

German Support Program for Retrieval and Safe Storage of Disused Radioactive Sealed Sources in Ukraine - 13194

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ABSTRACT

The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) on behalf of the Government of the Federal Republic of Germany supports the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) in enhancement of nuclear safety and radiation protection and strengthening of the physical protection.

One of the main objectives of the agreement concluded by these parties in 2008 was the retrieval and safe interim storage of disused orphan high radioactive sealed sources in Ukraine. At present, the Ukrainian National Registry does not account all high active radiation sources but only for about 70 - 80 %.

GRS in charge of BMU to execute the program since 2008 concluded subcontracts with the waste management and interim storage facilities RADON at different regions in Ukraine as well with the waste management and interim storage facility IZOTOP at Kiev. Below selected examples of removal of high active Co-60 and Cs-137 sources from irradiation facilities at research institutes are described.

By end of 2012 removal and safe interim storage of 12.000 disused radioactive sealed sources with a total activity of more than $5,7 \cdot 10^{14}$ Bq was achieved within the frame of this program. The German support program will be continued up to the end of 2013 with the aim to remove and safely store almost all disused radioactive sealed sources in Ukraine.

INTRODUCTION

The loss of surveillance and control of disused orphan high radioactive sealed sources in many countries worldwide has led to a remarkable number of accidental events with serious radiological and even fatal consequences in recent years. On the other hand the authorities of nuclear safety and radiation protection regulations in many countries are facing these challenges by means of appropriate regulation e.g. based on the 2004 IAEA Code of Conduct on the Safety and Security of Radioactive Sources [1] as well as of practical measures.

The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) on behalf of the Government of the Federal Republic of Germany supports the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) in enhancement of nuclear safety and

radiation protection and strengthening of the physical protection.

In 2008 a bilateral agreement was concluded by these parties on issues of mutual interests the objectives of which were the enhancement of nuclear safety, radiation protection and management of radioactive waste as well as strengthening of physical protection. Regarding high radioactive sealed sources which have been under improper control a special objective was devoted to the strengthening of the safety and control by means of removal, collection and safe storage of disused radioactive sources at interim storage facilities and thus also enhancing the physical protection.

The agreement is based on European (EU) and international (IAEA) rules and guidelines on nuclear and radiation safety and on management of radioactive waste, on manufacturing, use, handling, transport and storage of radioactive sources and on the 2004 IAEA Code of Conduct on the Safety and Security of Radioactive Sources containing a categorization of radiation sources as well as on all legal regulations and rules of Ukraine concerning radiation protection, safe transportation and management and storage of radioactive waste.

GRS in charge of the BMU and in close cooperation with SNRIU executes the program since end of 2008 with other subcontractors in Ukraine.

PROJECT ORGANIZATION

The German program of removal and safe interim storage of disused orphan high radioactive sealed sources in Ukraine was organized by GRS in the following way (see Fig. 1). On the one hand the beneficiaries, i.e. bankrupt industrial enterprises, state research institutes etc. were selected in close cooperation with SNRIU which serves as the program supervisor in Ukraine.

On the other hand direct contracts between GRS and proper subcontractors to perform the work in Ukraine were concluded after an evaluation process and approval by the BMU. Among others the waste management and interim storage facilities RADON for the regions Lvov, Dnepropetrovsk, Donetsk, Kharkov and Odessa as well as the waste management and interim storage facility IZOTOP at Kiev have been subcontracted. Subcontracts will partly be extended until 2013 (see Fig. 2).

The procedure of the work contained yearly campaigns (stages) with different steps.

First step to be performed by SNRIU always was the draft of a list of objects at the different regions in Ukraine where the disused radioactive sources were located. To these objects in most cases belong e.g. bankrupt industrial enterprises, institutes performing research and technical applications with radioactive sources, hospitals performing medical treatments with radioactive sources etc.

