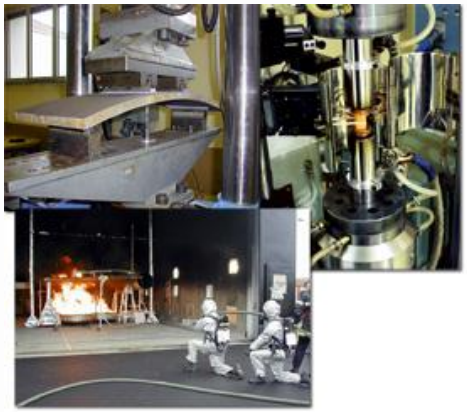

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MINISTÈRE
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DGA Aeronautical Systems

« Fire Safety Department »

Powerplant Task Group
Progress of the survey and test results

DGA

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Reminder of the preliminary works

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”.

Reminder of the preliminary works

Various methods of Heat Flux calibration are specified to set the burners depending on the test method

- **The choice is open for the calibration requirement (power or Heat Flux density)**
- **2 kind of devices are allowed (water-cooled calorimeter or heat transfer device)**
- **Depending on the test method, the Heat Flux density can be measured by a water-cooled-calorimeter or calculated by the heat transfer device**

✓ **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**

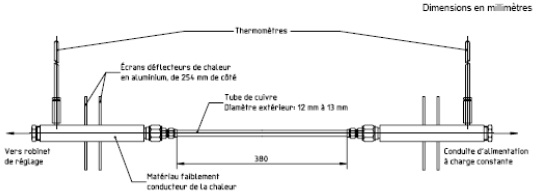


Figure B.4 — Vue générale du montage du tube étalon de mesure de la densité de flux thermique

✓ **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.

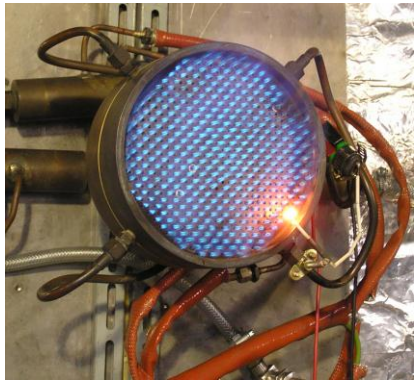
✓ **ISO 2685 : requirement : 11.6 W/cm² (+/- 1 W/cm²)**

The **Heat Flux density is calculated from the heat transfer device which measures a power** (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).

Reminder of the preliminary works

Various burners are allowed

AS401B
Propane Burner

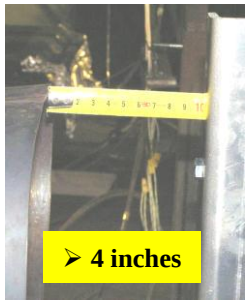


- ✓ **Aircraft Material Fire Test Handbook :**
  - ➔ Oil burner (such as Park PDL 3400) is described,
  - ➔ Gas burner (SAE AS401B Propane Burner) is also acceptable (chapt 12).
- ✓ **AC 20.135 :**
  - ➔ Oil burner is described,
  - ➔ Gas burner is also acceptable.
- ✓ **ISO 2685 :**
  - ➔ Oil burner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

Oil Burner

Reminder of the preliminary works

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



Oil Burner

Propane 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″)

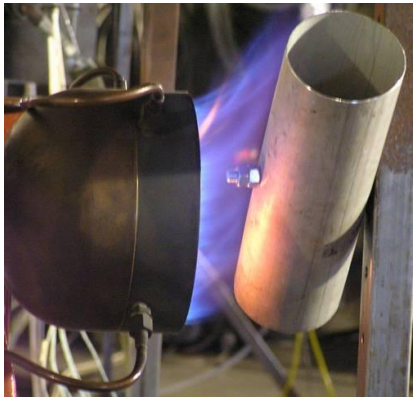
➢**AC 20.135 does not specifies the distance from the burner to the test sample**
(only specifies to maintain the distance for the test identical to the distance used for the calibration)

Reminder of the preliminary works

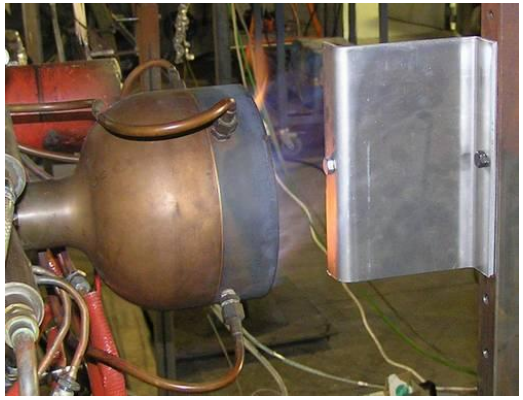
Comparative Fire Tests were performed with the 2 types of burners according to the ISO 2685 standard on various specimens

