



# Boeing Cargo MPS Halon 1301 Test Results

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# Boeing Halon 1301 Cargo MPS Test Results

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- A complete baseline set of Minimum Performance Standard (MPS) tests using Halon 1301 has been successfully completed in the Boeing MPS test facility.
  - 5 each of the Bulk Load, Containerized, Surface Burning and Aerosol Can Explosion Simulation Tests
- Peak temperature and time-temperature integrals are less than those published in DOT/FAA/TC-TN12/11 (Minimum Performance Standard for Aircraft Cargo Compartment Halon Replacement Fire Suppression Systems (2012 Update)).
- The Halon 1301 results obtained in the Boeing MPS test facility form the success criteria for Halon replacement fire suppression agents tested in the Boeing MPS facility.
  - The peak and time-temperature integrals are unique to the test facility, but expected to be similar to the FAA results

# Boeing Halon 1301 Cargo MPS Test Results

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- Multiple empty compartment agent concentration tests were used to determine for the Boeing MPS test cell:
  - Halon 1301 mass fill in the High Rate Discharge (HRD) bottle
    - Initial volumetric concentration of Halon 1301 was 5.0% +/- .1% for all empty compartment agent concentration tests
  - Time delay between HRD and Low Rate Discharge (LRD) bottle discharges
    - The average decay time from 5.0% to 3.0% for all empty compartment agent concentration tests was used to determine the LRD delay.
  - Mass flow rate of Halon 1301 from the LRD bottle
    - The mass flow rate was demonstrated to provide a constant Halon concentration of 3.0% +/- .1%

# Boeing Halon 1301 Cargo MPS Test Results

## Aerosol Can Explosion Simulation

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- 5 Halon 1301 Aerosol Can Explosion Simulation (ACES) tests were completed in the Boeing MPS test cell.
- All simulations were conducted with a volumetric concentration of Halon 1301 = 3.0%
  - Small flames were visible in 3 of the tests (less than 3” at the igniter, less than ½ second)
  - A larger “flash” was visible in 1 of the tests (separated from the igniter approx. 1-2 ft. in diameter)
  - No flame or flash visible in 1 of the tests
- Mixing fans were used to obtain a homogenous mixture of Halon 1301. The fans were turned off 10 seconds prior to simulator activation.
- The pressure rise from the ignition is distinct from, and significantly smaller than, the simulator discharge.

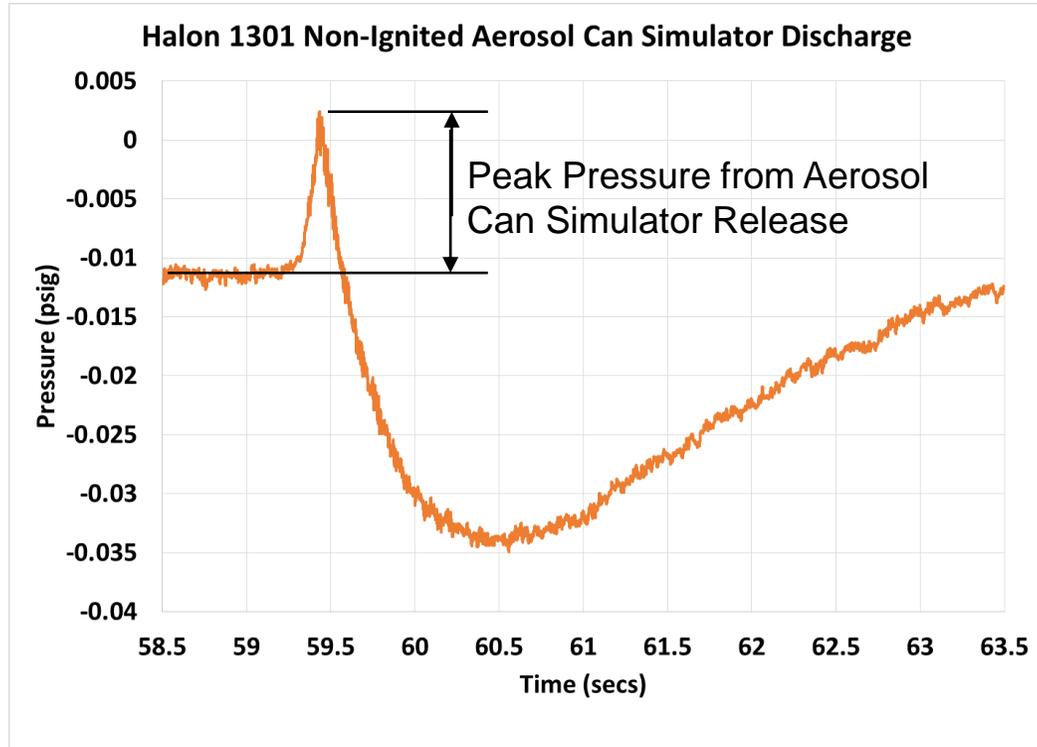
# Boeing Halon 1301 Cargo MPS Test Results Aerosol Can Explosion Simulation



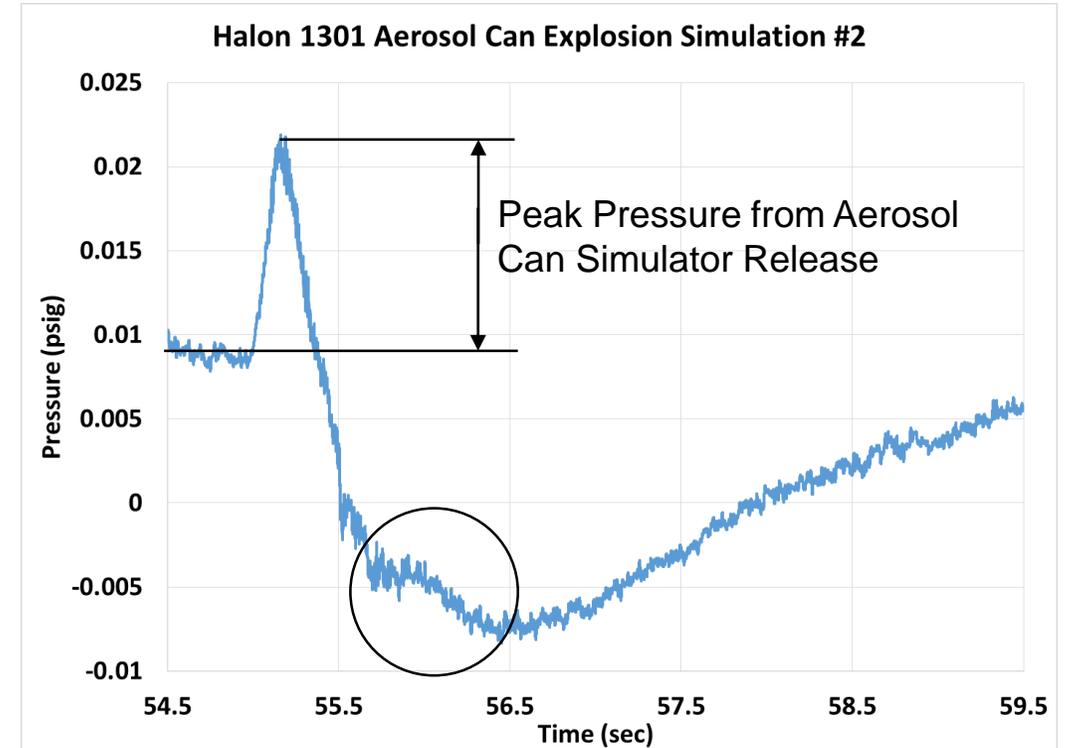
There is a noticeable time delay of about a half second between the release of the simulator gas cloud and the flash.