General Project structure

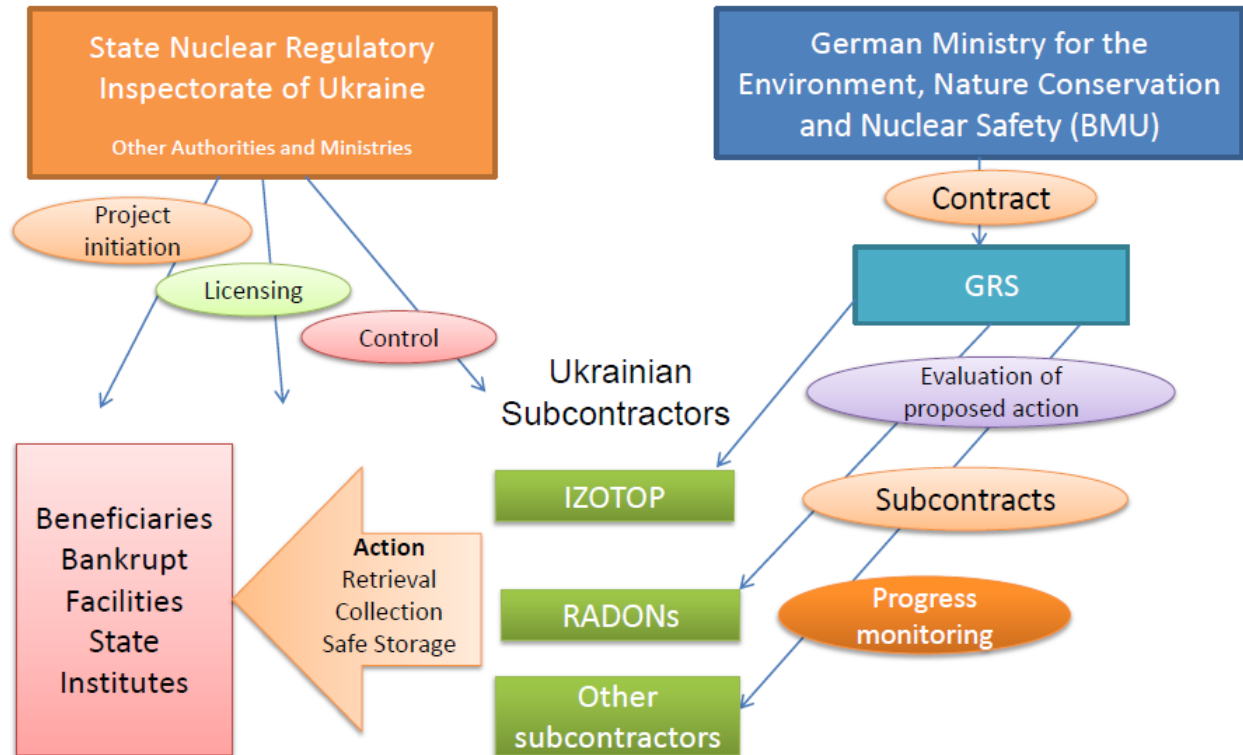


Fig. 1. General project structure of the German program of removal and safe interim storage of disused orphan high radioactive sealed sources in Ukraine

The second step contained gathering of more information concerning technical specifications and conditions available at the object on site by SNRIU and the subcontractor, i.e. number of sources, technical status, isotope and activity, storage conditions and risks etc. as well as a rough estimate of the feasibility and the efforts of retrieval.

In the third step a priority ranking list was agreed between the parties with regard to the urgency of retrieval as well as the yearly budget available at the German side. During the proposal and the realization phase site visits of selected objects in Ukraine were performed usually with participants from the German side (GRS and BMU) as well as from the SNRIU and its local representatives.

The fourth step includes the choice of the appropriate subcontractor among those mentioned above, the conclusion of the subcontract, the project design, the licensing procedure and the execution of work, documentation, reporting, quality control etc.

