



 AquaMist

Compact Archive  
Storage

Dr T R Nichols CPhys MIFireE

Mr A Palau Bosch

**tyco**  
Fire Protection Products

# // New Bodleian Library, Oxford University, UK



# // Description of the Site

## // Multi-Level and Multi-Type Risk Areas

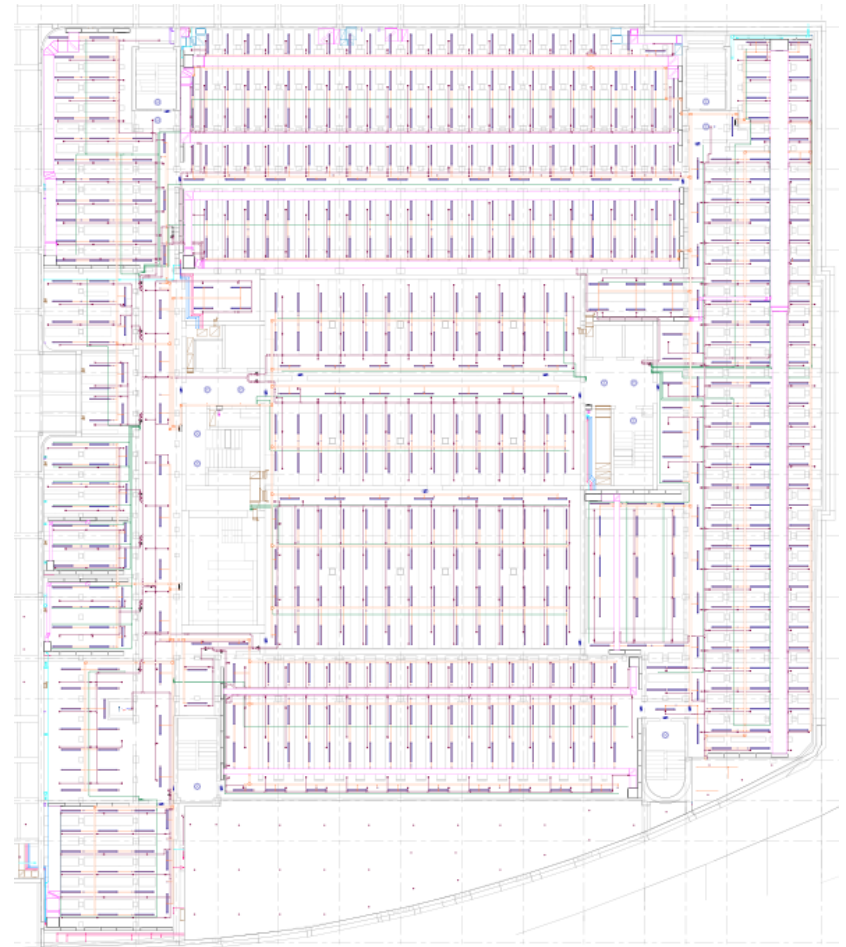
- 11 Levels
- Basement Archives
- Reading Rooms



# // Description of the Site

## // Archive Storage in Basement levels

- Storage in open racks and compact racks
- Low ceilings and confined with many obstructions (lighting, ducts)
- <150mm gap from racks to ceiling
- Compact racking gap 25mm to maximize storage and provide safe egress



# // Risk Analysis

- // Storage of various fire loads including paper, books, micro-film, CD cases
  - Fire load very large
- // Irreplaceable historical works and artefacts
- // Large areas, below and above ground with difficult access and egress
- // Ignition sources minimal
- // Main fire source due to arson
- // On-site water storage limited
- // Limited space to run extinguishing system pipe work

# // Consultant Assessment

## // Objectives:

- Quickly control fire within in prescribed area (defined as within a block of racks)
- Control of temperature
- Attenuation of Radiation (stopping of flame spread)
- Minimize collateral damage through water clean up

## // Design Parameters

- AMAO detailed as 144m<sup>2</sup> but later defined on formula based on actual quantity of nozzles activating
- Specified a high pressure mist system
- 30 minute run time



# // Tender Process

// Tender process identified that NO third party protocol exists for risks

// NFPA 750 requires that fire testing is undertaken pertinent to the risk

8.2.4.1 Fire test protocols shall be designed to replicate the range of the application parameters associated with a particular hazard or occupancy

// A performance based test was agreed with the stakeholders

- Bodleian Library
  - Archivists
  - Project Management
- Fire Consultant
- Independent verifier (Warrington Fire Research)
- Main Contractor
- Tyco Certified Distributor/Installer (EA-RS Fire Ltd)
- Tyco (LPG)

# // Defining the Tests

// Pass/fail criteria

// Protocol written to include:

- Test rig and layout, and type of test
  - Open rack tests
  - Compact rack test
  - Variations of compact rack gaps 25mm upwards
- Fire load (material type and configuration)
- Data acquisition (sensors, imaging)
- Hardware required (pumps, nozzles, pipe, tank, generator)
- Health & Safety procedures (fire brigade, etc)

// Location determined (Vinci Test Centre, Leighton Buzzard, UK)



