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The impact of flame retarded timber on Greek industry

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Introduction

- Timber in different forms contributes as first and secondary ignited material to the initiation and spreading of fires in industrial buildings.
- In the present work the effect of typical intumescent flame retardant (latest technology) will be examined on representative types of Timber.
- Analysis involved thermal behavior, and toxic species analysis of the samples.

Experimental techniques / Apparatus used:

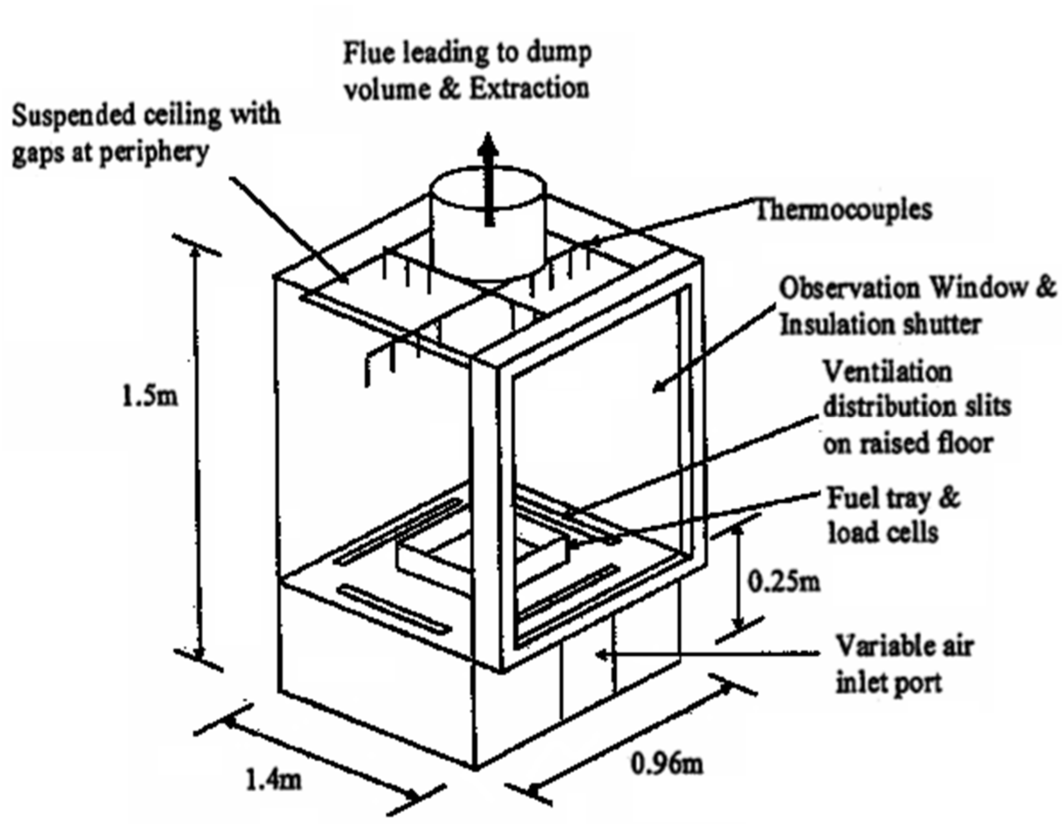
1.CONE CALORIMETER

- The apparatus used was a standard Cone Calorimeter manufactured in accordance to ISO 5660 (1993) and ASTM E1354 (1992).
- The tests were carried out in accordance with the test procedure of ISO 5660.

