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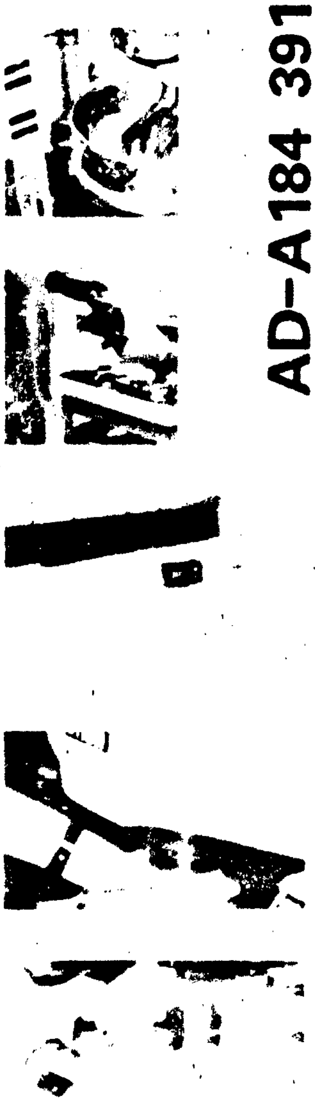

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LABORATORY INVESTIGATION OF ORGANIC CONTAMINANT IMMOBILIZATION BY PROPRIETARY PROCESSING OF BASIN F LIQUID ROCKY MOUNTAIN ARSENAL, DENVER, COLORADO

by

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The applicability of a proprietary solidification/stabilization process to liquid from a hazardous waste lagoon at the Rocky Mountain Arsenal, Denver, Colo., was investigated in laboratory studies. The proprietary process is cement based and is commercially available from Hazcon, Inc., Houston, Tex. The effectiveness of the Hazcon process for solidification of Basin F liquid was evaluated using an unconfined compressive strength test; its effectiveness for chemical stabilization of the organic content of the liquid was evaluated using batch leaching tests. The potential for ammonia release was also assessed by measuring ammonia gas concentrations in laboratory air during processing. The study was not designed to provide an evaluation of the capabilities of the Hazcon process for hazardous wastes in general.

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In a five-step sequential batch leach test, 86.7 percent of the total organic carbon in the solidified/stabilized material was leached. The concentrations of organic carbon in the leachate tended to stabilize at 50 mg/ℓ toward the end of the sequential leach procedure, indicating that continued batch leaching would extract most of the remaining organic carbon in the solidified/stabilized material. Thus, the Hazcon process did not effectively stabilize the organic content of Basin F liquid against aqueous leaching.

Unconfined compressive strength after a 28-day cure time averaged approximately 20,000 kPa for six replicates. Unconfined compressive strengths in this range indicate satisfactory solidification. Unconfined compressive strength was also measured after 7-, 14-, and 21-day cure times. The strength versus cure time curve indicated retarded set and the potential for further strength development after 28 days. Thus, the contaminants in Basin F liquid retarded the setting reactions responsible for development of a hardened mass, but they did not interfere with the setting reactions to the extent that Basin F liquid cannot be solidified by the Hazcon process.

Ammonia gas concentrations were measured inside and outside the laboratory hood in which Hazcon solidification/stabilization agents were added to and mixed with Basin F liquid. Ammonia gas concentrations under the hood ranged from 72 to >500 mg/cu m, the lower concentration being measured after the hood was turned on. The ammonia gas concentrations measured in this study indicated that evaluation of potential air quality and occupational health impacts may be needed before full-scale application of the Hazcon process to Basin F liquid.

PREFACE

The study described in this report was conducted to evaluate the effectiveness of the Hazcon solidification/stabilization process for Basin F liquid from the Rocky Mountain Arsenal, Denver, Colo. Funding was provided by the Office of the Program Manager, Rocky Mountain Arsenal Contamination Cleanup (AMXRM), Aberdeen Proving Ground, Md., under Intra-Army Order for Reimbursable Services No. 86-D-63. The AMXRM Project Officer for the study was Mr. Bruce M. Huenefeld.

