Peculiarities of the High-Level Concrete-Encased Radwaste Repository Disposition at the Radwaste Disposal Site of the Russian Research Center “Kurchatov Institute”

V.G. Volkov, N.N. Ponomarev-Stepnoi, G.G. Gorodetsky, Yu.A. Zverkov,
O.P. Ivanov, A.V. Lemus, S.G. Semenov, V.E. Stepanov, A.V. Chesnokov, A.D. Shisha
Russian Research Center “Kurchatov Institute”
1 Kurchatov Square, Moscow 123182
RUSSIA

ABSTRACT

The paper presents peculiarities of organization and performance of activities on disposition of the old repository that contained high-level waste and located at the radwaste disposal site of the Russian Research Center “Kurchatov Institute” in Moscow. The repository was constructed in the late 1950’s. A large number of cases with high-level waste were placed in the repository along with low- and intermediate-level waste. When the repository was filled in 1973, the entire radwaste mass was encased in concrete matrix which caused difficulties with the radwaste extraction and made the work on the repository disposition highly hazardous in terms of radiation conditions.

Based on results of the preliminary radiation survey of the repository, technologies and equipment to be used in disposition works were selected, and a decision on construction of external radiation shielding around the repository to maintain normal radiation conditions during these works was made.

Specific features of the selected radiation shielding design constructed around the repository and of a technology used for the radwaste extraction from the repository are provided. According to the technology, conventional construction machines equipped with a hydraulic hammer or a clamshell were used for destruction of the concrete-encased radwaste mass and extraction of low-level waste. Intermediate- and high-level waste was extracted by remotely controlled robots operating inside the radiation shielding structure.

Video cameras and a gamma imager were used for detection of high-level waste or fragments of such radwaste in the mass concrete being destroyed and for guiding remotely controlled robots.

Peculiarities of rapid control of changes in radiation conditions in the working areas are presented. This control was performed using a gamma locator with on-line transmission of its data to a PC for their processing.

With disposition of this not easily accessible repository, the stage of remediation of old repositories at the Kurchatov Institute radwaste disposal site approached completion. At present the work on soil decontamination is being continued at the site, and residual contamination of the soil and groundwater is being examined.

INTRODUCTION

Activities on remediation of radiation hazardous facilities at the Kurchatov Institute have been conducted since late 2001 under the general “Rehabilitation” project [1, 2].

According to this project, 10 old radwaste repositories and their respective site were basic targets of the remediation activities in 2002-2005. These old repositories were built at the Kurchatov Institute in the course of the work under the Atomic Project and development of nuclear power systems of various purposes. The repositories were situated in a specially allocated area in the north-west of the Kurchatov Institute site. As a result of the Moscow development, the Kurchatov Institute site became surrounded with the city housing estates and hence the old repositories now presented a potential radiation hazard to the population of the adjoining city district and the environment which lead to a decision on their disposition.

In 2002-2004, radwaste was successively extracted from 9 old repositories that contained for the most part low- and intermediate-level waste in the form allowing their easy extraction, and the repositories were dispositioned [2, 3]. The major radionuclides contributing to the radwaste activity in these repositories were Cs-137, Co-60 and Sr-90.

The work on disposition of these repositories was performed in conditions of a big city, almost without any recorded data on the repository design features and radwaste they contained. Therefore, remediation of these repositories was performed using a sequence of specific process operations specially developed for this purpose.

The work on disposition of repository No.4 was started in September 2004 and completed in July 2005. This repository was not easily accessible for extraction of the radwaste since along with low- and intermediate-level waste it contained a lot of cases with high-level waste, and all radwaste throughout the repository volume was encased in concrete. In addition to Cs-137, Co-60 and Sr-90, the radwaste in this repository also contained Am-241, Eu-152, Eu-154 and plutonium isotopes.

This repository was located near the external perimeter of the radwaste disposal site that immediately borders on the city housing estate which complicated significantly operations at the repository and made it necessary to take a set of preparatory measures, including development of a special technology for extraction of high-level waste from the repository.

