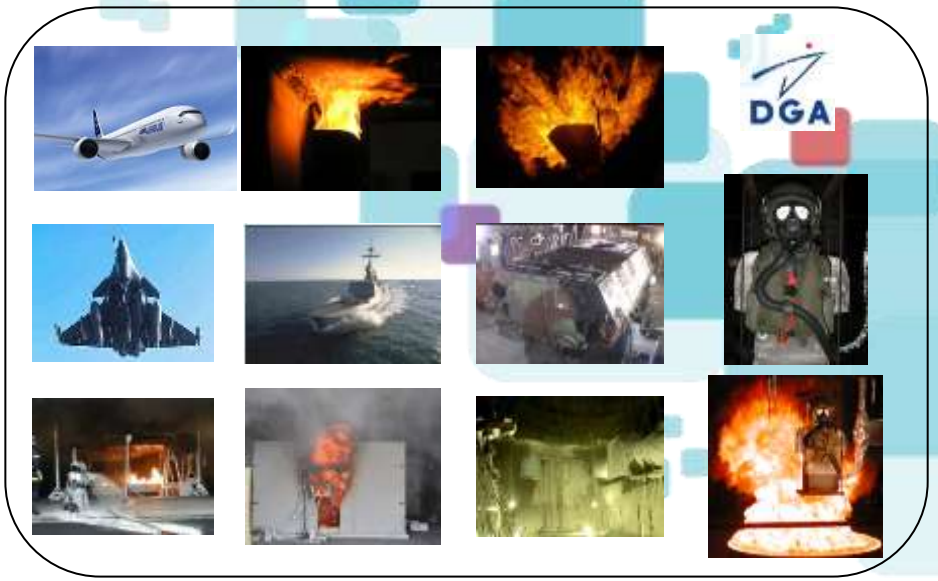
**DGA Aeronautical Systems**

*Fire Safety Department*

# POWERPLANT Fire tests

## Assessment of various characterization methods to compare Park vs Sonic burner flames



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# SCOPE

**Previous works performed in the framework of the 2014 FAA Powerplants Fire Testing Round Robin have shown discrepancies in test results between labs using various type of burners.**

**This Round Robin also shown significant differences in test results from Park and Sonic burners (which were supposed to be set to provide similar flame characteristics)**

**These slides present the works that DGA Aeronautical Systems carried out since the previous IASFPWG meeting** (Toulouse - May 2016)**, with the aim of :**

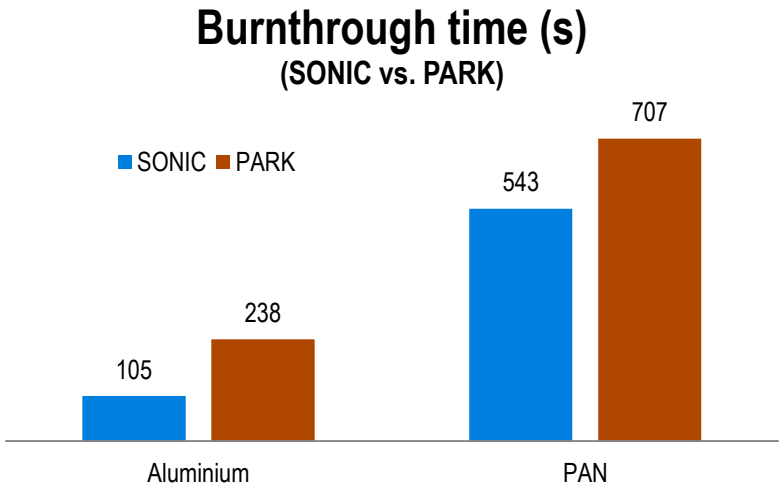
- **Comparing the flame characteristics from our Park and Sonic burners**
- **Assessing various new means for burner calibration or flame checking**

# 2014 Round Robin – DGA test results

## Burners Comparison:

**Significant differences in test results depending on the burner (up to 100% on the aluminum burnthrough time)**

*Each burner set according to the recommendations of the 2014 FAA Powerplants Comparative Testing Program.*

