Understanding
Training/Qualifying
Evaluating
Certifying
Advising
Informing

Performance evaluation tests of water-mist systems

Protection of diesel generators

Forewords about Water mist

A water-mist system is not a gaseous fire extinguishing system, nor is it a sprinkler system…

But water-mist :

-indeed shares a range of applications with the 2 above technologies.

-has a domain where it can reveal it full potential …

Forewords about Water mist
Extinguishing performance level

Extinguishing is made possible due to :

-A global inerting effect due to a favourable enclosure effect

and/or

-A critical quantity of mist reaching the fire, leading to a local "steam" inerting effect and effective cooling

and/or

- Dynamic effect

In major cases, solely the last 2 effects are achievable. The high flux density of mist at fire level and the "dynamic effect" imply in most cases a "local application" philosophy.

Forewords about Water mist
local application

Local application or OBJECT PROTECTION approach covers numerous applications in industrial environment where global inerting effect is not predominant and extinguishing performance is necessary

Ex : generators, engine test stands, quenching tanks…

Forewords about Water mist
local application

Drawback :

A “local application” approach requires a “fine” design; and is equipment/objet dependant.

Protection of diesel generators

Industry wants:

- Fast and effective extinguishing
- Optimal water consumption
- Continuous function of generators
  (run or die…) even if..

- Separate protection (several generators in a room)

Expected performances

-“Effective extinguishing” also means :

“No re-ignition”,

achieved by

-Durable protection (until manual intervention, same as “suppression/control systems

-or

-Sufficient (and efficient) cooling of the equipment

Need for a specific protocol

Existing protocols dedicated to “local application” did not allow a comprehensive performance-oriented evaluation of water-mist system.

- poor representativeness
- inadequate criteria or scenario set-up
- conjunction with hot equipment generally missing…

Expert in prevention and risk control

Request for a risk and a specific installation

Risk analysis

Tests definition

Test protocol

Fire tests

Performances verification

Test report

Risk assessment

- The main risk: diesel engine
- Diesel oil circulation under pressure
- Presence of hot spots
- Possible leakage of fuel in a more or less sprayed state that may QUICKLY develop into a pool fire