RADON Locations for temporary storage of RAM in Ukraine



Fig. 2. Locations of the GRS subcontractors - the waste management and interim storage facilities RADON for the regions Lvov, Dnepropetrovsk, Donetsk, Kiev, Kharkov and Odessa and the waste management and interim storage facility IZOTOP at Kiev

RADIATION PROTECTION AND WASTE MANAGEMENT REQUIREMENTS

At all stages of characterization of the given situation of disused radiation sources at the selected objects, the planning and realization of handling during removal and transportation as well as identification and the safe storage at an interim storage facility the following radiation protection and waste management as well as other safety requirements had to be observed:

- Investigation and description of the given radiological situation concerning the disused radiation sources, total number, type of radiation and activity, physical and chemical conditions, e.g. corrosion, tightness etc., dose rate, radioactive contaminations, properties of containers etc.,
- Work planning for handling and removal including expected radiation exposure to workers, training on mock ups to optimize time sequences and thus to reduce radiation doses with regard to ALARA,

- Installation of temporary radiation protection areas and proper radiation monitoring and contamination detectors, provision of radiation protection means, e.g. mobile shielding walls, protective garment, decontamination means etc.,
- Risk analyses including management of accidental situations during removal, transportation and storage with potential damage of radiation sources, loss of integrity and release of radioactivity into the environment, countermeasures and emergency preparedness measures.

The subcontractor had to elaborate a safety assessment report (SAR) as part of the contract with GRS and also as part of the licensing procedure ruled by SNRIU. Besides SNRIU also other regulatory authorities as e.g. the ministry of internal affairs and the ministry of health of Ukraine were involved in the licensing procedure. The applicant/licensee had to demonstrate all the safety requirements listed above in the SAR.

The SAR was always reviewed by GRS and if necessary the removal procedure was adjusted and completed. During SAR review of GRS special emphasis was put on the presentation and evaluation of the radiological situation before, during and after the work to be performed, the radiological hazards for the occupationally exposed workers and for the population. Analyses included also emergency situations as well as the transportation and handling process at the interim storage after retrieval at the object.

PROJECT REALIZATION

Overview

According to the described project organization in the time period from end of 2008 till the end of 2012 five project stages in the frame of the German support program were performed. An overview with the details of the different campaigns concerning also the numbers and parameters of the radiation sources removed and safely stored is indicated in Table I.

The stage 1 was realized in 2008 - 2009 by subcontracting the waste management and interim storage facilities RADON Dnepropetrovsk, Donetsk, Kharkov and Lvov. These RADON facilities removed disused radioactive sources (List 1) mainly of bankrupt industrial enterprises at their corresponding regions and stored them at their own storages sites.

An analogous approach was chosen 2011 at stage 4 in the Odessa region by subcontracting the responsible RADON facility for similar tasks as mentioned above.

The stage 3 contained among tasks for removal of disused radioactive sealed sources also the removal of open radioactive liquids from a storage and laboratory premise of the bankrupt RIUS experimental and research institute at Kiev. Moreover the decontamination of the laboratory

floor covering by scraping off spots of concrete layers had to be performed until the clearance dose rate was reached. This work was performed by the Kiev RADON facility in 2011.

