: 03088
Test passed

4. Test results

The products passed the type tests according to IEC 60 282-1 and VDE 0670 Teil 4 respectively at KEMA, FGH and EFEN test laboratories.

All requirements are fulfilled (see 3.).

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2004-11-18

EFEN GmbH Prüflabor Test Laboratory Eltville

Test Engineer

Head of laboratory

1. Type — HH-SI 10/24kV 6,3A FC TB ÜLA 442/56
Order-No.: 67240.0069

2. Reason for test

Temperature-rise tests and power-dissipation measurement

3. Tests performed / measurements

Measurement of temperatures, of voltage drop across fuse-link and power dissipation at different operating currents.

4. Applied standards

IEC 60282-1 1998-01 VDE 0670 Teil 4 Abs. 12 02/98

5. Test-laboratory, period of time

EFEN Prüflabor Eltville, 09/04/2000 – 09/08/2000

6. Arrangement of the equipment

The high-voltage fuse-link is mounted vertically in a fuse-base, with the striker-pin at the top.
The size of bare copper conductors is 25 mm².
Temperatures are measured at the fuse contacts (top and bottom), in the middle of the fuse with thermocouples and are recorded.
The test currents are recorded.

7. Inspection and test sequence

The fuse-link was loaded with test currents I = 3,15 A and I = 6,3 A

Test current I [A]	Comments
3,15	50% rated current
6,3	Rated current

Temperatures are measured at the fuse contacts and in the middle of the tube with thermocouples.
Calculation of power dissipation from recorded voltage drop and recorded test current.
Calculation of resistance depending on the currents.

8. Results

Type: HH-SI 10/24kV 6,3A FC TB ÜLA 442/56
R_{cold}: 299 mΩ

8.1 Temperature rise test

		Temperature			Temperature rise			Informative	
I [A]	$\vartheta_{amb.}$ [°C]	ϑ_{top} [°C]	ϑ_{bottom}	$\vartheta_{perm.}$ [°C]	$\Delta\vartheta_{top}$ [K]	$\Delta\vartheta_{bottom}$ [K]	$\Delta\vartheta_{perm.}$ [K]	ϑ_{center} [°C]	ϑ_{center} [K]
3,15	21	23	22	105	2	1	65	26	5
6,3	21	29	25	105	8	4	65	41	20

8.2 Power dissipation and resistance of the test object at defined currents.

I [A]	P_d [W]	$U_{fuse-link}$ [V]	R [mΩ]
3,15	3,05	0,97	307
6,3	13,1	2,09	330

9. Evaluation

The product passed the temperature-rise test acc. to IEC 60 282-1 and VDE 0670 Teil 4 respectively.

372 / 23
07/06/2001

EFEN GmbH Prüflabor Test Laboratory Eltville

Test engineer

Head of laboratory

1. Type — HH-SI 10/24kV 10A FC TB ÜLA 442/56
Order-No.: 67240.0109

2. Reason for test

Temperature-rise tests and power-dissipation measurement

3. Tests performed / measurements

Measurement of temperatures, of voltage drop across fuse-link and power dissipation at different operating currents.

4. Applied standards

IEC 60282-1 1998-01 VDE 0670 Teil 4 Abs. 12 02/98

5. Test-laboratory, period of time

EFEN Prüflabor Eltville, 09/04/2000 – 09/08/2000

6. Arrangement of the equipment

The high-voltage fuse-link is mounted vertically in a fuse-base, with the striker-pin at the top.
The size of bare copper conductors is 25 mm².
Temperatures are measured at the fuse contacts (top and bottom), in the middle of the fuse with thermocouples and are recorded.
The test currents are recorded.

7. Inspection and test sequence

The fuse-link was loaded with test currents I = 5,0 A and I = 10 A

Test current I [A]	Comments
5	50% rated current
10	Rated current

Temperatures are measured at the fuse contacts and in the middle of the tube with thermocouples.
Calculation of power dissipation from recorded voltage drop and recorded test current.
Calculation of resistance depending on the currents.

8. Results

Type: HH-SI 10/24kV 10A FC TB ÜLA 442/56
R_{cold}: 219 mΩ

8.1 Temperature rise test

		Temperature			Temperature rise			Informative	
I [A]	$\vartheta_{amb.}$ [°C]	ϑ_{top} [°C]	ϑ_{bottom}	$\vartheta_{perm.}$ [°C]	$\Delta\vartheta_{top}$ [K]	$\Delta\vartheta_{bottom}$ [K]	$\Delta\vartheta_{perm.}$ [K]	ϑ_{center} [°C]	ϑ_{center} [K]
5	21	24	23	105	3	2	65	30	9
10	21	34	28	105	13	7	65	55	34

8.2 Power dissipation and resistance of the test object at defined currents.

I [A]	P_d [W]	$U_{fuse-link}$ [V]	R [mΩ]
5	5,87	1,17	235
10	26,2	2,61	262

9. Evaluation

The product passed the temperature-rise test acc. to IEC 60 282-1 and VDE 0670 Teil 4 respectively.

372 / 23
07/06/2001

EFEN GmbH Prüflabor Test Laboratory Eltville

Test engineer

Head of laboratory

KEMA

HIGH–POWER LABORATORY
Utrechtseweg 310 – 6812 AR Arnhem – The Netherlands

720–00

REPORT OF PERFORMANCE

CLIENT	EFEN Elektrotechnische Fabrik GmbH, Eltville am Rhein, Germany
MANUFACTURER	EFEN Elektrotechnische Fabrik GmbH, Eltville am Rhein, Germany
APPARATUS	Current limiting fuses
DESIGNATION	HH–SI 10/24kV FC TB 442/56 1 – 2 – 4 – 6.3 – 10 – 16 – 20 – 25 – 31.5 – 40 – 50 – 63 A – 80 A
SERIAL No.	67240.0010, 67240.0020, 67240.0040, 67240.0060, 67240.0100, 67240.0160, 67240.0200, 67240.0250, 67240.0320, 67240.0400, 67240.0500, 67240.0630 and 67240.0800.

RATINGS ASSIGNED BY THE MANUFACTURER

Voltage	24	kV
Current	1 – 2 – 4 – 6.3 – 10 – 16 – 20 – 25 – 31.5 – 40 – 50 – 63 – 80	A (1)
Frequency	50	Hz
Breaking capacity at 24 kV	63	kA
Series	1	
Class	Back–up	

(1) The fuse–links 20 – 25 – 31.5 A and 40 – 50 – 63 A form a homgeneous series in accordance with Sub–clause 13.3.1 of IEC 60282–1.

The tests have been carried out strictly in accordance with IEC 60282–1, Sub–clause 13 (Test–duty 1).
The apparatus has complied with the relevant requirements.

Date of tests 22nd November 2000 and 13th March 2001

The performance of the apparatus tested and the observations made during the tests have been recorded in the tables with test results and the oscillograms

THIS REPORT CONSISTS OF:

Pages	15
Circuit diagrams	1
Oscillograms	36
Drawings	19
Photographs	5
Information sheet	B70E

KEMA Nederland B.V.

A.L.J. Janssen
Manager High–Power Laboratory

Arnhem, 27th February 2001

TABLE WITH TEST RESULTS

REPORT 720–00	TYPE OF TESTS REQUESTED: Test–duty 1	TEST CIRCUIT S02	PAGE 8

Condition before tests: Fuse–base in same condition.
Before each test new fuse–link.
Fuse–link mounted vertically in free air.
Distance fuse–link to floor 1.5 m.

Date and test	Fuse–link Type	Fuse–link Rated voltage kV / Rated current A	Resistance before test m Ω / after test MΩ	Test circuit Applied voltage kV	Test circuit Prospective current kA	Commencing of arcing after voltage zero °	Instantaneous current at initiation of arcing peak kA	Cut–off current peak kA	Pre–arcing time ms	Arcing time ms	Total operating time ms	Recovery voltage (1) kV	Switching voltage peak kV	Melt $\int I^2t$ $A^2s \times 10^6$	Total $\int I^2t$ $A^2s \times 10^6$	Energy $\int UIt$ kJ	Condition after test: Fuse–link / Striker; Behaviour during test; Remarks
001122 4044	HH–SI 10/24 FC TB 442/56 67240.0060 001645	24.0 / 6.3	290 / > 300	21.0	63.0	47	1.65	1.99	0.08	5.18	5.26	21.0	31.2	267	487	20.5	cold / operated; Fuse cleared.
001122 4045	HH–SI 10/24 FC TB 442/56 67240.0060 001646	24.0 / 6.3	290 / > 300	21.0	63.0	79	2.24	2.55	0.07	2.81	2.88	21.0	41.4	238	683	16.9	cold / operated; Fuse cleared.
001122 4046	HH–SI 10/24 FC TB 442/56 67240.0060 001647	24.0 / 6.3	290 / > 300	21.0	63.0	80	2.08	2.29	0.07	2.89	2.96	21.0	41.4	114	701	18.3	cold / operated; Fuse cleared.

Remarks: Fuse–base showed no visible change.

(1) Maintained for 15 s.

KEMA

TABLE WITH TEST RESULTS

REPORT 720–00	TYPE OF TESTS REQUESTED: Test–duty 1	TEST CIRCUIT S02	PAGE 9

Condition before tests: Fuse–base in same condition.
Before each test new fuse–link.
Fuse–link mounted vertically in free air.
Distance fuse–link to floor 1.5 m.

Date and test	Fuse–link Type	Fuse–link Rated voltage kV / Rated current A	Resistance before test mΩ / after test MΩ	Test circuit Applied voltage kV	Test circuit Prospective current kA	Commencing of arcing after voltage zero °	Instantaneous current at initiation of arcing peak kA	Cut–off current peak kA	Pre–arcing time ms	Arcing time ms	Total operating time ms	Recovery voltage (1) kV	Switching voltage peak kV	Melt ∫I2t A2s x 10^6	Total ∫I2t A2s x 10^6	Energy ∫UIt kJ	Condition after test: Fuse–link / Striker; Behaviour during test, Remarks
001122 4047	HH–SI 10/24 FC TB 442/56 67240.0100 001652	24.0 / 10	220 / > 300	21.0	63.0	47	2.24	2.36	0.10	5.22	5.32	21.0	32.4	173	715	24.3	cold / operated; Fuse cleared.
001122 4048	HH–SI 10/24 FC TB 442/56 67240.0100 001653	24.0 / 10	220 / > 300	21.0	63.0	77	2.57	2.90	0.08	3.14	3.22	21.0	42.4	251	959	22.5	cold / operated; Fuse cleared.
001122 4049	HH–SI 10/24 FC TB 442/56 67240.0100 001654	24.0 / 10	220 / > 300	21.0	63.0	80	2.52	2.88	0.08	2.78	2.86	21.0	42.2	175	942	21.7	cold / operated; Fuse cleared.

Remarks: Fuse–base showed no visible change.
Photograph 0401307.

(1) Maintained for 15 s.

KEMA

FGH
Engineering & Test GmbH
Mannheim-Rheinau, Hallenweg 40

Test Report
No. L 00038

Accredited testing laboratory to DIN EN 45001 for subject
Deutscher Akkreditierungs Rat DAT-P-103/00-00 High-voltage apparatus switchgear and controlgear
DAT-P-103/00-10 High-voltage cables and accessories

Duly signed copy 1E

Reference: 114-00/332...342, 370...373, 418...425, 549...569, 707...709

Apparatus: **Current-limiting fuse-link**

Types:
a) HH-SI 10/24kV 1A FC TB 442/56, Ident-No.: 67240.0010
b) HH-SI 10/24kV 2A FC TB 442/56, Ident-No.: 67240.0020
c) HH-SI 10/24kV 4A FC TB 442/56, Ident-No.: 67240.0040
d) HH-SI 10/24kV 6,3A FC TB 442/56, Ident-No.: 67240.0060
e) HH-SI 10/24kV 10A FC TB 442/56, Ident-No.: 67240.0100

Rated voltage: 24 kV
Rated current: a) 1 A, b) 2 A, c) 4 A, d) 6.3 A, e) 10 A
Class: Back-up

Manufacturer: EFEN Elektrotechnische Fabrik GmbH,
Postfach 12 54, D-65344 Eltville, Germany

Customer: EFEN Elektrotechnische Fabrik GmbH,
Postfach 12 54, D-65344 Eltville, Germany

Test Specification: IEC 60282-1 (1998-01), Ed.4.2

Tests performed: Breaking tests:

Test duty 2:
Verification of the operation with prospective current I2 at which current limiting occurs when a high level of energy is stored in the inductance of the circuit.

Test duty 3:
Verification of the operation at the rated minimum breaking current.

Test Results: During the breaking tests performed, the tested fuse-links fully complied with the standard conditions of behaviour with respect to breaking capacity.

Mannheim, September 6, 2000
Wa

FGH Engineering & Test GmbH

FGH Engineering & Test GmbH

Test Engineer:
(Heil)

Place and date of test: LPF Mannheim-Rheinau, May 29-30, and July 1-20, and August 23, 2000

Number of sheets: 50

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	24	6.3	67240.0060 HH-SI 10/24 kV 6,3A FC TB 442/56

Test-no. 114-00/			559	562	564	
Specimen		No.	Adjust-ment test	00758	00760	
Resistance		mΩ	-	303	300	
Test-duty (according to IEC 282-1)			3			
Power factor of the test circuit	cos φ		0.53			
Prospective breaking current (RMS)		A	29.3			
Maintained current with low voltage source	at 29.3..29.7 A at A	s		70	115	
Time of current-interruption while switching over from low voltage to high voltage circuit		ms		90	90	
Pre-arcing / Melting time	t_m	s		70	115	
Pre-arcing Joule Integral		A^2s		-	-	
Arcing time	t_{LB}	ms		98.1	141	
Arcing Joule Integral		A^2s		83.3	121	
Arcing time until breaking by the circuit breaker		ms		-	-	
Max. switching voltage	u_s	kV		36.0	36.7	
Power frequency recovery voltage	U_w	kV	24.7	25.0	25.1	
Maintaining voltage after breaking		s		>60	>60	
Test result:						
Fuse operated correct		y/n		yes	yes	
Switching voltage $u_s \leq$ permissive value		y/n		yes	yes	
Emission of flames or sand		y/n		no	no	
Damages (external)		y/n		no	no	
Operation of striker correct		y/n		yes	yes	

FGH Engineering & Test GmbH

No. L 00038

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	24	10	67240.0100 HH-SI 10/24kV 10A FC TB 442/56

Test-no.	114-00/		370	371	372	373
Specimen		No.	Adjust-ment test	00624	00625	00626
Resistance		mΩ	-	221	219	220
Test-duty (according to IEC 282-1)			2	2	2	2
Power factor of the test circuit	cos φ		0.086	0.086	0.086	0.086
Prospective breaking current (RMS)		A	426	424	424	424
Making angle after voltage zero		° el	8	9	8	8
Pre-arcing / Melting time	t_m	ms		3.49	3.51	3.48
Melting current	i_m	A		419	418	418
Pre-arcing Joule Integral		A^2s		159	157	158
Cut-off / Let through current	i_d	A		481	487	483
Arcing time	t_{LB}	ms		6.70	6.97	6.88
Arcing Joule Integral		A^2s		782	877	837
Arcing time until breaking by the circuit breaker		ms		-	-	-
Max. switching voltage	u_s	kV	-	39.6	37.0	38.2
Power frequency recovery voltage	U_w	kV	21.05	20.96	20.93	20.93
Maintaining voltage after breaking		s	-	>60	>60	>60
Test result:						
Fuse operated correct		y/n		yes	yes	yes
Switching voltage $u_s \leq$ permissive value		y/n		yes	yes	yes
Current limiting:	($I_d \leq$ Let-through characteristic)	y/n		-	-	-
Requirement for I2:	i_m/I = 0.85...1.06	i_m/I		0.99	0.99	0.99
Emission of flames or sand		y/n		no	no	no
Damages (external)		y/n		no	no	no
Operation of striker correct		y/n		yes	yes	yes

