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RÉPUBLIQUE FRANÇAISE

MINISTÈRE DE LA DÉFENSE

Toulouse Aeronautical Test Center (CEAT)

« Fire Safety Department »

AC 20-135 / ISO 2685
Fire tests on components used in fire zones.
Comparison of gas burner to oil burner.

DGA

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Various test methods, standards or guides are used to assess the fire behaviour of various components used in fire zones

✓ **Aircraft Material Fire Test Handbook :**

Chapter 12 is used to determine the capability of components & constructions to control the passage of fire or its effects in powerplant compartments,

✓ **AC 20.135 :**

Guidance to demonstrate the compliance with the powerplant fire protection requirements of the FAR (materials & components used in engines & APU installations and in areas adjacent to fire zones).

✓ **ISO 2685 :**

Test procedure for airborne equipments to assess the fire resistance of components, equipments & structures located in “fire zones”.

➢ The ISO standard is often asked / used by airplane suppliers to show the compliance with the FAR / CS requirements

Various methods of Heat Flux calibration are specified to set the burners

- ✓ **Aircraft Material Fire Test Handbook** Chapters 11 & 12 **:**

  requirement : > 10.6 W/cm² (9.3 Btu/ft².s) or > 4500 Btu/hr

  Heat Flux density is measured by a water-cooled calorimeter
  Power is measured by the heat transfer device

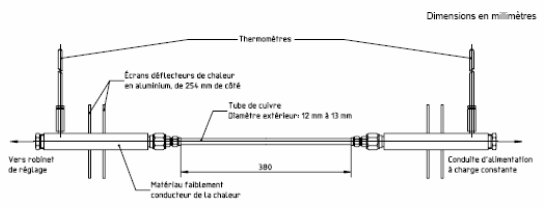


Figure B.4 — Vue générale du montage du tube étalon de mesure de la densité de flux thermique

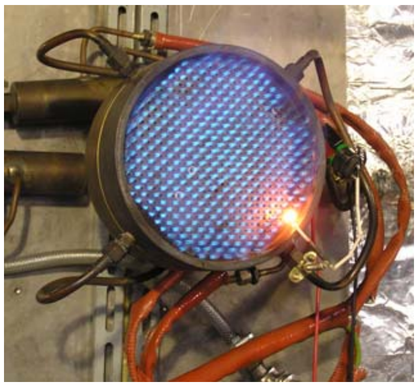
- ✓ **AC 20.135 : requirement : > 10.6 W/cm² (9.3 Btu/ft².s) or > 4500 Btu/hr**

  Parameters are measured by the heat transfer device or calorimeter. AC 20.135 does not clearly specify if the heat flux density must be measured from a water-cooled calorimeter or if it can be calculated from the power measured by the heat transfer device.

- ✓ **ISO 2685 : requirement : 11.6 W/cm² (+/- 1 W/cm²)**

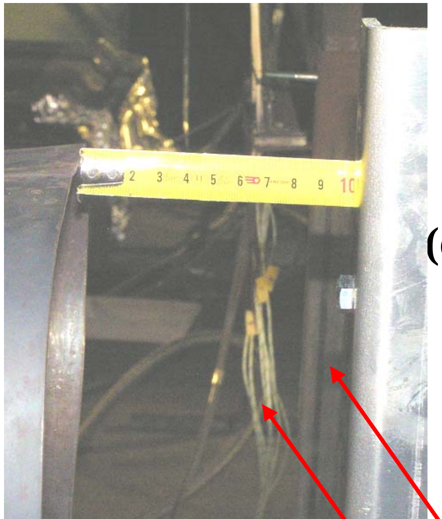
  The Heat Flux density is calculated from the heat transfer device (the total heat recorded by the heat transfer device is supposed to come from the surface of the tube in front of the burner exit).

> ➢ **Requirements : The choice is open (power or heat flux density)**
> ➢ **Heat Flux density : The choice is open for the device to use (water-cooled calorimeter or heat transfer device)**



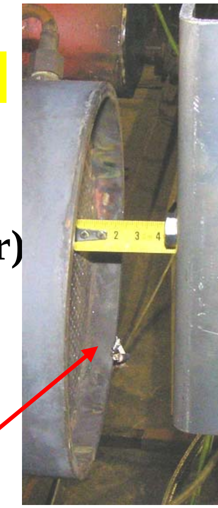
Various burners are described and/or approved

- ✓ **Aircraft Material Fire Test Handbook :**
  - ➔ Oil burner (such as Park PDL 3400) is described,
  - ➔ Gas burner (SAE AS401B Propane Burner) is also acceptable (chapt 12).
- ✓ **AC 20.135 :**
  - ➔ Oil burner is described,
  - ➔ Gas burner is also acceptable.
- ✓ **ISO 2685 :**
  - ➔ Oil burner or gas burner
    Can be used depending of the size of the critical part to be tested.



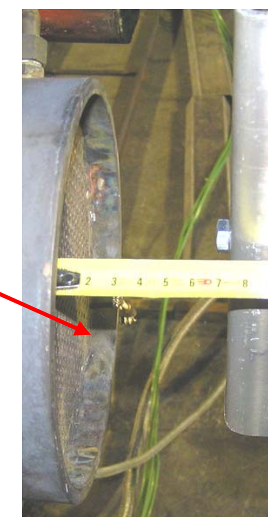
➢ 4 inches

➢ 2 inches



Various test configurations
(depending of the standard and the type of burner)

	Oil Burner	Gas Burner
FAR / CS (Handbook / AC 20-135)	4″ (101,6 mm)	2″ (50,8 mm)
ISO 2685	Env 100 mm (4″)	Env 75 mm (3″)