University of Leeds Cone Calorimeter

Experimental techniques / Apparatus used:
2. Fire Rig Enclosure

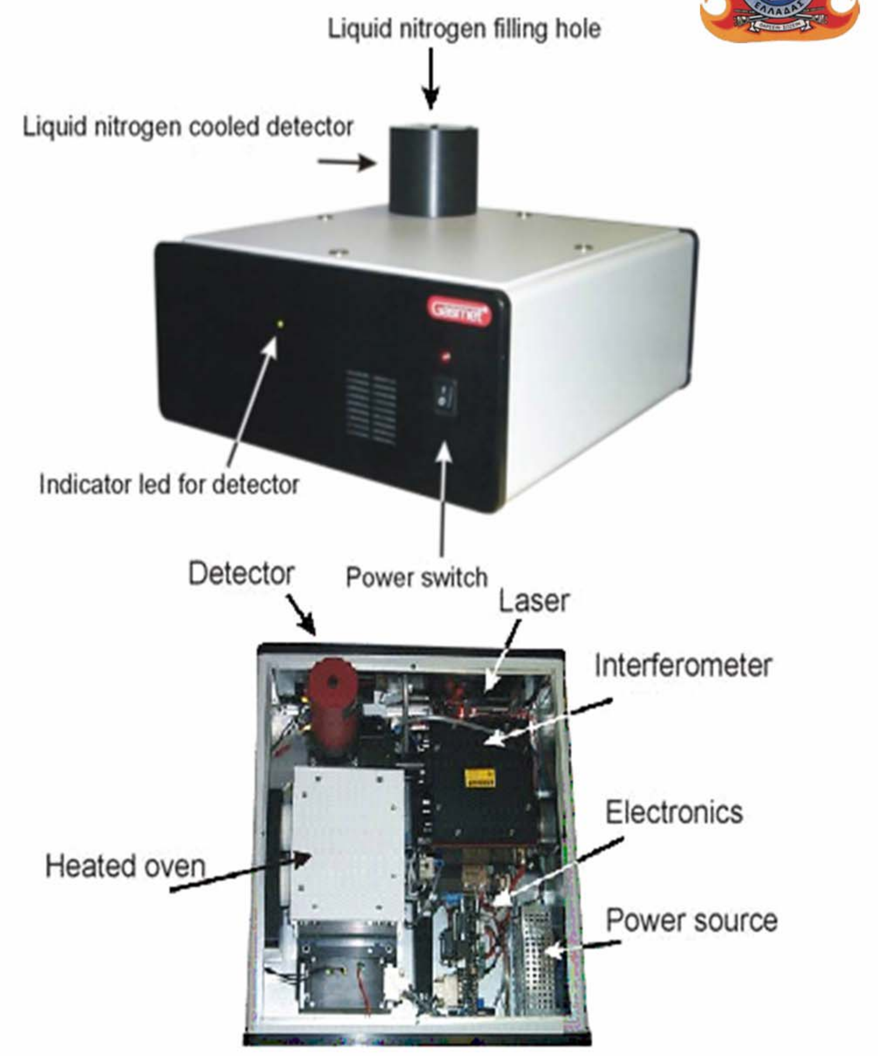
- A 1.56 m3 enclosed fire test facility, 1.4m x 0.92m x 1.22m, was used with separate entrained air inlet at floor level and fire product exit at ceiling level.
- The enclosure had 25mm thick high temperature insulated walls attached to a steel backing wall that was air sealed.



