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SUPERCOMPACTION OF RADIOACTIVE WASTE AT NPP KRŠKO

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ABSTRACT - The problem of radioactive waste management is both scientifically and technically complex and also deeply emotional issue. In the last twenty years the first two aspects have been mostly resolved up to the point of safe implementation. In the Republic of Slovenia, certain fundamentalist approaches in politics and the use of radioactive waste problem as a political marketing tool, brought the final radioactive repository siting effort to a stop. Although small amounts of radioactive waste are produced in research institutes, hospitals and industry, major source of radioactive waste in Slovenia is the Nuclear Power Plant Krško. When Krško NPP was originally built, plans were made to construct a permanent radioactive waste disposal facility. This facility was supposed to be available to receive waste from the plant long before the on site storage facility was full. However, the permanent disposal facility is not yet available, and it became necessary to retain the wastes produced at the plant in the on-site storage facility for an extended period of time. Temporary radioactive storage capacity at the plant site has limited capacity and having no other options available NPP Krško is undertaking major efforts to reduce waste volume generated to allow normal operation.

This article describes the Radioactive Waste Compaction Campaign performed from November, 1994 through November, 1995 at Krško NPP, to enhance the efficiency and safety of storage of radioactive waste. The campaign involved the retrieval, segmented gamma-spectrum measurement, dose rate measurement, compaction, re-packaging, and systematic storage of radioactive wastes which had been stored in the NPP radioactive waste storage building since plant commissioning.

INTRODUCTION

The Krško Nuclear Power Plant is a 2 loop Westinghouse-designed PWR nuclear electric generating station located by the Sava river, just outside the town of Krško in the Republic of Slovenia. Krško NPP, since startup in 1981, has supplied electric power to the republics of Slovenia and Croatia providing 15 to 20 % of total electricity generation. As a normal byproduct of the generation of electric power by a nuclear power plant, wastes from plant processes are generated. Some of these wastes contain radioactive materials resulting from the normal operations of a nuclear steam supply system, and must be stored in a safe and efficient manner in order to protect the public and plant staff from exposure to radioactive materials.

The Krško project was originally supposed to be the beginning of a very ambitious Yugoslav nuclear program. At that time, during the seventies, the radioactive waste management policy was also of general Yugoslav interest, concern and responsibility. When the construction of nuclear facilities was banned in 1987, the radioactive waste policy became a problem of republics of Slovenia and Croatia because these two republics owned the only nuclear power plant. According to the agreement between the governments of Croatia and Slovenia, a Project team, responsible for preliminary activities and preparation of all necessary documents and licences for the construction of final repository for low and intermediate activity waste, was established within the organisation of NPP Krško. During six years of Project team existence a conceptual design for shallow ground and tunnel type repository was prepared, together with preliminary safety assessments for both types of repository - to name just a few among more than ninety documents produced. Preliminary screening was performed, based on available geological, seismic, hydrogeological and other relevant data defining suitable candidate macro locations for the final repository according to recommendations of the International Atomic Energy Agency combined with methods successfully implemented elsewhere. Preliminary results have indicated that suitable locations for final repository are available in both Republics.

In January 1991, the Slovenian Republic Administration for Nuclear Safety issued "Guidelines for the Low and Intermediate Level Radwaste Repository Site Selection in Slovenia". According to the Guidelines, the site selection procedure is executed in four steps taking into consideration forty three criteria. In February 1993 the second step results were reviewed and public announcement was made for thirty-six potential locations covering the total area of 896 hectares situated in eastern and north-eastern parts of Slovenia. It should be noted that the public reaction after the announcement was much milder as compared to the reaction after the presentation of the first step results in June 1990. Despite considerable effort the Project team was never publicly accepted. Unfortunately, radioactive waste management was understood in Slovenia as an exclusive problem of the nuclear power plant, instead of being discussed and resolved within the scope of waste management at the state level. For this reason in 1993 the Slovenian government founded the Radioactive Waste Management Agency, reporting directly to the government. As a result of the third step of the selection process, five most suitable locations were identified and presented to the public provoking strong disapproval within the local communities where the locations have been identified. At that point the siting process was stopped and it is not expected to resume any activities in the near future. When the level of ecological consciousness of Slovenian people becomes high enough to understand the obligation to dispose of waste, including the radioactive waste, in a controlled manner, the process will continue with detailed investigations of candidate sites. The direct prerequisite for such a development is the clear standpoint of the Slovenian Government, Assembly and ecologists, indicating the firm intention to build the repository as a part of changing the attitude towards surroundings. Temporary radioactive storage capacity at the plant site has limited capacity and having no other options available, NPP Krško is undertaking major efforts to reduce waste to allow normal operation. Among many other activities, supercompaction of existing waste was one of viable options.

