VOLUME-REDUCING CONDITIONING OF FUEL ELEMENT BOXES

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ABSTRACT

The Central Decontamination Operation Department (HDB) of the Research Center Karlsruhe operates facilities for the disposal of radioactive waste. In general, their objective is to reduce the volume of the radioactive waste and to obtain waste products suitable for repository storage.

One of the central facilities of the HDB is the ILW scrapping facility which processes intermediate level waste. Since the ILW scrapping facility was not large enough to handle radioactive waste coming from the dismantling and operating of nuclear facilities, HDB expanded and built a larger hot cell. It contains a hydraulically driven metal cutter with a guiding channel and a high pressure compactor. A major task in the hot cell of the ILW scrapping facility is disposing of fuel element boxes. These are cut in pieces and scrapped, which is a unique technique in Germany for fuel element box disposal.

INTRODUCTION

The Central Decontamination Operation Department (HDB) is a subdivision of the Forschungszentrum Karlsruhe GmbH responsible for the treatment of radioactive waste. Therefore, the HDB operates among others a facility for conditioning intermediate level waste (ILW). Since the HDB processes waste from the dismantling of research reactors and the reprocessing facility at the Forschungszentrum Karlsruhe as well as from external nuclear power plants, the amount and the dimensions of the accumulating waste required the installation of a new ILW scrapping facility. The main prerequisite was to reach a significant reduction of the resulting waste product volume in order to lower the final storage costs. Planning and realization of this ILW plant extension was carried out in close cooperation with the Gesellschaft für Nuklearservice (GNS). Several new concepts of handling ILW were incorporated into the new facility. Since its commissioning in 1997, the conditioning of fuel element boxes has proved the applicability of these tools.

OVERVIEW OF THE ILW SCRAPPING PLANT

Figure 1 shows an overview of the new ILW scrapping plant. The design reflects the successive steps of the conditioning process:

The process starts with the unloading of the transport casks. The locks and the transport equipment of the ILW scrapping plant are designed to handle the following types of transport casks with inner containers:

- Large transport containers with a total mass of up to 100,000 kg (e.g. German standard type container MOSAIK 80 T, see Fig. 2)
  These transport casks contain core internals from nuclear power plants such as fuel element boxes. For unloading, they are placed on a railcar and moved into the transport cask lock. Then the cask is moved to the docking system of the shielding gate between cell 130 and the transport cask lock. The shielding window can be opened only after the cask is tightly coupled to the lock. Then the remote–controlled removal of the lid and the unloading of the carrier cage from the transport cask into cell 130 takes place.

- Transport containers of up to 1500 mm height and single drum containers (e.g. German standard type container MOSAIK II)
  They are transferred into the loading/unloading cell by use of a transport carriage. There, the lid of the transport cask is removed by a remote–controlled heavy load manipulator which is also utilized to move the waste-filled inner containers onto another transport carriage. The delivered waste is required to be packed in inner containers to prevent an inadmissibly high contamination of the loading/unloading cell. The inner containers are subsequently locked into the cell 130.

