GE
Digital Energy

GE TRANQUELL™ Surge Arresters

Product Selection & Application Guide

Polymer/Porcelain Station & Intermediate Class IEEE®/ANSI® C62.11

GE Surge Protection

The performance and reliability of today's electric power system can be enhanced with the unique characteristics of GE TRANQUELL arrester products. Since introducing the world's first metal oxide arrester in 1976, offering new concepts in surge arrester design and application, GE has developed and applied metal oxide technology for a variety of traditional and special applications. GE offers one of the most complete lines of surge arrester products in the world today; from distribution class to EHV arresters up to 612kV rating as well as high energy varistors for series capacitor applications.

Product and power systems engineers work closely to optimize product performance on the system. GE is one of the world's leading supplier of metal oxide arresters and specialty varistors.

Station Arresters are designed and manufactured in accordance with the latest revision of ANSI/IEEE C62.11. GE TRANQUELL polymer and porcelain arresters are designed to meet the most demanding service conditions.

Product Description

TRANQUELL arresters provide exceptional overvoltage protection of major power system equipment. Under normal system conditions, the arrester appears as a high impedance path. When a surge reaches the arrester, the arrester changes to a low impedance path and conducts only the current necessary to limit the overvoltage. As a result, TRANQUELL arresters absorb minimum energy to protect equipment insulation.

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Introduction

With experience dating back over 60 years, and arrester units built in the 1950's still in operation, GE has proven to be a leading supplier of these devices.

Arrester Construction

Metal Oxide Disks

The core operating component of a modern lightning arrester is the metal oxide varistor (MOV) element. As one of the worlds' leaders in MOV formulation, and their use in a gapless construction design, all classes of GE arresters offer the same quality MOV.

Classes of ANSI/IEEE C62.11 Arresters

GE TRANQUELL arresters are offered in all classes

- Station Class
- Porcelain Station Class
- Polymer Intermediate Class
- Polymer Distribution Class
- Polymer Riser Pole
- Polymer

Porcelain Surge Arresters

GE TRANQUELL porcelain surge arresters have been the industry standard for decades. Porcelain models cover voltage ratings from 3kV to 420kV. GE TRANQUELL Porcelain Extra High voltage (EHV) arresters cover ratings above 420kV.

With unrivaled mechanical strength, and an altitude rating to 12,000 feet ASL (3,600 M ASL) GE TRANQUELL porcelain models fill the most demanding applications. Tested in accordance with IEEE 693; most models meet the high seismic performance level.

Porcelain EHV Arrester

GE TRANQUELL EHV arresters incorporate a heat transfer system utilizing silicone-rubber material wedged between the metal oxide disk and internal porcelain wall. Heat generated in the valve element from steady state, temporary, or transient conditions is transferred through the silicone-rubber material to the porcelain housing and then dissipated to the outside environment.

GE TRANQUELL arresters are designed and tested in accordance with ANSI/IEEE C62.11 standards

Polymer Surge Arresters

GE TRANQUELL polymer surge arresters are constructed utilizing a rugged field-proven silicone alloy EPDM housing. Polymer models cover voltage ratings from 3kV to 228kV. GE TRANQUELL polymer arresters offer exceptional electrical characteristics such as low protective levels, high energy handling capability, and improved temporary over voltage (TOV) capability. The electrical performance of the polymer arresters is enhanced by its ability to easily transfer heat from the metal oxide elements to the outside environment. These light weight non-shattering design, fit both 8.75" and 10" mounting patterns.

Arrester Testing ANSI/IEEE C62.11

GE TRANQUELL arresters comply with the design tests outlined in ANSI/IEEE C62.11. At minimum the IEEE C62.11 clauses below are tested to, and met.

- Insulation Withstand
- Discharge Voltage
- Disc Accelerated Aging
- Contamination
- RIV
- High Current, Short Duration
- Transmission Line Discharge
- Duty Cycle
- Temporary Overvoltage
- Short Circuit
- Ultimate Mechanical Strength-Static
- Partial Discharge

In addition factory tests are performed on each metal oxide disk. Long-term stability tests are conducted on each and optimized. Every disk is subjected to an impulse current of 10kA 8/20ms to measure its discharge voltage or nominal protective level. A disk strength test series, consisting of multiple transmission-line discharges, is performed to make certain that the disk has full energy capabilities.

Selection of Arrester Rating

The objective of the application of an arrester is to select the lowest rated surge arrester that will have a satisfactory service life on the power system while providing adequate protection of equipment insulation. An arrester of the minimum practical rating is generally preferred because it provides the greatest margin of protection for the insulation. The use of a higher rating increases the capability of the arrester to survive on the power system, but reduces the margin of protection it provides for a specific insulation level. Thus, arrester selection must strike a balance between arrester survival and equipment protection.

Table 1 lists arrester ratings that would normally be applied on systems of various line-to-line voltages. The rating of the arrester is defined as the rms voltage at which the arrester passes the duty-cycle test as defined by the referenced standard. To decide which rating is most appropriate for a particular application, consideration must be given to the following system stresses to which the arrester will be exposed:

- Continuous system voltage
- Temporary overvoltages
- Switching surges (frequently a consideration in systems of 345kV and above, and for capacitor banks and cable applications)
- Lightning surges

The arrester selected must have sufficient capability to meet the anticipated service requirements in all categories.

For effectively grounded neutral systems, GE TRANQUELL arresters with MCOV equal to the maximum line to neutral kV is the normal application. As an example, a 230kV system usually has a maximum line-to-line continuous voltage of 242kV line-to-ground voltage.

Table 1A — Typical Arrester Ratings for System Voltages

Arrester Rating (kV) rms	MCOV[1] Capability (L-N) (kV) rms		NORMALLY USED ON SYSTEM VOLTAGE CLASS (L-L): High Impedance[2] Grounded, Ungrounded (Delta) Or Temporarily Ungrounded Circuits	NORMALLY USED ON SYSTEM VOLTAGE CLASS (L-L): Solidly Grounded Neutral kV rms
	Porcelain	Polymer		
3	2.55	2.55	2.4	4.16
6	5.1	5.1	4.8	4.8
9	7.65	7.65	6.9	12.47
10	8.4	8.4	8.32	13.8
12	10.2	10.2	12	--
15	12.7	12.7	13.8[2]	20.78
18	15.3	15.3	13.8	24.94
21	17	17	--	24.94
24	19.5	19.5	23[2]	--
27	22	22	23	34.5
30	24.4	24.4	24.94	34.5
36	29	29	34.5[2]	--
39	31.5	31.5	34.5[2]	--
45	36.5	36.5	34.5	--
48	39	39	46[2]	--
54	42	42	--	69
60	48	48	46	69
66	53	53	46	--
72	57	57	69[2]	--
90	74	70	69	115
96	76	76	--	115
108	84	84	--	138
108	88	88	--	138
120	98	98	115[2]	161
132	106	106	--	161

Table 1B — Typical Arrester Ratings for System Voltages

Arrester Rating (kV) rms	MCOV Capability (L-N) (kV) rms		NORMALLY USED ON SYSTEM VOLTAGE CLASS (L-L): High Impedance Grounded, Ungrounded (Delta) Or Temporarily Ungrounded Circuits	NORMALLY USED ON SYSTEM VOLTAGE CLASS (L-L): Solidly Grounded Neutral (kV) rms
	Porcelain	Polymer		
144	115	115	138[2]	161
168	131	131	138	--
172	140	140	161[2]	230
180	144	144	--	230
192	152	152	161	230
228	180	180	--	--
240	194	194	--	--
258	209	FOR NOMINAL 345kV SYSTEMS		
264	212	FOR NOMINAL 345kV SYSTEMS		
276	220	FOR NOMINAL 345kV SYSTEMS		
288	234	FOR NOMINAL 345kV SYSTEMS		
294	237	FOR NOMINAL 345kV SYSTEMS		
300	243	FOR NOMINAL 345kV SYSTEMS		
312	245	FOR NOMINAL 400kV SYSTEMS		
336	264	FOR NOMINAL 400kV SYSTEMS		
360	288	FOR NOMINAL 400kV SYSTEMS		
396	318	FOR NOMINAL 500kV SYSTEMS		
420	335	FOR NOMINAL 500kV SYSTEMS		
396	318	FOR NOMINAL 500kV SYSTEMS		
420	335	FOR NOMINAL 500kV SYSTEMS		
444	353	FOR NOMINAL 500kV SYSTEMS		
588	470	FOR NOMINAL 765kV SYSTEMS		
612	485	FOR NOMINAL 765kV SYSTEMS		

[1] TRANQUELL Arresters are designed to be operated at voltages equal to or less than their continuous capability as stated in MCOV column 2.

[2] Application of specific rating is permissible for ungrounded or resistance grounded systems where a single phase ground may be tolerated for a substantial period of time not to exceed the arrester's overvoltage capability.

Arrester Characteristics

Voltage arresters in service are continually exposed to system operating voltage. For each arrester rating there is a recommended limit to the magnitude of voltage which may be continuously applied. This has been termed the Maximum Continuous Operating Voltage (MCOV) of the arrester. The MCOV of each TRANQUELL arrester is contained in Table 2. These values meet or exceed those values contained in the referenced standard. The arrester rating must be selected such that the maximum continuous power system voltage applied to the arrester is less than, or equal to, the arrester's continuous voltage capability. Attention must be given to both the circuit connection (single phase, wye or delta) and the arrester connection (line-to-ground, line-to-line). In most cases, the arrester is connected line-to-ground and therefore must withstand line-to-ground system operating voltage. If an arrester is to be connected line-to-line, phase-to-phase voltage must be considered. In addition, attention should be given to an arrester application on the delta tertiary winding of a transformer where one corner of the delta is permanently grounded. In such circuits, the normal voltage continuously applied to the arrester will be the full phase-to-phase voltage even though the arresters are connected line-to-ground.

