ASSESSMENT OF HIGH VOLTAGE EQUIPMENTS OPERATIONAL RELIABILITY WITHIN THE MANAGEMENT OF BRASOV SDEE

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Abstract: This paper gives a summary of operational reliability results carried out on high voltage equipment (HVE) that are in Brasov SDEE management. The paper is structured in four parts. In the first part is made a brief presentation of HVE that are in Brasov SDEE management. The second part present the important elements that characterize the HVE operational reliability study. Part three summarizes synthetically the results of the analysis. It presents the values of the HVE operational reliability indicators in the period under review (2003-2010). The comments are about defects types, number of events and their hierarchy. The last part presents the conclusions of the analysis.

Key words: operational reliability, high voltage equipment, reliability indicators.

1. THE STRUCTURE OF HVE FROM BRASOV SDEE

The importance of operational reliability studies is well known [1, 2, 3]. The paper continues previous research of the authors [1, 4] and is devoted to evaluation of the main indicators of operational reliability of medium voltage equipment in an electricity distribution subsidiary.

The volume of installations that are in Brasov SDEE management includes the following components:

- 30 power substations, of which 10 stations of 110/6 kV , 10 substations of 110/20 kV and 10 substations of 110/20/6 kV. Of them ,the substations with the largest volume of installations are: substation 110/27,5/20/6 kV Zizin with a number of 23 bays of 110 kV high voltage and substation 110/20/6 kV Făgăraş with a number of 16 high voltage bays,
- 65 power transformers of 110/ MT;
- 623 measuring transformers,
- 114 HV electrical breakers.

The volume of power transformers that are in exploitation of Brasov SDEE, depending on the nominal voltage and nominal power is shown in fig.1 and 2.

In fig.3 presents the volume of measuring transformers according to their functional type (VT and CT). Breakers volume under review is presented according to their constructive type of them in fig.4.

