

High-voltage high-breaking capacity VV fuse-links

General information

ETI HV fuse-links named VV THERMO are designed to protect devices in switch-gears and other equipment (distribution transformers, capacitors, motors) from thermal and dynamic effects of shortcircuits and overcurrents. Time-current characteristics correspond to standard IEC 60282-1, item 3.3.3. Back-up fuse.

They are suitable for installation in:

- indoor and outdoor switchgear
- gas (SF6)-insulated enclosures
- special service conditions (different from normal conditions, described in item 2.1. of standard IEC 60282-1)

The most significant features of ETI high voltage fuses:

- Low temperature rise because of low power dissipation
- High breaking capacity 50 kA
- Possibility of three different striker pin forces: 80 N and 120 N (with integrated temperature dependent limiter) and 50 N.
- Reliable sealing system against humidity irruption
- Low switching voltages
- Upon a request, fuse links can be supplied into no-standard dimensions

Overview of standard and non-standard dimensions

ETI VV THERMO	2A	4A	6A	10A	16A	20A	25A	32A	40A	50A	63A	80A	100A	125A	160A	200A	250A	315A	
7,2 kV	192 x Ø 53										192 x Ø 68			192 x Ø 85					
	292 x Ø 53										292 x Ø 68			292 x Ø 85					
	442 x Ø 53										442 x Ø 68			442 x Ø 85					
	192 x Ø 53										192 x Ø 68			192 x Ø 85					
12 kV	292 x Ø 53										292 x Ø 68			292 x Ø 85					
	442 x Ø 53										442 x Ø 68			442 x Ø 85					
	192 x Ø 53										192 x Ø 68			192 x Ø 85					
	537 x Ø 85										537 x Ø 85			537 x Ø 85					
17.5 kV	292 x Ø 53										292 x Ø 68			292 x Ø 85					
	367 x Ø 53										367 x Ø 68			367 x Ø 85					
	442 x Ø 53										442 x Ø 68			442 x Ø 85					
	292 x Ø 53										292 x Ø 68			292 x Ø 85					
24 kV	292 x Ø 53										292 x Ø 68			292 x Ø 85					
	442 x Ø 53										442 x Ø 68			442 x Ø 85					
	537 x Ø 53										537 x Ø 68			537 x Ø 85					
	442 x Ø 53										442 x Ø 68			442 x Ø 85					
36 kV	442 x Ø 53										537 x Ø 68			537 x Ø 85					
	537 x Ø 53										537 x Ø 68			537 x Ø 85					

Standards

ETI VV (Medium Voltage) fuse-links comply with the following standards and specifications:

- IEC 60282-1, Sixth edition 11/2005 "Current limiting fuses"
- DIN 43625 "Hochspannungs-Sicherungen Nennspannung 3,6 bis 36kV"
- "VDE 0670 T402, Wechselstromschaltgeraete fuer Spannungen ueber 1 kV, Auswahl von strombegrenzenden Sicherungseinsaetzen fuer Transformatorstromkreise" / IEC 60787 "Application guide for the selection of high-voltage current limiting fuse-links for transformer circuits"
- IEC 60644 "Specification for high-voltage fuse-links for motor circuit applications"
- IEC 60549 "High-voltage fuses for external protection of power capacitors"

Certificates, Test reports

- CESI (Milan, Italy) certificate for 12kV, 17.5kV and 24kV
- KERI (Chang Wong, S.Korea) certificate for 7.2kV and 24kV
- ICMET (Craiova, Romania) test report for 36kV
- Test reports for 25kV, 38.5kV, 40.5kV and 42kV versions

Construction:

ETI high voltage fuses are designed to assure stable and reliable characteristics. The glazed porcelain tube (made in ETI own ceramic factory) is extremely high mechanical and thermal resistant.

Galvanically protected contact caps made of electrolytic copper are nickel - or upon customer request silver plated. Caps are rolled by pressing into the groove of the tube. The tightness of this connection is assured by a special seal resistant to ageing and high temperatures.

The design and method of production of the melting elements ensures precisely tolerances and stable time/current characteristics. Fuse elements are wounded on a ceramic carrier and electrically welded on a special copper strips.

The inside of the tube is filled with quartz sand with an exactly determined granulation and chemical structure. The sand guarantees good and reliable extinguishing of the electric arc.

