Boeing MPS Chamber: A Comparison of Suppressed and Unsuppressed Multiple Fuel Fires with Verdagent and Halon

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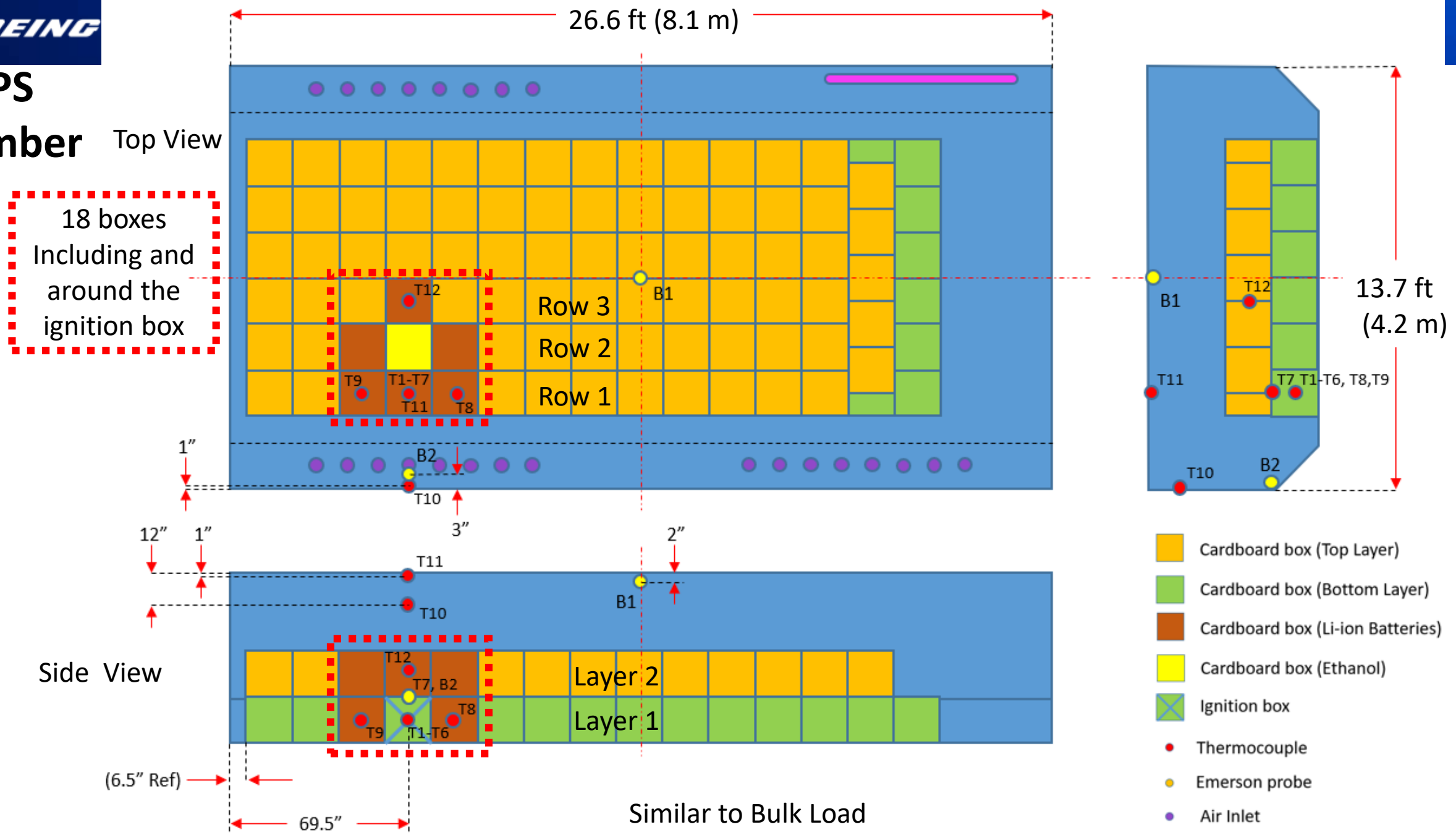
Outline

- Setup
  - MPS Chamber and Multiple Fuel Fire
- Autopsy of fires
  - Unsuppressed, Verdagent and Halon
    - Boxes involved and photos

- % Volume gases and Temperature
  - Time –Temp Integrals and Peak Temp
  - Temperature and Oxygen data
    - Unsuppressed, Verdagent and Halon
- Summary

MPS Chamber



Similar to Bulk Load

Setup

All dimensions +/- 0.25”

18 boxes

Including and around the ignition box

Ignition Box
15 lithium-ion cells, 500 mL ethanol Balloon, 2.5 lbs of shredded paper

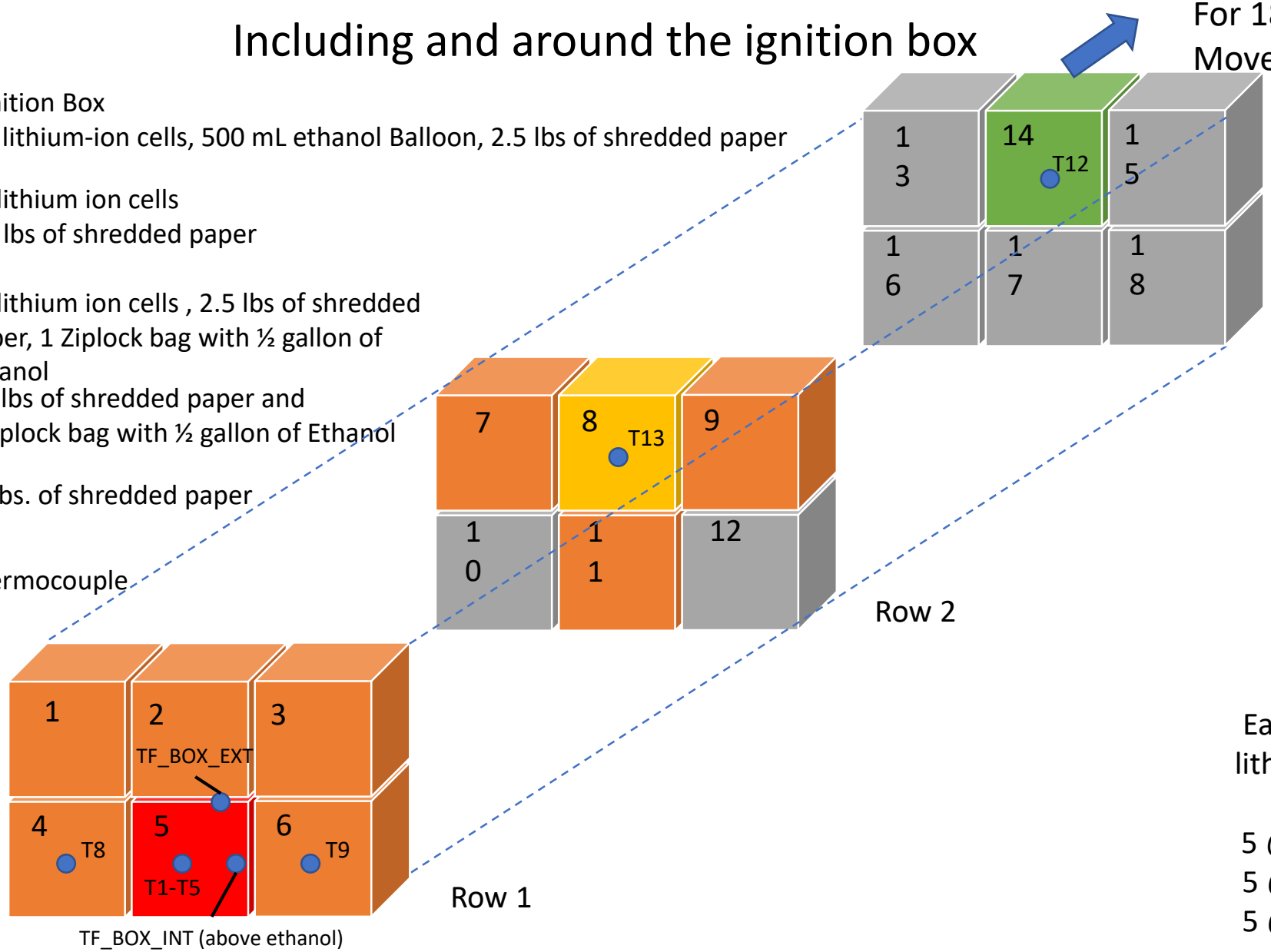
15 lithium ion cells
2.5 lbs of shredded paper