The work was conducted by the Environmental Engineering Division (EED), Environmental Laboratory (EL), US Army Engineer Waterways Experiment Station (WES). The report was written by Messrs. Tommy E. Myers and Mark E. Zappi of the Water Supply and Waste Treatment Group (WSWTG), EED. Technical review was provided by Messrs. M. J. Cullinane and D. E. Averett, EED. Chemical analyses were performed by the Analytical Laboratory Group, EED. Unconfined compressive strength tests were performed by the Concrete Technology Division, Structures Laboratory, WES. The report was edited by Ms. Jessica S. Ruff of the WES Information Products Division.

The study was conducted under the direct supervision of Mr. Norman R. Francingues, Jr., Chief, WSWTG, and under the general supervision of Dr. Raymond L. Montgomery, Chief, EED, and Dr. John Harrison, Chief, EL.

Commander and Director of WES was COL Dwayne G. Lee, CE. Technical Director was Dr. Robert W. Whalin.

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LABORATORY INVESTIGATION OF ORGANIC CONTAMINANT IMMOBILIZATION BY PROPRIETARY PROCESSING OF BASIN F LIQUID ROCKY MOUNTAIN ARSENAL, DENVER, COLORADO

PART I: INTRODUCTION

Background

1. Basin F is a hazardous waste storage/evaporation pond containing several million gallons of chemical waste from past industrial and military activities at the Rocky Mountain Arsenal. Solidification/stabilization is an innovative treatment technology that could be applied to Basin F liquid. The ability of various commercially available solidification/stabilization processes to solidify Basin F liquid was demonstrated in previous laboratory studies at the US Army Engineer Waterways Experiment Station (WES) (Myers and Thompson 1983). Although the tests proved successful, two significant process deficiencies were noted.

2. First, large quantities of ammonia gas were evolved from the liquid upon addition of various process additives, in particular, alkaline additives. Subsequent laboratory investigations showed that the release of ammonia can be eliminated or significantly reduced by including in the process additives a source (or sources) of magnesium and phosphate (Myers and Thompson 1984). Ammonia is then sequestered as ammonium magnesium phosphate.

3. Second, chemical leach tests showed that the processes were not completely successful in immobilizing organic contaminants. One of the six processes evaluated was specifically designed to chemically stabilize organics. The other five processes were developed for application to primarily metal-bearing wastes, and no claims were made for these processes regarding stabilization of organics. Statistical analysis of leach data showed that there were no significant differences in the ability of the various processes to immobilize the organic content in Basin F liquid.

4. Recently, Hazcon of Houston, Tex., developed a proprietary solidification/stabilization process for organic wastes. Hazcon claims that the process is different from those previously investigated and that the process can effectively stabilize organic contaminants against aqueous leaching. However, technical information on the Hazcon process is incomplete, and no

published data on the leachability of organic wastes solidified by the Hazcon process are available. Further, the published literature provides little evidence of organic contaminant stabilization against aqueous leaching by solidification/stabilization technology (Tittlebaum et al. 1985).

Purpose and Scope

5. This report presents the results of physical and chemical testing of Basin F liquid after solidification/stabilization by the Hazcon process. The purpose of this study was to determine the chemical stabilization efficiency of the Hazcon solidification/stabilization process for total organic carbon in Basin F liquid. The study included collection of solidified/stabilized Basin F liquid, identification of appropriate test methods, physical/chemical testing, and report preparation. The study was not designed to provide a evaluation of the capabilities of the Hazcon process for hazardous wastes in general.

Solidification/Stabilization Technology

6. Solidification/stabilization typically provides three major advantages over raw waste disposal. These are: (a) removal of free liquid, (b) development of structural integrity, and (c) improved contaminant isolation and containment (Malone and Jones 1979; Malone and Larson 1983; Cullinane, Jones, and Malone 1986). Isolation and containment of hazardous constituents are accomplished by waste entrapment in a cemented matrix and conversion of waste constituents to less leachable forms.

Solidification

7. Solidification is the process of eliminating free water in liquids and semisolids by hydration of a setting agent(s). Typical setting agents include portland cement, lime, fly ash, kiln dust, slag, and combinations of these materials. Coadditives such as soluble silicates and other materials are sometimes used with setting agents to give special properties to the final products. Generic descriptions of the commercially available solidification processes have been published by Malone and Jones (1979).

8. Hydration chemistry is a complex series of reactions that, depending on the setting agents used, produces crystals, amorphous gels, and

combinations of these solid forms (Bogue 1955). Although hydration reactions can continue for years, most of the physical properties of water-cement pastes reach quasi-steady state values after approximately 1 month. However, many contaminants in liquid wastes retard strength development and interfere with setting reactions to the extent that immobilization properties of the solidified product can be seriously impaired (Clark, Poon, and Perry 1985; Jones et al. 1985; Chalasani et al. 1986; Walsh et al. 1986).