TABLE I. Total Amount of Removed and Safely Stored Radiation Sources 2008-2012

| Nuclide | Stage 1, 4 Radon | | Stage 2, Institutes | | Stage 3, RIUS | | Stage 4, Odessa | | Stage 5, List 2 | | Summary | |
|---------------|------------------|---------------|-----------------------|---------------|-----------------|---------------|-----------------|---------------|-----------------|---------------|--------------------|---------------|
| | Activity [Bq] | No of sources | Activity [Bq] | No of sources | Activity [Bq] | No of sources | Activity [Bq] | No of sources | Activity [Bq] | No of sources | Activity [Bq] | No of sources |
| Am-241 | 1,76E+12 | 134 | | | 2,35E+11 | 16 | 5,55E+05 | 5 | 2,70E+10 | 1 | 2,02E+12 | 156 |
| C-14 | | | | | | | 4,45E+09 | 10 | 3,66E+04 | 30 | 4,45E+09 | 40 |
| Ce-139 | 1,00E+05 | 1 | | | | | 5,02E+05 | 5 | | | 6,02E+05 | 6 |
| Co-57 | 1,00E+05 | 1 | | | | | 4,93E+05 | 5 | 5,44E+09 | 13 | 5,44E+09 | 19 |
| Co-60 | 1,17E+12 | 85 | 3,82E+14 | 192 | 1,34E+07 | 7 | 3,70E+09 | 153 | 1,60E+10 | 86 | 8,33E+13 | 523 |
| Cs-137 | 2,34E+13 | 671 | 4,59E+13 | 27 | 1,20E+11 | 33 | 7,69E+11 | 25 | 2,45E+13 | 92 | 9,47E+13 | 848 |
| H-3 | 9,18E+13 | 4286 | | | | | 5,98E+10 | 56 | | | 9,19E+13 | 4342 |
| Hg-203 | 3,00E+05 | 1 | | | | | 1,34E+06 | 5 | | | 6,12E+09 | 6 |
| Ir-192 | 2,24E+09 | 2 | | | | | | | | | 4,49E+10 | 2 |
| Kr-85 | 3,64E+09 | 8 | | | 8,70E+08 | 1 | | | | | 4,51E+09 | 9 |
| Mn-54 | 1,00E+05 | 1 | | | | | 5,82E+05 | 5 | | | 6,82E+05 | 6 |
| Na-22 | 1,00E+05 | 1 | | | | | 5,83E+05 | 5 | | | 6,83E+05 | 6 |
| Ni-63 | 1,78E+08 | 24 | | | | | 8,00E+07 | 2 | 1,65E+09 | 15 | 1,91E+09 | 41 |
| Pm-147 | 2,04E+09 | 87 | | | | | | | | | 8,16E+09 | 87 |
| Po-208 | | | | | | | 4,49E+04 | 1 | | | 4,26E+10 | 1 |
| Pu-238 | | | | | 1,76E+10 | 10 | 8,88E+08 | 49 | | | 1,85E+10 | 59 |
| Pu-239 | 3,87E+10 | 1494 | | | | | 8,82E+09 | 1163 | 6,12E+09 | 2756 | 5,36E+10 | 5413 |
| Pu-242 | | | | | | | 5,30E+01 | 1 | | | 5,30E+01 | 1 |
| Ra-226 | 7,31E+07 | 13 | | | 9,50E+04 | 2 | 4,36E+05 | 3 | | | 7,36E+07 | 18 |
| Sn-113 | 1,00E+05 | 1 | | | | | 6,69E+05 | 5 | | | 7,69E+05 | 6 |
| Sr-90+Y-90 | 3,77E+09 | 367 | | | 1,65E+10 | 11 | 5,58E+08 | 77 | 4,26E+10 | 242 | 6,35E+10 | 697 |
| Tl-204 | 4,51E+09 | 5 | | | 5,30E+08 | 3 | | | | | 5,04E+09 | 8 |
| U-233 | | | | | | | 4,00E+03 | 1 | | | 4,00E+03 | 1 |
| U-234 | | | | | | | 2,00E+02 | 2 | | | 2,00E+02 | 2 |
| Y-88 | 1,00E+05 | 1 | | | | | 4,36E+05 | 4 | | | 5,36E+05 | 5 |
| Zn-65 | 1,00E+05 | 1 | | | | | | | | | 1,00E+05 | 1 |
| Sum | 1,18E+14 | 7184 | 4,28E+14 | 219 | 3,91E+11 | 83 | 8,48E+11 | 1582 | 2,46E+13 | 3235 | 5,72E+14 | 12303 |
| Period | 2008/2009 | | 2010/2011/2012 | | 2011 | | 2011 | | 2012 | | 2008 - 2012 | |

The radioactive sources collected by the RADON facilities as described above are placed mostly in old storage casks which do not always comply with the national and international requirements.

