

This paper describes objective technical results and analysis. Any subjective views or opinions that might be expressed in the paper do not necessarily represent the views of the U.S. Department of Energy or the United States Government.

SAND2018-4467C

# Indoor Fire Testing of Transportation Containers to Meet DOT Explosive Classification Requirements



PRESENTED BY

Debbie Finfrock

Presented at the  
Contractors  
Transportation  
Management  
Association 2018  
Workshop

Sandia National Laboratories is a multi-mission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

# Purpose

Hazard Classification testing for Mark Quality explosive parts packed in UN1A2 nine-gallon steel drums

Performed per 1998 version of TB 700-2, with guidance from 2012 TB 700-2 and STANAG 4240

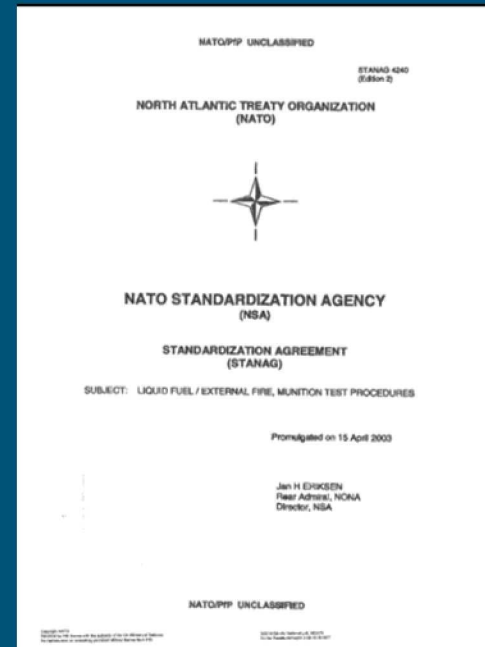
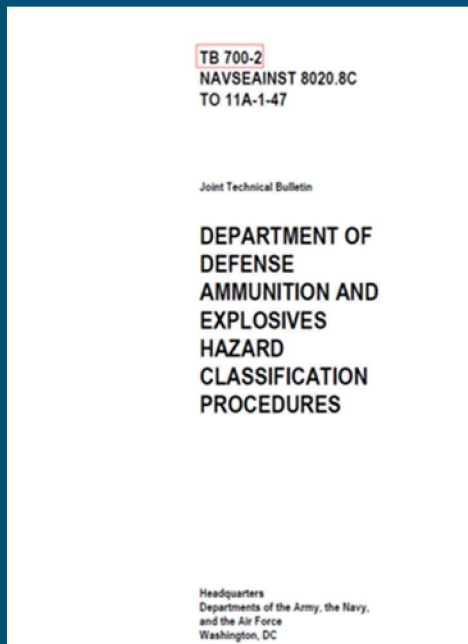
When 2012 TB 700-2 incorporated into 49 CFR 171.7, liquid pool fire required and wood crib fire no longer acceptable



# Coming Requirements Hard to Meet Outdoors

A pool fire with a quantity of fuel sufficient to maintain a fully developed fire for 150% of the estimated time required to cause all AE to react.

An average flame temperature of at least 800 °C, as measured by all valid thermocouples (sample rate > 1.0 Hz) at the test-item without contribution from the burning munition, will be considered a valid test.



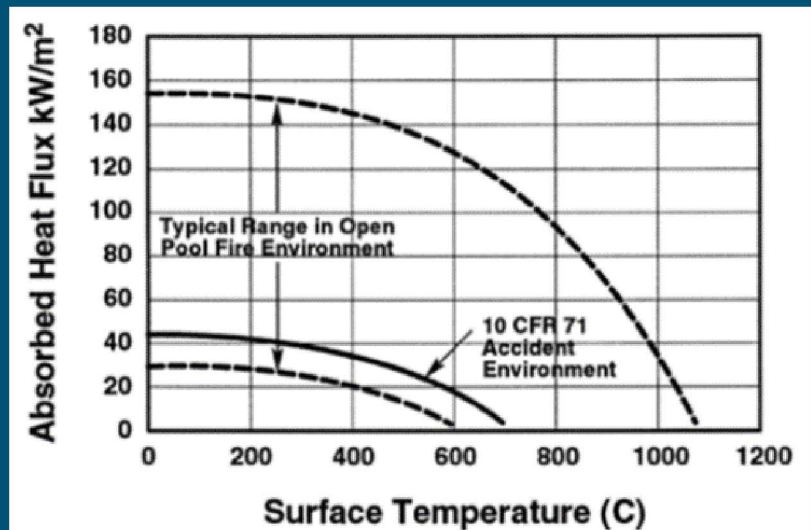
# Outdoor Pool Fires Still Limited

## Time Requirement

- Requires preliminary test with internal instrumentation to estimate reaction time
- Outdoor pool fires highly variable and test-to-test results not repeatable