15 lithium ion cells , 2.5 lbs of shredded paper, 1 Ziplock bag with ½ gallon of Ethanol

2.5 lbs of shredded paper and
1 Ziplock bag with ½ gallon of Ethanol

2.5 lbs. of shredded paper

Thermocouple



Each box of 15 lithium ion cells contains:
5 @ 100% SOC
5 @ 60% SOC
5 @ 30% SOC

18 box details

Box 14
½ gallon Ethanol bag
Box of 15 batteries

(heaters and TCs on batteries for 180 min tests)

½ gallon Ethanol in 12” x 12” bag

Box 5
½ liter Ethanol bag
w/ 7 ft Nichrome wire
Box of 15 batteries

Setup

Unsuppressed MFF

Test#2 Unsuppressed

~23 equivalent full boxes

Verdagent Suppressed MFF

Verdagent Suppressed tests 1 thru 5

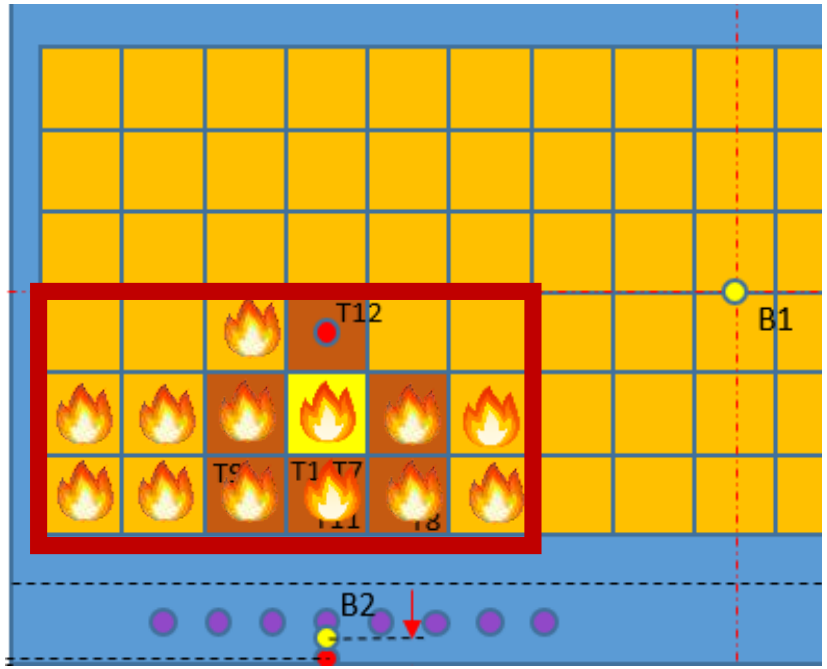
15-18 equivalent full boxes

Halon Suppressed MFF

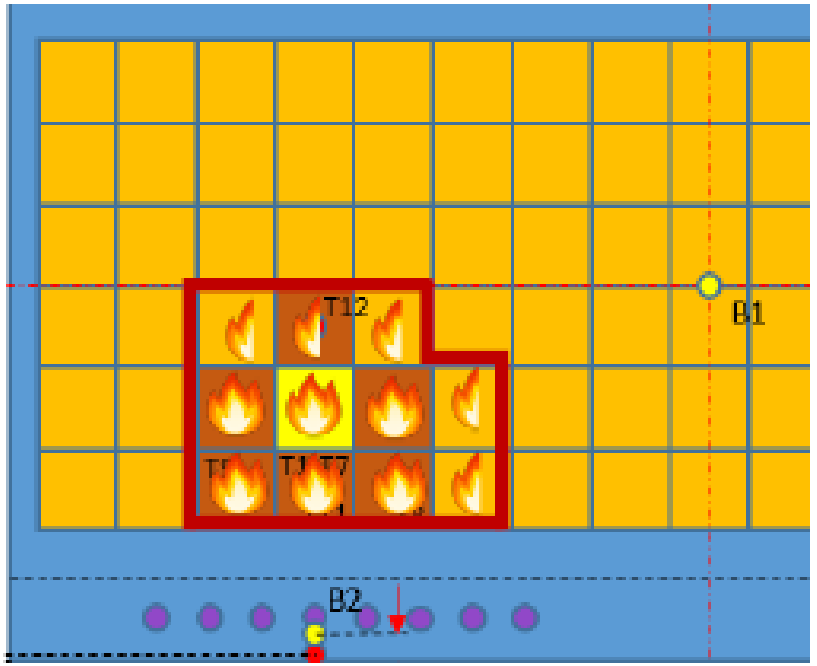
Halon Test 2:
~ 16 equivalent full boxes

