INNER LAYER CONFINEMENT REDUCTION METHOD FOR WIPP BOUND TRU WASTE PACKAGES

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ABSTRACT

The use of a technology that will breach inner layers of confinement inside of drums containing TRU waste destined for WIPP could provide significant savings to the clean-up and disposal process at many DOE sites. Breaching of the unfiltered, bagged waste will allow many drums to be shipped as it will eliminate the build up of hydrogen gas within the inner bags and will allow drums that would have been over the wattage limit to fall within the shipping requirements for the waste. Drum shipments to WIPP can be accelerated and costly repackaging efforts can be prevented. UltraTech International, Inc. with the assistance of the Idaho National Engineering and Environmental Laboratory (INEEL), has developed such a process. The process is being tested to insure it meets the fifteen criteria outlined by the TRU and Mixed Waste Focus Area (TMFA) for breaching inner layers of confinement.

INTRODUCTION

The Nuclear Regulatory Commission (NRC) has imposed a flammable gas concentration limit on transuranic (TRU) waste transported using the TRUPACT-II to minimize the potential for loss of containment during transport. This limit is set at the lower explosive limit of 5% by volume for hydrogen in air. Accident scenarios and the resulting safety analysis developed as part of the TRUPACT-II Safety Analysis Report, requires that this limit be complied with for a period of 60 days during which the TRU waste may be transported to the Waste Isolation Pilot Plant (WIPP). TRUPACT-II worst-case calculations and the current approach for demonstrating compliance with this requirement have prevented significant quantities of waste from being transported using the TRUPACT-II without additional testing or waste repackaging. This includes approximately 40% of the waste stored at the Idaho National Engineering and Environmental Laboratory (INEEL), Rocky Flats Environmental Technology Site (RFETS) and Los Alamos National Laboratory (LANL), and a significantly greater fraction of waste at the Savannah River Site (SRS).

Hydrogen gas build-up in transuranic waste results from the radiolysis of hydrogenous materials by alpha emitters contained within waste packages. Typically, TRU waste is packaged within one or more polyethylene (PE) or polyvinyl chloride (PVC) bags with one or more of these multi-layer bags of waste placed in one container (drum or box). Waste items may also be packaged within metal cans, fiberboard boxes, or plastic bottles that are also packaged in PE or PVC bags. Waste containers may contain waste items packaged in as many as six layers of bagging materials, termed layers of confinement. These layers of confinement impede the transport, via diffusion and permeation, of hydrogen from the innermost layer of confinement, which contains the waste, resulting in the potential build-up of hydrogen within this innermost layer of confinement. The NRC has identified the innermost layer of confinement as the point of compliance for the 5% allowable hydrogen concentration.

The TRUPACT-II SARP allows for waste that exceeds the allowable wattage limit to be tested to determine if its hydrogen gas generation rate is less than the allowable rate such that the 5% allowable hydrogen concentration limit will not be exceeded during the 60-day transportation period. However, for those waste containers that exceed the allowable gas generation rate, repackaging to remove layers of confinement is the only current option. Removing layers of confinement would increase the allowable hydrogen gas generation rate by increasing the hydrogen transport rate out of the innermost layer. The current intrusive approach to repackage requires the use of gloveboxes, is labor intensive and increases radiation doses to workers. An alternative that is more cost-effective, faster and reduces worker radiation exposure is needed. The TRU and Mixed Waste Focus Area (TMFA) in conjunction with the U.S. Department of Energy Carlsbad Field Office, has developed a set of criteria that any alternative inner layer of confinement breaching system must address. These criteria are listed in Table 1 along with how well a proposed method for breaching the inner layers of confinement meets these criteria, based on preliminary test results.

PROPOSED ALTERNATIVE

UltraTech International of Jacksonville, Florida evaluated several alternatives. The concept of piercing the bags with blades or pins was unable to meet the objectives outlined in Table I. Laser technology, while feasible, was very costly to develop. The use of vacuum technology combined with cryogenic cooling (termed the Ultra-BagBuster) was found to meet the criteria and be a viable alternative to intrusive repackaging to breach the inner layers of confinement.

The use of vacuum met many of the criteria established for a successful system such as worker safety, no degradation of the drum, and no repackaging. Pulling a vacuum on the contents of the drum creates a pressure differential across the sealed bags. The 15-psi of atmospheric pressure inside the bags causes the bags to inflate to fill the void between the bags and the drum until the tensile strength of the bags is reached and the bags are breached. Once one bag breaches, it deflates and creates additional void for the continued expansion of the remaining bags until all the bags have breached. Preliminary tests showed that polyethylene bags rapidly fail when a vacuum is drawn on the drum; however, PVC bags simply inflate but do not breach. Cryogenic cooling with liquid nitrogen (LN2) caused the PE and PVC bags to become brittle and rather than expanding they broke catastrophically when a vacuum was applied.

