RETURN TO 1998 ROD AR INDEX

Superfund Records Center
SITE: New Bedford
BREAK: 17.07
OTHER:
SDMS DocID 000200899

17.7.15

Keith R. Genovese
Regional Sales Representative

ENVIROSAFE MANAGEMENT SERVICES, INC.
P.O. Box 833 Valley Forge Penna. 19482-0833 • (215) 962-0800

METHODOLOGY FOR CHEMICAL FIXATION OF INORGANIC SLUDGES

PRESENTED AT
THE HENLEY GROUP, INC.
POLLUTION CONTROL WORKSHOP
10/21 - 22/87

RODNEY R. BARTCHY, JR.
VICE PRESIDENT
BUSINESS DEVELOPMENT
ENVIROSAFE SERVICES, INC.

Introduction

Often with a topic such as chemical fixation, terminology can be a stumbling block to understanding the performance and value of a waste treatment technique. Terms such as fixation, solidification & stabilization have been used interchangeably to describe the outcome of a series of chemical reactions between pozzolans & alkaline earth materials and waste materials. For convenience, fixation will be used in this paper.

While the term pozzolan may be relatively new, the uses of pozzolanic chemistry go back to Roman engineered structures. For example, the Colosseum is a structure consisting largely of pozzolanic concrete. The Pantheon, a 1900 year old temple, boasts a 143 foot span of unsupported ceiling dome constructed of pozzolanic concrete.

The Romans produced their concrete by mixing lime with a naturally occurring pozzolan, volcanic ash. Such natural convenience is not available in close proximity to most of us, perhaps fortunately too, given the eruption of Mt. Saint Helens as an example. "Manufactured" pozzolains such as flyash & cement kiln dust are now substituted for the naturally occurring materials in most cases.

Fixation Chemistry

The American Society for Testing & Materials (ASTM) defines a pozzolan as a " silaceous or alumino-silaceous material that in itself possesses little or no cementitious value, but that in finely divided form and in the presence of moisture will chemically react with alkali and alkaline earth hydroxides at ordinary temperatures to form or assist in forming compounds possessing cementitious properties". The pozzolanic chemistry of fixation is virtually identical to that of portland cement hydration & hardening: The principal chemical reactions are:

1. $CaO + SiO_2 + H_2O \longrightarrow x\,CaO \bullet ySiO_2 \bullet zH_2O$
2. $CaO + Al_2O_3 + H_2O \longrightarrow x\,CaO \bullet yAl_2O_3 \bullet zH_2O$
3. $CaO + Al_2O_3 + SiO_2 + H_2O \longrightarrow wCaO \bullet xAl_2O_3 \bullet ySiO_2 \bullet zH_2O$

The calcium oxide (CaO) is provided by lime while the aluminum oxide (Al_2O_3) + silicon dioxide (SiO_2) are provided by a pozzolan such as flyash. These compounds react with water to ultimately yield a cement-like mass of calcium aluminosilicates which can contain up to 44% by weight of chemically combined water. The capacity to chemically bond water is an important feature currently used by many in treating wastes to meet free liquids requirements.

Fixation utilizes the water bonding capability, calcium aluminosilicate cementitious structure, & the alkaline ph condition provided by calcium oxide to reach its treatment & containment objectives. This favorable balance of forces is achieved through a specifically tailored blending of waste, pozzolan & lime. Significant deviations from the specific blend can result in excessive volume or weight increases, failure to meet free liquids requirements, or poor chemical performance.

The source of the lime & pozzolans utilized is just as important since they vary in properties & performance. Commonly used lime sources include:

Fixation Chemistry (cont.)

quicklime (CaOO
hydrated lime ($Ca(OH)_2$)
lime kiln dust
dolomitic lime

Pozzolan sources include:

flyash
furnace dusts
pulverized slags
clay (burned at 600-900°C)
cement kiln dust
manufactured silicates

Given the variation in cost & quality, any evaluation of a fixation application must be site specific to the sources of lime & pozzolan available.

Physical Properties

The improvement obtained by fixation of hazardous waste is what makes pozzolanic chemistry something more than a minor geochemical specialty. Liquids & sludges can be treated to a soil-like consistency that meets free liquids requirements & is easily handled in onsite or offsite disposal facilities. With a different blend, a truly cementitious mass of fixated waste can be produced.

