Bowthorpe EMP
Transmission Line Arresters

TE connectivity ENERGY

Transmission Line Surge Arresters

Numerous technical publications have stated that lightning is responsible for approximately 65% of all of the non-scheduled outages occurring on transmission lines, thus creating many issues for power supply utilities.

Power supply utilities themselves have verified the load losses due to voltage sags on their systems from transitory outages caused by lightning activity and in some regions they have found serious permanent damage caused to the system itself due to these transitory disturbances occurring on important lines.

The effect of these transitory disturbances on transmission lines can also be more critical in areas with high ground resistivity when associated with high lightning activity.

Most non-scheduled outages are transitory in nature, with a fault time shorter than 1 minute, in many cases this is still deemed, by power supply utilities and their customers, to be unacceptable. This loss of supply is critical for all modern industries now so reliant on sophisticated electronic equipment and especially production processes sensitive to momentary disturbances on the system.

In order to reduce the number of non-scheduled outages in electrical systems, power companies and industrial consumers have been studying and promoting improvements to transmission lines thereby increasing their reliability.

There are different methods to improve transmission line performance due to lightning:

a) Increase the dry arcing distance from the insulators strings.

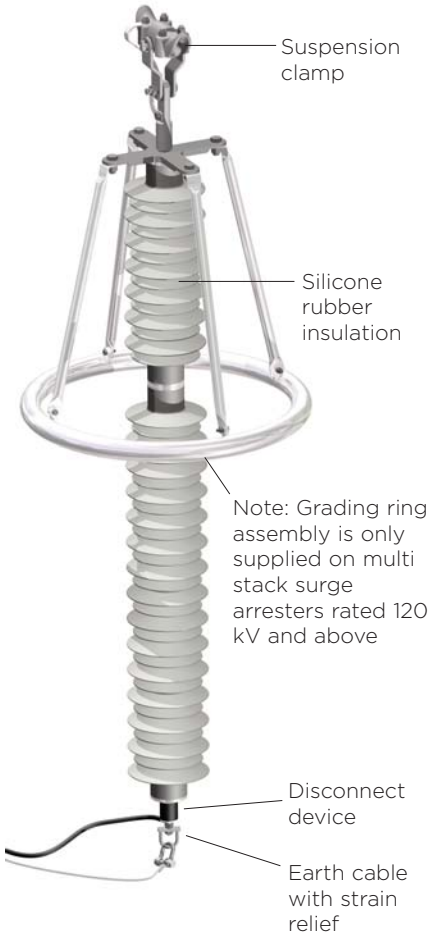
b) Install shield wires on lines without shield wires.

c) Improve the shield wire performance.

d) Improve the grounding system performance of surges by improving the tower footing resistance.

e) Installation of transmission line arresters to counteract the effects of lightning or switching activity.

Cases have shown transmission line surge arresters, electrically connected in parallel with the insulator string, have been considered as an effective method to improve transmission line performance especially when associated with improvements to the grounding system and usually presents the best benefit versus cost relationship in reducing flashovers of the insulator string due to excessive voltages.



Utility

- Utilities are required by demand to increase availability and reliability of transmission systems. Therefore eliminating operational high cost outages and mandatory penalties is high on the agenda.

Benefits of Bowthorpe EMP transmission line surge arrester installations

- Minimising circuit breaker operation with possible system outage resulting from back flashover on the transmission line
- Lightning overvoltages are absorbed over the length of the line reducing the severity of surge at the substation
- Transmission systems can be operated even where sub-soil gives poor tower footing resistance
- Eliminating interrupted power supply for sensitive industrial processes
- Installing transmission line surge arresters on a standard 3 phase voltage system along the line, at calculated intervals, allows for optimum performance of the TLA transmission line surge arrester, to give an increased system line voltage. Therefore eliminating the need to increase the standard insulation level required on conventional system upgrade (Typically requires a full system study).