An important element in the fuse-link construction is also the striker system. Part of that system is temperature sensitive element, which reacts in cases of temperature increasing of the fuse-link due to various reasons. The reaction temperature is set to approximately 250 ° C on fuse tube surface. The system reacts in such a way that short time overloads do not cause the fuse to interrupt the circuit unnecessarily. Only when inadmissible values of surrounding temperatures are exceeded, the fuse open the switch via the striker pin. Because of these characteristics, ETI "thermal" striker pin is convenient for the protection of the fuse enclosure of SF6 switchgears which requires additional protection features against inadmissible temperatures of certain switchgear parts.

Striker pin Type description, rated voltage 7,2 kV example:

- VVC; 50N striker force (C mark).
- VVT-D; Temperature limiter (VVT), 80N striker force (D mark).
- VVT-E; Temperature limiter (VVT), 120N striker force (E mark).

Technical data

rated voltage	Dimension "e" according to DIN and IEC	rated current	Striker type	Rated breaking capacity	Rated minimum breaking current	cold resistance	power dissipation	pre-arcing I ² t value	total I ² t value
[kV]	(mm)	I _n [A]		(kA)	(A)	[mΩ]	[W]	[A ² s]	[A ² s]
3/7.2	192	2 A	VV, VWF-D, VWF-E	50	12	580	4	6,1	57
		4 A			20	370	9	17,3	164
		6 A			25	260	10	36	340
		10 A			46	55	7	161	1 530
		16 A			60	37	13	250	2 270
		20 A			80	30	15	430	3 750
		25 A			105	25	20	650	5 500
		32 A			130	18,5	28	1 120	10 100
		40 A			178	13	33	2 270	18 100
		50 A			220	8.5	26	6 270	31 300
		63 A			270	7.0	43	10 200	50 800
		80 A			360	5.2	50	18 700	93 500
		100 A			540	4.6	66	38 000	197 000
		125 A			610	3.4	101	61 500	319 000
		160 A			810	2,55	135	102 200	528 000
	292	VV, VWF-D, VWF-E	50	2A	12	580	4	6,1	57
				4A	20	370	9	17,3	164
				6 A	25	260	10	36	340
				10 A	46	55	7	161	1 530
				16 A	60	37	13	250	2 270
				20 A	80	30	15	430	3 750
				25 A	105	25	20	650	5 500
				32 A	130	18,5	28	1 120	10 100
				40 A	178	13	33	2 270	18 100
				50 A	220	8.5	26	6 270	31 300
				63 A	270	7.0	43	10 200	50 800
				80 A	360	5.2	50	18 700	93 500
				100 A	540	4.6	66	38 000	197 000
				125 A	610	3.4	101	61 500	319 000
				160 A	810	2,55	135	102 200	528 000
	200 A	1000	2.1	155	151 780	789 270			
	250 A	1250	1.7	196	228 610	1 188 800			
	442	VV, VWF-D, VWF-E	50	2A	12	840	4,7	6,1	57
				4A	20	530	11,7	17,3	164
				6A	25	270	13,4	36	340
				10A	46	67,5	9	161	1530
				16A	60	45,3	16	250	2270
				20A	80	38	20	430	3750
				25A	105	30	25	650	5500
				32A	130	22,5	31	1120	10100
				40A	178	16,2	35	2270	18100
				50A	220	10,5	39	6270	31300
				63 A	270	8.5	62	10 200	50 800
				80 A	360	6.5	77	18 700	93 500
				100 A	540	5.7	105	38 000	197 000
125 A				610	4	115	61 500	319 000	
160 A				810	3.2	151	102 200	528 000	
200 A	1000	2.65	195	151 780	789 270				
250 A	1250	2.2	253	228 610	1 188 800				
315 A	1575	1.75	320	368 640	1 916 930				

