DGA Aeronautical Systems

Fire Safety Department

POWERPLANT Fire tests

Comparison of DGA's Park & Sonic Burners

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Powerplant Fire Tests

SCOPE

In the framework of the 2014 FAA / Powerplants / Comparative Testing, DGA carried out the Round Robin tests under several configurations to assess the effect of various parameters :

- Impact of the test cell size
- Airflow effect
- Comparison of test results from Park and Sonic burners

Powerplant Fire Tests

TEST CELLS

2 different cells

ETNA test cell (100m³/25m²)

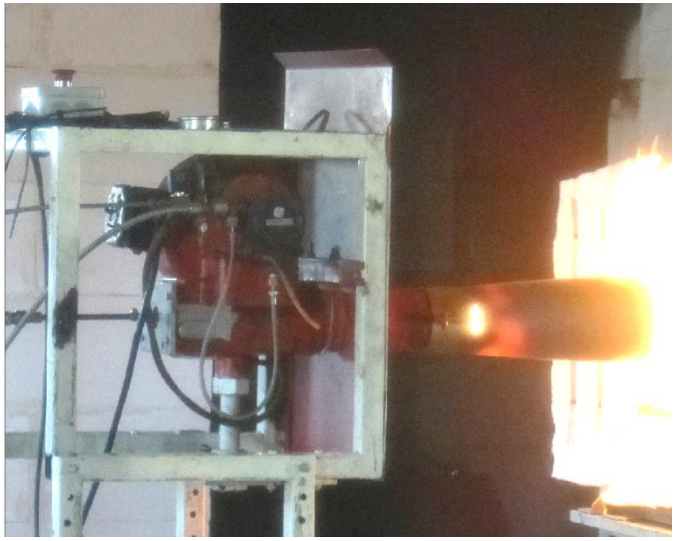
VULCAIN test cell (1000m³/130m²)

Powerplant Fire Tests

BURNERS

2 Burners

Park Burner



Sonic Burner

Powerplant Fire Tests

Test Samples *(FAA Comparative Test program)*

3 different "materials" provided by FAA:

2024 Aluminum

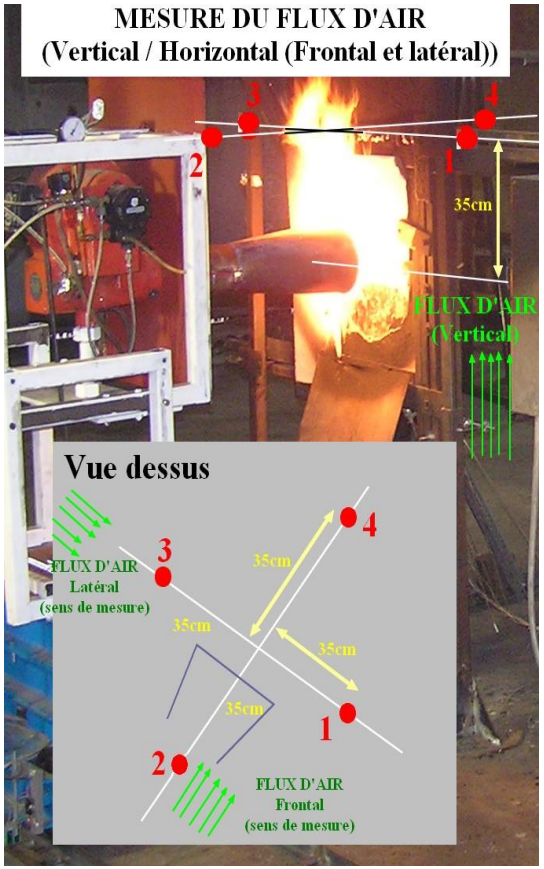
TextTech felt

(not enough material to assess airflow & cell size impact)

Home made FAA Copper slug calorimeter

Powerplant Fire Tests

Ventilation measurements



On Sonic Burner tests :

- 4 points of measurement
- 3 directions

Powerplant Fire Tests

Burner test configuration, Settings & Calibrations

Sonic Burner Parts/Setup

- Modified draft tube
- Spacer tube
- Static plate
- Beckett model F31 flame retention head (FRH)
- Delavan 2.5 gal/hr 80° W style fuel nozzle
- Burner cone

