PROTECTION OF AIRCRAFT HANGARS BY WATER MIST SYSTEMS BASED ON FULL-SCALE FIRE TESTS

BALTIC FIRE LABORATORY
POLAND

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The 22nd International Water Mist Conference, 11-12 October 2023, Copenhagen, Denmark

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QUOTE

…I believe that water mist is amazing, and I'm enthusiastic about this technology that was sleeping since 80's and became alive last years. But as I mentioned, big hangars with high ceilings heights are challenge. And we must take care on information because countries with poor codes and lack of knowledge about limits and listings is a biggest issue…

UNQUOTE

1.

Project background

Why Are Aircraft Hangars At Risk For Fires?

Aircraft hangars pose significant fire risks for multiple reasons, some of which are:

•**They have a large, open layout.** To serve their purpose, aircraft hangars need to be big and open. This can make fire and smoke difficult to control.

•**They house large equipment.** Aircraft hangars store large aircraft and spacecraft, which are at risk for fires themselves.

•**They store combustible materials.** Aircraft hangars usually have storage rooms where highly flammable materials (jet fuel, chemical additives, etc.) are kept.

NFPA 409

For the reasons listed above, fire safety experts have long warned of the risks associated with aircraft hangars. All structures must comply with certain building codes and fire protection regulations, but aircraft hangars have their own set of stricter rules in NFPA 409.

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4 Types of Aircraft Hangars Under NFPA 409

NFPA 409 lists fire protection requirements for aircraft hangars based on four classifications.

Group I

Group I aircraft hangars are required to have at least one of the following features and/or operating conditions:

- Aircraft access door height > 28 ft.
- Aircraft bay > 40,000 ft2
- Ability to house aircraft with tail height > 28 ft.

Group II

Group II aircraft hangars must have both features:

- Aircraft access door height ≤ 28 ft.
- Aircraft bay between 12,000-40,000 ft2, following Table 4.1.2 in NFPA 409 (type of construction and single fire area)

Group III

Group III aircraft hangars must be either a row hangar with various units, an open-bay hangar that can store multiple aircraft, or a freestanding unit for one aircraft. It must also have both of these features:

- Aircraft access door height ≤ 28 ft.
- Aircraft bay < 12,000 ft2, following Table 4.1.3 in NFPA 409 (type of construction and single fire area)

Group IV

Group IV aircraft hangars must be a structure built with membrane-covered, rigid steel framing. They must have an aircraft bay larger than Group III aircraft hangars.

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2.

Aim & objective

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Aim

- To contribute knowledge of full-scale fire testing in hangar protection based on a performance-based system approach, water mist system.
- specifically, the effect of the cooling effect of water mist on surrounding aircrafts and the main structure of the hangar ceiling.

Table of Contents: NFPA 409

Chapter 5 Performance-Based Design Approach

5.1 Performance-Based Design Approach.

The requirements of Chapter 5 shall be used to recognize performance-based practices.

5.2 Goals and Objectives.

The performance-based design shall meet the following goals and objectives:

(1) Allow an alternative means to be utilized for elements of an aircraft hangar as permitted in this standard
(2) The risk assessment, design criteria, design brief, system performance, and testing criteria are developed in accordance with this section
(3) Meet the scope and purpose of the standard as detailed in Section 1.1 and Section 1.2
(4) The performance-based design provides equivalent level of protection to the prescriptive requirements of this standard

5.3* Qualifications.

The performance-based design documents shall be prepared by a licensed professional engineer with experience in fire protection and life safety system design, risk assessments, and acceptable to the AHJ.

5.4* Independent Review.

The AHJ shall be permitted to require an approved, independent third party to review the proposed design brief based and the Performance-Based Design Report and the Design Brief.

5.5 Final Determination.

The authority having jurisdiction shall make the final determination as to whether the performance objectives have been met.

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Objective

- ➢ Experimental assessment of factors affecting hangar protection using high-pressure water mist.

- ➢ Factors considered:

- ✓ Nozzle spacing
- ✓ Nozzle droplet size
- ✓ System pressure
- ✓ Celling Temperature
- ✓ Thermocouples trees temperature (simulation of surrounding aircrafts)
- ✓ Heat flux density

Is water mist a new fashion in hangars ?

Why now ?

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Factors influencing the attractiveness of water mist systems in hangars :

- NFPA 409 – performance-based design approach chapter added, alternative systems
- Incidents in recent years related to false activation of foam systems with fatalities & material losses counted in millions of dollars
- Foam industry switch to fluorine free foams
- No cleanup, hangar downtime reduced to minimum

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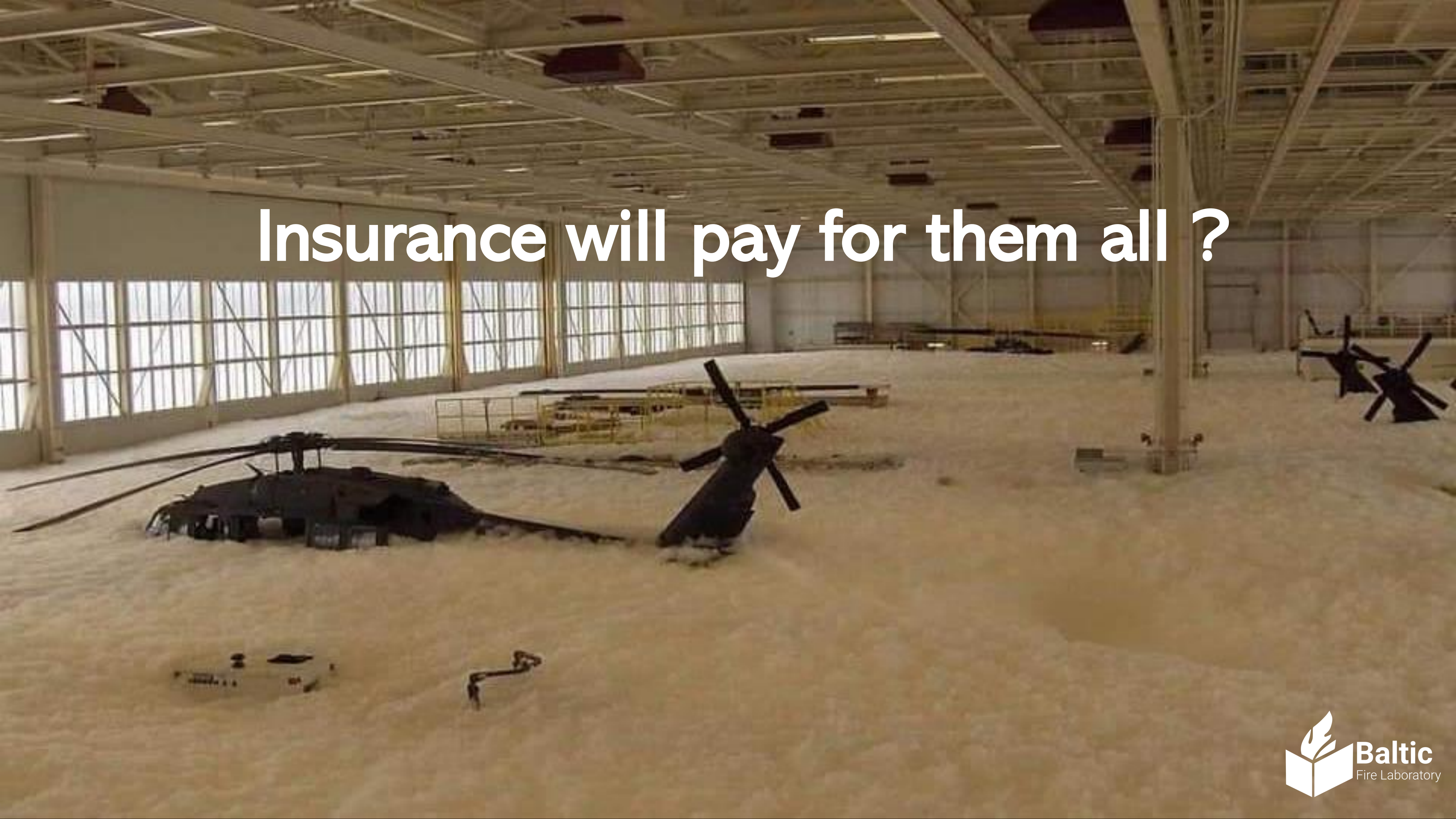
Insurance will pay for them all ?
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If foam system is safe ?

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Flood of foam buries black hawk helicopters
Press Esc to exit full screen
Let’s clean up the hangar !
CBS THIS MORNING
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3.

Methodology
Fire test protocol

Who should be involved in writing the test procedure for hangar protection ?

