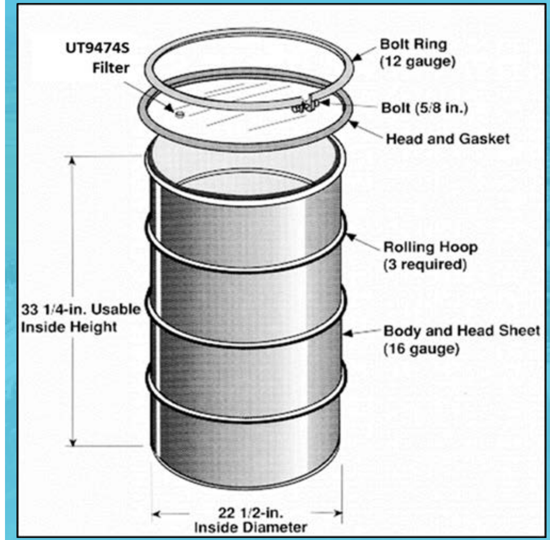
Sandia National Laboratories

Thermal Testing of 7A Drums Equipped With UT 9424S Filter



PRESENTED BY

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SNL

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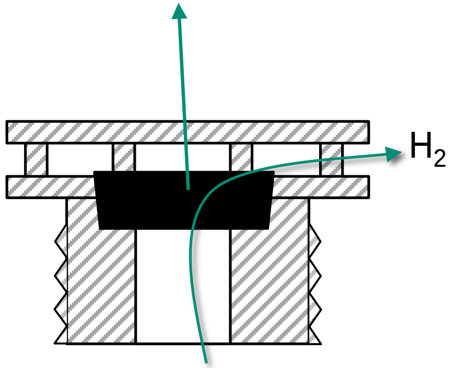
History 7A Testing at Sandia Prior 2019

2015-2016 7A Package Fire Response Tests with Carbon Filter (NUCFIL-019DS)

- POC and 7A filled near capacity with combustible
- Inside the fire, drum lid ejected
  - Air expansion is enough to cause lid ejection

NUCFIL-019DS



2017 7A Package Fire Response Tests with new Plastic Sleeve Filters (UT9474S)

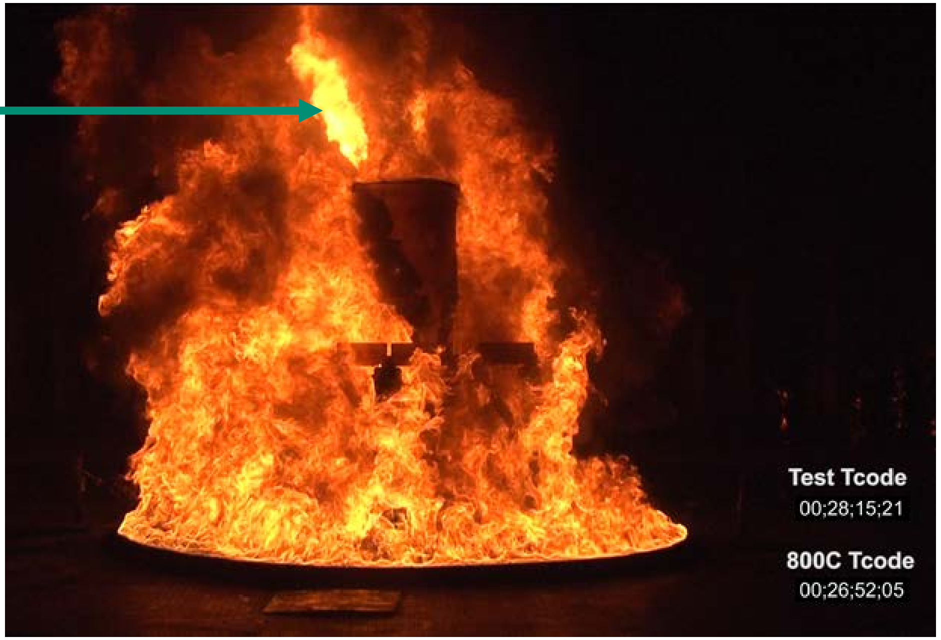
- Leveraging POC testing funds
- One 7A filled near capacity with combustibles - no instrumentation
- Inside the fire, 7A drum lid did not eject
- However, no test conducted with 7A drums partially filled with combustibles

UT9474S

Summary of 2017 Pool Fire Studies

- Documented in SAND2018-6570
- For drums with a **UT 9424S filter**
  1. The plastic filter sleeve melts/softens;
  2. The filter pops off about 1 min after fully engulfing conditions are met, opening up a ¾-inch diameter hole;
  3. The internal drum pressure is relieved through the ¾-inch diameter hole, and drum lid remains in place.
  4. At most **~2/3 of the material remained** inside the drum

Gas jet from filter hole



7A drum after 30-minute fully engulfing pool fire

Material left inside the drum: drum outside fire (left) and inside (right)

(a) (b)

UT 9424S filter before [left] and after [right] pool fire

Motivation for Current 7A Test Program

What happens when the 7A drums are loaded with bounding loads?

- Loading used in 2017 tests was not necessarily bounding
- Majority of the pressure built inside the drum is due to air
  - What if the load is small inside of the drum (~20%)?
- The more air volume, the faster the drum pressurizes, possibly leading to lid ejection **even with the new UT9474S filter**

