HIGH VOLTAGE PROTECTIVE ASSEMBLY

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***Abstract**:* This paper describes a new high voltage protective assembly, which comprises both fuse protection and overvoltage protection for overhead transformer- distribution stations. The metal-oxide surge arrester without gaps performs two functions: it limits overvoltages at transformer input and supports the carrier of gas expulsion fuse. That way one of the two support insulators per each pole can be substituted by the surge arrester. The high voltage protective assembly is advantageous for technical reasons and for significant economic savings.

Keywords: electric fuse, current limitation, overvoltage protection

1. Introduction

The protection of overhead transformer-distribution stations is put in practice by the use of H.V. fuses and surge arresters. Expulsion fuses and metal- oxide surge arresters without gaps are commonly used to this purpose [1, 2, 3, 4]. A set of three- pole H.V. fuses usually forms a separate electrical apparatus, comprising three single fuse bases installed on six support insulators. The surge arresters are installed on another base, separately, nearby the H.V. fuses.

The surge arrester without gaps, owing to its design, can perform not only the function of overvoltage protection. It can be used as a support insulator also. The surge arrester can be installed in vertical, horizontal or in any intermediate position. Thus, the three support insulators from 3- pole fuse protection set can be replaced by surge arresters type AZB. This solution is applied in the High Voltage Protective Assembly type WZZ, which incorporates both expulsion fuses and metal- oxide surge arresters without gaps, AZB type. A detail description and results of the tests performed on the High Voltage Protective Assembly type WZZ will be presented in the next section.

2. High voltage protective assembly

2.1. General

The High Voltage Protective Assembly type WZZ, Fig. 1, is applied to the protection of overhead transformer-distribution stations against the effects of overcurrents (short circuits, heavy overloads), lightning surges and switching overvoltages in AC networks. There are three options of the High Voltage Assembly, for rated voltages: 12, 17.5 and 24 kV respectively.

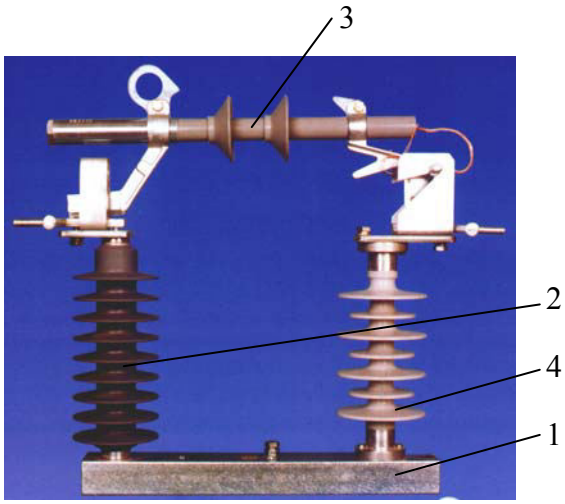

Fig. 1: High voltage protective assembly WZZ, rated voltage 17.5 kV
1- Base, 2- Surge arrester AZB, 3- Fuse carrier OWBG, 4- Support insulator

The WZZ Protective Assembly, Fig. 1, incorporates a base (1), expulsion fuse and metal-oxide surge arrester without gaps AZB (2), which is installed as a substitute of one of the two support (standoff) insulators (4) for each fuse-carrier. Two kinds of fuse carriers (3), type WGBNp and OWBG, can be applied in the WZZ Protective Assembly (see Sec. 2.2). The OWBG fuse carrier has an enhanced short circuit current breaking capacity in comparison to WGBNp. The second support insulator (4) of the fuse –carrier performs the function of insulation to earth for the WZZ protective assembly.

2.2. Gas expulsion fuse carrier

There are produced two types of gas expulsion fuse carriers, coded WGBNp and OWBG respectively, Fig. 2. The main difference between the two fuse carries is in the way and direction of gas expulsion. The WGBNp fuse carrier is open at both ends so gas expulsion is possible from the upper and lower outlet. The OWBG fuse carrier is closed at the upper end by a gas reservoir what results in an intensive gas expulsion in lower direction only. That is why the fuse carrier OWBG has an increased breaking capacity in comparison to the fuse carrier type WGBNp, Table 1. The design of both fuse carriers is similar, so the description will be given for the type OWBG only.

