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Compatability of Zinc Oxide Varistor with Different Dielectric Media Such As Air, Transformer Oil & Sf6

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ABSTRACT: The housing of the zinc oxide lightning arroester plays a major role for discharging the lightning surges. Previously, porcelain and silicon rubber housings were mainly used depending on the atmospheric conditions. But in practice, lot of problems were faced with these housing. In this paper, performance characteristics of ZnO blocksare studied with different dielectric materials like air, transformer oil and SF6. According to the analysis, we may implement the arrester and power transformer capability to design gas insulated and oil insulated arresters.

KEYWORDS: ZnO arrester blocks, Test chamber reference voltage, minimum continuous operating voltage (MCOV) , residual voltage & Aging.

I. INTRODUCTION

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

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

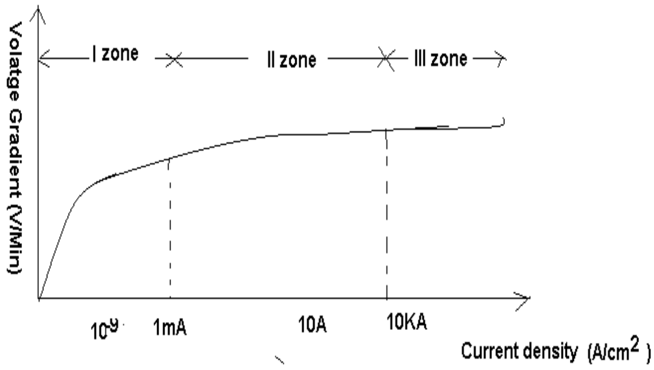

fig 1. v-i charecteristics of station type lightning arrester block

I Zone: Before saturation, leakage current through arrester is in the order of 10^{-9}A to 10^{-6}A.
II Zone: This region is saturation Zone, the leakage current through the arrester is in the order of 1mA to 100A.
IIIZone: 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,

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

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 is as follows.

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

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 for V-I characteristics at the various voltage levels.

This paper presents the performance of the arrester blocks (3KV) at different levels of temperature and different dielectrics like air, transformer oil and SF6. The various tests that are performed on the arrester blocks as per the standards are as follows.

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

Below listed tests are conducted on arrester blocks in air, transformer oil and SF6 dielectrics. The Arrester blocks are manufactured by Hitachi Technology and 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

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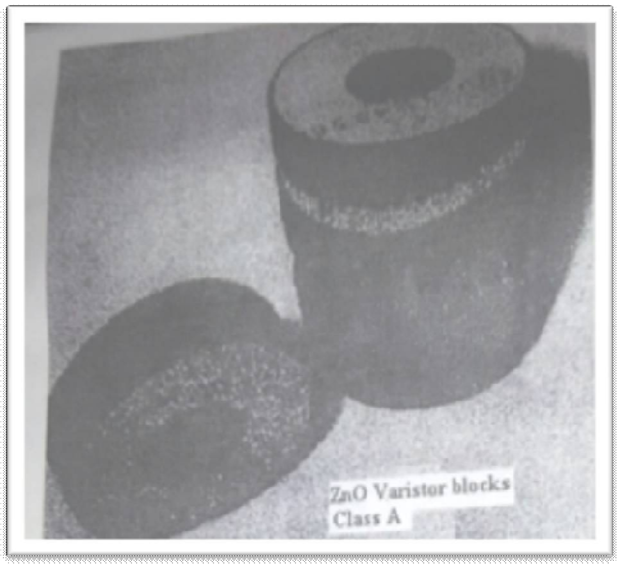