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	24	10	67240.0100 HH-SI 10/24kV 10A FC TB 442/56

Test-no. 114-00/		567	568	569	
Specimen	No.	Adjust-ment test	00627	00628	
Resistance	mΩ	-	220	218	
Test-duty (according to IEC 282-1)		3			
Power factor of the test circuit cos φ		0.53			
Prospective breaking current (RMS)	A	42.1			
Maintained current with low voltage source at 42 A / at A	s		2.66	1.48	
Time of current-interruption while switching over from low voltage to high voltage circuit	ms		90	90	
Pre-arcing / Melting time t_m	s		2.66	1.48	
Pre-arcing Joule Integral	A^2s		4960	2590	
Arcing time t_{LB}	ms		74.6	81.1	
Arcing Joule Integral	A^2s		128	121	
Arcing time until breaking by the circuit breaker	ms		-	-	
Max. switching voltage u_s	kV		50.5	37.4	
Power frequency recovery voltage U_w	kV	24.9	24.9	24.9	
Maintaining voltage after breaking	s		>60	>60	
Test result:					
Fuse operated correct	y/n		yes	yes	
Switching voltage $u_s \leq$ permissive value	y/n		yes	yes	
Emission of flames or sand	y/n		no	no	
Damages (external)	y/n		no	no	
Operation of striker correct	y/n		yes	yes	

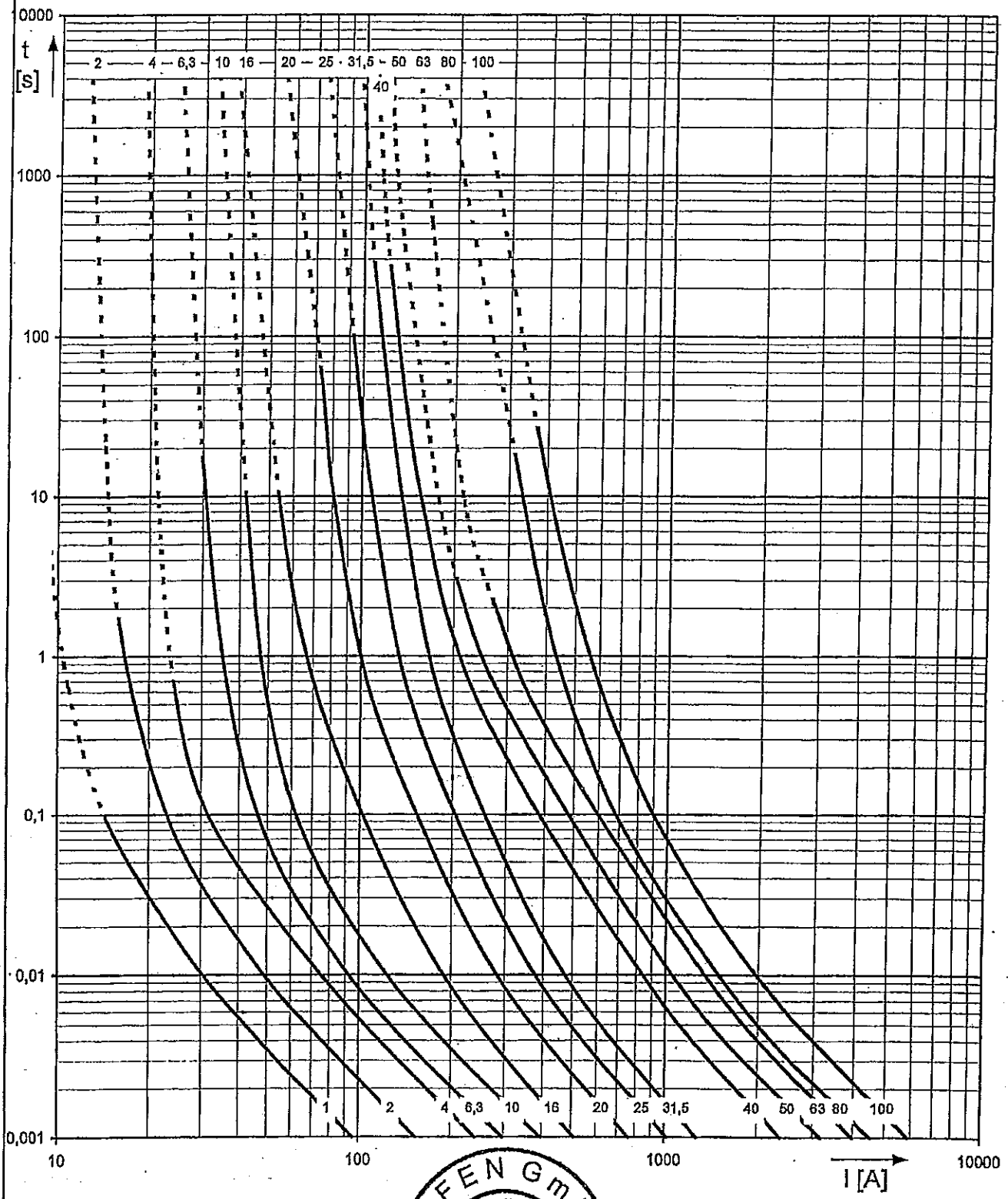
EFEN WICKMANN GRUPPE

Time-current characteristics of H.V. back-up fuse-links with ÜLA (controlled power dissipation)

Lab.-No. 01169

10/24 kV 1 A - 100 A acc. to IEC 60282-1 / VDE 0670 Teil 4

Order-No.: 67240.0019 - 67240.1009



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06.06.2001 / 23

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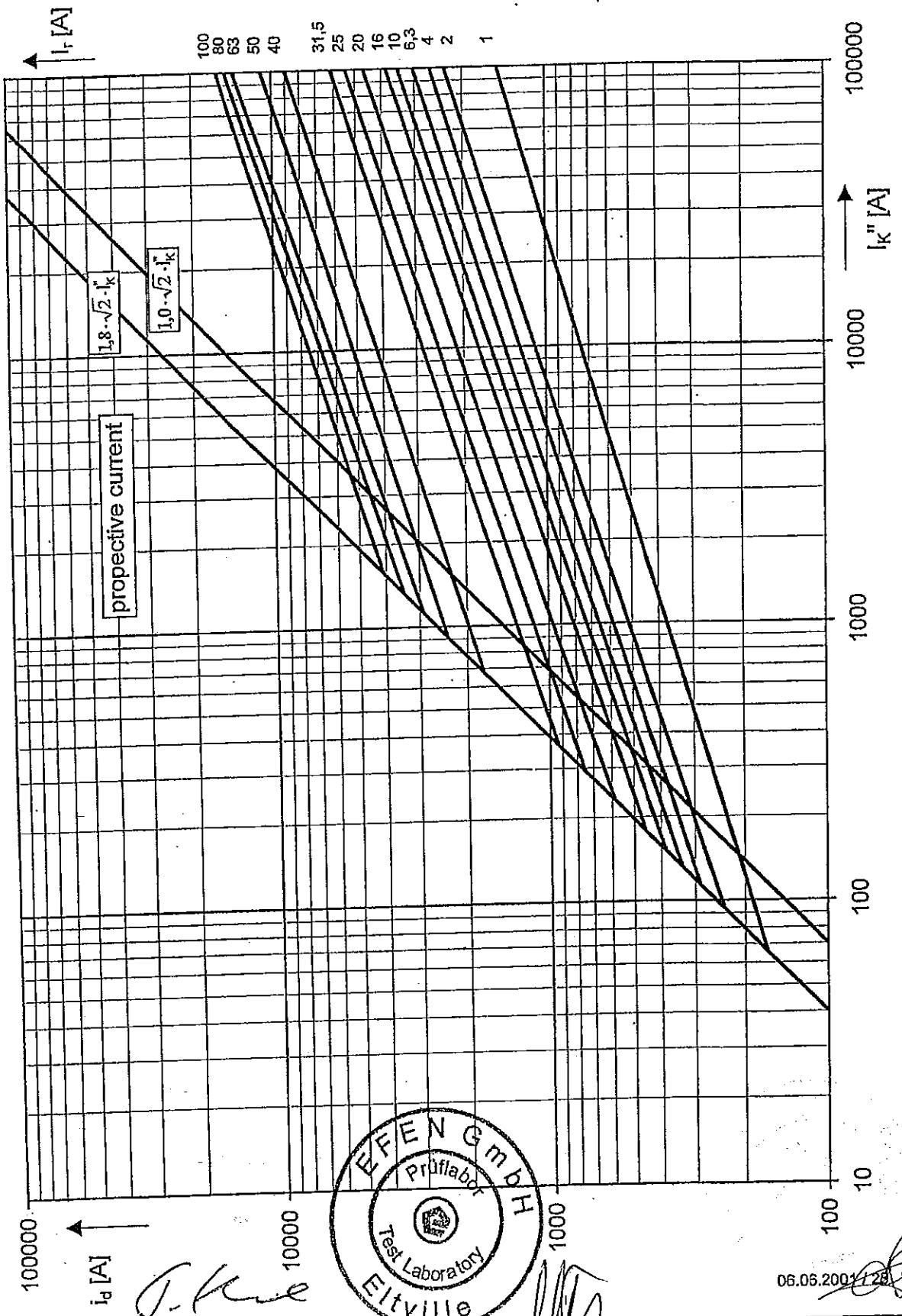
EFEN
WICKMANN GRUPPE

Cut-off characteristics of H.V. back-up fuse-links with ÜLA (controlled power dissipation)

Lab.-No. 01171 10/24 kV 1 A - 100 A acc. to IEC 60282-1 / VDE 0670 Teil 4

Order-No.: 67240.0019 to 67240.1009



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1. Type HH – fuse link with striker 81902.0100(3) (duration 30mm)

2. Reason for test

Test of Strikers

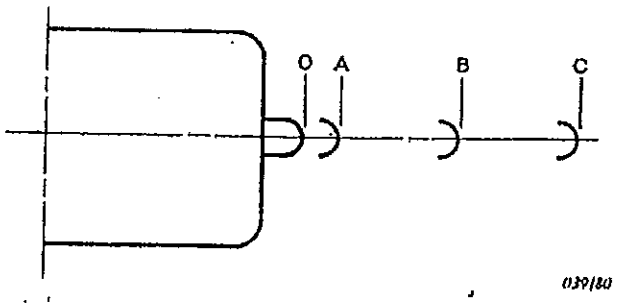
3. Tests performed / measurements

I. measurement of the duration of travel
II. measurement of the force-travel characteristics and calculation of the striker energy actuated by the spring
III. Verification of the withstand force according to applied standard (4)

4. Applied standards

IEC 60282-1 2002-01 VDE 0670 Teil 4 Abs. 12 02/98

4.1 standard in detail regarding strikers



OA – Free travel – No energy output specified.
AB – Further travel during which energy must be delivered.
OB – Minimum actual travel.
OC – Maximum actual travel.
CB – Maximum permitted return travel under withstand force (when applicable).

Type	Energy	Mechanical characteristics					
		Values of		Actual travel		Minimum withstand force	Maximum duration of travel (see note)
		Free travel (OA)*	Further travel during which energy must be delivered (AB)*	Min. (OB)*	Max. (OC)*		
	J	mm	mm	mm	mm	N	ms
Light	0,3 ± 0,25	2	8	10	30	Not applicable	100
Medium	1 ± 0,5	4	16	20	40	20	100
Heavy	2 ± 1	4	6	10	16	40	100

* See figure 12.

NOTE – Duration of travel is defined for actual fuse-links as the time from commencement of arcing to the time when travel OB is reached. For dummy fuses it is the time from application of voltage until travel OB is reached.

5. Test-laboratory, period of time

EFEN laboratory Eltville, 4.12.2003

6. Arrangement of the equipment

I. The tested fuse link is fixed in a fuse-base. An NC (normally closed) switch will be opened if the striker has travelled 30mm. Current, Voltage and the NC switch are recorded by an digital oscilloscope.

II. & III. The force-travel characteristics will be measured by an approved force meter*. For this measurement the striker will be prepared with an scale indicator for measuring the travelled way in mm.

*Zwick Z2.5 / TN1S Material testing device

7. Inspection and test sequence

I. Intact striker circuit is tested with current < 10A and voltage < 15V.
II. Current, voltage and the NC switch are recorded.
III. Force of striker is measured at Positions: 0, 10, und 20mm.
The Position of the Striker is measured at the minimum withstand force of 20N.

8. Results

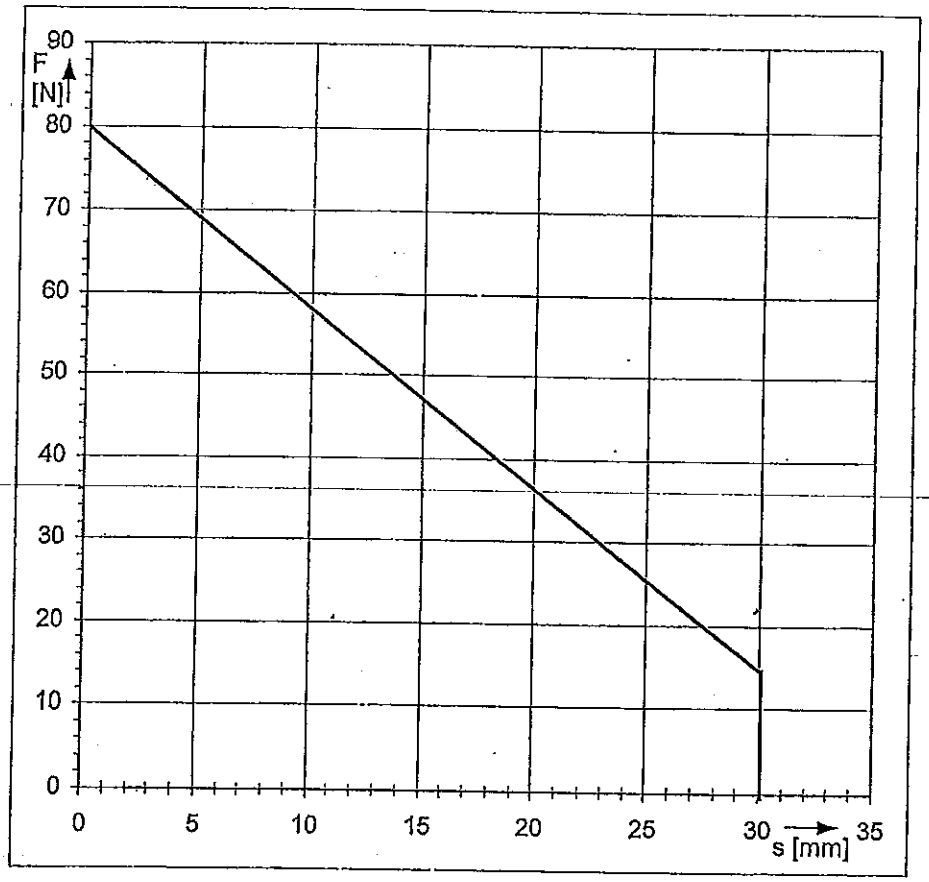
I. measurement of the duration of travel

	duration of travel	Current	Voltage
Sample 1	5 ms	9,9 A	< 15 V
Sample 2	2 ms	11,7 A	< 15 V
Sample 3	4 ms	10 A	< 15 V
Sample 4	6 ms	9,9 A	< 15 V

