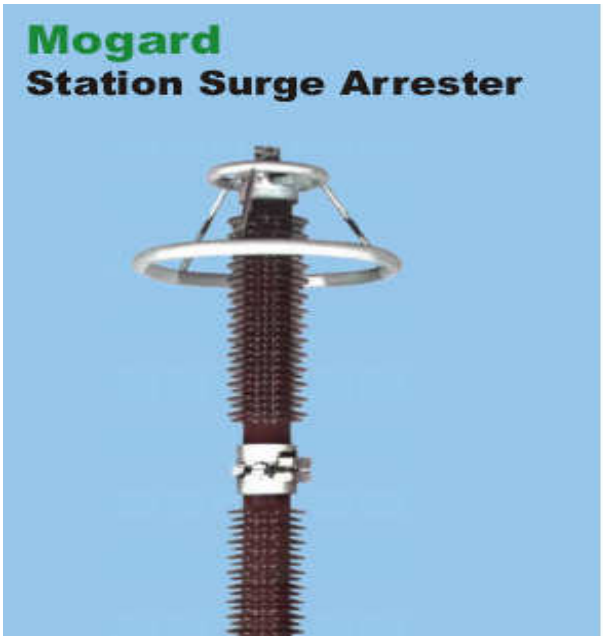
Elpro

Surge Protection Specialists



- **2.7-360 kV Rated Voltage**
- **Excellent Cantilever Strength**
- **Proven Field Record**
- **High Pressure Relief Capability**
- **Excellent Protective Characteristics**
- **High Durability**
- **Excellent Temporary Overvoltage and Surge Duty Capabilities**
- **Superior Contamination Performance**
- **Designed and tested in accordance with IEC 99-4 & ANSI/IEEE C62.11**

ELPRO's MOGARD Surge Arresters have been providing excellent protective characteristics, temporary overvoltage capability and switching-surge energy withstand to power systems for over 20 years. It is an improvement on the Fieldproven Arrester and incorporates the latest development in metal-oxide technology. An outdoor arrester basically consists of a column of highly non-linear metal oxide resistors, which are hermetically enclosed in porcelain containers. The column comprises metal oxide discs connected in series. The improved metal oxide discs have better volt-ampere characteristics & lower power dissipation. The Housing's shed profile has outstanding capability to withstand the effects of very severe external contamination. Since MOGARD Surge Arresters do not have series or shunt gaps, the reliability of the Arrester is enhanced: there is no sparkover protective characteristic, no gap reseal requirement, and no gap failure due to pollution induced coupling currents.
Additionally, the response time of the Arrester to overvoltages is extremely fast. At normal system voltage, the Arrester conducts a very small amount of current. When a surge reaches the Arrester, it instantaneously conducts the current necessary to limit the overvoltage. As a result, MOGARD Arresters absorb minimum energy to protect equipment insulation. MOGARD Surge Arresters are designed to meet or exceed the requirements of ANSI / IEEE C62.11 and IEC 99-4 standards.

Arresters of special design can be built to meet specific application requirements. The MOGARD Surge Arrester consists of a stack of Zinc Oxide discs mounted in a sealed porcelain housing. Each disc is wedged by means of a Silicon Rubber, which offers better heat transfer capability and protection against physical damage during transport. This allows for flexibility in transport and storage of Arresters. MOGARD Arrester is filled with dry air at positive pressure, effective and Hermetic Sealing is achieved by using special type of rubber gaskets. This ensures longer life.

Pressure Relief Device is an integral part of the MOGARD Arrester and prevents violent shattering of the Arrester in the event when Arrester has operated. Cutter plates are provided to guide the arc and allow it to follow the pre defined path outwards and through the venting ducts.

The ratings and maximum lightning impulse residual voltages, maximum switching impulse residual voltages and maximum steep current impulse residual voltages for the standard Surge Arresters for recommended system voltages are listed in Table 1a, 1b, 1c & 1d.

TABLE 1A for 9L11 Series of Arrester

Reference Standard		IEC -99-4
Arrester Type & Designation		Gapless, "MOGARD"
Arrester Class		Station
Nominal Discharge current	kA	10
Rated Frequency	Hz	48-62
Pressure Relief Capability, (0.2 sec)	kA rms	65
Line Discharge Class *		III
Energy Dissipation capability	kJ/kV of	10

(cumulative operation)	rating	
Components of the Continuous Leakage Current at MCOV		
- Resistive (Max.)	µ AP	400
- Capacitive (Max)	µ AP	1,500
Cantilever Strength	N-m	9,800

Nominal System Voltage U max	Arrester Rating for Grounded Neutral Circuits Ur	Model No.	MCOV Uc	Max Lightning Impulse Residual Voltage (8* 20 µ sec)			Max Switching Impulse Residual Voltage (30 * 90 µ sec)		Max Steep Current Impulse Residual Voltage (1* 20 µsec)
				at 5 kAP	at 10 kAP	at 20 kAP	at 250 AP	at 250 AP	at 10 kAP
kVrms	**kVrms**		**kVrms**	**kVP**	**kVP**	**kVP**	**kVP**	**kVP**	**kVP**
2.4	2.7	9L11BMH 002.7	2.2	8	8.3	9	6.7	7.5	9
4.16	3	9L11BNH 003	2.55	9	9.3	10	7.5	8.2	10
	4.5	9L11BMH 004.5	3.7	12	12.6	13	10	11	14
4.8	5.1	9L11BMH 005.1	4.2	13	14.1	15	11	12	15
6.9	6	9L11BMH 006	5.1	16	16.7	18	13	14	18
	9	9L11BMH 009	7.65	22	24	25	19	20	26
12.47	10	9L11BMH 010	8.4	25	26.1	28	21	22	29
13.2, 13.8	12	9L11BMH 012	10.2	29	31.3	33	25	26	34
	18	9L11BMH 018	15.3	43	46	49	37	39	50
	21	9L11BMH 021	17	48	50.9	54	41	43	56
23, 24, 94	24	9L11BMH 024	19.5	54	58.1	62	47	49	64
	27	9L11BMH 027	22	61	65.2	69	52	55	71
34.5	30	9L11BMH 030	24.4	68	72.1	77	58	61	79
46	39	9L11BMH 039	31.5	87	92.5	98	74	78	101
	54	9L11BMH 054	44	120	128.2	136	103	108	140
69	60	9L11BMH 060	49	134	142.8	152	115	120	156
	90	9L11BMH 090	73	201	215	228	172	181	235
	96	9L11BMH 096	78	215	229	243	184	193	251
115	108	9L11BMH 108	87	239	255	271	205	215	279
138	120	9L11BMH 120	98	269	287	304	230	242	314
	132	9L11BMH 132	107	294	313	333	251	264	343
161	144	9L11BMH 144	117	320	341	363	274	288	374
	172	9L11BMH 172	140	382	407	433	327	343	446
	180	9L11BMH 180	146	398	425	451	340	358	464
230	192	9L11BMH 192	156	425	454	482	364	382	496
345	258	9L11BMH 258	209	568	606	643	486	510	662
	264	9L11BMH 264	214	582	620	658	497	523	678
	276	9L11BMH 276	224	610	650	690	521	548	711

	288	9L11BMH 288	233	633	675	716	541	569	738
	294	9L11BMH 294	238	646	689	732	553	581	754
	300	9L11BMH 300	243	660	703	747	564	593	769
	312	9L11BMH 312	253	687	732	777	587	617	801
	336	9L11BMH 336	272	738	787	835	631	663	861
400	360	9L11BMH 360	292	792	844	896	677	712	923

TABLE 1B for 9L 12 Series of Arrester

Reference Standard		IEC -99-4
Arrester Type & Designation		Gapless, "MOGARD"
Arrester Class		Station
Nominal Discharge current	kA	10
Rated Frequency	Hz	48-62
Pressure Relief Capability, (0.2 sec)	kA rms	40
Line Discharge Class *		III
Energy Dissipation capability (cumulative operation)	kJ/kV of rating	6.5
Components of the Continuous Leakage Current at MCOV		
- Resistive (Max.)	µ AP	400
- Capacitive (Max)	µ AP	1,500