Key Features

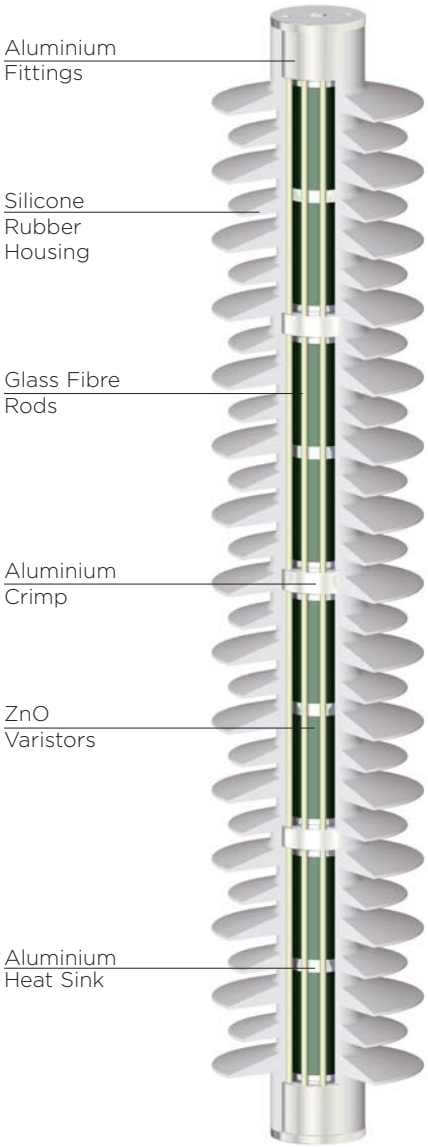
- Bowthorpe EMP surge arresters suspended from a transmission line giving enhanced transmission line performance

Standard

- IEC 60099-4 for ZnO surge arresters

Generic technical data

		TLPAA	TLPBA	TLPCA
System Voltage Up to U_{max}	kV	245	300	550
System Voltage U_{nom}	kV	220	275	500
Rated discharge current	kA	10	10	10
High current impulse (4/10 µs)	kA	100	100	100
Classification		2	2	3
Energy Capability at Ur	kJ/kV	4.1	6.4	7.8
Short circuit rating	kA	40	65	65



Qualification testing:

Decades of arrester and materials design and development experience has been combined to create the cage design surge arrester series. The basic construction comprises ZnO varistors assembled within an open cage design. The following IEC60099-4 design type tests have been carried out on the polymeric surge arresters.

- Insulation withstand tests on the arrester housing
- Residual voltage test
- Long duration current impulse withstand test
- Operating duty tests
- Short-circuit tests
- Internal partial discharge test
- Bending moment test (cantilever)
- Moisture ingress test
- Weather ageing test.
- Power frequency voltage versus time characteristics on the arrester
- Tracking and erosion
- UV testing

Electrical performance

Maximum System Voltage U_m (kV)	Rated Voltage U_r (kV)	Line Discharge Class	Long Duration Current 2000 μs (A)	Nominal Discharge Current (8/20 μs) (kA)	Rated Short Circuit Current (kA)	Energy Capability at Ur acc. to IEC 60099-4 (kJ/kV)	Arrester Type
24	18 - 30	2	500	10	40	4.1	TLPAA
	18 - 30	2	680	10	65	6.4	TLPBA
	18 - 30	3	760	10	65	7.8	TLPCA
36	27 - 42	2	500	10	40	4.1	TLPAA
	27 - 42	2	680	10	65	6.4	TLPBA
	27 - 42	3	760	10	65	7.8	TLPCA
72.5	60 - 75	2	500	10	40	4.1	TLPAA
	60 - 75	2	680	10	65	6.4	TLPBA
	60 - 75	3	760	10	65	7.8	TLPCA
123	108 - 120	2	500	10	40	4.1	TLPAA
	108 - 120	2	680	10	65	6.4	TLPBA
	108 - 120	3	760	10	65	7.8	TLPCA
145	120 - 132	2	500	10	40	4.1	TLPAA
	120 - 132	2	680	10	65	6.4	TLPBA
	120 - 132	3	760	10	65	7.8	TLPCA
170	144 - 150	2	500	10	40	4.1	TLPAA
	144 - 150	2	680	10	65	6.4	TLPBA
	144 - 150	3	760	10	65	7.8	TLPCA
245	192 - 216	2	500	10	40	4.1	TLPAA
	192 - 216	2	680	10	65	6.4	TLPBA
	192 - 216	3	760	10	65	7.8	TLPCA
300	252 - 288	2	680	10	65	6.4	TLPBA
	252 - 288	3	760	10	65	7.8	TLPCA
400	336 - 360	3	760	10	65	7.8	TLPCA
500	396 - 468	3	760	10	65	7.8	TLPCA