II. measurement of the force-travel characteristics and calculation of the striker energy

		Sample 1		Sample 2		Sample 3		
Position	Length / mm	Measurem. 1	Measurem. 2	Measurem. 1	Measurem. 2	Measurem. 1	Measurem. 2	Average:
O	0	77	76,8	85,5	81,7	78	78	79,5
A	4	66,5	66,4	67,5	67,4	71,7	69,7	68,2
B	20	37,7	36,1	33,7	33,1	36,2	36,5	35,6
	Energy / J:	0,83	0,82	0,81	0,80	0,86	0,85	0,83

$$Energy = \frac{(F_A + F_B) \times \overline{AB}}{2000} \qquad Energy[J];\ F_A[N];\ F_B[N];\ \overline{AB}[mm];$$



III. Verification of the withstand force of 20N at Position ≥ 20mm

	Measurement	Force / N	Length / mm
Sample 1	1	20	27,4
Sample 1	2	20	27,7
Sample 2	1	20	27,3
Sample 2	2	20	26,9
Sample 3	1	20	28,4
Sample 3	2	20	28,4

9. Evaluation

Type	Energy		Free travel	Further travel during which energy must be delivered	Actual travel			Minimum travel force	
	Actual value	Specified value	$\overline{OA}$	$\overline{AB}$	Actual value	Specified value Min. $\overline{OB}$	Specified value Max. $\overline{OC}$	Actual value	Specified value
	J		mm	mm	mm			N	
Medium	0,83	1±0,5	4	16	30	20	40	35,6	≥20

I. Measured duration of travel < maximum duration of travel (100ms)
II. striker energy is Medium 1J +-0,5 J
III. Verification of the withstand force proofed that the striker has the necessary force.

The striker full fills all Requirements of striker Type medium according to:
IEC 60282-1 2002-01; VDE 0670 Teil 4 Abs. 12 02/98

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2004-03-29

Test engineer

EFEN GmbH Prüflabor Test Laboratory Eltville

Head of Laboratory

EFEN WICKMANN GRUPPE

Type Test Report

Lab.-No. 01165

1. Object

Current-limiting high-voltage fuse-links
Class: Back-up
Striker: "medium"
Type: HH-SI 10/24kV 16A / 20A / 25 A / 31,5 A FC TB ÜLA 442/56
Ident-No.: 67240.0169 / 67240.0209 / 67240.0259 / 67240.0329

Rated voltage	10/24 kV			
Rated current	16 A	20 A	25 A	31,5A
Rated maximum breaking current	63 kA			
Rated frequency	50 Hz			
Rated minimum breaking current	54 A	73 A	93 A	105 A

2. Reason for test

Type test according to IEC 60282-1 (VDE 0670 Teil 4): 1998-02

3. Tests performed

3.1 Temperature-rise tests and power-dissipation measurement

Rated current		16 A	20 A	25 A	31,5A
Test laboratory		EFEN Prüflabor Eltville			
Test result: $\Delta\vartheta_{max}$ [1]		32 K	32 K	37 K	48 K
Test result: P_a	at 50% I_r	16,8 W	14,6 W	14,2 W	23,6 W
	at 100% I_r	72,5 W	76,3 W	89,2 W	127 W
EFEN Lab-No.		01146	01147	01148	01149
Test passed		Yes	Yes	Yes	Yes

[1] permissible temperature rise: 65 K

3.2 Breaking Test: Test Duty 1

Rated current	16 A	20 A	25 A	31,5A
Test Laboratory/ Document No	KEMA / 720-00			
Test circuit applied voltage: U	21 kV			
Test circuit prospective current I	63 kA			
EFEN Lab-No.	01072			
Test passed	Yes	Yes	Hom.	Yes

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3.3 Breaking Test: Test Duty 2

Rated current	16 A	20 A	25 A	31,5A
Test Laboratory / Document No	FGH / L 00039 1E			
Test circuit applied voltage U	20,92 kV	21,11 kV		21,04 kV
Test circuit prospective current I	520 A	776 A		1,37 kA
EFEN Lab-No.	00184			
Test passed	Yes	Yes	Hom.	Yes

3.4 Breaking Test: Test Duty 3

Rated current	16 A	20 A	25 A	31,5A
Test Laboratory / Document No.	FGH / L 00039 1E			
Test circuit applied voltage: U	24,0 kV	24,2 kV	24,5 kV	24,5 kV
Test circuit prospective current I	53,6 A	72,9 A	92,3 A	105 A
EFEN Lab-No.	00184			
Test passed	Yes	Yes	Yes	Yes

3.5 Tests for time-current characteristics
Test Laboratory: EFEN Prüflabor Eltville
EFEN Lab-No: 01169
Test passed

3.6 Cut-off characteristics
EFEN Lab-No: 01171

3.7 Test of strikers
Test result: 0,83 J => Type medium
Test Laboratory: EFEN Prüflabor Eltville
EFEN Lab-No: 03088
Test passed

4. Test results

The products passed the type tests according to IEC 60 282-1 and VDE 0670 Teil 4 respectively at KEMA, FGH and EFEN test laboratories.

All requirements are fulfilled (see 3.).

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2004-11-18

EFEN GmbH Prüflabor Test Laboratory Eltville

Test Engineer

Head of laboratory

1. Type — HH-SI 10/24kV 16A FC TB ÜLA 442/56
Order-No.: 67240.0169

2. Reason for test

Temperature-rise tests and power-dissipation measurement

3. Tests performed / measurements

Measurement of temperatures, of voltage drop across fuse-link and power dissipation at different operating currents.

4. Applied standards

IEC 60282-1 1998-01 VDE 0670 Teil 4 Abs. 12 02/98

5. Test-laboratory, period of time

EFEN Prüflabor Eltville, 03/07/2000 – 03/09/2000

6. Arrangement of the equipment

The high-voltage fuse-link is mounted vertically in a fuse-base, with the striker-pin at the top.
The size of bare copper conductors is 25 mm².
Temperatures are measured at the fuse contacts (top and bottom), in the middle of the fuse with thermocouples and are recorded.
The test currents are recorded.

7. Inspection and test sequence

The fuse-link was loaded with test currents I = 8 A and I = 16 A

Test current I [A]	Comments
8	50% rated current
16	Rated current

Temperatures are measured at the fuse contacts and in the middle of the tube with thermocouples.
Calculation of power dissipation from recorded voltage drop and recorded test current.
Calculation of resistance depending on the currents.

8. Results

Type: HH-SI 10/24kV 16A FC TB ÜLA 442/56
R_{cold}: 197 mΩ

8.1 Temperature rise test

		Temperature			Temperature rise			Informative	
I [A]	$\vartheta_{amb.}$ [°C]	ϑ_{top} [°C]	ϑ_{bottom} [°C]	$\vartheta_{perm.}$ [°C]	$\Delta\vartheta_{top}$ [K]	$\Delta\vartheta_{bottom}$ [K]	$\Delta\vartheta_{perm.}$ [K]	ϑ_{center} [°C]	ϑ_{center} [K]
16	22	54	40	105	32	18	65	97	75

8.2 Power dissipation and resistance of the test object at defined currents.

I [A]	P_d [W]	$U_{fuse-link}$ [V]	R [mΩ]
8	14,2	1,78	222
16	72,5	4,53	283

9. Evaluation

The product passed the temperature-rise test acc. to IEC 60 282-1 and VDE 0670 Teil 4 respectively.

372 / 23
07/06/2001

EFEN GmbH Prüflabor Test Laboratory Eltville

Test engineer

Head of laboratory

EFEN WICKMANN GRUPPE

Temperature-rise tests and power-dissipation measurement
HH-SI 10/24kV 20A FC TB ÜLA 442/56

Lab.-No. 01147

1. Type — HH-SI 10/24kV 20A FC TB ÜLA 442/56
Order-No.: 67240.0209

2. Reason for test

Temperature-rise tests and power-dissipation measurement

3. Tests performed / measurements

Measurement of temperatures, of voltage drop across fuse-link and power dissipation at different operating currents.

4. Applied standards

IEC 60282-1 1998-01 VDE 0670 Teil 4 Abs. 12 02/98

5. Test-laboratory, period of time

EFEN Prüflabor Eltville, 03/07/2000 – 03/09/2000

6. Arrangement of the equipment

The high-voltage fuse-link is mounted vertically in a fuse-base, with the striker-pin at the top.
The size of bare copper conductors is 25 mm².
Temperatures are measured at the fuse contacts (top and bottom), in the middle of the fuse with thermocouples and are recorded.
The test currents are recorded.

7. Inspection and test sequence

The fuse-link was loaded with test currents I = 10 A and I = 20 A

Test current I [A]	Comments
10	50% rated current
20	Rated current

Temperatures are measured at the fuse contacts and in the middle of the tube with thermocouples.
Calculation of power dissipation from recorded voltage drop and recorded test current.
Calculation of resistance depending on the currents.

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8. Results

Type: HH-SI 10/24kV 20A FC TB ÜLA 442/56
R_{cold}: 134 mΩ

8.1 Temperature rise test

		Temperature			Temperature rise			Informative	
I [A]	ϑ amb. [°C]	ϑ top [°C]	ϑ bottom	ϑperm. [°C]	$\Delta\vartheta$ top [K]	$\Delta\vartheta$bottom [K]	$\Delta\vartheta$ perm. [K]	ϑcenter [°C]	ϑcenter [K]
10	22	30	26	105	8	4	65	42	20
20	23	55	39	105	32	16	65	97	54

8.2 Power dissipation and resistance of the test object at defined currents.

I [A]	P_d [W]	$U_{fuse-link}$ [V]	R [mΩ]
10	14,6	1,46	146
20	76,3	3,82	191

9. Evaluation

The product passed the temperature-rise test acc. to IEC 60 282-1 and VDE 0670 Teil 4 respectively.

372 / 23
07/06/2001

EFEN GmbH Prüflabor Test Laboratory Eltville

Test engineer

Head of laboratory

1. Type — HH-SI 10/24kV 25A FC TB ÜLA 442/56
Order-No.: 67240.0259

2. Reason for test

Temperature-rise tests and power-dissipation measurement

3. Tests performed / measurements

Measurement of temperatures, of voltage drop across fuse-link and power dissipation at different operating currents.

4. Applied standards

IEC 60282-1 1998-01 VDE 0670 Teil 4 Abs. 12 02/98

5. Test-laboratory, period of time

EFEN Prüflabor Eltville, 03/07/2000 – 03/09/2000

6. Arrangement of the equipment

The high-voltage fuse-link is mounted vertically in a fuse-base, with the striker-pin at the top.
The size of bare copper conductors is 25 mm².
Temperatures are measured at the fuse contacts (top and bottom), in the middle of the fuse with thermocouples and are recorded.
The test currents are recorded.

7. Inspection and test sequence

The fuse-link was loaded with test currents I = 12,5 A and I = 25 A

Test current I [A]	Comments
12,5	50% rated current
25	Rated current

Temperatures are measured at the fuse contacts and in the middle of the tube with thermocouples.
Calculation of power dissipation from recorded voltage drop and recorded test current.
Calculation of resistance depending on the currents.

8. Results

Type: HH-SI 10/24kV 25A FC TB ÜLA 442/56
R_{cold}: 96,3 mΩ

8.1 Temperature rise test

		Temperature			Temperature rise			Informative	
I [A]	$\vartheta_{amb.}$ [°C]	ϑ_{top} [°C]	ϑ_{bottom}	$\vartheta_{perm.}$ [°C]	$\Delta\vartheta_{top}$ [K]	$\Delta\vartheta_{bottom}$ [K]	$\Delta\vartheta_{perm.}$ [K]	ϑ_{center} [°C]	ϑ_{center} [K]
25	22	59	41	105	37	19	65	109	87

8.2 Power dissipation and resistance of the test object at defined currents.

I [A]	P_d [W]	$U_{fuse-link}$ [V]	R [mΩ]
12,5	16,8	1,34	108
25	89,2	3,57	143

9. Evaluation

The product passed the temperature-rise test acc. to IEC 60 282-1 and VDE 0670 Teil 4 respectively.

372 / 23
07/06/2001

EFEN GmbH Prüflabor Test Laboratory Eltville

Test engineer

Head of laboratory

1. Type

HH-SI 10/24kV 31,5A FC TB ÜLA 442/56
Order-No.: 67240.0329

2. Reason for test

Temperature-rise tests and power-dissipation measurement

3. Tests performed / measurements

Measurement of temperatures, of voltage drop across fuse-link and power dissipation at different operating currents.

4. Applied standards

IEC 60282-1 1998-01 VDE 0670 Teil 4 Abs. 12 02/98

5. Test-laboratory, period of time

EFEN Prüflabor Eltville, 03/07/2000 – 03/09/2000

6. Arrangement of the equipment

The high-voltage fuse-link is mounted vertically in a fuse-base, with the striker-pin at the top.
The size of bare copper conductors is 50 mm².
Temperatures are measured at the fuse contacts (top and bottom), in the middle of the fuse with thermocouples and are recorded.
The test currents are recorded.

7. Inspection and test sequence

The fuse-link was loaded with test currents I = 16 A and I = 31,5 A

Test current I [A]	Comments
16	50% rated current
31,5	Rated current

Temperatures are measured at the fuse contacts and in the middle of the tube with thermocouples.
Calculation of power dissipation from recorded voltage drop and recorded test current.
Calculation of resistance depending on the currents.

8. Results

Type: HH-SI 10/24kV 31,5A FC TB ÜLA 442/56
R_{cold}: 79,4 mΩ

8.1 Temperature rise test

		Temperature			Temperature rise			Informative	
I [A]	$\vartheta_{amb.}$ [°C]	ϑ_{top} [°C]	ϑ_{bottom}	$\vartheta_{perm.}$ [°C]	$\Delta\vartheta_{top}$ [K]	$\Delta\vartheta_{bottom}$ [K]	$\Delta\vartheta_{perm.}$ [K]	ϑ_{center} [°C]	ϑ_{center} [K]
16	22	36	29	105	14	7	65	53	31
31,5	24	72	46	105	48	22	65	140	116

8.2 Power dissipation and resistance of the test object at defined currents.

I [A]	P_d [W]	$U_{fuse-link}$ [V]	R [mΩ]
16	23,6	1,48	92,2
31,5	127	4,03	128

9. Evaluation

The product passed the temperature-rise test acc. to IEC 60 282-1 and VDE 0670 Teil 4 respectively.

