TESTING BASED EVALUATION OF TECHNICAL SPECIFICATION OF METAL OXIDE VARISTORS ZINC IN THE HIGH VOLTAGE 110KV SURGE ARRESTER

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ABSTRACT

This paper presents the results of experiment based evaluation method for technical characteristics of metal oxides varistors zinc (V-MOV-ZnO)which makes up 110 kV surge arrester. All tests were implemented at the National Key Laboratory for High Voltage Techniques - Institute of Energy (HVLAB). The 8/20µs standard lightning impluse current tests were performed to test for the residual voltage; the voltage-current characteristics of metal oxides varistor zinc V-MOV-ZnO. Moreover, the voltage-current characteristics of V-MOV-ZnO was tested with 1mA current passed through resistor plate of V-MOV-ZnO. Once voltage applying to the V-MOV-ZnO is greater than U_{peak}, a small increasement of voltage will result in a very high current passing through the V-MOV-ZnO. This feature is used to discharge the lightning when very high transient over-voltage occurs. U_{peak} is reffered as a limit which must be taken into account when designing the V-MOV-ZnO arrester. All testing results practically allow to evaluate quality of the V-MOV-ZnO on some aspects arrcording to IEC 60099-4 and to ensure the effectiveness of surge arrester if utilized.

Key words: metal oxides varistor zinc; V-MOV-ZnO; surge arrester, test.

I. INTRODUCTION

Classical surge arrester (SA) ulitilized silicon carbide plate as nonlinear resistor (V-SiC). Nonlinear V-SiC resistors has been studied and successfully fabricated since the 1930s and 1940s. (Figure 1).

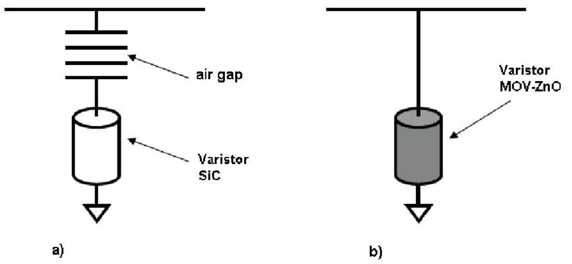

Figure 1: Discibre the classical surge arrester, V-SiC with air gap (a); and modern V-MOV-ZnO without gap (b).

V-SiC is widely used in industrial countries where V-SiC is manufactured as an overvoltage protection for electric devices after the World War II. [1].

About half a century ago, before 1990, Viet Nam Electricity industry only used nonlinear classical V-SiC resistors. Those V-SiC nonlinear resistors can withstand high current pulse, but can not tolerate the current successor at industrial frequency. Surge arrester V-SiC with more complex structure including the air gap ensured the flat in characteristics of volt – seconds and had capability to extinguish the arc of current successor at industrial frequency [2].

Nonlinear zinc metal oxide resistors (V-MOV-ZnO) had been researched and successfully applied to surge arrester in Japan since the early of 1980s. Atmospheric overvoltage caused by lightning may create a extreme high current which may reach hundreds of kA, that high current will destroy most of electrical equipments.

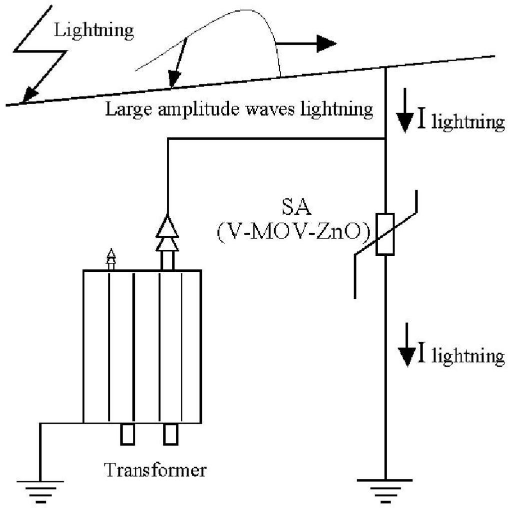

Figure 2: Diagram of surge arrester (V-MOV-ZnO) connected in parallel with protected object.

