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„Selection and application of overhead (aerial) low-voltage surges limiters on the example of ETITEC limiter manufactured by ETI POLAM"

The scope of the following article is reader introduction into problems concerning over-voltage protection accomplished in open wire power networks nn. In available professional literature one can find many articles concerning the multistage over-voltage protection in facilities, however comparatively there is little the information in relation to first-degree protection, which is the limiter of the class A, installed in places such as S/N transformer, across the a whole distributing power network nn and open wire lines of the buildings.

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1. INTRODUCTION

The analysis of threats coming from atmospherical, connecting and induced surges, etc. should not be carried through pure and simple within the area of the closed facility. Within the multistage surge protection framework, as the first degree of protection, the aerial limiter of the class A (according to VDE 0675) should be provided. Therefore the surge protection analysis should take into account also this degree of protection, all the more, that the surges limiters offer for such applications systematically expands, offering for customer every now and again more new solutions and better parameters. An example of such solutions is introduced surges limiter type ETITEC A, manufactured by ETI Polam along with many versions of clamps (connectors), which are described in the further part of this article.

Application of class A limiters notably improves working conditions of the nn power network and perfectly harmonizes the cooperation of the multi surge protection with further degrees of protection (limiters of the class B , C ... etc.). Therefore also the necessity of the usage suchlike protection in the connection with following degrees of protection and also with the surge protection in medium voltage networks.

2. NORMALIZATION CONDITIONS

Until now, for research and classification purposes of surge nn limiters adopted norms, in consideration of the lack of the suitable norms concerning low-voltage limiters. These norms are: IEC 60099-1 and IEC 60099-4. These norms refer to spark-less surge limiters type SN and WN (IEC 60099-4) and spark limiters (IEC 60099-1).

Norms which are obligatory within the whole range of surge nn limiters are divided in two categories:

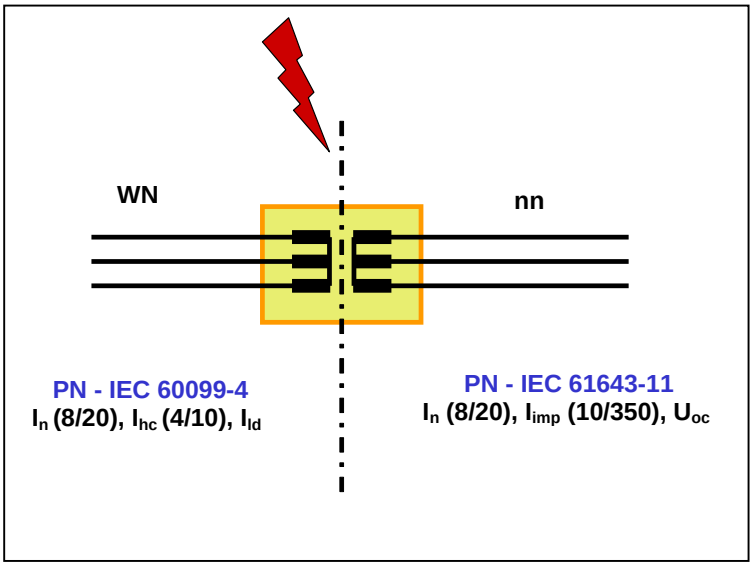
- l - concerning protecting devices;
- ll - concerning applications.

In category l of norms is the norm: VDE 0675, which first introduced concept of the multistage surge protection, but which refers first of all to interior limiters, beginning from class B. A key of the classification in this case, is the limiter installation place.

Second, and in present moment a most important and obligatory normative act, is the norm IEC 61643, with changes (Polish edition PN-IEC 61643). A key of the devices classification (called in this instance SPD - Surge Protection Devices), is the class of tests in the dependence from the internal construction: Class I, II or III of tests.

The category II of normative acts refers to applications of surge limiters in nn power network. To these category belongs norm PN-E-05100-1: 1998 which refers to the aerial power networks and „Surge Protection of the electro-energetic networks. Document “Executive advices” issued by PTPIREE, which are in principle a continuation of the document confirmed by the Department of the Energetic and The Atomic Energy - „Surge Protection of electro-energetic networks. Executive advices to Regulations to the Construction of Electric Devices". These two documents, at present, underlie the application of surge limiters, including surge limiters type nn. To two above described documents belongs also norm PN-IEC 60364-4-443. In case of the surge protection, this norm refers, except to the other problems so-called surges category, but only to electric installations in facilities, beginning from the surge category I to IV.

