# COMPATABILITY OF ZINC OXIDE VARISTOR WITH DIFFERENT DIELECTRIC MEDIA SUCH AS AIR, TRANSFOEMER OIL & SF6

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**Abstract**
**The housing of the zinc oxide lightening lightning arrester are plying major role for discharging the lightning surges. Previously porcelain and silicon rubber housing were mainly used depending on the atmospheric conditions but in practice lot of problems were faced with these housing. In this paper presenting the Zno blocks performance characteristics are going to study with different dielectric materials like air, transformer oil and SF6. According the analysis we may implement the arrester and power transformer capability to design Gas insulated and oil insulated arrester.**
**Keywords: Zno arrestor blocks, Test chamber reference voltage, minimum continuous operating voltage (MCOV)& residual voltage & Ageing.**

## 1. Introduction

The gapless ZnO lightning arrester blocks are having the non-linear characteristics. Under the surge condition these arrester acts as a low path resistance for discharging the high frequency surges to ground and acts as a high voltages high resistance for transmitting the power frequency voltages/currents travelling along the transmission line.

The non linear V-I characteristics of ZnO arrester characteristics are shown in fig1. The chareterics having three zones shown in fig1.

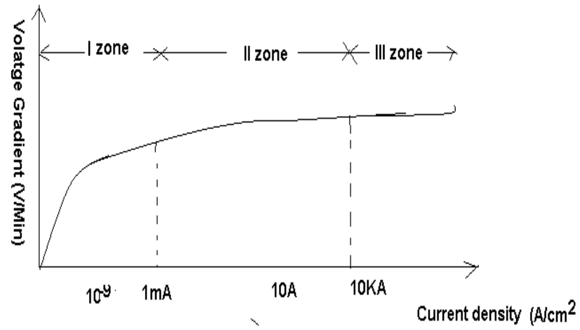



fig 1. v-i charecteristics of station type lightning arrester block

I- Zone : Before saturation, leakage curent through arrester in order of 10-10A to 10-6 A.
II Zone : This region is saturation Zone, the leakage current through the arrester in the order of 1mA to 100A.
III Zone : After the saturation zone, the leakage current through the arrester is 100A to 100KA.

**Non-linear co-efficient(β):-** The non linear co-efficient of the arrester is expanded as,

$$I = K V^{\beta} \quad \text{-----} \quad 1.1$$

Where,
I = Discharge current
V = Voltage across the arrester
β = Non-linear co-efficient(>1)

The linearity of the characteristics mainly depends on the value of non-linear co-efficient ( β)

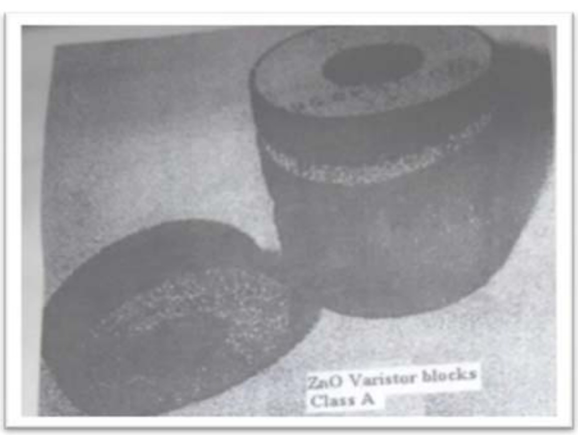
At any two current reference values the value of non linear coefficient calculates as follows,

$$\beta\ (Cal) = \frac{\mathrm{Log}(I_2)-\mathrm{Log}(I_1)}{\mathrm{Log}(V_2)-\mathrm{Log}(V_1)} \quad \text{------} \quad 1.2$$

I1, I2 are the reference currents of the arrester
V1 , V2 are the reference voltages at the same reference currents
The V-I characteristics of the arrester vary with temperature. If the temperature of the arrester is increased then the leakage current through it is also increased. When the lightning surge is discharged through it then the temperature of the block is increased hence the temperature is also considered into account for V-I characteristics at the various voltage levels.
The paper presents the performance of the arrester blocks (3KV) at the different levels of temperature and different dielectrics like air , transformer oil and SF6. The various testing that are performed on the arrester blocks as per the standards and testing as follows.