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)**

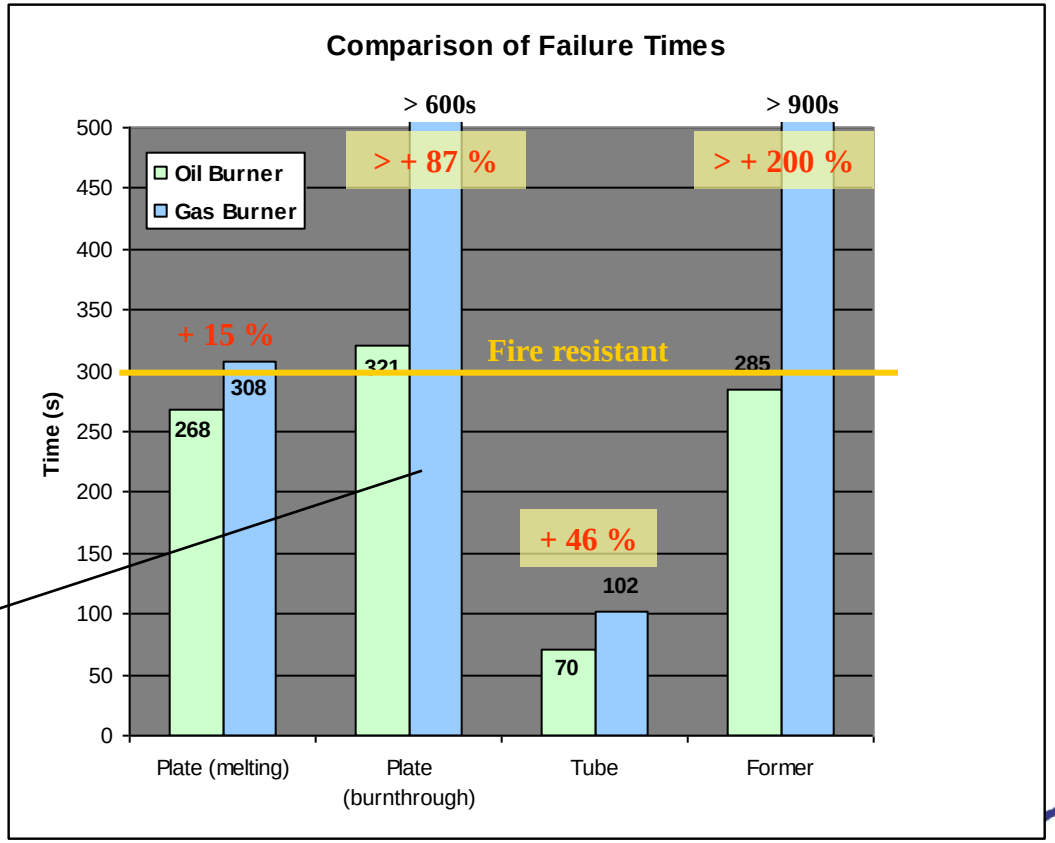


➢ **Former and bolt (simulating the critical part)**

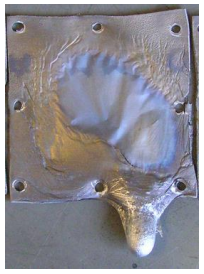
Reminder of the preliminary works

Comparison of failure time has shown significant differences (up to 200% on the burnthrough time)

- **In all cases, the gas burner was less severe**
- **But the gap between the burners seems to be very dependent on the type of specimen to be tested (size, shape, volume … ?)**