1. Fire Consultants
2. System Manufacturer
3. Fire Laboratory
4. Hangar Owner
5. Aircraft Manufacturer
6. Insurance Company
7. Authority Having Jurisdiction (AHJ)

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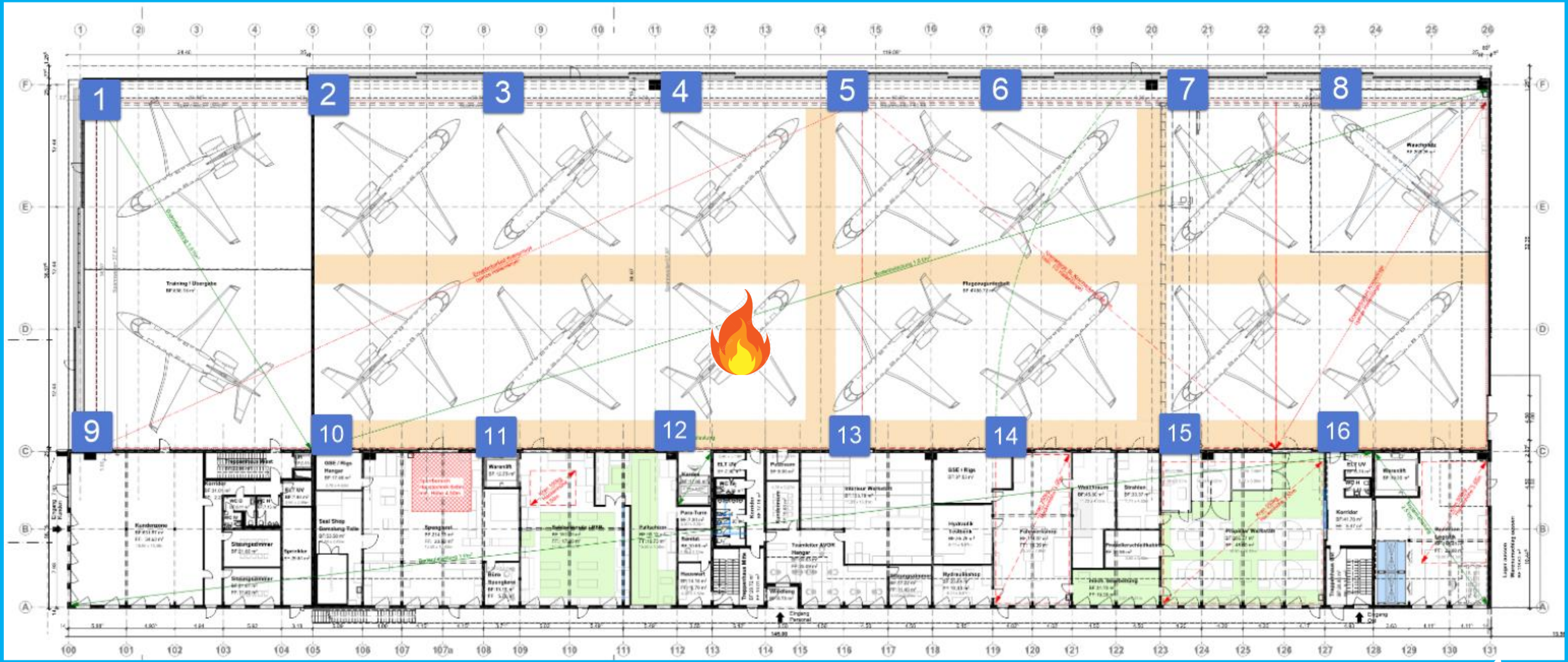
Adoption of fire development assumptions, considering the hangar layout.

HANGAR AREA



OFFICE AREA

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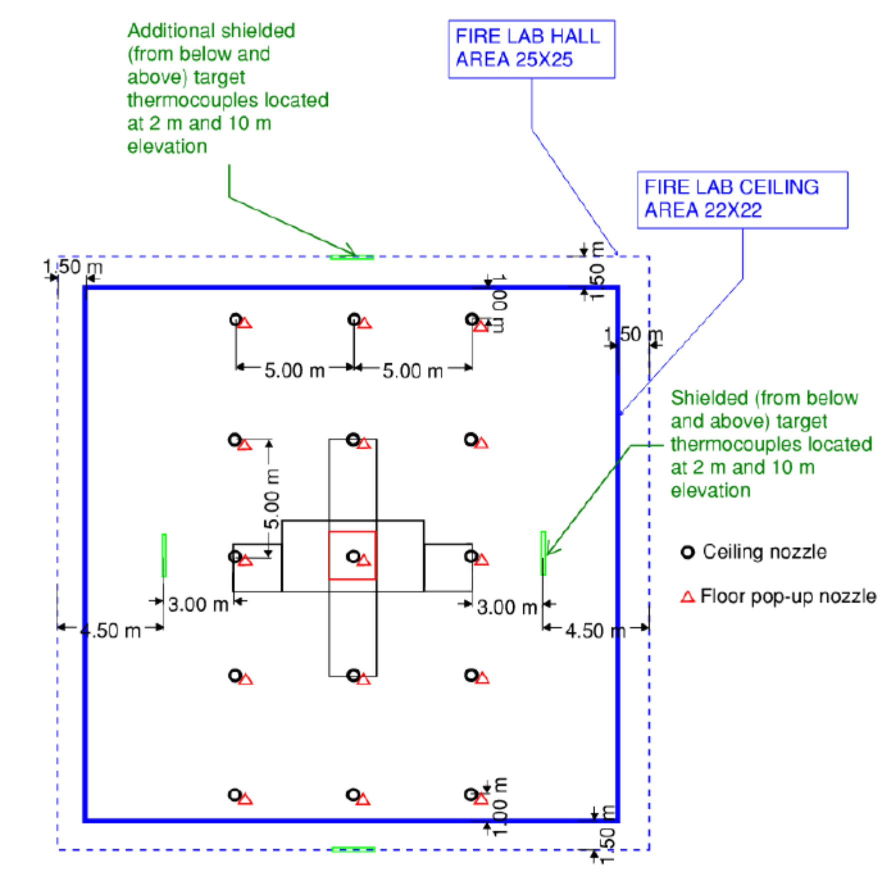
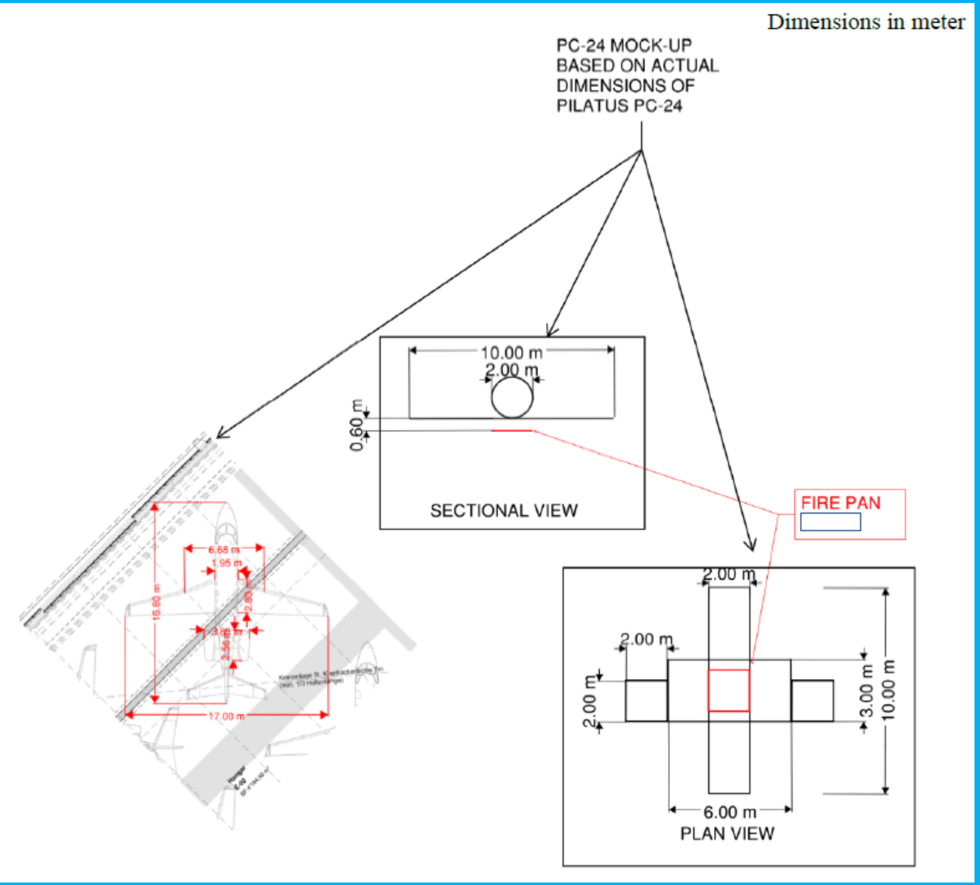
Initial test procedure drafts :

1. System layout & Instrumentation



2. Aircraft Mock-up



3. General test requirements – test conditions, laboratory size, - under development

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Test scenarios - Pass, Fail criteria

11.3 Concealed, Jet-Fuel pool fire

Criterion:	Suppression of the pool fire
Fuel:	Jet-Fuel A1
Type:	7-8 m^2 pool fire (size to be verified as per the fuel $H_{comb.}$)
Fire size:	12-14,0 MW (nominal)
Fire location:	The test fire shall be centered under the mock-up, on top of the floor nozzle position (see Figure 2).
Fire preburn time:	30 seconds
Test procedure:	The pool fire shall be ignited, and the water mist system should be activated subsequent to the required pre-burn time. Following the test duration, the fuel left in the pool or tray should be measured, if possible, and reignited to ensure that sufficient fuel remained in the pan.

11.4 Wood crib and Jet-fuel pool fire

Criterion:	Suppression of the crib fire and of the pool fire
Fuel:	Wood crib and jet fuel
Type:	Pool fire with crib
Fire size:	7,5 MW (nominal)
Wood crib:	The wood crib is to weigh 5,4 to 5,9 kg and is to be dimensioned approximately 305 mm by 305 mm by 305 mm. The crib is to consist of eight alternate layers of four trade size 38 mm by 38 mm kiln-dried spruce or fir lumber 305 mm long. The alternate layers of the lumber are placed at right angles to the adjacent layers. The individual wood members in each layer are to be evenly spaced along the length of the previous layer of wood members and stapled. After the wood crib is assembled, it is to be conditioned at a temperature of 49°C ± 5°C for not less than 16 hours. Following the conditioning, the moisture content of the crib is to be measured with a probe type moisture meter. The moisture content of the crib should not exceed 5 % prior to the fire test.

