HEAT RELEASE RATE Updates

2015 October Materials Meeting
Atlantic City, NJ

Materials Working Group

Michael Burns, FAA Tech Center

October, 2015

Federal Aviation Administration

AGENDA

➢ <u>HR2</u>: Design of Experiment (DOE) Draft Test Plan

➢ <u>OSU</u>: Airflow Split Round Robin Test Plan

➢ Next

DOE Draft Test Plan Concept

- Randomize 4 main parameters

- Initially use Material Simulator Test to study impacts on data

Parameter	DESCRIPTION	Min.	Avg.	Max.
System Air Flow rates	SCFM	19	20	21
Heat Flux (W/cm^2)	Center	3.60	3.65	3.70
Upper Pilot	Air (L/min)	0.8	1.0	1.2
	Methane (L/min)	1.3	1.5	1.7

Design of Experiment (DOE)

Data collection:

Software

- Time

- Thermopile voltage (Real time)

- Thermopile voltage (15 minute Running average)

- Center Heat flux (Real Time)

- Center Heat flux (60 second Running average)

- Inlet air Flow (SCFM)

- Inlet air temperature

Design of Experiment (DOE)

Data collection:

Manually recorded periodically

- Time

- Ambient Conditions

  - Room temp

  - Barometric Pressure

  - % Relative Humidity

- Inlet air % Relative Humidity

Design of Experiment (DOE)

Data collection:

Manually recorded periodically (Continued)

- % Power to Upper globars

- % Power to Lower globars

- Methane flow rate upper pilot burner

- Methane flow rate to lower pilot burner

- Air flow rate to upper pilot burner

- Air flow rate to lower pilot burner

Run Order	Series	Data Point	Airflow (SCFM)	Center Heat Flux (W/cm2)	Upper Pilot Flame Methane (L/min)	Upper Pilot Flame Air (L/min)
1	1	PRE	20	3.65	1.5	1.0
2	1	2	19	3.60	1.3	0.8
3	1	3	19	3.60	1.3	1.2
4	1	4	19	3.60	1.7	1.2
5	1	5	19	3.60	1.7	0.8
6	1	POST	20	3.65	1.5	1.0
7	2	PRE	20	3.65	1.5	1.0
8	2	2	19	3.70	1.3	0.8
9	2	3	19	3.70	1.3	1.2
10	2	4	19	3.70	1.7	1.2
11	2	5	19	3.70	1.7	0.8
12	2	POST	20	3.65	1.5	1.0
13	3	PRE	20	3.65	1.5	1.0
14	3	2	21	3.60	1.3	0.8
15	3	3	21	3.60	1.3	1.2
16	3	4	21	3.60	1.7	1.2
17	3	5	21	3.60	1.7	0.8
18	3	POST	20	3.65	1.5	1.0
19	4	PRE	20	3.65	1.5	1.0
20	4	2	21	3.70	1.3	0.8
21	4	3	21	3.70	1.3	1.2
22	4	4	21	3.70	1.7	1.2
23	4	5	21	3.70	1.7	0.8
24	4	POST	20	3.65	1.5	1.0

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Design of Experiment (DOE)

Daily Calibration Routine

- Insert HFG calibration assembly in machine and set airflow and heat flux parameters at nominal values (See data point PRE).

- Allow machine to reach equilibrium (workbook, section 2.10).

- Remove HFG calibration apparatus and close all doors.

- Conduct Methane gas calibration and record all values.

Design of Experiment (DOE)

<u>Daily PRE Test Routine (Nominal Parameters)</u>

- Light pilot burners and set as per data point PRE.

- Allow system to stabilize then record 5 minutes of data.

- Turn OFF upper and lower pilot burners.

<u>Daily TEST Routine</u>

- Insert HFG calibration assembly in machine and set air flow and heat flux parameters as per data point #2 for scheduled test day.

Design of Experiment (DOE)

Daily TEST Routine (Continued)

- Allow system to reach equilibrium.