372 / 23
07/06/2001

EFEN GmbH Prüflabor Test Laboratory Eltville

Test engineer

Head of laboratory

KEMA
HIGH-POWER LABORATORY
Utrechtseweg 310 – 6812 AR Arnhem – The Netherlands

720-00

REPORT OF PERFORMANCE

CLIENT	EFEN Elektrotechnische Fabrik GmbH, Eltville am Rhein, Germany
MANUFACTURER	EFEN Elektrotechnische Fabrik GmbH, Eltville am Rhein, Germany
APPARATUS	Current limiting fuses
DESIGNATION	HH-SI 10/24kV FC TB 442/56 1 – 2 – 4 – 6.3 – 10 – 16 – 20 – 25 – 31.5 – 40 – 50 – 63 A – 80 A
SERIAL No.	67240.0010, 67240.0020, 67240.0040, 67240.0060, 67240.0100, 67240.0160, 67240.0200, 67240.0250, 67240.0320, 67240.0400, 67240.0500, 67240.0630 and 67240.0800.

RATINGS ASSIGNED BY THE MANUFACTURER

Voltage	24	kV
Current	1 – 2 – 4 – 6.3 – 10 – 16 – 20 – 25 – 31.5 – 40 – 50 – 63 – 80	A (1)
Frequency	50	Hz
Breaking capacity at 24 kV	63	kA
Series	1	
Class	Back-up	

(1) The fuse-links 20 – 25 – 31.5 A and 40 – 50 – 63 A form a homgeneous series in accordance with Sub-clause 13.3.1 of IEC 60282-1.

The tests have been carried out strictly in accordance with IEC 60282-1, Sub-clause 13 (Test-duty 1).
The apparatus has complied with the relevant requirements.

Date of tests 22nd November 2000 and 13th March 2001

The performance of the apparatus tested and the observations made during the tests have been recorded in the tables with test results and the oscillograms

THIS REPORT CONSISTS OF:

Pages	15
Circuit diagrams	1
Oscillograms	36
Drawings	19
Photographs	5
Information sheet	B70E

KEMA Nederland B.V.

A.L.J. Janssen
Manager High-Power Laboratory

Arnhem, 27th February 2001

TABLE WITH TEST RESULTS

REPORT 720–00	TYPE OF TESTS REQUESTED: Test–duty 1	TEST CIRCUIT S02	PAGE 10

Condition before tests: Fuse–base new. Photograph 0401308.
Before each test new fuse–link.
Fuse–link mounted vertically in free air.
Distance fuse–link to floor 1.5 m.

Date and test	Fuse–link Type	Fuse–link Rated voltage kV / Rated current A	Resistance before test mΩ / after test MΩ	Test circuit Applied voltage kV	Test circuit Prospective current kA	Commencing of arcing after voltage zero °	Instantaneous current at initiation of arcing peak kA	Cut–off current peak kA	Pre–arcing time ms	Arcing time ms	Total operating time ms	Recovery voltage (1) kV	Switching voltage peak kV	Melt ∫I2t A2s x 10^6	Total ∫I2t A2s x 10^6	Energy ∫UIt kJ	Condition after test: Fuse–link / Striker; Behaviour during test; Remarks
001122 4050	HH–SI 10/24 FC TB 442/56 67240.0160 001659	24 / 16	190 / > 300	21.0	63.0	47	2.28	2.53	0.10	5.35	5.45	21.0	41.2	209	883	19.4	cold / operated; Fuse cleared.
001122 4051	HH–SI 10/24 FC TB 442/56 67240.0160 001660	24 / 16	190 / > 300	21.0	63.0	80	2.18	3.10	0.09	3.47	3.56	21.0	54.8	258	1120	20.6	cold / operated; Fuse cleared.
001122 4052	HH–SI 10/24 FC TB 442/56 67240.0160 001661	24 / 16	190 / > 300	21.0	63.0	81	2.32	3.12	0.09	3.45	3.54	21.0	55.9	252	1110	21.1	cold / operated; Fuse cleared.

Remarks: Fuse–base showed no visible change.

(1) Maintained for 15 s.

KEMA

TABLE WITH TEST RESULTS

REPORT 720–00	TYPE OF TESTS REQUESTED: Test–duty 1	TEST CIRCUIT S02	PAGE 11

Condition before tests: Fuse–base in same condition.
Before each test new fuse–link.
Fuse–link mounted vertically in free air.
Distance fuse–link to floor 1.5 m.

Date and test	Fuse–link Type	Fuse–link Rated voltage kV / Rated current A	Resistance before test mΩ / after test MΩ	Test circuit Applied voltage kV	Test circuit Prospective current kA	Commencing of arcing after voltage zero °	Instantaneous current at initiation of arcing peak kA	Cut–off current peak kA	Pre–arcing time ms	Arcing time ms	Total operating time ms	Recovery voltage (1) kV	Switching voltage peak kV	Melt ∫I2t A2s x 10^6	Total ∫I2t A2s x 10^6	Energy ∫UIt kJ	Condition after test: Fuse–link / Striker; Behaviour during test, Remarks
001122 4053	HH–SI 10/24 FC TB 442/56 67240.0200 001666	24 / 20	130 / > 300	21.0	63.0	47	2.80	3.19	0.13	0.28	0.41	21.0	43.8	487	1510	13.5	cold / operated; Fuse cleared.
001122 4054	HH–SI 10/24 FC TB 442/56 67240.0200 001667	24 / 20	130 / > 300	21.0	63.0	81	3.36	3.79	0.11	3.13	3.24	21.0	56.6	500	2050	29.3	cold / operated; Fuse cleared.
001122 4055	HH–SI 10/24 FC TB 442/56 67240.0200 001668	24 / 20	130 / > 300	21.0	63.0	80	4.33	3.85	0.11	3.30	3.41	21.0	56.2	470	2110	31.7	cold / operated; Fuse cleared.

Remarks: Fuse–base showed no visible change.

(1) Maintained for 15 s.

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TABLE WITH TEST RESULTS

REPORT 720–00	TYPE OF TESTS REQUESTED: Test–duty 1	TEST CIRCUIT S02	PAGE 12

Condition before tests: Fuse–base in same condition.
Before each test new fuse–link.
Fuse–link mounted vertically in free air.
Distance fuse–link to floor 1.5 m.

Date and test	Fuse–link Type	Fuse–link Rated voltage kV / Rated current A	Resistance before test mΩ / after test MΩ	Test circuit Applied voltage kV	Test circuit Prospective current kA	Commencing of arcing after voltage zero °	Instantaneous current at initiation of arcing peak kA	Cut–off current peak kA	Pre–arcing time ms	Arcing time ms	Total operating time ms	Recovery voltage (1) kV	Switching voltage peak kV	Melt ∫I2t A2s x 10^6	Total ∫I2t A2s x 10^6	Energy ∫UIt kJ	Condition after test: Fuse–link / Striker; Behaviour during test, Remarks
001122 4056	HH–SI 10/24 FC TB 442/56 67240.0320 001677	24 / 31.5	76.1 / > 300	21.0	63.0	48	4.38 (2)	4.55 (2)	0.19	5.79	5.98	21.0	46.3	1320	4650	66.1	warm / operated; Fuse cleared.
001122 4057	HH–SI 10/24 FC TB 442/56 67240.0320 001678	24 / 31.5	76.2 / > 300	21.0	63.0	82	4.76	5.14	0.16	3.30	3.46	21.0	60.8	1450	4920	49.5	warm / operated; Fuse cleared.
001122 4058	HH–SI 10/24 FC TB 442/56 67240.0320 001679	24 / 31.5	76.5 / > 300	21.0	63.0	82	4.72	5.14	0.16	3.23	3.39	21.0	61.3	1440	4840	48.7	warm / operated; Fuse cleared.

Remarks: Fuse–base showed no visible change.

(1) Maintained for 15 s.
(2) No cut–off current registrated on oscillogram, value obtained from display.

KEMA

FGH
Engineering & Test GmbH
Mannheim-Rheinau, Hallenweg 40

Accredited testing laboratory to DIN EN 45001 for subject

Deutscher Akkreditierungs Rat DAR

DAT-P-103/00-00 High-voltage apparatus switchgear and controlgear

DAT-P-103/00-10 High-voltage cables and accessories

Test Report

No. L 00039

Duly signed copy 1E

Reference: 114-00/164...175, 460...470

Apparatus: **Current-limiting fuse-link**

Types:
a) HH-SI 10/24kV 16A FC TB 442/56, Ident-No.: 67240.0160
b) HH-SI 10/24kV 20A FC TB 442/56, Ident-No.: 67240.0200
c) HH-SI 10/24kV 25A FC TB 442/56, Ident-No.: 67240.0250
d) HH-SI 10/24kV 31.5A FC TB 442/56, Ident-No.: 67240.0320

Rated voltage: 24 kV
Rated current: a) 16 A, b) 20 A, c) 25 A, d) 31.5 A
Class: Back-up

Manufacturer: EFEN Elektrotechnische Fabrik GmbH,
Postfach 12 54, D-65344 Eltville, Germany

Customer: EFEN Elektrotechnische Fabrik GmbH,
Postfach 12 54, D-65344 Eltville, Germany

Test Specification: IEC 60282-1 (1998-01), Ed.4.2

Tests performed: Breaking tests:

Test duty 2:
Verification of the operation with prospective current I2 at which current limiting occurs when a high level of energy is stored in the inductance of the circuit.

These fuse-links form a homogenous series, therefore only types a); b) and d) were tested.

Test duty 3:
Verification of the operation at the rated minimum breaking current

Test Results: During the breaking tests performed, the tested fuse-links fully complied with the standard conditions of behaviour with respect to breaking capacity.

Mannheim, September 6, 2000
Wa

FGH Engineering & Test GmbH

FGH Engineering & Test GmbH

Test Engineer:

(Heil)

Place and date of test: LPF Mannheim-Rheinau, March 15, 2000 and May 30-31, 2000

Number of sheets: 36

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	24	16	67240.0160 HH-SI 10/24kV 16A FC TB 442/56

Test-no. 114-00/			172	173	174	175
Specimen		No.	Adjust-ment test	00224	00225	00226
Resistance		mΩ	-	197	196	195
Test-duty (according to IEC 282-1)			2	2	2	2
Power factor of the test circuit	cos φ		0.012	0.012	0.012	0.012
Prospective breaking current (RMS)		A	520	520	520	521
Making angle after voltage zero		° el	12.2	10.4	10.4	10.4
Pre-arcing / Melting time	t_m	ms		3.58	3.57	3.47
Melting current	i_m	A		524	525	500
Pre-arcing Joule Integral		A^2s		244	246	215
Cut-off / Let through current	i_d	A		596	600	593
Arcing time	t_{LB}	ms		6.98	7.28	7.37
Arcing Joule Integral		kA^2s		1.18	1.38	1.36
Arcing time until breaking by the circuit breaker		ms		-	-	-
Max. switching voltage	u_s	kV		45.2	42.0	41.7
Power frequency recovery voltage	U_w	kV	20.92	20.92	20.94	20.96
Maintaining voltage after breaking		s	-	>60	>60	>60
Test result:						
Fuse operated correct		y/n		yes	yes	yes
Switching voltage $u_s \leq$ permissive value		y/n		yes	yes	yes
Current limiting:	($i_d \leq$ Let-through characteristic)	y/n		-	-	-
Requirement for I2:	i_m/I = 0.85...1.06	i_m/I		1.01	1.01	0.96
Emission of flames or sand		y/n		no	no	no
Damages (external)		y/n		no	no	no
Operation of striker correct		y/n		yes	yes	yes

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	24	16	67240.0160 HH-SI 10/24kV 16A FC TB 442/56

Test-no. 114-00/		463	464	465	
Specimen	No.	Adjust-ment test	00228	00229	
Resistance	mΩ	-	195	196	
Test-duty (according to IEC 282-1)		3			
Power factor of the test circuit cos φ		0.52			
Prospective breaking current (RMS)	A	53.6			
Maintained current with at 54 A low voltage source at A	s		30	40	
Time of current-interruption while switching over from low voltage to high voltage circuit	ms		133	140	
Pre-arcing / Melting time t_m	s		30	40	
Pre-arcing Joule Integral	A^2s		-	-	
Arcing time t_{LB}	ms		56	99	
Arcing Joule Integral	A^2s		137	248	
Arcing time until breaking by the circuit breaker	ms		-	-	
Max. switching voltage u_s	kV		34.7	34.6	
Power frequency recovery voltage U_w	kV	24.0	24.0	24.1	
Maintaining voltage after breaking	s		>60	>60	
Test result:					
Fuse operated correct	y/n		yes	yes	
Switching voltage $u_s \leq$ permissive value	y/n		yes	yes	
Emission of flames or sand	y/n		no	no	
Damages (external)	y/n		no	no	
Operation of striker correct	y/n		yes	yes	

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	24	20	67240.0200 HH-SI 10/24kV 20A FC TB 442/56

Test-no.	114-00/		168	169	170	171
Specimen		No.	Adjust-ment test	00239	00240	00241
Resistance		mΩ	-	131	133	131
Test-duty (according to IEC 282-1)			2	2	2	2
Power factor of the test circuit	cos φ		0.013	0.013	0.013	0.013
Prospective breaking current (RMS)		A	776	775	778	770
Making angle after voltage zero		° el	9.9	7.0	9.7	9.0
Pre-arcing / Melting time	t_m	ms		3.49	3.46	3.49
Melting current	i_m	A		788	777	786
Pre-arcing Joule Integral		A^2s		558	536	553
Cut-off / Let through current	i_d	A		867	855	860
Arcing time	t_{LB}	ms		7.04	7.01	6.98
Arcing Joule Integral		kA^2s		2.67	2.55	2.62
Arcing time until breaking by the circuit breaker		ms		-	-	-
Max. switching voltage	u_s	kV		44.9	44.4	44.4
Power frequency recovery voltage	U_w	kV	21.11	21.09	21.16	20.94
Maintaining voltage after breaking		s	-	>60	>60	>60
Test result:						
Fuse operated correct		y/n		yes	yes	yes
Switching voltage $u_s \leq$ permissive value		y/n		yes	yes	yes
Current limiting:	($i_d \leq$ Let-through characteristic)	y/n		-	-	-
Requirement for I2:	i_m/I = 0.85...1.06	i_m/I		1.02	1.00	1.02
Emission of flames or sand		y/n		no	no	no
Damages (external)		y/n		no	no	no
Operation of striker correct		y/n		yes	yes	yes

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	24	20	67240.0200 HH-SI 10/24kV 20A FC TB 442/56

Test-no.	114-00/		468	469	470	
Specimen		No.	Adjust-ment test	00244	00245	
Resistance		mΩ	-	131	134	
Test-duty (according to IEC 282-1)			3			
Power factor of the test circuit	cos φ		0.50			
Prospective breaking current (RMS)		A	72.9			
Maintained current with low voltage source	at 73 A at A	min		3:26	3:15	
Time of current-interruption while switching over from low voltage to high voltage circuit		ms		150	155	
Pre-arcing / Melting time	t_m	s		206	195	
Pre-arcing Joule Integral		A^2s		-	-	
Arcing time	t_{LB}	ms		23	31	
Arcing Joule Integral		A^2s		112	138	
Arcing time until breaking by the circuit breaker		ms		-	-	
Max. switching voltage	u_s	kV		34.9	34.5	
Power frequency recovery voltage	U_W	kV	24.2	24.2	24.2	
Maintaining voltage after breaking		s		>60	>60	
Test result:						
Fuse operated correct		y/n		yes	yes	
Switching voltage $u_s \leq$ permissive value		y/n		yes	yes	
Emission of flames or sand		y/n		no	no	
Damages (external)		y/n		no	no	
Operation of striker correct		y/n		yes	yes	

