Compact Archive Storage

Dr T R Nichols CPhys MIFireE
Mr A Palau Bosch
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 144m² 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 - The fuel tray was placed where indicated

Fuel - 120 ml RON95 petrol

Test 1 - Layout, showing the 900mm wide aisle
Sensor & Camera Location - Open Rack Test

Aisle Thermocouple
Nozzle Thermocouple
Pressure Sensor
Water Mist Nozzle
HD Colour Camera
FireVu Camera
Combination FTZ Camera
- Thermal B&W
- VGA Colour
Temperature Profile - Open Rack Test

Temperature Profile

- Temp Sensor 1
- Temp Sensor 2
- Temp Sensor 3
- Temp Sensor 4
- Temp Sensor Perimeter
- Average Temperature
Order of Nozzle Operation - Open Rack Test

NOZZLE ORDER
N.O. The order in which nozzles operated following ignition. Refer to report results.
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
Temperature Profile - Compact Rack Test
Order of Nozzle Operation - Compact Rack Test

ASILE THERMOCOUPLE

NOZZLE THERMOCOUPLE

PRESSURE SENSOR

WATER MIST NOZZLE

CARDBOARD REGISTER

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 drop in temperature

AquaMist
## Fire Spread - Compact Rack Test

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### Approx Percentage of Materials Burnt in Each Bay:

- **100%**
- **70%**
- **50%**
- **25%**
- **10%**
Fire Damage - Compact Rack Test

Test 2 - Row G Fire Damage

Test 2 - Row I Fire Damage

Cardboard register undamaged (came on all four boundaries).

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 11:38:34
Spot Temperature: 23°C
Ambient Temperature: 18°C
28 November 2012

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

Dear Sirs

Architectural Fire Tests

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

The tests were arranged as part of our project to provide High Pressure Water Mist Fire Fighting systems at a major archie 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 pendant sealed nozzles with a K175 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 pendant sealed nozzles with a K350 flow pressure co-efficient running at 70 bar at a maximum design spacing of 2.7m over and around the perimeter of storage blocks.

Both tests were 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 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 judgment of the Frontline Fire International Ltd consultant involved in it’s preparation and is based, in part, on information provided by others. No liability whatsover is accepted for the accuracy of such information.

Yours sincerely,

Terry M Watson CEng MIPAF MIMES EME
Consultant
On behalf of Frontline Fire International Ltd

26th 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

Ref: Validation of the Bodleian Library Fire Tests

At the request of R&S Fire and Security Services Ltd, Exova Warrington attended and witnessed two Aquamist Water Mist System fire tests undertaken at the Vortex Technology Centre, Leghorn Buzzard, LUT 4QH on the 15th October and 14th November 2012.

It is understood that the tests were installed on the Bodleian Library at Oxford University to verify the performance of the Aquamist 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 library’s 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 Aquamist 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 Javis of R&S Fire, Alan Pelley of LPG, Terry Watson and Chris George of FFI. A pre-check list of the rig construction, storage arrangement, Aquamist Water Mist installation, instrumentation and CCTV layouts was agreed and signed off by all parties in validation of those detailed and described in the Annexes accompanying this report.

It is confirmed by Exova Warrington Fire that the test plan procedures detailed in the Fire Plan documents DS20-FP-001 ISSUE 1 and DS20-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,

Ray Hammond

Exova Warrington Fire
“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”