Designs for unconfined compressive strengths of 20 PSI, 50 PSI (EPA's guidance criteria for free liquids treatment) & over 100 PSI can be prepared. Lower strength products often suffice if final cap support is the only intended end use. Support of structures or use of streep side slopes in confined placement onsite disposal situations may require higher strength. Properly applied, fixation as an onsite remedial technology, can be tailored to the end use requirements of any specific site.

Permeability reduction is another physical property benefit of fixation. When the blend of waste, lime, & pozzolan is properly compacted, the calcium aluminosilicates form a dense matrix that minimized internal pore volume, leading to reduced permeabilities. Permeability values are typically in the 10^{-5} to 10^{-6} cm/sec range, and depending on final needs & budgets, can be developed in the 10^{-7} cm/sec range & occasionally lower.

Chemical Properties

Along with enhanced physical properties, fixation provides significant chemical property improvements. Most notable are the results obtained when fixated wastes are subjected to the EPA-EP or TCLP leachate tests.

Data in table 1 shows fixation's performance for a variety of wastes & contaminants. For each of the 8 RCRA metals, fixation has proven effective over a significant range of initial contaminant

Table 1

Fixation Leachate Test Results

Metal	Waste Stream	Concentration in Raw Waste	Concentration in EPA/EP Leachate of Stabilized Wast
Arsenic	Lagoon Sludge	14.8 ppm	0.14 ppm
	Electric Furnace Dust	34 ppm	0.01 ppm
	Fly Ash	61 ppm	0.24 ppm
	Filter Sludge	26.5 ppm	0.015 ppm
	Metal Hydroxide Sludge	56 ppm	0.01 ppm
	Fly Ash	329 ppm	0.019 ppm
	Cupola Furnace Dust	640 ppm	0.11 ppm
	Air Pollution Control Residue	22 ppm	0.04 ppm
	Electric Furnace Dust	29.9 ppm	0.03 ppm
	Kiln Scrubber Residue	58 ppm	0.96 ppm
	Flue Gas Scrubber Residue	24 ppm	0.068 ppm
Barium	Barium Waste	343 ppm	11.2 ppm
	Ferric Hydroxide Sludge	240 ppm	0.13 ppm
	Vanadium Catalyst	42 ppm	0.52 ppm
	Fly Ash	793 ppm	0.46 ppm
	Electric Furnace Dust	576 ppm	2.49 ppm
	Flue Gas Scrubber Residue	1960 ppm	2.62 ppm
Cadmium	Electric Furnace Dust	1041 ppm	0.01 ppm
	Filter Sludge	17.7 ppm	0.01 ppm
	Waste Water Treatment Sludge	8.0 ppm	0.03 ppm
	Metal Hydroxide Sludge	300 ppm	0.01 ppm
	Cupola Furnace Dust	108 ppm	0.12 ppm
	Air Pollution Control Residue	30 ppm	0.58 ppm
	Flue Gas Scrubber Residue	76 ppm	0.32 ppm
Chromium	Rolling Mill Sludge	43 ppm	0.05 ppm
	Lagoon Sludge	1590 ppm	0.05 ppm
	Electric Furnace Dust	986 ppm	0.05 ppm
	Pelletized Asbestos Waste	156 ppm	0.05 ppm
	Electric Furnace Dust	848 ppm	0.05 ppm
	Fly Ash	126 ppm	0.10 ppm
	Ferric Hydroxide Sludge	1120 ppm	0.11 ppm
	Filter Sludge	73.6 ppm	0.05 ppm
	Metal Hydroxide Sludge	20,600 ppm	4.26 ppm
	Wastewater Treatment Sludge	886 ppm	0.05 ppm
	Metal Hydroxide Sludge	116 ppm	0.16 ppm
	Fly Ash	131 ppm	0.10 ppm
	Metal Hydroxide Sludge	5,000 ppm	0.05 ppm
	Cupola Furnace Dust	232 ppm	0.06 ppm
	Air Pollution Control Residue	22 ppm	0.07 ppm
	Electric Furnace Dust	2,660 ppm	0.18 ppm
	Flue Gas Scrubber Residue	118 ppm	0.10 ppm