Stabilization

9. Stabilization can be both physical and chemical. Physical stabilization refers to improved engineering properties such as structural integrity and dimensional stability (bearing capacity) and to physical entrapment of waste constituents in a hardened mass. Chemical stabilization is the alteration of the chemical form of the contaminants to make them less soluble and/or less leachable.

10. Solidification/stabilization processes can be formulated to minimize the solubility of metals by controlling pH and alkalinity (Shively et al. 1986). Because anions are typically more difficult to bind in insoluble compounds, most solidification/stabilization processes rely on physical entrapment (microencapsulation) to immobilize anions. Although solidification/stabilization processes are sometimes effective for inorganic wastes, stabilization of organic wastes has not been generally successful (Tittlebaum et al. 1985). If immobilization does occur, it is thought to be primarily by dispersion into and entrapment in the solid that forms.

11. Because contaminant interference with the setting reactions responsible for the development of a hardened mass is not well understood, process formulations cannot be developed solely on the basis of chemical characterization of the waste. Most solidification/stabilization vendors, therefore, conduct laboratory performance tests in order to evaluate different process formulations.

PART II: MATERIALS AND METHODS

Solidification Processing

12. Laboratory-scale solidification/stabilization of Basin F liquid was performed by Hazcon in their Houston, Tex., laboratory. A WES engineer and a representative from the Office of the Program Manager, Rocky Mountain Arsenal Contamination Cleanup, were present to observe the actual processing of Basin F liquid by Hazcon. Data on additive dosages, mixing equipment, and mixing time were obtained, and measurements of ammonia gas release during processing were made.

13. Additives were mixed with Basin F liquid in a hood with a Bamix M122 hand mixer. Three mixes were prepared: one large mix and two small mixes (see tabulation below). Freshly prepared solidified waste from the large mix was placed in cube molds for unconfined compressive strength testing, and freshly prepared solidified waste from the two small mixes was placed in 500-ml polyethylene bottles for leach testing. The cube molds were placed in large plastic bags, and the bottles containing material for leach testing were capped for transport to WES. At WES, samples were cured at 23° C and 95 percent relative humidity prior to testing.

Mix No.	Basin F Liquid, g	Type III Portland Cement, g	Hazcon Proprietary Additive,* g
1	1,500	3,500	500
2 & 3	500	1,080	165

14. Ambient air ammonia gas measurements were made during solidification processing with a bellows hand pump (National Drager, Inc., Model 6726065) and disposable ammonia detector tubes manufactured by National Drager, Inc. An ammonia detector tube consists of a graduated glass tube containing a reagent that changes color in the presence of ammonia gas. The length of the discoloration in the tube indicates the concentration of ammonia present in the gas sampled. Drager tubes (No. CH 25501) with an operating range of 18 to 540 g/cu m were used, according to manufacturer's instructions.

Characterization Tests for Basin F Liquid

15. Basin F liquid for this study was collected in June 1986 by Department of Army personnel. Limited physical/chemical characterization tests were conducted to provide a basis for comparing the results of this study with results from previous studies. Density was determined gravimetrically by weighing a known volume of liquid. Basin F liquid was chemically analyzed for total organic carbon (TOC), ammonia, arsenic, and copper, as described in the section Chemical Analytical Procedures.

Chemical Leach Testing

16. Two leach tests were conducted on solidified/stabilized samples after a 28-day cure time. The first, the Toxicity Extraction Procedure (EP) developed by the US Environmental Protection Agency (USEPA) for hazardous waste testing, was selected for leach testing because EP data for solidified/stabilized Basin F liquid were available from previous studies (Myers and Thompson 1983) for comparison. The second leach test, a sequential batch leach test, was used to determine the extent of chemical stabilization of the organic content in Basin F liquid provided by the Hazcon process.

Toxicity Extraction Procedure

17. The EP was run in duplicate on solidified/stabilized Basin F liquid using standard procedures (USEPA 1981). The EP involves a single batch extraction at a liquid-solids ratio of 20:1 using dilute acetic acid, gentle stirring for 24 hr, and filtration through a 0.45-μ membrane filter. The leachate was analyzed for the standard list of EP parameters (USEPA 1981) plus organic carbon and copper. The samples were prepared for EP leach testing by crushing to pass a 9.5-mm sieve, based on the standard procedure (USEPA 1981).