KRŠKO RADIOACTIVE WASTE SUPERCOMPACTION CAMPAIGN

Waste types and quantities

The types of wastes stored at NPP Krško include the concentrate from evaporation of plant process waste liquids (EB); used process filter cartridges (F); used protective clothing, gloves, and rags-compressible wastes (CW); depleted ion exchanger resins used in water purification systems (SR) and previously supercompacted waste (SC). Continuous operation since the commissioning of the plant had, by November 1995, resulted in the production of 9924 55-gallon and 617 85-gallon storage drums containing radioactive wastes.

TABLE I NPP Krško radioactive waste classification

Waste Type	1982-89	1990	1991	1992	1993	1994	1995	Total
EB	5220	522	279	382	213	133	397	7146
CW	2087	180	94	207	192	132	415	3304
0	246	3	0	0	0	0	3	252
SR	766	65	0	39	82	0	43	995
F	65	21	0	1	19	19	26	151
Total	8384	791	373	629	506	284	881	**11848**

Note: In 1988 and 1989, a quantity of 1924 standard 55 gallon storage drums containing compressible wastes were supercompacted and placed into 617 overpacks

Krško Radioactive Waste Storage Facility

The Krško Radioactive Waste Storage Facility is a seismically qualified 1470 m^2 building located within the protected area of Krško NPP . Construction is of steel-reinforced concrete, with 1 meter thick outer walls and 60 centimeter thick inner dividing walls. The roof slab is 1 meter thick except for the slabs above the entrance compartment, which are 60 centimeters thick. The facility is built on a reinforced concrete base pad, and is designed to withstand predicted potential earthquakes and extreme weather conditions.The waste storage areas interior to the building consist of six corridors 4.17 meters wide and in excess of 7 meters high. A second level of storage area is provided, supported on steel beams which are in turn supported on steel plates bolted to the dividing walls spaced at 0.5 meter intervals. The facility is continuously monitored for airborne radioactivity, and contamination surveys are regularly performed in accordance with the Krško site radiological control program. Prior to performance of the compaction campaign, the existing 55-gallon waste drums were stored, in two tiers 5 layers deep, horizontally on the concrete floor and on steel shelving. The steel shelving was supported by steel plates bolted to interior walls. Access for inspection and monitoring within the storage matrix was difficult.

Modifications to the Storage Facility

The storage facility was modified to accept the new TTC (overpack container) and an overhead crane added to transport them.The saddles used in the old storage configuration to support horizontally placed drums were removed since the new containers specially designed for the supercompaction campaign are stored in a vertical position. For the second level of waste container storage, the steel support structure required only minor modifications to accommodate the additional weight of the compacted wastes. Steel grating was installed on the steel support beams, and horizontal steel restraint structures were added in each compartment to provide additional stability for the new containers. Steel ribs were added to the support beams to prevent sliding of the grating during any seismic event.

Extended Storage Requirements

Construction of a new radioactive waste storage facility, in addition to the existing one, was considered, but the licensing process for construction of a new building would take considerable time, and the new facility would thus not be available before the current facility was completely full. Thus, NEK decided to explore techniques for more efficiently utilizing the available space in the existing storage facility.

In addition, the drums in use were not suitable for long-term storage in a temporary facility, and were also not suitable for off-site transportation or for permanent disposal. Thus, it was decided to repackage the existing filled drums into superior, specially designed containers or "overpacks". These containers had to be suitable for extended temporary storage, transportation to the final waste repository, and to facilitate handling for permanent disposal.

By 1995, the Radioactive Waste contained in the storage building occupied approximately 94% of the available storage space. With the plant designed to operate until the year 2023, the remaining storage space would be inadequate. However, it was determined that by supercompacting and repackaging the 8600 drums containing solidified evaporator concentrated compressible waste, it would be possible to gain enough space for 3000 additional drums.