12 Pass Fail Criteria

The following pass fail criteria are fixed for the test:

The pass fail criteria are based on the temperature measurements in various locations.

The temperature that are considered in the test are the temperatures at ceiling level and at the specified heights, on the sides of the mock-up, representing the potential damages that the fire may cause on the adjacent aircrafts or equipment. The temperature are fixed in order to achieve a complete protection of the building and of the building content with the possible exception of the aircraft involved in the fire.

Imposed limits are as follows:

Ceiling Temperature:	max. 250 °C on a 30 sec. average, starting after 60 sec. from the discharge activation.
Side temperature:	max 100 °C on a 30 sec. average, starting after 60 sec. from the discharge activation.

In addition to the measurement of the temperature on the sides of the mock-up there will be the measurement of the heat flux with a nominal limit of 4 KW/sq.mt in the same location of the thermocouples located on one side of the mock-up; this is a value that can be tolerated by most of the equipment that might be used in the Hangar.

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OK !

We are ready to perform
FULL SCALE FIRE TEST !

What does it look like ?
Where to do ?

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Full scale fire testing, what is it ?

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WANTED

FULL SCALE FIRE TESTS FACILITY

... in HANGAR size !

Dead or Alive

REWARD

$ 100,000 CASH

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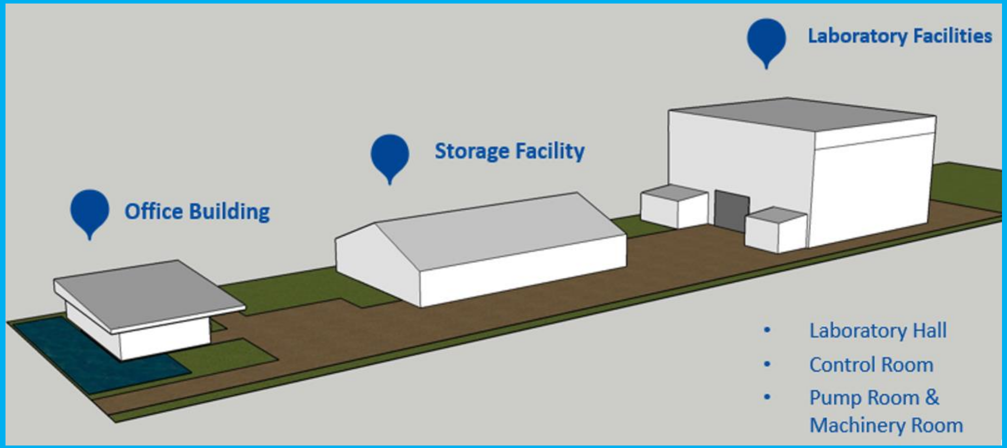

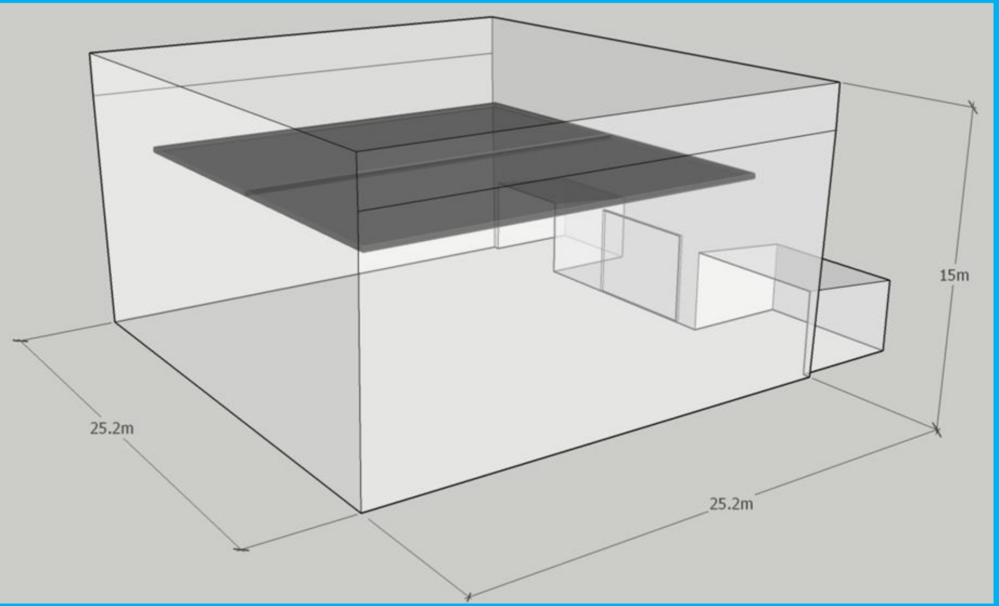

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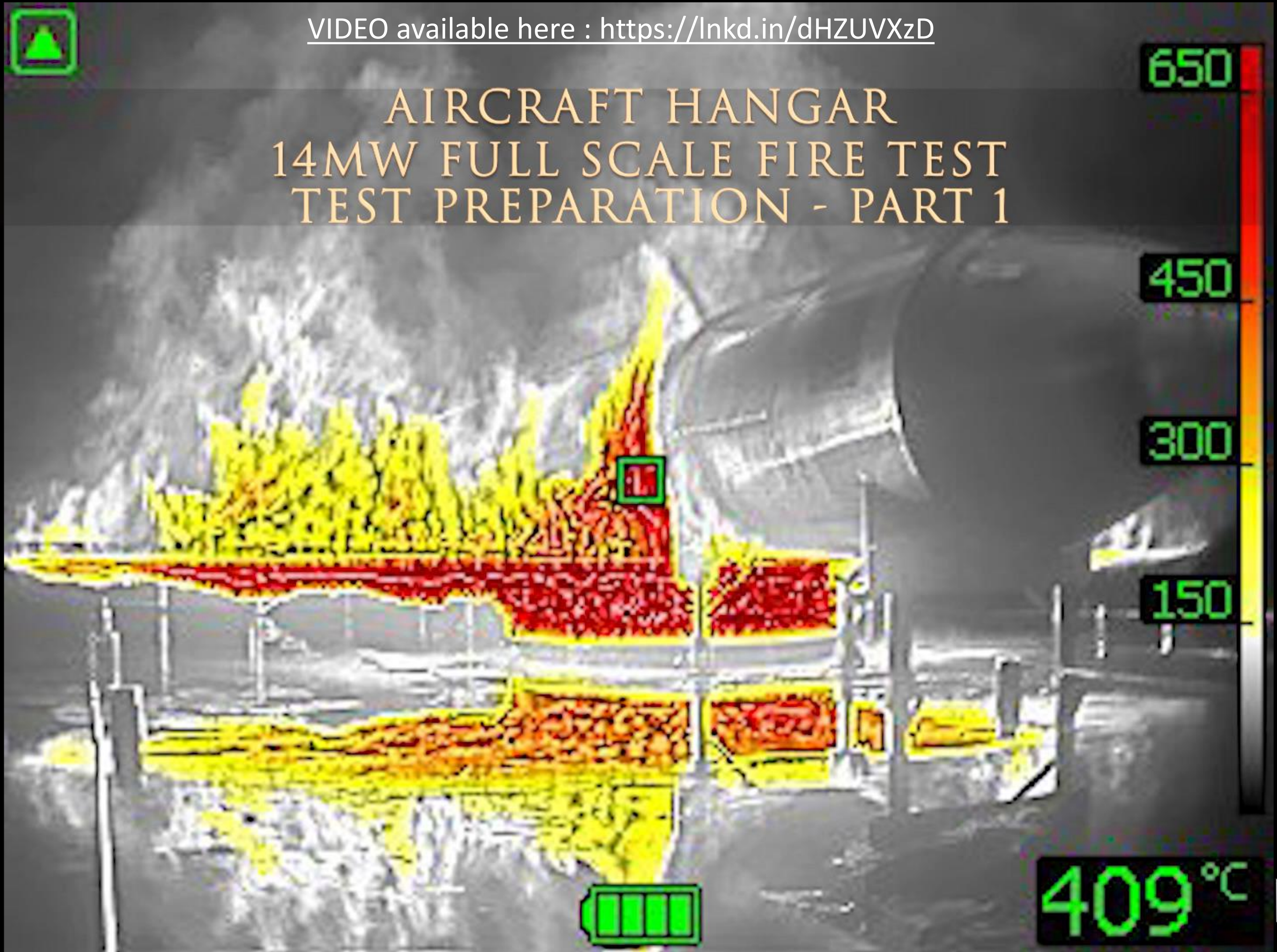
5.