Electrical Characteristics

System Voltage U_m kV	Rated Voltage U_r kV	Continuous operating voltage U_c kV	Line Discharge Class	Max. U_{res} tested with current wave									Steep Current (1/20 µs)
				Switching surge (30/60 µs)					Lightning Current (8/20 µs)				
				125 A kV	250 A kV	500 A kV	1000 A kV	2000 A kV	5 kA kV	10 kA kV	20 kA kV	40 kA kV	10 kA kV
24	18	14	2	36.6	37.6	38.9	40.5	42.4	46.2	49.7	54.7	62.3	53.3
	21	17	2	41.5	42.7	44.1	45.9	48.1	52.4	56.3	62.0	70.6	60.4
	24	19	2	48.8	50.2	51.9	54.0	56.6	61.6	66.2	73.0	83.0	71.1
	27	22	2	53.7	55.2	57.1	59.3	62.2	67.8	72.8	80.3	91.3	78.2
	30	24	2	58.6	60.2	62.3	64.7	67.9	73.9	79.4	87.6	99.6	85.3
	18	14	2	39.5	40.7	42.2	44.0	46.4	51.7	56.1	62.2	71.2	62.1
	21	17	2	46.5	47.9	49.7	51.9	54.8	61.0	66.2	73.4	83.9	73.2
	24	19	2	49.3	50.8	52.7	55.0	58.1	64.7	70.2	77.8	89.0	77.6
	27	22	2	57.9	59.7	61.9	64.6	68.2	75.9	82.4	91.4	104	91.1
	30	24	2	59.2	61.0	63.3	66.0	69.7	77.6	84.2	93.4	107	93.1
	18	14	3	42.8	43.8	45.3	46.5	48.7	54.1	56.6	62.0	69.1	61.5
	21	17	3	47.0	48.1	49.7	51.0	53.5	59.4	62.1	68.0	75.9	67.5
	24	19	3	53.5	54.7	56.6	58.1	60.9	67.7	70.7	77.5	86.4	76.9
	27	22	3	58.5	59.8	61.8	63.5	66.5	73.9	77.3	84.7	94.4	84.0
	30	24	3	64.2	65.7	67.9	69.7	73.1	81.2	84.9	93.0	104	92.3
36	30	24	2	58.6	60.2	62.3	64.7	67.9	73.9	79.4	87.6	99.6	85.3
	36	29	2	70.8	72.8	75.2	78.2	82.0	89.3	96.0	106	120	103
	42	34	2	83.0	85.3	88.2	91.7	96.2	105	113	124	141	121
	30	24	2	59.2	61.0	63.3	66.0	69.7	77.6	84.2	93.4	107	93.1
	36	29	2	72.2	74.4	77.2	80.6	85.0	94.7	103	114	130	114
	42	34	2	83.8	86.3	89.5	93.4	98.6	110	119	132	151	132
	30	24	3	64.2	65.7	67.9	69.7	73.1	81.2	84.9	93.0	104	92.3
	36	29	3	74.9	76.6	79.2	81.4	85.2	94.7	99.0	108	121	108
	42	34	3	85.6	87.6	90.5	93.0	97.4	108	113	124	138	123
72.5	60	48	2	117	120	125	129	136	148	159	175	199	171
	72	58	2	142	146	150	156	164	179	192	212	241	206
	75	60	2	149	153	158	165	173	188	202	223	253	217
	60	48	2	116	119	124	129	136	152	165	183	209	182
	72	58	2	138	142	148	154	163	181	196	218	249	217
	75	60	2	145	149	155	162	170	190	206	228	261	228
	54	43	3	107	110	113	116	122	136	142	155	173	154
	60	48	3	118	120	124	128	134	149	156	170	190	169
	72	58	3	143	146	151	155	162	180	188	206	230	205
	75	60	3	146	150	155	159	166	185	193	212	236	210

* TOV curves are given in technical data sheets for selected surge arrester (on request)