➢ 3 inches

SUMMARY OF THE SITUATION

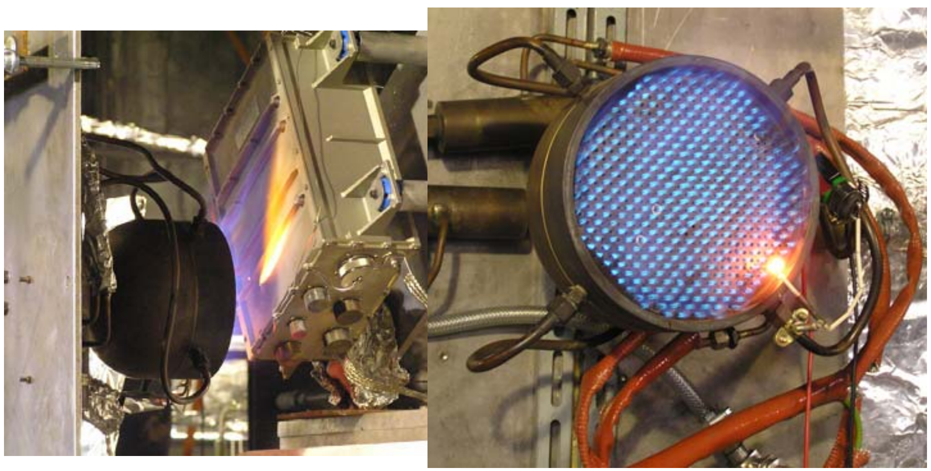
To test the same kind of components used in the same area (fire zones) :

- **Several standards or guidance providing :**
  - **2 different methods of heat flux calibration,**
  - **2 different burners,**
  - **Various test configuration (positions of the burner)**

- **But same acceptance criteria :**
  - **Fire resistant : 5 mn**
  - **Fireproof : 15 mn**

Experiences with the Park burner has shown the difficulty to obtain the same test results using only one type of burner

What about the test results with 2 so different burners used in accordance with various standards ?



➢ **AS401B gas burner**

➢ **Park oil burner**

Some recent tests performed on real components according to ISO 2685 :

➔ **failed when performed with oil burners,**

➔ **passed when performed with gas burner.**

CEAT ran a short preliminary study on simple test specimens to compare these various test configurations.

Test Program

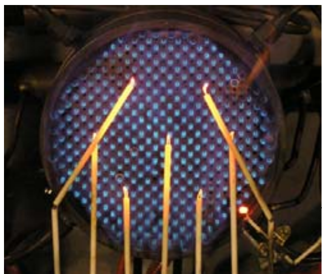
- **Tested configurations (position of the burner) :**
  - **Oil Burner / d = 4 inches (ISO, FAA : Handbook, AC)**
  - **Gas burner / d = 3 inches (ISO)**
  - **Gas burner / d = 2 inches (FAA : Handbook, AC)**

Tested samples

-Simulating critical areas to be tested

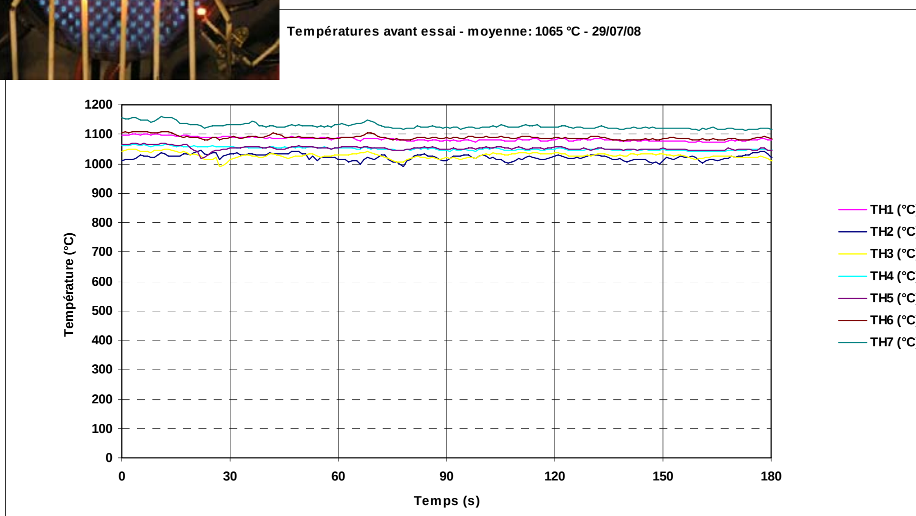
-Sizes of the samples / critical areas were in accordance with all test methods (< 2xS_{burner})

