Development of Technical Design for Waste Processing and Storage Facilities for Novi Han Repository

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1. Introduction

The radioactive waste repository Novi Han was been established following a type Soviet design TP-4891 of 1956. It was set in operation in October 1964.

Radioactive waste stored at Novi Han Repository generated on using of some sources of ionizing radiation in industry, medicine, agriculture, scientific research and education.

The Novi Han Repository has been the subject of several studies carried out by international experts. One of the recommendations given by the IAEA experts concerned the need for the construction of storage facility for disused sealed radioactive sources based on the international requirements and recommendations in this field. Further on the upgrading of the repository also shall include the construction of the facilities for the management of solid and liquid radioactive waste which not meet the Novi Han Repository waste acceptance criteria.

EMPRESARIOS AGRUPADOS INTERNATIONAL S.A. (Spain) and ENPRO Consult Ltd. (Bulgaria) were awarded a contract by the Central Finance and Contracts Unit to develop the Technical Design of the waste processing and storage facilities at Novi Han Repository.

At present conceptual design phase is finished. This conceptual design covers the definition of the basic design requirements to be applied to the installations defined above, following both European and Bulgarian legislation.

2. Basic criteria for the layout and sizing of buildings

The design of the Treatment and Storage Facilities incorporates appropriate features for the safe handling, conditioning and storing of radioactive wastes. The waste packages produced can be safely stored for long periods of time, awaiting eventual disposal in a licensed repository when that becomes available.

The general design characteristics are described under specific headings as follows:

- **Technology**: technology sophistication is kept at a minimum, and the only equipment selected is such that has proved to be fully operational for the intended purpose;
- **Robustness**: the facilities are rugged, easy to operate without extensive training of operating staff, and have a high degree of accessibility;
- **Engineering**: the facility equipment is easy to maintain and possibly to extend;
- **Flexibility**: the design incorporates features that provide the possibility of establishing temporary workplaces for non-habitual activities rather than permanent installations;
- **Economy**: the costs of constructing, operating and expanding the facilities have been kept as low as reasonably possible;

- **Safety**: radiation protection and industrial safety aspects are appropriately considered for both the plant operation staff and for the general publics off-site;
- **Licensing**: a general safety analysis report will be developed. It is to be noted that all aspects of licensing the facilities are the responsibility of the Novi Han;
- In-drum cementation into **200 l steel drums** is the basis for the process of conditioning and storing the institutional wastes.

Safety functions, applicable to treatment and storage activities for very low, low and medium radioactive institutional wastes, are

- Required function of maintaining the **integrity** of the storage and packages that contain radioactive materials;
- Function of **confining** wastes with no radiological risk to persons and to environment;
- Function that can **prevent** or mitigate the consequences of an event that might cause a radiation release exceeding the pre-established limits. A first classification of potential accidents can be established based on their estimated frequency of occurrence.

These facilities should ensure:

- Appropriate conditions to work for authorised operation personnel;
- Allowable conditions for inspections;
- Adequate means of protection of workers, waste and installations, including: shielding, static and dynamic confinement, liquid controls both intake and leakage, radiological zone classification, predefined routing both people and materials, handling and maintenance;
- Adequate response in emergency situations, following the analysis of accidents in the facilities, which involves safety requirements.

3. Waste streams

The analysis of inventories of stored and estimated future wastes and its subsequent processes focuses the following waste streams (see Figure 1):

DSRS:

- Very short-lived radioactive sources;
- Short-lived radioactive sources (Co, Cs, Sr & other 12 radionuclides):
  - manual handling;
  - remote handling;
- Long-lived radionuclide sources:
  - (LLSRS) α, β relatively low activity, e.g. smoke detectors, lightning rods, calibration sources;
  - ^{226}Ra sources;
- Neutron sources;
- High Activity sources (Cs and Co);
- Other sources (unknown).

Liquid waste:

- Aqueous;
- Organic (inmiscible with water);
- Spent ion exchange resins;

Biological waste;

Solid waste:

- Solid compactable wastes;
- Scrap metal. Operational containers of DSRS;
- Wood;
- Soil, rubble, glass, ceramics and construction debris;
- Graphite;

Gaseous: airborne effluents.

Other streams with small quantities, non-significant, and very special characteristics, have not been included. Although, it is possible to analyse, case by case, in the frame of the defined design.

4. Processing of Radioactive Waste

As the planned time for conditioning the current stored wastes has no constraints; the strategy is to design simple and small-scale systems.

Given the temporary nature of storage in Novi Han and the current unavailability of final disposal acceptance criteria, waste **retrievability** is an international recommendation that should be taken into consideration in the treatment and conditioning proposals.