For a future safe disposal it is aimed to ship the radioactive sources to the “Vector” storage and disposal facility which is currently under construction at the Chernobyl exclusion zone. For the disposal it will be necessary to design, certify and manufacture corresponding casks.

For the removal and safe storage of high active radiation sources from state scientific research institutes of stage 2 in 2010 - 2012 as well as for the execution of stage 5 (List 2, bankrupt industrial enterprises) in 2012 which from the contents of work is very similar to stage 1 the waste management and interim storage facility IZOTOP at Kiev was chosen as the responsible subcontractor. The work of stage 5 (List 2) of objects in the western as well as in the southern regions of Ukraine was completed by the end of 2012.

Contrary to the technical procedures described in the stages above where the radiation sources were in most cases already contained in storage casks at the bankrupt enterprises, the radiation sources at the scientific research institutes were contained in disused irradiation facilities and first had to be removed from these devices and put into appropriate casks.

In view of the remarkable activities of these gamma radiation sources and due to lack of appropriate transport and storage casks in Ukraine with sufficient radiation attenuation of the shielding walls GRS ordered five new transport and storage casks within the frame of the German support program.

The procurement of these new casks was carried out within a subcontract between GRS and the company UJP at Prague, Czech Republic. UJP was responsible for the design, construction, testing and certification according to the IAEA and EU safety standards and requirements. The design was also agreed with the technical requirements of the beneficiary IZOTOP Kiev.

More technical details of stage 2 will be described below.

Kiev Cell Biology Institute and Sevastopol Kovalevski Institute

In both institutes identical disused gamma irradiation facilities “Issledovatel” were available and since several years out of operation. The facilities were equipped with different numbers and types of sources. Nevertheless, the technical procedures of removal of the high active gamma radiation sources were almost the same. Below the example of the Sevastopol Kovalevski Institute procedure will be described in more detail.

The planning phase started in early 2010 and the removal of the radiation sources and the transportation from Sevastopol at the Crimea peninsula to IZOTOP Kiev was carried out in January 2011.

The radioactive inventory of the irradiation facility consisted of 27 sealed sources of Cs-137 with an activity of 1,7 T Bq per source, i.e. a total activity of $45,9 \cdot 10^{12}$ Bq with regard to 01 January 2010. The scheme of the irradiation facility as well as of the sealed source is shown in Fig. 3.

These sealed sources inside the irradiation facility at the bottom of a channel were originally positioned in different vertical tubes at the wall around a cylindrical chamber, the inner volume of which served as the irradiation volume for the specimen to be irradiated. During the removal procedure a transfer cask was put above the channel (see Fig. 4). The pull out of the sources was made by hand using special tongs. Directly after pull out of the tubes the sources were lifted and placed in the transfer cask. Finally, all sources were put from the transfer cask into the transport and storage cask with overpack for the safe road transportation towards Kiev (see Fig. 4).