Surge arresters with other characteristics are available on request

Mechanical Characteristics

Temporary Overvoltage capability for 1 sec* T_c kV	Creepage length mm	Overall length mm	Disconnect drawing reference E1	Strain relief system drawing reference E2	Weight Kg	Drawing Reference	Product code
20	970	335	BOW-19-012		5	BOW-38-001	TLPAA1-18
23	970	335	BOW-19-012		5	BOW-38-001	TLPAA1-21
26	970	335	BOW-19-012		5	BOW-38-001	TLPAA1-24
30	970	335	BOW-19-012		5	BOW-38-001	TLPAA1-27
33	970	335	BOW-19-012		5	BOW-38-001	TLPAA1-30
21	1340	449	BOW-19-012		7	BOW-39-001	TLPBA1-18
24	1340	449	BOW-19-012		7	BOW-39-001	TLPBA1-21
27	1340	449	BOW-19-012		7	BOW-39-001	TLPBA1-24
31	1340	449	BOW-19-012		7	BOW-39-001	TLPBA1-27
34	1340	449	BOW-19-012		7	BOW-39-001	TLPBA1-30
21	1100	400	BOW-19-012		10	BOW-30-001	TLPCA1-18
24	1100	400	BOW-19-012		10	BOW-30-001	TLPCA1-21
28	1100	400	BOW-19-012		10	BOW-30-001	TLPCA1-24
31	1100	400	BOW-19-012		10	BOW-30-001	TLPCA1-17
35	1100	400	BOW-19-012		10	BOW-30-001	TLPCA1-30
33	970	335	BOW-19-012		5	BOW-38-001	TLPAA1-30
40	970	335	BOW-19-012		5	BOW-38-001	TLPAA1-36
46	970	335	BOW-19-012		5	BOW-38-001	TLPAA1-42
34	1340	449	BOW-19-012		7	BOW-39-001	TLPBA1-30
41	1340	449	BOW-19-012		7	BOW-39-001	TKPBA1-36
48	1340	449	BOW-19-012		7	BOW-39-001	TLPBA1-42
35	1100	400	BOW-19-012		10	BOW-30-001	TLPCA1-30
41	1100	400	BOW-19-012		10	BOW-30-001	TLPCA1-36
48	1100	400	BOW-19-012		10	BOW-30-001	TLPCA1-42
66	1940	670	BOW-19-012		9	BOW-38-002	TL2PAA1-60
79	1940	670	BOW-19-012		9	BOW-38-002	TL2PAA1-72
83	2250	750	BOW-19-012		10	BOW-38-002	TL2PAA2-75
68	1948	604	BOW-19-012		10	BOW-39-002	TLPBA2-60
82	3872	1096	BOW-19-012		18.5	BOW-39-003	TLPBA3-72
86	3872	1096	BOW-19-012		18.5	BOW-39-003	TLPBA3-75
62	1815	590	BOW-19-012		15.5	BOW-30-002	TLPCA2-54
69	1815	590	BOW-19-012		15.5	BOW-30-002	TLPCA2-60
83	3625	1085	BOW-19-012		26.5	BOW-30-003	TLPCA3-72
86	3625	1085	BOW-19-012		26.5	BOW-30-003	TLPCA3-75

