Office of Environment, Health, Safety and Security
Operating Experience Level 3

OE-3: 2018-04 **May 2018**

Pipe Over-Pack Container (POC) Fire Test Results

PURPOSE

This Operating Experience Level 3 (OE-3) document provides information shared with Department of Energy (DOE) Facilities with respect to Pipe Over-Pack Container (POC) Fire test results and their potential effect on safety basis analyses prior to future planned updates to DOE-STD-5506-2007, *Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities*. Phase I and II POC Fire Tests were initially reported in a published Sandia Report, SAND2017-5684, Pipe Over-Pack Container Fire Testing: Phase I & II, May 2017. Follow-on tests that have been conducted since these tests will be reported in additional Sandia Reports in the near future. However, due to the impact the information from these tests can have on safety basis conclusions and to provide potential resolution to declared Potential Inadequacy of Safety Analyses and prohibitions in documented safety analysis documents within the DOE complex, initial results and interpretations of the data obtained and design resolution to the POC are presented below in this OE-3 Report.

BACKGROUND

On February 14, 2014, an airborne radiological release occurred at DOE's Waste Isolation Pilot Plant (WIPP) near Carlsbad, NM. On March 4, 2014, an Accident Investigation Board was appointed to determine the cause of the release. The Phase 2 investigation report was issued on April 16, 2015, describing in detail the known facts concerning the event. It was determined that the WIPP release was not an accident type previously delineated in DOE-STD-5506-2007. As a result, a thorough review was conducted of DOE-STD-5506-2007 and areas identified that required improvement. At that time a project to update DOE-STD-5506-2007 was initiated. In the same time frame, an Evaluation of the Safety of the Situation was submitted to the National Nuclear Security Administration's (NNSA) Los Alamos Field Office (NA-LA), requesting a Damage Ratio (DR) of Zero (0) be applied to all POCs that contained combustible and reactive waste. The NA-LA Safety Basis Review Team questioned the validity of this request because the original test series in 1996 was in support of particulate and residue waste from Rocky Flats, and did not support use of the POC for combustibles beyond limited materials utilized for internal packaging of the particulate and residue waste. As a result, tests of the POC with combustible waste contents were initiated as an initial effort to obtain data to properly assign a DR and also, if needed, an Airborne Release Fraction/Respirable Fraction . This data would be used to support an update to DOE-STD-5506-2007.

DOE-STD-5506-2007 describes fire damage testing for TRU waste containers in Section 4.4.3. In the last paragraph, it states: "In the case of POCs, the containers are designed in a manner that precludes their failure during expected storage area fires. POCs involved in storage and room fires need not be further evaluated in an accident analysis."

Consequently, a DR of 0 may have been assigned to POCs in some safety basis documents. However, this DR value offered

for POCs bounded by the fuel pool fire could be non-zero for POCs containing combustible TRU wastes. A review of prior POC fuel pool fire testing described in the standard has highlighted that this POC testing was performed with aluminum metal samples and not with surrogate contaminated combustible wastes inside the pipe component (PC). The presence of combustible waste inside the PC can result in its pressurization beyond that experienced in the POC development testing. Consequently, the use of a DR of 0 as justified in NSTR-001-97 for residues and particulates from Rocky flats or the airborne release fraction for pool fires of 6E-6 for powders presented in the last paragraph of Section 4.4.3 is not supported by previous testing when POCs contain combustible wastes.

Additionally, this DR is not appropriate for all types of fires, namely (as discussed in the last paragraph in Section 4.4.3) "engulfing fuel pool fires that last longer than 30 minutes exceed the testing conditions and may cause sufficient impact to POCs to warrant assessing the release."