Metal	Waste Stream	Concentration in Raw Waste	Concentration in EPA/EP Leachate of Stabilized Wa
Lead	Lagoon Sludge	58 ppm	0.01 ppm
	Ferric Hydroxide Sludge	82 ppm	0.21 ppm
	Filter Sludge	412 ppm	0.2 ppm
	Metal Hydroxide Sludge	680 ppm	1.24 ppm
	Wastewater Treatment Sludge	1,960 ppm	0.3 ppm
	Metal Hydroxide Sludge	566 ppm	0.58 ppm
	Fly Ash	21 ppm	0.05 ppm
	Metal Hydroxide Sludge	130 ppm	0.07 ppm
	Cupola Furnace Dust	17,240 ppm	1.05 ppm
Mercury	Lagoon Sludge	6.09 ppm	0.0025 ppm
	Metal Hydroxide Sludge	75 ppm	0.0005 ppm
	Cupola Furnace Dust	1.01 ppm	0.001 ppm
Selenium	Fly Ash	42 ppm	0.49 ppm
	Kiln Scrubber Residue	4.0 ppm	0.01 ppm
Silver	Electric Furnace Dust	143 ppm	0.05 ppm
	Pelletized Asbestos Waste	16 ppm	0.05 ppm
	Filter Sludge	29.4 ppm	0.05 ppm
	Metal Hydroxide Sludge	28 ppm	0.05 ppm
	Cupola Furnace Dust	32 ppm	0.05 ppm
	Kiln Scrubber Residue	12 ppm	0.05 ppm

Chemical Properties (cont.)

concentration. For example, chromium levels in excess of 20,000 ppm and lead in excess of 17,000 ppm have been successfully fixated to fall below EPA's 100 x drinking water standard threshold for EP toxicity. The ability to manage a variety of contaminants also enables fixation to handle mixed or multi-component wastes. Since remedial projects, even routine daily waste generation, are rarely simple matters, fixation's broad base of applicability makes it a candidate technology under difficult conditions.

The mechanisms for chemical improvement are a combination of ph elevation and calcium aluminosilicate encapsulation of waste materials. Many metals exhibit similar solubility characteristics at varying ph levels, i.e., the degree of acidity or alkalinity present. In particular, metals in hydroxide & oxide form tend to become nearly insoluble in the ph range of 8-12. Fixation provides such a ph range which effectively maintains metals in an insoluble condition, preventing their leaching into the environment.

The calcium aluminosilicates crystals formed during pozzolanic reactions provide an extra measure of leachate performance. These crystals grow & form around the blended waste particles, encapsulating them & forming a protective barrier which resists attack by leachate test media. The longer the pozzolanic reactions proceed, the greater the effect.

In one test case, a composite of several lead bearing wastes was prepared at a concentration of 6404 mg/Kg. Blends of waste, lime & pozzolan were prepared using lime at varying concentrations (Table 2). Three blends (#1-3) were subjected to EPA-EP leachate testing immediately following preparation. The fourth blend was allowed to react for 24 hours, then subjected to the EPA-EP. The increased lime yielded progressively more alkaline ph values and lower lead levels as one would expect. Blend #4, identical to #3 in formulation, provided the lowest lead levels. After 24 hours, the pozzolanic reactions had already made substantial progress in encapsulating the waste, reducing leachate levels from 1.38 ppm to 0.88 ppm. This extra 0.50 ppm is the fixation benefit over & above the ph effect on solubility.

The Impact of Time

Like all chemical processes, time is an important factor in fixation. As we've seen in the lead study, substantial progress can be made even within 24 hours. Since the basic pozzolanic chemistry is similar to that of portland cement hydration & hardening, it is no surprise that there are longer term reactions in fixation analogous to those of cement.

Strength development in cement continues for months. Although a substantial portion of its ultimate strength is achieved within 28 days. Studies of fixated wastes have exhibited similar properties as shown in Table 3. Following an initial strength test after 28 days, identical specimens were maintained at ambient temperature for up to 27 months. Long term test results show strength increasing from 30% for the soil with organics (12 months) to 1000% for the tank bottoms sludge at 23 months.

TABLE 2

LEAD LEACHING STUDY

BLEND #	QUICKLIME ADDITION (%)	pH OF LEACHATE AT EXTRACTION COMPLETION	Pb IN EPA-EP, mg/L
1	2	5.4	33.3
2	4	6.5	11.0
3	8	10.9	1.38
4	8	7.1	0.88