Table I Comparison Chart – TMFA/DOE Criteria vs. Ultra-BagBuster Preliminary Results

Primary TMFA/DOE Objectives	Ultra-BagBuster
Mechanism to breach inner layers of packaging in 55-gallon drums	Results to date show 100% effectiveness
Method to validate/document the confinement layers are breached	WIPP Approved Performance Testing Plan (pending)
Technology will be available for use in the year 2000	System will be available in 2001
TMFA/DOE Criteria/Requirements	**Ultra-BagBuster**
Minimized addition of material that will increase the waste volume.	No addition material is added that would increase the waste volume.
No exposure of personnel to radioactive or RCRA hazardous contaminants.	No exposure of personnel to radioactive or RCRA hazardous contaminants.
No repackaging of drum.	No repackaging of drum.
Be capable of breaching bags with or without a rigid polyethylene liner present.	Capable of breaching bags with or without rigid liner present.
All containers must comply with DOT 7A following the ICR process.	The Ultra-BagBuster process does not affect the container's integrity. However, if the container's DOT 7A status was obtained based on having sealed bags of waste inside, UltraTech or the DOE will need to retest 1A2, 17H or 17C drums with un-bagged waste to obtain 7A ratings.
Impacts to the drum integrity are not acceptable.	The process is designed so that the drum does not have any effect from the vacuum process since it is processed in a chamber.
Disturbance of waste material should be minimized.	While the bags become inflated or deflated, the Ultra-BagBuster process should not affect the waste forms.
Treatment should result in negligible change to the waste matrix chemical composition.	The process will change liquids to gas or solid, but will not change the chemical composition. The cryogenic temperature minimizes the potential for chemical reactions.
Thermal or chemical impacts to the waste form should be minimized.	The process imparts no heat nor chemically alters the waste.
WIPP WAC and TRAMPAC criteria shall not be impacted by the ICR method.	No WIPP WAC or TRAMPAC criteria are impacted.
System operations should remain simple and easy to perform.	System operations will be simple and easy to perform. Full automation may be possible and the system is portable.
Implementation and operational costs should be minimized.	The Ultra-BagBuster process should be economically attractive.
System throughput must be 15 drums per day.	One system set up on a semi-manual basis is expected to process 2 drums per hour or 16 units for a 9-hour shift.
The ability to operate the system outside of a containment area is a benefit.	The Ultra-BagBuster system is portable and will not require a containment area. It will require approximately 200 ft^2 for the processing equipment.
An effective ICR system needs to be operational within 9-months.	The Ultra-BagBuster process will be available for use in 2001.

SYSTEM DESCRIPTION

The Ultra-BagBuster system is shown in Figure 1. The heart of the system is the 2" diameter Ultra-Rad Filter and filter cap combination (items 1 and 2, respectively, in Figure 1) that is inserted into the drum lid. The filter has a hole saw blade (1G) covered in a protective wax (1F). As the filter is drilled into the lid, the wax melts onto the lid and saw blade to seal off the drum contents from escaping. The saw blade transitions into self-tapping threads and when the filter is fully seated on the lid a silicone gasket (1D) is compressed to produce a leak tight seal. The Ultra-Rad Filter assures that there is a 99.97 % retention of radioactive particles inside the drum during the LN2 injection and subsequent evacuation process.

To begin the process of breaching the inner layers of confinement, the drum is positioned on the base of a "bell jar" shaped secondary chamber (item 3 in Figure 1) where LN2 is injected into the drum and the chamber and drum are subsequently evacuated. The chamber is designed to encompass the drum and withstand a full vacuum on its sidewalls.

The LN2 is injected into the drum via a tube port in the filter at a rate that limits pressurization of the drum to less than 5 psi. The liquid nitrogen rapidly turns to gas, which is vented through the filter. The introduction of the LN2 accomplishes two key items; first it chills the drum, the bags and its contents to a temperature well below 0° Fahrenheit. Secondly, it creates an oxygen and hydrogen poor environment in the drum external to the bags. The combination of -200°C and minimal oxygen reduces the possibility of an oxidation reaction occurring.

As the drum is being chilled, the top portion of the secondary chamber is lowered over the drum to form a vacuum-tight seal. The secondary chamber has a connection valve (item 10 in Figure 1) that is either closed, open to the atmosphere or opened to the containment tank (item 6 in Figure 1).

