4.10 Silicone Long Rod Insulators for Overhead Power Lines

4.10.1 3FL Silicone Long Rod Insulators – Performance Meets Durability

Good reasons to use 3FL
The new Siemens silicone long rod insulators type 3FL (fig. 4.10-1) combine the highest levels of electrical insulation and mechanical tensile strength with a compact, lightweight design. Thanks to their superior design and minimized weight, 3FL long rod insulators are especially suited for overhead compact-line applications where low tower design and short line spans are required. They are also more economical to transport and install.

Design
The 3FL insulator housing is a one-piece HTV[1] silicone rubber housing made by the one-shot injection molding process. The HTV silicone is directly molded onto the core rod by overlapping the triple junction point and part of the metal end fittings. The design ensures a total enclosure of the most sensitive part of a silicone insulator – the junction zone (metal end fitting/FRP rod/silicone housing), where usually the highest electrical field strength is concentrated. This overlapping system eliminates any need of traditional sealing systems while preventing any moisture ingress attacks (fig. 4.10-2).

Core
The core rod is a boron-free, corrosion-resistant ECR[2] glass-fiber-reinforced plastic rod (FRP rod). Due to the extremely high hydrolysis and acid resistance of the FRP rod the risk of so-called brittle fracture is completely eliminated for 3FL insulators.

End fittings
The end fittings, made of hot-dip galvanized forged steel or ductile cast iron, are directly attached to the FRP core rod by a circumferential crimping process. Each crimping process is strongly monitored with a special control system. A complete range of end fittings according to the latest IEC and ANSI standards is available up to 210 kN of SML. The 3FL is 100% exchangeable and compatible with existing insulators and line hardware of all types.

The special design of the end fitting in the junction minimizes the electrical field strength and partial discharge inside the junction zone as well as on the silicone housing surface, by utilizing an integrated grading ring. This reliably prevents corrosion of the insulating material and eliminates the risk of subsequent failure of the insulator.

1 HTV: High-temperature vulcanizing
2 ECR glass: Electrical- and corrosion-resistant glass

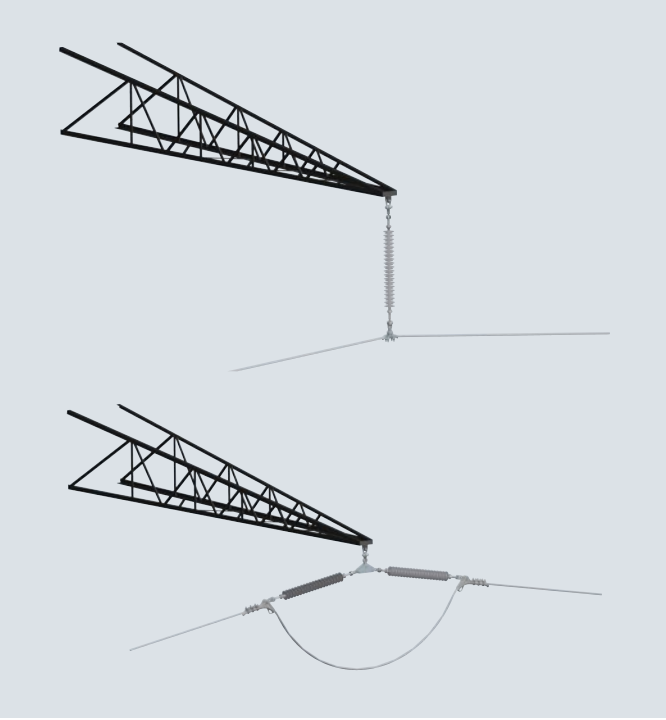


Fig. 4.10-1: **3FL long rod insulators can be used either as suspension or tension insulatorsrequirements**

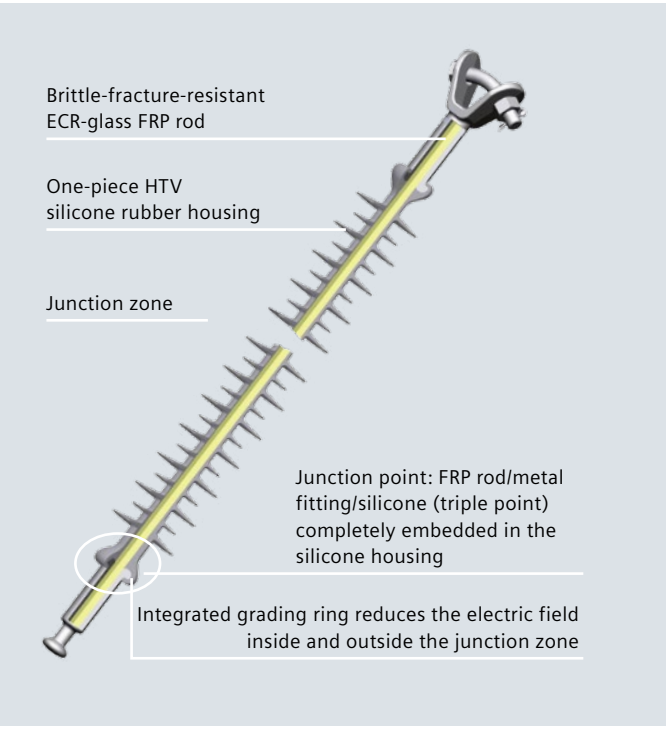


Fig. 4.10-2: **3FL – a superior design to meet the highest requirements**

3FL – HTV silicone rubber housing for best pollution performances (fig. 4.10-3)
The excellent pollution layer characteristics of the HTV silicone rubber ensure maximum reliability of the 3FL insulator, even under extreme service conditions. The high hydrophobic housing prevents the formation of conductive film on its surface. Even the most severe ambient conditions, such as salt fog in coastal regions or dust-laden air in industrial areas, cannot impair the intrinsic hydrophobicity of the HTV silicone rubber. Surface currents and discharges are ruled out. Neither water nor dirt on the housing surface can cause insulator flashovers – a significant factor for insulator performance.

Quality from Siemens
According to long-established Siemens tradition and experience in high-voltage equipment for more than a century, each production step for the 3FL – beginning with numerous incoming raw material inspections through the assembly of the individual components to routine tests of the finished product – is rigorously monitored and well controlled.

Fig. 4.10-3: **HTV silicone rubber for best pollution performances**

4.10.2 Maximized Service Life

No moisture ingress
The one-piece housing of the 3FL insulators, i.e. weathersheds and core rod sheath (coating) is one-piece, and has only one internal interface throughout the whole insulator, namely the boundary interface between the housing and the FRP core rod. This design eliminates all internal interfaces between weathersheds and the core rod coating. These kinds of longitudinal interfaces are normally very sensitive to tangential electrical field stress, which in worst case scenarios can easily lead to erosion damage of the polymer interfaces. In particular leading to erosion of the bonding between sheds and rod sheath, and thus damage to the insulator housing.

