Safety and Security of Radioactive Sealed and Disused/Orphan Sources in Ukraine - German Contribution – 13359

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ABSTRACT

Within the scope of 'Nuclear Security of Radioactive Sources', the German government implemented the modernization of Ukrainian State Production Company's transport and storage facility for radioactive sources (TSF) in Kiev. The overall management of optimizing the physical protection of the storage facility (including the construction of a hot cell for handling the radioactive sources) is currently carried out by the German Federal Foreign Office (AA). AA jointly have assigned Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH, Germany's leading expert institution in the area of nuclear safety and waste management, to implement the project and to ensure transparency by financial and technical monitoring.

Sealed radioactive sources are widely used in industry, medicine and research. Their life cycle starts with the production and finally ends with the interim/long-term storage of the disused sources. In Ukraine, IZOTOP is responsible for all radioactive sources throughout their life cycle.

IZOTOP's transport and storage facility (TSF) is the only Ukrainian storage facility for factory-fresh radioactive sources up to an activity of about 1 million Ci (3.7 1016 Bq). The TSF is specially designed for the storage and handling of radioactive sources. Storage began in 1968, and is licensed by the Ukrainian state authorities. Beside the outdated state of TSF's physical protection and the vulnerability of the facility linked with it, the lack of a hot cell for handling and repacking radioactive sources on the site itself represents an additional potential hazard.

The project, financed by the German Federal Foreign Office, aims to significantly improve the security of radioactive sources during their storage and handling at the TSF site. Main tasks of the project are a) the modernization of the physical protection of the TSF itself in order to prevent any unauthorized access to radioactive sources as well as b) the construction of a hot cell to reduce the number of transports of radioactive sources within the city of Kiev. In future, the new established hot cell at IZOTOP's transport and storage facility will be useful for identification and characterization of orphan/disused radioactive sources.

The projects implemented are performed in accordance with international recommendations (e. g. IAEA) and national normative documents and will make a crucial contribution towards an improved safety and security management of radioactive sources in Ukraine.

INTRODUCTION

The 'G8 Global Partnership (G8GP) against the Spread of Weapons and Materials of Mass Destruction' was established at the G8 summit meeting in Kananaskis, Canada, in June 2002. The Kananaskis summit resulted, inter alia, in a new prescription for international co-operation in non-proliferation. The participants agreed to provide up to US$ 20 billion over a time period of 10 years, to be used to implement definite projects within the Global Partnership framework. There was also consensus to focus first on the implementation of co-operation projects in the Russian Federation, with Russia providing US$ 2 billion and Germany1 pledging up to US$ 1.5 billion. In extension of that first step, the Ukraine has also been a beneficiary since 2004.

The German support and funding focuses on three core areas of the Global Partnership:

- destruction of chemical weapons,
- disposal of radioactive reactor compartments of decommissioned Russian nuclear submarines at the long-term interim storage facility in Sayda Bay
- security of nuclear material against proliferation of weapons and material of mass destruction

The projects relating to the destruction of chemical weapons and to the physical protection fall within the competence of Germany's Federal Foreign Office; the Federal Ministry of Economics and Technology is responsible for the project with regard to the disposal of nuclear submarines.

The overall management of realizing the projects intended to optimize the system of physical protection of nuclear facilities and material lies with the German Foreign Ministry. In order to ensure transparency as well as financial and technical monitoring, the ministry has commissioned Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH in Cologne with project implementation. GRS, being Germany's central expert institution in the area of nuclear safety, provides knowledge, methods and data for assessing and, where necessary, improving the safety of technical facilities. GRS has been active in Russia in various fields since the beginning of the 1990's.

A proposal to modernize the transportation and storage facility (TLK) of the Ukrainian State Production Company IZOTOP within the scope of the G8GP programme was submitted to GRS by the Ukrainian government. Since 2010, the German government has been providing financial resources for the modernization of the TLK. The main tasks are the modernization of physical protection by constructional and technical measures as well as the construction of a hot cell.

With the realization of the project, the modernization of the physical protection of the TLK will prevent any unauthorized access to the highly radioactive sources in the storage itself. In addition,

[1] The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the German Federal Foreign Office have been involved in German-Russian cooperation in the field of physical protection of nuclear material since the mid and late nineties, respectively.

the construction of a hot cell on TLK premises allows for a considerable reduction of transports of radioactive sources within the city of Kiev. In the past, these transports - needed for handling and repacking of radioactive sources in a downtown facility - have represented an increased risk of theft of radioactive material for misuse.

