WM'00 Conference, February 27 – March 2, 2000, Tucson, AZ

THE HISTORY AND DEPLOYMENT OF WATERWORKS CRYSTALS® TECHNOLOGY TO ACHIEVE LIFE-CYCLE COST REDUCTIONS

Scott Altmayer, P.E.
Technical Manager
WaterWorks America, Inc.
5991 Center Street
Mentor, OH 44060-2273

ABSTRACT

The goal of this discussion/presentation is to clarify applications for an emerging alternative to "dewater" low-level radioactive waste/mixed waste (LLW/MW), wastewater, and sludge using **WaterWorks Crystals®**. Most waste handling, processing, and disposal sites have restrictions to control the receipt, handling, and shipment of wet wasteforms. For selected wasteforms, this alternative can significantly reduce lifecycle costs and simultaneously simplify field processes so they are safer and quicker to apply in support of ALARA goals.

Recent advances in aqueous superabsorbent polymer technology using **WaterWorks Crystals®** allow for low-volume, low-weight, cost-effective options to solidify, transport, and bury large volumes of wet wastes and liquids. These methods have been proven at a variety of facilities. Selected/example technical options, sensitivities, volumes, and life-cycle costs will be compared and contrasted to "conventional" technologies.

For over 20 years traditional waste dewatering and stabilization/solidification (S/S) processes (i.e. evaporation, clay, cement, CKD) have been used. Recent waste reduction initiatives by Federal agencies, and cost-cutting measures by companies often require that these familiar technologies be re-evaluated. They are often over-used for simple dewatering processes and may introduce a variety of subtle issues (i.e. more waste, inhalation hazards, and excess labor) that result in greater long-term liabilities and increased life-cycle waste management costs.

The audience may use this information to make site-specific safety, cost, and compliance evaluations regarding use of **WaterWorks Crystals®.**

INTRODUCTION

For too many people, the idea of nuclear and hazardous waste from our high-tech society conjures up the vision of an ugly, corroded, leaking drum with black ooze coming out. Unfortunately, this vision is at least in part representative of America's industrial legacy. Throughout the post-war technology growth era, we have tended to manage the tailend of the nuclear and hazardous cycles by simply placing unwanted and untreated liquid and solid residues "in the back 40". This resulted in the environmental and groundwater calamities of the 1960's and 1970's that we are cleaning up today.

HISTORY

The basic result of this unregulated dumping by industry was the contamination of surface waters. The reason for this was a nationwide infrastructure of contamination point-sources in the form of uncontrolled chemical and radioactive disposal "pits and trenches" with no liners, no caps, weak operations, and no monitoring. Needless to say, these landfills quickly degraded, subsided, and directly released contaminants into the surrounding watersheds by surface runoff or subsurface aquifers.

TECHNICAL RECOVERY

Since the early 1980's, Federal agencies have promulgated laws and national technical groups have developed technical standards to help manage and repair this tenacious assault left in the environment. The USEPA enacted what is commonly known as "Superfund Legislation" to mitigate chemical contamination. The USNRC closed several disposal sites, promulgated a national low-level radioactive waste policy, and promulgated 10CFR61 to control the proper design and operation of radioactive-waste disposal sites and assure proper wasteform integrity.

TECHNICAL REQUIREMENTS

The promulgation of these new laws in the early 1980's resulted in a series of waste management improvements that were centered around immobilizing the chemical and radioactive hazards at the point-of-generation prior to the waste entering the controlled land fill. The terms stabilization/solidification (S/S), binding, and encapsulation were used to describe the broad range of fixation processes. At the same time, industry responded by developing appropriate tools and processes to meet these new regulatory standards. Finally, the USEPA and USNRC tasked the technical community with developing performance tests to quantify the efficiency and effectiveness of these fixation technologies and processes.

The USEPA's 40CFR 260 series laws require a weak acid leach test on wasteforms. The USNRC's 10CFR61 law also required a similar type of acid leach test on stabilized or solidified wasteforms. Both agencies required "process control plans" and testing to assure quality wasteforms were developed (i.e. ANS 16.1, ANS 55.1, Waste Analysis Plan). Both agencies adopted the terms to qualitatively define the characteristics of final wasteforms. Solidification tended to refer to making a monolithic rock-like wasteform capable of withstanding soil overburden pressures of at least 50 psig. Stabilization referred to chemical or ionic bonding that did not necessarily change the physical traits of the wasteform.

Finally, safe and efficient disposal had arrived by combining a series of engineered barriers. They included point-of-generation process controls on wasteform integrity and leachability, multi-linear/multi-layer leachate collection systems, operational controls, routine monitoring, and good capping. Therefore, any liquids moving within a disposal cell were minimized and properly controlled.

Both USEPA and USNRC recognized the value and necessity of absorbents to supplement and augment the S/S binding processes. Absorbents are primarily designed to address, and eliminate, the physical waste characteristic of a free-liquid. Absorbents may or may not provide a measure of chemical or ionic bonding. The typical gravimetric test used by USNRC and USEPA to measure free-liquids is the USEPA's Paint Filter Test (SW-846, Method 9095). This is a relatively simple, fast, and cost-effective low-stress test.

