Enhancing Liquid Availability Through Mechanical Compaction: An Alternative To Incineration - 9095

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ABSTRACT

The paper describes the investigations, processes, and equipment to remove incidental liquids found within transuranic (TRU) organic sludge matrix drums at the Advanced Mixed Waste Treatment Project (AMWTP) at the Idaho National Laboratory. Mechanical vibration was investigated as a means to collapse void spaces within the sludge thus bringing liquids to the drum surface for subsequent absorption. Over fifty percent of the AMWTP organic set-up drum inventory contain liquids and could benefit from this process by allowing them to meet the Waste Isolation Pilot Plant (WIPP) Waste Acceptance Criteria (WAC).

INTRODUCTION

From the early 1950s to mid 1980s, the Idaho National Laboratory has accumulated radioactive and hazardous wastes. Operations to dispose of this waste have been in effect for over 40 years and began with disposal in unlined pits, trenches, soil vaults, and aboveground storage. The majority of the waste is the result of the manufacturing of nuclear components at the Rocky Flats Plant in Colorado and was shipped to Idaho in the 1970s and 1980s. This waste includes debris rags, work clothing, machine parts, tools, soil, and sludge contaminated with TRU isotopes. One of the major disposal operations to address this waste is the AMWTP. AMWTP, managed by Bechtel BWXT Idaho (BBWI), is contracted to characterize and ship TRU waste to the WIPP. One of the waste streams currently being processed is the organic set-ups. Organic set-ups are contaminated with polychlorinated biphenyls (PCBs). PCBs are regulated under the Environmental Protection Agency (EPA) Toxic Substance Control Act (TSCA). For TSCA regulated waste, it is prohibited for the WIPP to receive wastes containing liquids.[1] Approximately 4,617 drums containing organic set-ups have undergone a real-time radiography (RTR) examination to date. RTR is a nondestructive examination technique, similar to an x-ray, which is routinely used to identify liquid within TRU waste. Based on the RTR examination there are 3,142 drums containing liquids or 68% of the organic set-up drums characterized. Prior to disposal, the liquid had to be remediated. Specifically, TRU contaminated waste containing PCB incidental liquids require processing into a non-liquid form in order to meet WIPP's WAC. The AMWTP has obtained an EPA Risk-Based Disposal Approval (RBDA) to solidify this liquid and dispose at the WIPP. This paper summarizes the AMWTP efforts to address the organic set-up incidental liquids.

PROBLEM STATEMENT

Approximately one percent of the drums contain the challenging waste stream of organic set-ups and incidental liquid on the waste surface where it can be readily solidified. The remaining drums have liquids that coexist with the bagging and waste matrix (between the bagging and the drum liner, or between the liner and drum). The percentage of drums in each of these locations can be summarized as follows:

- On top of the sludge: 1%
- On the side: 28%
- On the bottom: 1%
- On the side and bottom: 55%
- Other: 15%

The volume of the liquid varies from one fourth of a teaspoon to five to six gallons per drum. Accessing and finding one fourth of a teaspoon of liquid within a drum for absorption is a challenge. The sludge stream contains volume percent levels of chlorinated solvents and oils contaminated with polychlorinated biphenyls (PCBs). The design of the AMWTP, originally envisioned by British Nuclear Fuels, included an incinerator to address the organic waste stream. Due to a lawsuit opposing the use of incineration, the practice was dropped from the plant design and therefore, an alternative was needed. Approximately 50% of the drums containing organic set-ups contain residual incidental liquids. In over 90% of the drums, the liquid is not on the surface but entrained within the sludge matrix. Per WIPP's WAC, WIPP is not permitted to receive residual liquids containing PCBs. Prior to disposal, the liquid must be removed or treated. Specifically, TRU-contaminated PCB waste containing residual incidental liquids must be processed into a non-liquid from to meet WIPP's WAC. The AMWTP obtained an EPA Risk-Based Disposal Approval (RBDA) to process residual incidental PCB liquids into a non-liquid form and disposal at the WIPP facility. The next challenge was developing a method to remediate teaspoon quantities of liquids entrained within the sludge.