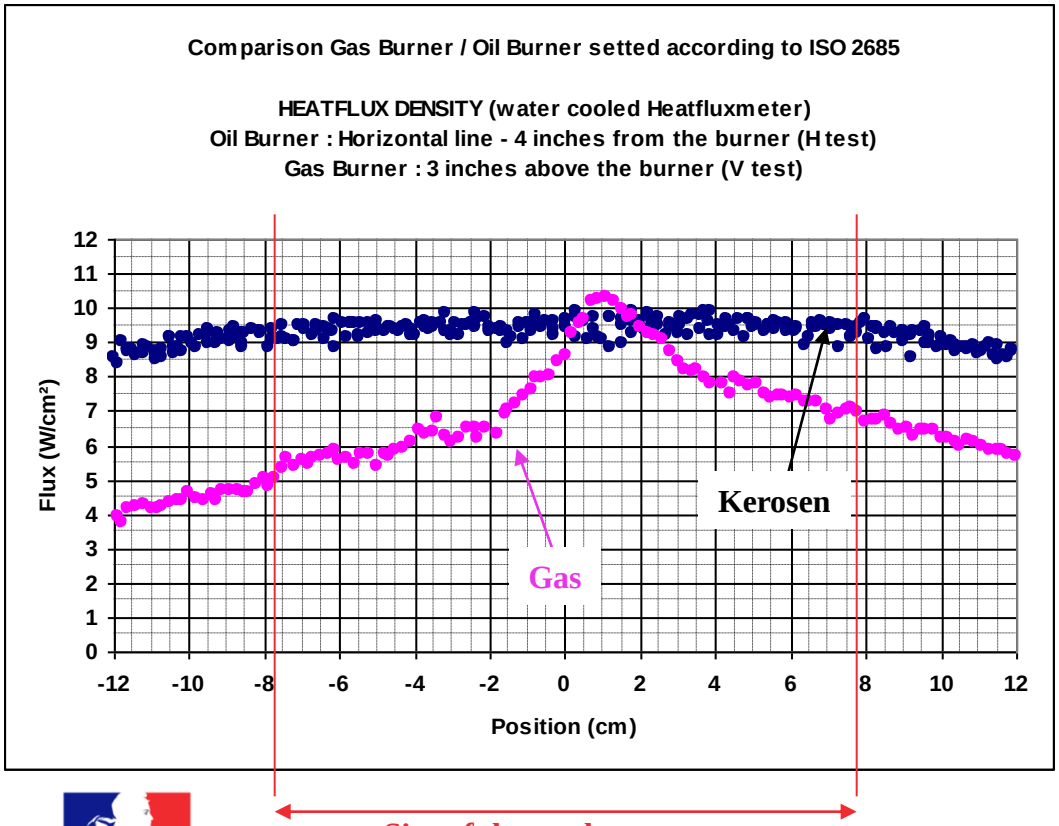


The development of an alumina sheet prevents the burnthrough



Reminder of the preliminary works

Heat Flux mappings of the burners are significantly different



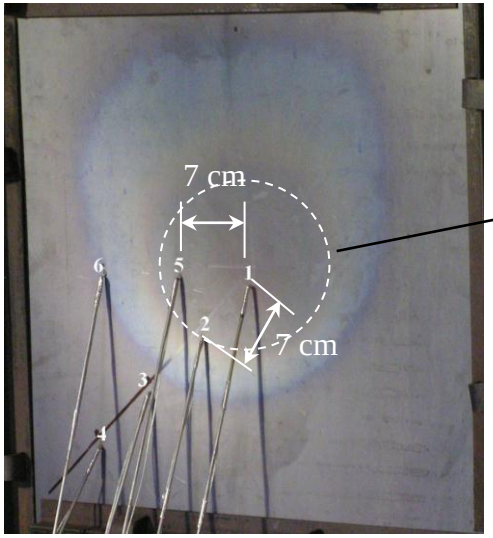
- The 2 burners meet the calibration requirements of the ISO 2685
➔ Oil burner: The heatflux distribution is homogeneous
➔ Gas burner: Peak of heatflux

We can easily understand that the 2 types of burners can produce different test results.

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

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

Reminder of the preliminary works



S : ~ 28 inch²
(>5“x5“)

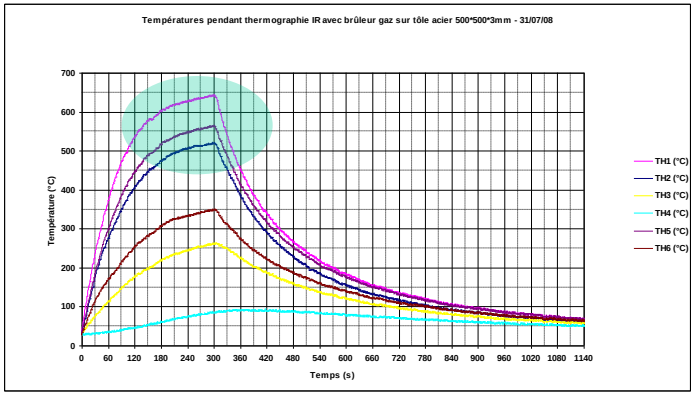
AC 20.135
requirement

The temperature increase velocities are also different

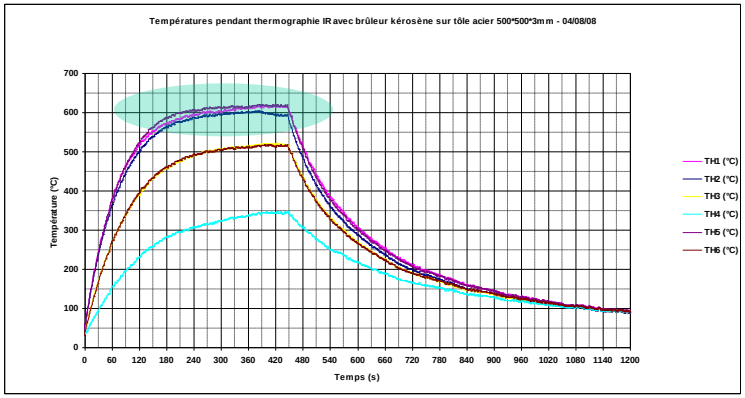
- **The T° at the centre of the specimen is a bit higher using the gas burner (but decreases with the distance from the center)**

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

➢ **Gas Burner**



➢ **Oil Burner**



Reminder of the preliminary works

Following these preliminary works,
EASA and DGA proposed to review the ISO 2685 test method to improve the reliability / representativeness of the test results.