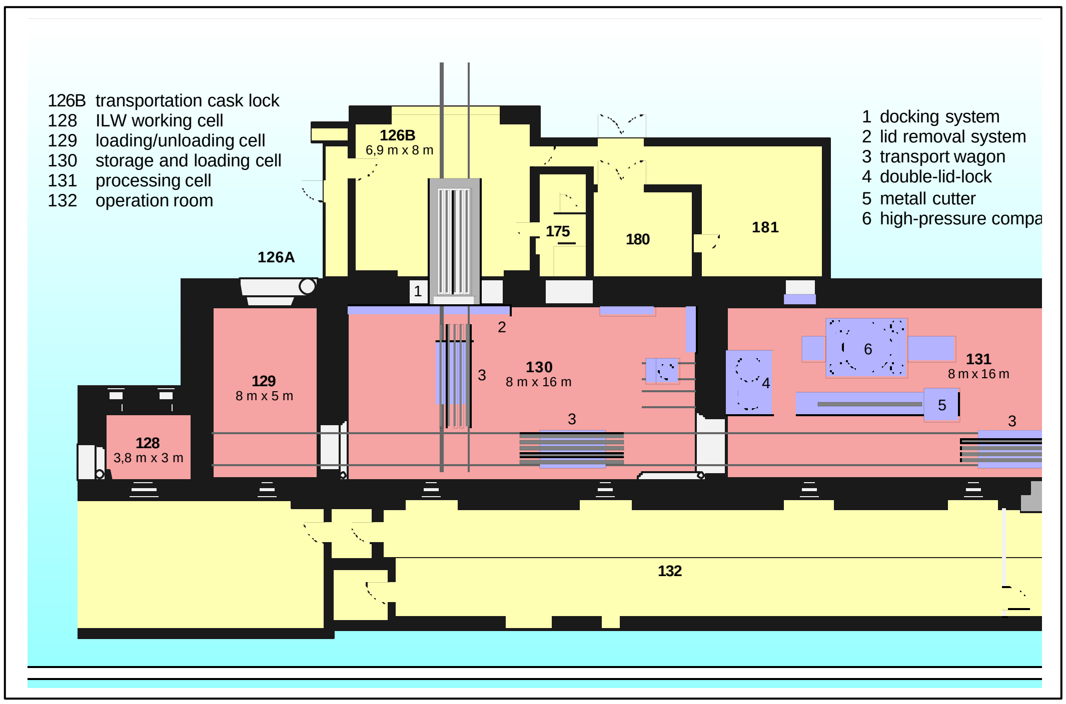

Fig. 1: Schema of the new ILW scrapping facility

Fig. 2: MOSAIK 80 T transport cask filled with fuel element boxes in front of the transport cask lock

Cell 130 is used for maintenance and repair work as well as for the decontamination of containers and machinery, if necessary. From here, the inner containers are moved on to the processing cell via two different lock mechanisms depending on their geometry. Drums with a volume of 200 l and 400 l, respectively, are handled by a special drum lock. All other containers are transferred into the processing cell through a shielding gate by transport carriage.

In the processing cell, metallic waste of a size corresponding to the inner dimensions of 200 l and 400 l drums as well as bulky waste such as tubes, profiles or steel tanks up to a length of about 4.5 m can be processed and conditioned.

According to the processing concept, the contaminated or activated waste is, if necessary, sorted on a sorting table using master-slave manipulators. To reduce long components such as core internals to small pieces, the processing cell contains a hydraulically driven metal cutter with a guiding channel and a cut length limitation unit (s. Fig. 3). The resulting pieces are packed into cylindrical sheet metal cartridges, which fit into the high pressure compaction unit. There, a volume reduction by a factor of 4 to 6 is achieved by a compaction pressure of 500 bar. The compaction unit can be equipped with three different stamps whose diameters are 535 mm, 624 mm or 710 mm, respectively. The stamp exchange is done remote-controlled by manipulators. The advantage of this is the ability to adapt to different waste dimensions.

Afterwards, the processed and compacted cartridges are packed into drums. These are returned to the loading/unloading cell via the drum lock and cell 130. In this cell, the packaging into containers suitable for final storage is performed. Following the release measurements, these containers are removed from the ILW scrapping plant.