Flame calibrations



➢ T° Gas Burner

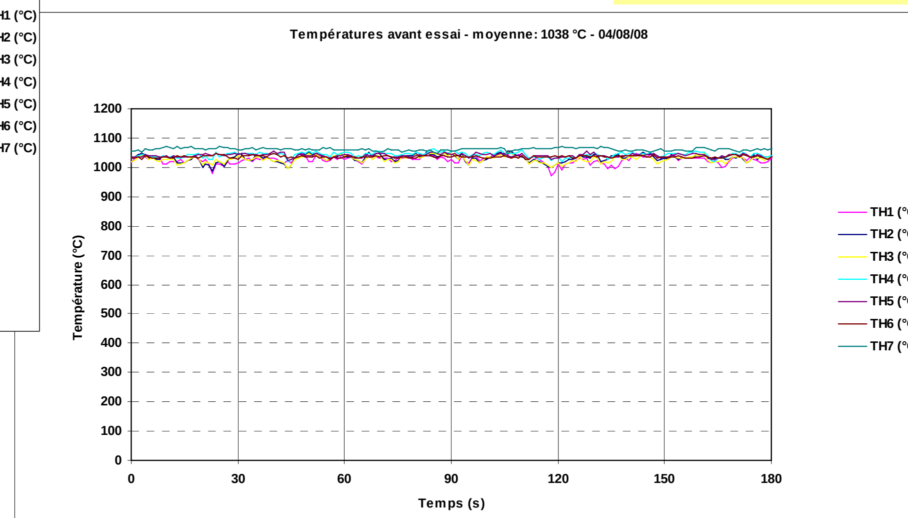
dist. Burner = 3 inches



ISO requirement : 1100°C +/- 80°C

➢ T° Oil Burner

dist. Burner = 4 inches



- Gas Burner : av. flame T° = 1065°C
- Oil Burner : av. flame T° = 1038°C

Comparison of gas burner to oil burner

Flame calibrations

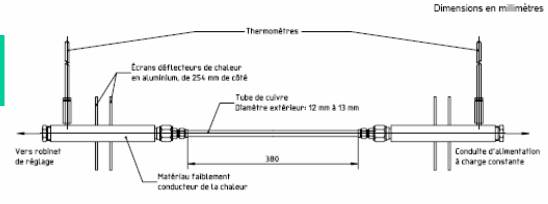
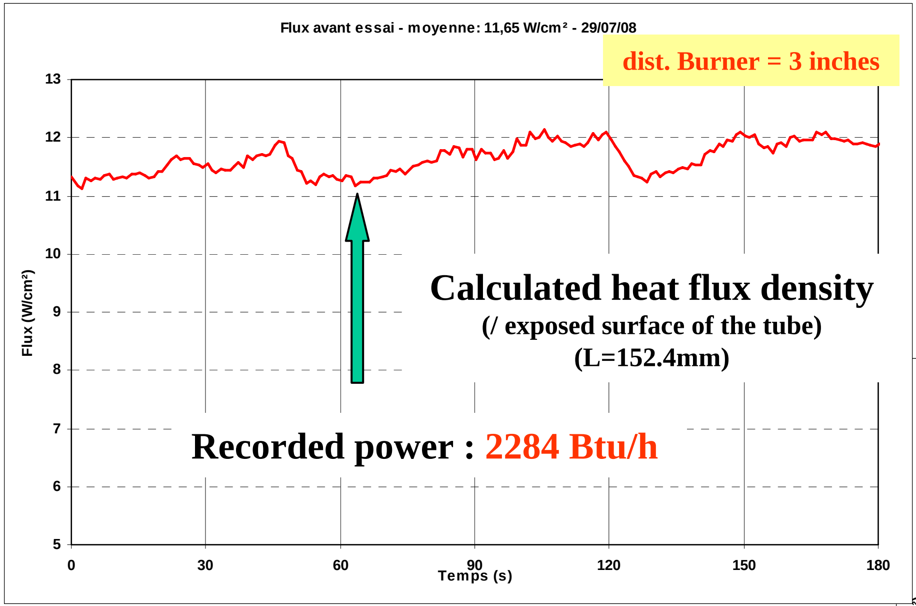


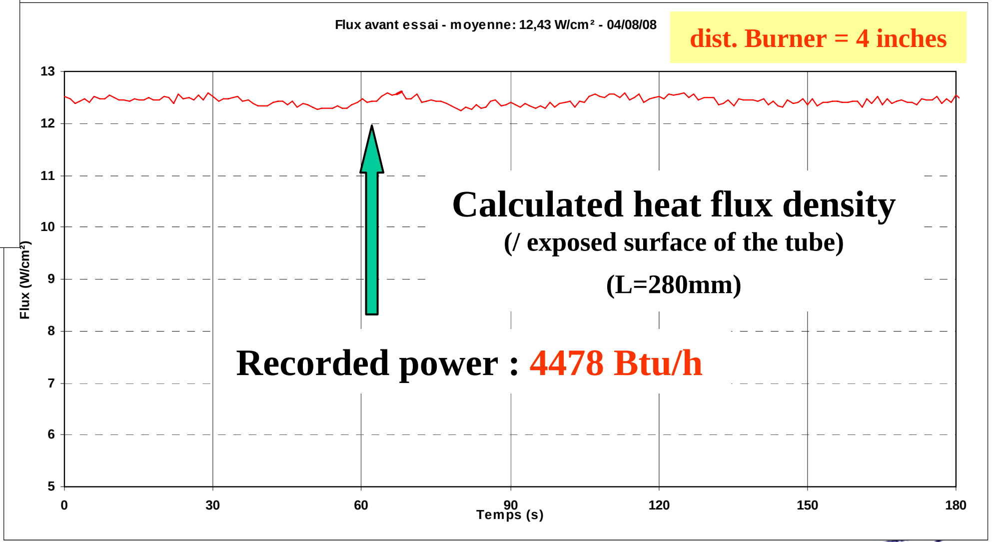
Figure B.4 — Vue générale du montage du tube étalon de mesure de la densité de flux thermique

➢ Heat Flux – Gas Burner



ISO requirement : 11.6 W/cm² +/- 1 W/cm²

➢ Heat Flux – Oil Burner



- **Gas Burner : av. heat flux = 11.65 W/cm²**
- **Oil Burner : av. heat flux = 12.43 W/cm²**

Tests on small 2024 aluminium plate

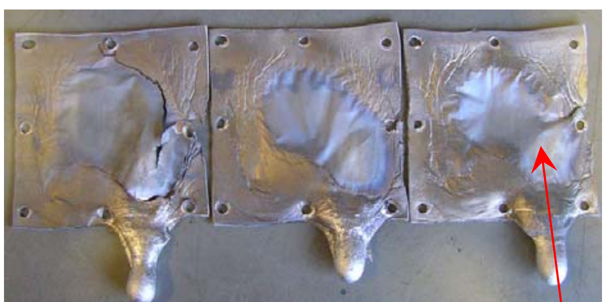
dist. Burner = 3 inches

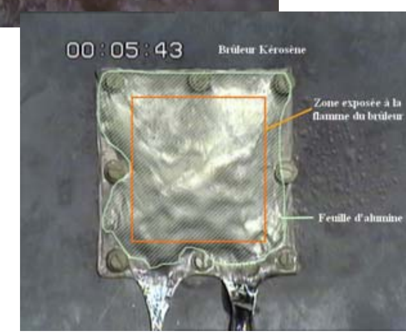
Gas Burner

A 1.2mm aluminium plate is fitted behind a 3mm steel plate, simulating a critical area to be tested

dist. Burner = 4 inches

Oil Burner





Gas Burner, dist. Burner = 3 inches:

Melting (s)	Burnthrough (s)
290	> 600
309	> 600
315	> 600

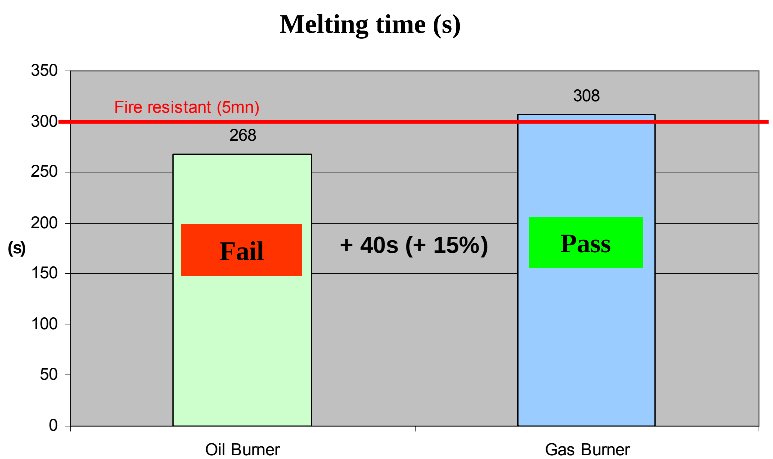
Alumina sheet

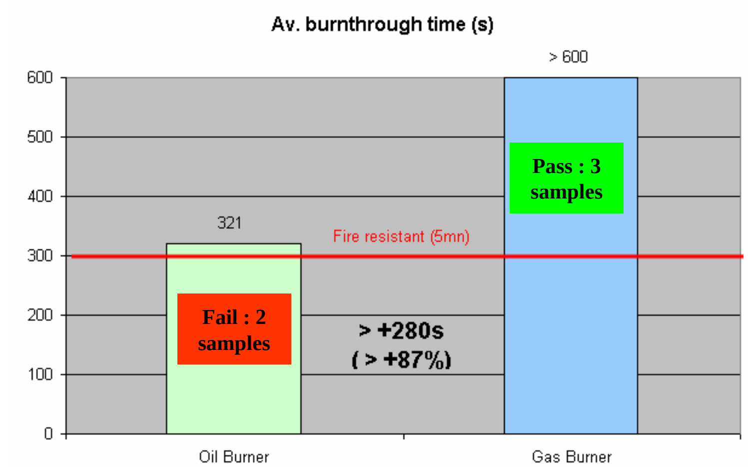
	Oil Burner			Gas Burner		
	Test 1	Test 2	Test 3	Test 1	Test 2	Test 3
Fire resistant (5mn) Burnthrough	4mn41s Fail	7mn16s Pass	4mn06s Fail	Pass	Pass	Pass
Fire resistant (5mn) Fusion	4mn41s Fail	4mn35s Fail	4mn06s Fail	4mn50s Fail	5mn09s Pass	5mn25s Pass
Behaviour at 10mn Burnthrough	4mn41s Fail	7mn16s Fail	4mn06s Fail	Pass	Pass	Pass

Oil Burner, dist. Burner = 4 inches:

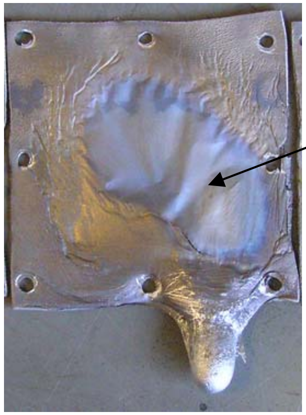
Melting (s)	Burnthrough (s)
281	281
275	436
246	246

Tests on small 2024 aluminium plate

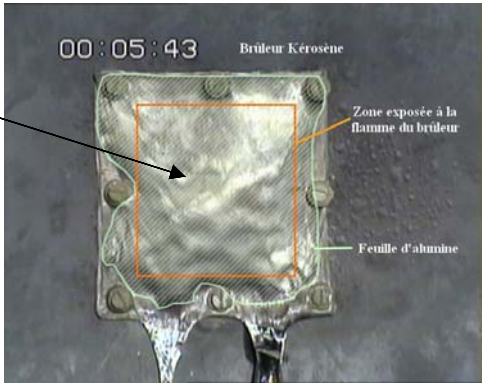




Gas Burner



Melted areas



Oil Burner

Tests on aluminium tube – ISO 2685 standard

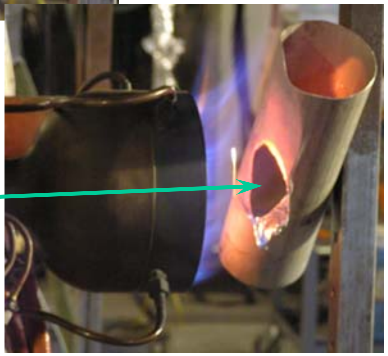
dist. Burner = 3 inches

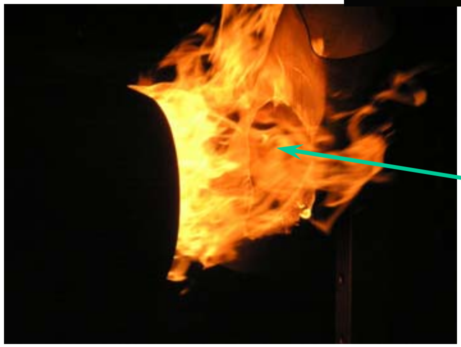
Nut & bolt simulating a critical part

L=30 cm / Ø=10 cm / th.=1.2mm

Failure time : burnthrough / fall of the bolt

dist. Burner = 4 inches





- failure time :

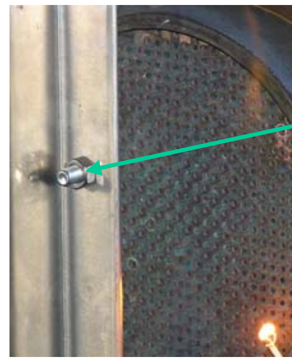
1mn 42 s
(+45 %)

- Failure time :