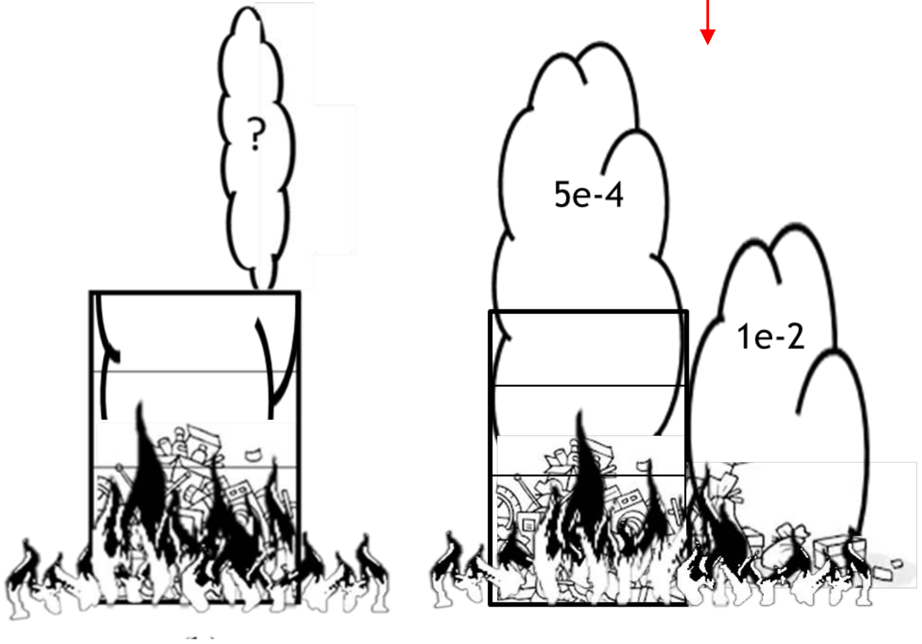
What is the ARF for 7A drum under confined under ventilated burning conditions?

- Not currently covered under DOE-STD-5506-2007
- Fuel-rich environment inside the drum

TABLE 4.5-1 ARF*RF Value Applicable to TRU Waste Accidents

Waste Form[1] (surface-contaminated)		Explosion[2]	Over-Pressure[3]	Fire[4]	Mechanical Insults	
					Spill[5]	Impact[6]
Combustible – cellulose, plastics	Ambient Atm.	(see fire)[7]	---	1E-2[7]	---	---
	In container	(see fire)	1E-4	5E-4	1E-4	1E-4/2E-3
	In-flight	1E-4	---	---	---	---
Grout – cement, concrete		3E-4[ED][8, 9]		<1E-6	7E-5	7E-4
Sludge or liquid slurries		MR[10]	1E-4	2E-3	4E-5	MR[11]

RF assumed 1



-1/3 of the material is assumed to eject when the lid comes out
-Unconfined burn (ARF=1e-2)
-Confined burn (ARF=5e-4)

Outline of Current Test Series

Green items completed
Blue partially completed

1. Conduct pool fire tests to:
   a) TGA Analysis to identify worst case scenario for material composition of drum contents
   b) Test response of drum with worst case scenario/s identified in (1) while equipping the lid with a UT-9424S filter
   c) Obtain temperature profile near drum to attempt to replicate with radiant heat setup
   d) Obtain drum internal pressure profile to serve as verification for proper radiant heat setup
2. Reproduce fire environment based on data acquired in (2), but using a radiant heat setup to obtain:
   a) Plume shape of effluent gas coming out of filter orifice on 7A drum lid for aerosol collection system design
   b) Obtain velocity profile of effluent gas for aerosol collection system design
3. Conduct exploratory benchtop tests using small-scale tube furnace and debris samples contaminated with specified amounts of CeO_2 for design of ARF measurement technique
4. Using the knowledge learned in (2) and (3), perform a full-scale radiant heat test with an appropriately-sized ARF measurement system as identified by the tests in (3).
5. Conduct NQA-1 ARF Tests

Main Focus of Talk

Funded by $850k from NNSA-NSR&D

Definition of typical and bounding inventory

LANL Database: 50 Drum Sample

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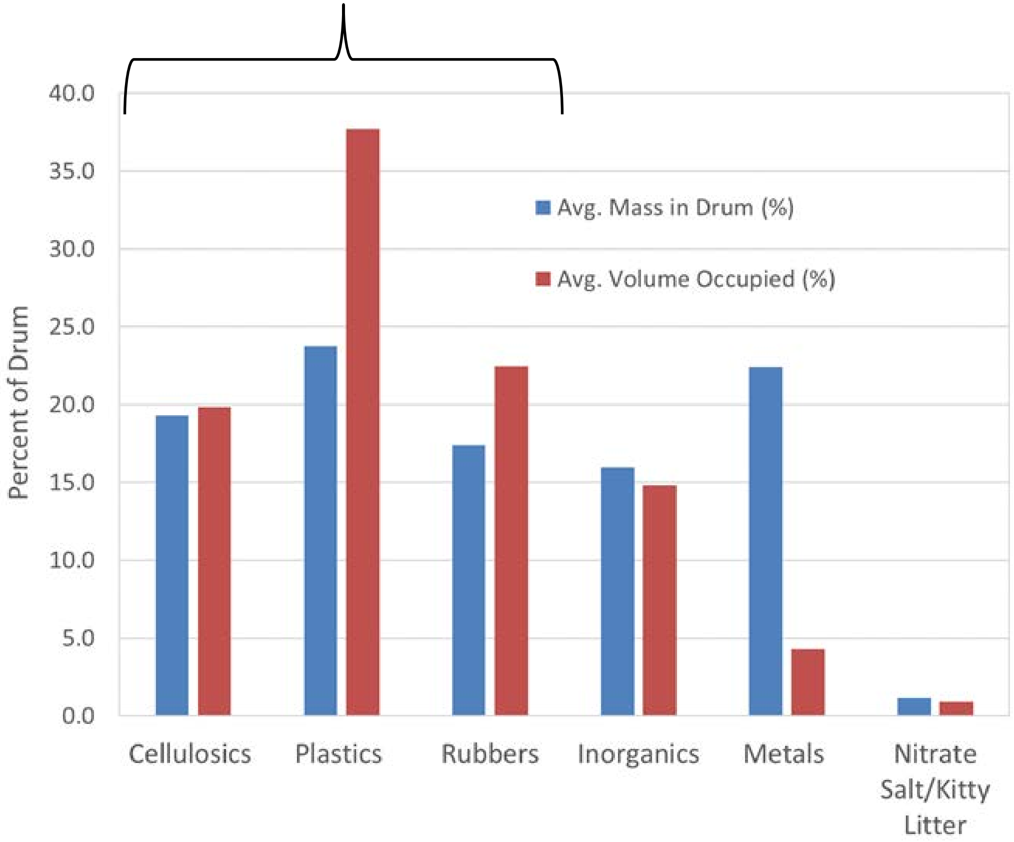
E58 =AVERAGE(E7:E57)

