Prof. Farhadzadeh Elmar Mehtievich we congratulate
on the 80th anniversary of his birth

Computer Technology of Formation Control Samples of Fire Safety Rules of Objects Electro Power Systems

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Abstract

The safety of electrical power system facilities is one of the most important characteristics of operational efficiency. The importance of safety is shown, first of all, that their discrepancy to shown requirements results not only in the big material damage, but also to infringement of ecology, a traumatism and destruction of the personnel serving object. Increase of efficiency of the control and the analysis of execution of Safety rules can be reached on the basis of computer technologies, by transition from the qualitative characteristic of safety to quantitative. The initial stage of increase of safety of objects of electro power systems is transition to modelling control samples Fire Safety rules, to a substantiation of volume samples and to documentary acknowledgement of execution of Safety rules.

Keywords: Safety, object, rules, sample, modelling, the control

I. Introduction

1. Statement of the problem. Along with reliability (dependability, maintainability, durability and persistence) [1] and efficiency, safety is the most important characteristic of the performance of electric power systems (EES).is safety of work. Consequences of absence of safety show not only in the big damage, but also, unfortunately, in infringement of ecology, a traumatism and destruction of the personnel. According to [2] with 2005 on 2015 on objects of an electro power complex of Russia there were 11485 fires on which 242 persons were lost, have was traumatized 472 persons, and the direct material damage has made nearby 3 billion rbl. Of them on transformer substations there were 36,5% of fires.

The control of a condition of safety of objects EPS carried out by a number of the organizations [2] including, annually inspectors of corresponding departments of Management EPS. As a result of check certificates in which the revealed infringements are resulted are made. On the basis of certificates the plan of measures on elimination of these of infringement is made. This system has proved the working capacity. However, in due course, preservation of efficiency of the control becomes more and more problematic. Influence on this system renders:

– unfairly intensive operation of the equipment and devices (further ED) objects service life, which exceeds settlement. In other words, the fact of their ageing insufficiently full considered. In many power supply systems, the relative number of such objects exceeds 50%. Their reliability regularly decreases owing to growth of speed of deterioration;

– in system of maintenance service and scheduled repair, presence at ED residual deterioration is insufficiently considered. That brings mistakes in an estimation of their loading ability and residual service life;
– absence of recommendations on operation ED, which service life, exceeds settlement, corresponding supervising and methodical instructions;
– an insufficient system effectiveness of improvement of professional skill of the personnel. The system of remote training at absence of corresponding methodical instructions lost the efficiency, and traditional methods of improvement of professional skill demanded not only greater expenses, but also did not consider absence of the personnel for business trip on rates;
– increase in distinction in knowledge of young experts of bachelors and necessary in EPS engineers;
– discrepancy of an existing material resources for diagnostics of a technical condition growing old ED to shown requirements;
– consequence of reduction of number of the personnel was sharp decrease in quality of examination;
– absence of computer technologies of the analysis possible discrepancy of a condition of safety of objects to shown requirements. It essentially limited opportunities of the joint analysis of safety of objects, the enterprises and Managements EPS, revealing of characteristic infringements, formation system a plan of measures on increase of safety;
– subjective character of the control safety of objects shown requirements.

In these conditions maintenance of execution of Fire safety Rules (FSR) objects EPS becomes in a number of the major problems EPS.

II. The automated system of the selective control of execution of safety Rules.

Distinction of objects EPS cause distinction of features of maintenance of their safety. Various kinds of safety, the monitoring system of execution and the analysis of results cause multidimensionality of a problem. Below the characteristic of the automated system of forming sample of Rules for check of safety of objects EPS on example FSR is resulted.