1mn 10 s

Tests on 2024 aluminium former – ISO 2685 standard

dist. Burner = 3 inches



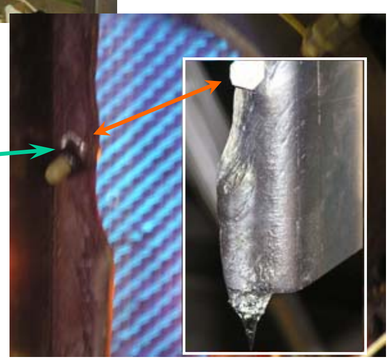
Nut & bolt simulating a critical part

thickness=5 mm

Failure time : fall of the bolt

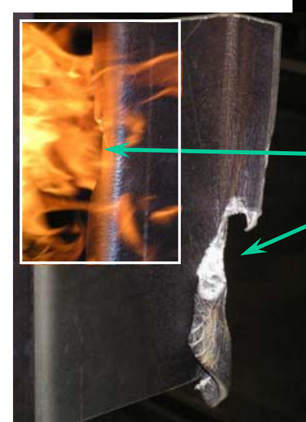
dist. Burner = 4 inches

Failure time :
> 15 mn



Fire resistant (5mn) :
Pass

Fire proof (15mn) : Pass

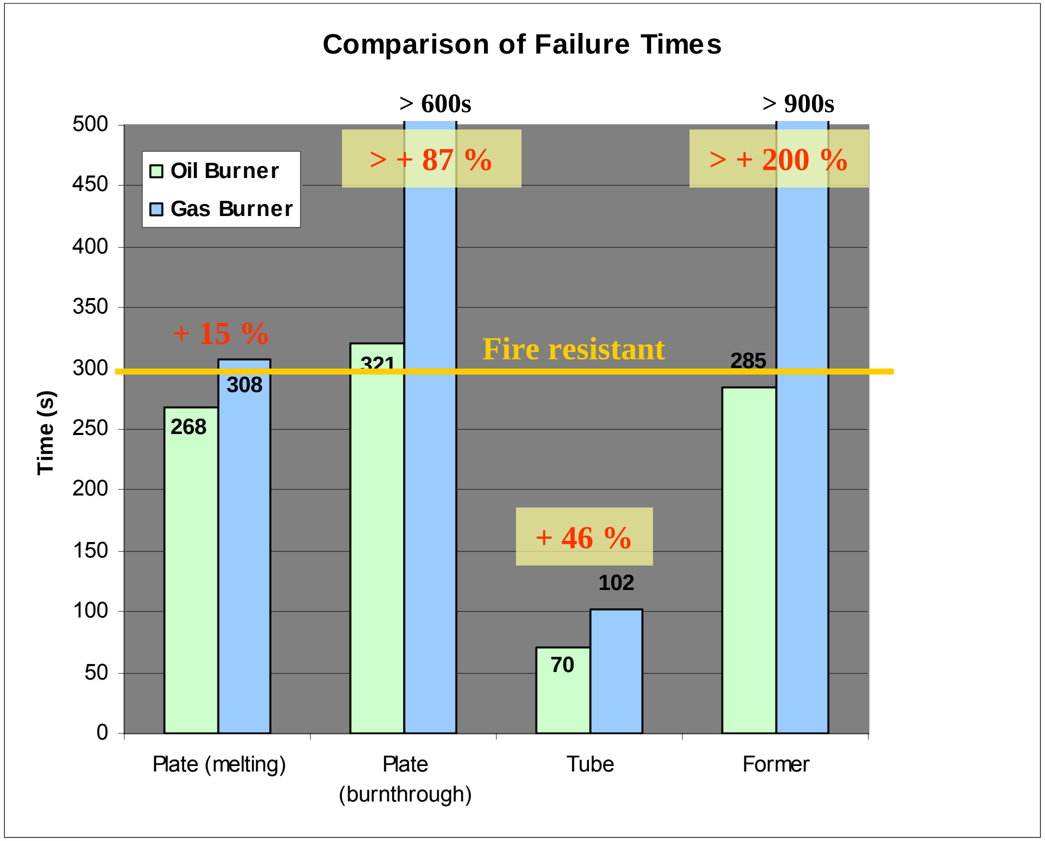


Failure time :
4 mn 45 s

Fire resistant (5mn) :
Fail

Fire proof (15mn) : Fail

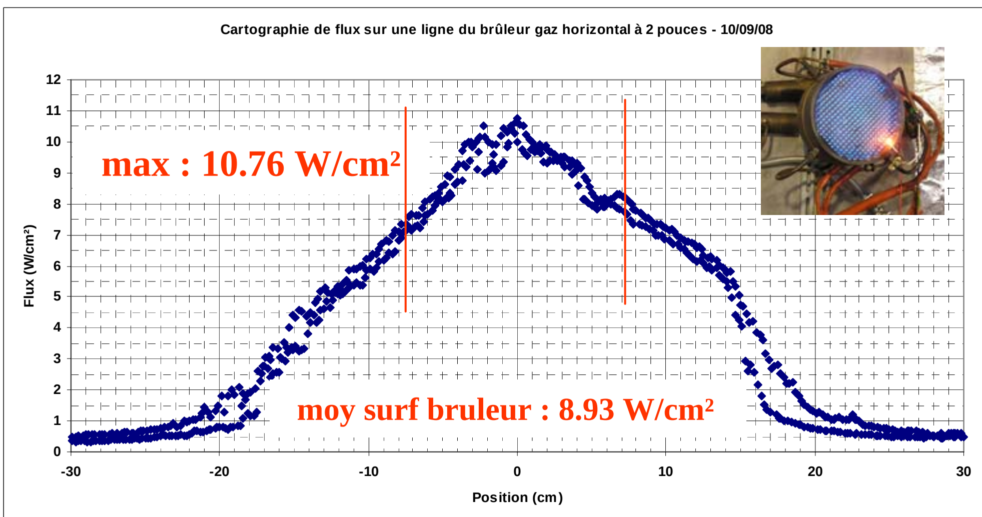
Comparison of failure times



- In all cases, the gas burner is less severe

Comparison of the ISO gas burner flame
To
FAA Handbook / AC 20.135 requirements

Heat flux Mapping (gas burner)
(horizontal centre line)



Burner setting according to the ISO specification

Flame measurement according to AC 20.135
(d = 2 inches)

