Atomic Energy, Vol. 109, No. 2, 2010

INFORMATION-ANALYTICAL SYSTEM FOR TRACKING THE REHABILITATION OF A TEMPORARY STORAGE FACILITY FOR SPENT NUCLEAR FUEL AND RADIOACTIVE WASTES IN THE VILLAGE OF GREMIKHA

D. B. Stepennov and S. B. Maksimov

UDC 621.039.7.004.9

An information-analytical system for solving various problems facing developers and implementing agencies at all stages of work has been developed at Russian Science Center Kurchatov Institute as part of a project for ecological rehabilitation of a temporary storage site located in the village of Gremikha for nuclear fuel and radioactive wastes. The information-analytical system accumulates all information on the project: technical characteristics of the objects, cartographic information, documentation, and information on the participants of the project, technologies, and equipment. The centralized storage of the initial data and the data obtained from examinations makes its use effective for all participants of the project. Analysis of the stored information and the formation of structured sets of data are necessary for planning further work on the project and choosing concrete design solutions, exchanging information between participants in the work, and providing information to state organs and the public.

Since 2003, the Russian Science Center Kurchatov Institute has been coordinating, as part of the concept of ecological rehabilitation of former shore-based technical bases of the northern region of Russia, work on the ecological rehabilitation of temporary storage site for spent nuclear fuel and radioactive wastes in Guba Chervyanaya (village of Gremikha). The site is located on the Kola Peninsula 300 km to east of Murmansk. The work is being done under the direction of Rosatom with the support of the French Atomic Energy Commission, the European Bank for Reconstruction and Development, and the European Commission as part of the program TASIS [1].

An information-analytical system has been developed for tracking the ecological rehabilitation at all stages from complex engineering-radiation examination and design to implementation of the design solutions. This system solves the following problems:

1) input of data on the work and results of measurements under field and laboratory conditions;

2) centralized storage of initial data and data obtained as a result of examination, which makes the system effective for all participants of the project; the database contains reference information on the object undergoing rehabilitation, its technical characteristics, cartographic formation, documentation, information on the project participants, technology, and equipment; and

3) analysis of the information in order to construct a structured set of data which are required for further work on the project, information exchange between the participants doing the work, providing information to government organs and the public.

The information-analytical system is intended for controlling data and projects, geological information work, three-dimensional modeling, and information support.

Institute of Nuclear Reactors at the Russian Science Center Kurchatov Institute, Moscow, Russia. Translated from Atomnaya Énergiya, Vol. 109, No. 2, pp. 95–100, August, 2010. Original article submitted November 11, 2009.

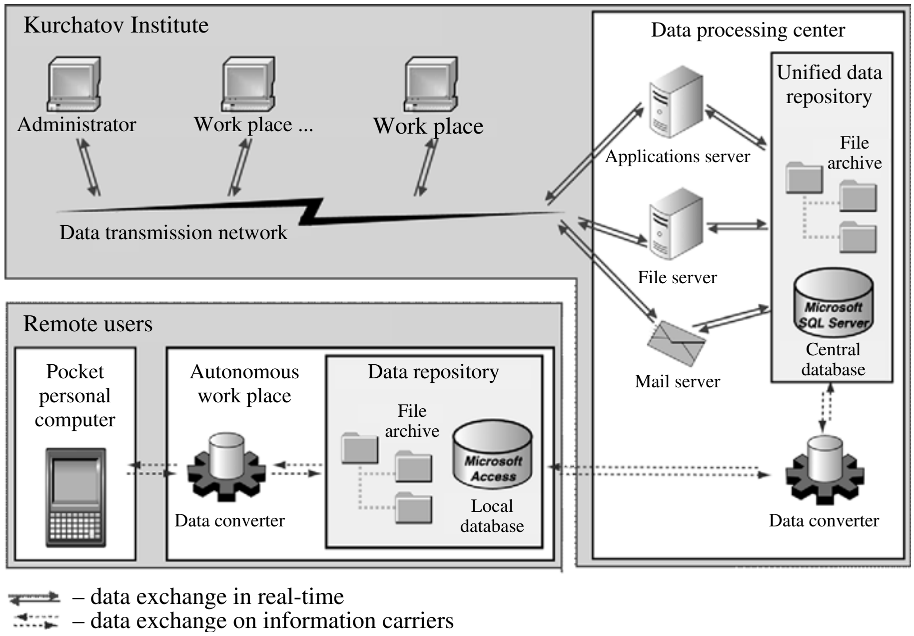


Fig. 1. Structure of the program-apparatus complex.