Autopsy

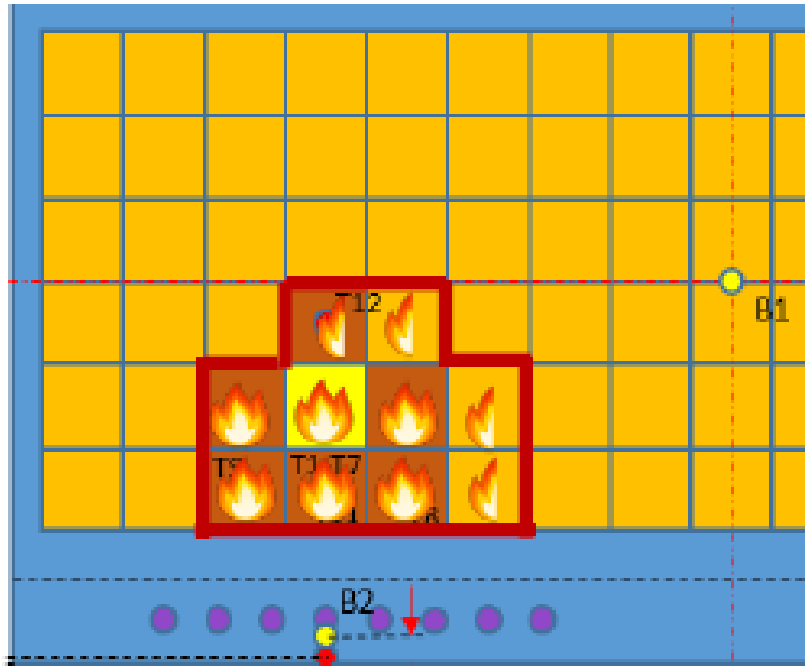
Unsuppressed MFF



Verdagent Suppressed MFF



Halon Suppressed MFF



Autopsy

Battery Autopsy

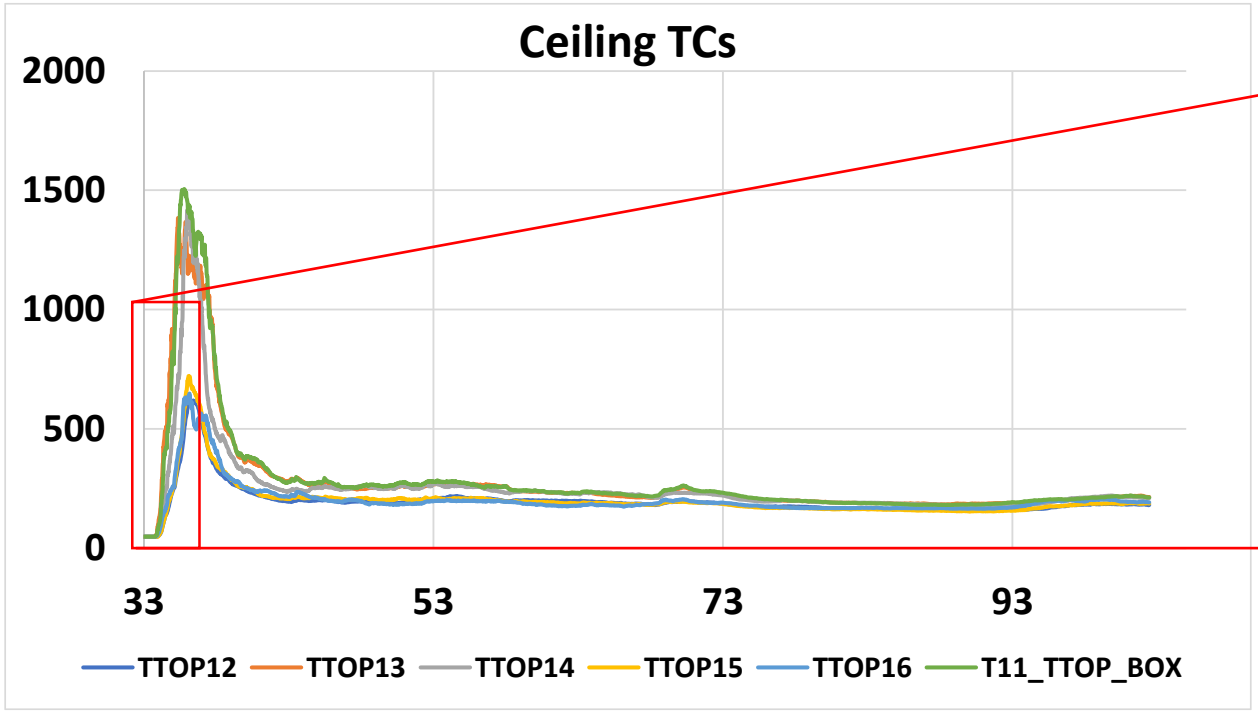
Unsuppressed				
Damage				
None observed	Slight burnt	Mostly burnt	Exploded empty	missing
15	17	88	25	5

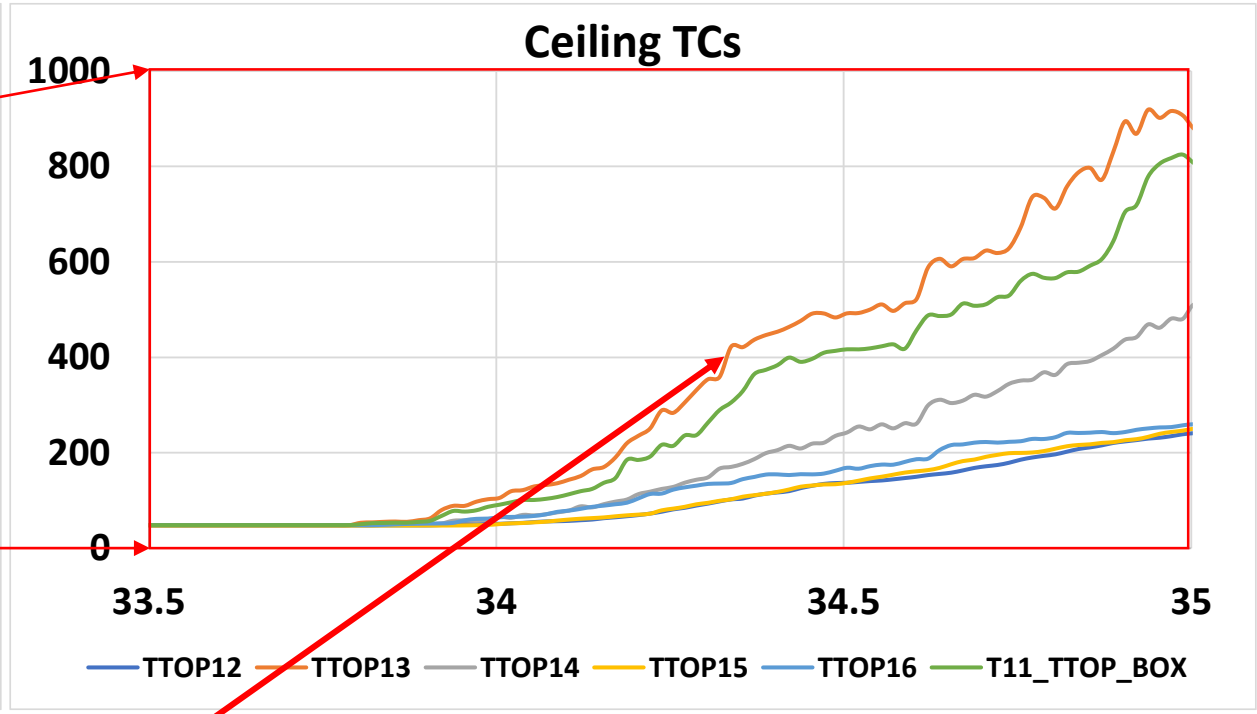
VERDAGENT				
Damage				
None observed	Slight burnt	Mostly burnt	Exploded empty	missing
30	20	73	26	1

