

Implementation of Information Management System for Radiation Safety of Personnel at the Russian Northwest Center for Radioactive Waste Management "SevRAO" – 13131

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ABSTRACT

The report is an overview of the information-analytical system designed to assure radiation safety of workers. The system was implemented in the Northwest Radioactive Waste Management Center "SevRAO" (which is a branch of the Federal State Unitary Enterprise "Radioactive Waste Management Enterprise RosRAO"). The center is located in the Northwest Russia.

In respect to "SevRAO", the Federal Medical-Biological Agency is the regulatory body, which deals with issues of radiation control. The main document to regulate radiation control is "Reference levels of radiation factors in radioactive wastes management center." This document contains about 250 parameters. We have developed a software tool to simplify control of these parameters.

The software includes: input interface, the database, dose calculating module and analytical block. Input interface is used to enter radiation environment data. Dose calculating module calculates the dose on the route. Analytical block optimizes and analyzes radiation situation maps. Much attention is paid to the GUI and graphical representation of results. The operator can enter the route at the industrial site or watch the fluctuations of the dose rate field on the map. Most of the results are presented in a visual form.

Here we present some analytical tasks, such as comparison of the dose rate in some point with control levels at this point, to be solved for the purpose of radiation safety control. The program helps to identify points making the largest contribution to the collective dose of the personnel. The tool can automatically calculate the route with the lowest dose, compare and choose the best route. The program uses several options to visualize the radiation environment at the industrial site. This system will be useful for radiation monitoring services during the operation, planning of works and development of scenarios.

The paper presents some applications of this system on real data over three years - from March 2009 to February 2012.

INTRODUCTION

The Northwest Radioactive Waste Management Center "SevRAO" is a branch of the Federal State Unitary Enterprise "Radioactive Waste Management Enterprise "RosRAO". The center was established in 2000. The center is involved in work with spent nuclear fuel and radioactive waste. Wastes have been accumulated after activity of the Navy, nuclear submarines disposal and after remediation of contaminated sites. The Russian government has decided to include "SevRAO" to the list of enterprises that contain special radiation-hazardous or nuclear-hazardous industries and facilities involved in development, producing, transporting, operating or storing nuclear weapon and radioactive materials.

The law requires the Federal Medical Biological Agency (FMBA) to regulate the entire nuclear sector in Russia. FMBA is represented by regional departments. Regional Department - 120 is the Regulator for "SevRAO".

DESCRIPTION OF THE FACILITY

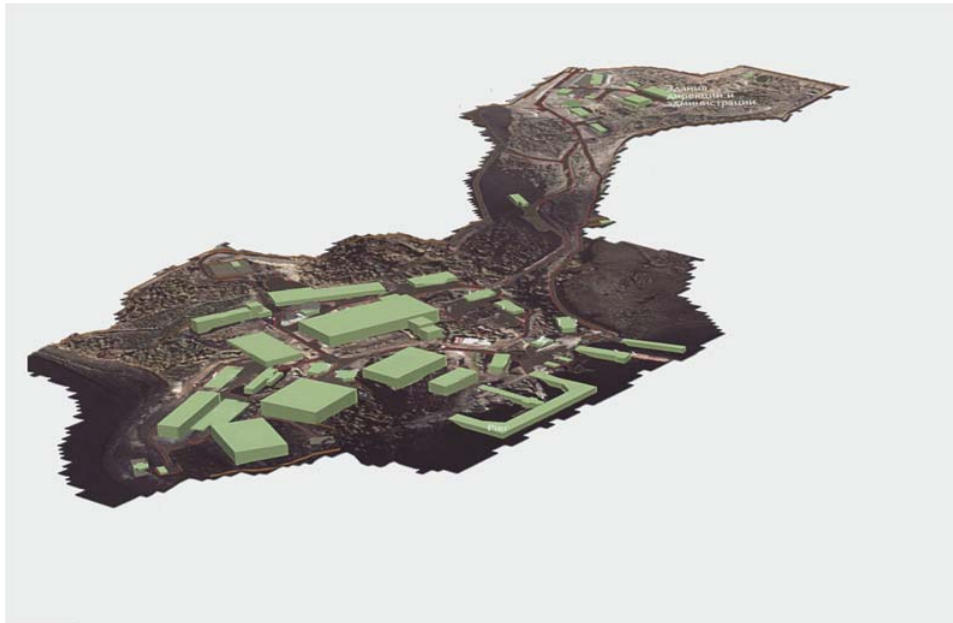


Figure 1. Technical area HPZ "SevRAO".