Realization of the project is now carried out within the framework agreement 'German-Ukrainian cooperation in securing nuclear material against theft and misuse in the frame of the G8 Global Partnership against the spread of mass destruction weapons and materials'. This framework agreement was signed by the Federal Republic of Germany, represented by the Federal Foreign Office and GRS, on July 9th, 2009.

According to its commissioning, GRS checks in particular whether the funds are used purposefully and appropriately. This task also includes, among others, a review of the vulnerability assessment, and subsequent supervision of the project development, including detailed measures, as well as the financial and time frame of the project. Further responsibilities include policing the procurement, constructions, installation of technical equipment, and acceptance inspection of the security systems.

IZOTOP COMPANY

The 'Ukrainian State Production Company IZOTOP' was founded in 1962 in the former Soviet Union and now belongs to the Ukrainian Ministry of Industrial Policy. Currently, IZOTOP employs app. 130 people, about 20 of them working at the transport and storage facility (TLK). Financing of the company is exclusively based on projects which results in a lack of funds for modernization of the physical protection of the TLK or the construction of a hot cell from IZOTOP's own resources.

IZOTOP is responsible for the entire life cycle of radioactive sources in Ukraine. 95% of the radioactive sources are imported directly by IZOTOP. For the remaining 5% IZOTOP is at least involved in customs formalities and permission affairs. While radioactive sources, imported e. g. from the United States, Great Britain or China, will be returned after their use in Ukraine to the country of origin, the sources imported from Russia must be disposed of either in an interim (RADON) or a long-term storage (VEKTOR) in Ukraine (Fig. 1).

From IZOTOP's TLK, the radioactive sources will be transported to the end-user, who now is responsible for the proper security of the sources during their intended use. After their operating time, the radioactive sources will be returned either to IZOTOP or transported as waste into storage facilities. An interim storage may take place in the designated RADON interim storage facilities; in the long term, the sources will be transported and stored at the VECTOR site (Fig. 1).

The TLK is specially designed for the storage and handling of radioactive sources. Storage operation started in 1968, and is licensed by the Ukrainian authority up to an activity of about 1 million Ci (3.7 1016 Bq). The warehouse itself consists of 500 canyons, providing special shielding for containers with radioactive sources. According to the valid licence, a total number of

3.000 highly active Co-60 sources can be stored at the same time.