To protect over voltage for electrical equipment, the surge arrester is connected in parallel with equipments. When over-voltage appears, due to the the non-linear characteristic the resistor of the surge arrester (Figure 2) fall down very quickly to small values. As aresult, V-MOV-ZnO will allow the current of over-voltage passing through (early discharge) and divert lightning current to ground. Thus, electrical equipmens are safely protected and grid operation is not affected. [3].

II. TESTING FOR V-MOV-ZnO

The surge arrester and all other products of electrical engineering industry must meet several strick requirements from the research to manufacturing and commissioning stages. Especially, they must pass the quality control testing to ensure the specifications in order to safely protect electrical equipments and eliminate problems which may occure during grid operation. [5].

1. Type tests

These tests are to research in designing and creating new products. The test will calibrate a product to determine the its characteristics and to demonstrate that product is in compliance with manufacturing standards. These tests do not need to do again in other products, unless there is any modification in design of product. In that case, only the experiments related to the modification needs to test again.

2.Routine tests

These test are to perform on each individual surge arrester, surge arrester element, lightning protection materials to ensure products meet the required technical regulations which include following tests:
- Periodic test for batches of product: Check quality of V-MOV-ZnO or surge arrester periodically or check the batches of products.
- Factory tests: qualify surge arrester quality before delivery.
- Test before installation: check the basic quality field of the surge arrester, all the transportion and storaging proccess of the surge arrester must meet technical criteria for installation.

3. Acceptance tests

These tests are performed when the agreement on a product between the manufacturer and the buyer was meet. Nonlinear resistor block (V-MOV-ZnO) is the core element of the surge arrester, therefore quality test is a very important task. [4].

Within the scope of this paper and next coming paper we will only focus on the test before installation of surge arrester.

III. SPECIMEN PREPARATION AND MEASUREMENT CIRCUIT

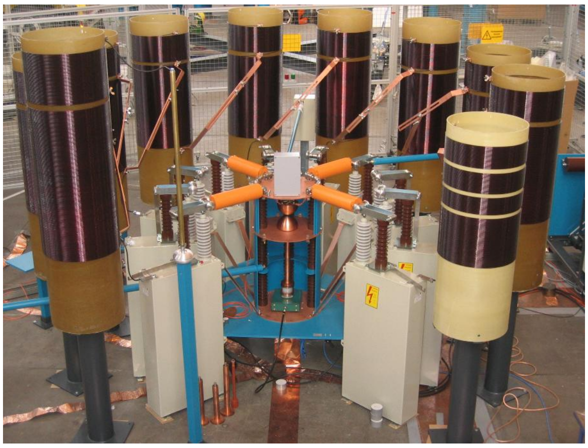

Figure 3: Standard test with 8/20 μs pulse for V-MOV-ZnO resitor block at HVLAB.

The specimen is a non-linear resistor block (V-MOV-ZnO) which was 110 kV surge arrester type of Simens.

The capacitors in the impulse current test set of HighVolt-IP 125/100 (German) are arranged in a semicircle to keep a specified distance with the specimen. This design ensures the circuit will have a small inductance for short time impulse current. (Figure 3).

IV. TEST RESULT AND ANALYSIS

The voltage-current characteristics of non-linear resister V-MOV-ZnO (Figure 4) show the linear relationship at 1mA current. When voltage applying to the V-MOV-ZnO is greater than U_{peak}, only a small increasement of voltage will make the current conducting through the V-MOV-ZnO increase significantly.