EASA and DGA with the support of FAA proposed to run a survey and a round robin with the aim of :

- Identifying the different parameters which could have an effect on the test results
- Getting data to harmonize the various test methods and to extend the usage of the NexGen Burner to the powerplant fire tests.

Survey Update

12 labs are more or less involved in the action

- **Element**
- **Jehier**
- **Akro Fireguard**
- **University of Cincinnati**
- **SNECMA**
- **DGA**
- **LEFAE**
- **FAA**
- **Airbus**
- **Honeywell**
- **GE**
- **Fire Precaution**
- **Environ Lab**

8 labs participated in the Round Robin tests

- 3 labs have received the sets of bolts & nuts but the test results are still waited
(2 did not reply to the survey)

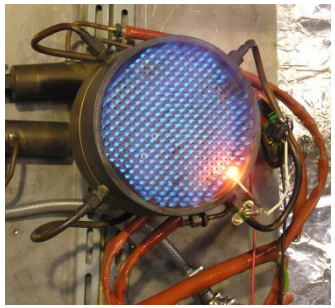
- 1 lab did not reply technical element to the survey and did not ask the materials for the tests

10 labs participated in the survey

Survey Update

Test Methods

- 9 labs perform the tests according to the ISO2685 and AC20.135 (or chap12 of the handbook)
- 1 lab only performs the tests according to the AC20.135 (using an oil burner)



Burners

- 2 labs only use an oil burner
- 1 lab only uses a gas burner
- 7 labs use the 2 kinds of burners (Oil & Gas) (but only 4 labs provided test results from the 2 burners)

Survey Update

Test Configuration

Position of the burner during tests (and calibration) :

- **4 labs perform the tests only on horizontal position**

- **1 lab performs the tests only on vertical position**

- **4 labs can perform the tests on horizontal, vertical and various positions**

1 lab can perform the tests on vertical position but only do the calibration on horizontal position

Survey Update

Calibration

Thermocouples

According to the ISO2685 standard, the thermocouples / junctions should be : Non-Aspirated and Exposed

➔ **5 labs use Exposed and Non-Aspirated thermocouples**

➔ **2 labs use unexposed thermocouples**

➔ **2 other labs use aspirated thermocouples**

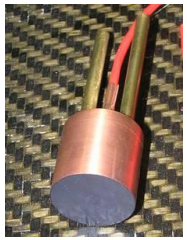
Survey Update

Calibration

Heat Flux Measurement

➔ **1 lab only uses water-cooled calorimeter (allowed in AC 20135 and chap12 of the handbook) (this lab does not perform test according to the ISO 2685 standard)**

➔ **8 labs use the heat transfer device described in the ISO standard (Some of these labs can use water-cooled calorimeter to perform the tests according to the other standards)**



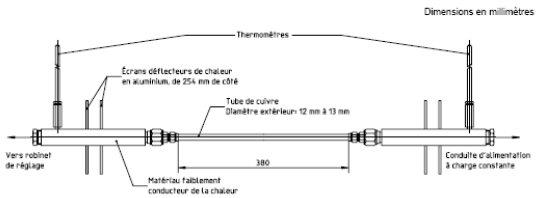


Figure B.4 — Vue générale du montage du tube étalon de mesure de la densité de flux thermique

Survey Update

Calibration

Heat Flux Measurement

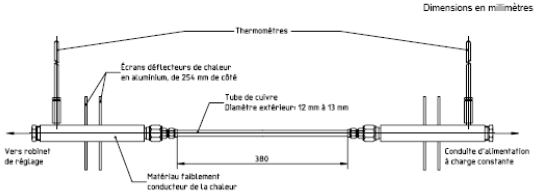


Figure B.4 — Vue générale du montage du tube étalon de mesure de la densité de flux thermique

Significant differences on the heat transfer device :

381mm exposed + 254 insulated

➔ **the length of the copper tube varies from 374mm to 635mm** (*the insulated ends can contribute to heat the water by heat conduction and modify the measurement (and calibration)*) **(higher length of heat transfer => lower power of the burner)**

➔ **localisation of the inlet/oultlet water T° measurement varies from 150mm of the end of the copper tube to 228 (ISO requirement)**

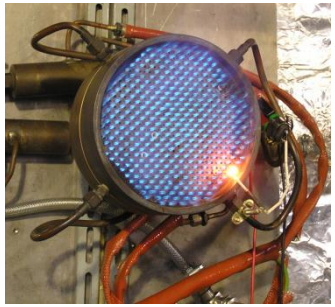
➔ **Calculation of the heat flux :**

*** <u>length of the heat transfer device tube exposed to the flame taken into account for the calculation</u>:**

- propane burner : 152mm to 173mm (higher length => higher power of the burner)

- oil burner : 280mm to 330mm (higher length => higher power of the burner)

