RECENT EXPERIENCES WITH CEMENT SOLIDIFICATION SYSTEMS

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ABSTRACT

Recent developments and experiences with cement solidification systems are concerned with modified in-drum mixers (DEWA and MOWA) for solidification of evaporator concentrates, sludges, dry filter residues and stationary or mobile continuous mixing systems. Plants and processes are described including throughputs, dose rates, radiation exposure of the staff and product qualities obtained. The data are based on more than 2800 drums, mainly produced in the years 1983 and 1984.

INTRODUCTION

Treatment of different types of commercial nuclear wastes - evaporator concentrates, decontamination effluents, filter aid sludges, trash and metal scrap - has been performed in West Germany by various volume reduction and solidification techniques, e.g., drying[1], pyrolysis[2], incineration[3], high force compaction[4,5], bituminization and cementation[6,11]. Especially in the area of cementation, much experience is available at NUKEM and TRANSNUKLEAR, based on R&D work, engineering activities and service activities at different nuclear power plants (KKB, GKN, Biblis, KKU, KKS, KKP, KCB Borssele). Recent developments and experiences are concerned with modified in-drum mixers for solidification of evaporator concentrates, sludges, dry filter residues and stationary or mobile continuous mixing systems.

MODIFIED DEWA SOLIDIFICATION UNIT

The mobile DEWA solidification plant was described by B. Christ and P. Vygen in detail[8]. The standard process started with 200- or 400-l barrels, prefilled with cement, which were connected to a steel shielded hot cell containing a planetary mixer, metering and cleaning devices and a dust-exhaustor, which was connected to a HEPA-filter system. The liquid waste was filled in portions through a metering tank into the drums and was homogeneously mixed with the cement. In active operation, filling ratios of 88-92% of the drum volume could be realized. Owing to requirements of customers the hollow spaces subsequently were filled with inactive concrete.

In the modified process, which is in active operation since 1984, no prefilling of barrels with cement is used. Liquid waste is metered into empty drums, dry cement is fed into the mixing position from an external hopper with a spiral tube conveyor. The metering of cement and homogeneous mixing is carried out within 10-15 min. The filling ratio amounts to 97-98 Vol% (Fig. 1).

With the modified unit 17 m^3 PWR-evaporator concentrates and 75 m^3 BWR-spent resin sludges with specific activities of 0.8-3.0 Ci/m^3 (3.0-11.1·10^{10} Bq/m^3) have been solidified. Binder materials were Portland cement with additives or blast furnace slag (bfs) cement. The waste loading amounted to 130 l/200 l drum for evaporator concentrate (18-20 wt% dry solid content) or 125 l/200 l drum for spent resin sludges (24-28 wt% dry solid content). The corresponding w/c-ratios were 0.55-0.60 and 0.42-0.45 respectively. Solidification was performed in standard drums with a shielding during handling; in total 730 drums were produced (Table I). Average throughput was 16 drums per 8 hr. shift. The cement products hardened during 12 hrs. without free standing water and visible crack formation. Compressive strengths after 28 days curing time were 16 N/mm^2 (resin sludges) and more than 20 N/mm^2 respectively (evaporator concentrate). At the drum surface 350-450 mrem/hr dose rate have been measured, in 1 m distance 20-35 mrem/hr.

Fig. 1. Surface of DEWA-Cement Product.

The unit was operated by a staff of 3 to 4 people. Due to the shielding and mostly remote drum handling the average personal dose rate amounted to 4-7 mrem per day.

TABLE I

Summary of Solidification Runs With Active Wastes

SYSTEM	WASTES	SOURCES	ACTIVITIES	WASTE LOADING	PACKAGES	NUMBER
DEWA, mod.	Evaporator Concentrates	PWR	0.8-1.3 Ci/m³	130 l	200-l-drum	730
(TRANSNUKLEAR)	Spent Resin Sludges (Powder/Bead Resins)	BWR	3.0 Ci/m³	125 l	200-l-drum	
MOWA	Filter Sludges	PWR	0.12 Ci/m³	100-120 l	400-l-drum	
(TRANSNUKLEAR)	Evaporator Concentrates	PWR	2.5-5.2 Ci/m³	95-120 l	200-l-drum, CS*	1960
	Bead Resin Suspension	PWR	300 Ci/m³	80- 90 l	200-l-drum, CLS*	
	Filter Residues (dry)	BWR	0.3-3.0 Ci/m³	200 l	400-l-drum, CS or SS*	
Continuous Mixer (ALKEM)	Soft Trash	Fuel Fabrication	<0.05-0.1 Ci/kg	40- 60 kg	200-l-drum	150
	Metal Scrap			40- 60 kg		

* CS = Concrete shielding CLS = Concrete/lead shielding SS = Steel shielding

MOWA

The MOWA is a mobile waste solidification plant for processing liquid, pumpable wastes, e.g., evaporator concentrates, sludges or spent ion exchange resins, and solid waste materials, especially dried filter residues, with binders on basis cement or DOW binder material[8,9]. For treatment of liquids the waste is suctioned by vacuum or fed via a circuit into the MOWA-metering system, two heavily shielded metering tanks inside an accessible sealed cell. Sludges or concentrates are dosed automatically into the sludge metering tank (volumetrically controlled) and fed into the disposal drums, which already contain cement and additives. Bead ion exchange resins are treated in the second resin dosing tank by partial dewatering and are likewise pumped into the disposal drums. Mixing with cement is achieved by a lost paddle during and after feed pumping in two mixing positions. Owing to the heavy shielding of pipings and tanks in the sludge tank, wastes with up to 25 Ci/m^3 β/γ-activity can be treated, in the resin tank wastes with up to 1000 Ci/m^3 Co-60 equivalent.

