Idaho Cleanup Project

Fire Testing to Support Waste Sack Storage at INL

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Purpose

- Provide information on a series of fire tests that permitted increased flexibility in the storage of waste sacks at the INL

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Background

- The Radioactive Waste Management Complex (RWMC) is operated by the Idaho Cleanup Project (ICP) and is located at the Idaho National Laboratory (INL) Site
- The primary mission of the RWMC is to safely dispose of low-level radioactive waste and remediate buried mixed transuranic (TRU) waste in the Subsurface Disposal Area (SDA) of the RWMC
- The Accelerated Retrieval Project (ARP) is conducting excavation operations to remove specific targeted waste items at RWMC within the INL

Background, continued

- The process involves excavation and opening of drums to determine if they contain target material to be removed for later disposal at an authorized facility
- Non-targeted and secondary waste remains in the SDA enclosure and is the primary material of concern in the fire scenarios to be discussed.

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Background, continued

- To facilitate the removal of the waste, tent structures that are constructed of NFPA 701 compliant material have been and are being constructed at the excavation areas
- Based on the size and operations within these structures, the DOE Orders require a fixed fire suppression system that typically consists of automatic sprinklers
- Due to various constraints, automatic sprinklers were not provided in the ARP tent structures. The lack of sprinklers has required a strict set of controls and demonstration that potential fire scenarios are limited
- The ARP configuration for waste staging prior to reburial was judged to pose a minimal fire hazard, but a confirmatory technical basis was sought via fire testing

Basis for Fire Testing and Modeling

- Some wastes and the soil sacks are combustible, so conceivably the arrays of staged material might burn
- There are two types of waste:
  - Non-targeted waste – material not required to be retrieved
  - Secondary waste – material generated by operations and maintenance personnel that is left in the excavation area
- Fire testing was needed to determine if a new operating strategy was required
- There were two pertinent safety concerns:
  1. The size of a fire which might occur involving these wastes.
  2. The total quantity of radiological material that might be released in such a fire

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Basis for Fire Testing and Modeling

- With respect to radiological release, the existing waste staging strategy would be supported by testing that demonstrated:
  - limited fire propagation in a storage array (i.e., if the fire died out without affecting much of the array);
  - a low damage ratio as fire propagated through an array (i.e., showing that most waste was not affected by fire that effectively skipped through the array and went out); or
  - such slow propagation that suppression by the fire department could be assured (i.e., showing limited fire scope 30-minutes after achieving a known detectable size)
- Conversely, a result demonstrating that the entire array could be affected prior to manual suppression would not support the waste staging strategy

Fire Testing of Waste Sacks

- Small scale testing conducted at HAI's Baltimore office
- Large scale testing conducted at Omega Point in Texas
- The purpose of the tests was to evaluate:
  - The potential for a sustained fire resulting from exposure to a flaming fire
  - Propagation throughout a typical waste sack array
  - The potential for involvement of the waste sack contents
  - The effects of the prototype "X" frame sack stiffener compared to standard cardboard stiffeners

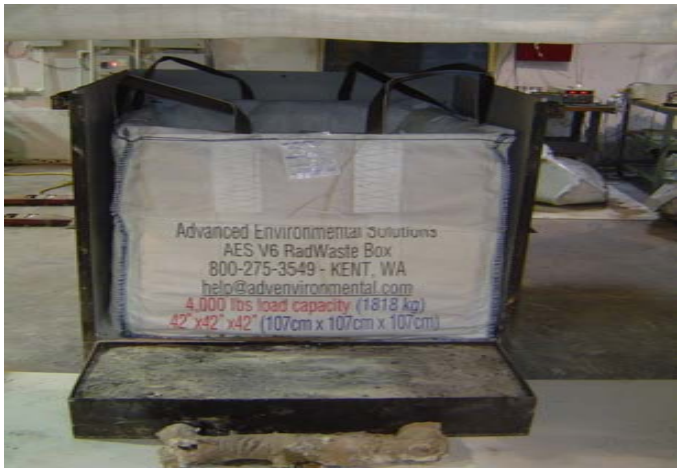
Fire Testing – Small Scale Tests

- Testing was conducted under the HAI calorimetry hood
- The test article was a single waste sack with contents representative of those encountered at the ARP
- The smoldering fire scenario utilized a tubular heater embedded in a drum inside the sack near the bottom with its heated length passing through the center of the sack.
- The waste sacks, contents and soil were all provided by APR personnel and the preparation (loading) of the test articles for the first four tests conducted was supervised by ARP personnel

Fire Testing – Small Scale Tests

- The flaming fire exposure was a propane sand burner positioned along the front face of the test article.