Data from examining radiologically dangerous objects are analyzed using the apparatus-program complex of the system [2]. The complex (Fig. 2) includes the following:

1) data processing center, operating round the clock and accumulation all data; the data are accessed along a local grid through automated used work places;

2) autonomous work places for inputting data and computer modeling, which are implemented on the basis of personal computers and make it possible to work autonomously without being connected to the data processing center; and

3) pocket personal computers for inputting the result of examinations under field conditions.

The documentation database started operating in 2004 and includes registration cards of documents and an archive of computer files. At the present time it contains approximately 2500 documents and, on average, 80 new documents are entered monthly. Documentation information is stored in the form of a card index, containing arbitrary information, and an archive with files of documents. The database permits searching information on the content of the documents from the archive and on the parameters of the cards in the card index as well as forming structured lists of documents.

The results of a survey in 2007 and inventorying of previously accumulated information has been used as a basis for a database of spent nuclear fuel and radioactive wastes. The spent nuclear fuel stored in the temporary repository consists of spent fuel assemblies from water moderated and cooled reactors from submarines and spent removable parts of reactors with liquid-metal coolant Alpha class boats.

The temporary repository contains solid and liquid radioactive wastes. According to the regular technology, they must be stored differently in different repositories. Actually, because of the effect of precipitation and defects in the containers, in individual cases solid and liquid radioactive wastes are stored together with spent nuclear fuel. The spent fuel assemblies are stored in type-6 (TK-6) and -11 (TK-11) containers and type-22 cans.

As a result of inventorying the spent fuel assemblies, the following information was entered into the database: aerosol activity (alpha and beta), radiation conditions near the containers, presence and specific activity of water in the containers, presence, state, and results of dynamometric measurements on fuel assemblies in containers, and their photographs. The database contains information on 107 TK-6 and 9 TK-11 containers. The information on 16 cans includes data on the presence of spent fuel assemblies in the cells, their number (if they are present), and information about deformations.

Fig. 2. Three-dimensional visualization of the section of the grounds of the temporary storage site.

The database for spent nuclear fuel and radioactive wastes contains information about eight removable parts of Alpha class submarines: year of removal, activity, category of the wastes (low-, medium-, and high-level wastes), and cool-down time (years), percent burnup.

The information on liquid radioactive wastes which is presented in the database includes information obtained as a result of surveying containers, wells, floating containers, and a pump station. The database also contains information about liquid radioactive wastes located in TK-6 and TK-11 containers. The database contains information on the physical characteristics and activity of objects that makes it possible to differentiate liquid radioactive wastes by activity (low-, medium-, and high-level wastes).

Information about solid radioactive wastes includes data on containers on the temporary storage site, on 456 containers in building 19, on wastes in areas near building 1, and other objects.

The database contains information on the physical characteristics and activity of objects that makes it possible to classify solid wastes according to their degree of radioactivity. The information presented in the database covers a large portion of the volume of radwastes present in the temporary storage site. However, information on predicted volumes of secondary wastes is not available in the database at the present time. An engineering-radiation survey of the objects and grounds of the temporary storage site has shown that the volume of the secondary radwastes will grow substantially as buildings are demolished and grounds are rehabilitated (recultivation of the soil), so that the composition of the data stored in the information-analytical system will be continually increasing.

Report formats have been developed for representing clearly the information on the examination of objects and outputting information on paper carriers: examination of TK-6 and TK-11 containers, receiving recesses in building 1 and temporary packing in building 19, inventorying of liquid and solid radwastes, as well as removable parts.

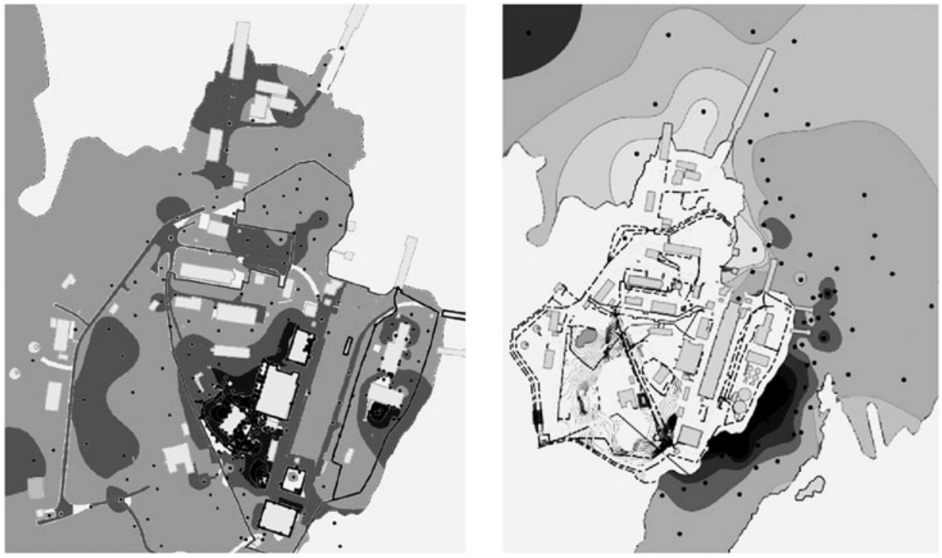
The database contains citations to other information bases as well as documents relevant to the work. The interface of the information-analytic system is used for calendar planning. For each type of work there is an accounting card that contains information the character of the work, the work time, the equipped used, co-workers, and documentation. The database makes it possible to follow the running state of the work, monitor the completion times, the material resources, and the labor costs. The accounting card contains citations to documentation, which was created as the work was performed, as well as objects and resources. For strategic planning, the information-analytic system makes it possible to structure all project work.