Halon				
Damage				
None observed	Slight burnt	Mostly burnt	Exploded empty	missing
22	23	73	27	5

Autopsy

All of these tests use a ceiling thermo couple (TC) data to time align the data for direct comparison





TTOP 13 reached 200 @ 34.2 min
TTOP Box reached 200 3 seconds later

Time aligned:
New Zero time

Data

% V Oxygen and Ceiling TC Temperature

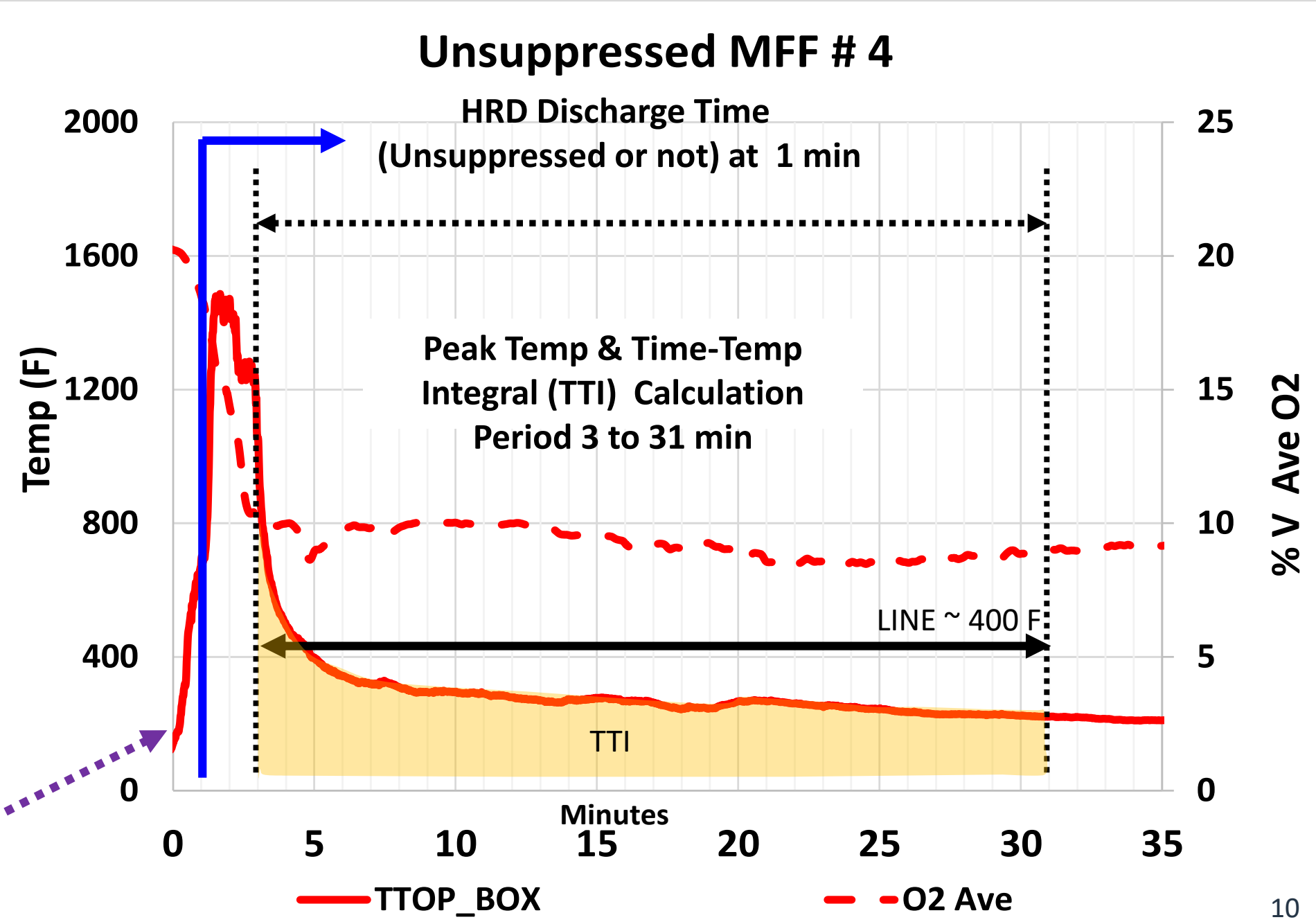
Data Layout
HRD at 1 min
Test for 35 min

TTI, Peak Temp
3-31 min
MPS requirement

Peak Temp
1057, F

TTI
8064, F-min

First Ceiling TC to 200 F
Set to time zero



Evolution of the MFF

First MFF Fire

(Suppressed)

Look similar to a bulk load

Ethanol was not part of the fire

Suppressed

(Verdagent)

Multiple Fuel Fire (MFF)

Bulk Load (BL)