Electrical Characteristics

System Voltage U_m kV	Rated Voltage U_r kV	Continuous operating voltage U_c kV	Line Discharge Class	Max. U_{res} tested with current wave									Steep Current (1/20 µs)
				Switching surge (30/60 µs)					Lightning Current (8/20 µs)				
				125 A kV	250 A kV	500 A kV	1000 A kV	2000 A kV	5 kA kV	10 kA kV	20 kA kV	40 kA kV	10 kA kV
123	108	86	2	212	218	226	235	246	268	288	318	360	309
	120	96	2	235	241	249	259	272	296	318	350	399	341
	108	86	2	203	209	217	226	239	266	288	320	366	319
	120	96	2	223	230	239	249	263	293	318	352	403	351
	96	77	3	183	187	194	199	208	232	242	265	296	263
	108	86	3	205	209	216	222	233	259	270	296	330	294
	120	96	3	226	231	238	245	257	285	298	327	364	324
145	120	96	2	235	241	249	259	272	296	318	350	399	341
	132	106	2	264	271	280	291	305	333	358	394	449	384
	120	96	2	223	230	239	249	263	293	318	352	403	351
	132	106	2	253	260	270	282	297	331	359	399	456	397
	108	86	3	205	209	216	222	233	259	270	296	330	294
	120	96	3	226	231	238	245	257	285	298	327	364	324
	132	106	3	246	252	260	267	280	311	325	356	397	354
170	144	115	2	283	291	301	313	328	357	384	424	480	412
	150	120	2	293	301	311	324	339	370	397	438	498	426
	144	115	2	274	283	293	306	323	360	390	433	495	432
	150	120	2	286	295	306	319	337	375	407	451	516	450
	138	110	3	272	279	288	296	310	345	360	395	440	392
	144	115	3	285	292	302	310	325	361	377	413	461	410
	150	120	3	295	302	312	321	336	374	391	428	477	425
245	192	154	2	381	392	405	421	441	481	516	569	648	555
	198	158	2	389	399	412	429	450	490	526	580	660	565
	192	154	2	362	372	386	402	426	474	514	570	652	568
	198	158	2	372	384	398	415	438	488	530	587	711	586
	180	144	3	346	354	366	376	394	438	457	501	559	497
	192	154	3	366	375	388	398	417	463	484	531	592	527
	198	158	3	385	394	407	418	438	487	509	558	622	554
	216	173	3	409	419	433	445	466	517	541	593	661	588

* TOV curves are given in technical data sheets for selected surge arrester (on request)

Surge arresters with other characteristics are available on request

Mechanical Characteristics

Temporary Overvoltage capability for 1 sec* T_c kV	Creepage length mm	Overall length mm	Disconnect drawing reference E1	Strain relief system drawing reference E2	Weight Kg	Drawing Reference	Product code
119	3837	1245	BOW-19-012		15.5	BOW-38-003	TL3PAA3-108
132	3837	1245	BOW-19-012		15.5	BOW-38-003	TL3PAA3-120
123	3872	1096	BOW-19-012		18.5	BOW-39-003	TLPBA3-108
137	3872	1096	BOW-19-012		18.5	BOW-39-003	TLPBA3-120
110	3625	1085	BOW-19-012		26.5	BOW-30-003	TLPCA3-96
124	3625	1085	BOW-19-012		26.5	BOW-30-003	TLPCA3-108
138	3625	1085	BOW-19-012		26.5	BOW-30-003	TLPCA3-120
132	3837	1245	BOW-19-012		15.5	BOW-38-003	TL3PAA3-120
145	3837	1245	BOW-19-012		15.5	BOW-38-003	TL3PAA3-132
137	3872	1096	BOW-19-012		18.5	BOW-39-003	TLPBA3-120
150	5212	1545	BOW-19-012		25.5	BOW-39-004	TLPBA31-132
124	3625	1085	BOW-19-012		26.5	BOW-30-003	TLPCA3-108
138	3625	1085	BOW-19-012		26.5	BOW-30-003	TLPCA3-120
152	3625	1085		BOW-19-013	26.5	BOW-30-003	TLPCA3-132
158	4500	1729		BOW-19-013	24	BOW-38-004	TL4PAA2-144
165	4500	1729		BOW-19-013	24	BOW-38-004	TL4PAA2-150
164	5820	1700		BOW-19-013	28.5	BOW-39-005	TLPBA32-144
171	5820	1700		BOW-19-013	28.5	BOW-39-005	TLPBA32-150
159	4725	1501		BOW-19-013	38	BOW-30-004	TLPCA31-138
166	4725	1501		BOW-19-013	38	BOW-30-004	TLPCA31-144
173	4725	1501		BOW-19-013	38	BOW-30-004	TLPCA31-150
211	6395	2304		BOW-19-013	30	BOW-38-005	TL5PAA3-192
218	6395	2304		BOW-19-013	30	BOW-38-005	TL5PAA3-198
219	7744	2421		BOW-19-013	37	BOW-39-006	TLPBA33-192
226	7744	2421		BOW-19-013	37	BOW-39-006	TLPBA33-198
207	7250	2186		BOW-19-013	55	BOW-30-006	TLPCA33-180
221	7250	2186		BOW-19-013	55	BOW-30-006	TLPCA33-192
228	7250	2186		BOW-19-013	55	BOW-30-006	TLPCA33-198
248	7250	2186		BOW-19-013	55	BOW-30-006	TLPCA33-216