Sonic Burner Settings

- Face of FRH to nozzle tip: 1-1/8"
- Fuel nozzle adapter to static plate: 2-3/8"
- Static Plate Angle: centerline of igniters at 0°
  - Looking into the cone of the burner from above, the centerline between the igniters will be at 0° on the burner reference plane
  - Fuel pressure: 95 psi +/- 5 psi
    - Note: This pressure is to be used as a starting point when flow checking the fuel flow rate. Actual pressure used during testing should be that found from the procedure on slide 6 with a tolerance of +/- 5 psi
- Air pressure: 50 psi
- Air Temperature: 50° ± 10°F
- Fuel Temperature: 42° ± 10°F

Federal Aviation Administration

Burner configurations & settings in accordance with the 2014 FAA Powerplants Comparative Testing Program.

Calibration

SONIC burner

- All labs will calibrate using 1/8", exposed bead, Type K, stainless steel sheathed thermocouples for calibration
- Labs utilizing the Sonic Burner are not expected to necessarily achieve the calibration temperatures or heat fluxes, but rather are calibrating the fuel/air temperature and pressure input to the burner. Temperature and heat flux calibration data should be recorded and reported however.

Park burner

- Labs utilizing burners other than the Sonic Burner, should calibrate to a minimum average of 2000°F, with each thermocouple reading 2000°F ± 150°F. In addition, the burner should provide a heat flux density of at least 9.3 BTU/ft^2-s or 4500 BTU/hr as per AC 20-135.
- Changing or deviating from provided burner settings to achieve higher or more uniform calibration temperatures is not recommended
- Three separate calibration runs should be recorded
- Each calibration should include a 2-minute warm-up of the burner, a 1-minute thermocouple flame soak, and a 30-second data collection period of flame temperature. This should be followed by the heat flux calibration.

Federal Aviation Administration 18

Powerplant Fire Tests

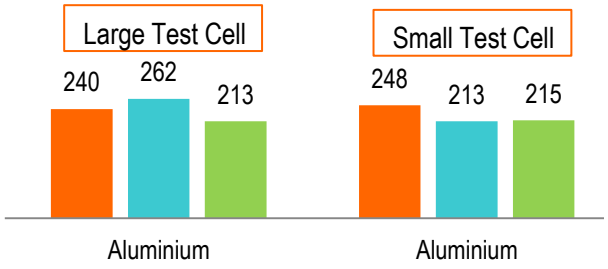
Test Results

Cell size impact

Large Cell: $1000m^3/130m^2$
Small Cell: $100m^3/25m^2$

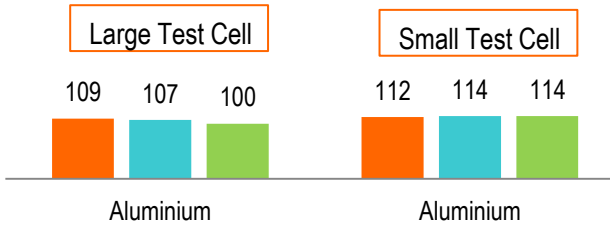
No effect of cell size

Burnthrough time (s)
(Park Burner)



No effect of cell size

Burnthrough time (s)
(Sonic Burner)



Powerplant Fire Tests

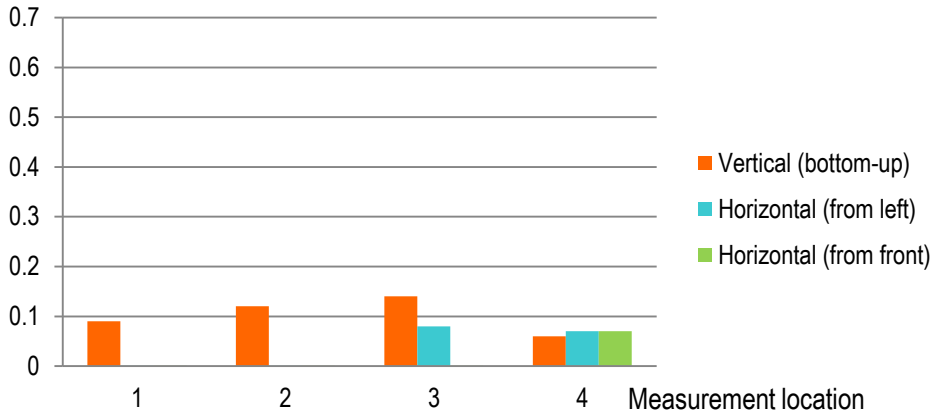
Test Results
Airflow impact

Significant differences in Airflow (up to 0,63 m/s in small cell)