TABLE 3

FIXATION
LONG TERM STRENGTH DEVELOPMENT

WASTE	INITIAL STRENGTH	LONG TERM STRENGTH 12 MONTHS	18 MONTHS	23 MONTHS	27 MO
SOIL WITH ORGANICS	59	80	-	-	-
ACRYLIC LATEX EMULSION	64	116	-	-	-
GALVANIZING WASTE	38	-	130	-	-
TREATMENT SLUDGE	74	-	496	-	-
INCINERATOR SLUDGE	126	-	435	-	-
BAGHOUSE DUST	44	-	301	-	-
NEUTRALIZED PICKLE LIQUOR SLUDGE	241	-	333	-	-
PAINT & METAL FINISHING SLUDGE	46	-	-	97	-
TANK BOTTOMS SLUDGE	61	-	-	637	-
COAL GASIFIER SLUDGE	58	-	-	340	-
MIXED BIOLOGICAL & METAL SLUDGE	81	-	-	268	-
METAL HYDROXIDE SLUDGE & SAND	58	-	-	-	18

VALUES IN POUNDS PER SQUARE INCH.
TEST CYLINDERS SOAKED IN WATER FOR 4 HOURS PRIOR TO TESTING.

The Impact of Time (cont.)

The speed & extent of such strength development is totally dependent on the nature of the waste, the blend of lime & pozzolan utilized & the requirements of the project. Where rapid performance is needed, an enriched fixative blend can be used to achieve high strength, low permeability & good chemical properties.

Where some flexibility is available, the fixative blend can be prepared in a leaner, less expensive design. Immediately after blending it may appear plastic & putty-like. Stockpiled for 2-3 days it assumes a firm, soil-like consistency which can be placed & compacted in a disposal area using standard earth moving equipment. Over a period of 3-6 weeks the pozzolanic reactions within this compacted mass reach their designed physical & chemical performance targets. Over 6 weeks, further development will continue to proceed.

The Roman structures prepared with pozzolanic concrete now, take on greater significance. Fixation can be a permanent remedy whose long term performance improves with age, providing containment & treatment with the same pozzolanic chemistry that still supports buildings nearly 2000 years old.

Regulatory Requirements

The environmental industry is driven by regulations & fixation is certainly a by-product of that regulation. Prior to the 1984 RCRA amendments, remedial applications of onsite fixation were often pragmatic measures designed to solidify lagoons for capping or removal of waste in more convenient bulk solid form.

Among the specific timetables in the RCRA Amendments are:

5/85 - Ban on bulk free liquids in landfills

11/88 - Ban on land disposal of F001-F005 wastes
6/87 - California list of wastes
8/88 - Ban on 1/3 of listed wastes

/89 - Ban on 2/3 of listed wastes

/90 - Ban on remaining listed & characteristic wastes

Congressional intent was to require treatment of wastes prior to land disposal. Those not properly treated would be "banned" from land disposal.

It its 6/11/86 guidance document (OSWER Policy Directive #9487.00 - 2A) on bulk liquids, EPA cites "chemical stabilization is a method that may be used to treat bulk hazardous liquids prior to landfilling . . . . examples of the most commonly used stabilization technologies are portland cement-based & pozzolanic processes". To insure that fixation occurred, EPA proposed that fixated samples exhibit 50 PSI unconfined compressive strength.

Regulatory Requirements (cont.)

The 1988, 1989 & 1990 dates will result in pretreatment for the 3 million tons/yr currently land disposed offsite & 8 million tons/yr. land disposed onsite. Table 4 lists those wastes impacted by each date.

Electroplaters generating F006 sludges and wastes from ferrous metals industries will be impacted by the August 1988 date now only 10 months away. Waste generators will need to make provisions to properly pretreat their wastes at onsite or offsite facilities prior to disposal. For inorganics, fixation will be a principal pretreatment technology. One need only examine the number of fixation systems proposed in Part "B" Permit Applications at commercial waste disposal facilities to appreciate the importance of this technique to the industry.

Fixation Applications

Fixation can be applied as an:

- "end of the pipe" treatment method prior to onsite or offsite disposal.
- an onsite remedial technique to treat & contain sludges & solids in lagoons, waste piles & areas of contaminated soil.
- a treatment process employed at commercial disposal facilities, just upstream of the final secure disposal cell.

Some of these concepts are already in practice as outlined in the following profiles.