This paper presents measures taken in the course of preparations for disposition of repository No.4; describes peculiarities of organization of the process used for radwaste extraction from the repository, including instruments and equipment employed by the process; describes special features of organization of radiation monitoring during the operations, including gamma dose rate control in radwaste extraction working areas, dose rate control throughout the radwaste disposal site, application of special technologies for suppression of radioactive aerosols and control of aerosol activity in the air; and presents main results of the activities aimed at disposition of this repository.

GENERAL CHARACTERIZATION OF REPOSITORY No.4

Repository No.4 was situated at a distance of 20-25 m from the municipal garage building located near the external perimeter of the radwaste disposal site, and at a distance of 50-100 m from the city housing estate.

In its design the repository represented an underground concrete structure measuring 20x7.2 m, 4.0-4.5-m deep, with the wall thickness of about 1 m.

The repository space was divided into three cells of equal volume, covered atop by a common concrete ceiling of thickness 0.5-1 m. The repository internal partitions were up to 0.5-m thick and were made of bricks. Holes measuring 1.0x1.0 m intended for radwaste loading were provided in the concrete ceiling above each of the repository cells. The repository concrete ceiling was covered atop by a 2-3-m thick layer of soil and sand.

The total capacity of the repository was estimated at 625 m^3. According to the archival data, the radwaste might include up to 245 cases filled with high-level waste that were placed in the repository mixed up with low- and intermediate-level waste, various reactor equipment components, construction materials and rubbish. After filling the repository, the radwaste throughout its volume was grouted, therefore the radwaste mass represented a monolithic concrete block with strong reinforcement of various metal radwaste fragments and cases with high-level waste.

The radiation survey of the repository performed in advance of the disposition operations has revealed that the gamma dose rate produced by the cases with high-level waste runs as high as 0.3 Sv/hr and above, which called for construction of external radiation shielding for operations at the repository. Analysis of radwaste samples taken from the repository revealed the presence of Cs-137, Sr-90, Co-60, Eu-152, Eu-154 and plutonium isotopes in the radwaste. The basic dose-contributing radionuclides in the radwaste were Cs-137 and Co-60. Besides, Am-241 with high specific activity exceeding the radionuclide content of fuel compositions was detected in the radwaste, which suggested that the radwaste contained pure sources of this radionuclide.

PECULIARITIES OF ORGANIZATION OF OPERATIONS AT THE REPOSITORY

Since almost no reliable archival data were available on design features of the old repositories, their location and geometry, and on type and composition of the radwaste they contained, a special technology was developed to perform the work on the radwaste extraction and disposition of these repositories [3]. According to this technology, the following successive operations were performed to accomplish the work on disposition of the old repositories: exploratory drilling at the repository boundaries and of the radwaste mass; radiation survey and visual inspection of the repositories; cleaning of fill-up soil from the repository ceilings; extraction of the radwaste from the repositories, radwaste sorting and loading into certified containers; examination and disposition of repository structures; soil sorting and removal of contaminated soil from the repository pits; final radiation survey of the repository pits and their backfilling with clean soil.

It should be noted that the sequence of operations listed above was used for disposition of old repositories that were easily accessible for the radwaste extraction since they contained mostly low- and intermediate-level waste, and high-level waste was found in these repositories in minor amounts in the form of separate fragments.

Repository No. 4 was not easily accessible for the radwaste extraction because it contained numerous cases with high-level waste and the entire radwaste mass was encased in high-strength concrete. This made it necessary to make modifications in the repository disposition process described above to organize the work at this repository, including implementation of preparatory measures aimed at assurance of radiation safety in operations at the repository.

The following measures were taken in preparation for disposition of repository No.4:

– an external radiation shielding was constructed around the repository;

– a special operating technology was developed for extraction of the radwaste using conventional construction machines and robots;

– a set of process operations on high-level waste measurement and loading into containers using remotely controlled robots was developed and tried out;

– reinforced metal containers with concrete inserts and concrete lids intended for high-level waste were fabricated.

