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Type SMX Station Class Gapless Metal Oxide Surge Arresters

Introduction
The Westinghouse Type SMX solid state metal oxide surge arresters are completely gapless from 2.7 KV through 612 KV. No gaps are necessary with the Westinghouse developed MOXIDE™ metal oxide disc with superior non-linear characteristics resulting in the lowest protective levels available without the aid of either series or parallel gaps.

The type SMX gapless station class arresters conduct only a few milliamperes at normal operating voltage. At a voltage surge, the arrester only conducts enough current to limit the voltage to the required protective levels.

The SMX arresters are constructed with singly stacked MOXIDE discs on all designs through 612 KV. Increased energy capabilities at EHV ratings are achieved by using larger MOXIDE discs. The MOXIDE disc technology was developed by Westinghouse in conjunction with an EPRI project starting in 1975 for development of completely gapless arresters through 1200 KV.

Basis of Arrester Rating
The SMX arresters are rated in accordance with the IEEE Proposed Draft 6, dated 10/86, of "Standards for Metal Oxide Surge Arresters for Alternating-Current Power Circuits," 3.3.11. A complete design test report is available from your Westinghouse Bloomington representative. The duty cycle test is performed at a voltage level above its maximum continuous operating voltage① to demonstrate the ability of the SMX arrester to perform its operating duty even under extreme service conditions. The voltage at which the duty cycle was performed is the voltage rating on the arrester nameplate.

Protective Characteristics
The protective characteristics of the Westinghouse SMX are shown in Table A. The gapless arrester has no sparkover, only the discharge voltages need to be compared with the insulation strength of the protected equipment.

Ambient Temperature
The SMX arrester is designed for an ambient temperature of −40°C to +40°C.

Temporary ambients exceeding 40°C are permissible – up to 60°C. However, it is recommended that Westinghouse be consulted for proper arrester selection on applications where ambient conditions exceed 40°C.

Application and Arrester Selection
For proper selection of the type SMX arrester, the following must be considered:
A. The maximum system voltage.
B. Temporary overvoltages (magnitude and duration).
C. Line discharges during switching surges (more frequently a consideration of 345 KV systems and above).

A. The Maximum System Voltage
Arresters in service are continually exposed to line-to-ground power frequency voltage. For each standardized maximum system voltage, there are several arrester ratings available.

The minimum type SMX arrester rating for a specific system voltage can be used for solidly grounded systems. The arrester rating must be selected so that the maximum continuous voltage applied to the arrester terminals is less than or equal to the maximum continuous operating voltage (MCOV) of the arrester. For temporarily ungrounded, impedance grounded or ungrounded systems, higher rated arresters may need to be chosen.

B. Temporary Overvoltage Capability
Ferroresonance, ground faults, long unloaded and uncompensated lines are common causes of temporary power frequency overvoltages. These overvoltages can persist from cycles to hundreds of seconds depending on the system components and line parameters. Since the Westinghouse SMX metal oxide arrester has no series or parallel gaps, the concern about continuous gap arcing and failure of the gap to clear is eliminated. The limiting factor thus only becomes the total amount of energy the arrester can absorb without exceeding the design capability.

The total energy in Joules absorbed by the arrester is a function of the magnitude and duration of overvoltage, the non-linear coefficient and steady state operating point of the metal oxide, along with the mass and heat transfer capability of the housing assembly. Figure A illustrates the magnitude of overvoltage in terms of per unit of maximum continuous operating voltage which the SMX surge arrester can withstand.