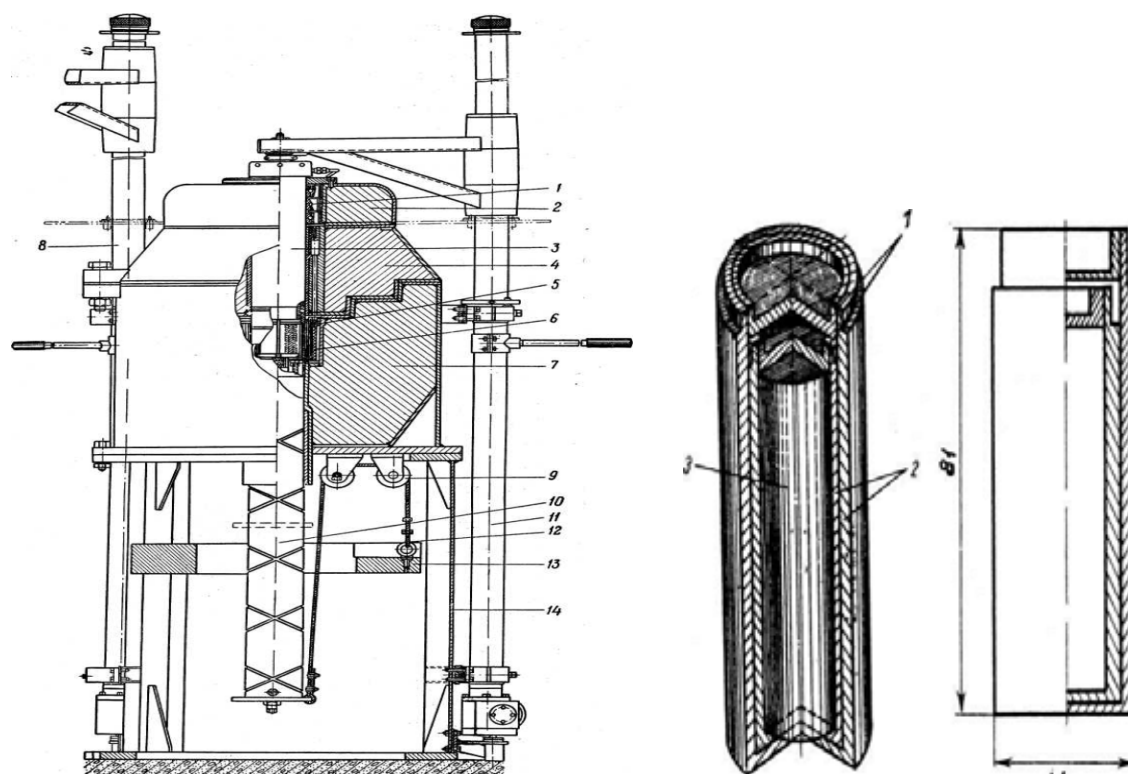


Fig. 3. Left: Scheme of the Gamma Irradiation Facilities “Issledovatel” (1, 2 - Upper Shielding Parts, 3 - Plug, 4 - Lid, 5 - Irradiation Part, 6 - Radiation Sources, 7 - Cask Wall, 8 - 13 Mechanism for Lifting the Plug, 14 - Platform), Right: Radiation Sources with Isotope Cs-137 (1 - Sealing, 2 - Ampulla, 3 - Isotope Cs-137, Diameter - 11,5 mm, Height - 84,0 mm)

The procedure of removal at the Kiev Cell Biology Institute was carried out analogously. In this case 12 sealed sources of Co-60 with a total activity of $2,7 \cdot 10^{12}$ Bq as of 01 January 2010 have been removed and safely disposed.

For identification the sealed sources were taken out of the transport and storage cask in the hot cell of the Kiev Institute of Physics. In a chemical treatment the source capsule was cleaned and the identification number was revealed.

Currently within the frame of another German support project IZOTOP will be equipped with an own hot cell to be able to treat and repack the sealed sources at its own territory and thus to avoid additional transportation through the city of Kiev [2].



Fig. 4. Left: Gamma Irradiation Facility “Issledovatel” with Transfer Cask above the Irradiation Channel, Right: Transport and Storage Cask with Overpack at the Transport Vehicle

Kiev Irradiation Treatment and Material Science Institute RADMA

At the institute two identical disused gamma irradiation facilities UKT and UK 250000, respectively, were available and since several year out of operation. Thus the technical procedures of removal of the high active gamma radiation sources were almost the same.

The planning phase started in early 2011 and the removal of the radiation sources of the first facility UKT and the transportation from RADMA to IZOTOP Kiev was carried out in December 2011 and of the second facility UK 250000 in January 2012, respectively.

The radioactive inventory of the irradiation facilities consisted of 90 sealed sources of Co-60 each with a total activity of 80 T Bq for UKT and a total activity of 300 T Bq for UK 250000, respectively, i.e. a total summary activity of $3,8 \cdot 10^{14}$ Bq with regard to 01 April 2011. The scheme of the irradiation facilities is shown in Fig. 5.