Technical data

rated voltage	Dimension "e" according to DIN and IEC	rated current	Striker type	Rated breaking capacity	Rated minimum breaking current	cold resistance	power dissipation	pre-arcing I ² t value	total I ² t value			
[kV]	(mm)	I _n [A]		(kA)	(A)	[mΩ]	[W]	[A ² s]	[A ² s]			
6/12	192	2 A	VVC, VWT-D, VWT-E	50	12	980	6	6,1	57			
		4 A			20	650	15	17,3	164			
		6 A			27	435	21	36	340			
		10 A			50	87	8	161	1 530			
		16 A			80	60,5	19	250	2 270			
		20 A			100	47	22	430	3 750			
		25 A			125	37	34	650	5 500			
		32 A			160	27	43	1220	10 100			
		40 A			200	21	54	2 270	18 100			
		50 A			250	14	44	6 270	31 300			
	292	VVC, VWT-D, VWT-E	63	2 A	12	980	6	6,1	57			
				4 A	20	650	15	17,3	164			
				6 A	25	435	21	36	340			
				10 A	46	87	8	161	1 530			
				16 A	60	60,5	19	250	2 270			
				20 A	80	47	22	430	3 750			
				25 A	105	37	34	650	5 500			
				32 A	130	27	43	1220	10 100			
				40 A	178	21	54	2 270	18 100			
				50 A	220	14	44	6 270	31 300			
				63 A	270	10,5	65	10 200	50 800			
				80 A	360	8	73	18 700	93 500			
				100 A	540	7,3	109	38 000	197 000			
				125 A	610	5,1	137	61 500	319 000			
				160 A	810	4	189	102 200	528 000			
				442	VVC, VWT-D, VWT-E	63	2 A	12	980	6	6,1	57
	4 A	20	650				15	17,3	164			
	6 A	25	435				21	36	340			
	10 A	46	87				8	161	1 530			
	16 A	60	60,5				19	250	2 270			
	20 A	80	47				22	430	3 750			
	25 A	105	37				34	650	5 500			
	32 A	130	27				43	1220	10 100			
	40 A	178	21				54	2 270	18 100			
	50 A	220	14				44	6 270	31 300			
	63 A	270	10,5				65	10 200	50 800			
	80 A	360	8				73	18 700	93 500			
	100 A	540	7,3				109	38 000	197 000			
	125 A	610	5,1				137	61 500	319 000			
	160 A	810	4				189	102 200	528 000			
	200 A	1000	3,3				238	151 780	789 270			
	537	VVC, VWT-D, VWT-E	63				160 A	810	4	189	102 200	528 000
							200 A	1000	3,3	238	151 780	789 270
							250 A	1250	2,65	305	228610	1 188 800

Technical data													
rated voltage	Dimension "e" according to DIN and IEC	rated current	Striker type	Rated breaking capacity	Rated minimum breaking current	cold resistance	power dissipation	pre-arcing I ² t value	total I ² t value				
[kV]	(mm)	I _n [A]		(kA)	(A)	[mΩ]	[W]	[A ² s]	[A ² s]				
10/17.5	292	2 A	VVC, VVT-D, VVT-E	50	12	1400	8	6,1	57				
		4 A			20	900	17	17,3	164				
		6 A			27	670	35	36	340				
		10 A			50	115	11	161	1 530				
		16 A			80	82	28	250	2 270				
		20 A			100	65	38	430	3 750				
		25 A			125	54	45	650	5 500				
		32 A			160	38	61	1220	10 100				
		40 A			200	29	69	2 270	18 100				
		50 A			250	19	63	6 270	31 300				
		63 A			283	15	91	10 200	50 800				
		80 A			400	11	118	18 700	93 500				
		100A			550	9,4	158	38000	197000				
		367			367	2 A	VVC, VVT-D, VVT-E	63	12	1400	8	6,1	57
						4 A			20	900	17	17,3	164
	6 A		25	670		35			36	340			
	10 A		46	115		11			161	1 530			
	16 A		60	82		28			250	2 270			
	20 A		80	65		38			430	3750			
	25 A		105	54		45			650	5500			
	32 A		130	38		61			1220	10 100			
	40 A		178	29		69			2 270	18 100			
	50 A		220	19		63			6 270	31 300			
	63 A		270	15		91			10 200	50 800			
	80 A		360	11		118			18 700	93 500			
	100 A		540	9.5		156			38 000	197 000			
	125 A		610	6.8		193			61 500	319 000			
	160 A		810	5.5		255			102 200	528 000			
	442	442	2 A	VVC, VVT-D, VVT-E	63	12	1400	8	6,1	57			
			4 A			20	900	17	17,3	164			
			6 A			25	670	35	36	340			
			10 A			46	115	11	161	1 530			
			16 A			60	82	28	250	2 270			
			20 A			80	65	38	430	3 750			
			25 A			105	54	45	650	5 500			
			32 A			130	38	61	1220	10 100			
			40 A			178	29	69	2 270	18 100			
			50 A			220	19	63	6 270	31 300			
			63 A			270	15	91	10 200	50 800			
			80 A			360	11	118	18 700	93 500			
			100 A			540	9.5	156	38 000	197 000			
			125 A			610	6.8	193	61 500	319 000			