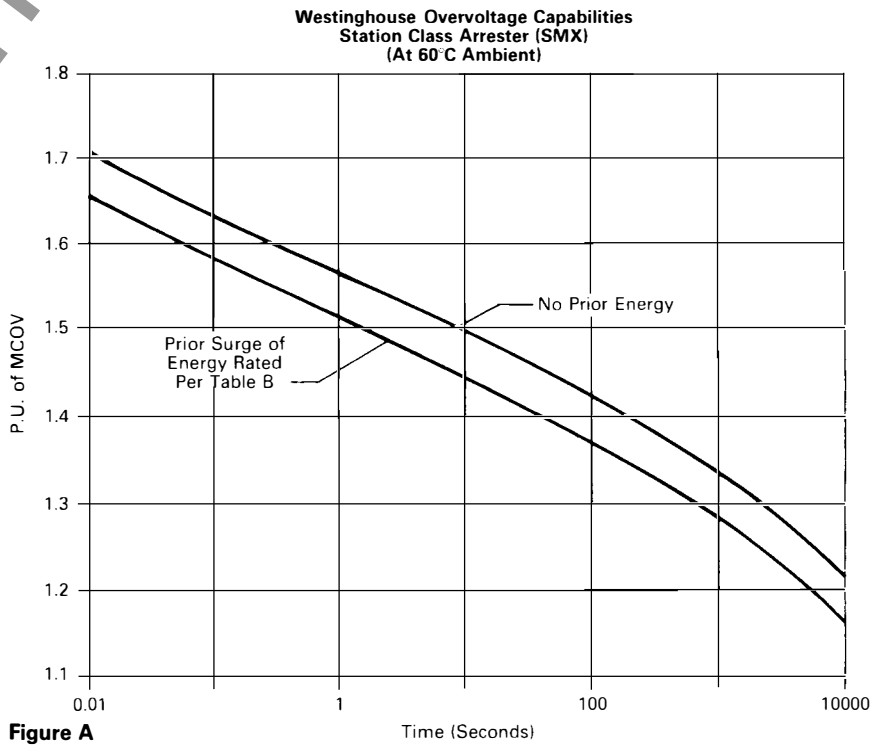

Figure A

① See Table A.

TABLE A – Westinghouse SMX Station Surge Arrester Characteristics

Arrester Rating Duty Cycle KV-RMS	Arrester Maximum Continuous Operating Voltage KV-RMS	Maximum .5 μsec Discharge Voltage KV-Crest①	Maximum Switching Surge Protective Level KV-Crest②	Maximum Discharge Voltage With an 8 × 20 μsec Current Wave KV-Crest 1.5 KA	3.0 KA	5.0 KA	10 KA	20 KA	40 KA
2.7	2.3	8.8	6.6	7.0	7.3	7.5	7.9	8.6	9.3
3.0	2.55	8.8	6.6	7.0	7.3	7.5	7.9	8.6	9.3
4.5	3.8	13.1	9.7	10.4	10.8	11.2	11.8	12.8	13.7
5.1	4.3	15.4	11.5	12.3	12.7	13.1	13.9	14.9	16.1
6.0	5.1	17.6	13.1	14.1	14.6	15.0	15.9	17.2	18.5
7.5	6.4	22.0	16.4	17.5	18.2	18.7	19.8	21.4	23.0
8.5	7.2	24.1	17.9	19.2	19.9	20.5	21.7	23.5	25.3
9.0	7.7	26.5	19.7	21.1	21.9	22.6	23.9	25.9	27.8
10	8.4	28.4	21.1	22.6	23.5	24.2	25.6	27.7	29.8
12	10.2	35.3	26.3	28.1	29.1	30.1	31.8	34.4	37.0
15	12.7	44.1	32.8	35.1	36.4	37.6	39.7	43.0	46.2
18	15.3	52.9	39.4	42.2	43.7	45.1	47.7	51.6	55.5
21	17.0	59.5	44.3	47.5	49.2	50.8	53.6	58.0	62.5
24	19.5	68.4	50.9	54.5	56.5	58.3	61.6	66.6	71.7
27	22.0	77.2	57.4	61.5	63.8	65.8	69.5	75.2	81.0
30	24.4	86.0	64.0	68.6	71.0	73.3	77.5	83.9	90.2
36	29.0	101.3	75.4	80.8	83.7	86.4	91.3	98.7	106.3
39	31.5	107.9	80.2	86.0	89.1	92.0	97.2	105.0	113.2
45	36.5	125.5	93.4	100.0	103.7	107.0	113.1	122.2	131.7
48	39	134.4	100.0	107.1	111.0	114.6	121.1	130.9	141.0
54	42	134	104	111	114	117	123	131	141
60	48	152	118	126	130	133	139	149	161
72	57	183	141	151	155	160	167	178	193
90	70	226	174	186	192	197	206	220	238
96	76	244	188	201	207	213	223	238	257
108	84	268	207	221	228	235	245	262	283
120	98	317	250	261	269	277	290	309	334
132	106	341	270	282	290	299	312	333	360
144	115	366	289	302	311	320	335	357	385
168	131	421	332	347	358	368	385	410	443
172	140	451	356	372	383	395	413	440	475
180	144	463	366	383	394	405	424	452	488
192	152	488	385	403	415	427	446	475	514
228	180	579	457	478	492	507	530	565	610
240	190	610	495	503	518	533	558	594	642
258	209	671	546	554	570	587	614	654	706
264	212	683	556	564	580	597	625	666	719
276	220	707	576	584	601	619	647	689	745
288	230	738	601	609	627	645	675	719	777
294	235	756	616	624	643	661	692	737	796
300	240	768	626	634	653	672	703	749	809
312	245	786	641	649	668	688	720	767	828
336	269	866	705	715	736	757	792	844	912
360	288	927	755	765	788	811	848	903	976
396	318	1040	823	841	861	883	922	974	1056
420	335	1090	863	882	903	926	967	1022	1107
444	353	1147	908	928	950	975	1017	1075	1165
588	470	1581	1204	1231	1260	1292	1349	1425	1545
612	485	1614	1230	1258	1288	1321	1378	1457	1579