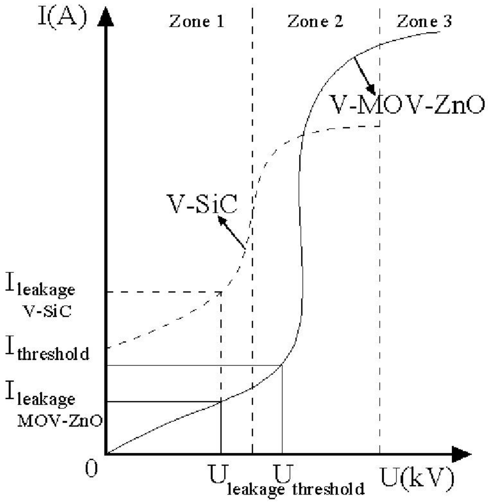

Figure 4: Voltage-current linear of V-MOV-ZnO compare to classical non-linear resistor Cacbuasilic V-SiC.

This feature is used to discharge the lightning when the over-voltage current appeare. U_{peak} is based reference limit used to design the core of V-MOV-ZnO. The manufacturer often select this value in range of (50 ÷ 70)% U_{peak} to design the nominal voltage of the V-MOV-ZnO.

Before and during the test, HVLAB's staff calibrated the IP-125/100 test set by calibration specimen to ensure accurate measurement result. [6].

Zone 1: The V-MOV-ZnO linear domain, V-MOV-ZnO, the leakage current is very small ($I_{leakage} = 10^{-7} \div 10^{-6}$ A). When over voltage occurs, voltage applied on the V-MOV-ZnO increases suddenly as well and this non-linear resistor V-MOV-ZnO change to operate in Zone 2.

Zone 2: Due to the nonlinear properties of V-MOV-ZnO, when the voltage increase a small value, the current through the V-MOV-ZnO increased rapidly and help to divert the ligtning current to the ground, prevent electrical equipments from breakdown due to lightning. Relationship between current and voltage in the Zone 2 is represented by the equation:

$$\mathbf{I = k.U^{\propto}}$$

Here: $\propto$ - non-linear parameter,
k - constant

Zone 3: Saturation operation zone of V-MOV-ZnO.

In Figure 4:

- Voltage U_{peak} corresponds to current value of 10^{-3}A passing through the V-MOV-ZnO element.
- Working voltage U_c is the voltage which can maintain for long time on V-MOV-ZnO. U_c has the value about (50 ÷ 60)%U_{peak} (depending on the manufacturer's design).
- Leakage current $I_{leakage}$ is current passing V-MOV-ZnO, which corresponds to the applied working voltage U_c on V-MOV-ZnO.
- $\propto$ nonlinear parameter in Zone 2 of V-MOV-ZnO linear characteristics can be determined by the formula:

$$\alpha = \frac{\lg I_2 - \lg I_1}{\lg U_2 - \lg U_1}$$

Table 1: Results with standard impluse current 8/20µs applied to check for the residual voltage of V-MOV-ZnO

Fig	Comment	Ip/kA	T1/µs	T2/µs	TEnd/µs	Up/kV
1	8/20, ResVM, DUT: N01, 4xC, Uch=15kV	5.360	7.611	19.19	27.89	11.55
2	8/20, ResVM, DUT: N01,4xC, Uch=22kV	10.09	7.751	18.80	25.41	12.62
3	8/20, ResVM, DUT: N02, 4xC, Uch=35kV	22.46	7.685	18.62	24.97	14.19
4	8/20, ResVM, DUT: N03, 4xC, Uch=41kV	30.12	7.662	18.55	23.89	14.68
5	8/20, ResVM, DUT: N01+N02, 4xC, Uch=45kV	21.82	7.785	18.97	25.92	26.82
6	8/20, ResVM, DUT: N04, 5xC, Uch=25kV	15.92	7.823	18.79	25.38	13.01
7	8/20, ResVM, DUT: N05, 6xC, Uch=24,5kV	18.67	7.902	19.10	25.58	13.30

Before perform the 8/20µs impulse current test, the people in chagre of testing had calibrated the standard value of 10 kA impulse current test for V-MOV-ZnO. Standard test with 8/20µ impulse current is performed to check for residual voltage of the V-MOV-ZnO.