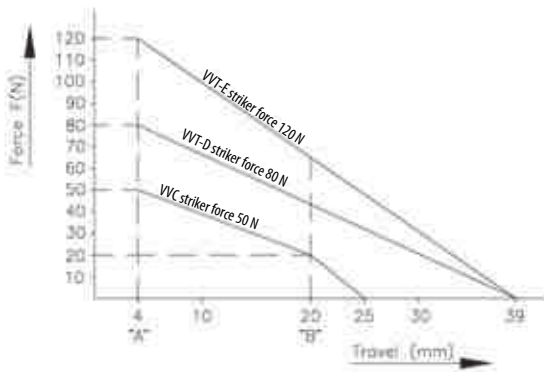
Technical data

rated voltage	Dimension "e" according to DIN and IEC	rated current	Striker type	Rated breaking capacity	Rated minimum breaking current	cold resistance	power dissipation	pre-arcing I ² t value	total I ² t value	
[kV]	(mm)	I _n [A]		(kA)	(A)	[mΩ]	[W]	[A ² s]	[A ² s]	
10/24	292	2 A	VVC, VWT-D, VWT-E	31,5	12	2040	12	6,1	57	
		4 A			20	1300	35	17,3	164	
		6 A			27	900	56	36	340	
		10 A			50	160	19	161	1 530	
		16 A			80	106	35	250	2 270	
		20 A			100	85	44	430	3 750	
		25 A			125	67	58	650	5 500	
		32 A			160	48	71	1220	10 100	
		40 A			200	37.5	95	2 270	18 100	
		50 A			250	25	81	6 270	31 300	
		63A			283	20	120	10 200	50 800	
		442			442	2 A	VVC, VWT-D, VWT-E	63	12	2040
	4 A		20	1300		35			17,3	164
	6 A		25	900		56			36	340
	10 A		46	160		19			161	1 530
	16 A		60	106		35			250	2 270
	20 A		80	85		44			430	3 750
	25 A		105	67		58			650	5 500
	32 A		130	48		71			1220	10 100
	40 A		178	37.5		95			2 270	18 100
	50 A		220	25		81			6 270	31 300
	63A		270	20		120			10 200	50 800
	80 A		360	15		157			18 700	93 500
	100 A		540	13.8		235			38 000	197 000
	125 A		610	9.6		304			61 500	319 000
	537	537	2 A	VVC, VWT-D, VWT-E	63	12	2040	12	6,1	57
			4 A			20	1300	35	17,3	164
			6 A			25	900	56	36	340
			10 A			46	160	19	161	1 530
			16 A			60	106	35	250	2 270
			20 A			80	85	44	430	3 750
			25 A			105	67	58	650	5 500
			32 A			130	48	71	1220	10 100
			40 A			178	37.5	95	2 270	18 100
			50 A			220	25	81	6 270	31 300
			63A			270	20	120	10 200	50 800
80 A			360			15	157	18 700	93 500	
100 A			540			13.8	235	38 000	197 000	
125 A			610			9.6	304	61 500	319 000	
	160 A	810	8	410	74 650	388 180				

Technical data

rated voltage	Dimension "e" according to DIN and IEC	rated current	Striker type	Rated breaking capacity	Rated minimum breaking current	cold resistance	power dissipation	pre-arcing I ² t value	total I ² t value
[kV]	(mm)	I _n [A]		(kA)	(A)	[mΩ]	[W]	[A ² s]	[A ² s]
20/36	442	2 A	VVC, VVT-D, VVT-E	20	12	2900	17	6,1	57
		4 A			20	1870	45	17,3	164
		6 A			27	1300	73	36	340
		10 A			50	225	28	161	1 530
		16 A			80	150	53	250	2 270
	537	VVC, VVT-D, VVT-E	31,5	2 A	12	2900	17	6,1	57
				4 A	20	1870	45	17,3	164
				6 A	25	1300	73	36	340
				10 A	46	225	28	161	1 530
				16 A	60	150	53	250	2 270
				20 A	80	122	74	430	3 750
				25 A	105	95	87	650	5 500
				32 A	130	69	111	1 220	10 100
				40 A	178	52	139	2 270	18 100
				50 A	220	35	125	6 270	31 300
				63 A	270	28	185	10 200	50 800
				80 A**	360	21	213	18 700	93 500