The database of the results of the engineering visual examination contains a description and photographs of 384 defects of buildings and structures with the results of the following measurements:

1) the equivalent dose rate of γ-rays on the grounds of the temporary storage site and in the environs of the storage site for solid radwastes at heights of 0.1 and 1 m above ground for 2003 and 2006;

2) the β-particle distribution at the surface of the ground on the grounds of the temporary storage site and in the environs of the temporary storage site for solid radioactive wastes for 2006;

a



b

Fig. 3. Distribution of the specific activity of ^{90}Sr in soil on the territory of the temporary storage site (*a*) and ^{60}Co in bottom deposits in near-shore water area (*b*) with the zoning scheme and measurement point (data for 2005–2006).

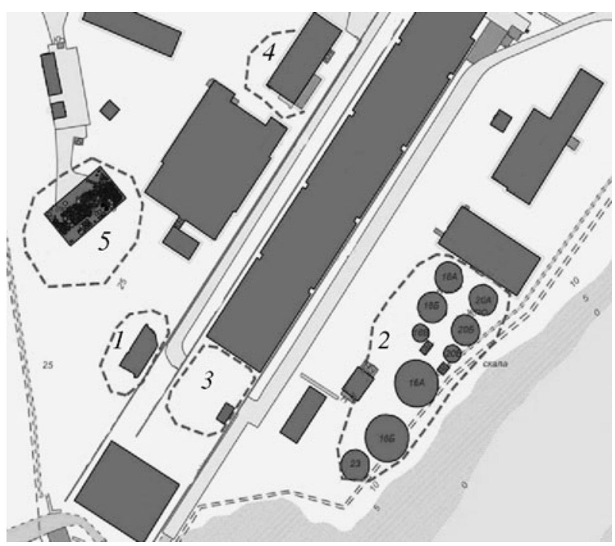


Fig. 4. Main sections of soil contamination on the grounds of the temporary storage site: *1*) site beneath a cliff; *2*) storage site of liquid radioactive wastes; *3*) area between the dry dock and building 1B; *4*) pits at building 1; *5*) temporary storage site for solid radwastes.

3) the specific activity of ^{137}Cs, ^{90}Sr, and ^{60}Co in the soil on the grounds of the temperature storage site for 2003, 2005, and 2006;

4) the specific activity of ^{137}Cs, ^{60}Co, ^{40}K in the bottom deposits of the near-shore part of the reservoir of the temporary storage site for 2003 and 2006;

5) the specific activity of ^{137}Cs and ^{90}Sr in soil near a storage site for solid radwastes for 2006;

Fig. 5. Three-dimensional dynamical modeling of the removal of spent fuel assemblies.

6) the equivalent γ-ray dose rate on an area beneath a cliff in the region of building 1B at height 1 m above the ground in 2006;

7) the β-particle flux density at the ground surface beneath a cliff in the region of building 1B for 2006; and

8) samples on a site in the region of building 1B over 2006.

In all, the database contains 16802 point measurements for 2003–2006, including 2404 for 2003, 3294 for 2005, and 11104 for 2006.

The two-dimensional cartographic foundation consists of the territory of the temporary storage site on the scale 1:500, the water area of the Svyatonosskii gulf, and the territory of the ecological research zone. A three-dimensional model of the temporary storage site was build on the basis of the two-dimensional cartographic foundation and the construction documentation; the model includes a model of the territory, buildings, and structures, and special technology (Fig. 2). The function of the three-dimensional model is as follows:

1) modeling of the movements and manipulations of the special technology and objects, including personnel with determination of the optimal paths and zones of manipulation;

2) modeling of various technological and production processes; and

3) modeling and prediction of different irregular and emergency situations.