Fig. 1 Norms concerning surge limiters



3. SELECTION OF THE LIMITERS TO PARTICULAR POWER NETWORK CONDITIONS

The correct selection of surge limiters should consider at least basic parameters, which are:

) continuous working voltage Uc (in the dependence of the power network type);
a) rated discharge current In;
b) maximum discharge current Imax (relatively Iimp);
c) surges endurance TOV;
d) voltage level of the protection Up;
e) operational temperature range;
f) kinds of connections clamps (connectors).

Ad. a) Continuous Working Voltage Uc -- this is the maximum efficient value alternate voltage or the maximum constants voltage, which can be applied continuously to the limiter. This voltage is equal to the rated voltage. This voltage is very crucial to the vitality and the efficiency of the varistor surge protection limiters, which are now the most practical type of limiters. The above mentioned norm (PN-E -- 05100-1) and "Executive advices” are recommended for limiters with Uc=500V, but "Executive Advices” supplement this

information, that in secondary circuits for signaling and lighting purposes, application of limiters with Uc=280V is allowed. ETITEC type surge limiters are using both these voltage values, and also Uc=660 V (see the Table 1). Rules of the selection given in both documents are limited, because continuous working voltage should be defined in dependence of the power network type according to following formula:

$$Uc \geq UmSURGE$$

Where Um - is the highest value of inter-phase voltage, which may appear in normal working conditions of the power network.
Detailed information is given in the Table 2.

Ad. b) Rated discharge current In - this is the current peak value in limiter with 8/20 μs shape. This value is used for classification of the limiter in class II tests and for so-called conditioning of the limiter in Class A and II. A most often used value In is 5kA. Etitec A limiters are also available in 15A version, whose usage is described in the next chapter.

Ad. c) Maximum discharge current Imax, this is the current peak value in the limiter with shape 8/20 μs and the size in compliance with a operational tests sequence for the class II. Imax value is greater than In (usually at least twice) and is declared by the manufacturer. This value is used in the tests, to prove the correct operation and the thermal stability of the limiter. The selection of this parameter is in principle a secondary matter , because it gets out of the selection of the previous parameter, which is In. Etitec A limiters have Imax value equal to 10 or 30 kA.

Ad d) TOV over-voltage (surge), this is so-called the dynamic (TOV - Temporary Over-voltage) over-voltage and in the norm PN-IEC 61643-1 is defined as follows: this is the maximum efficient value of alternating or stable over-voltage, which exceeds the maximum continuous working voltage in power network over the definite period of time. Used over-voltage limiter must have higher TOV surge endurance, than liable to appear in the power network surges, in compliance to following formula:

$$U_T \geq U_{TOV}$$

Where:
U_T – over-voltage endurance of the limiter TOV (kV)
U_{TOV}- TOV over-voltage value, occurring in the power network (kV)

Table 3 shows norm requirements in this range.

Ad e) Voltage protection level Up is a parameter characterizing the limiter operation within the range of efficiencies in voltage limiting on the clamps of the limiter. This value is given by manufacturer.
A general rule of the selection is, that Up value of the limiter used in the open wire line nn was lower than 6kV (for 230/400 V power network), as a practical rule, limiters have considerably better Up values, eg. for Etitec′a And - Up value is ≥ 2, 0 kV (Uc=500V, In=15 kA). The smaller Up value the better protecting proprieties of the limiter. This why always is recommended special care in selection of as lowest as possible Uc value, because the smaller Uc level the better Up value. Up parameters of the ETITEC A over-voltage limiter are listed in the Table 1.

Ad. f) Working temperature range refers to resistances of the over-voltage limiter during unprofitable (bad) weather conditions. This demands from manufacturers construction of

100% hermetic limiters, but also to apply suitable materials, resistant on jumps of the temperature. The over-voltage limiter must have the wider working temperature range, than liable to appear in his working environment. The working temperature range of ETITEC A limiters are in the following ranges: from - 40 °C up to +80 °C.

Ad. g) Linear Clamps {Connectors}, in the dependence of the version, are intended to other type of wires. Detailed solutions are demonstrated in the Table 4. Generally, different versions of the limiter type ETITEC A are designed for power network with „naked" lines - without the isolation or for the network with lines in the isolation (the type AsXSn). There is also available „universal l (Fig. 5) version", which serves exclusively to the exchange of limiters which became worn out after the many years′- exploitation and after screw out of "old one", this version is screwed in, without the need of the exchange the all complete set with the clamps {connectors}.
The earthing clamp {connector}PE is adapted to connecting directly to the flexible earthing line Al or Cu to 25 mm2.