OVERVIEW

The POC was developed at Rocky Flats to transport more-concentrated plutonium and americium residues than previously packaged TRU waste to WIPP for disposal. The 1996 Sandia National Laboratories (SNL) test series was performed to determine the degree of protection POCs provided during postulated storage accident events. One of these tests exposed four of the POCs to a 30-minute engulfing pool fire, resulting in one of the pipe over-packs losing its lid and exposing the top of the PC to the fire environment. The contents of the PC in the test were non-surrogate inert materials, which would not generate prototypic internal pressure within the PC if heated. RF used the results of the 1996 test to develop a DR of 0 for their use with residues and particulates. This is the use currently contained and described in DOE-STD-5506-2007. POCs, however, are now being used to store combustible TRU waste at DOE sites for which the 1996 tests are not representative. At the request of DOE's Office of Environmental Management (EM) and NNSA, SNL has conducted a series of new fire tests on standard pipe over-pack containers (12 in). While there are several other POC designs, they are either authorized only for shipment of non-combustible waste or have never been used for shipment of waste to WIPP. The purpose of these fire tests was to examine whether PCs with combustibles could reach a temperature that would result in (1) decomposition of inner contents, (2) generation of sufficient gas to cause the PC to over-pressurize and release its inner contents into the fire, or (3) confirmation that sufficient heat was present in time to allow an engineered design change to eliminate the potential problem all-together. Tests conducted during 2015, 2016, 2017 and 2018 and described herein, were done in several phases. The goal of the first test series was to determine if the internal PC would reach high enough temperatures (e.g. 240 °C) to decompose typical combustible materials within the PC (i.e. pyrolysis). During these tests, it was determined that the magnitude of damage to the POC was dependent upon whether the POC lid was retained or ejected. Therefore, subsequent tests were conducted to determine under what heat loads (i.e., incident heat fluxes) the drum lid is lost from the POC, exposing the inner contents with subsequent ignition of the fiberboard liner. The final two test series conducted were explicitly designed to test an alternate filter vent for use in the currently approved POC in single drum and stacked drum configurations. Filters for venting are required during storage and transport to WIPP and are also a required component for the POC.

SUMMARY AND CONDUCT OF POC FIRE TESTS

The goal of the 2015-2016 test series was to see if the PCs filled with inert material inside the POCs would reach temperatures that

would result in the generation of sufficient gas to cause over-pressurization of the PC and subsequent release of its aerosol contents when engulfed in a fire. All tests were conducted inside the Fire Laboratory for Accreditation of Models and Experiments (FLAME) test cell located in SNL's Thermal Test Complex . A 3-m circular pool was utilized and centered within FLAME. The pool, initially filled with Jet-A fuel, employed a remote refueling system to add fuel to the pool in discrete amounts to keep the POC fully engulfed. This resulted in a total power of 100 MW based on the heat of combustion of Jet-A fuel times the burn rate. To limit the fire to the desired time, the pool employs a drain system that dumps all remaining fuel at the end of the test which effectively quickly terminates the fire. Fuel consumption for these tests was approximately 7 gallons per minute. These initial tests consisted of a one hour burn which exceeded the normal 30-minute fire test requirements. These tests were conducted in an attempt to reach steady state temperatures on the numerous thermocouples (TCs) within the POC and on the PC. Intended use of the data is for empirical support to analytical modeling and therefore should not be considered typical for bounding safety basis analysis unless sufficient fuel and configuration exists for an extreme fire in a facility under evaluation. Thermocouple data from these initial tests are available for use in estimating unmitigated temperatures the POC would experience from a pool fuel fire considering actual fuel quantities available in analyzed accident scenarios. Subsequent tests were limited to a nominal 30-minute test burn. In these tests, lid loss from the POC was consistently demonstrated at approximately 3 minutes for appropriately torqued lids. Therefore, unmitigated analysis considering fires lasting longer than 3 minutes should consider that complete combustion of the fiberboard within the POC will result (See Figure 1).

Figure 1
All fiberboard consumed by fire after lid loss.

All tests consisted of one POC placed at the center of the pool, with additional drums placed outside of the fuel pan in selected tests at various distances to reflect various potential intensities of a facility fire. The POC at the center of the pool was always resting on a square-grid table, 1-m above the fuel pool surface and directly above a 55 gallon drum. This stacked configuration is representative of what is seen in storage facilities with drums stacked in arrays and represents a conservative position with respect to the engulfing flames. In all initial tests the top center drum was instrumented with at least four TCs while the lower empty drum was never instrumented. All drums and PCs were extensively photographed before and after the test to document effects resulting from the fire tests.

FILTER DESIGN CHANGE AND 2017/2018 TESTING

The 2015-2016 testing led to a strategy of employing an engineering solution to prevent POC lid loss. UltraTech International, Inc. (UltraTech) provided a potential alternate filter for testing. This new filter used a different design assembly that, in the event of a fuel pool fire, would allow unobstructed flow of internal POC gasses out of the ¾-inch drum lid opening in which the filter is installed. The filter threads are reduced in diameter from the typical standard approved filter, and a

polyethylene sleeve is used between the filter and the drum lid to secure the filter in place. Under the temperature conditions of a pool fire, the plastic sleeve melts and allows the filter to be ejected. Testing completed in November 2017 confirmed that, for the test conditions of the pool fire, pressure relief with this new design filter is sufficient to prevent 55-gallon drum lid loss although drum lid seal failures were noted (three identical repeated tests demonstrated this). Absent lid loss as shown in Figures 2, 3, and 4, the insulating properties of the packing (fiberboard) surrounding the PC prevent excessive temperature that could cause pyrolysis of combustible material inside the PC or damage the seals on the PC. The pristine condition of waste contained within the PC after the test is shown in Figure 5. This new filter design also has been tested and certified to maintain Type A certification of the POC as required by 49 CFR 173 for use in commercial transportation.