Electrical Characteristics

System Voltage U_m kV	Rated Voltage U_r kV	Continuous operating voltage U_c kV	Line Discharge Class	Max. U_{res} tested with current wave									Steep Current (1/20 µs)
				Switching surge (30/60 µs)					Lightning Current (8/20 µs)				
				125 A kV	250 A kV	500 A kV	1000 A kV	2000 A kV	5 kA kV	10 kA kV	20 kA kV	40 kA kV	10 kA kV
300	252	202	2	489	504	523	546	576	641	696	772	883	770
	264	211	2	512	527	547	571	602	671	728	807	923	805
	276	221	3	535	547	566	581	609	677	707	775	864	769
	288	230	3	559	571	591	607	636	706	738	809	902	803
400	336	269	3	642	657	679	697	731	812	849	930	1037	923
	360	288	3	677	692	715	735	770	855	894	980	1093	972
500	396	317	3	770	788	815	837	877	974	1018	1116	1244	1107
	420	336	3	813	832	860	883	925	1028	1075	1178	1313	1169
	444	355	3	856	876	905	930	974	1082	1132	1240	1383	1230
	468	374	3	899	920	951	976	1023	1137	1188	1302	1452	1292

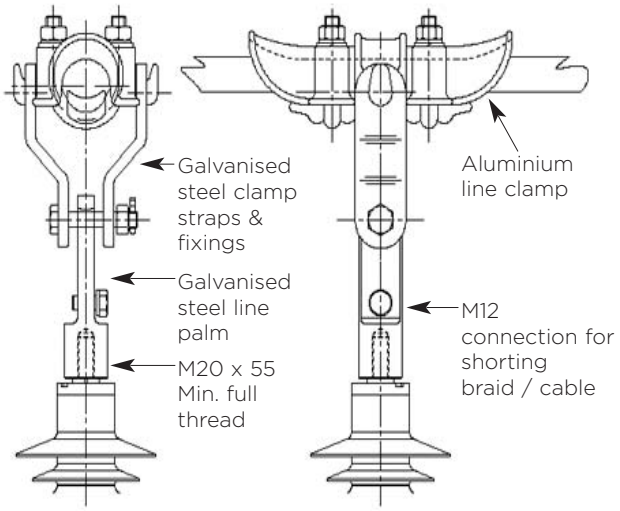
* TOV curves are given in technical data sheets for selected surge arrester (on request)

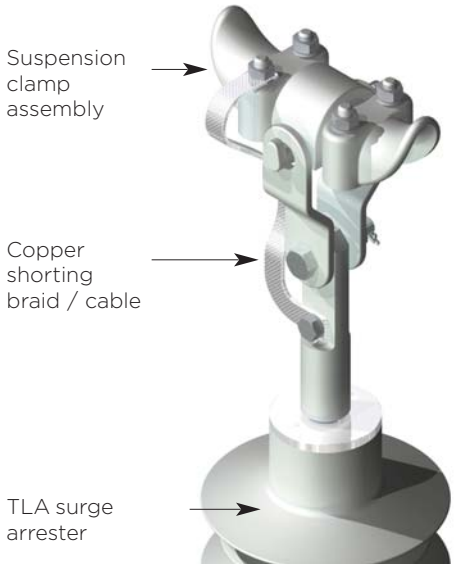
Surge arresters with other characteristics are available on request