- **Maximum Heat-Flux : 10.76 W/cm²**
  Handbook/AC requirements : ≥ 10.6 W/cm²

- Power : 2698 Btu/h (+20%)
  ISO calculated heat flux : 13.76 W\cm²

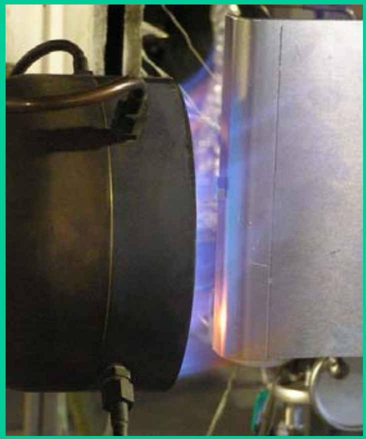
➔ The gas burner is in accordance with the AC / Handbook requirement
➔ But the heat flux peak is thin

Comparison of the ISO gas burner flame To FAA Handbook / AC 20.135 requirements

ISO 2685 standard configuration

Failure Time :
> 15 mn
Fire resistant (5mn) : Pass
Fireproof (15mn) : Pass

ISO flame settings + AC 20.135 test configuration
(d = 2 inches)

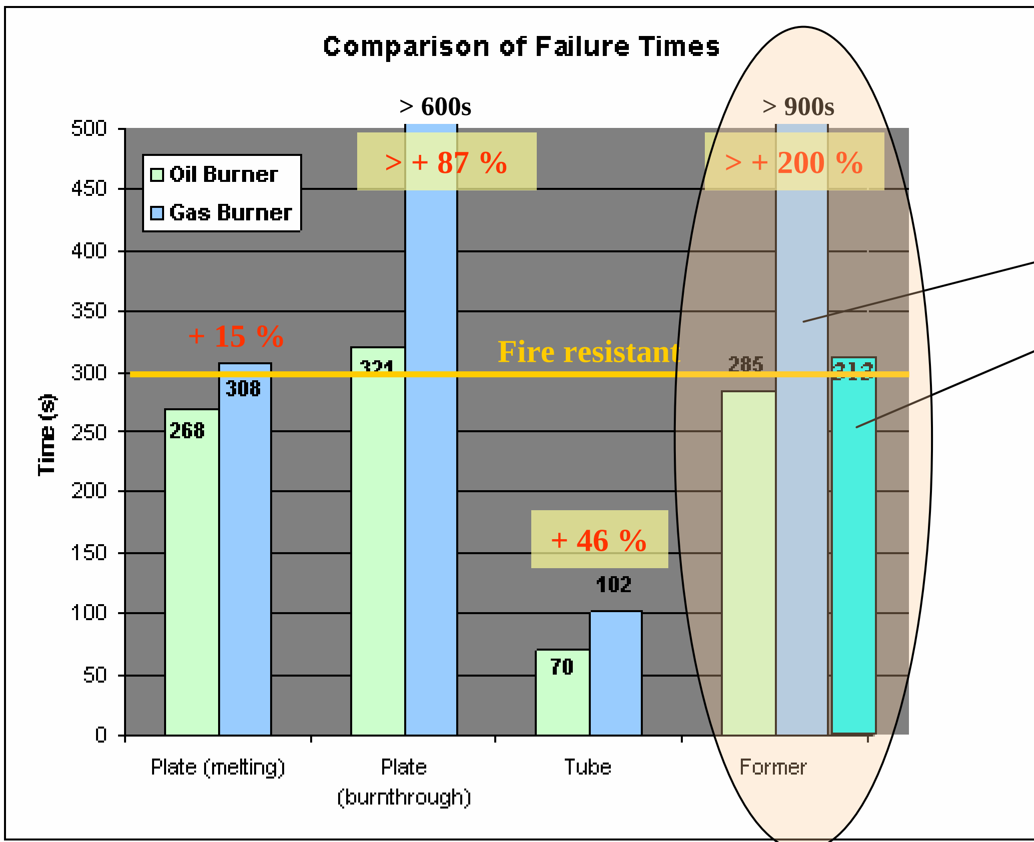


Failure Time :
5 mn 13 s
Fire resistant (5mn) : Fail
Fireproof (15mn) : Pass

ISO & AC 20.135 configuration (Oil Burner)

Failure Time :
4 mn 45 s
Fire resistant (5mn) : Fail
Fireproof (15mn) : Fail

Comparison of failure times



- ISO gas burner at d = 3 inches
- ISO gas burner at d = 2 inches

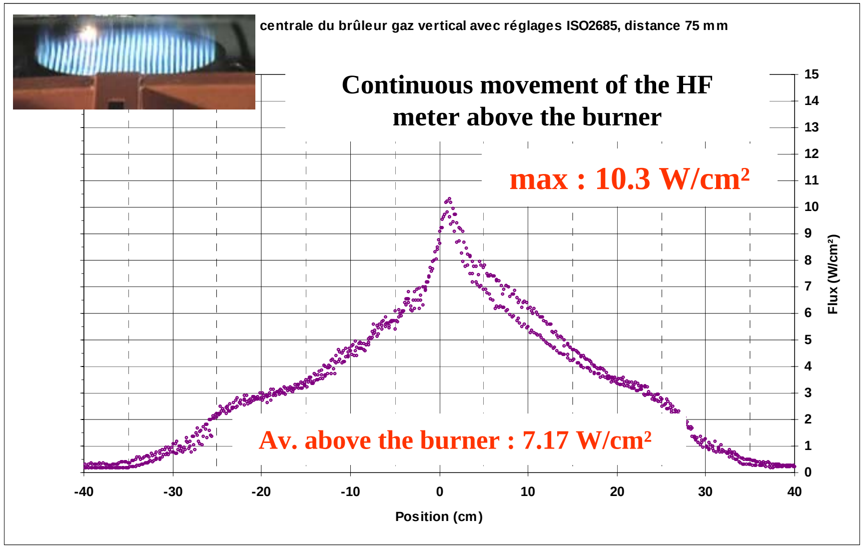
If used at d= 2 inches from the test sample

- ➢ ISO gas burner is in accordance with AC/Handbook requirements
- ➢ Gas burner & Oil burner test results are very close

Comparison of the ISO gas burner flame To FAA Handbook / AC 20.135 requirements

(ISO 2685 is often used by suppliers to demonstrate the compliance with the FAA / EASA requirements)

Heat flux Mapping
(centre line (vertical impact position))