Soil sack



Propane sand burner

Small Scale Tests

Photographs taken during flaming exposure test with non-targeted waste and cardboard stiffeners (Test 1F) during and after operation of the propane burner

Fire Testing – Small Scale Tests - Results

- Nine tests were conducted:
  - Six flaming fire exposures of non-targeted waste sacks
  - Two flaming fire exposures of secondary waste sacks
  - One smoldering fire in a non-targeted waste sack.
- In all but one of the flaming fire exposure tests, the waste sack material was quickly ignited and continued to burn until all of the material that wasn't covered in soil or pressed against the gypsum wallboard lined support frame was consumed

Small Scale Tests - Summary

- During one test, the flame front of the burning sack material propagated only halfway along the side faces toward the rear face of the waste sack
- The involvement of the contents of the sack in the fire event depended on whether the contents were exposed to fire after the walls of the sack collapsed
- The contents of one or more drums were ignited and continued to burn for more than an hour for 4 of the 6 tests of sacks containing non-targeted waste
- 25% of the drums contained in the non-targeted waste sacks were ignited during these tests

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Small Scale Tests - Summary

- During both tests involving the flaming fire exposure of waste sacks containing secondary waste, the secondary waste was ignited and was eventually extinguished when the soil on top of the waste shifted covering the area that was ignited
- The use of gypsum wallboard as stiffeners and horizontal banding was demonstrated to have a positive impact in limiting the exposure of the sack contents during a fire event
- The utilization of the prototype waste sack incorporating the tubular aluminum “X” frame stiffener was also demonstrated to have a positive impact in reducing the heat release rate of the resultant fire

Small Scale Tests - Summary

Stiffeners Utilized	Drums or Bags Ignited	Combustible Material Consumed	Soot Produced	Maximum Heat Release Rate Excluding Burner	Average Heat Release Rate (1 to 6 min after Burner Secured)
		[kg/test]	[g/test]	[kW/test]	[kW/test]
Cardboard	**4 of 16**	**12.2**	**236**	**406**	**91**
Gypsum Wallboard (Std or Type X)	**2 of 13**	**4.6**	**60**	**152**	**42**
Aluminum "X" Frame	**1 of 3**	**2.2**	**43**	**70**	**22**

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Small Scale Tests - Conclusions

- The combustibility of the materials used to construct the waste sacks facilitates the fire progression from one sack to the next in the staging area
- The potential for this occurrence was demonstrated by the total consumption of the waste sacks above the soil level and on the exterior where not pressed against the support frame
- The potential for involving the contents of the sacks was demonstrated and found to be a random event dependent on the extent of the exposure after the sack walls collapsed

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Small Scale Tests - Conclusions

- The exposure was reduced when the 5/8 inch Type X gypsum wallboard was used instead of the standard cardboard stiffeners and metal bands as the amount of soil that shifted was decreased
- A prototype waste sack that incorporated a tubular aluminum “X” frame stiffener was found to reduce the heat release rate of the fire and would correlate to a slower fire spread rate throughout a waste sack array

Large Scale Fire Tests

- Larger scale fire testing was conducted to investigate the spread and speed of the fire from one sack to the adjacent sacks and the subsequent involvement of the waste sack contents in the fire
- The tests were conducted under the calorimetry hood located at Intertek Testing Services in Elmendorf, Texas
- The test array consisted of sixteen 42 inch wide waste sacks arranged in a four by four array

Large Scale Fire Tests

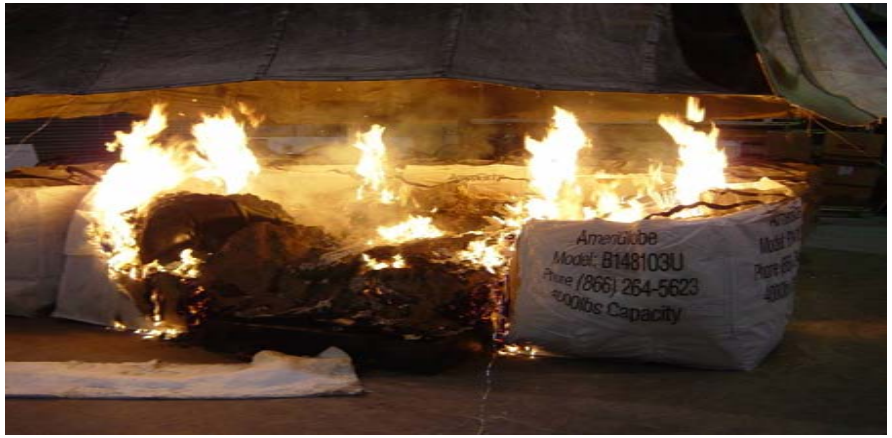
- During one test, a second level of sacks was added to the array for a total of 32 waste sacks – a combination of non-targeted and secondary waste was used
- Two types of stiffeners for waste sacks were utilized during these tests
  - A standard 0.5-in. thick cardboard sheet stiffeners currently incorporated in the waste sack
  - An “X” frame stiffener constructed of aluminum tubing to reduce the amount of combustible material