- IEC 99-1 to IEC 99 -5
- IS: 3656, 7650 and 7652
- JEC standards

The listed various tests are conducted on arrester blocks in air , transformer oil and SF6dielectrics. The Arrester blocks those are manufactured by Hitachi Technology and manufactured from Crompton Greaves Pvt Ltd. In NASIK Maharashtra.
D5- Type No : 2002121268(Class-B)
Distribution Type arrester block
D7-Type No : 2002124268(Class-A)
Station Type arrester block



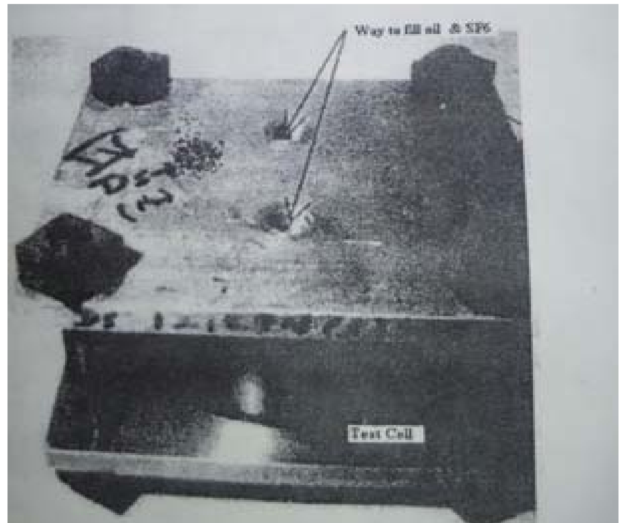




Fig 3. Testing Chamber

**Arrester Block Specifications**:
Rated Voltage of each block : 3KV
MCOV : 2.98 KV
Residual Voltage : 7.2KV
Dimensions : 4cm x 2cm.
**Test cell Arrangements**:
Upper & Lower Plate dimensions :
12cm x 12cm x 10mm
Insulating Fiber p;ate diameter : 10cm
Insulatiing Fiber height : 10cm
Volume of the test cell(Tr-oil) : $\pi r^2 h$

= $3.14 \times 5^2 \times 10$
=785 mm(Appox)
SF6 gas pressure = 2kg/cm$^2$

As per IEC 92 standards we conducted three test in three zones as follows

1. Reference voltage(1mA) Test:
2. Ageing Test
3. Residual Voltage Test

**1. The Reference Voltage (1mA) Test**: -
The voltage across the arrestor block when 1mA current flowing through it called reference voltage. The test was completed in above air, oil and SF6 dielectric media at various temperatures from 30$^o$ to 120 $^o$ and measured the voltage across the varistor block and calculated resistance at 1mA and 4mA also and calculated non-linear co-efficient.
The following observations are recorded from the above reference voltage test.

a) The Non-linearity co-efficient is dependent of dielectric media i.e. there is no change in linearity coefficient with respect to media

b) The non –linear co-efficient value is reduced with respect to temperature in pre-breakdown region, increasing temperature reduces the non linearity.

c) The non linear co-efficient is higher value for high energy blocks and vice versa.

d) The non-linear co-efficient is maximum at 1mA reference current as shown in fig 3.

| S No. | Temp. °C | Vdc @ 1mA(KV) | | | Vdc @ 4mA(KV) | | | Resistance (M-Ohms) | | | Non-linear co-eficient (β) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Air | Tr-Oil | SF6 | Air | Tr-Oil | SF6 | Air | Tr-Oil | SF6 | |
| 1 | 32 | 3.9 | 3.88 | 3.88 | 4 | 3.98 | 3.85 | 3.9 | 3.89 | 4 | 54 |
| 2 | 60 | 3.8 | 3.85 | 3.85 | 4 | 3.94 | 3.85 | 3.8 | 3.81 | 3.9 | 45 |
| 3 | 80 | 3.8 | 3.75 | 3.8 | 3.9 | 3.91 | 3.9 | 3.8 | 3.75 | 3.8 | 35 |
| 4 | 100 | 3.6 | 3.65 | 3.6 | 3.9 | 3.84 | 3.84 | 3.7 | 3.64 | 3.7 | 24 |
| 5 | 120 | 3.6 | 3.54 | 3.6 | 3.6 | 3.84 | 3.85 | 3.6 | 3.54 | 3.5 | 18 |