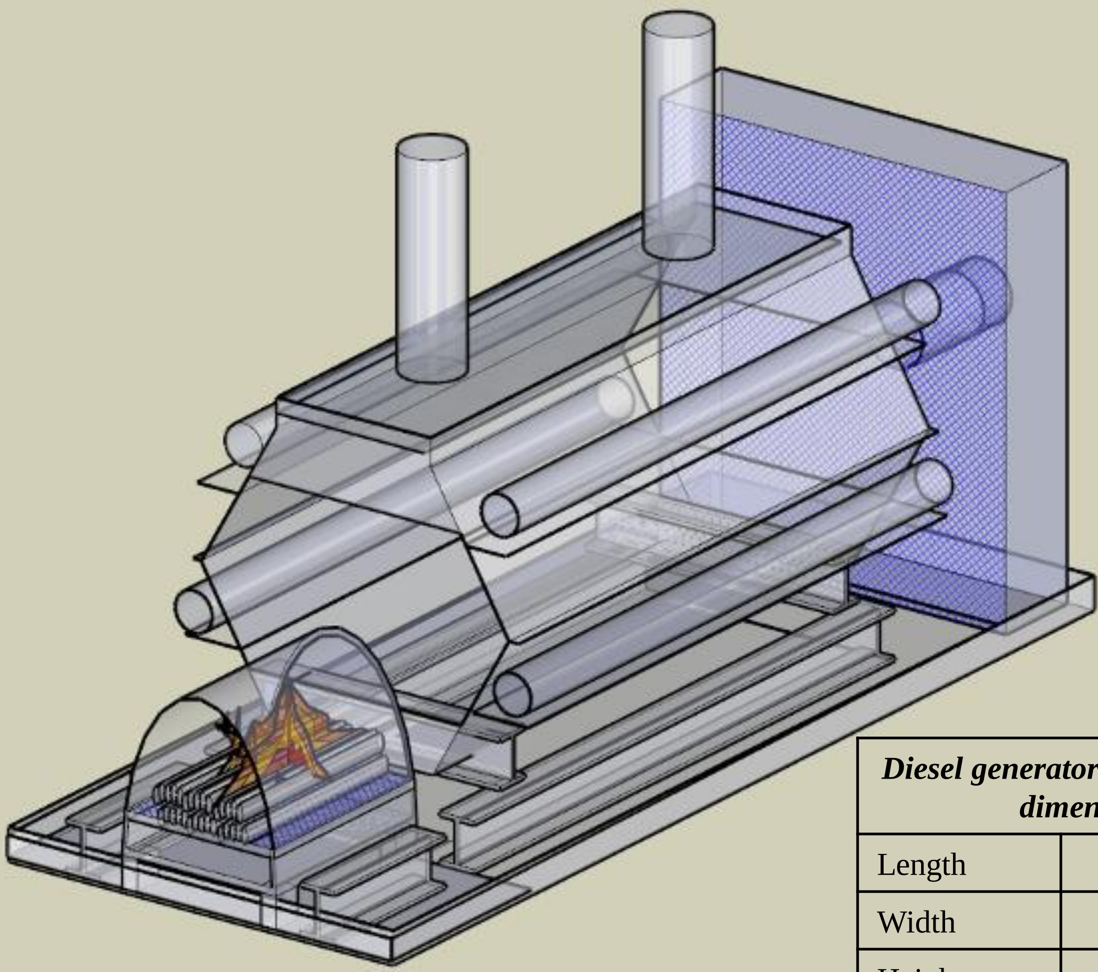
Risk assessment

For the generator:

Protections fitting out electric circuits generally limit the risk of fire spread due to a priming in the winding of the generator and in the junction box because they order a quick stop of the machine.

The risk is greater at the output of the generator cable to the junction box, and in the junction box due to the density of connections.

Test mock-up



Diesel generator mock-up main dimensions	
Length	5.20 m
Width	2.00 m
Height	2.00 m

(class 1250/1500 KVA)

Measurements

-Temperatures in the mock-up (surface and ambient temperature)

- Ambient temperatures in the very close environment
- Heat flux
- Pressure and flow rate
- 3 video cameras to observe the events and the visual observations

Fires

Pool fires characteristics		
Fire type	Tray: steel plate 0.7 x 0.7 m	Tray: steel plate 0.7 x 1.41 m
Area	0.5 m²	1 m²
Combustible	Diesel oil	
Density (literature data)	0.845 kg/l	
PCI (literature data)	42 MJ/kg	
Combustible quantity	15 l	30 l
Theoretical approximate power in free burning (maxi)	530 kW	1,1 MW

Fires

Fires

Spray fires		
Fire type	Small spray fire	Large spray fire
Characteristic	Full cone 45°	Full cone 45°
Combustible	Diesel oil	
Density (literature data)	0.845 kg/l	
PCI (literature data)	42 MJ/kg	
Maximum flow	0.8-1 l/m	4-5 l/m
Indicative power in free burning (max)	480-590 kW	2.3 – 3 MW

Fires

Small spray 1 l/min

Fires

Large spray 4 l/min

Fires

Flowing fire		
Fire type	Small flowing fire	Large flowing fire which may develop into a pool fire
Characteristic	Free flowing	Free flowing
Fuel	Diesel oil	
Density (literature data)	0.845 kg/l	
PCI (literature data)	42 MJ/kg	
Maximum flow	1 l/m	4-6 l/m
Indicative power in free burning (max)*	410 kW	1.9 – 2.8 MW

* : burning yield estimated at 80% of the nominal flow

Fires

Flowing fire 5 l/min (early stage)

Fires

This scenario is critical as high HRR can be reached in minutes, which can exceed water-mist suppression capabilities.

Water-mist should suppress the fire at an early stage and prevent the forming of a large surface burning slick.

The maximum fire size able to be extinguished is a valuable information which **defines the limits** of a system/configuration

Fires

Large leak 5 l/min

Fires

Simulated alternator fire

Evaluation tests objectives

-Performance level verification :

-Extinguishing

-Cooling, including the equipment

-Additives compatibility, if applicable

- Hydraulic calculation verification

-Tests conditions validate the fundamental design criteria of water-mist system but also environment parameters

Evaluation tests objectives

Validation of fundamental design criteria

Nozzle spacing

Flow rate/pressure

Distance nozzles→equipment

Duration of protection

Use of additives

Additives

-Enhance performance :

→ at final stage of extinguishing, when the water-mist can effectively reach the combustible surface

→ help in eliminating the last residual flames

→ help the extinguishing in semi-obstructed zones

→ Prevent reignition

-Compatibility with the system must be evaluated

Tests in penalizing situation
Research of the system limits
Notion of safety Margin