Once the drum is sufficiently chilled (approximately 5 minutes) the bags inside the drum are extremely brittle. At this point, some PVC bags with trapped air implode as the air inside cools and contracts. The brittle condition of the bags will not support the stresses in the wall of the bag and as it implodes the wall shatters into fragments, producing a significant breaching of the bag. This phenomenon will occur in some percentage of the PVC bags, but not in all of the PVC bags and not in any of the PE bags.

When the drum contents are sufficiently chilled, the secondary chamber and drum are evacuated into the containment tank. The vacuum is applied to the secondary chamber at a rate that will not pressurize the drum to more than 5 psi preventing the drum from collapsing or burping. The pressure inside the drum is equilibrated to the pressure outside the drum in the secondary chamber via a pressure differential port located in the filter cap.

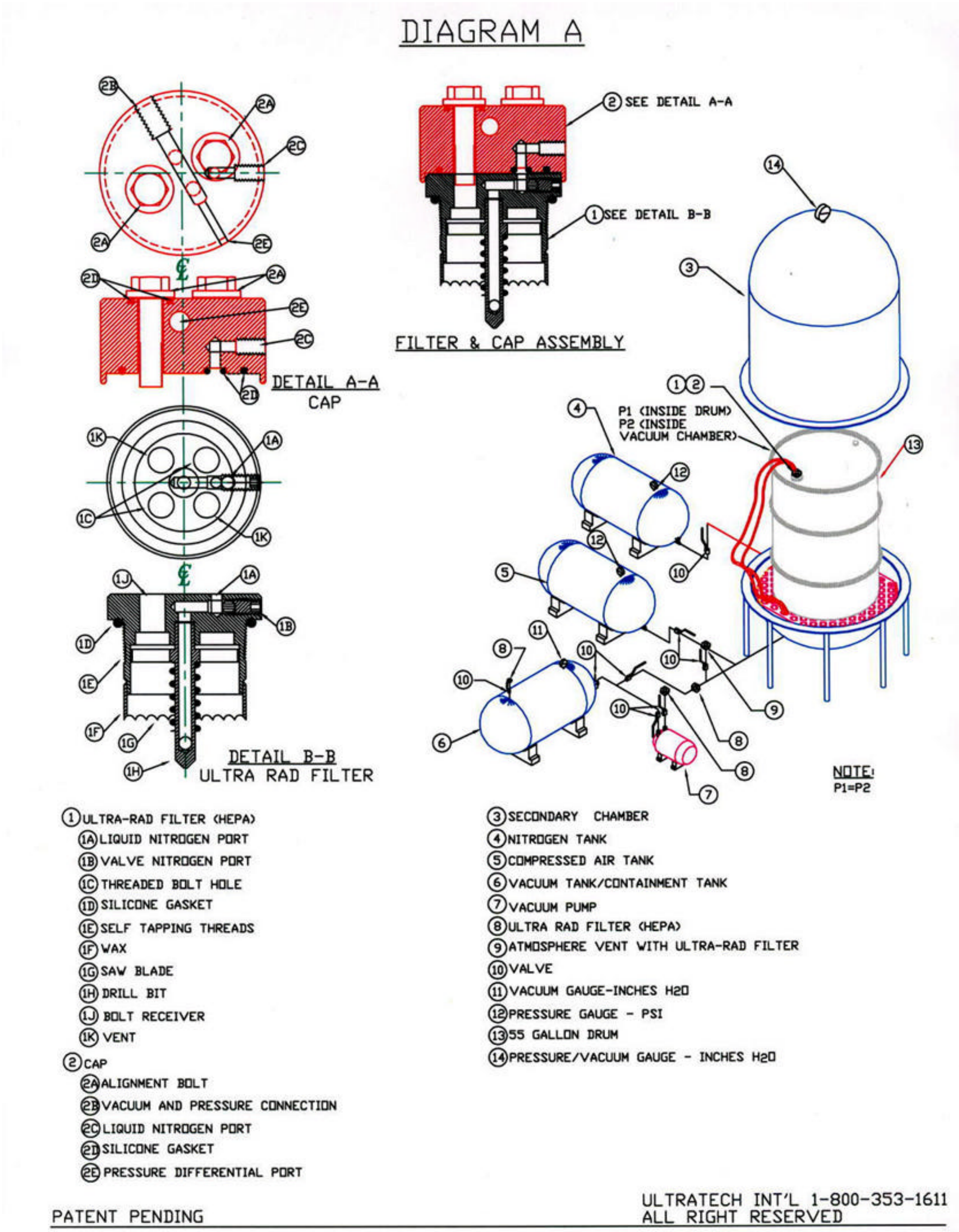

Fig. 1. Configuration of the Ultra Rad Filter and Cryogenic Cooling/Vacuum System.