Figure 1 shows the technical area of the facility. This is not an actual but a perspective map. Some buildings are not built yet (such as "cumulative storage" near the pier). Site is located on

the sea shore. The final stage of works is transportation of wastes and spent nuclear fuel to Murmansk, containerization and transportation to long-term storage.

Transportation of spent nuclear fuel (SNF) will consist of several stages. The first stage is removal of SNF from dry storage facility (DS - the largest building on the map) to cumulative storage facility and then - to the pier. From the pier SNF will be shipped. Non-damaged cells with SNF will be moved first, this technology is perfected. One container can be transported per day. According to experts, condition of 50 percent of cells is unknown, they can be damaged. These containers will be moved secondarily. Transportation of fuel is scheduled for 2014, but now it's clear, that start of work should be postponed to a later date. Now "SevRAO" carries out partial remediation of the site and prepares SNF for transportation.



Figure 2. Interior of dry storage facility.

Figure 2 shows the difference between past and present condition of the dry storage facility. The Building was renovated and the floor was covered with steel plates, 40 mm thick. Figure 2 also shows old transportation containers and SNF cells covers. There are 3500 such cells and 40 containers at the site. Total activity of SNF is $1.3 \cdot 10^{17}$ Bq and activity of radioactive wastes is $6.0 \cdot 10^{14}$ Bq.

Other buildings were also renovated. Figure 3 shows past and present condition of radiation safety service building. This building contains dosimetrist workplaces, office of automatic radiation situation control system (ASCRO), radiochemical laboratory and on duty dosimetrist office. Earlier ASCRO included 15 detectors, but now only 5-6 are operational. Most of the measurements are being performed in manual mode. There are rules of daily, weekly, and monthly measurements.



Figure 3. Radiation safety service building

DESCRIPTION OF THE METHOD

Number and location of control points are registered in the low-level document [1]. This document is reviewed and approved annually. This document is consistent with documents, which regulate handling of natural or artificial sources of ionizing radiation: “Radiation Safety Standards” and “Basic Sanitary Regulations for Radiation Safety”. In turn, these documents are consistent with basic international safety norms.

The reference levels are set for operative control of each parameter. These values are chosen to ensure non-exceeding of basic limits and implementation of the ALARA principle. All radiation and non-radiation factors from all controlled sources were taken into account. Possible measurement error, present and perspective level of protection was also taken into account. Excess of reference level is a cause to investigate reason of this excess.

Document [1] contains about 250 controlled parameters. 76 of them are included in a list of control points and the reference values of dose rate at these points. The points located at the technical areas (industrial site) and at buildings on the industrial site. For each point there are two control values: the first is the value in non-active state, and the second is the state during work.

Analysis of such a large number of parameters takes a long time, and the personnel is involved in other works, such as issuance of a work order, measurements at the control points, cargo monitoring, and the most important is making decisions in emergency situations, for example excess of reference levels in the ASCRO system. When the containers are loaded on ships, analysis will have to be done very quickly. It is clear that the personnel need information-analytical system to carry out real-time calculations.

This system is even more important for Regulator. Regulator works with multiple enterprises at the same time and is guided in topography of each object worse than the personnel. Moreover, Regulator has limited time for analysis of each facility.

Table I shows an example of the control values of dose rate inside buildings and at the industrial site. For each building or structure, there is single control value of dose rate, but in two versions: in non-active state and during the work.

Table I. Control values of dose rate for the industrial site.