# Boeing Halon 1301 Cargo MPS Test Results

## Aerosol Can Explosion Simulation



Non-Ignited Simulator Discharge into 3.0% Halon 1301

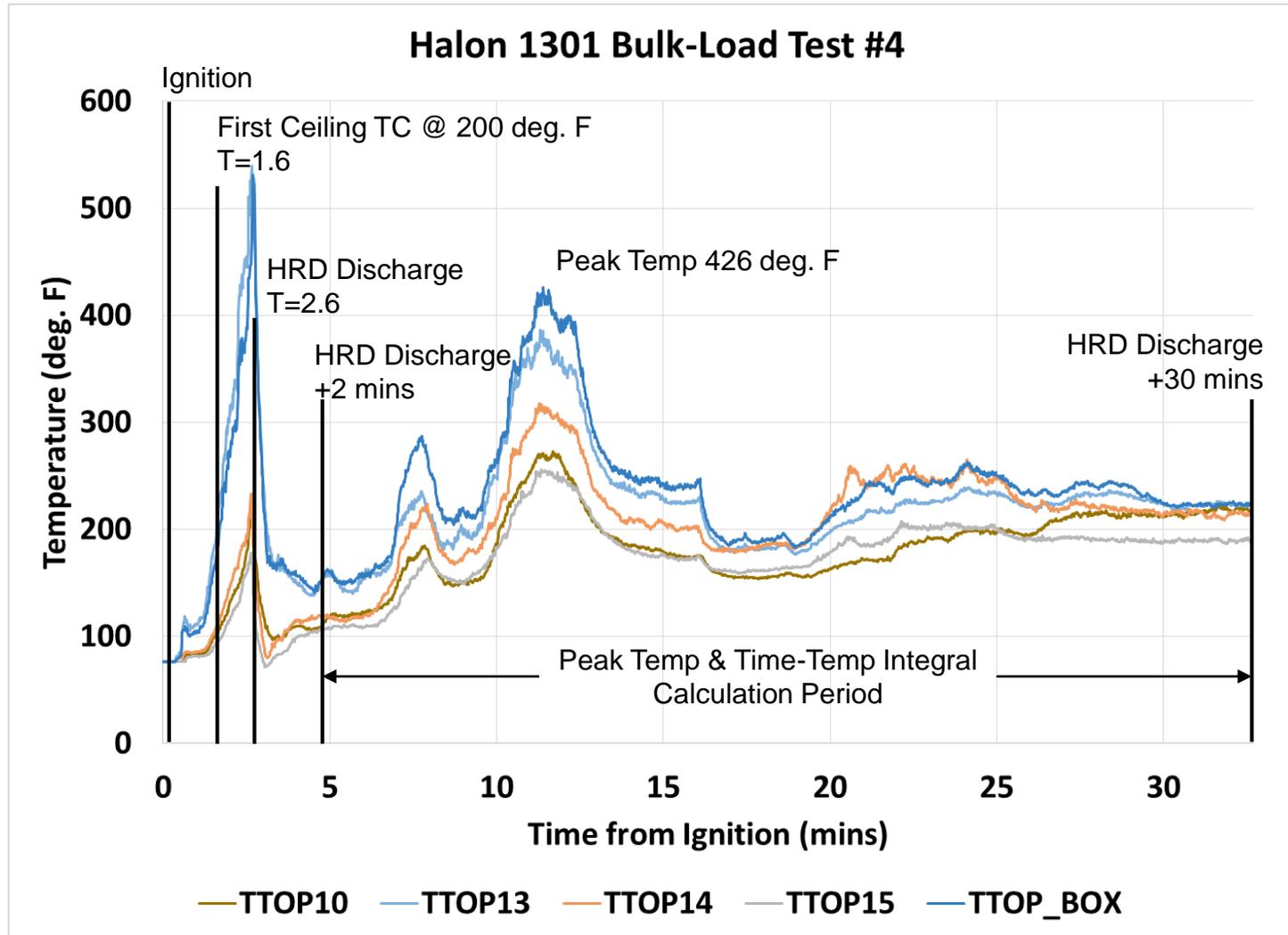


Ignited Simulator Discharge into 3.0% Halon 1301

- The pressure response on the right is from the ignited test which had a “flash”, the most significant visual response during all of our Halon tests. The ignition response can be seen approximately 1/2 second after the pressure response from the simulator discharge. The pass/fail criteria of being less than the simulator pressure rise was met.
- Not all ignited test conditions exhibit the secondary ignition response.

