

IT/Server Room Fire Test Demonstrations – VESDA & photoelectric conventional point detectors

Technical Report

October 2008

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Executive Summary

This Case Study presents the results from a series of demonstration tests conducted at the Xtralis Test Facility IT/server room. Smoke tests were conducted in various locations within the room to demonstrate a VESDA smoke detector's early warning (EW) and very early warning (VEW) detection capability at the ceiling, return air grill, duct and cabinet. Comparison results between VESDA and conventional point (spot-type) detectors are included.

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Background

A series of demonstration smoke tests to the local Australian fire industry was organised by Xtralis with the assistance of AG Coombs Group, Emerson Network Power, Notifier Inertia, BlueFire Systems, Walker Fire Protection and Incite Fire. The demonstrations were conducted over 8 sessions between August 21 and 25 (2008) at the Xtralis Test Facility IT/server room shown below (Figure 1).



Figure 1 – Xtralis Test Facility IT/server Room.

The purpose of the smoke tests was to illustrate the very early warning detection capability of the VESDA system:

- During the early (smouldering) developing stage of fire incidents;
- In a high airflow environment with airflow patterns encountered in IT/server rooms;
- With different sampling options (ceiling, return air grill, duct and cabinet).

The VESDA system performance was also compared against conventional point type smoke detectors under identical sampling options (ceiling, return air grill, duct).

The attendees (more than 150 in total) from the fire industry consisted of fire engineers/consultants, architects, installers, end users, delegates from the government, insurance, IT and telecommunication, and finance.

Challenges of Fire Detection in IT/Server Rooms

The following challenges for fire detection in IT/server room environments are normally encountered:

- Varying fuel loads and ignition sources
 - Large number and concentration of electronic devices generate excessive amounts of heat, which create a fire risk
 - The combustion of plastics may smoulder for long periods and generate minimal quantities of smoke without visible flame.
- Obstructions that interfere with the movement of smoke towards detection points
 - The presence of server cabinets obstruct smoke movement
- High airflow
 - High airflow creates smoke dilution

Testing Room and Cabinets

Geometry

The IT/server room dimensions are:

- Length: 11.0 m
- Width: 6.5 m
- Ceiling height: 3 m (Excluding ceiling and floor voids)
- Floor void: 0.3 m
- Ceiling void: 0.3 m (not used for the demo)

An illustration of the IT/server Room is shown below (Figure 2).

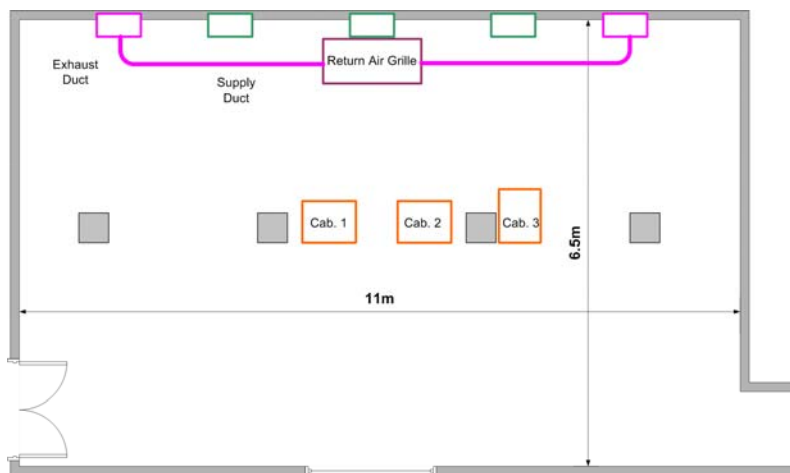


Figure 2 – Schematic of IT/server Room.

Ventilation

The IT/server room consists of 5 wall ducts for air supply and return. The 1st and 5th ducts are connected to the return air grill. The center three ducts supply air to the floor void.

The ventilation configuration of the IT/server room is such that air is introduced through the floor (perforated tiles) and exhausted via the return air grill (Figure 3).