SOLUTION

Numerous methods to economically and safely remediate liquids from the waste drums have been investigated. These included decanting, piercing and draining, and mechanical vibration. Decanting is not an option because the liquid is not on the surface in a majority of the drums but entrained within the sludge. Accurately determining the location to pierce and drain the liquid was deemed to be a significant hurdle. In addition, secondary waste would be generated. The ideal solution is in-situ remediation and therefore mechanical vibration was investigated. It was hoped that mechanical vibratory impulses would collapse the voids within the sludge thus driving the liquid to the surface where it could be readily absorbed. Mechanical vibration was investigated as a means to bring the liquid to the surface for subsequent absorption. Vibration takes advantage of the thixotropic properties of the sludge and the density difference between the liquid and the primary sludge matrix i.e. calcium silicate. A thixotropic material becomes more fluid with increasing time of applied force. This applied force is obtained by use of a commercial mechanical vibrator. Vibratory impulses assist in settling the sludge by reducing the internal friction between particles. The mixture becomes unstable, allowing entrapped liquid to rise to the surface while the heavier sludge settles. Bringing the liquid and waste matrix into contact allows the liquid to be absorbed into the unsaturated waste matrix. Those liquids that are not absorbed into the base matrix rise to the top where they can be readily absorbed. Drums containing entrained liquids were overpacked and subjected to mechanical vibration. Mechanical compaction does not change the characteristics or composition of the waste and was shown to consolidate the existing free liquids throughout the different matrices of the drum. Also, most importantly, the system will not pose an unreasonable risk of injury to human health or to the environment and will enhance liquid availability for eventual absorption and disposal at WIPP. Spills or releases during operation are likely to be the most significant opportunity for human or environmental exposure to PCBs. However, ventilation and Personal Protective Equipment (PPE) will be the primary containment and a soft-sided mobile tent the secondary containment.

EQUIPMENT

There are numerous commercial vendors which manufacture vibrating tables capable of handling approximately 500 pound 55 gallon drums. A commercial vibrating table was purchased from Vibco of Rhode Island. Cost and access to technical support staff were the primary reason for selecting Vibco. Both frequency and amplitude were investigated. Frequency is the number of vibration cycles per minute and is often presented as revolutions or vibrations per minute (rpm or vpm). Frequency should have an effect on lighter masses. The amplitude is the maximum distance the vibrating head moves from its position of rest. Amplitude will have an effect on heavier masses. The force a drum experiences is a function of weight, frequency, and amplitude. Compaction force is expressed in terms of a G force. Although actually a measurement of acceleration, the term G-force is typically used to refer to the force an accelerating object "feels". That is, a G force of two means that a person experiencing this force would feel twice as heavy as normal. Relative to this investigation it is sufficient to understand that G force is related to Newton's second law, $F=ma$, where F is force, m is mass and a is acceleration.

LOCATION

The drums are to be vibrated within the RTR unit. To accomplish this, the vibration table was mounted onto a metal frame designed to be loaded onto the RTR cart. The RTR cart can roll into and out of the RTR unit as needed. The power to operate the vibration table was run below the cart track. The vibration frequency increased a harmonic that could easily be heard outside of the RTR unit. Because of the noise, testing was suspended. The cart was then rolled out and the vibration test repeated. At approximately 12 Hertz (Hz) the drum began to "walk" on the vibration table and the test was again suspended. A secondary harmonic developed around 24 Hz. Increasing the frequency to 30 Hz yielded good results. Because of the concern that a drum could "walk" off the vibration table, no additional drums were vibrated within the RTR unit. Shaking occurred outside to the RTR unit to allow for visual verification of the drum stability.