# Boeing Halon 1301 Cargo MPS Test Results

## Bulk-Load Fire Test #4 - Example



### Test sequence

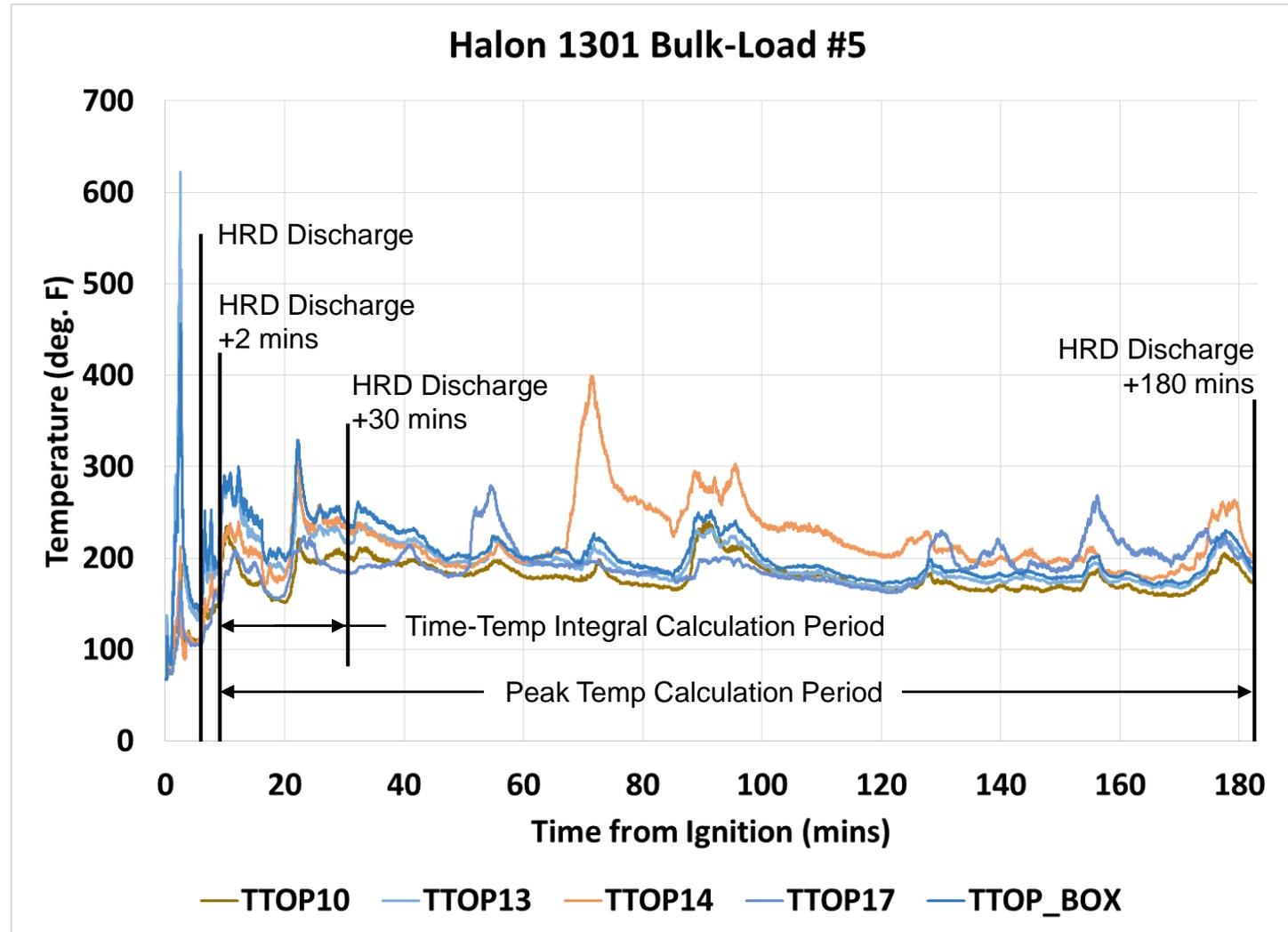
- Ignition
- HRD is activated 1 minute after first ceiling TC reaches 200 deg. F
- LRD is activated after time delay
- Peak temp calculated over  $T=HRD+2$  through end of test ( $T=HRD+30$  or  $T=HRD+180$ )
- Time-temp integral calculated over  $T=HRD+2$  through  $T=HRD+30$

### Example: Bulk-Load test #4

- T=0: Ignition
- T=1.6: 200 deg. F
- T=2.6: HRD discharge
- T=11.4: Peak temp = 426 deg. F
- Max time-temp integral: 6686 deg. F - min

# Boeing Halon 1301 Cargo MPS Test Results

## Bulk-Load Fire, 180 minutes



- One of the 5 bulk-load test conditions was conducted for 180 minutes
- Peak temp calculated over  $T=HRD+2$  through  $T=HRD+180$
- Time-temp integral calculated over  $T=HRD+2$  through  $T=HRD+30$
- The long term temperature profile was cyclic as additional boxes became involved in the fire; however the temperature was not increasing meeting the MPS criteria.

# Boeing Halon 1301 Cargo MPS Test Results

## Bulk-Load Summary – Tabular Results

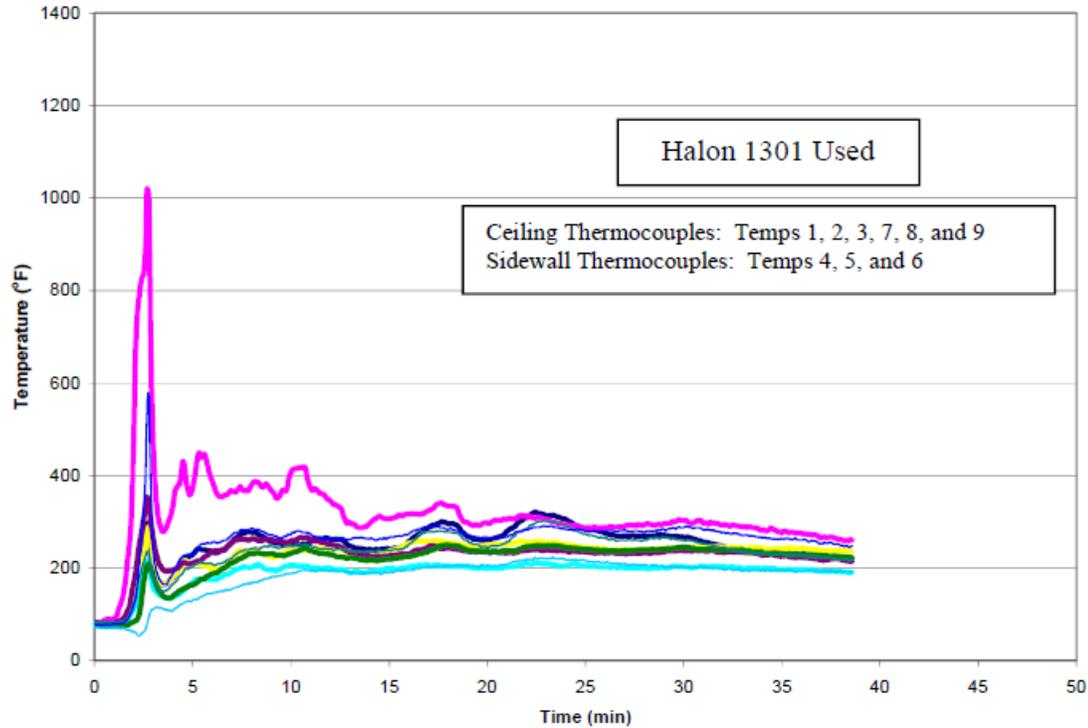
Note: DOT/FAA/TC-TN12/11 includes results for six bulk-load test conditions; however only 5 tests of each scenario are required.