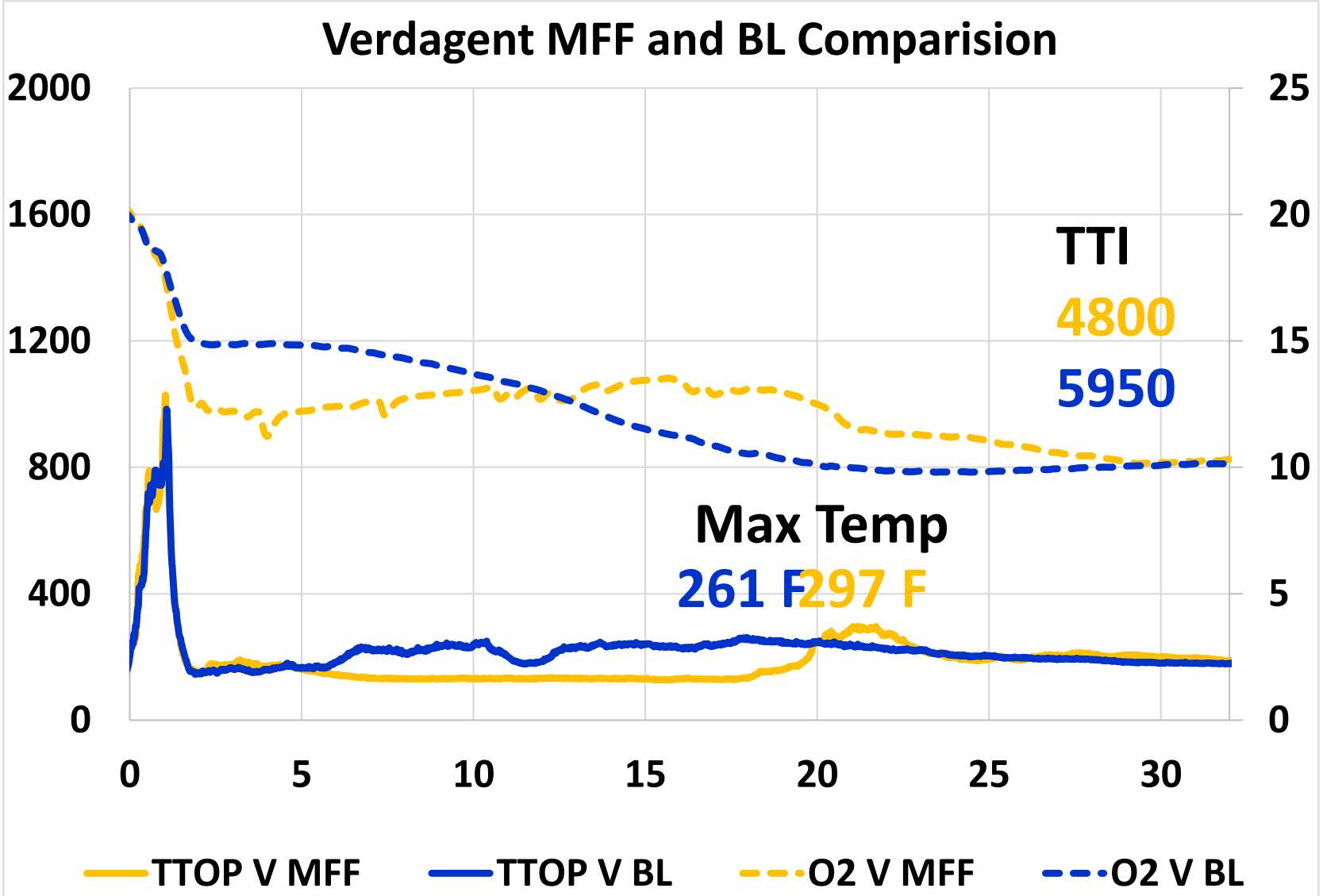
MFF # 1

IATA Boxes and Jugs

8 and 14

Ethanol

Were not involved



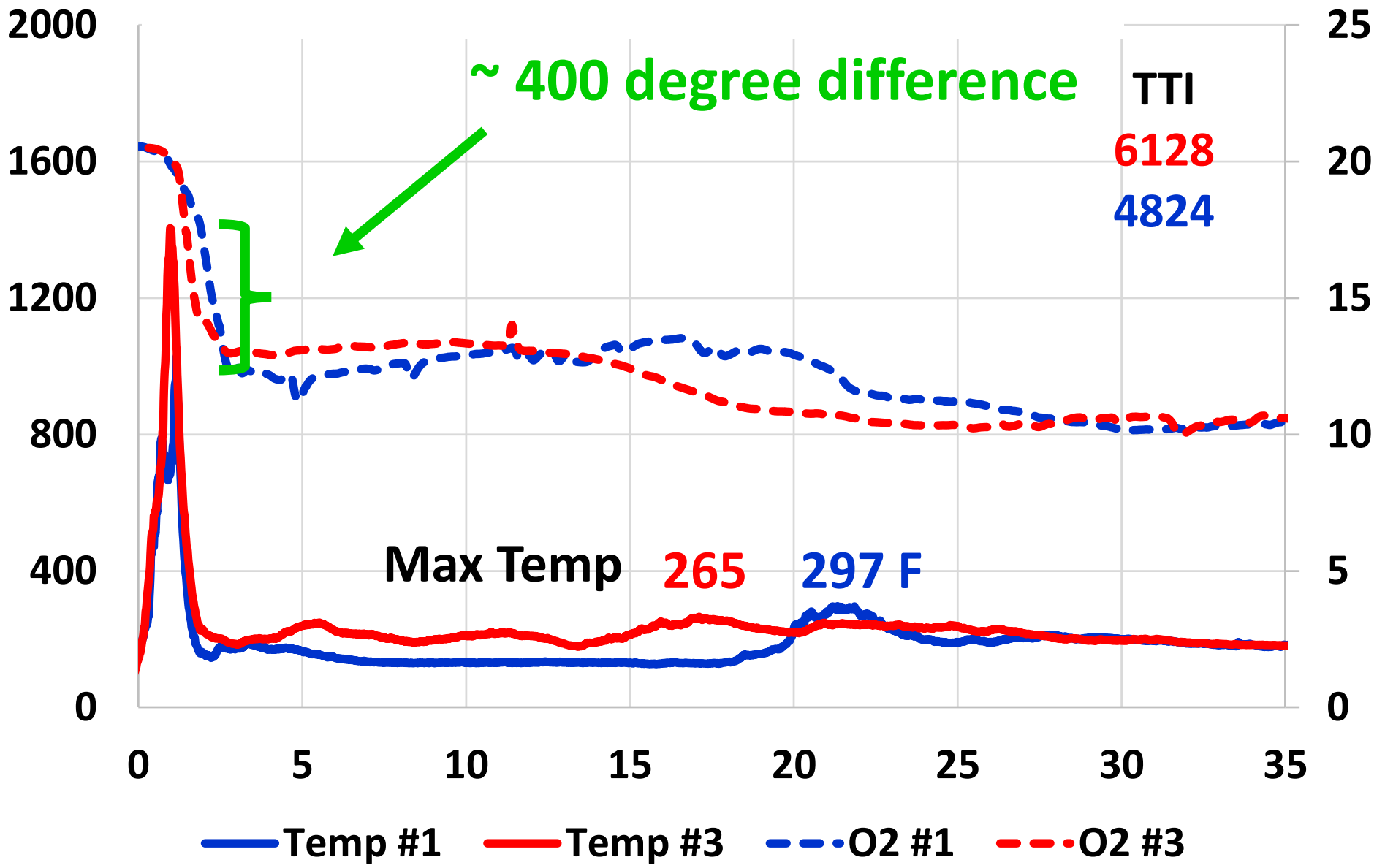
Evolution of the MFF

Second MFF Compared to First (Suppressed)