Experimental set-up

VIDEO available here : https://lnkd.in/dHZUVXzD

AIRCRAFT HANGAR
14MW FULL SCALE FIRE TEST
TEST PREPARATION - PART 1



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Laboratory view with full scale aircraft mock-up

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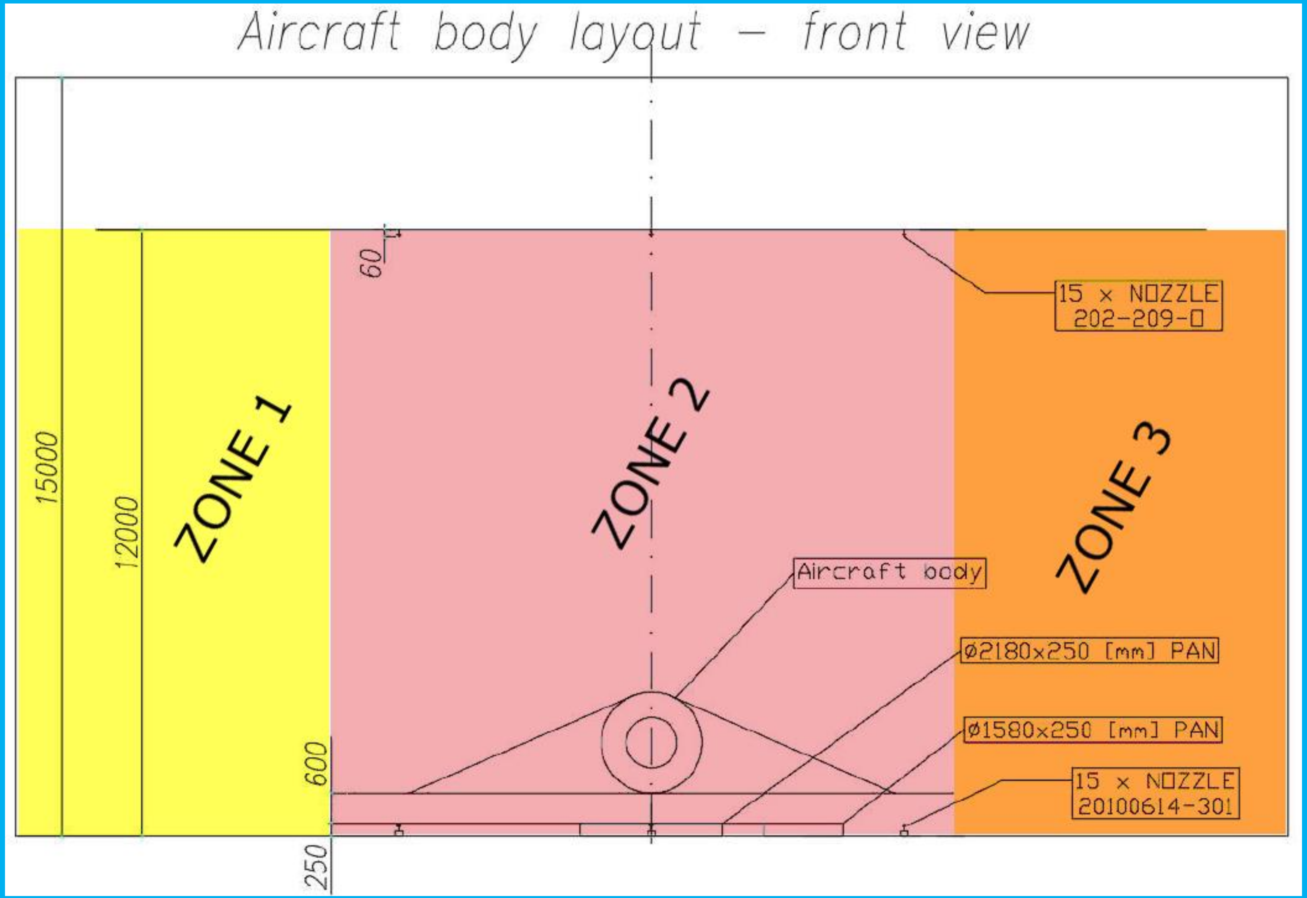
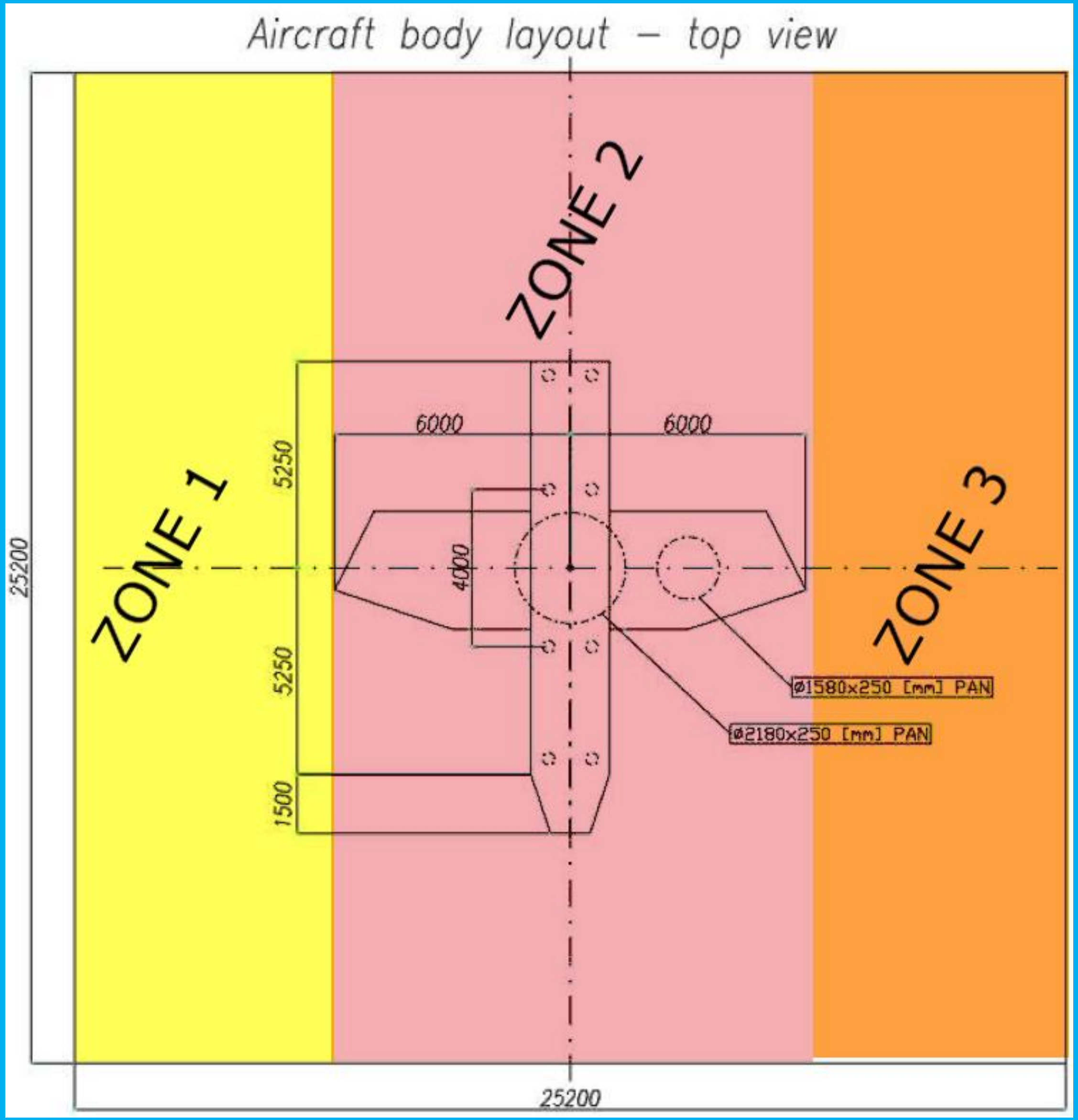
Laboratory layout, general.





Zoned deluge system :
ZONE 2 – protected by water mist nozzles
ZONE 1 & 3 – unprotected zones