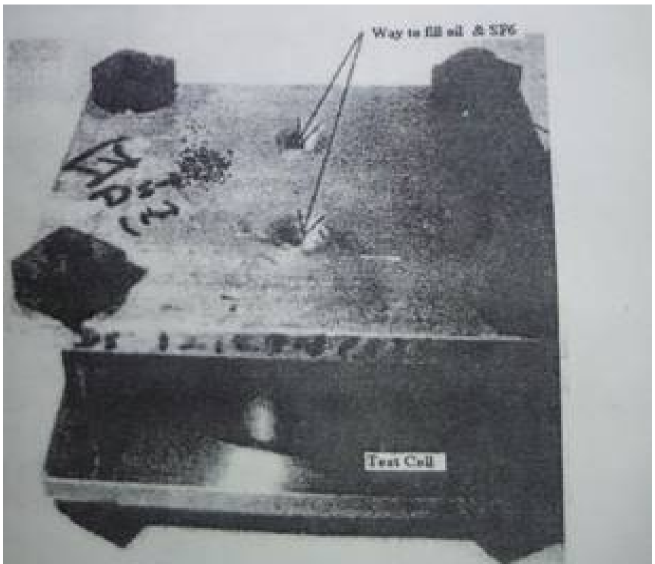

Fig 3. Testing Chamber

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 plate diameter: 10cm Insulatiing Fiber height : 10cm
Volume of the test cell (Tr-oil) : $\pi r^2 h$
= $3.14 \times 5^2 \times 10$
=785mm(Approx)
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. Aging Test
3. Residual Voltage Test

II. THE REFERENCE VOLTAGE (1MA) TEST

The voltage across the arrester block when 1mA current flows through it is called reference voltage. The test is completed in air, oil and SF6 dielectric media at various temperatures from 30^o to 120 ^{o}. Voltage across the varistor block is measured. Resistance at 1mA and 4mA, non-linear co-efficient are also calculated.
The following observations are recorded from the above reference voltage test.

a) The Non-linearity co-efficient is independent 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, i.e increasing temperature reduces the non linearity.

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c) The non linear co-efficient is of 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 coefficient (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

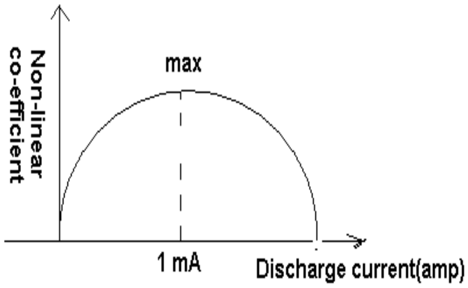

Fig 3. Non linearity versus discharge current

III. ACCELERATED AGING TEST

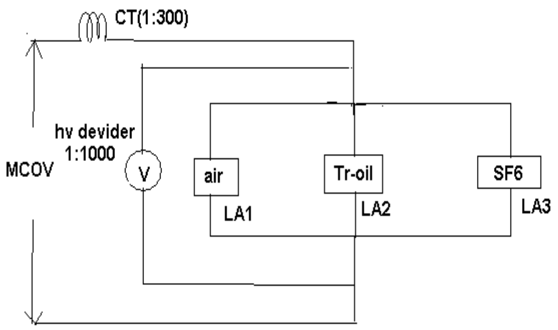

fig 4. Accelarated aging test of varistor blocks in air, oil & SF6

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

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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

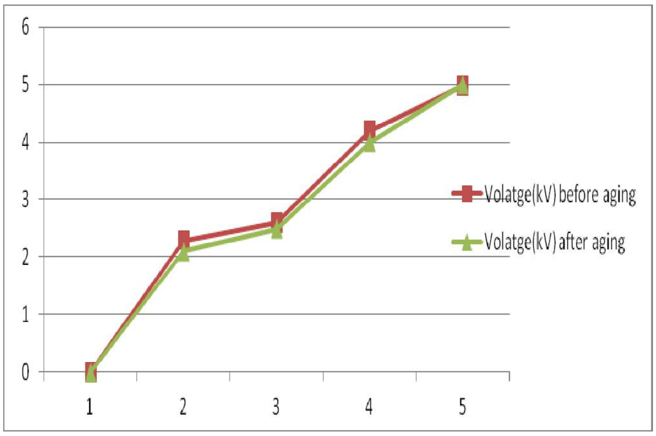

Fig. 5. V-I characteristics of ZnO varistor before and after aging in Tr-oil @25^0 C

IV. RESIDUAL VOLTAGE TEST

As per IEC 99-4 standards, the rated current of 10KA, 8/20 micro-sec is passed through the varistor in three insulating media cells. Then the temperature of the blocks is maintained and voltage across the test cells is measured. 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 dependent on 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

V. DEGRADATION & POROSITY TEST

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

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VI. 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 are having a deviation of about 2 to 3% from their original values as shown in fig 5. Hence the lightning arrester can be designed with transformer oil as insulating media against the problem of housing instead of solid dielectrics (porcelain) . This paper may also propose that the distribution transformer can be built with arrester without housing by providing transformer oil as insulating dielectric media with in a transformer tank by providing proper discharging inside the transformer.

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BIOGRAPHY

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