Test-no. 470: An restrike with current duration 8 ms, 58.3 ms after first break

FGH Engineering & Test GmbH

No. L 00039 Sheet 17

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	24	25	67240.0250 HH-SI 10/24kV 25A FC TB 442/56

Test-no. 114-00/			457	458	459	
Specimen	No.		Adjust-ment test	00256	00257	
Resistance	mΩ		-	96.6	96.3	
Test-duty (according to IEC 282-1)			3			
Power factor of the test circuit	cos φ		0.51			
Prospective breaking current (RMS)	A		92.3			
Maintained current with at 92 A low voltage source at A	min			2:20	1:47	
Time of current-interruption while switching over from low voltage to high voltage circuit	ms			116	127	
Pre-arcing / Melting time t_m	s			140	107	
Pre-arcing Joule Integral	A^2s			-	-	
Arcing time t_{LB}	ms			41.8	43.6	
Arcing Joule Integral	A^2s			334	294	
Arcing time until breaking by the circuit breaker	ms			-	-	
Max. switching voltage u_s	kV			35.5	35.6	
Power frequency recovery voltage U_w	kV		24.5	24.4	24.5	
Maintaining voltage after breaking	s			>60	>60	

Test result:

Fuse operated correct	y/n		yes	yes	
Switching voltage $u_s \leq$ permissive value	y/n		yes	yes	
Emission of flames or sand	y/n		no	no	
Damages (external)	y/n		no	no	
Operation of striker correct	y/n		yes	yes	

No. L 00039

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	24	31,5	67240.0320 HH-SI 10/24kV 31,5A FC TB 442/56

Test-no. 114-00/			164	165	166	167
Specimen		No.	Adjust-ment test	00270	00271	00272
Resistance		mΩ	-	79.6	79.5	79.0
Test-duty (according to IEC 282-1)			2	2	2	2
Power factor of the test circuit	cos φ		0.096	0.096	0.096	0.096
Prospective breaking current (RMS)		kA	1.37	1.37	1.37	1.37
Making angle after voltage zero		° el	7.6	8.3	8.3	8.3
Pre-arcing / Melting time	t_m	ms		3.51	3.51	3.55
Melting current	i_m	kA		1.30	1.29	1.30
Pre-arcing Joule Integral		kA^2s		1.48	1.47	1.48
Cut-off / Let through current	i_d	kA		1.38	1.38	1.38
Arcing time	t_{LB}	ms		6.43	6.64	6.55
Arcing Joule Integral		kA^2s		4.38	4.88	4.68
Arcing time until breaking by the circuit breaker		ms		-	-	-
Max. switching voltage	u_s	kV		52.9	49.9	50.9
Power frequency recovery voltage	U_w	kV	21.06	21.04	21.04	21.04
Maintaining voltage after breaking		s	-	>60	>60	>60
Test result:						
Fuse operated correct		y/n		Yes	Yes	Yes
Switching voltage $u_s \leq$ permissive value		y/n		Yes	Yes	Yes
Current limiting:	($i_d \leq$ Let-through characteristic)	y/n		-	-	-
Requirement for I2:	i_m/I = 0.85...1.06	i_m/I		0.95	0.94	0.95
Emission of flames or sand		y/n		no	no	no
Damages (external)		y/n		no	no	no
Operation of striker correct		y/n		Yes	Yes	Yes

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	24	31.5	67240.0320 HH-SI 10/24kV 31,5A FC TB 442/56

Test-no.	114-00/		460	461	462	
Specimen		No.	Adjust-ment test	00274	00275	
Resistance		mΩ	-	79.8	79.5	
Test-duty (according to IEC 282-1)			3			
Power factor of the test circuit	cos φ		0.51			
Prospective breaking current (RMS)		A	105			
Maintained current with low voltage source at 105 A at A		s		40	49	
Time of current-interruption while switching over from low voltage to high voltage circuit		ms		121	123	
Pre-arcing / Melting time	t_m	s		40	49	
Pre-arcing Joule Integral		A^2s		-	-	
Arcing time	t_{LB}	ms		49	47	
Arcing Joule Integral		A^2s		426	413	
Arcing time until breaking by the circuit breaker		ms		-	-	
Max. switching voltage	u_s	kV		35.7	35.6	
Power frequency recovery voltage	U_w	kV	24.5	24.5	24.5	
Maintaining voltage after breaking		s		>60	>60	
Test result:						
Fuse operated correct		y/n		yes	yes	
Switching voltage $u_s \leq$ permissive value		y/n		yes	yes	
Emission of flames or sand		y/n		no	no	
Damages (external)		y/n		no	no	
Operation of striker correct		y/n		yes	yes	

Test-no. 461: An restrike with current duration 6 ms, 114 ms after first break

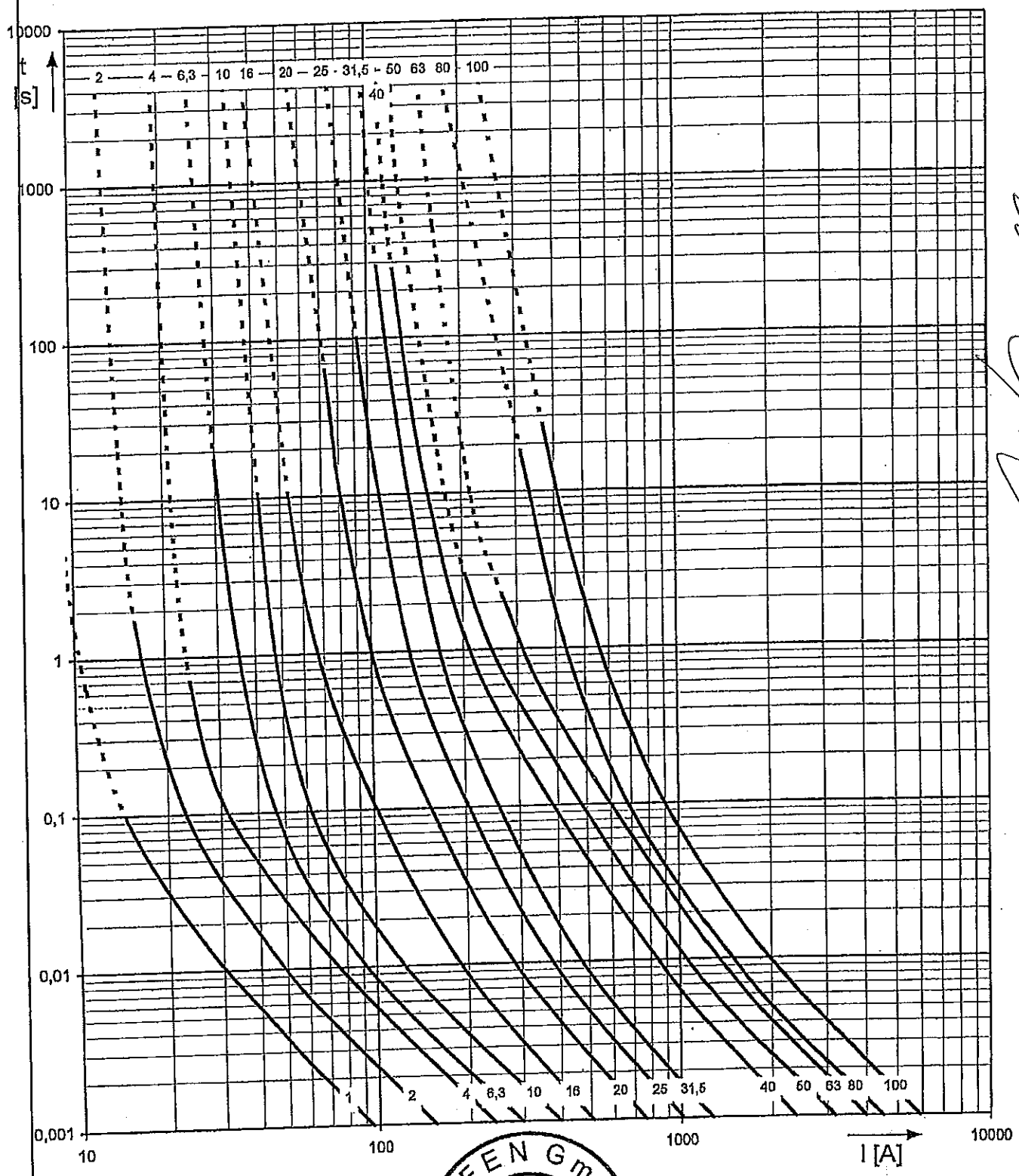
EFEN WICKMANN GRUPPE

Time-current characteristics of H.V. back-up fuse-links with ÜLA (controlled power dissipation)

Lab.-No. 01169

10/24 kV 1 A - 100 A acc. to IEC 60282-1 / VDE 0670 Teil 4

Order-No.: 67240.0019 - 67240.1009



EFEN GmbH Prüflabor Test Laboratory Eltville

06.06.2001 / 23

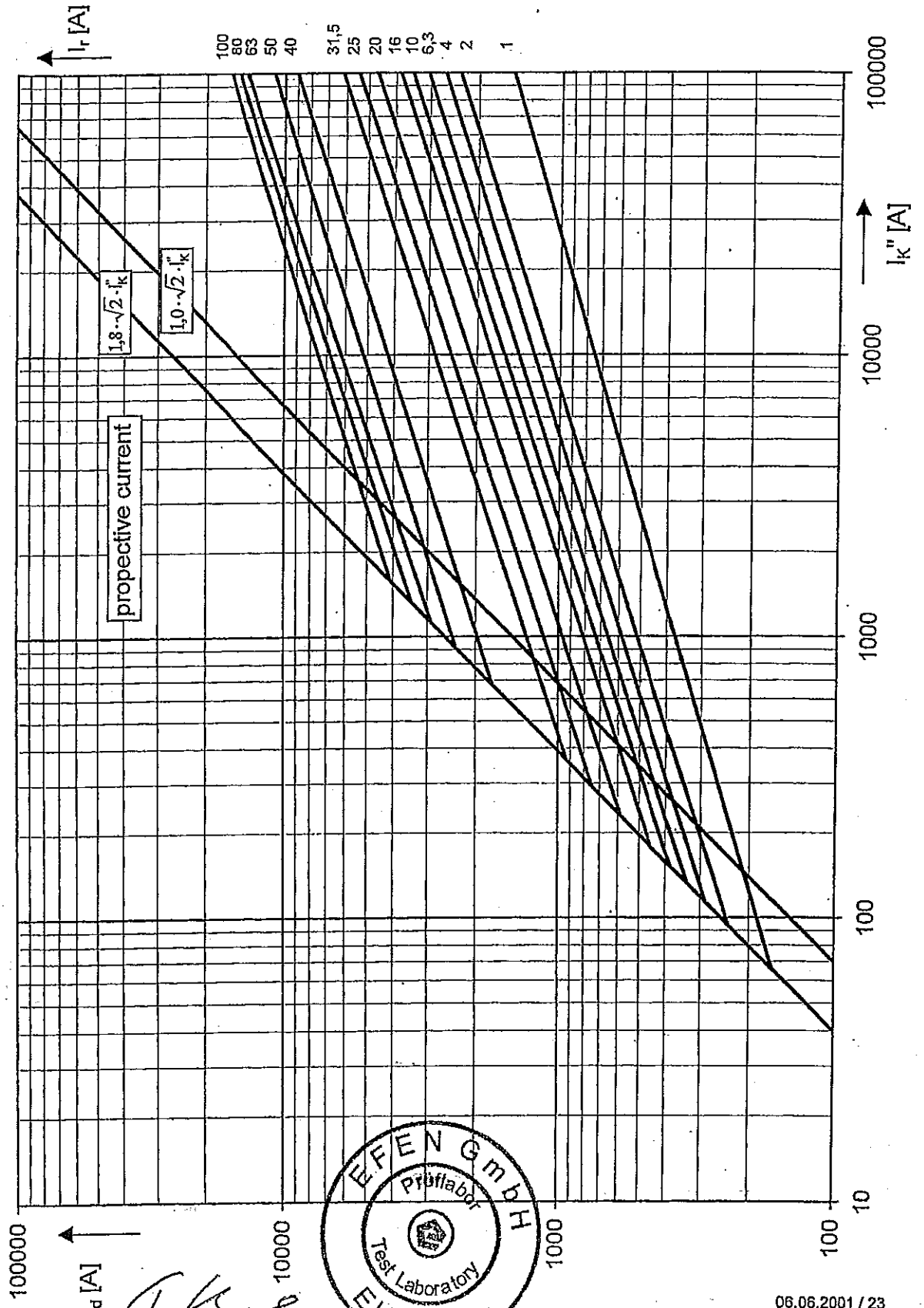
EFEN GmbH
Postfach 1254 · D-65332 Eltville · Tel. 0049 (0) 6129 46-0 · Fax 46222 · e-Mail: efen@efen.com · Internet: www.efen.com

EFEN
WICKMANN GRUPPE

Cut-off characteristics of H.V. back-up fuse-links with ÜLA (controlled power dissipation)

Lab.-No. 01171 10/24 kV 1 A - 100 A acc. to IEC 60282-1 / VDE 0670 Teil 4

Order-No.: 67240.0019 to 67240.1009



EFEN GmbH

Postfach 1254 · D-65332 Eltville · Tel. 00 49 (0) 61 29 46-0 · Fax 4 62 22 · e-Mail: efen@efen.com · Internet: www.efen.com

1. Type HH – fuse link with striker 81902.0100(3) (duration 30mm)

2. Reason for test

Test of Strikers

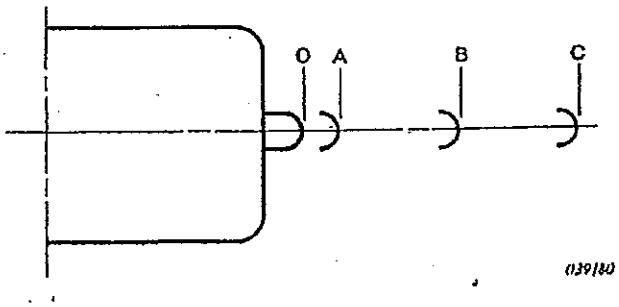
3. Tests performed / measurements

I. measurement of the duration of travel
II. measurement of the force-travel characteristics and calculation of the striker energy actuated by the spring
III. Verification of the withstand force according to applied standard (4)

4. Applied standards

IEC 60282-1 2002-01 VDE 0670 Teil 4 Abs. 12 02/98

4.1 standard in detail regarding strikers



OA – Free travel – No energy output specified.
AB – Further travel during which energy must be delivered.
OB – Minimum actual travel.
OC – Maximum actual travel.
CB – Maximum permitted return travel under withstand force (when applicable).

Type	Energy	Mechanical characteristics					
		Values of		Actual travel		Minimum withstand force	Maximum duration of travel (see note)
		Free travel (OA)*	Further travel during which energy must be delivered (AB)*	Min. (OB)*	Max. (OC)*		
	J	mm	mm	mm	mm	N	ms
Light	0,3 ± 0,25	2	8	10	30	Not applicable	100
Medium	1 ± 0,5	4	16	20	40	20	100
Heavy	2 ± 1	4	8	10	16	40	100

* See figure 12.