The fuse carrier type OWBG is made up of an insulating liner of high electrical and mechanical strength, with an ablative auxiliary tube, which is glued to the inside of the liner, a conducting ferrule of the upper gas-reservoir with a nut and bolt electrode. The lower contact of the fuse -link carrier with the terminal of flexible tail electrode is permanently fastened on the tube. The upper terminal is fixed to the upper ferrule with an adjustment of the

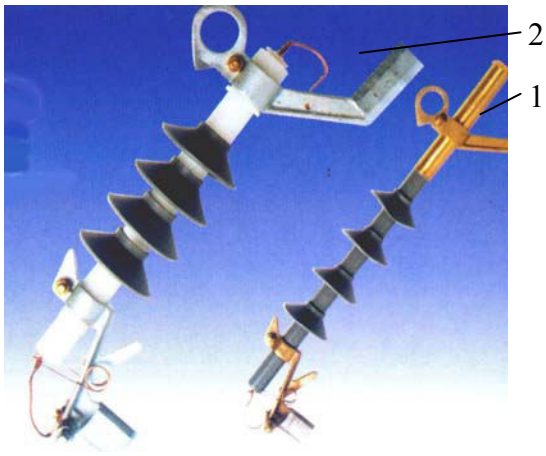

Fig. 2: Fuse link carrier for WZZ protective assembly
1- Fuse carrier OWBG-17.5, 2- Fuse carrier WGBNp-17.5

contacts distance of the carrier to the relevant dimensions of the fuse base. There in lower contact is set a spring which drives the flexible tail.

The fuse - link comprises a fuse -element that is coated with ablative material, a flexible tail and clamping sleeve, Fig. 3.

Table 1. Ratings of fuse carriers

Voltage		12 kV	17.5 kV	24 kV
Conventional thermal current of fuse- carrier	WBGNP	25 A	25 A	25 A
	OWBG	40 A	40 A	
Breaking current	WBGNP	3.15 kA	3.15 kA	3.15 kA
	OWBG	8 kA	5 kA	
Fuse-link currents	WBGNP	4÷25 A	4÷25 A	4÷25 A
	OWBG	4÷40 A	4÷40 A	
Frequency		50 Hz		

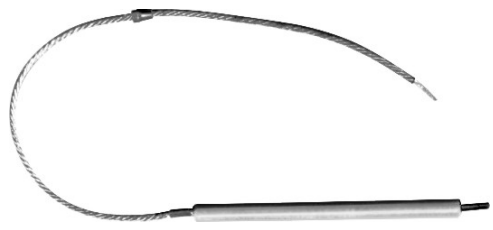

Fig. 3: Fuse link for WZZ protective assembly

2.3. Surge arrester

AZB type surge arrester without gaps, Fig. 4, is made of zinc- oxide varistor. The varistor pellets are connected in series and housed in a glass- epoxy

Fig. 4: Metal- oxide surge arrester without gaps type AZB

tube, which is closed at both ends by metal ferrules with connection terminals of the arrester. The set is sheathed with silicon elastomer, forming a tight, cylindrical housing with protective fins. The material and the creepage distance provide adequate insulating properties.

The arrester's end-of-life is indicated by a black insulating ring which is placed between the two protective fins of the surge arrester. When the arrester fails, the power arc is ignited along the surface of the ZnO varistor block. During arc creeping the black ring is sectioned then ejected to the ground indicating arrester's end-of-line.

The main advantages of surge arresters type AZB are:

- stability of protective characteristics,
- suitability to the installation in vertical or horizontal position,
- mechanical robustness, e.g. against vandalism
- long creepage distance,
- suitability to the application as the support insulator,
- in the case of short circuit current flow through the surge arrester there is no danger of fragmentation (explosion) of arrester housing.

