HEAT RELEASE RATE Updates

2017 March Materials Meeting Mobile, AL

Materials Working Group

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March, 2017

AGENDA

- OSU Guidance Document Update
- Action items from October Conference (Task group break-out meeting)
- Calibration
- Chapter HR updates
- Preliminary HR2 Comparison Data

2017 IMFTWG: OSU Guidance Document

- Standardization issues related to the OSU heat release rate test method that may not be clearly identified in the current Fire Test Handbook.

- Chaired by Yaw Agyei, Yonas Behboud (Boeing) and Martin Spencer (Marlin Engineering).

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- Draft outline presented at June materials meeting

2017 IMFTWG: OSU Guidance Document

OSU Guidance Document:

- All labs were requested to provide feedback on what they would like to see in this document.
- Such as: lab design, test equipment or material related issues or any other thing you can think of that would help standardize procedures and equipment
- **Update: No progress to report**

2017 IMFTWG: Action Item Update

Airflow Split:

- The working group would like to conduct research into the replacement of all orifice meters with mass flow meters and control valves to achieve the target flow of 85 cfm and 75% / 25% airflow split.
- Everyone wants action but no general agreement on how to precede was found.
- A decision was made to form a small group of labs who would like to purchase and install this equipment in their lab on a research basis.
- Once data is gathered it could then be presented to the task group to see if there is much improvement in test results.

Action Items:

- Labs were requested to have internal discussions on willingness to participate in a focus group. This group will need to purchase & install the needed airflow control (and measure) test equipment followed by testing.

2017 IMFTWG: Action Item Update

HR2 / OSU

Use of Oxygen Depletion:

- Discussion concerning Dr. Rich Lyon's (FAA) recently published Tech Note comparing Thermopile (TP) and Oxygen Depletion (OD) methods for measuring heat release rate.

Action Item:

- Industry was tasked with forming a small group of labs who would agree to purchase and install the necessary oxygen measuring equipment and gather some data to be presented before the task group.

Industry Response:

- Industry agreed not to pursue this methodology

2017 IMFTWG: Action Item Update

Acceptable HR2 variability

There was some discussion concerning what should be considered acceptable repeatability/reproducibility criteria for the HR2.

Action Item:

- Industry needs to define goals for acceptable HR2 variability.

HR2: Calibration

DOE data:

- Research options to improve the current calibration method.
- Goal: Improve repeatability from calibration to calibration (<5%).
- Investigate modified ‘Step’ method and a new “Ramp Down” calibration approach.
- Calibration method to require sample holder (with millboard & drip pan) be in place during the calibration.

HR2: Calibration

- Current Calibration Method (Step)
  - Unit is preheated at 4 SLPM for 3 minutes.
  - Flow is set to a baseline flow of 1 SLPM.
  - Flow step changes from 1-2, 1-3, 1-4 SLPM after stabilizing for 3 minutes at each flow.
  - A 10 second mV average of the thermopile is recorded during the final 3 minute period.

$$K_h = \frac{(210.8-22)}{(22.41*.01433*1000)} \ (or\ 0.588) * (F_1 - F_0 / V_1 - V_0)$$

HR2: Calibration

- Modified Step Method
  - Incorporate a new 20 second moving average of the thermopile signal (Replacing the average mV value of the final 10 seconds of data during each of the 3-minute step changes).
  - Replace 3-minute preheat with a mV threshold limit which starts the calibration process.
  - Remainder of calibration process unchanged.

HR2: Calibration

- Proposed Ramp Down Method
  - Start of calibration same as Step change method (20 s moving avg. / mV Threshold).
  - Replace step change in flow (1-2, 1-3, 1-4 SLPM) with subtle changes in flow (ramp) over a certain time frame.
  - Instantaneous thermopile mV and gas flow are recorded during the ramping process to calculate slope needed to determine Kh.

HR2: Calibration

- R&D Software Program (Marlin Engineering)
  - Flexibility built into the program to adjust parameters:
    - ✓ Selectable: Step or Ramp Method
    - ✓ Adjustable mV Threshold value
    - ✓ Threshold: Auto / Manual
    - ✓ Adjustable Start / Stop Flow Rate and Time (Ramp Method)

HR2: Calibration

- R&D Software Program (Marlin Engineering)

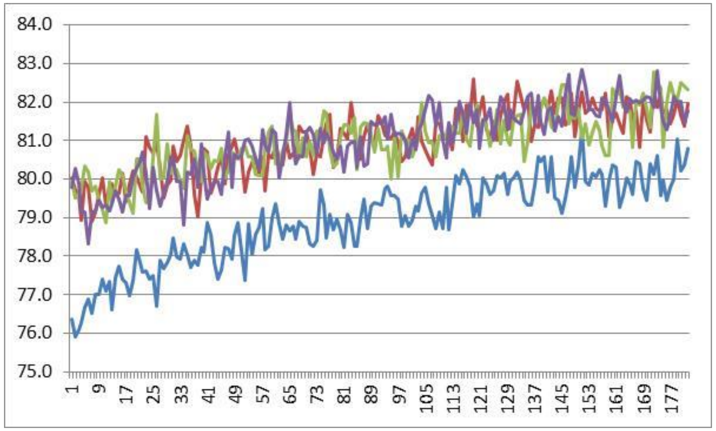
EXAMPLE	Flow			Minutes		
	Start	Stop	Delta	5	10	15
	4	3	1	0.0033	0.0017	0.0011
	4	2	2	0.0067	0.0033	0.0022
	4	1	3	0.0100	0.0050	0.0033
				Rate Change (L/sec)		