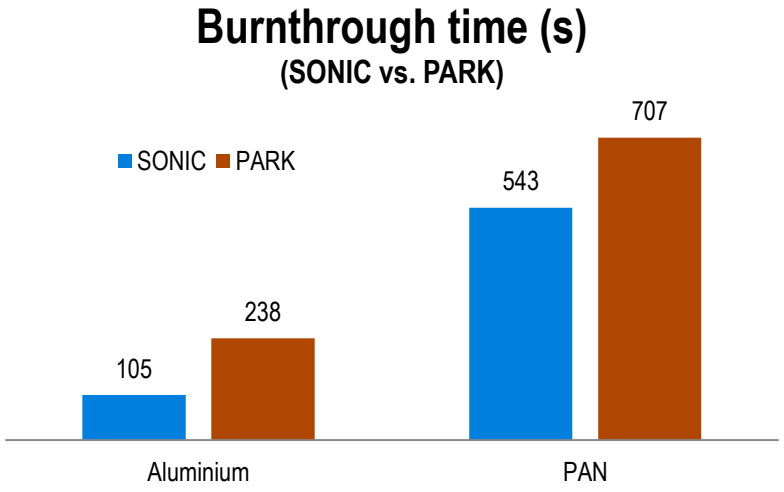


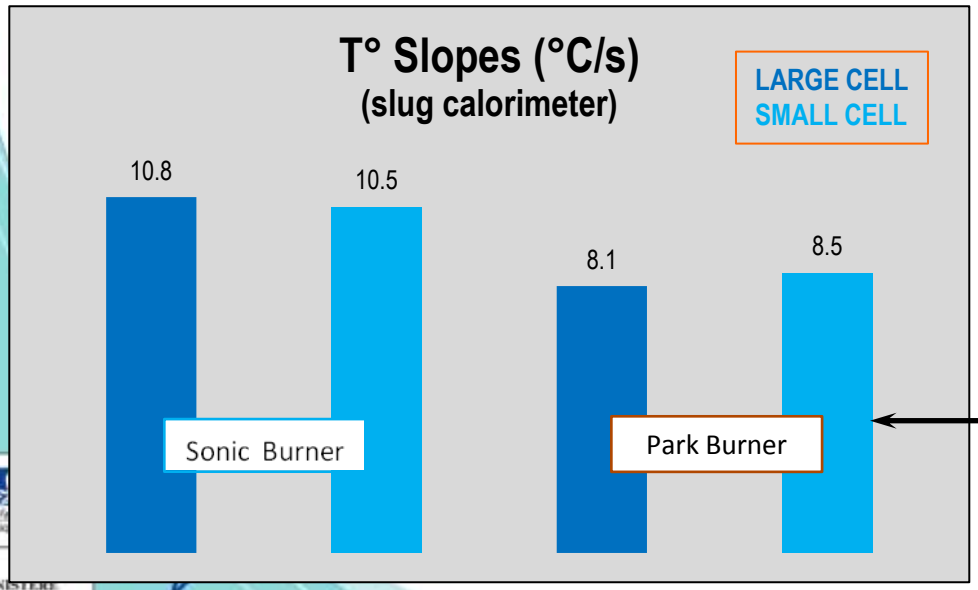
# 2014 Round Robin – DGA test results

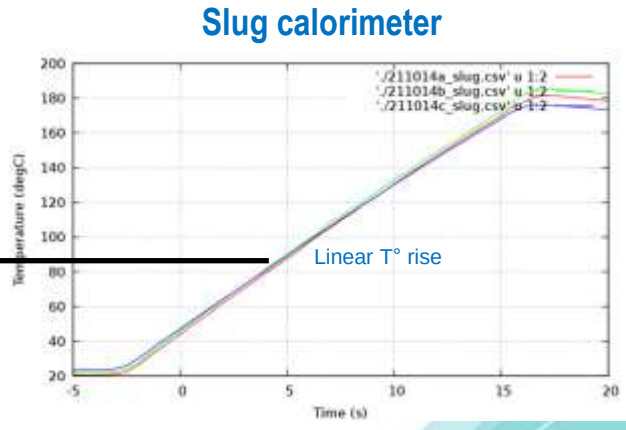
## Burners Comparison:

➔ Slopes of T° from the FAA slug calorimeter are different, indicating that the thermal powers of the burners are different.