NOTE – Duration of travel is defined for actual fuse-links as the time from commencement of arcing to the time when travel OB is reached. For dummy fuses it is the time from application of voltage until travel OB is reached.

5. Test-laboratory, period of time

EFEN laboratory Eltville, 4.12.2003

6. Arrangement of the equipment

I. The tested fuse link is fixed in a fuse-base. An NC (normally closed) switch will be opened if the striker has travelled 30mm. Current, Voltage and the NC switch are recorded by an digital oscilloscope.

II. & III. The force-travel characteristics will be measured by an approved force meter*. For this measurement the striker will be prepared with an scale indicator for measuring the travelled way in mm.

*Zwick Z2.5 / TN1S Material testing device

7. Inspection and test sequence

I. Intact striker circuit is tested with current < 10A and voltage < 15V.
II. Current, voltage and the NC switch are recorded.
III. Force of striker is measured at Positions: 0, 10, und 20mm.
The Position of the Striker is measured at the minimum withstand force of 20N.

8. Results

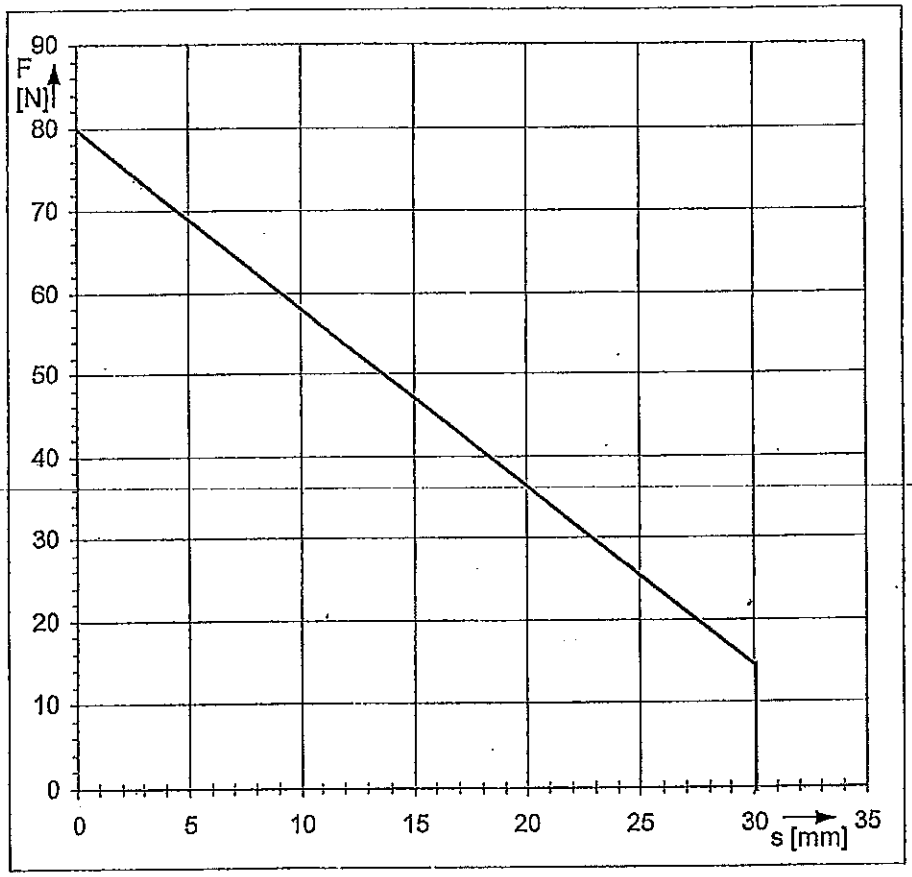
I. measurement of the duration of travel

	duration of travel	Current	Voltage
Sample 1	5 ms	9,9 A	< 15 V
Sample 2	2 ms	11,7 A	< 15 V
Sample 3	4 ms	10 A	< 15 V
Sample 4	6 ms	9,9 A	< 15 V

II. measurement of the force-travel characteristics and calculation of the striker energy

		Sample 1		Sample 2		Sample 3		
Position	Length / mm	Measurem. 1	Measurem. 2	Measurem. 1	Measurem. 2	Measurem. 1	Measurem. 2	Average:
O	0	77	76,8	85,5	81,7	78	78	79,5
A	4	66,5	66,4	67,5	67,4	71,7	69,7	68,2
B	20	37,7	36,1	33,7	33,1	36,2	36,5	35,6
	Energy / J:	0,83	0,82	0,81	0,80	0,86	0,85	0,83

$$Energy = \frac{(F_A + F_B) \times \overline{AB}}{2000} \qquad Energy[J];\ F_A[N];\ F_B[N];\ \overline{AB}[mm];$$



III. Verification of the withstand force of 20N at Position ≥ 20mm

	Measurement	Force / N	Length / mm
Sample 1	1	20	27,4
Sample 1	2	20	27,7
Sample 2	1	20	27,3
Sample 2	2	20	26,9
Sample 3	1	20	28,4
Sample 3	2	20	28,4

9. Evaluation

Type	Energy		Free travel	Further travel during which energy must be delivered	Actual travel			Minimum travel force	
	Actual value	Specified value	$\overline{OA}$	$\overline{AB}$	Actual value	Specified value Min. $\overline{OB}$	Specified value Max. $\overline{OC}$	Actual value	Specified value
	J		mm	mm	mm			N	
Medium	0,83	1±0,5	4	16	30	20	40	35,6	≥20

I. Measured duration of travel < maximum duration of travel (100ms)
II. striker energy is Medium 1J +-0,5 J
III. Verification of the withstand force proofed that the striker has the necessary force.

The striker full fills all Requirements of striker Type medium according to:
IEC 60282-1 2002-01; VDE 0670 Teil 4 Abs. 12 02/98

370 / 65

2004-03-29

Test engineer

EFEN GmbH Prüflabor Test Laboratory Eltville

Head of Laboratory

EFEN WICKMANN GRUPPE

Type Test Report

Lab.-No. 01166

1. Object

Current-limiting high-voltage fuse-links
Class: Back-up
Striker: "medium"
Type: HH-SI 10/24kV 40A / 50A / 63A FC TB ÜLA 442/56
Ident-No.: 67240.0409 / 67240.0509 / 67240.0639

Rated voltage	10/24 kV		
Rated current	40 A	50 A	63 A
Rated maximum breaking current	63 kA		
Rated frequency	50 Hz		
Rated minimum breaking current	125 A	205 A	280 A

2. Reason for test

Type test according to IEC 60282-1 (VDE 0670 Teil 4): 1998-02

3. Tests performed

3.1 Temperature-rise tests and power-dissipation measurement

Rated current		40 A	50 A	63 A
Test laboratory		EFEN Prüflabor Eltville		
Test result: $\Delta\vartheta_{max}$ [1]		40 K	55 K	61 K
Test result: P_a	at 50% I_r	20,9 W	25,5 W	28,7 W
	at 100% I_r	114 W	147 W	170 W
EFEN Lab-No.		01150	01151	01152
Test passed		Yes	Yes	Yes

[1] permissible temperature rise: 65 K

3.2 Breaking Test: Test Duty 1

Rated current	40 A	50 A	63 A
Test Laboratory / Document No	KEMA / 720-00		
Test circuit applied voltage: U	21 kV		
Test circuit prospective current I	63 kA		
EFEN Lab-No.	01072		
Test passed	Yes	Hom.	Yes

3.3 Breaking Test: Test Duty 2

Rated current	40 A	50 A	63 A
Test Laboratory / Document No	FGH / L 01005 1E		
Test circuit applied voltage U	21,14 kV		20,95 kV
Test circuit prospective current I	2,26 kA		4,27 kA
EFEN Lab-No.	01070		
Test passed	Yes	Hom.	Yes

3.4 Breaking Test: Test Duty 3

Rated current	40 A	50 A	63 A
Test Laboratory / Document No.	FGH / L 01005 1E		
Test circuit applied voltage: U	24,9 kV	25,0 kV	25,0 kV
Test circuit prospective current I	122 A	202 A	278 A
EFEN Lab-No.	01070		
Test passed	Yes	Yes	Yes

3.5 Tests for time-current characteristics
Test Laboratory: EFEN Prüflabor Eltville
EFEN Lab-No: 01169
Test passed

3.6 Cut-off characteristics
EFEN Lab-No: 01171

3.7 Test of strikers
Test result: 0,83 J => Type medium
Test Laboratory: EFEN Prüflabor Eltville
EFEN Lab-No: 03088
Test passed

4. Test results

The products passed the type tests according to IEC 60 282-1 and VDE 0670 Teil 4 respectively at KEMA, FGH and EFEN test laboratories.

All requirements are fulfilled (see 3.).

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2004-11-18

EFEN GmbH Prüflabor Test Laboratory Eltville

Test Engineer

Head of laboratory

1. Type — HH-SI 10/24kV 40A FC TB ÜLA 442/56
Order-No.: 67240.0409

2. Reason for test

Temperature-rise tests and power-dissipation measurement

3. Tests performed / measurements

Measurement of temperatures, of voltage drop across fuse-link and power dissipation at different operating currents.

4. Applied standards

IEC 60282-1 1998-01 VDE 0670 Teil 4 Abs. 12 02/98

5. Test-laboratory, period of time

EFEN Prüflabor Eltville, 01/04/2001 – 01/10/2001

6. Arrangement of the equipment

The high-voltage fuse-link is mounted vertically in a fuse-base, with the striker-pin at the top.
The size of bare copper conductors is 50 mm².
Temperatures are measured at the fuse contacts (top and bottom), in the middle of the fuse with thermocouples and are recorded.
The test currents are recorded.

7. Inspection and test sequence

The fuse-link was loaded with test currents I = 20 A and I = 40 A

Test current I [A]	Comments
20	50% rated current
40	Rated current

Temperatures are measured at the fuse contacts and in the middle of the tube with thermocouples.
Calculation of power dissipation from recorded voltage drop and recorded test current.
Calculation of resistance depending on the currents.

8. Results

Type: HH-SI 10/24kV 40A FC TB ÜLA 442/56
R_{cold}: 43,9 mΩ

8.1 Temperature rise test

		Temperature			Temperature rise			Informative	
I [A]	ϑ amb. [°C]	ϑ top [°C]	ϑ bottom	ϑperm. [°C]	$\Delta\vartheta$ top [K]	$\Delta\vartheta$bottom [K]	$\Delta\vartheta$ perm. [K].	ϑcenter [°C]	ϑcenter [K]
20	20	31	27	105	11	7	65	49	29
40	20	60	44	105	40	24	65	133	113

8.2 Power dissipation and resistance of the test object at defined currents.

I [A]	P_d [W]	$U_{fuse-link}$ [V]	R [mΩ]
20	20,9	1,04	52,3
40	114	2,85	71,3

9. Evaluation

The product passed the temperature-rise test acc. to IEC 60 282-1 and VDE 0670 Teil 4 respectively.

372 / 23
07/06/2001

EFEN GmbH Prüflabor Test Laboratory Eltville

Test engineer

Head of laboratory

1. Type — HH-SI 10/24kV 50A FC TB ÜLA 442/56
Order-No.: 67240.0509

2. Reason for test

Temperature-rise tests and power-dissipation measurement

3. Tests performed / measurements

Measurement of temperatures, of voltage drop across fuse-link and power dissipation at different operating currents.

4. Applied standards

IEC 60282-1 1998-01 VDE 0670 Teil 4 Abs. 12 02/98

5. Test-laboratory, period of time

EFEN Prüflabor Eltville, 01/04/2001 – 01/10/2001

6. Arrangement of the equipment

The high-voltage fuse-link is mounted vertically in a fuse-base, with the striker-pin at the top.
The size of bare copper conductors is 50 mm².
Temperatures are measured at the fuse contacts (top and bottom), in the middle of the fuse with thermocouples and are recorded.
The test currents are recorded.

7. Inspection and test sequence

The fuse-link was loaded with test currents I = 25 A and I = 50 A

Test current I [A]	Comments
25	50% rated current
50	Rated current

Temperatures are measured at the fuse contacts and in the middle of the tube with thermocouples.
Calculation of power dissipation from recorded voltage drop and recorded test current.
Calculation of resistance depending on the currents.

8. Results

Type: HH-SI 10/24kV 50A FC TB ÜLA 442/56
R_{cold}: 33,7 mΩ

8.1 Temperature rise test

		Temperature			Temperature rise			Informative	
I [A]	$\vartheta_{amb.}$ [°C]	ϑ_{top} [°C]	ϑ_{bottom} [°C]	$\vartheta_{perm.}$ [°C]	$\Delta\vartheta_{top}$ [K]	$\Delta\vartheta_{bottom}$ [K]	$\Delta\vartheta_{perm.}$ [K]	ϑ_{center} [°C]	ϑ_{center} [K]
25	21	35	28	105	14	7	65	54	34
50	21	76	46	105	55	25	65	154	133

8.2 Power dissipation and resistance of the test object at defined currents.

I [A]	P_d [W]	$U_{fuse-link}$ [V]	R [mΩ]
25	25,5	1,05	40,8
50	147	2,95	58,8

9. Evaluation

The product passed the temperature-rise test acc. to IEC 60 282-1 and VDE 0670 Teil 4 respectively.

372 / 23
07/06/2001

EFEN GmbH Prüflabor Test Laboratory Eltville

Test engineer

Head of laboratory

1. Type — HH-SI 10/24kV 63A FC TB ÜLA 442/56
Order-No.: 67240.0639

2. Reason for test

Temperature-rise tests and power-dissipation measurement

3. Tests performed / measurements

Measurement of temperatures, of voltage drop across fuse-link and power dissipation at different operating currents.

4. Applied standards

IEC 60282-1 1998-01 VDE 0670 Teil 4 Abs. 12 02/98

5. Test-laboratory, period of time

EFEN Prüflabor Eltville, 01/04/2001 – 01/10/2001

6. Arrangement of the equipment

The high-voltage fuse-link is mounted vertically in a fuse-base, with the striker-pin at the top.
The size of bare copper conductors is 50 mm².
Temperatures are measured at the fuse contacts (top and bottom), in the middle of the fuse with thermocouples and are recorded.
The test currents are recorded.

7. Inspection and test sequence

The fuse-link was loaded with test currents I = 31,5 A and I = 63 A

Test current I [A]	Comments
31,5	50% rated current
63	Rated current

Temperatures are measured at the fuse contacts and in the middle of the tube with thermocouples.
Calculation of power dissipation from recorded voltage drop and recorded test current.
Calculation of resistance depending on the currents.

8. Results

Type: HH-SI 10/24kV 63A FC TB ÜLA 442/56
R_{cold}: 23,7 mΩ

8.1 Temperature rise test

		Temperature			Temperature rise			Informative	
I [A]	$\vartheta_{amb.}$ [°C]	ϑ_{top} [°C]	ϑ_{bottom} [°C]	$\vartheta_{perm.}$ [°C]	$\Delta\vartheta_{top}$ [K]	$\Delta\vartheta_{bottom}$ [K]	$\Delta\vartheta_{perm.}$ [K]	ϑ_{center} [°C]	ϑ_{center} [K]
31,5	20	34	29	105	14	9	65	56	36
63	22	83	59	105	61	37	65	163	141

8.2 Power dissipation and resistance of the test object at defined currents.

I [A]	P_d [W]	$U_{fuse-link}$ [V]	R [mΩ]
31,5	28,7	0,91	28,9
63	170	2,69	42,8

9. Evaluation

The product passed the temperature-rise test acc. to IEC 60 282-1 and VDE 0670 Teil 4 respectively.

