



# **COOPER** Power Systems

## **Surge Arresters**

**UltraSIL Housed VariSTAR  
5 kA and 10 kA Class1 60099-4  
for MV Systems to 36 kV**



## Features and Detailed Description

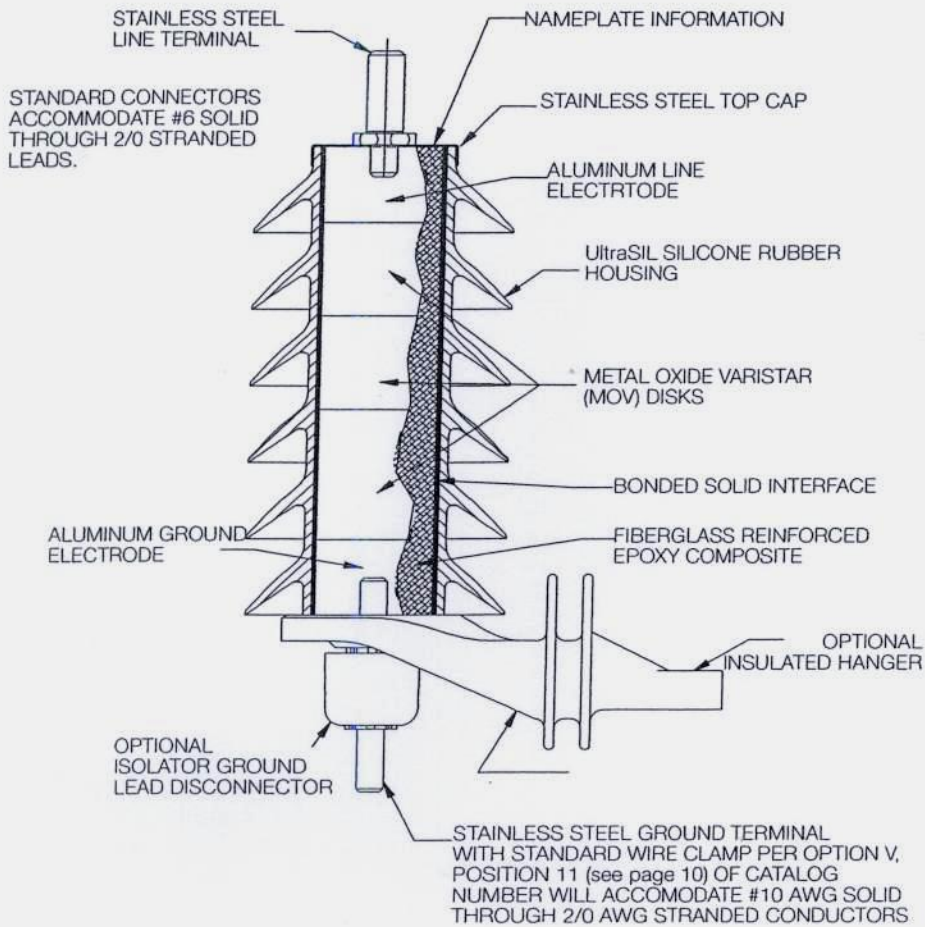


Figure 2.  
Cutaway illustration of an UltraSIL housed VariSTAR arrester.

### DESIGN TESTING

The housing material, internal components and hardware work as a system and stand up to years of exposure to environmental extremes. To assure a superior level of performance, the components and the assembled arrester units have been subjected to a testing program that accurately simulates years of exposure to field conditions. Tests include:

- IEC 60099-4 Testing – Full certification to performance requirements by an independent laboratory has been completed. A certified test report is available. Refer to Table 9.

Additional design verification of the UltraSIL housed arrester includes testing for:

- UV Withstand
- High Voltage Dielectric Integrity
- Wet Arc Tracking Resistance
- Thermal Shock
- Multi-stress Environmental Test and Cycling
- Coefficients of Expansion and Materials Compatibility
- Cantilever Strength
- Terminal and Disconnecter Torque

This is only a partial listing of the comprehensive design tests performed

on the UltraSIL arrester.

### ROUTINE TESTS

A complete automated production test program ensures a quality product. Each metal oxide varistor receives a series of electrical tests. Quality is further demonstrated by tests performed to destruction on samples from every lot of varistors.