	A	B	C	D	E	F	G	H	I	J	K	L
6	Container	WG Summary	Type	Waste Stream	Cellulosics (kg)	Plastics (kg)	Rubber (kg)	Inorganic Matrix (kg)	Iron-based Metals (kg)	Aluminum-based Metals (kg)	Other Metals (kg)	Other Inorganics (kg)
7	67727	Debris	Original	New Gen Awaiting Assignm	8.6	1.5			0.2			
8	67744	Debris	Original	New Gen Awaiting Assignm	3.4	0.4			6			
9	67748	Debris	Original	New Gen Awaiting Assignm	4.2	0.6			7			
10	67745	Debris	Original	New Gen Awaiting Assignm	3.4	0.5			6			
11	67742	Debris	Original	New Gen Awaiting Assignm	4.4	0.6			9			
12	87826	Debris	RemediationDaughter	LA-MHD01.001	24.8	0.5						
13	87827	Debris	RemediationDaughter	LA-MHD01.001	8.8	0.5						
14	67723	Debris	Original	New Gen Awaiting Assignm	6	1.5	0.5		1	1		
15	67743	Debris	Original	New Gen Awaiting Assignm	4.5	0.7			16			
16	67720	Debris	Original	New Gen Awaiting Assignm	4	1.4			2			0
17	67693	Debris	Original	New Gen Awaiting Assignm	3.5	1.4	0.1					
18	67718	Debris	Original	New Gen Awaiting Assignm	3	1.5	9.8				9.3	
19	67716	Debris	Original	New Gen Awaiting Assignm	2	3						
20	67758	Debris	Original	New Gen Awaiting Assignm	1.5	2.3						
21	67697	Debris	Original	New Gen Awaiting Assignm	0	0.5	15.6					
22	67698	Debris	Original	New Gen Awaiting Assignm	0	0.5	10.1					
23	67757	Debris	Original	New Gen Awaiting Assignm	2	3.5	3.6					
24	67704	Debris	Original	New Gen Awaiting Assignm	0	2.6	25.6					
25	67713	Debris	Original	New Gen Awaiting Assignm	0	2.6	20.8					
26	67759	Debris	Original	New Gen Awaiting Assignm	3	6.2						
27	67703	Debris	Original	New Gen Awaiting Assignm	2.4	5						
28	67715	Debris	Original	New Gen Awaiting Assignm	0.1	1.5	11.3		1		4	2
29	67751	Debris	Original	New Gen Awaiting Assignm	3	7			5		1.5	1
30	67666	Debris	Original	New Gen Awaiting Assignm	0.5	1.5			2.1			
31	68987	Debris	RemediationDaughter	LA-MHD01.001	1	3		0.9				
32	67726	Debris	Original	New Gen Awaiting Assignm	0.8	3						
33	67728	Debris	Original	New Gen Awaiting Assignm	1.6	6		0.1				0.1
34	67717	Debris	Original	New Gen Awaiting Assignm	0.5	2						

Majority by volume are combustibles

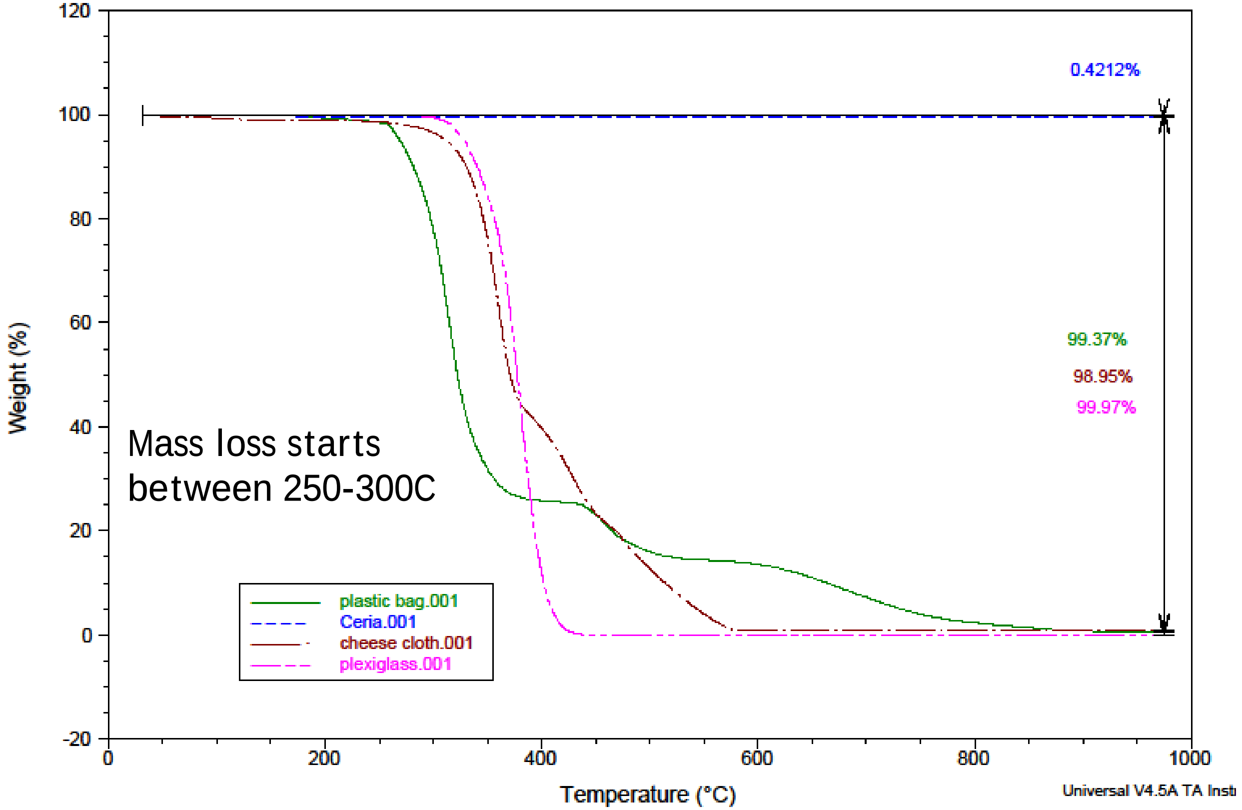


48% of drums plastics > 50% volume
26% of drums cellulose > 50% volume
14% of drums rubber > 50%