## Temperature Requirement

- Wind major source of uncertainty, as flames blown away from some packages during fire



# FLAME Facility Advantages



## Controlled airflow - no wind

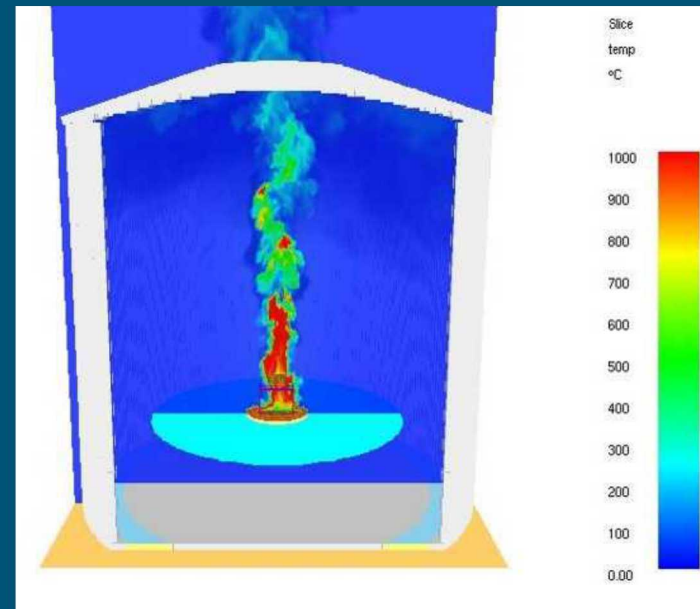
- Eliminates major source of variability

## Amenable to modeling

- Modeling results showed 800°C can be met

## Well-controlled hazard zone

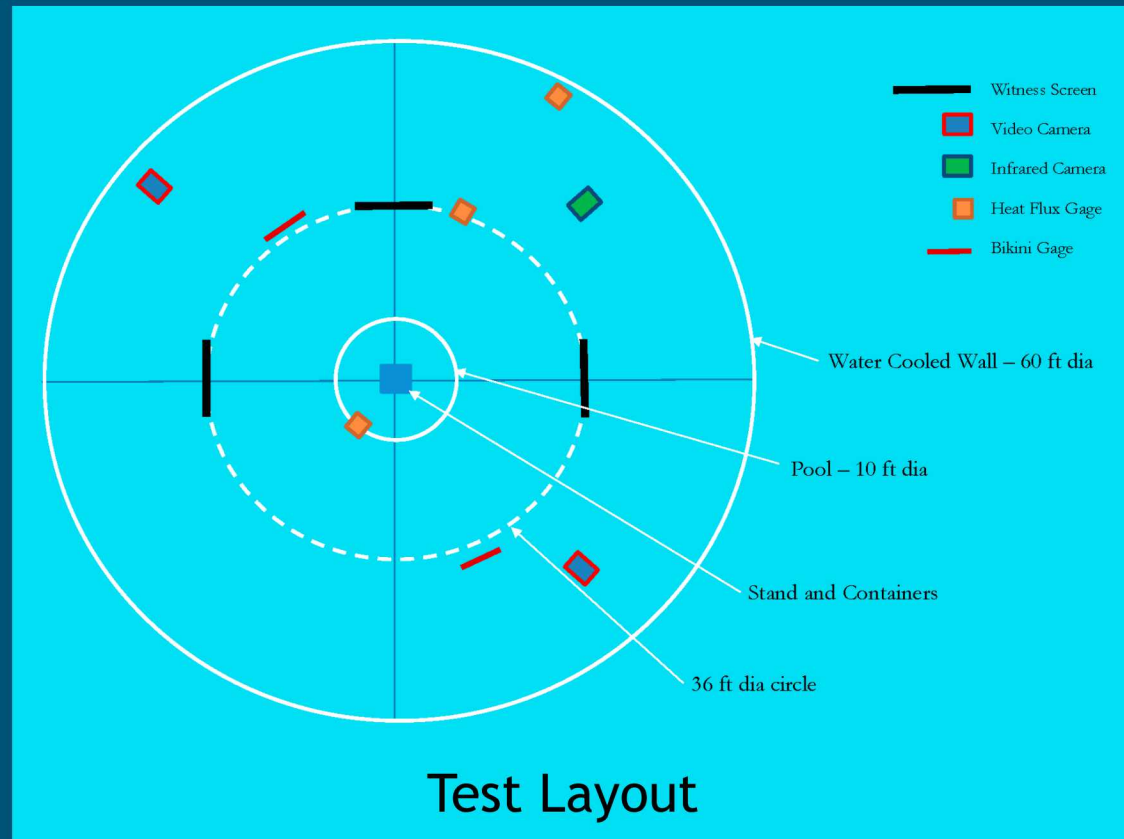
- Fire - 12 MW, ~30 m (100 ft) radius
- Explosive - Up to 500 g for 1.4 , ~ 8 m (26 ft) radius
- Fumes from decomposed foam scrubbed and dispersed at altitude where no personnel are located