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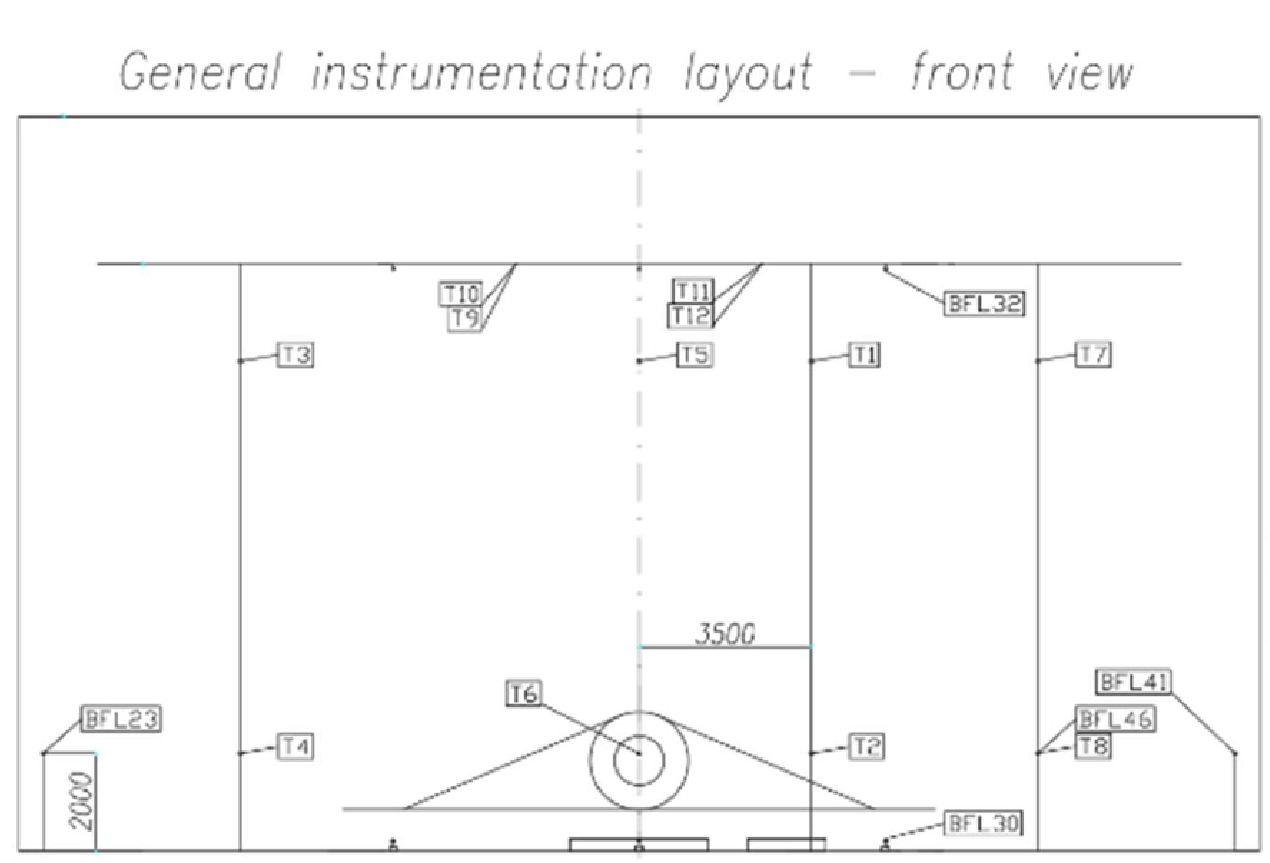
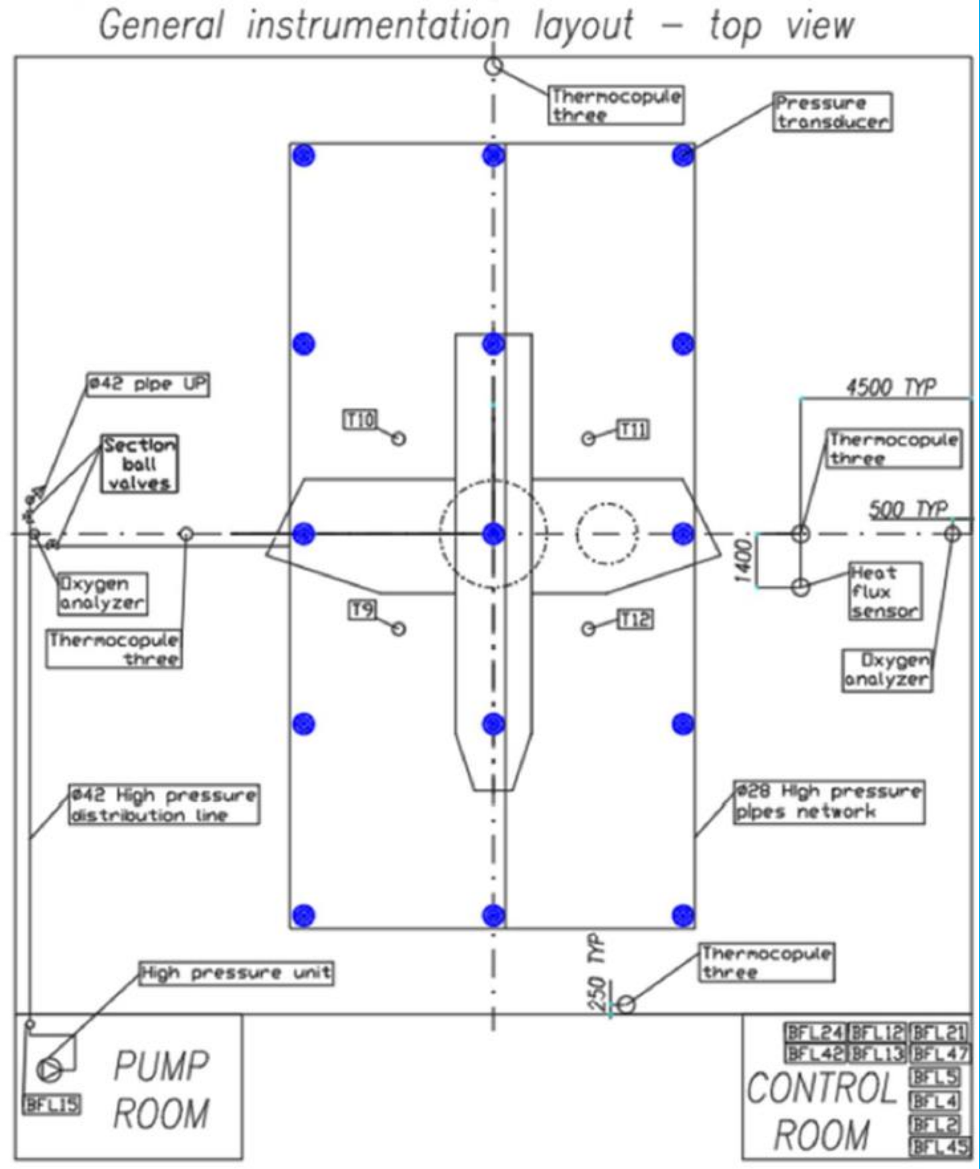
Laboratory layout, instrumentation.





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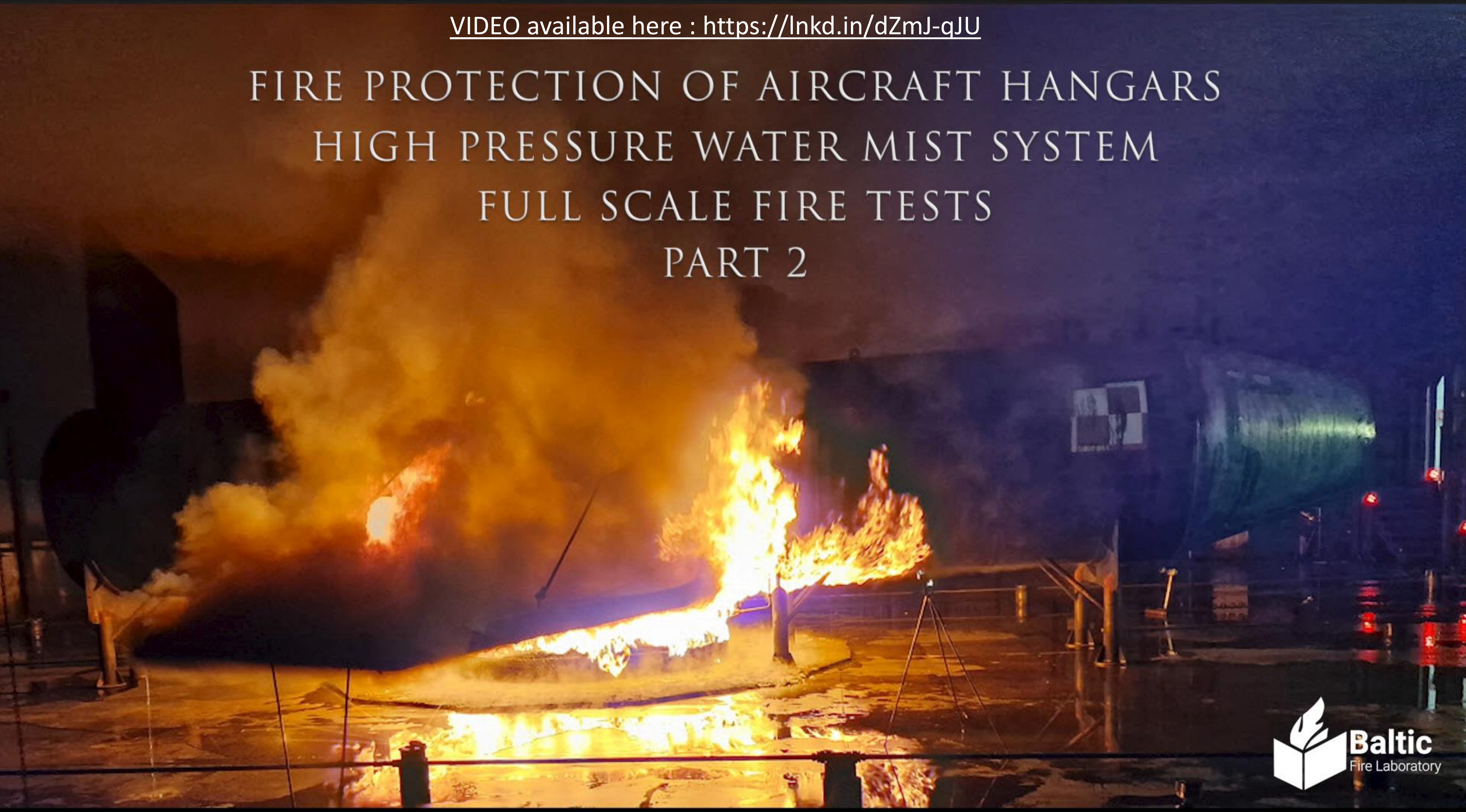
VIDEO available here : https://lnkd.in/dZmJ-qJU