As the drum is evacuated, the air trapped in the sealed, bagged waste will try to expand. However, because the bags are now brittle they will fail catastrophically, literally shattering large openings or sections into fragments as shown in Figure 2.

Fig. 2. Six layers of polyethylene bags breached (on left) and one layer of a PVC bag breached (on right)

Once a specific time period has elapsed or a pressure build-up in the containment tank meets certain parameters, the vacuum process is halted and clean air is allowed to fill the chamber and the drum. The drum at this point is not only full of breached bags, but it is also free of hydrogen and VOC gasses.

The containment tank contains all of the gas pulled from the drum. What becomes of this gas is a decision left to the individual DOE sites based on the waste and the site’s criteria. There are many options including:

- venting to the atmosphere
- putting the gas through a carbon or other type of filter process
- any other options that work for the site

If there are sealed cans/containers or aerosol cans in the waste, it may be necessary to pressurize the drum contents using compressed air to breach these containers. The drum contents may be pressurized using a compressor (item 5 in Figure 1) before or after the vacuum process.

The Ultra-BagBuster technology meets requirements for the desired result of breached bags inside of waste drums. In particular, it is non-intrusive, provides worker safety, breeches bags regardless of size or placement in the drum, does not degrade the drum’s 7A rating, nor does it use heat or other treatment type methods.

PRELIMINARY RESULTS

Preliminary testing showed that polyethylene bags will rapidly fail based on the vacuum alone without the chilling process. This works with a single layer or as many as six layers of bags within bags. However, the nature of PVC bags caused them to inflate rather than breach.

Chilling the drum contents with liquid nitrogen caused the PVC bags to become brittle so that when the vacuum was applied, they breached very quickly as shown in Figure 3.

Fig. 3. PVC Bag breached using UltraTech's
Inner Layer of Confinement Reduction Method

A variety of combinations of PE and PVC bags were all successfully breached including combination packages of up to six layers of alternating PVC and PE bags. Additional tests were performed on the 55-gallon drum liners made of 8-mil polyethylene. The process successfully breached these bags as well as shown in Figure 4.

Another potential bag/waste combination that could present a problem was using a bag pulled tight up to a metal can filled with a solid (such as sand). The concern was the lack of internal atmosphere in the bag. Preliminary results show this combination to be successfully breached as shown in Figure 5.

Fig. 4. Eight mil polyethylene 55-gallon liner after the LN2 injection and evacuation process

Fig. 5. Breached polyethylene bag that was tightly sealed around a paint can filled with sand

The UltraTech Method for Breaching Inner Layers of Confinement is also referred to as the Ultra-BagBuster process as a shorter, working name. Based on the results of the preliminary testing the process has been refined to meet the criteria outlined by the TRU and Mixed Waste Focus Area and comments from various sites who have reviewed the technology.

SYSTEM TESTING AND EVALUATION

The INEEL, with funding provided by the TMFA, has developed a test plan (see Method for Breaching the Inner Layers of Confinement in TRU Waste Drums, INEEL/Ext-01-00078) to evaluate the overall performance of the Ultra-BagBuster technology against the criteria specified in Table 1. The tests are designed to evaluate the ability of the freeze/evacuate process to breach various packaging configurations for four different representative waste types. Packaging configurations are based on waste packaging descriptions in Revision 12 of the TRUPACT-II Content Codes (TRUCON) document. Waste types selected include solidified inorganic waste, solid inorganic heterogeneous waste, solid organic heterogeneous waste and solidified organic waste. The worst case packaging configurations consist of the maximum layers of confinement for each of these waste types.

Waste surrogate packaging configurations will be fabricated to determine:

- Effect of overall bag volume
- Effects of void volume
- Effects of bagging material type
- Effects of waste material composition within the bags

Waste materials to be used include simulated inorganic sludge (both damp and dry), organic liquid stabilized with Petroset, and heterogeneous waste consisting of glass, brick, metal, paper, cloth/rags and rubber. A split-plot statistical design has been used to determine the total number of configurations and tests to be run. Depending upon the results of testing, the statistical design has been established to be able to conclude with 95% confidence that the real waste success rate will be at least 95%

Testing is scheduled to begin in mid February 2001, so results should be available to present during the Waste Management 2001 Symposium.

SUMMARY

The Ultra-BagBuster technology has the potential to significantly reduce the cost, radiation exposure and the overall schedule associated with dispositioning those wastes that currently exceed the allowable TRUPACT-II hydrogen gas generation rates. Additionally, the Ultra-BagBuster technology could be modified or used in conjunction with low temperature vacuum desorption to remove chlorinated volatile organic compounds from debris waste forms to facilitate use of hydrogen gas getters. This would enable the use of the hydrogen gas getter DEB and possibly eliminate the need for an advanced hydrogen gas getter.