

Remote-Handled Transuranic Waste Drum Venting - Operational Experience and Lessons Learned - 8207

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ABSTRACT

Remote-handled transuranic (RH TRU) waste drums must be vented to meet transportation and disposal requirement before shipment to the Waste Isolation Pilot Plant. The capability to perform remote venting of drums was developed and implemented at the Idaho National Laboratory. Over 490 drums containing RH TRU waste were successfully vented. Later efforts developed and implemented a long-stem filter to breach inner waste bags, which reduced layers of confinement and mitigated restrictive transportation wattage limits. This paper will provide insight to the technical specifications for the drum venting system, development, and testing activities, startup, operations, and lessons learned.

INTRODUCTION

The Idaho Cleanup Project (ICP) at the Idaho National Laboratory (INL) successfully initiated the first-ever shipments of remote-handled transuranic (RH TRU) waste to the Waste Isolation Pilot Plant (WIPP) in January 2007. The development and implementation of characterization capabilities necessary to qualify the waste for transportation and disposal at WIPP preceded this significant accomplishment. The venting of the waste drums was the first step in the overall process implemented to support shipment of waste to WIPP.

Venting of waste containers destined for WIPP is required to allow aspiration of hydrogen and other flammable volatile organic compounds to ensure internal concentrations do not exceed safe limits and provide for equalization of pressure. Additionally, each debris waste stream must be headspace gas sampled to confirm acceptable knowledge concerning the assignment of hazardous waste numbers.

The ICP inventory of RH TRU waste consists of 675 drums (80 m³) of RH TRU waste generated by five different generators. The wastes are contained in both 30- and 55-gal size drums. The majority of these drums required venting to comply with transportation and WIPP disposal requirements. Radiation contact dose rates ranged up to a maximum of 52 R/hr, with most of the drums being less than 10 R/hr. The majority of the waste drums consisted of debris waste forms.

RH TRU DRUM VENTING SYSTEM DEVELOPMENT

Development of the RH TRU Drum Venting System (DVS), including a filter to allow headspace gas sample collection, was initiated in 2005. A decision was made to competitively bid the design, development, testing, and operation of the RH TRU DVS.

A technical specification was developed to define performance criteria. This specification also addressed concerns expressed by the Defense Nuclear Facilities Safety Board (DNFSB). The DNFSB, an independent Federal agency established by Congress in 1988 to provide safety oversight of the nuclear weapons complex operated by the Department of Energy (DOE), has over the years identified several concerns regarding handling of unvented TRU drums, venting of TRU waste drums with concentrations of hydrogen and/or volatile compounds in excess of Lower Flammability Limit, and handling of newly vented drums [1]. The RH TRU DVS design planning took into account these concerns and lessons learned from across the complex and made every effort to build-in engineered safety features in the system.

These concerns were primarily associated with the physical protection of personnel and containment of radiological contents if a deflagration or detonation were to take place in a drum containing high concentrations of flammable VOCs during venting.

Contracting Approach

The DVS was the first-ever for venting RH TRU waste, and due to the limited quantity of waste containers requiring venting and need for demonstrated venting experience, it was decided services from the commercial sector would be the most effective approach and could capitalize on ICP venting development activities started in the early 1990s. Interest from commercial vendors was sought in 2004 for RH TRU characterization activities.

Based on review of the responses and cost analyses of developing one-of-a-kind system at ICP, we decided that a turnkey system developed by commercial vendor that meets the “ICP Performance Specification” was desirable. We also decided that instead of buying a system outright, it would be best to obtain venting as a “service,” meaning the vendor would design and build a system that meets ICP project specifications, support system installation onsite, provide qualified staff to vent the containers, and demobilize the system. This approach would encourage vendors to invest some of their own resources in a venting system that could be used at other DOE sites across the complex. A proposal for providing venting services was sought from two companies based on responses received in 2004, and only one company, Nuclear Filter Technology, responded with a bid. The proposal was evaluated by a team of personnel, and the contract was established with a number of clarifications and changes to the specification based on negotiations.

The subcontract for design, fabrication, and demonstration testing of the RH TRU DVS was awarded to Nuclear Filter Technology in 2005. Nuclear Filter Technology (NucFil) originally established itself in 1986 to provide safe venting of flammable gas mixtures from nuclear waste containers. They developed the activated carbon-bonded media filter, which provided the means for many DOE sites to address these safety concerns. Since that time, NucFil has developed other product lines such as DVSSs, real-time gas measurement systems, gas generation testing equipment, and other waste management support services primarily to DOE sites.

Development of Performance Criteria

A survey was performed of existing DVSs used for venting contact-handled TRU waste to support development of the technical specification. A literature search was performed on pressurizing and venting drums with elevated levels of hydrogen and flammable volatile compounds. The issues related to personnel safety during handling of unvented as well as newly vented drums were also evaluated. Incidents such as TRU waste drum fires and drum deflagration events heightened the visibility of the venting issues and actually helped in developing the specification.