Table 2a
— Polymer Station Class Arrester Characteristics

				MAXIMUM DISCHARGE VOLTAGE USING 8/20 CURRENT WAVE-kV					
Rated Voltage (kV)	Maximum Continuous Operating Voltage (MCOV) (kV) rms	Maximum 0.5μs Discharge Voltage kV [(1)]	Maximum Switching Surge Protective Level kV [(2)]	1.5kA	3kA	5kA	10kA	20kA	40kA
3	2.6	8.4	6.0	6.4	6.7	7.1	7.6	8.4	9.6
6	5.1	16.7	11.9	12.8	13.5	14.1	15.2	16.8	19.1
9	7.7	25.0	17.8	19.2	20.2	21.1	22.7	25.1	28.3
10	8.4	27.8	19.8	21.4	22.5	23.5	25.3	28.0	31.8
12	10.2	33.3	23.7	25.6	26.9	28.1	30.3	33.5	38.1
15	12.7	41.7	29.7	32.0	33.7	35.2	37.9	42.0	47.6
18	15.3	50.1	35.6	38.4	40.4	42.3	45.5	50.4	57.2
21	17.0	56.3	40.1	43.2	45.5	47.6	51.2	56.7	64.4
24	19.5	63.9	45.5	49.1	51.6	54.0	58.1	64.3	73.0
27	22.0	72.9	51.9	56.0	58.9	61.6	66.3	73.4	83.3
30	24.4	80.4	57.2	61.7	64.9	67.9	73.1	80.9	91.9
36	29.0	95.9	68.3	73.6	77.4	81.0	87.2	96.5	109.6
39	31.5	104.2	74.2	80.0	84.1	88.0	94.7	104.8	119.0
45	36.5	120.9	86.1	92.8	97.6	102.1	109.9	121.7	138.1
48	39.0	128.7	91.6	98.8.0	103.9	108.7	117.0	129.5	147.1
54	42.0	144.4	102.8	110.9	116.6	122.0	131.3	145.3	165.0
60	48.0	163.5	116.4	125.5	132.0	138.0	148.6	164.5	186.8
72	57.0	191.8	136.6	147.3	154.9	162.0	174.4	193.1	219.2
90	70.0	241.8	172.1	185.6	195.2	204.2	219.8	243.3	276.3
96	76.0	257.4	183.2	197.6	207.8	217.4	234.0	259.0	294.1
108	84.0	288.9	205.6	221.8	233.2	244.0	262.6	290.7	330.1
108	88.0	288.9	205.6	221.8	233.2	244.0	262.6	290.7	330.1
120	98.0	326.9	241.3	251.0	263.9	276.1	297.2	329.0	373.6
132	106.0	352.0	252.0	270.0	284.0	298.0	317.0	353.0	404.0
144	115.0	386.1	285.0	296.5	311.7	326.1	351.0	388.6	441.2
168	131.0	445.0	330.0	343.0	363.0	380.0	409.0	446.0	503.0
172	140.0	455.0	338.0	351.0	372.0	389.0	419.0	457.0	516.0
180	144.0	476.0	354.0	367.0	389.0	407.0	438.0	478.0	539.0
192	152.0	508.0	377.0	391.0	415.0	434.0	467.0	509.0	575.0
228	180.0	604.0	448.0	465.0	493.0	516.0	556.0	607.0	684.0

[(1)] Maximum discharge voltage for a 10kA impulse current wave which produces a voltage wave cresting in 0.5 μs. This can be used for coordination where front-of-wave sparkover was formerly used.

[(2)] Based on a 500A surge of 45-μs time to crest through 88kV MCOV, and 1,000A surge of 45-μs time to crest for 98kV MCOV and higher ratings.

Arrester Characteristics (Continued)

Table 2B — Porcelain Station Class Arrester Characteristics

Type	Rated Voltage (kV)	Maximum Continuous Operating Voltage (MCOV) (kV) rms	Maximum 0.5μs Discharge Voltage kV [1]	Maximum Switching Surge Protective Level kV [2]	MAXIMUM DISCHARGE VOLTAGE USING 8/20 CURRENT WAVE-kV					
					1.5kA	3kA	5kA	10kA	20kA	40kA
4 Hole NEMA	3	2.55	9.1	6.3	6.9	7.2	7.5	8	9	10.3
	6	5.1	17.9	12.4	13.6	14.2	14.8	15.8	17.7	20.3
	9	7.65	26.6	18.4	20.2	21.1	22	23.5	26.4	30.2
	10	8.4	29.3	20.3	22.2	23.3	24.2	25.9	29.1	33.3
	12	10.2	35.5	24.6	26.9	28.2	29.4	31.4	35.2	40.4
	15	12.7	44.2	30.6	33.5	35.1	36.6	39.1	43.9	50.3
	18	15.3	53.3	36.8	40.4	42.3	44.1	47.1	52.8	60.6
	21	17	59.1	40.9	44.8	46.9	48.9	52.3	58.7	67.2
	24	19.5	67.8	46.9	51.4	53.8	56.1	60	67.3	77.1
	27	22	76.5	52.9	58	60.8	63.3	67.7	75.9	87
	30	24.4	84.9	58.7	64.3	67.4	70.3	75.1	84.2	96.5
	36	29	101	69.7	76.4	80	83.4	89.2	100	115
	39	31.5	110	75.8	83	86.9	90.6	96.9	109	125
	45	36.5	128	88.3	96.8	102	106	113	127	146
	48	39	136	93.8	103	108	113	120	135	155
	54	42	135	100	107	112	117	125	136	151
	60	48	150	111	119	125	130	139	151	168
	72	57	178	132	141	148	154	165	179	199
	90	70	225	166	178	187	195	208	226	251
	90	74	238	176	188	198	206	220	239	265
	96	76	238	176	188	198	206	220	239	265
	108	84	269	199	213	224	233	249	270	300
	108	88	275	203	218	228	238	254	276	306
	120	98	306	235	242	254	265	283	307	341
	132	106	332	254	263	276	287	307	333	370
	144	115	360	276	285	299	312	333	361	402
	168	131	416	319	330	346	360	385	418	464
	172	140	438	336	347	363	379	405	439	488
	180	144	450	345	357	374	390	416	452	502
	192	152	476	365	377	395	412	440	477	531
	228	180	568	436	450	472	492	526	570	634
	258	209	659	526	522	547	570	609	661	735
	264	212	662	528	524	550	573	612	664	738
	276	220	687	548	544	570	594	635	689	766
	288	234	728	581	577	605	630	673	731	812
	294	237	743	593	589	617	643	687	746	829
	300	243	759	606	601	630	657	702	762	846
	312	245	773	617	612	641	668	714	775	862
	336	264	833	665	659	690	719	767	835	929
	360	288	933	734	732	771	798	849	945	1053
	396	318	1139	816	822	861	897	959	1055	--
	420	335	1278	901	900	945	986	1058	1164	--
	444	353	1351	953	952	999	1043	1199	1231	
	588	470								
	612	485								
	588	470								
	612	485								

[1] Maximum discharge voltage for an impulse current wave which produces a voltage wave cresting in 0.5 μs. Discharge currents are 10kA for 2.55 - 245kV MCOV. This can be used for coordination where front-of-wave sparkover formerly was used

[2] Discharge voltages are based on a 500A surge of 45 μs time to crest through 88kV. MOV and 1,000A surge of 45 μs-time to crest through 180kV MCOV and 2,000A through 245kV MCOV MAXIMUM 0.5μS

Temporary Overvoltages

Temporary overvoltages (TOV) can be caused by a number of system events such as line-to-ground faults, circuit backfeeding, load rejection and ferroresonance. The system configuration and operating practices should be reviewed to identify the most probable forms of temporary overvoltages which may occur at the arrester location.

The primary effect of temporary overvoltages on metal oxide arresters is increased current and power dissipation, and a rising arrester temperature. TOV figures on page 7 show the temporary overvoltage capability of GE arrester designs. This figure defines the duration and magnitude of temporary overvoltages that may be applied to the arrester before the arrester voltage must be reduced to the arresters' continuous operating voltage capability. These capabilities have been defined independent of system impedance and are therefore valid for voltages applied at the arrester location.

Table 4 - Energy Capability

Arrester Rated Voltage (kV) rms	Housing Type	Arrester Type	kJ/kV OF MCOV
3 - 144kV	Polymer	Intermediate/ Station	6
2 - 57kV	Polymer	Station	6
3 - 228kV	Polymer	Station	9
3 - 48kV	Porcelain	Station	9
54 - 312kV	Porcelain	Station	13

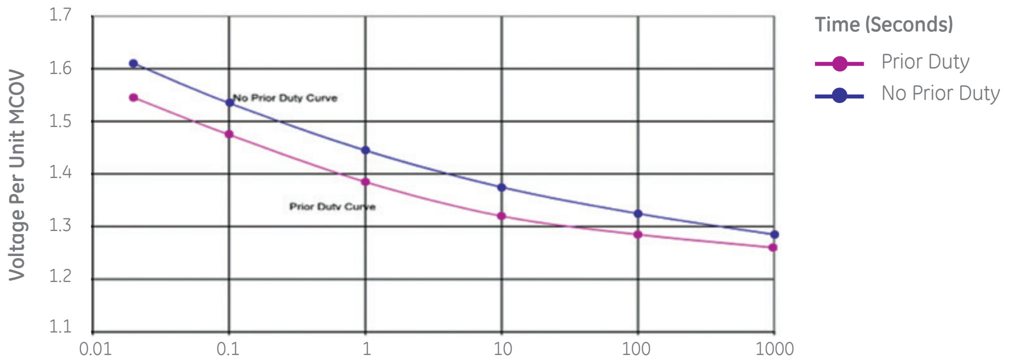
Table 5 — Pressure Relief

Arrester Type	Arrester Series	Pressure Relief Capability-Symmetrical rms kA	
		Ansi Standard C62.11 Minimum	Product Demonstrated Values
Porcelain Station-Porcelain top *	9L11ZGB	None	10
Porcelain Station-Metal top *	9L11ZGA	40-65	65
Porcelain Station-Metal top *	9L11ZTA	40-65	93
Silicone Station-Metal top, rigid core **	9L11HMA	40-65	63
Polymer Station-4 hole NEMA or eyebolt **	9L11XPA/XPB	40-65	80
Polymer Station-4 hole NEMA or eyebolt ** (compact designs)	9L11XPN/XPT/XPM	40-65	40
Polymer Intermediate-4 hole NEMA or eyebolt **	9L12PPA/PPB	16.1	40
Polymer Intermediate-eyebolt **	9L12PPT	16.1	16.1

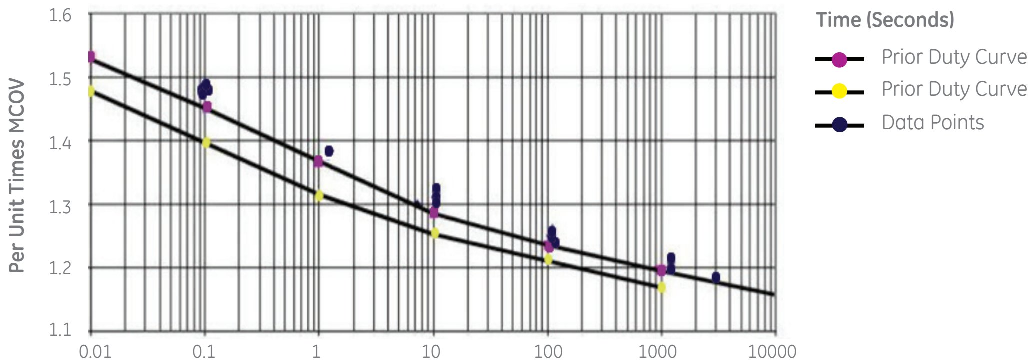
* Rating for initial venting only
** Polymer arrestors will survive multiple venting events

TOV Curves for Porcelain and Polymer Station and Intermediate Class Arresters

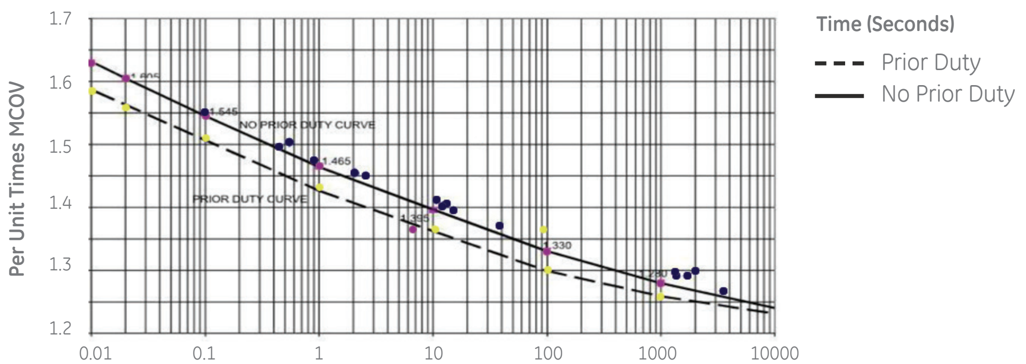
TOV Curves for 9L117 Series Station Class Arresters