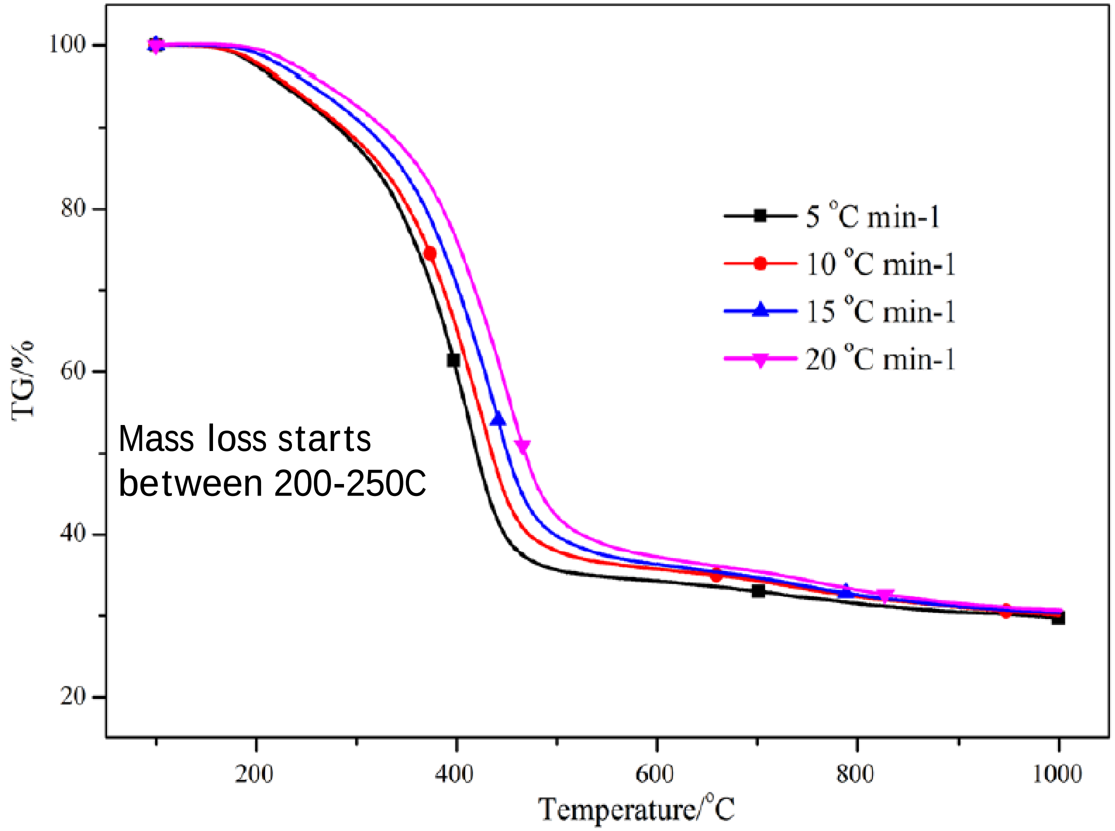
In some drums, one of these materials occupied up to 85% of the volume of the drum

TGA Analysis in Nitrogen Environment

TGA Cellulose, PMMA, Plastic Bag Gloves



TGA analysis: Rubber Gloves



Compromise the lid → Use material with that the decomposes at lowest temperature
Maximize aerosol release → Use material that generates more soot

Pool Fire Test Matrix

- Mock fire tests demonstrated that with no material inside the drum, the lid will not be ejected with the new filter.
  - Rapid air expansion is believed to be one of the major factors, if not the biggest factor, leading to ejection of the lid

	Test #1				Test #2
Test Location	Center	55 kW/m2	45 kW/m2	35 kW/m2	Center
% of drum volume occupied by debris	20.00%	20.00%	20.00%	20.00%	60.00%
Volumetric debris composition	85% rubber, 15% cellulose, + plastic bag	85% rubber, 15% cellulose, + plastic bag	85% rubber, 15% cellulose, + plastic bag	85% rubber, 15% cellulose, + plastic bag	50% cellulose, 40% plastic, 10% rubber, + plastic bag.[1]

Use more rubber to pressurize the drum quickly (worse case)

[1]Drum was equipped with rigid liner, therefore volume percentages are based on the remaining volume after liner is placed inside drum. This mass includes the rigid liner.

Material Debris in Drums

Test 1

Test 2

Mass Loss Results

	Test #1				Test #2
Test Location	Center	55 kW/m2	45 kW/m2	35 kW/m2	Center
% of drum volume occupied by debris	20.00%	20.00%	20.00%	20.00%	60.00%
Volumetric debris composition	85% rubber, 15% cellulose, + plastic bag	85% rubber, 15% cellulose, + plastic bag	85% rubber, 15% cellulose, + plastic bag	85% rubber, 15% cellulose, + plastic bag	50% cellulose, 40% plastic, 10% rubber, + plastic bag.[1]
Lid Loss?	No	No	No	No	No
Initial mass of drum contents (kg)	2.80	3.00	3.68	3.58	8.86
Pre-tested and fully assembled drum mass (kg)	31.18	31.20	31.90	32.10	38.60
Mass Loss (kg)	2.44	0.50	0.14	0.02	6.30
Mass Loss (% of initial contents)	**87.14%**	**16.67%**	**3.80%**	**0.56%**	**71.11%**
Peak Pressure differential	~16 psi	N/A	N/A	N/A	~2 psi