# FLAME Facility Limitations

Safety Basis explosives limits per test:

Hazard Class	N.E.W. (g)
1.1	90
1.2	90
1.3	362
1.4	500
1.5	90
1.6	362



Water-cooled walls at 18.8-m (60-ft) diameter and cannot be hit with projectiles; this limits ability to test anything other than expected 1.4 packages

To maintain 1-m (3-ft) perimeter of fuel around packages, tested packages must be  $\leq 1$ -m diameter

# Strategy to Minimize Risk

## Computation Fluid Dynamics Modeling

- Find best container location
- Predict flame thermocouple (TC) response
- Fire Dynamics Simulator (FDS) software from NIST

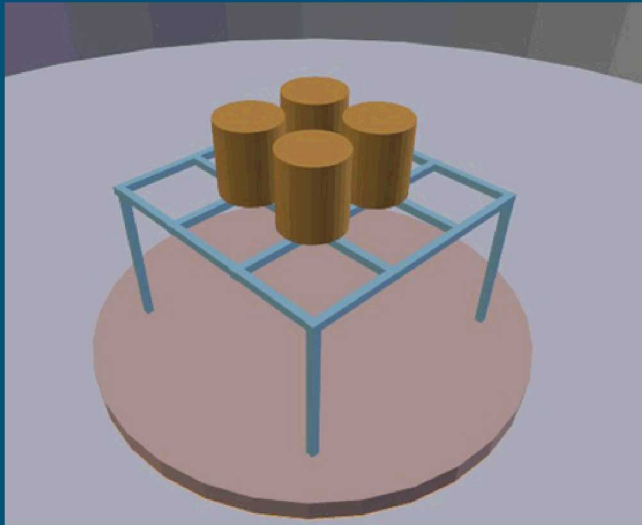
## Mock Test

- Verify 800C flame TC requirements met
- Determine time to 600C on internal TCs
- Perform “Lessons Learned” session