# // Test Rig



# // Water Mist Components



- Test Nozzles
- Pump Set
- Generator
- Water Supply

# // Sensors



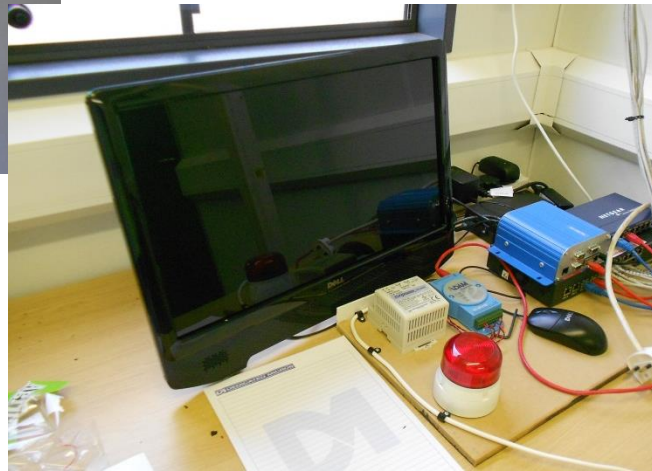
- Thermocouples
  - Probe & Plate type
- Pressure Transducers
- Cardboard Register (compact rack test only)



# // Cameras



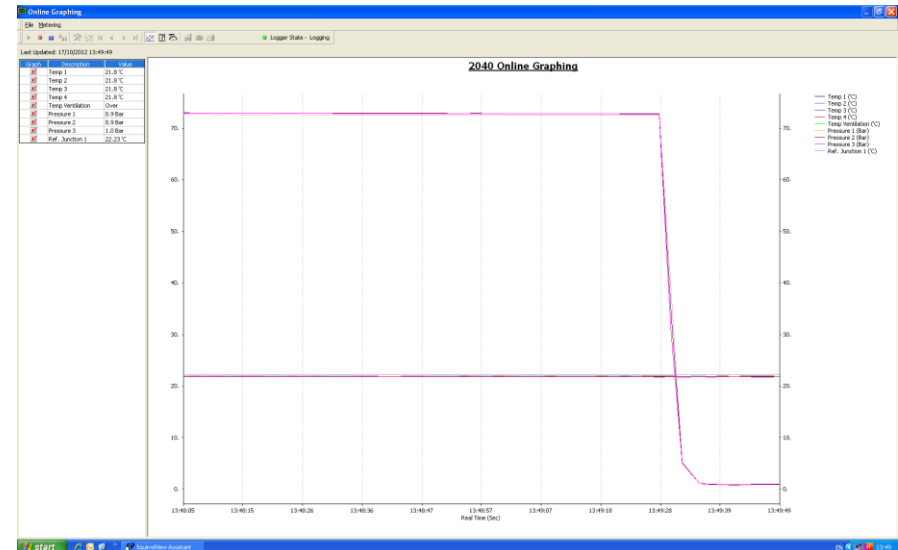
- VGA + Intelligent Video to detect smoke & flame
- 720 HD
- Pan Tilt Zoom Combined Thermal



# // Data Acquisition



- Multi-channel analyser
- Data logging
- Temperature averaging function
- Time stamp
- Fully calibrated



# // Location of Fire – Open Rack Test



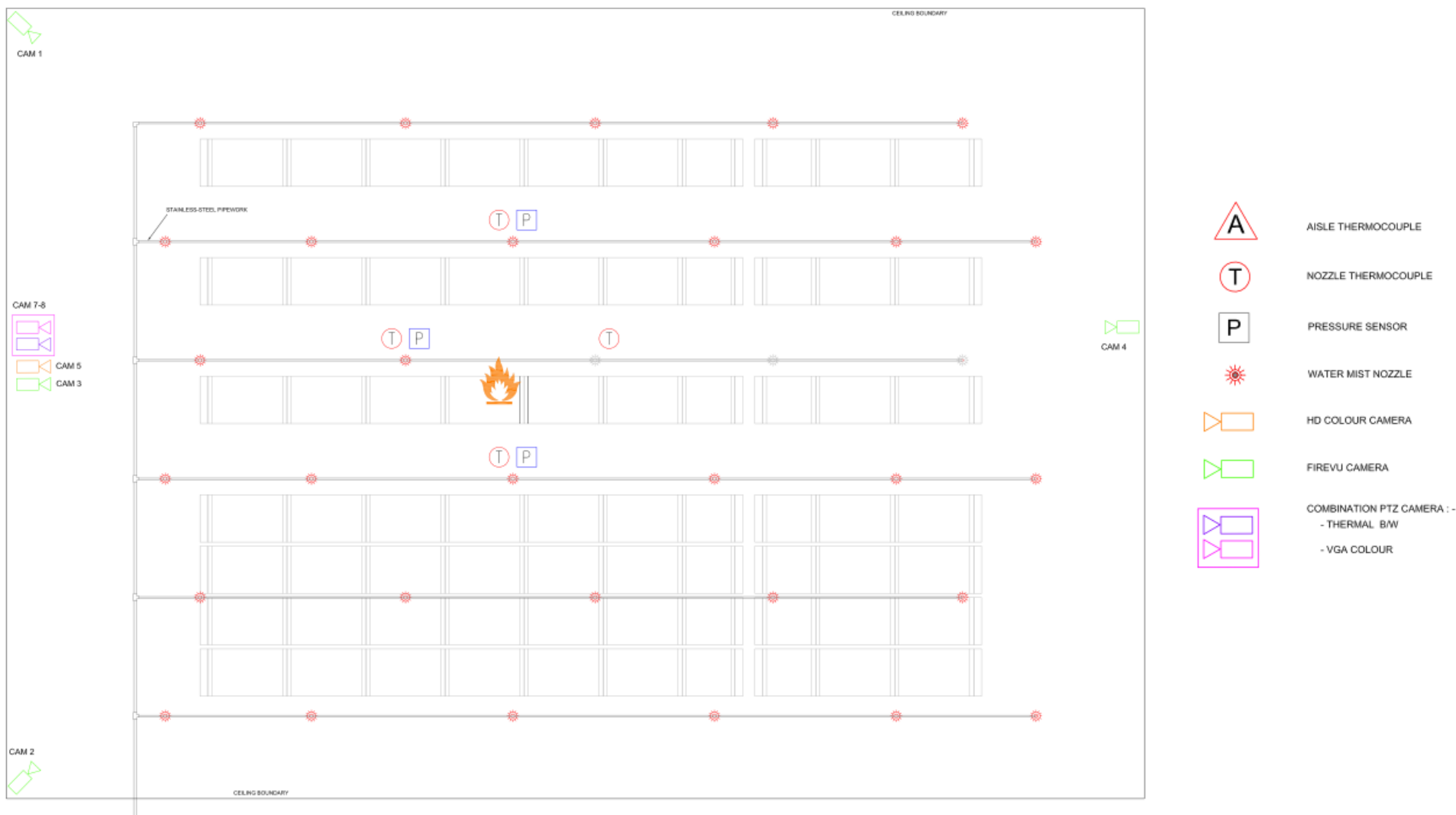
Test 1 - Layout, showing the 900mm wide aisle