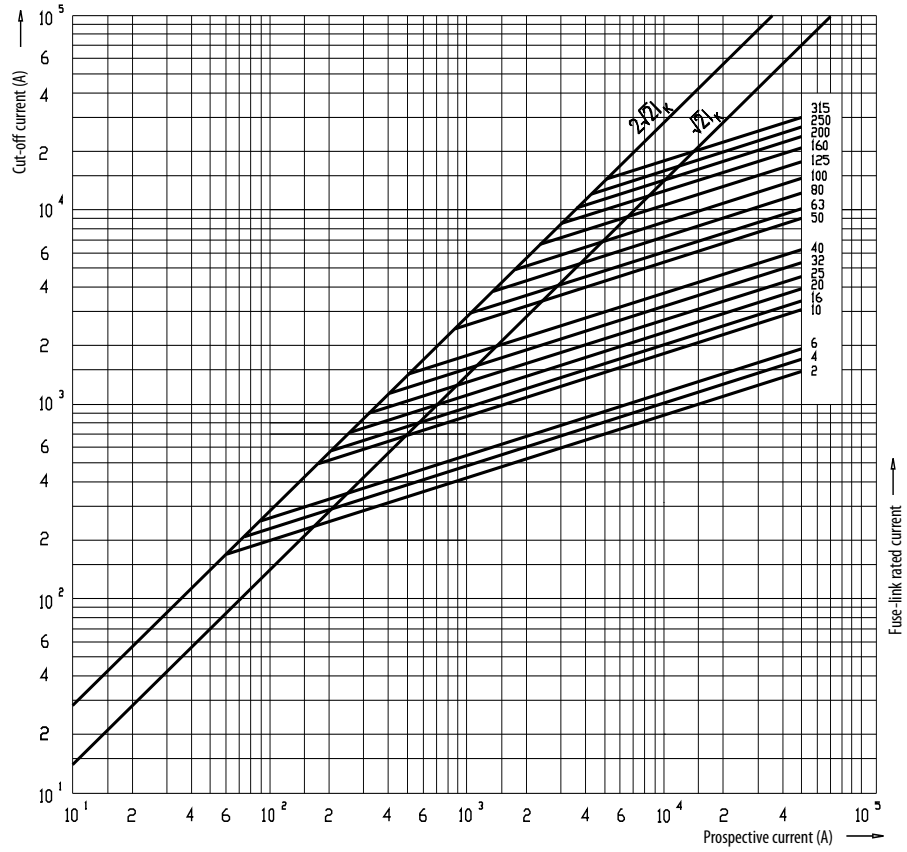
Force / travel striker pin diagram