➔ But no effect on burnthrough time

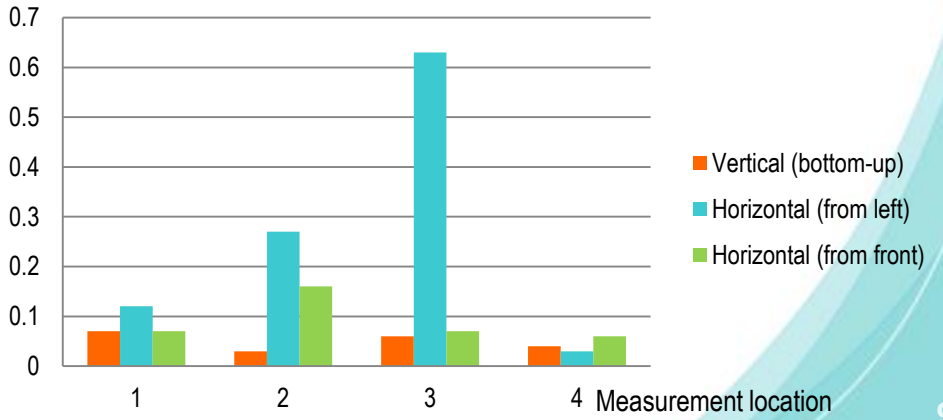
Sonic / Alu

Air velocity (m/s)
(Large test cell) 1000m³

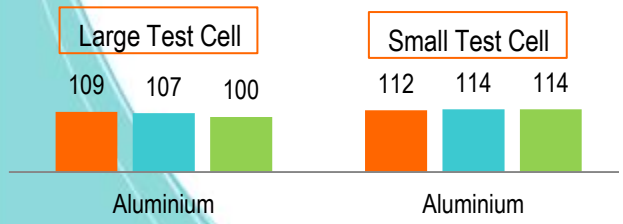


Sonic / Alu

Air Velocity (m/s)
(Small test cell) 100m³



Burnthrough time (s)
(Sonic Burner)



Powerplant Fire Tests

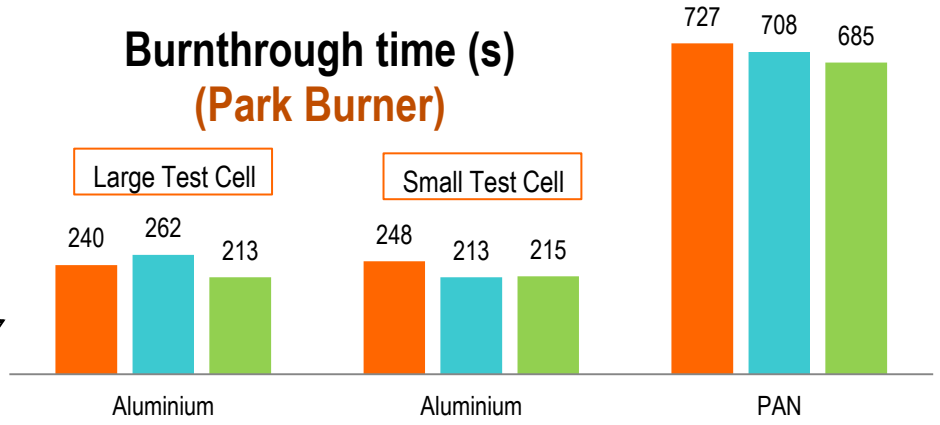
Test Results

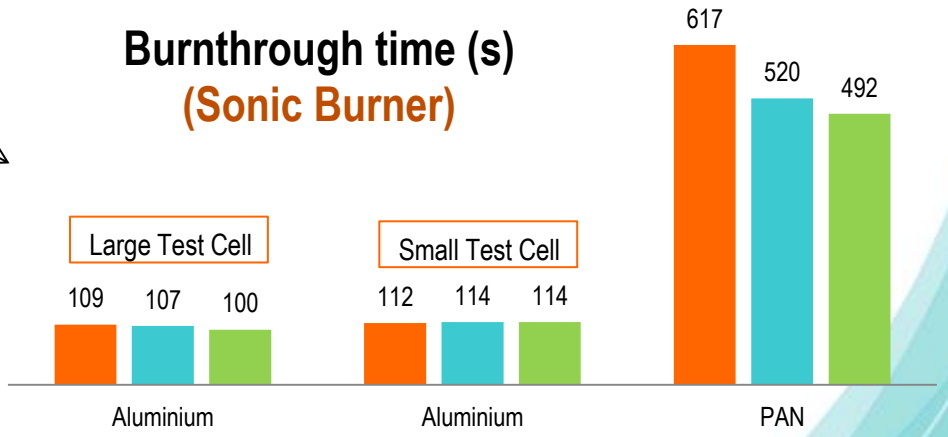
Burners Comparison:

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

Sonic : good repeatability

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



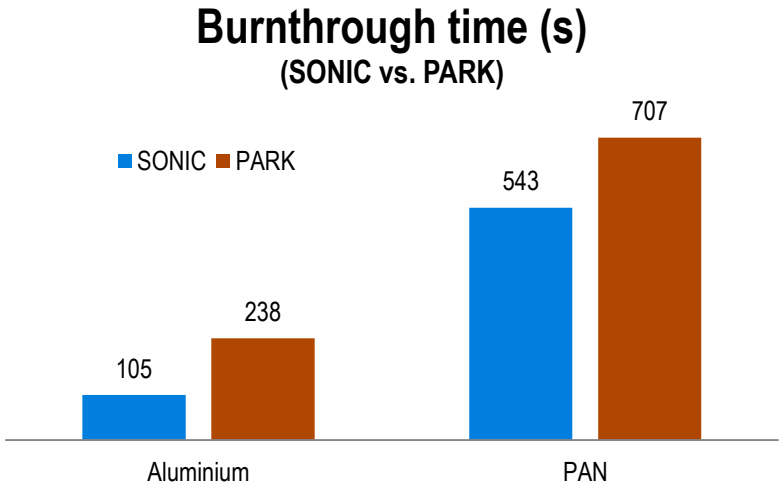


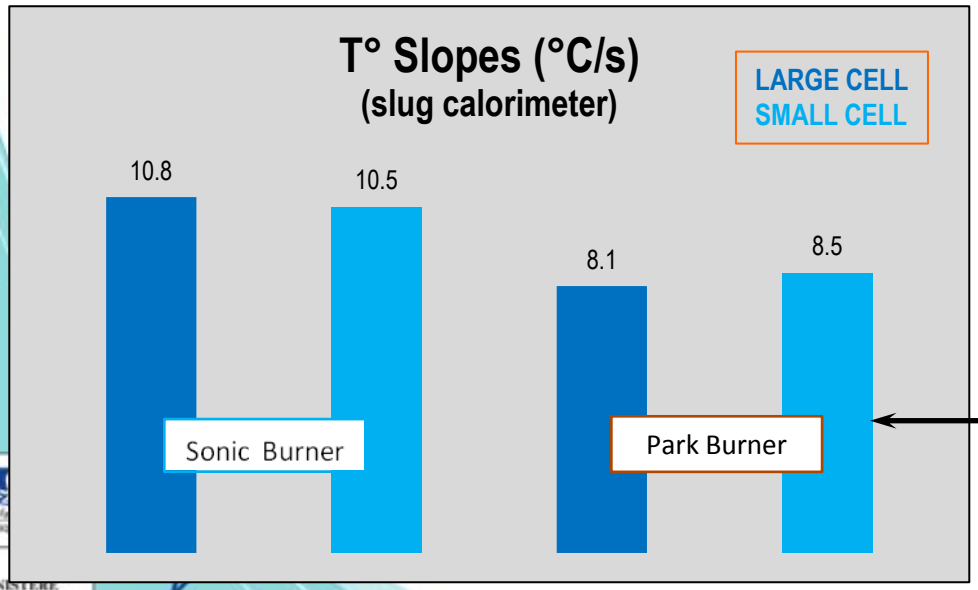
Powerplant Fire Tests

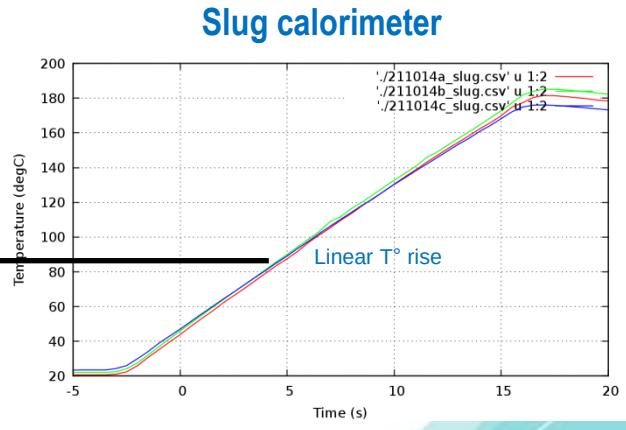
Test Results

Burners Comparison:

➔ Slopes of T° from the slug calorimeter are different, indicating that the powers of the burners are different. (up to 30% more for the Sonic Burner)





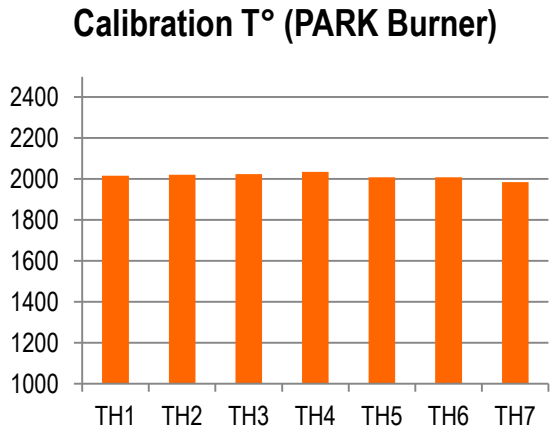


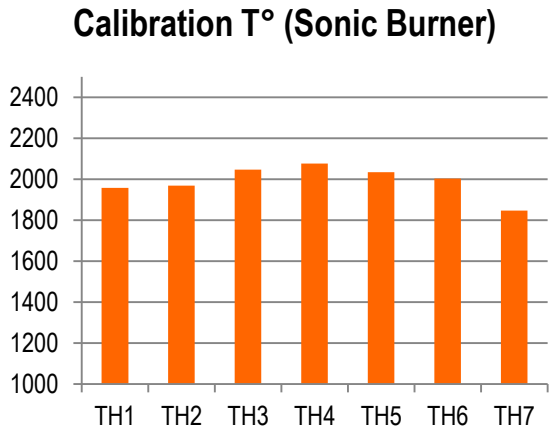
Powerplant Fire Tests

Test Results

Burners Comparison:

➔ T° : Calibration recordings show a better homogeneity of the Park Burner flame.





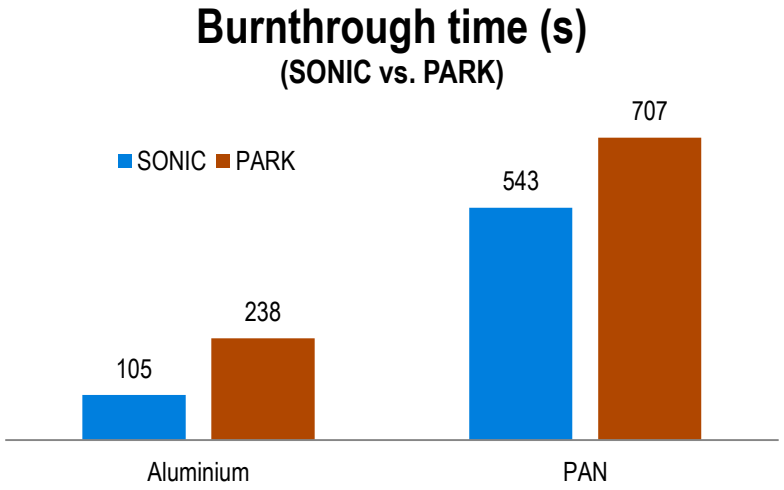
Powerplant Fire Tests

Test Results

Burners Comparison:

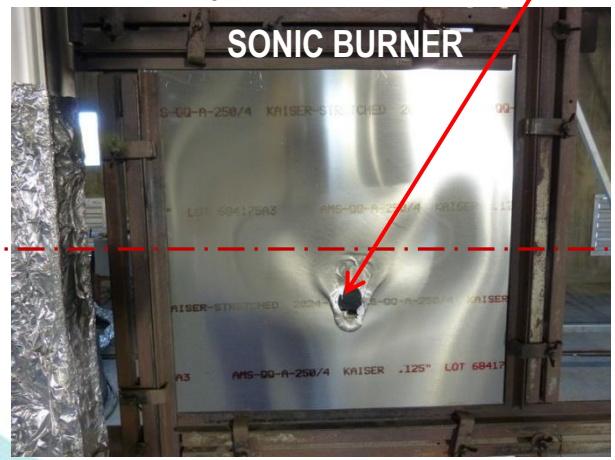
Differences on power and T° lead to significant differences on :