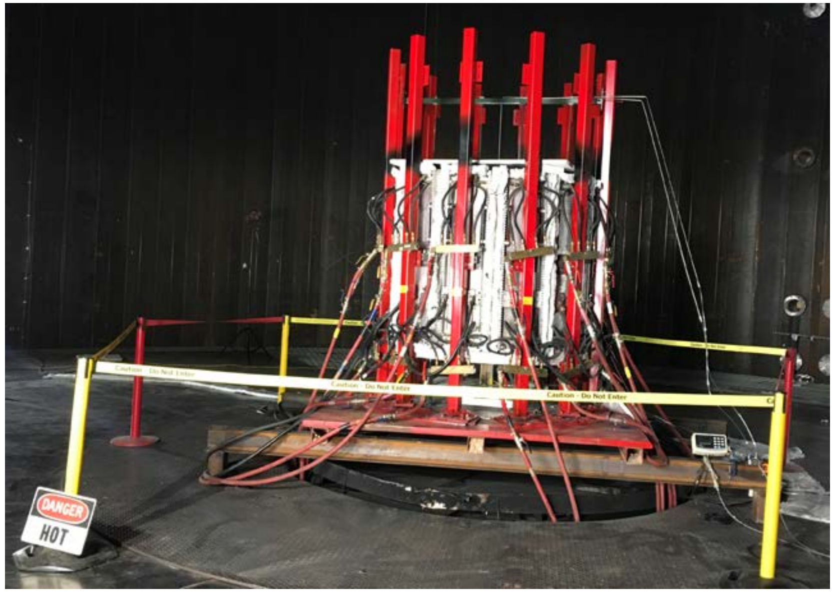
[1]Drum was equipped with rigid liner, therefore volume percentages are based on the remaining volume after liner is placed inside drum. Mass includes the rigid liner in Test #21

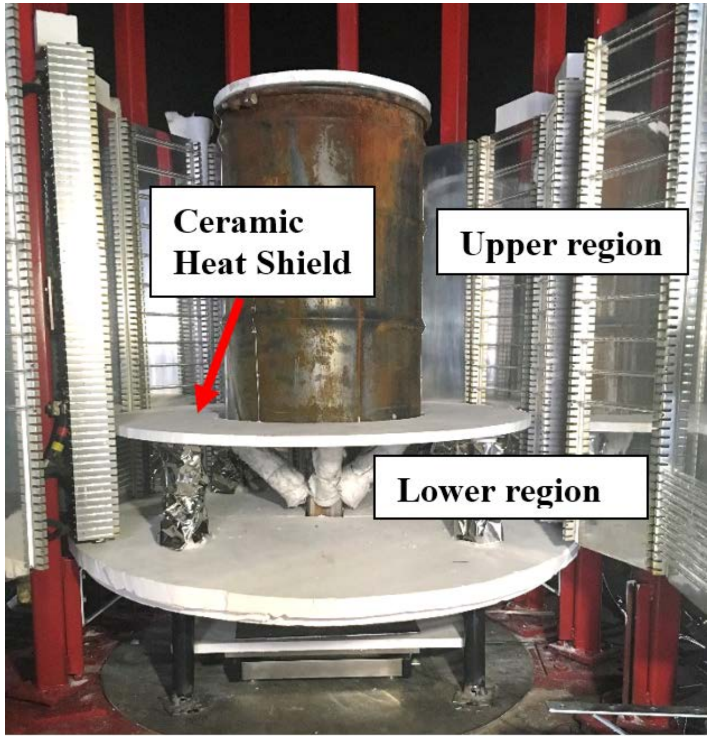
High mass loss. How much CeO_2 are we releasing in this confined burn configuration?

Radiant Heat Test Matrix Setup

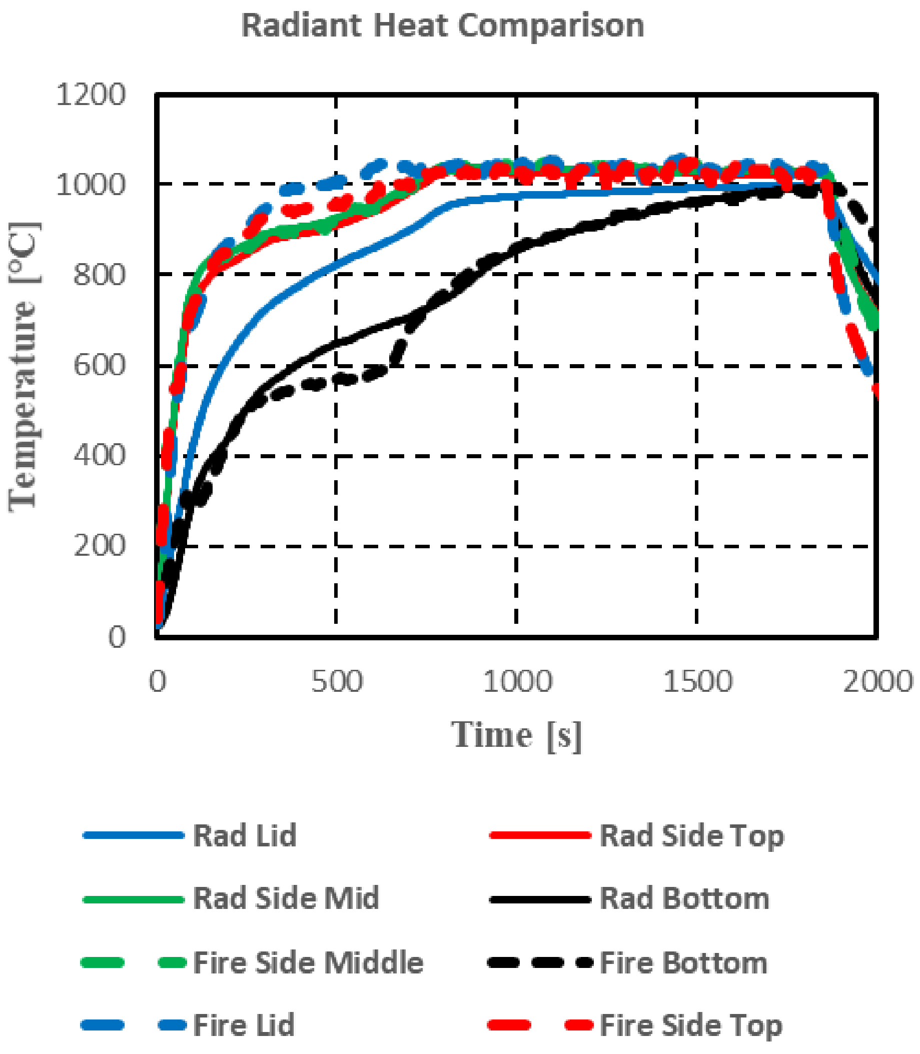
Loading is essentially the same as pool fire tests #1 and #2, but note that *no filter was used on the drum lid on either of these radiant heat tests*