Survey Update



Gaz Burner

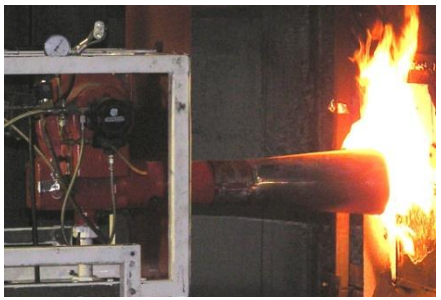
Main differencies :

Internal diameter (requirement : 171mm) : varies from 152mm (to be confirmed) to 171mm
Additional element : 1 inch disk above the internal nozzle to spread out flame T°
(1 lab (no test result from this lab))

Flame monitoring :
- **2 labs monitor the GAS/AIR FLOW RATES**
- **5 labs monitor the GAS/AIR PRESSURES**

Gas pressure : from 46 to 56 mm H2O
Air pressure : from 204 to 480 mm H2O
(ISO 2685 indication : differential pressures : gas 45 mm H2O / Mixing Air 435 mm H2O)

Survey Update



Oil Burner

6 different burners :

3 Park burners / 1 Carlin modified / 1 Carlin 210CRD / 1 Weishaupt WL 20A / 1 Blue Angel / 1 AFG Series (B2503) / 1 no reply

Main differences :

Various additional elements :

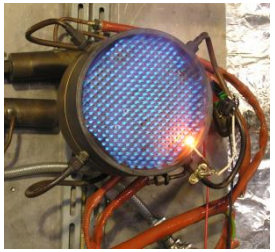
- **Disk to reduce the opening instead of the air tube reducing cone**
- **Multiple hole in disk**
- **Raised fuel nozzle height to minimize fuel from hitting air duct**
- **Lowered exhaust nozzle on air tube to get flame out of the nozzle (?)**
- **Additional flame guide inside the cone**
- **3 axis adjustment of the positioning of the nozzle**

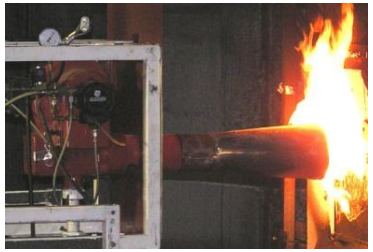
Various nozzles :

- **Various trademark : Monarch, Govmark (?), Steinen, Delevan**
- **Various spray angles : from 60° to 90°**
- **Nominal Flow rate : from 2 to 2.25 gal per hour**

Various fuels : Diesel / Jet A / Aviation fuel (Av Gas) / NATO F34 (equiv to LP8)

Round Robin Update

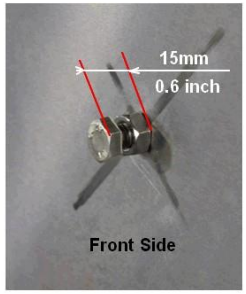




Test Results

Test samples :