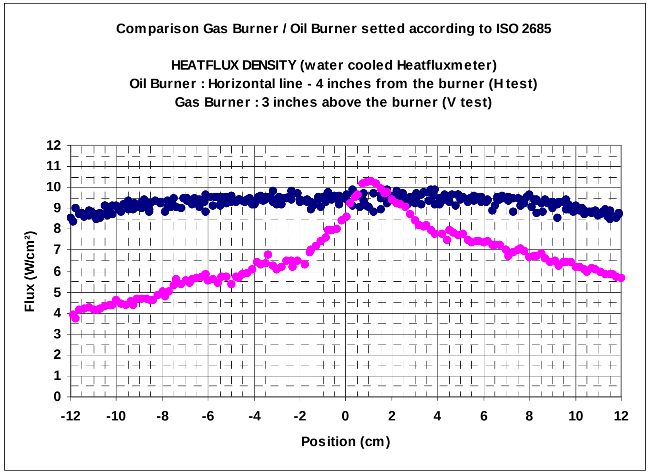
Handbook/AC requirements : $\geq$ 10.6 W/cm²

(using a Heat Flux Transducer)

- **Maximum Heat-Flux (gas burner) : 10.3 W/cm²**

When the heat flux density is measured with a water cooled calorimeter :
➔ The gas burner is close to the AC / Handbook requirement
➔ But the heat flux peak is very thin

Comparison of the oil burner flame (set according to ISO 2685) To FAA Handbook / AC 20.135 requirements



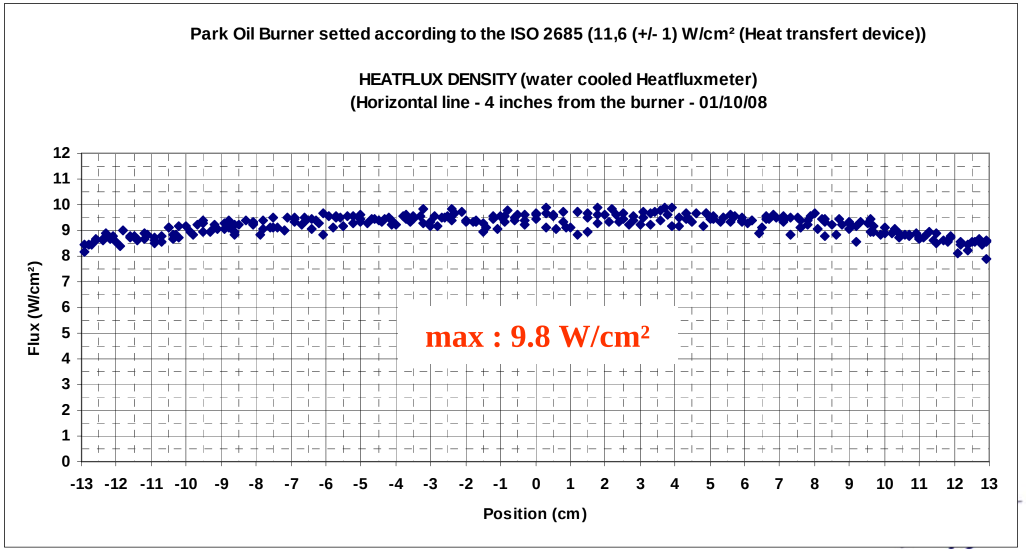
Heat flux Mapping

Handbook/AC requirements : ≥ 10.6 W/cm²
(using a Heat Flux Meter)

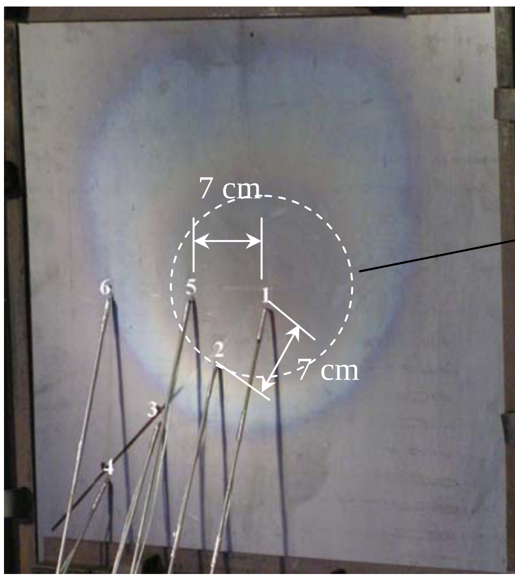
- **Maximum Heat-Flux : 9.8 W/cm²**

When the Park Burner is set according to ISO 2685 specifications :

➔The heat flux density is not in accordance with the Handbook / AC requirements.

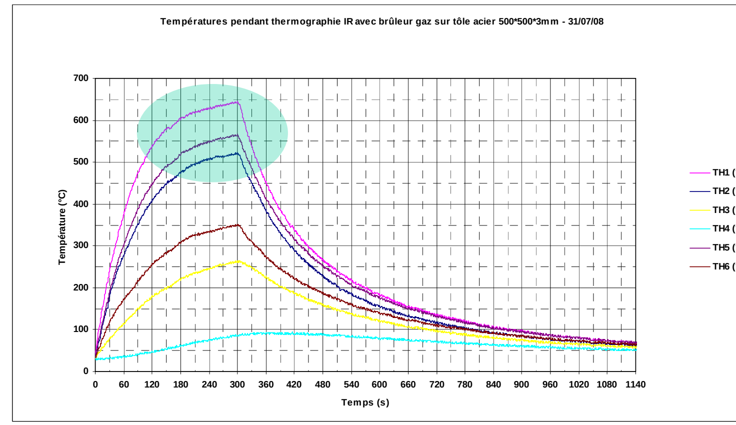


T° (steel plate - 3mm 500x500 mm)

