ENGINEERED NEAR SURFACE DISPOSAL FACILITY OF THE INDUSTRIAL COMPLEX FOR SOLID RADWASTE MANAGEMENT AT CHERNOBYL NUCLEAR POWER PLANT

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ABSTRACT
As a part of the turnkey project “Industrial Complex for Solid Radwaste Management (ICSRM) at the Chernobyl Nuclear Power Plant (ChNPP)” an Engineered Near Surface Disposal Facility (ENSDF, LOT 3) will be built on the VEKTOR site within the 30 km Exclusion Zone of the ChNPP. This will be performed by RWE NUKEM GmbH, Germany, and it governs the design, licensing support, fabrication, assembly, testing, inspection, delivery, erection, installation and commissioning of the ENSDF.

The ENSDF will receive low to intermediate level, short lived, processed / conditioned wastes from the ICSRM Solid Waste Processing Facility (SWPF, LOT 2), the ChNPP Liquid Radwaste Treatment Plant (LRTP) and the ChNPP Interim Storage Facility for RBMK Fuel Assemblies (ISF). The ENSDF has a capacity of 55,000 m³.

The primary functions of the ENSDF are:
- to receive, monitor and record waste packages,
- to load the waste packages into concrete disposal units,
- to enable capping and closure of the disposal units,
- to allow monitoring following closure.

The ENSDF comprises the turnkey installation of a near surface repository in the form of an engineered facility for the final disposal of LILW-SL conditioned in the ICSRM SWPF and other sources of Chernobyl waste. The project has to deal with the challenges of the Chernobyl environment, the fulfillment of both Western and Ukrainian standards, and the installation and coordination of an international project team. It will be shown that proven technologies and processes can be assembled into a unique Management Concept dealing with all the necessary demands and requirements of a turnkey project.

The paper emphasizes the proposed concepts for the ENSDF and their integration into existing infrastructure and installations of the VEKTOR site. Further, the paper will consider the integration of Western and Ukrainian Organizations into a cohesive project team and the requirement to guarantee the fulfillment of both Western standards and Ukrainian regulations and licensing requirements.

The paper provides information on the output of the Detail Design and will reflect the progress of the design work.

GENERAL
As a part of the turnkey project “Industrial Complex for Solid Radwaste Management (ICSRM) at the Chernobyl Nuclear Power Plant (ChNPP)” an Engineered Near Surface Disposal Facility (ENSDF, LOT 3) will be built on the VEKTOR site within the 30 km Exclusion Zone of the ChNPP. This will be performed by
RWE NUKEM GmbH, Germany, and it governs the design, licensing support, fabrication, assembly, testing, inspection, delivery, erection, installation and commissioning of the ENSDF. The ENSDF is financed by the European Union within the framework of the TACIS Program (Technical Assistance for the CIS). The ENSDF will be operated by “Technocentre” as a part of the VEKTOR complex.

The ENSDF will receive low to intermediate level, short lived, processed / conditioned wastes (LILW-SL) from the ICSRM Solid Waste Processing Facility (SWPF, LOT 2), the ChNPP Liquid Radwaste Treatment Plant (LRTP) and the ChNPP Interim Storage Facility for RBMK Fuel Assemblies (ISF) conditioned at the SWPF or LRTP. It has a capacity of 55,000 m³. The design of the ENSDF is based on the El Cabril facility (Spain), which was adapted to the requirements of the ICSRM.

The primary functions of the ENSDF are:

- to receive, monitor and record waste packages,
- to load the waste packages into concrete disposal units,
- to enable capping and closure of the disposal units,
- to allow monitoring following closure.

The ENSDF will include a newly built disposal facility based on modular structure with mobile containment and lifting frameworks and a waste package control unit facility. An existing building will be used for services and maintenance.

The facility includes auxiliary systems such as power distribution, diesel driven emergency electrical power unit, fire detection/protection systems, communication systems, environmental and personal radiation monitoring equipment and access control.

The entire installation and supplied equipment is designed to comply with Design Events I and II for Operational Requirements and Design Events III and IV for Emergency Requirements as well as with Ukrainian regulations. The Design Events I – IV are:

**Design Event I** (or Operational Events): This consists of that set of events that are expected to occur regularly or frequently in the course of normal operation of the facilities of the ENSDF. Examples are: transfer, handling, transportation, storage and maintenance activities.