(up to 30% more for the Sonic Burner)



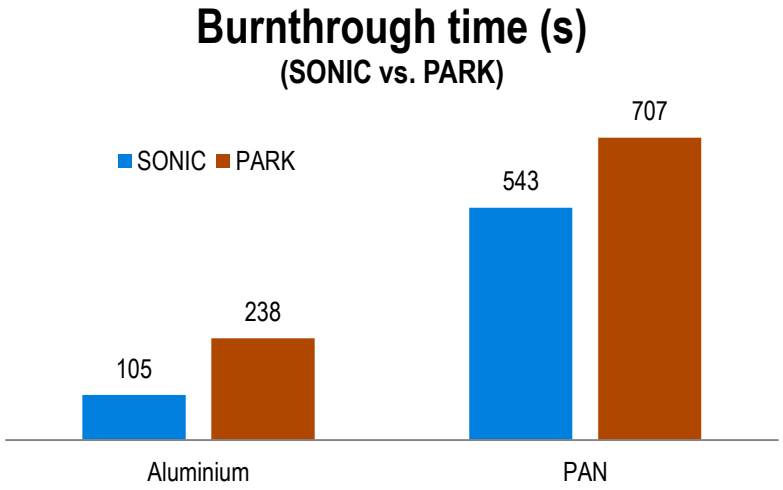



# 2014 Round Robin – DGA test results

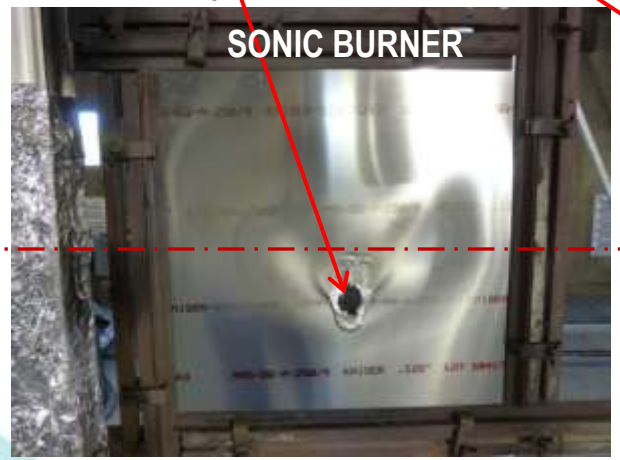
## Burners Comparison:

**Difference on power leads to significant differences on :**

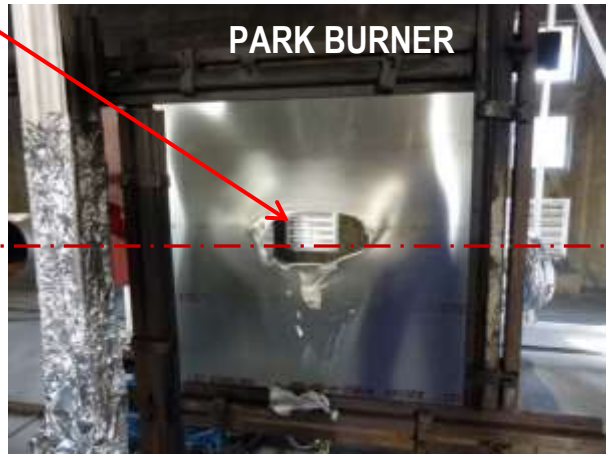
- **Burnthrough times**
- **Burnthrough profiles**




Small burnthrough well below the centerline




Large burnthrough on the centerline

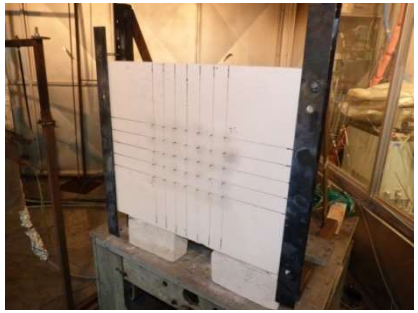



Horizontal centerline

# Flame characterisation – Work progress

## Various devices used for flame characterisation

35 Slug Thermocouples



35 Thermocouples

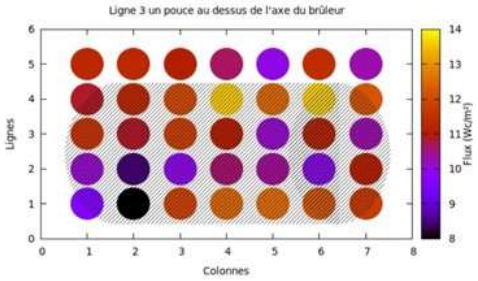
FAA Slug Calorimeter

3 Plate Thermocouples

- All thermocouples / Slug / and plate thermocouples in an insulating board
- To characterise the flame under the same conditions (representative of a test on aluminium plate)