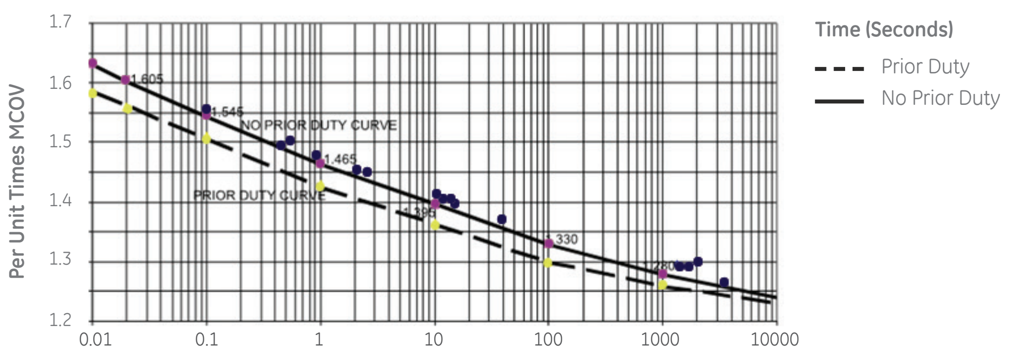
TOV Curves for 9L11XPA/B/E Series Polymer Station Class Arresters



TOV Curves for 9L11XPM/N/T Series 4Hole NEMA & Eyebolt Polymer Station Class Arresters



TOV Curves for 9L12 Series Intermediate Class Arresters



Service Conditions & Other Considerations

Arrester Withstand Capability

GE TRANQUELL arresters are built in accordance with contamination tests outlined in ANSI/IEEE C62.11. More demanding tests than those outlined in the ANSI/IEEE C62.11 have shown that TRANQUELL arresters have outstanding capability to withstand the effects of very severe external contamination.

In applications where severe contamination is anticipated and extra leakage (creepage) distance is required for other station insulation, the arrester leakage distance should be reviewed. An arrester connected line-to-ground needs to have a leakage distance no greater than that required for the other line-to-ground insulation in the station. Extra leakage distance arrester housings are available. Manual hot washing of TRANQUELL arresters with a single stream of pressurized, de-ionized water is permissible, provided electric utility industry accepted safety precautions are observed.

Arrester Failure & Pressure Relief

In the event that the capability of a GE TRANQUELL arrester is exceeded, the metal oxide disks may crack or puncture. Such damage may reduce the arrester internal electrical resistance. Although this will limit the arrester's ability to survive future system conditions, it does not jeopardize the insulation protection provided by the arrester.

In the unlikely case of complete failure of the arrester, a line-to-ground arc will develop and pressure will build up inside the housing. This pressure will be safely vented to the outside and an external arc will be established provided the fault current is within the pressure relief fault current capability of the arrester. This low-voltage arc maintains equipment protection. All ratings of metal top porcelain station arresters will withstand a system available short circuit current of at least 65,000 amperes rms. symmetrical (169,000 amperes, first crest) in accordance with the test procedures outlined in ANSI/IEEE C62.11. Porcelain pressure relief/ fault current capability for all GE TRANQUELL arresters is shown in Table 5.

Once an arrester has safely vented, it no longer possesses its pressure relief/ fault current capability. An arrester that has vented should be replaced immediately.

For a given application, the arrester to be selected should have a pressure relief/fault current capability greater than the maximum short-circuit current available at the intended arrester location including appropriate allowances for system growth. As with any porcelain arrester, the pressure relief apertures should be oriented away from adjacent apparatus to minimize damage to that apparatus in case of a pressure relief operation.

Ambient Temperature

Ambient temperature is an important consideration in the application of metal oxide arresters. Metal oxide materials exhibit a temperature dependent loss characteristic; the higher the ambient temperature, the higher will be the disk temperature when the arrester is operated at its continuous voltage capability.

The referenced standards indicate that the ambient temperature not exceeding 40°C is the standard service condition for arresters.

Altitude

GE TRANQUELL arresters are designed for altitudes between 6,000 and 12,000 ft. (3600 m) above sea level, depending upon the specific model arrester. For higher altitude applications, extra clearances may be required in the design of the arrester housing. In general, the insulation design of the substation will dictate the arrester clearances. For each 1000 ft. above a 10,000 ft. altitude, arrester clearances should increase approximately three percent.

Mounting Considerations

GE TRANQUELL arresters are designed to be self-supporting for base mounting in a vertical position. However, units for other mounting arrangements are available on request. Arresters may be horizontally mounted if the cantilever loading, including arrester weight, icing, and terminal loads, does not exceed the maximum working cantilever strength. Where applicable, the pressure relief vents should be located on the underside of the arrester. Units for suspension mountings are also available.

The rated working cantilever strengths for various arrester ratings are shown in Table 6 and are defined in accordance with ANSI C29.9 [8]. The defined strengths exceed the requirements for US Seismic Zone 3 (< 0.2g). For arresters installed in higher zones, seismic requirements need to be specified.

In the installation of arresters, recommended clearances between the arrester and any adjacent equipment must be observed. Failure to do so may result in unwanted flashovers and electrical overstress to internal arrester elements.

GE TRANQUELL arresters are designed to have a uniform voltage gradient along the length of the porcelain column. Where applicable, a grading ring is mounted on top of the arrester to establish a more uniform voltage distribution along the arrester. Clearly, if the arrester were mounted adjacent to a ground plane, this uniformity would be disturbed. To avoid such a situation, the minimum clearances to ground planes and other phase conductors must be observed.

Field Testing

In general, it is impractical to fully test an arrester in the field without high-voltage test equipment and accurate instrumentation. Instead, the arrester leakage current can be used to monitor the over-all state or condition of the arrester. For example, an abnormal leakage current measurement can be indicative of a wet, surface-contaminated, or vented arrester.

Arrester leakage current can be monitored by a surge-counter leakage meter or by an oscilloscope connected directly to a surgecounter test connection. Typical arrester leakage currents of station arresters operating at their continuous voltage capability and at 20°C are in the range of one-half to three milliamperes. Contamination of the arrester housing will contribute another component to the leakage current. If leakage current is to be used as an indication of arrester condition, the arrester must be clean, and the voltage and temperature must correspond to some standard test conditions, specific to each arrester location.

Arrester Selection Summary

The arrester selection process should include a review of all system stresses and service conditions expected at the arrester location. System stresses include continuous operating voltage, temporary overvoltages, and switching surges. If arresters of different ratings are required to meet these individual criteria, the highest resulting rating must be chosen. The arresters' capability for contamination, pressure relief, ambient temperature, and altitude must exceed the specified requirements.

Insulation Coordination

Once an arrester has been selected, the protection it provides to the equipment insulation can be determined. This protection is dependent on the protective characteristics of the arrester, the lightning and switching surges expected on the system, and the insulation characteristics of the protected equipment. It is quantified in terms of the protective ratio which is the ratio of the equipment insulation withstand to the arrester protective level. The objective is to meet or exceed the minimum protective ratios for the various classes of voltage surges as recommended in the application standards. An alternate measure is the percent protective margin which is the protective ratio minus one, times 100%. For example, a protective ratio of 1.53 corresponds to a 53% protective margin.

Arrester Protective Characteristics

The protective characteristic of GE TRANQUELL arresters is solely defined by the discharge voltage and is generally proportional to arrester MCOV. For any one arrester, the discharge voltage is a function of the magnitude of the arrester current and, in the impulse region, of the time to crest of the arrester current. In general, for any specific applied impulse current through the arrester, the time-to-crest for the voltage wave will be less than the time-to-crest for the current wave. Figure 1 shows the test results of a 10 kA 8/20 μs current impulse test.

GE TRANQUELL protective characteristics have been defined for fast impulse currents with times-to-crest shorter than 8 μs. Available data on lightning strikes and simulation studies on impulse transients within substations both indicate that arresters in service may be subjected to fast current impulse waves. To illustrate arrester protection for slower transients, the discharge voltages have been defined for standard switching surge currents.

The arrester protective characteristic is a continuous function defined over a range of discharge currents and their resultant discharge voltages. The insulation withstand of equipment on the other hand, is generally defined only at three voltage points through the use of the standard switching surge, the full wave, and the chopped wave tests. To facilitate comparison with these three withstands, three protective levels are selected for coordination with the transformer insulation characteristics. They are described as follows:

- Switching Surge Protective Level: This is the crest discharge voltage that results when a 36/90 •s current impulse is applied to the arrester. To define the arrester's switching surge protective level, a "switching surge coordination current" is defined for the various system voltages. These currents are: 500 amperes for maximum system line-to-line voltages to 150kV, 1000 amperes for systems 151 to 325kV, and 2000 amperes for systems above 325kV.
- Impulse Protective Level: This is the crest discharge voltage that results when an 8/20 •s current impulse is applied to the arrester. The resultant crest voltages for a variety of crest currents are given in the applicable Arrester Characteristics Table. To allow coordination with transformer insulation, a specific current impulse magnitude must be selected based on the system voltage. Reference [5] provides guidance for this selection.
- Front-of-Wave Protective Level: This is the discharge voltage for current impulses having a faster time to crest than the 8/20 •s current impulse. This resultant crest voltage is listed as the front-of-wave (FOW) protective level. This protective level is derived by applying a series of current wave impulses to an arrester with varying times to crest (1, 2, 8 ms) and extending the measured voltages to 0.5 •s in accordance with ANSI/IEEE.

Protective Ratios

The three-point method is usually applied for insulation coordination. In this method the protective ratios are calculated at three separate points within the volt-time domain; namely switching surge, full wave, and chopped wave regions. If the following protective ratios are met or exceeded, satisfactory insulation coordination will be achieved according to the minimum recommendations given in ANSI C62.22.

These calculated protective ratios assume negligible arrester lead length and separation distance between the arrester and the transformer.

$$\frac{\text{Switching Surge Withstand}}{\text{Switching Surge Protective Level}} >= 1.15$$

$$\frac{\text{Full Wave Withstand (BIL)}}{\text{Impulse Protective Level}} >= 1.20$$

$$\frac{\text{Chopped Wave Withstand}}{\text{Front-of-Wave Protective Level}} >= 1.25$$

In many cases, the calculated protective ratios exceed the minimum protective ratios recommended by ANSI by a considerable amount in actual power system applications.

As a specific example in protective ratio calculation, consider a 550kV BIL transformer protected by a 144kV rated GE TRANQUELL polymer station surge arrester. The three transformer insulation withstand voltages are as specified in ANSI C57.12.00[9]. The calculated ratios indicate that the arrester would provide excellent protection for the transformer insulation.

