

CASE STUDY: USE OF CIRCULATING FLUIDIZED BED BOILER BYPRODUCT TO SOLIDIFY OILY SLUDGE

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INTRODUCTION

An oil recycler in Jacksonville, Florida abruptly ceased operation in June 2004. No effort was made during shutdown of the facility to secure or remove product in the 24 tanks used in the recycling operation. Within several weeks of shutdown the USEPA conducted a removal action to remove free liquids from the tanks and to secure the site. At the completion of the 2004 removal action, many tanks still contained varying quantities of liquid and sludge, with the largest tank on site containing on the order of 200,000 gallons of oily sludge. A second removal action was conducted in 2008 to remove the remaining liquids and sludge, demolish the tanks, and clean the area around the tanks in order to allow the release of non-impacted precipitation from the site.

The liquid removed from the tanks was sent off-site for treatment or recycling and the sludge was sent to a Subtitle D landfill for disposal. One of the landfill acceptance criteria was the sludge could not contain free liquid. The sludge was oily in nature and for the most part could not meet the landfill free-liquid requirement without the addition of a solidification agent. Common solidifying agents are cement, kiln dust, and lime. For this project circulating fluidized bed boiler byproduct was available from a local power plant. At the power plant limestone is added to coal and petroleum coke fuel as part of the flue gas desulfurization process. The resulting byproduct is unhydrated, high in calcium oxide and calcium sulfate, and is an effective solidification agent. This paper describes the Site, provides a general overview of waste treatment, discusses selection of the solidification agent, describes full-section implementation, and provides a summary and conclusion.

SITE DESCRIPTION

The Site has an irregular shape as depicted on Figure 1. The Site is bound on the south by a street, the east by an active railroad track, the north by a railroad spur which



Figure 1. Plan view of the Site

is immediately adjacent to parking for a sports stadium, and to the west by a street. The southern portion of the Site is a vacant area surrounded by a chain-link fence. The 24 tanks were located inside a poured concrete secondary containment system on the northern portion of the site. The tanks ranged in volume from approximately 2 to 2,400m³ gallons, and were interconnected by a complex pipe network. The tanks collectively contained 1,300m³ gallons of liquid, solids, and sludge. The single largest

tank, 240,000m³ gallons in capacity, contained 800m³ gallons of oily liquid and sludge. The site prior to the second (2008) removal action is shown in Figure 2.



Figure 2. Tanks inside secondary containment system prior to 2008 removal action

OVERVIEW OF WASTE TREATMENT

The terms solidification, stabilization, and encapsulation are often used interchangeably as methods for the treatment of wastes. However each treatment has distinct objectives¹:

- Solidification – “A process in which materials are added to a liquid or a semi liquid waste to produce a solid. It may or may not involve a chemical bonding between the toxic contaminant and the additive.”
- Stabilization – “A process by which a waste is converted to a more chemically stable form. The term entails the use of a chemical reaction to transform the toxic component to a new non-toxic compound.”
- Encapsulation – “A process involving the complete coating or enclosure of a toxic particle or waste agglomerate with a new substance, e.g., the additive or binder. Microencapsulation is the encapsulation of individual waste particles. Macroencapsulation is the encapsulation of an agglomeration of waste particles or microencapsulated materials.”

Solidification is typically applied to waste materials that need to be treated to meet disposal requirements at a solid waste disposal facility. In addition to solidifying the waste, other property changes may be required such as minimum strength and resistance to thermal or wetting and drying cycles. Stabilization and encapsulation are typically performed to either treat impacted materials to meet the landfill disposal requirements or to allow them to be left in place thereby mitigating impacts to human

health or the environment. No other parameters were identified during this project requiring treatment other than the presence of free liquids; therefore, solidification of the sludge for off-site disposal was the treatment objective in the 2008 removal action.

Common solidification agents are cement, lime, kiln dust, or fly ash. All have some degree of exothermic reaction that will consume free liquid when mixed with a liquid or semi-solid waste. This property as well as the anhydrous and cementaceous nature of these products, makes them suitable as a solidification agent. These agents may also be effective at stabilization or encapsulation; however, other specialty chemicals may be used separately or as an additive to the above, especially when stabilization is required.