Tabela 1. Basic parameters for over-voltage limiters type ETITEC A

Technical parameters	**ETITEC A 280/5**	**ETITEC A 500/5**	**ETITEC A 660/5**	**ETITEC A 280/15**	**ETITEC A 500/15**	**ETITEC A 660/15**
Continuous working voltage Uc [V]	280	500	660	280	500	660
Rated discharge current In [kA]	5	5	5	15	15	15
Max. Discharge current Imax [kA]	10	10	10	30	30	30
Protection level Up for given value In [V]	950	1500	1750	1600	2000	2200
Working temperature range [°C]	-40 ÷ +80					
Equipped with disconnector	no	no	no	yes	yes	yes

Table 2. Selection of continuous working voltage Uc in dependence of network type and limiter connection method.

Network configuration/ connection method	TN-S	TN-C	TN-C-S	TT	IT
Between phase (L1, L2, L3) and PEN wire or PE relatively N	280 V	280 V	280 V	280 V	500 V
Between phases L1, L2, L3	500 V	500 V	500 V	500 V	500 V

Table 3. Extract from requirements according to TOV surge endurance of over-voltage limiters (for 230/400 V power networks)

Method of limiter connections	**Minimal voltage value U_T endured by limiter in period of 5 sec.**	**Minimal voltage value U_T endured by limiter In the period of 0,2 sek.**
TN Configuration		
L-(PE)N or L-N	333,5 V	-
TT Configuration		
L-PE	398,4 V	1430 V
L-N	333,5 V	-
N-PE	-	1200 V
IT Configuration		
L-PE	-	1430 V
L-N	333,5 V	-
N-PE	-	1200 V

TN, TT and IT Configuration		
L-PE	398,4 V	1430 V
L-(PE)N	333,5 V	-
N-PE	-	1200

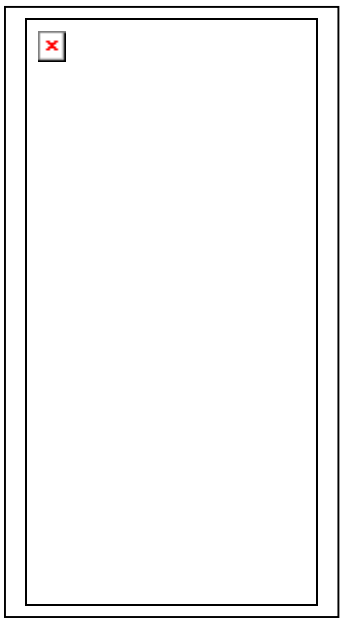
Table 4. List of linear clamps (connectors) used in over-voltage limiter type ETITEC A (500/5 without disconnector and failure indicator)

Signature	Type of linear clamp	Application	Photo
ETITEC A .../.../A	**Corrosion resistant metal connector**	**„Naked" lines up to 120 mm^2**	
ETITEC A .../.../B	**Double connector cutting-through isolation in both sides**	**Line with wires with isolation. Ideal for connections, using wires in insulation. May work also as single connector. Wire diameters: up to 95 mm^2. Torque: 22 Nm**	
ETITEC A .../.../C	**Double connector cutting-through isolation on one side**	**Lines with wires in insulation. Ideal for connections in open wire lines using "naked" wires, with wires in insulation. May work also as single connector. Wire diameters: up to 95 mm^2. Torque: 22 Nm**	
ETITEC A .../.../D	**Outlet in form of ASXSn wire 16 mm^2, 200 mm long**	**Adapter for work in insulating lines with majority of double cutting-through connectors.**	
ETITEC A .../.../E	**Pin M8**	**„Universal" version, which is needed in case of equipment exchange. There is no need to exchange the whole set with linear connector.**	

4. APPLICATION AND ASSEMBLING ADVICES

Fundamentals of open wire lines over-voltage limiters usage are described in above mentioned norm PN-E-05100-1; 1998 and in „Advices ...” given by PTPiREE. Generally, the complete sets of over-voltage limiters should be installed in:

- SN/nn transformers - on the secondary side of the transformer (reasonable in this case is installation of limiters with Uc=500 V in consideration of possible voltage oscillations level and with In= kA in consideration of the transformer cost and considerably better abilities to hold out the energy absorbed by the limiter 15 kA and finally the more efficient protection of the transformer);
- every passage of the open wire line into cable- and vice versa;
- every open wire connection, unless is fulfilled the condition, that over-voltage limiters are installed on the distance not longer than 300m;
- if we deal with the extensive open wire line, then we should to comply with above mentioned condition of 300m, i.e. that the maximum distance between complete sets of limiters is not longer than 300m;
- versions with the switch (O) Fig. 2, which serves also as failure indicator, should be installed in places, where particular sections of the network are overhauled, because for switch off devices of the earthing short-circuit in case of limiter damage, short-circuit caused by this kind of the limiter can be „read-out” as transient short-circuit and the phase can stay without the protection.



Rys.2 Version ETITEC A 15 kA – O of the limiter with disconnector and clamp for non-insulating line

The most important assembly advices are given below:

- The distance between a limiter and a protected device must be smallest (eg. limiters used for transformers protection should be installed directly on the transformer);
- Particular sections of earthing lines must be not smaller than 10mm^2 (Cu) and 16mm^2 (Al);
- wires connecting the limiter with the protected phase line and the earth should be as shorter as possible, because of postponements on them voltages of several hundred kV (Fig. 3) during the flow of percussive currents;

- limiters installed in lines should be located in places of the earthing the protective PE line or protective-neutral line PEN. In other cases earthing must be performed in such way, that PE or PEN wire is connected to the earthing clamp of limiter;
- Resistance of over-voltage limiters should be not greater than 10 Ω,
- versions of limiters with the switch must be earthed via flexible line (thin wire). Usage of the hoop iron or stiff lines is inadmissible .

5. CONCLUSION

This article brings into question basic problems of the selection and the usage of open wire lines over-voltage limiters type nn ETITEC. Author did not scooped the whole problem, because were describable the all matter of other such problems as: the origin and kinds of surges, the classification of over-voltage limiters in compliance with PN-IEC 61643-1, description of requisite tests of limiters, the selection for energy- endurances or the co-ordination between limiters and their usage in the power DC networks.
However, the author tried to show, that there existing simple and strait criteria of the selection of open wire lines surge limiters on the example of ETITEC A limiter manufactured by ETIPolam. He gave also basic data, which is very essential to accomplishment of the correct selection. Essential are also advices concerning usage and assembly. Special attention deserves the fact, that these limiters are a requisite degree of the protection in the idea of the multistage surge protection systems and their installation perfectly harmonizes and improves the work of limiters already used in building facilities.

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Fig. 3 Typical values for lightning (rod) currents :

Shock current i_b = 20 kA => $i_b / 2$ = 10 kA
Line wave impedance Z_w = 400 Ω => U_v = 4000 kV

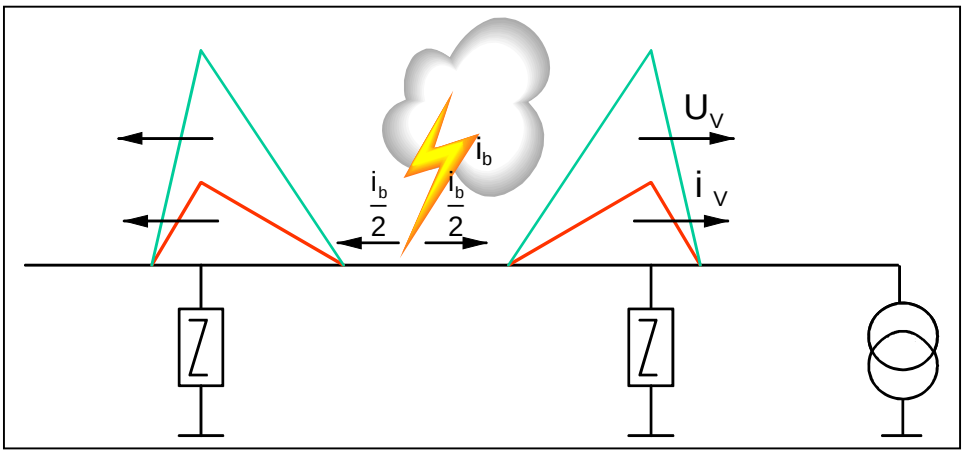

Fig. 4 ETITEC A limiters with clamp B for insulating line

Fig. 5 ETITEC A limiters for non-insulating line