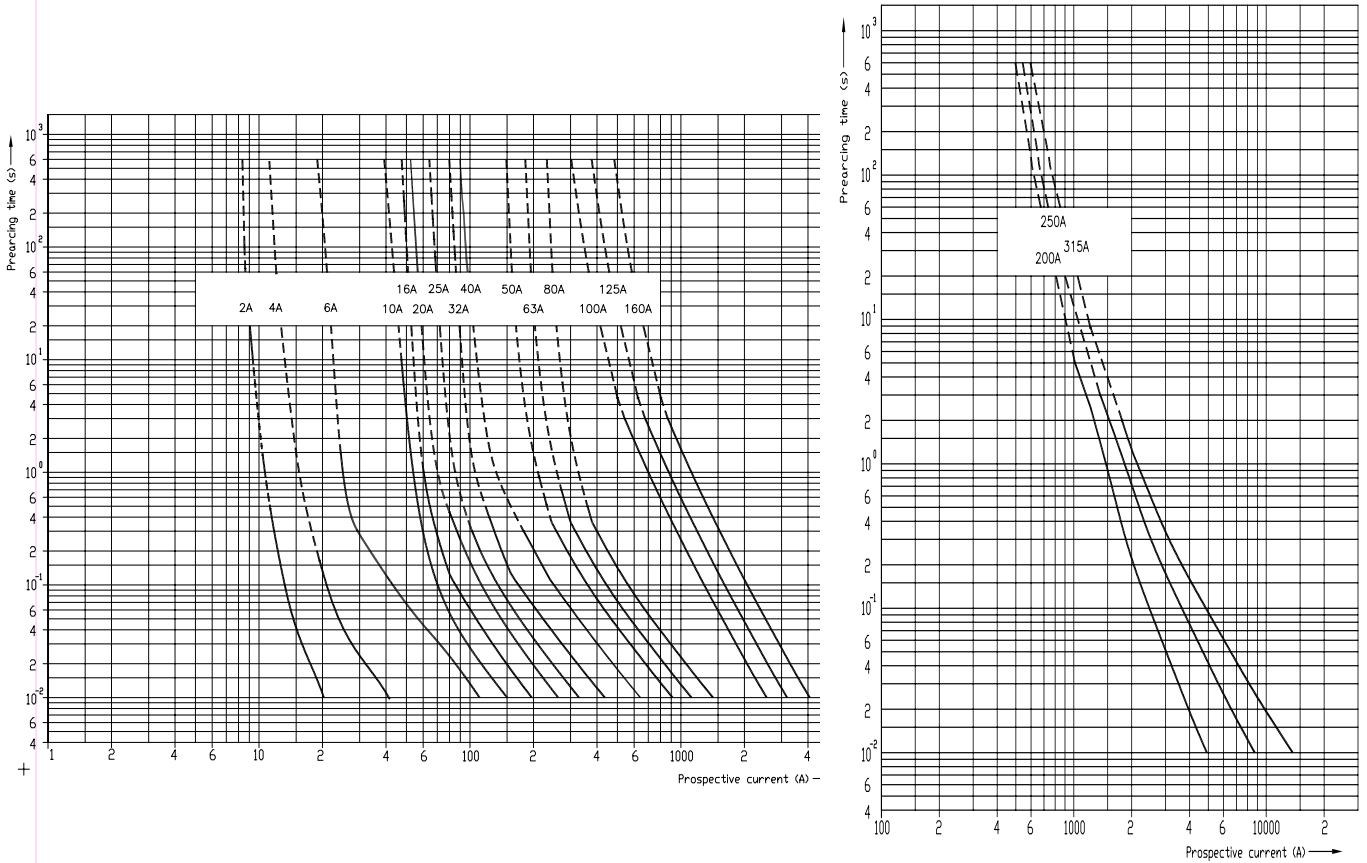
Connection in indoor switchgear, example:



Cut-off current diagram for VV-Thermo fuse links



Time-current characteristics for VV-thermo fuse links

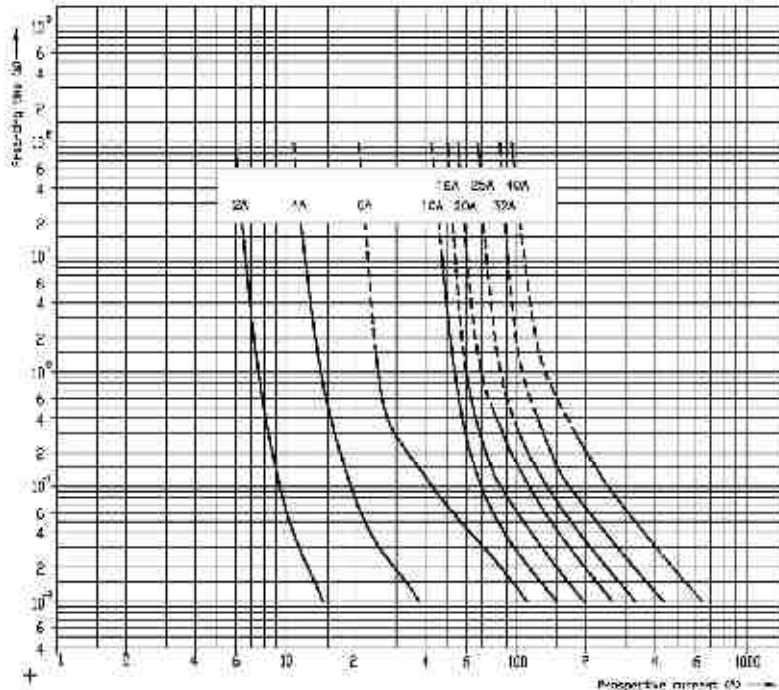


High voltage fuse-links for liquid-immersed transformer protection

Technical data

rated voltage	Dimension "e" according to DIN and IEC	rated current	Striker type	Rated breaking capacity	Rated minimum breaking current	cold resistance	power dissipation	pre-arcing I ² t value	total I ² t value
[kV]	(mm)	I _n [A]		(kA)	(A)	[mΩ]	[W]	[A ² s]	[A ² s]
6/12	292	2A	WVT-D	50	12	980	6	6,1	57
		4A			20	650	15	17,3	164
		6A			25	435	21	36	340
		10A			46	87	8	161	1530
		16A			60	60,5	19	250	2270
		20A			80	47	22	430	3750
		25A			105	37	34	650	5500
		32A			130	27	43	1220	10100
		40A			178	21	54	2270	18100
10/24	292	2A	WVT-D	50	12	2040	12	6,1	57
		4A			20	1300	35	17,3	164
		6A			25	900	56	36	340
		10A			46	160	19	161	1530
		16A			60	106	35	250	2270
		2A			442	WVT-D	50	12	2040
	4A	20	1300	35				17,3	164
	6A	25	900	56				36	340
	10A	46	160	19				161	1530
	16A	60	106	35				250	2270
	20A	80	85	44				430	3750
	25A	105	67	58				650	5500
	32A	130	48	71				1220	10100
	40A	178	37,5	95				2270	18100

Time-current characteristics



High voltage fuses for protection of voltage transformers

Technical data

rated voltage	Dimension "e" according to DIN and IEC	rated current	Striker type	Rated breaking capacity	Rated minimum breaking current	cold resistance	power dissipation	pre-arcing I ² t value	total I ² t value
[kV]	(mm)	I _n [A]		(kA)	(A)	[mΩ]	[W]	[A ² s]	[A ² s]
10/24	235	2A	/	20	12	2040	14	6,1	57
		4A			20	1300	38	17,3	164

Selection of fuses for transformer protection

For HV fuse-link rated current selection, following transformer technical features has to be known:

- Rated power P_n (kVA)
- Short-circuit voltage U_{cc} (%)
- Rated current I_{nt}
- Inrush current usually between $8-12 \times I_{nt}$
- Short-circuit current I_{cc}
- Overload current usually $1.4 I_{nt}$
- Maximum short-circuit duration. Standard 2 sec for transformers up to 630 kVA and 3 sec for higher rated powers

Following HV fuse-link technical features has to be known:

- Rated voltage U_n (kV)
- Rated current I_n (A)
- I/t Characteristics According to the curves
- Melting current (0.1 sec) $I_{f(0.1sec)}$
- Melting current at 2s ec or 3sec melting time
- Minimum breaking current I_3 (A)
- Breaking capacity I_1 (kA)

General about transformer protection:

- Fuse-link rated voltage U_n must be higher then network voltage.
- Maximum fuse-link breaking current I_1 must be higher then short circuit-current I_{cc} .
- Inrush current should not melt the fuse-link. Melting current at 100 msec must be higher than 12 times transformer rated current
- Fuse-link has to operate before the expected short-circuit current damage the transformer $I_{cc} > I_f$ (2 sec) or $I_{cc} > I_f$ (3 sec)
- Fuse-link must be able to withstand possible short duration overloads. $I_n \text{ FUSE} > 1.4 I_n \text{ TRAF0}$

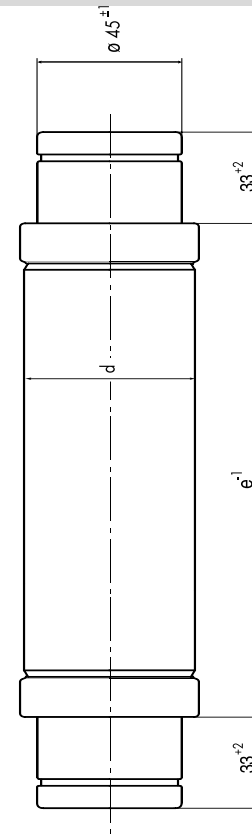
Selection table for VV - THERMO back-up fuse links