Listed are the varistor tests performed in accordance with IEC 60099-4:

- Physical Inspection
- Discharge Voltage
- $V1\text{mA}/\text{cm}^2$
- Leakage Current at 80% of  $V1\text{mA}/\text{cm}^2$  Voltage
- High Current, Short Duration Withstand
- Thermal Stability
- Aging

Each fully assembled VariSTAR arrester must pass the following routine tests:

- Physical Inspection
- Reference Voltage Test  
UNS  $I_{\text{ref}} = 3\text{ mA}$   
UHS  $I_{\text{ref}} = 4\text{ mA}$
- Partial Discharge Test  
@  $1.05 \times U_C \leq 10\text{ pc}$

### GENERAL APPLICATION RECOMMENDATIONS

The rating of an arrester is the maximum power frequency line-to-ground voltage at which the arrester is designed to pass the IEC operating duty test. Table 1 provides a *general* application guide for the selection of the proper arrester rating for a given system voltage and system grounding configuration.

Gapless surge arresters must be selected with sufficient steady-state self impedance to withstand the application of line-to-earth power frequency voltages under all system conditions of operation.

### Continuous Voltage

A preliminary selection that is based on selecting an arrester having a "Continuous Operating Voltage", or  $U_C$ , that equals or exceeds the normal system *maximum* line-to-earth operating voltage is made. Reference IEC 60099-5.

### Power-Frequency Overvoltages

The second application criterion to be met is a condition established by the effectiveness of system grounding. During a single line-to-earth fault, under maximum system voltage conditions, the arrester selected should have a "Rating" ( $U_r$ ) that will not be exceeded by the voltages on the unfaulted phases at the point of arrester application. One must pay particular attention to systems having low coefficients of grounding, ungrounded systems and systems that are resonant grounded or that may become ungrounded under abnormal conditions of operation. This second voltage consideration may be modified for various system conditions as long as the application does not violate the selected arrester's "Temporary Overvoltage Capability (TOV)" (see Figure 3).

Temporary system conditions resulting in *sinusoidal power-frequency voltages* that exceed arrester "Continuous Operating Voltage, ( $U_c$ )" or even "Arrester Rating, ( $U_r$ )" can be allowed. Consider the permissible magnitude and duration of these overvoltages (including the full time of system back-up protection), with appropriate allowances for any recent arrester discharge energies.

The voltage withstand capability application on ungrounded systems is 1.035 per unit of COV ( $U_c$ ) for 24 hours. Systems which permit earth faults to remain undetected or operate with one phase earthed for periods in excess of 24 hours will require the use of an arrester having a  $U_c$  (continuous capability) equal to the system maximum phase-to-phase voltage.

Under some special system conditions, such as transformer energization using certain types of connections and ferroresonance, higher voltages can be experienced by the arrester. To ensure that the arrester's capabilities will not be exceeded, the resources of the Thomas A. Edison Technical Center and their systems application engineers are available to make recommendations.

Consult with your Cooper representative to have your individual system application needs studied.

TABLE 1  
Commonly Applied Voltage Ratings ( $U_r$ ) of VariSTAR Arresters

System Voltage (kV rms)		Arrester Rating — $U_r$ (kV rms)		
Nominal	Maximum	Four-Wire Star Multi-Grounded Neutral	Three-Wire Star Solidly Grounded Neutral at Source	Delta, Ungrounded, & Resonant Impedance Grounded Star
3.3	3.7	3	6	6
6.6	7.3	6	9	9
10.0	11.5	9	12	12-15
11.0	12.0	9-10	12	12-15
16.4	18.0	15	-	18-21
22.0	24.0	18-21	24	24-27
33.0	36.3	27-30	36	36-36

### PERFORMANCE TEST CHARACTERISTICS

UltraSIL housed VariSTAR arresters meet the following design tests as described by IEC 60099-4:

- Operating Duty Test:
  - UNS – twenty (20) current surges of 5 kA, 8/20  $\mu$ s waveshape followed by two (2) high current surges of 65 kA crest (4/10  $\mu$ s).
  - UHS – twenty (20) current surges of 10 kA, 8/20  $\mu$ s waveshape followed by two (2) high current surges of 100 kA crest (4/10  $\mu$ s).
- Long Duration Current Impulse Withstand Test:
  - UNS – eighteen (18) current surges of 75 A, 1000  $\mu$ s duration.
  - UHS – eighteen (18) current surges of the energy associated with the line parameters for IEC Class 1 performance (approximately 250 A, 2000  $\mu$ s).

Following each of these tests, the arresters remain thermally stable as verified by:

- Continually decreasing leakage current values during a thirty minute power monitoring period when energized at  $U_c$ .
- No evidence of physical or electrical deterioration.
- The IN (5 kA or 10 kA) discharge voltage measured after each test changed less than 5% from the initial values.

Full IEC 60099-4 certification has been completed and independently verified.

### PRESSURE RELIEF (FAULT CURRENT WITHSTAND TESTS)

These tests demonstrate the ability to withstand fault currents for specific durations.