The irradiation facility consisted of a cylindrical basket of 30 tubes originally containing 3 sealed sources each (see Fig. 6). The basket was located in a water basin at the bottom of 3,5 m depth. The basins of both irradiation facilities were connected by a sluice so that a basket could be moved under water from one basin into the other.

Whereas at the facility UK 250000 with thick shielding walls and a lifting apparatus specimen could be irradiated inside the basket under water as well as free in air by lifting the basket out of the water at the adjacent facility UKT irradiation was possible under water only.

During the removal procedure the basket tubes were opened and the radiation sources were shaking out into a cup (see Fig. 7). Afterwards the transport and storage cask containing a water drainage tub was let down to the basin bottom and the radiation sources were put from the cup into the cask, the cask was closed under water and lifted up. All the procedure was performed by hand using special tongs and other remote handling devices and controlled by under water camera.

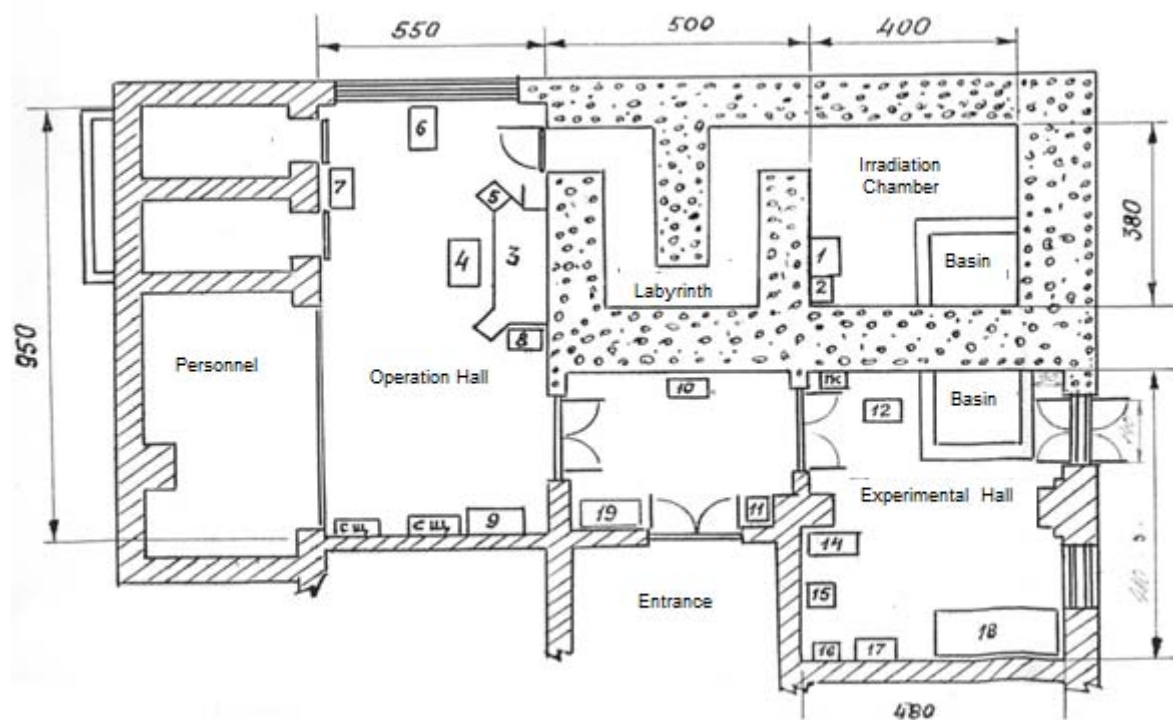


Fig. 5. Scheme of the Gamma Irradiation Facilities UK 250000 (Upper Basin and Irradiation Chamber) and UKT (Lower Basin) at RADMA Institute Kiev (Dimensions in cm)