## Classification Test

- Implement “Lessons Learned”
- Perform successful test

# Modeling – Location of Drums in Fire



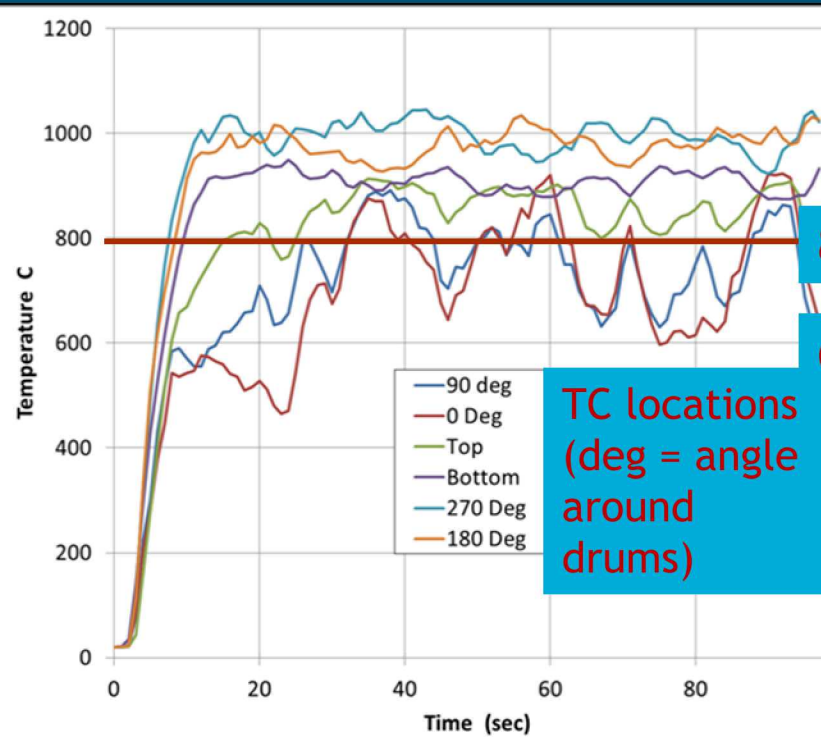
## Average TC temperatures from the simulation runs

Number of containers	Platform height above pool (m)	Average temperature of all thermocouples (°C)	Average range (°C)	Standard deviation (°C)
3	0.46	754	45	16
3	1	784	45	15
3	1*	904	51	15
3	1.3	798	43	14
4	1*	906	80	23

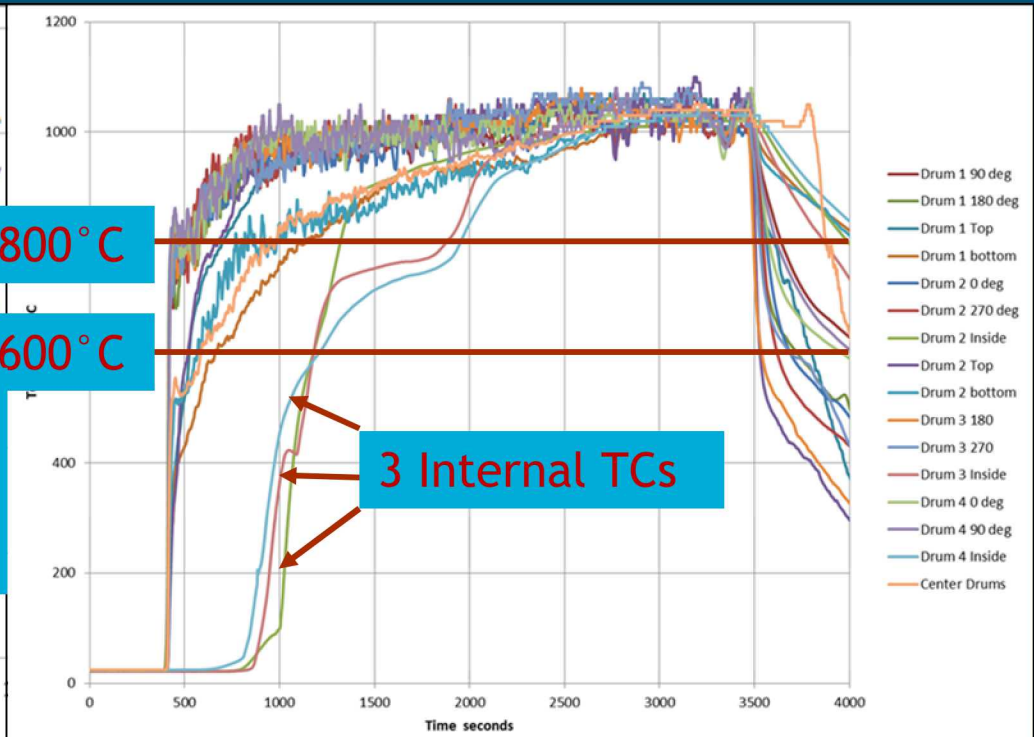
\* Drums contributing to radiation to thermocouples