Sequential batch leach test

18. A sequential batch leach test (SBLT) was conducted by leaching solidified/stabilized samples with successive aliquots of distilled-deionized water on a mechanical shaker for 24 hr using a 4:1 (weight/weight) liquid-solids ratio. Samples were prepared for a SBLT by grinding on a Brinkman centrifugal grinding mill to pass 0.5-mm screen. Five successive leach steps were used, and each step was replicated four times. After filtration through

a 0.45-μ membrane filter, the leachates were analyzed for TOC. No other analyses were performed.

Chemical Analytical Procedures

19. Total organic carbon was determined using an Oceanographic International 543B organic carbon analyzer and standard procedures (Ballinger 1979). Arsenic was determined by hydride generation (Ballinger 1979) using a Perkin-Elmer 305 atomic absorption spectrophotometer coupled with a Perkin-Elmer Model MHC-10 hydride generator. Copper was analyzed using directly coupled plasma emission spectroscopy on a Beckman Spectraspan IIIB plasma emission spectrometer. Barium, cadmium, chromium, lead, and silver were analyzed by flameless atomic absorption spectrophotometry using a Perkin-Elmer Model 5000 atomic absorption spectrophotometer coupled with a Perkin-Elmer Model 500 hot graphite atomizer. Selenium was analyzed by flameless atomic absorption spectrophotometry using the Zeeman effect on a Perkin-Elmer Zeeman 30-30. Mercury was analyzed by the cold vapor technique (Ballinger 1979) using a Perkin-Elmer Model 301 atomic absorption spectrophotometer. Ammonia was analyzed using a Technicon Autoanalyzer and standard procedures (Ballinger 1979). Pesticide analyses were conducted using a Hewlett Packard 5985A gas chromatograph/mass spectrometer and standard procedures (USEPA 1982). All analyses were performed by the Analytical Laboratory Group (ALG), WES. The ALG carries out a quality assurance and quality control program involving replicate analyses, internal standards, equipment calibration, quality control samples, and reagent control for each type of analysis. The ALG also participates in the USEPA's quality assurance program for certification and monitoring USEPA contract laboratories.

Unconfined Compressive Strength Test

20. Unconfined compressive strength of solidified/stabilized Basin F liquid was determined according to American Society for Testing Materials procedure C-109 (Compressive Strength of Hydraulic Cement Mortars) after 7-, 14-, 21-, and 28-day cure times.

PART III: RESULTS AND DISCUSSION

Characterization of Basin F Liquid

21. Key physical and chemical characteristics of the liquid processed by Hazcon and the liquid used in previous studies are compared in Table 1. The Basin F liquid used in previous studies was concentrated to one-third original volume by thin-film evaporation (Myers and Thompson 1983). The data in Table 1 show that the liquid processed by Hazcon is very similar to the Basin F concentrate used in previous investigations of the applicability of solidification/stabilization technology to Basin F liquid. Densities of the two liquids were the same. Both are approximately 1.25 times as dense as water.

22. Comparison of the TOC, ammonia-nitrogen, and copper concentrations also shows similarity between the two liquids. Total organic carbon in the Basin F liquid used in this study was 97,000 mg/ℓ, and in the concentrate previously studied, the TOC concentration was 98,200 mg/ℓ. The ammonia-nitrogen concentration in the Basin F liquid used in this study was 40,700 mg/ℓ, and in the concentrate previously studied, the concentration was 40,000 mg/ℓ. The copper concentration in the Basin F liquid used in this study was 5,860 mg/ℓ, and in the concentrate previously studied, the copper concentration was 6,600 mg/ℓ. Arsenic in the June 1986 liquid was only 43 percent of the concentration in the concentrate.

23. The liquid used in this study is for the most part the same as the liquid used in previous studies. These data indicate that the concentration technique used in previous studies produced a liquid that was equivalent in physical and chemical properties to the liquid in Basin F as of June 1986.