No	Name of the area	Name of the control point	Dose rate, mSv/h	
			In a quiet state	During work
1	HPZ ¹	Point # 1	0.0003	0.0005
2		Point # 2	0.0003	0.0005
3		Point # 3	0.0003	0.0005
4		Point # 4	0.0005	0.0006
5		Point # 5	0.0005	0.0007
6	RSRA ²	Point # 6	0.0005	0.007
7		Point # 7	0.0005	0.0007
8		Point # 8	0.0004	0.0005
9		Point # 9	0.0006	0.0008
10	CAA ³	Point # 10	0.05	0.1
11		Point # 11	0.2	0.3

¹ Health protection zone

² Radiation safety regime area

³ Controlled access area

12		Point # 12	0.002	0.005
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It was decided to develop the information-analytical system (IAS) in the framework of Russian-Norwegian cooperation between Federal Medical Biophysical Center (FMBC) and Norwegian Radiation Protection Authority (NRPA). By the beginning of this work FMBC already had experience in the development of IAS RADRUE [4]. This system was used in international epidemiological projects for reconstruction of doses received by the liquidators of the Chernobyl accident. Over 2008-2010 FMBC developed an information-analytical system for radiation safety of the SevRAO personnel. From 2010 to 2012, the system was finalized and introduced to Operator and to Regulator.

The program has two modes of operation: routine and emergency. In routine mode, the database is filled with ambient dose rate equivalent and system calculates the effective dose. In emergency mode, the system calculates equivalent dose in various organs on the basis of the associated absorbed dose. The system includes a list of environmental indicators: activity of mushrooms, vegetation, sediment and soil.

The system can be subdivided into two parts: basic and analytical. The basic part is used for data input, interpolation and mapping of radiation situation and input of stuff rates. The analytical part analyzes the recent and planned activities in terms of the ALARA principle, and makes recommendations to reduce the doses of personnel. The first block explores the changing of ambient dose equivalent at a specific point in a given period of time. and plotting dependence of ambient dose rate on the distance (Figure 4.).

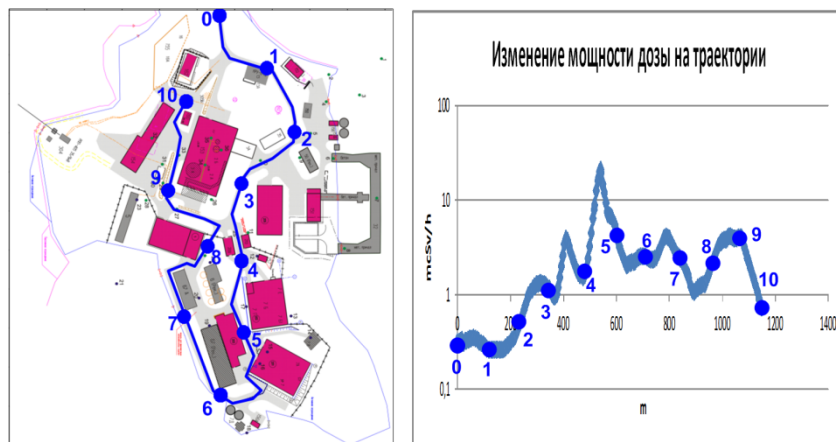


Figure 4. Plot for ambient dose rate vs the distance.

The second block enables visualization of contours with threshold values of doses on topographical maps and charts of premises. Threshold values of doses selected on the basis of document [2] NRB-99. It indicates places where limitation of work duration is necessary.

The third block indicates critical areas: areas of the industrial site, where additional measurements of radiation situation are required to reduce the error of the dose calculation. The first method is based on the search for regions with a maximum gradient of the radiation situation grid. The second one is based on the determination of the maximum difference of interpolated and measured values. Figure 5 illustrates the critical areas. Label size reflects the need for measuring.