University of Leeds Fire Rig Enclosure

Experimental techniques /Apparatus used :
3. FTIR analyzer

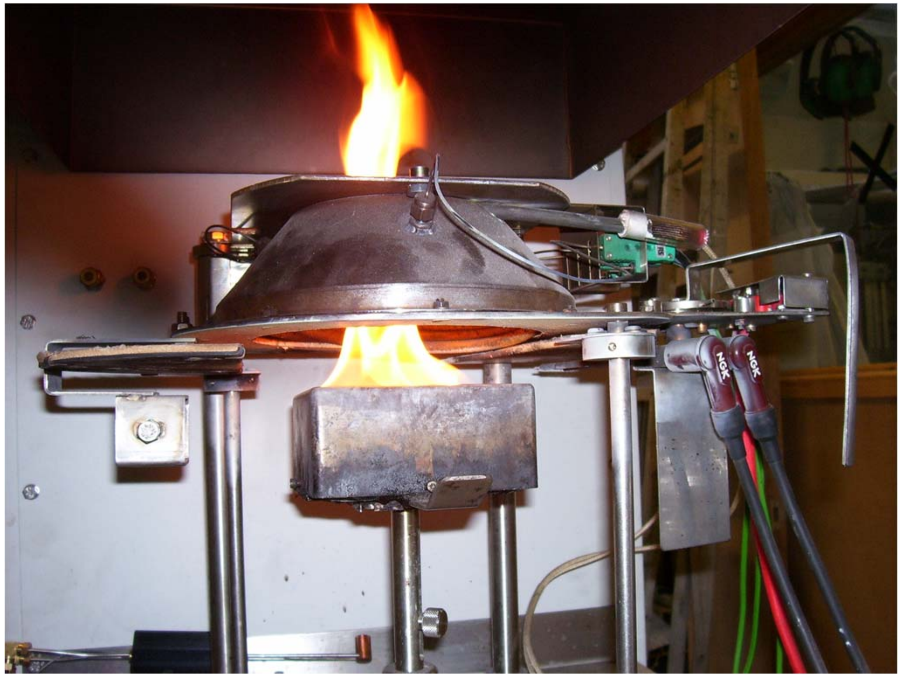
- A TEMET GASMET CR-Series portable FTIR analyzer was linked to the above instruments
- This has a multi-pass, gold-coated sample cell with a 2m path length and volume of 0.22l.
- A liquid nitrogen cooled MCT detector was used that scans 10 spectra per second and several scans are used to produce a time-averaged.



University of Leeds FTIR and its internals.

Thermal behaviour of various untreated timber in Cone Calorimeter tests.

- **'No significant' differences were observed in terms of HRR values.**
- **Some slightly lower HRR peak values (kW/m2) were noted for homogeneous (pine) compared with composite in nature samples (e.g., MDF, chipboard).**



Pine exposed at Heat flux 35kW/m2

Thermal behaviour of <u>flame retarded timber in Cone Calorimeter tests.</u>

The main findings are the following:

- 'No ignition' of all flame retarded samples was observed at 35kW/m2.
- the intumescent paint swell into a thick, robust foam upon exposure to heat, thus protecting the underlying material from fire by providing a physical barrier to heat and mass transfer.