Ammonia Gas Release During Processing

24. Release of ammonia gas during solidification/stabilization processing of Basin F liquid was first reported in a study involving several proprietary processes (Myers and Thompson 1983). During outdoor mixing of 2-ℓ batches of Basin F concentrate with process additives, the amount of ammonia gas released was occasionally overwhelming, forcing workers to leave the immediate area. However, no ambient air measurements of ammonia gas were

Table 1

Physical and Chemical Characterization of Basin F Liquid

Parameter	Concentrate from Previous Studies	Liquid in This Study
Density (at 20° C), kg/ℓ	1.248*	1.248
Total organic carbon, mg/ℓ	98,200.**	97,000.
Ammonia-nitrogen, mg/ℓ	40,000.*	40,700.
Copper, mg/ℓ	6,600.**	5,860.
Arsenic, mg/ℓ	7.25**	3.10
pH	6.7-7.2**	5.7

* Myers and Thompson 1984.
** Myers and Thompson 1983.

made. In a follow-up study on the feasibility of chemically sequestering ammonia gas release, Myers and Thompson (1984) measured ammonia gas release in a sealed glove box. When no sequestering reagents were used, the ammonia gas concentration 10 min after lime, fly ash, and soil were mixed with Basin F concentrate reached approximately 4,200 mg/cu m. Without sequestering, 27.3 percent of the ammonia in Basin F concentrate was released within 50 min. These data indicated that unless the release of ammonia is controlled, large-scale solidification/stabilization of Basin F liquid could pose a serious occupational hazard and, potentially, an air pollution problem.

25. In this study, ammonia gas concentrations measured inside and outside the hood showed significant ammonia release during additive mixing (see following tabulation). The concentrations under the hood ranged from 72 to >500 mg/cu m, the lower concentrations being measured after the laboratory hood was turned on. One hour after mixing was completed, the ammonia concentration in the laboratory air in the middle of the room was 90 mg/cu m. This is 5 times the threshold limit value adopted by the American Conference of Governmental Industrial Hygienists (1984) for chemical substances in the work environment. The concentrations measured in this study are consistent with previous findings and indicate that large-scale application of the Hazcon process to Basin F liquid could pose a serious occupational hazard and, potentially, an air pollution problem.

Sample Description	Ammonia mg/cu m
1 ft from mixing bowl after addition of initial portion of portland cement (hood off)	>500
2 ft from mixing bowl after complete additive mixing (hood on)	72
Middle of the room, 1 hr after processing completed	90

Unconfined Compressive Strength

26. Unconfined compressive strengths (UCS) for Hazcon solidified/stabilized Basin F liquid after 7-, 14-, 21-, and 28-day cure times are presented in Figure 1. Each point in Figure 1 is an average of six replicates. The maximum UCS for Hazcon solidified/stabilized Basin F liquid was 2,902 psi (20,000 kPa). This value, typical of concrete, is somewhat lower than the expected value if clean water had been used instead of Basin F liquid. Expected 28-day UCS values for varying clean water-cement ratios (from Herubin and Marotta 1981) are shown below. The equivalent water-cement ratio for the weight of Basin F liquid to weight of portland cement used by Hazcon is 0.43. As indicated in the tabulation, clean water-cement ratios between 0.41 and 0.48 provide a 28-day UCS of 5,000 to 6,000 psi (34,500 to 41,400 kPa). Depression of UCS below theoretical values for clean water is expected because many waste constituents interfere with the setting reactions responsible for strength development (Jones et al. 1985, Chalasani et al. 1986, Walsh et al. 1986).

Water-Cement Ratio, by Weight	Compressive Strength at 28 days psi*
0.41	6,000
0.48	5,000
0.57	4,000
0.68	3,000
0.82	2,000

* To convert values to kilopascals, multiply by 6.894757.