6.
Results

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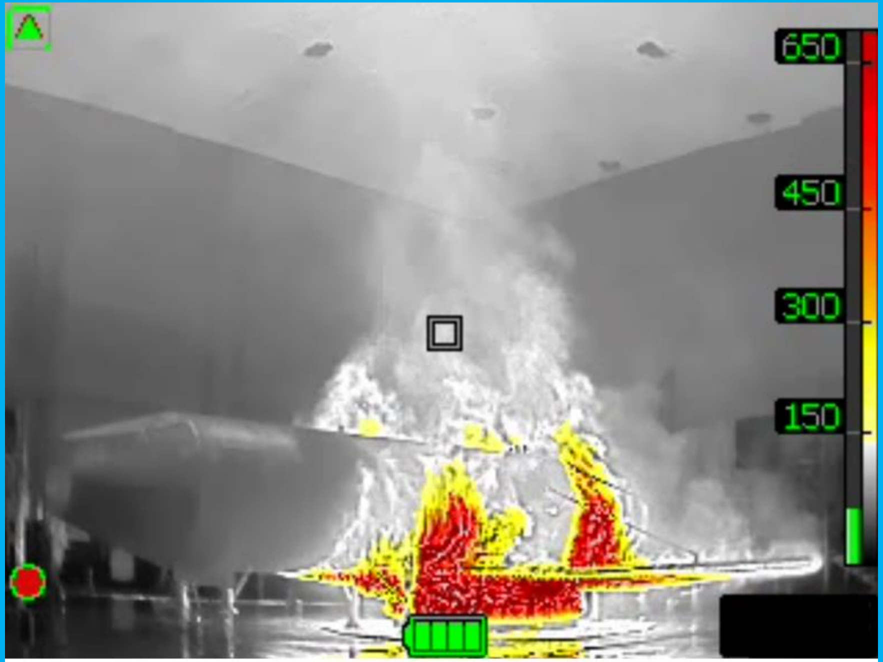
Test scenario 11.3 suppression of centered pool fire 6.5 [m2]

Celling & floor nozzles activated

Fire ignition – test 16, scenario 11.3



Fire developed 60 seconds after ignition – thermal view.

Fire developed 60seconds after ignition – pre burn time end.

Fire in 10min after high pressure mist nozzles discharge (60 sec pre-burn + 600sec discharge) after system discharge – end of test data record - pass / fail criteria.

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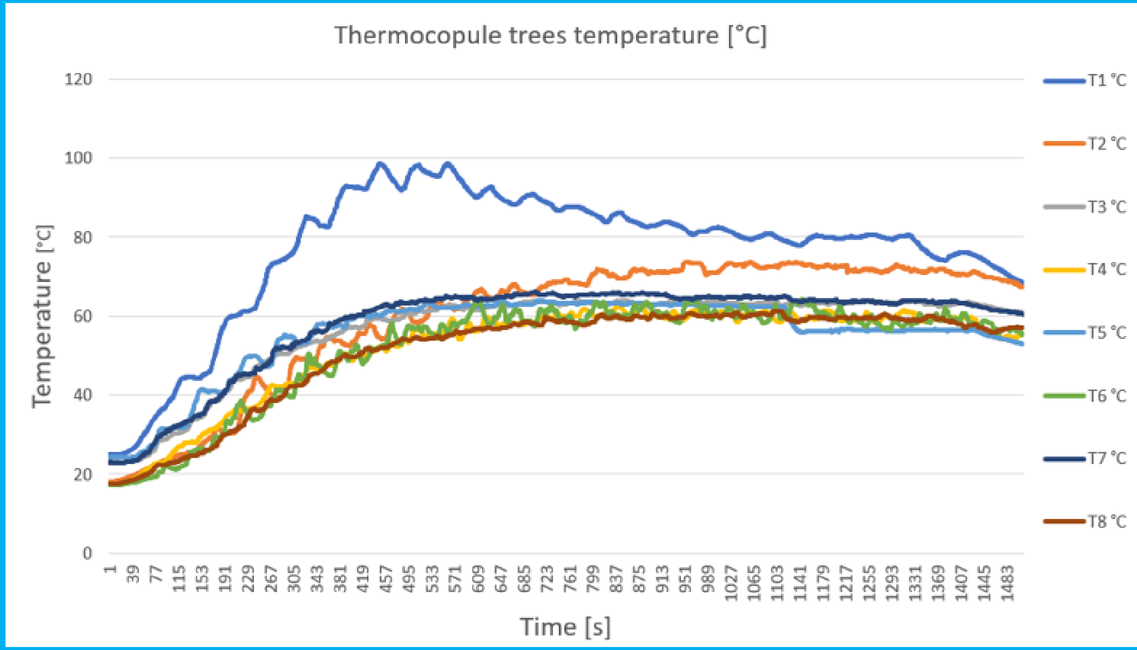