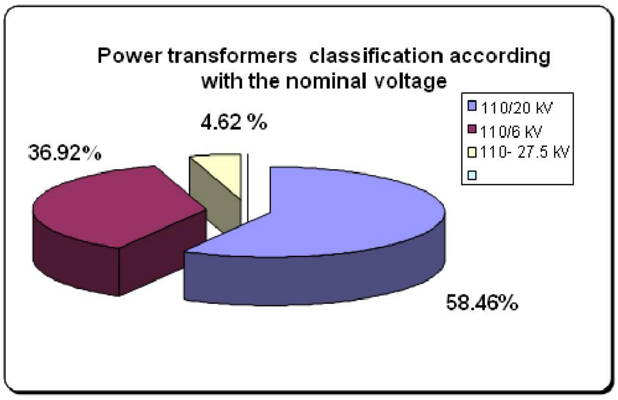

Fig. 1. The volume of power transformers according with the nominal voltage

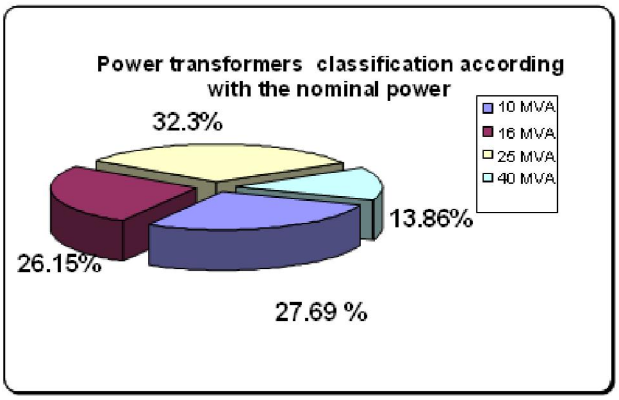

Fig. 2. The volume of power transformers according with the nominal power

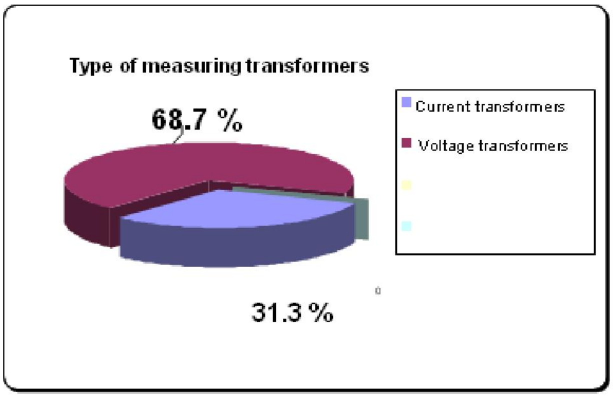

Fig. 3. The volume of measuring transformers according of their type

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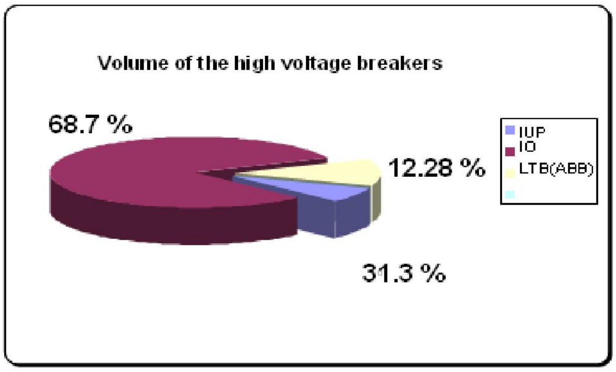

Fig. 4. The volume of high voltage breakers according with their type

2. THE IMPORTANT ELEMENTS WHICH CHARACTERISING THE OPERATIONAL RELIABILITY STUDY OF HVE

The study is based on analyze of all the events that took place in Brasov Distribution System in period 2003-2010. For this purpose were included and the events that took occurred on the power line connected to these substations, both on the upper and lower voltage level of the voltage. The events occurring on the power lines have influence on the behavior of the electrical equipments from substations in terms of their application. Also the proper functioning of equipment from substations (specially the switching equipment) leads to the removal as soon as possible of defects from these electrical lines by limiting the consequences of these faults. In that way a double bound is created between the electrical equipment from substations and power lines connected to these stations.

Electrical equipment that are analyzed in detail are: power transformers, measuring transformers voltage and power) electrical breakers and their actuators.

Global indicators of presented equipments are evaluated above:

- $\upsilon(T_A)$ – annual number of events;
- $\beta(T_A)$ – annual period of unavailability.

There have been made hierarchy for the analyzed equipment as follow:

- number evolution of defects;
- chance of occurrence of the defect ;
- impact of failure in terms of main components of the HVE.

3. THE RESULTS OBTAINED BASED ON THE STUDY

Figure 5 presents the evolution of $\upsilon(T_A)$ indicator and figure 6 shows the development of $\beta(T_A)$ indicator with reference to all power substations and all power lines connected to these stations broken down by years of study. The analysis was based on events recorded under control points.

Analyzing the events occurred in function to the occasion of their appearance (fig. 7), we obtain the following distribution areas:

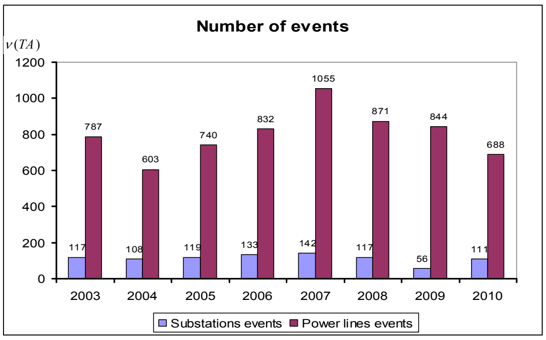

Fig. 5. The evolution of $\upsilon(T_A)$ indicator in period of analysis

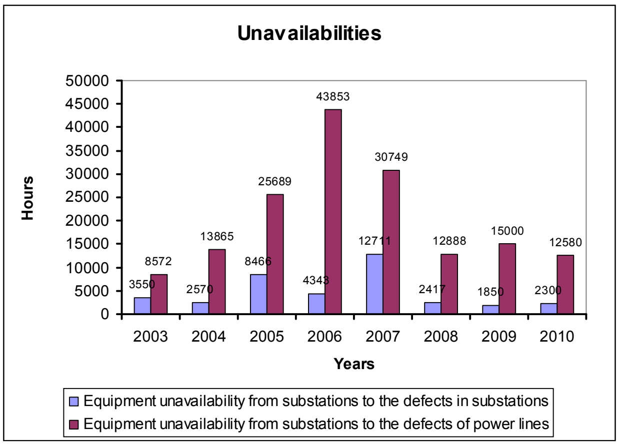

Fig. 6. The evolution of $\beta(T_A)$ indicator in period of analysis

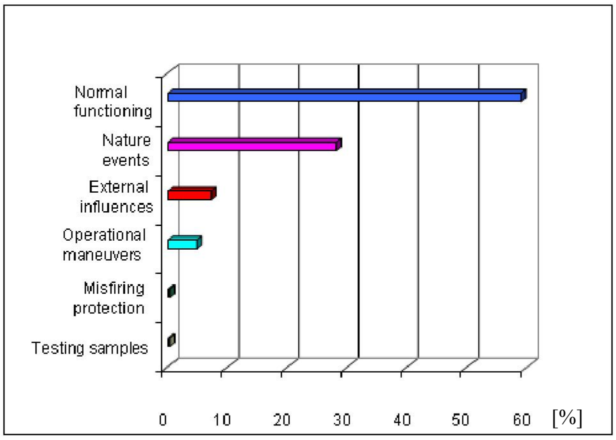

Fig. 7. The distribution of the events depending of their appearance

3.1. Calculation of global indicators for operational reliability of electrical equipment

Based on data systematized in the characteristics of each event were calculated the indicators of operational reliability for key equipment: power transformers, measuring transformers, breakers.

A. Power transformers

The number of power transformers defects is small compared with other equipment from substation. The distribution of the relativ number of events/defects is presented in figure 9.

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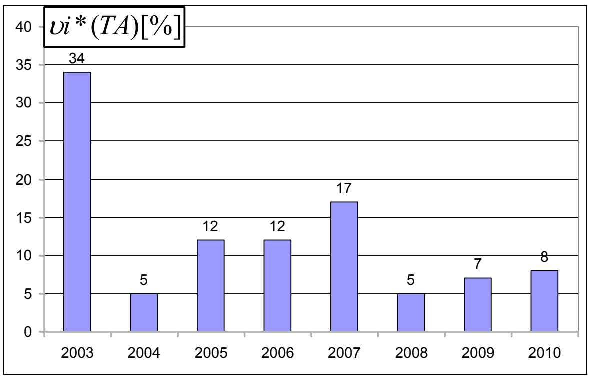

Fig.9. Distribution defects relative number of power transformers

Table 1 presents the main reliability indicators in experimental values for power transformers. The indicators were calculated based on formulas from the literature [1], [2] , being presented the characteristic data years 2003, 2005, 2008.

Making a breakdown by components of faults appeared to the power transformers, result the distribution defects relativ number of components from fig.10.

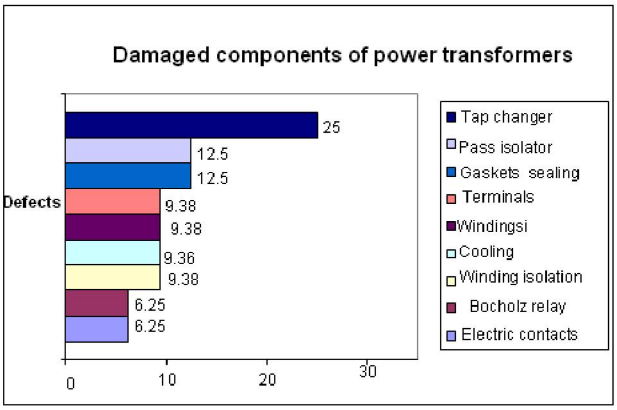

Fig. 10. Ranking the elements of power transformers in terms of impact of their failure

B. Measuring transformers

The distribution of failure relative number of measuring transformers, depending on their type –current and voltage, is shown in figure 11.