# Flame characterisation – Work progress

## Heat flux mapping (35 slug thermocouples)



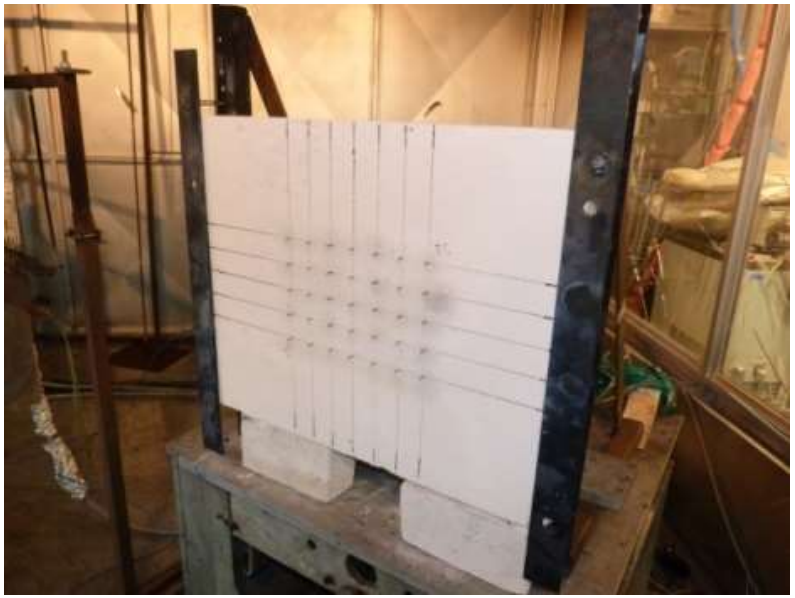

35 Slug Thermocouples

Failed

This type of TC used for the assessment of skin burn does not withstand excessive exposition time

# Flame characterisation – Work progress

## T° mapping (35 - K Type - thermocouples)



# Flame characterisation – Work progress

## T° mapping

### ➔ Park Burner

**Settings : AC 20.135**

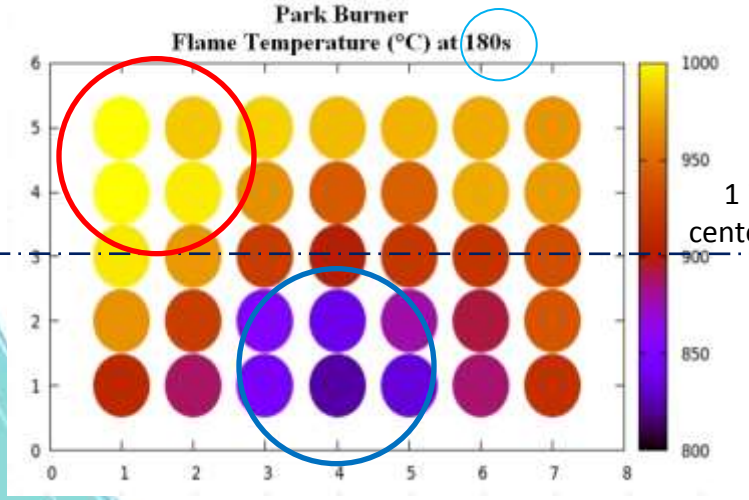
| BTU/h | W/cm² | T (°F) | T (°C) | Fuelflow (gal/h) |
|---|---|---|---|---|
| 4604 | 12,78 | 1958 | 1070 | 2,2 |

### ➔ Sonic Burner

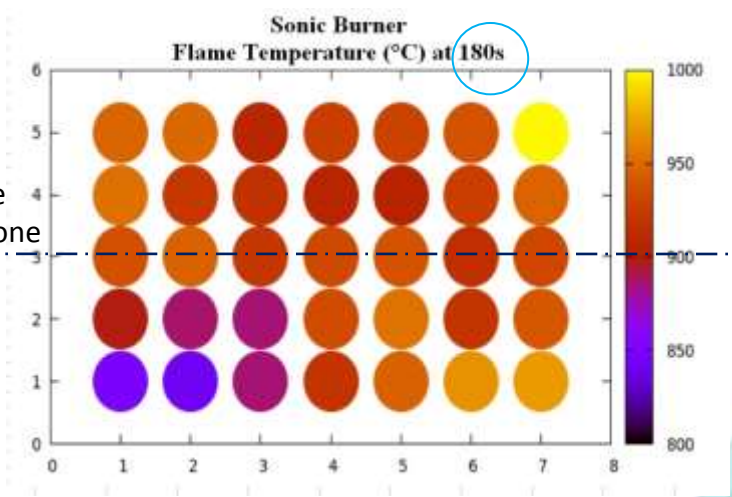
**Settings : RR 2014**

Flame checked according to AC 20.135

| BTU/h | W/cm² | T (°F) | T (°C) | Fuelflow (gal/h) |
|---|---|---|---|---|
| 4949 | 13,74 | 2013 | 1100 | 2,44 |