Nominal System Voltage U max	Arrester Rating for Grounded Neutral Circuits Ur	Model No.	MCOV Uc	Max Lightning Impulse Residual Voltage (8* 20 µ sec)			Max Switching Impulse Residual Voltage (30 * 90 µ sec)		Max Steep Current Impulse Residual Voltage (1* 20 µsec)
				at 5 kAP	at 10 kAP	at 20 kAP	at 250 AP	at 250 AP	at 10 kAP
kVrms	kVrms		kVrms	kVP	kVP	kVP	kVP	kVP	kVP
2.4	2.7	9L12BNH 002.7	2.2	8	8	9	7	7.8	9
4.16	3	9L12BNH 003	2.55	9	9	10	7	8	10
	4.5	9L12BNH 004.5	3.7	12	13	14	10	10.6	14
4.8	5.1	9L12BNH 005.1	4.2	13	14	15	11	12	16
6.9	6	9L12BNH 006	5.1	16	17	18	13	14	19

	9	9L12BNH 009	7.65	23	24	26	19	20	27
12.47	10	9L12BNH 010	8.4	25	26	29	21	22	29
13.2, 13.8	12	9L12BNH 012	10.2	30	31	34	25	26	35
	18	9L12BNH 018	15.3	44	46	50	36	38	52
	21	9L12BNH 021	17	48	51	56	40	42	57
23, 24, 94	24	9L12BNH 024	19.5	55	58	64	46	48	65
	27	9L12BNH 027	22	62	66	71	51	54	73
34.5	30	9L12BNH 030	24.4	68	73	79	57	59	81
46	39	9L12BNH 039	31.5	88	93	101	73	76	104
	54	9L12BNH 054	44	121	129	140	101	106	144
69	60	9L12BNH 060	49	135	144	157	113	118	160
	90	9L12BNH 090	73	203	216	235	169	177	241
	96	9L12BNH 096	78	217	230	251	181	189	257
115	108	9L12BNH 108	87	242	256	280	201	210	286
138	120	9L12BNH 120	98	272	288	314	226	236	322
	132	9L12BNH 132	107	297	315	344	247	258	352
161	144	9L12BNH 144	117	323	343	374	269	282	384
	172	9L12BNH 172	140	386	410	446	321	336	458
	180	9L12BNH 180	146	402	427	465	335	350	477
230	192	9L12BNH 192	156	430	456	497	358	374	510

TABLE 1C for 9L 13 series Arrester

Reference Standard		IEC -99-4
Arrester Type & Designation		Gapless, "MOGARD"
Arrester Class		Station
Nominal Discharge current	kA	10
Rated Frequency	Hz	48-62
Pressure Relief Capability, (0.2 sec)	kA rms	40
Line Discharge Class *		II

Energy Dissipation capability (cumulative operation)	kJ/kV of rating	4.5
Components of the Continuous Leakage Current at MCOV		
- Resistive (Max.)	µ AP	400
- Capacitive (Max)	µ AP	1,500
Cantilever Strength	N-m	3,100

Nominal System Voltage U max	Arrester Rating for Grounded Neutral Circuits Ur	Model No.	MCOV Uc	Max Residual Lightning Impulse Voltage (8* 20 µ sec)			Max Switching Impulse Residual Voltage (30 * 90 µ sec)		Max Steep Current Impulse Residual Voltage (1* 20 µsec)
				at 5 kAP	at 10 kAP	at 20 kAP	at 125 AP	at 500 AP	at 10 kAP
kVrms	kVrms		kVrms	kVP	kVP	kVP	kVP	kVP	kVP
2.4	2.7	9L13BNH 002.7	2.2	9	9	10	7	7.4	10
4.16	3	9L13BNH 003	2.55	10	10	11	8	8.4	12
	4.5	9L13BNH 004.5	3.7	13	14	16	11	11.5	16
4.8	5.1	9L13BNH 005.1	4.2	15	16	17	12	12.6	18
6.9	6	9L13BNH 006	5.1	17	19	21	14	15	21
	9	9L13BNH 009	7.65	25	27	30	20	21	31
12.47	10	9L13BNH 010	8.4	28	29	32	22	23	33
13.2, 13.8	12	9L13BNH 012	10.2	33	35	39	27	28	40
	18	9L13BNH 018	15.3	49	52	57	39	41	59
	21	9L13BNH 021	17	54	58	63	44	46	65
23, 24, 94	24	9L13BNH 024	19.5	62	66	72	50	52	75
	27	9L13BNH 027	22	69	74	81	56	59	84
34.5	30	9L13BNH 030	24.4	77	82	90	62	65	93
46	39	9L13BNH 039	31.5	98	105	115	79	83	119
	54	9L13BNH 054	44	136	145	160	110	115	165
69	60	9L13BNH 060	49	152	162	178	123	128	184
	90	9L13BNH 090	73	228	244	268	184	193	276
115	96	9L13BNH 096	78	243	260	286	196	206	295
138	108	9L13BNH 108	88	274	293	322	221	232	332

TABLE 1D for 9L14 Series of Arresters

Arrester Type & Designation		Gapless, "MOGARD"
Arrester Class		Station
Nominal Discharge current	kA	10
Rated Frequency	Hz	48-62
Pressure Relief Capability, (0.2 sec)	kA rms	40
Line Discharge Class *		I
Energy Dissipation Capability (cumulative operation)	kJ/kV of rating	2.5
Components of the Continuous Leakage Current at MCOV		
- Resistive (Max.)	µ AP	400
- Capacitive (Max)	µ AP	1,500
Cantilever Strength	N-m	3,100

Nominal System Voltage U max	Arrester Rating for Grounded Neutral Circuits Ur	Model No.	MCOV Uc	Max Residual Impulse Lightning Voltage (8* 20 µ sec)			Max Switching Impulse Residual Voltage (30 * 90 µ sec)		Max Steep Current Impulse Residual Voltage (1* 20 µsec)
				at 5 kAP	at 10 kAP	at 20 kAP	at 125 AP	at 500 AP	at 10 kAP
kVrms	kVrms		kVrms	kVP	kVP	kVP	kVP	kVP	kVP
2.4	2.7	9L14BNH 002.7	2.2	9	10	13	7.2	8	11
4.16	3	9L14BNH 003	2.55	10	11	14	8	9	12
	4.5	9L14BNH 004.5	3.7	15	15	20	11	12	17
4.8	5.1	9L14BNH 005.1	4.2	16	17	22	12	13	19
6.9	6	9L14BNH 006	5.1	19	20	26	15	16	23
	9	9L14BNH 009	7.65	28	30	38	21	23	33
12.47	10	9L14BNH 010	8.4	31	32	42	23	25	36
13.2, 13.8	12	9L14BNH 012	10.2	37	39	50	28	30	43
	18	9L14BNH 018	15.3	54	57	74	41	44	63
	21	9L14BNH 021	17	60	64	82	46	48	70
23, 24, 94	24	9L14BNH 024	19.5	68	73	94	52	55	80
	27	9L14BNH 027	22	77	82	105	59	62	90
34.5	30	9L14BNH 030	24.4	85	90	116	65	69	100
46	39	9L14BNH 039	31.5	109	116	149	84	88	128

APPLICATION CRITERION

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

To decide on the appropriate rating of the Arrester for a particular application, the following main system stresses should be considered to which the Arrester will be exposed.

1. Continuous System Voltage
2. Temporary Overvoltage
3. Switching Surges.

(Switching Surges for transmission systems above 345kV and for capacitor banks and cable application)

CONTINUOUS SYSTEM VOLTAGE

Arresters in systems are continuously 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 is termed as 'Maximum Continuous Operating Voltage' (MCOV) of the Arrester. The typical value of MCOV for MOGARD Arresters is given in Tables **1A, 1B, 1C & 1D**.

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 MCOV capability. 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 used between lines, the phase-to-phase voltage must be considered. In case the Arrester is being used for the delta-connected tertiary winding of the transformer where one corner of the delta is permanently grounded, in such cases full phase-to-phase voltage will be applied to the Arrester even though the Arrester is connected between line and ground.

TEMPORARY OVERVOLTAGE

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 Arrester temporary overvoltage capability must meet or exceed the expected temporary overvoltages. If detailed transient system studies or calculations are not available, it is traditional to consider as a minimum, the overvoltages due to single line-to-ground faults. The Arrester application standard ANSI C62.22 gives some guidance in determining the magnitude of single line-to-ground fault over-voltages. These overvoltages depend on details of system grounding.

The primary effects of temporary overvoltages on metal oxide arresters are - increased current and power dissipation and rising Arrester temperature. Tables 2A, 2B, 2C & 2D show the temporary overvoltage capability of ELPRO's MOGARD Arrester. This table defines the duration and magnitude of temporary overvoltages that may be applied to the Arrester before the Arrester voltage must be reduced to the Arrester's continuous operating voltage capability. These capabilities have been defined independent of system impedance and are therefore valid for voltages applied at the Arrester location.