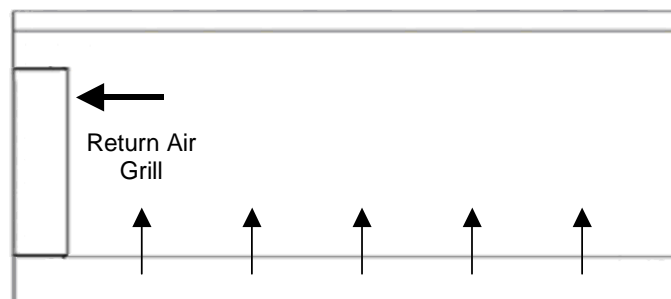


Figure 3 – IT/server Room Ventilation Configuration.

Air velocities measured at various locations were:

- Perforated tiles: 0.2 to 0.8 m/s
- Return air grille: 2.1 m/s (average)
- Exhaust ducts (each): 7.5 to 7.8 m/s

During the demonstration tests, the total air exchange rate in the test room was approximately 26 air change rates per hour (ACH).

Cabinet

Three cabinets with different ventilation schemes (Figure 4) were placed at the center of the room.

The ventilation for the 1st cabinet, labelled as “Cab.1 (Bottom-up)”, was from bottom to top. The air velocity measured at the top vents was approximately 0.35 m/s.

The 2nd cabinet, labelled as “Cab.2 (Fully sealed)”, was fully sealed and comprised a mixing fan.

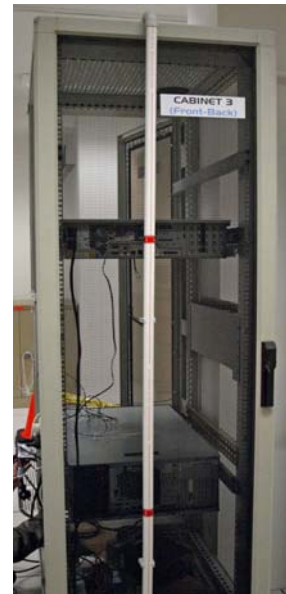
The 3rd cabinet, labelled as “Cab.3 (Front-back)”, had front to back ventilation generated by the exhaust fans of servers.



Cab 1 (Bottom-up)



Cab.2 (Fully sealed)



Cab.3 (Front-back)

Figure 4 – Cabinets with Different Ventilation Schemes.

Fire Detection Systems Installed

VESDA System - Ceiling

One Xtralis VLP detector with a single pipe and two branches was installed on the ceiling. The layout of the pipe network is shown below (Figure 5).

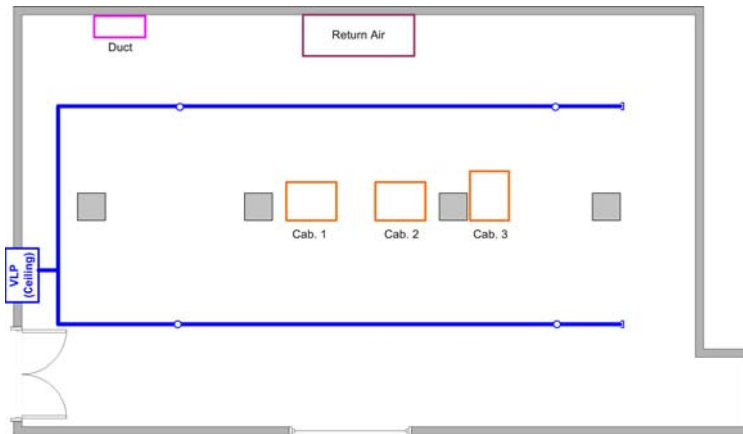


Figure 5 – VESDA System Layout – Ceiling Protection.

Parameters of the ceiling VLP system were:

- Number of sampling holes: 4
- Sampling holes size: 3 mm
- Sampling holes spacing: 6 x 3 m
- Maximum transport time: 17 seconds

VESDA System – Return Air

One Xtralis VLC detector was installed across the return grille. It comprised a single pipe with two sampling holes in front of the return air grille. The layout of the pipe network is shown below (Figure 6).