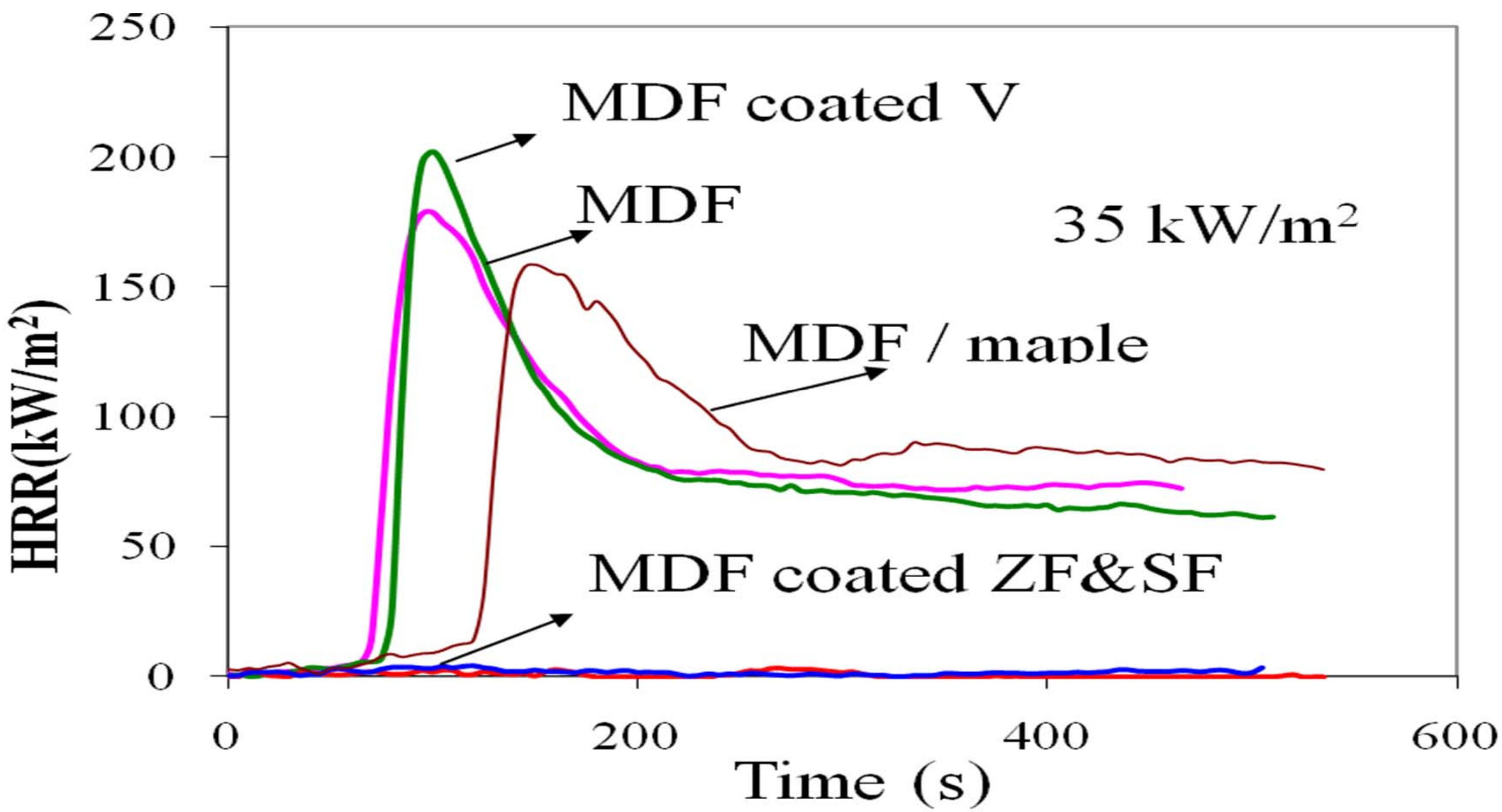
'Zero Flame' treated Pine exposed at Heat flux 35 kW/m2

Thermal behaviour of flame retarded timber in Cone Calorimeter tests.

- A considerable ignition delay 5 to 30 (compared to untreated sample) is seen at 50kW/m2 and 65kW/m2.
- The intumescent char cracks marginally thus allowing the formation of only thin flamelets scattered on the sample's surface.

'Zero Flame' treated Pine exposed at Heat flux 65 kW/m2

HRR (kW/m2) vs time for MDF,varnished MDF,MDF faced by maple,'Zero Flame' retardant MDF, 'Synto Flame' retardant MDF at 35kW/m2.



Toxic emissions of flame retarded timber in Cone Calorimeter tests.

- In most cases of samples with ‘no ignition’, -compared to untreated samples- there is either reduction in toxic emissions by a factor of 2 (‘Zero Flame’ paint) or almost equal to unity (‘Synto Flame’ paint).
- As irradiance increases, increasing values of toxic emissions by volume are seen during flaming combustion.

Comparative effects of flame retardant treatment on major exhaust emissions (during flaming combustion).

(a) small scale

$\dfrac{\textit{Coated emission}}{\textit{Bare emission}}$	$35kW/m^2$ Heat flux		$50kW/m^2$ Heat flux		$65kW/m^2$ Heat flux	
	'Zero Flame'	'Synto Flame'	'Zero Flame'	'Synto Flame'	'Zero Flame'	'Synto Flame'
'Peak **CO**(ppm) Ratio'	↓	↓	↓	↑	↑	↑
'Peak **HCN**(ppm) Ratio'	≈	≈	≈	≈	↑	↑
'Peak **Acrolein**(ppm) Ratio'	↓	↓	↓	≈	≈	↑
'Peak **N0** (ppm)Ratio'	≈	≈	≈	≈	↑	↑

↑ ↓

Each arrow indicates decreasing/increasing up to a factor of 2-3. Two arrows together is equivalent to a change by a factor of 3-6.Three arrows together is equivalent to a change by a factor for greater than 6.

≈ almost equal to unity.