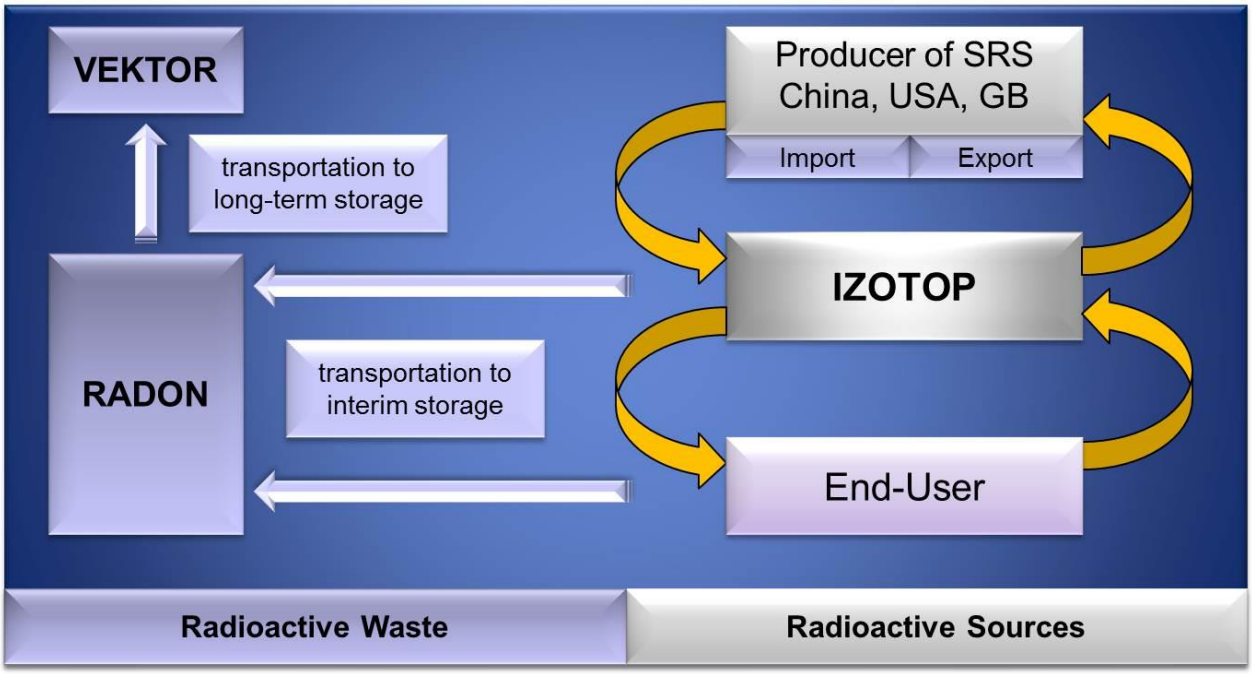

Fig. 1 Life cycle of radioactive sources (SRS) in Ukraine

IZOTOP's TLK is the only Ukrainian storage facility for "fresh" radioactive sources. The complex is located on the eastern outskirts of Kiev near the village Priliski and about 1 km apart from the Kiev - Boryspil highway. The complex covers approximately 6 hectares and is surrounded by an app. 1,100 m long, 2.8 m high reinforced concrete fence. Fig. 2 shows an aerial view as well as a photograph of the TLK.

Beside the outdated state of the TLK's physical protection and the vulnerability of the facility linked with it, the lack of a hot cell for handling and repacking radioactive sources represents an additional potential danger; currently, the radioactive sources are transported through the city of Kiev to an app. 50-year-old hot cell at the Kiev Institute for Nuclear Research (KINR). This hot cell no longer constitutes the technical state of the art and is connected with a high transport risk. Crossing the River Dnieper is just possible via two bridges, which practically does not allow variations in the transport routes. This poses both threats to the population and an increased potential regarding the theft of radioactive material for misuse.

Fig. 2 Aerial view (left) and photograph (right) of IZOTOP's transport and storage facility (TLK)

MODERNIZATION OF PHYSICAL PROTECTION IN ACCORDANCE WITH INTERNATIONAL RECOMMENDATIONS

Security requirements should be based on a graded approach, taking into account the current evaluation of the threat, the relative attractiveness of a radioactive source, the nature of the source, and potential consequences associated with its unauthorized removal or sabotage. The design of a security system should take into account the current national threat assessment and may include the development and application of a design basis threat (DBT), also defined at State level. For evaluation of the security system, a vulnerability assessment (VA), which is a systematic appraisal of the effectiveness of a security system for protection against an assumed threat, has to be conducted [1].

The Code of Conduct applies to radioactive sources that may pose a significant risk to individuals, society, and the environment, i. e. sources in Categories 1 - 3. Appropriate security measures should be applied to reduce the likelihood of malicious acts involving these sources [2]. As a basic principle of the Code of Conduct, every State has to take the appropriate measures necessary to ensure that radioactive sources are securely protected during their useful lives and at the end of their useful lives. Targets of possible actions in terms of theft are warehouses and distribution centers for radioactive sources, temporary storages as well as buildings and local areas where radioactive sources are handled. With regard to the potential hazard by theft of radioactive sources from the site, the storage facility of IZOTOP is classified by the competent Ukrainian authorities as a facility to be particularly secured.

The following protection goals have to be achieved by security measures:

- Preventing the theft of radioactive sources,
- Prevention of exposure to radioactive substances and their release by sabotage, terrorist attack, theft of sensitive information.

The process to specify an appropriate security level for a source consists of the categorizsation of the sources based on their potential to cause harm and of assigning an appropriate security level to each category.

Categorization of radioactive sources

The categorization of a radioactive source is based on the so-called D value. The D value represents the specific activity of a radionuclide which could cause severe deterministic health effects. The D-value therefore is used for the normalization of radionuclide activities (A) in order to compare risks of different radionuclides of different activities. Accordingly, the calculated A/D value results in the category of the source. Sources with an A/D value ≥ 1,000 correspond to the first category (TABLE I).

At locations where multiple sources are in close proximity, e. g. storages of radioactive sources or production facilities of radioactive sources, the sum of the radionuclides is used, taking into account their D value, to determine the category. If sources with various radionuclides are aggregated, then the sum of the A/D ratios should be used in determining the category, in accordance with the formula:

$$Gesamt\ A/D = \sum_n \frac{\sum_i A_{i,n}}{D_n} \qquad \text{(Eq. 1)}$$

$A_{i,n}$ = activity of each individual source i of radionuclide n.

D_n = D value according to the hazard potential for radionuclide n.