All UltraSIL housed arresters have been tested in accordance with the requirements listed in IEC 60099-4 and are non-fragmenting to the levels shown in Table 2.

TABLE 2  
Pressure Relief Tests

Arrester Type	IEC Pressure Relief Class	Fault Current Amplitude (kA rms) Sym.	Minimum Fault Current Duration (Seconds)
UNS/UHS	B	0.8 20	0.5 0.2

**TEMPORARY  
OVERVOLTAGE (TOV)  
CAPABILITY  
(POWER FREQUENCY  
WITHSTAND VOLTAGE  
VERSUS TIME  
CHARACTERISTIC)**

The ability to withstand system power frequency overvoltage conditions is shown in Figure 3. The graph shows for a given voltage magnitude (on a per unit of  $U_C$  basis), the time an arrester can survive a temporary power frequency overvoltage condition and recover without thermal runaway.

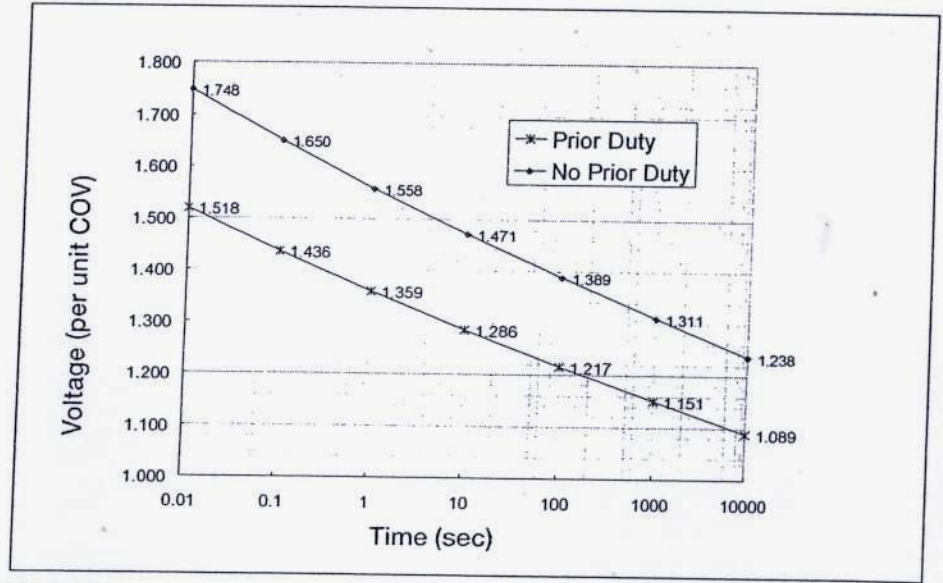


Figure 3. Temporary Overvoltage Capability (followed by  $U_C$ ), 60° C ambient, UNS and UHS. The 24 hour TOV without prior duty is 1.173 per unit of  $U_C$ . The 24 hour TOV with prior duty is 1.035 per unit of  $U_C$ .

**PROTECTIVE  
CHARACTERISTICS**

UltraSIL arresters provide excellent overvoltage protection for electrical equipment throughout the MV distribution system.

The protective characteristics of the UltraSIL housed arrester family are shown in Tables 3 and 4.

TABLE 3  
Protective Characteristics - VariSTAR UNS,  $I_N = 5$  kA IEC 60099-4

$U_r$ Arrester Rating (kV rms)	$U_C$ COV (kV rms)	Steep Current Residual Voltage (kV Crest)	Lightning Impulse Residual Voltage (kV Crest) 8/20 $\mu$ s Current Wave					
			1.5 kA	3 kA	5 kA	10 kA	20 kA	40 kA
3	2.55	10.9	9.0	9.7	10.4	11.4	13.0	15.1
6	5.1	21.8	17.9	19.4	20.8	22.7	26.0	30.2
9	7.65	31.4	25.8	28.0	30.0	32.8	37.4	43.5
10	8.4	32.7	26.9	29.1	31.2	34.1	38.9	45.3
12	10.2	41.1	33.8	36.5	39.2	42.9	48.9	56.9
15	12.7	51.3	42.2	45.7	49.0	53.6	61.1	71.1
18	15.3	61.6	50.6	54.8	58.8	64.3	73.4	85.3
21	17.0	65.4	53.7	58.2	62.4	68.2	77.9	90.6
24	19.5	76.3	62.7	67.8	72.8	79.6	90.8	106.0
27	22.0	86.3	71.0	76.8	82.4	90.1	103.0	120.0
30	24.4	96.2	79.1	85.6	91.8	100.0	115.0	133.0
33	27.0	107.0	87.8	95.6	102.0	112.0	127.0	148.0
36	29.0	115.0	94.7	103.0	110.0	120.0	137.0	160.0