Used
Bags of ethanol

Instead of
IATA Boxes and plastic jugs

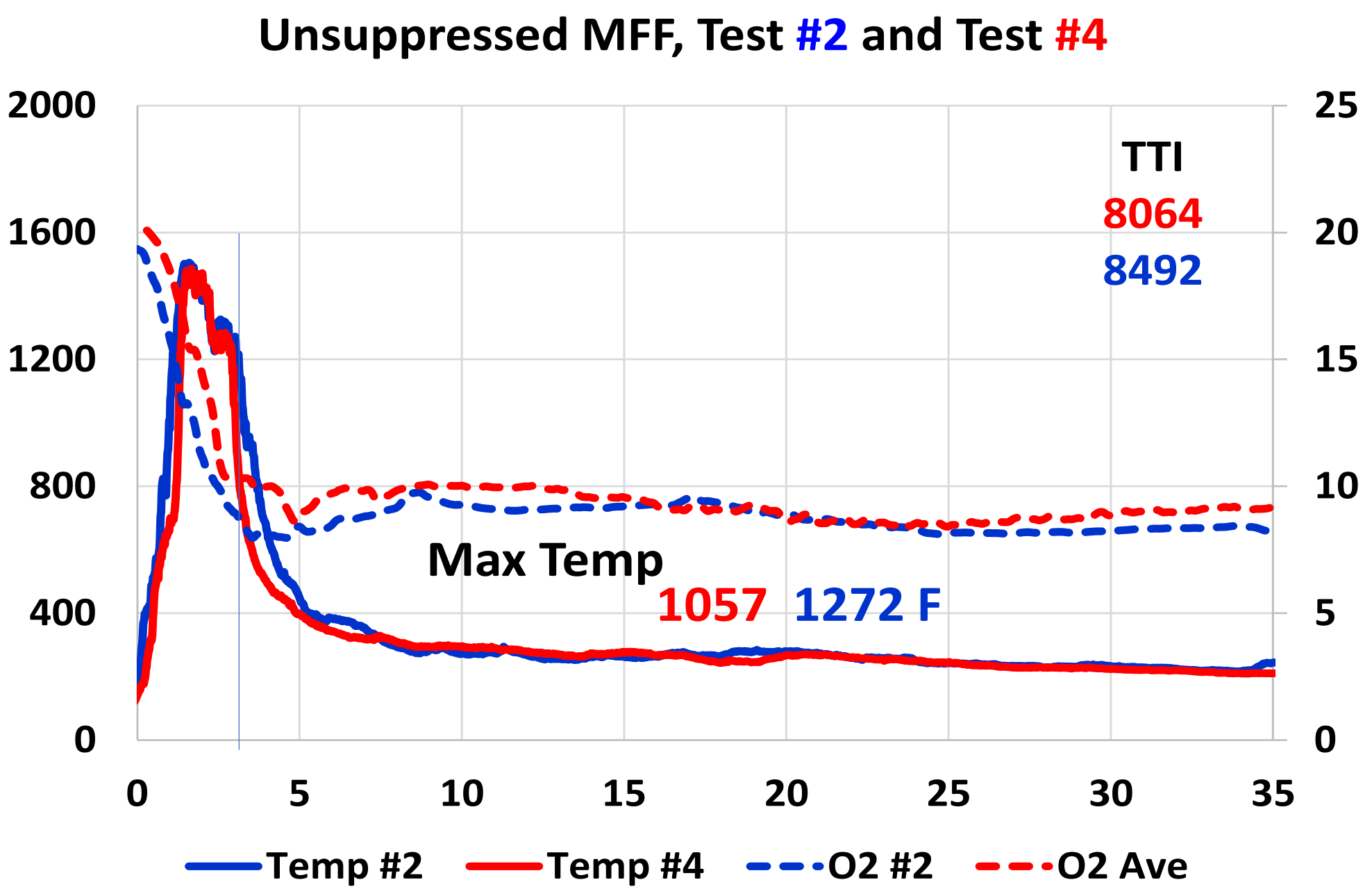
Box 8 was involved
Box 14 was not



2 Unsuppressed Multiple Fuel Fires