The categorization of radioactive sources in the TLK warehouse is determined according to the applicable Ukrainian rules and international recommendations. The assessment of the potential hazard of the radioactive sources contained in the TLK warehouse and therefore the source categorization is of central importance for assigning an appropriate security level.

In IZOTOP's storage facility, the activity of the radionuclide inventory is up to 1016 Bq. Following the IAEA guidelines, the inventory of the facility induces category 1 already when filled by 10% (137Cs). A listing of D values of individual radionuclides and their categorization according to their activity is given in the IAEA Safety Guide RS-G-1.9 "Categorisation of Radioactive Sources"of 2004 [3] and Implementing Guide "Security of Radioactive Sources" of 2009 [1].

Assigning an appropriate security level

According to the IAEA guidelines for the radioactive sources considered, a sufficient level of security has to be achieved that takes into account the potential damage that could cause unauthorized use. Therefore, the sources are assigned to a security level according to their category with a corresponding protection goal. This goal determines the requirements for the security system (e. g. concerning detection, delay, response time and security management), which must ensure the achievement of the protection goal.

For the sources of the categories 1 - 3, the following security levels are defined (Tab. 1):

- Security level A: Prevent unauthorized removal of a source,
- Security level B: Minimize the likelihood of unauthorized removal of a source,
- Security level C: Reduce the likelihood of unauthorized removal of a source.

The assignment of security levels to each category, the corresponding A/D values and examples of radiation sources are given in Tab. 1.

The security level A has to be assigned to sources of category 1 in the TLK.

TABLE I. Assignment of security levels to categories of radioactive sources

Category	Source	Activity ratio	Security level
1	RITEG's, Teletherapy sources	A/D ≥ 1000	A
2	Industrial gamma radiography sources	1000 > A/D ≥ 10	B
3	Fixed industrial gauges that incorporate high activity sources, Well logging gauges	10 > A/D ≥ 1	C
4 5	Low dose rate brachytherapy, X ray fluorescence (XRF) devices,	1> A/D ≥ 0,01	Basic safety standards
Aggregation	Aggregate $A/D = \sum_n \frac{\sum_i A_{i,n}}{D_n}$	$A_{i,n}$ = activity of each individual source *i* of radionuclide *n*. D_n = D value for radionuclide *n*.	

Security level A measures

In the following, the IAEA recommendations regarding security level A are described. The goal of security level A is to prevent the unauthorized removal of radioactive sources. In case of any unauthorized access or attempt of unauthorized removal, detection of such unauthorized intrusion has to occur early enough to enable response personnel to interrupt the adversary and prevent the source from being removed [1].

In order to achieve this goal, the following measures are recommended:

- Detection
  - Electronic intrusion and tamper detection system
  - Remote monitoring of CCTV
  - Rapid, dependable, diverse communication systems e. g. phones, radios
  - Daily checking through physical checks, CCTV, tamper indicating devices, etc.
- Delay
  - Multi-barrier system to delay the intrusion (at least two barriers: walls or fences)
- Response
  - Capability for immediate response with size, equipment, and training to interdict
- Security management
  - Identification and verification: lock controlled by swipe card reader or personal identification number
  - Background checks for all personnel authorized for unescorted access to the source location and for access to sensitive information
  - Procedures to identify sensitive information and protection from unauthorized disclosure

CONSTRUCTION OF A HOT CELL

For the handling and repacking of radioactive sources, a hot cell is needed, which will be constructed in the warehouse itself. A concept design study, recently finished, has demonstrated that such a hot cell with the required dimensions (app. 2.5 x 2.5 x 3.0 m) can be placed within the architecture of the existing building (Fig. 3). Radiation protection calculations considering the maximum activity to be handled within the cell (500 TBq for ^{60}Co actual handling, 1,850 TBq maximum total activity in the hot cell) as well as the radiation protection to be guaranteed to the operating personnel resulted in a wall thickness of about 1.5 m, taking into account a heavy concrete with a density of 2.5 t/m^3. Charging of the hot cell now can be managed either via the

storage canyons or the railway ramp directly. By construction measures, the total area of the hot cell itself and interconnected rooms will be separated from the remaining part of the warehouse with its storage canyons and also dispose of a separate admission control system. All further details as requested by the future operator (IZOTOP) and the approval agency have been considered within the scope of the concept design study and have in the meantime been licensed. The current schedule intends final completion by November 2012.