2.1. Conditions of application of the automated system

* presence of the list of the enterprises of a power supply system with the instruction; names and type of the enterprises; names and types of objects of the enterprise;
* the approved list of consumers of the analysis of results of the control of execution FSR. To them concern:
** department of the chief engineer of a power supply system. Approves decisions on monitoring procedure of execution FSR of the enterprises and actions on reduction of danger of occurrence of fires by objects of enterprises EPS;
** the head of a department of the control over Management EPS, providing conformity of fire safety of enterprises EPS to shown requirements;
** heads of the enterprises of a power supply system;
** chiefs of objects of the enterprises of a power supply system;
* list FSR reflecting features of objects of enterprises EPS. As an example in table 1 fragments of codes FSR are resulted.

The code Rules in [3] include the following information: the first position corresponds to the name of section FSR; the second and the third - to number of chapter FSR; the fourth and the fifth - to number of item of chapter FSR; the sixth and the seventh - to number of the sub item of item of chapter FSR. For example, the first Rule located in section A, in the first chapter and in first item FSR, looks like A010100 (see tabl.1). The Rule located in section, in the fifth chapter, in 32 items and the fourth sub item designated as B053204.

Table 1. Fragment of codes FSR of transformer substations.

№	Code	№	Code	№	Code	№	Code
1	A010100	*48*	A021300	*95*	Б040400	*142*	Б053204
2	A010200	*49*	A021400	*96*	Б040500	*143*	Б053205
3	A010301	*50*	A021500	*97*	Б040600	*144*	Б053206
4	A010302	*51*	A021600	*98*	Б040700	*145*	Б053207
5	A010303	*52*	A030101	*99*	Б040800	*146*	Б053208
6	A010304	*53*	A030102	*100*	Б040900	*147*	Б053300
7	A010305	*54*	A030103	*101*	Б041000	*148*	Е140100

The list of results of the control of execution FSR of names of sections used at the analysis and chapters of the collection of Rules in [3] are resulted in table 2.

Table 2. Data on sections and chapters FSR.

Classifiers FPR	The name of sections and chapters	Code	Distribution samples
Section A	General provisions	A	7
Chapter 1	Organizational requirements of fire safety	01	1
Chapter 2	The basic requirements to the organization of preparation of the personnel	02	2
Chapter 3	The basic documentation on fire safety	03	4
Section B	The basic requirements of fire safety at the enterprises of branch	B	5
Chapter 4	The maintenance of territory	04	4
Chapter 5	The maintenance of buildings and constructions	05	1
Section E	Switching centre	E	5
Chapter 14	Switching centre of power stations and substations	14	1
Chapter 15	Cable facilities	15	1
Chapter 16	Power transformers	16	1
Chapter 17	Storage installations	17	2
Section Z	Repair and reconstruction of the equipment	Z	0
Chapter 21	Fire safety at repair and reconstruction of the process equipment	21	0
Chapter 22	Fire safety at carrying out welding and other inflammable works	22	0
Section I	Fire-prevention water supply and fire extinguishing means	I	8
Chapter 23	Fire-prevention water supply	23	6
Chapter 24	Installations of detection and fire extinguishing	24	0
Chapter 25	Fire extinguishing means of fires	25	2
Section K	The order of the organization of suppression of fires on the equipment of power objects energized up to 0,4 кV	K	0
Chapter 26	General provisions	26	0
Chapter 27	Safety requirements at performance of works on fire extinguishing	27	0
Chapter 28	Actions of the personnel at occurrence of a fire	28	0
Section P	Applications	P	0
Numbers	1÷13	29	0

* presence of the approved plan of the control of conformity of fire safety of enterprises EPS to shown requirements;
* the approved list of the documents confirming full executions FSR;
* an opportunity of annual improvement of professional skill of executives of requirements of maintenance of fire safety;
* presence at the enterprises of the complete set of the documents confirming executions FPR.