TYPICAL OVERVOLTAGE CHARACTERISTICS FOR MOGARD ARRESTERS

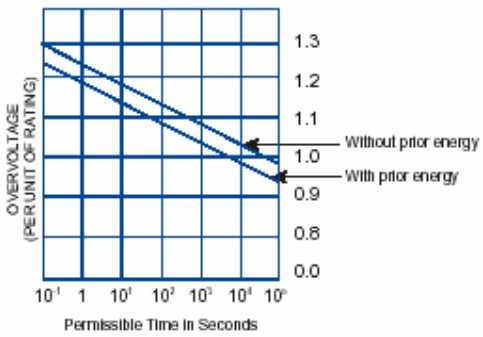


FIG - 1

FIG - 1

TABLE 2A for 9L11 Series of Arrester

Reference Standard		IEC -99-4
Arrester Type & Designation		Gapless, "MOGARD"
Arrester Class		Station
Nominal Discharge current	kA	10
Rated Frequency	Hz	48-62
Pressure Relief Capability, (0.2 sec)	kA rms	65
Line Discharge Class *		III
Energy Dissipation Capability (cumulative operation)	kJ/kV of rating	10
Components of the Continuous Leakage Current at MCOV		
- Resistive (Max.)	µ AP	400
- Capacitive (Max)	µ AP	1,500
Cantilever Strength	N-m	9,800

Nominal System Voltage U max	Creepage Distance	Arrester Rating for Grounded Neutral Circuits Ur	Min. Reference Voltage at 5m AP	MCOV Uc	Temporary Overvoltage (Prior energy)				Insulation Withstand of Housing		
					0.1 sec	1 sec	10 sec	100 sec	Wet PF (1 minute withstand)	Dry Lightning Impulse	Wet Switching Impulse
kVrms	mm	kVrms		kVrms	kVrms	kVrms	kVrms	kVrms	kVrms	kVP	kVP
2.4	63	2.7	2.7	2.2	3.3	3.2	3	2.9			
4.16	109.2	3	3	2.55	3.7	3.5	3.4	3.2			
		4.5	4.5	3.7	5.5	5.3	5.1	4.8			
4.8	126	5.1	5.1	4.2	6.3	6	5.7	5.5			
6.9	181	6	6	5.1	7.4	7.1	6.8	6.5	28	75	NA
		9	9	7.65	11	10.6	10.1	9.7			
12.47	327	10	10	8.4	12.3	11.8	11.3	10.8			
13.2, 13.8	362	12	12	10.2	14.7	14.1	13.5	12.9			

		18	18	15.3	22.1	21.2	20.3	19.4			
		21	21	17	25.8	24.7	23.7	22.6	50	125	NA
23, 24, 94	655	24	24	19.5	29.4	28.2	27	25.8			
		27	27	22	33.1	31.8	30.4	29.1			
34.5	906	30	30	24.4	36.8	35.3	33.8	32.3	70	170	NA
46	1208	39	39	31.5	47.9	45.9	44	42			
		54	54	44	66.3	63.6	60.9	58.2	140	325	NA
69	1815	60	60	49	73.6	70.6	67.6	64.6			
		90	90	73	110.4	105.9	101.4	96.9			
		96	96	78	117.8	113	108.2	103.4	230	550	NA
115	3075	108	108	87	132.5	127.1	121.7	116.3			
138	3625	120	120	98	147.2	141.2	135.2	129.2	275	650	NA
		132	132	107	162	155.4	148.8	142.2	325	750	NA
161	4250	144	144	117	176.7	169.5	162.3	155.1			
		172	172	140	211	202.4	193.8	185.2			
		180	180	146	220.9	211.9	202.9	193.9	460	1050	NA
230	6125	192	192	156	235.6	226	216.4	206.8			
		258	258	209	316.6	303.7	290.8	277.9			
		264	264	214	323.9	310.7	297.5	284.3			
		276	276	224	338.7	324.9	311.1	297.3	460	1050	700
		288	288	233	353.4	339	324.6	310.2			
		294	294	238	360.7	346	331.3	316.6			
		300	300	243	368.1	353.1	338.1	323.1			
345	9056	312	312	253	382.8	367.2	351.6	336			
		336	336	272	412.3	395.5	378.7	361.9	630	1425	1050
400	10500	360	360	292	441.7	423.7	405.7	387.7			

TABLE 2B for 9:12 Series of Arresters

Reference Standard		IEC -99-4
Arrester Type & Designation		Gapless, "MOGARD"
Arrester Class		Station
Nominal Discharge current	kA	10
Rated Frequency	Hz	48-62
Pressure Relief Capability, (0.2 sec)	kA rms	65
Line Discharge Class *		III
Energy Dissipation Capability (cumulative operation)	kJ/kV of rating	6.5
Components of the Continuous Leakage Current at MCOV		
- Resistive (Max.)	µ AP	400
- Capacitive (Max)	µ AP	1,500
Cantilever Strength	N-m	6,300

Nominal	Creepage	Arrester	Min.	MCOV	Temporary Overvoltage (Prior	Insulation Withstand of Housing

System Voltage U max	Distance	Rating for Grounded Neutral Circuits Ur	Reference Voltage at 5m AP	Uc	energy)				Wet PF (1 minute withstand)	Dry Lightning Impulse	Wet Switching Impulse
					0.1 sec	1 sec	10 sec	100 sec			
kVrms	mm	kVrms	at 3.25m AP	kVrms	kVrms	kVrms	kVrms	kVrms	kVrms	kVP	kVP
2.4	63	2.7	2.7	2.2	3.2	3	3	2.9	28	75	NA
4.16	109.2	3	3	2.55	3.5	3.4	3.4	3.2			
4.8	126	4.5	4.5	3.7	5.3	5.1	5.1	4.8			
		5.1	5.1	4.2	6	5.7	5.7	5.5			
6.9	181	6	6	5.1	7.1	6.8	6.8	6.5			
12.47	327	9	9	7.65	10.6	10.1	10.1	9.7			
		10	10	8.4	11.8	11.3	11.3	10.8			
13.2, 13.8	362	12	12	10.2	14.1	13.5	13.5	12.9			
23, 24, 94	655	18	18	15.3	21.2	20.3	20.3	19.4	50	125	NA
		21	21	17	24.7	23.7	23.7	22.6			
		24	24	19.5	28.2	27	27	25.8			
34.5	906	27	27	22	31.8	30.4	30.4	29.1	70	170	NA
		30	30	24.4	35.3	33.8	33.8	32.3			
46	1208	39	39	31.5	45.9	44	44	42			
69	1815	54	54	44	63.6	60.9	60.9	58.2	140	325	NA
		60	60	49	70.6	67.6	67.6	64.6			
115	3075	90	90	73	105.9	101.4	101.4	96.9	230	550	NA
		96	96	78	113	108.2	108.2	103.4			
		108	108	87	127.1	121.7	121.7	116.3			
138	3625	120	120	98	141.2	135.2	135.2	129.2	275	650	NA
161	4250	132	132	107	155.4	148.8	148.8	142.2	325	750	NA
		144	144	117	169.5	162.3	162.3	155.1			
230	6125	172	172	140	202.4	193.8	193.8	185.2	460	1050	NA
		180	180	146	211.9	202.9	202.9	193.9			
		192	192	156	226	216.4	216.4	206.8			

TABLE 2C for 9L13 Series Arrester

Reference Standard		IEC -99-4
Arrester Type & Designation		Gapless, "MOGARD"
Arrester Class		Station
Nominal Discharge current	kA	10
Rated Frequency	Hz	48-62
Pressure Relief Capability, (0.2 sec)	kA rms	40
Line Discharge Class *		II
Energy Dissipation Capability (cumulative operation)	kJ/kV of rating	4.5
Components of the Continuous Leakage Current at MCOV		
- Resistive (Max.)	µ AP	400
- Capacitive (Max)	µ AP	1,500
Cantilever Strength	N-m	3,100