**TABLE 4**  
Protective Characteristics – VariSTAR UHS, I<sub>N</sub> = 10 kA, Class 1 IEC 60099-4

UltraSil HD Star		1/2 Wave		8/20 Wave Forms					30/60 Switching Surge	
Rating	MCOV	(kV, peak) 10 kA	(kV, peak) 1.5 kA	(kV, peak) 3 kA	(kV, peak) 5 kA	(kV, peak) 10 kA	(kV, peak) 20 kA	(kV, peak) 40 kA	(kV, peak) 125 A	(kV, peak) 500 A
3	2.55	10.8	8.2	8.7	9.1	9.9	10.9	12.3	7.1	7.6
6	5.1	21.5	16.3	17.4	18.2	19.8	21.9	24.7	14.1	15.1
9	7.65	32.4	24.6	26.1	27.3	29.8	33.0	37.1	21.3	22.7
10	8.4	34.4	26.0	27.7	29.0	31.6	34.9	39.4	22.6	24.1
12	10.2	43.2	32.7	34.8	36.4	39.7	43.9	49.5	28.3	30.3
15	12.7	52.2	39.6	42.1	44.0	48.0	53.1	59.8	34.3	36.6
18	15.3	64.8	49.1	52.3	54.7	59.6	65.9	74.2	42.6	45.5
21	17	68.8	52.1	55.4	58.0	63.2	69.9	78.7	45.1	48.2
24	19.5	79.5	60.2	64.1	67.0	73.1	80.8	91.1	52.2	55.8
27	22	92.4	70.0	74.5	77.9	84.9	93.9	106	60.6	64.8
30	24.4	100.5	76.1	81.0	84.7	92.4	102	115	66.0	70.5
33	27	114.2	86.5	92.1	96.3	105	116	131	75.0	80.1
36	29	120.8	91.5	97.3	102	111	123	138	79.3	84.7

**INSULATION WITHSTAND CHARACTERISTICS**

**TABLE 5**  
Housing Insulation Withstand Voltages, U<sub>r</sub> 3-36 kV, UNS and UHS, I<sub>N</sub> = 5 & 10 kA Class 1

Arrester Housing Designation (Digits 6 & 7)	Leakage Distance (mm)	Strike (mm)	105 mm			127 mm			105 mm			127 mm			127 mm		
			1.2/50µs Impulse (kV Crest)	1 min. Dry (kV rms)	1 min. Wet (kV rms)	1.2/50µs Impulse (kV Crest)	1 min. Dry (kV rms)	1 min. Wet (kV rms)	1.2/50µs Impulse (kV Crest)	1 min. Dry (kV rms)	1 min. Wet (kV rms)	1.2/50µs Impulse (kV Crest)	1 min. Dry (kV rms)	1 min. Wet (kV rms)	1.2/50µs Impulse (kV Crest)	1 min. Dry (kV rms)	1 min. Wet (kV rms)
03	183	79	78	47	23	92	50	36	70	44	22	85	53	29	70	42	23
04	256	106	91	56	34	105	55	38	79	52	33	99	56	37	82	51	33
05	330	133	104	64	43	117	63	51	89	55	42	109	60	49	90	62	45
06	404	159	117	78	55	126	86	57	93	61	48	119	80	58	97	72	55
07	477	186	129	87	66	137	96	68	98	62	51	122	81	60	107	81	66
08	551	213	140	96	77	148	106	79	104	65	55	126	82	65	118	89	78
09	625	239	-	-	-	159	116	90	-	-	-	130	83	70	129	98	89
10	698	266	-	-	-	171	126	100	-	-	-	136	86	75	140	106	99
11	772	293	-	-	-	183	135	111	-	-	-	142	90	80	152	114	109
12	846	320	-	-	-	195	144	121	-	-	-	149	94	86	164	122	119
13	919	346	-	-	-	207	153	131	-	-	-	158	99	92	177	130	128
14	993	373	-	-	-	220	161	140	-	-	-	167	105	98	190	138	137
15	1067	400	-	-	-	233	170	150	-	-	-	177	112	105	204	146	146
16	1140	426	-	-	-	246	178	159	-	-	-	187	120	112	218	154	154
17	1214	453	-	-	-	259	185	168	-	-	-	199	128	120	233	161	162
18	1288	480	-	-	-	-	-	-	-	-	-	-	-	-	248	169	169
19	1361	506	-	-	-	-	-	-	-	-	-	-	-	-	264	178	176
20	1435	533	-	-	-	-	-	-	-	-	-	-	-	-	280	184	183
21	1509	560	-	-	-	-	-	-	-	-	-	-	-	-	296	191	189