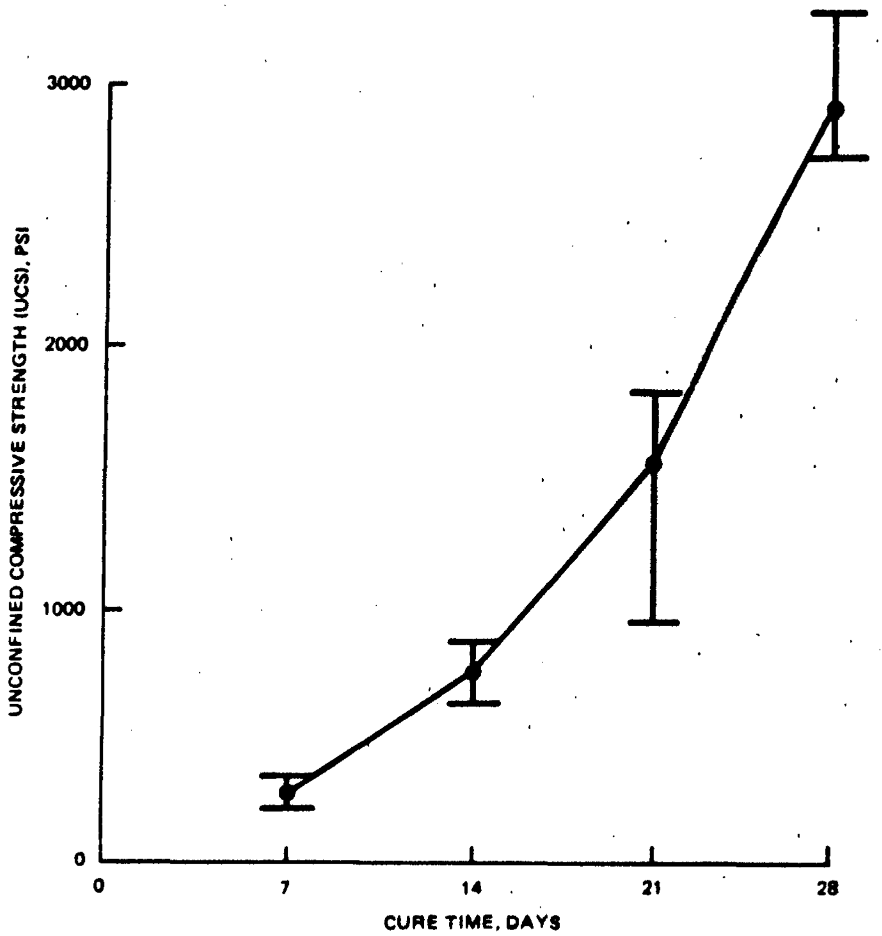

Figure 1. Unconfined compressive strength versus cure time, Hazcon solidified/stabilized Basin F liquid (error bars show range for six replicates)

27. The UCS versus cure time curve shown in Figure 1 also indicates delayed or retarded strength development for the Hazcon solidified/stabilized Basin F liquid. A typical UCS versus cure time curve for clean water and portland cement asymptotically approaches a maximum value, beginning about the 28th day. The Hazcon solidified Basin F liquid UCS-cure time curve indicates that an asymptotic approach to some limiting value had not begun by the 28th day. There is, therefore, a potential for further strength development. The retardation of strength development indicated in Figure 1 is particularly significant because in the Hazcon process a special type of portland cement, Type III, was used. Type III portland cement is a high-early strength cement

that sets much quicker than the portland cement (Type I) used in routine applications. The effect of the contaminants in Basin F liquid on strength development can be put into perspective by comparing the strength development curves for portland cement Types I and III (Figure 2) with the Hazcon solidified/stabilized Basin F liquid strength development curve (Figure 1). The UCS of the Hazcon solidified/stabilized Basin F liquid could not be compared to the UCS for the processes previously studied because UCS was not measured in the previous work.