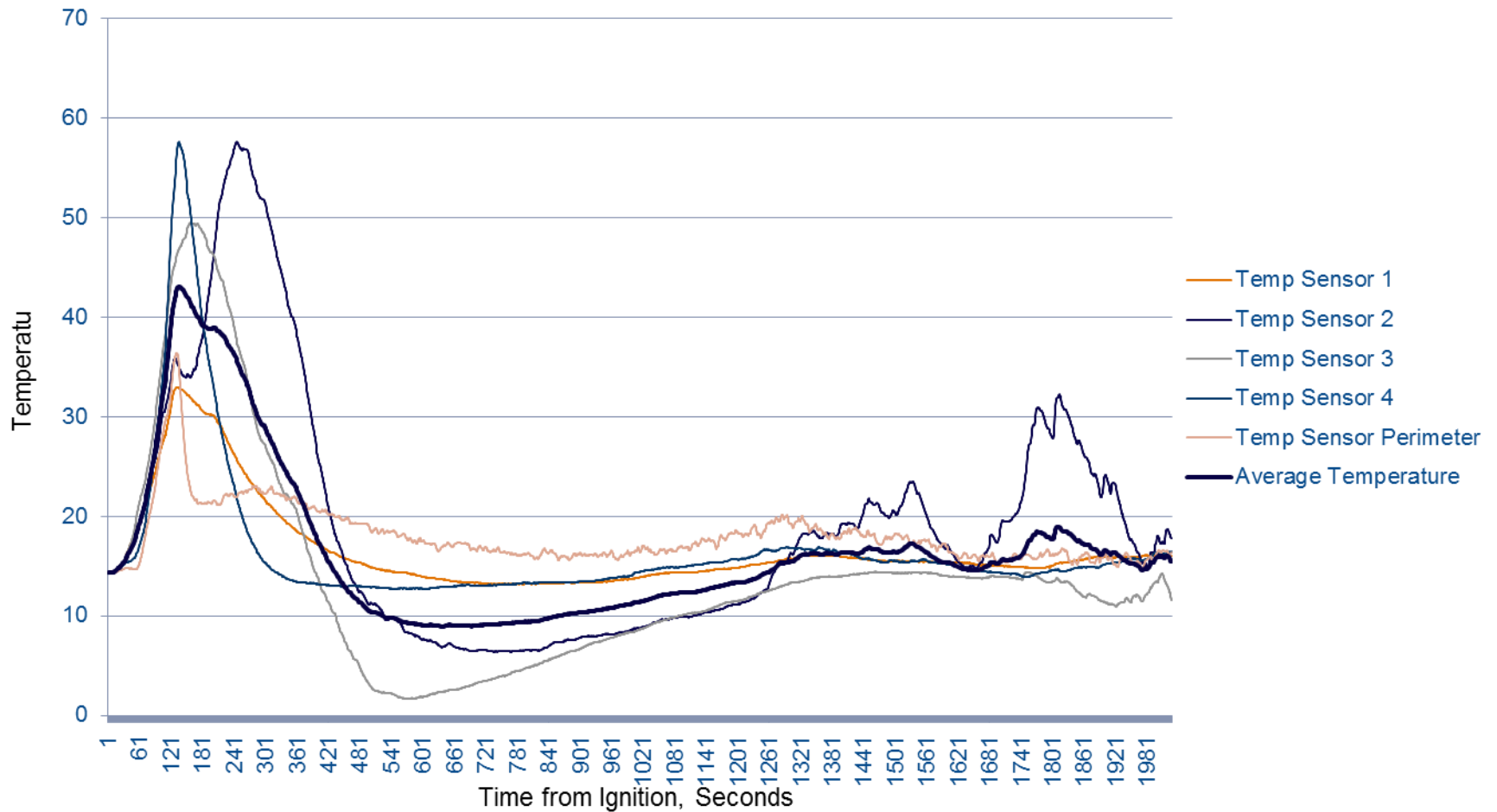
Test 1 -The fuel tray was placed where indicated

