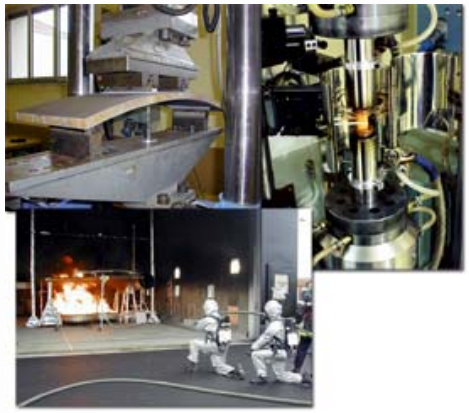

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RÉPUBLIQUE FRANÇAISE

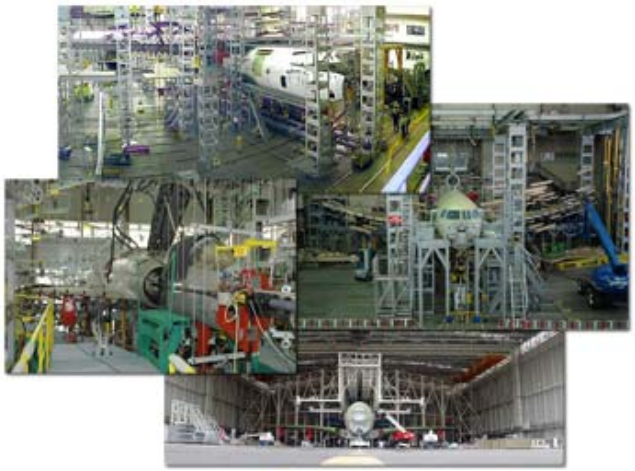
MINISTÈRE DE LA DÉFENSE

DGA Aeronautical Systems

(ex. CEAT)

« Fire Safety Department »

Fire tests on components used in fire zones.
(AC 20-135 / ISO 2685)



DGA

Serge LE NEVE
E-mail : Serge.le-neve@dga.defense.gouv.fr

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 assess the fire resistance and capability of materials & components to control the passage of fire 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

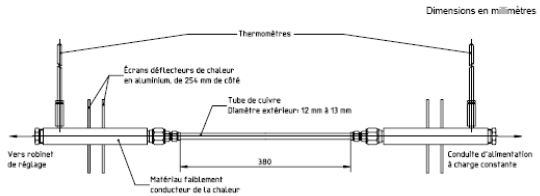


Figure B.4 — Vue générale du montage du tube étalon de mesure de la densité de flux thermique

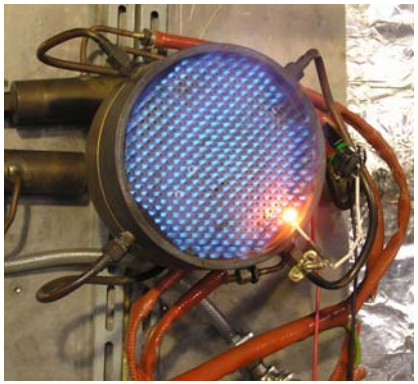
✓ **AC 20.135 : requirement : > 10.6 W/cm² (9.3 Btu/ft².s) or > 4500 Btu/hr**

Parameters are measured by the heat transfer device or by a 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 :**

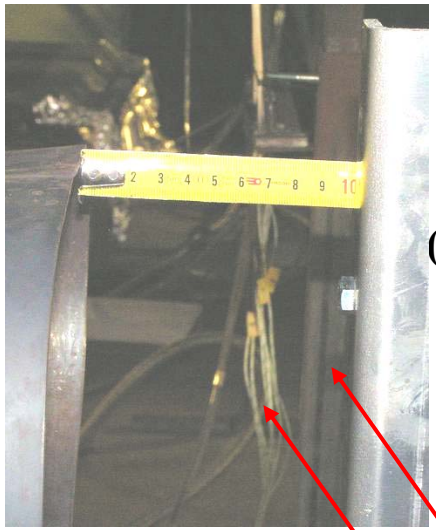
➔ Oil burner is described,

➔ Gas burner is also acceptable.

✓ **ISO 2685 :**

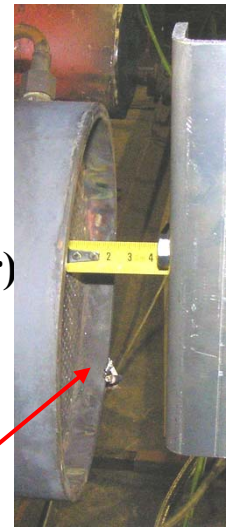
➔ Oil burner or gas burner can be used depending of the size of the critical part to be tested.

Fire on Components used in Fire Zones (AC20-135 / ISO 2685)



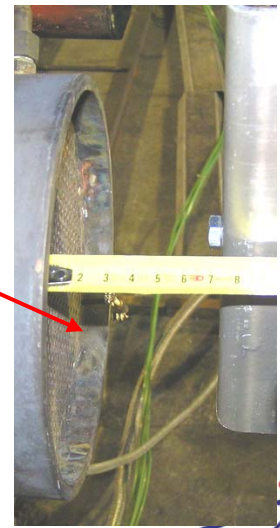
➢ 4 inches

➢ 2 inches



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

	Oil Burner	Gas Burner
FAR / CS (Handbook chap 12))	4″ (101,6 mm)	2″ (50,8 mm)
ISO 2685	Env 100 mm (4″)	Env 75 mm (3″)



➢ **AC 20.135 does not specifies the distance from the burner to the test sample**
(only specifies to maintain the distance for the test identical to the distance used for the calibration)