Commercial Fixation Facility

Envirosafe Services, Inc. (ESI) operated a pozzolanic fixation facility and landfill in Honey Brook, PA. Honey Brook is located in southeastern Pennsylvania equidistant between Reading and the Maryland border. This facility was in operation from the latter part of 1979 until it was filled to capacity in the Spring of 1984. During this time, more than 260,000 tons of various hazardous and near hazardous wastes were received, pozzolanically fixated, and land disposed. Some of the waste types successfully processed at Honey Brook were:

metal hydroxide sludge
paper coating wastes
electric furnace dust
ceramic/porcelain sludge
aluminum dross waste
calcium fluoride sludge
battery cases
foundry waste
scrubber sludge
rare earth metal sludges
electroplating sludges
chromium oxide waste

TABLE 4

WASTE IMPACTED BY 'BAN' DATES

6/88 DATE		6/89 DATE	5/90 DATE
F006		F010	D001
F007		F011	D002
F008		F012	D003
F009		F024	D004
F019			D005
			D006
K001	K050	K009	D007
K004	K051	K010	D008
K008	K052	K019	D009
K011	K060	K025	D010
K013	K061	K027	D011
K014	K062	K028	D012
K015	K069	K029	D013
K016	K071	K038	D014
K017	K073	K039	D015
K018	K083	K040	D016
K020	K084	K041	D017
K021	K085	K042	
K022	K086	K043	K002
K024	K087	K095	K003
K030	K099	K096	K005
K031	K101	K097	K006
K035	K102	K098	K007
K036	K103	K105	K023
K037	K104		K026
K044	K106		K032
K045			K033
K046			K034
K047			K093
K048			K094
K049			K100
P CODED WASTES		P CODED WASTES	P CODED WASTES
U CODED WASTES		U CODED WASTES	U CODED WASTES

Commercial Fixation Facility (cont.)

grinding wheel waste
titanium bearing sludge
incinerator ash
waste water treatment sludge

The fixation process at Honey Brook employed fly ash and lime (CaO) respectively as the pozzolan and the reaction initiator. Stringent material acceptance criteria were placed on both of these materials.

Fly Ash

Particle size - 70% min. passing through No. 325 mesh sieve.
Loss on Ignition - 7% max.
Pozzolanic reactivity - 700 psi min.
Moisture - 12% max.

Lime (CaO)

Available lime - 85% min.
Particle size - 100% passing through No. 10 mesh sieve.
40% passing through No. 100 mesh sieve.

Prior to receipt at the Honey Brook facility, wastes were individually blended in bench scale studies with lime & flyash to determine the proper formulation that would meet:

- 50 PSI unconfined compressive strength
- permeability preferably in the 10^{-6} cm/sec range

In addition fixated wastes were subjected to the ASTM method "A" leachate test. Results were forwarded to the Pennsylvania DER for review. Leachate results had to be below 100 times drinking water standards to be accepted as satisfactorily fixated by the DER.

Upon approval by Pennsylvania DER, the wastes could be received at Honey Brook & quality control tested to determine conformance with presubmitted analytical data. Conforming loads were then stored in a paved & roofed enclosure prior to processing.

During processing, wastes were blended with flyash, then conveyed to a lime silo where lime has metered from a storage silo onto the conveyor. The blend of waste, lime & flyash was then thoroughly mixed in a pugmill & conveyed to a stockpile. Dump trucks would transport the blend, a material of damp soil consistency, to a specially prepared & lined disposal cell. The material would be spread in 12-18" layers, then compacted with a roller to a specified in-place density. Over the next 3-6 weeks the material would harden as the pozzolanic reactions set in.

Fixation Applications (cont.)

In addition to lime & flyash source material quality control, samples of blended material were tested for lime & flyash content to assure proper materials ratios. Compacted material was checked for in-place density since satisfactory compaction (90-95% of proctor density) enhances final physical properties. On occasion, drilling rigs were employed to extract cores of previously fixated wastes to examine their performance.

With the impending 8/88 target date for pretreatment, Envirosafe has utilized the Honey Brook experience in starting up a new fixation process at its Idaho disposal facility. A similar operation is planned at the Ohio based disposal facility near Toledo.

Onsite Remedial Application

The practice of waste specific evaluation, quality control, & standards of physical & chemical performance are readily applied to onsite remedial problems. Witness the plight of one Midwestern client faced with the closure of lagoons & waste piles collectively comprising 20,000 tons of F006 & other inorganic wastes.