THE TECHNOLOGY OF DESTRUCTION OF THE CONCRETE-ENCASED RADWASTE MASS AND RADWASTE EXTRACTION FROM THE REPOSITORY

To perform the work on destruction of the concrete-encased radwaste mass in repository No.4, extraction and packing of low-, intermediate- and high-level waste, there was developed a special technology reflecting the following features and sequence of these operations (Fig. 1.):

– the work on radwaste extraction from repository No.4 and disposition of this repository is performed successively for its cells No.1, No.2 and No.3;

– when radiation conditions are normal after opening a repository cell, the concrete-encased radwaste mass is destroyed by an excavator with a hydraulic hammer located atop the repository shielding structure. This work is done through an opening produced by temporary removal of one or two concrete plates in the shielding structure ceiling, with low-level waste mass debris and crushed concrete being accumulated inside the shielding structure;

– the low-level waste and crushed concrete are removed from the top of the repository through the temporary opening in the shielding ceiling using the excavator with a clamshell;

– if cases with high-level waste or fragments of such radwaste are found resulting in worsened radiation conditions, the ceiling of the external shielding is restored completely, and all operations on demolition of the concrete-encased radwaste mass and extraction of high-level waste and its fragments are performed inside the shielding structure;

– subsequent handling of intermediate- and high-level waste extracted from the destroyed mass concrete, including radwaste sorting, loading into containers and removal, is conducted inside the shielding structure using remotely controlled robots;

– remote control of robots, including their aiming at cases with high-level waste or high-level waste fragments, is executed using a special system comprising video cameras and a gamma imaging device;

– measurement of extracted intermediate- and high-level waste, including cases with high-level waste or fragments of the latter, is performed in a measurement bench located in a special radwaste loading section arranged inside one of the shielding structure process bays where radwaste is delivered by robots;

– a container type to be used for high-level waste loading and a method of this waste packing in containers are defined based on radwaste measurement results;

– metal container shall be used for low-level waste, concrete containers – for intermediate-level waste, and reinforced metal containers with concrete inserts – for cases with high-level waste and fragments of the latter;

– after the loading, containers with intermediate- and high-level waste are transferred from the loading section to another section inside the shielding structure where additional check measurements are performed;

– after the check measurements, the containers loaded with high- and intermediate-level waste are transferred from the shielding structure to the area of their piling and temporary storage until their removal to the MosNPO “Radon” yard.

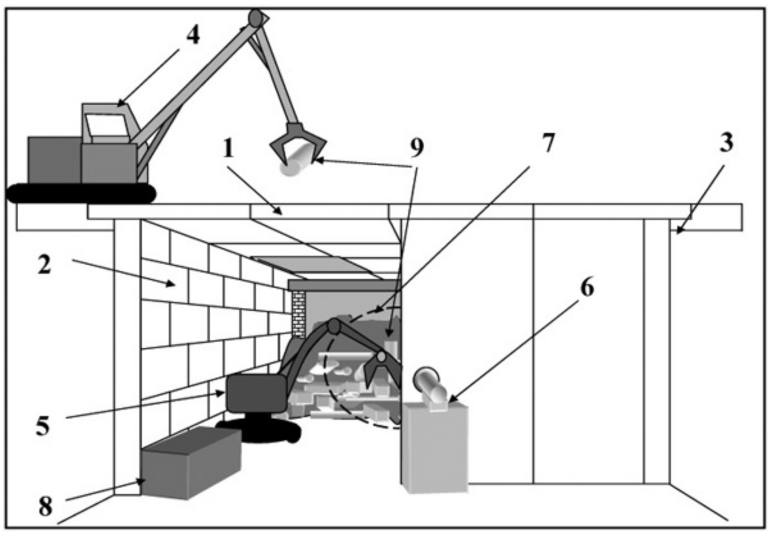

Fig. 1. The technology of destruction of the concrete-encased radwaste mass and high-level waste extraction from repository No.4: (1) ceiling of radiation shielding formed by paving slabs; (2) external supports of radiation shielding formed by foundation concrete blocks; (3) ground level; (4) excavator for radwaste mass demolition and extraction of low-level waste and concrete spills; (5) remotely controlled robot; (6) gamma imager located outside the radwaste massive behind concrete wall; (7) field of vision of gamma imager; (8) reinforced metal container for packaging of high-level waste; (9) radwaste prepared for packaging into containers.