Waste Volume Reduction

In 1988 and 1989, a quantity of 1924 standard 55 gallon storage drums containing compressible wastes were supercompacted using a large mobile "supercompactor" owned by Westinghouse Electric Corporation.. The compressed drums, referred to as "pucks" were placed into 617 overpacks (85 gallon steel drums) and returned to storage in the storage building. Additionally, tests were performed in order to determine the efficiency of the supercompactor when used to compact drums containing evaporator concentrates solidified in vermiculite cement. Due to the porous nature of the vermiculite cement, and the high compaction power of the mobile supercompactor, the tests showed that these drums could be reduced in volume by up to 50%. Thus, it was decided by NEK management to use waste compaction technology to address the lack of storage space and to meet the requirements of volume reduction.

Tube Type Containers (TTCs)

Use of the 85-gallon overpacks, which were used for storage of the compacted waste drums resulting from the 1988-89 compaction tests, was determined to be impractical. These overpacks are not qualified to contain weight greater than 500 kg. The Tube Type Containers (TTCs) were thus specially designed for use in the Krško radioactive waste facility, and were produced on the basis of NEK specifications. The TTCs are qualified as IP-2 transportation package per IAEA Safety Series No. 6, "Regulations for the Safe Transport of Radioactive Wastes" (IAEA, 1985, amended 1990). The TTCs are made of steel, 2700 mm high, with an internal diameter 640 mm, wall thickness of 2 mm, bottom and top closure cap thickness 2.5 mm, and total weight, including waste, of 2500 kg. The height of the TTCs was chosen to optimize their placement in the storage building, and to contain from 4 to 10 pucks depending on the type of waste and the volume reduction achieved or 3 standard 55 gallon waste drums if repackaging is needed. Calculations addressing different types of overpacks showed that the use of these specially designed overpacks would dramatically reduce the volume of the stored wastes following the supercompaction campaign.

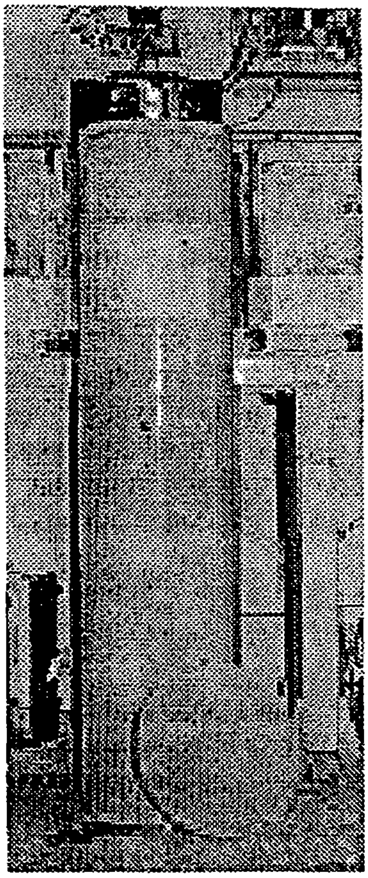

Fig 1. TTC

The TTCs are qualified for use for extended temporary storage, and for later transportation to a final disposal site. As part of the qualification procedure, they were subjected to a severe regime of stacking and drop tests. Each TTC is coated, interior and exterior, with qualified primer and paint. These coatings ensure that moisture from outside cannot enter the container, and that any trace corrosive material (boric acid) will not corrode and degrade the container walls. In addition, these coatings provide a high degree of fire resistance.

Before the start of the TTC filling operation, a measured quantity of desiccant material was added to the bottom of the TTC. The same desiccant material was also used to fill the voids during the filling process and to cap off the remaining empty space on the top of the TTC. This ensures that the pucks inside the TTC's are securely immobilized, while at the same time absorbing any residual moisture. After a TTC has been filled with pucks of compacted waste, the closure lid is welded to the body of the TTC. Welding of the closure lid of filled TTCs was performed on a specially designed base table, which turns on interior ball-bearings. The welder stands behind lead shielding to minimize the radiological dose received while welding the closure lid, and the TTC turns in place, allowing the welding to be performed in minimum time and with minimum manipulation by personnel.

SUPER COMPACTION CAMPAIGN EQUIPMENT

The Westinghouse/Scientific Ecology Group (SEG) Mobile Supercompactor used for the campaign is a 1000 ton hydraulically operated press contained in one standard 12 m truck trailer, along with its equipment: a hydraulic power unit, a waste drum loading system, an air filtration system, a liquid collection system, and a compacted drum unloading crane.

