CHARACTERISTICS OF FAULTS IN SYSTEMS FOR DISTRIBUTION OF ELECTRICITY

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REZUMAT. La etapa actuală în sistemele electrice de distribuţie au loc un numar mare de refuzuri, condiţionate de diferiţi factori de influenţă. Asigurarea continuităţii alimentării cu energie electrică este o problemă stringentă pentru sistemul energetic. Sporirea fiabilităţii sistemelor de distribuţie poate fi realizata numai în bază de cunoaştere profundă a factorilor, ce sunt cauză a refuzurilor, ale echipamnetelor instalate în aceste sisteme, ceea ce-ar permite o planificare justificată a activităţilor serviciilor de exploatare. Această lucrare este consacrată aprecierii comportamentului factorilor de influenţă asupra procesului de distribuţie a energiei electrice în vederea elaborarii mecanismului de asigurare a continuităţii acestui proces.

Cuvinte cheie: sisteme de distribuţie, factori aleatori de influenţă, fiabilitatea sistemelor de distribuţie.

ABSTRACT. At the present stage in the distribution systems of electric power take place a significant number of refusals, conditioned by various random factors of influence. The ensurance of continuity of electric supply to consumers is a very current issue for the power system. To increase the reliability of distribution systems is absolutely necessary to know the factors that cause the refusals of the installed equipment and their characteristics for planning grounds, technical, operational services activities.

This paper is devoted to assessing behavioral factors of influence on the process of electricity distribution and production of mechanism to ensure the continuity of this process.

Keywords: distribution systems, random factors of influence , the reliability of distribution systems.

1. INTRODUCTION

In the electrical distribution systems take place a significant number of refusals, which affect the reliability of electricity supply to all consumers. Factors that determine the behavior of these interruptions and determine their level of influence on the reliability of equipment installed in distribution systems, permit the development of the mechanism for ensuring continuity of electricity supply to consumers.

Causal factors of refusals and their impact on the reliability of distribution systems are currently not studied at the level stipulated by documents in force as to indicators of reliability [1], [4], [5]. Ensurance of continuity of quality power supply of consumer can be achieved only on the bases of profound knowledge of the phenomena that accompany this process, which permits a justified planning from technical and economic point of view, measures and activities of exploitation services of distribution systems in view to ensure the normal indicators of reliability [2], [3], [5].

2. OBJECTIVES OF WORK

This paper aims to determine the behavior of the factors of influence on the reliability of distribution systems and supply of electricity to consumers, with the objectives of the development of criteria for processing experimental data on refusals in the operation of these systems in order to determine the mechanism of projection and ensuring the reliability level of electricity supply to consumers.

3. MATERIALS AND METHODS

To determine the behavior of the factors of influence on the process of electricity supply of consumers all interrupts that have occurred in republican electrical distribution systems have been recorded. Records were made during the seven years (2005-2011).

To determine the causal factors of interruptions, the concept of analysis and systematization of experimental data on refusals of electrical distribution systems and the scheme of the classification of cuts was developed, which gave the opportunity to highlight factors influencing the process of electric supply.

As a result were determined 12 random factors that generated the appearance of refusals in the operation of the distribution systems and influenced the process of supply of electricity to consumers of all categories of reliability.

To assess the behavior of examined factors of influence the analytical algorithm for calculating the level of reliability that systematizes the sequence of operations performed in the assessment of reliability was developed. The algorithm for calculating and forecasting the reliability of distribution systems consists of the following operations:

- Selection and processing of experimental data on refusals of electrical distribution systems;
- Classification of interruptions according to the character of their origin (planned, random and maneuvers);
- Classification of random refusals according to the factors of influence for each system and season;
- Reporting of random refusals to a specific unit of length (100 km network);
- Establishing of regularities of occurrence of breaks and their parameters (X media, D, σ, V, X min, X max, K l. up, K l. down);
- Determining the basic indicators of reliability of distribution systems (λ, μ, τ, T med);
- Estimate the ponderabilities of factors of influence on the reliability indicators ($Kp._1$, $Kp._2$, $Kp._2$,, $Kp._{12}$);
-Prognosis of factors of influence and of the parameters of conditioned breaks.