No great annual volume of wastes will advise a simpler design and more generic processes, equipment and facilities.

The processes selection has to consider: simplicity, no exceptional level of technical operating, easy to control, commonly available reagents and packs and robustness and resistance.

Before any treatment, an initial classification and segregation must separate the potential clearable wastes.

A previous control of received wastes in the Treatment facility will be performed in order to optimise the process. The starting point is the **segregation** of the radioactive wastes based on the pre-established waste streams.

The **simultaneous work** in all of processes will be considered as the normal operation. For this reason, and considering the necessary space in the building and the ALARA principle for workers, the waste treatment and conditioning works will be arranged into lots or campaigns, based on the daily working capacity and the proposed equipment and systems.

It is understood that the wastes will be received in the usual containers: metal boxes, plastic drums, plastic bags, operating containers (DSRS), etc. accepted for current internal transport and storage.

4.1. Treatment and Conditioning of Disused Sealed Sources

The following basic objectives are sought: reduction in volume (segregation of the non-radioactive part) and acceptable final waste package (more appropriate for handling and storage).

The processes that will be followed:

- Separation of the DSRS with very short lived radionuclides, which will be stored, in appropriate form, for decay;
- Encapsulation of very DSRS. Specifically standardised designed capsules, with the related required actions, as welding or sealing, will be used;
- Encapsulation into specifically standardised designed containers, including shielding materials, as stainless steel, bentonite or high density polyethylene, according with the sources;
- Conditioning in the most appropriate waste package: 200 l drums, without or with concrete lining, or metallic containers.

To realise this processes will be used different operating / working areas, according to characteristics of the DSRS:

- Workbenches with extractor hood/fumes cupboard;
- Gloves boxes; shielding and closed, connecting to ventilation system;
- Portable shielding elements, with the intention of the protection near to the radioactive source;
- Hot cell.

Number of sources and positioning inside specific container and package will be defined for each one type of DSRS

4.2. Treatment of Liquid Radioactive Wastes

The following basic objectives are sought: reduction in volume (concentration of the contaminated part) and acceptable final solid waste form (more appropriate for handling and storage).

The treatment process that will be followed:

A system is provided that recirculates the liquid wastes (only aqueous, non organic), by means of recirculation and homogenisation pump, from a collection tank, through filter and demineraliser, to a control tank. The final control of the treated liquid will determine its destination: Novi Han “conditionally pure water” collection tank or treatment and conditioning as radioactive waste.

Filtration (replaceable filters, cartridge type) and **demineralisation** (replaceable and selective ion exchange resin beds, in metal casing, with non-recoverable internal plastic casing) made up the process, with the possibility of isolation of each one if the available data of solid particles and dissolved solids would be known.

4.3. Treatment of Solid Radioactive Waste

The following basic objectives are sought: reduction in volume (separation of the contaminated part) and a stable final waste package with an optimised degree of fill, suitable for storage

The treatment process to be followed:

Decontamination. Remove detachable contamination from the scrap metal and DSRS containers. Prior surface contamination control will be exercised so as not to use this process with non-decontaminable materials. This process will be carried out in a blasting chamber, similar to a glove box, connected to a ventilation system and confined. The secondary wastes will be the contaminated abrasive media, periodically removed, which will be conditioned by embedment with concrete into drums.

Cutting. Using thermal or mechanical processes to adapt the size of the scrap metal and DSRS operating containers to the decontamination chamber or to optimise fill up the storage containers (200 l drums). Portable equipment will be used, with fan extraction in workbench area, and screens to prevent particle scattering. Said portable equipment will be complemented with a fixed semi-automated vertical saw, for large size waste and/or wastes unsuitable for thermal cut. Mechanical cutting would be used also to size compactable materials, prior to compacting.

Compactor. Low pressure compacting equipment with hydraulic circuit, closed chamber fan extraction and piston suitable for dealing with wastes inside 200 l drums. Low pressure is proposed for compactable wastes: paper, rags, protective clothing, plastics, thin plate, etc, with a view to future supercompaction of the drums for final storage.

The **airborne** effluents will be collected in ventilation filters, both pre-filters and HEPA. The treatment of those spent filters will be sizing (cutting or dismantling) and compacting, as a solid waste.

4.4. Conditioning of liquid and solid radioactive waste

The conditioning process for liquid radioactive waste will be followed:

Considering a reduction in waste volume, due to proposed treatment, and the estimated reception of future wastes, there is no need to consider solutions other than **solidification with cement**; a simple, proven and acceptable conditioning process for the quantities of wastes envisaged.