According to the technology described above, all radwaste extraction and handling operations shall be accompanied by stringent radiation monitoring, application of dust suppression means and control of aerosol volume activity in the working area air.

To enable remote control of robots, a purpose developed viewing and guidance system was installed inside the shielding structure. In addition, robots and construction machines used in operations at the repository were provided with external video cameras.

In subsequent operations at the repository, radwaste samples were taken and subjected to spectrometric and radiochemical examinations. Based on their results, the technology described above was modified as necessary and supplemented by further details on the work procedure and sequence of operations to be performed.

DESIGN OF THE EXTERNAL RADIATION SHIELDING CONSTRUCTED AROUND THE REPOSITORY

The external shielding structure design was defined on the basis of advance calculations performed to assess changes in radiation conditions near the repository resulting from its opening and withdrawal of high-level waste [4]. The calculations encompassed various radiation shielding designs and took into account peculiarities of the repository location, geometry of the repository space to be opened, and specific activity ratios of the major dose-contributing radionuclides (Co-60 and Cs-137).

Results of the calculations were used for designing and construction of the radiation shielding in the form of external support walls made up of 600×600×2400-mm foundation blocks and reinforced with metalwork. Metal trusses of the external shielding ceiling formed by 6-m long and 0.2-m thick paving slabs were placed on the external support walls (Fig. 2a).

Fig. 2. Shielding structure: top view (a) and view from the labyrinth (b)

The shielding structure completely closed the repository pit on the north-west, south-east and south-west. The shielding structure had the following dimensions: width - 10 m; length – 32 m; height – 3.6 m (from the bottom of the repository concrete foundation).

A labyrinth was arranged on the south-eastern side of the repository pit at the exit of the shielding structure to ensure access of robots to the radwaste mass (Fig. 2b). The same labyrinth was used for accommodation of various process equipment and containers for loading the radwaste, for measurements of extracted radwaste and preliminary washing of special machines. For this purpose, two process bays having the width of 10.0 m, the length of 6.0 m and the height of 3.6 m were arranged inside the shielding structure. They were connected with the exit to the radwaste disposal site and with the radwaste mass in repository No.4 via the labyrinth.

It should be noted that while constructing the external radiation shielding, soil excavated from the pit made around the repository to install support structures of the shielding was piled and formed into a mound on the north-western side of the repository located near the external perimeter of the radwaste disposal site adjoining the city housing estate. This was done to enhance the radiation shielding in the direction of the city housing estate and ensure radiation safety of the local population.

To collect and remove surface water in the course of operations at the repository, a special pit was provided inside the shielding structure labyrinth for collection of near-surface water and atmospheric precipitates that were further removed to the Kurchatov Institute special sewerage system.

The walls that formed the process bays were made of demountable concrete blocks, hence it was possible to move them inside the repository as its cells were successively destroyed and dispositioned.

The shielding structure process bays intended for operations on radwaste mass demolition, extraction of radwaste, their measurement, preliminary sorting and packing into containers were provided with a portable lighting system protected from damages that might be caused by fragments of the concrete-encased radwaste mass being destroyed.

To ensure reliable power supply of samplers and other equipment used in the operations, stationary electric mains were installed around the shielding structure. Power cables were laid along the perimeter of the shielding structure external walls in metal conduits preventing the cable from being damaged by moving machines.

To limit escape of aerosol contaminants during the operations dust suppression facilities spraying special polymer compounds were installed inside the external shielding structure in the process bay intended for operations on destruction of the concrete-encased radwaste mass when building the shielding structure.

Therefore, the described shielding structure design and its equipment enabled operations inside this structure using remotely controlled special machines, and limited radioactive contamination spreading by air and through soil.

DESIGN OF CONTAINERS FOR HIGH-LEVEL WASTE LOADING

Special reinforced metal containers provided with concrete inserts and concrete lids were developed for packaging and transportation of cases with high-level waste and intermediate-level waste (Fig. 3).

