840 KV 176.4KJ IMPULSE CURRENT GENERATOR L.I.P.L. TEST AT 20KA ON 156KV UNIT OR 208 KV UNIT FOR 800KV SYSTEM

DEVELOPMENT OF POLYMER SURGE ARRESTERS FROM 11 kV TO 1200kV COVERING MV, HV,EHV & UHV

INTRODUCTION

1. Electrical power system is exposed to different over voltages due to lightning or switching surges endangering the equipment insulation.
2. Lightning strokes into the electric power system or its vicinity lead to lightning over voltages lasting for micro seconds.
3. Switching action in the system causes switching over voltages lasting for milli seconds. Switching over voltages increase with increase in the operating voltage of the system.
4. Operating conditions due to load rejection cause temporary over voltages lasting for several seconds.
5. The insulation of the equipment is not capable of withstanding lighting and switching over voltages.

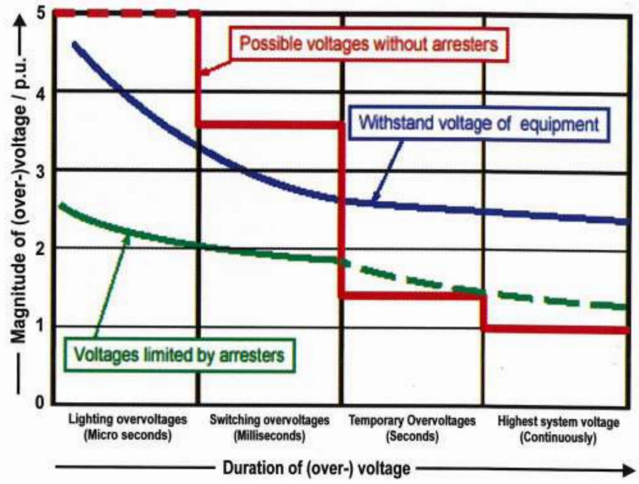
PROTECTION:

To protect electrical power system equipment from lightning and switching over voltages, surge arresters are used as a tool for insulation coordination.

Upto approximately 132kV, the system insulation has to be designed to withstand primarily lightning surges.
Above 132kV both lightning and switching surges have to be considered. For EHV and UHV systems switching over voltages in combination with insulator contamination becomes the predominating factor in the insulation design.

With the increasing system voltage, switching over voltage becomes more and more dimensioning factor for high voltage equipment.

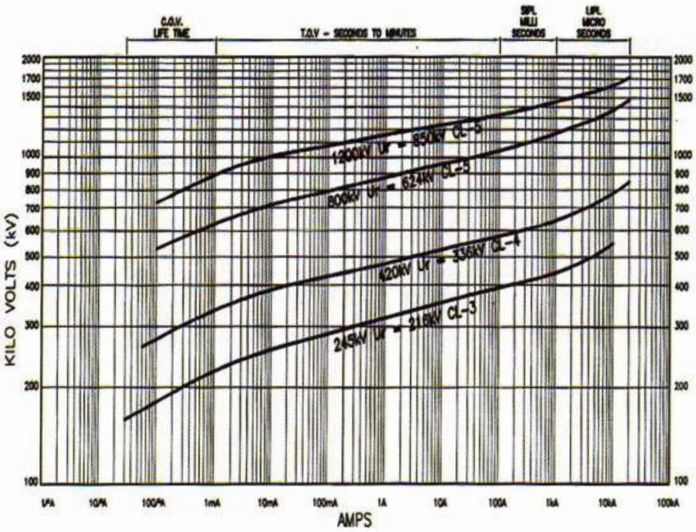
The lightning and switching impulse withstand voltage of the equipment to be protected and the lightning and switching protective levels of the arrester to be taken into account and safety margin is to be coordinated.



INSULATION COORDINATION

- Over voltages in electric power system compared to the insulation level of equipment
- Red line - voltages without arrester. Blue line - equipment withstand voltage. Green line - voltage limited by arrester.
- The purpose of using a surge arrester is to always limit the voltage across the terminals of the equipment to be protected below its insulation withstand voltage.
- This is achieved by connecting the surge arresters in parallel to the terminals of the equipment to ground.

As a thumb rule an arrester with a lightning impulse protective level equal to 60% to 70% of standard lighting impulse withstand voltage of the equipment to be protected results in comfortable 30% to 40% safety margin and will act as an extremely reliable and economical device to protect substation equipment and in particular the power transformers.



PERFORMANCE OF SURGE ARRESTERS BASED ON V-I CURVES OF DIFFERENT RATINGS OF ARRESTERS.

TECHNOLOGICAL DEVELOPMENTS IN SURGE ARRESTERS:

The first technical broucher about surge Arresters was published during 1981 describing effects on gapless metal oxide surge Arresters from various electrical stresses encountered in ac network.

Since then improvements were going on and cigre working group A3.17 took over on the task to evaluate the stresses on MO arresters and reviewed the then existing test procedures. A research project was started to investigate the energy handling capability of the M.O varistors under different impulse stresses. The energy handling capability is to be divided into thermal energy and impulse energy handling capabilities.

The latest IEC 60099-4 of 2014 itself envisages developments in arrester field by introducing changes in certain tests and deleting few tests.

The two important tests introduced are repetitive charge transfer rating Q_{rs} and thermal energy withstand capability W_{th} verified in duty cycle testing.

SURGE ARRESTER REQUIREMENTS

Performance of a Zinc Oxide Surge Arrester is defined by

a) Protective levels

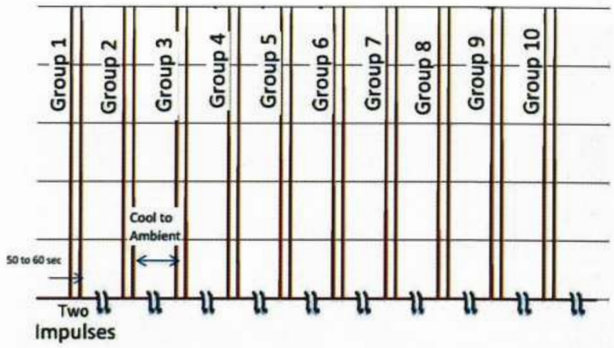
b)Its temporary over voltage withstand capabilities

c) Impulse Energy Q_{rs} and thermal energy W_{th} withstand capabilities

d) Long term stability of the Zinc Oxide blocks.