- Remove the HFG calibration assembly.

- Light pilot burners and set as per data point #2 for scheduled test day.

- Allow system to stabilize then record 5 minutes of data.

Design of Experiment (DOE)

Daily TEST Routine (Continued)

- Systematically change inputs per Test Matrix, recording the time of each change.

- Allow system to reach equilibrium at each step before recording 5 minutes of data.

- Turn OFF upper and lower pilot burners.

Design of Experiment (DOE)

Daily POST Test Routine (Nominal Parameters)

- Insert HFG calibration assembly in machine and set airflow and heat flux parameters at nominal values (See data point POST).

- Allow system to reach equilibrium.

- Remove the HFG calibration assembly.

- Light pilot burners and set as per data point POST.

Design of Experiment (DOE)

Daily POST Test Routine (Continued)

- Allow system to stabilize then record 5 minutes of data.

- Turn OFF upper and lower pilot burners.

- Repeat steps on following day until matrix is complete.

Material or Simulator Testing?

- TBD

MATERIAL SIMULATOR TEST

- Lower Pilot (Nominal Parameters)

  - Air set to 1.0 ± 0.2 L/min

  - Methane set to 120 ± 5 mL/min

- Upper Pilot (Nominal Parameters Initially)

  - Air set to 1.0 ± 0.2 L/min

  - Methane set via software program (1.5 L/min)

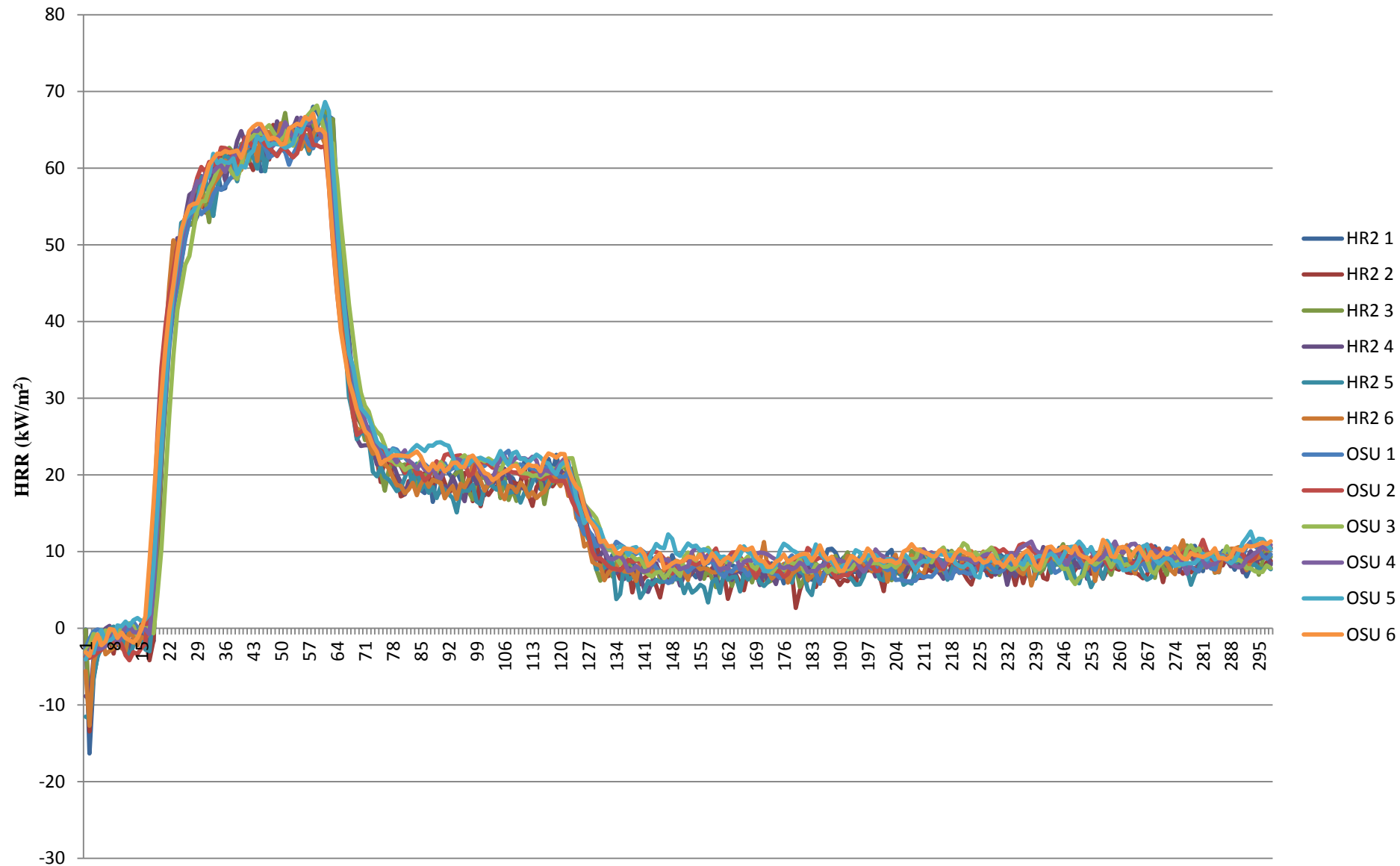- Empty Sample Holder Inserted in Holding Chamber