Fuel - 120 ml RON95 petrol

# // Sensor & Camera Location - Open Rack Test

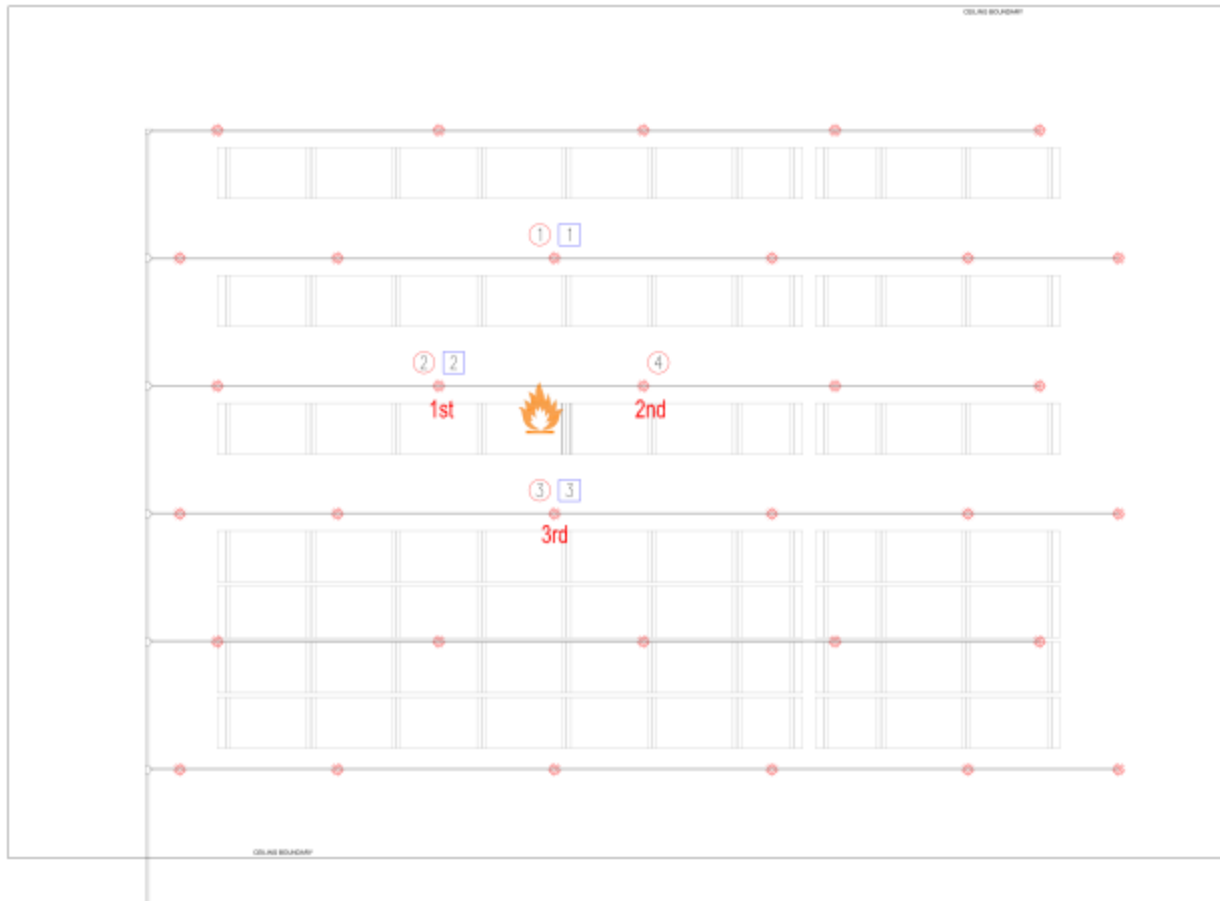


# // Temperature Profile - Open Rack Test





# // Order of Nozzle Operation - Open Rack Test



AISLE THERMOCOUPLE



NOZZLE THERMOCOUPLE



PRESSURE SENSOR

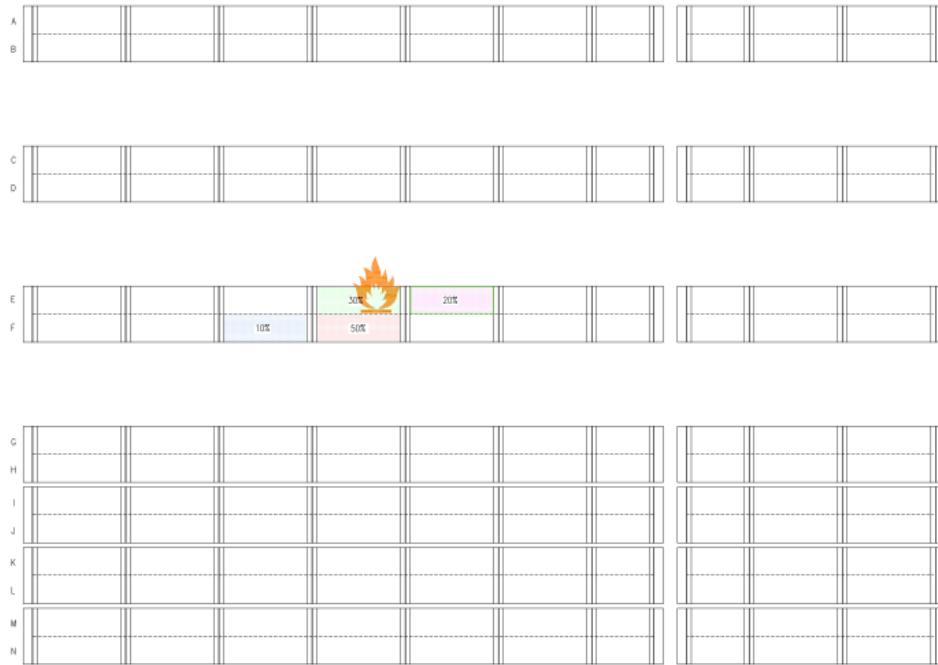


WATER MIST NOZZLE

2nd

NOZZLE ORDER  
N.B. The order in which nozzles operated following ignition. Refer to report results.