Q_{rs} **Repetitive charge transfer** rating which is a product of current and time defined in coulombs is the impulse current stress to be withstood by the MO varistors.

Q_{rs} TESTING:



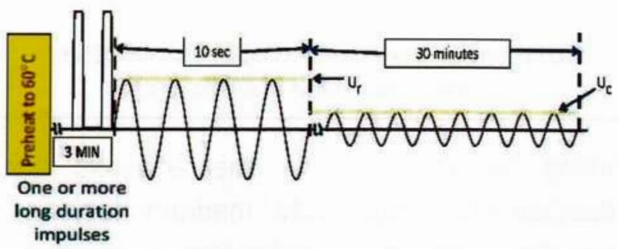
10 samples to be tested in 10 groups.2 impulses to each sample 50-60 seconds between impulses cool samples to ambient between groups.

TESTING FOR REPETITIVE CHARGE TRANSFER RATING Q_{rs} DEFINED in coulombs

CLAIMABLE Q_{rs} VALUES

- From 0.1C to 1.2C in steps of 0.1C
- From 1.2C to 4.4C in steps of 0.4C
- From 4.4C to 10.0C in steps of 0.8C
- From 10C to 20C in steps of 2C
- From 20C upwards in steps of 4C

W_{th}**-Thermal energy rating** verified by OD test on 3 samples. Cumulative thermal energy W_{th} in kJ/kV injected in 3 minutes by one or more long duration impulses without causing thermal run away.



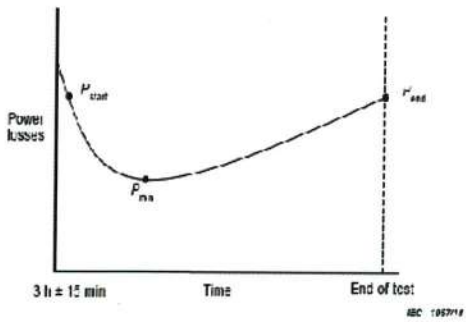
EDITION 3.0-OPEARTING DUTY TEST –W_{th} INJECTION

CLAIMABLE W_{TH} VALUES

1 to 5 kJ/KV in Steps of 0.5 KJ/KV
5 to 16kJ/kV in Steps of 1 kJ/kV
16 to 30 kJ/kV in Steps of 2 kJ/kV
30 and up kJ/kV in steps of 6 kJ/kV

TESTING FOR THERMAL ENERGY RATING W_{th} in kJ/kV

LONG TERM STABILITY TEST (Accelerated ageing test) at 115^{0}C AC or DC upto 6kV



P_{end} to P_{start} – Not more than 1.1
P_{min} to P_{start} – Not more than 1.3

ILLUSTRATION OF POWER LOSSES VERSUS TIME DURING LONG TERM STABILITY TEST

Taking the Q_{rs} and W_{th} the arresters are classified under high duty, medium duty and Low duty and the classification is as given below.

	ARRESTER CLASS	STATION			DISTRIBUTION		
Edition 3.0	Designation	SH	SM	SL	DH	DM	DL
	I_n-NDC in kA	20	10	10	10	5	2.5
	Switching surge impulse discharge current in kA	2	1	0.5	--	--	--
	Q_{rs} (C)	≥2.4	≥ 1.6	≥ 1.0	≥ 0.4	≥ 0.2	≥0.1
	W_{th}(kJ/kV of U_r)	≥ 10	≥ 7	≥ 4	--	--	--
	Q_{th} (C)	--	--	--	≥ 1.1	≥ 0.7	≥ 0.45

Sub-classifications – within each class there are designations relating to the duty that the arrester will experience as noted below.

SH= Station **High** DH=Distribution **High**
SM=Station **Medium** DM = Distribution **Medium**
SL=Station **Low** DL = Distribution **Low**

The arrester Q_{rs} (charge in coloumbs) and W_{th} (energy in kJ/kV) should satisfy minimum guaranteed values and can be higher than the minimum prescribed which can be used for quality comparison.

First selection is between high, medium and low duties. Second selection can be Q_{rs} (c) and W_{th} (kJ/KV) above the minimum level . Other tests like heat dissipation behavior of thermally prorated section, test on dielectrically prorated section, accelerated ageing test and insulation withstand tests have been pruned to simulate the present improved quality of surge arresters being claimed across the globe.

First generation varistors were unstable. Their leakage current was increasing with time and caused increase of temperature and decrease of energy absorption capability. Present day varistors leakage current decreases with time and so needs a change in testing procedure.

Comparison of the classification system according to IEC 60099-4:2009 (Edition.2.2) and to IEC 60099-4: 2014 (Edition.3.0)

Old LDC	Corresponding new thermal energy rating as per 8.7.3 W_{th}kJ/kV	Corresponding new repetitive charge transfer rating as per 8.5.4 Q_{rs} C
1	2	0.5
2	4	1
3	7	1.6
4	10	2.4
5	14	3.6

High Current Generator, 48.6 kJ
Pre conditioning at 100kA before OD Test

Partial discharge test on 168kV
Arrester with 300kV Test Transformer

L.I.P.L Test at 20kA on 168kV surge Arrester
176kJ, 840kV IMPULSE GENERATOR

PARADIGM SHIFT FROM PORCELAIN TO POLYMER ARRESTERS: After introduction of Fibre Reinforced Plastic (FRP) and silicone Rubber as insulation material for high voltage equipment, new arrester design concepts using these materials are established as an alternative to the traditional porcelain arresters.

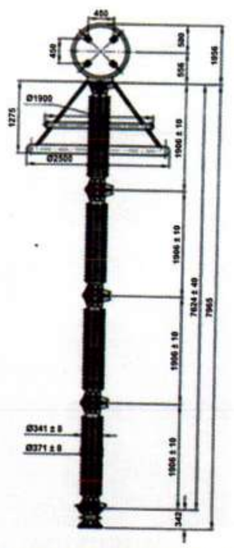
The change to polymer Arresters has been carried consistently and finally the surge Arrester designs as per IEC 60099-4 of 2014 Ed.3.0 available are:

- TUBE design A -polymer Arresters for EHV 400kV and UHV 750kV ratings.
- CAGE design B polymer Arresters for H.V 66kV to 220kV
- WRAP design B polymer Arresters for M.V 30kV and below.