Mechanical Characteristics

Temporary Overvoltage capability for 1 sec* T_c kV	Creepage length mm	Overall height mm	Disconnect drawing reference E1	Strain relief system drawing reference E2	Weight Kg	Drawing Reference	Product code
287	13564	4552	BOW-19-012	BOW-19-013	65.5	BOW-38-009	TLPBA3332-252
301	13564	4552	BOW-19-012	BOW-19-013	65.5	BOW-38-009	TLPBA3332-264
317	8350	2799	BOW-19-012	BOW-19-013	67	BOW-30-007	TLPCA331-276
331	8350	2799	BOW-19-012	BOW-19-013	67	BOW-30-007	TLPCA331-288
386	10875	3484		BOW-19-013	90	BOW-30-009	TLPCA333-336
414	10875	3484		BOW-19-013	90	BOW-30-009	TLPCA333-360
455	14500	4569		BOW-19-013	115	BOW-30-012	TLPCA3333-396
483	14500	4569		BOW-19-013	115	BOW-30-012	TLPCA3333-420
511	14500	4569		BOW-19-013	115	BOW-30-012	TLPCA3333-444
538	14500	4569		BOW-19-013	115	BOW-30-012	TLPCA3333-468

Line configuration



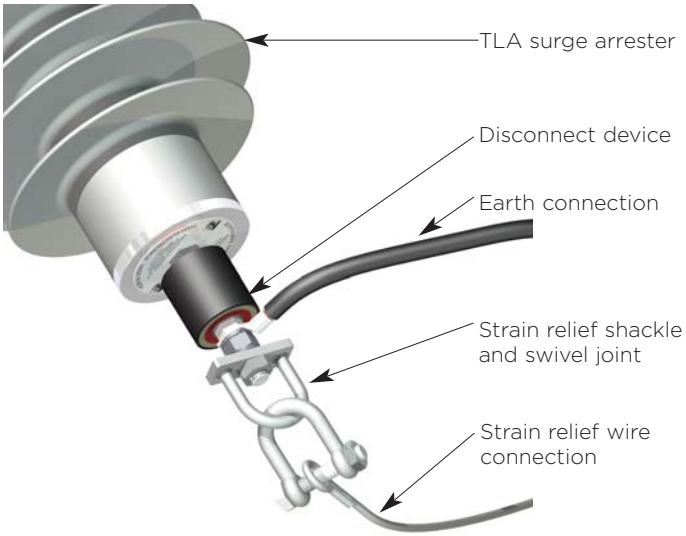


Clamp	Drawing Reference	Conductor	"U" Bolt
		Range Dia.	**Torque**
L1	No clamp		
L2	BOW-30-014	9.5 -19 mm	45 Nm
L3		18 - 30 mm	45 Nm
L4		30 - 45 mm	75 Nm
L5		45 - 65 mm	75 Nm