**Design Event II** (or Likely Sequences): This consists of that set of events that, although not occurring regularly, can be expected to occur with moderate frequency or on the order of once during a calendar year of operation of the facilities of the ENSDF. Examples are: short duration loss of electrical power, single operator error followed by proper corrective action, minor failure of mechanical and handling equipment, failure of electrical monitoring and auxiliary system, spurious operation of active components, minor leakage of radioactive waste and repair activities.

**Design Event III** (or Unlikely Sequences): This consists of that set of infrequent events that could reasonably be expected to occur during the lifetime of the facilities of the ENSDF. Examples are: an extended loss of external power supply, major mechanical malfunction during operation, jamming of mechanical equipment, handling and transportation accident with load drop, leakage of radioactive waste, loss of containment, major malfunction of auxiliary system and severe external climatic conditions.

**Design Event IV** (or Very Unlikely Sequences): This consists of the events that are postulated because their consequences may result in the maximum potential impact on the immediate environs. Their consideration establishes a conservative “design basis” for systems with Important Confinement Features. Typically this set of events will consist of External Events that have lower frequencies of occurrence than considered in Design Events I, II and III. Examples are: Earthquake, Flooding, External Fire and Explosion and Tornado.

**DESCRIPTION OF THE OPERATION**

The lifetime of the disposal facility is divided into three distinct phases:

- The operating phase during which the waste is deposited into the facility.
- The monitoring and control phase lasting for the entire period of 300 years during which the waste presents a radioactive hazard.
- The free use phase during which the site may be utilized without any radiological limitation.

During the operating phase the processed and conditioned waste from the SWPF and the LRTP will be transferred by special trailer to the Waste Package Control Unit located at the entrance to the VEKTOR site. Each package is identified, checked, dose monitored and the data are registered. Only waste packages, which meet all waste acceptance criteria will be accepted for disposal. The main waste acceptance criteria are:

- Radionuclide content: The type and content of radionuclides in the waste packages should be known with sufficient accuracy to ensure compliance with authorized limits, and the package should be documented accordingly.

- Alpha activity: The specific alpha activity should not exceed 1,200 Bq/g.

- Surface dose rate: The surface dose rate should not exceed 10 mSv/h and the dose rate at 1 m distance should not exceed 0.5 mSv/h.

- Surface contamination: The surface contamination should not exceed 0.4 Bq/cm² for Alpha, and 4 Bq/cm² for Beta and Gamma.

- Structural stability: The structural stability of the waste package should be such that the performance of the disposal system is assured.

- Leachability: The leachability of the waste form should be such, that the release of radionuclides does not exceed levels consistent with the requirements of the overall disposal system.

- Gross weight: The gross weight should not exceed 20.0 te.

- Origin of the waste: Only waste packages from the LRTP or the SWPF will be accepted.

The trailer is unloaded by an overhead travelling crane installed within the mobile framework and the waste package transferred directly into a disposal unit. The function of the two mobile frameworks (one for each section) is to protect the operated Disposal Unit and the waste packages from atmospheric precipitation. This enables a permanent readiness for waste reception.

Each mobile framework (33 m × 28.1 m × 18.5 m) is equipped with a bridge crane of carrying capacity 20/5 te. The crane is used for unloading of containers with radioactive waste products from the trailer, their weighing and location at the final positions in the Disposal Units.

The disposal facility consists of two sections. It has a total capacity of 63,200 m³ and is equivalent to approximately 55,000 m³ of waste packages.

The vertical walls measuring 273.1 m x 18.8 m, with a height of 7.5 m and thickness of 400 mm, define the limit of section. Each of the two sections consists of eleven modular Disposal Units with dimensions in plan 24.8 m x 18.8 m. The general arrangement is shown in figure 1.

![Figure 1: General Arrangement](image)

Each unit is built on a layer of materials (gravel, cement, concrete) which provides an underground waterproofing system isolating the facility from the water table.
The lower slab of reinforced concrete facilitates the collection of infiltrated water and its disposal through a piped network to a final collection point where it is monitored. A section through a disposal unit is given in figure 2.

**Figure 2: Disposal Unit. Section**

The design of the ENSDF is originally based on the El Cabril facility built by INITEC in Spain and already in operation.

During the basic design phase a new requirement was added to the ENSDF: namely the direct disposal of unshielded 200 l drums from LRTP. That means, the originally designed disposal container for LRTP waste is now solely used as a transportation container between the two facilities. This modification almost doubles the disposal capacity but requires additional characterization and storage equipment for 200 l drums. To compensate for the higher nuclide inventory inside the storage vaults, an additional imbedding of the drums layer by layer is required. To provide additional shielding the drums are stored in the center of the storage vaults with the disposal containers coming from the SWPF on the outside. The general storage procedure is given in figure 3.