372 / 23
07/06/2001

EFEN GmbH Prüflabor Test Laboratory Eltville

Test engineer

Head of laboratory

KEMA
HIGH–POWER LABORATORY
Utrechtseweg 310 – 6812 AR Arnhem – The Netherlands

720–00

REPORT OF PERFORMANCE

CLIENT	EFEN Elektrotechnische Fabrik GmbH, Eltville am Rhein, Germany
MANUFACTURER	EFEN Elektrotechnische Fabrik GmbH, Eltville am Rhein, Germany
APPARATUS	Current limiting fuses
DESIGNATION	HH–SI 10/24kV FC TB 442/56 1 – 2 – 4 – 6.3 – 10 – 16 – 20 – 25 – 31.5 – 40 – 50 – 63 A – 80 A
SERIAL No.	67240.0010, 67240.0020, 67240.0040, 67240.0060, 67240.0100, 67240.0160, 67240.0200, 67240.0250, 67240.0320, 67240.0400, 67240.0500, 67240.0630 and 67240.0800.

RATINGS ASSIGNED BY THE MANUFACTURER

Voltage	24	kV
Current	1 – 2 – 4 – 6.3 – 10 – 16 – 20 – 25 – 31.5 – 40 – 50 – 63 – 80	A (1)
Frequency	50	Hz
Breaking capacity at 24 kV	63	kA
Series	1	
Class	Back–up	

(1) The fuse–links 20 – 25 – 31.5 A and 40 – 50 – 63 A form a homgeneous series in accordance with Sub–clause 13.3.1 of IEC 60282–1.

The tests have been carried out strictly in accordance with IEC 60282–1, Sub–clause 13 (Test–duty 1).
The apparatus has complied with the relevant requirements.

Date of tests 22nd November 2000 and 13th March 2001

The performance of the apparatus tested and the observations made during the tests have been recorded in the tables with test results and the oscillograms

THIS REPORT CONSISTS OF:

Pages	15
Circuit diagrams	1
Oscillograms	36
Drawings	19
Photographs	5
Information sheet	B70E

KEMA Nederland B.V.

A.L.J. Janssen
Manager High–Power Laboratory

Arnhem, 27th February 2001

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TABLE WITH TEST RESULTS

REPORT 720–00 | TYPE OF TESTS REQUESTED: Test–duty 1 | TEST CIRCUIT S02 | PAGE 13

Condition before tests: Fuse–base in same condition.
Before each test new fuse–link.
Fuse–link mounted vertically in free air.
Distance fuse–link to floor 1.5 m.

Date and test	Fuse–link Type	Rated voltage kV / Rated current A	Resistance before test mΩ / after test MΩ	Test circuit Applied voltage kV	Test circuit Prospective current kA	Commencing of arcing after voltage zero °	Instantaneous current at initiation of arcing peak kA	Cut–off current peak kA	Pre–arcing time ms	Arcing time ms	Total operating time ms	Recovery voltage (1) kV	Switching voltage peak kV	Melt ∫I2t kA2s x 10^6	Total ∫I2t kA2s x 10^6	Energy ∫UIt kJ	Condition after test: Fuse–link / Striker; Behaviour during test Remarks
001122 4059	HH–SI 10/24 FC TB 442/56 67240.0400 001684	24 / 40	44.9 / > 300	21.0	63.0	49	6.85	6.85	0.31	6.15	6.46	21.0	48.6	4.77	12.4	112	hot / operated; Fuse cleared.
001122 4060	HH–SI 10/24 FC TB 442/56 67240.0400 001685	24 / 40	44.9 / > 300	21.0	63.0	80	7.49	7.49	0.25	4.40	4.65	21.0	57.0	4.91	14.3	108	hot / operated; Fuse cleared.
001122 4061	HH–SI 10/24 FC TB 442/56 67240.0400 001686	24 / 40	44.8 / > 300	21.0	63.0	80	7.54	7.54	0.25	4.51	4.76	21.0	56.5	4.82	15.3	119	very hot / operated; Fuse cleared.

Remarks: Fuse–base showed no visible change.

(1) Maintained for 15 s.

KEMA

E40E

TABLE WITH TEST RESULTS

TEST CIRCUIT S02 | PAGE 14

REPORT 720–00 | TYPE OF TESTS REQUESTED: Test–duty 1

Condition before tests: Fuse–base in same condition.
Before each test new fuse–link.
Fuse–link mounted vertically in free air.
Distance fuse–link to floor 1.5 m.

Date and test	Fuse–link Type	Fuse–link Rated voltage kV	Fuse–link Rated current A	Resistance before test mΩ	Resistance after test MΩ	Test circuit Applied voltage kV	Test circuit Prospective current kA	Commencing of arcing after voltage zero °	Instantaneous current at initiation of arcing peak kA	Cut–off current peak kA	Pre–arcing time ms	Arcing time ms	Total operating time ms	Recovery voltage (1) kV	Switching voltage peak kV	Melt ∫I2t kA2s x 10^6	Total ∫I2t kA2s x 10^6	Energy ∫UIt kJ	Condition after test: Fuse–link / Striker — Behaviour during test, Remarks
001122 4062	HH–SI 10/24 FC TB 442/56 67240.0630 001709	24	63	24.0	> 300	21.0	63.0	49	10.1	10.1	0.47	6.49	6.96	21.0	50.6	16.6	42.6	230	very hot / operated — Fuse cleared.
001122 4063	HH–SI 10/24 FC TB 442/56 67240.0630 001710	24	63	23.9	> 300	21.0	63.0	80	11.3	11.3	0.35	4.81	5.16	21.0	57.0	15.6	49.2	241	very hot / operated — Fuse cleared.
001122 4064	HH–SI 10/24 FC TB 442/56 67240.0630 001711	24	63	23.7	> 300	21.0	63.0	81	11.3	11.3	0.36	4.77	5.13	21.0	57.8	16.0	47.5	230	very hot / operated — Fuse cleared.

(1) Maintained for 15 s.

Remarks: Fuse–base showed no visible change.
Photograph 0401309.

KEMA

FGH
Engineering & Test GmbH
Mannheim-Rheinau, Hallenweg 40

Test Report

Accredited testing laboratory to DIN EN 45001 for subject

Deutscher Akkreditierungs Rat DAR

DAT-P-103/00-00 High-voltage apparatus switchgear and controlgear

DAT-P-103/00-10 High-voltage cables and accessories

No. **L 01005**

Duly signed copy 1E

Reference: 114-00/1074...1081, 1129...1154

Apparatus: **Current-limiting fuse-link**

Types: a) HH-SI 10/24kV 40A FC TB 442/56, Ident-No.: 67240.0400
b) HH-SI 10/24kV 50A FC TB 442/56, Ident-No.: 67240.0500
c) HH-SI 10/24kV 63A FC TB 442/56, Ident-No.: 67240.0630

Rated voltage: 24 kV
Rated current: a) 40 A, b) 50 A, c) 63 A
Class: Back-up

Manufacturer: EFEN Elektrotechnische Fabrik GmbH,
Postfach 12 54, D-65344 Eltville, Germany

Customer: EFEN Elektrotechnische Fabrik GmbH,
Postfach 12 54, D-65344 Eltville, Germany

Test Specification: IEC 60282-1 (1998-01), Ed.4.2

Tests performed: Breaking tests:

Test duty 2:
Verification of the operation with prospective current I2 at which current limiting occurs when a high level of energy is stored in the inductance of the circuit.

These fuse-links form a homogenous series, therefore only types a) and c) were tested.

Test duty 3:
Verification of the operation at the rated minimum breaking current

Test Results: During the breaking tests performed, the tested fuse-links fully complied with the standard conditions of behaviour with respect to breaking capacity.

Mannheim, January 15, 2001
Hch

FGH Engineering & Test GmbH

Test Engineer:

Place and date of test: LPF Mannheim-Rheinau, November 30, and December 12 and 13, 2000

Number of sheets: 32

No. L 01005 Sheet 14

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	24	40	67240.0400 HH-SI 10/24kV 40A FC TB 442/56

Test-no. 114-00/			1078	1079	1080	1081
Specimen		No.	Adjust-ment test	001688	001689	001690
Resistance		mΩ	-	45.1	45.4	45.5
Test-duty (according to IEC 282-1)			2	2	2	2
Power factor of the test circuit	cos φ		0.09	0.09	0.09	0.09
Prospective breaking current (RMS)		kA	2.26	2.26	2.26	2.26
Making angle after voltage zero		° el	9.4	9.0	9.0	9.0
Pre-arcing / Melting time	t_m	ms		3.73	3.73	3.75
Melting current	i_m	kA		2.37	2.37	2.36
Pre-arcing Joule Integral		kA^2s		5.31	5.27	5.25
Cut-off / Let through current	i_d	kA		2.46	2.45	2.47
Arcing time	t_{LB}	ms		6.61	6.56	6.67
Arcing Joule Integral		kA^2s		14.1	13.5	14.5
Arcing time until breaking by the circuit breaker		ms		-	-	-
Max. switching voltage	u_s	kV		52.7	53.9	52.3
Power frequency recovery voltage	U_W	kV	21.16	21.14	21.14	21.14
Maintaining voltage after breaking		s		60	60	60
Test result:						
Fuse operated correct		y/n		yes	yes	yes
Switching voltage $u_s \leq$ permissive value		y/n		yes	yes	yes
Current limiting:	($i_d \leq$ Let-through characteristic)	y/n		yes	yes	yes
Requirement for I2:	i_m/I = 0.85...1.06	i_m/I		1.05	1.05	1.04
Emission of flames or sand		y/n		no	no	no
Damages (external)		y/n		no	no	no
Operation of striker correct		y/n		yes	yes	yes

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	24	40	67240.0400 HH-SI 10/24kV 40A FC TB 442/56

Test-no.	114-00/		1129	1130	1131	
Specimen		No.	Adjust-ment test	001691	001692	
Resistance		mΩ	-	45.2	45.1	
Test-duty (according to IEC 282-1)			3			
Power factor of the test circuit	cos φ		0.51			
Prospective breaking current (RMS)		A	122			
Maintained current with low voltage source	at 122 A at A	min		4:12	4:17	
Time of current-interruption while switching over from low voltage to high voltage circuit		ms		151	148	
Pre-arcing / Melting time	t_m	s		252	257	
Pre-arcing Joule Integral		kA^2s		-	-	
Arcing time	t_{LB}	ms		176	157	
Arcing Joule Integral		kA^2s		1.80	1.67	
Arcing time until breaking by the circuit breaker		ms		-	-	
Max. switching voltage	u_s	kV		36.1	59.1	
Power frequency recovery voltage	U_W	kV	25.0	24.9	24.9	
Maintaining voltage after breaking		s		60	60	
Test result:						
Fuse operated correct		y/n		yes	yes	
Switching voltage $u_s \leq$ permissive value		y/n		yes	yes	
Emission of flames or sand		y/n		no	no	
Damages (external)		y/n		no	no	
Operation of striker correct		y/n		yes	yes	

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	24	50	67240.0500 HH-SI 10/24kV 50A FC TB 442/56

Test-no. 114-00/		1146	1147	1148	
Specimen	No.	Adjust-ment test	001706	001707	
Resistance	mΩ	-	35.0	34.9	
Test-duty (according to IEC 282-1)		3			
Power factor of the test circuit cos φ		0.50			
Prospective breaking current (RMS)	A	202			
Maintained current with at 201 A low voltage source at A	s		2.66	2.65	
Time of current-interruption while switching over from low voltage to high voltage circuit	ms		151	159	
Pre-arcing / Melting time t_m	s		2.66	2.65	
Pre-arcing Joule Integral	kA^2s		107	107	
Arcing time t_{LB}	ms		95.2	66.8	
Arcing Joule Integral	kA^2s		3.06	2.33	
Arcing time until breaking by the circuit breaker	ms		-	-	
Max. switching voltage u_s	kV		36.0	35.9	
Power frequency recovery voltage U_w	kV	24.8	25.0	25.0	
Maintaining voltage after breaking	s		60	60	
Test result:					
Fuse operated correct	y/n		yes	yes	
Switching voltage $u_s \leq$ permissive value	y/n		yes	yes	
Emission of flames or sand	y/n		no	no	
Damages (external)	y/n		no	no	
Operation of striker correct	y/n		yes	yes	

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	24	63	67240.0630 HH-SI 10/24kV 63A FC TB 442/56

Test-no.	114-00/		1074	1075	1076	1077
Specimen		No.	Adjust-ment test	001713	001714	001715
Resistance		mΩ	-	24.4	24.2	24.1
Test-duty (according to IEC 282-1)			2	2	2	2
Power factor of the test circuit	cos φ		0.09	0.09	0.09	0.09
Prospective breaking current (RMS)		kA	4.26	4.32	4.27	4.27
Making angle after voltage zero		° el	9.4	8.3	9.0	9.0
Pre-arcing / Melting time	t_m	ms		3.71	3.73	3.72
Melting current	I_m	kA		4.42	4.42	4.42
Pre-arcing Joule Integral		kA^2s		18.2	18.3	18.4
Cut-off / Let through current	i_d	kA		4.49	4.47	4.48
Arcing time	t_{LB}	ms		6.62	6.59	6.53
Arcing Joule Integral		kA^2s		42.4	41.3	41.9
Arcing time until breaking by the circuit breaker		ms		-	-	-
Max. switching voltage	u_s	kV		54.9	55.0	54.2
Power frequency recovery voltage	U_w	kV	20.90	21.17	20.95	20.93
Maintaining voltage after breaking		s		60	60	60

Test result:

Fuse operated correct	y/n		yes	yes	yes
Switching voltage $u_s \leq$ permissive value	y/n		yes	yes	yes
Current limiting: ($i_d \leq$ Let-through characteristic)	y/n		yes	yes	yes
Requirement for I2: i_m/I = 0.85...1.06	i_m/I		1.02	1.04	1.04
Emission of flames or sand	y/n		no	no	no
Damages (external)	y/n		no	no	no
Operation of striker correct	y/n		yes	yes	yes

FUSE-LINKS - BREAKING TESTS

Tested fuse-link	Ur [kV]	Ir [A]	Type
	24	63	67240.0630 HH-SI 10/24kV 63A FC TB 442/56

Test-no. 114-00/				1152	1153	1154	
Specimen			No.	Adjust-ment test	001718	001719	
Resistance			mΩ	-	24.1	24.1	
Test-duty (according to IEC 282-1)				3			
Power factor of the test circuit		cos φ		0.50			
Prospective breaking current (RMS)			A	278			
Maintained current with low voltage source	at 279 A		s		1.95		
	at 277 A					1.96	
Time of current-interruption while switching over from low voltage to high voltage circuit			ms		150	151	
Pre-arcing / Melting time		t_m	s		1.95	1.96	
Pre-arcing Joule Integral			kA^2s		152	150	
Arcing time		t_{LB}	ms		111	76.2	
Arcing Joule Integral			kA^2s		5.58	4.83	
Arcing time until breaking by the circuit breaker			ms		-	-	
Max. switching voltage		u_s	kV		51.2	36.2	
Power frequency recovery voltage		U_W	kV	25.0	25.0	25.0	
Maintaining voltage after breaking			s		60	60	
Test result:							
Fuse operated correct			y/n		yes	yes	
Switching voltage $u_s \leq$ permissive value			y/n		yes	yes	
Emission of flames or sand			y/n		no	no	
Damages (external)			y/n		no	no	
Operation of striker correct			y/n		yes	yes	