Furthermore, the junction point in the connection zone, where all three elements (FRP rod, metal end fitting, and silicone housing) meet each other, is absolutely water- and air-tight sealed during manufacturing by using an overmolding housing system. It totally encloses this junction point with the HTV silicone rubber of the housing itself. The highest bonding strength of the one-piece HTV silicone housing to the FRP core rod combined with the overmolding design system prevent moisture ingress at the connection zone of the insulator (fig. 4.10-4).

Minimized electrical field strength
After numerous electrical calculations regarding E-field distribution along the insulator, and the connection zone on the high-voltage side in particular, the design of the 3FL insulator was optimized for maximum reduction of electrical field stress, reduced corona effect, and minimized RIV value. Two design keys ensure improved life expectancy by reducing electrical field stress in the triple point and on the silicone surface:

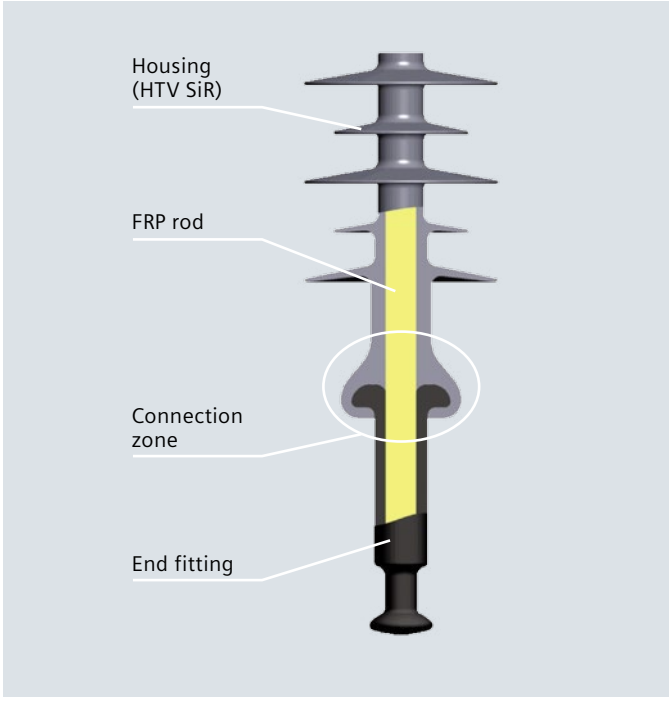


Fig. 4.10-4: **3FL cross-section**

- The spherical-shaped rim of the end fitting inside the housing homogenizes the E-field distribution on the high-voltage side of the 3FL insulator with an integrated grading ring up to 170 kV (fig. 4.10-5, table 4.10-1).
- The overmolded design system and the silicone housing shape at the connection zone reduce the electrical field strength inside the housing, at the inner triple point in particular, as well as on the silicone surface directly. This by displacing the higher electrical field strength outside the housing (i.e. to the surrounding air area), and by taking advantage of the higher silicone relative permittivity (fig. 4.10-6).

In this way, 3FL insulators can be applied on 170 kV systems without the need for additional grading/corona rings.

Standards and tests
All 3FL long rod insulators are designed and tested in compliance with the latest IEC standards.

Each Siemens 3FL insulator that leaves the factory is routinely tested with a corresponding mechanical tensile test load of at least 50 percent of the defined SML load for at least ten seconds.

IEC 61109	Insulators for overhead lines – Composite suspension and tension insulators for a.c. systems with a nominal voltage greater than 1,000 V
IEC 62217	Polymeric insulators for indoor and outdoor use with a nominal voltage >1,000 V
IEC 60815	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions
IEC 61466-1, -2	Composite string insulator units for overhead lines with a nominal voltage greater than 1,000 V

Table 4.10-1: **Product standards**

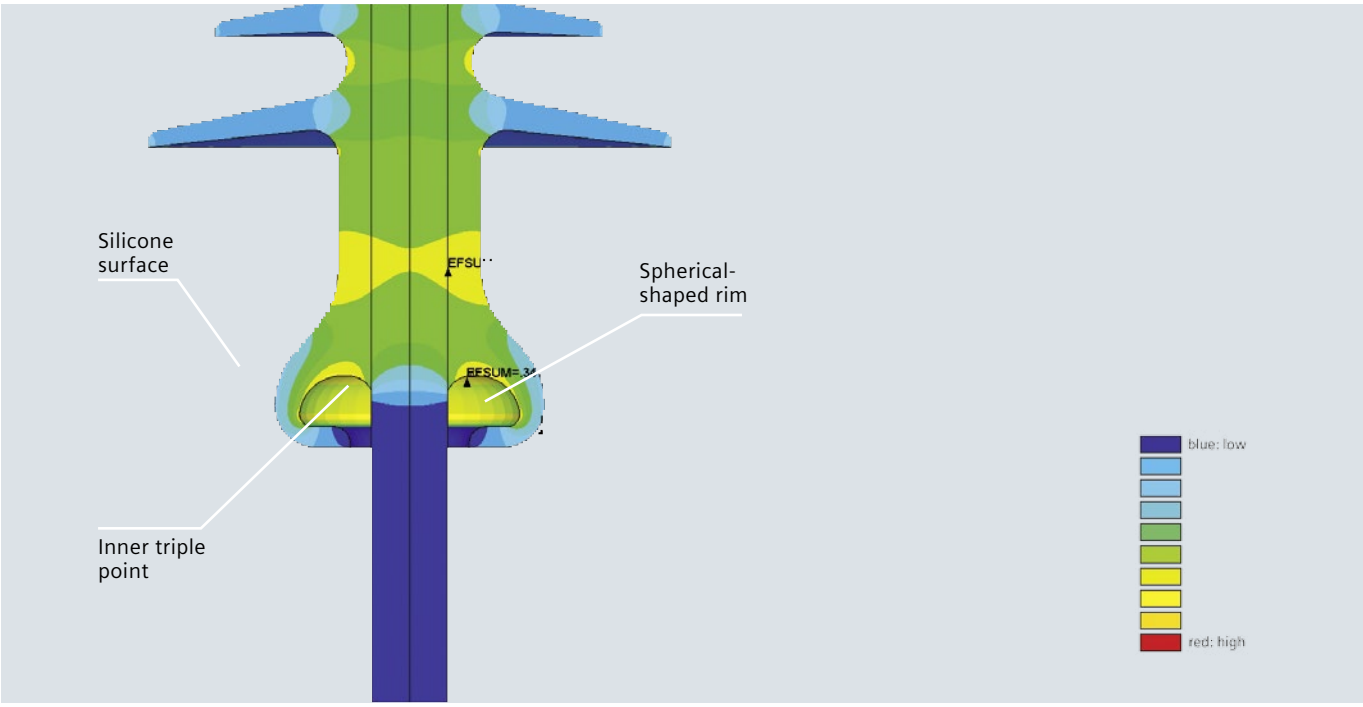


Fig. 4.10-5: **E-field distribution (%/mm) in silicone housing and in FRP core rod at 3FL insulator high-voltage end**