PROBLEM

In the late 1980's, the USEPA placed a landban on the direct disposal of bulk liquids in hazardous landfills (4). However, they maintained an allowance for disposal of absorbed liquids in containers provided the absorbents would not release liquid and meet certain criteria. The USEPA promulgated laws that identified acceptable characteristics, classes and tests for absorbents. About this same time the USDA had completed developmental testing on similar polymers for water control in agricultural soils (2). This law includes non-biodegradable, high-density polyacrylate polymer absorbents like **WaterWorks Crystals®.**

LIQUID TESTING

The USEPA also started development of a new test to evaluate absorbents under pressure (50 psig) which became known as the Liquid Release Test (SW-846, Method 9096) (4). The wide variation in wastestreams, S/S additives, and absorbents made this test impractical to mandate as a law. However, it is regularly used by many waste generators and disposal sites to qualitatively assure greater margins of safety beyond the gravimetric Paint Filter Test. Some generators or treatment sites have adopted site-specific or waste-specific testing of other physical wasteform parameters like: freeze-thaw cycling (Fernald, INEL), transport vibration (Mound, Fernald), compactibility (Envirocare), or overburden pressure (Hanford).

FREE-LIQUID SOLUTIONS

In response to the new USNRC and USEPA laws and "No Free Liquids" policy, industry responded with a plethora of appropriate and versatile technologies and additives to assure compliance. Also, the hazardous waste treatment and disposal industry saw a large growth spurt.

Examples of "traditional stabilization and solidification (S/S) agents are specified y vendors include concrete, vinyl esterstyrene, various cements, bitumen, flyash, lime, cement kiln dust (1,2,3). Fundamental dewatering technologies (i.e. filters, evaporators, clarifying) recycle water at the point-of generation. However, the advent of a robust, high-tech polymer like **WaterWorks Crystals®** yielded a new dewatering method that is often more cost-effective and safer than some traditional techniques.

WaterWorks Crystals® superabsorbent polymer was developed for use in various environmental soil media and then customized to meet industrial and waste management applications, demands, and requirements. Superabsorbent cross-linked polyacrylate salts are an aid to a total system for aqueous waste management. The key to their performance is that they are not biodegradable and are not time or heat sensitive. Once a liquid is stabilized, it will remain a gel for a long time (>ten years) and won't turn back to a liquid. Wastes such as paints, adhesive latexes, textile emulsions, rinse water, and pesticide residue in water can be gelled and disposed of as "non-liquids" in licensed appropriate landfills. For example, 2.5 kg (5.5 lbs.) of **WaterWorks Crystals®** will typically stabilize 208 liters (i.e. 55 gallons) of contaminated wastewater, at a rate which can be more cost-effective than thermal treatment or incineration (5).

ABSORBENTS

Although the USEPA had promulgated laws allowing the generic use of high-tech substances like **WaterWorks Crystals®** to avoid/prevent free-liquids, their broad use has been delayed. The technology was relatively new in the early 1980's and encountered difficulty emerging in a growing waste management industry that was both uncomfortable or ignorant of these new technology applications. Waste generators/processors had become comfortable using mass quantities of cheap traditional S/S agents (i.e. kiln dust, fly ash, lime) for most problems on most wasteforms, including absorbtion. However, as transport and disposal prices increased, some businesses looked at the overall cost of managing "free" S/S additives and recognized them as a cost liability. As generators attempted to minimize waste, they targeted the blatant overuse of cheap inefficient additives like lime… was cheap to buy, messy or unsafe to use, expensive to bury, and sometimes failed. A classic example is DOE's early attempts to solidify radioactive salty sludges with concrete that too often resulted in thousands of containers, some leaking, that held unsolidified concrete-like substances (i.e. pondcrete).

WATERWORKS CRYSTALS® USE

In the early 1990's, radioactive waste disposal sites waste generators and remediation companies began to look at substituting **WaterWorks Crystals®** for some of the traditional absorbents to control water in wet-sludge, soil, and debris. **WaterWorks Crystals®** were generically authorized by USEPA in 40CFR268. They are necessary and sufficient to allow many wasteforms to pass disposal site criteria by preventing free-liquids during transportation, temperature cycles, handling stresses, or disposal. They are fast and easy to prove on a wasteform and cost-effective to use due to their safety, simplicity, and high-efficiency.

CASE STUDY OVERVIEW

Three short case studies are outlined below using reference applications (Table I) and cost information (Table II). They demonstrate how **WaterWorks Crystals®** can directly reduce costs, improve safety, and/or assure compliance.

Case Study #1

A commercial excavation project removed 1000 cy of lead soil. Near the end of the project, the excavation filled with 20,000 gallons (-75 metric tonnes) of water from runoff and an aquifer. The contractors baseline estimate included solidifying water for disposal with several hundred tons of fly-ash/lime mixture. The baseline cost to treat and bury the water was over $50,000 not counting schedule delays. Instead, the contractor used a couple of tons of **WaterWorks Crystals®** and saved approximately $25,000 on this project.