# // Fire Spread - Open Rack Test



APPROX PERCENTAGE OF MATERIALS BURNT IN EACH BAY: -



# // Fire Damage - Open Rack Test



As found



As cleared showing  
damage to only one section

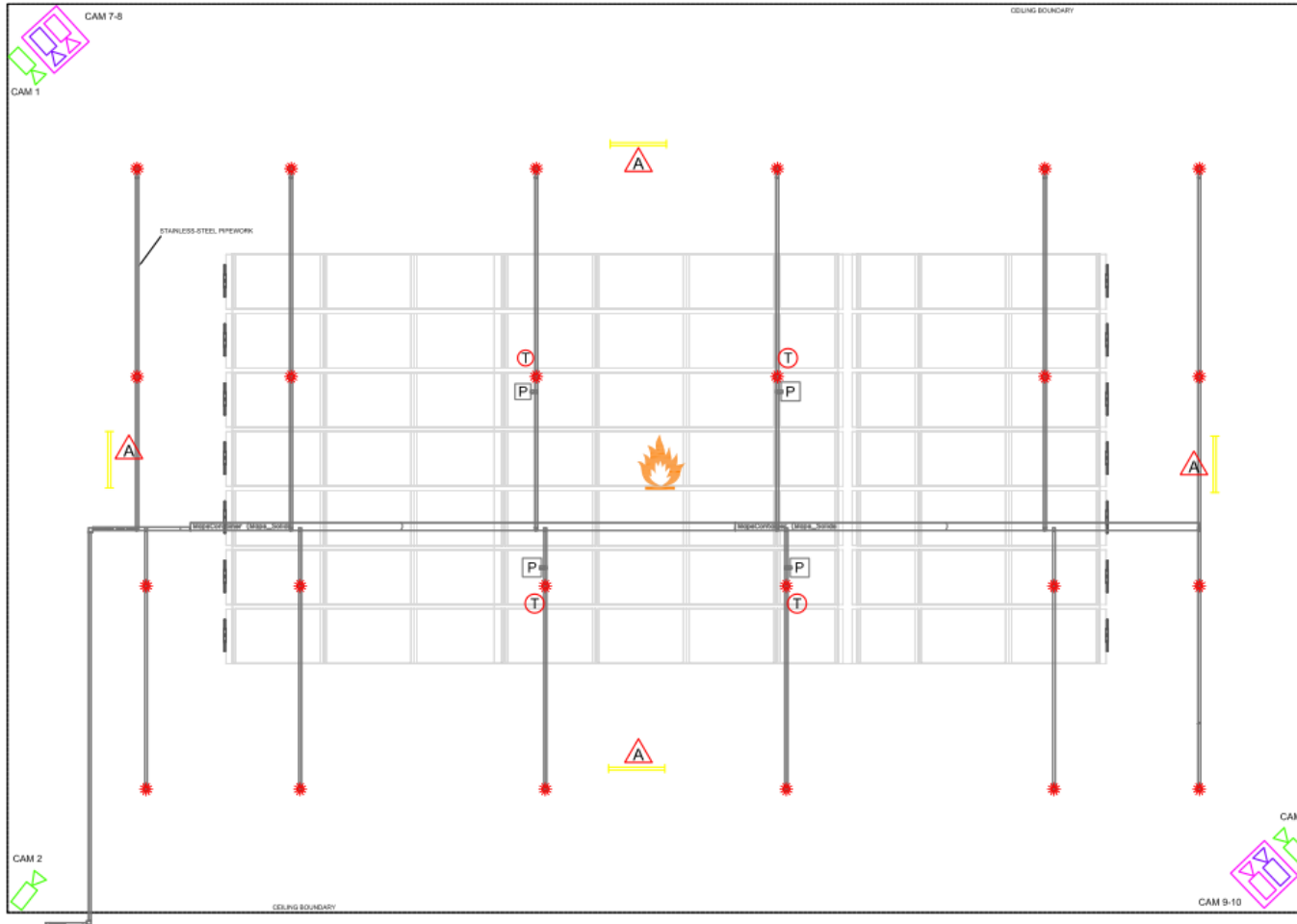
# // Location of Fire – Compact Rack Test