Nominal System Voltage U max	Creepage Distance	Arrester Rating for Grounded Neutral Circuits Ur	Min. Reference Voltage at 2.25m AP	MCOV (Uc)	Temporary Overvoltage (Prior energy)				Insulation Withstand of Housing		
					0.1 sec	1 sec	10 sec	100 sec	Wet PF (1 minute withstand)	Dry Lightning Impulse	Wet Switching Impulse
kVrms	mm	kVrms	kVrms	kVrms	kVrms	kVrms	kVrms	kVrms	kVrms	kVP	kVP
2.4	63	2.7	2.7	2.2	3.3	3.2	3	2.9	28	75	NA
4.16	109	3	3	2.55	3.7	3.5	3.4	3.2			
		4.5	4.5	3.7	5.5	5.3	5.1	4.8			
4.8	126	5.1	5.1	4.2	6.3	6	5.7	5.5			
6.9	181	6	6	5.1	7.4	7.1	6.8	6.5			
		9	9	7.65	11	10.6	10.1	9.7			
12.47	327	10	10	8.4	12.3	11.8	11.3	10.8			
13.2, 13.8	362	12	12	10.2	14.7	14.1	13.5	12.9			
		18	18	15.3	22.1	21.2	20.3	19.4	50	125	NA
		21	21	17	25.8	24.7	23.7	22.6			
23, 24, 94	655	24	24	19.5	29.4	28.2	27	25.8			
		27	27	22	33.1	31.8	30.4	29.1	70	170	NA
34.5	906	30	30	24.4	36.8	35.3	33.8	32.3			
46	1208	39	39	31.5	47.9	45.9	44	42			
		54	54	44	66.3	63.6	60.9	58.2	140	325	NA
69	1815	60	60	49	73.6	70.6	67.6	64.6			
		90	90	73	110.4	105.9	101.4	96.9	230	550	NA
		96	96	78	117.8	113	108.2	103.4			
115	3075	108	108	88	132.5	127.1	121.7	116.3			
138	3625	120	120	98	147.2	141.2	135.2	129.2	275	650	NA

TABLE 2D for 9L 14 Series of Arresters

Reference Standard		IEC -99-4
Arrester Type & Designation		Gapless, "MOGARD"
Arrester Class		Station
Nominal Discharge current	kA	10
Rated Frequency	Hz	48-62
Pressure Relief Capability, (0.2 sec)	kA rms	40
Line Discharge Class *		I
Energy Dissipation Capability (cumulative operation)	kJ/kV of rating	2.5
Components of the Continuous Leakage Current at MCOV		
- Resistive (Max.)	µ AP	400
- Capacitive (Max)	µ AP	1,500
Cantilever Strength	N-m	3,100

Nominal System Voltage (Ur)	Creepage Distance	Arrester Rating (Ur)	Min. Reference Voltage at 1.5mAP	MCOV (Uc)	Temporary Overvoltage (Prior energy)				Insulation Withstand of Housing		
					0.1 sec	1 sec	10 sec	100 sec	Wet PF (1 minute withstand)	Dry Lightning Impulse	Wet Switching Impulse
kVrms	mm	kVrms	kVrms	kVrms	kVrms	kVrms	kVrms	kVrms	kVrms	kVP	kVP
2.4	63	2.7	2.7	2.2	3.3	3.2	3	2.9	28	75	NA
4.16	109.2	3	3	2.55	3.7	3.5	3.4	3.2			
		4.5	4.5	3.7	5.5	5.3	5.1	4.8			
4.8	126	5.1	5.1	4.2	6.3	6	5.7	5.5			
6.9	181	6	6	5.1	7.4	7.1	6.8	6.5			
		9	9	7.65	11	10.6	10.1	9.7			
12.47	327	10	10	8.4	12.3	11.8	11.3	10.8			
13.2, 13.8	362	12	12	10.2	14.7	14.1	13.5	12.9			
		18	18	15.3	22.1	21.2	20.3	19.4	50	125	NA
		21	21	17	25.8	24.7	23.7	22.6			
23, 24, 94	655	24	24	19.5	29.4	28.2	27	25.8			
		27	27	22	33.1	31.8	30.4	29.1	70	170	NA
34.5	906	30	30	24.4	36.8	35.3	33.8	32.3			
46	1208	39	39	31.5	47.9	45.9	44	42			

The curve of the recommended TOV of MOGARD Arresters is shown in fig. 1 in per unit of the Arrester rating. This curve defines the duration and the magnitude of the temporary overvoltages that may be applied to the Arrester before the Arrester voltage must be reduced to the Arrester's continuous operating voltage capability. These capabilities have been defined independent of the system impedance and are therefore valid for voltages applied at the Arrester location.

SWITCHING SURGE

The ability of MOGARD Arresters to dissipate overhead line switching surges can be quantified to a large degree in terms of energy. The unit used in quantifying the energy capability of the Metal Oxide Arrester is kilojoules per kilovolts (kJ/kV). This is conventional as the Arresters are constructed of series repeating sections.

The maximum amount of energy that can be dissipated in MOGARD Arrester is given in Tables 1A, 1B, 1C & 1D. In defining these capabilities, it is assumed that multiple discharges are distributed over a one-minute period. For single Arrester operation, the energy should not exceed 85% of these values.

TABLE 2D for 9L 14 Series of Arresters

Reference Standard		IEC -99-4
Arrester Type & Designation		Gapless, "MOGARD"
Arrester Class		Station
Nominal Discharge current	kA	10
Rated Frequency	Hz	48-62
Pressure Relief Capability, (0.2 sec)	kA rms	40
Line Discharge Class *		I
Energy Dissipation Capability (cumulative operation)	kJ/kV of rating	2.5
Components of the Continuous Leakage Current at MCOV		
- Resistive (Max.)	µ AP	400

- Capacitive (Max)	µ AP	1,500
Cantilever Strength	N-m	3,100

Nominal System Voltage (Ur)	Creepage Distance	Arrester Rating (Ur)	Min. Reference Voltage at 1.5m AP	MCOV (Uc)	Temporary Overvoltage (Prior energy)				Insulation Withstand of Housing		
					0.1 sec	1 sec	10 sec	100 sec	Wet PF (1 minute withstand)	Dry Lightning Impulse	Wet Switching Impulse
kVrms	mm	kVrms	kVrms	kVrms	kVrms	kVrms	kVrms	kVrms	kVrms	kVP	kVP
2.4	63	2.7	2.7	2.2	3.3	3.2	3	2.9	28	75	NA
4.16	109.2	3	3	2.55	3.7	3.5	3.4	3.2			
4.8	126	4.5	4.5	3.7	5.5	5.3	5.1	4.8			
		5.1	5.1	4.2	6.3	6	5.7	5.5			
6.9	181	6	6	5.1	7.4	7.1	6.8	6.5			
12.47	327	9	9	7.65	11	10.6	10.1	9.7			
		10	10	8.4	12.3	11.8	11.3	10.8			
13.2, 13.8	362	12	12	10.2	14.7	14.1	13.5	12.9			
23, 24, 94	655	18	18	15.3	22.1	21.2	20.3	19.4	50	125	NA
		21	21	17	25.8	24.7	23.7	22.6			
		24	24	19.5	29.4	28.2	27	25.8			
34.5	906	27	27	22	33.1	31.8	30.4	29.1	70	170	NA
		30	30	24.4	36.8	35.3	33.8	32.3			
46	1208	39	39	31.5	47.9	45.9	44	42			

MOGARD Arresters have considerably more capability in applications where the discharges take place over a longer period of time. After one minute of cooling period, the above discharge may be repeated. The one-minute cooling period allows the disc temperature distribution to become uniform.

The actual amount of energy discharged in a metal oxide Arrester during a switching surge is a complex function of both the Arrester volt-ampere characteristic and the details of the system. The energy likely to be discharged can be determined on a Transient Network Analyzer (TNA) or with a digital circuit analysis program like the Electromagnetic Transients Program (EMTP) where system and Arresters details can be represented accurately.

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 resistance, pressure relief, ambient temperature, and altitude must exceed the specified requirements.

METAL OXIDE DISCS

Metal Oxide Discs are composed of a specially formulated compound of zinc oxide and small amounts of other selected metal oxides. These ingredients are mixed in powdered form, pressed to form a disc, fired at high temperatures and under a definite temperature profile, resulting in a dense polycrystalline ceramic. The basic molecular structure is a matrix of highly conductive zinc oxide grains surrounded by resistive intergranular layers of metal oxide elements. Under electrical stress, the intergranular layers conduct, resulting in a highly nonlinear characteristic. For example, a change of Arrester current of 100,000 to 1 (0.1A to 10,000A) results in a voltage change of only 54 percent. Metal oxide elements in ELPRO's MOGARD Arresters maintain stable characteristics. Accelerated life tests show that Arrester losses will not increase during an Arrester's service life when exposed to a continuous steady-state voltage. Stable metal oxide characteristics enable ELPRO's MOGARD Arresters to maintain their low

protective characteristics. As a result, equipment protection is never compromised. The collaring system used on ELPRO discs has a dual purpose:

DISC COLLARING

1) To provide an insulating collar to prevent flashover at high currents.
2) To prevent the disc watts from increasing during aging from surface oxygen reduction.