To facilitate handling of the overpacks used for the compaction campaign, a 4 Ton Electric Overhead Traveling Crane was provided. This crane conforms to FEM 1.001 (3rd Edition 1987) rules for hoisting appliances. Crane rails to support the equipment were installed permanently in the 6 storage cell ceilings. The crane itself is constructed and installed so that it can be removed from one storage cell, and then installed in another. This provides the capability to quickly recover any overpack or drum which may be damaged, and to facilitate repackaging and replacement within the new storage configuration.

In order to facilitate the loading of the overpacks and prevent dropping the overpack or contents, a loading platform was built for the campaign. The platform was designed to accommodate six (6) overpacks, thereby allowing the platform operator to select an overpack based on partial fill and compacted drum size. The platform was equipped with a hoist capable of picking up a compacted drum at the compactor exit conveyor and lift them to the top of the platform, there to be lowered into the selected TTC. Sufficient working space is available to permit the lowering of uncompacted drums into the overpacks should that be desirable.

A conveyor system specially designed for use with the platform was also installed. This included a loading conveyor where the drums to be compacted were deposited by the forklift, to be fed by gravity to the compactor loading arm. A special interlock built into the system allowed only one drum at a time to roll into the loading arm, allowing the next drum to take its loading position once the loading arm was lowered. At the exit end of the compactor, a gravity type conveyor system was installed. This conveyor, completely enclosed to prevent the spread of airborne contamination, ran from the compactor unloading chute to just below the overpack loading platform where the compacted drums were picked up by the platform lifting hoist. A system of drip pans was also provided to prevent spills of liquids onto the compacting area floor when drums containing liquids were ejected from the compactor.

COMPACTION CAMPAIGN ACTIVITIES

In order to ensure proper identification of the contents of the existing drums prior to compaction, drums were inspected, weighed, and scanned using a segmented gamma spectrometer. The segmented gamma spectrometer was chosen for use in the supercompaction campaign in order to provide state-of-the-art measurement technology, capable of categorizing the wastes much more accurately than the standard external dose rate measurements employed at most commercial nuclear stations. The gamma spectrometer was used on all but a few drums during the campaign, and scanning of each drum took approximately fifteen (15) minutes. The remaining drums were above the weight limit for the scanning equipment, and so were measured using the standard practice of external dose measurement.

Using the segmented gamma spectrometer, the radiological (isotopic) content of each drum and dose rate measurements were taken, and the data from each drum recorded. These measurements provide a detailed record of the contents of each TTC, and the data necessary to calculate, in advance, the dose rate which will result when several pucks are placed into a TTC. Once the weight, activity and dose measurements had been determined and recorded, drums were sorted by these criteria for compaction. Drums identified as containing spent ion exchanger resins or filters were separated and not compacted. The scanning of all waste drums handled during the campaign was performed by NEK personnel in accordance with the NEK Radiological Protection Procedures.

The first radioactive waste storage drum was compacted, with representatives of the Slovenian Safety Authorities present, on November 3, 1994. The compaction operation was interrupted due to a hydraulic system failure in the supercompactor, which was returned to the Westinghouse European Service Center in Belgium for repairs. Repair work was completed on March 21, and the unit was immediately returned to Krško.

Operations resumed on March 27, 1995. At the end of the campaign, a total of 8770 drums had been compacted. These include 7135 drums containing evaporator concentrates, and 1635 Compressible Wastes drums. In addition, 387 drums containing filters and spent ion exchanger resins were repackaged into TTC overpacks without being compacted, and 766 of these were relocated to shielded storage positions without being repackaged (Fig. 2).A total of 1745

TTC's were used for the campaign. The final volume reduction achieved was 27% of the original volume(Fig. 3).