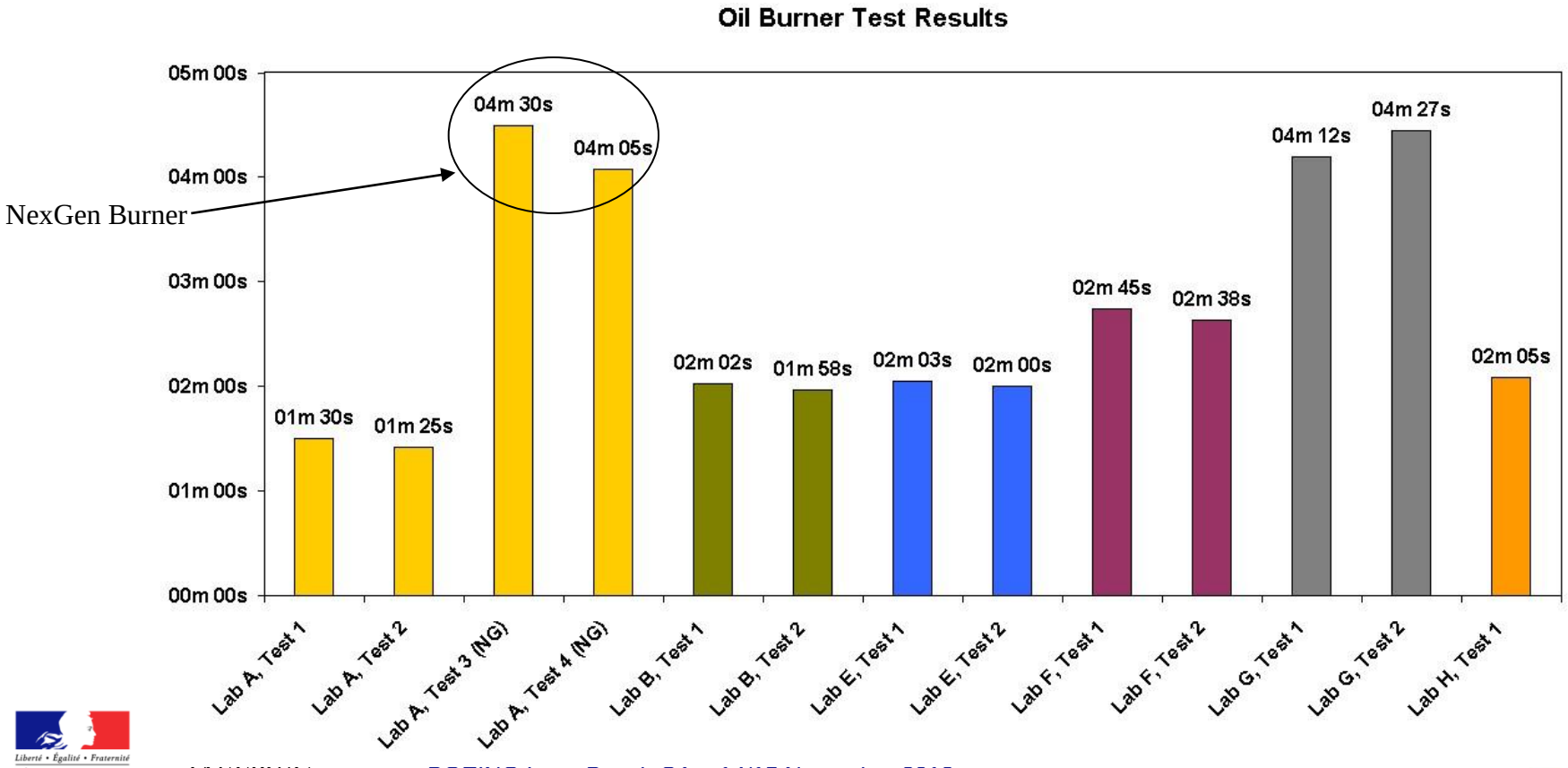
2024 T3 aluminium plate 60 x 60 cm / 3mm thickness
(with a bolt fitted in the center of the plate to simulate the critical part to be tested and improve the repeatability of the tests)



Round Robin Update

Oil Burner

Good repeatability / Bad reproducibility / scattered results (up to 200%)