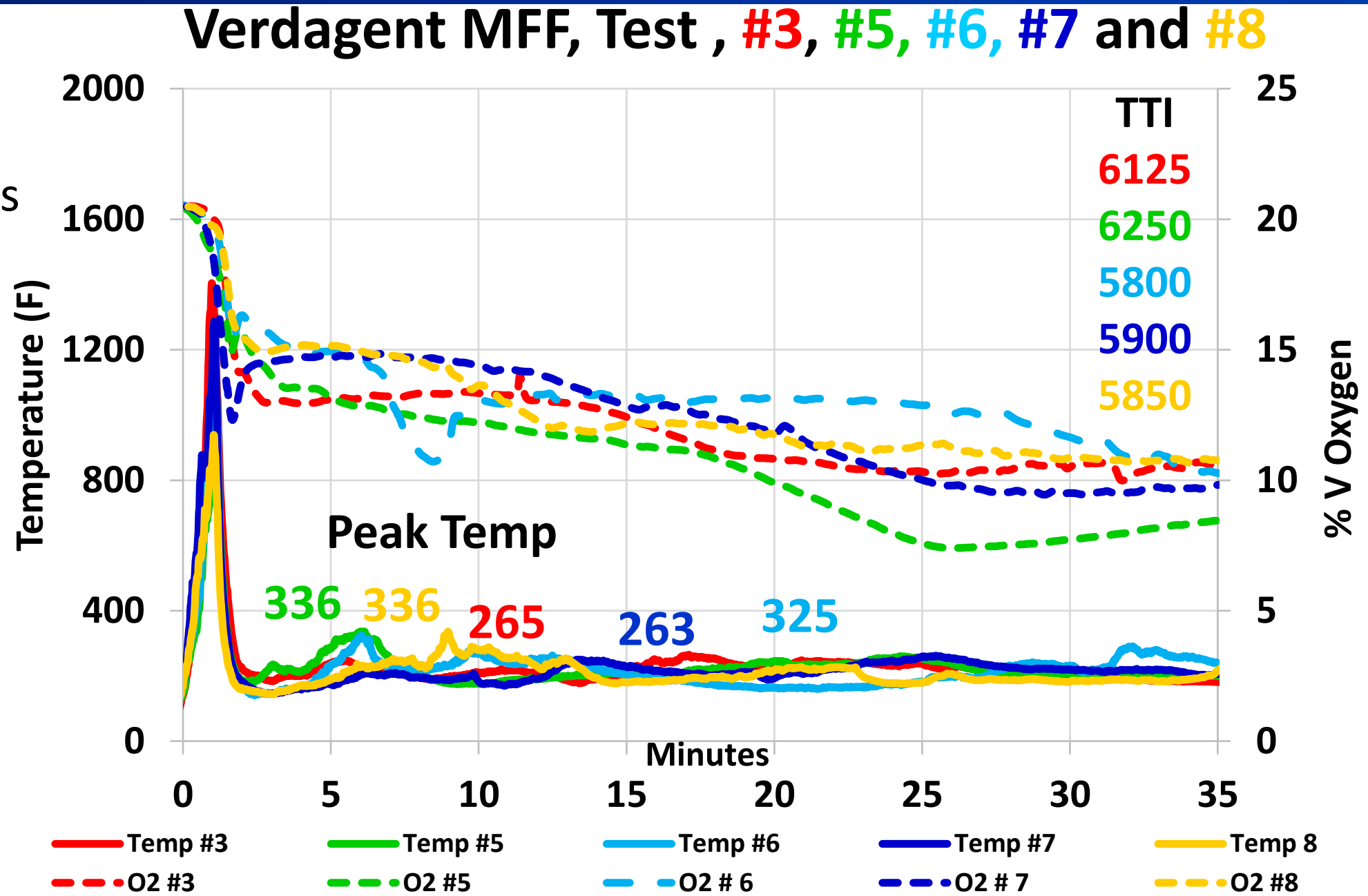
Bags of ethanol

Box 8 was involved
Box 14 was not



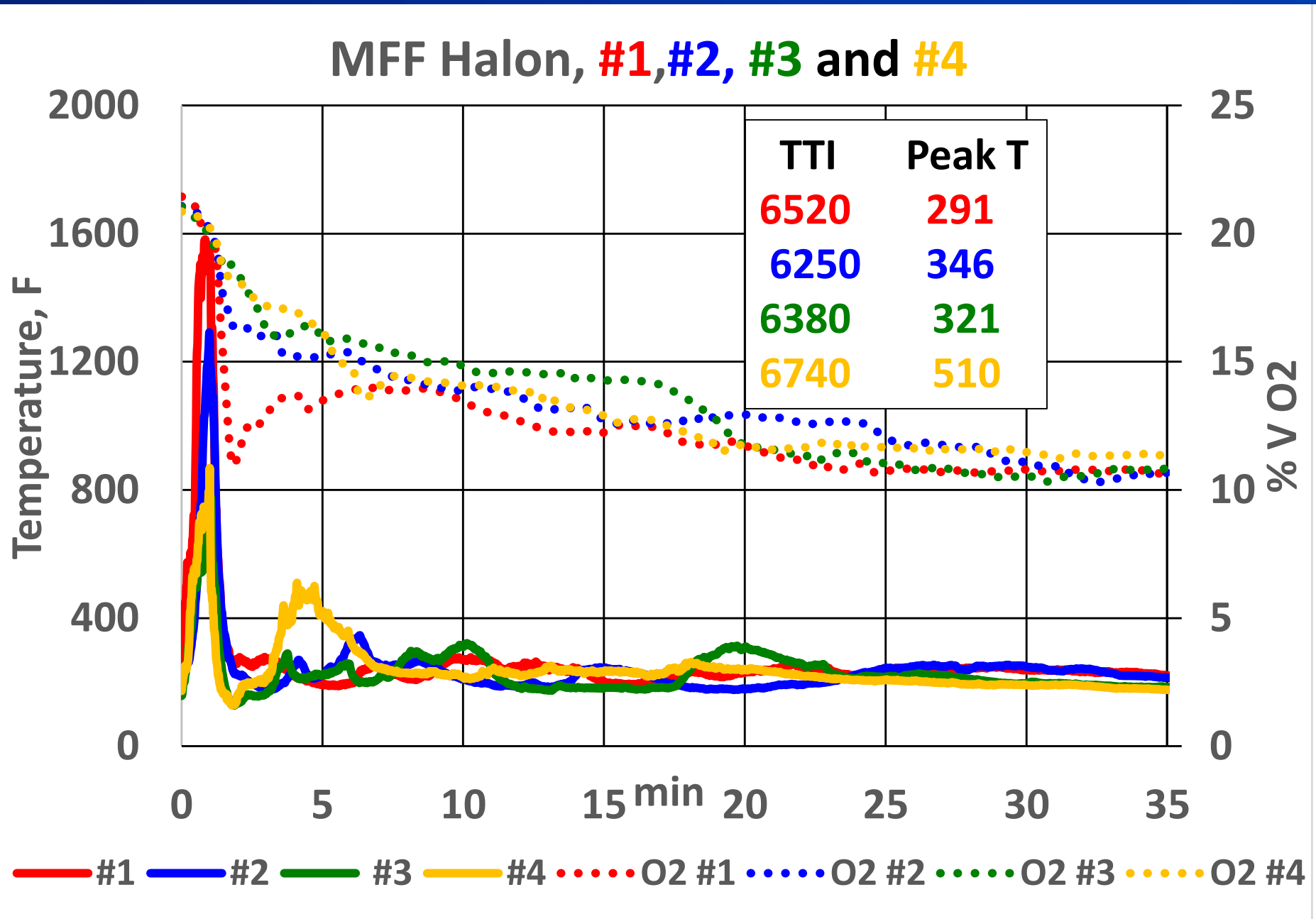
Comparison of 5 VERDAGANT Multiple Fuel Fires