2.2. A way of elimination of subjective character of sample controllable FSR

As general number FSR of concrete objects together with sub items and appendices is estimated in hundreds [3], the control of execution of all Rules demands a lot of time, is labour-consuming, and considering annual periodicity of the control - and is inexpedient. Labour input of the control caused by a wide spectrum of means of maintenance of fire safety when the inspector in many of them is incompetent. If besides to consider, that in some cases the control is carried out by the expert on suppression of fires which is not familiar with fire-dangerous ED EPS, labour input of the objective control essentially increases. Therefore, in practice the control of execution FSR carried out under preliminary made list of questions. Their number depending on type of object varies within the limits of (15÷25). As an example in table 2 distribution of traditional control sample FSR in volume n_s=18 under chapters of the collection of Rules [3] is resulted also. Asymmetry of distribution pays attention. Certainly, this list has subjective character, as well as process of the control. And use of identical questions for all same objects of the enterprise, and is frequent - and all same enterprises essentially deforms the characteristic of the revealed infringements, does its unpresentable.

Increase of efficiency of the control of performance FSR, as well as the control of many other things of Rules, reached application of computer technologies. In particular, subjective character of the control and its uniformity it is possible to avoid in the known way - modelling casual sample of Rules from set FSR. For what, proceeding from general number FSR for the set object equal K_i^{ob} where $i = 1, m_{ob}$; m_{ob} - the number of the same objects of enterprises EPS, "is played" $K_{s,i}^{ob} << K_i^{ob}$ serial numbers of Rules, where $K_{s,i}^{ob}$ - volume of sample (s) Rules i- th type of object, under the formula:

$$N_j^{ob} = Abc\left[\xi_j \cdot K_i^{ob}\right] + 1 \qquad (1)$$

where: $j = 1, K_{s,i}^{ob}$; N_j^{ob} - casual and j- th realization of serial number FSR; ξ_j - j- th realization of a random variable ξ corresponding uniform distribution in an interval [0,1].

Random variables ξ modelled by subroutine RANDU(ξ). At formation of control sample corrected manually, for example, at absence of the automated system of formation of control sample and synthesis of results of the control, it is possible to take advantage of function SLCIK in system Excel or (for an example) the table of random numbers [4]. For example, if $\xi_j = 0,7213$, and $K_i^{ob} = 566$, number next (j- th) Rules will be equal: (0,7213·566 =408,3. Hence, N_j^{ob} =409. It is necessary to note, that at modelling control sample FPR the opportunity of equality of serial numbers of realizations of separate Rules not excluded. Such it is possible, if size $\left|\xi_i - \xi_j\right| \cdot M_i < 1$, where ξ_i and ξ_j - i- th and j- th realizations ξ. As presence of identical serial numbers of control sample is deprived physical sense (it means that execution of some Rule should supervised twice), in algorithm of calculation check of each realization on individuality provided. If the serial number of the Rule in sample repeats, this realization excluded from consideration. As FSR in the received sample in volume $K_{s,i}^{ob}$ place in the any order for convenience of recognition of Rules expediently to range their serial numbers N_j^{ob} in ascending order together with a code of each Rule.

2.3. The importance of scoping of sample

One of the basic questions at modelling serial numbers FSR is the volume of sample. Unfortunately, known methods of calculation of the minimal volume of sample of general set as FSR there is no general set of random variables here cannot used. However, for FSR many features of traditional calculation of volume of sample are characteristic. Here as [5]:

– the increase in volume of sample demands increase in time of the control, and reduction - leads to increase in risk of the erroneous decision;
– heterogeneity even the big sample does not guarantee success;
– extrapolation of results of the control over set FSR on its sections is erroneous;
– as a whole, scoping of sample is a sequence of the big number of compromises.

As an example in table 3 list FSR for control sample $K_{s,i}^{ob} = 20$ is resulted.

Table 3. Results of modelling and ranging FSR.