Case Study #2
A DOE project excavated radioactive soil along a coastal waterway. Due to field conditions, work occurred between tidal flows with minimal onsite dewatering available. Rolloff containers and gondola cars were loaded with layers of wet soil/sludge and **WaterWorks Crystals®** and shipped to a Envirocare of Utah. Liquids that had been released in transit were passively solidified at the point-of generation. There was no leakage and no free-liquids upon receipt.

Case Study # 3
A DOE site near Dayton Ohio carried out a tritiated water solidification demonstration to compare differential solidification costs. The baseline was a cementation process using cement or a well-known modified clay solidification agent. The alternate solidifier was **WaterWorks Crystals®** aqueous superabsorbent polymer. Preliminary information indicates a nominal direct material cost of $1/gallon using **WaterWorks Crystals®** which is approximately 75% less than the direct material cost for the clay-based solidification agents (7). Besides the direct material savings, there are routinely overall lifecycle cost savings through efficiency and safety improvements.

UNPLANNED COSTS/CONSEQUENCES

According to DOE, the average planned life-cycle cost to manage low-level radioactive waste (LLW) is approximately $3,000 per cubic meter, and the average cost to manage mixed waste is approximately $17,000 per cubic meter. Approximately 40% of these costs involve "soft"resources like programmatic, project management, and infrastructure issues (6).

These estimates do not typically include the costs of "unplanned" tasks tied to schedule delays, demurrage, poor performance, or operational/regulatory penalties. Such costs are typically large, $50,000 - $500,000 per event, and directly prevent the timely completion of an equivalent amount (15 - 150 cubic meters) of planned LLW. A review of various non-conformance reports from DOE and other regulatory agencies readily shows several incidents of leaking containers, spills, and improper waste treatment or shipping involving aqueous liquids (2). The results of these events were typically work stoppages at an overall cost of million of dollars.

In most cases, judicious application of **WaterWorks Crystals®** absorbent early in the planning process uses a small fraction (<5%) of the life-cycle cost noted above. The results will be overall cost-savings, fewer uncertainties, better risk management, and efficient selection/use of proper technologies.

CONCLUSION

WaterWorks Crystals® polymer are a viable alternative to traditional absorbents. They have been demonstrated to stop free-liquids, save money, improve safety, and proactively assure regulatory compliance on a variety of hazardous and radioactive waste streams.

Waste generators should consider using **WaterWorks Crystals®** to solidify water and prevent leakage in containers of wet demolition debris, wetted asbestos, soils, and sludges, wastewater and residues.

REFERENCES

1. Richland Disposal Facility, License # WN-IO19 Appendix C, Approved Solidification Media, Appendix D, Approved Stabilization Media

2. Draft Report, Management of Contaminated Liquids (pg. 15-32). H. R. Libowitz, R.Witelles, S.L.Unger, B.M. Eliash, M.J. Carr F-92-CLLF-50006.

3. Envirocare of Utah Disposal Facility, License, Approved Reagents for Mixed Waste Stabilization and LLW Solidification.

4. Contaminated Liquids in Landfills/Development of Liquid Release Test. Federal Register 56 FR 55646 (10/29/91), 52FR 23965 (6/24/87), and 51 FR 46E24 (12/24/86).

5. Chemical Week, July 18, 1979 p.40

6. DOE BEMR, 1996

7. "The Use of Innovative Super Absorbents To Economically Stabilize Contaminated Aqueous Decontamination Wastewater For Disposal, September 1999", Richard Blauvelt, Don Krause, William Lupichek, James Fontaine, Harold Shoemaker, Scott Altmayer

TABLE I

WaterWorks Crystals® Application

Wasteform	Relative Water %	Absorbent Placement	Absorbent Blending
Contaminated Water	High > 90%	Bulk Additive	None
Slurry Sludge	High	Bulk	Vert/Lat Probe, Pugmill
Wet Waste Asbestos	Average > 10%	Bulk, Layered	Broadcast Pugmill
Dry Soil (< Optimum%)	Low < 5%	Top/Bottom Perimeter	Minimal Broadcast
Condensation	Low < 1%	Top/Bottom Perimeter	None, Broadcast

TABLE II

Example Cost Comparison

"100-tons of Rad-soil w/ 10 tons of extra water"

Major Cost Element	Baseline "Do Nothing"	Lime, Clay	Evap. Kiln Dry	Organic Cobs	Water Works Crystals®
Excavate & Stage (> $10/ton)	$1k	$1k	$1k	$1k	$1k
Process & Load (> $10/ton)	Soil $1k Sorb-$0 Qty- 0	$1k $1200 20t sorb	$1k $6000 10t H_2O	$1k $1775 2.5t sorb	$1k $1601 0.1t sorb
ShipWaste (> $50/ton)	Soil $5k Sorb-0	$5k $1000	$4.5k $0	$5k $125	$5k $5
Bury Waste (> $150/ton)	Soil $1.5k Sorb $0	$15k $3000	$13.5k $0	$15k $375	$15k $15
Total (Delta)	$22,000 0%ref	$27,200 + 24%	$26,000 + 18%	$24,725 +10%	$23,621 +7%