A number of factors need to be accounted for when selecting a solidification agent: availability, material and delivery cost, effectiveness, and presence of deleterious contaminants. Cement is usually effective as a solidifying agent, but may be the most expensive. For this reason, several solidification agents should be evaluated. One of the concerns with coal combustion products is the potential for trace amounts of metals to be present that may leach, thereby impacting the ability to meet disposal requirements.

SELECTION OF SOLDIFICATION MATERIAL

As discussed previously, the sludge could not contain free liquid in order to be accepted for disposal at a Subtitle D landfill. The criteria for determining the presence of free liquids is the paint filter test⁴. In this test the material being tested cannot release free liquid within five minutes after placement in a paint filter. The paint filter test apparatus is shown in Figure 3. A preliminary review of solidification agents was conducted,



Figure 3. Paint filter test setup

including cement, kiln dust, and lime. Based on prior success on other projects, the contractor proposed a locally available material; a byproduct from the circulating fluidized bed (CFB) boilers at the JEA Northside Generating Station. The boilers are fueled by a blend of coal and petroleum coke to which lime is added during power generation to create thermal mass and aid in the removal of sulfurous gas emissions². The resulting dry fly and bed ash byproducts are referred to as EZSORB[®]. The physical and chemical properties of EZSORB[®] are summarized in Table 1. EZSORB[®] was selected for bench scale testing because it was less expensive than other solidification material and based on the lime content, possessed good solidification potential.

Table 1. Chemical Properties and Composition of EZSORB [®] 2,3		
Properties	Bed Ash*	Fly Ash
Color:	Light brown to tan	Light to dark grey
Typical dry density Mg/m ³ :	1.52 to 1.68	.72 to .88
Particle size:	Fine to coarse granules	Very fine granules
Typical Lime Content at loading, %:	24 to 32	-----
<i>*Exothermic upon contact with water</i>		
Chemical Composition		
Compound Description	Compound	Concentration %
Aluminum	Al ₂ O ₃	0.186
Calcium	CaO	59.3581
Iron	Fe ₂ O ₃	0.622
Magnesium	MgO	1.1147
Nickel	NiO	0.3008
Phosphorus	P ₂ O ₅	0.2898
Sulfur	SO ₃	32.5722
Silicon	SiO ₂	1.811
Strontium	SrO	0.1681
Vanadium	V ₂ O ₅	3.5774

Field bench scale testing was conducted to evaluate the effectiveness of the EZSORB[®] at solidifying the oily sludge contained in the tanks at the site. The initial plan was to add 10, 20 and 40 percent EZSORB[®] by weight of the sludge in Tanks 02, 106, and 107, These three tanks contained 88 percent of the sludge on-site. With a 10 percent solidification agent added to the sludge from Tank 02 the mixture passed the paint filter test. Still, it appeared moist after mixing. There was concern that road vibrations during transport to the disposal facility could exacerbate the release of free liquid, resulting in the material being rejected by the landfill operator. Therefore, an increased amount of

solidification agent was added to the sludge from Tanks 106 and 107. Tanks 106 and 107 were tested at 20 and 40 percent solidification agent by weight.

The next day it was observed that the treated sludge from Tanks 106 and 107 exhibited a significant decrease in free liquids and increased unconfined strength. These observations indicated that less solidification agent would be required than initially anticipated if the treated materials were allowed to cure following treatment. Samples of the solidified material were subjected to the toxicity characteristic leaching procedure (TCLP) to confirm that the solidifying agent did not increase the mobility of the hazardous constituents in the sludge, which is a typical concern with the use of a CCP as a solidification agent. The TCLP test results for the solidified material were compared to those for untreated (i.e., 0 percent solidifying agent) in Table 2. A review of the data indicated that there was effectively no difference in the concentrations of tested constituents leached from the treated and untreated samples. Based on this evaluation the EZSORB[®] was selected to solidify the sludge.