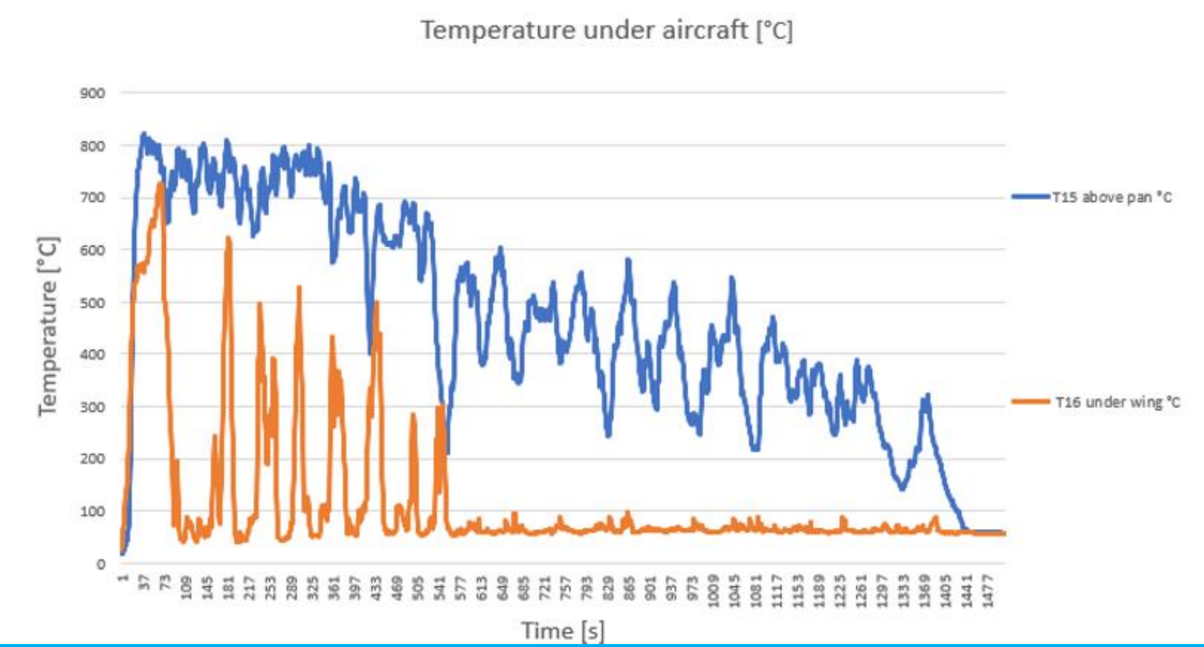

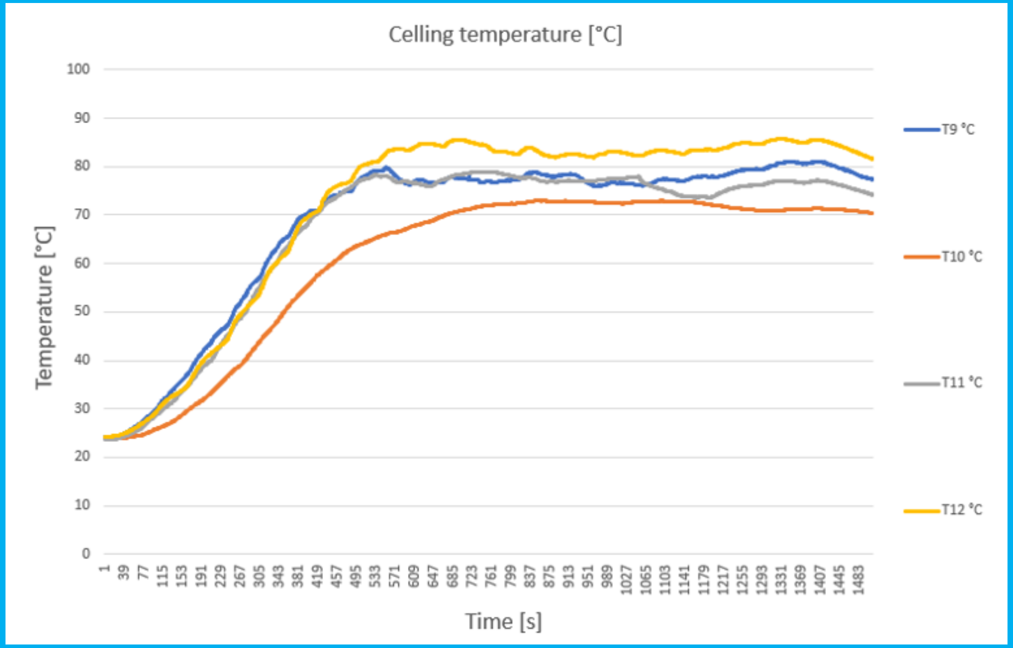

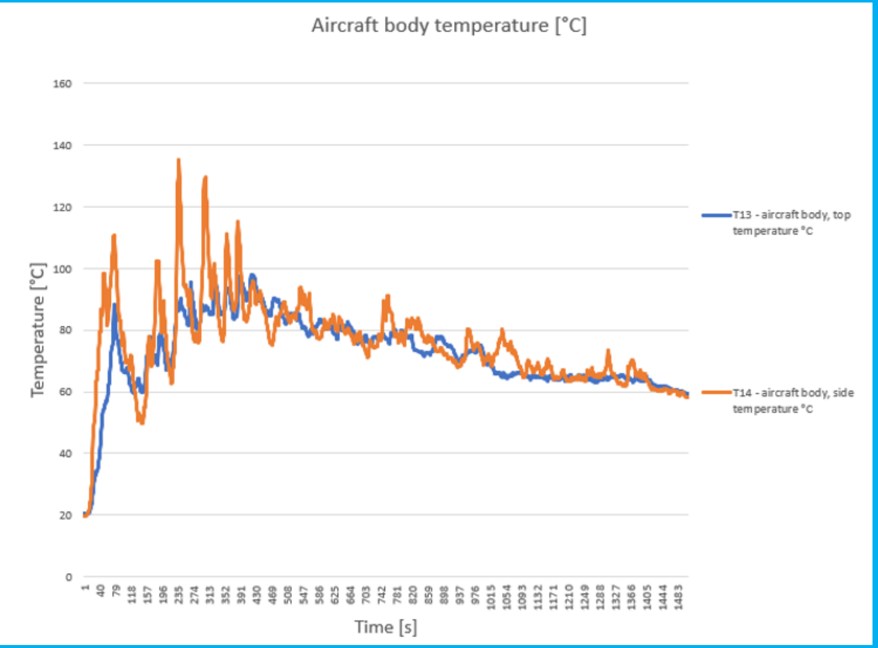

Test charts
Celling & floor
nozzles activated

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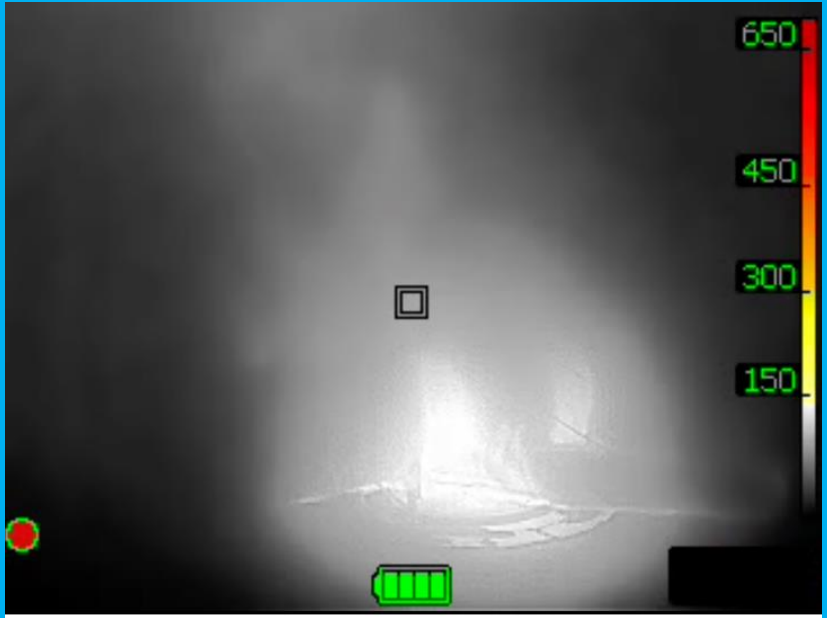
Test scenario 11.3 suppression of centered pool fire 6.5 [m2] Celling nozzles activated ONLY

Fire ignition in the pool.

Fire developed 60seconds after ignition – pre burn time end.

Fire developed 60seconds after ignition – pre burn time end – thermal view.



Fire in 10min after high pressure mist discharge (60 sec pre-burn + 600sec discharge) after - end of test data record - pass / fail criteria.

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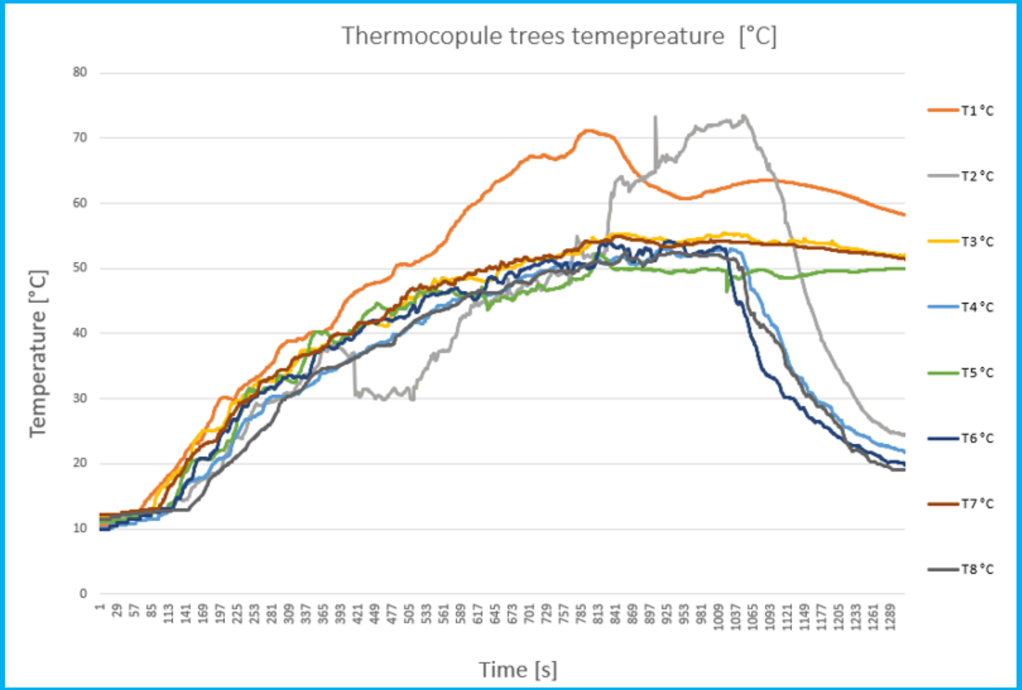