The ELPRO high dielectric insulating collar system is a nonporous crystalline that completely seals the circumference of the disc thereby preventing any oxygen depletion from the zinc oxide grains. This system ensures that varistor disc will have a stable aging characteristic in any surrounding atmosphere: gas, liquid or solid. Many collar systems can provide the insulation to withstand and prevent flashover at high currents but only a non-porous inorganic material can ensure long term stable aging characteristics.

DISC COLLARING

SPRAY DRYING

CONSTRUCTION

HEAT TRANSFER

MOGARD Arresters incorporate a heat transfer system utilizing silicon rubber material wedged between the Zinc Oxide Disc and the internal porcelain wall. Heat generated in the discs from steady state, temporary or transient conditions is transferred through the silicon rubber material and porcelain housing and then dissipated to the outside environment. This patent mechanism of heat transfer by

conduction, convection and radiation is far superior than the restricted air convection method utilized in other conventional designs with symmetric assembly.

FIG - 2

ECCENTRIC ASSEMBLY

Cross Sectional view of ELPRO MOGARD Arrester

Cross Sectional view of ELPRO MOGARD Arrester

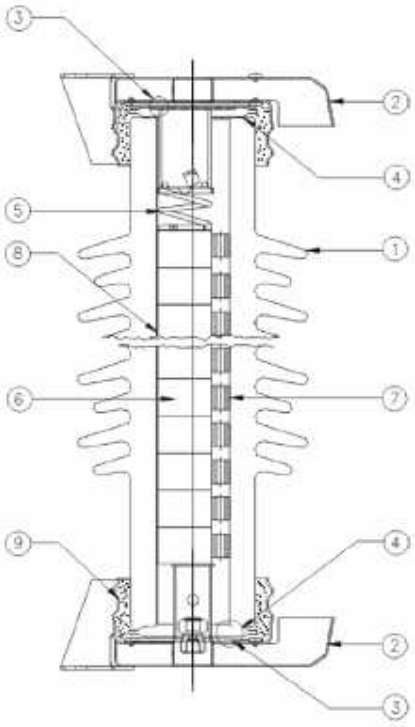


FIG - 3

Sr. No.	Description
1	Container / Porcelain
2	Clamping Ring

3	Pressure Sensitive diaphragm
4	Rubber Gasket
5	Spring
6	Zinc Oxide Discs Disc
7	Silicon Wedge
8	Silicon Strip
9	Sulphur Cement

ARRESTER MODELLING

The MOGARD Arrester can be readily modeled for system studies. Typical voltage-current points for MOGARD Arresters can be obtained via your local ELPRO representative or from our Head Office . The points are normalized on the Arrester maximum discharge voltage at 10 kA and are generated by applying current waves of different magnitudes and times-to-crest to the Arrester and measuring the resultant crest voltages. The maximum values are appropriate for the computation of protective ratios in insulation co-ordination and the minimum values may be used in computation of maximum Arrester energies.

In studies involving switching surges, the 30/90 µs voltampere relationship should be used to model the Arrester. This type of model is sufficient for switching surges of longer duration. For lightning or fast switching surge studies, a conservative choice would be the use of the front-of-wave characteristic because it yields the highest calculated voltages and the lowest protective ratio. Depending on the actual waveforms, however, the 8/20 µs characteristic may be an appropriate choice. In calculations involving ferroresonance or load rejection overvoltages, the power frequency characteristic (1 ms wave front test data) could be used to determine the Arrester volt-amp curve and the Arrester duty. It should be noted that when a metal oxide Arrester is used to control temporary overvoltages that can last for many power frequency cycles, the material exhibits some time dependence. For fixed amplitude, sinusoidal power frequency voltage applied to the metal oxide, the first few cycles of Arrester current tend to be greater in magnitude than the subsequent cycles. If the Arrester is to be modeled for such an application, the specific voltcurrent- time relationship should be applied.

APPLICATION OPPORTUNITIES

MOGARD Arresters offer considerable advantages because of their unique operating mode, high-energy absorption, and low protective level in a variety of situations where other types of Arresters have been found difficult to apply. Such situations include the protection of shunt capacitor banks, cable circuits and switch-connected equipment.

SHUNT CAPACITOR BANK & CABLE CIRCUIT

The switching of shunt capacitor banks or cables can produce surges that may result in significant duty to Arresters. This is particularly so if the switching device should restrike with trapped charge on the capacitor or cable. The Arresters exposed to this duty may be located on either side of the switching device. MOGARD Arresters limit the surge voltages by diverting the system current from the capacitor to the Arrester. The duty imposed on the Arrester depends on the size of the bank and the source impedance of the power system. The application of Arresters near large shunt capacitor banks generally requires an analytical investigation of the surge currents resulting from the switching and restriking of these capacitors. If an adjacent substation also has a shunt capacitor bank, the phenomenon of voltage magnification may cause higher surge currents in the remote Arresters than in the Arresters at the substation where the switching is being performed. The application of MOGARD

Arresters on large capacitor banks should be reviewed with your local ELPRO representative or should be done in consultation with our Head Office.

SWITCH CONNECTED EQUIPMENT

Equipment insulation can be subjected to high frequency, low energy transients initiated by some types of switchgear including air break switches. These transients have resulted in multiple operations and excessive power frequency energy in silicon carbide Arresters. MOGARD Arresters, however, maintain a higher average resistance during conduction, thus reducing the energy discharge and increasing the Arrester's ability to survive.

SPECIAL APPLICATIONS OF MOGARD METALOXIDE TECHNOLOGY

In some power system installations, special ELPRO Arresters are required to address particular needs of the application. These requirements include high-energy capability, low protective levels or unusual voltage stresses. For any such requirement, please refer to our head office.

ARRESTER CONTAMINATION

MOGARD Arresters are built in accordance with contamination tests outlined in ANSI/IEEE C62.11. MOGARD 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 MOGARD 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 MOGARD Arrester is exceeded, the metal oxide discs may crack or puncture. Such damage will 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 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. Pressure relief/fault current capability for all ELPRO MOGARD Arresters is shown in Tables **1A, 1B, 1C & 1D.**

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. In applications where an Arrester pressure relief/fault current capability is exceeded, it should be mounted in an enclosure to prevent a safety hazard. A physical installation of this nature might be used for the protection of a large generator.

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 disc temperature when the Arrester is operated at its continuous voltage capability. The reference standards indicate that the ambient temperature not exceeding 40℃ is the standard service condition for Arresters. MOGARD Arresters are designed to operate at a weighted average temperature of 45℃ with excursion s to 60℃.

ALTITUDE

MOGARD Arresters are designed for altitudes not exceeding 10,000 ft. (3050 m) above sea level. 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 300 ft. (100 m) above a 10,000 ft. (3050 m) altitude, Arrester clearances should increase approximately by one percent.

MOUNTING CONSIDERATIONS

MOGARD 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. The rated working cantilever strengths for various Arrester ratings are shown in Table 3.

Table 3 Cantilever Strength

Arrester Type	Working Cantilever Strength
	N-m
9L11 Series	9,800
9L12 Series	6,300
9L13 Series	3,100
9L14 Series	3,100

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. The minimum recommended clearances are shown in Tables 4A, 4B, 4C & 4D. MOGARD 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. The recommended three-phase installation plan is shown in fig.4, fig. 5 & fig. 6.

3-PHASE INSTALLATION PLAN FOR 9L11...SERIES.

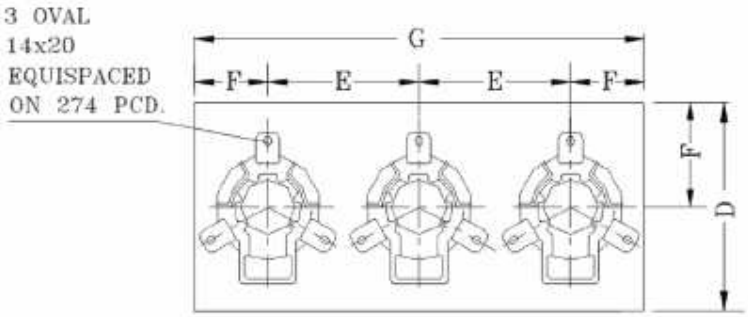


FIG - 4

3-PHASE INSTALLATION PLAN FOR 9L12 SERIES.