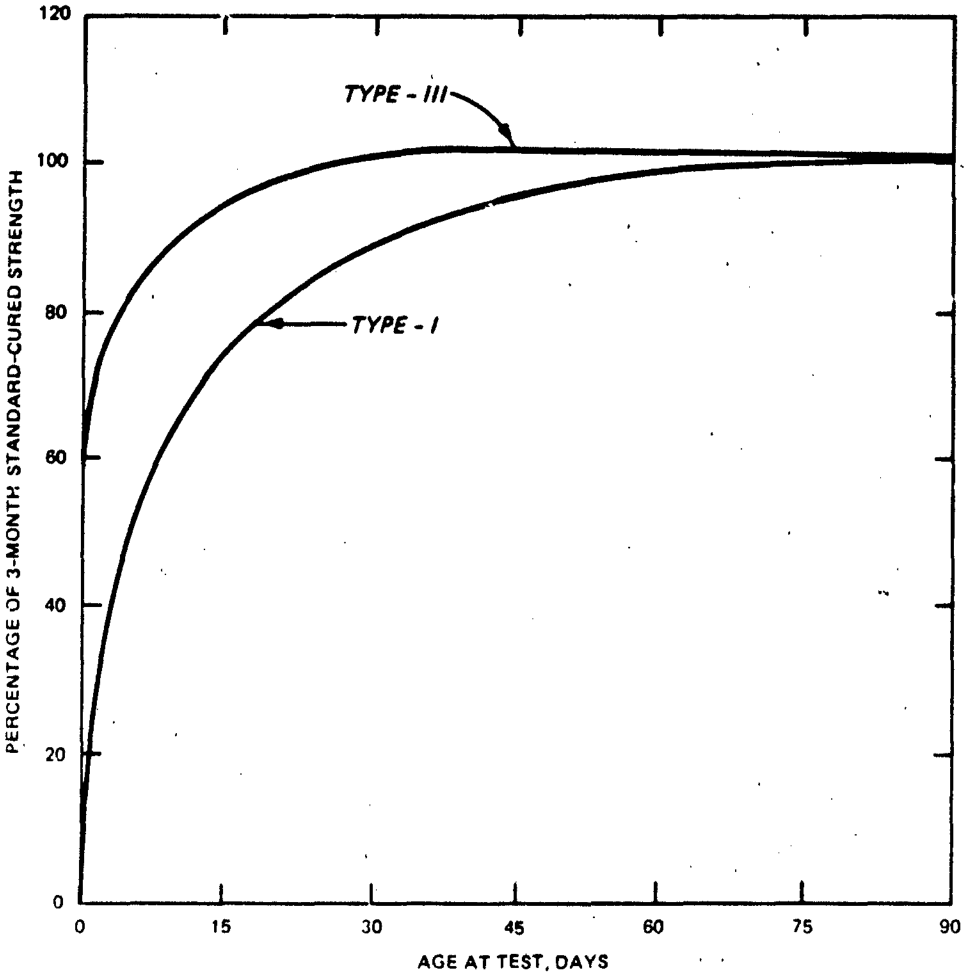

Figure 2. Typical strength-cure time curves for portland cement, Types I and III (from Urquhart 1959)

Chemical Leach Tests

Sequential batch leach test

28. Sequential leaching with water is a common technique for evaluating chemical stabilization of contaminants (Garrett et al. 1984, Chalasani et al. 1986, Shively et al. 1986). In general, the first extraction in a SBLT for soluble organics yields the highest contaminant concentration. Chalasani et al. (1986), for example, found that 88 percent of the ethylene glycol in portland cement stabilized waste leached in the first step of a five-step procedure. Four subsequent leach steps extracted another 6 percent, for a total extraction efficiency of 94 percent in the five-step procedure.

29. The extent to which the Hazcon process chemically stabilized the organic content of Basin F liquid is indicated by the TOC concentrations in leachate from the SBLT and the cumulative percent extracted (Table 2). The percent extracted was calculated on the basis of TOC analysis of the solidified/stabilized material prior to leaching. Approximately 67 percent of the organic carbon was leached in the first step. At the end of the five-step sequential leach procedure, approximately 87 percent of the organic carbon had

Table 2

TOC Concentrations and Percent Extracted in Sequential Leaching of Hazcon Solidified/Stabilized Basin F Liquid

Step No.	TOC in Leachate* mg/ℓ	Standard Deviation** mg/ℓ	Cumulative Percent Extracted† %
1	3,110	232	67.2
2	575	52	79.6
3	189	3.8	83.7
4	77	2.9	85.4
5	62	2.1	86.7

* Mean of four separate extraction sequences.

** Standard deviation for leachate TOC in four separate extraction sequences.

† Based on TOC analysis of Hazcon solidified/stabilized material prior to leaching.

leached. Continued leaching would have extracted even more. Thus, less than 13 percent of the TOC was resistant to leaching after solidification/stabilization using the Hazcon process. These data show that the Hazcon process did not effectively stabilize the organic content in Basin F liquid against aqueous leaching.

30. Caution must be exercised in extrapolating the SBLT data to the field because the surface area-to-mass ratio in the SBLT may be different from that in the field. Further, the impact of grinding on contaminant mobility is poorly understood. It has been suggested that the amount of contaminant leached after grinding represents the mass that was physically entrapped (Chalasani et al. 1986). However, the effects of grinding on contaminant solubility and chemical stabilization of contaminants have not been studied. The distinction between physical and chemical stabilization is important because the effectiveness of the entrapment mechanism responsible for physical stabilization depends on the permeability and durability of the solidified product, whereas chemical stabilization does not. Hence, contaminants that have been simply entrapped can be leached in varying degrees, depending on site-specific factors (unrelated to the solidification process), such as climatology, hydrogeology, and disposal site design.