When lightning current flows through V-MOV-ZnO to the ground, there is a residual voltage (U_{res}) appearing on V-MOV-ZnO due to existing ground resistance and resistance of V-MOV-ZnO. The value of the standard 8/20µs impluse current ranges from 1kA to the tens of kA.

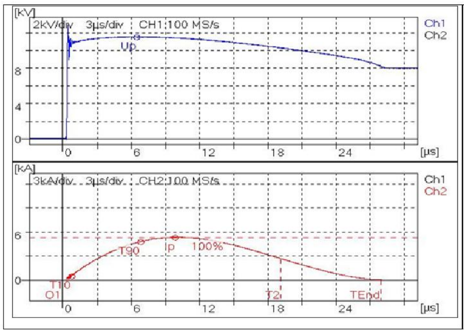

Fig. 1

Ch1: impulse voltage
Up = 11.55 kV

Ch2: impulse current
Ip = 5.360 kA
T1 = 7.611 µs
T2 = 19.19 µs
TEnd = 27.89 µs

Comment: 8/20, ResVM, DUT: N01, 4xC, Uch=15kV

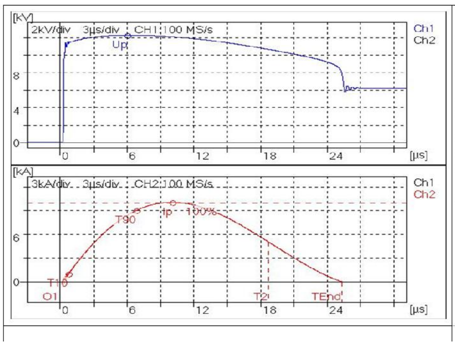

Fig. 2

Ch1: impulse voltage
Up = 12.62 kV

Ch2: impulse current
Ip = 10.09 kA
T1 = 7.751 µs
T2 = 18.80 µs
TEnd = 25.41 µs

Comment: 8/20, ResVM, DUT: N01,4xC, Uch=22kV

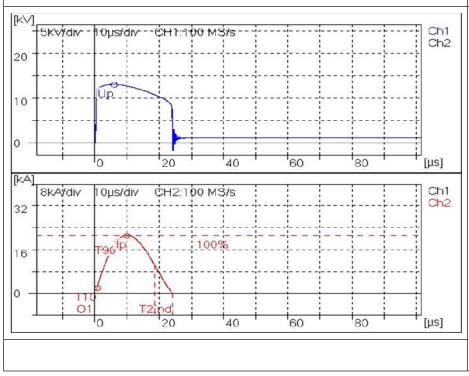

Fig. 3

Ch1: impulse voltage
Up = 14.19 kV

Ch2: impulse current
Ip = 22.46 kA
T1 = 7.685 µs
T2 = 18.62 µs
TEnd = 24.97µs

Comment: 8/20, ResVM, DUT: N02, 4xC, Uch=35kV

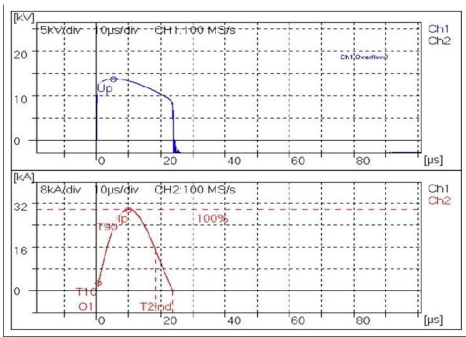

Fig. 4

Ch1: impulse voltage
Up = 14.68 kV

Ch2: impulse current
Ip = 30.12 kA
T1 = 7.662 µs
T2 = 18.55 µs
TEnd = 23.89 µs

Comment: 8/20, ResVM, DUT: N03, 4xC, Uch=41kV

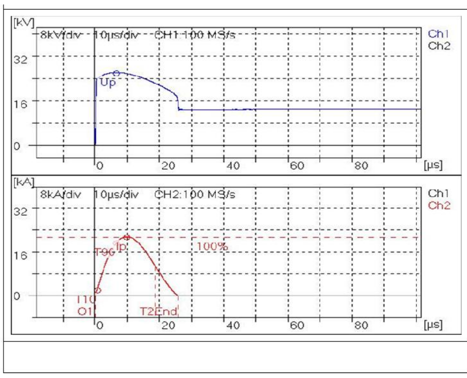

Fig. 5

Ch1: impulse voltage
Up = 26.82 kV

Ch2: impulse current
Ip = 21.82 kA
T1 = 7.785 µs
T2 = 18.97 µs
TEnd = 25.92µs

Comment: 8/20, ResVM, DUT: N01+N02, 4xC, Uch=45kV

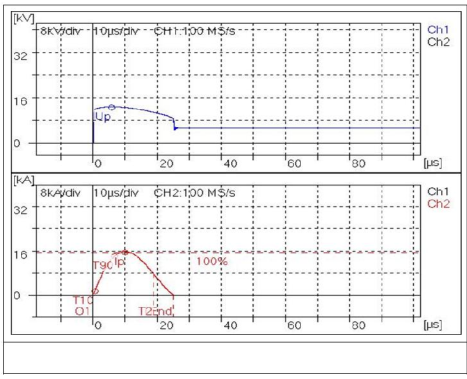

Fig. 6

Ch1: impulse voltage