If the separation distance between the transformer and arrester is not negligible, the transformer voltage can oscillate above the arrester voltage during lightning transients, thus reducing the protective ratio. Guidance in estimating these effects can be obtained from ANSI C62.22 and References [10] and [11]. When making such transformer voltage estimates for shielded stations, it is suggested that the front-of-wave protective level of the arrester be used as an approximation for the arrester voltage. In decisive situations, it is suggested that digital computer studies be performed in which the arrester and substation details can be modeled.

Figure 2

Arrester voltage and current osillograms for 10kA, 8/20us current impulse test

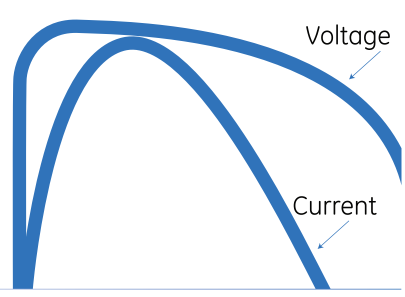


Table 6 — Cantilever Strength

Arrester Rated Voltage (kVrms)	Housing Type	Arrester Series	Arrester Type	Rated Ultimate Cantilever Strength		Maximum Working Cantilever Strength	
				in-lbs.	n-m	in-lbs.	n-m
3 - 72kV	Polymer	9L11PPA/PPB	Intermediate	4,000	452	2,000	226
90 - 144kV	Polymer	9L11PPA/PPB	Intermediate	10,000	1,130	5,000	565
3 - 144kV	Polymer	9L11XPA/XPB	Station	20,000	2,260	10,000	1,130
3 - 48kV	Porcelain	9L11ZGA	Station	70,000	7,909	28,000	3,163
54 - 444kV	Porcelain	9L11ZTA	Station	150,000	16,947	60,000	6,779
396 - 612kV	Porcelain	9L16GNS	Station	275,000	31,070	110,000	12,428

Table 7

Transformer Insulation Arrester Protective Withstand And Test Wave	Arrester Protective Withstand And Test
Switching Surge 250/2500 μs voltage	Switching Surge 36/90 μs current
Full wave 1.2/50 μs voltage wave	Impulse 8/20 μs current
Chopped wave 1.2/50 μs voltage	Front-of-wave 0.5μs current wave

Table 8 — Example of a 144kV Rated Protective Ratio Calculation

Transformer Withstand Tests	Transformer Withstand Voltages (kV)	Arrester Protective Levels (kV)	Protective Ratios
Switching Surge	460	285	1.61
Full Wave	550	351	1.57
Chopped Wave	630	386.1	1.63

Polymer Station Class

Electrical Characteristics — 4 hole NEMA and Eyebolt - for Indoor and Outdoor

STANDARD ARRESTER CATALOG NUMBER		ARRESTER RATINGS				MAXIMUM DISCHARGE VOLTAGE- 8/20 CURRENT WAVE-kV					
4 Hole Nema	Eyebolt Terminal	Rated Voltage (kV) rms	Maximum Continuous Operating Voltage (Mcov) (kV) rms	Maximum 0.5μs Discharge Voltage kV [1]	Maximum Switching Surge Protective Level kV [2]	1.5kA	3kA	5kA	10kA	20kA	40kA
9L11XPA003S	9L11XPB003S	3	2.55	8.4	6	6.4	6.7	7.1	7.6	8.4	9.6
9L11XPA006S	9L11XPB006S	6	5.1	16.7	11.9	12.8	13.5	14.1	15.2	16.8	19.1
9L11XPA009S	9L11XPB009S	9	7.65	25	17.8	19.2	20.2	21.1	22.7	25.1	28.3
9L11XPA010S	9L11XPB010S	10	8.4	27.8	19.8	21.4	22.5	23.5	25.3	28	31.8
9L11XPA012S	9L11XPB012S	12	10.2	33.3	23.7	25.6	26.9	28.1	30.3	33.5	38.1
9L11XPA015S	9L11XPB015S	15	12.7	41.7	29.7	32	33.7	35.2	37.9	42	47.6
9L11XPA018S	9L11XPB018S	18	15.3	50.1	35.6	38.4	40.4	42.3	45.5	50.4	57.2
9L11XPA021S	9L11XPB021S	21	17	56.3	40.1	43.2	45.5	47.6	51.2	56.7	64.4
9L11XPA024S	9L11XPB024S	24	19.5	63.9	45.5	49.1	51.6	54	58.1	64.3	73
9L11XPA027S	9L11XPB027S	27	22	72.9	51.9	56	58.9	61.6	66.3	73.4	83.3
9L11XPA030S	9L11XPB030S	30	24.4	80.4	57.2	61.7	64.9	67.9	73.1	80.9	91.9
9L11XPA036S	9L11XPB036S	36	29	95.9	68.3	73.6	77.4	81	87.2	96.5	109.6
9L11XPA039S	9L11XPB039S	39	31.5	104.2	74.2	80	84.1	88	94.7	104.8	119
9L11XPA045S	9L11XPB045S	45	36.5	120.9	86.1	92.8	97.6	102.1	109.9	121.7	138.1
9L11XPA048S	9L11XPB048S	48	39	128.7	91.6	98.8.0	103.9	108.7	117	129.5	147.1
9L11XPA054S	9L11XPB054S	54	42	144.4	102.8	110.9	116.6	122	131.3	145.3	165
9L11XPA060S	9L11XPB060S	60	48	163.5	116.4	125.5	132	138	148.6	164.5	186.8
9L11XPA072S	9L11XPB072S	72	57	191.8	136.6	147.3	154.9	162	174.4	193.1	219.2
9L11XPA090S	9L11XPB090S	90	70	241.8	172.1	185.6	195.2	204.2	219.8	243.3	276.3
9L11XPA096S	9L11XPB096S	96	76	257.4	183.2	197.6	207.8	217.4	234	259	294.1
9L11XPA108S	9L11XPB108S	108	84	288.9	205.6	221.8	233.2	244	262.6	290.7	330.1
9L11XPA120S	9L11XPB120S	120	98	326.9	241.3	251	263.9	276.1	297.2	329	373.6
9L11XPA132S	9L11XPB132S	132	106	352	252	270	284	298	317	353	404
9L11XPA144S	9L11XPB144S	144	115	386.1	285	296.5	311.7	326.1	351	388.6	441.2
9L11XPA168S	9L11XPB168S	168	131	445	330	343	363	380	409	446	503
9L11XPA172S	9L11XPB172S	172	140	455	338	351	372	389	419	457	516
9L11XPA180S	9L11XPB180S	180	144	476	354	367	389	407	438	478	539
9L11XPA192S	9L11XPB192S	192	152	508	377	391	415	434	467	509	575
9L11XPA228S	9L11XPB228S	228	180	604	448	465	493	516	556	607	684

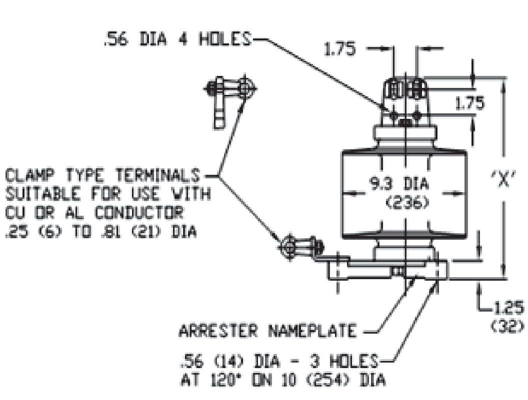
(1) Maximum discharge voltage for a 10kA impulse current wave which produces a voltage wave cresting in 0.5 μs. This can be used for coordination where front-of-wave sparkover was formerly used.

(2) Based on a 500A surge of 45-μs time to crest through 88kV MCOV, and 1,000A surge of 45-μs time to crest for 98kV MCOV and higher ratings.

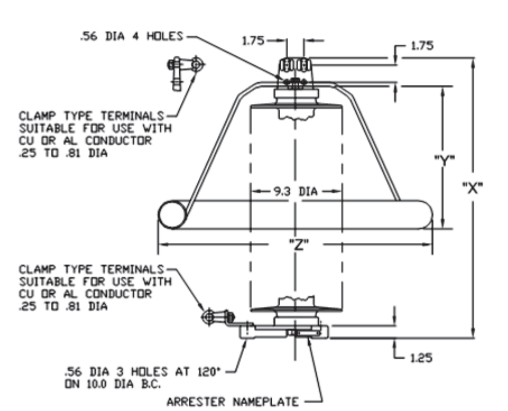
Physical Characteristics — 4 Hole NEMA - for Indoor and Outdoor

STANDARD ARRESTER CATALOG NUMBER		ARRESTER RATINGS					INSULATION WITHSTAND DISTANCE					
4 Hole NEMA	Duty Cycle	MCOV (kV) rms	Height "X"		Polymer	Creepage Distance	Phase to Phase		Phase to Ground		Weight	
			in	mm	Drawing	in/mm	in	mm	in	mm	lbs	kg
9L11XPA003S	3	2.55	13.7	348	1	23	12.3	312.4	7.7	195.58	20.3	9.2
9L11XPA006S	6	5.1	13.7	348	1	23	12.3	312.4	7.7	195.58	20.8	9.4
9L11XPA009S	9	7.65	13.7	348	1	23	12.3	312.4	7.7	195.58	21.3	9.7
9L11XPA010S	10	8.4	13.7	348	1	23	12.3	312.4	7.7	195.58	21.6	9.8
9L11XPA012S	12	10.2	16.3	414	1	31	12.3	312.4	7.7	195.58	25.2	11.4
9L11XPA015S	15	12.7	16.3	414	1	31	12.3	312.4	7.7	195.58	25.8	11.7
9L11XPA018S	18	15.3	16.3	414	1	31	12.3	312.4	7.7	195.58	26.3	11.9
9L11XPA021S	21	17	21.7	551	1	46	12.3	312.4	7.7	195.58	33.6	15.2
9L11XPA024S	24	19.5	21.7	551	1	46	12.3	312.4	8	203.2	34.2	15.5
9L11XPA027S	27	22	21.7	551	1	46	12.3	312.4	8.8	223.52	34.7	15.7
9L11XPA030S	30	24.4	21.7	551	1	46	12.3	312.4	9.6	243.84	35.2	16.0
9L11XPA036S	36	29	27	686	1	46	13.8	350.5	11	279.4	36.5	16.5
9L11XPA039S	39	31.5	27	686	1	62	14.6	370.8	11.8	299.72	43.5	19.7
9L11XPA045S	45	36.5	27	686	1	62	16.3	414.0	13.5	342.9	44.4	20.1
9L11XPA048S	48	39	27	686	1	62	17	431.8	14.2	360.68	45.2	20.5
9L11XPA054S	54	42	32.3	820	1	78	18.6	472.4	15.8	401.32	52.6	23.8
9L11XPA060S	60	48	32.3	820	1	78	20.6	523.2	17.8	452.12	53.6	24.3
9L11XPA072S	72	57	48.1	1222	1	92	23.4	594.4	20.6	523.24	76.7	34.8
9L11XPA090S	90	70	48.1	1222	1	124	27	685.8	24.5	622.3	77	34.9
9L11XPA096S	96	76	48.1	1222	1	124	30.5	774.7	28	711.2	80	36.3
9L11XPA108S	108	84	58.8	1494	2	156	44.5	1130.3	36.5	927.1	98.9	44.8
9L11XPA120S	120	98	58.8	1494	2	156	49	1244.6	41	1041.4	101	45.8
9L11XPA132S	132	106	69.3	1760	2	156	53	1346.2	45	1143	105	47.6
9L11XPA144S	144	115	69.3	1760	2	186	56	1422.4	48	1219.2	120.1	54.4
9L11XPA168S	168	131	87.9	2233	2	234	74	1879.6	60	1524	152	68.9
9L11XPA172S	172	140	87.9	2233	2	234	77	1955.8	63	1600.2	152	68.9
9L11XPA180S	180	144	87.9	2233	2	234	78	1981.2	64	1625.6	152	68.9
9L11XPA192S	192	152	87.9	2233	2	234	84	2133.6	70	1778	152	68.9
9L11XPA228S	228	180	115.7	2939	2	312	94	2387.6	80	2032	201	91.1