1 inch above the centerline of the cone




Sonic Burner : better T° homogeneity

Park Burner : Hot / Cold spots

# Flame characterisation – Work progress

## FAA Slug Calorimeter

### ➔ Park Burner

**Settings : AC 20.135**

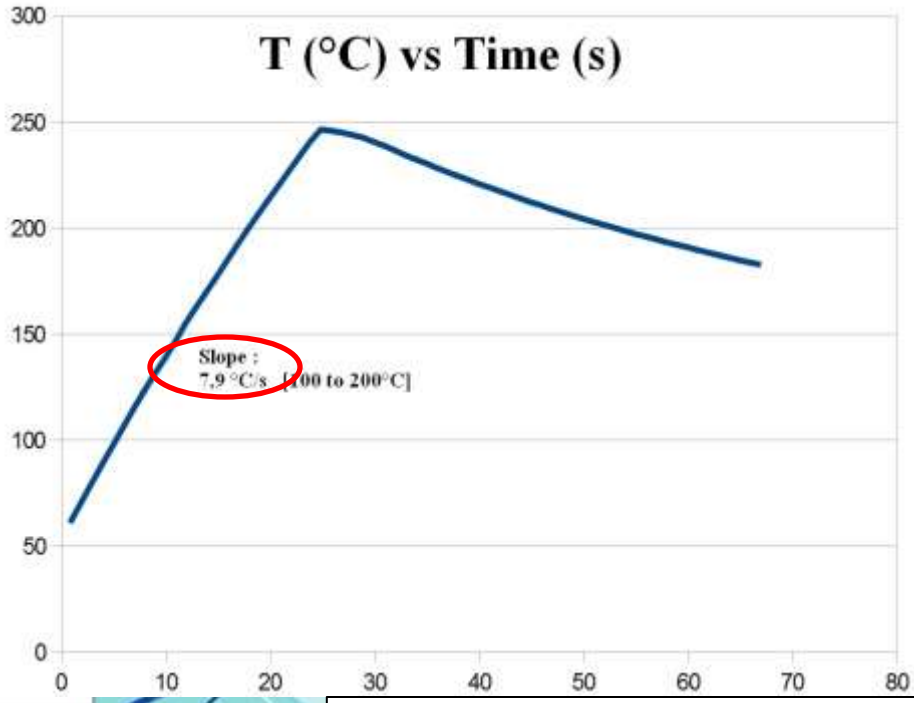
| BTU/h | W/cm² | T (°F) | T (°C) | Fuelflow (gal/h) |
|---|---|---|---|---|
| 4642 | 12,89 | 1971 | 1077 | 2,2 |