Up = 13.01 kV

Ch2: impulse current
Ip = 15.92 kA
T1 = 7.823 µs
T2 = 18.79 µs
TEnd = 25.38µs

Comment: 8/20, ResVM, DUT: N04, 5xC, Uch=25kV

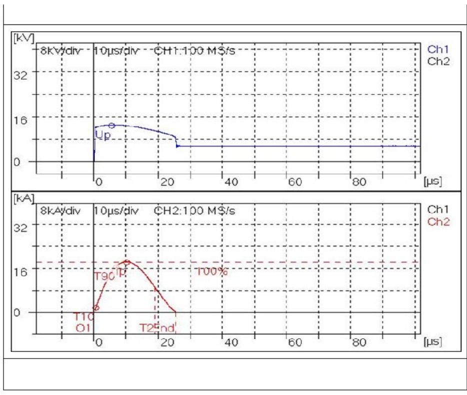

Fig. 7

Ch1: impulse voltage
Up = 13.30 kV

Ch2: impulse current
Ip = 18.67 kA
T1 = 7.902 µs
T2 = 19.10 µs
TEnd = 25.58 µs

Comment: 8/20, ResVM, DUT: N05, 6xC, Uch=24,5kV

According to IEC 60099-4, the V-MOV-ZnO resistive plates used in 110 kV surge arrester must withstand the value 10 kA of standard current impulse when the the 8/20µs impulse current is performed. [7].

V. CONCLUSION

Based on test results obtained, conclusions can be as follow:

- When the applied voltage increases from U_{ch} = (15 ÷ 41) kV, the pulse current flowed through the V-MOV-ZnO increased from I_p = (5.360 ÷ 30.12) kA and the samples did not crack during the tests. This will help to determine the insulating properties; the energy absorption capacity of the V-MOV-ZnO is completely in compliance to the IEC

60099-4 when perform the 8/20μs impulse current test.

- The 8/20μs impulse current values recorded in Table 1 are the impulse current which was discharged through the V-MOV-ZnO after V-MOV-ZnO had absorbed a fraction of the energy. All of those values exceeded the standard value of 10 kA. This showed the ability of V-MOV-ZnO in protecting elcetrical equipments when over voltages occur.

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