Large Scale Test Fire Scenario

- The flaming fire exposure was produced by a propane sand burner positioned along the front face of the waste sack
- Intertek's calorimetry hood was equipped to measure heat release rate and smoke production rate
- The calorimetry hood incorporated an oxygen consumption methodology

Large Scale Test Results

- Three tests were conducted
  - one 16-sack array test with the standard cardboard stiffeners,
  - one 16-sack array test with the prototype “X” frame stiffeners,
  - and one two-tier sack array test incorporating the cardboard stiffeners utilizing 32 sacks.



8 minutes after ignition – front row view – single-tier sack array with cardboard stiffeners (Test 1A)

Full Scale Test

8 minutes after ignition – front row view – single-tier sack array with cardboard stiffeners (Test 1A)

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Test 1 Results

- One 16-sack array test with the standard cardboard stiffeners
  - The test was secured approximately 2.5 hours after ignition of the propane sand burner.
  - At that time flames were still emerging from the drum at the top of Sack 14 and burning material at the back of Sack 15 was reduced to small flames.
  - Dissection of the array revealed 7 of the 54 drums contained in the array showed signs of involvement in the fire (charring or melting of contents) and 4 of the 7 bags of secondary waste had melted or charred contents.

Test 1 Results

- One 16-sack array test with the standard cardboard stiffeners
  - Overall 5 of the 16 sacks had contents involved in the fire, including the secondary waste sack.
  - All of the 5 sacks which had contents involved in the fire were along the perimeter of the array

Test 2 Results

- One 16-sack array test with the prototype "X" frame stiffeners
  - The test was secured 3 hours after ignition of the propane sand burner.
  - The burning of the drums in Sack 13 was continuing; however, burning elsewhere in the array was limited to smoldering combustion.
  - Overall 8 sacks had contents involved in the fire. Seven of the eight sacks that had contents become involved in the fire were on the perimeter of the array. Overall 8 sacks had contents involved in the fire. Seven of the eight sacks that had contents become involved in the fire were on the perimeter of the array.

Test 2 Results

- One 16-sack array test with the prototype "X" frame stiffeners
  - Dissection of the array revealed:
    1. 9 of 53 drums contained in the array showed signs of involvement.
    2. All of the secondary waste bags contained in the sack in front of the burner had some involvement
    3. They all had an edge near the sack wall between sacks 1 and 2 which were exposed early in the fire.

Test 3 Results

- One two-tier sack array test incorporating the cardboard stiffeners utilizing 32 sacks
  - Dissection of the array, revealed that 24 of the 45 drums contained in the non-targeted waste sacks in the top tier of the array were involved in the fire.
  - Thirteen of the 16 sacks in the top tier of the array had contents, either secondary or non-targeted waste, become involved in the fire.

Test 3 Results

- One two-tier sack array test incorporating the cardboard stiffeners utilizing 32 sacks
  - None of the drums of non-targeted waste or bags of secondary waste that were contained in the lower tier of the array became involved in the fire.

Fire Testing Conclusions

- The combustibility of the materials used to construct the waste sacks facilitates the fire progression from one sack to the next in the staging area when an individual sack is exposed to an initial flaming fire exposure
- The potential for involving the contents of the sacks was demonstrated and found to be a random event dependent on the extent of the exposure after the sack walls collapsed
- A prototype waste sack that incorporated a tubular aluminum “X” frame stiffener was found to reduce the heat release rate of the fire and correlated to a slower fire spread rate throughout the waste sack array

Fire Testing Conclusions

- The testing supported a conclusion that the waste staging configuration was acceptable considering both fire size and potential radiological release.
  - There was limited fire propagation in the storage array.
  - There was a low damage ratio in all the fire tests.
  - The slow propagation allows adequate response by the fire department.

Fire Test Video

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