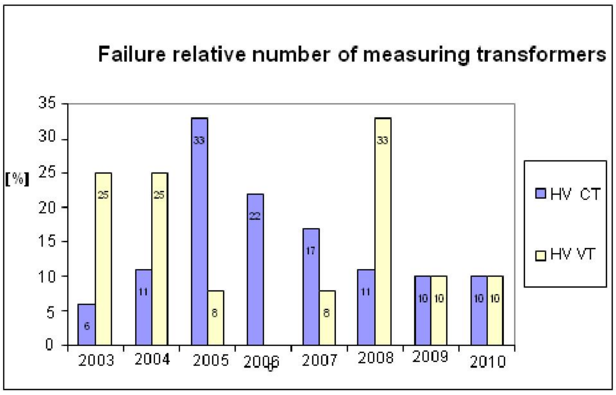

Fig.11. The distribution of failure relative number of measuring transformers

In second tabel are shown the main reliability indicators in experimental values for measuring transformers.

Watching the failure by components of measuring transformers, the result represent the distribution of failure relative number by components of measuring transformers.

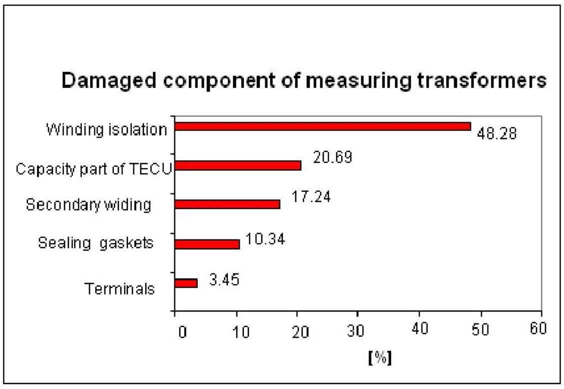

Fig.12. Elements hierarchy of measuring transformers – current and 110kV voltage in terms of their failure impact

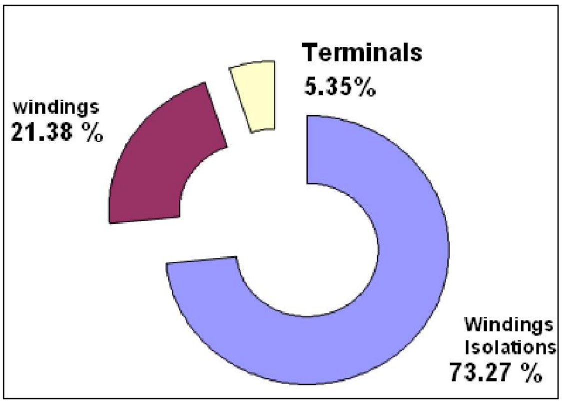

Fig.13. Elements hierarchy of measuring transformers – current and voltage in terms of their failure impact

C. Electric breakers

An important part of the failurs of the electric breakers from the substations has occurred as a result of their applications based on the defects from the power lines. In this respect, result the distribution of requests relative number from figure 14.

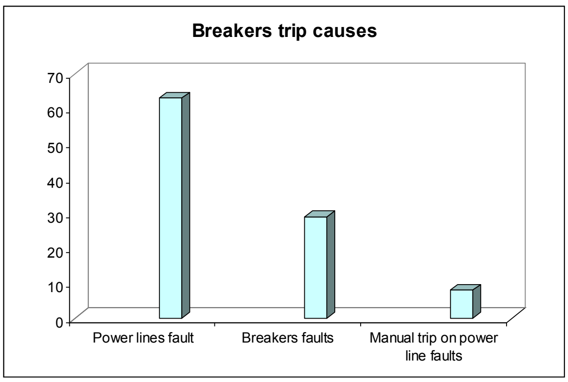

Fig.14. The distribution of requests relative number of breakers based on the defects from power lines

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Hierarchy of defects relative number of breakers is shown in figure 15.