One main objective of the performance specification [2] was ensuring remote handling capability, minimal exposure of personnel to radiation, and adequate protection of personnel if a drum explosion occurred during venting.

Key technical and performance requirements for the RH TRU DVS were:

- The DVS shall be capable of securely installing a WIPP-certified vent filter with a minimum H₂ diffusivity of 3.7E-06 mol/s/mf in a RH TRU waste drum lid (30- or 55-gal) without unacceptable hazard to operator from radiation and air emissions during normal operations and possible abnormal events during venting (e.g., ignition of combustible gases inside a drum). The drum filter shall remain seated, in the drum lid and be functional throughout all expected drum-handling operations.
- Design, build, and test a containment chamber for the DVS that can withstand 340 psig pressures postulated inside a drum resulting in deflagration pressure of 103.5 psig at drum lid level [3]. The containment chamber was required to contain debris resulting from the explosion.
- The DVS shall be capable of venting at least 10 drums per 10-hr day and capable of being decontaminated and repaired following an abnormal venting occurrence to be operable and back on line within 8 days of the occurrence.
- The system was required to be tested for the requirements identified in the performance specification at the vendor's location before shipping and retested on-site once it is reassembled to the same requirements.

After a proposal was received from the vendor, based on mutual negotiations, the system design was agreed upon that included a number of engineered features to mitigate the drum deflagration events and enhance worker protection. The primary engineered features included:

- Nitrogen purge before start of filter installation to eliminate oxygen from the exhaust system to prevent explosion induced by static charge.
- Continued nitrogen flow during installation for providing dilution of flammable gases that might be released from un-vented drum and/or provide inert environment at the point of drilling.
- A tested and proven "cold drilling" process (controlled rotation speed and start stop sequence)
- Addition of temperature gauge to detect elevated temperatures at drum lid level and a pressure gauge near the drum lid that can sense change in pressure, which can be used to indicate an abnormal event.
- Exhaust line (with in-line HEPA filter and vacuum routed outside the building).
- Addition of quick-disconnects to the exhaust and air supply lines to allow for reduced radiation exposure and decontamination after abnormal event.

DVS System Design

NucFil has designed five DVSs before development of the RH TRU DVS. NucFil adapted its filter installation device used in all of the previous DVSs, known as a Powerhead (see Fig. 1), to the needs of a remote handled system. This Powerhead design is responsible for successfully venting thousands of contact-handled waste drums.

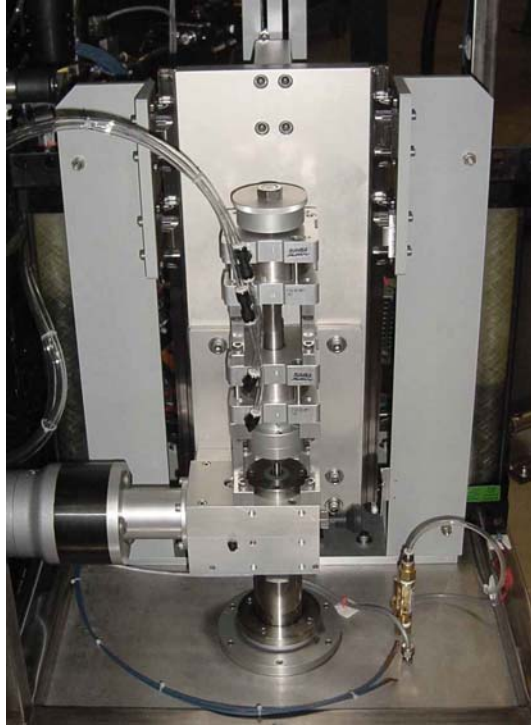


Fig. 1. Powerhead Assembly.

The first design challenge was to determine how to move the drums to and from the Powerhead for venting. A bridge crane was determined to be the ideal drum transporting device as it is a reliable, industrially standardized piece of equipment that is easily adapted for operation by camera rather than direct observation.

The second design challenge was to determine how to combine the worst case drum deflagration containment requirements with the crane operation. A cylindrical containment chamber was designed with the strength to withstand a possible deflagration event as well as have a large opening for easy depositing of drums by the crane. The lid of the containment chamber was designed to transport the Powerhead as well as seal the chamber in a single step. The drums are held in position by a series of interchangeable drum supports that adapt the chamber for 30- and 55-gal drums. The actual drum venting then takes place inside the sealed chamber.

The entire venting operation is shielded by concrete rounds and blocks. The shielding prevented any operator line of sight with the drums, forcing all drum movement to be monitored by four cameras. The entire DVS was designed to be run outdoors in all weather conditions except high wind.