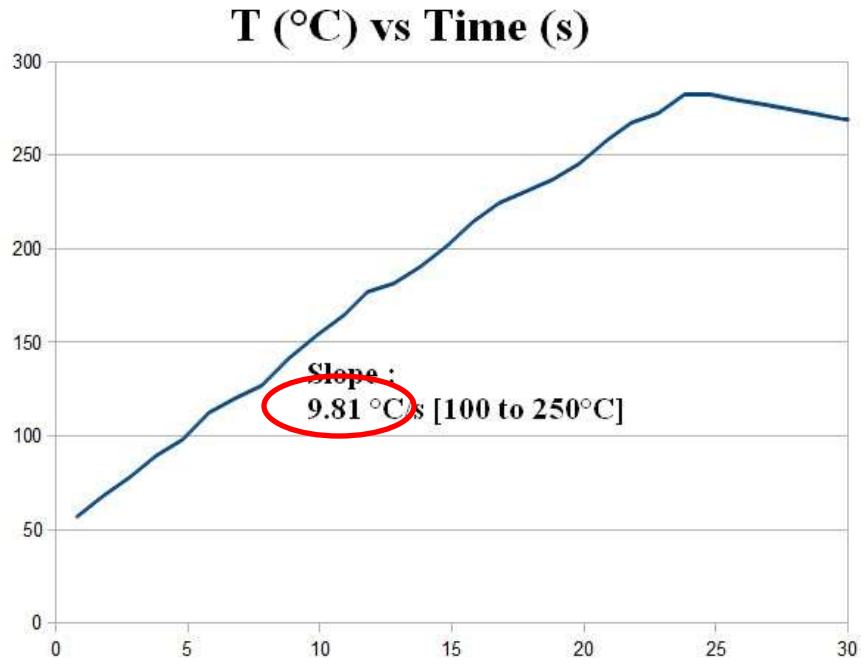
### ➔ Sonic Burner

**Settings : RR 2014**

Flame checked according to AC 20,135

| BTU/h | W/cm² | T (°F) | T (°C) | Fuelflow (gal/h) |
|---|---|---|---|---|
| 4886 | 13,57 | 2008 | 1098 | 2,44 |




➔ Sonic Burner shows higher Slope of increasing T° **(+24%)**

# Flame characterisation – Work progress

## Plate thermocouples : Flame characterisation

➔ **Park Burner**

**Settings : AC 20.135**

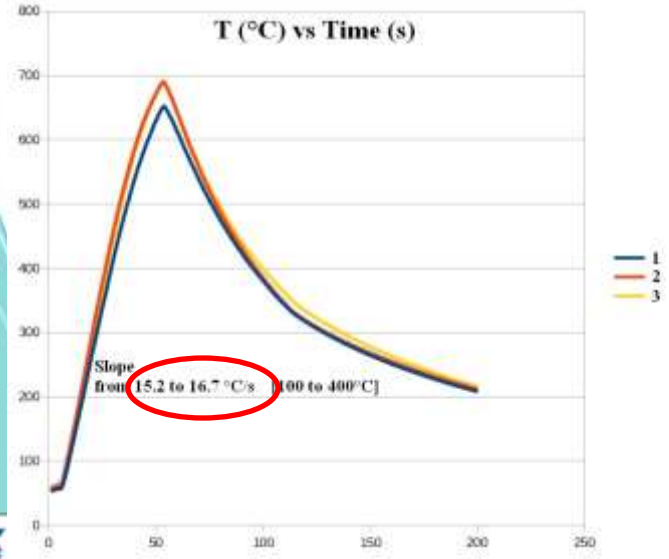
| BTU/h | W/cm² | T (°F) | T (°C) | Fuelflow (gal/h) |
|---|---|---|---|---|
| 4604 | 12,78 | 1958 | 1070 | 2,2 |

➔ **Sonic Burner**

**Settings : RR 2014**

Flame checked according to AC 20.135

| BTU/h | W/cm² | T (°F) | T (°C) | Fuelflow (gal/h) |
|---|---|---|---|---|
| 4886 | 13,57 | 2008 | 1098 | 2,44 |



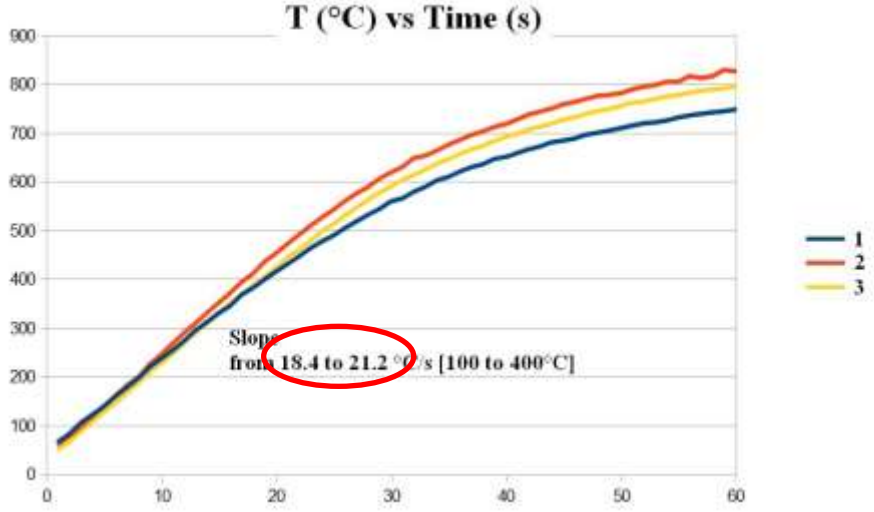




Plate thermocouples and FAA slug calorimeter show exactly the same results :