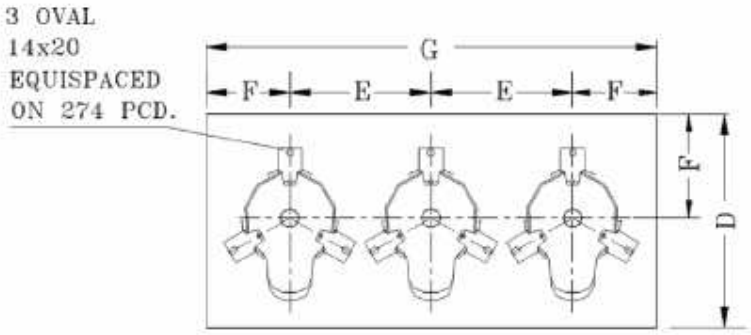


FIG - 5

3-PHASE INSTALLATION PLAN FOR 9L13 & 9L14.... SERIES.

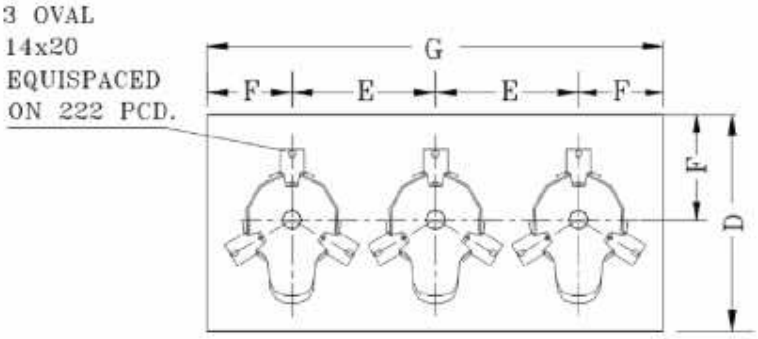


FIG - 6

TABLE 4A FOR 9L 11 SERIES OF ARRESTER

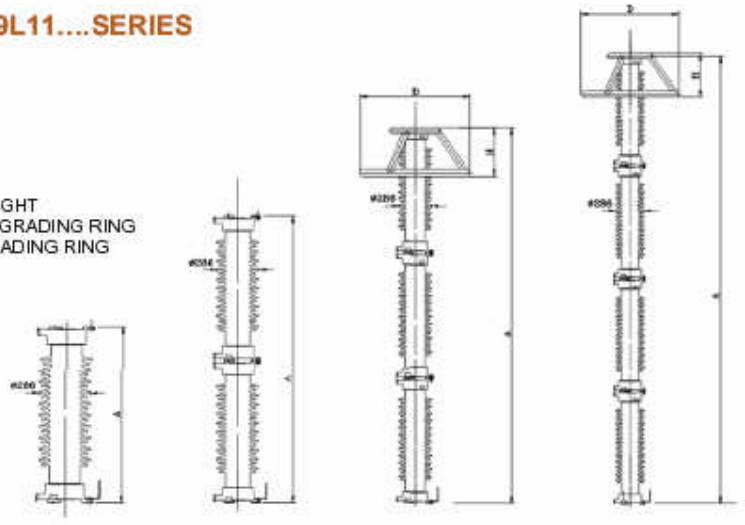
Nominal System voltage (kV)	Arrester Rating (kV)	Approximate Arrester Height Fig. 7 (mm)	Approximate Arrester Weight * (kg)	Min. Clearance (mm)	Min. space for three phase Installation. Ref. Fig. 4 (mm)					
		A			F	E	D	G	Grading Ring Details	
									D (mm)	H (mm)
2.4 - 4.8	2.7 - 4.5	412	37	150	310	470	620	1560		
	2.7 - 4.5*	412	42	150	310	470	620	1560		
4.8 - 6.9	5.1 - 6	412	39	150	310	470	620	1560		
	5.1 - 6*	412	44	150	310	470	620	1560		
12.47 - 13.8	9 - 12	412	41	150	310	470	620	1560		
	9 - 12*	412	46	150	310	470	620	1560		
23 - 24.94	18 - 24	475	47	250	410	570	820	1960		
	18 - 24*	475	52	250	410	570	820	1960		
34.5	27 - 30	664	65	370	530	690	1060	2440		
	27 - 30*	664	70	370	530	690	1060	2440		
46	39	664	68	370	530	690	1060	2440		
	39*	664	72	370	530	690	1060	2440		
69	54 - 60	980	92	580	740	900	1480	3280		
	54 - 60*	980	97	580	740	900	1480	3280		
115	90 - 108	1231	122	650	810	970	1620	3560		
	90 - 108	1231	127	650	810	970	1620	3560		
138 - 161	120 - 144*	1960	214	1000	1420	1840	2840	6520	585	280
230	172 - 192*	2940	317	1620	1920	2210	3840	8260	585	280
345	258 - 312*	4420	340	2670	3160	3640	6320	13600	970	432
400	336 - 360*	4420	465	2670	3160	3640	6320	13600	970	432

***Arrester weight is inclusive of accessories as applicable.**

DIMENSIONS FOR 9L11....SERIES

FIG - 7

A ARRESTER HEIGHT
D DIAMETER OF GRADING RING
H HEIGHT OF GRADING RING



upto 108 kV | from 120kV-144kV | from 172kV-192kV | from 258kV-360kV

TABLE 4B FOR 9L 12 SERIES OF ARRESTER

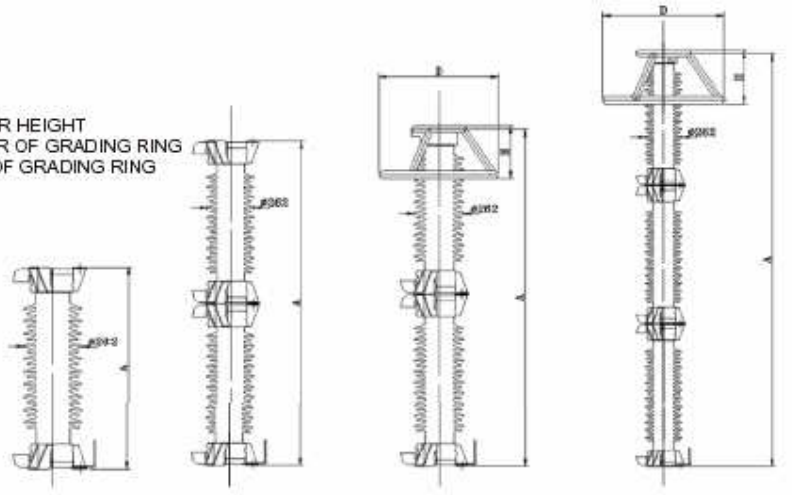
Nominal System voltage (kV)	Arrester Rating (kV)	Approximate Arrester Height Fig. 8 (mm)	Approximate Arrester Weight * (kg)	Min. Clearance (mm)	Min. space for three phase Installation. Ref. Fig. 5 (mm)					
		A			F	E	D	G	Gradimg Ring Details	
									D (mm)	H (mm)
2.4 - 4.8	2.7 - 4.5	372	22	150	310	470	620	1560		
	2.7 - 4.5**	372	30	150	310	470	620	1560		
4.8 - 6.9	5.1 - 6	372	24	150	310	470	620	1560		
	5.1 - 6**	372	32	150	310	470	620	1560		
12.47 - 13.8	9 - 12	372	26	150	310	470	620	1560		
	9 - 12**	372	34	150	310	470	620	1560		
23 - 24.94	18 - 24	435	30	250	410	570	820	1960		
	18 - 24**	435	38	250	410	570	820	1960		
34.5	27 - 30	561	37	370	530	690	1060	2440		
	27 - 30**	561	45	370	530	690	1060	2440		
46	39	561	40	370	530	690	1060	2440		
	39**	561	48	370	530	690	1060	2440		
69	54 - 60	813	58	580	740	900	1480	3280		
	54 - 60**	813	66	580	740	900	1480	3280		
115	90 - 108**	1374	110	650	810	970	1620	3560		
138 - 161	120 - 144**	1626	140	1000	1420	1820	2840	6520	838	254
230	172 - 192**	2439	200	1620	1920	2210	3840	8260	970	585

*Arrester weight is inclusive of accessories as applicable.
**Arrester weight with Insulating Base & Discharge counter.