<u>EP leach test</u>

31. The EP is part of the USEPA's official protocol for classifying hazardous wastes under the Resource Conservation and Recovery Act (RCRA) regulatory system. The EP is used to identify wastes that, although not specifically listed in 40 CFR 261 (<u>Code of Federal Regulations</u>) as hazardous, pose substantial hazard when improperly managed. If the EP extract of a solid waste contains contaminants in concentrations 100 times greater than those specified in the National Interim Primary Drinking Water Standards, the waste is considered hazardous and must be managed and disposed of in accordance with RCRA regulations for hazardous wastes. Passing the EP, however, does not confer nonhazardous status. Listed wastes that have been treated by solidification/stabilization are still considered hazardous and must go through a formal process of delisting in order to be disposed as nonhazardous waste.

32. The EP leachate data for Hazcon solidified/stabilized Basin F liquid and the EP limits for each parameter are presented in Table 3. The EP leachate for the Hazcon solidified/stabilized Basin F liquid did not exceed

Table 3

Contaminant Concentrations in EP Leachate from Hazcon Solidified/Stabilized Basin F Liquid

Contaminant	EP Limit Concentration mg/ℓ	Concentration in EP Leachate, mg/ℓ
Arsenic	5.0	0.011
Barium	100.0	0.30
Cadmium	1.0	<0.0001
Chromium	5.0	<0.05
Lead	5.0	<0.001
Mercury	0.2	<0.0008
Selenium	1.0	<0.005
Silver	5.0	0.065
Endrin	0.02	0.0004
Lindane	0.4	<0.00001
Methoxychlor	10.0	<0.00001
Toxaphene	0.5	<0.0002
2,4-D (2,4-Dichlorophenoxyacetic acid)	10.0	<0.00001
2,4, 5-TP Silvex (2, 4, 5-Trichlorophenoxypropionic acid)	1.0	<0.00001
Total organic carbon	*	1,292.
Copper	*	0.407

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* No specified limit.

any of the EP limits. In previous studies, EP leachates from solidified/stabilized Basin F liquid were also below the EP limits (Myers and Thompson 1983). The EP does not have limits for most organic contaminants and, as a result, is of limited value in evaluating solidification/stabilization of organic wastes such as Basin F liquid. The experience that has been developed with the EP for TOC in Basin F, however, does provide a basis for comparing TOC leachability.

33. To compare TOC (no EP limit) leachability for the Hazcon process with the processes previously investigated, EP data for TOC were normalized with respect to the amount of Basin F liquid processed for solidification. By normalizing EP leachate TOC concentrations with respect to the amount of Basin F liquid processed for solidification, the effect of different additive dosages among the processes is eliminated. The tabulation that follows lists the normalized EP contaminant concentrations for TOC for the Hazcon process and the mean and range reported by Myers and Thompson (1983) for normalized EP leachate data. Normalized TOC concentration for the Hazcon product was within the range previously reported. Thus, the extent of immobilization provided by the Hazcon process for TOC in Basin F liquid, under the conditions of the EP test, was similar in effectiveness to the immobilization provided by the processes evaluated previously.

Source	TOC*
Hazcon, this study	125
Previous study	
Mean	195
Range	108-320

* Grams of contaminant mass leached per litre of Basin F liquid solidified.

PART IV: SUMMARY AND CONCLUSIONS

34\. Physical strength tests showed that the Hazcon process can convert Basin F liquid to a hardened solid mass. Sequential batch leach tests showed that greater than 86 percent of the total organic carbon could be leached from Hazcon solidified/stabilized Basin F liquid. The Toxicity Extraction Procedure showed that Hazcon solidified/stabilized Basin F liquid did not exceed the limits for the contaminants specified by the US Environmental Protection Agency for the procedure.

35\. The Hazcon solidification/stabilization process is a cement-based process that possesses chemical stabilization properties similar to other cement-based solidification/stabilization processes. As shown in previous studies for other solidification/stabilization processes, the Hazcon process did not effectively stabilize the total organic carbon in Basin F liquid. Chemical stabilization of organics in Basin F liquid by the Hazcon solidification/stabilization process does not appear technically feasible.

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