Drawing 1 (Polymer)



Drawing 2 (Polymer)



GRADING RINGS		
kV-Rated	Drop Inches (Y)	Diameter Inches (Z)
108	4.8	14.0
120 - 144	9.0	16.5
168 - 228	14.5	27.9

Note: Grading Rings are required on all arresters rated 108kV and above

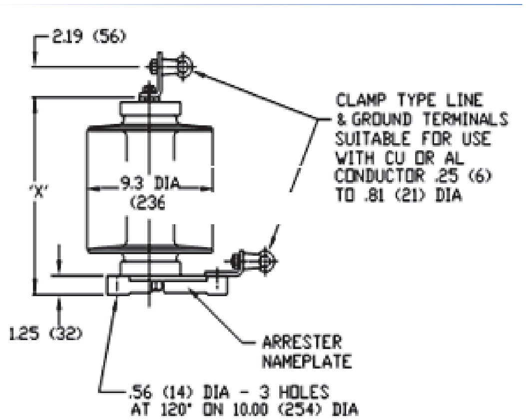
XPA series arresters have 10 inch base bolt center

Polymer Station Class (Continued)

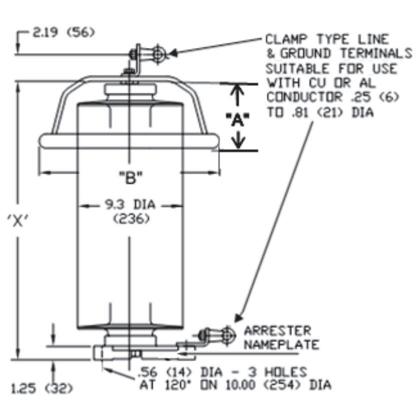
Physical Characteristics — Eyebolt - for Indoor and Outdoor[3]

STANDARD ARRESTER CATALOG NUMBER		ARRESTER RATINGS						INSULATION WITHSTAND DISTANCE					
4 Hole NEMA	Duty Cycle (kV) rms	MCOV (kV) rms	Height "X"		Polymer	Creepage Distance		Phase to Phase		Phase to Ground		Weight	
			in	mm	Drawing	in	mm	in	mm	in	mm	lbs	kg
9L11XPB003S	3	2.55	10.2	259	1A	23	584	12.3	312.4	7.7	195.6	20.3	9.2
9L11XPB006S	6	5.1	10.2	259	1A	23	584	12.3	312.4	7.7	195.6	20.8	9.4
9L11XPB009S	9	7.65	10.2	259	1A	23	584	12.3	312.4	7.7	195.6	21.3	9.7
9L11XPB010S	10	8.4	10.2	259	1A	23	584	12.3	312.4	7.7	195.6	21.6	9.8
9L11XPB012S	12	10.2	12.8	325	1A	31	787	12.3	312.4	7.7	195.6	25.2	11.4
9L11XPB015S	15	12.7	12.8	325	1A	31	787	12.3	312.4	7.7	195.6	25.8	11.7
9L11XPB018S	18	15.3	12.8	325	1A	31	787	12.3	312.4	7.7	195.6	26.3	11.9
9L11XPB021S	21	17	18.2	462	1A	46	1168	12.3	312.4	7.7	195.6	33.6	15.2
9L11XPB024S	24	19.5	18.2	462	1A	46	1168	12.3	312.4	8	203.2	34.2	15.5
9L11XPB027S	27	22	18.2	462	1A	46	1168	12.3	312.4	8.8	223.5	34.7	15.7
9L11XPB030S	30	24.4	18.2	462	1A	46	1168	12.3	312.4	9.6	243.8	35.2	16.0
9L11XPB036S	36	29	18.2	462	1A	46	1168	13.8	350.5	11	279.4	36.5	16.5
9L11XPB039S	39	31.5	23.5	597	1A	62	1575	14.6	370.8	11.8	299.7	43.5	19.7
9L11XPB045S	45	36.5	23.5	597	1A	62	1575	16.3	414.0	13.5	342.9	44.4	20.1
9L11XPB048S	48	39	23.5	597	1A	62	1575	17	431.8	14.2	360.7	45.2	20.5
9L11XPB054S	54	42	28.8	732	1A	78	1981	18.6	472.4	15.8	401.3	52.6	23.8
9L11XPB060S	60	48	28.8	732	1A	78	1981	20.6	523.2	17.8	452.1	53.6	24.3
9L11XPB072S	72	57	34	864	1A	92	2337	23.4	594.4	20.6	523.2	76.7	34.8
9L11XPB090S	90	70	44.6	1133	1A	124	3150	27	685.8	24.5	622.3	77	34.9
9L11XPB096S	96	76	44.6	1133	1A	124	3150	30.5	774.7	28	711.2	80	36.3
9L11XPB108S	108	84	55.3	1405	2A	156	3962	44.5	1130.3	36.5	927.1	98.9	44.8
9L11XPB120S	120	98	55.3	1405	2A	156	3962	49	1244.6	41	1041.4	101	45.8
9L11XPB132S	132	106	55.3	1405	2A	156	3962	53	1346.2	45	1143.0	105	47.6
9L11XPB144S	144	115	65.8	1671	2A	186	4724	56	1422.4	48	1219.2	120.1	54.4
9L11XPB168S	168	131	84.4	2144	2A	234	5944	74	1879.6	60	1524.0	152	68.9
9L11XPB172S	172	140	84.4	2144	2A	234	5944	77	1955.8	63	1600.2	152	68.9
9L11XPB180S	180	144	84.4	2144	2A	234	5944	78	1981.2	64	1625.6	152	68.9
9L11XPB192S	192	152	84.4	2144	2A	234	5944	84	2133.6	70	1778.0	152	68.9
9L11XPB228S	228	180	112.2	2850	2A	312	7925	94	2387.6	80	2032.0	201	91.1

Drawing 1 (Polymer)



Drawing 2 (Polymer)



GRADING RINGS		
kV-Rated	Drop Inches (Y)	Diameter Inches (Z)
108 - 120	4.8	14.0
132 - 144	9.0	16.5
168 - 228	14.5	27.9

Note: Grading Rings are required on all arresters rated 108kV and above

Porcelain Station Class

Electrical Characteristics — 4 Hole NEMA - for Indoor and Outdoor Upright Mounting

ARRESTER RATINGS					MAXIMUM DISCHARGE VOLTAGE USING 8/20 CURRENT WAVE-kV					
Arrester Catalog Number	Rated Voltage (kV)	Maximum Continuous Operating Voltage (MCOV) (kV) rms	Maximum 0.5μs Discharge Voltage kV [1]	Maximum Switching Surge Protective Level kV [2]	1.5kA	3kA	5kA	10kA	20kA	40kA
9L11ZGA003S	3	2.55	9.1	6.3	6.9	7.2	7.5	8	9	10.3
9L11ZGA006S	6	5.1	17.9	12.4	13.6	14.2	14.8	15.8	17.7	20.3
9L11ZGA009S	9	7.65	26.6	18.4	20.2	21.1	22	23.5	26.4	30.2
9L11ZGA010S	10	8.4	29.3	20.3	22.2	23.3	24.2	25.9	29.1	33.3
9L11ZGA012S	12	10.2	35.5	24.6	26.9	28.2	29.4	31.4	35.2	40.4
9L11ZGA015S	15	12.7	44.2	30.6	33.5	35.1	36.6	39.1	43.9	50.3
9L11ZGA018S	18	15.3	53.3	36.8	40.4	42.3	44.1	47.1	52.8	60.6
9L11ZGA021S	21	17	59.1	40.9	44.8	46.9	48.9	52.3	58.7	67.2
9L11ZGA024S	24	19.5	67.8	46.9	51.4	53.8	56.1	60	67.3	77.1
9L11ZGA027S	27	22	76.5	52.9	58	60.8	63.3	67.7	75.9	87
9L11ZGA030S	30	24.4	84.9	58.7	64.3	67.4	70.3	75.1	84.2	96.5
9L11ZGA036S	36	29	101	69.7	76.4	80	83.4	89.2	100	115
9L11ZGA039S	39	31.5	110	75.8	83	86.9	90.6	96.9	109	125
9L11ZGA045S	45	36.5	128	88.3	96.8	102	106	113	127	146
9L11ZGA048S	48	39	136	93.8	103	108	113	120	135	155
9L11ZTA054S	54	42	135	100	107	112	117	125	136	151
9L11ZTA060S	60	48	150	111	119	125	130	139	151	168
9L11ZTA072S	72	57	178	132	141	148	154	165	179	199
9L11ZTA090S	90	74	238	176	188	198	206	220	239	265
9L11ZTA096S	96	76	238	176	188	198	206	220	239	265
9L11ZXA108S	108	84	269	199	213	224	233	249	270	300
9L11ZTA108S	108	88	275	203	218	228	238	254	276	306
9L11ZTA120S	120	98	306	235	242	254	265	283	307	341
9L11ZTA132S	132	106	332	254	263	276	287	307	333	370
9L11ZTA144S	144	115	360	276	285	299	312	333	361	402
9L11ZTA168S	168	131	416	319	330	346	360	385	418	464
9L11ZTA172S	172	140	438	336	347	363	379	405	439	488
9L11ZTA180S	180	144	450	345	357	374	390	416	452	502
9L11ZTA192S	192	152	476	365	377	395	412	440	477	531
9L11ZTA228S	228	180	568	436	450	472	492	526	570	634
9L11ZTA258S	258	209	659	526	522	547	570	609	661	735
9L11ZTA264S	264	212	662	528	524	550	573	612	664	738
9L11ZTA276S	276	220	687	548	544	570	594	635	689	766
9L11ZTA288S	288	234	728	581	577	605	630	673	731	812
9L11ZTA294S	294	237	743	593	589	617	643	687	746	829
9L11ZTA300S	300	243	759	606	601	630	657	702	762	846
9L11ZTA312S	312	245	773	617	612	641	668	714	775	862
9L11ZTA336S	336	264	833	665	659	690	719	767	835	929
9L11ZTA360S	360	288	933	734	732	771	798	849	945	1053
9L11ZTA396S	396	318	1139	816	822	861	897	959	1055	--
9L11ZTA420S	420	335	1278	901	900	945	986	1058	1164	--
9L11ZTA444S	444	353	1351	953	952	999	1043	1199	1231	
9L16GNS588S	588	470								
9L16GNS612S	612	485								
9L16GNS588S	588	470								
9L16GNS612S	612	485								

[1] Maximum discharge voltage for an impulse current wave which produces a voltage wave cresting in 0.5 μs. Discharge currents are 10kA for 2.55 - 245kV MCOV. This can be used for coordination where front-of-wave sparkover formerly was used.