Table 2. TCLP Results for Untreated and Treated Sludge

Contaminant	Bed Ash, %	Tank 02	Tank 106	Tank 107
Benzene	0	0.096	0.370	0.015
	10	0.063	NA	NA
	20	0.074	0.243	NA
	40	0.591	0.220	0.014
o-Cresol	0	I	0.100	U
	10	NA	NA	NA
	20	0.049	0.094	I
	40	0.052	0.099	U
m-Cresol	0	0.461	0.130	0.173
	10	NA	NA	NA
p-Cresol	20	0.195	0.041	0.165
	40	0.198	0.045	0.103
Cresol	0	0.507	0.193	0.070
	10	NA	NA	NA
	20	0.244	0.135	0.176
	40	0.250	0.145	0.113
Tetrachloroethylene	0	I	0.083	I
	10	I	NA	NA
	20	I	0.053	NA
	40	I	0.022	I
Meythl ethyl ketone	0	U	U	U
	10	0.179	NA	NA
	20	0.199	U	NA
	40	0.122	U	0.264

All concentrations presented in ug/L.
 I= detected in sample but at concentrations above method detection limit and below reporting limit
 NA= not analyzed
 U= not detected above method detection limit

FULL-SCALE IMPLEMENTATION

The general steps followed in the removal action were:

- Pump and treat water impounded inside the secondary containment system.
- Remove all trash and debris and wash the slab to provide a safe work environment.
- Remove and clean piping connecting the various tanks.
- Remove liquid and treat sludge from the smaller tanks progressing to the larger tanks (The tanks were demolished and the steel recycled as they were emptied).
- Send liquids to an industrial waste water treatment facility.
- Solidify sludge on the floor of the secondary containment system.
- Demobilize and secure site.

EZSORB[®] was delivered to the site in covered roll-off boxes, which also served as a container for storing the material on-site until use as shown in Figure 4.



Figure 4. EZSORB[®] solidification agent delivered to site in covered roll off box

When possible, the contractor mixed the EZSORB[®] and sludge inside of the tanks, as shown in Figure 5.



Figure 5. Treatment of sludge in small tank

The contractor established a procedure for removing sludge from the large tanks and mixing it with EZSORB[®] on the floor of the secondary containment area, as shown in Figure 6.



Figure 6. Removal and treatment of sludge in large tank

As noted earlier, the solidified sludge was allowed to cure after mixing, as shown in Figure 7.



Figure 7. Treated sludge stockpiled for curing prior to disposal

Once cured, the solidified sludge was loaded into trucks for disposal. The paint filter test was conducted prior to loading the material for disposal. Following removal of all materials and demolition of the tanks, the floor of the secondary containment area was cleaned, as shown in Figure 8.



Figure 8. Final cleaning of secondary containment following demolition

SUMMARY AND CONCLUSION

The use of solidification agents is a common practice to achieve acceptance of materials into landfills in accordance with solid waste rules pertaining to free liquids. Several solidification agents are commercially available that may achieve these results; however, the end-user must be judicious in their selection of a solidification agent in order to retain project value, meet project objectives, and avoid exacerbating existing issues.

A successful solidification project provides value and depends on a comprehensive evaluation process to evaluate selection of and use of a solidification agent. Preliminary evaluation activities should include assembling information on solidification agents available to the project, including practical use experience. This should be followed by field trials to confirm the ability of the selected solidification agent(s) to meet project objectives. The field trial(s) should be used to optimize the solidification agent add ratio, including consideration of time dependency (curing) and site conditions (i.e., temperature, humidity, etc.) that may exist during the project. Site conditions and curing can greatly affect the efficacy of a solidification program. Optimizing the solidification agent add ratio ensures that treatment objectives are met and excess cost is not incurred for the purchase, mixing, transportation, and disposal of quantities of solidification agent above those necessary to meet the treatment objectives. Optimization maximizes value to the client. Finally, an analytical program must be undertaken to verify that the treated materials do not create disposal conditions (i.e., leaching metals, pH, odor) that are more detrimental than the originally untreated materials.

On this project as with other projects, a comprehensive solidification evaluation process results in a successful project.

REFERENCES

[1] Florida Department of Environmental Protection, "Engineering Controls Focus Group - Final Report", June 1999, amended.

[2] EZSORB® General Information Cut Sheet, undated.

[3] EZSORB® General Elemental Composition, undated.

[4] USEPA Method 9095B, "Paint Filter Test", November 2004.