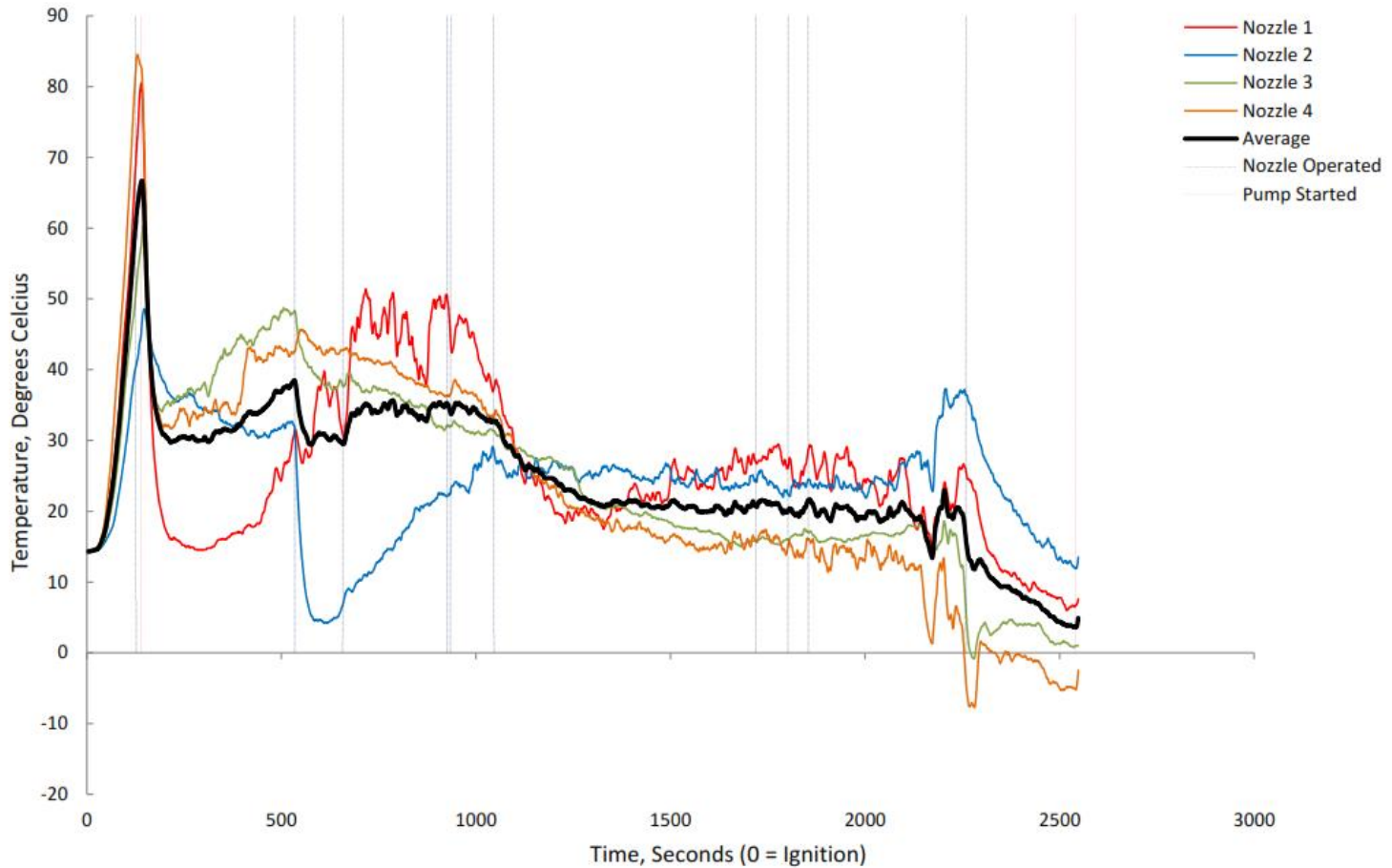
Test 2 - Full arrangement, 25mm gap. Fire was started on row H

Fuel - 120 ml RON95 petrol

# // Sensor & Camera Location - Compact Rack Test



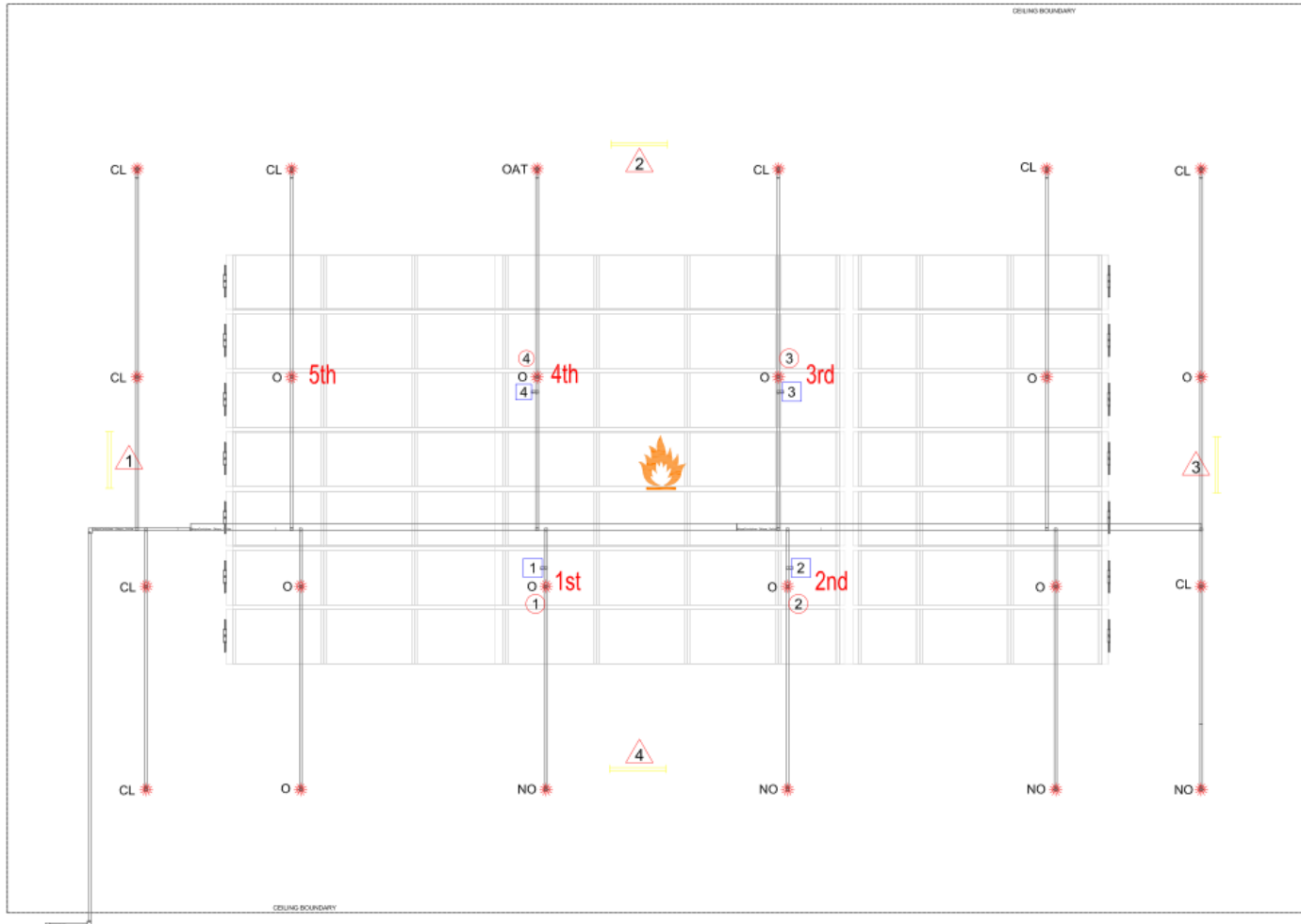
# // Temperature Profile - Compact Rack Test