MATERIAL SIMULATOR TEST

(Empty Sample Holder Inserted in Holding Chamber for 1 minute)

- START TEST (60 Seconds in Holding Chamber)

- 0:00:00 - Flow rate 1.5 L/min for 15 seconds

- 0:00:15 - Set flow rate to 4 L/min for 45 seconds

- 0:00:60 - Set flow rate to 2 L/min for 60 seconds

- 0:02:00 - Set flow rate to 1.5 L/min for 3 minutes

- 0:05:00 - End Test

Material Simulator Test Using a Mass Flow Meter (Methane Gas)

HRR (kW/m²)

Legend:
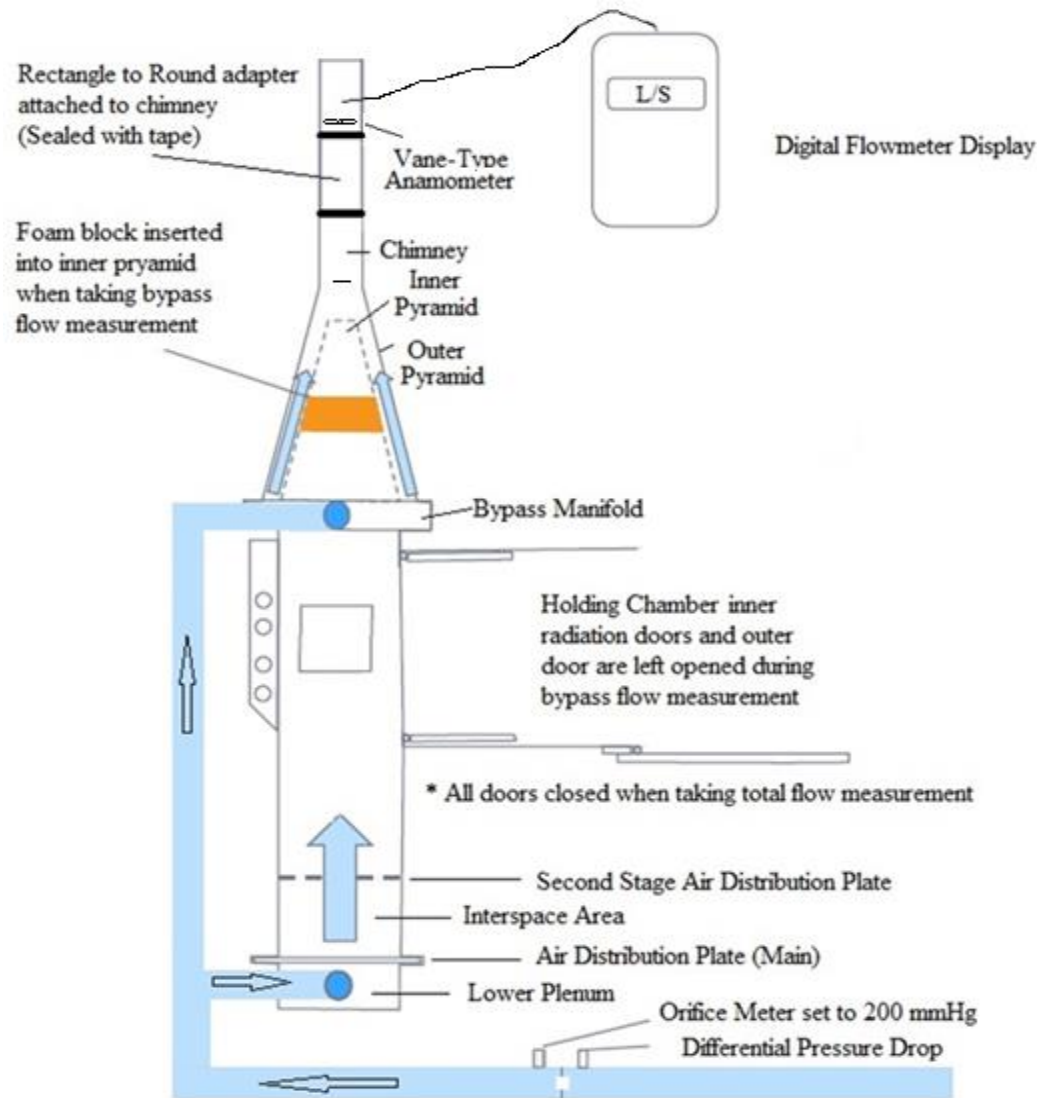- HR2 1
- HR2 2
- HR2 3
- HR2 4
- HR2 5
- HR2 6
- OSU 1
- OSU 2
- OSU 3
- OSU 4
- OSU 5
- OSU 6

Heat Release Rate Test Apparatus
June 2015

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HR2 Simulator Test Data

RUN	PHRR	TTP	THR
1	68	57	65
2	66	57	63
3	68	60	64
4	67	59	65
5	67	59	63
6	67	61	64
AVG	**67**	**59**	**64**
STDEV	**0.6**	**1.6**	**0.8**
% STDEV	**0.9%**	**2.7%**	**1.2%**

OSU Simulator Test Data

RUN	PHRR	TTP	THR
1	66	64	64
2	65	59	65
3	68	62	64
4	67	58	65
5	69	64	66
6	67	61	65
AVG	**67**	**61**	**65**
STDEV	**1.3**	**2.5**	**0.8**
% STDEV	**2.0%**	**4.1%**	**1.3%**

OSU Airflow Measurement Test Plan

Rectangle to Round adapter attached to chimney (Sealed with tape)

Vane-Type Anamometer

L/S

Digital Flowmeter Display

Foam block inserted into inner pryamid when taking bypass flow measurement

Chimney

Inner Pyramid

Outer Pyramid

Bypass Manifold

Holding Chamber inner radiation doors and outer door are left opened during bypass flow measurement

* All doors closed when taking total flow measurement

Second Stage Air Distribution Plate

Interspace Area

Air Distribution Plate (Main)