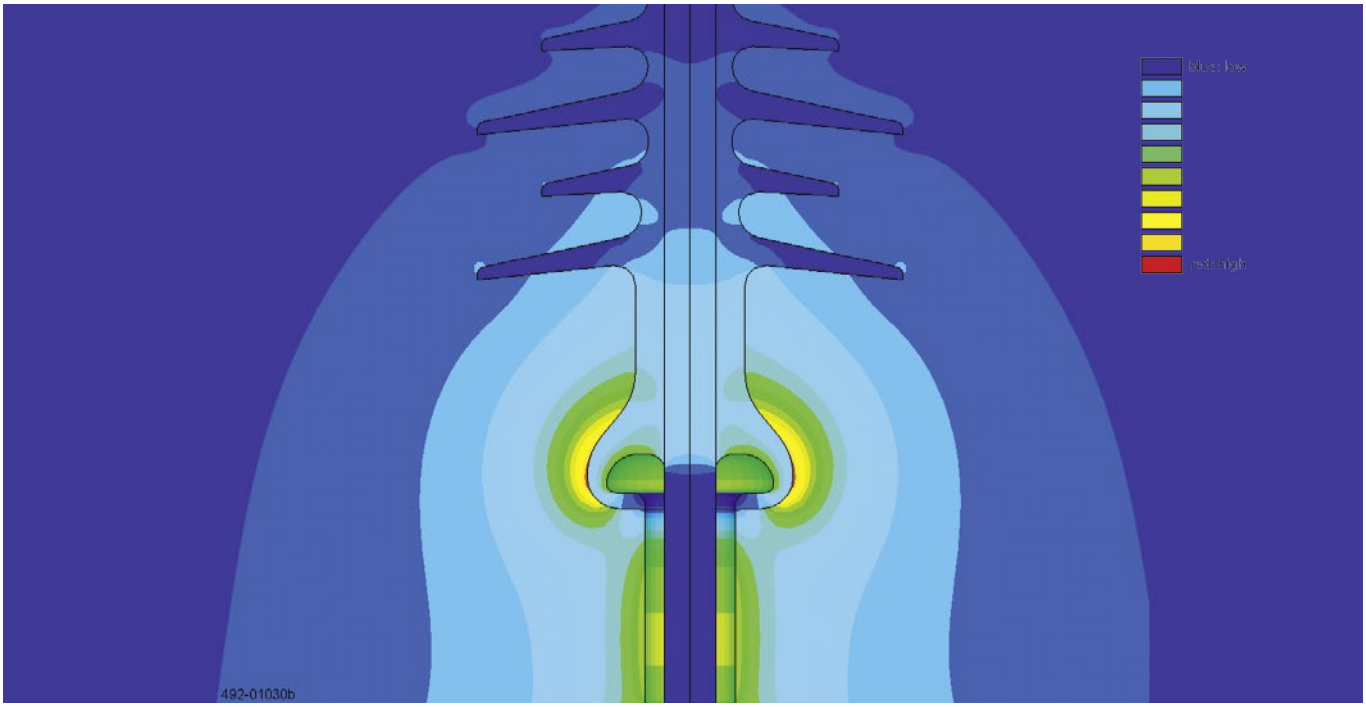
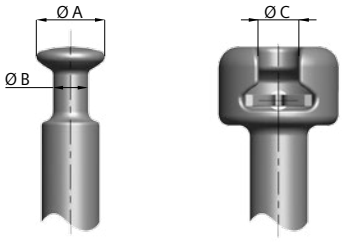
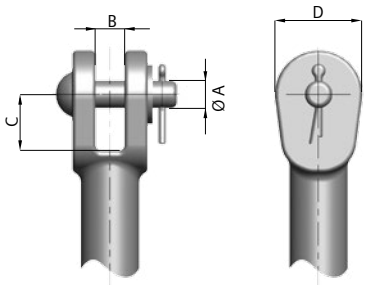


Fig. 4.10-6: **E-field distribution (%/mm) at 3FL insulator high-voltage end**



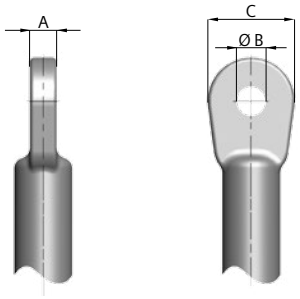
Socket and Ball
acc. to IEC 60120

Designation	SML	Dimensions in mm		
		A	B	C
16	70 kN / 100 kN / 120 kN	33	17	19
20	160 kN / 210 kN	41	21	23



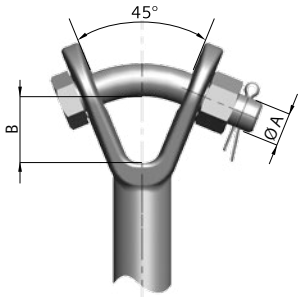
Clevis
acc. to IEC 60471 and IEC 61466-1

Designation	SML	Dimensions in mm			
		A	B	C	D
13L	70 kN	13	14	17	42
16L	100 / 120 kN	16	18	32	46
16N	100 / 120 kN	16	18	32	46
19L	160 kN	19	20	37	56
19N	160 kN	19	22.5	26	56
22L	210 kN	22	20	43	60
22N	210 kN	22	26	30	60



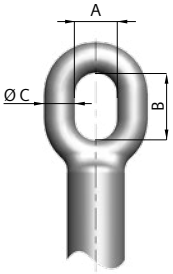
Tongue
acc. to IEC 60471 and IEC 61466-1

Designation	SML	Dimensions in mm		
		A	B	C
13L	70 kN	13	14	42
16L	100 kN / 120 kN	16	17.5	46
16N	100 kN / 120 kN	12.7	17.5	46
19L	160 kN	19	20	56
19N	160 kN	19	20.6	46
22L	210 kN	19	24	60
22N	210 kN	22	23.8	52



Y-Clevis
acc. to IEC 61466-1

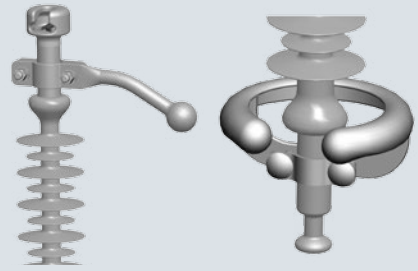
Designation	SML	Dimensions in mm	
		A	B
16	70 kN	16	32
19	100 / 120 kN	19	34
22	160 / 210 kN	22	41



Eye
acc. to IEC 61466-1

Designation	SML	Dimensions in mm		
		A	B	C
17	70 kN	20	32	15
24	100 kN / 120 kN	24	48	19
25	160 kN / 210 kN	25	50	22
30	160 kN / 210 kN	30	60	25

Arcing horns Corona ring



Recommended corona rings (diameter in mm) by line voltage

Line voltage (kV)	Ground end (top end fitting)	Line end (conductor end fitting)
≤ 170 kV	None	None
245 kV	None	Ø 210
300 kV	None	Ø 330
362 kV	None	Ø 330
420 kV	Ø 210	Ø 330
550 kV	Ø 210	Ø 420

Accessories

Arc protection devices such as arcing horns and corona rings for reduction of electrical field stress and corona effect are carefully designed based on numerous electrical simulations regarding electrical field distribution. For system voltages above 170 kV, corona rings are included in the 3FL insulator application as a standard feature. Customer-specific solutions as well as other connection and cable clamps are also available on request.