Thermal behaviour of untreated timber in Fire Enclosure tests.

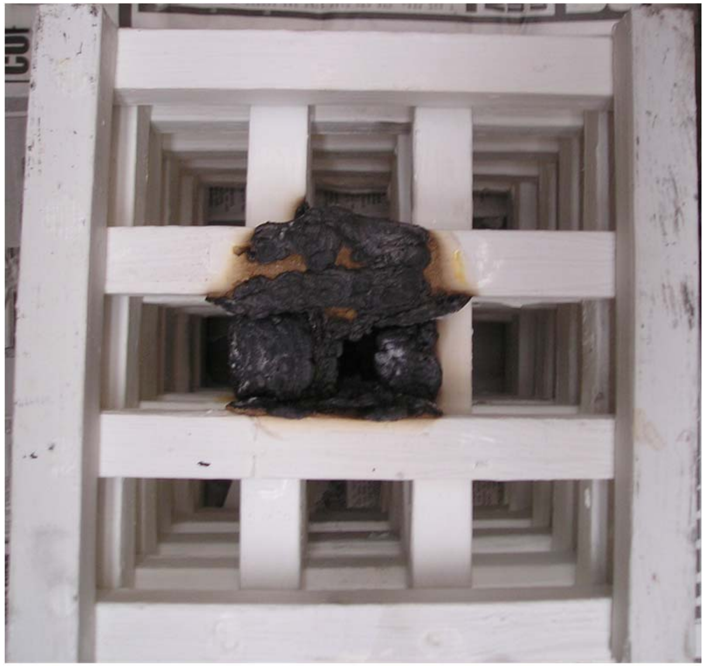
- The untreated sample clearly burned faster and with the highest HRR.
- it was chosen to be tested in form of cribs, because in real fires there are complex wooden geometries and configurations strongly affecting the "spreading of fires".

Untreated pine crib at 550 sec. into the test.

Thermal behaviour of <u>fully flame retarded timber</u> in Fire Enclosure tests.

- In all fully-treated (100%) cases, there was no ignition, and increasing amounts of ethanol, i.e., 6, 20, and 30g, were used as ignition sources.

- A “weak” flame initially developed from the burning of ethanol, which “triggered” the in-tumescent flame retardant paint to expand and form “instant firewalls” to contain and finally suppress the developing fire.



100% treated pine crib (used 20g of ethanol as ignition source) in the end of experimental process.