The filter was designed to provide gas venting and diffusion as well as support the need for post-installation syringe sampling, and was designated the 407DS. NucFil's direct sample style filters use a

sintered stainless steel media for particle filtration and silicone septa for needle insertion for gas sample collection.

The 407DS filter has a special feature designed specifically for remote-handled drums, which is a locking top thread. Once the filter is fully installed and the o-ring is compressed, the drum lid locks above the top thread, keeping the filter from backing out. This design feature ensures consistent compression, requires no post-installation torque testing, and ensures that the filter does not strip-out from over torquing.

DVS Fabrication

The RH DVS was designed, engineered, and fabricated in Golden, Colorado, for a demonstration test with CWI representatives. Parts were purchased and manufactured in-house and were assembled into the primary subsystems, including the crane, containment chamber, powerhead, shielding and operator controls. The crane was assembled first and the other systems were installed under it. All of the subsystem controls were routed to the primary operating area known as the “control hut.”

System Factory-Testing

During the fabrication of the RH TRU DVS, several systems needed proof testing to ensure compliance with the contracted technical specifications. The containment chamber pressure test was by far the most difficult to complete. This test required ensuring that the containment chamber would not rupture if the worst possible deflagration event occurred during venting, by hydrostatically pressurizing the chamber to 125 psig. The picture below shows the test setup where the water was pumped into the chamber and the internal pressure and 1.5-in. thick lid deflection were monitored.



Fig. 2. Containment Chamber Test Fixture.

Additionally, the Powerhead was tested to determine how much heat was generated during the filter installation process. Any temperature in excess of the minimum ignition temperature of the most flammable VOC gas mixture would have been unacceptable. The test results showed that the on-off cycling by the Powerhead known as “cold drilling” kept temperatures below 138°F.

The final factory test performed before shipment was a functionality test. CWI personnel were present for the demonstration of the equipment where six simulated RH drums were processed. This test was a verification of minimum processing speeds, radiation control, specification compliance and operability. The result of this test was a list of minor modifications to the equipment to ensure a smooth transition into hot operations in Idaho.

DVS INSTALLATION AND STARTUP

Existing building 1634 at INTEC was modified to accommodate the RH TRU DVS. Although the DVS had been designed for outside operation, a strategy change was made to provide indoor year-round operating capability. Key advantages of using this facility included an existing overhead crane to support emplacement of shielding blocks and removal of the concrete storage box lid; adequate building heat to support headspace gas sampling; and the facility was available for immediate use. Modifications to building 1634 consisted of:

- Power upgrades and connections to the RH TRU DVS
- Installation of a grounding system
- Installation of anchor bolts to support the DVS crane system
- Ventilation connection for the DVS off-gas system
- Emplacement of shielding blocks for personnel radiation protection
- Installation of an integrated building camera system to allow Operators to get an overview of the entire DVS process.
- Installation of flow control meters on the purge gas line to ensure adequate nitrogen gas purge rates.



Fig. 3. Assembled RH TRU Drum Venting System.

After installation of the RH TRU DVS was completed, nonradioactive demonstration acceptance testing was performed to verify system performance to the technical specification. Before performing the onsite acceptance testing, NucFil personnel operating the DVS received site-specific training necessary to

perform as an operator. The acceptance testing demonstrated both system functionality and final qualification of NucFil personnel to operating procedures.

A contractor management self-assessment and contractor readiness assessment were performed to assess readiness to perform nuclear operations. This level of review was necessary to (1) verify implementation of the authorization basis that increased the radioactive source term to Hazard Category 2 levels and (2) due to the first-ever venting and headspace gas sampling of RH TRU waste drums. The assessments resulted in several pre-start findings that were addressed before receiving authorization to initiate drum venting operations. Key pre-start findings were:

- Improving adequacy of air sampling and monitoring
- Improving adequacy of radiological contamination controls and placement of radiological monitors
- Providing documentation verifying inspection of anchor bolts for the RH TRU DVS crane
- Performing modifications on vendor supplied equipment without obtaining prior authorization or approval.

Approval to begin drum venting operations was provided, and venting operations were initiated in November 2006 and concluded April 2007.

OPERATIONAL EXPERIENCE AND LESSONS LEARNED

Over 490 drums of RH TRU waste were successfully vented using the NucFil 407-DS filter. During the venting campaign, no radiological contamination was detected nor released. Production operations were planned at 10 drums per day with a weekly production goal of 40 drums per week. The NucFil DVS demonstrated capability of venting up to 23 drums per day. No significant operational issues were encountered during the venting operation. Two 30-gal drums were over-packed into 55-gal drums due to concave drum lids that did not allow complete filter installation. Key operational lessons learned included:

- Ensuring work plans and schedules provided a constant feed of drums for venting
- Providing a more complete set of backup spare parts; the part that breaks is never what you planned for
- Long duration venting campaigns should consider allowances for a second Powerhead to minimize downtimes if a significant failure occurs.