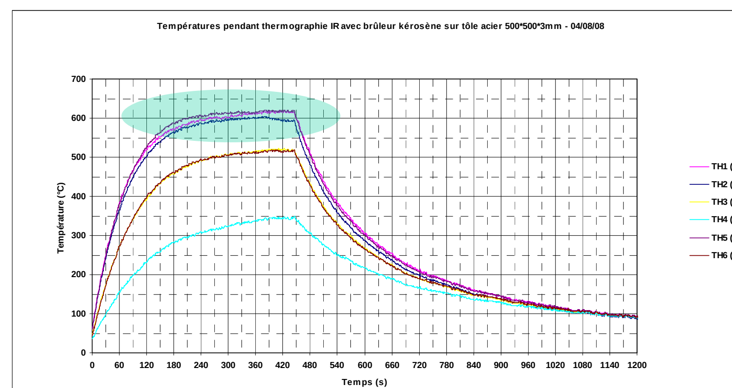


- **Gas Burner**

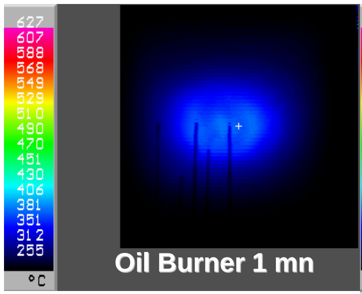
S : ~ 28 inch²
(>5“x5“)

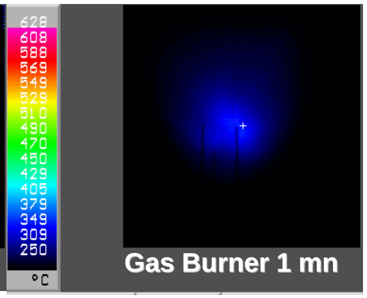


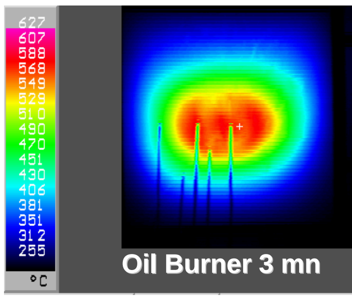
- **Oil Burner**

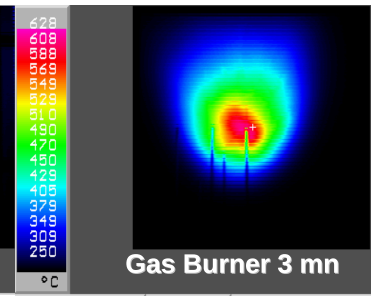


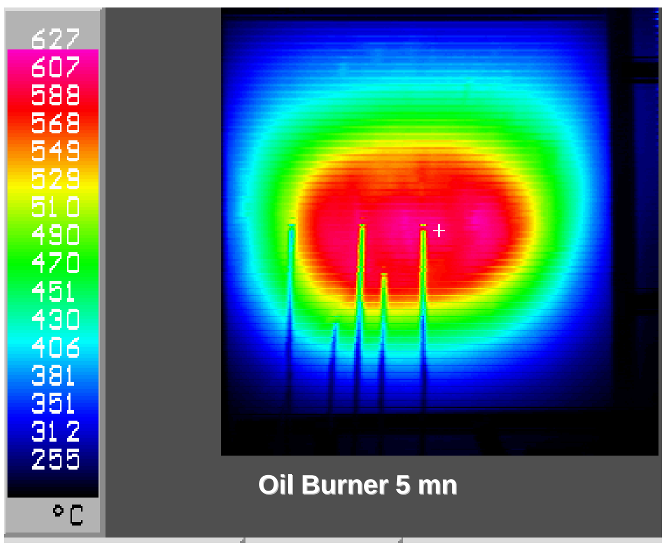
IR mapping (steel plate - 3mm 500x500 mm)

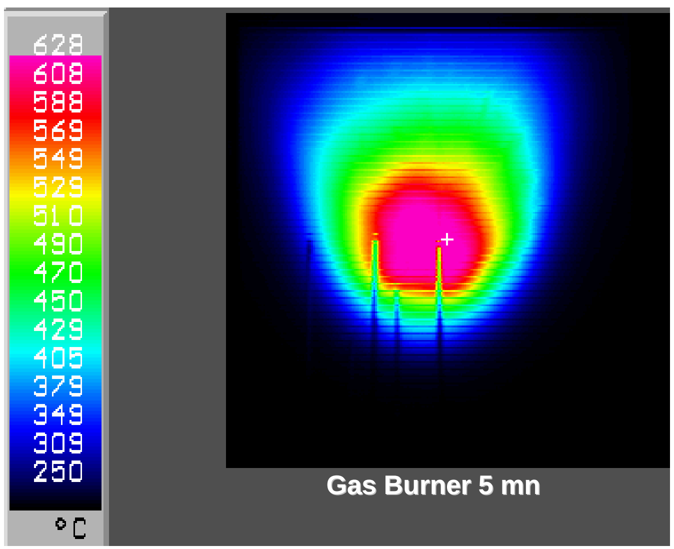












- **Estimated area >520°C :**
- **Oil Burner : 189 cm²** **(~ 14cm x 14cm)**
- **Gas Burner : 49 cm²** **(~ 7cm x 7cm)**

►Conclusion 1

These tests show that :

- **Within the ISO 2685 standard, the gas burner flame is always less severe than the oil burner flame,**
- **Heat flux methods of measurement are not equivalent and the values of heat flux calibrations must not be compared,**
- **When the gas burner and oil burner are calibrated according to the ISO standard, their flames are not in accordance with the Handbook / AC 20-135 requirements,**

Conclusion 2

Gas burner and oil burner are not equivalent

Gas burner :

- **Could be used within the Handbook/AC on small items.**
- **Practical aspect : Should not be used on medium size items under the Handbook test configuration (d=2 inches) (too close to the burner => possible burner damages (heat concentration – radiation from the sample)**
- **When this burner is used, as specified in the various standards it <u>should be used only on small critical parts</u>**
- **Because of thermal diffusion effect, it should be allowed only on small <u>items</u>**
  (gas burner should not be allowed to test large items with a small critical part, even if the critical part is at the centre line of the burner)

►Conclusion 3

As the ISO standard is often used in substitution with the FAA guidances and as the gas burner can be less severe than the oil burner :

➔ The ISO 2685 standard and (or) the Handbook / AC should be revised to fix all these « anomalies »

➔ As the ISO 2685 is currently under discussion within the TC20 ISO committee, the french mirror committee will probably ask for a complete review

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