Lower Plenum

Orifice Meter set to 200 mmHg

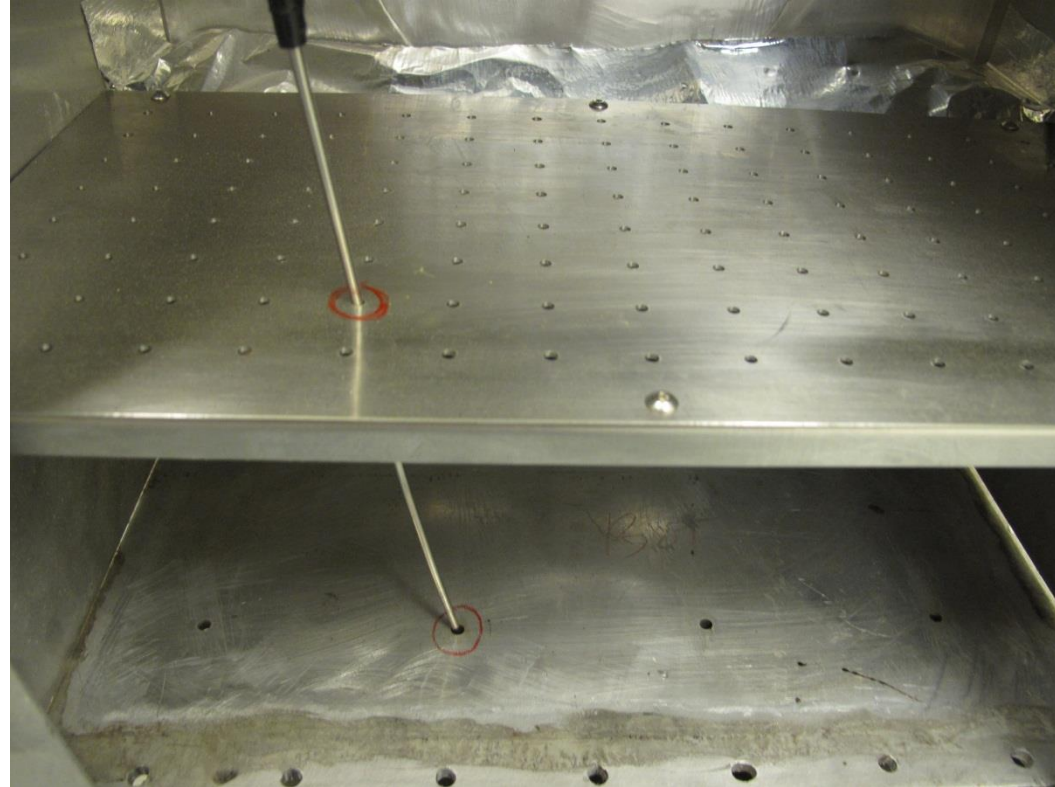Differential Pressure Drop

OSU Airflow Measurement Test Plan

OSU Airflow Measurement Test Plan

OSU Airflow Measurement Test Plan

Airflow Split Data
- Install Airflow Measuring Equipment (No plug; Doors Closed)
- Measure and record Total Airflow
- Measure and record Bypass Airflow (Plug Inserted; Doors Open)

Pressure Data
- Install lower plenum probe; measure and record (No plug; Doors Closed)
- Install interspace area pressure probe; measure and record (No plug; Doors Closed)

Data Submittal
- Submit data to Tech Center for review
- When instructed, forward equipment to next facility

OSU Airflow Measurement Test Plan

Heat Flux
- Set Center Heat Flux
- Verify 4-corner uniformity
- Record baseline millivolt reading (No Pilot flames lit)

Calibration
- Conduct methane gas calibration

Testing
- Record baseline millivolt Reading (Both upper and lower pilot lit)
- Test coupons per heat release requirements of FAR 25.853 Appendix F (ONLY POSITIVE HEAT RELEASE VALUES RECORDED).
- Submit **RAW HEAT RELEASE RATE DATA** to FAA Technical Center (No thermopile millivolt data please)

NEXT

- Complete DOE Test Plan (Task Group input)

- Follow-on Material Testing (DOE)

- Begin Airflow Measurement Round Robin Testing

- <u>Announcement</u>: 2016 NBS Smoke Density Round Robin (Spring / Summer Timeframe)

QUESTIONS?

"The only place success comes before work is in the dictionary"

Vince Lombardi