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

## Farhadzadeh E.M., Muradaliyev A.Z., Ismailova S.M., Yusifli R.F.

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Azerbaijan Scientific-Research and Design-Prospecting
Institute of Energetic AZ1012, Ave. H.Zardabi-94,
e-mail: elmeht@rambler.ru

**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 | E140100 |

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; $\xi_j$ - j- th realization of a random variable $\xi$ corresponding uniform distribution in an interval [0,1].

Random variables $\xi$ modelled by subroutine RANDU($\xi$). 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 $\xi_i$ and $\xi_j$ - i- th and j- th realizations $\xi$. 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.

| № | \multicolumn{3}{c}{Results of modelling} | | | \multicolumn{2}{c}{Results of ranging} | |
|---|---|---|---|---|---|---|
| | Random variables | Serial numbers FPR | Coordinates FPR | Serial numbers FPR | Coordinates FPR |
| 1 | 0,1009 | 45 | А021000 | 37 | А020502 |
| 2 | 0,3754 | 165 | Е150300 | 44 | А020900 |
| 3 | 0,0842 | 37 | А020502 | 45 | А021000 |
| 4 | 0,9901 | 433 | П291107 | 52 | А030101 |
| 5 | 0,128 | 56 | А030105 | 56 | А030105 |
| 6 | 0,6606 | 289 | З211401 | 136 | Б052900 |
| 7 | 0,3106 | 136 | Б052900 | 165 | Е150300 |
| 8 | 0,8526 | 373 | И240400 | 278 | З210502 |
| 9 | 0,6357 | 278 | З210502 | 287 | З211200 |
| 10 | 0,7379 | 323 | З221500 | 289 | З211401 |
| 11 | 0,9852 | 431 | П291105 | 306 | З220400 |
| 12 | 0,118 | 52 | А030101 | 323 | З221500 |
| 13 | 0,8345 | 365 | И232403 | 325 | З221701 |
| 14 | 0,8868 | 388 | И241900 | 351 | И231200 |
| 15 | 0,9959 | 436 | П291110 | 365 | И232403 |
| 16 | 0,6548 | 287 | З211200 | 373 | И240400 |
| 17 | 0,8012 | 351 | И231200 | 388 | И241900 |
| 18 | 0,7435 | 325 | З221701 | 431 | П291105 |
| 19 | 0,6991 | 306 | З220400 | 433 | П291107 |
| 20 | 0,0989 | 44 | А020900 | 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.

14

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 | |
|---|---|---|---|---|---|
| Sections | Chapter | | | On set FSR | Under chapters FSR |
| | 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

15

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.
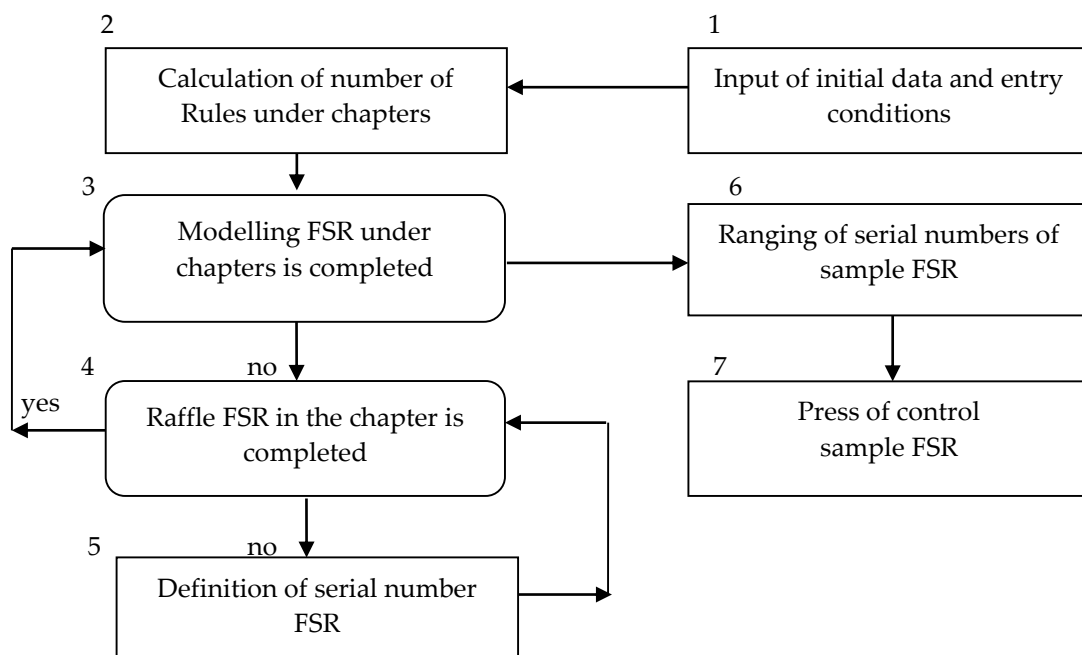


**Fig. 1.** The integrated block diagram of algorithm of modelling of sample FSR.

### 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

| № | | SS № 1 | | SS № 2 | | SS № 3 | | SS № 4 | | SS № 5 |
|---|----|---------|-----|----------|-----|----------|-----|----------|-----|----------|
| | | | | | | Substation | | | | |
| 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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