The surge arrester meets the requirements for the IEC Zone III-Class outdoor use. The properties of AZB type surge arresters, confirmed by the Power Engineering Institute in Warsaw, are given in Table 2. They conform with standards: PN-IEC 99-4: 1993 and IEC-600099-4: 1998.

Table 2. Ratings of surge arresters type AZB

Continuous operating voltage (kV)	2.55 ÷ 34.0
Rated discharge current 8/20 μs	10 kA
Maximum discharge current 4/10 μs	100 kA
Short- circuit strength (0.2 s)	20 kA
Energy absorbing capacity	3.7 kJ/kV
Class of line discharge	1
Surge current withstand capacity of 2000 μs duration	230 A

2.4 Support insulator

The support outdoor insulator type C04 – 145, Fig. 5, is made up of a round glass-epoxy rod that is covered by a silicon sleeve with anti-rain protective fins. Aluminum ferrules are mounted at both ends of the insulator. The main field of application of composite insulators C04 – 145 is high voltage overhead electrical equipment:

- fuse-bases type PBNUs-24,
- high voltage protective assemblies type WZZ,
- transmission lines and switchgear,
- disconnectors and mechanical switches.

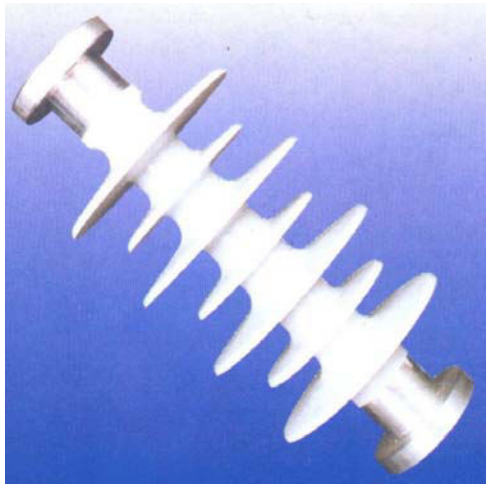

Fig. 5: Support outdoor insulator type C04 – 145

3. Tests

The High Voltage Protective Assembly Type WZZ - 12, WZZ - 17.5 and WZZ – 24 passed the type tests performed by The Institute of High Voltage, Gdansk University of Technology and The Power Engineering Institute in Warsaw. The tests have confirmed the ratings of fuse carriers given in Table 1. Exemplary oscillograms from the breaking capacity tests, for rated voltage 12.0 and 17.5 kV, are shown in Fig. 7 and Fig. 8, for the fuse carriers OWBGw6-12 and OWBG2-17.5 respectively.

4. IMMUNITY TO FUSE MALFUNCTION DURING STORMS

Nuisance fuse operation during thunderstorms may appear [5]. It is due to the interaction between surge arresters, transformer and fuse. If a lightning stroke is of long duration, the short- duration high current pulse is followed by a long duration low current pulse. An average amplitude of that low current pulse is 100 A, and its duration may be many miliseconds. Under these circumstances, the voltage across the transformer primary is not the sinusoidal AC line voltage but is much higher and constant, due to operation of surge arrester voltage under low current pulse. The transformer core becomes saturated then and the winding inductance dramatically drops. Resulting abnormal

magnetizing current can melt the fuse and cause nuisance operation.

Fuse malfunction as described in the reference [1] has not been observed in wide application on site of the WZZ protective assembly.

5. AVANTAGES OF WZZ ASSEMBLY

The High Voltage Protective Assembly type WZZ is advantageous for the following features: stable protective characteristics:

- large energy absorption capacity
- pollution-proof
- mechanical robustness
- low mass
- simplified construction of pole transformer.

6. APPLICATION EXAMPLE

An example of application of the High Voltage Protective Assembly type WZZ to the protection of an overhead transformer- distribution station is shown on site in Fig. 6.