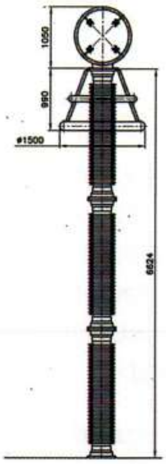
VARIOUS RATINGS OF POLYMER ARRESTERS:

TUBE DESIGN-DIMENSIONAL DETAILS

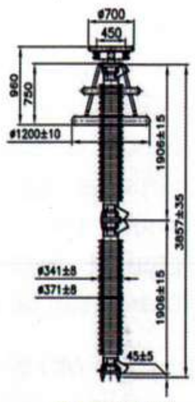
850kV ARRESTER



624kV SA (4 UNITS)

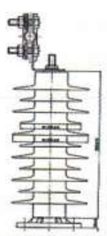


624kV SA(3 UNITS)



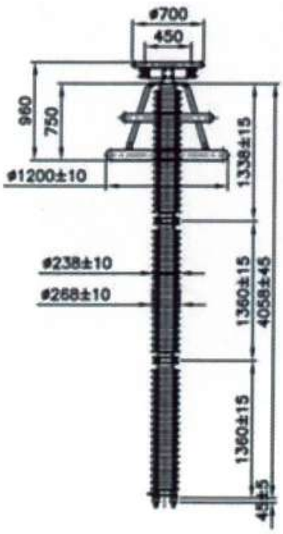
336kV SA

WRAP DESIGN

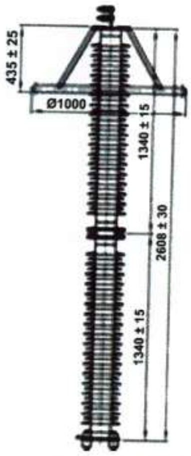


36kV SA

CAGE DESIGN- DIMENSSIONAL DETAILS



336kV ARRESTER



216kV ARRESTER

120kV ARRESTER

60kV ARRESTER

PORCELAIN ARRESTERS Vs POLYMER ARRESTERS:

If the pressure relief rating of porcelain arrester is exceeded, it may explode violently, expelling porcelain and internal components potentially damaging the equipment and injuring personnel in the substation. When porcelain arrester vents, the housing becomes weak. The claimed pressure relief capability of porcelain housed arrester is only for the first venting. The venting of a shorted arrester results in a circuit breaker operation. Most utilities will automatically reclose at least once into a fault. This could cause the porcelain arresters definitely to explode. The failed polymer housed surge arrester can be reclosed number of times without shattering.

Porcelain surface has hydrophilic properties and the silicon polymer has hydrophobic property. In high pollution condition, polymer Insulation electric strength is greater than in porcelain insulator.

For ultra high voltage arresters the tube design is adopted for the mechanical consideration to meet total height of 8 M per arrester column. Primarily the number of units per column of arrester are to be reduced for proper distribution of voltage across units. With the reduction of units per arrester column along with proper design of grading ring which takes into account the overall diameter, height and size of grading rings used the near uniform voltage distribution can be achieved.

In the tube design the same MO blocks are used as in porcelain housing giving excellent electrical characteristics. In the case of UHV arresters to meet the mechanical consideration silicone composite housing with increased diameter and thickness of the FRP tube is to be coordinated.

COMPOSITE TUBE DESIGN: The FRP tube is the structural part in a hollow composite insulator. The tube material consists of Boron free ECR grade fiberglass rowing embedded in epoxy to give good electrical insulation and mechanical properties. The volume fraction of fibre with fibre architecture influences the properties of the FRP tube. The wall thickness of the FRP tube is based upon axial stress and cantilever strain.

The silicone polymer is injection moulded onto the tube in a single shot and the end flanges are fixed with pressure relief device and directional venting system. The tube design gives the best choice to reduce the number of units to 4 for 624kV arresters for 800kV system to minimize the variations in distribution of voltage across units of arrester

INJECTION MOULDING IN PROGRESS

EJECTION OF PRODUCT AFTER INJECTION MOULDING

INJECTIOIN MOULDING OF HOLLOW CORE INSULATOR AND CAGE DESIGN OF ARRESTER

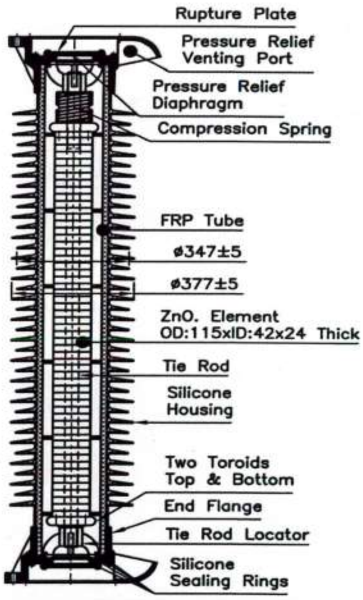
MAIN FEATURES OF OBLUM TUBE DESIGN:

1) Safest short circuit performance with no failure and no ejection of internal components. Disadvantage of shattering of porcelain during short circuit is avoided.
2) Available in two units (in series each of 168kV for 336kV rating) for 420kV system and 4 units in series each of 156kV or 208KV for 624kV for 800kV system and 4 units of each of 212.5kV for 850kV rating and 4 Nos. of 850kV units in parallel for 1200kV system.
3) Longest arresters with highest rated voltage can be made to reduce number of units per column of arrester for uniform distribution of voltage
4) Mechanical strength can be improved with increase of wall thickness of composite hollow core insulator used in the tube design.
5) Internal radial discharges can be avoided by increasing gap between disc and tube.
6) Best choice to reduce number of units to 3 for 624kV rating for 800kV system and 2 units for 400kV system to minimize the variations in distribution of voltage across units.
7) Excellent track and erosion resistance with high resistance to Ozone and Corona and insensitive to UV Radiation with self extinguishing flame retardancy.