Dry radioactive wastes, especially BWR-powdered filter residues, are metered by an additional device into empty drums with the lost stirrer (Fig. 2). 200-l-drums filled with dry waste (surface dose rate up to 8 rem/hr) are transferred to a shielded, container, which is mounted in a mobile frame with a rotating and tilting device and can be evacuated. Waste is removed from the drums by a movable suction lance, which is installed in one mixing position of the MOWA. During exhaustion, the drums are tilted and rotated. After transferring the waste of the 200-l-drum into a 400-l-drum (concrete/steel shielded), some water and cement slurry (w/c - 0.30) from a conventional continuous mixing system is added during mixing with the lost paddle. Exhaustion, metering and mixing are visually controlled by an in-drum viewing system. During processing, container and 400-l-drum are connected to the MOWA-offgas and vacuum system.

Fig. 2. Modified MOWA-unit.

Active operation of the MOWA has been performed by TRANSNUKLEAR with filter sludges (containing powder resins), PWR-evaporator concentrates, PWR-bead resins, dry powder resins and filter residues with specific raw waste activities in the range of 0.01-300 Ci/m^3 ($3.7 \cdot 10^8$ - $1.1 \cdot 10^{13}$ Bq/m^3), (see Table I). All waste types were successfully solidified with OPC or bfs-cement and additives. With PWR-evaporator concentrates waste loadings of 95-120 l per 200-l-drum are possible, due to a filling ratio of 85-95 Vol%. The corresponding w/c-ratios amount to 0.44-0.57. With dry filter residues 200 l waste per 400-l-drum has been solidified. The throughput during evaporator concentrate processing was up to 42 waste packages per 8 hr shift; with dry filter residues 8-10 drums per 8 hr shift were treated. The cement product hardened within 12 hr, compressive strength after 28 days curing time is higher than 20 N/mm^2.

For packaging evaporator concentrate/filter residue-cement products, concrete or steel shielded

200-l or 400-l-drums have been used (surface dose-rate ≤ 200 mrem/hr, dose rate in 1 m distance 10 mrem/hr). During operation the staff - 1 foreman and 2 coworkers - obtained an average dose rate of 3-8 mrem/man·day. In total 1830 drums were produced. As DEWA, during transportation no technical failures and no problems concerning the radiation exposure and contamination occurred.

CONTINUOUS MIXERS

Continuous mixers for radioactive waste treatment are investigated in a NUKEM-R&D program on quality assurance of low level and intermediate level wastes, inactively operated in the in-situ test facility[10] and actively operated by ALKEM since June 1984:

- solidification of LLW in rectangular or square containers up to 10 m^3 volume (mobile system)
- mixing of pelletized waste cement product and mortar for transfer to an 1000 m^3 underground cavity (stationary system)
- mixing of shredded, Pu contaminated soft waste with cement slurry, overpouring of solid metal scrap in a 200-l drum (stationary system).

The mobile NUKEM-system, which contains a modified conventional continuous mixer and a gravimetrically controlled cement feed system, is mounted in a rectangular rack with the dimensions 2.70x2.20x1.96 m (LxWxH) and can be transported with a fork lift truck. For LLW-handling, no shielding is provided. Liquid waste can be metered into a separate metering tank, which is connected to the mixer rack by a pump and a circuit line. For solid waste metering a second gravimetrically controlled feed system can be installed. Average throughput of the system is 40-70 kg/min corresponding to 20-40 l/min waste product, depending on waste loading and w/c-ratio. Due to the improved construction, products with very low w/c-ratios can be homogeneously mixed and solidified.

The mixing of shredded waste with cement lime has been investigated and optimized by NUKEM for the ALKEM-solidification process. TRU-waste from fuel fabrication at ALKEM contains about 50 wt.% soft waste, e.g., PVC and rubber. AFter a washing process for Pu-recovery the soft waste is shredded to particles smaller than 5 mm. The shredded material is pneumatically transferred to a cyclone above a cement blender, where the waste can be homogenized. In the cementation unit the waste is homogeneously mixed with bfs-cement, additives and water or a liquid waste stream, which has also been treated for Pu-recovery before. The mixture is poured directly into a 200-l-drum over pieces of hard solid waste[11]. According to safety requirements for handling of plutonium, all active contaminated equipment is located within glove boxes. Connection of 200-l-drums with the cementation box is performed by a double lid system.

During active operation, 150 drums with solidified materials were produced. The waste loadings were 40-60 kg soft trash and 40-60 kg metallic scrap per 200-l-drum (Table I). The products hardened within 18 hrs., the compressive strengths amounted to ≤10 N/mm^2. The surface dose rates are lower than 10 mrem/hr, the dose rates in 1 m distance lower than 1 mrem/hr. The throughput including Pu-recovery and shredding is 1-2 drums per 8 hr.-shift.

CONCLUSIONS

The mobile in drum mixing systems DEWA and MOWA allow safe treatment of different types of liquid and solid, low and intermediate level wastes in barrels with volumes between 100 and 400 l. For handling of wastes requiring heavy shielding, the anticipated advantages of the lost paddle (MOWA), low contamination risk and low radiation exposure of the staff at high waste throughput, have been confirmed. Slight modifications similar to the modified DEWA-process will allow improved filling ratios of the drums up to 98 Vol% and the application of bigger drum sizes. The newly developed powder transfer system firstly allows homogeneous mixing of intermediate level dry BWR-filter residues with cement. First active experiences with a continuous mixer in a stationary equipment at ALKEM yield positive results. According to a further demand for direct solidification of LLW in containers up to 10 m^3 volume in West Germany, a new compact unit is in the testing stage which will complete our cementation capabilities.

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