Figure 2
POC drum after pool fire with UT9424S. Note filter adjacent to open ¾-in bung hole along with apparent drum lid seal failure in the foreground

Figure 3
POC drum using UT9424S with drum lid removed after pool fire showing charred fiberboard lid

Figure 4
Post test condition with charred fiberboard cover removed showing fiberboard remaining between drum circumference and PC

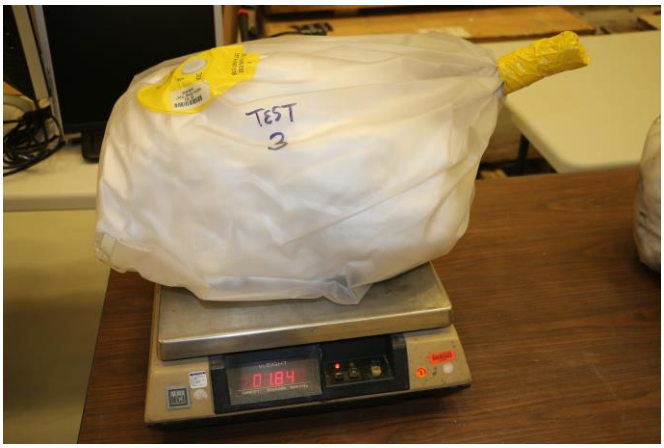

Figure 5
Pristine nature of surrogate waste from PC after pool fire tests with UltraTech 9424S Filter

During conduct of the 2017 tests, with the new filter, pyrolysis gasses were observed exiting under pressure from the ¾ inch vent opening after the filter loss, and igniting after exit. Indications from infrared measurements led to questions with respect to stacking of drums with the new filter and the potential effect in the event of a pool fire. Subsequent stacking tests were therefore conducted in March and early April 2018.

Two tier POC tests were conducted with a metal pallet between layers positioned both to allow flare impingement on the drum above and blocked by the pallet; use of the WIPP slip sheet between the stack in a limited 5 minute fire; and finally a three tier POC test with a pallet blocking the flare (which was found to be bounding in the two tier tests) between each level. The single drum stack configuration rather than a drum array is considered bounding to other instances where up to four POC drums are configured on a pallet, banded or un-banded, and stacked as well as the various authorized WIPP stacking configurations.

TEST RESULTS

For the POCs, results included temperature measurements of the exterior and interior of POC components, limited pressure data, as well as qualitative data that showed the state of the POC components after the fire. Complete results will be published in official Sandia Reports at a later time, and will subsequently be incorporated in a revision to DOE-STD-5506-2007.

DISCUSSION AND RECOMMENDED USE OF RESULTS

Test results above support a conclusion that as long as the drum lid remains on the outer Type A drum (even with 55 gallon drum lid seal degradation), the fiberboard will sustain charring, but self-extinguishes when the flames from the pool fire die down. As a result of the insulating effect provided by the fiberboard, maximum temperatures within the PC component do not exceed 80°C, which does not threaten ordinary combustibles placed in the PC (See Figure 5). The filter gasket and O-ring of the PC after the tests where lid ejection did not occur were found to remain pristine.

The engineered filter replacement is an UltraTech 9424S filter (Patent Pending) which is a special modification to the previous WIPP approved UltraTech 9424 filter. With Type A testing already accomplished, WIPP is working to approve the UltraTech 9424S filter in the next update to the approved filter list associated with the approved POC design criteria.

For Safety Basis purposes, POCs that have the UltraTech 9424S filter installed per manufacturer's specifications in the 55-gallon drum ¾ inch lid opening can be assigned a DR of zero, irrespective of whether they contain residues, particulates, combustibles, or any other waste form in an authorized configuration for scenarios bounded by the evaluated test conditions.

This OE-3 document requires no follow-up report or written response.

Contact information on following page.

INFORMATION CONTACT

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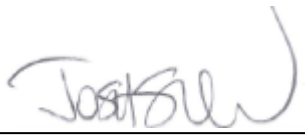

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