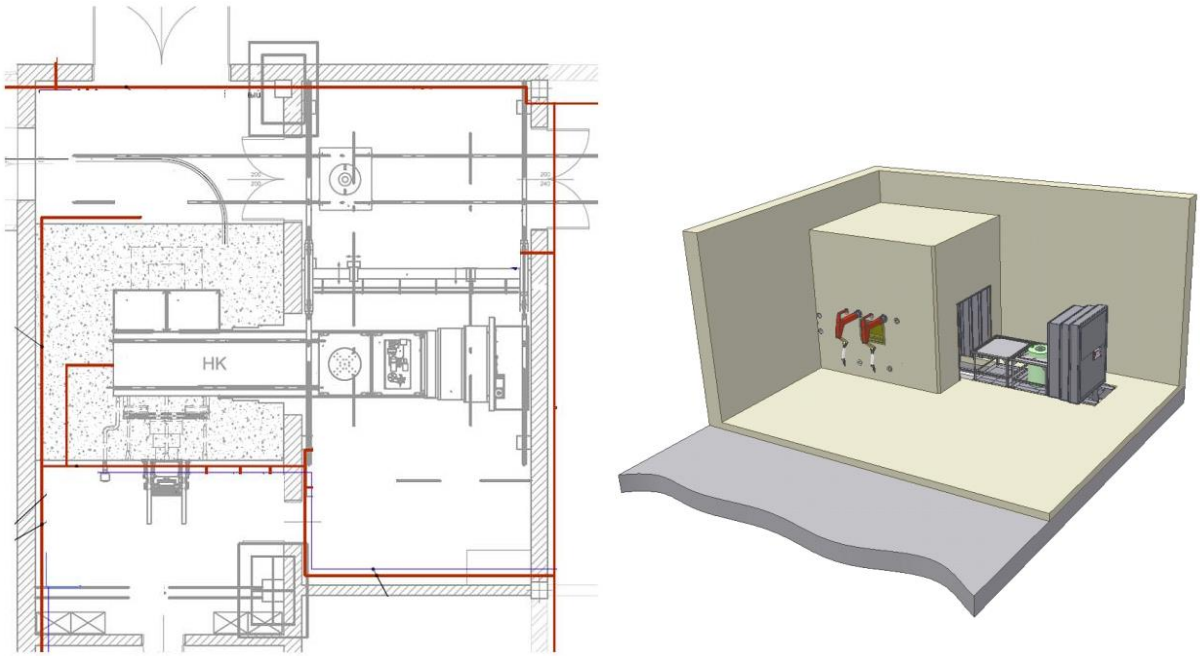

Fig. 3 Top view (left) and sketch view (right) of the hot cell layout within TLK's warehouse; rightmost is the charging equipment for different types of containers, on the front side is the operator's place with lead glass window and manipulators.

PROJECT MANAGEMENT

The project was initiated by the *note verbale* of the German Federal Foreign Office to the Ukrainian Foreign Ministry dated 29th September, 2009 and the note in reply dated 29th December, 2009.

After the German government's decision to implement projects within the scope of the G8 Global Partnership in Ukraine, a new framework agreement was signed by the German Federal Foreign Office and GRS, titled " German-Ukrainian cooperation in securing nuclear material against theft and misuse in the frame of the G8 Global Partnership against the spread of mass destruction weapons and materials" (Fig. 4).