Based on the foregoing, the random factors were examined taking into account three parameters:

- Frequency of appearance of conditioned refusals in the distribution systems for each season;
- Duration of these refusals;
- Number of energy consumers affected.

For processing characteristic information referring to conditioned refusals of the examined systems, based on a standard method of analysis and calculation, the concept of assessing the behavior of factors of influence by using the concept of a specific unit of length (100 km of network) was proposed, which allows to determine and compare the influence of these factors on the actual level of reliability for all electrical networks, regardless of their summary length.

In assessing the reliability of electric distribution systems and determining the behavior of the factors of influence were used: graph theory and matrices, probability theory, statistical analysis methods and processing of experimental data on refusals in the distribution systems, theory of linear equations and nonlinear, mathematical modeling, computers with software, ,,Microsoft Excel", ,,StatGraphics", ,,Curve Expert", ,,EasyFit 5.5 Professional".

4. MODEL RESULTS

Using the classification scheme and the concept developed for processing of interruptions, the frequency of appearance of refusals due to each random factor, for 100 km of line, for each system depending on the season was determined. All this has made it possible to simplify the calculation and determine the distribution of interruptions for all random factors of influence, depending on frequency of appearance per system and season, for determining the complex structures and to frame measures to increase the reliability of distribution systems.

It was established that to prognosticate the behavior of random factors on the reliability of electricity distribution systems, it is imperative to determine the distribution laws of refusals caused by respective factors and parameters of these distributions. In accordance with the observed the experimental distributions and theoretical were considered for the following indicators: frequency of refusals on the system and season, length of refusals and number of consumers disconnected.

To determine the parameters of distributions refusals depending on their appearance per system and season the frequencies of their appearance for 100 km of network were analyzed, for all factors of influence.

The values of examined parameters in accordance with the developed criterion allow to predict which is the expected number of interruptions caused by each random factor in part in the 100 km network, in any distribution system. The use of the criterion of prognosis has the margin of error of 5% and makes it possible to establish the mechanism to ensure continuity of supply of electricity to consumers.

As a result of processing of experimental data, it was found that the random interruptions from the point of view of their occurrence per system and season is characterized by Normal-Gaussian distribution for all 12 factors of influence. This allows to examine the results regarding the processing of refusals as a consistent set of data belonging to the same community.

In Table 1 are developed mathematical models and their parameters, determining the laws of experimental and theoretical distribution of random interruptions by duration.

Table 1.

Mathematical models that determine the behavior of factors of influence depending on the length of refusals

No.	Factors	Type of function	Mathematic model	Parametres of mathematical model			
				a	b	c	d
1	Acts of vandalism	Weibull	$y = a - be^{-cx^d}$	539,34	536,02	3,54	-2,07
2	Actions of animals and birds	Weibull	$y = a - be^{-cx^d}$	1611,64	1681,86	0,23	-0,56
3	Actions of mechanisms	Weibull	$y = a - be^{-cx^d}$	275,12	271,17	4,46	-2,42
4	Damages caused by vegetation	Weibull	$y = a - be^{-cx^d}$	507,71	503,03	5,28	-2,29
5	Quality of electric energy electrice	Weibull	$y = a - be^{-cx^d}$	221,52	219,37	4,13	-2,18
6	Climatic conditions	Lognormal 3-parametres	$y = e^{a+b/x+c\ln(x)}$	11,57	-3,40	-2,28	-
7	Defects caused by Consumers	Weibull	$y = a - be^{-cx^d}$	1206,12	1196,70	3,24	-2,11
8	Defects in equipment	Lognormal 3-parametres	$y = e^{a+b/x+c\ln(x)}$	11,74	-3,97	-2,19	-
9	Defects in transport networks	Weibull	$y = a - be^{-cx^d}$	295,68	292,83	4,87	-2,28
10	Defects at PDC	Weibull	$y = a - be^{-cx^d}$	1167,29	1168,84	2,23	-1,80
11	Errors of exploitation	Exponential	$y = ae^{b/x}$	1,58	4,48	0,00	0,00
12	Unstated factors	Weibull	$y = a - be^{-cx^d}$	3663,49	3609,07	46,88	-2,94