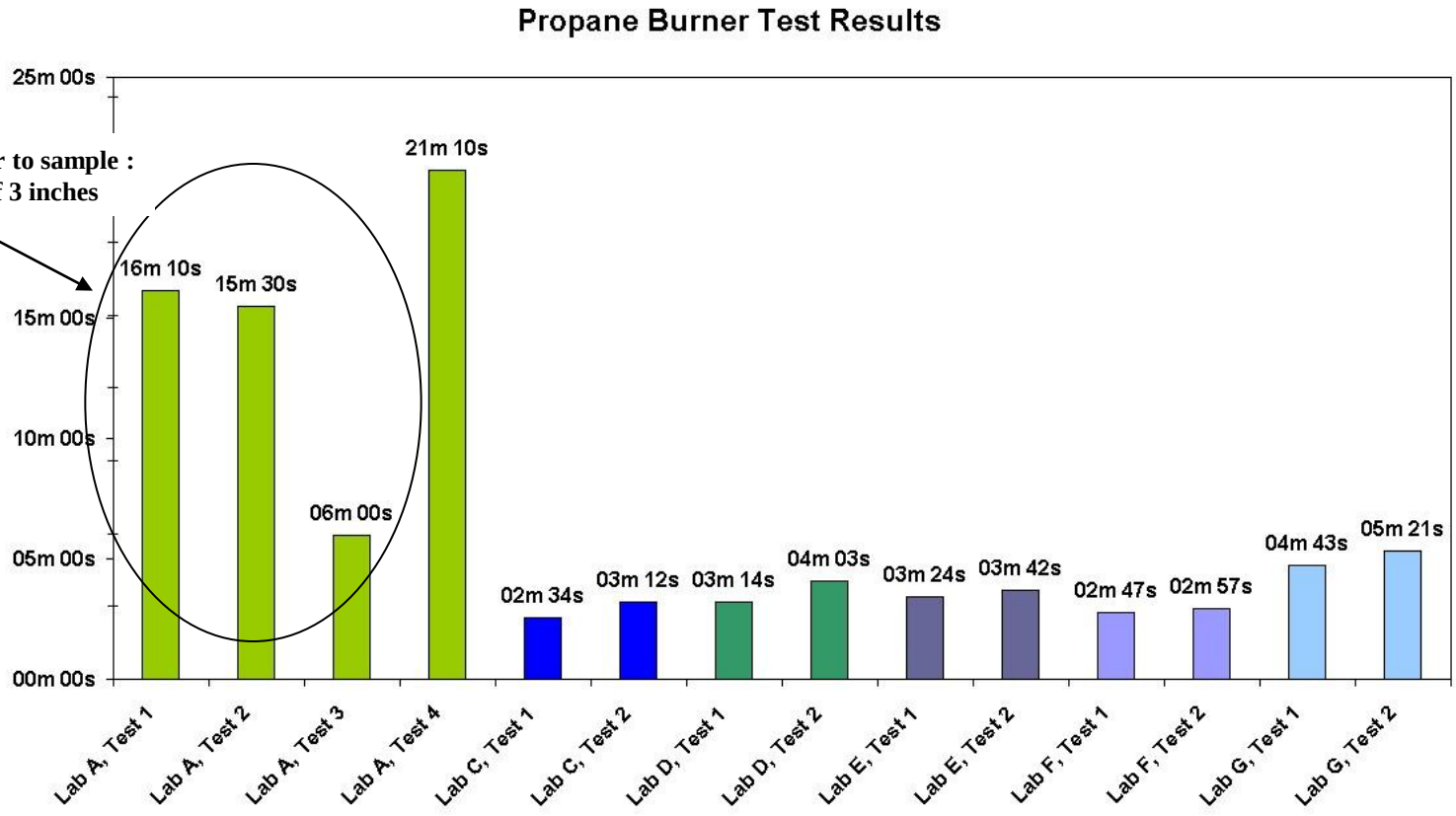


Round Robin Update

Propane Burner

Quite good repeatability / Bad reproducibility

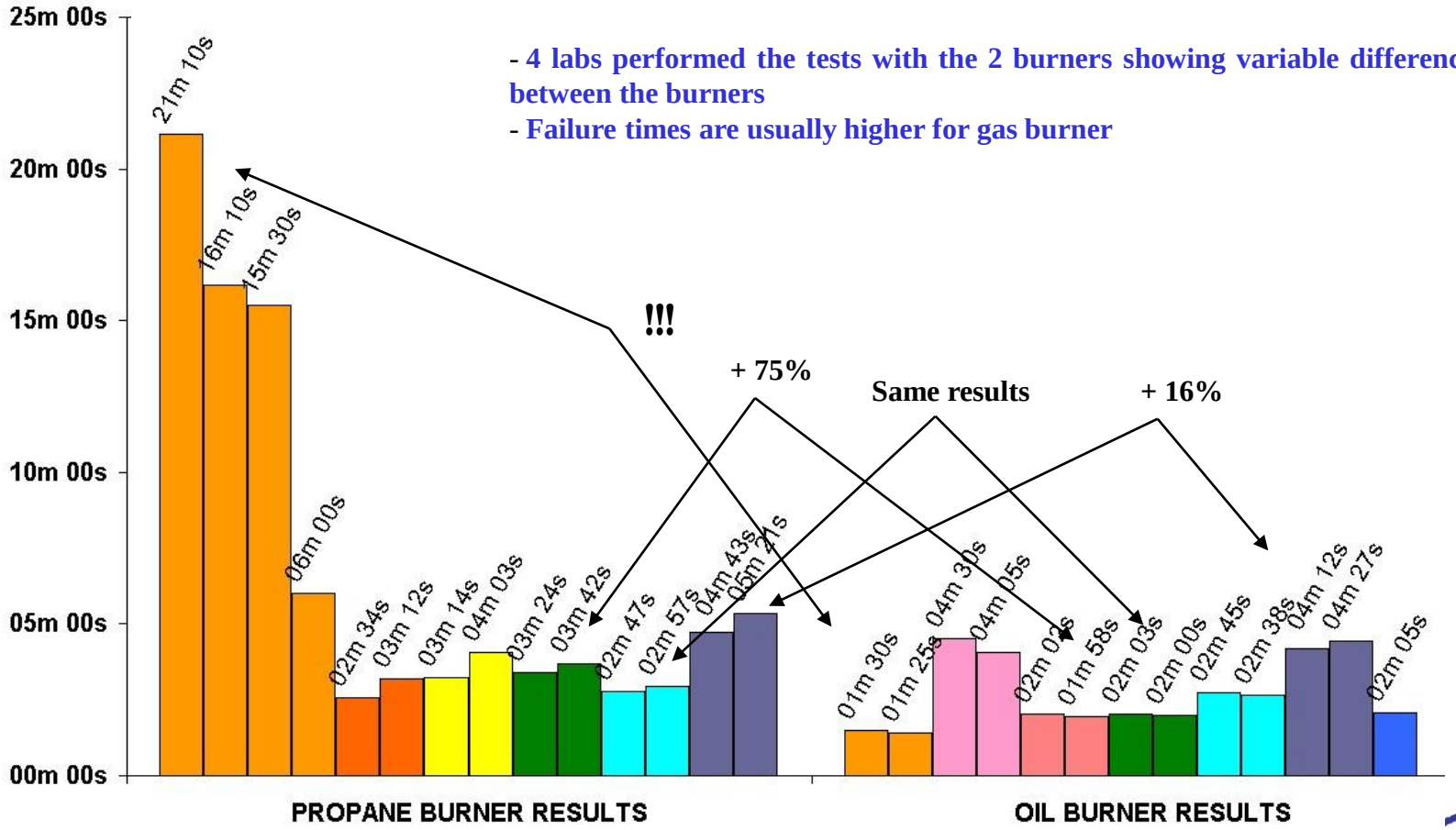
Distance from burner to sample :
2 inches instead of 3 inches