Fig. 3. Reinforced metal containers with concrete inserts (a) and concrete lids (b)

The concrete insert thickness required to meet radiation standards for containers with radwaste was defined based on estimated specific activities of the high-level waste and its isotopic composition.

The calculations assumed that Co-60 and Cs-137 were the basic gamma-emitting radionuclides, with the specific activity ratio of these radionuclides in the radwaste varying in the range from 1/10 to 1/1.5, and activity of other radionuclides, such as Am-241, Eu-154 and Eu-152, was less by 2 or 3 orders of magnitude. It was obtained from calculations that 250-mm thick concrete inserts would be required for packing high-level waste into metal containers.

When loading the containers, the high-level waste or radwaste fragments were placed inside the concrete inserts. Then the container filled with the high-level waste was closed by the 100-mm thick concrete lid and removed from the shielding structure to a special area where the concrete lid was additionally grouted in concrete to ensure complete sealing. The total thickness of the concrete layer produced when sealing the container was equal to that of the concrete insert, i.e. 250 mm.

MONITORING OF OPERATIONS INSIDE THE SHIELDING STRUCTURE

Process operations performed inside the shielding structure using conventional construction machines and robots were monitored by means of a specially developed video system.

Using this system during operations inside the shielding structure, special equipment operators were able to view any work areas, precisely aim special equipment arms at targets, and remotely control robots operating inside the shielding structure.

The system designed for control of the construction machines comprised video cameras, TV monitors, video camera rotators and control panel. The system functionality allowed servicing two construction machines at a time.

The system designed for remote control of the robots included, along with the above components, a gamma imager – a device for producing gamma imagers of high-level gamma sources [5, 6].

The gamma imager was used to detect the most active gamma sources, such as intermediate- and high-level waste or their fragments found in the concrete-encased radwaste mass being destroyed.

When conducting operations at the repository, the gamma imager was installed at the entrance of the shielding structure process bay (Fig. 1, item 6) where the radwaste mass was destroyed, and intermediate- and high-level waste and their fragments were extracted. To reduce background noise in the detector, the instrument was enclosed in lead shielding of thickness about 5 cm and installed behind the internal partition of the shielding structure labyrinth opposite the radwaste mass being destroyed.

During operations at the repository, the gamma imager worked in the mode of continuous generation of gamma images combined with video images, with one combined image produced in about 160 seconds.

When cases with high-level waste, high-level waste fragments or other high-level gamma sources were revealed and identified during operations on destruction of the concrete-encased radwaste mass, their images were recorded by the gamma imager. The gamma images of the high-level sources were further analyzed to assess their gamma dose rate levels and the possibility to extract and remove them from the destroyed radwaste mass. Spectrometers were used to determine radionuclide composition of detected gamma sources in the radwaste.

If high-level waste was found, all subsequent operations on their extraction, fragmentation and handling were conducted by robots inside the shielding structure.

The robots demolished or fragmented remains of the radwaste concrete matrix with a hydraulic hammer, gripped high-level gamma-source fragments with hydraulic shears, and removed the former to a sorting area arranged in one of the process bays inside the shielding structure. Aiming of the robots at high-level sources and operations on their extraction, fragmentation and packing in containers were also monitored using a combined gamma and video image on the gamma imager display (Fig. 4).