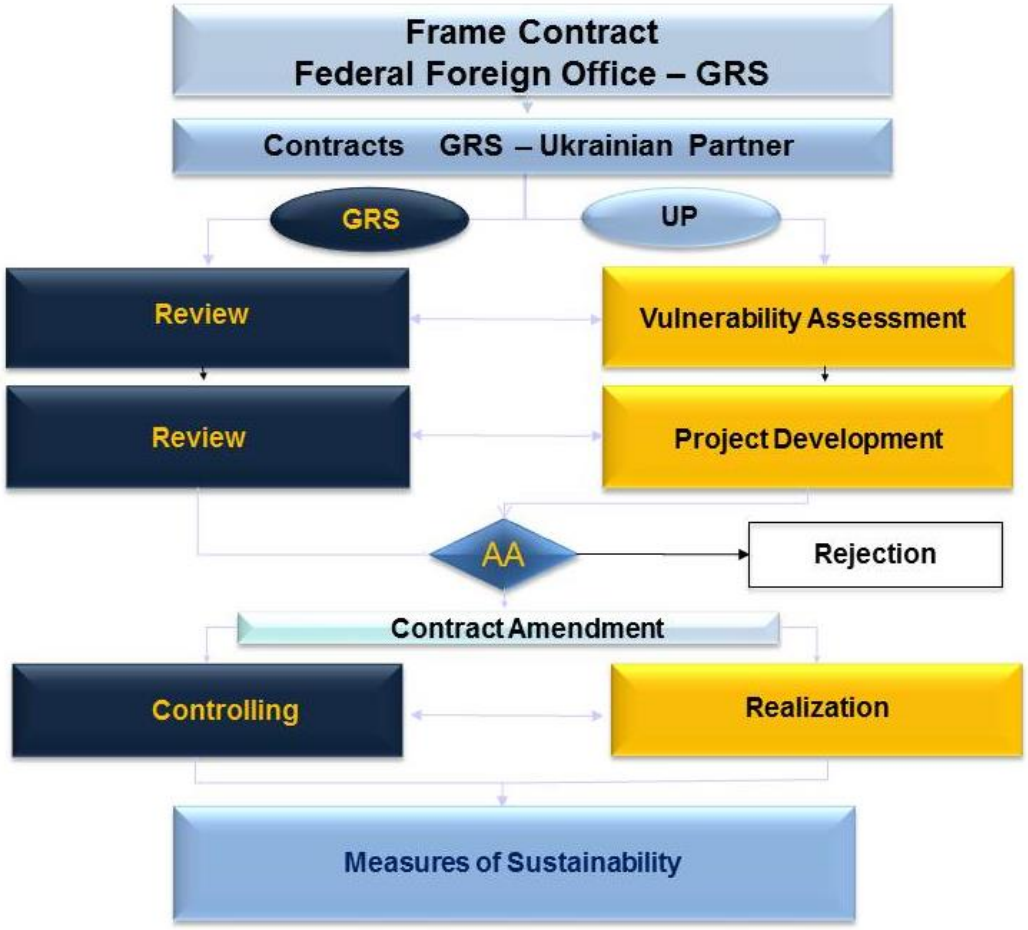

Fig. 4 Sketch layout of project management within the scope of German-Ukrainian co-operation

The contract for realization of the "IZOTOP" project was signed on 30th August, 2010 by GRS and the Ukrainian State Production Company IZOTOP. The contract implies a cost limitation of € 4.9 million in total, about € 0.2 million of which were provided for the detailled conception of both subprojects, a) physical protection and b) hot cell construction.

Accordingly, IZOTOP developed in a first step - supported by its Ukrainian subcontractor Specatomenergo - a concept for the modernization of the TLK's physical protection including a vulnerability assessment. Project approval by the German Federal Foreign Office is expected for mid-November 2011.

In parallel, IZOZOP also developed a concept of a hot cell to be constructed in the storage warehouse with the help of its Czech subcontractor UJP/VF. Meanwhile, the overall hot cell design has been finalized, and approval by German Federal Foreign Office was granted on 27th September, 2011. Corresponding amendments to the contract between IZOTOP and GRS for the realization of the project are in preparation.

SUMMARY

Within the scope of the 'G8 Global Partnership against the Spread of Weapons and Materials of Mass Destruction', the modernization of the storage facility for radioactive sources (TLK) of the Ukrainian State Production Company IZOTOP in Kiev was successfully implemented in Ukraine. All procurements and measures, as resulted by leading composite design concept studies, are in accordance with international recommendations (e. g. IAEA) and Ukrainian national normative documents.

The conception of the project's main tasks, a) modernization of the physical protection of the TLK itself and b) construction of a hot cell in the TLK's warehouse have been finalized. The realization of both sub-projects now will contribute significantly towards an improved security of radioactive materials in Ukraine. Completion of the work is scheduled for the end of 2012.

OUTLOOK

During the remaining term of the G8 Global Partnership, until at least the end of 2012, the various projects funded by the German government – some of which have only very recently become operational – must be completed.

Although the initial focus of the Global Partnership was on projects in Russia as stated by the heads of states, the partnership extended to other recipient countries, in particular to those of the former Soviet Union. A further need is stated e. g. by Ukrainian government to extend the implemented global partnership programme.
Besides the Russian Federation and the countries of the former Soviet Union, G8 Leaders agreed at the 2008 Summit in Toyako on evolving the Global Partnership to address new challenges by implementing projects worldwide on the basis of the Kananaskis principles and guidelines once the current programme has come to an end in 2012.

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[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Categorization of Radioactive Sources, IAEA Safety Standards Series No. RS-G-1.9, IAEA, Vienna (2005).