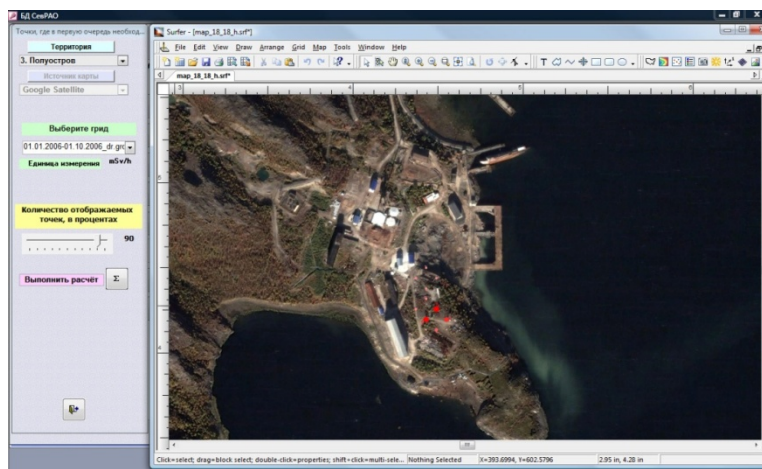


Figure 5. Arrangement of critical areas

One of the challenges of optimizing the exposure of the personnel solved by IAS is a search for sites on the map, which give the largest contribution to the collective dose. This task has important practical use. It helps to decide how to distribute the available resources to minimize the collective dose.

Figure 6 shows the contribution to the collective dose from the five paths. Orange broken curves show the trajectories of the staff, while red circles show the areas, which make the biggest contribution to the collective dose. Work to reduce doses in these areas should be done in the first place. System processes the two-dimensional histogram with dose rate distributions, staff time and collective doses for each cell. The collective dose in each cell is calculated as dose rate in this cell multiplied by the total time spent by the staff in that cell.

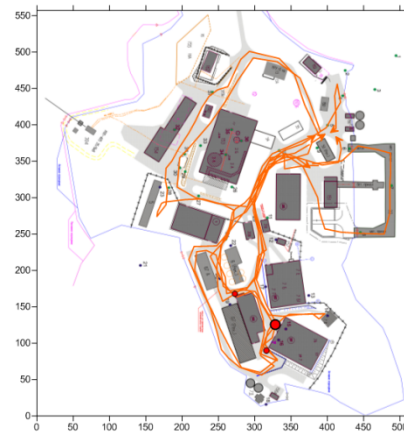


Figure 6. Areas make biggest contribution to the collective dose.

The fourth type of tasks is the work with the data on the activity in the soil. The program allows forecasting cesium-137 and strontium-90 activity in the soil at depths of 0, 10, 20, 50, 100, 150, 200 and 300 cm. The basis for the calculation is the measurements made in 2009.

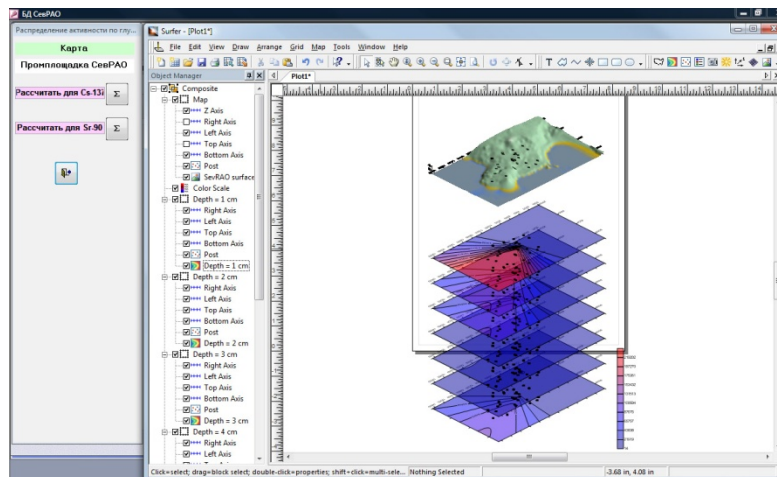


Figure 7. Forecast of cesium-137 and strontium-90 activity in the soil.

Visualizing of the radiation situation

The program primarily uses a graphical representation of information. Information is presented in the form of visualized radiation situation at the site and in structures and a graphical representation of routes of staff. Our algorithms are based on the representation of the radiation situation as a grid.