| Test | DOT/FAA/TC-TN12/11 |                      | Boeing           |                      |
|------|--------------------|----------------------|------------------|----------------------|
|      | Max Temp. (deg F)  | Max Area (deg F-min) | Max Temp (deg F) | Max Area (deg F-min) |
| 1    | 511                | 7979                 | 379              | 6502                 |
| 2    | 431                | 8885                 | 432              | 7401                 |
| 3    | 450                | 9068                 | 392              | 6468                 |
| 4    | 382                | 8939                 | 426              | 6686                 |
| 5    | 632                | 9413                 | 399              | 6574                 |
| 6    | 461                | 8704                 |                  |                      |

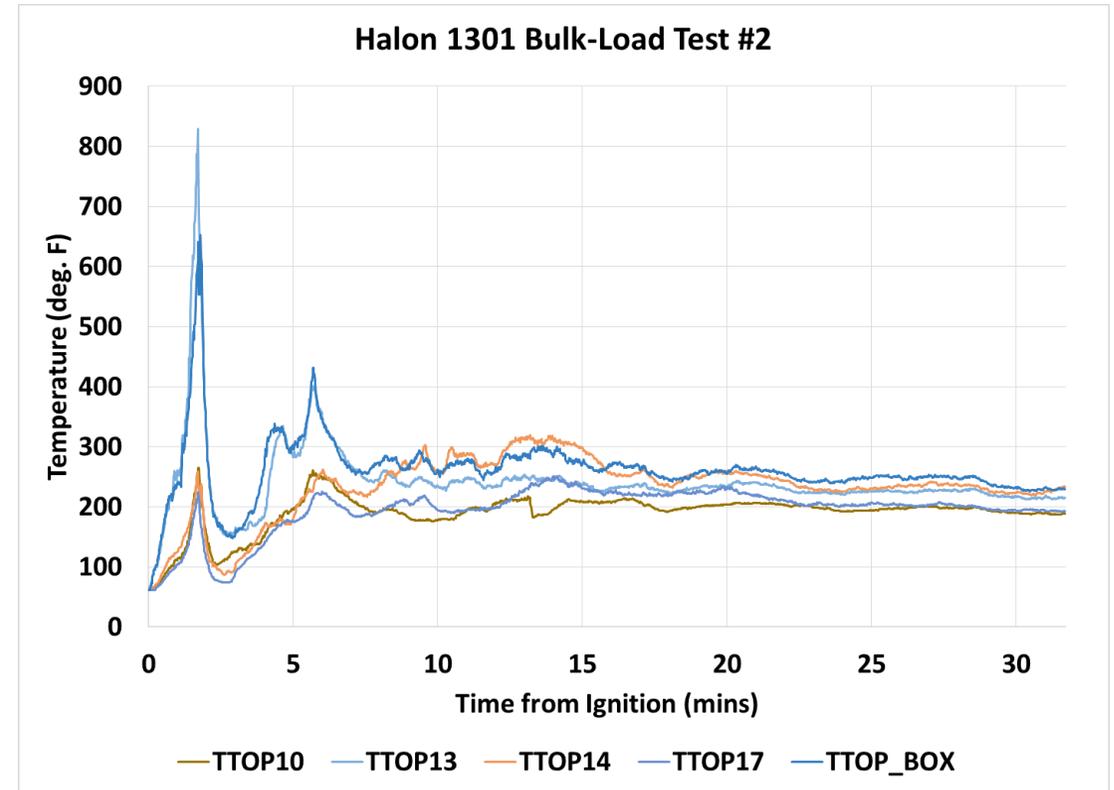
|                               |     |      |      |       |
|-------------------------------|-----|------|------|-------|
| Maximum                       | 632 | 9413 | 432  | 7401  |
| Average                       | 478 | 8831 | 406  | 6726  |
| Sample Standard Deviation     | 86  | 480  | 23   | 386   |
| Population Standard Deviation | 79  | 438  | 20   | 346   |
| Sum of Std. Dev. + Max.       | 711 | 9851 | 455  | 7787  |
| MPS Acceptance Criteria       | 710 | 9850 | 455* | 7787* |

\*Acceptance criteria for alternative agents tested in the Boeing MPS facility.