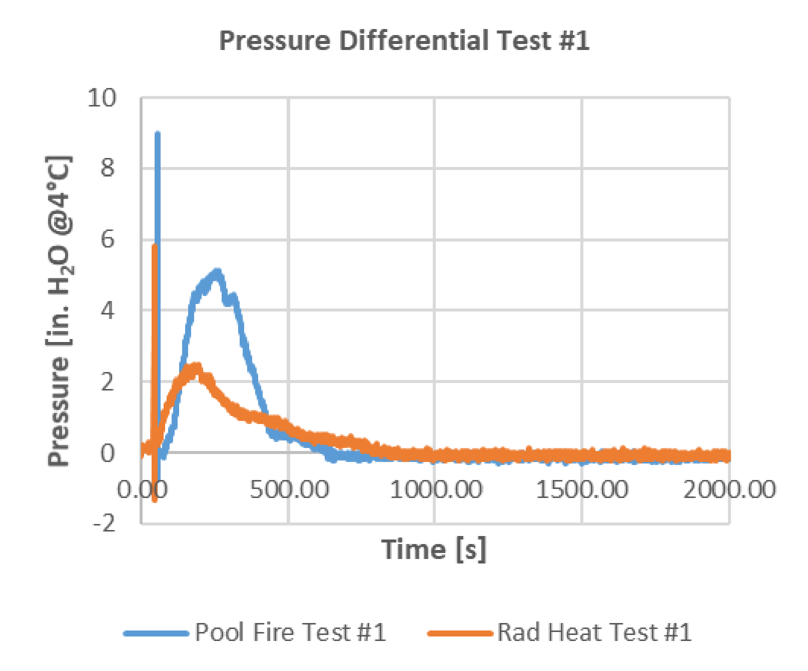
	Test #1	Test #2
Test Location	Center	Center
% of drum volume occupied by debris	20.00%	60.00%
Volumetric debris composition	85% rubber, 15% cellulose, + plastic bag	50% cellulose, 40% plastic, 10% rubber, + plastic bag.[1]
[1]Drum was equipped with rigid liner, therefore volume percentages are based on the remaining volume after liner is placed inside drum. This mass includes the rigid liner		