➢ 3 inches

SUMMARY OF THE SITUATION

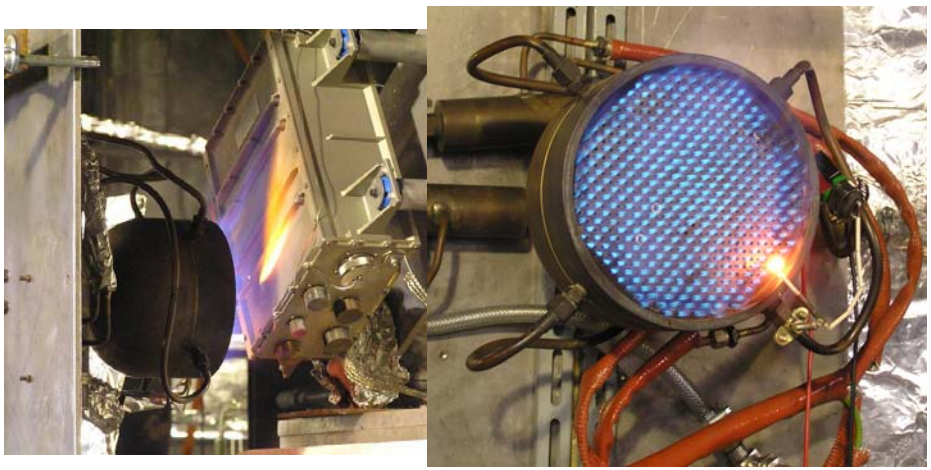
To test the same kind of components used in fire zones :

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

- **And all these standards have the same acceptance criteria :**
  - **Fire resistant : 5 mn**
  - **Fireproof : 15 mn**

Experiences with the Park oil burner has shown the difficulty to obtain a good reproducibility between labs using only one type of burner

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

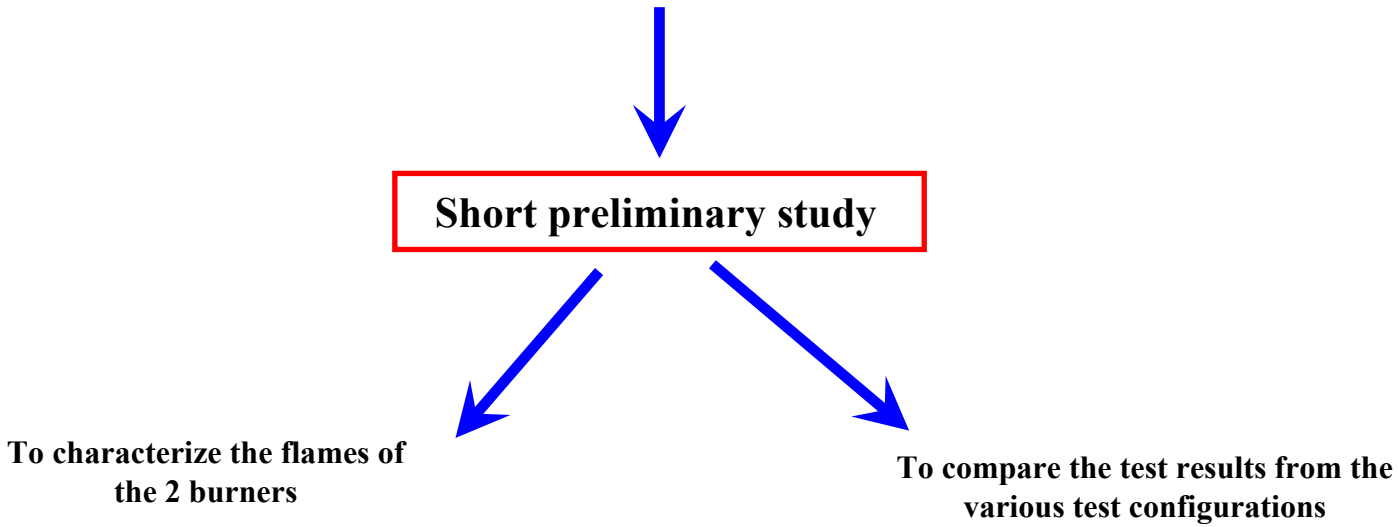


➢ **AS401B gas burner**

➢ **Park oil burner**

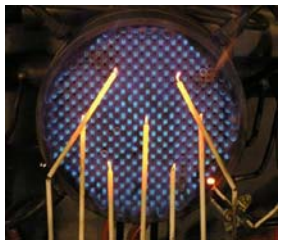
Some qualification tests performed on components according to ISO 2685 :

- ➔ **failed when performed with oil burner,**
- ➔ **passed when performed with gas burner.**



Fire on Components used in Fire Zones (AC20-135 / ISO 2685)

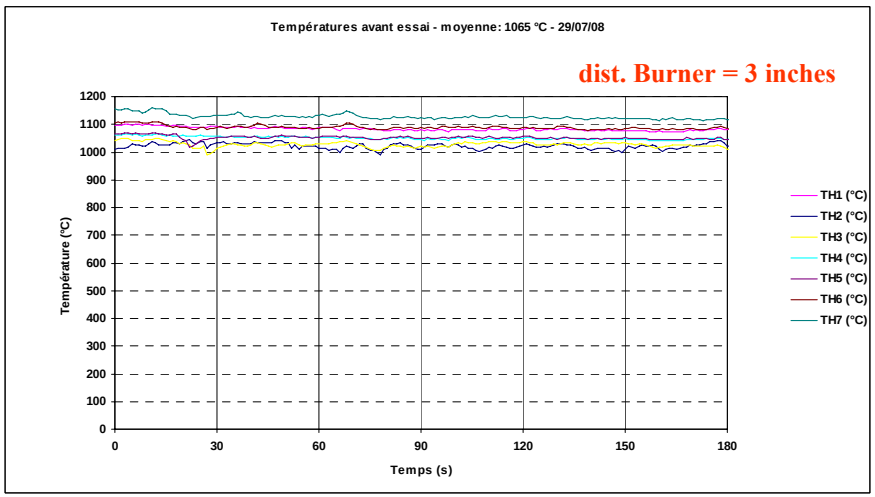
Flame calibrations (T°)