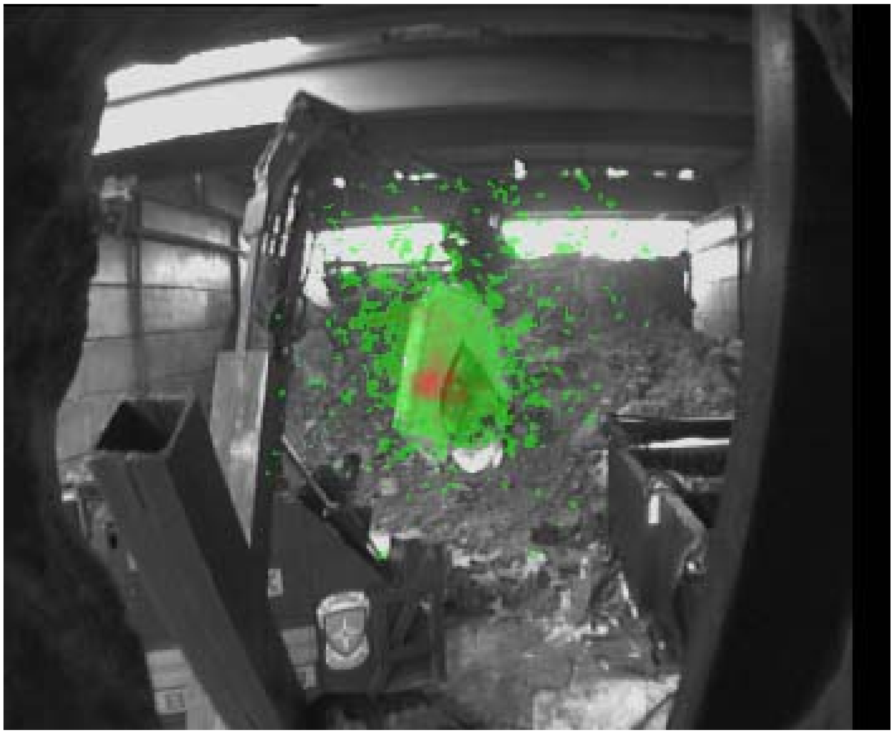

Fig. 4. The moment of extraction of a high-level waste fragment by a robot

It should be noted that the capability to quickly produce images and remove first of all the high-level waste allowed a significant reduction (2 to 5 times) in the gamma dose rate inside the shielding structure during the operations at the repository, which made it possible to partially open the shielding ceiling and remove low-level waste and concrete breakage using conventional construction machines placed atop the shielding structure ceiling.

SORTING OF RADWASTE EXTRACTED FROM THE REPOSITORY

During operations at the repository, all construction machines, robots and working areas were equipped with specially developed threshold collimated detectors (TCD).

The threshold detectors built around scintillator-photodiode detectors operating in current mode were provided with light and audible alarms to ensure warning when a specified threshold value of gamma dose rate is exceeded. The signal from the instrument detector is transmitted to its control unit, and the instrument readings correspond to the gamma dose rate produced by a point gamma source in the instrument field of view. When a gamma source producing a signal exceeding a preset threshold value appeared in the instrument collimator field of view, the instrument audible and light alarms turned on.

During operations at the repository the TCD mounted on a tripod was located at a distance from the radwaste mass being destroyed or the opening in the ceiling of the repository shielding structure. When extracting the radwaste, the robot or excavator clamshell was fixed in the instrument collimator field of view, and the radwaste specific activity was estimated with the TCD. The measurement results were used for preliminary sorting of the radwaste to specific activity levels, and for identification of container type required for the radwaste packaging. This obviated the necessity for resorting of the radwaste and significantly simplified the process of the radwaste packaging in containers.

When the threshold detectors produced an alarm, the work was stopped, and additional dose measurements of the clamshell with the radwaste were performed manually using detection units mounted on a 4-meter extension boom. Thus the use of the TCD enabled enhanced monitoring of radiation conditions in the repository working areas which reduced the dose burden to personnel.

MONITORING OF RADIATION CONDITIONS DURING OPERATIONS AT THE REPOSITORY

A special spectrometric system of remote gamma field distribution measurement built around a gamma locator was used for radiation monitoring in the course of remediation activities at the radwaste disposal site [6, 7].

With the gamma locator which detector unit was installed on the roof of the municipal garage building located outside the external perimeter of the radwaste disposal site, the site was scanned on a regular basis for measurement of the high-energy photon flux, and the measurement results were further used to calculate gamma dose rate distributions. The dose rates were calculated and presented as maps based on the distributions obtained for planes varying in height above the site surface. The produced dose rate distribution maps were used for analysis of the dose rate dynamics throughout the entire radwaste disposal site, evaluation of contribution to the dose rate from various gamma sources found on the site, prediction of personnel exposure doses when planning operations in different areas within the site, and implementation of necessary corrective measures if the allowable levels were exceeded.