- Fully ventilated enclosure
- Continuous heating of the test mock-up
- Work with and without additives
- Maximum nozzle spacing
- Water mist released on fully developed fires
- Open and partially obstructed fires
- Effect of forced ventilation alongside the mock-up also studied

Video

Tested system :

SIEMENS Sinorix H20 Jet

Twin fluid single pipe system

Pressure (nozzle) : 8-10 bar

Water flow rate per nozzle : 18 l/min

8 top nozzles + 6 side nozzles

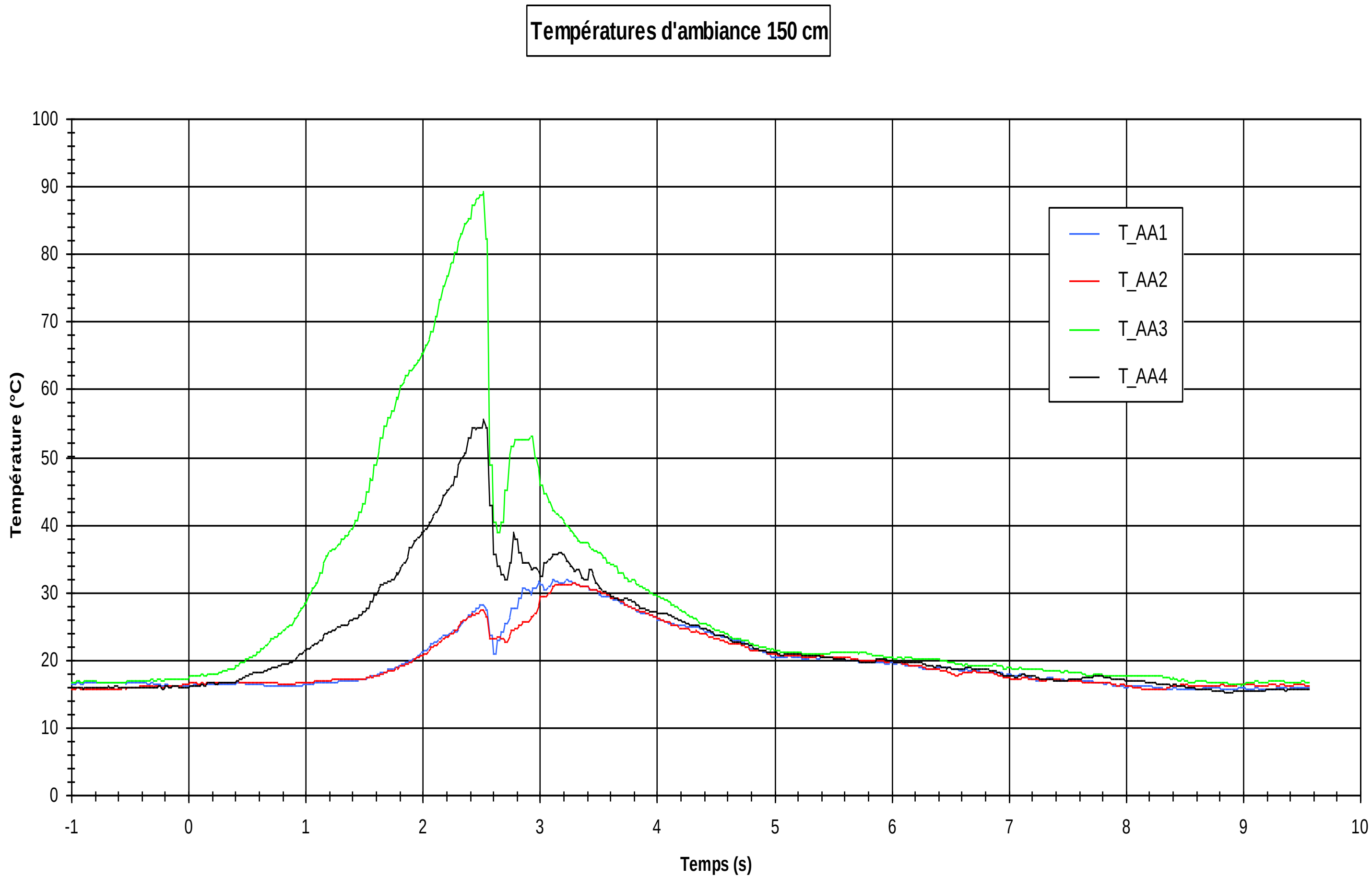
$Dv_{0.90}$ = 150 µm

Velocity : 50 to 150 m/s

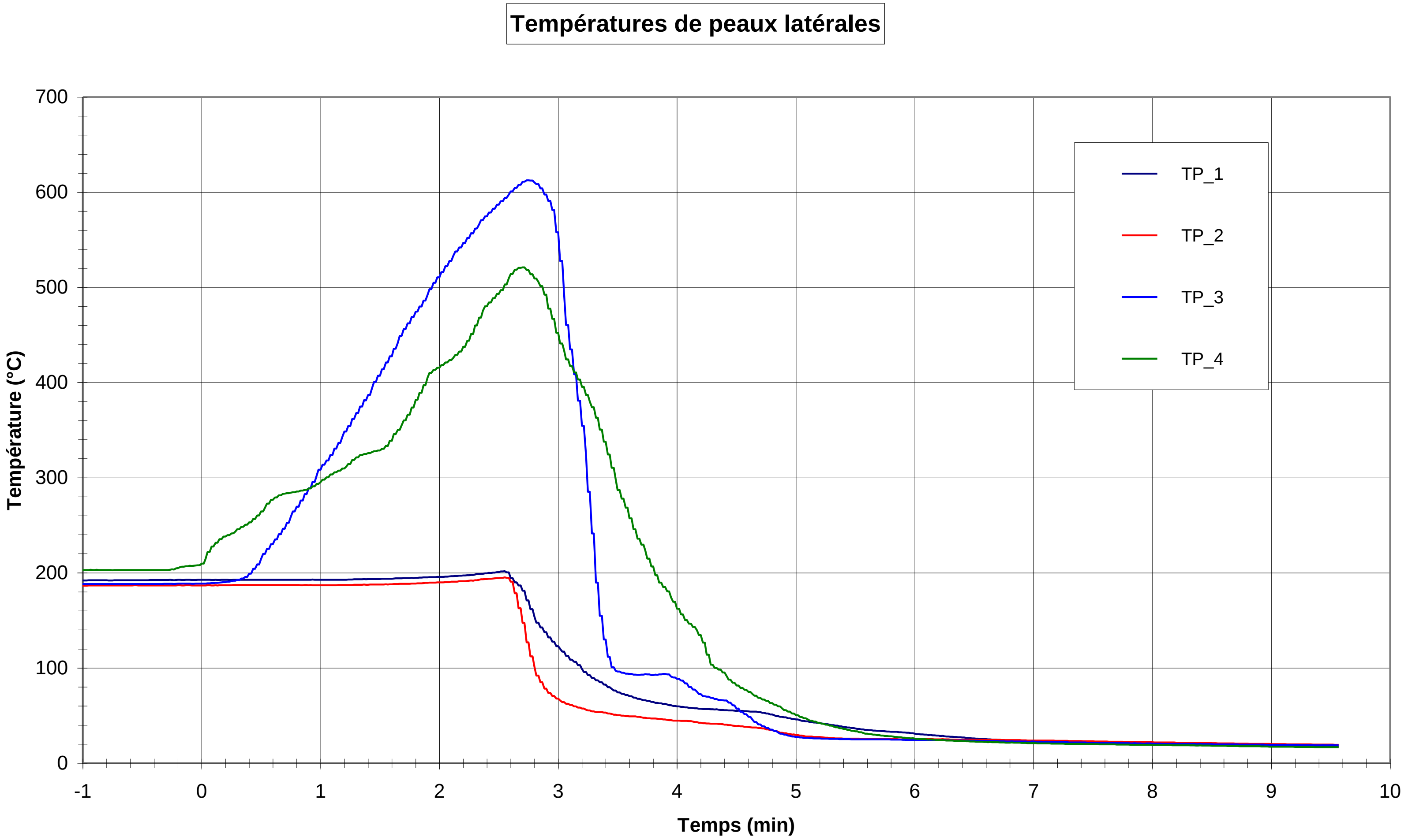
Extinguishing mechanisms for this application

- gas phase cooling→ remove heat from the fire
- local vaporization → local inerting effect at fire level
- Dynamic effects
- attenuation of radiative heat flux → to prevent fire spread
- Surface cooling → to prevent reignition