DVS MODIFICATIONS FOR BAG BREACHING

After completing the initial drum venting campaign, development of transportation decay heat wattage limits revealed that a significant portion of an ICP RH TRU waste stream generated by ANL-E could not comply with the limits. The presence of double heat-sealed bags affected the diffusion of hydrogen from the package and resulted in wattage limits that could not be met without remediation. Breaching the heat-sealed bags containing the waste cans would reduce the layers of confinement and allow for an increase in wattage limits. The options available to remediate the waste were to either process the drums through a hot cell by opening the drum and breaching the heat-sealed bags; or find an alternative approach to breach the bags. A concept was developed to capitalize on the existing DVS system and experience and develop a filter with sufficient length to puncture the drum lid and extend far enough into the drum to compress the heat-sealed bags against the upper inner waste can [4, 5]. The filter was then driven through the heat-sealed bags and top of the inner waste can lid to breach the bags. Extending the filter into the upper waste

can allowed a means of verifying bag-breaching using radiography, if needed. The development of the long-stem filter was selected as the preferred alternative to mitigate the decay heat wattage issue.

DVS Modifications and Filter Design

The RH TRU DVS required modifications to two subsystems to complete the installation of long filters, the Powerhead and the containment chamber. Though the Powerhead was designed to handle a large range of filter lengths, certain modifications were required to ensure proper installation of long filters. The Powerhead itself needed switch position modifications to indicate to the control logic where to begin drilling as well as where to perform the new reverse sequence. Reversing of the filter is required to unwind the inner bags from the drill bit of the filter. The logic itself had to be modified to perform the reverse, as well as modify the purging of the drill area. Purging was turned off during drilling in an effort to minimize the energy introduced into the potentially contaminated headspace of the drum.

The containment chamber was modified to align the drums in the center of the Powerhead. This new drum alignment ensured penetration of the top inner container as well as not interfering with the previously installed filter.

The new long filter, known as the 407LS, was designed to provide a gas pathway from inside of the bags to the headspace of the drum. The gas pathway is provided by slots that run vertically along the shaft of the 407LS. Unfortunately, the slots severely weakened the torque resistance of the filter, requiring the tube to be strengthened, which made it quite bulky. The length was determined by analyzing the three types of drum internal configurations including two 7-gal, one 5-gal and one 10-gal, and three 5-gal inner containers. The 407LS is of sufficient length to provide 1 to 2 inches of penetration into the top inner container.



Fig 4. Installed Long-Stem Filter.

Verification of Bag-Breaching

A series of mock-up test drums were prepared to demonstrate both successful breaching of the heat-sealed bags and also determine whether the breaching would result in release of radioactive material. Based on the waste packaging and modifications made to the DVS in operating mode, it was believed to be highly unlikely that a release would occur. The test drums were prepared according to the waste generator procedures and fluorescein was used as a surrogate tracer material for radioactive material. Placement of the tracer material in the test drums were representative of both the expected location of radiological contamination and then a conservative placement of tracer directly beneath the drum lid. After filter insertion tests were completed, test drums were opened to validate breaching of the inner bags and upper waste can. In summary, the tests showed for the expected waste packaging case that radiological materials would not be released. However, the more conservative tests did show a release of tracer from the drum.

A radiological containment tent was designed and placed around the DVS to ensure containment and protection of personnel.



Fig. 5. Breach Bag Testing – UV Light Check.



Fig. 6. (Left) Long-Stem Filter Penetration; (Right) Bag Breaching Through Multiple Layers.

Bag-Breaching Operations

Bag-breaching operations were initiated in October 2007 and concluded November 14, 2007. Over 80 waste drums were re-vented using the long-stem filter. Production operations were planned at six drums per day. However, as operation and radiological controls personnel became experienced and proficient with moving drums in and out of the containment tent to access the DVS, this production rate would be as high as nine drums a day. All operations were successfully completed with no radiological contamination

release from the drums. Completion of this activity allowed transportation qualification of RH TRU waste drums to support the accelerated shipment schedule.

CONCLUSION

A corroborative effort between CWI and Nuclear Filter Technology resulted in successful venting of over 490 ICP RH TRU waste drums to support characterization and transportation of waste for disposal at WIPP. Venting allowed for compliance with transportation criteria and the filter designed for venting provided capability to collect headspace gas samples for meeting characterization needs. Development of the bag-breaching filter capitalized on the existing DVS capability and protection features to reduce the inner layers of confinement in over 80 RH TRU waste drums. The completion of both venting and bag-breaching operations support the U.S. Department of Energy's goal of accomplishing accelerated disposition of ICP stored RH TRU waste.

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