Note ①: Equivalent front-of-wave producing a voltage wave cresting in .50 μsec. Protective level is maximum discharge voltage for a 10 KA impulse current wave on arresters through 360 KV, 15 KA for ratings 396 – 564 KV and 20 KA for ratings 588 – 612 KV, per latest proposed standards.

Note ②: Switching surge characteristics based on maximum switching surge coordination current of 500 amperes on arrester ratings 2.7 KV through 108 KV; 1,000 amperes on ratings 120 through 228 KV and 2,000 amperes on 240 KV ratings and above, per latest proposed standard.

C. Line Discharge and Switching Surge Durability

The SMX surge arresters have the unique capability of absorbing high energy levels per Table B. All designs use single column MOXIDE elements. The SMX surge arrester can absorb up to the kilojoule (kilowatt seconds) per kilovolt of duty cycle shown in this table.

Table B – Arrester Energy Capabilities

Arrester Ratings KV – Duty Cycle	Arrester Energy KJ/KV
2.7 – 48	4.2
60 – 360	7.5
396 – 444	13.5
588 – 612	13.5

Since the Westinghouse SMX metal oxide surge arrester is completely gapless, the surge energy durability of the arrester can be calculated simply in terms of energy absorption per cubic centimeter of metal oxide or, for the convenience of the user, in terms of energy per KV of arrester rating. The complications of series or parallel gaps, simple or current limiting versions, and their ability to cool or clear are thus eliminated.

Figure B, for example, shows the number of discharges a 180 KV SMX surge arrester can absorb in terms of per unit of the crest of maximum system line to ground voltage. Although a 4 P.U. charge voltage is highly unlikely, figure B shows that on a 100 mile line, 3 such discharges could be absorbed within seconds. Similar curves for other system voltages are available from Westinghouse.

In developing these curves, a simplified but very conservative approach was taken, i.e., all of the energy on the system is assumed to be absorbed by the surge arrester.