Generally, there is a certain route of the monitoring team on the industrial site. There are reference points to measure dose rate on this route. These data can be converted to grid of radiation situation by interpolation. We used a method called "Kriging" [4]. This method uses

variogram analysis, which finds an approximation of the dependence between the conditional variance and the relative positions of points and uses this approximation to determine statistical weight of the points [5].

We can visualize the resulting grid as a set of contour lines. The Grid is matched with the schemes of the industrial site and buildings, using geographic coordinates. Figure 8 shows an example of the radiation situation indoor and on the industrial site. Data were obtained in October 2009

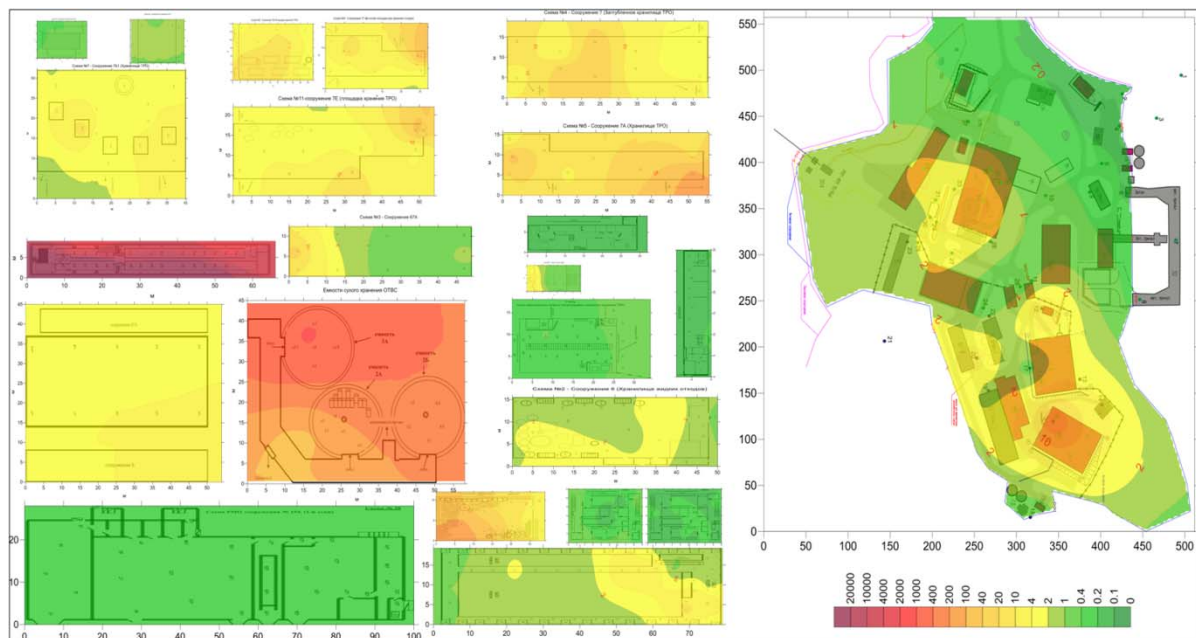


Figure 8. Visualization of the radiation situation in buildings and on the industrial site.

The operator is primarily interested in the absolute levels of dose, as they relate to the absolute values of local pollution. For the regulator, the radiation situation itself isn't as important as comparison of this radiation situation with the reference levels. Therefore, the form of visualization for the operator will be different from that for the regulator.

Figure 9 shows the radiation situation on the industrial site in terms of reference levels of dose rate. These maps show not the absolute values of the dose rate at each control point, but the ratio of the measured dose to the reference level in the point. We used reference levels for non-active state for the left picture and levels for state during work for the right. The scale contains only two ranges: more than one (yellow) and less than one (green). The green range means that the actual dose rate is below target levels. The yellow one indicates a situation where the real value of the dose rate exceeds the reference level for the control points. Regulator needs one look to the

screen to see, where levels have been exceeded⁴. For example it is clear that areas with the highest dose are located to south of the pier, but the excess of reference levels occurred in the upper part of the scheme.