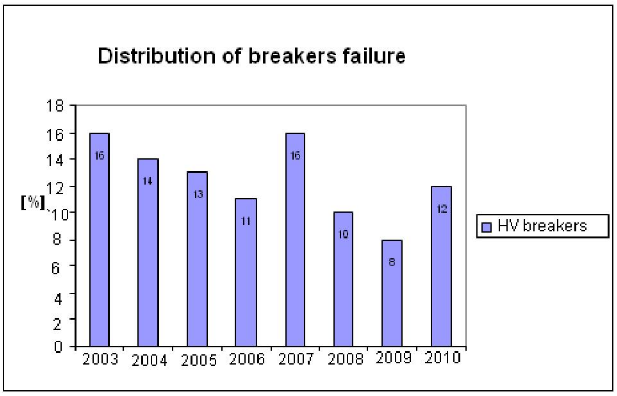

Fig.15. The distribution of defects relative number of breakers

In the third tabel are presented the main reliability indicators in experimental values for breakers.

Making a breakdown of defects by components of electrical breakers results the hierarchy of events relative number (fig.16), respectively the distribution of unavailability relative duration (fig 17).

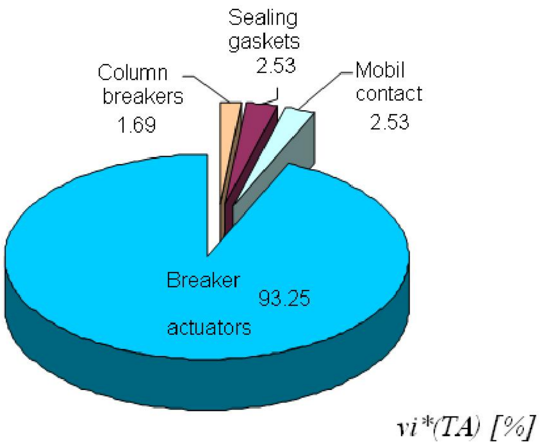

Fig.16. The distribution of relative number events at the level of electrical breakers from substations

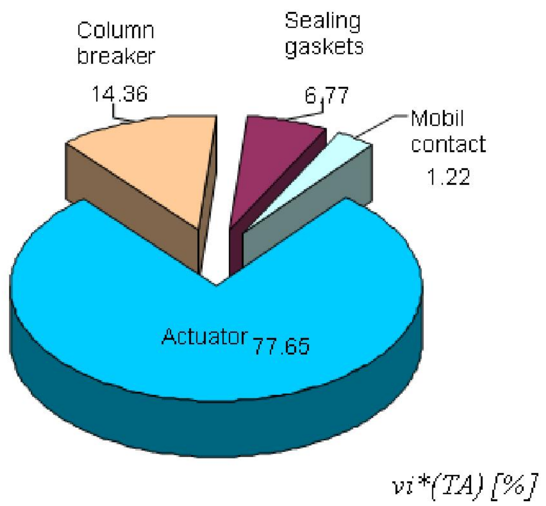

Fig. 17. The distribution of unavailability relative duration at the level of electrical breakers from substations

It can be observed that an impoertant part of the breakers defects are caused by the actuators failure. Following results the distribution of events relative number and the unavailability relative duration. (fig. 18, 19)

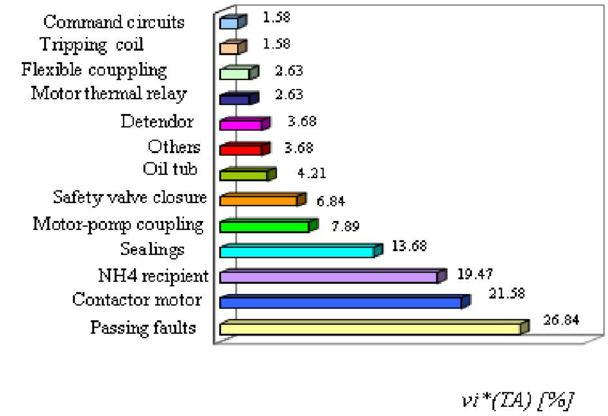

Fig. 18. The distribution of events relative number at the level of actuators of breakers from substations