№	Results of modelling			Results of ranging	
	Random variables	Serial numbers FPR	Coordinates FPR	Serial numbers FPR	Coordinates FPR
1	0,1009	45	A021000	37	A020502
2	0,3754	165	E150300	44	A020900
3	0,0842	37	A020502	45	A021000
4	0,9901	433	П291107	52	A030101
5	0,128	56	A030105	56	A030105
6	0,6606	289	3211401	136	Б052900
7	0,3106	136	Б052900	165	E150300
8	0,8526	373	И240400	278	3210502
9	0,6357	278	3210502	287	3211200
10	0,7379	323	3221500	289	3211401
11	0,9852	431	П291105	306	3220400
12	0,118	52	A030101	323	3221500
13	0,8345	365	И232403	325	3221701
14	0,8868	388	И241900	351	И231200
15	0,9959	436	П291110	365	И232403
16	0,6548	287	3211200	373	И240400
17	0,8012	351	И231200	388	И241900
18	0,7435	325	3221701	431	П291105
19	0,6991	306	3220400	433	П291107
20	0,0989	44	A020900	436	П291110

Data of modelling allow draw the important conclusion: casual character small samples causes non-uniformity of their distribution under chapters. We based on data of table 4, where the number of Rules on sections and chapters of collection FSR is resulted, it is possible to conclude:

– casual samples of Rules insufficiently full reflect the maintenance of chapters FSR;
– take place the chapter of collection FSR, which Rules are not presented absolutely not in sample. It A01, B05, E14, E16, E17, C18, C19, C20, I25.
– number of controllable Rules in each chapter insufficiently full characterizes volume of these chapters. Discrepancy of number of Rules of separate chapters and numbers of controllable Rules under these chapters observed. For example, execution of 46 Rules of the fifth chapter of section B is represented sample of 4 Rules. At the same time, 37 Rules 22 chapters of section 3 are not presented absolutely not in control sample. To lacks this way of a finding of control sample concerns and the appointed volume of sample.

Scoping samples from the sets, which are not concerning a class general, represents a complex and unresolved problem [5]. Now the volume of sample defined proceeding from indirect restrictions. In our case is an opportunity to estimate fire safety of objects in an interval of duration of business trip of the inspector. But also the appointed volume of sample should cover, at least, all of chapter FSR. For example, for samples from general set in sociology a popular belief, that the volume of sample should be equal 10% from general set which is estimated in millions [6].

Table 4. Illustration advantages of block modelling of sample FPR.

Serial numbers		Code of sections and chapters	Number FSR on sections and chapters	Modelling of sample	
				On set FSR	Under chapters FSR
Sections	Chapter				
	1	01	29	0	3
	2	02	22	3	2
	3	03	40	2	4
1		*A*	*91*	*5*	*9*
	4	04	10	1	1
	5	05	46	0	5
2		*B*	*56*	*1*	*6*
	6	14	15	0	1
	7	15	29	1	3
	8	16	20	0	2
	9	17	10	0	1
3		*E*	*74*	*1*	*7*
	10	18	22	0	2
	11	19	17	0	1
	12	20	14	0	1
4		*C*	*51*	*0*	*4*
	13	21	29	3	3
	14	22	37	3	4
5		*Z*	*66*	*6*	*7*
	15	23	31	2	3
	16	24	20	2	2
	17	25	16	0	2
6		*I*	*67*	*4*	*7*
	18	29	33	3	3
7		*P*	*33*	*3*	*3*
Bcero			**438**	**20**	**43**

2.4. A block method of formation of volume of sample

It is offered to spend liquidation of discrepancies of result of modelling of control sample of Rules not under the formula (1) for $K_{s,i}^{ob}$, and under chapters FSR, i.e. to apply a "block" way of modelling. Thus, the minimal number of controllable Rules in each chapter accepted equal to unit. Calculation of volume of sample in each chapter spent as follows:

– we define the chapter (c) with the minimal number of Rules, we establish for this chapter number of controllable Rules equal to unit;

– the number of controllable Rules of other chapters (see table 4), and them for considered objects - 18, is defined by the attitude of number of Rules in each chapter to the minimal number of Rules of one of chapters $K_{i,min}^{ob}$ with the standard order of their rounding off. For example, for 22

chapters $K_i^{ob} = 37$. As $K_{i,min}^{ob} = 10$, the number of realizations of controllable sample from 22 chapters will be equal to four.