➔ Higher Slope of increasing T° from the Sonic Burner **(+24%)**

# Flame characterisation – Work progress

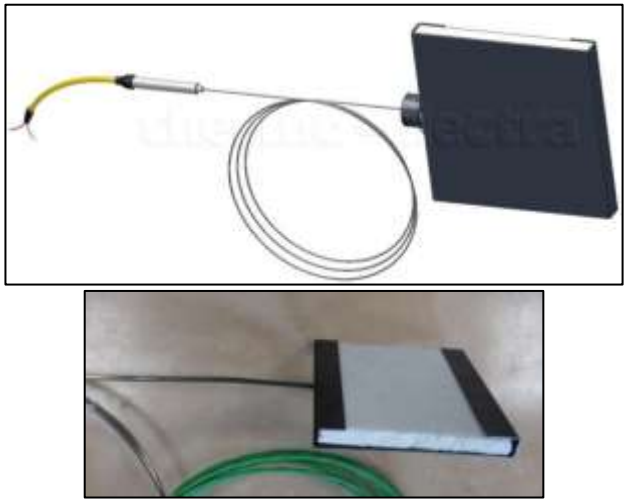
**Plate thermocouples :** **What is a “Plate Thermocouple” ?**

➔ **A small slug calorimeter (10cm x 10cm)**

- Inconel plate + thermocouple on backside
- Insulating board

**FAA Copper Slug Calorimeter**


**Plate thermocouple**



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# Flame characterisation – Work progress

## Plate thermocouples : What is a “Plate Thermocouple” ?

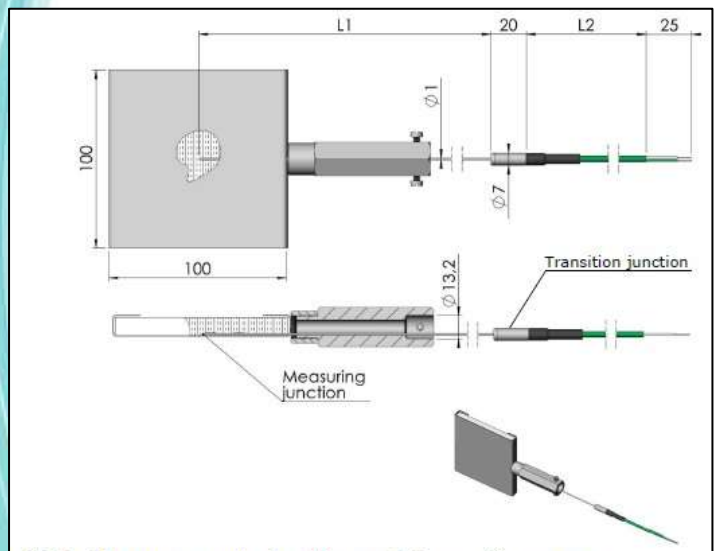



**Plate thermocouple for fire resistance furnaces, EN 1363-1 or ISO 834**

**Model 5928060**

**Design**
Temperature of a metal plate is measured by a thermocouple according to EN 1363-1/ISO 834.

A protective tube (not included) could be passed over the thermocouple and cable to protect it and keep it in place when mounted in a furnace.

**Max. temperature**

| | |
|---|---|
| Probe: | 1200 °C |
| Transition junction: | 100°C |
| Extension cable: | 200°C |

Operating temperature and environment influence lifetime of sensor.

**Probe**
Metal-sheathed mineral-oxide insulated cable:
Stainless steel type Inconel 600. Type: K
Class: 1 (IEC 60584-2)
Measuring junction: Insulated. The probe tip is centered on the plate by two welded clamps.

**Insulation**
The plate is insulated by Carbowool, 200-300 kg/m³

**Signal connection**
FEP insulated cable, TEX/CUTEXTW 24F. Part number 04-21110.
Colour code according to IEC 60584-3.

**Certificate**
Measuring value: Certificate EN10204 3.1

**Dimensions and part numbers**

| Part No. | L1 mm | L2 mm |
|---|---|---|
| 5928060-001 | 3000 | 500 |
| 5928060-002 | 2000 | 500 |
| 5928060-003 | 1500 | 500 |
| 5928060-004 | 1000 | 500 |
| 5928060-005 | 2500 | 500 |
| 5928060-006 | 1500 | 1500 |