Maximum values		units	3FL2	3FL3	3FL4	3FL5	3FL6
Highest voltage for equipment, U_m	from	kV	12	72.5	72.5	72.5	72.5
	to	kV	72.5	550	550	550	550
Nominal system voltage, U_n	from	kV	10	60	60	60	60
	to	kV	69	500	500	500	500
Specified mechanical load, SML class	–	kN	70	100	120	160	210
Maximum section length, length increments 52 mm (with Socket and Ball)	from	mm	332	821	821	871	871
	to	mm	782	6,125	6,125	6,125	6,125

4

Long rod insulators type 3FL2, SML 70 kN

3FL2 long rod insulators are designed to meet the highest requirements in distribution power systems up to 72 kV. They have high lightning impulse and power-frequency withstand voltages and a long creepage class (> 31 mm/kV). 3FL2 insulators are available with mechanical ratings up to SML = 70 kN.

End fittings with SML = 70 kN

Designation as per standard	Standard	Connection length
Name/size		V, mm
Ball 16	IEC 60120	75
Socket 16A	IEC 60120	79
Clevis 13L	IEC 60471	87
Tongue 13L	IEC 60741	87
Y-clevis 16	IEC 61466-1	94
Eye 17	IEC 61466-1	93

Technical data 3FL2

Highest voltage for equipment	Typical nominal system voltages	Lightning impulse withstand voltage (1.2/50 µs, dry)	Power-frequency withstand voltage (50 Hz, 1min., wet)	Arcing distance	Creepage distance	Housing length	Section length* (with Socket and Ball)	Catalog number	Weight (with Socket and Ball)
U_m, kV	U_n, kV	$LIWL_{min}$, kV	$PFWL_{min}$, kV	S, mm	C, mm	H, mm	L, mm		W, kg
12.0	10, 11, 12	158	73	214	426	178	331	3FL2 018-4SB11-1XX1	1.6
24.0	15, 20, 22, 24	216	89	300	805	268	421	3FL2 027-4SB11-1XX1	2.0
36.0	30, 33, 35, 36	243	111	390	1,184	358	511	3FL2 036-4SB11-1XX1	2.4
72.5	60, 66, 69, 72	400	200	660	2,321	628	781	3FL2 063-4SB11-1XX1	3.6

*Reference value of the section length of an insulator for version with Socket and Ball end fittings of size 16 in accordance with IEC 60120. To obtain the section length of an insulator equipped with other end fittings, the housing length and connection lengths (see table "End fittings") of both end fittings must be added together.

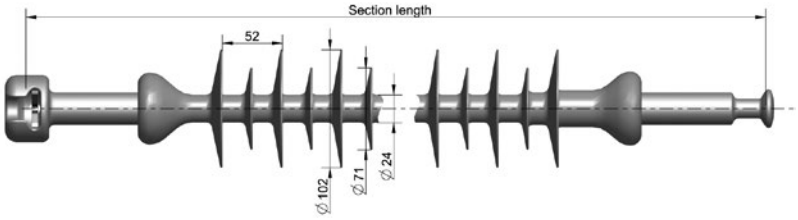
Long rod insulators 3FL3 and 3FL4

3FL silicone long rod insulators for suspension and tension applications are available in lengths appropriate for 60 kV through 550 kV. Length increments are 52 mm. A few selected insulator lengths are listed in the following table. Intermediate, shorter, or longer lengths available on request.

		3FL3	3FL4
Specified mechanical load	SML:	100 kN	120 kN
Routine test load	RTL:	50 kN	60 kN