Thus it is obvious, that the volume of sample of the control of performance FSR will be approximately equal to the attitude of number of Rules of set for considered (i) object K_i^{ob} and the minimal number of Rules of each of chapters $K_{i,min}^{ob}$.

According to results of the calculations resulted in table 4 size $K_i^{ob} = 438$ $K_{i,min}^{ob} = 10$, and volume of sample $n_i = 43$. Thus, all the lacks of formation noted above samples eliminated. The increase in volume of control sample FSR with 20 up to 43 can be eliminated doubly: transition from one control over year to two, i.e. transition to half year an interval of the control and change of structure of the control.

The block diagram of algorithm of block modelling control samples FSR is resulted on fig.1.

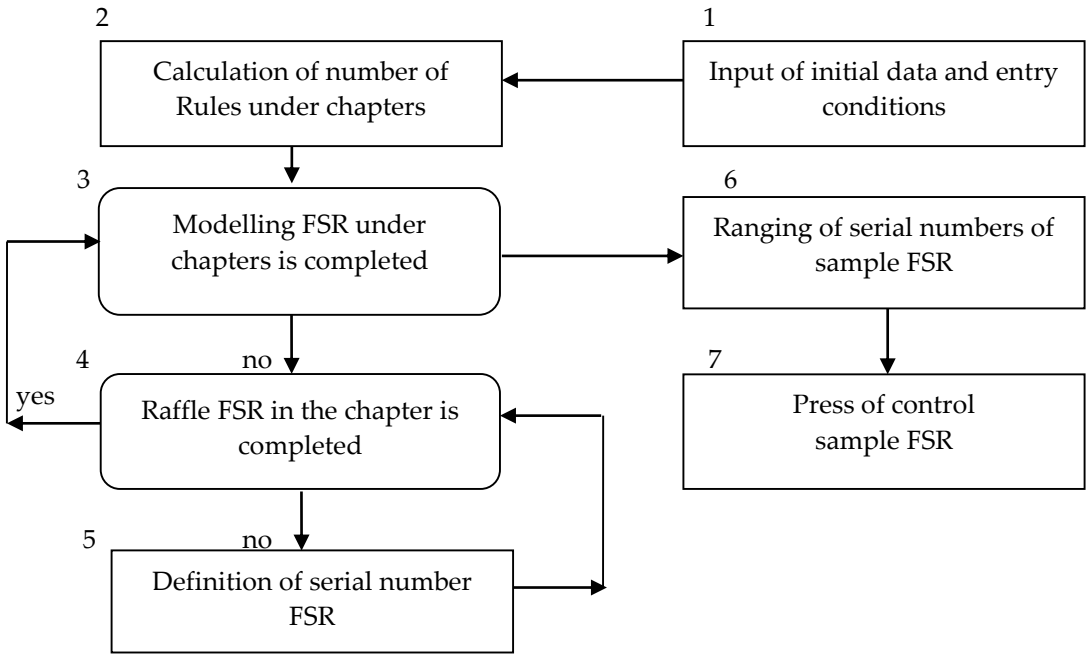

Fig. 1. The integrated block diagram of algorithm of modelling of sample FSR.

III. The organization of the selective control of execution FSR

The following sequence of actions is provided:

3.1. According to the approved schedule of carrying out of the selective control of execution FSR at the enterprises for two weeks up to the appointed term, the department of the control of execution FSR of management EPS for all objects of the enterprise prepares individual list FSR which control of execution is a subject to check. Individual lists FSR affirm the Head of a department, and its copy in an electronic kind and on paper, carriers send to the Director.