[2] Discharge voltages are based on a 500A surge of 45 μs time to crest through 88kV MOV and 1,000A surge of 45 μs-time to crest through 180kV MCOV and 2,000A through 245kV MCOV.

Porcelain Station Class (Continued)

Electrical Characteristics — Top Eyebolt - For Indoor or Cubicle Mounting

	Arrester Ratings					Maximum Discharge Voltage Using 8/20 Current Wave-KV					
Type	Arrester Catalog Number	Rated Voltage (kV)	Maximum Continuous Operating Voltage (MCOV) (kV) rms	Maximum 0.5μs Discharge Voltage kV [1]	Maximum Switching Surge Protective Level kV [2]	1.5kA	3kA	5kA	10kA	20kA	40kA
Porcelain Top (eyebolt) Indoor/ Cubicle	9L11ZGB003S	3	2.55	9.1	6.3	6.9	7.2	7.5	8	9	10.3
	9L11ZGB006S	6	5.1	17.9	12.4	13.6	14.2	14.8	15.8	17.7	20.3
	9L11ZGB009S	9	7.65	26.6	18.4	20.2	21.1	22	23.5	26.4	30.2
	9L11ZGB010S	10	8.4	29.3	20.3	22.2	23.3	24.2	25.9	29.1	33.3
	9L11ZGB012S	12	10.2	35.5	24.6	26.9	28.2	29.4	31.4	35.2	40.4
	9L11ZGB015S	15	12.7	44.2	30.6	33.5	35.1	36.6	39.1	43.9	50.3
	9L11ZGB018S	18	15.3	53.3	36.8	40.4	42.3	44.1	47.1	52.8	60.6
	9L11ZGB021S	21	17	59.1	40.9	44.8	46.9	48.9	52.3	58.7	67.2
	9L11ZGB024S	24	19.5	67.8	46.9	51.4	53.8	56.1	60	67.3	77.1
	9L11ZGB027S	27	22.0	76.5	52.9	58.0	60.8	63.3	67.7	75.9	87.0

[1] Maximum discharge voltage for an impulse current wave which produces a voltage wave cresting in 0.5 μs. Discharge currents are 10kA for 2.55 - 245kV MCOV. This can be used for coordination where front-of-wave sparkover formerly was used.

[2] Discharge voltages are based on a 500A surge of 45 μs time to crest through 88kV MOV and 1,000A surge of 45 μs-time to crest through 180kV MCOV and 2,000A through 245kV MCOV.

Physical Characteristics
— 4 Hole NEMA - for Indoor and Outdoor Upright Mounting

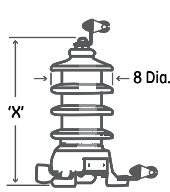
								INSULATION WITHSTAND DISTANCE					
Standard Arrester Catalog Number	Duty Cycle (kV) rms	MCOV (kV) rms	Porcelain	Height "X"		Creepage Distance		Phase to Phase		Phase to Ground		Weight	
			Drawing	in	mm	in	mm	in	mm	in	mm	lbs	kg
9L11ZGA003S	3	2.55	2	19.13	485.9	6.2	157.5	12	304.8	6	152.4	65	29.5
9L11ZGA006S	6	5.1	2	19.13	485.9	6.2	157.5	12	304.8	7	177.8	65	29.5
9L11ZGA009S	9	7.65	2	19.13	485.9	6.2	157.5	13	330.2	7	177.8	66	30.0
9L11ZGA010S	10	8.4	2	19.13	485.9	6.2	157.5	13	330.2	8	203.2	66	30.0
9L11ZGA012S	12	10.2	2	21.13	536.7	11.1	281.9	14	355.6	8.5	215.9	72	32.7
9L11ZGA015S	15	12.7	2	21.13	536.7	11.1	281.9	14	355.6	8.5	215.9	73	33.2
9L11ZGA018S	18	15.3	2	24.13	612.9	20	508.0	16	406.4	9	228.6	80	36.4
9L11ZGA021S	21	17	2	24.13	612.9	20	508.0	16	406.4	9	228.6	81	36.8
9L11ZGA024S	24	19.5	2	24.13	612.9	20	508.0	17	431.8	11	279.4	82	37.3
9L11ZGA027S	27	22	2	28.13	714.5	31.7	805.2	18	457.2	12	304.8	90	40.9
9L11ZGA030S	30	24.4	2	28.13	714.5	31.7	805.2	18	457.2	12	304.8	91	41.4
9L11ZGA036S	36	29	2	28.13	714.5	31.7	805.2	20	508	14	355.6	93	42.3
9L11ZGA039S	39	31.5	2	31.88	809.8	41	1041.4	21	533.4	14	355.6	105	47.7
9L11ZGA045S	45	36.5	2	31.88	809.8	41	1041.4	21	533.4	15	381	107	48.6
9L11ZGA048S	48	39	2	31.88	809.8	41	1041.4	22	558.8	15	381	109	49.5
9L11ZTA054S	54	42	3	38.13	968.5	60	1524	24	609.6	18	457.2	180	81.8
9L11ZTA060S	60	48	3	38.13	968.5	60	1524	25	635	19	482.6	185	84.1
9L11ZTA066S	66		3	44.13	1120.9	80	2032	26	660.4	20	508	220	100.0
9L11ZTA072S	72	57	3	50.63	1286.0	101	2565.4	33	838.2	27	685.8	250	113.6
9L11ZTA090S	90	70	3	50.63	1286.0	101	2565.4	35	889	29	736.6	260	118.2
9L11ZTA096S	96	76	3	50.63	1286.0	101	2565.4	37	939.8	31	787.4	265	120.5
9L11SXA108S	108	84	3	57.13	1451.1	122	3098.8	38	965.2	32	812.8	280	127.3
9L11ZTA108S	108	88	3	57.13	1451.1	122	3098.8	39	990.6	33	838.2	285	129.6
9L11ZTA120S	120	98	3	57.13	1451.1	122	3098.8	42	1066.8	36	914.4	290	131.8
9L11ZTA132S	132	106	4	76.63	1946.4	140	3556	44	1117.6	38	965.2	395	179.6
9L11ZTA144S	144	115	4	82.63	2098.8	160	4064	51	1295.4	46	1168.4	425	193.2
9L11ZTA168S	168	131	4	89.13	2263.9	181	4597.4	59	1498.6	54	1371.6	465	211.4
9L11ZTA172S	172	140	5	89.13	2263.9	181	4597.4	78	1981.2	59	1498.6	475	215.9
9L11ZTA180S	180	144	5	89.13	2263.9	181	4597.4	83	2108.2	64	1625.6	480	218.2
9L11ZTA192S	192	152	5	96.13	2441.7	202	5130.8	83	2108.2	67	1701.8	515	234.1
9L11ZTA228S	228	180	5	108.63	2759.2	244	6197.6	92	2336.8	73	1854.2	590	268.2
9L11ZTA240S	240	194	5	108.63	2759.2	244	6197.6	103	2616.2	85	2159	595	270.5
9L11ZTA258S	258	209	6	128.13	3254.5	262	6654.8	111	2819.4	92	2336.8	700	318.2
9L11ZTA264S	264	212	6	133.63	3394.2	282	7162.8	116	2946.4	96	2438.4	725	329.6
9L11ZTA276S	276	220	6	133.63	3394.2	282	7162.8	120	3048	100	2540	730	331.8
9L11ZTA288S	288	234	6	140.63	3572.0	303	7696.2	128	3251.2	106	2692.4	775	352.3
9L11ZTA294S	294	237	6	140.63	3572.0	303	7696.2	130	3302.0	110	2794.0	786	357.3
9L11ZTA300S	300	243	6	140.63	3572.0	303	7696.2	130	3302.0	110	2794.0	785	356.8
9L11ZTA312S	312	245	6	147.13	3737.1	324	8229.6	130	3302	110	2794	800	362.6
9L11ZTA336S	336	264	6	150.1	3812.5	340	8636	--	--	--	--	--	--
9L11ZTA360S	360	288	6	160.1	4067.3	366	9296.4	--	--	--	--	--	--
9L11ZTA396S	396	318	7	192.1	4879.3	425	10795	--	--	--	--	--	--
9L11ZTA420S	420	335	7	205.1	5210.3	467	11861.8	--	--	--	--	--	--
9L11ZTA444S	444	353	7	205.1	5209.54	467	11861.8	--	--	--	--	--	--
9L16GNS588S	588	470											
9L16GNS612S	612	485											
9L16GNS588S	588	470											
9L16GNS612S	612	485											

Porcelain Station Class (Continued)

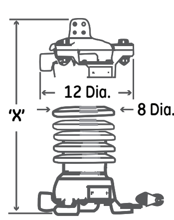
Porcelain Physical Characteristics — 4 Hole NEMA - for Indoor or Cubicle Upright Mounting

		ARRESTER RATINGS						INSULATION WITHSTAND DISTANCE					
Standard Arrester Catalog Number	Duty Cycle (kV) rms	MCOV (kV) rms	Porcelain	Height "X"		Creepage Distance		Phase to Phase		Phase to Ground		Weight	
			Drawing	in	mm	in	mm	in	mm	in	mm	lbs	kg
9L11ZGB003S	3	2.55	1	12.0	304.8	11.1	281.9	11.0	279.4	5.5	139.7	35	15.9
9L11ZGB006S	6	5.10	1	12.0	304.8	11.1	281.9	11.0	279.4	5.5	139.7	40	18.2
9L11ZGB009S	9	7.65	1	12.0	304.8	11.1	281.9	11.0	279.4	5.5	139.7	40	18.2
9L11ZGB010S	10	8.40	1	12.0	304.8	11.1	281.9	11.0	279.4	5.5	139.7	40	18.2
9L11ZGB012S	12	10.20	1	12.0	304.8	11.1	281.9	11.0	279.4	6.5	165.1	42	19.1
9L11ZGB015S	15	12.70	1	16.25	412.8	20.0	508.0	11.0	279.4	7.5	190.5	50	22.7
9L11ZGB018S	18	15.30	1	16.25	412.8	20.0	508.0	11.0	279.4	9.0	228.6	50	22.7
9L11ZGB021S	21	17.00	1	16.25	412.8	20.0	508.0	11.0	279.4	9.0	228.6	51	23.2
9L11ZGB024S	24	19.50	1	16.25	412.8	20.0	508.0	11.0	279.4	9.0	228.6	52	23.6
9L11ZGB027S	27	22.00	1	28.13	714.5	31.7	805.2	18.0	457.2	12.0	304.8	60	27.3