# // Temperature Profile - Compact Rack Test, Aisle Boundary



# // Order of Nozzle Operation - Compact Rack Test



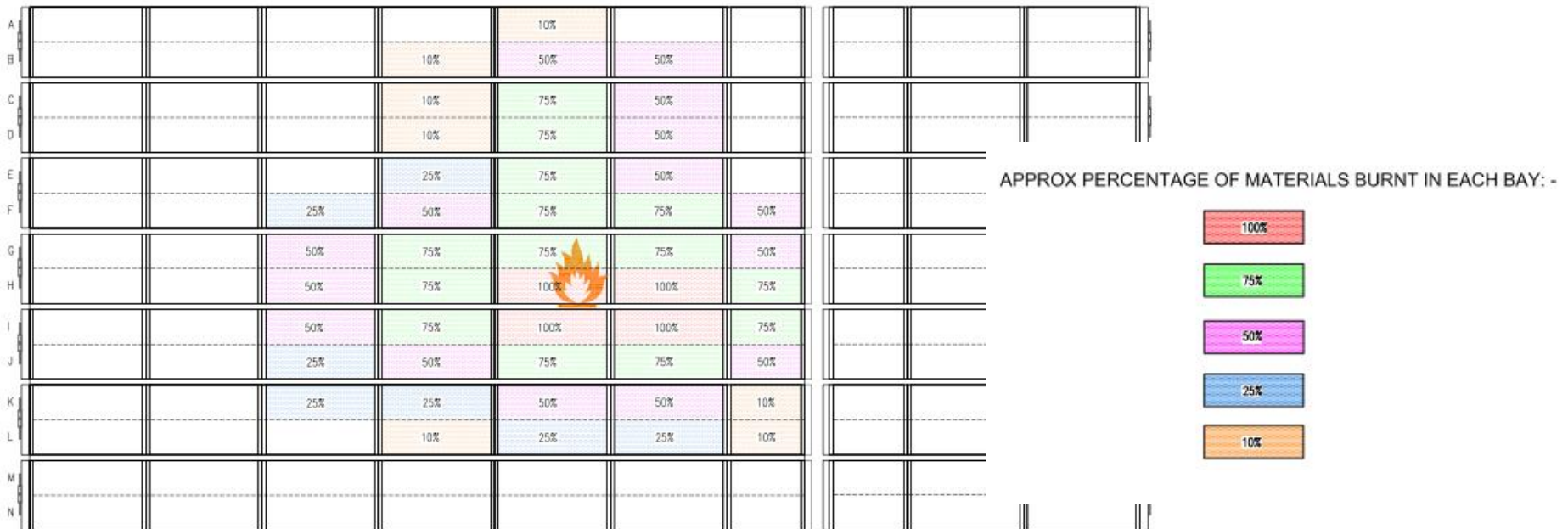
- AISLE THERMOCOUPLE
- NOZZLE THERMOCOUPLE
- PRESSURE SENSOR
- WATER MIST NOZZLE
- CARDBOARD REGISTER
- 3rd**  
NOZZLE ORDER  
*N.B. The order in which nozzles operated following ignition. Refer to report results.*

**STATUS OF NOZZLES : -**  
(on examination following fire brigade access)

- CL Nozzle Closed - Bulb Intact
- O Nozzle Open - Bulb Operated
- NO Not Operated - Bulb burst by fire brigade spray but piston not operated
- OAT Operated After 30 mins Test Period when pumps turned off and thus rise in temperature.



# // Fire Spread - Compact Rack Test



# // Fire Damage - Compact Rack Test



Test 2 - Row G Fire Damage



Cardboard register undamaged (same on all four boundaries).



Test 2 - Row I Fire Damage



Thermal image of aisle nozzle discharge post fire brigade intervention. Location right of rack A as taken from pump set using one of the hand-held thermal imaging cameras.