Pt (kVA)	6/7,2 kV					10/12 kV					15/17.5kV				
	Transformer rated primary current Ip(A) at 6 kV	Inrush current (A)	HV Fuse-link rated current		LV Fuse- Link NH gG	Transformer rated primary current Ip(A) at 10 kV	Inrush current (A)	HV Fuse-link rated current		LV Fuse- Link NH gG	Transformer rated primary current Ip(A) at 15 kV	Inrush current (A)	HV Fuse-link rated current		LV Fuse- Link NH gG
			I_{HV} min (A)	I_{HV} max (A)				I_{LV} (A)	I_{HV} min (A)				I_{HV} max (A)	I_{LV} (A)	
50	5	58	10	16	63	3	35	6	10	63	2	23	6	10	63
75	7	86	16	20	100	4	52	10	16	100	3	35	6	10	100
100	10	115	25	32	125	6	70	10	16	125	4	46	10	16	125
125	12	145	32	40	160	7	86	16	20	160	5	58	10	16	160
160	15	185	40	50	200	9	110	20	25	200	6	74	16	20	200
200	19	230	40	50	250	12	138	25	32	250	8	92	20	25	250
250	24	289	50	63	315	14	173	32	40	315	10	115	25	32	315
315	30	364	50	63	400	18	218	40	50	400	12	145	32	40	400
400	39	462	63	80	500	23	276	50	63	500	15	185	40	50	500
500	48	577	80	100	630	29	346	50	63	630	19	230	40	50	630
630	61	727	100	125	800	36	437	63	80	800	24	293	50	63	800
800	77	923	100	125	1000	46	554	80	100	1000	31	370	63	80	1000
1000	96	1154	125	160	1250	58	692	100	125	1250	38	462	80	100	1250
1250	120	1440	160	200*	1250	72	866	100	125	1250	48	577	100	125	1250
1600	154	1848	200*	250*	1500	92	1109	125	160	1500	62	739	125	160	1500
2000	192	2310	250*	315*	1600	115	1380	160	200*	1600					

* Note: nonstandard tube dimension

Selection table for VV - THERMO back-up fuse links

Pt (kVA)	20/24 kV					30/36 kV				
	Transformer rated pri- mary current Ip(A) at 20 kV	Inrush current (A)	HV Fuse-link rated current		LV Fuse- Link NH gG	Transformer rated pri- mary current Ip(A) at 30 kV	Inrush current (A)	HV Fuse-link rated current		LV Fuse- Link NH gG
			I_{HV} min (A)	I_{HV} max (A)				I_{LV} (A)	I_{HV} min (A)	
50	1	18	4	6	63	1	12	2	4	63
75	2	26	4	6	100	1	17	4	6	100
100	3	35	6	10	125	2	23	6	10	125
125	4	43	6	10	160	2	29	6	10	160
160	5	55	10	16	200	3	37	6	10	200
200	6	70	10	16	250	4	46	10	16	250
250	7	86	16	20	315	5	58	10	16	315
315	9	109	20	25	400	6	73	16	20	400
400	12	138	25	32	500	8	92	20	25	500
500	14	173	32	40	630	10	115	20	25	630
630	18	217	40	50	800	12	145	25	32	800
800	23	277	50	63	1000	15	185	40	50	1000
1000	29	346	50	63	1250	19	230	50	63	1250



Definitions and terms

Back-up fuse-links

According to standard IEC 60282-1 Fifth edition (2002-01), item 3.3.3, Back-up fuse is current-limiting fuse capable of breaking, under specified conditions of use and behaviour, all currents from the rated maximum breaking current (I_b) down to the rated minimum breaking current (I_a).

Back-up fuse links should not operate below their minimum breaking current. If the short-circuit current of the transformer is lower than the minimum breaking current, additional protection must be provided.

Rated voltage range voltages

ETI VV Thermo fuse-links must be operated at the rated voltage. At lower operating voltages without limitation provided, please contact ETI team.

Breaking capacity I_b

This value (sometimes named "rated maximum breaking current" of current indicates, that this is the maximum current which can be interrupted by the fuse-link. I_b should be greater than the maximum expected short circuit current at the fuse-link site.

Minimum breaking current I_a

This value (sometimes named "rated minimum breaking current" is specified for Back-up fuse-links. Up from this current, fuse-link is capable to breaking fault current.

Power dissipation of a fuse-link P_n

The power dissipation of a VV Thermo fuse-link is specified at the rated current of the fuse-link. For calculations of protection with VV Thermo fuse-link, it should be noted, that operating current is normally below half of the rated current.

Time-current characteristics

I/t characteristics represents the correlation between current and time up to the melting of a silver fuse element. For coordination with other protection devices, melting integral must be referred for melting times below 100ms.

Current limitation

This is most significant advantage of fuse-links compared to mechanical switches. Contacts of that switches need much longer time as fuse-link to interrupt fault currents. VV fuse-link interrupt fault current within few milliseconds and sinusoidal current does not reach its peak value.

Switching voltages

Between current-limiting process, short circuit current must be limited and reduced as soon as possible. This require a switching voltage that exceed the normal system voltage and force the current to zero.

Permissible value of switching voltage is 2.2 times peak value of the maximum rated voltage.