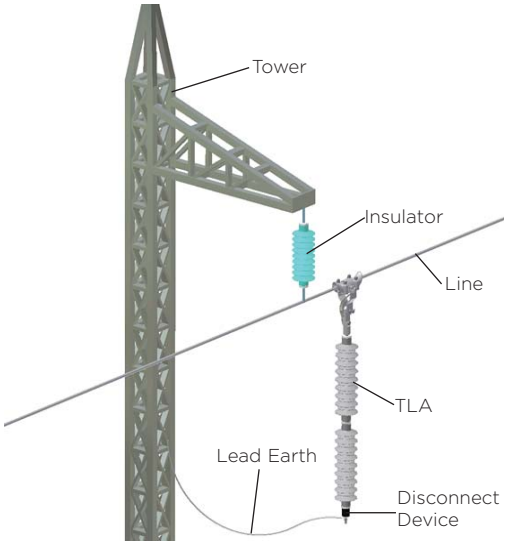
Earthing configuration

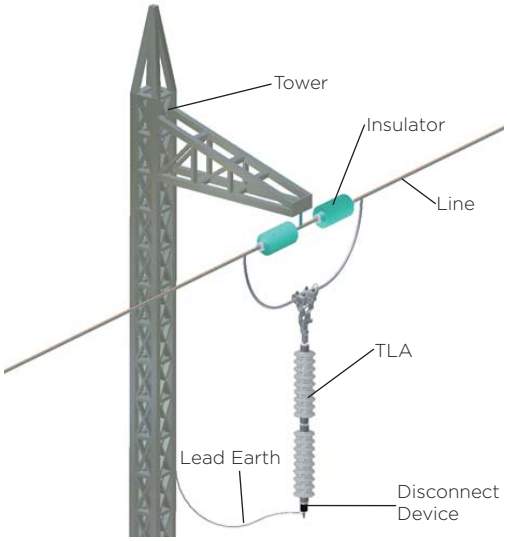
TLPCA disconnect - E1

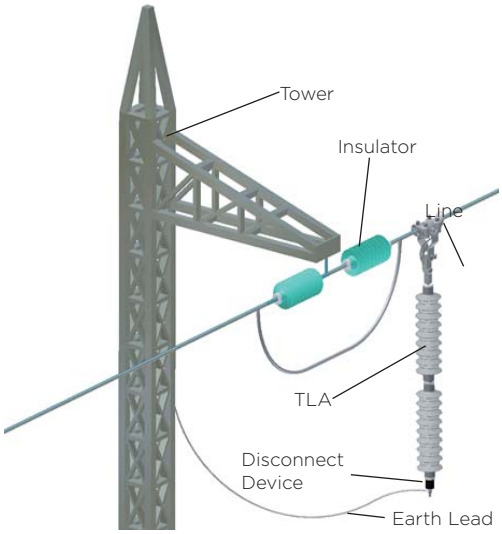
TLPCA strain relief system - E2



Tower installation configuration







The number of the surge arresters installed on the tower depends on the tower geometry and configuration as well as the earthing impedance behaviour.

For towers with a horizontal conductor configuration, normal practice is to install a surge arrester on both of the two outside phase conductors.

For towers with a vertical conductor configuration, the resultant transient voltage across the insulators string sets is usually higher at the bottom phase, which presents a lower distance to the soil and lowest coupling with the shield wire. Therefore, transmission lines with a vertical configuration and low tower footing impedance, only one surge arrester is necessary to install on the bottom phase. For higher impedances it may be necessary to install two or three surge arresters subject to the line analysis.

A direct lightning strike to the transmission line without a shield wire will cause discharge current i(t) to divide into two current waves travelling in both directions along the line with magnitude of i(t) / 2 (it is valid when we consider the impedance of the discharge channel as infinite). This current therefore produces a voltage wave v (t) in both directions which considering as a first approach that the transmission line is without losses and distortions, results in a voltage along the line can be estimated by:

$V(t) = Z_0 . i(t) / 2$
(Where Z_0 is the surge impedance)

For lines with shield wires, the voltages on the top of the tower will be significantly lower and will depend on the lightning striking point, the tower impedance and mainly of the earthing transient behaviour.

We are able to carry out a computational study to set where transmission line surge arresters are to be installed for optimum line performance.

A data sheet is available to collate line information.

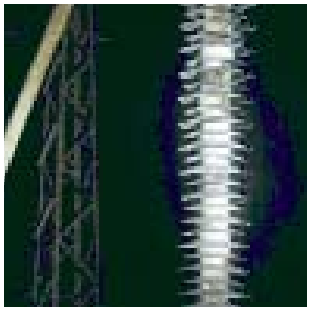
Surge arrester attributes

Sealing:
All arrester cores are encapsulated in silicone insulating housing which is a permanent chemical bond between the arrester core and the silicone housing. This design prevents moisture from entering during severe thermal fluctuations due to normal climatic and energy absorption events.

Polymer housing:
Hydrophobic silicone insulating material is used for all Bowthorpe EMP transmission line surge arrester housings. The housing material has a proven performance in long term TERT and UV ageing tests and a proven resistance to flammability.

Integrated design:
The design is void and gap free ensuring peak performance under the harshest conditions. The arresters' void-free construction eliminates moisture vapor transmission.

Ground lead disconnect GLD:
Our ground lead disconnect, (GLD) is designed to operate in the event of an arrester failure, removing the earth connection and fault from the line.



Safe mode of failure:
Our high energy surge arresters are tested in accordance IEC 60099-4.

About TE Connectivity

TE Connectivity is a global, $14 billion company that designs and manufactures over 500,000 products that connect and protect the flow of power and data inside the products that touch every aspect of our lives. Our nearly 100,000 employees partner with customers in virtually every industry – from consumer electronics, energy and healthcare, to automotive, aerospace and communication networks – enabling smarter, faster, better technologies to connect products to possibilities.

TE Energy – innovative and economical solutions for the electrical power industry: cable accessories, connectors & fittings, insulators & insulation, surge arresters, switching equipment, street lighting, power measurement and control.

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