Figure 6 – VESDA System Layout – Return Air Protection.

Parameters of the return air VLC system were:

- Number of sampling holes: 2
- Sampling holes size: 6 mm
- Sampling holes coverage: 0.5 x 0.8 m (0.4 m²)
- Sampling holes orientation: 30° to the incoming flow
- Maximum transport time: 8 seconds

VESDA System – In-Duct

One Xtralis VLC detector was installed in the 1st exhaust duct. The sampling pipe consisted of two sampling holes inside the duct. The VLC exhaust pipe was also positioned inside the duct with holes at the same orientation as the sampling holes to equalise the pressure.



Figure 7 – VESDA System Layout – Duct Protection.

VESDA System – Cabinet

One Xtralis VLF detector with a single pipe was used to protect the three cabinets. The layout of the pipe network and sampling options for each cabinet are shown below (Figure 8). The red labels on the pipe signify the location of the VESDA sampling holes.



Cabinet 1



Cabinet 2 (capillary)



Cabinet 3

Figure 8 – VESDA System Layout – Cabinet Protection.

Parameters of the VLF system were:

- Total sampling holes: 5
- Sampling hole per cab: 1 or 2
- Sampling holes size: 3 mm
- Maximum transport time: 20 seconds

VESDA in Floor Void Protection (illustration only)

A section of VESDA sampling pipe was installed inside the floor void. This set-up served to illustrate the layout of VESDA floor void protection (Figure 9).



Figure 9 – VESDA in Floor Void Protection (illustration).

VESDA Smoke Threshold Settings

The following smoke thresholds were set for all VESDA detectors:

- Alert alarm: 0.03 %obs/m;
- Action alarm: 0.065 %obs/m;
- Fire 1 alarm: 0.1 %obs/m;
- Fire 2 alarm: 2.0 %obs/m.

Point (Spot-type) Detectors

For comparison purposes, photoelectric conventional point detectors (spot-type) smoke were mounted next to VESDA sampling holes for ceiling, air return, and in-duct protection. Figure 6 shows an example of air return grille protection.

The point (spot-type) detector's Fire alarm threshold was set to 1.4 %obs/m (Mode 1 – most sensitive) incorporating a 5 second verification period.

Signaling and Monitoring

A PROACTIV fire alarm control panel (FACP) was used to log alarm times for each individual point-type detectors, the event logs and alarm times of the VESDA detectors at the same time. For demonstration purposes, the following notification and display options were implemented through the PROACTIV panel and PSM software.

Displayed by PSM:

- PSM with floor plan: All events;
- Smoke trends: All detectors.

Notification controlled by the FACP and PSM:

- Strobes and sounders: Fire alarms for VESDA and point detectors;
- Text-to-speech: All alarms;
- SMS announcement: Alert alarm (Pre-alarm) for the VESDA and point detectors;
- Fire policy reminder: Fire alarms for the VESDA detector.

Fire/Smoke Tests

Three types of fire/smoke tests were conducted at different locations to simulate typical fire scenarios that might occur in an IT/Server room:

- Overheated PVC wire test;
- Overheated resistor test;
- Smouldering smoke pellet test.

The PVC wire and resistor test methods were used to demonstrate a VESDA smoke detector's VEW detection performance. The purpose of smoke pellet test was to illustrate the difference in response times between VESDA and point detectors. Please refer to the following sections for full descriptions of these test methods.

A description of the tests that were performed is shown in Table 1.