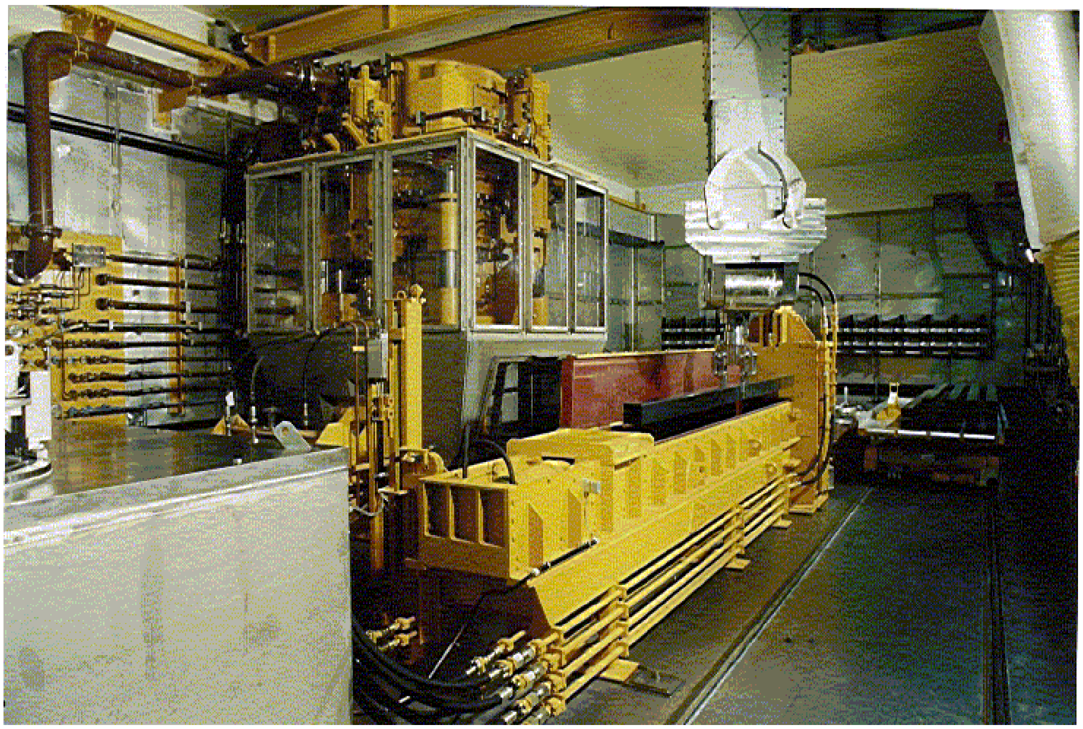

Fig. 3: View of the processing cell with metal cutter and high pressure compaction unit

CONDITIONING OF FUEL ELEMENT BOXES AS AN EXAMPLE OF ILW WASTE

For the transport of fuel element boxes from the nuclear power plants to the ILW scrapping facility special transport casks of the MOSAIK 80 T type are used. Each MOSAIK 80 T contains a carrier cage with 66 fuel element boxes (see Fig. 4). After unloading the carrier cage from the transport cask, it is transferred to the processing cell by a transport carriage. There, the fuel element boxes are extracted and separately cut into pieces with the hydraulically driven metal cutter. The size of these pieces is determined according to the total radiation exposure time during operation of each fuel element box. Due to the variable cutting length, it is possible to react immediately to the different requirements. Afterwards, the pieces are packed into 170 l cartridges, which can hold 4-6 fuel element boxes each.

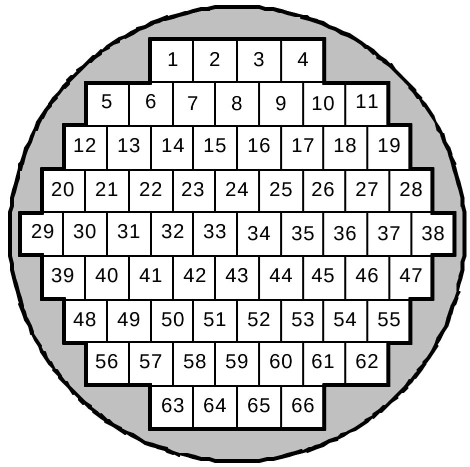

Fig. 4: Carrier Cage of the MOSAIK 80 T containing 66 fuel element boxes

Experience has shown that additional shaking of the cartridges filled with fuel element box pieces is useful in order to minimize the cavity in the cartridges after cutting. After this, the cartridges are compacted with the high pressure compactor. After compaction the pellets are packed remote-controlled into 200 l drums according to their weight and height in order to optimize the drum use. After transport to the loading/unloading cell, the 200 l drums are packed into special transport casks of the MOSAIK II type. Because of the high dose rate of the fuel element boxes, these transport casks contain an additional 40–50 mm lead inlay to ensure compliance with allowed dose rate levels.

Cutting and high pressure compaction of the fuel element boxes only would result in about 17 fuel element boxes fitting into one 200 l drum. Due to the shaking of the cartridges, the number of fuel element boxes per 200 l drum has increased to up to 22. This leads to a reduction from previously four resulting waste products to three.

Until the end of 1999 a total number of 396 fuel element boxes from the Philippsburg nuclear power plant and another 396 fuel element boxes from the ISAR nuclear power plant were conditioned in the new ILW scrapping plant since its commissioning in 1997. Two further transport casks of the MOSAIK 80 T type are already in store at the HDB, waiting to be conditioned in 2000.

DESCRIPTION OF THE WASTE PRODUCTS

As described before the fuel element boxes are packed together in cartridges and subsequently compacted. The resulting pellets are different in their height depending on the effect of shaking the cartridges before compaction. Even if the number of fuel element boxes seems to be similar in each cartridge, the effect is seen on the height of the resulting pellet. The average height of the pellets without shaking is about 27 cm, while the average height with shaking is about 23 cm. Normally each cartridge contains 5-6 fuel element boxes. But after the shaking only 2/3 of the total volume of the cartridge is used. The cartridge will not be completely filled in order to reach an optimum of volume reduction, the cartridge should not be too heavy. Table 1 and 2 contain the exact pellet data after compaction. For this comparison two batches with fuel element boxes of the Philippsburg nuclear power plant without shaking and two with shaking are taken. The results of the other batches are similar.