**Figure 3: General Storage Procedure**
The disposal container coming from SWPF is a reinforced concrete container “KTZ-3.0” which is approved in Ukraine. The “KTZ-3.0” has a useable volume of 3.0 m³ (1,940 mm x 1,940 mm x 1,660 mm with 150 mm thick concrete walls). The selection of this type of container is the result of a detailed comparative assessment among existing nuclear waste containers. Manufacturing will be carried out by Ukrainian manufactures. The container is suitable for transportation and storage; therefore, no additional shielding is required.

The 200 l drums from LRTP are standardized steel drums (diameter – 600 mm, height – 843 mm, thickness of the steel – 1.5 mm). For transportation of the LRTP drums a shielding is necessary. For this purpose the reinforced concrete container “KZNP-2.1” will be used. The “KZNP-2.1” has a useable volume of 2.1 m³ and 200 thick concrete walls, and it has the same dimensions as the “KTZ-3.0”. Therefore, the same handling equipment as for the SWPF containers can be used for the LRTP transportation containers.

The filling of a Disposal Unit with waste packages is carried out in the following sequence:

- containers from the SWPF (4 layers by 2 lines on the perimeter of a Disposal Unit) and 200 l drums from the LRTP (in the central part of the Disposal Unit) are located in the specified places in the Disposal Unit;
- once the first layer is filled with 455 drums from the LRTP and 64 containers from the SWPF it will be capped with a 120 mm thick mortar layer;
- once a disposal unit is full to depth of four SWPF waste containers (256 in total) and seven 200 l drums (3,185 in total) the upper layer will be capped with a mortar layer;
- after that, a 600 mm thick reinforced concrete slab for the initial covering of the unit will be created;
- the concrete slab will be covered with bitumen and a polyurethane film, the mobile framework will be moved to the next disposal unit;
- once all disposal units of both sections are full the sections will be finally covered as shown on figure 4. The final cover consists of several layers:
  - sand - 30 cm;
  - bitumen covering;
  - sand - 30 cm;
  - clay - 1 m;
  - sand - 20 cm;
  - gravel - 30 cm;
  - vegetative ground - 30 cm.

Figure 4: Closing of the ENSDF
At this point, the operational phase is finished, and the monitoring and control phase starts.

The ENSDF is designed to receive 525 containers from the SWPF and 7,000 drums from the LRTP per year. The operation time is 175 days per year. One disposal unit will be full within approximately 85 days. The 22 disposal units of the ENSDF will be full within approximately 10 years.

**MONITORING AND CONTROL PHASE**

The monitoring and control phase lasts for the entire period of 300 years during which the waste presents a radioactive hazard.

The comprehensive technical solutions which are employed in the ENSDF will provide protection from radioactive hazards for a period of 300 years until decay of short lived LILW is ensured.

To ensure an institutional period of 300 years the design includes a multi barrier system, which comprises of:

- a solid matrix inside the concrete containers in which the immobilized wastes are embedded;
- a solid matrix inside the disposal units created by the capping of the 200 l drums with mortar;
- engineered concrete disposal units, situated above the level likely to be reached by the water table and covered by several layers of waterproof and draining materials;
- the site which in itself provides radionuclide retention by virtue of being made up from a series of impermeable layers.

Integrity of the multi-barrier system over the 300 years is established by monitoring any infiltration water, collected via an underground network.

After the 300 years the site may be utilized without any radiological limitation.

**EXECUTION OF THE PROJECT**

For the successful execution of the project a close co-operation of Western and Ukrainian experts is essential. Therefore, RWE NUKEM GmbH subcontracted the Ukrainian design organizations STC KORO, Zhovty Vody, and OSI NPP, Kiev. With the designer of the El Cabril facility INITEC, Madrid, a Consulting Agreement was signed.

The “Technical Project” – a special Ukrainian design documentation, which has to be approved by the responsible Ukrainian authorities – and the Preliminary Safety Analyses Report (PSAR) and the Environmental Impact Assessment (EIA) are finalized by STC KORO and OSI NPP. These documents now have to be approved by “Technocentre” and by the Ukrainian authorities.

Presumably, in summer 2003, after approval, it is planned to start the procurement and the construction activities. RWE NUKEM’s philosophy for this project is to procure as much as possible in Ukraine, and to deliver only some key components from Western countries. This approach facilitates the further licensing and approval procedures.

The commissioning is scheduled for the late 2004.