# 9 Modeling and Mock Test Temperatures

## Drum Temperature Modeling Results

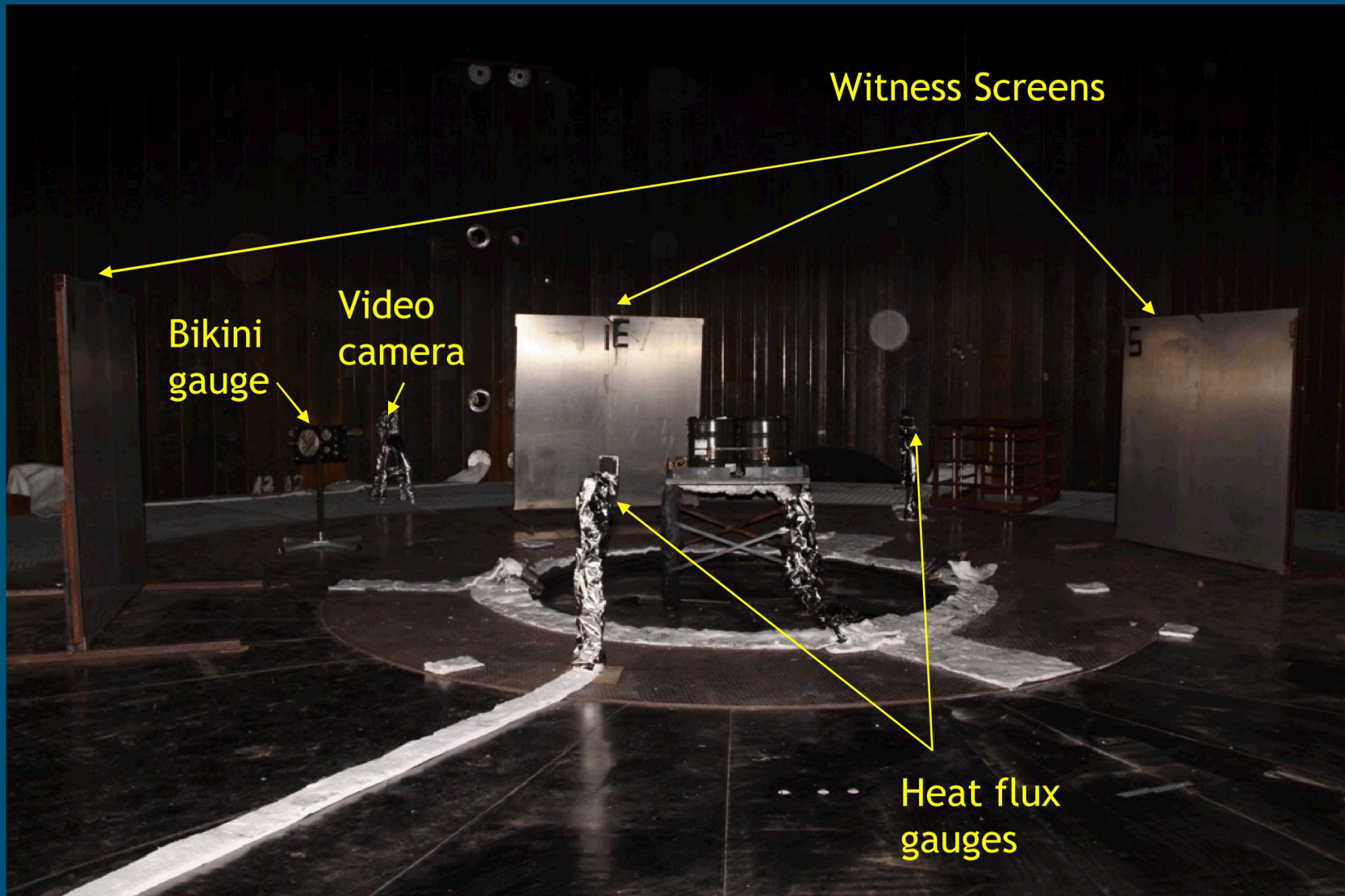


## Drum Temperature Mock Test Measurements

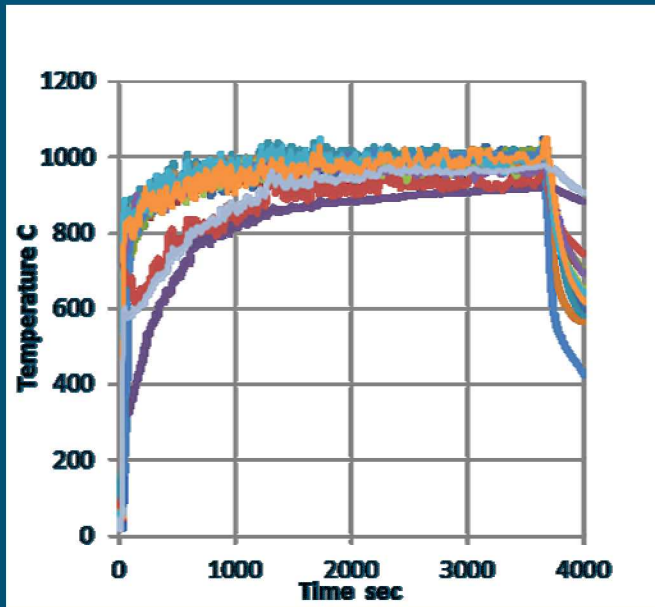


**800 °C External STANAG Requirement**  
**600 °C Internal Explosive Safety Requirement**

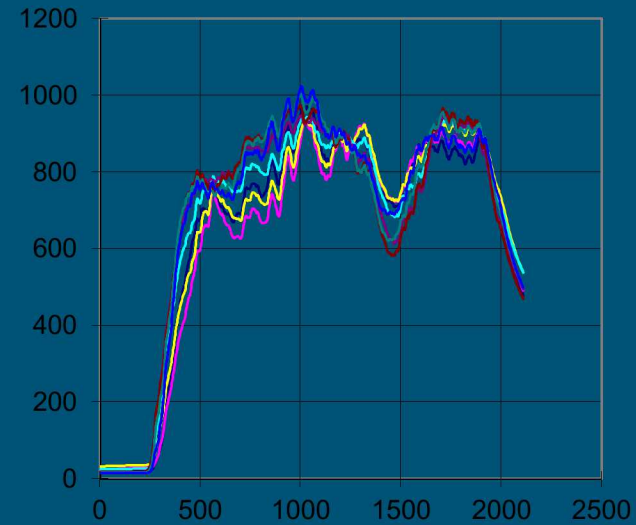