3.2. Within two weeks the inspector on fire safety of objects of the enterprise together with Chiefs of objects prepare copies of the documents confirming performance control FSR for each controllable object.

3.3. Results of the control will be coordinated with Director of the enterprise;

3.4. Certificates of the control, together with confirming performance FSR of documents affirm the head of a department on fire safety;

3.5. All these documents placed in archive of a database of the automated monitoring system of execution FSR.

In table 5 results of block modelling control samples FSR for five objects are resulted. Results of the analysis of an opportunity of repetition control FSR at modelling control samples the same objects allow to conclude, that repeated FSR (in tab. 5 are allocated by a font) make about 10%.

Table 5. An example of questions for control of substation

	№	Substation									
		SS № 1		SS № 2		SS № 3		SS № 4		SS № 5	
First half of year	1	37	A020502	5	A010303	4	A010302	23	A010800	90	A031502
	2	***44***	***A020900***	8	A010306	16	A010502	***44***	***A020900***	100	B040900
	3	45	A021000	33	A020302	23	A010800	69	A030503	***154***	***E140700***
	4	***52***	***A030101***	***44***	***A020900***	62	A030402	92	B040100	192	E160101
	5	56	A030105	***52***	***A030101***	78	A030604	99	B040800	196	E160200
	6	136	B052900	131	B052400	79	A030700	108	B050503	228	J180500
	7	165	E150300	141	B053203	104	B050300	111	B050506	230	J180700
	8	278	Z210502	146	B053208	128	B052100	119	B051200	236	J181301
	9	287	Z211200	191	E152700	138	B053100	127	B052000	299	Z211505
	10	289	Z211401	***205***	***E161100***	149	E140200	151	E140400	300	Z211506
	11	306	Z220400	211	E161700	***154***	***E140700***	176	E151400	316	Z220906
	12	323	Z221500	***221***	***E171000***	168	E150600	187	E152300	336	Z221900
	13	***325***	***Z221701***	232	J180900	185	E152100	200	E160600	340	I230200
	14	***351***	***I231200***	252	J190900	203	E160900	***205***	***E161100***	348	I230902
	15	352	I231300	274	Z210200	214	E170300	210	E161600	***351***	***I231200***
	16	365	I232403	283	Z210800	218	E170700	***221***	***E171000***	357	I231800
	17	373	I240400	284	Z210900	237	J181302	222	J180100	373	I240400
	18	388	I241900	302	Z220100	293	Z211405	227	J180400	382	I241300
	19	***400***	***I251100***	304	Z220202	294	Z211406	318	Z221000	***400***	***I251100***
	20	431	P291105	350	I231100	322	Z221400	393	I250400	409	P290202
	21	433	P291107	***400***	***I251100***	*325*	*Z221701*	394	I250500	430	P291104
	22	436	P291110	428	P291102	430	P291104	411	P290204	435	P291109

This information is rather useful, since repeated FSR in control samples allow to judge a degree of identity of the approach to maintenance of performance FSR on all same objects of enterprise EPS. If to consider, that maintenance of performance FSR on the same objects of the enterprise is carried out on-line, existing lacks of execution FSR for all same objects of the enterprise in many respects are similar - it is possible to approve, that set control samples the same objects will be completely characterized fire safety as the enterprises as a whole, and each of objects.

Conclusion

1. Perfection of the monitoring system of execution of Fire prevention rules first of all can be reached by transition to formation of control sample of Rules on the COMPUTER:

2. Modelling of control sample of Rules on their set for the same objects has a number of essential lacks, basic of which are:
   - subjective character of purpose of volume of the control of sample;
   - casual character of sample FSR does not reflect distinction of number of Rules on sections and chapters;
3. The block way of modelling of control sample under chapters is recommended.
4. The probability of recurrence control FSR in the list of Rules of some objects does not exceed units of percent.

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