This difference obviously demonstrates the difference in approaches to the handling of information by the operator and the regulator.

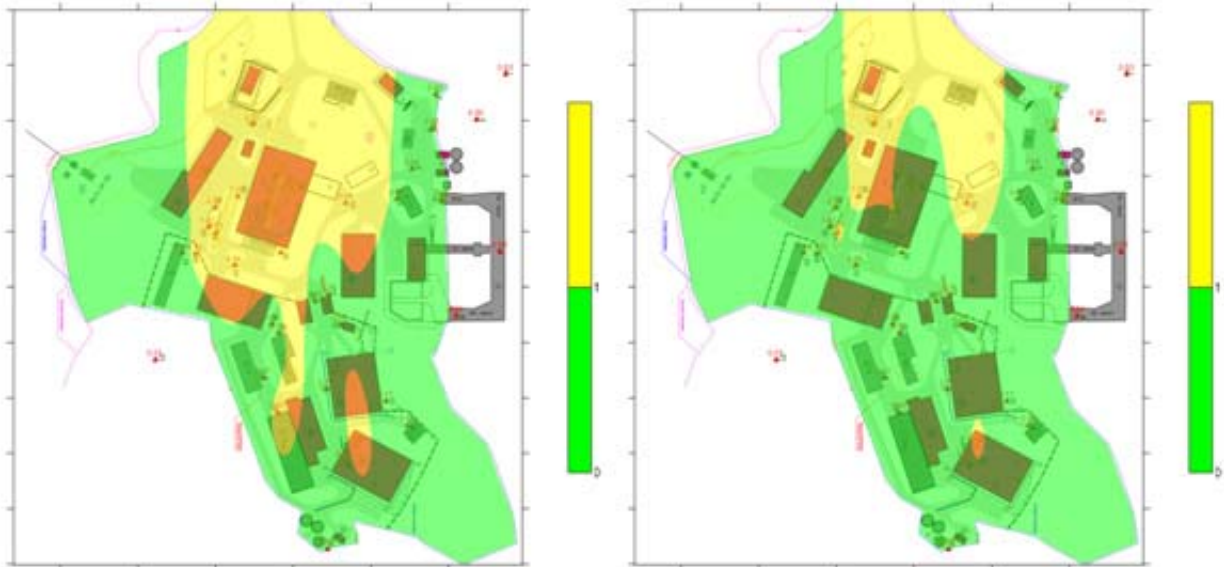


Figure 9. A graphical representation of the reference levels at the industrial site in a normal state (left) and during work (right).

After the regulator notices excessive levels, he can use other features of the system. For example, he can examine the time dependence of dose rate in points of interest. Figure 10 shows 4 control points chosen by Regulator. These points are located in or near the yellow zone, illustrated in the previous figure. The yellow line represents the reference level and the red one represents the maximum level.

⁴ Our example is conditional because it uses conditional, and not the actual reference levels to highlight information content of the visualization system.