General Trend They are all similar



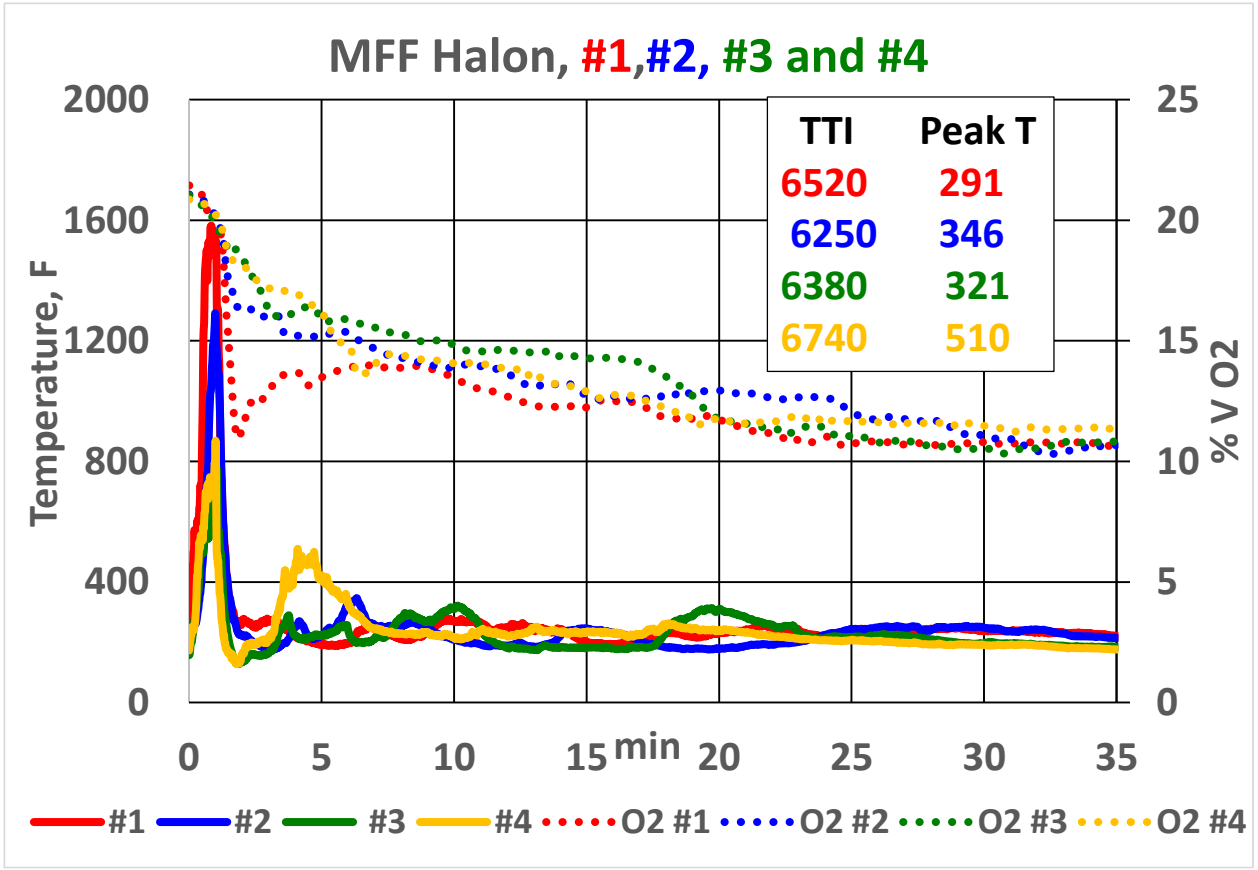
Comparison of 5 Halon Multiple Fuel Fires

General Trend They are similar

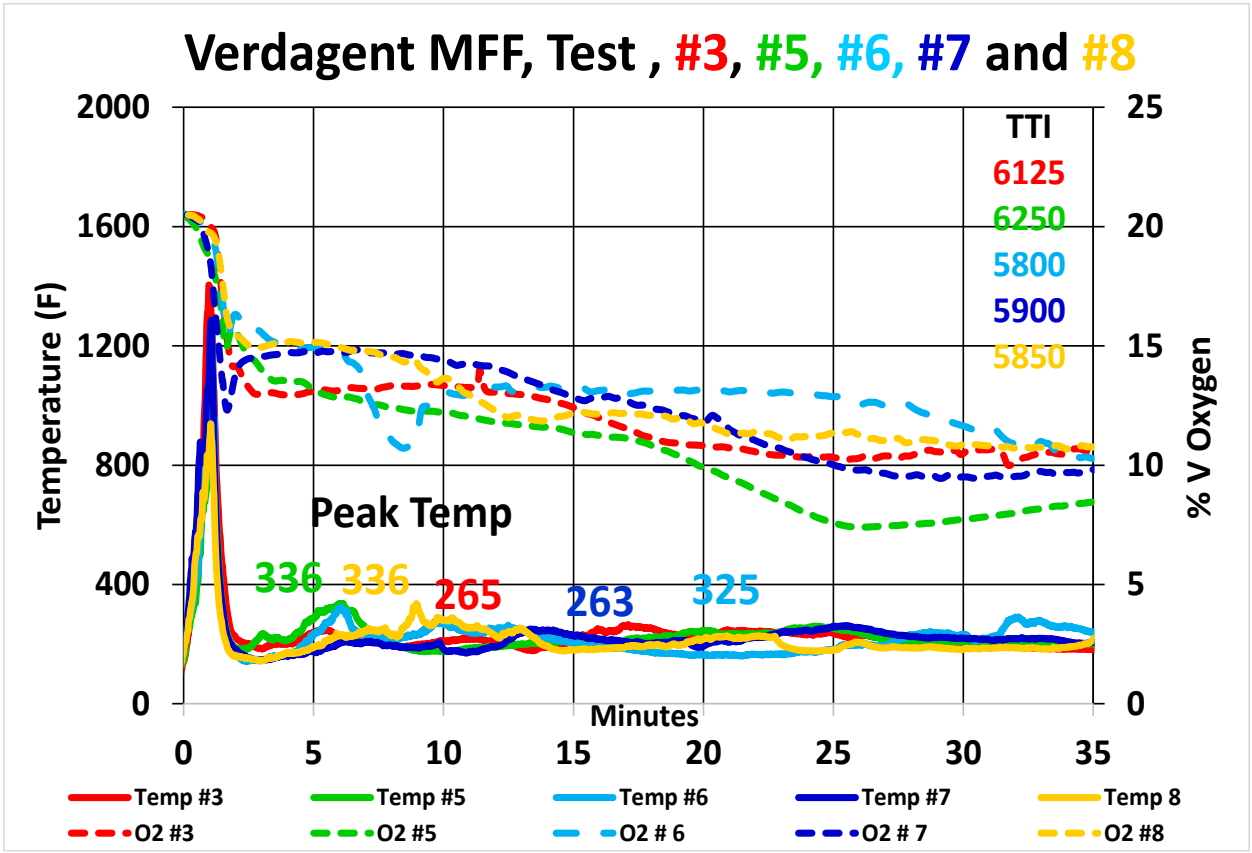


% V Oxygen and TTOP Box Temperature plots

Halon



VERDAGENT



Generally they look very similar

MPS dictates a new agent needs to average better than the max + SD For Halon Testing

	MFF	
	Halon	
run	TTI	Peak T
1	6520	291
2	6250	346
3	6380	321
4	6740	510
5		
Ave	6473	367
SD	182	85
Criteria	6922	595

	VERD	
run	TTI	Peak T
1	6125	265
2	6250	336
3	5800	325
4	5900	263
5	5850	336
Ave	5985	305
SD	173	34

Criteria = Max +SD		
Max	6740	510

Ave	5985	305

* All 5 need to be done

	TTI	and	Peak Temp
*Current Criteria	6922		595
VERDAGENT Ave	5985		305

VERDAGENT easily passes this criteria

Conclusions

- Halon tests appear to follow the same pattern as VERDAGENT tests with regard to:
  - number of boxes burned
  - number of batteries burned
  - fire spread

- Verdagent performed a little better than Halon with regard to :
  - Time Temp integral
  - Peak T

  - Verdagent will pass the MFF Criteria based on Halon Baseline Testing