Fire development results

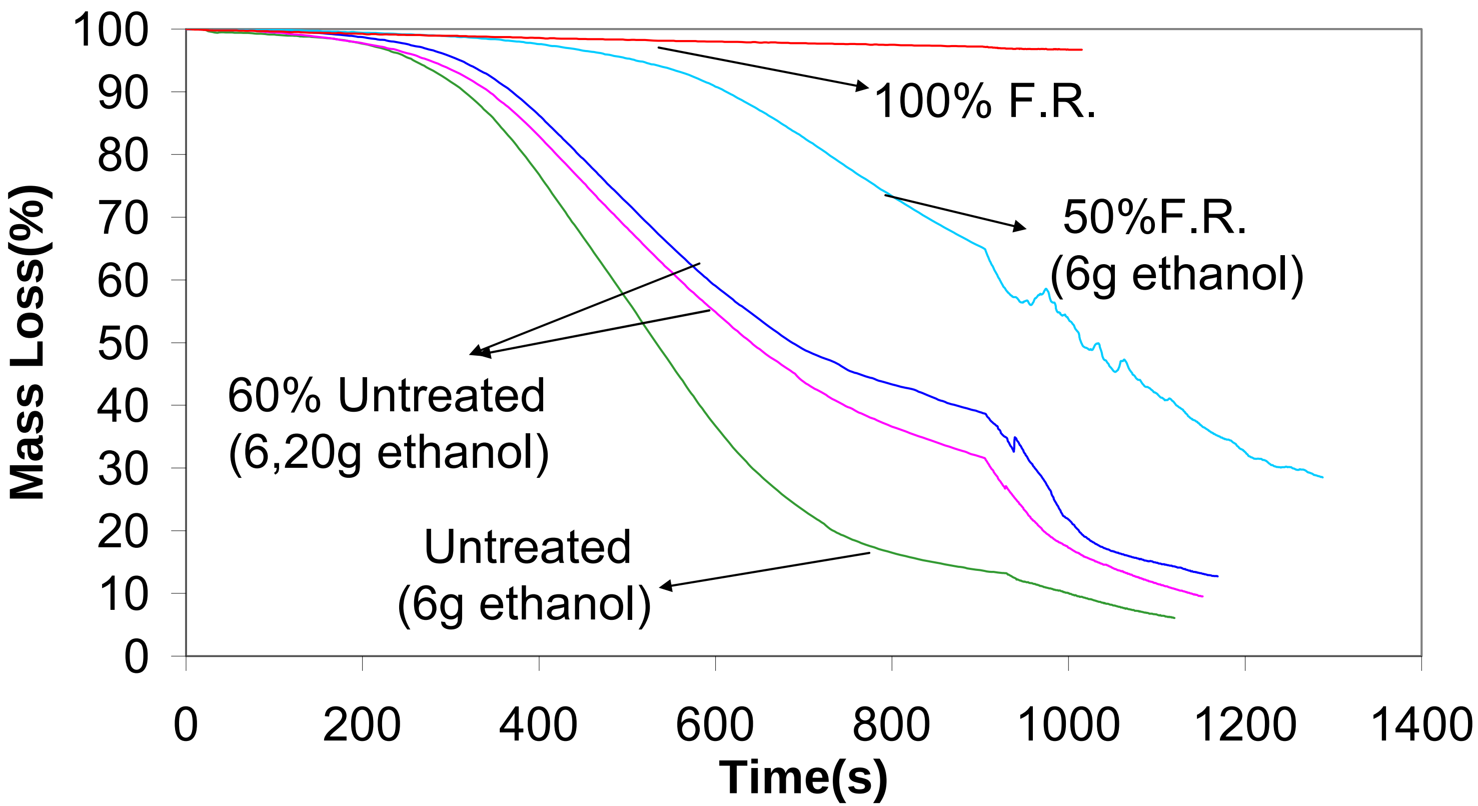


Figure 2: Mass loss (%) vs time for pine cribs with different FR treatment levels with 75kg/h air flow rate.

FTIR Toxic Gas Analysis

- In most fully-treated (100%) cases, even in the half-treated (50%) cases, lower or almost equal to unity emissions were measured compared with the bare samples.
- This is due to the fact that, in such cases, due to the in-tumescent action, there was either ‘no ignition’ of the samples (100%-treated cases), or a considerable delay was seen (50%-treated cases).

Comparative effects of flame retardant treatment on major exhaust emissions (during flaming combustion).

(b) medium scale

Coated emission / *Bare emission*	100%F.R. 6g ethanol	100%F.R. 20g ethanol	100%F.R. 30g ethanol	50%F.R. 6g ethanol	60% Untreated 6g ethanol	60% Untreated 20g ethanol
'Peak **CO**(ppm) Ratio'	↓↓↓	↓↓↓	↓↓↓	↓↓	≈	≈
'Peak **HCN**(ppm) Ratio'	↓↓	↓↓	↓	↓	↑↑	↑↑
'Peak **Acrolein**(ppm) Ratio'	↓	↓	↓	↓	≈	≈
'Peak **N0x**(ppm) Ratio'	↓	↓	≈	≈	↑↑	↑↑

Conclusions/suggestions

- ‘No ignition’ and lower toxic emissions compared to untreated samples were observed at 35kW/m2 (small scale).

- The same behavior was observed in those cases where wooden surfaces located next to ignition source had been treated (medium scale).

It is proposed that the application of intumescent flame retardants :

1. on wooden surfaces located close to ignition sources
2. in the most probable areas for a fire to break out,

could be a safe and effective approach in reducing fire losses in industries

- The above experimental data (small and medium scale) are compiled in the form of a database that can be used for validation of mathematical fire models and related software applications.

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Thank you all so much for your attention!