FRP TUBE

Hollow core Insulator after moulding

Internal Assembly SH 156kV Q_{rs}:5.2C (Ed3)cl-V (Ed 2.2)

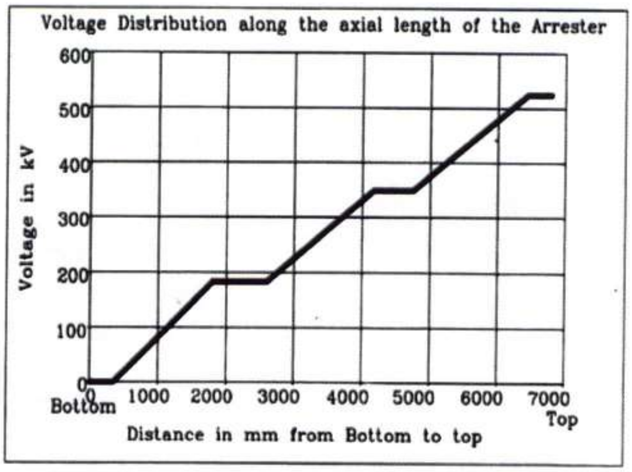


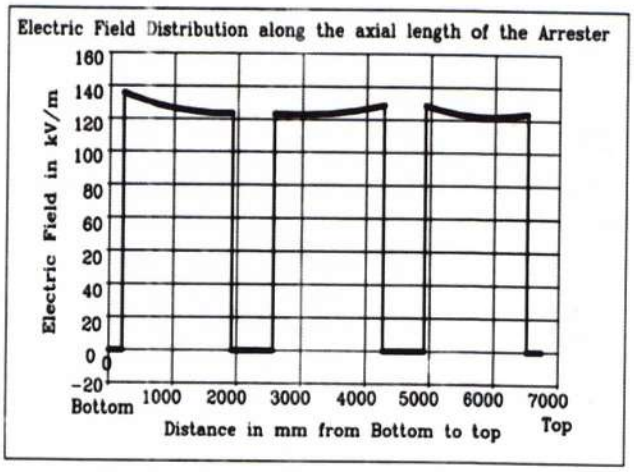
ASSEMBLY OF ARRESTER (DESIGN A)

TUBE CONSTRUCTION

VOLTAGE DISTRIBUTION –GRADING RING OPTIMIZATION OR CAPACITANCE GRADING:

The voltage distribution along the block column depends on the capacitance of the Zinc Oxide blocks and the influence of stray capacitances. As the height of Arrester increases the self capacitance of the arrester decreases and the leakage capacitance increases. It has been observed that the self capacitance of Arrester for 800kV being 30pF the stray capacitance is around 120 pF. For taller arresters the influence of stray capacitance makes the voltage distribution less linear. The grading ring is suitably designed to make the voltage distribution near uniform across units of arrester.





Grading ring Optimization carried for 624kV Surge Arrester

TESTS CONDUCTED ON TUBE DESIGN:

BEFORE TEST **AFTER TEST**

SHORT CIRCUIT TEST UPTO 65kA

SEISMIC TEST ON 624kV 20kA class-V POLYMER SURGE ARRESTERS

BENDING MOMENT TEST ON 156kV TUBE DESIGN S.A.

CAGE DESIGN CONSTRUCTION & CONFIGURATION

Zinc Oxide blocks of each unit of Arrester with spacers are assembled in a cage of 8 Boron free ECR grade FRP Rods to form open cage design in between end terminals under axial pre compression. The pre compressed unit stack is crimped on the end terminals and on the spacers at high crimping force to hold the cage for a tensile force of 8T (minimum), the cage construction is injection moulded covering all the internal parts including the end terminals in a single shot using HTV silicone rubber of wacker. Thus the module is sealed throughout the length from top terminal to bottom terminal and from outside till the surface of the blocks, making the arrester of fully moulded voidless construction leaving no way for the diffusion of moisture and no condensation on the internal parts in any form that is detrimental to the arrester performance

In the case of fully moulded cage construction having no voids there is no separate sealing system and no separate pressure release arrangement and no part of the internal components are exposed.

In case of an over load or short circuit the arc escapes directly through the silicone polymer housing and so no possibility of any internal parts being ejected and damaging other equipment. The silicone rubber should have high track, erosion and UV radiation resistance guaranteeing long term stability of the housing material.

MAIN FEATURES OF OBLUM CAGE DESIGN:

1. Fully moulded construction of all internal and external components and so no way for moisture ingress.
2. No partial discharges as the construction is voidless.
3. Non-explosive failure mode as silicone rubber provides low pressure escape of the arc during a short circuit.
4. Excellent resistance to ageing under climatic and electrical stress.
5. Excellent track and erosion resistance with high resistance to Ozone and Corona and insensitive to UV Radiation with self extinguishing flame retardancy.
6. Good pollution performance due to hydrophobic nature with excellent dielectric strength.
7. Exceptional tolerance to seismic disturbance.
8. Low weight and resistant to transport damages, and careless handling.

THE FOLLOWING ARE THE SIGNIFICANT ADVANTAGES:

1. Short circuit arc is commuted to outside by burning, cracking and tearing of silicone rubber and so ZERO short circuit failures of violent nature.

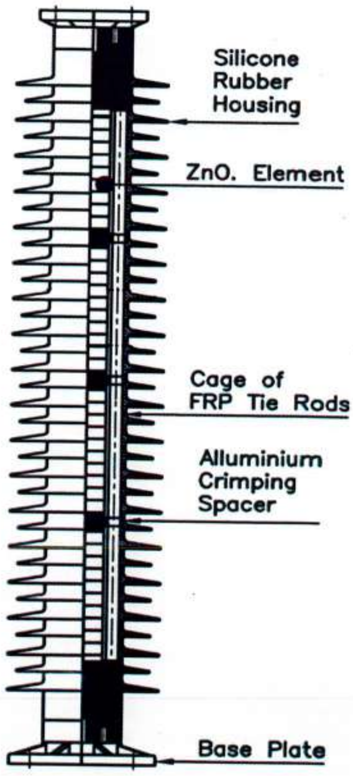
2. As it is fully moulded construction without any voids the question of moisture entry does not arise and not possible.

3. Radial discharges due to pollution and tracking of collar of MO resistors and eventual short circuit failure of the arrester totally is avoided.

4. As the silicone rubber is moulded on the MO Resistoirs, heat dissipation is rapid (Due to temporary over voltage and energy discharges due to switching surges).