Technical data 3FL3 and 3FL4

Highest voltage for equipment based on 25 mm/kV	Lightning impulse withstand voltage (1.2/50 µs, dry)	Switching impulse withstand voltage (250/ 2,500 µs, positive, wet)	Power-frequency withstand voltage (50 Hz, 1 min, wet)	Arcing distance	Standard creepage distance catalog code: 3	Extra-high creepage distance catalog code: 4	Nominal housing length	Section length* with Socket and Ball	Catalog code	Grading ring diameter top/ bottom (earth-/ HV-side)	App. net weight for standard creepage distance
U_m kV	LIWV kV	SIWV min kV	PFWV kV	S mm	C mm	C mm	H mm	L mm	3FL_1-___2-_3_4_521-1_6_71	D mm	W kg
<72.5	449	–	160	644	1,706	2,291	614	821	3FLx - 061-3SB11-1XX1	x / x	3.2
72.5	476	–	180	696	1,868	2,516	666	873	3FLx - 067-3SB11-1XX1	x / x	3.3
72.5	503	–	200	748	2,031	2,740	718	925	3FLx - 072-3SB11-1XX1	x / x	3.4
72.5	530	–	220	800	2,194	2,964	770	977	3FLx - 077-3SB11-1XX1	x / x	3.5
72.5	556	–	240	852	2,356	3,189	822	1,029	3FLx - 082-3SB11-1XX1	x / x	3.6
72.5	583	–	260	904	2,519	3,413	874	1,081	3FLx - 087-3SB11-1XX1	x / x	3.7
72.5	610	–	280	956	2,681	3,637	926	1,133	3FLx - 093-3SB11-1XX1	x / x	3.8
72.5	637	–	300	1,008	2,844	3,862	978	1,185	3FLx - 098-3SB11-1XX1	x / x	3.9
72.5	664	–	320	1,060	3,007	4,086	1,030	1,237	3FLx - 103-3SB11-1XX1	x / x	4.0
123	690	–	340	1,112	3,169	4,310	1,082	1,289	3FLx - 108-3SB11-1XX1	x / x	4.1
123	717	–	360	1,164	3,332	4,535	1,134	1,341	3FLx - 113-3SB11-1XX1	x / x	4.2
123	744	–	380	1,216	3,494	4,759	1,186	1,393	3FLx - 119-3SB11-1XX1	x / x	4.3
145	771	–	400	1,268	3,657	4,983	1,238	1,445	3FLx - 124-3SB11-1XX1	x / x	4.4
145	797	–	420	1,320	3,820	5,208	1,290	1,497	3FLx - 129-3SB11-1XX1	x / x	4.5
145	824	–	440	1,372	3,982	5,432	1,342	1,549	3FLx - 134-3SB11-1XX1	x / x	4.6
145	851	–	460	1,424	4,145	5,656	1,394	1,601	3FLx - 139-3SB11-1XX1	x / x	4.7
170	882	–	469	1,476	4,307	5,881	1,446	1,653	3FLx - 145-3SB11-1XX1	x / x	4.8
170	913	–	478	1,528	4,470	6,105	1,498	1,705	3FLx - 150-3SB11-1XX1	x / x	4.9
170	943	–	488	1,580	4,633	6,329	1,550	1,757	3FLx - 155-3SB11-1XX1	x / x	5.0
170	974	–	497	1,632	4,795	6,554	1,602	1,809	3FLx - 160-3SB11-1XX1	x / x	5.1
170	1,005	–	506	1,684	4,958	6,778	1,654	1,861	3FLx - 165-3SB11-1XX1	x / x	5.2
170	1,036	–	515	1,736	5,120	7,002	1,706	1,913	3FLx - 171-3SB11-1XX1	x / x	5.3
170	1,066	–	525	1,788	5,283	7,227	1,758	1,965	3FLx - 176-3SB11-1XX1	x / x	5.4
170	1,097	–	534	1,840	5,446	7,451	1,810	2,017	3FLx - 181-3SB11-1XX1	x / x	5.5
170	1,128	–	543	1,892	5,608	7,675	1,862	2,069	3FLx - 186-3SB11-1XX1	x / x	5.6
170	1,159	–	552	1,944	5,771	7,900	1,914	2,121	3FLx - 191-3SB11-1XX1	x / x	5.7
170	1,189	–	562	1,996	5,933	8,124	1,966	2,173	3FLx - 197-3SB11-1XX1	x / x	5.8
245	1,220	–	571	2,003	6,096	8,348	2,018	2,225	3FLx - 202-3SB11-1XS1	x / Ø210	6.8
245	1,251	–	580	2,055	6,259	8,573	2,070	2,277	3FLx - 207-3SB11-1XS1	x / Ø210	6.9
245	1,282	–	586	2,107	6,421	8,797	2,122	2,329	3FLx - 212-3SB11-1XS1	x / Ø210	7.0
245	1,313	–	593	2,159	6,584	9,021	2,174	2,381	3FLx - 217-3SB11-1XS1	x / Ø210	7.1
245	1,344	–	599	2,211	6,747	9,246	2,226	2,433	3FLx - 223-3SB11-1XS1	x / Ø210	7.2
245	1,375	–	605	2,263	6,909	9,470	2,278	2,485	3FLx - 228-3SB11-1XS1	x / Ø210	7.3
245	1,406	–	612	2,315	7,072	9,694	2,330	2,537	3FLx - 233-3SB11-1XS1	x / Ø210	7.4
245	1,437	–	618	2,367	7,234	9,919	2,382	2,589	3FLx - 238-3SB11-1XS1	x / Ø210	7.5
245	1,468	1,032	625	2,419	7,397	10,143	2,434	2,641	3FLx - 243-3SB11-1XS1	x / Ø210	8.4
300	1,499	1,042	631	2,456	7,560	10,367	2,486	2,693	3FLx - 249-3SB11-1XM1	x / Ø330	8.5
300	1,530	1,052	637	2,508	7,722	10,592	2,538	2,745	3FLx - 254-3SB11-1XM1	x / Ø330	8.6
300	1,561	1,062	644	2,560	7,885	10,816	2,590	2,797	3FLx - 259-3SB11-1XM1	x / Ø330	8.7
300	1,623	1,081	656	2,664	8,210	11,265	2,694	2,901	3FLx - 269-3SB11-1XM1	x / Ø330	8.9
300	1,654	1,091	663	2,716	8,373	11,489	2,746	2,953	3FLx - 275-3SB11-1XM1	x / Ø330	9.0
300	1,716	1,111	676	2,820	8,698	11,938	2,850	3,057	3FLx - 285-3SB11-1XM1	x / Ø330	9.2
362	1,778	1,130	688	2,924	9,023	12,386	2,954	3,161	3FLx - 295-3SB11-1XM1	x / Ø330	9.4
362	1,809	1,140	695	2,976	9,186	12,611	3,006	3,213	3FLx - 301-3SB11-1XM1	x / Ø330	9.5
362	1,840	1,150	701	3,028	9,348	12,835	3,058	3,265	3FLx - 306-3SB11-1XM1	x / Ø330	9.6
362	1,873	1,170	709	3,132	9,673	13,284	3,162	3,369	3FLx - 316-3SB11-1XM1	x / Ø330	9.8



[1] Specified mechanical load (SML): use »3« for 100 kN; use »4« for 120 kN.
[2] Nominal housing length in mm/10. [3] Standard creepage distance: »3«; Extra-high creepage distance: »4«.
[4] Upper end fitting (earth side) [5] Bottom end fitting (high-voltage side)
[6] Upper corona ring (earth side) [7] Bottom corona ring (high-voltage side). For all insulator types having no preinstalled corona rings and indicated by the code »X« optional corona rings can be added, if requested. For this, use the smallest corona ring available, i.e. catalog code »S«, please refer to page 10 for further catalog numbering information.