Even with onsite plate & frame dewatering, costs for excavation, removal & offsite disposal totalled $135/ton, a price tag of $2.7 million. Seeking an acceptable onsite solution, the client entered into a site specific fixation program encompassing:

- sampling of lagoons & waste piles
- preparation of fixation blends utilizing 5 different technical approaches
- selection of a specific blend optimizing factors such as cost, chemical & physical performance, volume increase & ease of implementation
- preparation of RCRA closure plan documents for state & federal review
- field implementation of the approved closure plan

In this instance both a cement-based and a mixed kiln dust based approach yielded best results of the 5 fixation technical approaches. Table 5 lists some performance data from some of the formulations. The data for this particular waste site exhibit:

- reasonable consistency among formulations in achieving low nickel values, the target parameter
- a very wide range of strengths achieveable
- permeabilities grouped in the 10^{-5} to 10^{-6} range using different additive sources
- a wide range of volume increase (stabilized vs. unstabilized)

TABLE 5

ON-SITE REMEDIAL PROJECT

FORMULATION	PRINCIPAL ADDITIVES CEMENT	LIME	FLYASH	POZZALIME	VOLUME INCREASE %	(PSI) STRENGTH	(cm/sec) PERMEABILITY	N: Ir
1	-	X	X	-	108	167	2.07 X 10-5	
2	X	-	X	-	193	669	9.29 X 10-6	
3	-	-	X	X	153	117	6.72 X 10-6	
4	X	-	-	-	19	86	-	
5	-	-	-	X	33	46	10-5	

Onsite Remedial Application (cont.)

The data in Table 5 show that fixation of a specific waste is a choice of approaches, not a case of one additive or patented method meeting all needs. This reinforces the need to carefully examine your choices of lime & pozzolan and to have a clear understanding of your physical & chemical requirements. This is the best insurance of obtaining your best value for your fixation dollar. For this particular project the cost for mobilization, demobilization, in-situ fixation, placement, & compaction & quality control will be approximately $35/ton. This represents a savings of $100/ton as compared to offsite disposal.

Onsite Waste Treatment Application

As the 1988, 1989 & 1990 target dates approach for pretreatment of waste prior to land disposal, waste generators will examine the choice between onsite or offsite pretreatment such as fixation.

Offsite fixation at a commercial treatment or disposal facility will be costly, judging by prices in the $250-400/ton range at some current operations. These prices are driven by:

- increasing regulatory & monitoring costs of commercial firms.
- need to overtreat to meet the higher level of regulatory scrutiny received by commercial facilities.
- need to recover costs quickly in a dynamic changing market.
- expected high demand vs. limited supply of services.

Large waste generators may choose fixation of their wastes in an "end of pipe" onsite installation prior to offsite disposal. With maximum control & experience with their waste, the generator can develop the amount of fixation needed to gain landfill acceptance as treated material. Large generators with favorable bulk disposal pricing may thus retain $100/ton range pricing rather than $200+/ton pricing. The savings may more than pay for the cost of additives & processing.

Evaluating Fixation For Your Application

Fixation is an environmental management technique applicable to private industry for remedial projects & treatment of ongoing waste streams. How do you go about evaluating its usefullness for your plant, cleanup site, or entire system of facilities?

You start by taking & maintaining a running inventory of remedial projects that could require offsite disposal or onsite containment of more than 1000 tons of waste or contaminated soil. As you enter the RIFS (Remedial Investigation & Feasibility Study) or closure. Plan stage, budget time & money to evaluate fixation. For $1000-$3000 you should be able to obtain from a qualified vendor a 4-8 week screening evaluation of fixation as applied to your specific problem.

Evaluating Fixation For Your Application (cont.)

Be prepared to discuss & agree upon performance objectives during the screening study, establishing target criteria for:

- strength
- permeability
- leachate test performance
- volume increase
- cost

Be sure that representative samples of your waste are incorporated into the study & obtain assurances that the lime & pozzolan sources used in the study are in fact available to your project site.

If the study yields results meeting your physical & chemical criteria at an estimated cost of implementation that is competitive with other alternatives, you must now make your case to the regulatory agencies. Be sure that your fixation vendor can back you up in these meetings with credibility, supporting data & workable field implementation plans.

Evaluating fixation for treating an ongoing waste stream also begins with an inventory. In this case, at least 1000 tons/year is a good starting point to consider some onsite fixation. If delisting as a result of fixation is a real possibility, you may wish to set a lower tonnage threshold. Your approach for an ongoing stream parallels that of a remedial project:

- set performance objectives
- use representative samples of waste
- use available pozzolan & lime sources
- be sure your vendor can back you up during regulatory agency discussions.

Successfully implementing fixation as part of your remedial & waste disposal programs requires a cooperative effort between client, vendor & regulatory agency. The rewards of this effort are a cleaner environment and substantial savings that let you stretch your environmental budget to cover additional pressing needs. It is the prospect for all parties to emerge a winner that gives fixation such a promising future.