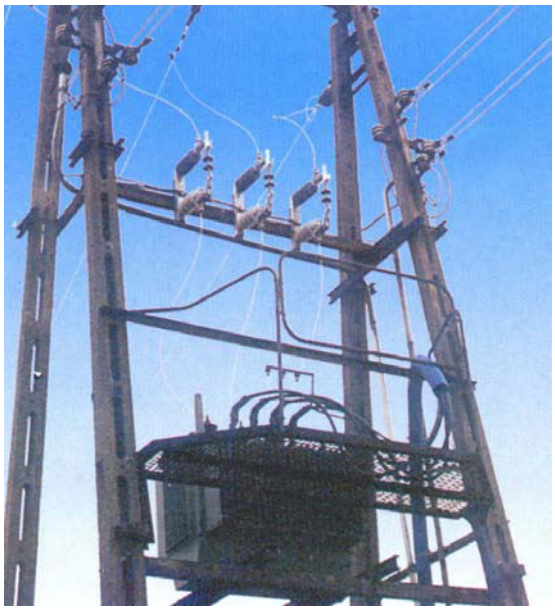

Fig. 6 Combined short circuit current and overvoltage protection of an overhead transformer- distribution station using the High Voltage Protective Assembly type WZZ 17.5

CONCLUSIONS

The High Voltage Protective Assembly type WZZ is a novelty in the field of the protection of overhead transformer- distribution stations. Owing to the performance of two functions by one assembly that is short circuit protection and surge protection, the WZZ is advantageous for technical reasons and significant economic effects.

ACKNOWLEDGEMENTS

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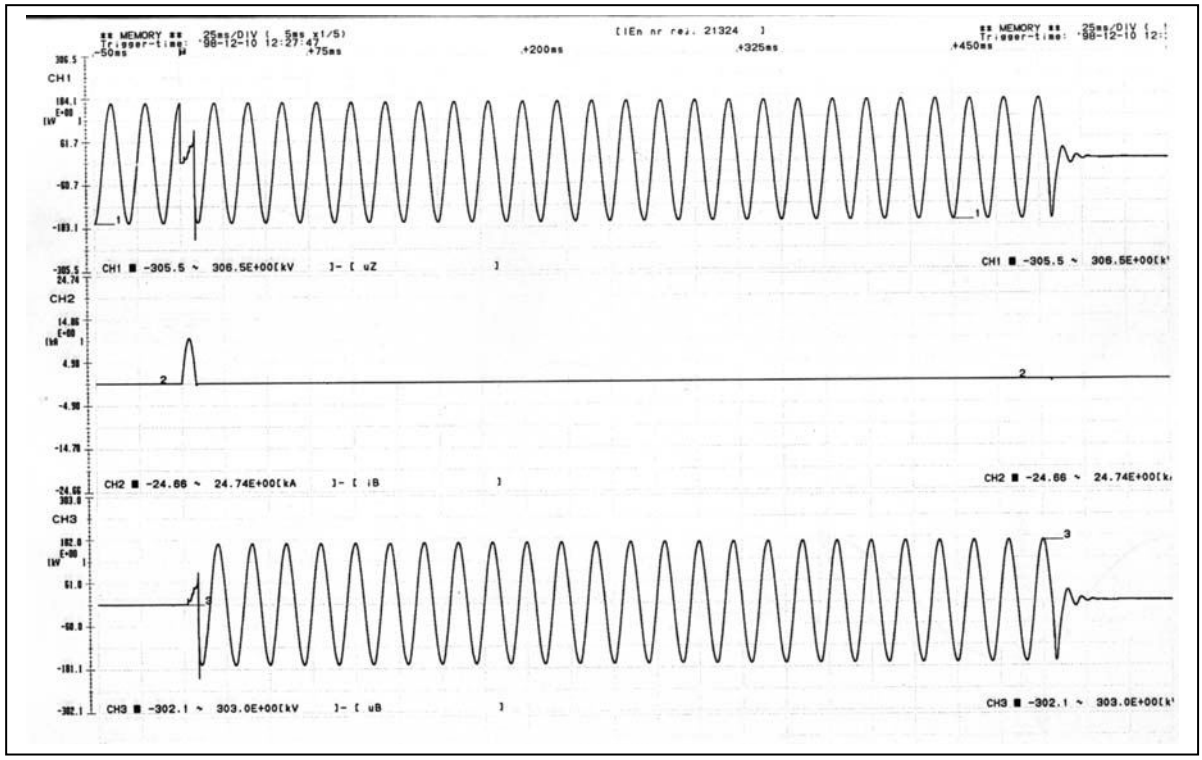

Fig. 7 Breaking capacity test of WZZw-12 High Voltage Protective Assembly, with fuse base PBGw 1-12, fuse carrier OWBGw6-12 and fuse link 40A.