# Boeing Halon 1301 Cargo MPS Test Results Bulk-Load Fires Compared



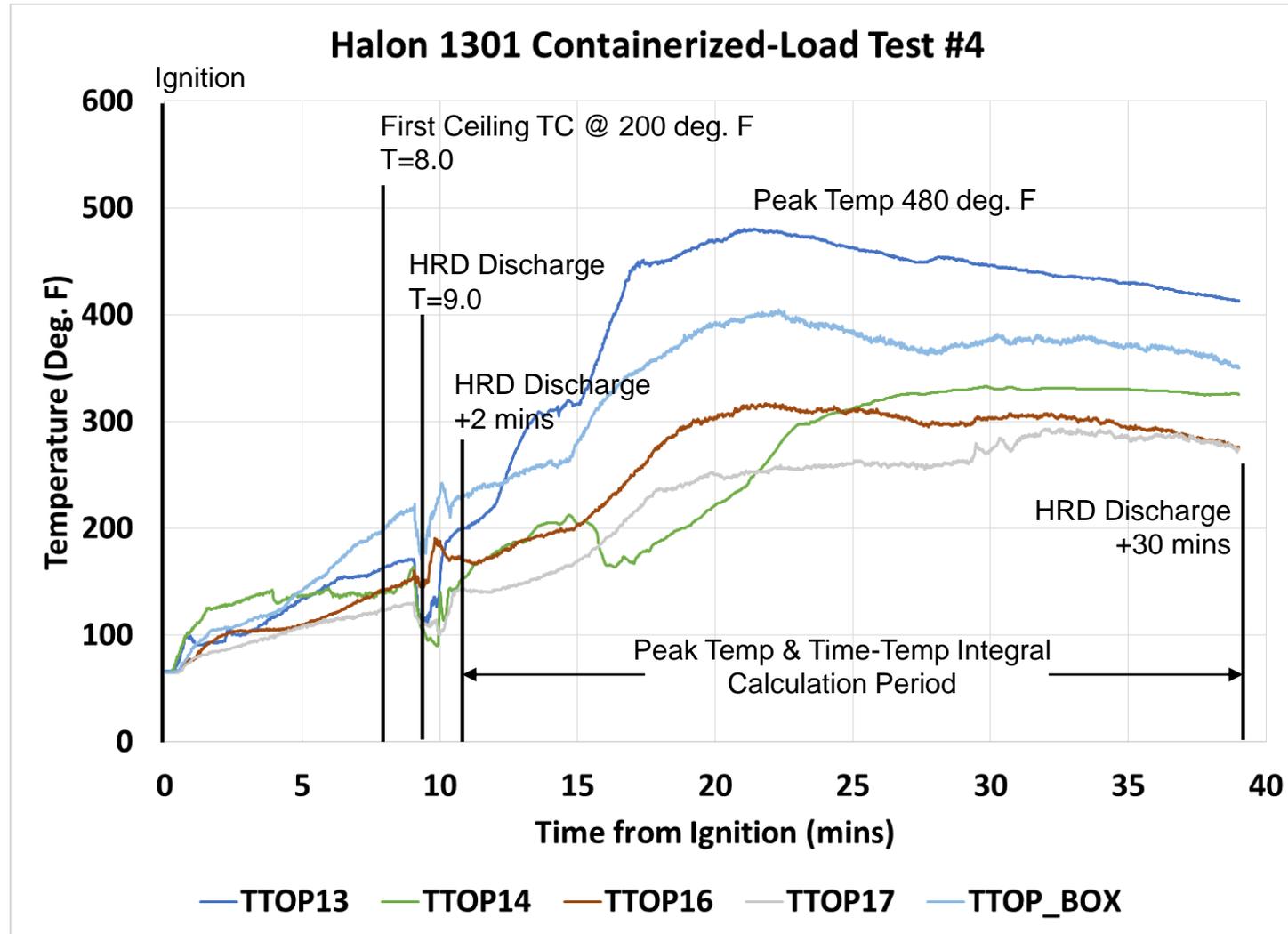
Bulk-load, FAA MPS facility



Bulk-load, Boeing MPS facility

The temperature profile observed in the Boeing MPS facility exhibits a similar shape to the FAA bulk-load profile published in DOT/FAA/AR-00/28; however, peak temperatures and time temperature integrals are lower in the Boeing test facility.

# Boeing Halon 1301 Cargo MPS Test Results Containerized-Load Fire



## Test sequence

- Ignition
- HRD is activated 1 minute after first ceiling TC reaches 200 deg. F
- LRD is activated after time delay
- Peak temp calculated over  $T=HRD+2$  through end of test ( $T=HRD+30$  or  $T=HRD+180$ )
- Time-temp integral calculated over  $T=HRD+2$  through  $T=HRD+30$

## Example: Containerized-Load test #4

- T=0: Ignition
- T=8.0: 200 deg. F
- T=9.0: HRD discharge
- T=21.4: Peak temp = 480 deg. F
- Max time-temp integral: 11713 deg. F - min

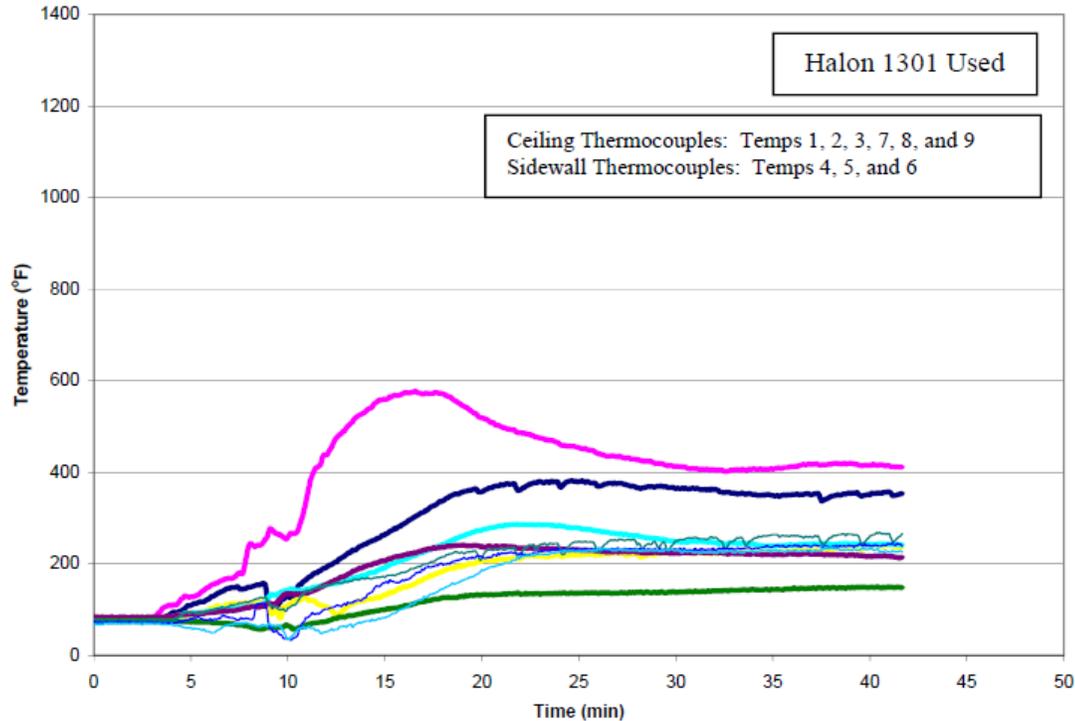
# Boeing Halon 1301 Cargo MPS Test Results Containerized-Load Summary – Tabular Results

| Test | DOT/FAA/TC-TN12/11   |                         | Boeing              |                         |
|------|----------------------|-------------------------|---------------------|-------------------------|
|      | Max Temp.<br>(deg F) | Max Area<br>(deg F-min) | Max Temp<br>(deg F) | Max Area<br>(deg F-min) |
| 1    | 607                  | 13573                   | 388                 | 9721                    |
| 2    | 577                  | 12998                   | 426                 | 9930                    |
| 3    | 606                  | 13108                   | 398                 | 9610                    |
| 4    | 520                  | 11937                   | 480                 | 11713                   |
| 5    | 498                  | 10966                   | 424                 | 10339                   |