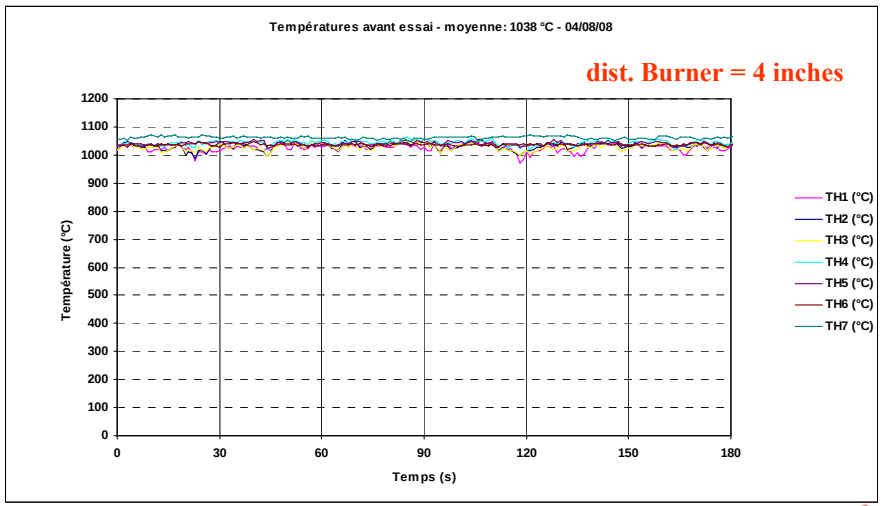
ISO requirement : 1100°C +/- 80°C

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

➢ T° Gas Burner



➢ T° Oil Burner



Fire on Components used in Fire Zones (AC20-135 / ISO 2685)

Flame calibrations (power, HF density)

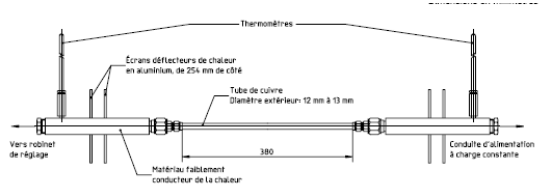
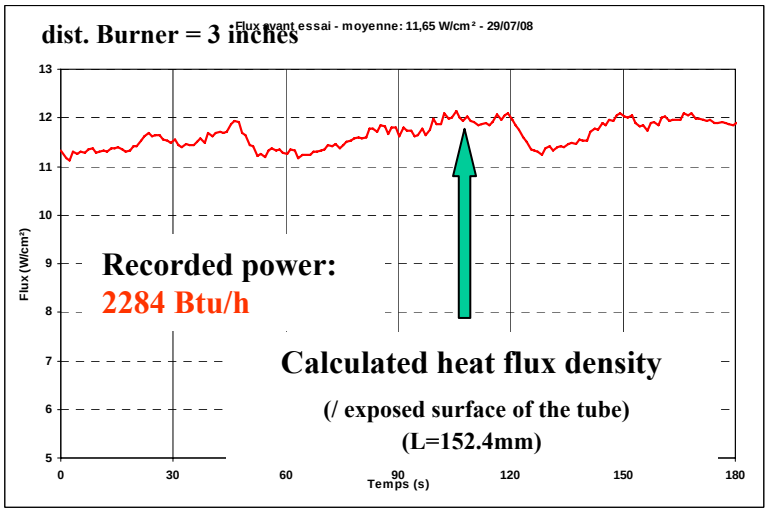


Figure B.4 — Vue générale du montage du tube étalon de mesure de la densité de flux thermique

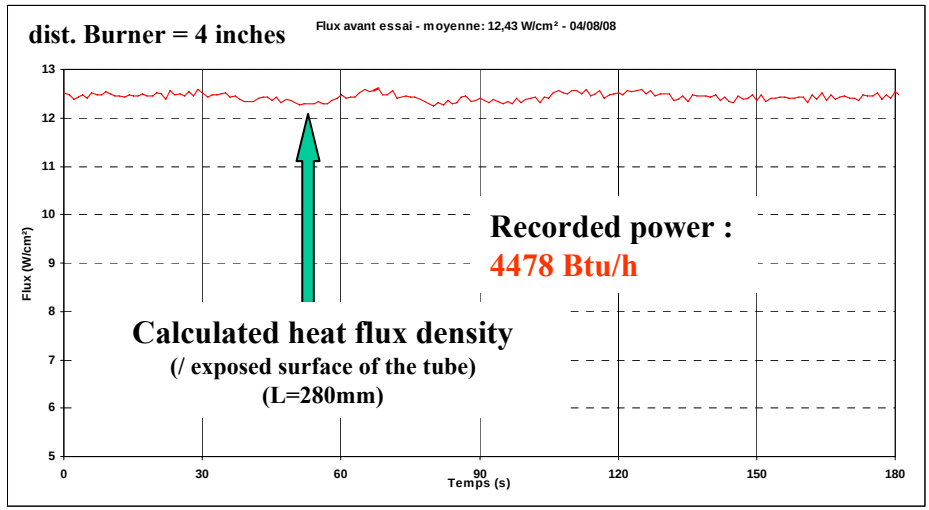
ISO requirement : 11.6 W/cm² +/- 1 W/cm²