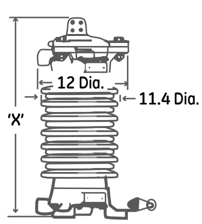
Porcelain Drawings



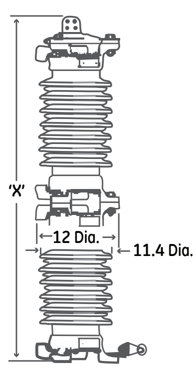
Drawing 1



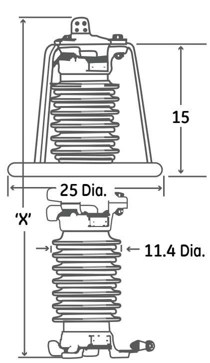
Drawing 2



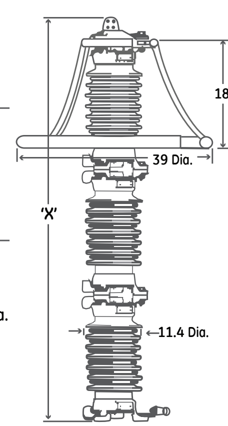
Drawing 3



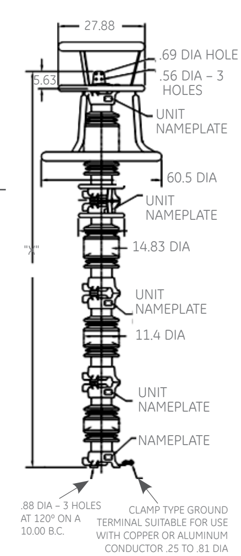
Drawing 4



Drawing 5



Drawing 6



Drawing 7

Silicon Station Class

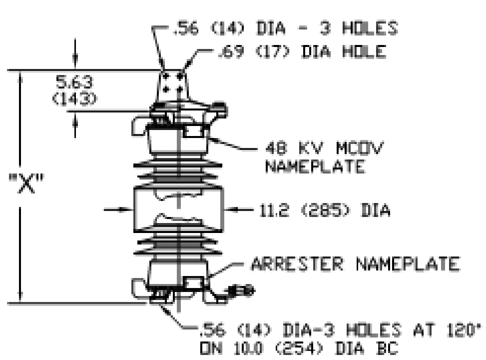
Electrical Characteristics
— 4 Hole NEMA - for Indoor or Outdoor Mounting

ARRESTER RATINGS					MAXIMUM DISCHARGE VOLTAGE USING 8/20 CURRENT WAVE-KV					
Arrester Catalog Number	Rated Voltage (kV)	Maximum Continuous Operating Voltage (MCOV) (kV) rms	Maximum 0.5μs Discharge Voltage kV (1)	Maximum Switching Surge Protective Level kV (2)	1.5kA	3kA	5kA	10kA	20kA	40kA
9L11HMA054S	54	42	133	94	103	108	113	121	131	146
9L11HMA0060S	60	48	152	107	118	124	129	138	150	166
9L11HMA0072S	72	57	181	127	140	147	153	164	178	198
9L11HMA0090S	90	70	222	156	172	181	188	201	218	243
9L11HMA0590S	90	74	235	165	182	191	199	213	231	256
9L11HMA0596S	96	76	241	170	187	196	205	218	237	263
9L11HMA108S	108	84	266	187	207	217	226	241	262	291
9L11HMA108S	108	88	279	196	217	227	237	253	274	305
9L11HMA120S	120	98	311	228	241	253	264	282	305	340
9L11HMA132S	132	106	336	247	261	274	285	305	330	367
9L11HMA144S	144	115	365	268	283	297	310	330	358	399
9L11HMA168S	168	131	416	305	323	338	353	376	408	454
9L11HMA172S	172	140	444	326	345	362	377	402	436	485
9L11HMA180S	180	144	457	335	355	372	388	414	449	499
9L11HMA192S	192	152	482	354	374	393	409	437	473	527
9L11HMA228S	228	180	571	419	443	465	485	517	561	624
9L11HMA240S	240	190	602	472	468	491	511	546	592	658
9L11HMA258S	258	209	663	519	515	540	563	601	651	724
9L11HMA264S	264	212	673	526	522	548	571	609	660	735
9L11HMA276S	276	220	698	546	542	568	592	632	685	762
9L11HMA288S	288	230	729	571	566	594	619	661	716	797
9L11HMA312S	312	245	777	608	603	633	660	704	763	849
9L11HMA396S	396	318	1009	790	783	821	856	914	991	1102
9L11HMA420S	420	335	1063	832	825	865	902	963	1043	1161
9L11HMA444S	444	353	1120	876	869	912	950	1014	1100	1223

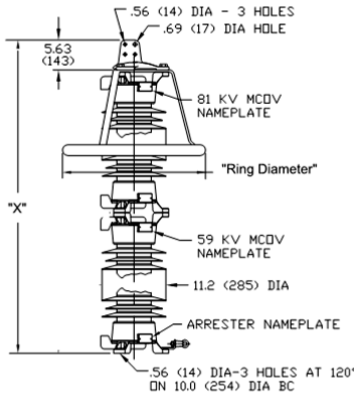
Silicon Station Class (Continued)

Mechanical Characteristics — 4 Hole NEMA - for Indoor or Outdoor Mounting

								INSULATION WITHSTAND DISTANCE								
Standard Arrester Catalog Number	Duty Cycle (kV) rms	MCOV (kV) rms	Height "X"		Silicon	Creepage Distance		Phase to Phase		Phase to Ground		Weight		Ring Diameter	
			in	mm	Drawing	in	mm	in	mm	in	mm	lbs	kg	in.	mm
9L11HMA054S	54	42	38.1	967.7	8	83	2108.2	15.6	396.2	10.9	276.9	104	47		
9L11HMA0060S	60	48	38.1	967.7	8	83	2108.2	17.1	434.3	12.5	317.5	107	48		
9L11HMA0072S	72	57	38.1	967.7	8	83	2108.2	19.5	495.3	14.8	375.9	112	51		
9L11HMA0090S	90	70	44.4	1127.8	8	113	2870.2	26	660.4	18.2	462.3	125	57		
9L11HMA0590S	90	74	44.4	1127.8	8	113	2870.2	27	685.8	19.2	487.7	128	58		
9L11HMA0596S	96	76	44.4	1127.8	8	113	2870.2	27.5	698.5	19.8	502.9	130	59		
9L11HMA108S	108	84	52.1	1323.3	8	142	3606.8	31.2	792.5	21.8	553.7	141	64		
9L11HMA108S	108	88	52.1	1323.3	8	142	3606.8	32.2	817.9	22.9	581.7	144	65		
9L11HMA120S	120	98	52.1	1323.3	8	142	3606.8	36.4	924.6	25.5	647.7	149	68		
9L11HMA132S	132	106	58.8	1493.5	8	171	4343.4	38.4	975.4	27.6	701	167	76		
9L11HMA144S	144	115	58.8	1493.5	8	171	4343.4	40.8	1036.3	29.9	759.5	172	78		
9L11HMA168S	168	131	76.9	1953.3	8	196	4978.4	44.9	1140.5	34.1	866.1	231	105		
9L11HMA172S	172	140	76.9	1953.3	9	196	4978.4	77	1955.8	48.9	1242.1	257	116	25	635
9L11HMA180S	180	144	76.9	1953.3	9	196	4978.4	78	1981.2	50	1270	257	116	25	635
9L11HMA192S	192	152	83.2	2113.3	9	225	5715	80.1	2034.5	52	1320.8	262	119	25	635
9L11HMA228S	228	180	90.9	2308.9	9	254	6451.6	87.4	2220	59.3	1506.2	291	132	25	635
9L11HMA240S	240	190	98.6	2504.4	9	285	7239	90	2286	61.9	1572.3	317	144	25	635
9L11HMA258S	258	209	105.3	2674.6	9	313	7950.2	116.6	2961.6	73.9	1877.1	330	150	39	990.6
9L11HMA264S	264	212	105.3	2674.6	9	313	7950.2	117.4	2982	74.6	1894.8	349	158	39	990.6
9L11HMA276S	276	220	105.3	2674.6	9	313	7950.2	119.5	3035.3	76.7	1948.2	351	159	39	990.6
9L11HMA288S	288	230	112	2844.8	9	344	8737.6	122.1	3101.3	79.3	2014.2	360	163	39	990.6
9L11HMA312S	312	245	129.7	3294.4	9	367	9321.8	126	3200.4	83.2	2113.3	406	184	39	990.6
9L11HMA396S	396	318	151.8	3855.7	9	455	11557	178.4	4531.4	112.9	2867.7	532	241	80	2032
9L11HMA420S	420	335	158.5	4025.9	9	484	12293.6	182.8	4643.1	117.3	2979.4	539	244	80	2032
9L11HMA444S	444	353	165.2	4196.1	9	514	13055.6	187.5	4762.5	122	3098.8	564	256	80	2032



Drawing 8



Drawing 9

Polymer Intermediate Class

Electrical Characteristics

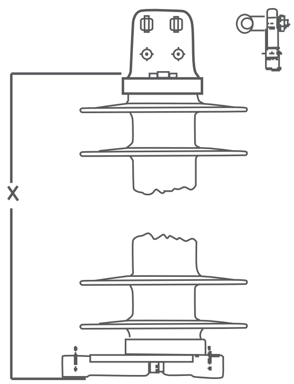
GE CATALOG						MAXIMUM DISCHARGE VOLTAGE USING AN 8/20 CURRENT WAVE (KV)					
# 4 Hole Nema	# Eyebolt	Duty Cycle Rating (kV) rms	Maximum Continuous Operating Voltage (MCOV) (kV) rms	Maximum 0.5μs Discharge Voltage kV (1)	Maximum Switching Surge Protective Level kV (2)	1.5kA	3kA	5kA	10kA	20kA	40kA
9L12PPA003S	9L12PPB003S	3	2.55	8.6	6.4	6.8	7.2	7.5	8.1	9	10.1
9L12PPA006S	9L12PPB006S	6	5.1	17.1	12.7	13.6	14.4	15	16.2	17.9	20.2
9L12PPA009S	9L12PPB009S	9	7.65	25.8	19.1	20.5	21.6	22.6	24.4	27	30.4
9L12PPA010S	9L12PPB010S	10	8.4	28.4	21.1	22.6	23.8	24.9	26.9	29.8	33.5
9L12PPA012S	9L12PPB012AS	12	10.2	34.1	25.3	27.1	28.6	29.9	32.3	35.8	40.3
9L12PPA015S	9L12PPB015S	15	12.7	42.9	31.8	34.1	36	37.6	40.6	44.9	50.6
9L12PPA018S	9L12PPB018S	18	15.3	51.6	38.3	40.9	43.2	45.2	48.8	54	60.9
9L12PPA021S	9L12PPB021S	21	17	56.9	42.2	45.1	47.7	49.9	53.8	59.6	67.1
9L12PPA024AS	9L12PPB024AS	24	19.5	68.3	50.6	54.2	57.2	59.9	64.6	71.5	80.6
9L12PPA027S	9L12PPB027S	27	22	77.4	57.4	61.4	64.9	67.9	73.2	81	91.3
9L12PPA030S	9L12PPB030S	30	24.4	85.3	63.3	67.7	71.5	74.8	80.7	89.3	101
9L12PPA036AS	9L12PPB036AS	36	29	102	76	81.3	85.9	89.8	96.9	107	121
9L12PPA039S	9L12PPB039S	39	31.5	108.4	80.4	86.1	90.9	95.1	102.6	113.6	127.9
9L12PPA045AS	9L12PPB045AS	45	36.5	125.1	92.8	99.3	104.9	109.8	118.4	131.1	147.6
9L12PPA048AS	9L12PPB048AS	48	39	136.6	101.3	108.4	114.5	119.8	129.2	143	161.1
9L12PPA054AS	9L12PPB054AS	54	42	147.9	109.7	117.4	125	129.7	139.9	154.9	174.5
9L12PPA060AS	9L12PPB060AS	60	48	165	122.4	131	138.3	144.7	156.1	172.8	195
9L12PPA072AS	9L12PPB072AS	72	57	199	147.7	158.1	166.9	174.6	188.4	209	235
9L12PPA090S	9L12PPB090S	90	70	250	185.7	198.7	209.8	219.5	236.8	262	295
9L12PPA096S	9L12PPB096S	96	76	261.7	194.1	207.7	219.4	229.5	247.6	274.1	308.8
Contact Factory	Contact Factory	108	84	296	219.5	234.9	248.1	259.6	280	310	349.2
9L12PPA108S	9L12PPB108S	108	88	296	219.5	234.9	248.1	259.6	280	310	349.2
9L12PPA120S	9L12PPB120S	120	98	327.7	243	26.1	274.7	287.4	310	343.2	386.6
9L12PPA132S	9L12PPB132S	132	106	375.2	278.3	297.8	314.5	329.1	355	393	443
9L12PPA144S	9L12PPB144S	144	115	392	290.9	311.3	328.7	343.9	371	411	463