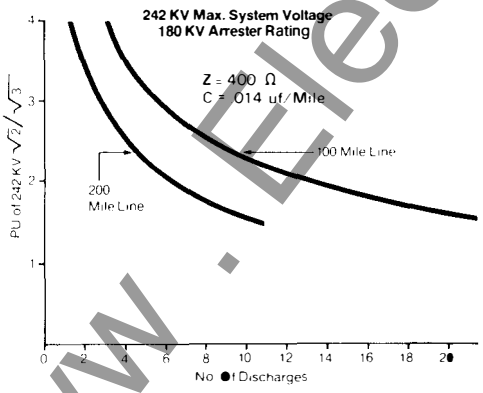

Figure B

This is calculated on the basis of total energy available 1/2 CE^2 where:

C = Capacitance in microfarads of a given length of line

E = Crest value of surge voltage = Crest maximum line to ground voltage × P.U.

Arrester Insulation Withstand Test Voltages

The assembled insulating members of the SMX arrester will withstand impulse and power-frequency voltages between line and ground terminals in accordance with the proposed standards and ANSI C62.1. See Table C.

Special Applications

Special applications may require more detailed system analysis for a proper arrester selection. Westinghouse ANACOM III power system studies features analog models of many power systems elements including arresters. By placing the analog circuit under the control of the digital computer, the ANACOM III can perform hundreds of simulations in a matter of minutes. For further information contact your Westinghouse representative.

Contamination

The type SMX arrester has easily passed the contamination test prescribed in the proposed standard. Because the SMX arrester has no gaps – series or parallel – it has an outstanding capability of withstanding the effects of very severe external contamination, wind driven rain and partial hot line washing. In highly contaminated environments when insulation flashovers may be a problem, extra creep type SMX arresters can be supplied.

Pressure Relief Capability

The type SMX arrester is designed to transfer the fault current arc to the outside of the arrester in the unlikely event that the arrester may be damaged or its thermal capability exceeded. Internal pressure buildup is safely vented to the outside provided that the arrester fault current is well within the pressure relief capability of the arrester given in Table D below. All designs were tested in compliance with the latest pressure relief standards for heavy duty arresters (IEEE 3.3.11, Draft 6).

Table C – Station Arresters

Voltage Rating of Arrester KV; rms	Impulse Test 1.2 × 50 Microsecond Full Wave KV Crest① (BIL)	Alternating-Current 60-Hz Test Voltage KV, Rms 1-Minute Dry	10-Second Wet
2.7	60	21	20
3	60	21	20
4.5	75	27	24
5.1	75	27	24
6	75	27	24
7.5	95	35	30
8.5	95	35	30
9	95	35	30
10	110	50	45
12	110	50	45
15	110	50	45
18	150	70	60
21	150	70	60
24	150	70	60
27	200	95	80
30	200	95	80
36	200	95	80
39	250	120	100
45	250	120	100
48	250	120	100
54	350	175	145
60	350	175	145
72	350	175	145
90	450	225	190
96	450	225	190
108	550	280	230
120	550	280	230
132	650	335	275
144	650	335	275
168	750	385	315
172	825	465	385
180	825	465	385
192	900	465	385
228	1050	545	445
240	1050	545	445
258	1175	625	520
264	1300	680	565
276	1300	680	565
288	1300	680	565
300	1300	680	565
312	1300	680	565
336	1550	810	675
360	1550	810	675
396	1980	1020	840
420	2100	1090	890
444	2220	1150	940
468	2350	1210	990
588	2600	1360	1130
612	2600	1360	1130

● The values given apply for either positive or negative waves.

Table D

SMX Arrester Rating	Pressure-Relief Rating KA (RMS SYM)
3 – 15①	65
18 – 48①	60
60 – 336	60
396 – 444	65
576 – 612	75

① Metal top designs only. Test values for arresters with porcelain tops have not been standardized. For porcelain top tests, contact your Westinghouse representative.

Further Information:
Price List 38-310
Descriptive Bulletin 38-311
Dimension Sheet 38-313

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