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

➢ **Heat Flux – Gas Burner**



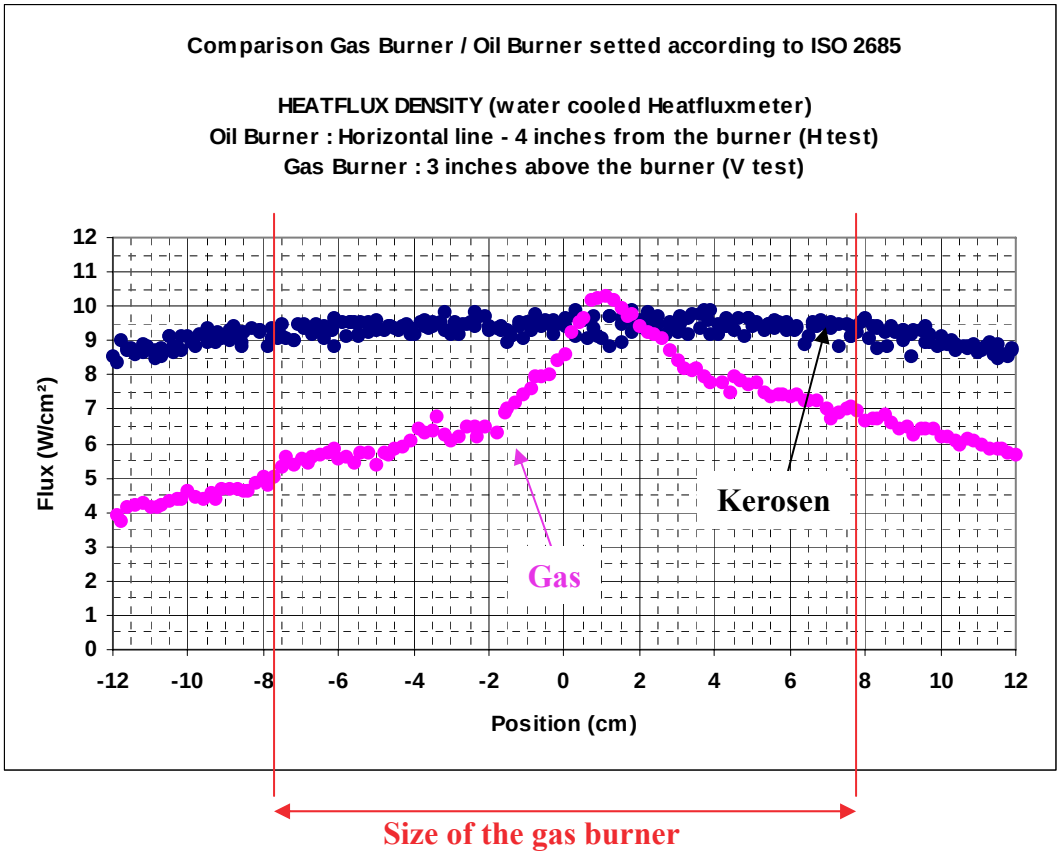
➢ **Heat Flux – Oil Burner**



The both Heat flux densities are close but due to the size of the oil burner's exit, the power of the oil burner is twice over.

Fire on Components used in Fire Zones (AC20-135 / ISO 2685)

Heat Flux mapping



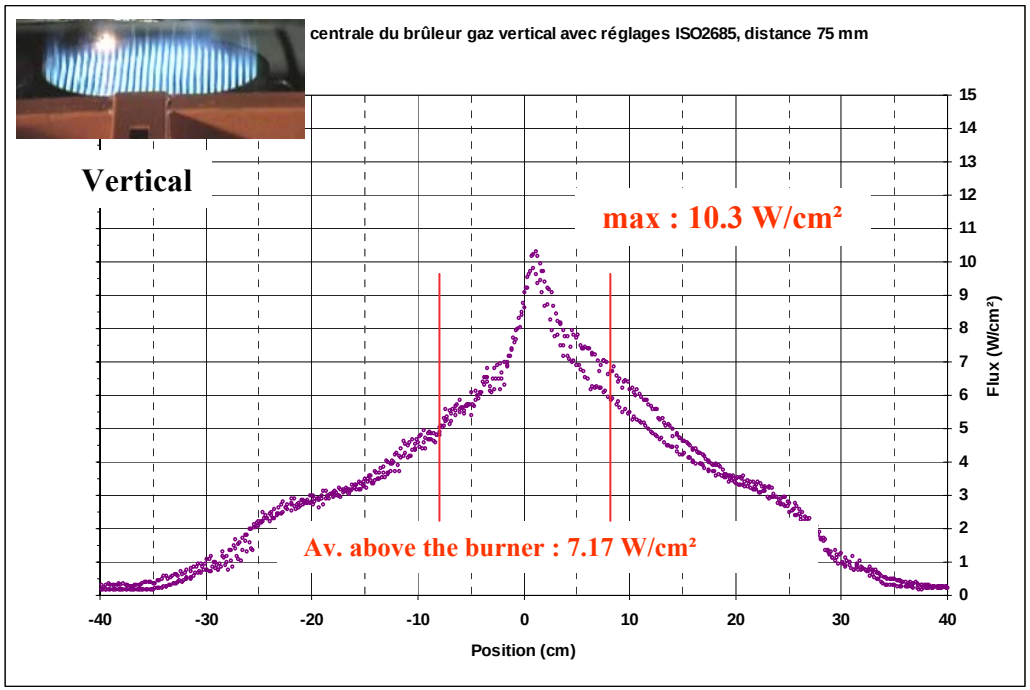
- The burners were calibrated according to the ISO 2685 (using the heat transfer device)

- The mapping were made using a water-cooled calorimeter with a continuous displacement at the centreline of the burners

➔ Oil burner :The heatflux distribution is homogeneous
➔ Gas burner: Peak of heatflux

Fire on Components used in Fire Zones (AC20-135 / ISO 2685)