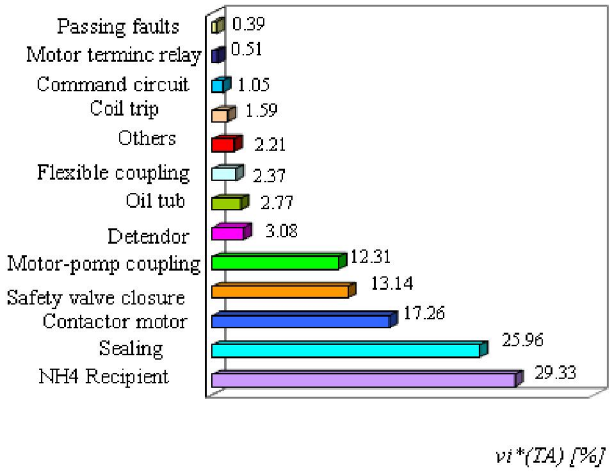

Fig. 19. The distribution of unavailability relative duration at the level of actuators of the breakers from substations

3.2. Evolution of the operational reliability of analyzed equipment

Based on existing statistics during the analysis, we determined the values of operational reliability function [$\hat{R}$ (6)], in accordance with the model presented in [1]. The results are shown in Fig. 20.

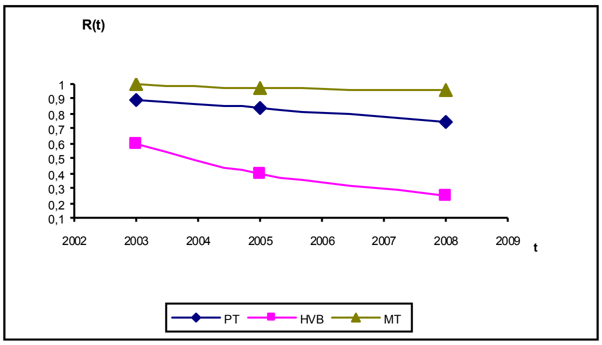

Fig. 20. Evolution of reliability during analysis

By processing the statistical data obtained from monitoring the operation of medium voltage equipment in SDEE Brasov, using the FRVA [1] or determined expressions of random variable distribution functions for the proper functioning (TBF). Here is the pointer expressions F (t) for the theoretical distribution that more accurately reflects the empirical distribution:

- For TP:
  - Exponential:

$$1\text{-}\,e^{-2.61\cdot 10^{-5}\cdot t} \qquad (1)$$

- For MT:
  - Exponential:

$$1\text{-}\,e^{-2.34\cdot 10^{-5}\cdot t} \qquad (2)$$

- For HVB:
  - Normal:

$$\frac{10^{-5}}{0.107\sqrt{2\pi}}\int_{-\infty}^{t} e^{\frac{(z-6384.93)^2}{2\left(0.107\cdot 10^5\right)^2}}\cdot dz \qquad (3)$$

4. CONCLUSIONS

After analyzing the operational reliability of high voltage equipments from the substations related to EDTS – Brasov SDEE results the following conclusions:

1) The events number from substations has increased significantly until 2008 and then was followed by a sharply decrease. This trend is followe by the unavailability duration too. The decreased of events number is coinciding with two moments, namely:
   a. Installation of a significant number of reclosers on OHL 20kV, and also the RED MT modernization (transformers and medium voltage network), which determined the decreas of defects number in substations.
   b. Changing the organization of society by founding 110 kV Tehnical direction aims the high voltage management, which determined the modification of maintenance strategies regarding the equipments.

2) The vast majority of events occurred after the normal operation of the plant. This was due to aging equipment that had a exceeded lifetime. In this respect the analysis underpinning the operational reliability of maintenance and refurbishment of electrical installations.

3) The main weak components regarding the exquipment examined are:
   a) For transformers – tap changers. To reduce wear tap changers should be made a detailed analysis of the values needed for the power strip, both as time and as reference value.
   b) For the measuring transformers – winding insulation. In this respect it is proposed to extend the types of preventive measures on their equipment. For that is necessary to provide the bands with modern equipment and also training the staff in accordance wih the equipment used.
   c) For breakers – the actuators. Considering the exceeded lifetime of the high voltage breakers it is necessary a detailed analysis for all the actuators, respectively replacing the components which are unsafe when functioning.

As a follow of this results,in the investment program for 2011 were introduced actions to improve the high voltage equipment reliability from the substations.

According with this action we are reminding: establishing an frequently predictive programm of maintenance, replacing the breakers and measuring transformers with low reliability and to promote the modernization of substations.

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