Round Robin Update

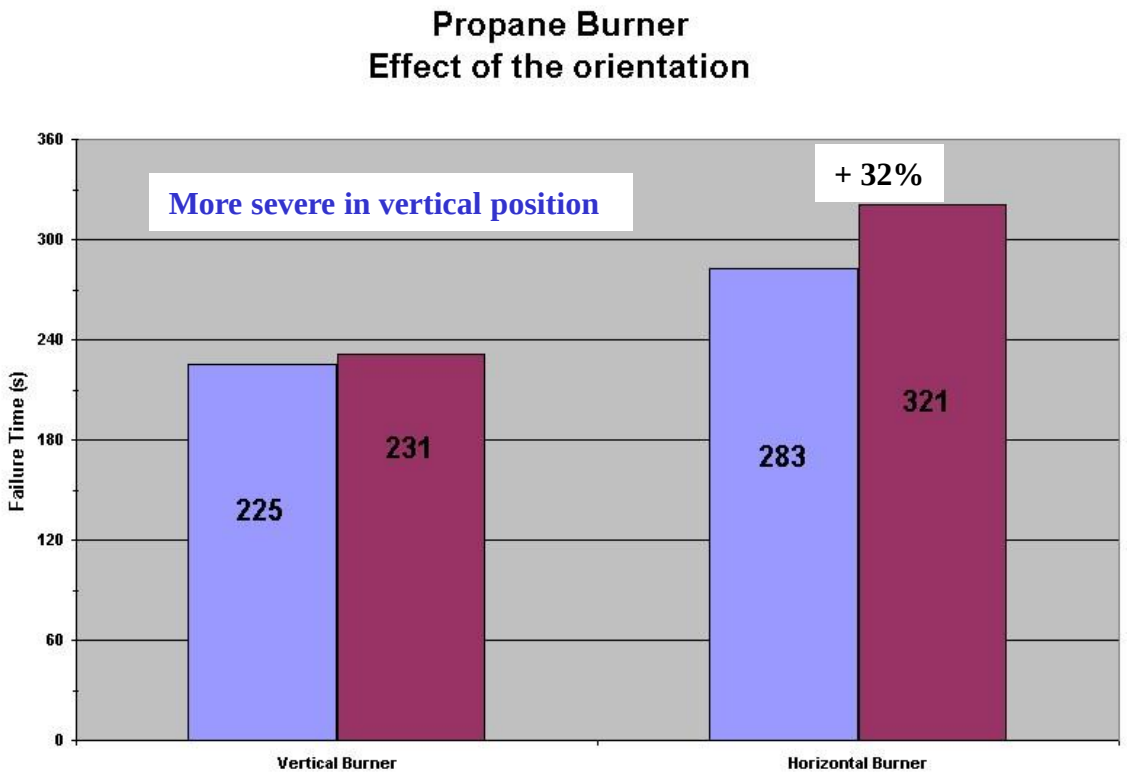
Comparison GAZ BURNER / OIL BURNER

- **4 labs performed the tests with the 2 burners showing variable differences between the burners**
- **Failure times are usually higher for gas burner**



Round Robin Update

Effect of the Burner Orientation



Conclusions

➔ **Many differences between labs (equipments, methods of calibration, additional elements)**

➔ **Good repeatability of the test results**
➔ **Bad reproducibility (between labs)**

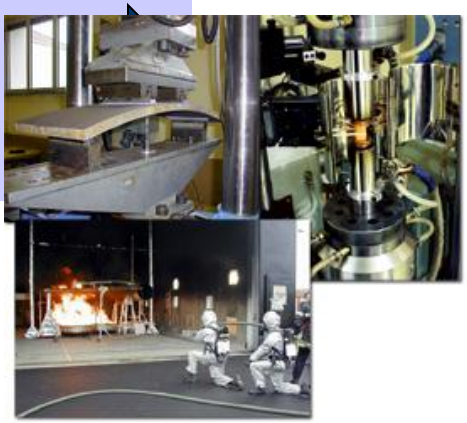
➔ **Failure times usually higher for gas burner**
➔ **Gap between the test results from the 2 burners are very dependent on the size / shape of the specimen**

➔ **Effect of the orientation of the burner on the test results**

Potential improvements :

- ➔ **Positioning of Burner / Specimen should be representative of the real configuration**
- ➔ **harmonise the heat transfer device (and the calculation of the heatflux density),**
- ➔ **harmonise the thermocouples,**
- ➔ **Standardize the burner (oil burner, additional elements, nozzles, …)**
- ➔ **…**

Or wait for the adjustment of the NexGen Burner for the powerplant fire resistance tests …



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