120kV CAGE CONSTRUCTION

FULLY MOULDED ARRESTER IN CAGE DESIGN (120kV)



CROSS SECTION OF FULLY MOULDED ARRESTER (120kV)

CAGE CONSTRUCTION

DIFFERENT CONFIGURATIONS IN CAGE DESIGN

360kV ARRESTER

216kV ARRESTER

120kV ARRESTER

60kV ARRESTER

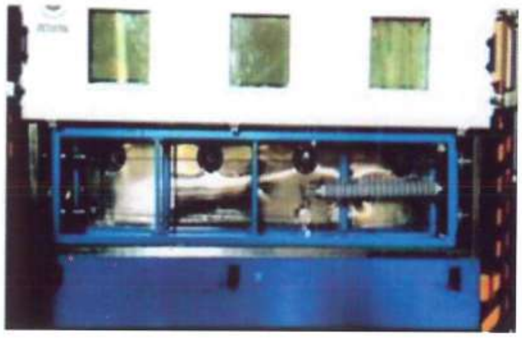
TESTS CONDUCTED –CAGE DESIGN

BEFORE TEST

Photograph No. 202: Condition of the sample after test

AFTER TEST

SHORT CIRCUIT TEST UPTO 65KA



BENDING MOMENT TEST ON 120kV CAGE SA

SEISMIC TEST ON 360kV CAGE ARRESTERS

WRAP DESIGN

Stack fully wrapped with rhombic openings

Moulded Arrester

1. Metal Oxide varistor blocks are wrapped helically with boron free ECR grade banding ribbon
2. The crosswise helical winding is such, as to create rhombic “windows”
3. The MOV stack is moulded with silicone polymer to cover total length including the end terminals

BEFORE TEST AFTER TEST

SHORT CIRCUIT TEST

POLYMER ARRESTER –POLYMER FOR OUTDOOR USE

Stability under exposure to discharges and arcing, differentiates outdoor insulation from indoor insulation. Corona discharges and dry band arcing occur when the surface of an energized insulator is covered by an electrolytic film, formed by the presence of moisture and contamination. The intense localized energy of the dry band arcs can cause material degradation in the form of tracking and /or erosion. In addition, environmental factors such as ultra violet (UV) from sunlight, moisture, temperature etc., can contribute to the degradation of the polymer which could lead to premature failure.

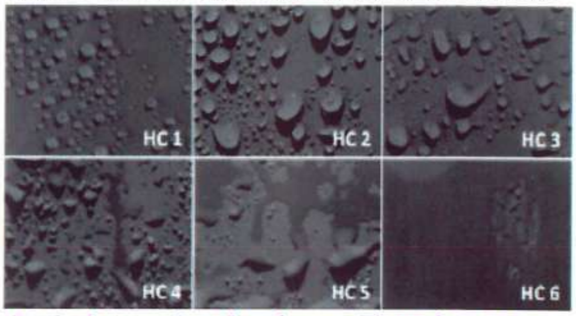
HYDROPHOBICITY OF SILICONE POLYMER:

Detailed studies have shown that the surface of silicone Polymer is relatively dynamic in comparison to porcelain and glass. Polymer molecules have much greater freedom for rearrangement in the bulk or at the surface. The hydrophobicity or water repellency of the surface of polymers plays an important role in the electrical performance of polymeric Arresters.

SERVICE RELIABILITY: silicone polymer of wacker being used in arresters with the addition of fillers in compounding, provide the proper balance of tracking, ageing, hydrophobicity, tear strength, flexibility, UV resistance, bonding characteristics, and other properties to withstand decades of service to meet mechanical, environmental, ageing and electrical withstand levels.

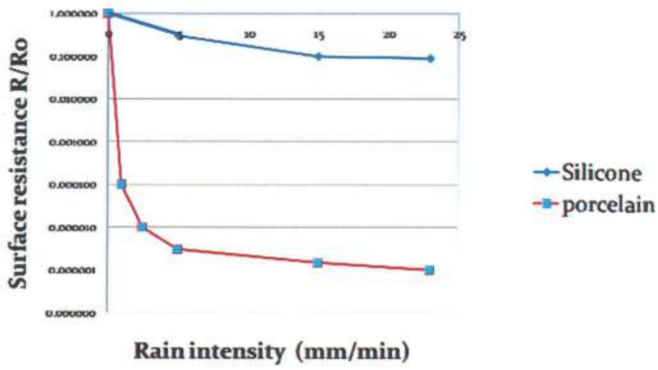
Destruction and Recovery of hydrophobicity :

Corona discharges and dry band arcing occur when the surface of an energized insulator is covered by an electrolytic film, formed by the presence of moisture and contamination increasing in the leakage current thus increasing the temperature causing reduction in hydrophobicity. The silicone polymer of low molecular weight have the tendency to reach the surface and the hydrophobicity is recovered.



Typical examples of surfaces with HC from 1 to 6

HYDROPHOBICITY OF SILICONE RUBBER



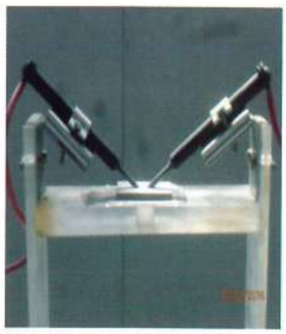
SURFACE RESISTANCE –PORCELAIN & POLYMER

Creepage level of 31mm/kV is not required in the case of polymer surge Arresters

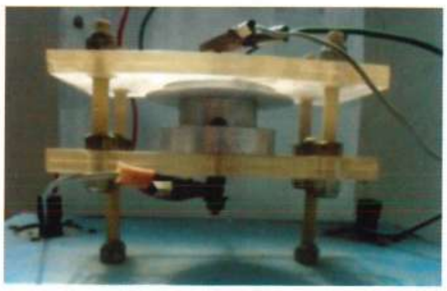
The tests on Silicone Rubber include:

1. 4.5kV tracking resistance test.
2. Dry arc resistance test.
3. Volume and surface resistivity test.
4. Flammability test.
5. UV test by Xenon Arc Lamp.