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

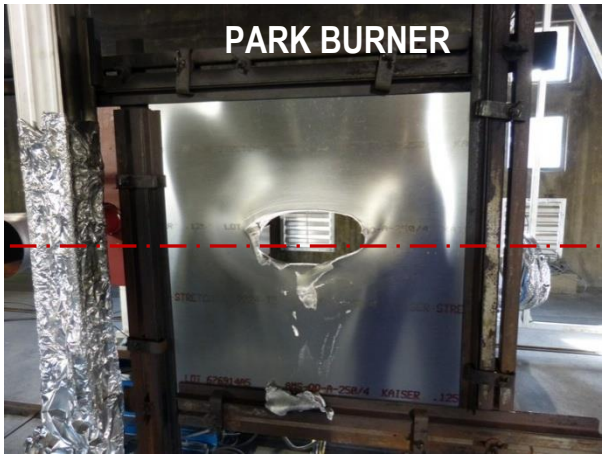


Hot spot ?
Hot spot below the horizontal centerline ?.
(probably not included in a copper tube calorimeter HF measurement)

Small burnthrough well below the centerline



Large burnthrough on the centerline



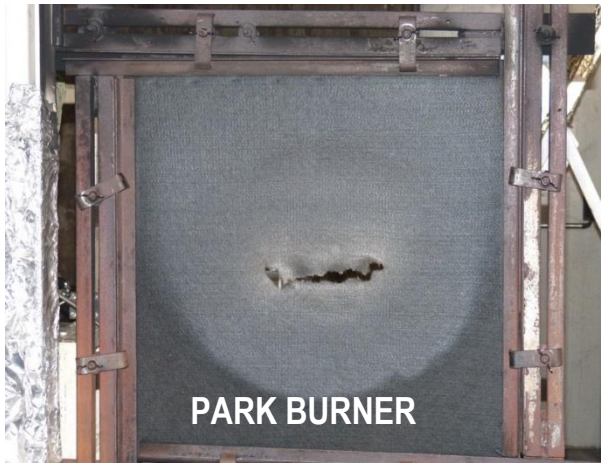
Horizontal centerline

Powerplant Fire Tests

Test Results

Burners Comparison:

Same differences on PAN material's burnthrough profiles :



Powerplant Fire Tests

Summary

Under our test configurations:

- **Did not find any impact of cell size on test results**
- **Airflow / ventilation around the test specimen were significantly different but did not show any effect on test results** *("extreme" ventilation conditions not assessed)*

- **Tests and calibration measurements by slug calorimeter show :**
  - **Good repeatability of test results from Sonic Burner**
  - **But significant differences between Sonic and Park Burners :**
    - Sonic Burner flame has power / heat-flux in excess compared to Park Burner
    - Sonic flame T° is less homogeneous

Powerplant Fire Tests

Outlooks

- **Sonic fuel flow should be reduced to decrease the flame power / heatflux**
- **Slug calorimeter is a good calibration device and should be used to compare the burner flame characteristics** *(Park and Sonic)***. And could be used as a new calibration mean instead of the copper tube calorimeter :**
  - **Advantage: the whole flame is measured (not only the centerline)**
  - **Disadvantage: bulky, not commercially available**

➔ **Alternative solution : plate thermocouple (small plate, commercially available, cheap)**

Powerplant Fire Tests

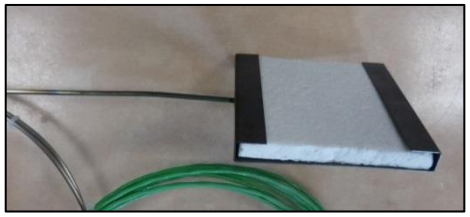
What is a « Plate thermocouple » ?

A small slug calorimeter (10cm x 10cm)

- Inconel plate + thermocouple on backside
- Insulating board

FAA Copper Slug Calorimeter

Plate thermocouple



Powerplant Fire Tests

Plate thermocouple:

A new way to calibrate / check the burner flame ?