It should be noted that comparison of dose rate measurements made by standard dosimeters and calculated values obtained from gamma locator measurements showed their good agreement. The conventional dosimeters, however, even when placed at the height of 2-3 m above the radwaste disposal site surface, did not allow detecting changes in the dose rate at higher elevations (e.g. on the top floors of the municipal garage building). Therefore, the measurements of the dose rate distributions with height performed with the gamma locator represented an additional efficient automated means of radiation monitoring over the entire radwaste disposal site, including its external perimeter.

In view of specificity of location of repository No.4, the organization of radiation monitoring with the gamma locator as described above was modified for operations at this repository, and the second gamma locator was installed on the roof of the municipal garage building.

In this case the first locator, as before, was used to monitor radiation conditions over the entire radwaste disposal site. This locator scanned the site step by step, detected the most intensely radiating surfaces and objects and measured their photon fluxes taking into account their spectral features. The photon flux distributions obtained were further used for calculation of dose rate distributions in all points and throughout the height of the scanned space, which were presented in the form of a color palette superimposed onto a coordinate image of the site.

The second locator was used for continuous monitoring of radiation conditions directly in the repository working area. This gamma locator measured photon flux immediately from the opening in the shielding structure ceiling and in space around the repository. Results of the measurements were processed on a PC with special codes, and further transmitted via Internet to operating personnel monitors as a video imaged of the scanned area, characteristics of the detected gamma spectrum, and measured values of the dose rate.

When reference dose rate levels were exceeded, alarms appeared on the PC screen, which made it possible to quickly respond to changes in the radiation conditions, make decisions on interruption of the operations at the repository, timely detect and eliminate reasons that caused the dose rates to exceed the reference levels. This allowed radiation safety monitoring virtually for each of the process operations, including those relating to the radwaste mass destruction and high-level waste extraction that were performed inside the shielding structure.

The organization of radiation monitoring with the gamma locators described above made it possible to quickly obtain information on radiation conditions, avoid personnel exposure above the allowed levels, and ensure that applicable radiation safety rules and regulations are observed during operations at repository No.4.

CONCLUSION

The work on radwaste extraction from old repository No.4 and disposition of this repository was performed at the Kurchatov Institute radwaste disposal site in the period from September 2004 to June 2005. This repository was not easily accessible for extraction of the radwaste since the entire radwaste mass was encased in high-strength concrete, and included a lot of cases with high-level waste. The radiation examination of the cases showed that the gamma dose rate they produced might be as high as 0.3 Sv/hr and above.

Taking into account radiation characteristics of the radwaste and location of the repository in close vicinity to the city housing estate, the decision was made to arrange an additional external radiation shielding for operations on disposition of this repository, for which purpose a shielding structure was constructed around the repository.

In accordance with the developed technology, the work on destruction of the concrete-encased radwaste mass and extraction of high-level waste was performed inside the shielding structure using remotely controlled robots.

A process control system based on video cameras and a gamma imager was developed for remote control of robots, detection of intense gamma sources and aiming of robots at such sources during operations inside the shielding structure.

Radiation conditions in repository working areas and throughout the radwaste disposal site were monitored remotely with gamma locators, along with standard dose metering instruments.

Threshold collimated detectors were used for immediate control of radiation conditions during extraction of the radwaste, its sorting and packaging into containers.

Each process operation with the radwaste was accompanied by intensive dust suppression through application of special polymer compounds, and by control of aerosol activity in the working area air.

As a result of the work performed, 487.1 m^3 of solid radwaste were extracted from this not easily accessible repository, including 103.7 m^3 of intermediate- and high-level waste, and 383.4 m^3 of low-level waste. The total activity of the radwaste removed from the repository was 1.06×10^{13} Bq (about 290 Ci), which was almost twice the activity of the radwaste removed from the other 9 old repositories at the radwaste disposal site, which had been dispositioned before.