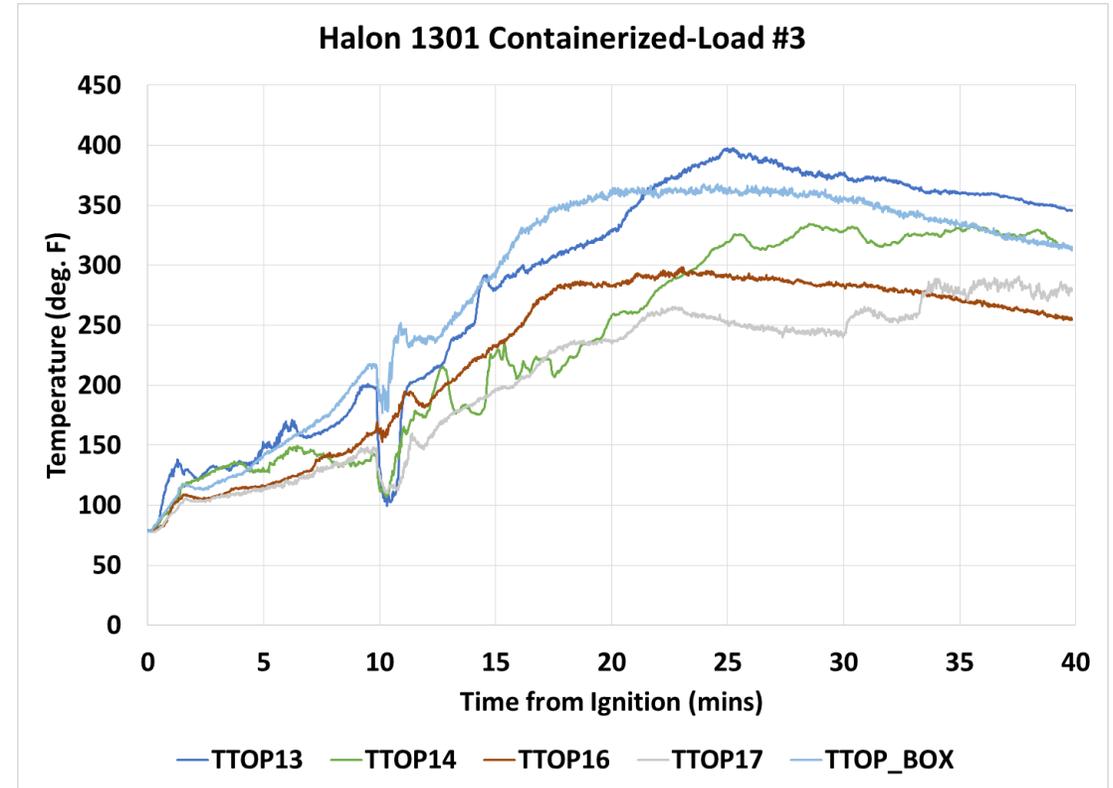
|                               |     |       |      |        |
|-------------------------------|-----|-------|------|--------|
| Maximum                       | 607 | 13573 | 480  | 11713  |
| Average                       | 562 | 12516 | 423  | 10263  |
| Sample Standard Deviation     | 50  | 1053  | 36   | 857    |
| Population Standard Deviation | 45  | 942   | 32   | 767    |
| Sum of Std. Dev. + Max.       | 652 | 14515 | 516  | 12570  |
| MPS Acceptance Criteria       | 650 | 14520 | 516* | 12570* |

\*Acceptance criteria for alternative agents tested in the Boeing MPS facility.

# Boeing Halon 1301 Cargo MPS Test Results Containerized-Load Fires Compared



Containerized-load, FAA MPS facility

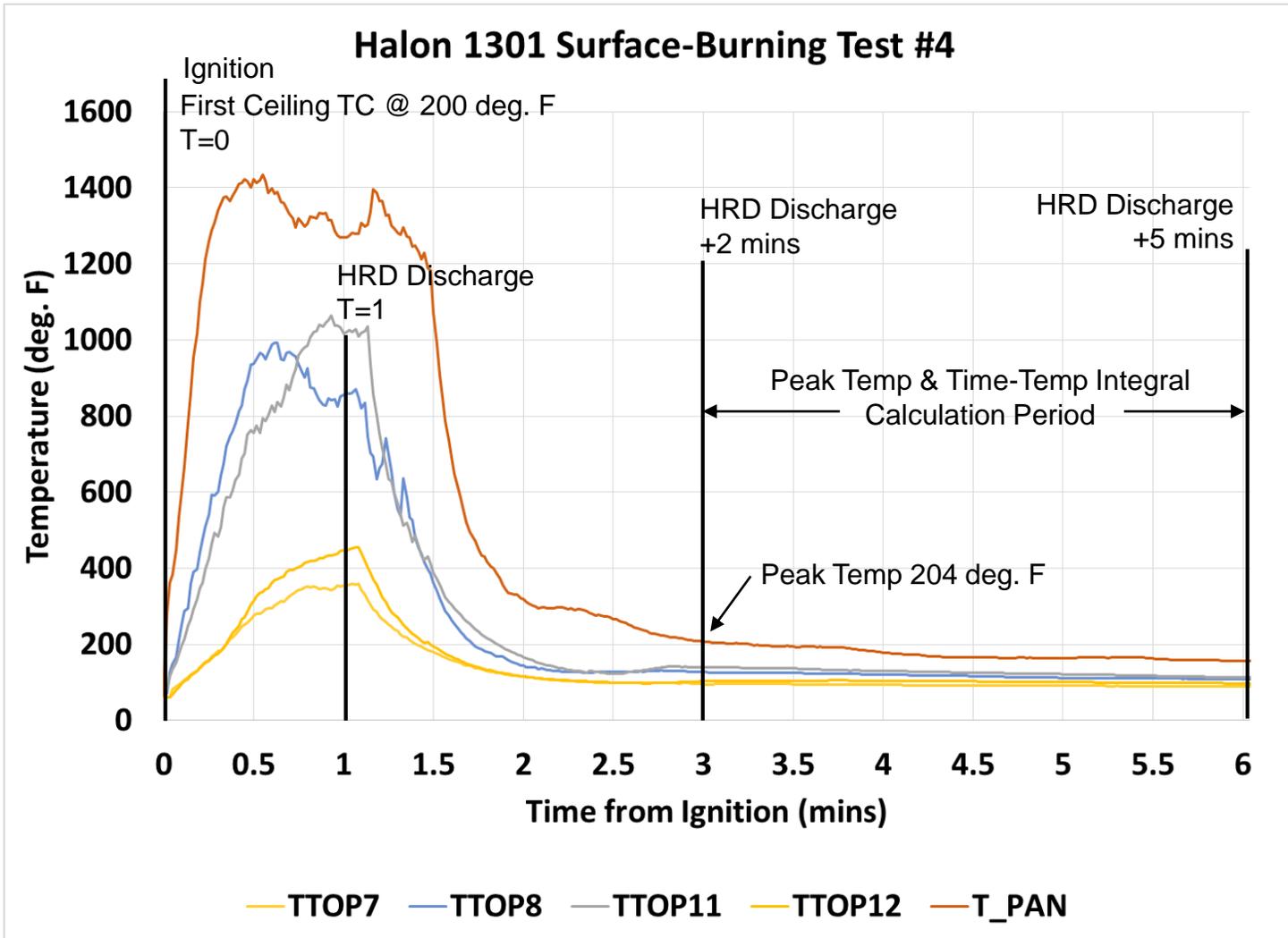


Containerized-load, Boeing MPS facility

The temperature profile observed in the Boeing MPS facility exhibits a similar shape to the FAA containerized-load profile published in DOT/FAA/AR-00/28; however, peak temperatures and time temperature integrals are lower in the Boeing test facility.