Fig. 6. Irradiation Basket with Tubes originally containing the Radiation Sources, Left: Side View, Right: Top View

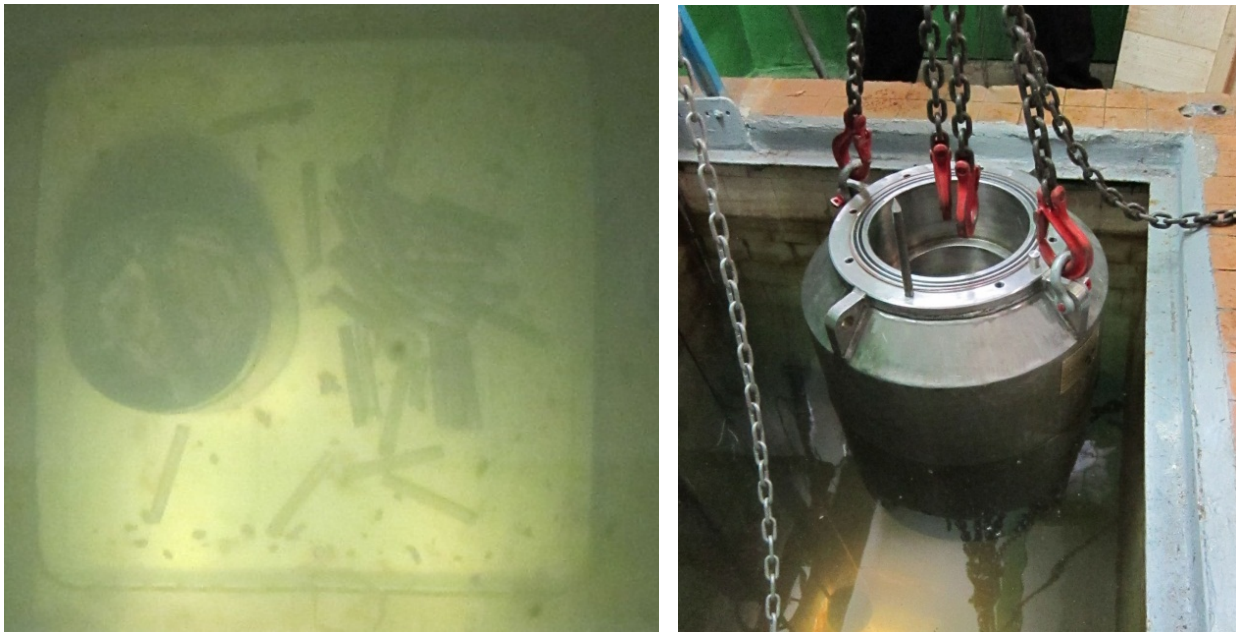


Fig. 7. Left: Empty Irradiation Basket and Radiation Sources in the Cup at the Basin Bottom, Right: Let down of the Transport and Storage Cask to the Basin Bottom

SUMMARY AND CONCLUSIONS

By the end of 2012 removal and safe interim storage of more than 12.000 disused radioactive sealed sources with a total activity of more than $5,7 \cdot 10^{14}$ Bq from bankrupt entities in Ukraine was achieved within the frame of the German support program which significantly reduced the radiological risk in vast regions of Ukraine.

The work performed within almost four years was only possible owing to an excellent cooperation between GRS, BMU, SNRIU and other authorities and the subcontractors IZOTOP, RADON and UJP.

The radioactive sources collected by now at interim storage facilities are placed mostly in old casks which do not always comply with the national and international standards and requirements. For a future safe disposal at “Vector” storage at the Chernobyl exclusion zone it is necessary to design, certify and manufacture corresponding casks.

At present, the National Registry of Ukraine does not account all high active radiation sources. A complete accounting of all radiation sources in the Registry is urgently needed.

The German support program will be continued up to the end of 2013 with the aim to remove and safely store almost all disused radioactive sealed sources in Ukraine.

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