Overall, the harmonic frequency is dependent of the weight and the loading of the sludge within the drum. Uneven distribution of weight changed the frequency at which a harmonic developed. Care was taken to select at frequency that maintained drum stability. In most cases 30 Hz yielded good results and was the frequency utilized.

MECHANICAL VIBRATION AND LIQUID ABOSORPTION

Organic set-ups were produced at Rocky Flats by mixing organic liquid with Microcel-E a synthetic calcium silicate. The amount of material added to the mixture was not metered (*Acceptable Knowledge Document for INEEL Stored Transuranic Waste-Rocky Flats Plant Waste-INEL-96/0280 Rev. 03*). However, the operator would adjust the composition if the outgoing mixture did not have a paste-like consistency. The mixture was then drop into an o-ring bag contained in a 55-gallon drum (*INEL-96/0280 Rev. 03*). This relied on operator training and experience. It is likely that current drums that arrived at AMWTP from Rocky Flats had liquid and voids present. This is supported by the RTR record which clearly shows voids and voids with incidental liquids.

In all cases, mechanical vibration consolidated the waste matrix within the drum. As discussed, the volume reduction ranged from three to 14 liters. When the sludge collapses, the bulk matrix i.e. calcium silicate (Microcel-e) comes into contact with the incidental liquid. In cases where the calcium silicate is not saturated, the liquid is absorbed into the bulk matrix. If the calcium silicate is saturated, the excess liquid rises to the top.

CONCLUSION

Mechanically vibrating the waste collapses the void volumes within the sludge. The reduction in void volume ranged from three to 14 liters. This collapse either forces the liquid to the top or to be absorbed into the bulk matrix. Based on the results of this study the AMWTP now implements mechanical vibration as part of their process for addressing incidental liquids in organic set-ups. Drums that have incidental liquids within the bagging and entrained within the sludge are excellent candidates. Given the distribution of liquids in the drum inventory, more than 50% of the drums will benefit from mechanical vibration. Although the liquid within the bagging and matrix may be absorbed within the matrix, the drum may still require additional processing to absorb liquid between the liner and bagging as well as between the liner and drum walls. Also, to prevent drum "walking" during testing, an overpack container will be mounted onto the vibration table.

As submitted to the EPA, the RBDA discussed mechanical vibration as a means to enhance liquid availability for subsequent absorption and disposal at the WIPP. The RBDA request did not specifically discuss the potential for absorption of the incidental liquid back into the bulk matrix as a result of mechanical vibration. Based on this study, however, mechanical vibration alone is sufficient to qualify the waste for disposal at the WIPP. The basis for determining liquids for disposal at the WIPP is a qualified RTR examination. The tests show that applying mechanical compaction on drums with liquid in the bagging resulted in a condition where absorption of the liquids was possible, therefore, a WIPP compliant PCB container. For liquids that do not absorb into the waste matrix after mechanical vibration is completed, absorption (or removal) of any residual liquids would follow.

Fifty percent of the organic set-up drum inventory at AMWTP will benefit from this process. Mechanical vibration is intended solely to address incidental liquids to meet the WIPP WAC, will not change the nature or quantity of PCB-contaminated TRU waste, and is not defined as treatment under AMWTP's Hazardous Waste Management Act (HWMA)/Resource Conservation and Recovery Act (RCRA) regulations. Work can be performed under the current storage permit. This work represents a major cost effective step forward in the disposal of this waste at the WIPP. There were conditions found, however, that compaction would not address. Based on Real Time Radiography (RTR) examination, liquid that is outside of the bagging was not remediated. AMWTP is currently exploring other industrial mixing technologies, such as the use of acoustics, in future mechanical vibratory operations.

REFERENCES

1. DOE/WIPP-02-3122 Contact-Handled Transuranic Waste Acceptance Criteria for the Waste Isolation Pilot Plant, U.S. Department of Energy, Carlsbad Field Office, Carlsbad, New Mexico, Latest Revision