Technical data 3FL3 and 3FL4

Highest voltage for equipment based on 25 mm/kV	Lightning impulse withstand voltage (1.2/ 50 µs, dry)	Switching impulse withstand voltage (250/ 2500 µs, positive, wet)	Power-frequency withstand voltage (50 Hz, 1 min., wet)	Arcing distance	Standard creepage distance catalog code: 3	Extra-high creepage distance catalog code: 4	Nominal housing length	Section length* with Socket and Ball	Catalog code	Grading ring diameter top/bottom (earth-/HV-side)	App. net weight for standard creepage distance
U_m kV	LIWV kV	SIWV min kV	PFWV kV	S mm	C mm	C mm	H mm	L mm	3FL_[1]-___[2]-_[3]_[4]_[5]21-1_[6]_[7]1	D mm	W kg
362	1,889	1,179	713	3,184	9,836	13,508	3,214	3,421	3FLx - 321-3SB11-1XM1	x / Ø330	9.9
362	1,922	1,199	720	3,288	10,161	13,957	3,318	3,525	3FLx - 332-3SB11-1XM1	x / Ø330	10.1
362	1,939	1,209	724	3,340	10,324	14,181	3,370	3,577	3FLx - 337-3SB11-1XM1	x / Ø330	10.2
420	1,971	1,229	732	3,399	10,649	14,629	3,474	3,681	3FLx - 347-3SB11-1SM1	Ø210 / Ø330	11.3
420	2,004	1,248	740	3,503	10,974	15,078	3,578	3,785	3FLx - 358-3SB11-1SM1	Ø210 / Ø330	11.5
420	2,037	1,268	748	3,607	11,300	15,527	3,682	3,889	3FLx - 368-3SB11-1SM1	Ø210 / Ø330	11.7
420	2,054	1,278	752	3,659	11,462	15,751	3,734	3,941	3FLx - 373-3SB11-1SM1	Ø210 / Ø330	11.8
420	2,070	1,288	756	3,711	11,625	15,975	3,786	3,993	3FLx - 379-3SB11-1SM1	Ø210 / Ø330	11.9
420	2,103	1,307	763	3,815	11,950	16,424	3,890	4,097	3FLx - 389-3SB11-1SM1	Ø210 / Ø330	12.1
420	2,136	1,327	771	3,919	12,275	16,873	3,994	4,201	3FLx - 399-3SB11-1SM1	Ø210 / Ø330	12.3
420	2,169	1,346	779	4,023	12,600	17,321	4,098	4,305	3FLx - 410-3SB11-1SM1	Ø210 / Ø330	12.5
420	2,185	1,356	783	4,075	12,763	17,546	4,150	4,357	3FLx - 415-3SB11-1SM1	Ø210 / Ø330	12.6
420	2,201	1,366	787	4,127	12,926	17,770	4,202	4,409	3FLx - 420-3SB11-1SM1	Ø210 / Ø330	12.7
420	2,218	1,376	791	4,179	13,088	17,994	4,254	4,461	3FLx - 425-3SB11-1SM1	Ø210 / Ø330	12.8
420	2,251	1,396	798	4,283	13,413	18,443	4,358	4,565	3FLx - 436-3SB11-1SM1	Ø210 / Ø330	13.0
550	2,284	1,415	806	4,362	13,739	18,892	4,462	4,669	3FLx - 446-3SB11-1SL1	Ø210 / Ø420	14.8
550	2,300	1,425	810	4,466	14,064	19,340	4,566	4,773	3FLx - 457-3SB11-1SL1	Ø210 / Ø420	15.0
550	2,300	1,425	810	4,674	14,714	20,238	4,774	4,981	3FLx - 477-3SB11-1SL1	Ø210 / Ø420	15.4
550	2,300	1,425	810	4,778	15,040	20,686	4,878	5,085	3FLx - 488-3SB11-1SL1	Ø210 / Ø420	15.6
550	2,300	1,425	810	4,882	15,365	21,135	4,982	5,189	3FLx - 498-3SB11-1SL1	Ø210 / Ø420	15.8
550	2,300	1,425	810	4,986	15,690	21,584	5,086	5,293	3FLx - 509-3SB11-1SL1	Ø210 / Ø420	16.0
550	2,300	1,425	810	5,090	16,015	22,032	5,190	5,397	3FLx - 519-3SB11-1SL1	Ø210 / Ø420	16.2
550	2,300	1,425	810	5,194	16,340	22,481	5,294	5,501	3FLx - 529-3SB11-1SL1	Ø210 / Ø420	16.4
	2,300	1,425	810	5,350	16,828	23,154	5,450	5,657	3FLx - 545-3SB11-1SL1	Ø210 / Ø420	16.7
	2,300	1,425	810	5,454	17,153	23,603	5,554	5,761	3FLx - 555-3SB11-1SL1	Ø210 / Ø420	16.9
	2,300	1,425	810	5,558	17,479	24,051	5,658	5,865	3FLx - 566-3SB11-1SL1	Ø210 / Ø420	17.1
	2,300	1,425	810	5,662	17,804	24,500	5,762	5,969	3FLx - 576-3SB11-1SL1	Ø210 / Ø420	17.4
	2,300	1,425	810	5,818	18,292	25,173	5,918	6,125	3FLx - 592-3SB11-1SL1	Ø210 / Ø420	17.7

End fittings types and standards

Type	Standard	Catalog code	Length V
Ball 16	IEC 60120	B	108 mm
Socket 16A	IEC 60120	S	99 mm
Socket 16B	IEC 60120	R	103 mm
Clevis 16L	IEC 60471	C	119 mm
Tongue 16L	IEC 60741	T	118 mm
Y-clevis 19	IEC 61466-1	Y	127 mm
Eye 24	IEC 61466-1	E	128 mm

Section length adjustment table* for other end fittings combinations, Base end fittings: Socket and Ball (catalog code: SB)

Upper end fitting (earth side)	Bottom end fitting (high-voltage side)	Catalog code	Length change, mm
Clevis 16L	Tongue 16L	CT	+30
Clevis 16L	Clevis 16L	CC	+31
Clevis 16L	Eye 24	CE	+40
Clevis 16L	Ball 16	CB	+20
Tongue 16L	Tongue 16L	TT	+29
Eye 24	Ball 16	EB	+29
Eye 24	Eye 24	EE	+49
Y-clevis 19	Eye 24	YE	+48
Y-clevis 19	Ball 16	YB	+28

* To determine the section length of an insulator with a different end fitting combination than Socket and Ball, please add the appropriate adjustment section length shown in the table above. For all other configurations not shown in this table, contact your Siemens representative.

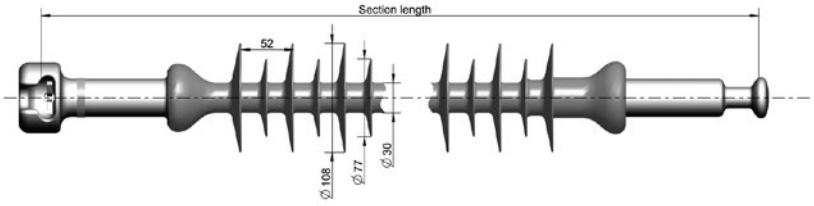
Long rod insulators 3FL5 and 3FL6

3FL silicone long rod insulators for suspension and tension applications are available in lengths appropriate for 60 kV through 550 kV. Length increments are 52 mm. A few selected insulator lengths are listed in the following table. Intermediate, shorter, or longer lengths available on request.