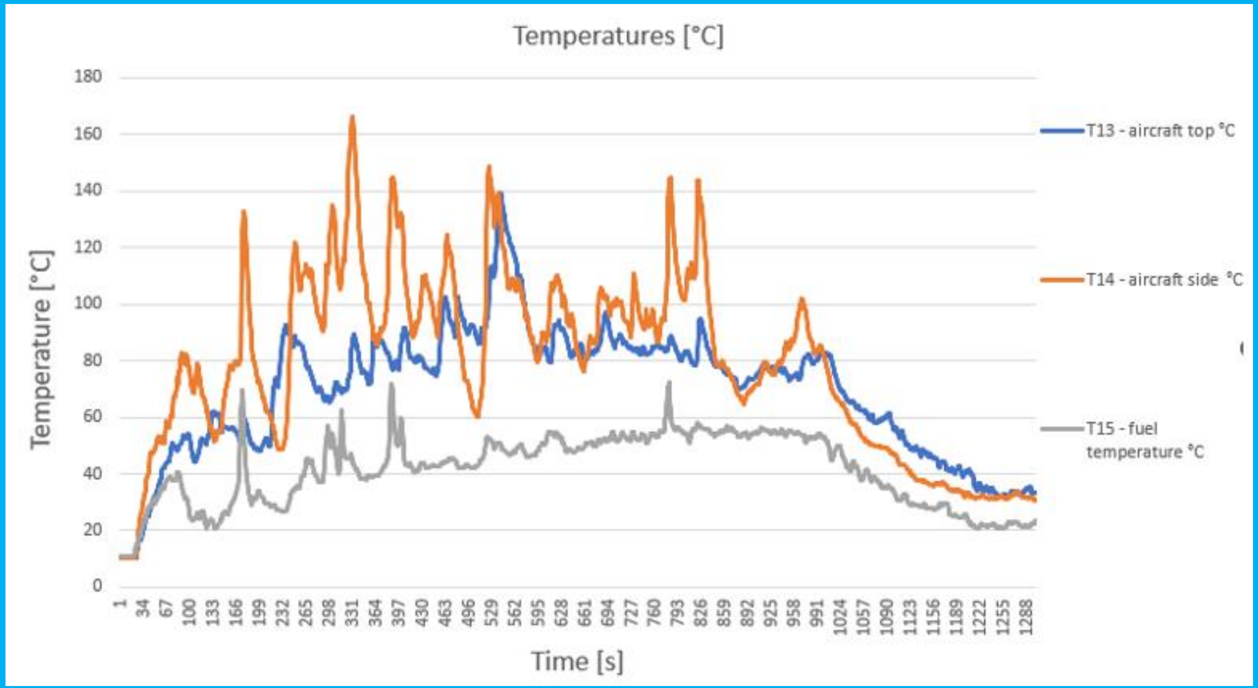

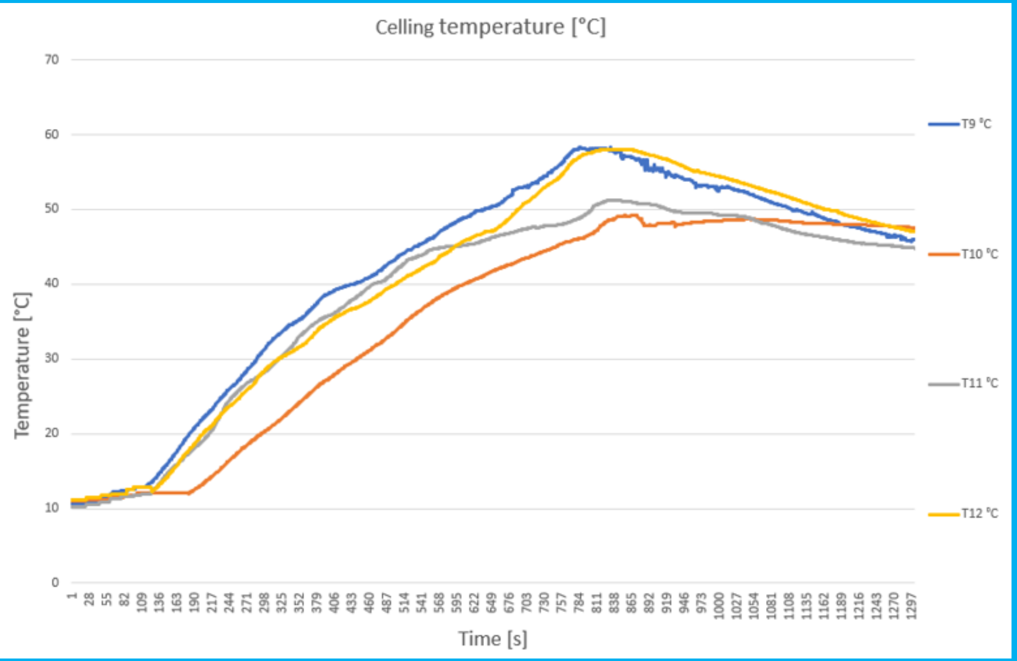

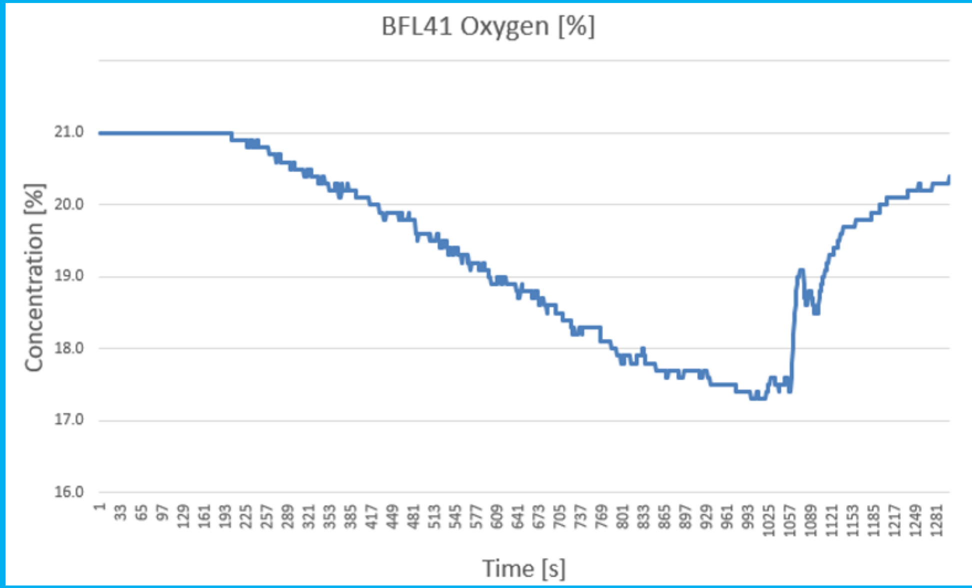

Test charts
Celling nozzles
Activated ONLY

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Is there anything else we could do now when we have data from full-scale testing ?

Yes, we can !

Verify the CFD model based on test & 3D scan data

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VIDEO available here : https://www.linkedin.com/feed/update/urn:li:activity:7115984169595211776/

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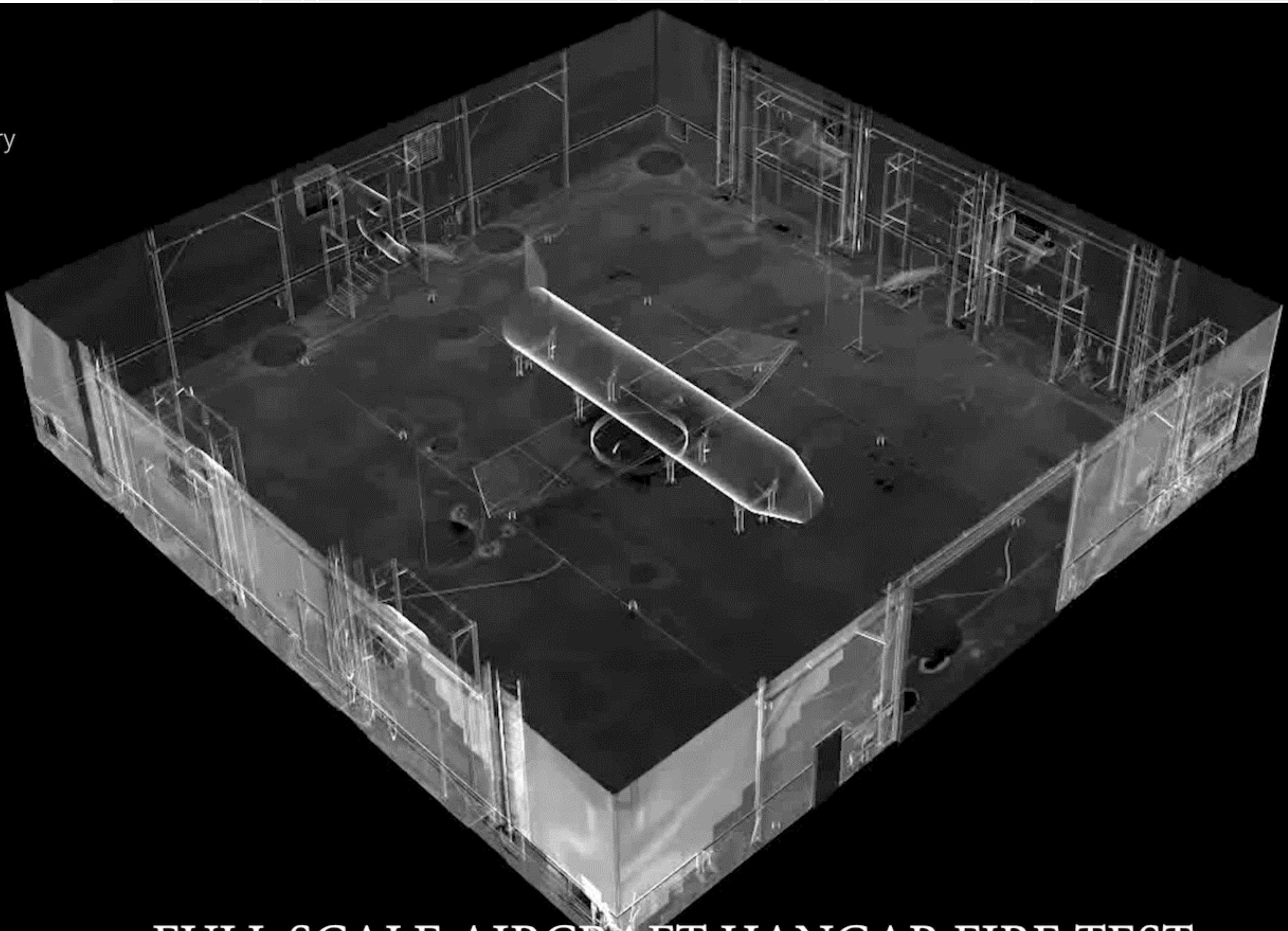

FULL SCALE AIRCRAFT HANGAR FIRE TEST
CFD SUPPORTED TESTS – 3D SCAN AS INPUT DATA


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6.
Conclusions

Conclusions refer EXCLUSIVLEY for this project which was subject of performance test approval.

- Celling & floor nozzles system is recommended to be used in final installation based on performance tests data.
- ‘’ONLY celling nozzles’’ configuration without floor nozzles is less efficient in terms of protection hangar floor area - under aircraft (pool fire) – local floor explosions on laboratory floor during tests.
- Celling temperature (hangar roof structure) is well controlled by celling water mist celling nozzles.
- Temperature on thermocouples trees simulating surrounding aircrafts is well managed by water mist system, mainly by floor nozzles.
- Heat flux density, 8 meters from center of ignition measured on end of pre-burn time (60sec) is in range of sensor sensitivity, due to 12 [m] height of laboratory celling the convection column directs gases and heat centrally upwards limiting the spread of heat.

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The future of fire testing is in fire science

FIRE SCIENCE SHOW

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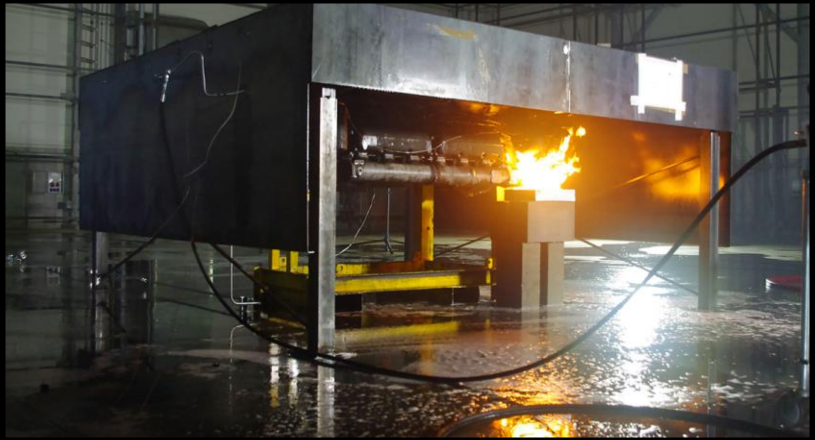
Invitation "Holistic approach to car park fire safety" Bogdan PhD under prof. W. Węgrzyński supervision

Questions ?
Thank you



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