# Boeing Halon 1301 Cargo MPS Test Results

## Surface-Burning Fire



### Test sequence

- Ignition
- HRD is activated 1 minute after first ceiling TC reaches 200 deg. F
- Peak temp & time-temp integral calculated over  $T=HRD+2$  through  $T=HRD+5$

### Example: Surface-Burning test #4

- T=0: Ignition
- T=0: 200 deg. F
- T=1.0: HRD discharge
- T=3.0: Peak temp = 204 deg. F
- Max time-temp integral: 521 deg. F - min

# Boeing Halon 1301 Cargo MPS Test Results Surface-Burning Summary – Tabular Results

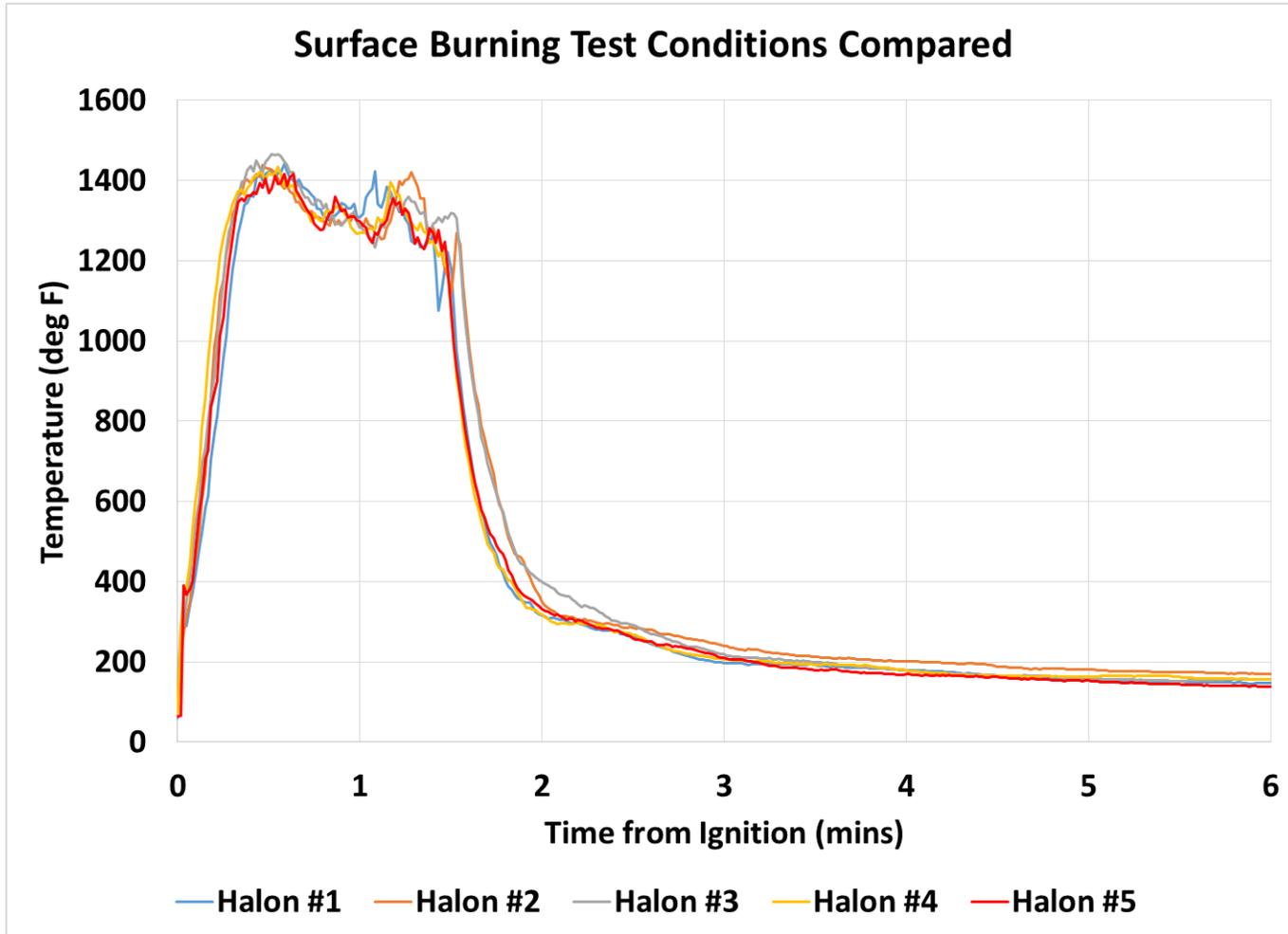
| Test | DOT/FAA/TC-TN12/11   |                         | Boeing              |                         |
|------|----------------------|-------------------------|---------------------|-------------------------|
|      | Max Temp.<br>(deg F) | Max Area<br>(deg F-min) | Max Temp<br>(deg F) | Max Area<br>(deg F-min) |
| 1    | 549                  | 1150                    | 232                 | 573                     |
| 2    | 539                  | 1160                    | 197                 | 507                     |
| 3    | 549                  | 1167                    | 213                 | 517                     |
| 4    | 517                  | 1119                    | 204                 | 521                     |
| 5    | 514                  | 1114                    | 206                 | 484                     |

|                               |     |      |      |      |
|-------------------------------|-----|------|------|------|
| Maximum                       | 549 | 1167 | 232  | 573  |
| Average                       | 534 | 1142 | 210  | 520  |
| Sample Standard Deviation     | 17  | 24   | 13   | 33   |
| Population Standard Deviation | 15  | 22   | 12   | 29   |
| Sum of Std. Dev. + Max.       | 564 | 1189 | 245  | 606  |
| MPS Acceptance Criteria       | 570 | 1190 | 245* | 606* |

\*Acceptance criteria for alternative agents tested in the Boeing MPS facility.