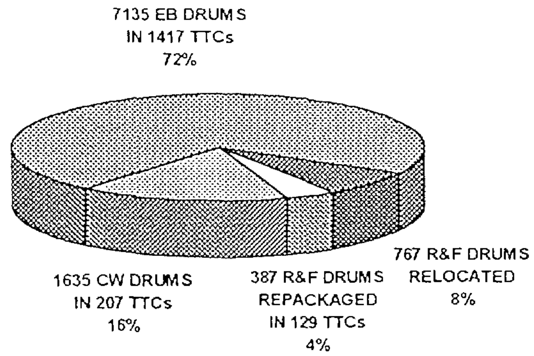

Figure 2 Radioactive waste by type after supercompaction

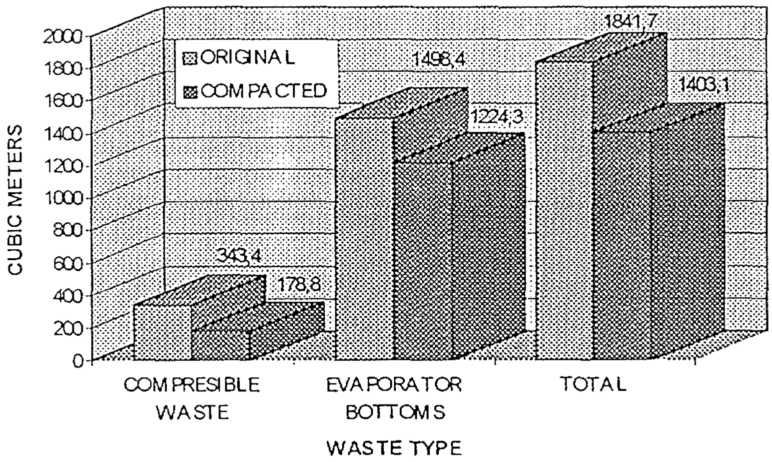

Figure 3 Volume reduction by type after supercompaction

Radiological Controls

Health Physics coverage was performed by the NEK Health Physics department. Monitoring, dose assessment, and radiological controls were performed in accordance with Krško radiological control procedures. An ALARA study was performed prior to the start of the campaign, which provided estimates of doses expected for each member of the campaign staff. Due to extra measures taken by Krško Health Physics and the campaign staff the actual total dose accumulated during the campain (238.81 mManSv) was substantially lower than originally estimated dose (514.31 mManSv).

Each member of the campaign crew was provided with presentations and instruction prior to the start of the project. Each member's responsibilities and duties were explained, along with requirements of site procedures for radiological control and personnel monitoring. By systematically storing the drums within the storage matrix, dose rates resulting from handling were reduced, and the remaining resin/filter drums could be stored separately in cell D where they are shielded by filled TTC's. TTCs containing waste with higher dose rates were placed interior to the storage matrix, so that high activity TTCs are surrounded by the lower activity TTCs which provide additional shielding. This resulted in a considerably reduced dose rate at the boundaries of the storage matrix in keeping with ALARA principles. The dose rate in the access areas of the radioactive waste storage building varies from zero to 50 μSv per hour. In the accessible areas in front of the storage cells, the highest dose rate in any area accessible by personnel is 150 μSv per hour.

Records Keeping and Traceability

Project records were kept on printed paper and in a computerized data base. These records show the exact number of drums compacted, their type, weight, dose rate, final TTC location, and the TTC location in the storage building. Records were kept during the performance of the campaign by the QC/Record Keeper, who recorded each drum location in the TTCs, the drum and TTC numbers, and ensured documented TTC desiccant fill and lid welding verification. The location of each closed TTC within the storage building was recorded, as were dose rate measurements on contact, at 1 meter, and at 2 meters.

Gamma spectrometer data were used to calculate predicted dose rates from filled TTCs. When the fill was complete, predicted and actual dose rates were compared to ensure accuracy. Logs were kept of the activities on each shift.

CONCLUSION

The Radioactive Waste Compaction Campaign was performed from November, 1994 through November, 1995 at Krško NPP, to enhance the efficiency and safety of storage of radioactive waste. The campaign involved the retrieval, segmented gamma-spectrum measurement, dose rate measurement, compaction, re-packaging, and systematic storage of radioactive waste which had been stored in the NPP radioactive waste storage building since plant commissioning. The final volume reduction achieved was 30% of the original volume. Additional storage space was provided for at least five years of normal plant operation.

In addition to the reduction in volume, the compaction campaign brought additional benefits. By placing the supercompacted drums into new type container with thicker walls, superior stability is achieved, which diminishes the probability of handling accidents during storage, transportation and final disposal activities. During the supercompaction campaign a more precise estimate of types and quantities of radionuclides contained in wastes was achieved using a direct segmented gamma-spectrum measurement, and by a combination of external dose and gamma-spectrum measurements.

REFERENCES

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