Name: Camera Location 17  
Date: 14/11/2012 11:38:36  
Spot Temperature: 23°C  
Ambient Temperature: 16°C

# // Endorsement – Consultant & Test Authority



Our ref: FFI/TMW/07068  
28 November 2012

Tyco Fire Protection Products  
5-7 Top Angel, Buckingham Industrial Park  
Buckingham MK18 1TH

Dear Sirs

## Archive Fire Tests

Further to our recent communications we would confirm our attendance and witnessing of full scale fire tests of Archive storage of Class 'A' combustibles protected by Aquafoq High Pressure Water Mist systems carried out at the Vinci Technology Centre on 19 October 2012 and 14 November 2012.

The tests were arranged as part of project to provide High Pressure Water Mist Fire Fighting systems at a major archive storage facility for one of our valued customers. The specialist contractor for fixed fire protection systems on the project is R&S Fire & Security Services Ltd and they arranged for the testing to be carried out so that the use of the water mist design put forward by yourselves is appropriate for the unique and challenging arrangement of the archive proposed on the project. The storage arrangement is a combination of fixed solid shelved racking and mobile racking and the test rig was designed to accurately replicate the arrangements on site. Two tests were carried out to simulate the fixed racking arrangement and the mobile racking arrangement in a configuration perceived to be the most challenging which could be expected.

For the first test, carried out on 14 November, the racking configuration was adjusted to simulate the fixed racking arrangement with back to back open shelving loaded with a replication of the archive storage 'typical' arrangement of Class 'A' combustibles. The protection comprised pendent sealed nozzles with a K1.75 flow/pressure co-efficient running at 70 bar at a maximum design spacing of 2.5m down the aisles. For the second test, carried out on 14 November, the racking configuration was adjusted to simulate the compact archive storage with racks rolled to the 'closed' position. The protection comprised pendent sealed nozzles with a K3.5 flow/pressure co-efficient running at 70 bar at a maximum design spacing of 2.7m over and around the perimeter of storage blocks.

In both tests the system operated successfully and was observed to suppress and control, but not extinguish, the fire within the proposed design parameters for the design period of 30 minutes.

It should be understood that as the full test report has not yet been verified or validated, the submission of this letter constitutes neither a warranty of future results, nor an assurance against risk. The opinion represents only the best judgement of the Frontline Fire International Ltd consultant involved in it's preparation and is based, in part, on information provided by others. No liability whatsoever is accepted for the accuracy of such information.

Yours sincerely

A handwritten signature in blue ink, appearing to read 'Terry M Watson'.

Terry M Watson CEng MFire MCIBSE MSpRHE  
Consultant  
On behalf of Frontline Fire International Ltd

## CONSULTANTS & ENGINEERS

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26<sup>th</sup> February 2013

LPG Fire Ltd.  
Unit 5 to 7  
Top Angel  
Buckingham Industrial Park,  
Buckingham,  
Bucks  
MK18 1TH,  
United Kingdom

for the attention of Dr Tim Nichols

Dear Sir

## Ref. Validation of the Bodleian Library Fire Tests

At the request of R&S Fire and Security Services Ltd, Exova Warrington Fire attended and witnessed two Aquafoq Water Mist System fire tests undertaken at the Vinci Technology Centre, Leighton Buzzard, LU7 4QH on the 19th October and 14th November 2012.

It is understood that the fire tests were instigated at the request of the Bodleian Library at Oxford University to verify the performance of the Aquafoq High Pressure Water Mist system design proposal for protection of the Bodleian Library's specific storage arrangements. It is further understood that the test rig was custom built, in emulation of the libraries storage facility, utilizing the same racking arrangements and storage materials as used by the library.

The brief of Exova Warrington Fire was to provide independent third-party verification that the tests followed the specific protocols and procedures determined as appropriate by R&S Fire and Security Services Ltd as agreed with the requirements of the Bodleian Library. Exova Warrington Fire was not a party to the determination of these protocols or the agreed design basis of the Aquafoq Water Mist System.

Prior to the commencement of each live fire test, the test rig was inspected by Ray Hammond of Exova Warrington Fire in attendance with Paul Darke of R&S Fire, Alex Palau of LPG, Terry Watson and Chris George of FFI. A pre-check list of the Rig construction, storage arrangement, Aquafoq Water Mist installation, instrumentation & CCTV layouts was agreed and signed off by all parties in validation of those detailed and described in the Annex's accompanying this report.

It is confirmed by Exova Warrington Fire that the test plan procedures detailed in the Fire Plan documents 8036-FP-001\_issue-1 and 8036-FP\_002\_issue-1 were accurately followed and the subsequent description within this report is a true reflection of the events that took place.

Yours faithfully  
for Exova Warrington Fire

A handwritten signature in blue ink, appearing to read 'Ray Hammond'.

Ray Hammond

# // Endorsement – Fire Brigade

*“Sir*

*I would like to comment on the first fire test that was conducted on the Vinci site at Leighton Buzzard on behalf of the Bodleian Library Oxford.*

*The water mist system worked well and stopped the fire spreading for a full 30 minutes.*

*On arrival at an incident I would have been happy to commit crews into the building to fully extinguish a fire controlled to this extent.*

*Indeed when our crews entered the rig to extinguish the fire I was impressed by the lack of fire and smoke damage to the surrounding books/ structure.*

*I look forward to working with you on subsequent tests.*

*Regards*

*Mark Hutchings  
Station Commander  
Bedfordshire Fire and Rescue Service”*



 AquaMist

Thank You

***tyco***  
*Fire Protection Products*