# Test Setup Conforms to Requirements



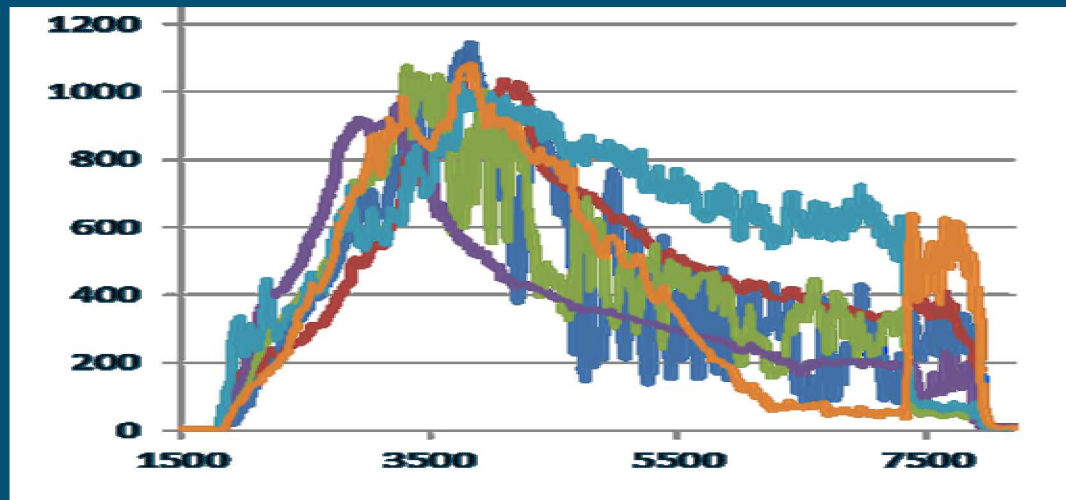
# Classification Fire Temperature Data



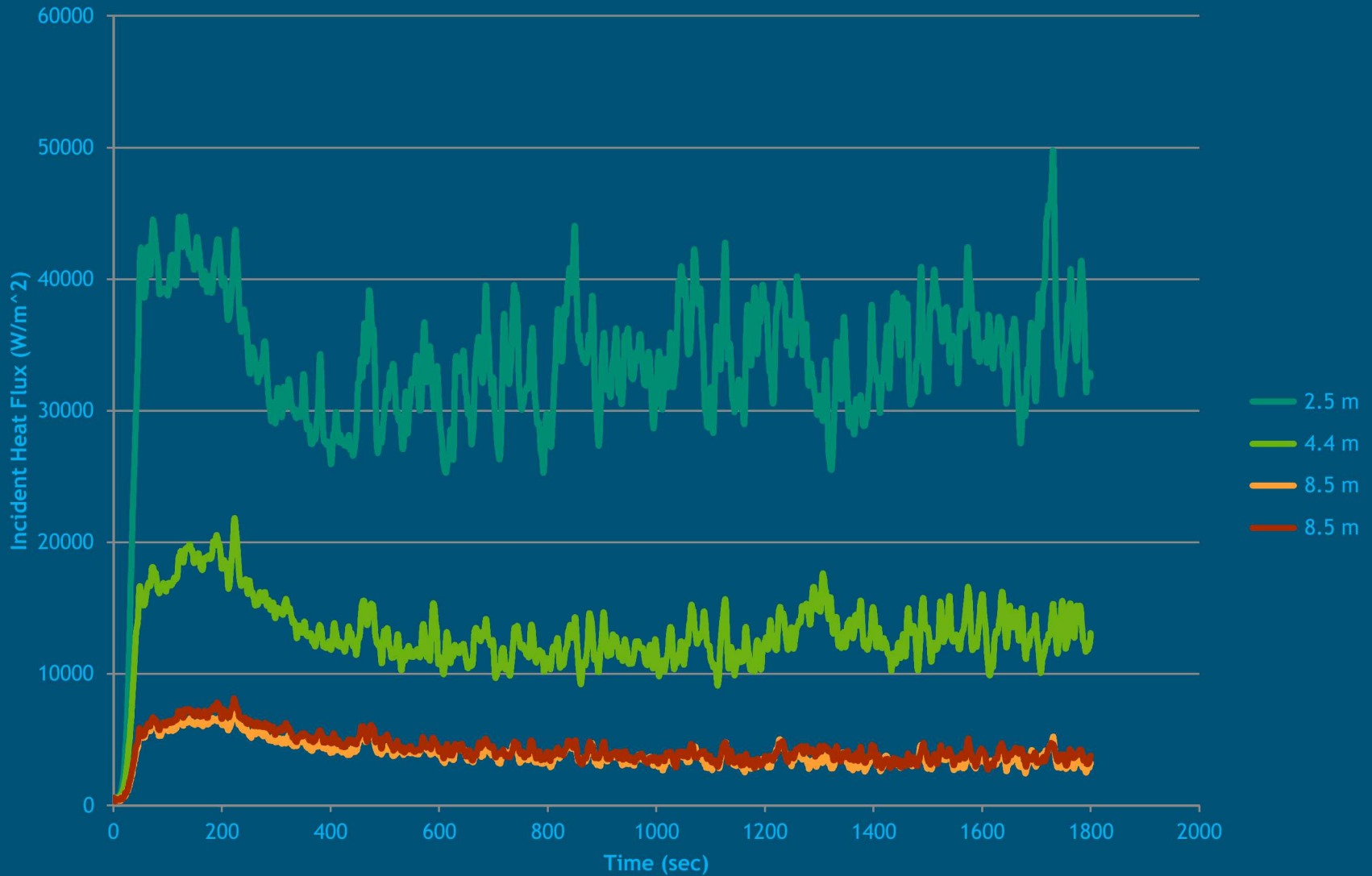
## Outdoor Pool Fire



## Outdoor Crib Fire



# Classification Fire Heat Flux Data





## Shipping Container Fire Test

10/22/15

# Classification Fire Results



## Test Successful for 1.4S Classification

- No explosions
- No debris or metallic projections
- No fireballs or jets of flame >3 ft from drums
- No thermal or blast effects
- Outer packaging remained intact
- Explosives completely consumed



Walt Gill, Test Engineer

Sylvia Gomez, Test Director

Brandon Servantes, FLAME Facility Manager

Anay Luketa, Fire Modeler