# Boeing Halon 1301 Cargo MPS Test Results

## Surface-Burning Fires Compared

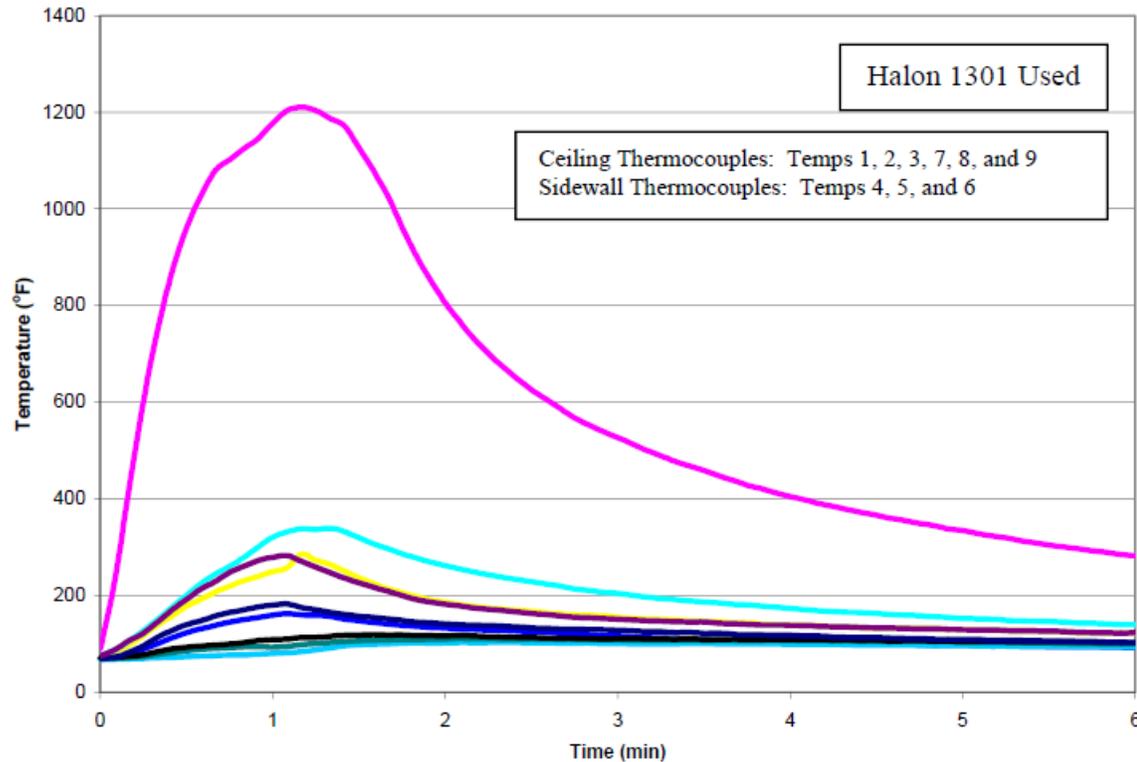


The Boeing MPS test cell provides for very consistent fires and thus the temperature profiles for all 5 surface-burning test conditions are extremely similar.

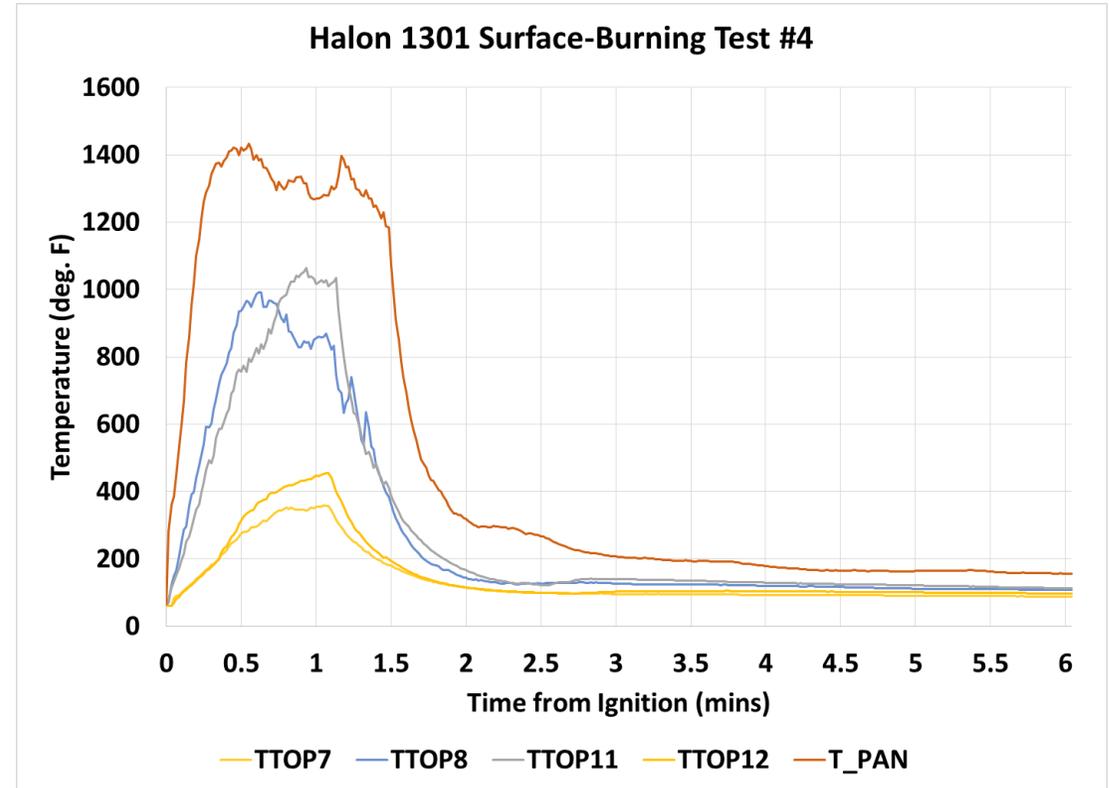
Peak temp for all 5 conditions in Boeing MPS facility

# Boeing Halon 1301 Cargo MPS Test Results

## Surface-Burning Fires Compared



Surface-burning, FAA MPS facility



Surface-burning, Boeing MPS facility

- Temperatures in the Boeing facility were initially higher but dropped more rapidly upon fire extinguishment.
- Temperatures at T=HRD+2 are much lower than in the FAA MPS facility

# Boeing Halon 1301 Cargo MPS Test Results

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- A complete set of baseline Halon 1301 MPS tests has been successfully completed in the Boeing Cargo MPS test facility.
- Peak temperature and time-temperature integrals are less than those published in DOT/FAA/TC-TN12/11. Calibration of the test facility with Halon 1301 ensures equivalent performance of agents.
- Acceptance criteria for alternative agents to be tested in the Boeing Cargo MPS test facility have been established via the Halon 1301 baseline tests.