		3FL5	3FL6
Specified mechanical load	SML:	160 kN	210 kN
Routine test load	RTL:	80 kN	105 kN

Technical data 3FL5 and 3FL6

Highest voltage for equipment based on 25 mm/kV	Lightning impulse withstand voltage (1.2/50 µs, dry)	Switching impulse withstand voltage (250/ 2,500 µs, positive, wet)	Power-frequency withstand voltage (50 Hz, 1 min, wet)	Arcing distance	Standard creepage distance catalog code: 3	Extra-high creepage distance catalog code: 4	Nominal housing length	Section length* with Socket and Ball	Catalog code	Grading ring diameter top/ bottom (earth-/ HV-side)	App. net weight for standard creepage distance
U_m kV	LIWV kV	SIWV min kV	PFWV kV	S mm	C mm	C mm	H mm	L mm	3FL_[1]-___[2]-_[3]_[4]_[5]21-1_[6]_[7]1	D mm	W kg
<72.5	449	–	160	643	1,702	2,288	614	878	3FLx - 061-3SB21-1XX1	x / x	5.2
72.5	476	–	180	695	1,865	2,512	666	930	3FLx - 067-3SB21-1XX1	x / x	5.3
72.5	503	–	200	747	2,027	2,736	718	982	3FLx - 072-3SB21-1XX1	x / x	5.4
72.5	530	–	220	799	2,190	2,961	770	1,034	3FLx - 077-3SB21-1XX1	x / x	5.6
72.5	556	–	240	851	2,352	3,185	822	1,086	3FLx - 082-3SB21-1XX1	x / x	5.7
72.5	583	–	260	903	2,515	3,409	874	1,138	3FLx - 087-3SB21-1XX1	x / x	5.9
72.5	610	–	280	955	2,678	3,634	926	1,190	3FLx - 093-3SB21-1XX1	x / x	6.0
72.5	637	–	300	1,007	2,840	3,858	978	1,242	3FLx - 098-3SB21-1XX1	x / x	6.1
123	664	–	320	1,059	3,003	4,082	1,030	1,294	3FLx - 103-3SB21-1XX1	x / x	6.3
123	690	–	340	1,111	3,166	4,307	1,082	1,346	3FLx - 108-3SB21-1XX1	x / x	6.4
123	717	–	360	1,163	3,328	4,531	1,134	1,398	3FLx - 113-3SB21-1XX1	x / x	6.5
123	744	–	380	1,215	3,491	4,755	1,186	1,450	3FLx - 119-3SB21-1XX1	x / x	6.7
145	771	–	400	1,267	3,653	4,980	1,238	1,502	3FLx - 124-3SB21-1XX1	x / x	6.8
145	797	–	420	1,319	3,816	5,204	1,290	1,554	3FLx - 129-3SB21-1XX1	x / x	6.9
145	824	–	440	1,371	3,979	5,428	1,342	1,606	3FLx - 134-3SB21-1XX1	x / x	7.1
145	851	–	460	1,423	4,141	5,652	1,394	1,658	3FLx - 139-3SB21-1XX1	x / x	7.2
170	882	–	469	1,475	4,304	5,877	1,446	1,710	3FLx - 145-3SB21-1XX1	x / x	7.3
170	913	–	478	1,527	4,466	6,101	1,498	1,762	3FLx - 150-3SB21-1XX1	x / x	7.5
170	943	–	488	1,579	4,629	6,325	1,550	1,814	3FLx - 155-3SB21-1XX1	x / x	7.6
170	974	–	497	1,631	4,792	6,550	1,602	1,866	3FLx - 160-3SB21-1XX1	x / x	7.7
170	1,005	–	506	1,683	4,954	6,774	1,654	1,918	3FLx - 165-3SB21-1XX1	x / x	7.9
170	1,036	–	515	1,735	5,117	6,998	1,706	1,970	3FLx - 171-3SB21-1XX1	x / x	8.0
170	1,066	–	525	1,787	5,279	7,223	1,758	2,022	3FLx - 176-3SB21-1XX1	x / x	8.1
170	1,097	–	534	1,839	5,442	7,447	1,810	2,074	3FLx - 181-3SB21-1XX1	x / x	8.3
170	1,128	–	543	1,891	5,605	7,671	1,862	2,126	3FLx - 186-3SB21-1XX1	x / x	8.4
170	1,159	–	552	1,943	5,767	7,896	1,914	2,178	3FLx - 191-3SB21-1XX1	x / x	8.5
170	1,189	–	562	1,995	5,930	8,120	1,966	2,230	3FLx - 197-3SB21-1XX1	x / x	8.7
245	1,220	–	571	2,002	6,092	8,344	2,018	2,282	3FLx - 202-3SB21-1XS1	x / Ø210	9.7
245	1,251	–	580	2,054	6,255	8,569	2,070	2,334	3FLx - 207-3SB21-1XS1	x / Ø210	9.8
245	1,282	–	586	2,106	6,418	8,793	2,122	2,386	3FLx - 212-3SB21-1XS1	x / Ø210	10.0
245	1,313	–	593	2,158	6,580	9,017	2,174	2,438	3FLx - 217-3SB21-1XS1	x / Ø210	10.1
245	1,344	–	599	2,210	6,743	9,242	2,226	2,490	3FLx - 223-3SB21-1XS1	x / Ø210	10.2
245	1,375	–	605	2,262	6,906	9,466	2,278	2,542	3FLx - 228-3SB21-1XS1	x / Ø210	10.4
245	1,406	–	612	2,314	7,068	9,690	2,330	2,594	3FLx - 233-3SB21-1XS1	x / Ø210	10.5
245	1,437	–	618	2,366	7,231	9,915	2,382	2,646	3FLx - 238-3SB21-1XS1	x / Ø210	10.6
245	1,468	1,032	625	2,403	7,393	10,139	2,434	2,698	3FLx - 243-3SB21-1XM1	x / Ø210	11.5
300	1,499	1,042	631	2,455	7,556	10,363	2,486	2,750	3FLx - 249-3SB21-1XM1	x / Ø330	11.7
300	1,530	1,052	637	2,507	7,719	10,588	2,538	2,802	3FLx - 254-3SB21-1XM1	x / Ø330	11.8
300	1,561	1,062	644	2,559	7,881	10,812	2,590	2,854	3FLx - 259-3SB21-1XM1	x / Ø330	11.9
300	1,623	1,081	656	2,663	8,206	11,261	2,694	2,958	3FLx - 269-3SB21-1XM1	x / Ø330	12.2
300	1,654	1,091	663	2,715	8,369	11,485	2,746	3,010	3FLx - 275-3SB21-1XM1	x / Ø330	12.3
300	1,716	1,111	676	2,819	8,694	11,934	2,850	3,114	3FLx - 285-3SB21-1XM1	x / Ø330	12.6
362	1,778	1,130	688	2,923	9,019	12,382	2,954	3,218	3FLx - 295-3SB21-1XM1	x / Ø330	12.9
362	1,809	1,140	695	2,975	9,182	12,607	3,006	3,270	3FLx - 301-3SB21-1XM1	x / Ø330	13.0
362	1,840	1,150	701	3,027	9,345	12,831	3,058	3,322	3FLx - 306-3SB21-1XM1	x / Ø330	13.1
362	1,873	1,170	709	3,131	9,670	13,280	3,162	3,426	3FLx - 316-3SB21-1XM1	x / Ø330	13.4



[1] Specified mechanical load (SML): use »3« for 100 kN; use »4« for 120 kN.
[2] Nominal housing length in mm/10. [3] Standard creepage distance: »3«; Extra-high creepage distance: »4«.
[4] Upper end fitting (earth side) [5] Bottom end fitting (high-voltage side)
[6] Upper corona ring (earth side) [7] Bottom corona ring (high-voltage side). For all insulator types having no preinstalled corona rings and indicated by the code »X« optional corona rings can be added, if requested. For this, use the smallest corona ring available, i.e. catalog code »S«, please refer to page 10 for further catalog numbering information.