Test voltage 12 kV, prospective short circuit current 8.27 kA, making angle 90º, arcing time 8.3 mS.

Breaking capacity test of I_1 current performed by The Institute of Power Engineering in Warsaw, Distribution Equipment Laboratory, by the courtesy of The Laboratory.

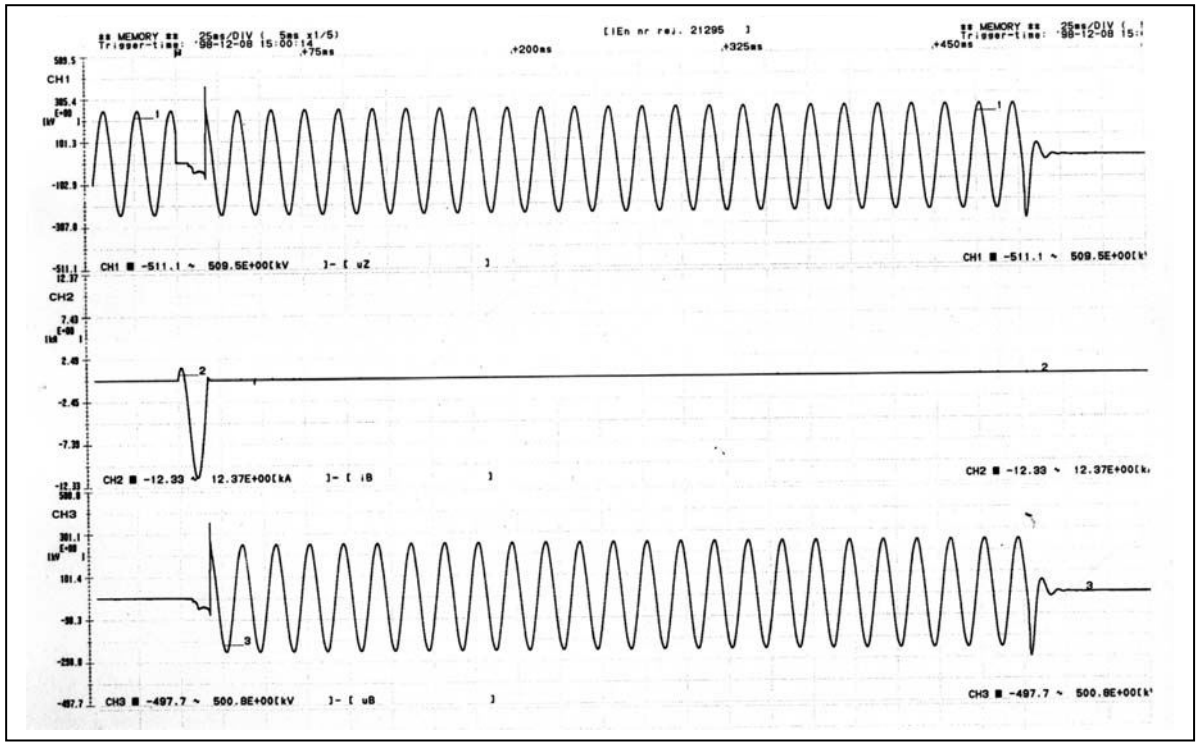

Fig. 8 Breaking capacity test of WZZ-17.5 High Voltage Protective Assembly, with fuse base PBG1-17.5, fuse carrier OWBG2-17.5 and fuse link 40A.

Test voltage 17.8 kV, prospective short circuit current 5.03 kA, making angle 142º, arcing time 17.8 ms.

Breaking capacity test of I_1 current performed by The Institute of Power Engineering in Warsaw, Distribution Equipment Laboratory, by the courtesy of The Laboratory.