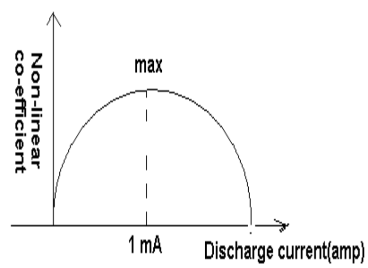



Fig 3. Non linearity versus discharge current

## 2. Accelerated Ageing Test:-

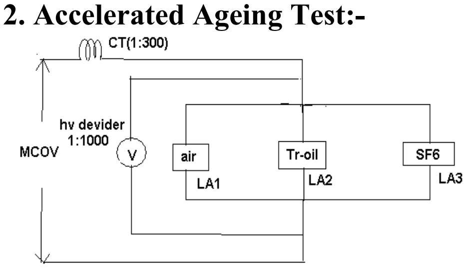



fig 4. Accelarated aging test of varistor blocks in air, oil & SF6

According to IEC 99-4, the ageing test was held at minimum continuous operating voltage(MCOV) at 115± 4° C up to 1000 hrs continuously. Then at the rated voltage of the varistor block watt-losses to be measured after ageing. The results of the varistor block before and after ageing of 1000 hrs compared with different dielectrics air, transformer shown in fig 4

| Before aging (Watt-loss) | | After aging (Watt-loss) | |
|---|---|---|---|
| At MCOV | At rated Voltage | At MCOV | At rated Voltage |
| 0.31 | 4.7 | 0.34 | 5.1 |
| 0.3 | 4.62 | 0.34 | 5.1 |

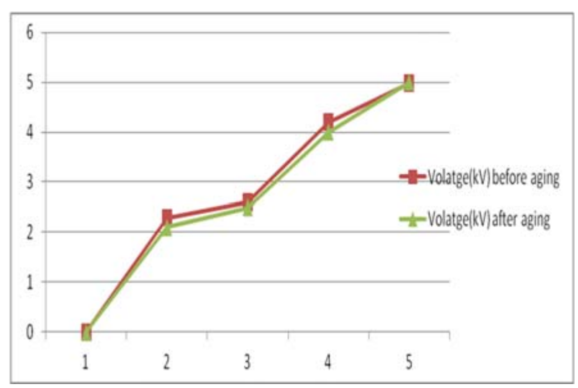



Fig. 5. V-I characteristics of ZnO varistor before and after aging in Tr-oil @25$^0$

3. **Residual voltage Test**: As per IEC 99-4 standards the rated current 10KA, 8/20micro-sec passed through the varistor in three insulating media cells then the temperature of the blocks is to be maintained and measured the voltage across the test cells. In this experiment the practical values of residual voltages of ZnO blocks at different voltages are recorded. The observations are as follows,

a) Residual voltage is a dependent of temperature of the blocks i.e if the block temperature is increased then the residual voltage increased slightly.
b) Residual voltage is independent of di-electric media.
c) There is no damage of arrester blocks physically
d) The V-I characteristics of the blocks are not changed.

| Temp | Residual Voltage (KV) | | |
|---|---|---|---|
| | Air | Tr-Oil | SF6 |
| 30$^o$C | 7.86 | 7.88 | 7.55 |
| 120$^0$C | 7.88 | 7.92 | 7.84 |

**4. Degradation & Porosity Test:-**

After completion of aging in transformer oil, the varistor blocks are tested under degradation and porosity tests. The quantity of oil consumption is not differing (in PPM) much more than original conditions.

**5. Conclusion**: -

The V-I characteristics of ZnO varistor blocks (Class A & Class B) are obtained in both dielectrics such as air and transformer oil. The characteristics having deviation of 2 to 3% of their original values shown in fig 5.Hence the lightning arrester can design with transformer oil as insulating media against the problem of housing instead of solid dielectrics (porcelain) . This paper may also proposed that the distribution transformer can built with arrestor without housing by providing transformer oil as insulating dielectric media with in a transformer tank by providing proper discharging in size of the transformer.

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