DIMENSIONS FOR 9L12.....SERIES

FIG - 8

A ARRESTER HEIGHT
D DIAMETER OF GRADING RING
H HEIGHT OF GRADING RING



upto 60 kV | from 90kV-108kV | from 120kV-144kV | from 172V-192kV

TABLE 4C for 9L 13 Series of Arresters

Nominal	Arrester	Approximate	Approximate	Min.	Minimum space for three phase

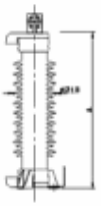
System Voltage (kV)	Rating (kV)	Arrester Height Fig. 9 (mm) A	Arrester Weight * (kg)	Clearance (mm)	Installation, Ref. Fig. 6 (mm)			
					F	E	D	G
2.4 - 4.8	2.7 - 4.5	370	13	150	310	470	620	1560
	2.7 - 4.5**	370	20	150	310	470	620	1560
4.8 - 6.9	5.1 - 6*	370	14	150	310	470	620	1560
	5.1 - 6**	370	21	150	310	470	620	1560
12.47 -13.8	9.0 - 12	370	15	150	310	470	620	1560
	9.0 - 12**	370	22	150	310	470	620	1560
23 - 24.94	18 - 24	470	23	150	530	690	1060	2400
	18 - 24**	470	30	370	530	690	1060	2400
34.5	27 - 30	560	25	370	530	690	1060	2440
	27 - 30**	560	32	370	530	690	1060	2440
46	39	560	32	370	530	690	1060	2440
	39**	560	39	370	530	690	1060	2440
69	54 - 60	875	47	580	740	900	1480	3280
	54 - 60**	875	54	580	740	900	1480	3280
115	96	1435	57	650	810	970	1620	3560
115	96**	1435	65	650	810	970	1620	3560
138	108-120	1750	77	1000	1420	1820	2840	6520
138	108-120**	1750	82	1000	1420	1820	2840	6520

TABLE 4D for 9L 14 Series of Arresters

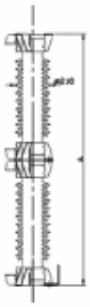
Nominal System Voltage (kV)	Arrester Rating (kV)	Approximate Arrester Height Fig. 9 (mm) A	Approximate Arrester Weight * (kg)	Min. Clearance (mm)	Minimum space for three phase Installation, Ref. Fig. 6 (mm)			
					F	E	D	G
2.4 - 4.8	2.7 - 4.5	370	14	150	310	470	620	1560
	2.7 - 4.5**	370	21	150	310	470	620	1560
4.8 - 6.9	5.1 - 6*	370	15	150	310	470	620	1560
	5.1 - 6**	370	22	150	310	470	620	1560
12.47 -13.8	9.0 - 12	370	16	150	310	470	620	1560
	9.0 - 12**	370	23	150	310	470	620	1560
23 - 24.94	18 - 24	470	19	370	530	690	1060	2440
	18 - 24**	470	26	370	530	690	1060	2400
34.5	27 - 30	560	25	370	530	690	1060	2440
	27 - 30**	560	32	370	530	690	1060	2440
46	39	560	26	370	530	690	1060	2440
	39**	560	33	370	530	690	1060	2440

Dimensions for 9L13.....& 9L14.....SERIES

FIG - 9



For 9L13.....upto 60kV
For 9L14.....from 2.7kV-39kV



A - Arrester Height

For 9L13.....from 90kV - 120kV

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. A surge-counter leakage meter can monitor Arrester leakage current. 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.

INSULATION CO-ORDINATION

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 MOGARD 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 timeto- crest for the current wave. Figure 10 shows the test results of a 10 kA 8/20 µs current impulse test.

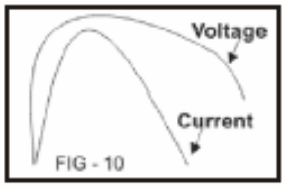


FIG - 10

MOGARD protective characteristics have been defined for fast impulse currents with times-to-crest shorter than 8 ms. Available data on lightning strokes 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. Three protective levels are selected for co-ordination with the transformer insulation characteristics. They are described as follows:

SWITCHING SURGE PROTECTIVE LEVEL

This is the crest discharge voltage that results when a 30/90µs current impulse is applied to the Arrester. To define the Arrester's switching surge protective level, “switching surge coordination current” is defined for the various system voltages. These currents are: 500 amperes for maximum system line-to-line voltages to 150 kV, 1000 amperes for systems 151 to 325 kV, and 2000 amperes for systems above 325 kV.

IMPULSE PROTECTIVE LEVEL

This is the crest discharge voltage that results when an 8/20 µs 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 co-ordination with transformer insulation, a specific current impulse magnitude must be selected based on the system voltage.

FRONT-OF-WAVE PROTECTIVE LEVEL (STEEP CURRENT IMPULSE PROTECTIVE LEVEL)

This is the discharge voltage for current impulses having a faster time to crest than the 8/20 µs 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 µs) and extending the measured voltages to 0.5 µs in accordance with ANSI/IEEE C62.11.

PROTECTIVE RATIOS

The three-point method is usually applied for insulation co-ordination. 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 co-ordination will be achieved according to the minimum recommendations given in ANSI/IEEE C62.22.

Switching Surge Withstand / Switching Surge Protection Level > = 1.15

Full Wave Withstand (BIL) / Impulse Protection Level > = 1.20

Chopped Wave Withstand / Front-of-Wave Protection Level > = 1.20

These calculated protective ratios assume negligible Arrester lead length and separation distance between the Arrester and the transformer. In many cases, the calculated protective ratios exceed the minimum protective ratios recommended by ANSI by a considerable amount in actual power system applications.

MOGARD SURGE ARRESTERS

ARRESTER TESTING
DURABILITY TESTS & QUALITY ASSURANCE

MOGARD Arresters comply with the design tests outlined in ANSI/IEEE C62.11 and IEC 99-4. They exceed the requirements for the duty-cycle test, high-current short duration test, and the low-current long-duration test (transmission line discharge test) with no loss in protective capability. The ANSI/IEEE duty-cycle test and IEC operating duty test verify that the MOGARD Arresters can dissipate lightning and switching surges while operating at rated voltage, and thermally recover at maximum continuous operating voltage (MCOV) of 60℃ at an elevated tem perature. In other words, the Arrester can selfcool under applied voltage after absorbing transient energy. Gapless construction and a special shed design provide excellent contamination performance exceeding ANSI/IEEE contamination test requirements. Factory tests are performed on each metal oxide disc. Long-term stability tests are conducted on each production lot to verify that the disc formulation and factory processes are consistent and optimized. Every disc is subjected to an impulse current equal to the nominal discharge current of the Arrester and 8/20 µ sec wave shape to measure its discharge voltage or nominal protective level. A disc strength test series consisting of multiple transmission-line discharges is performed to make certain that the disc has full energy capability.

COUPLING CAPACITOR

IMPULSE GENERATOR

TABLE 5A for 9L11 Series of Arrester

Arrester Rating (Ur)	Arrester Unit Shipping Dimension			Approximate Shipping weight for complete arrester, inclusive of accessories as applicable.
(kV)	(mm)	(mm)	(mm)	(kg)
	l	b	h	
2.7-4.5	584	483	483	62
2.7-4.5**	584	483	483	95
5.1-6	584	483	483	64
5.1-6**	584	483	483	97
9.0-12	584	483	483	66
9.0-12**	584	483	483	100
18-24	660	483	483	73
18-24**	660	483	483	106
27-30	838	483	483	94
27-30**	838	483	483	119
39	838	483	483	90
39**	838	483	483	105
54-60	1219	483	483	132
54-60**	1219	483	483	165
90-108	1473	483	483	154
90-108**	1473	483	483	187
120-144**	1219	483	483	312
172-192**	1219	483	483	466
258-312**	1364	483	483	481
336-360**	1346	483	483	675

TABLE 5A for 9L11 Series of Arrester

Arrester Rating (Ur)	Arrester Unit Shipping Dimension			Approximate Shipping weight for complete arrester, inclusive of accessories as applicable.
(kV)	(mm)	(mm)	(mm)	(kg)
	l	b	h	
2.7-4.5	584	483	483	62
2.7-4.5**	584	483	483	95
5.1-6	584	483	483	64
5.1-6**	584	483	483	97
9.0-12	584	483	483	66
9.0-12**	584	483	483	100

18-24	660	483	483	73
18-24**	660	483	483	106
27-30	838	483	483	94
27-30**	838	483	483	119
39	838	483	483	90
39**	838	483	483	105
54-60	1219	483	483	132
54-60**	1219	483	483	165
90-108	1473	483	483	154
90-108**	1473	483	483	187
120-144**	1219	483	483	312
172-192**	1219	483	483	466
258-312**	1364	483	483	481
336-360**	1346	483	483	675

TABLE 5B fo 9L12 Series of Arrester

Arrester Rating (Ur)	Arrester Unit Shipping Dimension			Approximate Shipping weight for complete arrester, inclusive of accessories as applicable.
(kV)	(mm)	(mm)	(mm)	(kg)
	l	b	h	
2.7-4.5	584	483	483	47
2.7-4.5**	584	483	483	60
5.1-6	584	483	483	49
5.1-6**	584	483	483	62
9.0-12	584	483	483	51
9.0-12**	584	483	483	64
18-24	660	483	483	56
18-24**	660	483	483	72
27-30	787	483	483	65
27-30**	787	483	483	81
39	787	483	483	72
39**	787	483	483	88
54-60	1092	483	483	98
54-60**	1092	483	483	114
90-108**	1092	483	483	185
120-144**	1092	483	483	218
172-192**	1092	483	483	350

