HEAT RELEASE RATE Updates

Virtual Materials Working Forum

HR2 Background / Methane MFC Matrix Testing

Michael Burns, FAA Tech Center

April 20th, 2021

HR2 Update

BACKGROUND

- TRL 5 (Repeatability) – May 2019
- NPRM Released (July 2019)
- Conference Presentations (October 2019)
- June FAATC Virtual Meeting (June 2020):
- Current Work (Feb/Mar 2021):
  - Methane MFC Test Matrix – In progress
  - Air MFC Replacement with Sonic Choke – In progress
  - TRL 6 (Reproducibility) – In progress
  - R&D Heater Development – In progress

HR2 Methane MFC Validation

- The FAATC currently has two operational HR2 units fabricated by two different manufacturers (Marlin Engineering & Deatak).
- The FAATC desired to have confidence the Methane flow measurements were accurate during calibration.
- To assist in this determination an independent mass flow controller (MFC) was purchased through MKS Inc,.
- Additionally, a wet test meter was plumbed inline to help add more reliability of measurement.

Design Specification (Mass flow controller / WTM data)

Deatak HR2 : OEM MFC
MFC - MKS Instruments Inc.
P/N: GM50A028104SBM020
Range: 0 – 10 L/min

Independent source: MFC
MKS Instruments Inc.
P/N 1480A02814CS1BM /
PR4000B2V2
Power/Display unit
Range: 0 – 10 L/min

M.E. HR2: OEM MFC
MFC - Sierra Instruments, Inc.
P/N: C100L-NR-2-OV1-SV1-
PV2-V1-S1-C3
Range: 0 – 10 L/min

Wet Test Meter: Elster American Meter
P/N: AL-18-3
Range: 0 – 8 L/min

HR2 Methane MFC Matrix

Concept Design

- Compare OEM MFC values, independent MFC values and exchanged (swapped) MFC values of two HR2 test articles supplied by two different manufacturers.
- The end goal is to compare % delta between HR2 manufacturers in three configurations: OEM, MKS and Swapped MFC.
- Additionally to determine the % delta from each units OEM MFC to the MKS MFC, swapped OEM MFC and WTM.

HR2 Methane MFC Matrix

Test Plan

- Average of 5 calibration cycles were conducted
- WTM plumbed inline just prior to the Upper Pilot Burner for each configuration
- WTM water temperature and ambient absolute pressure were used to calculate air density (lbs./ft^3)
- Each day heat flux measurement was verified to be within range and the stability requirements were satisfied prior to conducting a calibration.

HR2 Methane MFC Matrix

- The MFC's are calibrated with a reference temperature of 0 °C and reference pressure of 1 atmosphere (760 mmHg) at the 3 SLPM requirement during calibration.
- With these parameters a mass flow rate of 0.513 lbs./hr. can be determined.

MFC = 0 °C Ref. WTM = ~25 °C Ref.

- Using the density and mass flow rate of Methane, the wet test meter volumetric flow rate was calculated.
- Actual flow (L/min) = Amount of gas flowed / (Time (s) / 60)

Example: Flowing 3 liters as per WTM dial rotation and stop watch @ 55 seconds: 3 / (55 / 60) = 3.27 Actual Volume Flow

HR2 Methane MFC Matrix

HR2 Mass flow Controller Test Matrix

- Configuration #1 – OEM MFC & WTM
- Configuration #2 – MKS MFC & WTM
- Configuration #3 – Swapped OEM MFC's & WTM

Deatak MFC with M.E. MFC / M.E. MFC with Deatak MFC

- Average values for Thermal Stability Temperature (°C), Calibration Factor (W/°C), Baseline Temperature (°C) & Delta T (°C) were calculated and compared.

HR2 Methane MFC Matrix

Wet Test Meter & MKS Mass Flow Controller Equipment

HR2 Methane MFC vs. MFC Matrix

	% Delta Between Manufacturers		
Deatak / M.E.	**OEM MFC**	**MKS MFC**	**Swapped OEM MFC**
Thermal Stability Temperature (°C)	-0.5%	0.0%	0.2%
Calibration Factor (Kh) W/°C	3.0%	3.0%	1.5%
Avg Baseline (°C)	0.5%	1.1%	0.8%
Average Delta T	-2.9%	-3.0%	-1.5%

	% Delta From OEM MFC to:	
Deatak HR2	**MKS MFC**	**M.E. OEM MFC**
Thermal Stability Temperature (°C)	-0.4%	-0.5%
Calibration Factor (Kh) W/°C	-0.1%	0.7%
Avg Baseline (°C)	-0.6%	-0.4%
Average Delta T	0.1%	-0.7%

M.E. HR2	**MKS MFC**	**Deatak OEM MFC**
Thermal Stability Temperature (°C)	0.1%	0.2%
Calibration Factor (Kh) W/°C	-0.1%	-0.8%
Avg Baseline (°C)	0.1%	-0.1%
Average Delta T	0.1%	0.8%

HR2 Methane MFC vs. WTM Matrix

Deatak HR2	OEM MFC	MKS MFC	Swapped OEM MFC
Calculated Volume Flow	3.24	3.23	3.25
Recorded Volume Flow	3.22	3.21	3.24
% Delta	0.5%	0.7%	0.3%

M.E. HR2	OEM MFC	MKS MFC	Swapped OEM MFC
Calculated Volume Flow	3.24	3.25	3.28
Recorded Volume Flow	3.22	3.22	3.26
% Delta	0.7%	1.1%	0.8%

HR2 Methane MFC Matrix

Summary Discussion

- The average values for Thermal Stability Temperature (°C), Calibration Factor (W/°C), Baseline (°C) & Delta T (°C) were calculated and compared between the two manufacturers of HR2 units for each of the three configurations.
- Data shows very good correlation between both manufacturers in all three configurations.
- Confidence was gained conducting this experimentation regarding accuracy of Methane flow rate during the calibration cycles for both HR2 units.

Questions May Be Directed To:

Michael Burns

Aerospace Engineering Technician

FAA Fire Safety R&D Team, ANG E212

Phone (609) 485-4985

Fax (609) 485-5158

Email: mike.burns@faa.gov