Heat Flux mapping



Other example of a Heat Flux mapping on the gas burner

Showing :

➔ **A very thin peak of heatflux**
➔ **A very low average of heatflux (7.17 W/cm²)**

ISO requirement : 11.6 W/cm² +/- 1 W/cm²
(calculated from the power measured with the Heat Transfer Device)

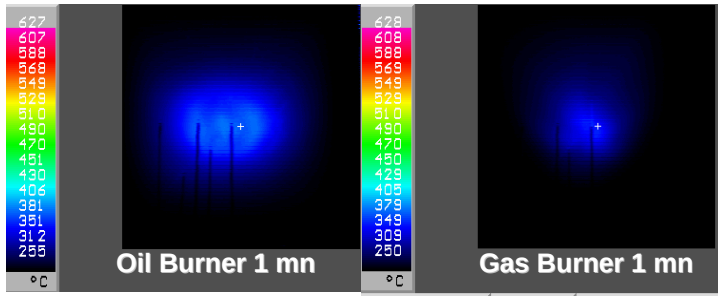
Fire on Components used in Fire Zones (AC20-135 / ISO 2685)

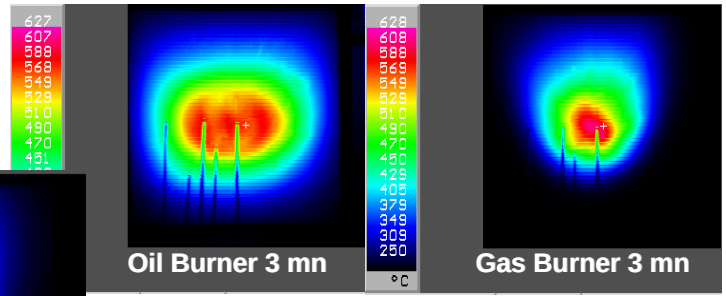
IR mapping (steel plate - 3mm 500x500 mm)

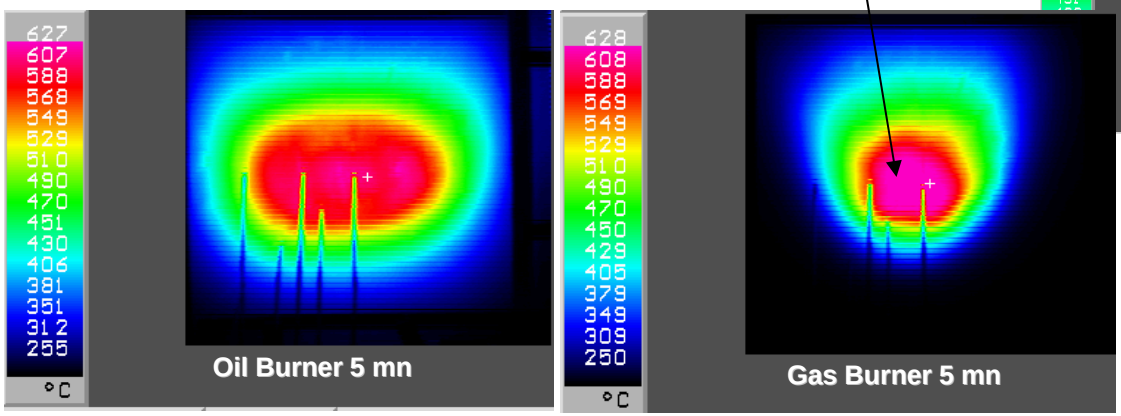
- The size of the thermally affected area is wider using the oil burner

- The temperature at the centre is locally a bit higher using the gas burner

➔ Globally, the thermal effect using the oil burner seems higher





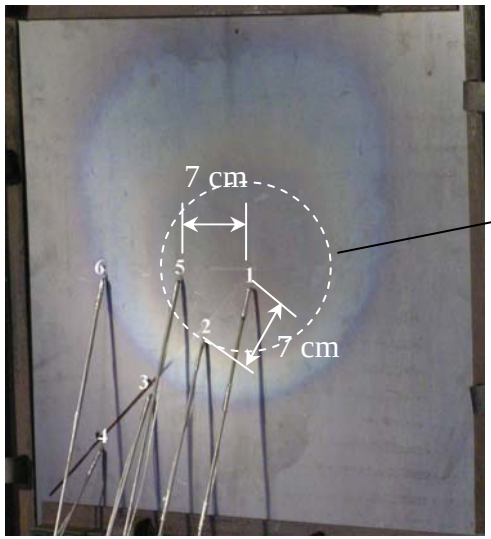


➢ <u>Estimated area >520°C :</u>

➢ Oil Burner : 190 cm²
(≃ 14cm x 14cm)

➢ Gas Burner : 50 cm²
(≃ 7cm x 7cm)

Fire on Components used in Fire Zones (AC20-135 / ISO 2685)



S : ~ 28 inch²
(>5“x5“)

AC 20.135
requirement

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

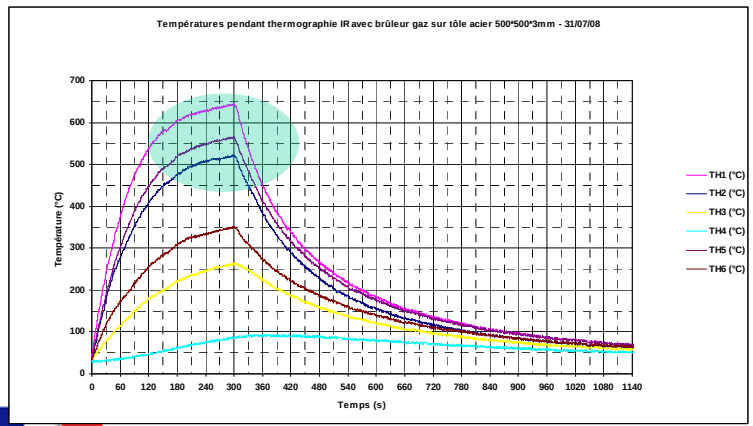
The records of the temperatures during the mapping show :