TABLE 5C for 9L13 Series of Arrester

Arrester Rating (Ur)	Arrester Unit Shipping Dimension			Approximate Shipping weight for complete arrester, inclusive of accessories as applicable.
(kV)	(mm)	(mm)	(mm)	(kg)
	l	b	h	
2.7-4.5	610	406	406	30
2.7-4.5**	610	406	406	43
5.1-6	610	406	406	31
5.1-6**	610	406	406	44
9.0-12	610	406	406	32
9.0-12**	610	406	406	45
18-24	711	406	406	41
18-24**	711	406	406	49
27-30	787	432	432	41
27-30**	787	432	432	63
39	787	483	483	59
39**	787	483	483	75
54-60	1219	483	483	93
54-60**	1219	483	483	109
90-96	1118	483	483	99
90-96**	1118	483	483	114
108-120	1118	483	483	119
108-120**	1118	483	483	134

TABLE 5D for 9L14 Series of Arrester

Arrester Rating (Ur)	Arrester Unit Shipping Dimension			Approximate Shipping weight for complete arrester, inclusive of accessories as applicable.
(kV)	(mm)	(mm)	(mm)	(kg)
	l	b	h	
2.7-4.5	610	406	406	331
2.7-4.5**	610	406	406	46
5.1-6	610	406	406	32
5.1-6**	610	406	406	47
9.0-12	610	406	406	33
9.0-12**	610	406	406	48
18-24	711	406	406	37
18-24**	711	406	406	52
27-30	787	406	406	46
27-30**	787	406	406	61
39	787	406	406	48

INSTRUCTIONS FOR MOGARD PORCELAIN TYPE SURGE ARRESTERS

CAUTION: THE EQUIPMENT COVERED BY THESE INSTRUCTIONS SHOULD BE INSTALLED AND SERVICED ONLY BY COMPETENT PERSONNEL FAMILIAR WITH GOOD SAFETY PRACTICES. THIS INSTRUCTION IS WRITTEN FOR SUCH PERSONNEL AND IS NOT INTENDED AS A SUBSTITUTE FOR ADEQUATE TRAINING AND EXPERIENCE IN
SAFE PROCEDURES FOR THIS TYPE OF EQUIPMENT.

WARNING: ARRESTERS APPLIED AT VOLTAGE HIGHER THAN RATING MAY CAUSE DAMAGE AND/OR INJURY. CHECK THE ARRESTER RATING MARKED CLEARLY ON THE NAMEPLATE TO ASSURE CORRECT APPLICATION.

INTRODUCTION

The MOGARD Porcelain housed Arrester is designed to limit surge voltage by conducting the surge current to ground, and thus avoiding equipment damage. The Arrester is of single pole design, suitable for outdoor use, and designed in accordance with the latest revision of the ANSI/IEEE C62.11 and IEC 99-4 standard. Three Arresters are required for three-phase installation.

The MOGARD Arrester consists of a stack of metal oxide discs, which are wedged by means of Silicon Rubber wedges in a porcelain housing. A metal end fitting provides a means for bolting the Arrester to a foundation. An outline drawing of the Arrester should be reviewed for details.

CONTINUOUS OPERATING VOLTAGE

MOGARD Arresters must be applied where the continuous phase-to-ground power frequency voltage at the Arrester location does not exceed the Arrester continuous voltage capability as indicated on the nameplate. In case of doubt concerning application, consult your local ELPRO company representative or our head office.

ALTITUDE AND TEMPERATURE

The 9L11, 9L12, 9L13 & 9L14 series Arresters are suitable for operation at 0-10,000 feet (3,050m) above mean sea level. These Arresters can be used in locations where the maximum temperature does not exceed 60°C and where the weighted average tem perature does not exceed 40℃.

INITIAL INSPECTION

Although it is very unlikely, extraordinarily rough handling can result in damage to the MOGARD Arrester. Careful inspection of each Arrester prior to installation is required to assure that no damage has occurred during shipment. ***If damage is apparent, do not install Arrester.*** Claims for shipping damage should be registered immediately with the common carrier.

The model number, rating, maximum continuous operating voltage (MCOV), pressure relief capability & arrester serial number are identified on the nameplate. The nameplate information should be checked against the shipping memorandum. If at any time it is necessary to correspond with the ELPRO company, complete nameplate data should be furnished in order to expedite replies.

INSTALLATION

LOCATION

Install the Arrester electrically as close as practicable to the equipment to be protected. Keep the Arrester connections short and direct. The footings of all outdoor piers or supports should extend below the frost line and be elevated above the ground line sufficiently to meet personnel safety requirements.

CLEARANCE

The term "clearance" means the actual distance between any parts of the Arrester at line potential and any object at ground potential or other phase potential. Clearances listed on the appropriate outline print packed with each Arrester are the minimum recommended and were determined such that the operation and capability of the Arrester is not significantly affected. These clearances apply for conventional outdoor substations. These values should be used only after it has been determined that any local codes or standard practices do not require larger clearances. The values shown are suitable for altitudes up to 3,300 feet (1,000 meters). For operation at higher altitudes, add 3 percent for each additional 1000 feet (300 meters) of elevation. The arrangement of the foundation plans can be modified if proper clearances are to be maintained.

MOUNTING

Each Arrester is shipped as assembled individual units. Install the Arrester vertically on the foundation, using care to see that it is perpendicular, shimming under all but one foot if necessary. It is important that all feet rest solidly on the foundation before the foundation bolts are drawn down to avoid unnecessary stresses in the end fittings. Tighten the bolts firmly. Please refer to MOGARD Instruction and Maintenance Manual for details.

LINE AND GROUND CONNECTIONS

Connect the Arrester ground to the apparatus ground and the main station ground utilizing a reliable common ground network of low resistance. Connection to the line should be made through a suitable line connector. Line connections should be made in such a manner that no excessive mechanical stress is placed on the Arrester.

CAUTION: ALWAYS BE CERTAIN THAT THE GROUND CONNECTION IS FIRMLY MADE BEFORE

CONNECTING THE ARRESTER TO AN ENERGIZED LINE. IF AN INSULATING UNIT IS USED AT THE GROUND END TO PERMIT USE OF A DISCHARGE COUNTER, THE DISCHARGE COUNTER MUST BE CONNECTED (OR THE INSULATING UNIT SHORTED OUT) BEFORE CONNECTING THE ARRESTER TO AN ENERGIZED LINE.

PERIODIC INSPECTION, MAINTENANCE AND REMOVAL

Before inspecting or handling, disconnect the Arrester from the line. When a metal-oxide Arrester is disconnected from an energized line, it is possible for a small amount of static charge to be retained by the Arrester. The energy available in the form of retained charge on the MOGARD Arresters is imperceptibly small. After disconnecting the Arrester from the line, a slight "pin-prick" type spark may be felt by anyone touching the line end. As a precautionary measure, install a temporary ground on the line end of the Arrester after it is disconnected from the line. This will ensure that any retained charge is discharged to ground. *Remove the temporary ground before the Arrester is re-installed.* MOGARD Arresters require no special care. They may be hot-washed, subject to the usual care and techniques used in hot-washing insulation to avoid external flashover. These Arresters do not require testing, and no test, which applies power voltage in excess of maximum Arrester voltage rating should be made without consulting the ELPRO Company. There is no single field test, which will indicate the complete operating characteristics of the Arrester.

WARNING: TO AVOID ELECTRICAL SHOCK WHEN REMOVING AN ARRESTER FROM SERVICE, CONSIDER IT TO BE FULLY ENERGIZED UNTIL BOTH THE LINE AND GROUND LEADS ARE DISCONNECTED.

STORAGE

As all MOGARD Arresters are designed for outdoor use, they may be stored outdoors if suitable precautions are taken to prevent deterioration of the packing material. The Arresters may be covered with a polyethylene or other waterproof covering to keep them dry, clean, and free from litter until used. In climates where outdoor temperature and humidity extremes rapidly deteriorate the packing material, it is recommended that Arresters to be stored outdoors be removed from their packing and be bolted (vertically) to a skid.

DISCHARGE COUNTERS

An insulating base is required when installing a discharge counter with Arresters. Both of these are accessories and are available on separate request. Install the discharge counter and insulating bases as shown on the outline drawing furnished with the counter.

Elpro

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