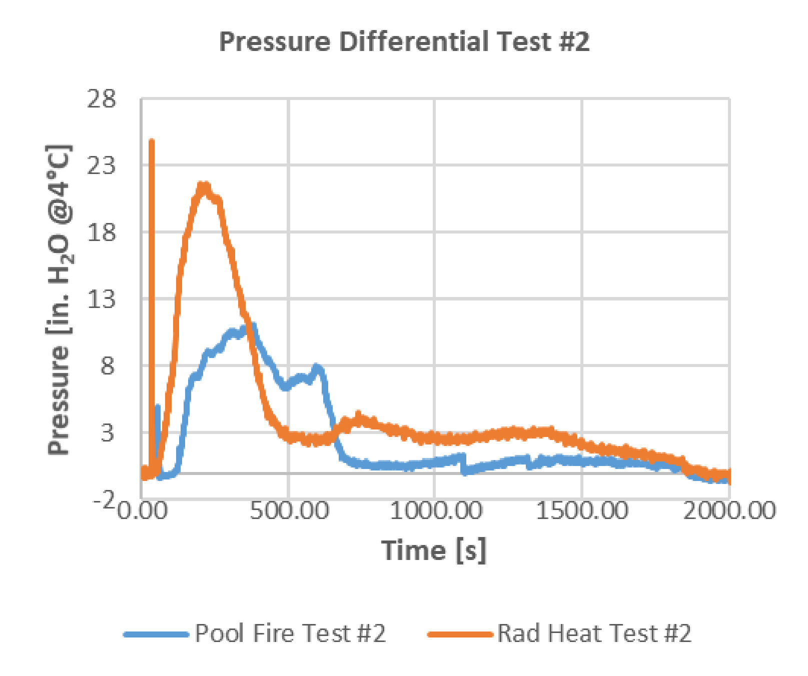




Profile Matching for Radiant Heat Tests



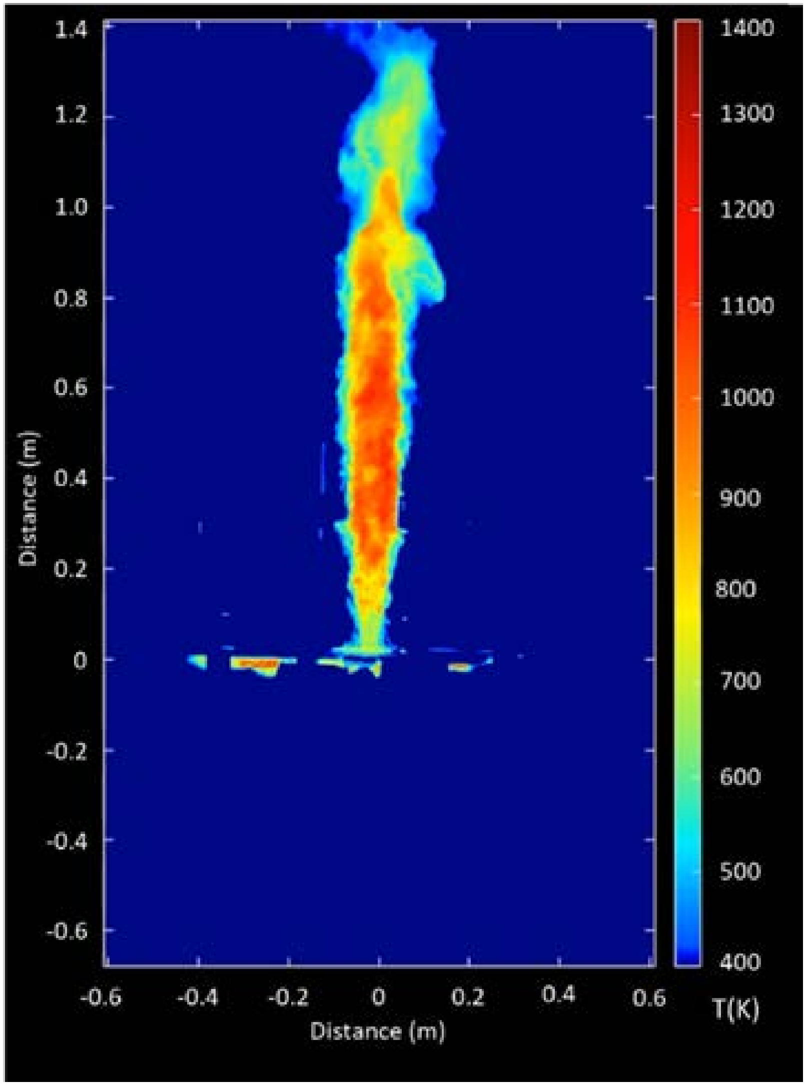


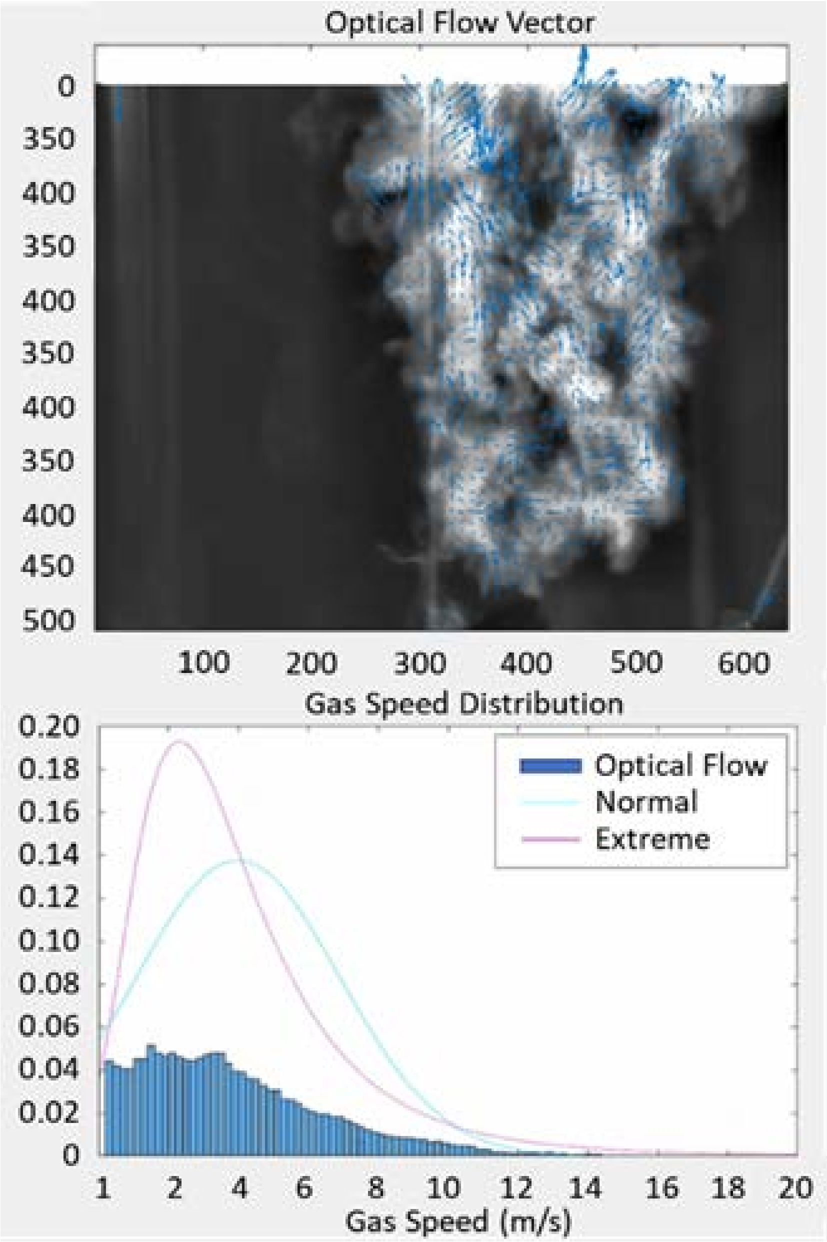


Capable of reproducing temperatures on skin of the drum

Gas Temperature and Speed: Test #2

Data can be used for model validation and ARF System Design





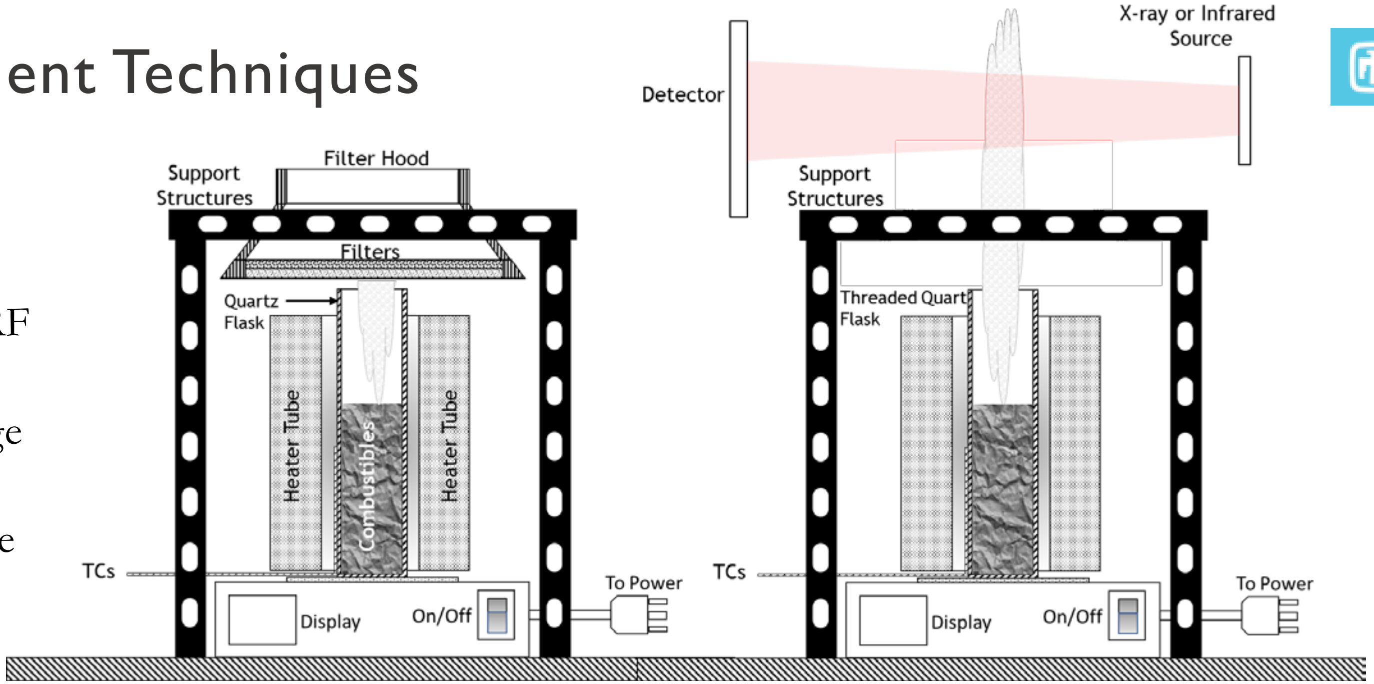
Radiant Heat Test #2

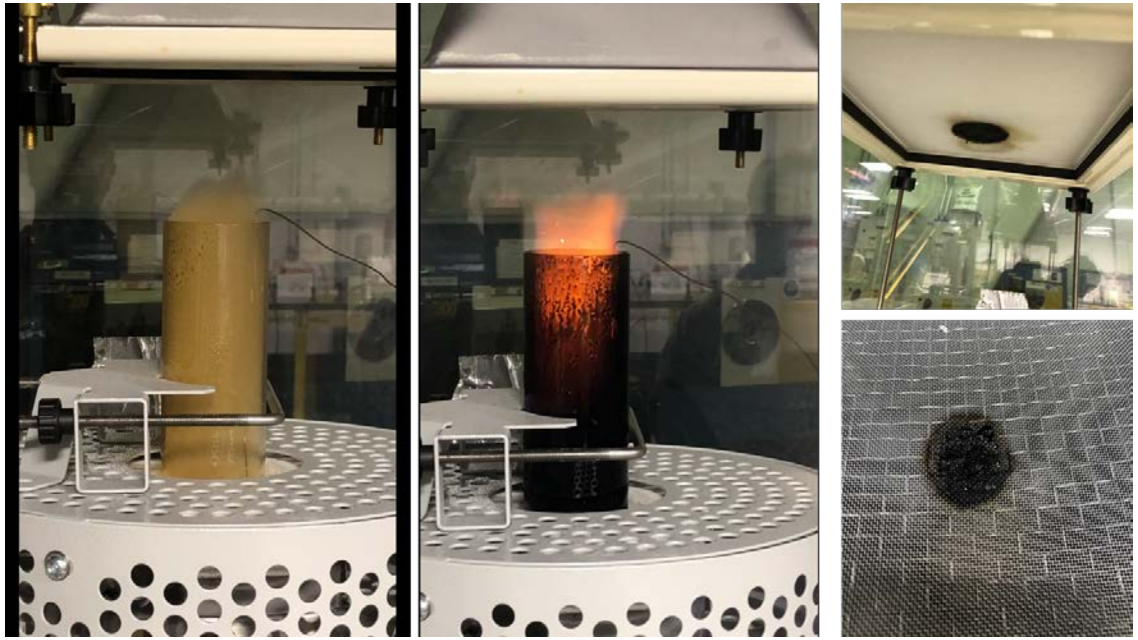
High soot release starting about 5 minutes into the test

~2/3 of mass is lost within 10 minutes

Benchtop Tests – ARF Measurement Techniques

- Small Scale Filter Collection System
  - Collect material release and left in flask to determine ARF via chemical analysis
  - May give an early indication of the ARF expected in large scale test
  - Test spectral system's ability to detect CeO2 and measure CeO2 concentrations of materials of interest
- X-ray Fluorescence Spectrometry
  - Huge potential as a diagnostic tool
  - Can be used to determine concentrations in material collected in filters or in gas jet if proven to work
- Beer-Lambert Infrared Spectrometry
  - Already used at SNL to obtain AlO2 particles concentrations inside a propellant fire
  - Needs accurate particle temperature measurements
    - Looking at using X-ray Fluorescence to determine particle temperatures





Conclusion

We believe use of UT9474S will result if far fewer number of lid losses in a fire

- Material tested is in pristine condition at the start
- No moisture added
  - WIPP will not accept material with free liquids

Capability to reproduce fire environment in radiant heat environment

- Allows fielding of diagnostic equipment to measure important variables (Data validation)

Know approximate mass loss from the drum as a function of time

- Significant within first 10 minutes of the fire
- Present significant challenges for fielding an aerosol collection system

Need to develop design aerosol measurement system

- Currently looking into fielding new systems for obtaining ARF
- Several NSR&D Proposals

Thanks