TRACKING RESISTANCE TEST



DRY ARC RESISTANCE TEST



SURFACE RESISTIVITY TESTING

PERFORMANCE UNDER POLLUTION CONDITIONS

1. Problems due to pollution was the reason to change over to Polymer housed Arresters.

2. The hydrophobic surface of Polymeric housing reduces considerably the problem of pollution.

3. The figure illustrates three possible mechanisms which can effect a multi unit MO HV Arrester operating in polluted environment.

a. External flash over of the housing if the environmental conditions are too severe.

b. The surface current along one unit of high external conductivity commuting to the MO column of next unit heating the MO resistors of this unit.

c. Internal partial discharges are initiated by radial electric field stress due to different voltage distributions along the internal MO column and the outer surface of the housing.

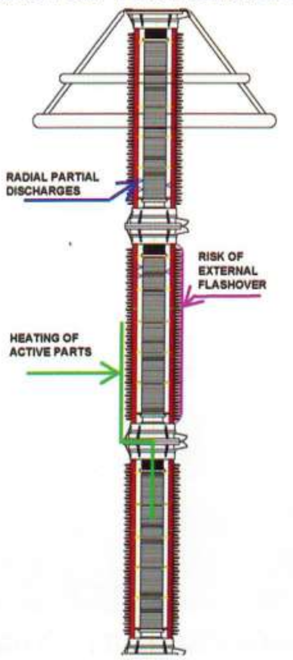
d. The best way to avoid partial heating of individual units is to apply single unit Arresters wherever possible or to reduce No. of units per column.

e.The external distribution shows statistical behavior in case of surface conductivity due to pollution.

f. In Type 'A' design the radial voltage stress appears across the gap between MO resistors and the housing due to geometry and the dielectric constants of different materials.

g. To reduce the effect of radial discharges it is necessary to have sufficiently large gap between MO column to housing. The salt fog tests have shown that a minimum gap of 30mm to 40mm is necessary depending on the rating to effectively avoid any internal partial discharges.

PERFORMANCE UNDER POLLUTION CONDICTIONS FOR TUBE DESIGN:



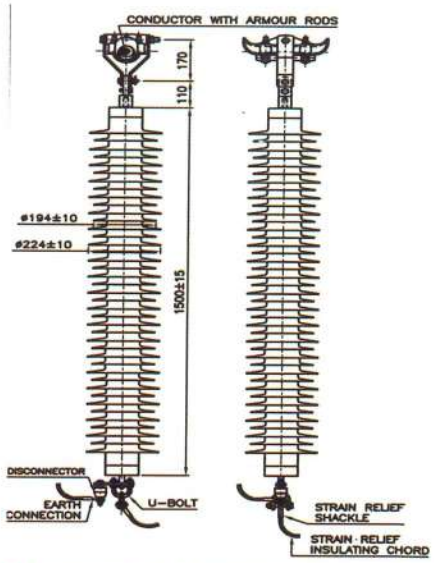
TUBE Design A: Radial partial discharges can be avoided by increasing the gap between MO column to housing. Gap of 30mm to 40mm or more is required depending on the rating of Arrester.

CAGE design B: Being fully moulded construction no gap or void and so no radial partial discharges.

TRANSMISSION LINE ARRESTERS:

Overhead transmission lines are the most vulnerable for lightning strokes. More than 50% of electrical faults of overhead lines are known to be caused by lightning induced voltages reaching the tower and causing the line insulator to flash over, resulting in an interruption.

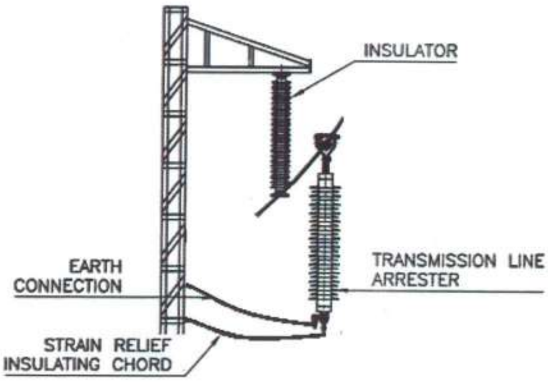
Back flash over occurs during the lightning discharge current, flowing through the tower and due to tower footing impedance producing potential differences across the line insulator. Back flash over is most prevalent when tower footing impedance is high. Installation of ZnO arresters across the line insulators (at frequent intervals) would minimize/eliminate the possibilities of insulation flashover.



TRANSMISSION LINE ARRESTER (NGLA) FOR 132kV SYSTEM SUSPENDED FROM THE CONDCUTOR WITH ARMOUR RODS

Transmission line arresters are designed with or without series gap. From the reliability view point, non gapped configuration with disconnecting device is preferred.

Besides, usage of the transmission line arresters allows to reduce the insulation level (BIL) of the substation equipments, e.g. power transformers, as the lightning surges are suppressed in the line itself by the line arresters. Hence, the no. of surges experienced by the substation arresters would be reduced and hence the reliability of the entire system would be enhanced.



CONNECTION TO SUSPENSION INSULATOR

THE ADVANTAGES OF TRANSMISSION LINE ARRESTERS (TLA)

1) Line compaction: Allows for maximum reduction in width and height of transmission lines by elimination of Shield wires.
2) Line uprating: Increased phase conductor clearances required for voltage can be obtained without major structure modifications by elimination of Shield wires.
3) Provides improved reliability.
4) Low installed cost.
5) Improved outage performance of existing shielded and unshielded lines which is accomplished by greatly reducing the frequency of line insulation flashovers due to shielding failure and back flashover.
6) TLA can improve the performance of lines with high grounding resistance which is often the main cause of Back flash on line protected with Shield wires.
7) The TLA is especially beneficial for very tall structures with long spans like river crossings and other terrain which make Shield Wires impractical or impossible.

ARRESTER SUSPENDED FROM TRANSMISSION LINE:

Non gapped line arresters are suitable for all system voltages and for protection against both lightning and or switching related phenomena.

The selection of NGLA for line protection differs only slightly from typical arrester selections. The most significant difference is the use of disconnectors for NGLA.

NGLA for transmission lines, sometimes named TLA, are in most cases directly suspended from the line conductor parallel to the transmission line insulator. As over head line insulation is generally self-restoring, failed TLA must facilitate fast reclosing. This can be done by isolating the line arresters from the line in the event of overloading by the use of a disconnector for NGLA.The ground lead from disconnector is connected to the tower steel structure. For NGLA, utilization of appropriate Disconnector is essential.