➢ Generate least squares fit of flow rate vs. mV data points (SLPM/mV)

$$K_h = \frac{(210.8-22)}{(22.41 * .01433 * 1000)}\ (or\ 0.588) * (\mathrm{SLOPE})\ \mathrm{kW/mV}$$

➢ Calibration Factor Range: 0.085 +/- 0.010

HR2: Calibration



- Overshoot problems at low thresholds (during R&D of new calibration method)
- 86 mV threshold / 4 - 1 SLPM / 240 seconds optimal.
- Sample Holder / Threshold / Method pros and cons

HR2: Calibration

Modifications to Ramp Method (9 Min calibration time)

- No sample holder and why (only HSI installed)
- Thermal Stability Voltage Range: 30 second average @ end of 5 minute preheat: 86 +/- 4 mV (approximately 5%)
- 4 minute ramp down (4L down to 1L)
- Slope determined and used to calculate CF
- CF must be 0.085 +/- 0.010 kW/mV
- If recal required; must wait 15 minutes with no flames before repeating
- New Calibration repeatability data; < 2% variation in CF's (10)

Chapter HR Updates

- Hardware Changes
  - Replace the main air supply Mass Flow Meter (MFM) with a Mass Flow Controller (MFC).
  - Replace the panel mounted flowmeter for the upper pilot airflow with a MFC.
  - Require a regulated pressure input to MFC's

    (Currently set to 20 psig inlet pressure)

Chapter HR Updates

System Airflow (MFC Requirements):

- Airflow is measured in standard cubic feet per minute (SCFM) referenced to STP 0ºC at 760 mmHg.
- The flow rate through the environmental chamber will be set to 20 ± 0.4 SCFM at 70 to 75°F $\leq$ 65% RH.
- Calibrated for air annually with NIST traceability.
- Minimum accuracy of $\pm$ 2% of F.S.

Chapter HR Updates

Mass Flow Controller P/N C100H1-NR-16-OV1-SV1-PV2-V1-S1-C3 or product of similar specification or function has been found suitable.

Standard Accuracy: ± 2% of F.S.

Range: 800 SLPM Air

Fittings: 0.75 inch Female NPT

Seals: Viton

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Chapter HR Updates

Upper Pilot Methane / Airflow (MFC Requirements)

- Thermal-based MFC having nominal 0.25 inch inlet / outlet fittings.
- Calibrated annually with NIST traceability.
- Calibrated for Methane / Air respectively.
- Minimum accuracy of ± 1% of F.S.
- Referenced to STP 0ºC at 760 mmHg

Chapter HR Updates

Mass Flow Controller P/N C100L-NR-2-OV1-SV1-PV2-V1-S1-C3 or product of similar specification or function has been found suitable.

Standard Accuracy: ± 0.2% of F.S. / ± 1% of Setpoint

Range: 5,000 sccm (CH_4 or Air)

Fittings: 0.25 inch compression

Seals: Viton

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2017 IMFTWG: HR2 Comparison Data

2017 IMFTWG: HR2 Task Group

HR2 preliminary comparison data:

- Issues with reference parameters for MFC (Main air flow)
- Differences in airflow readings between the 2 units (lower plenum area)
- Globar / Penetration leakage (approx. 22% airflow loss)
- Initial correlation readings between the 2 units:

	DEATAK	ME
Upper Globar	21.5 amps	21.8 amps
Lower Globar	30.4 amps	30.1 amps
Baseline mV	54.6 mV	55.8 mV
4 SLPM TSV	83 mV	86 mV
Calibration Factor	0.086 kW/mV	0.087 kW/mV
T’pile Resistance (ambient)	72.5 ohms	109.3 ohms

2017 IMFTWG: HR2 Task Group

Thermopile Upgrade R&D:

- 5 hot thermocouples mV input to DAS (Tc_{hot}).
- 1 Reference thermocouple (lower plenum) mV input to DAS (Tc_{ref}).
- All thermocouples may displayed as independent temperature readings (using electronic cold junction software).
  - ❖ This would eliminate 5 lower plenum penetrations reducing leakage potential (3 Thermocouples, 1 thermocouple wire, 1 signal output wire)
- Thermopile mV signal to DAS =

$$(Tc_{hot\ 1} - Tc_{ref}) + (Tc_{hot\ 2} - Tc_{ref}) + (Tc_{hot\ 3} - Tc_{ref}) + (Tc_{hot\ 4} - Tc_{ref}) + (Tc_{hot\ 5} - Tc_{ref})$$

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