The developed mathematical models confirm that the 12 factors of influence, in terms of the duration of caused interruptions have different behaviors. From the above it can be concluded that 9 of them (vandalism, animal and bird action, the action of different mechanisms, damages caused by vegetation, power quality, defects caused by consumers, defects in transport networks, defects at PDC, unstated factors) are characterized by Weibull type of distribution law, two factors (defects in equipment, climatic conditions) have a type of Lognormal distribution (3 parameters) and a factor (operating errors) is of an Exponential distribution.

In Table 2 the developed mathematical models that determine the distribution laws of refusals caused by factors of influence depending on the number of consumers affected.

Table 2.

Mathematical models that determine the behavior of random factors depending on the number of consumers affected

No.	Factors	Type of function	Mathematic model	Parameters of mathematical model			
				a	b	c	d
1	Acts of vandalism	Weibull	$y = a - be^{-cx^d}$	536,83	532,20	543529,85	-2,22
2	Actions of animals and birds	Weibull	$y = a - be^{-cx^d}$	312,19	308,95	1701520,8	-2,39
3	Actions of mechanisms	Weibull	$y = a - be^{-cx^d}$	265,37	262,20	106432,41	-2,20
4	Damages caused by vegetation	Weibull	$y = a - be^{-cx^d}$	536,87	534,68	31362,10	-2,10
5	Quality of electric energy electrice	Weibull	$y = a - be^{-cx^d}$	223,60	221,12	125087,27	-2,35
6	Climatic conditions	Lognormal 3-Param.	$y = e^{a+b/x+c\ln(x)}$	23,52	-463,72	-2,40	-
7	Defects caused by Consumers	Weibull	$y = a - be^{-cx^d}$	1274,46	1272,51	1597,60	-1,91
8	Defects in equipment	Weibull	$y = a - be^{-cx^d}$	6701,21	6748,98	2285,59	-1,59
9	Defects in transport networks	Weibull	$y = a - be^{-cx^d}$	292,31	289,20	675132,55	-2,34
10	Defects at PDC	Weibull	$y = a - be^{-cx^d}$	1103,55	1099,74	54475,74	-1,96
11	Errors of exploitation	Weibull	$y = a - be^{-cx^d}$	104,71	104,92	467,17	-1,54
12	Unstated factors	Log-Logistic 3-Param.	$y = a/[1 + (x/b)^c]$	3804,47	464,45	3,36	-

It was established that by the number of consumers affected, 10 factors are described by the type of Weibull distribution law (acts of vandalism, animal and bird action, the action of different mechanisms, damage caused by vegetation, power quality, defects caused by consumers, defects in transport networks, PDC defects, defects in equipment, operating errors), one of them (the climate) describes the type Lognormal model (3 parameters) and unstated factors with Log-Logistic model (3 parameters).

5. CONCLUSIONS

1. The developed mathematical models confirm that, in terms of duration of caused interruptions , 9 factors (acts of vandalism, actions of animals and birds, the action of different mechanisms, damages caused by vegetation, power quality, defects caused by consumers, defects in transport networks, defects at PDC, unstated factors) have distribution that correspond to the function of Weibull type, two factors (defects in equipment, climatic conditions) have a type of Lognormal distribution and a factor (operating errors) is of an Exponential distribution.

2. By the number of consumers affected, 10 factors are described with the type of Weibull distribution law (acts of vandalism, action of animals and birds, the action of different mechanisms, damages caused by vegetation, power quality, defects caused by consumers, defects in transport networks, defects at PDC, defects in equipment, operating errors), one (the climatic conditions) is described with the type of Lognormal model, and unstated factors with Log-Logistic model.

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