- The T° at the centre is a bit higher using the gas burner

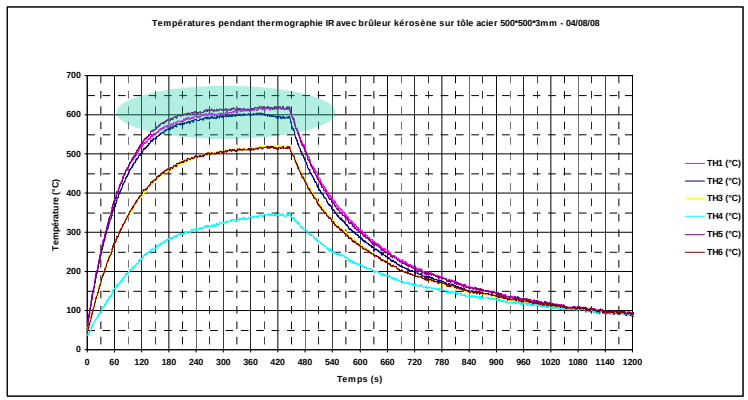
- The T° within the central circle is not homogeneous using the gas burner (Δ > 100°C)

- The T° provided with the oil burner are very homogeneous

➢ Gas Burner



➢ Oil Burner

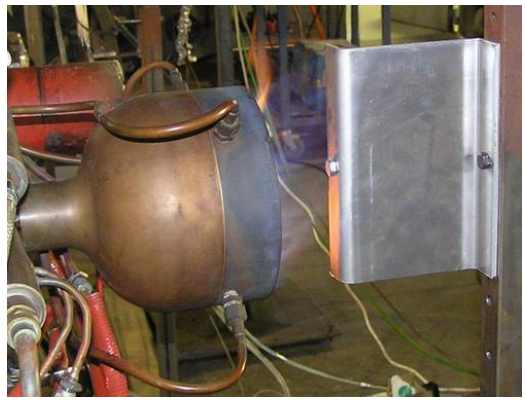


Comparative Fire Tests

3 different specimens including a critical area were submitted to the burners calibrated in accordance with the ISO 2685 standard.

➢ **Small aluminium plate**

➢ **Tube and bolt (simulating the critical part)**



➢ **Former and bolt (simulating the critical part)**

Fire on Components used in Fire Zones (AC20-135 / ISO 2685)

Comparative Fire Tests

Oil Burner

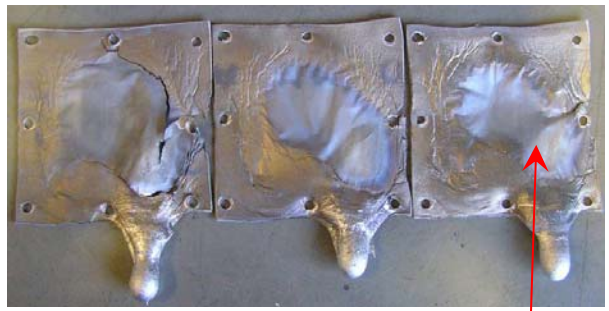
dist. Burner = 4 inches

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

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

Gas Burner

dist. Burner = 3 inches



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

Alumina sheet

2 criteria were analysed :

- **Burnthrough time**
- **Aluminium melting time**

Times to burnthrough were delayed due to the development of an alumina sheet during the test

- **gas burner > 10mn**
- **oil burner : 1 burnthrough time abnormally high (7mn 16s)**

- **The melting times from the gas burmer are higher (+15%)**

Comparative Fire Tests

Test results analyse :

- **Fire resistance criteria: Only 1 case fails the test with the gas burner. 5 cases fail the test with the oil burner**
- **Burnthrough at 10mn : 3 successes with the gas burner / 3 failures with the oil burner**

	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

Comparative Fire Tests

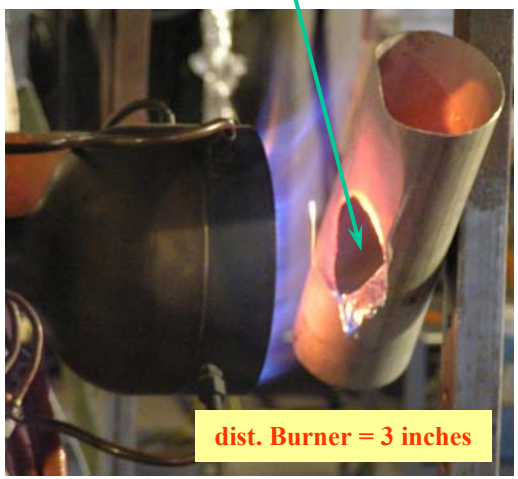
Bolt simulating a critical part

L=30 cm / Ø=10 cm / th.=1.2mm

Failure time : burnthrough / fall of the bolt

➢ **failure time :**

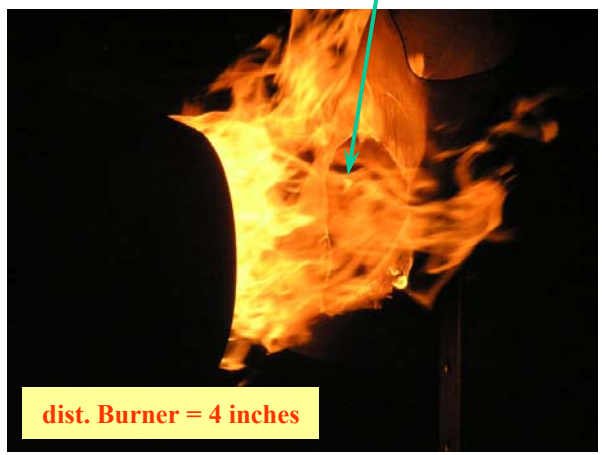
1mn 42 s



The failure times from the gas burmer is higher (+45%)