PROTECTIVE DISTANCE:

- A detailed system study is required to determine how far a surge Arrester can be located away from the equipment and still provide adequate protection.
- In the absence of system studies, approximate calculations for evaluation of the increase in surge Arrester protective level due to separation is evaluated by thumb rule.

$$U = U_a + (2 x S x L)/v$$ where

U_a= Arrester residual voltage

S= Steepness of incoming surge

L= Distance between arrester and protected object

v= Velocity of incoming surge

U = Voltage at protected object

L=a+b where a= separation distance and

b=b1+b2 =lead length

ENERGY CALCULATION AS PER IEC 60099-5:

$$W = U_{ps} X \frac{U_{rp} - U_{ps}}{Z_s} x 2 x \frac{L}{C}$$

Where

W is the Energy, L is the line Length

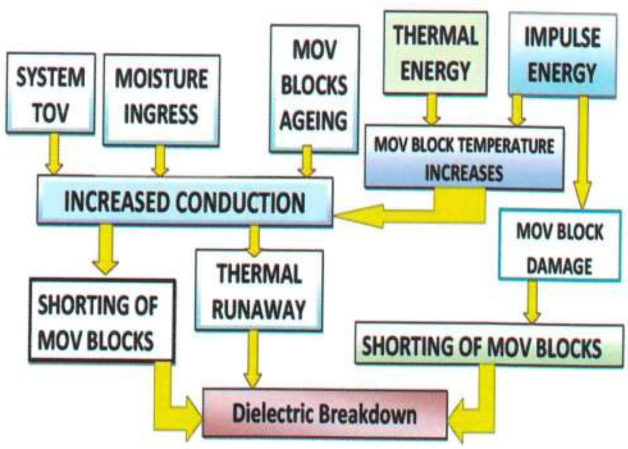
C is the speed of light

Zs is the line Surge Impedence

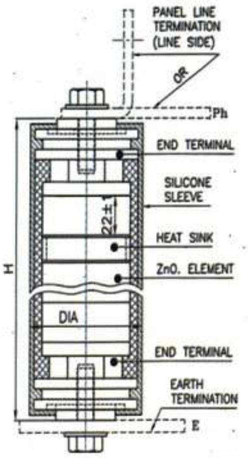
Ups is the arrester RDV at switching impulse current

Urp is the maximum switching over voltage.

ARRESTER FAILURE MODES



SURGE SUPPRESSOR STACKS FOR INDOOR APPLICATION:



SPF STACKS OF DIFFERENT RATINGS

30kV 10kA Class-3

24kV 10kA Class-2

12kV 10kA Class-2

9kV 10kA Class-1

Dimensional details:

			CLASS-1		CLASS-2		CLASS-3	
U_r-kV	I_n-kA	HEIGHT mm	MODEL	DIA-mm	MODEL	DIA –mm	MODEL	DIA –mm
3	10	125±2	SPF-SS-3C1	56±1	SPF-SS-3C2	64±2	SPF-SS-3C3	79±2
4.5	10	125±2	SPF-SS-4.5C1	56±1	SPF-SS-4.5C2	64±2	SPF-SS-4.5C3	79±2
6	10	175±4	SPF-SS-6C1	56±1	SPF-SS-6C2	64±2	SPF-SS-6C3	79±2
7.2	10	175±4	SPF-SS-7.2C1	56±1	SPF-SS-7.2C2	64±2	SPF-SS-7.2C3	79±2
9	10	175±4	SPF-SS-9C1	56±1	SPF-SS-9C2	64±2	SPF-SS-9C3	79±2
12	10	200±5	SPF-SS-12C1	56±1	SPF-SS-12C2	64±2	SPF-SS-12C3	79±2
15	10	200±5	SPF-SS-15C1	56±1	SPF-SS-15C2	64±2	SPF-SS-15C3	79±2
18	10	275±6	--	56±1	SPF-SS-18C2	64±2	SPF-SS-18C3	79±2
21	10	275±6	--	56±1	SPF-SS-21C2	64±2	SPF-SS-21C3	79±2
24	10	275±6	--	56±1	SPF-SS-24C2	64±2	SPF-SS-24C3	79±2
30	10	400±8	--	56±1	SPF-SS-30C2	64±2	SPF-SS-30C3	79±2
36	10	400±10	--	56±1	SPF-SS-36C2	64±2	SPF-SS-36C3	79±2
42	10	400±10	--	56±1	SPF-SS-42C2	64±2	SPF-SS-42C3	79±2

U_r – Rated voltage in kV_{rms} I_n- Nominal discharge current For other ratings forward enquiry

SURGE ARRESTER OF WRAP DESIGN (PBW) FOR OUTDOOR APPLICATION

9kV 5kA DISTRIBUTION TYPE

12kV 10kA cl1 24kV 10kA cl1 SAs WITH DISCONNECTOR

42kV & 9kV 10kA cl-2 SAs WITH BASE

30kV, 24kV & 9kV 10kA class-3 ARRESTERS WITH BASE

Dimensional details for PBW Arresters :

			CLASS-1		CLASS-2		CLASS-3	
U_r-kV	I_n-kA	HEIGHT mm	MODEL	DIA-mm	MODEL	DIA –mm	MODEL	DIA –mm
7.2/9/10.5/12/15	10	210±10	PBW-C1	145±5	PBW-C2	156±5	PBW-C3	166±7
27/30/36	10	390±15	PBW-C1	146±5	PBW-C2	156±6	PBW-C3	166±7
39/42	10	450±15	PBW-C1	146±5	PBW-C2	156±6	PBW-C3	166±7

U_r – Rated voltage in kV_{rms} I_n- Nominal discharge current For other ratings forward enquiry