- Commonly used to control T° in Fire Resistance Furnaces according to naval and building regulations (Bulkhead and door Fire Resistance Tests),
- Widely studied by SP Technical Research Institute of Sweden to calculate incident radiant heat-flux

| | |
|---|---|
| **Design** | |
| Application | Fire testing |
| Requirements | According to ISO 834 EN 1363 Part 1 |
| Material | Special treated heat resistant Plate |
| Dimensions | 100 x 100 x 10 mm |
| Center part | Specially treated for optimal cosine sensitivity |
| Connection | 1/4 BSP female |
| **Sheath** | |
| Construction | Mineral insulated |
| Material | Inconel 600 |
| Insulation | MgO |
| Diameter "D" | 1 mm |
| Length "L" | 2000 mm |
| **Lead wire** | |
| | PTFE insulated flexible thermocouple wire, braiding 260 °C |
| Wire length "K" | 1000 mm |
| **Element** | |
| Calibration | Type K thermocouple |
| Accuracy | According IEC 584-1 / DIN 43710 |
| Thermocouple | Pre-aged |
| Hot junction | Insulated |
| Testing | Tested at 500 Volt/20 °C |
| Insulation resistance | Minimum 100 M ohm |

# Summary / Findings

- **Flame characterisations were made under conditions representative to the conditions seen by a plate sample submitted to fire**
  *(characterisation means more representative than copper tube calorimeter and thermocouple rack)*

- **Under these conditions :**
  - **Sonic burner flame is more homogeneous in T° than Park burner**
  - **Thermal power of the Sonic burner (RR2014 settings) was significantly higher (+24%)**

- **Flame characterisations and test results show the importance / effect of the power (measured with a slug calorimeter (and flat thermocouples)) on test results (significant difference on burnthrough time despite similar flame T°)**

- **Works has shown that copper tube calorimeter is not reliable to check or calibrate a flame to be applied on large plate sample or large equipment**
  **(better appropriated to calibrate a flame intended to be used on hoses / pipes)**

- **The works show the interest of the "slug type" measurement methods to characterise, calibrate or just check the thermal power of a flame intended to be applied on "large" samples**

- **Plate thermocouples are commercially available and should be investigated as a new mean of flame characterisation**

# Next Work

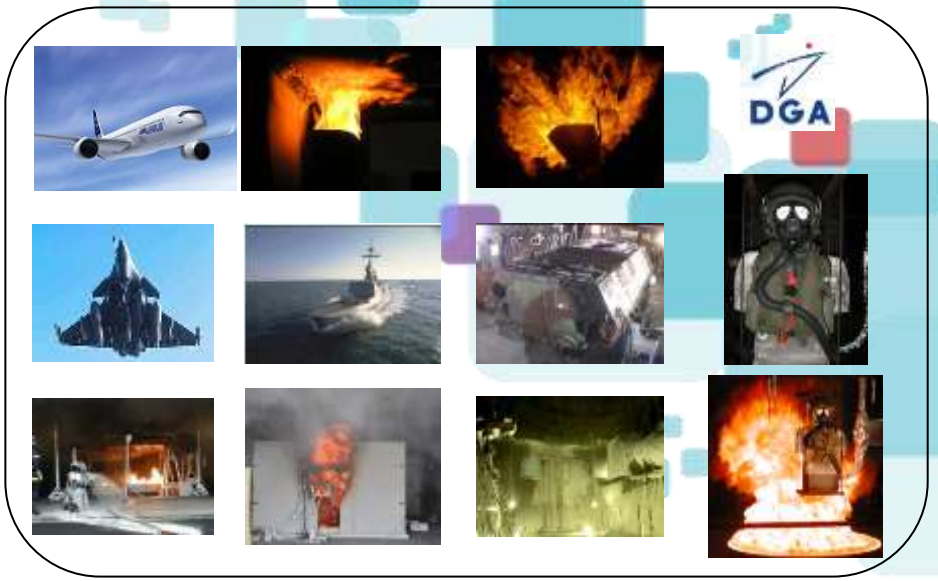
- Based on our Park Burner : find a Sonic setting which provides the same flame characteristics when measured with the FAA slug calorimeter and plate thermocouples
- Perform comparative fire tests on aluminium and composite materials (600mm x 600mm)
- Run mini French Round Robin

**DGA Aeronautical Systems**

*Fire Safety Department*

# POWERPLANT Fire tests

## Assessment of various characterization methods to compare Park vs Sonic burner flames



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