The proposal is a semi-automated process consisting in the mixing cement and radioactive liquid waste, which discharges directly into 200 l drums, with the help of disposable blade mixers. Water supply for washing and, if necessary, additional injection will be provided to the cementation unit, through a water injection tank. It might be possible to use the treated water from the Decontamination Station and Installation for Processing of Spent Water and Solutions (under construction).

This conditioning process also will be followed for other wastes:

This solidification process will also apply to wastes other than aqueous liquids, in order to embed the wastes in concrete, inside a drum with a concrete lining. However, aqueous liquid waste could be used as setting water.

The solidification process for the organic liquids (inmiscibles with water) will require a previous adsorption in oleophylic debris, type diatomaceous earth, vermiculite, clay and, even, natural fibbers. This adsorption process produces a solid without integrity, only restrained from dispersing, which requires the subsequent embedding and/or encapsulation.

Biological wastes (pre-treated in gypsum): embedded in concrete in 200 l drums with concrete lining, using the concrete unit. This waste requires the fixed positioning of the wastes inside the drum, using an internal metallic container.

The secondary wet wastes generated, in the processes, will be filters, abrasive media and spent resins. These ones will be embedded in concrete, inside 200 l drums with concrete lining.

The preparation of drums with reinforced concrete shielding (as a package to use) should be made outside the Treatment facility, as a standardised process in conventional facilities. Nevertheless, in special situations, these packages could be prepared in this facility with due precaution. In this case, it will be better idea to use "clean" setting water and it will be necessary to prepare moulds and reinforced steel bars.

With the proposed treatment processes, subsequent solid waste conditioning will be:

- Compacted wastes: 200 l drum, without any other processing;
- Metal wastes, wood cut-offs: 200 l drum, without any other processing, or immobilised with low density concrete inside drum;
- Soil, rubble, construction debris: 200 l drum, without any other processing;
- Graphite: concrete and steel shielded 200 l drums.

4.5. Control of waste packages

The last activity for completion the treatment and conditioning process of wastes will be the control of waste packages, before transfer to the Storage building. This control will include the measurement of surface contamination of packages, dose rate in contact and at 1 m, weight and identification (labelling).

This information will be included in the final protocol form, with the data on the isotopic content, nature and mechanical characteristics of the wastes. This information must be archived and controlled for the whole time of storage

5. Storage of radioactive waste

The objectives to achieve in the Storage facility design will be the following:

- Safely store the conditioned radioactive wastes, separated from the environment, for the required period;
- Static barriers, between stored wastes and external environment;
- Stable waste form;
- Acceptable physical characteristics of packages for storage and handling;
- Safe handling and maintenance of the waste packages;
- Acceptable radiological levels, both inside and outside of the facility, according the Radiation Protection requirements;
- Accident identification and classification and mitigation of effects plan.

In the specific case of Novi Han, also the following conditions will be taken in consideration:

- Given the temporary nature of storage in Novi Han and the current unavailability of final disposal acceptance criteria, waste retrievability is an international recommendation that should be taken into account in the storage facility proposals;

- Before storage, an initial classification must separate the radioactive wastes packages based on the pre-established waste streams. This activity shall be carried out in the Treatment facility in order to optimise the storage process;
- The waste packages will be standardised, facilitating their handling with forklifts or transpallets.

5.1. Storage facility

The following basic objectives are sought: safe conditions for storing, both inside and outside of building, and the possibility to retrieve the wastes.

The following requirements will be taken into account:

- Area definition. Different rows for different types of waste packages, with free space between them. Specific area for decay of selected wastes (DSRS and soil, mainly). Shielding and separated area for maintenance and monitoring activities. Access for inspections;
- Storage criteria: same type of package, same stream of DSRS and conditioned wastes and equivalent radiological characteristics;
- Capacity. Stacking with stabilisation plates or specific pallets. Four levels in height, for 200 l drums and three levels, for special packages. Rows of containers, aligned north-south. Double row, and free space for inspection, block (2 drums and space);
- Protection of operation personnel. Remote control. Operated from Control Room with support of closed circuit television and pre-established storage positions. Bridge-crane. Utilisation of grippers and handling tools.

5.2. Waste packages

Packages preparation and production will be standardised so that they will be suitable for handling, transport and storage. It will also permit stacking them..

The number of different types of packages must be minimised, in order to minimise the number of related handling tools.

- Standard 200 l drums (with different internal configurations, such as concrete-lining with reinforcement steel bars, light neutron shielding material lining, etc.);
- Overpacks for DSRS. Metallic specific containers, prism-shaped, containing the long term storage container specifically designed for high activity sources.

Fifire 1: Waste streams