➢ **Failure time :**

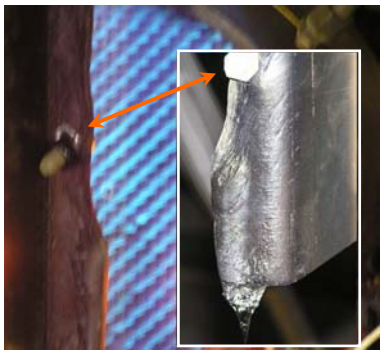
1mn 10 s



Fire on Components used in Fire Zones (AC20-135 / ISO 2685)

Comparative Fire Tests

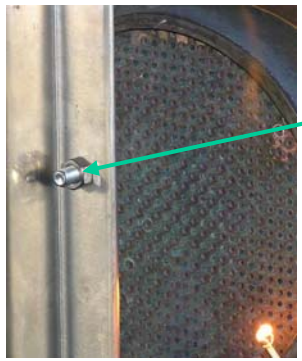
dist. Burner = 3 inches



Failure time :
> 15 mn

Fire resistant (5mn) :
Pass

Fireproof (15mn) : Pass



Nut & bolt simulating a critical part

thickness=5 mm
Failure time : fall of the bolt

This assembly is Fireproof (>15 mn) when tested with the gas burner

But

Failed with the oil burner at less than 5mn

dist. Burner = 4 inches

Failure time :
4 mn 45 s

Fire resistant (5mn) :
Fail

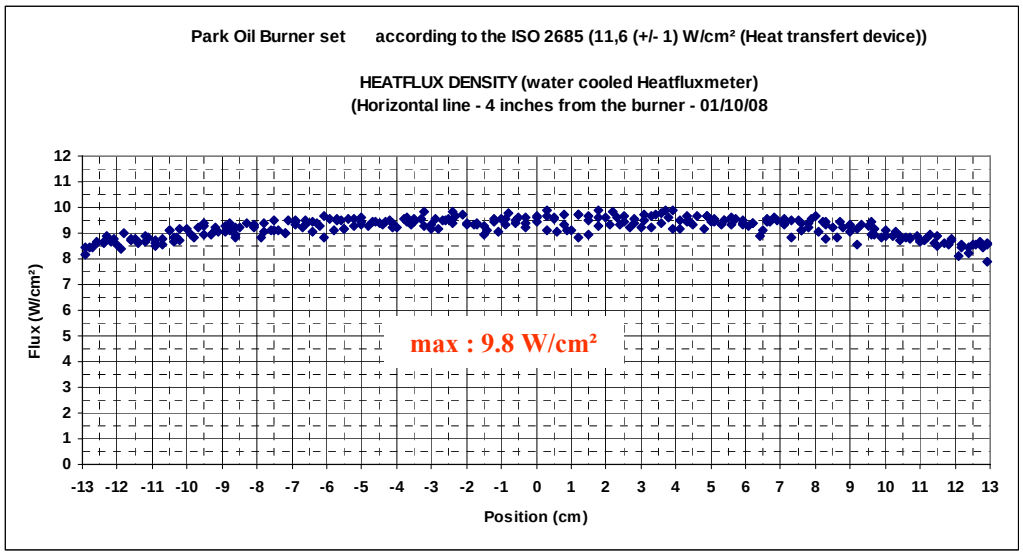
Fire proof (15mn) : Fail

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

Handbook/AC requirements :
- **> 10.6 W/cm² (using a calorimeter)**
- **or > 4500 BTU/h (using the heat transfer device)**

Heat flux Mapping of the oil burner

(the burner was calibrated using a heat transfer device (according to the ISO2685) then mapped using a water-cooled calorimeter)

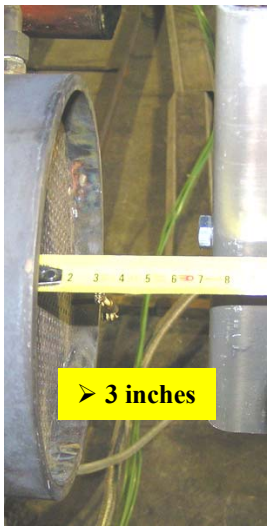


This mapping shows that when the oil Burner is set according to ISO 2685 specifications :

➔**The heat flux density (measured using a calorimeter) is not in accordance with the Handbook / AC requirements.**

But it is when the heat flux is calculated from the power (measured using the heat transfer device) !

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



➢We calibrated the gas burner (in horizontal position) according to the ISO requirements (d = 3 inches)
➔Recorded power : 2138 Btu/h (calculated heat flux from this power : 10.91 W/cm²)

➢ Then we measured the flame according to Handbook & AC 20.135 requirements (d = 2 inches)
➔Recorded power : 2698 Btu/h (calculated heat flux from this power : 13.76 W/cm²)
(+ 24%)