Table 1 – Test Plan and Configurations

Test Number	Test Type	Test Location	Ventilation Condition	Remark
1	1m PVC cable	Floor L1	2 exhaust fans	VEW
2	1m PVC cable	Floor L2	2 exhaust fans	VEW
3	1m PVC cable	Floor L3	1 or 2 exhaust fans	Duct/Return Detection
4	1m PVC cable	Cabinet 1	2 exhaust fans	Bottom-Up
5	Resistor x 2	Cabinet 2	Internal fan	Sealed
6	Resistor x 1	Cabinet 3	Server fan	Front-Back
7	Smoke pellet	Floor L2	2 exhaust fans	EW

The fire/smoke source locations for each test are:

- Location for Test 1: furthest from all VESDA sampling holes and point-type detectors;
- Location for Tests 2 & 7: located between two ceiling VESDA sampling holes and point-type detectors,
- Location for Test 3: located close to the return air grille;
- Locations for Tests 4, 5, & 6: inside each cabinet.

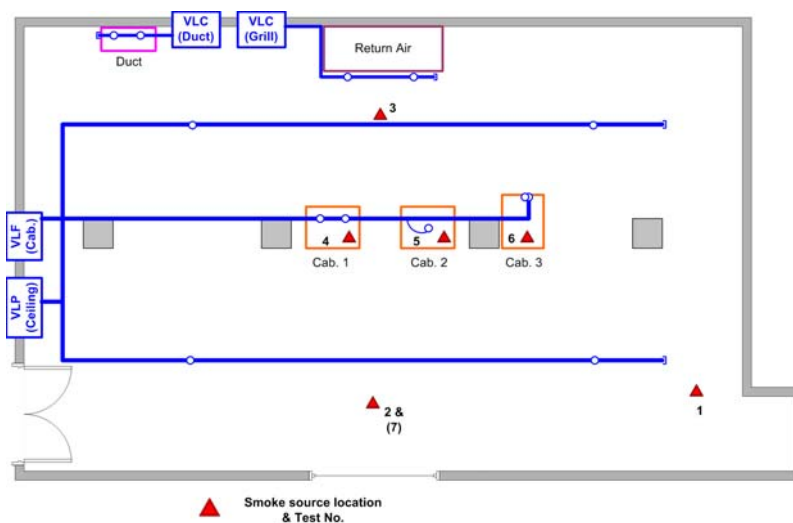


Figure 10 – Fire/smoke Locations.

Overheated PVC Wire Test

This test method is in accordance to a BS 6266 smoke test. It utilizes an overheated cable to simulate the early stage (incipient) of fires (i.e. a cable tray within an IT/Server room).

A standard transformer provided 6 VDC 20 A (max) current to a 1 m PVC coated cable. The configuration of the test method is shown below (Figure 11). Power-on times for the transformer were set to 60 seconds and 10 seconds for the tests in the room and inside the cabinet respectively. One of the test requirements for detection performance is for a pre-alarm to be generated within 120 seconds from the time that the transformer is de-energized.

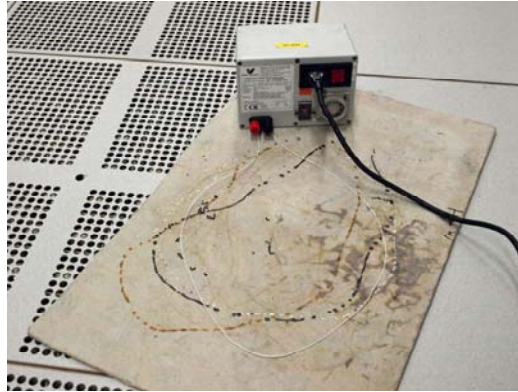


Figure 11 – Overheated Cable Test.

Overheated Resistor Test

This test method is in accordance to the Fire Industry Association (FIA) code of practice (CoP) for ASD systems to test VEW detection performance for cabinet protection. A normal carbon film type resistor between 68 to 680 k Ω was overheated to simulate a failure of components inside the cabinet. The power-on time for the transformer supplying current to the resistors was 10 seconds. The burning of overheated resistors is shown below (Figure 12).