During operations at the repository, the gamma dose rate at the radwaste disposal site perimeter varied over the range from 0.21 to 0.67 μSv/hr, while at the Kurchatov Institute perimeter it was in the range from 0.08 to 0.14 μSv/hr. The personnel external exposure during the period of operations at the repository was as follows: mean dose – 3.14 mSv/yr; collective dose – 84.9 mSv. The volume activity of the air along the radwaste disposal site perimeter and at the Kurchatov Institute site was by 3-5 orders of magnitude less than allowable levels for urban population.

Thus the work organization and process equipment used for operations at the not easily accessible repository, and radiation monitoring instruments employed in the operations allowed disposition of the repository found in the open ground amidst a big city to be completed rather quickly, meeting radiation safety requirements for personnel and urban population.

With disposition of this not easily accessible repository, the stage of remediation of old repositories at the Kurchatov Institute radwaste disposal site has been almost completed.

At present the work on soil decontamination is being continued at the site, and residual contamination of the soil and groundwater is being examined. Based on results of this work, a final decision will be made concerning advisability of construction of additional engineering barriers preventing contamination release beyond the site.

REFERENCES

1. V.G. Volkov, N.N. Ponomarev-Stepnoi, E.S. Melkov, E.P. Ryazantsev et al. “Status of Activities on Rehabilitation of Radioactively Contaminated Facilities and the Site of Russian Research Center “Kurchatov Institute”. –In: Proceedings of WM’03 Conference, Tucson, Arizona, USA, February 23-27, 2003, WM Symposia Inc. (2003).
2. V.G. Volkov, N.N. Ponomarev-Stepnoi, G.G. Gorodetsky, Yu.A. Zverkov et al. “The First Stage of Liquidation of Temporary Radwaste Repositories and Rehabilitation of the Radwaste Disposal Site at the Russian Research Center “Kurchatov Institute”. –In: Proceedings of WM’04 Conference, Tucson, Arizona, USA, February 29 - March 4, 2004, WM Symposia Inc. (2004).
3. V.G. Volkov, G.G. Gorodetsky, Yu.A. Zverkov, A.V. Lemus et al. “Radioactive Waste Management Technologies Used in Rehabilitation of Radioactively Contaminated Facilities and Areas at the RRC “Kurchatov Institute” Site”. –In: Proceedings of the 7th International Conference “Safety of Nuclear Technologies: Radioactive Waste Management” (September 27 - October 1, 2004, St.-Petersburg, Russia), Pro Atom publisher, 2004, pp. 141-156.

4. V.G. Volkov, N.N. Ponomarev-Stepnoi, G.G. Gorodetsky, Yu.A. Zverkov et al. “Main Results of the Second Stage of Liquidation of Temporary Radwaste Repositories and Rehabilitation of the Radwaste Disposal Site at the Russian Research Center “Kurchatov Institute”. –In: Proceedings of WM’05 Conference, Tucson, Arizona, USA, February 27 - March 3, 2005, WM Symposia Inc. (2005).
5. A.N. Sudarkin, O.P. Ivanov, V.E. Stepanov, V.N. Potapov et al. “High-Energy Radiation Visualizer (HERV). A New System for Imaging in X-Ray and Gamma-Ray Emission Regions.” –IEEE Transaction on Nuclear Science, vol. 43, No. 4, 1996, p. 2427.
6. V.N. Potapov, O.P. Ivanov, S.M. Ignatov, N.K. Kononov et al. “New Instruments and Radiation Monitoring Systems for Employment in Rehabilitation Activities at Radwaste Disposal Site of the RRC “Kurchatov Institute”. –In: Proceedings of the 7th International Conference “Safety of Nuclear Technologies: Radioactive Waste Management”, (September 27 - October 1, 2004, St.-Petersburg, Russia), PRo Atom publisher, 2004, pp. 371-377.
7. V.N. Potapov, O.P. Ivanov, S.M. Ignatov, N.K. Kononov et al. “The System for Monitoring of Main Dose Rate Sources for Application at Rehabilitation Works”. –In: Proceedings of WM’04 Conference, Tucson, Arizona, USA, February 29 - March 4, 2004, WM Symposia Inc. (2004).