➢ we made a heat flux mapping of the flame at d = 2 inches

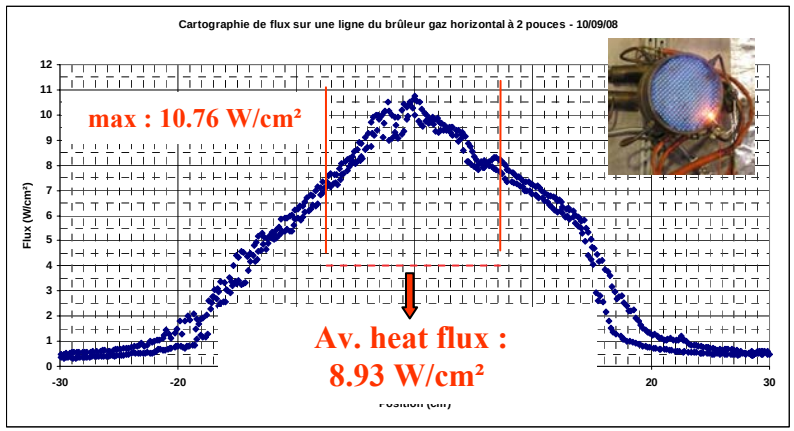
Fire on Components used in Fire Zones (AC20-135 / ISO 2685)

	Recorded power (heat transfert device)	Heat Flux (calculated)	
➢ d = 3 inches	**2138 Btu/h**	**10.91 W/cm²**	Max **Heat Flux** (From the mapping) (water-cooled calorimeter)
➢ d = 2 inches	**2698 Btu/h** **+ 24%**	**13.76 W/cm²**	**10.76 W/cm²**

➔ **At d=2 inches the power increases of 24% and the gas burner is in accordance with the AC / Handbook requirements** (≥ *10.6 W/cm²*)

➔ **But the mapping shows that the heat flux is not homogeneous (av. Heat flux is less than 9 W/cm²)**

Heat flux Mapping (horizontal centre line)



Fire on Components used in Fire Zones (AC20-135 / ISO 2685)

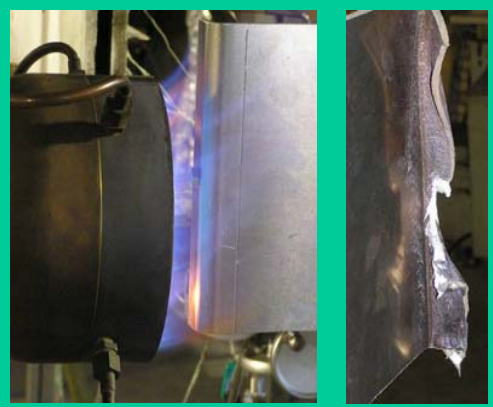
➢We carried out a last test using the gas burner at d=2 inches (test condition of the Handbook chap. 12)
➢ Under this test condition, the failure time was close to the test results using the oil burner and very far from the test results at d=3 inches

Using the gas burner, the test results according to the ISO 2685 are not equivalent to those obtained according to the AC & Handbook

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

Fire on Components used in Fire Zones (AC20-135 / ISO 2685)

Many other tests were performed and showed that :

- **Due to these differences between these 2 burners:**
  - **Many other factors insufficiently defined in these standards have significant effects on the test results:**
    - **size of the specimen,**
    - **size of the critical parts,**
    - **orientation of the burner,**
    - **position of the specimen in front of the burner,**

Conclusion 1

All these tests show that :

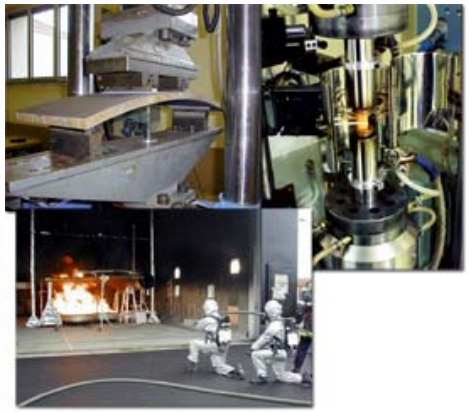
- **These 2 burners are not equivalent,**
- **Within the ISO 2685 standard, the flame of the gas burner is always less severe than the flame of the oil burner,**
- **The heat flux methods of measurement are not equivalent and the values of heat flux calibrations must not be compared,**
- **When the gas burner and oil burner are calibrated according to the ISO standard, their flames are not always in accordance with the Handbook / AC 20-135 requirements,**
- **Other considerations should be addressed, such as the representativity of a gas flame to simulate a fire occurring in power plant installations (where the only threat is a kerosen fire)**
- **FIRE SOURCES, METHODS of CALIBRATION and TEST CONFIGURATIONS NEED HARMONIZATION**

Conclusion 2

As the ISO standard is often used in substitution with the FAA test methods and guidances :

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

➔ **The ISO 2685 is currently under revision within the TC20 ISO committee. A task group involving the EASA is working on this subject to propose some improvements.**



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RÉPUBLIQUE FRANÇAISE

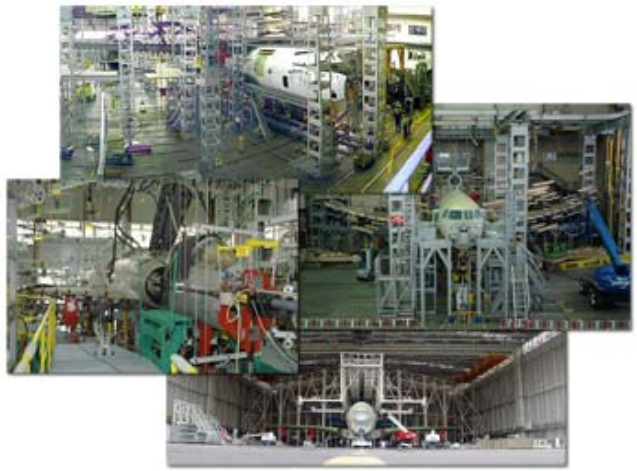
MINISTÈRE DE LA DÉFENSE

DGA Aeronautical Systems

(ex. CEAT)

« Fire Safety Department »

Fire tests on components used in fire zones.
(AC 20-135 / ISO 2685)



DGA

Serge LE NEVE

E-mail : Serge.le-neve@dga.defense.gouv.fr