Identity (M 80 T)	Pellet-Number	Number of fuel element boxes	Height of the pellet [cm]
80003	1	5	25
	2	6	29
	6	6	28
	7	6	34
	8	6	27
	9	6	23
	10	5	26
	13	5	25
	14	4	21
	15	5	26
	33	6	24
	45	6	26
Result		**66**	**314**
80006	1	6	27
	2	5	27
	3	5	28
	4	6	30
	6	6	25
	8	4	28
	10	5	27
	11	6	28
	12	5	25
	13	5	26
	14	6	28
	16	7	31
Result		**66**	**330**

Table 1: Comparison of number of fuel element boxes and the resulting pellet height after compaction without shaking of the cartridges

Identity (M 80 T)	Pellet-Number	Number of fuel element boxes	Height of the pellet [cm]
80004	29	5	20
	30	6	22
	31	6	22
	32	5	19
	33	6	25
	34	5	22
	35	6	18
	36	5	23
	37	6	27
	38	6	22
	39	5	24
	40	5	26
Result		**66**	**270**
80005	17	5	20
	18	5	21
	22	6	25
	23	6	22
	19	5	20
	20	5	20
	24	6	27
	25	6	25
	28	5	24
	27	6	23
	26	6	28
	21	5	18
Result		**66**	**273**

Table 2: Comparison of number of fuel element boxes and the resulting pellet height after compaction with shaking of the cartridges

ACTIVITY OF FUEL ELEMENT BOXES

While loading the fuel element boxes in the MOSAIK 80 T transport cask at the nuclear power plant, the activity could only be estimated. The fuel element boxes are stored in water basins until the loading. Under water the dose rate of each fuel element box is measured. The dose rate of the fuel element boxes varies depending on the radiation exposure time of the fuel element box. The dose rate of the fuel element boxes compacted at the HDB varied from 0.3 up to 2 Sv/h on the surface. After compaction a dose rate up to 120 Sv/h was measured on the surface of the 200 l drums.

The activity of the fuel element boxes is calculated from their exposure time in the reactor. By the knowledge of the nuclides coming from the activation of the fuel element boxes and the exposure time of each fuel element box the total amount of activity of the 66 fuel element boxes can be calculated. This calculation provides the complete declaration of the fuel element boxes for the transport and for the conditioning at the HDB.

It is noted which fuel element boxes are packed together in the cartridge for compaction. After the compaction, the resulting pellets are loaded in 200 l drums and it is recorded which pellets are loaded together. The dose rate on the surface and in distance of 1 m is measured. The average dose rate in at 1 m is used to calculate the activity of the waste product. Each nuclide contributes to the dose rate. From the contribution of each nuclide to the average dose rate the activity of each nuclide can be calculated. This methods provides a precise determination of the total activity. A comparison of pre-processing and post-processing activity has shown that the calculation of the fuel element boxes slightly overestimates the activity. Table 3 shows the ratio of the both activities on the example of the fuel element boxes of the Philippsburg power plant.

Identity (M80 T)	pre-processing activity [Bq]	post-processing activity [Bq]	post/pre-ratio
80001	1,1 E 14	2,2 E 13	0,16
80002	1,1 E 14	2,2 E 13	0,20
80003	1,3 E 14	2,2 E 13	0,17
80004*	1,8 E 14	6,7 E 13	0,37
80005*	1,9 E 14	5,8 E 13	0,31
80006	2,5 E 14	5,9 E 13	0,24

*Number of resulting waste products: 3

Table 3: Comparison of the pre-processing activity and the post-processing activity on example of fuel element boxes of the Philippsburg power plant

CONCLUSIONS

The processing of ILW waste in the new ILW scrapping plant has shown that the described method of handling ILW is a new possibility of conditioning. Besides, experience has shown that the cutting of metal waste with following compaction is very practicable and economic due to the savings in final storage volume. Furthermore, compared to other methods of conditioning the dose rate for the personnel is also reduced to a minimum.

After a few adaptations, in the new ILW scrapping facility nearly all kind of core internals can be conditioned. Therefore, the new ILW scrapping plant provides flexibility and effectiveness in handling ILW.

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