Technical data 3FL5 and 3FL6

Highest voltage for equipment based on 25 mm/kV	Lightning impulse withstand voltage (1.2/ 50 µs, dry)	Switching impulse withstand voltage (250/ 2500 µs, positive, wet)	Power-frequency withstand voltage (50 Hz, 1 min., wet)	Arcing distance	Standard creepage distance catalog code: 3	Extra-high creepage distance catalog code: 4	Nominal housing length	Section length* with Socket and Ball	Catalog code	Grading ring diameter top/bottom (earth-/HV-side)	App. net weight for standard creepage distance
U_m kV	LIWV kV	SIWV min kV	PFWV kV	S mm	C mm	C mm	H mm	L mm	3FL_[1]-___[2]-_[3]_[4]_[5]21-1_[6]_[7]1	D mm	W kg
362	1,889	1,179	713	3,183	9,832	13,504	3,214	3,478	3FLx - 321-3SB21-1XM1	x / Ø330	13.6
362	1,922	1,199	720	3,287	10,158	13,953	3,318	3,582	3FLx - 332-3SB21-1XM1	x / Ø330	13.8
362	1,939	1,209	724	3,339	10,320	14,177	3,370	3,634	3FLx - 337-3SB21-1XM1	x / Ø330	14.0
420	1,971	1,229	732	3,398	10,645	14,625	3,474	3,738	3FLx - 347-3SB21-1SM1	Ø210 / Ø330	15.1
420	2,004	1,248	740	3,502	10,971	15,074	3,578	3,842	3FLx - 358-3SB21-1SM1	Ø210 / Ø330	15.4
420	2,037	1,268	748	3,606	11,296	15,523	3,682	3,946	3FLx - 368-3SB21-1SM1	Ø210 / Ø330	15.6
420	2,054	1,278	752	3,658	11,459	15,747	3,734	3,998	3FLx - 373-3SB21-1SM1	Ø210 / Ø330	15.8
420	2,070	1,288	756	3,710	11621	15,971	3,786	4,050	3FLx - 379-3SB21-1SM1	Ø210 / Ø330	15.9
420	2,103	1,307	763	3,814	11,946	16,420	3,890	4,154	3FLx - 389-3SB21-1SM1	Ø210 / Ø330	16.2
420	2,136	1,327	771	3,918	12,272	16,869	3,994	4,258	3FLx - 399-3SB21-1SM1	Ø210 / Ø330	16.5
420	2,169	1,346	779	4,022	12,597	17,317	4,098	4,362	3FLx - 410-3SB21-1SM1	Ø210 / Ø330	16.7
420	2,185	1,356	783	4,074	12,759	17,542	4,150	4,414	3FLx - 415-3SB21-1SM1	Ø210 / Ø330	16.9
420	2,201	1,366	787	4,126	12,922	17,766	4,202	4,466	3FLx - 420-3SB21-1SM1	Ø210 / Ø330	17.0
420	2,218	1,376	791	4,178	13,085	17,990	4,254	4,518	3FLx - 425-3SB21-1SM1	Ø210 / Ø330	17.1
420	2,251	1,396	798	4,282	13,410	18,439	4,358	4,622	3FLx - 436-3SB21-1SM1	Ø210 / Ø330	17.4
550	2,284	1,415	806	4,361	13,735	18,888	4,462	4,726	3FLx - 446-3SB21-1SL1	Ø210 / Ø420	19.2
550	2,300	1,425	810	4,465	14,060	19,336	4,566	4,830	3FLx - 457-3SB21-1SL1	Ø210 / Ø420	19.5
550	2,300	1,425	810	4,673	14,711	20,234	4,774	5,038	3FLx - 477-3SB21-1SL1	Ø210 / Ø420	20.0
550	2,300	1,425	810	4,777	15,036	20,682	4,878	5,142	3FLx - 488-3SB21-1SL1	Ø210 / Ø420	20.3
550	2,300	1,425	810	4,881	15,361	21,131	4,982	5,246	3FLx - 498-3SB21-1SL1	Ø210 / Ø420	20.6
550	2,300	1,425	810	4,985	15,686	21,580	5,086	5,350	3FLx - 509-3SB21-1SL1	Ø210 / Ø420	20.8
550	2,300	1,425	810	5,089	16,012	22,028	5,190	5,454	3FLx - 519-3SB21-1SL1	Ø210 / Ø420	21.1
550	2,300	1,425	810	5,193	16,337	22,477	5,294	5,558	3FLx - 529-3SB21-1SL1	Ø210 / Ø420	21.4
	2,300	1,425	810	5,349	16,825	23,150	5,450	5,714	3FLx - 545-3SB21-1SL1	Ø210 / Ø420	21.8
	2,300	1,425	810	5,453	17,150	23,598	5,554	5,818	3FLx - 555-3SB21-1SL1	Ø210 / Ø420	22.1
	2,300	1,425	810	5,557	17,475	24,047	5,658	5,922	3FLx - 566-3SB21-1SL1	Ø210 / Ø420	22.3
	2,300	1,425	810	5,661	17,800	24,496	5,762	6,026	3FLx - 576-3SB21-1SL1	Ø210 / Ø420	22.6
	2,300	1,425	810	5,817	18,288	25,169	5,918	6,182	3FLx - 592-3SB21-1SL1	Ø210 / Ø420	23.0

End fittings types and standards

Type	Standard	Catalog code	Length V
Ball 20	IEC 60120	B	135 mm
Socket 20	IEC 60120	S	129 mm
Clevis 19L	IEC 60471	C	145 mm
Clevis 22L	IEC 60471	C	154 mm
Tongue 19L	IEC 60741	T	144 mm
Tongue 22L	IEC 60741	T	153 mm
Y-clevis 22	IEC 61466-1	Y	156 mm
Eye 25	IEC 61466-1	E	153 mm

Section length adjustment table* for other end fittings combinations, Base end fittings: Socket and Ball (catalog code: SB)

Upper end fitting (earth side)	Bottom end fitting (high-voltage side)	Catalog code	Length change, mm
Clevis 19L	Tongue 19L	CT	+25
Clevis 19L	Clevis 19L	CC	+26
Clevis 19L	Eye 25	CE	+34
Clevis 19L	Ball 20	CB	+16
Tongue 19L	Tongue 19L	TT	+24
Eye 25	Ball 20	EB	+24
Eye 25	Eye 25	EE	+42
Y-clevis 22	Eye 25	YE	+45
Y-clevis 22	Ball 20	YB	+27

* To determine the section length of an insulator with a different end fitting combination than Socket and Ball, please add the appropriate adjustment section length shown in the table above. For all other configurations not shown in this table, contact your Siemens representative.