Polymer Intermediate Class (Continued)

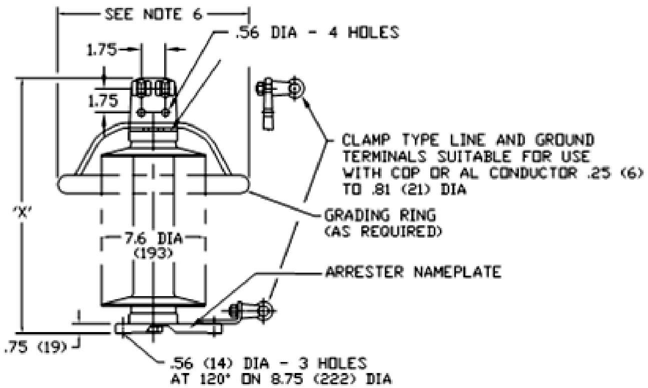
Mechanical Characteristics
— 4 Hole NEMA - for Indoor or Outdoor Upright Mounting

4Hole NEMA	Duty Cycle (kV) rms	MCOV (kV) rms	Drawing Number	Height "X"		Leakage		Phase to Phase		Phase to Ground		Weight	
				in	mm	in	mm	in	mm	in	mm	lbs	kg
9L12PPA003S	3	2.55	1	6.8	172.7	15.4	391.2	4.4	111.8	3.3	83.8	6.2	2.8
9L12PPA006S	6	5.1	1	6.8	172.7	15.4	391.2	4.6	116.8	3.2	81.3	6.2	2.8
9L12PPA009S	9	7.65	1	6.8	172.7	15.4	391.2	4.7	119.4	3.3	83.8	6.2	2.8
9L12PPA010S	10	8.4	1	6.8	172.7	15.4	391.2	4.9	124.5	3.5	88.9	6.2	2.8
9L12PPA012S	12	10.2	1	6.8	172.7	15.4	391.2	4.9	124.5	3.5	88.9	6.2	2.8
9L12PPA015S	15	12.7	1	12.2	309.9	30.8	782.3	6.2	157.5	4.8	121.9	10	4.5
9L12PPA018S	18	15.3	1	12.2	309.9	30.8	782.3	6.6	167.6	5.2	132.1	10	4.5
9L12PPA021S	21	17	1	12.2	309.9	30.8	782.3	7.6	193.0	6.2	157.5	10	4.5
9L12PPA024S	24	19.5	1	12.2	309.9	30.8	782.3	7.6	193.0	6.2	157.5	10	4.5
9L12PPA027S	27	22	1	17.6	447.0	46.2	1173.5	9.6	243.8	8.2	208.3	13.5	6.1
9L12PPA030S	30	24.4	1	17.6	447.0	46.2	1173.5	9.8	248.9	8.4	213.4	13.5	6.1
9L12PPA036S	36	29	1	17.6	447.0	46.2	1173.5	9.8	248.9	8.4	213.4	13.5	6.1
9L12PPA039S	39	31.5	1	23.0	584.2	61.6	1564.6	12.8	325.1	11.4	289.6	17	7.7
9L12PPA045S	45	36.5	1	23.0	584.2	61.6	1564.6	12.8	325.1	11.4	289.6	17	7.7
9L12PPA048S	48	39	1	23.0	584.2	61.6	1564.6	12.8	325.1	11.4	289.6	17	7.7
9L12PPA054S	54	42	1	28.4	721.4	77.0	1955.8	15.8	401.3	14.4	365.8	19.6	8.9
9L12PPA060S	60	48	1	28.4	721.4	77.0	1955.8	15.8	401.3	14.4	365.8	19.6	8.9
9L12PPA072S	72	57	1	33.8	858.5	92.4	2347.0	19.8	502.9	18.4	467.4	23.1	10.5
9L12PPA090S	90	70	1A	44.0	1117.6	109.0	2768.6	40.0	1016.0	33.0	838.2	52	23.6
9L12PPA096S	96	76	1A	44.0	1117.6	109.0	2768.6	42.0	1066.8	35.0	889.0	53	24.1
9L12PPA108S	108	88	1A	44.0	1117.6	109.0	2768.6	46.0	1168.4	39.0	990.6	54	24.5
9L12PPA120S	120	98	1A	66.5	1689.1	162.0	4114.8	51.0	1295.4	44.0	1117.6	67.5	30.7
9L12PPA132S	132	106	1A	66.5	1689.1	162.0	4114.8	55.0	1397.0	47.0	1193.8	67.5	30.7
9L12PPA144S	144	115	1A	66.5	1689.1	162.0	4114.8	58.0	1473.2	50.0	1270.0	67.5	30.7

4 Hole Nema — Drawing 1



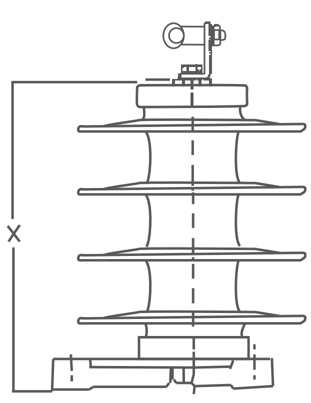
4 Hole Nema — Drawing 1A



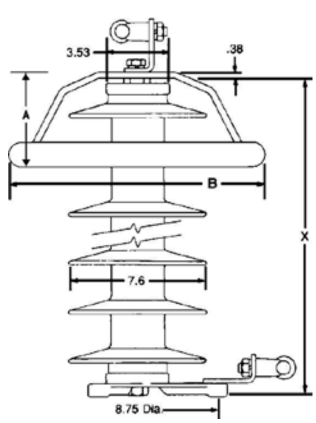
Mechanical Characteristics
— Eyebolt - for Indoor or Outdoor Upright Mounting

Eyebolt Terminal	Duty Cycle (kV) rms	MCOV (kV) rms	Drawing Number	"X" Dimensions		Leakage		Phase to Phase		Phase to Ground		Weight	
				in	mm	in	mm	in	mm	in	mm	lbs	kg
9L12PPB003S	3	2.55	2	6.8	172.7	15.4	391.2	4.4	111.8	3.3	83.8	6.2	2.8
9L12PPB006S	6	5.1	2	6.8	172.7	15.4	391.2	4.6	116.8	3.2	81.3	6.2	2.8
9L12PPB009S	9	7.65	2	6.8	172.7	15.4	391.2	4.7	119.4	3.3	83.8	6.2	2.8
9L12PPB010S	10	8.4	2	6.8	172.7	15.4	391.2	4.9	124.5	3.5	88.9	6.2	2.8
9L12PPB012S	12	10.2	2	6.8	172.7	15.4	391.2	4.9	124.5	3.5	88.9	6.2	2.8
9L12PPB015S	15	12.7	2	12.2	309.9	30.8	782.3	6.2	157.5	4.8	121.9	10	4.5
9L12PPB018S	18	15.3	2	12.2	309.9	30.8	782.3	6.6	167.6	5.2	132.1	10	4.5
9L12PPB021S	21	17	2	12.2	309.9	30.8	782.3	7.6	193.0	6.2	157.5	10	4.5
9L12PPB024S	24	19.5	2	12.2	309.9	30.8	782.3	7.6	193.0	6.2	157.5	10	4.5
9L12PPB027S	27	22	2	17.6	447.0	46.2	1173.5	9.6	243.8	8.2	208.3	13.5	6.1
9L12PPB030S	30	24.4	2	17.6	447.0	46.2	1173.5	9.8	248.9	8.4	213.4	13.5	6.1
9L12PPB036S	36	29	2	17.6	447.0	46.2	1173.5	9.8	248.9	8.4	213.4	13.5	6.1
9L12PPB039S	39	31.5	2	23.0	584.2	61.6	1564.6	12.8	325.1	11.4	289.6	17	7.7
9L12PPB045S	45	36.5	2	23.0	584.2	61.6	1564.6	12.8	325.1	11.4	289.6	17	7.7
9L12PPB048S	48	39	2	23.0	584.2	61.6	1564.6	12.8	325.1	11.4	289.6	17	7.7
9L12PPB054S	54	42	2	28.4	721.4	77.0	1955.8	15.8	401.3	14.4	365.8	19.6	8.9
9L12PPB060S	60	48	2	28.4	721.4	77.0	1955.8	15.8	401.3	14.4	365.8	19.6	8.9
9L12PPB072S	72	57	2	33.8	858.5	92.4	2347.0	19.8	502.9	18.4	467.4	23.1	10.5
9L12PPB090S	90	70	2A	44.0	1117.6	109.0	2768.6	40.0	1016.0	33.0	838.2	52	23.6
9L12PPB096S	96	76	2A	44.0	1117.6	109.0	2768.6	42.0	1066.8	35.0	889.0	53	24.1
9L12PPB108S	108	88	2A	44.0	1117.6	109.0	2768.6	46.0	1168.4	39.0	990.6	54	24.5
9L12PPB120S	120	98	2A	66.5	1689.1	162.0	4114.8	51.0	1295.4	44.0	1117.6	67.5	30.7
9L12PPB132S	132	106	2A	66.5	1689.1	162.0	4114.8	55.0	1397.0	47.0	1193.8	67.5	30.7
9L12PPB144S	144	115	2A	66.5	1689.1	162.0	4114.8	58.0	1473.2	50.0	1270.0	67.5	30.7

Eyebolt Terminal — Drawing 2



Eyebolt Terminal — Drawing 2A



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