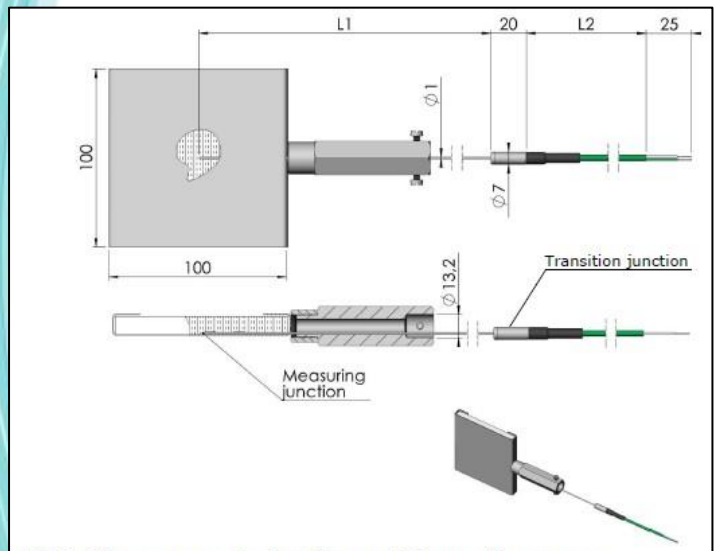


Plate thermocouple for fire resistance furnaces, EN 1363-1 or ISO 834

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**

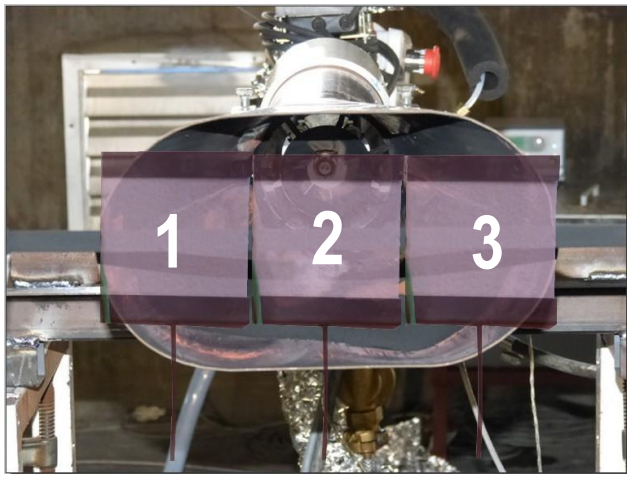
Design	
Application	Fire testing
Requirements	According to ISO 834 EN 1363 Part 1
Material	Special treated heat resistant Plate
Dimensions	100 x 100 x 10 mm
Center part	Specially treated for optimal cosine sensitivity
Connection	1/4 BSP female
Sheath	
Construction	Mineral insulated
Material	Inconel 600
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
Thermocpuple	Pre-aged
Hot junction	Insulated
Testing	Tested at 500 Volt/20 °C
Insulation resistance	Minimum 100 M ohm

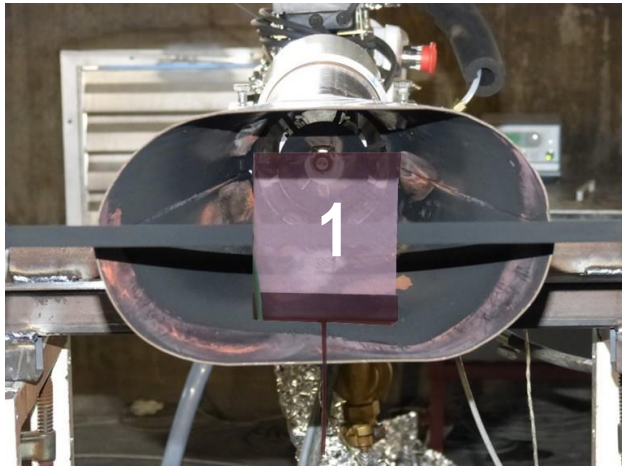
Powerplant Fire Tests

Plate thermocouple: A new way to calibrate / check the burner flame ?

NEXT WORK :

- To characterise comparatively SONIC and PARK burner's flames using 1 and 3 plate thermocouples
- To adjust the SONIC settings to provide the same flame from the two burners
- To compare test results on aluminium plate (600x600 mm)





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