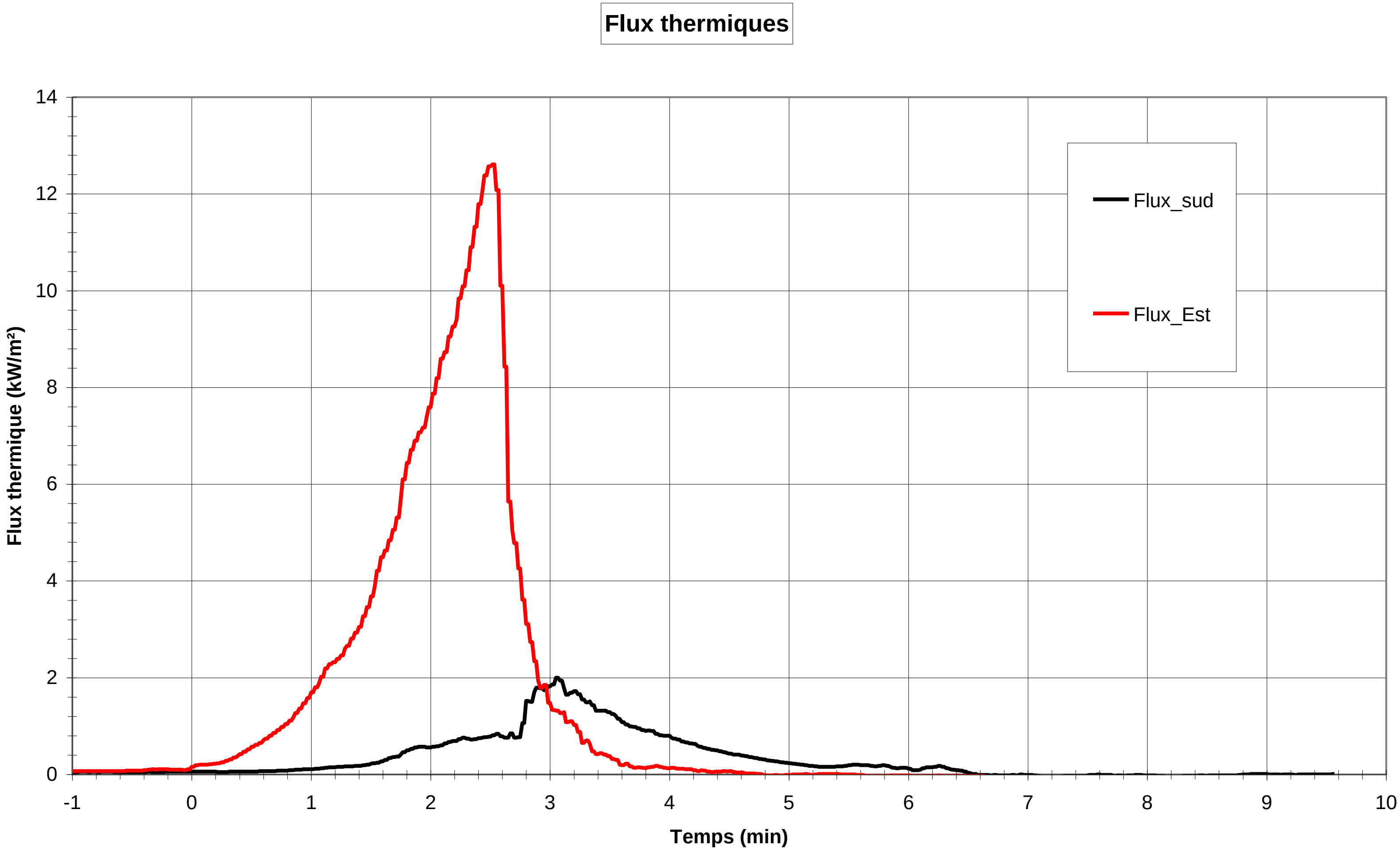
Extinguishing mechanisms : gas phase cooling



Extinguishing mechanisms : surface cooling



Reduction of radiative heat flux



heat flux at 1.50 m from fire

Conclusion

or “*Conditions for a successful extinguishing*”

Quite simple but…

1) Reach the fire…
   - ❖ Enough water at fire level…
   - ❖ Enough momentum…

2) Achieve sufficient cooling of the equipment to prevent any reignition

3) Avoid any « dead zone » where remaining flames can sustain. → Additives can help !

Thank you for your attention !