TECHNICAL PARTICULARS FOR MV, HV, EHV and UHV POLYMER SURGE ARRESTERS –STATION CLASS

S.No.	Description	9kV			30kV			60kV	120kV	198kV	216kV	336kV	624kV	850kV
1.	Highest system voltage kV rms	12			36			72.5	145	245	245	420	800	1200
2.	Model	PBW-Wrap							PBC-Cage			PAT-TUBE		
3.	U_r –Rated voltage kVrms	9			30			60	120	198	216	336	624	850
4.	Uc -MCOV(kVrms)	7.65			25			51	102	168	184	267	490	730
5.	I_n –NDC (8/20μs) kA	10										20		
6.	Rated frequency	48Hz to 62Hz												
7.	LD class (IEC 99-4 Ed.2.2) Q_{rs}(IEC 99-4 Ed.3) in coulomb W_{th} (IEC 99-4 Ed.3) in kJ/kV	1 0.5 2	2 1 4	3 1.6 7	1 0.5 2	2 1 4	3 1.6 7	3 1.6 7	3 1.6 7	3 1.6 7	3 1.6 7	4 2.4 10	5 3.6 14	5 3.6x4 14x4
8.	Max RDV kVp a)5kA b)10kA c)20kA	27 29 32	25 27 30	24 26 29	90 95 105	85 90 100	80 85 95	160 170 190	320 340 380	518 550 610	560 600 650	800 850 925	1380 1480 1580	1440 1580 1720
9.	Max. Switch. Imp. R.V.(kVp) a)500A b)1000A c) 2000A	23 -	21 -	- 20	76 -	72 -	- 68	- 136	- 272	- 455	- 496	- - 670	- - 1220	- - 1500
10.	Max. Steep Current impulse RDV(kVp) at NDC	32	30	29	105	100	95	190	380	610	650	670	1580	1860
11.	Leakage current a.IR at MCOV in μA b.Ic at MCOV in μA	<350 ≈800	<400 ≈1200	<400 ≈1400	<350 ≈800	<400 ≈1200	<400 ≈1400	<400 ≈1400				<500 ≈1500		
12	High current impulse withstand value (4/10 μs) kA	100												135
13	TOV (kVp) i)1.0Sec ii)10.0Sec iii)100.0Sec	15 14 13			51 49 47			101 97 93	204 195 187	335 321 307	366 351 335	570 546 522	1059 1015 970	1442 1382 1322
14.	Insulation Withstand a)Lightning Impulse (kVp) b)Power frequency kVrms c)Switching Imp (Wet)(kVp)	75 28 NA			170 70 NA			325 140 NA	650 275 NA	1050 460 700	1050 460 700	1425 630 1050	2200 NA 1550	2200 NA 1800
15	Partial discharge P.D	Less than 10pC												
16.	Pressure Relief Current kA	20						63				65		
17.	Creepage distance-mm (min)	300			900			1815	3625	6125	6125	10500	20000	32300
18.	Max. Cantilever strength of arrester Kgf	150kgf										250kgf	4 units 150kgf 3Units 250kgf	500kgf
19	Min. Energy discharge capability kJ/kV of U_R	2	5	8	2	5	8	8	8	8	8	12	13	55MJ(4 column)
20	Overall height in mm	210 –5			390–10			730– 15	1382– 25	2450– 50	2580–50	3812–30	7624–40 (4 Units) 6600–40 (3 Units)	9209–45

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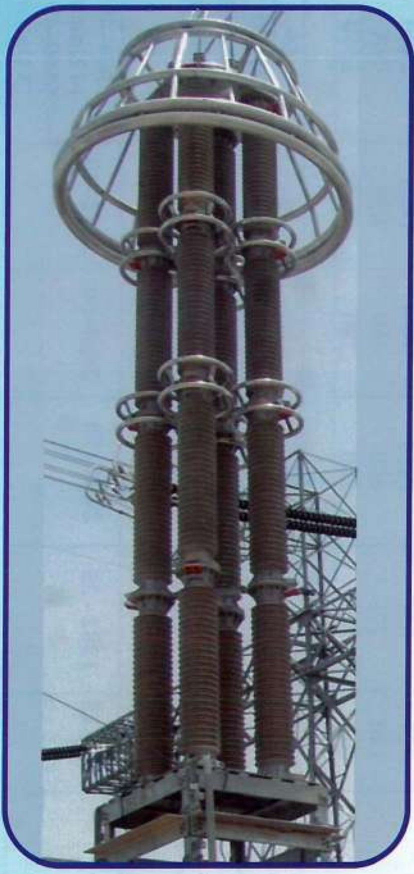
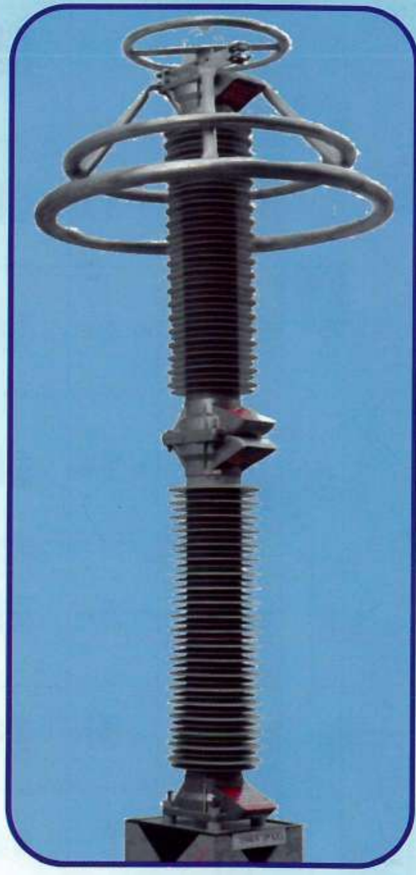


UHV 850kV
Surge Arrester
For 1200kV System

UHV 624Kv
Surge Arrester
For 800kV System



UHV 336Kv
Surge Arrester
For 420kV System

850kV 20kA Discharge Class-V UHV Surge Arresters with a protective level of 1720Kv LIPL and 1500kV SIPL to give a protective margin of 28% and 20% respectively for a Transformer with LIWL of 2200kV and SIWL of 1800kV.

624kV 20kA Discharge Class-V UHV Surge Arresters with a protective level of 1480kV LIPL and 1220kV SIPL to give a protective margin of 31.8% and 27% respectively for a Transformer with LIWL of 1950kV and SIWL of 1550kV

336kV 20kA Discharge Class-IV EHV Surge Arresters with a protective level of 850kV LIPL and 670kV SIPL to give a protective margin of 52.9% and 56.7% respectively for a Transformer with LIWL of 1300kV and SIWL of 1050kV.

Product Range :
a) Medium Voltage Arresters below 30kV in Wrap Design
b) H.V. Arresters from 66kV to 220kV in Cage Design (Design-B)
c) EHV (400kV) and UHV (800kV Arresters in Tube Design (Design-A)

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