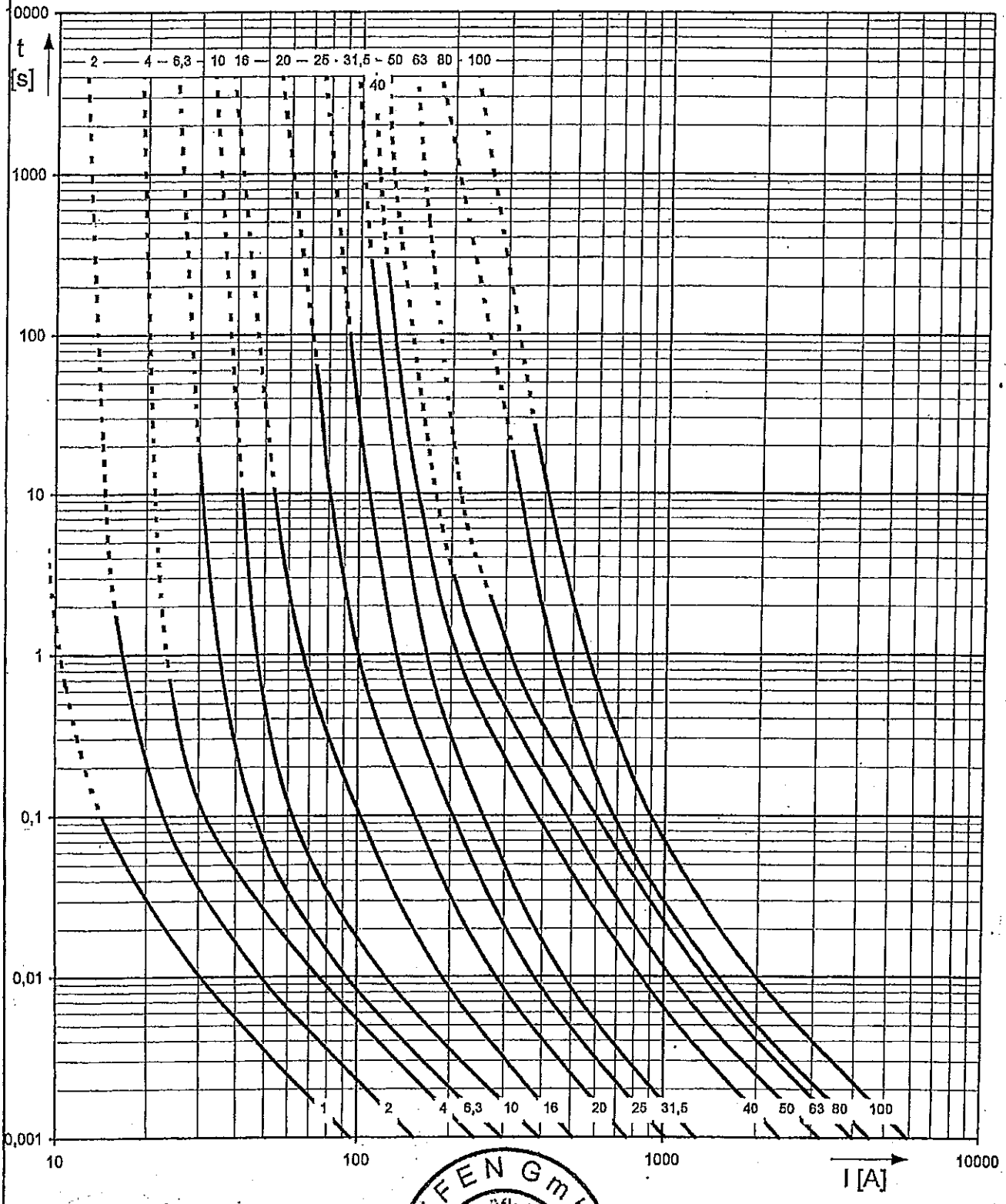
EFEN WICKMANN GRUPPE

Time-current characteristics of H.V. back-up fuse-links with ÜLA (controlled power dissipation)

Lab.-No. 01169

10/24 kV 1 A - 100 A acc. to IEC 60282-1 / VDE 0670 Teil 4

Order-No.: 67240.0019 - 67240.1009



EFEN GmbH Prüflabor Test Laboratory Eltville

06.06.2001 / 23

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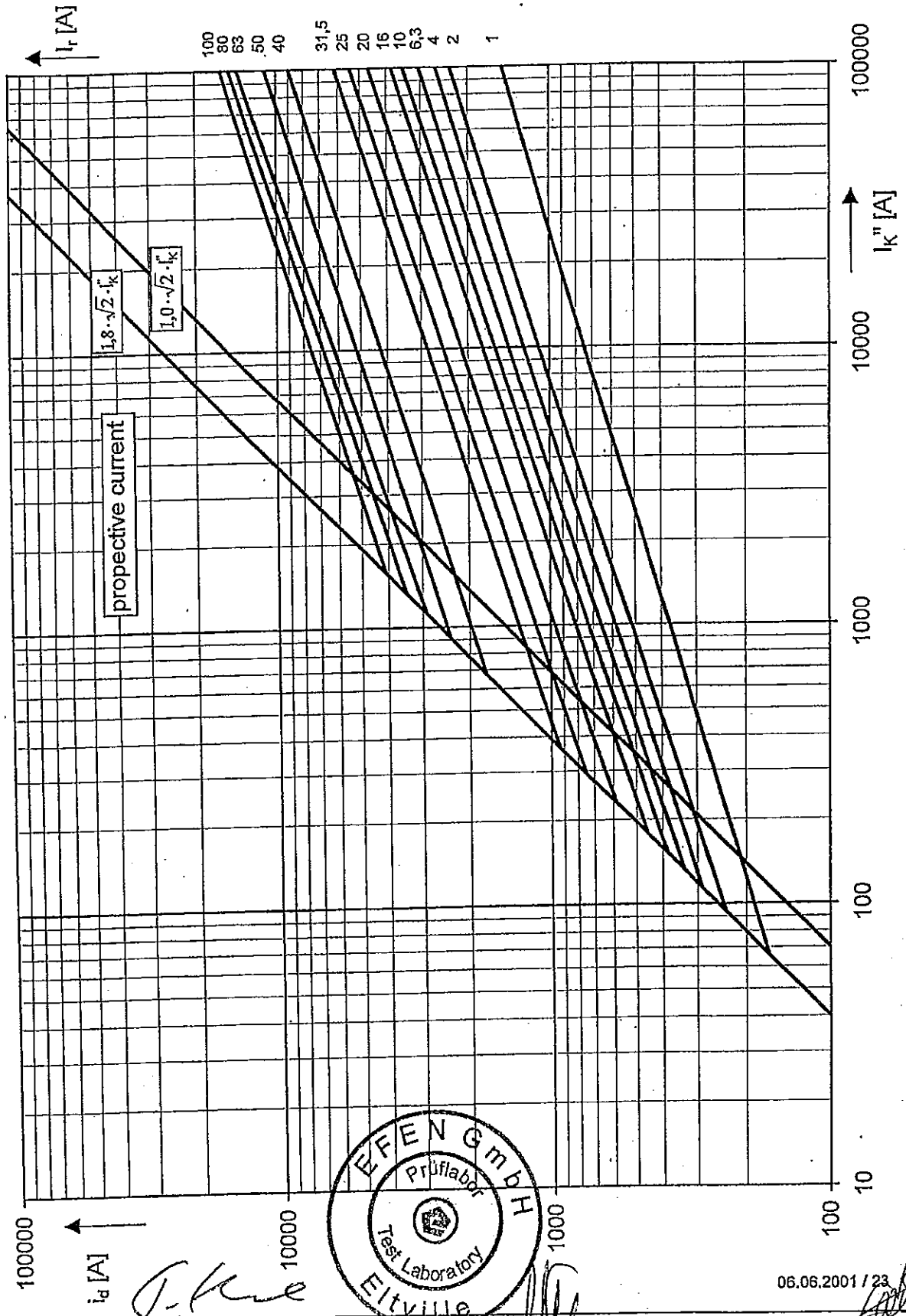
WICKMANN GRUPPE

Cut-off characteristics of H.V. back-up fuse-links with ÜLA (controlled power dissipation)

Lab.-No. 01171 10/24 kV 1 A - 100 A acc. to IEC 60282-1 / VDE 0670 Teil 4

Order-No.: 67240.0019 to 67240.1009



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1. Type HH – fuse link with striker 81902.0100(3) (duration 30mm)

2. Reason for test

Test of Strikers

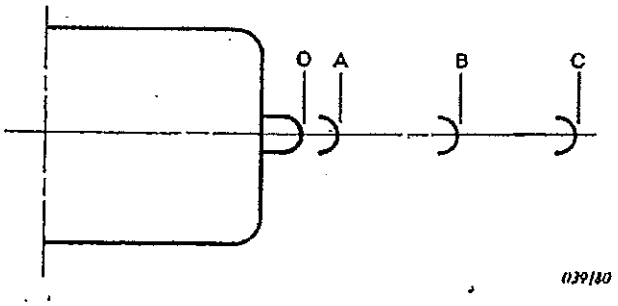
3. Tests performed / measurements

I. measurement of the duration of travel
II. measurement of the force-travel characteristics and calculation of the striker energy actuated by the spring
III. Verification of the withstand force according to applied standard (4)

4. Applied standards

IEC 60282-1 2002-01 VDE 0670 Teil 4 Abs. 12 02/98

4.1 standard in detail regarding strikers



OA – Free travel – No energy output specified.
AB – Further travel during which energy must be delivered.
OB – Minimum actual travel.
OC – Maximum actual travel.
CB – Maximum permitted return travel under withstand force (when applicable).

Type	Energy	Mechanical characteristics					
		Values of		Actual travel		Minimum withstand force	Maximum duration of travel (see note)
		Free travel (OA)*	Further travel during which energy must be delivered (AB)*	Min. (OB)*	Max. (OC)*		
	J	mm	mm	mm	mm	N	ms
Light	0,3 ± 0,25	2	8	10	30	Not applicable	100
Medium	1 ± 0,5	4	16	20	40	20	100
Heavy	2 ± 1	4	6	10	16	40	100

* See figure 12.

NOTE – Duration of travel is defined for actual fuse-links as the time from commencement of arcing to the time when travel OB is reached. For dummy fuses it is the time from application of voltage until travel OB is reached.

5. Test-laboratory, period of time

EFEN laboratory Eltville, 4.12.2003

6. Arrangement of the equipment

I. The tested fuse link is fixed in a fuse-base. An NC (normally closed) switch will be opened if the striker has travelled 30mm. Current, Voltage and the NC switch are recorded by an digital oscilloscope.

II. & III. The force-travel characteristics will be measured by an approved force meter*. For this measurement the striker will be prepared with an scale indicator for measuring the travelled way in mm.

*Zwick Z2.5 / TN1S Material testing device

7. Inspection and test sequence

I. Intact striker circuit is tested with current < 10A and voltage < 15V.
II. Current, voltage and the NC switch are recorded.
III. Force of striker is measured at Positions: 0, 10, und 20mm.
The Position of the Striker is measured at the minimum withstand force of 20N.

8. Results

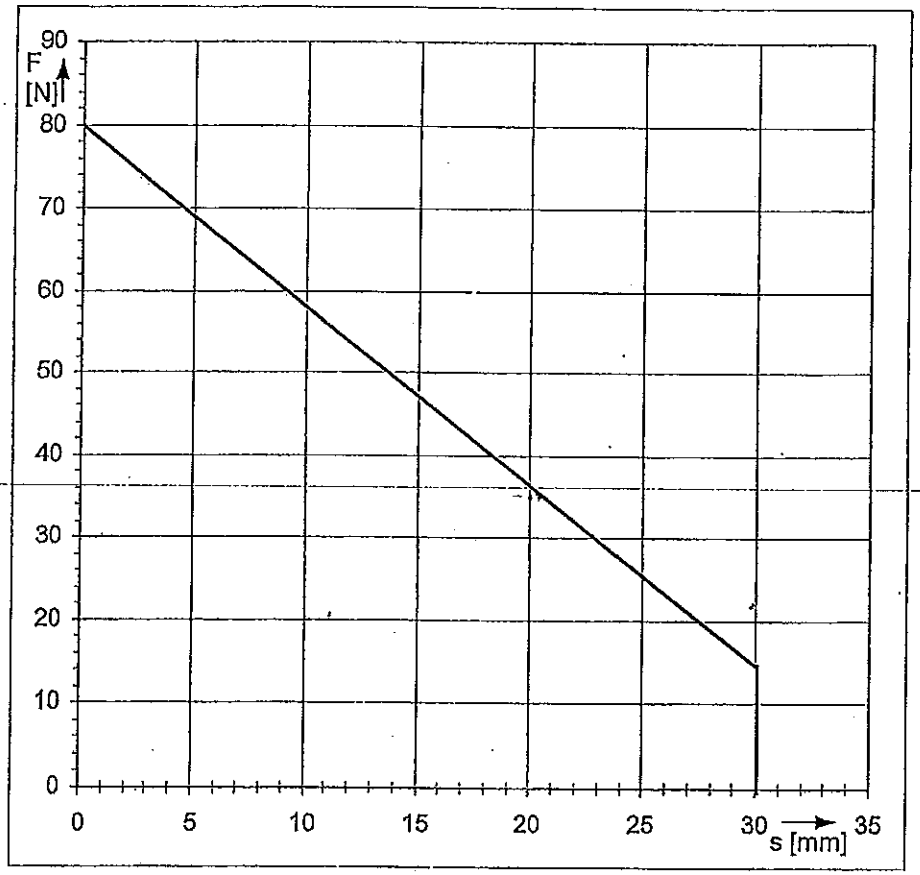
I. measurement of the duration of travel

	duration of travel	Current	Voltage
Sample 1	5 ms	9,9 A	< 15 V
Sample 2	2 ms	11,7 A	< 15 V
Sample 3	4 ms	10 A	< 15 V
Sample 4	6 ms	9,9 A	< 15 V

II. measurement of the force-travel characteristics and calculation of the striker energy

		Sample 1		Sample 2		Sample 3		
Position	Length / mm	Measurem. 1	Measurem. 2	Measurem. 1	Measurem. 2	Measurem. 1	Measurem. 2	Average:
O	0	77	76,8	86,5	81,7	78	78	79,5
A	4	66,5	66,4	67,5	67,4	71,7	69,7	68,2
B	20	37,7	36,1	33,7	33,1	36,2	36,5	35,6
	Energy / J:	0,83	0,82	0,81	0,80	0,86	0,85	0,83

$$Energy = \frac{(F_A + F_B) \times \overline{AB}}{2000} \qquad Energy[J];\ F_A[N];\ F_B[N];\ \overline{AB}[mm];$$



III. Verification of the withstand force of 20N at Position ≥ 20mm

	Measurement	Force / N	Length / mm
Sample 1	1	20	27,4
Sample 1	2	20	27,7
Sample 2	1	20	27,3
Sample 2	2	20	26,9
Sample 3	1	20	28,4
Sample 3	2	20	28,4