The information-analytical system is used at all stages of the rehabilitation of the temporary storage site, including the complex engineering-radiation survey, data processing, development of designs, and modeling.

When point measurements are performed on site the maps created beforehand and transferred into a pocket computer can be examined and any required corrections can be made under field conditions [3]. The operator performing on-site measurements enters data using a pocket computer equipped with a satellite navigation system and site map, which simplifies entering data to pressing buttons and inserting a measured value. The system automatically ties the value entered to the operator's on-site coordinates. The results of the measurements are transferred from the pocket computer into a personal computer or into the server of the information-analytical system, forming the database of point measurements.

The results of the point measurements are used to construct maps of the distribution of radionuclides over the grounds and water area with a determination of the zones of accumulation and directions of the run-off of radionuclides (Fig. 3). There data are used to determine the volumes of radwastes in performing project work.

The information-analytical system was used to make a preliminary assessment of the propagation of radioactive and chemical contamination or radioactive and chemical contamination in a vertical profile of soil and underground waters located within the territory of the temporary storage site [4] and sections with specific activity of soil contamination above 10^4 Bq/kg (Fig. 4).

The soil volumes were determined use a computational technology based on three-dimensional volume modeling of the required territory in a metric coordinate system followed by calculation of the volume. A triangulation model of the soil surface neglecting buildings and structures, which is based on a geodesic study performed in 2006, was used together with a triangulation model constructed of a conventional rock surface from the results of a geological survey, as the boundary surfaces of the desired volume. The three-dimensional visualization and modeling make it possible to solve the following problems:

1) minimizing the dose load to workers during the works through performing preliminary three-dimensional modeling and choosing optimal technical solutions;

2) construction of scenarios based on developed sequences of technological operations followed by visualization for the purpose of modeling the behavior of personnel during work and in the case where emergency situation arise (Fig. 5);

3) review information from the database directly during the work with three-dimensional models of the temporary storage site, buildings, structures, and objects in real-time; and

4) development of demonstration material based on the scenarios developed in order to clarify the crux of the scenarios to the executers, administrative organs, and interested individuals; this makes it possible to accelerate the process of obtaining approvals for design solutions from the supervisory agencies.

Thus, the information-analytical system helps address the following tasks of information support for the temporary storage site:

1) automating control of the work: calendar and resource planning, monitoring;

2) control of documentation for the project; identification, storage, transmission, archiving, and providing access;

3) collection, storage, analytic processing, and visualization of the data from surveys of the buildings, structures, territory, and water-are of the object;

4) classification of the spent nuclear fuel and radioactive wastes;

5) computer modeling in three-dimensional space of the main technical solutions for rehabilitation of the temporary storage site;

6) computer modeling in three-dimensional space of radiological safety on the grounds of the temporary storage site, in the sanitary-protected zone and in the observation zone;

7) analysis and visualization of data from radiation monitoring and physical protection of the object;

8) modeling of emergency situations, automation of the emergency response.

The information-analytical system can be used to make the surveying and rehabilitation of any radiologically dangerous objects more efficient.

REFERENCES

1. N. N. Ponomarev-Stepnoi, B. S. Stepennov, and V. N. Kovalenko, et al., “Ecological rehabilitation of the temporary storage site for spent nuclear fuel and radwastes in Guba Chervyanaya,” *Bezop. Okruzh. Sredy*, No. 1, 92–97 (2008).
2. D. B. Stepennov, N. M. Belyaeva, S. B. Maksinmov, et al., “Application of the IAS apparatus-program complex for entering and processing data from complex engineering and radiologically examination of the temporary storage site for spent nuclear fuel and radwastes in the village of Gremikha,” in: *Coll.: Apparatus for Ensuring Nuclear and Radiological Safety of the Objects of Rosatom (Nuclear Instrument Building – 2007)*, SNIIP, Moscow, April 18–19, 2007, pp. 93–102.
3. D. B. Stepennov and S. B. Maksimov, *Information-Analytic System for Tracking the Work on the Rehabilitation of the Temporary Storage Site for Spent Nuclear Fuel and Radwastes in the Village of Gremikha, Catalogue of Innovative Designs for Handling Radwastes, Decommissioning, and Ecological Rehabilitation,* Rosatom (2007).
4. D. B. Stepennov, E. R. Strizhakova, and G. K. Vasiliev, “Problems of the recultivation of soil contaminated by radionuclides and other technogenic contaminants at temporary storage sites for spent nuclear fuel and radwastes,” in: *11th Int. Ecological Symp. on Atomic Urals, Industrial Urals* (2005), pp. 301–302.