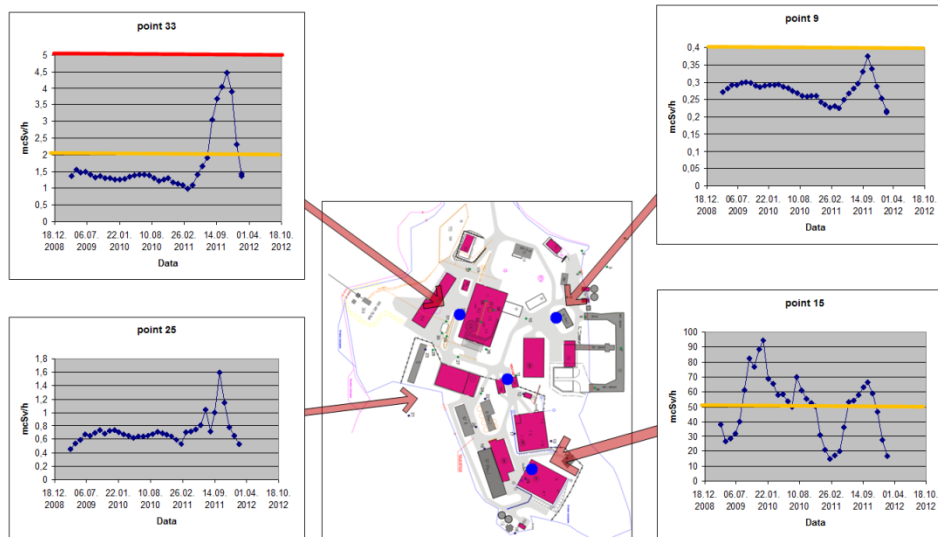


Figure 10. The time dependence of the ambient dose rate at the points of the "SevRAO" industrial site.

To get an overview of personnel exposure, the Regulator can plot the histogram of the effective dose (Figure 11), data were obtained in 2012. We see that doses are not so large; the maximum dose is 4.4 mSv per year and it has been received by the only man. This can be explained by the fact that the active phase of the work is not begun yet. However, in 2012 at the dry storage area there was a case of exposure with 1 mSv per day. Therefore, when starting transportation of fuel, it is important to plan each action. It is necessary to analyze the data using the information analytical system, so the operator can make decisions quickly.

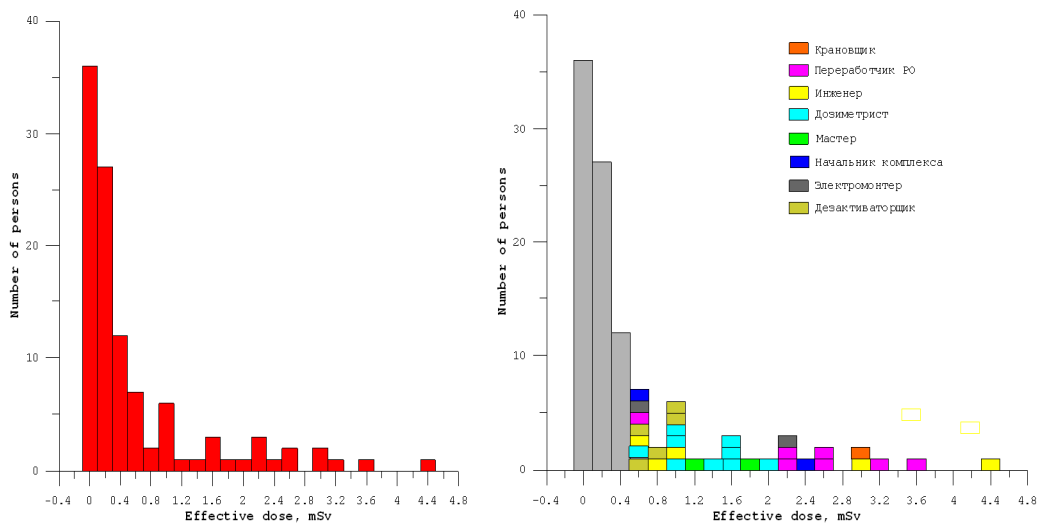


Figure 11. Histogram of the effective dose.

CONCLUSIONS

Summarizing the features of the system, we find that its implementation has 2-5 times reduced the time to process the information for the Operator, and made easier just-in-time control of a large number of parameters to the Regulator. Also, the analytical section gives to the Operator a set of effective tools to plan work.

The current form of the system requires additional time of the personnel to input data. This prevents the full implementation of IAS in practical activities of radiation safety department of “SevRAO”. It became clear that the system needs finalization to create a program that facilitates the data input for staff. Therefore, after the implementation of the current version, enhancing the system will continue.

Use of the information-analytical system puts into practice ALARA principles. The system allows forecasting of the dose when planning works, helps to determine trajectories with a minimum dose for one worker and minimize the collective dose for all staff. The software allows promptly find excesses of reference levels during operation. A graphical presentation of the radiation situation data simplifies the control.

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