EFFECT OF CURE TIME AND SAMPLE SIZE ON COMPRESSIVE STRENGTH OF LLW*

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ABSTRACT

One area of interest in the solidification of low level radioactive waste is the compressive strength. This paper deals with the results of compressive strength tests performed at various cure times on cylinder and cube samples of six simulated wastes expected to be generated at the West Valley Demonstration Project.

INTRODUCTION

A commercial nuclear fuel reprocessing plant was operated in West Valley, New York at the Western New York Nuclear Service Center from 1966 to 1972. West Valley Nuclear Services Company, Incorporated, a wholly-owned subsidiary of Westinghouse Electric Corporation, and a contractor to the U. S. Department of Energy was formed to carry-out the solidification of the high-level radioactive wastes generated from the reprocessing operation, and to decontaminate and decommission the equipment and facilities. These tasks will generate a large volume and variety of low level waste streams which will require disposal in an environmentally acceptable manner. The NRC regulation "Licensing Requirements for Land Disposal of Radioactive Waste," 10CFR, Part 61, has established a waste classification system based on the radionuclide concentrations in the wastes. According to this classification, the more radioactive wastes (Class B and C) should be stabilized prior to disposal. The lower activity liquid wastes (Class A) do not require stabilization, but should be solidified or absorbed to meet the free liquid requirements (i.e., no more than 0.5 percent of the waste volume as free liquid). Cement encapsulation tests were thus conducted on several identified wastes to determine a recipe that would result in a stable waste form with maximum waste loadings.

Jar scale tests were performed on simulated wastes to develop and evaluate the cement encapsulation recipes. Using the most promising recipe, full scale encapsulation tests were then performed. From these full scale tests, samples were made for the waste form qualification testing as described in the NRC "Branch Technical Position-Waste Form."

Six simulated wastes were successfully run at full scale to make the samples at waste/cement weight ratios of ~ 1 and volume packaging efficiencies of ~ 60-70%. These included:

(1) The supernatant from high-level waste Tank 8D-2 which has been treated by ion exchange to remove much of the radioactivity (~ 39 w/o (weight percent) total solids).

(2) same as above, but volume reduced by evaporation (~ 53 w/o total solids).

(3) hydroxide and carbonate sludge from the Low-Level Waste Treatment Facility (LLWTF) (~ 19 w/o total solids).

(4) sludge (filter precoat) from the Fuel Receiving and Storage pool (FRS), (~ 29 w/o total solids).

(5) ion exchange resin (Duolite CS-100) from the LLWTF.

(6) ion exchange resin (Duolite ARC) from the FRS.

This paper deals with the results of compressive strength tests performed at various cure times on both cylinder and cube samples. A previous paper dealt with the leachability aspects of the waste forms.[1]

EXPERIMENTAL METHODS

The samples were all made from full scale tests, run in a high shear mixer that was available at the R&D Center. The waste/cement mixtures were placed in 0.15 meter (6 inch) ID by 0.3 meter (12 inch) high plastic, single use cylinder molds, meeting ASTM C-470, C-39 and C-192, or in 0.05 meter (2 inch) brass cube molds meeting ASTM C-109.

The molds were kept at room temperature for periods > 29 days, ~ 6 months, and ~ 1 year. The top surface of the cylindrical samples was capped with high strength capping compound, per ASTM C-617, before crushing.

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The compressive strength at room temperature was determined in accordance with ASTM C-39 using a calibrated 1.8×10^6 Newton (400,000 lb) hydraulic press. A cross-head travel speed 2.1×10^{-5} meter/second (0.05 in/min) was used for all tests.

RESULTS

The results of the compressive strength testing are shown in Table I. All of the compressive strengths greatly exceeded by a factor of $\sim$ 7 to $\sim$ 70, the 345 kPa (50 psi) minimum compressive strength guideline as described in the NRC "Branch Technical Position-Waste Form."

Longer term testing should be evaluated for specific waste streams, after taking into consideration both any suspected adverse interactions on the cement curing and the margin that the specific waste forms exceed the minimum compressive strength guideline.

The effect of sample size is also shown in Table I. The small cube samples generally exhibit higher compressive strengths than the larger cylinders, some by a factor of $\sim$ 3. Therefore, cube samples could be used for compressive strength testing and the values obtained reduced by a factor of 3 to get a conservative value for larger samples, thus minimizing the amount of material required for testing.

CONCLUSIONS

From the results presented here, it can be concluded that it is possible to use cement to encapsulate six of the simulated wastes expected to be generated at the West Valley site, at volume packaging efficiencies of 60-70%, and easily meet the compressive strength guideline.

Longer term testing should be evaluated for specific waste streams, after taking into consideration both any suspected adverse interactions on the cement curing and the margin that the specific waste forms exceed the minimum compressive strength guideline.

Small cube samples can be used to determine the compressive strength of the cement encapsulated wastes, and a conservative value for large samples can be obtained by dividing the cube results by 3.

REFERENCES

1. D. C. Grant, et al., "Leachability of Cement Encapsulated West Valley Radwaste Streams," presented at the Material Research Society, 1984 Fall Meeting, Boston, Mass., November 26-30, 1984, and published in the Conference Proceedings - Nuclear Waste Management.

TABLE I

Summary of Average Compressive Strengths

		Cylinders Average* Compressive Strength		% Change,		Cubes Average Compressive Strength	
Waste Type	Cure Time, days	kPa	(psi)	$\sim$ 1 mo. to $\sim$ 1 yr.	Cure Time, days	kPa	(psi)
39 w/o supernatant	40	3133	(453)				
	195	5113	(743)		153	4755	(690)
	368	4590	(663)	+ 46.4			
53 w/o supernatant	37	2597	(337)		150	4285	(625)
	365	3980	(580)	+ 72.1			
LLWTF Sludge	37	10280	(1490)		149	14950	(2170)
	365	7270	(1053)	- 29.3			
FRS Sludge	35	16997	(2467)				
	190	16757	(2430)		190	47915	(6950)
	363	10597	(1537)	- 37.7			
LLWTF Resin	56	9953	(1443)				
(CS-100)	146	9130	(1177)		147	9455	(1370)
	319	7550	(1097)	- 24.0			
FRS Resin	33	7927	(1150)				
(ARC)	188	7930	(1153)		189	8070	(1170)
	362	8140	(1180)	+ 2.6			

*Average of three samples.