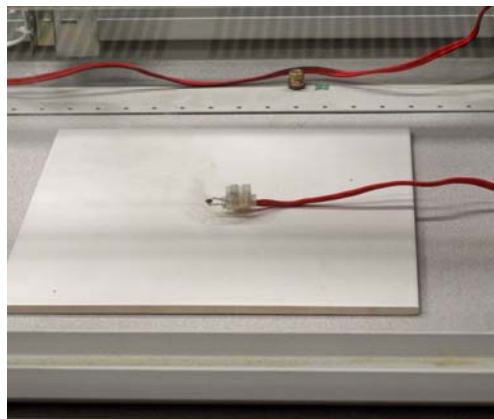


Figure 12 – Overheated Resistor Test.

Smoke Pellet Burning Test

This test method is a modified version of the FIA CoP for ASDs, Smoke Pellet Performance Test, designed to test Class C ASD systems, which are equivalent to point detectors. This test method utilizes a small amount of smoke pellet powder (2-4 grams), as the smoke source. The smoke test is shown below (Figure 13).

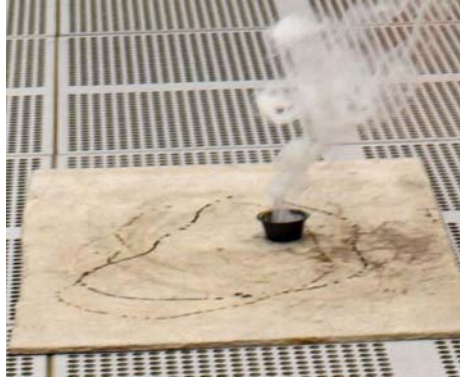


Figure 13 – Smoke Pellet Test.

Test Results

Activation Times

Detailed results (response times) for the VESDA and point detectors are included in Appendix A.

Table 2 and Table 3 present summaries of the average and range of activation times for tests performed over the 8 sessions.

Table 2 – Summary Test Results for Room Tests.

Test Location	First responded detector	Responded VESDA detectors	Average VESDA Alert times and ranges (s)			Point detector
			Ceiling	Return	Duct	
Worse-case location, L1	Ceiling (VLP)	All	93s (74-122s)	117s (99-154s)	159s (96-217s)	ND
Normal-case location, L2	Cabinet (VLF)	All	92s (63-128s)	99s (79-138s)	98s (78-138s)	ND
In front of grille, L3	Duct (VLC)	Duct	NA	(Not enough to count)	21s (17-24s)	ND
Normal-case location [#] , L7	Cabinet (VLF)	All	55s (37-94s)	43s (36-60s)	45s (30-61s)	(In some tests*)

[#]: Large-scale smoke test;

*: Reported above pre-alarm level in 3 out of 8 tests;

NA: Not Available (smoke was unable to reach the sampling points due to air flow and detector position);

ND: No Detection.

Table 3 - Summary Test Results for In-Cabinet Tests.

Test Location	Responded VESDA detectors	Average VESDA Alert times and ranges (s)		Point detector
		Cabinet	Return	
Cab. 1, L4 (1m cable)	Cabinet, Return	53s (47-64s)	76s (64-92s)	ND
Cab. 2, L5 (2 resistors)	Cabinet	26s (22-28s)	NA	NA
Cab. 3, L6 (1 resistor)	Cabinet, Return [#]	26s (24-28s)	37s [#] (28-47s)	ND

[#]: Missed 2 out of 8 tests;

NA: Not Available (smoke was unable to reach the sampling points due to air flow and detector position)

ND: No Detection.

Smoke Trends

Smoke trends varied between tests but generally showed obscuration levels peaking around 0.1 to 0.2 % obs/m.

Some typical smoke trends recorded by the VESDA detectors for each test are shown in the following figures:

- Test 1 smoke trend recorded by the Ceiling VLP: Figure 14;
- Test 2 smoke trend recorded by the Return VLC: Figure 15;
- Test 3 smoke trend recorded by the Duct VLC: Figure 16;
- Test 4 smoke trend recorded by the Cabinet VLF: Figure 17;
- Test 5 smoke trend recorded by the Cabinet VLF: Figure 18;
- Test 6 smoke trend recorded by the Cabinet VLF: Figure 19;
- Test 7 smoke trend recorded by the Ceiling VLP: Figure 20.

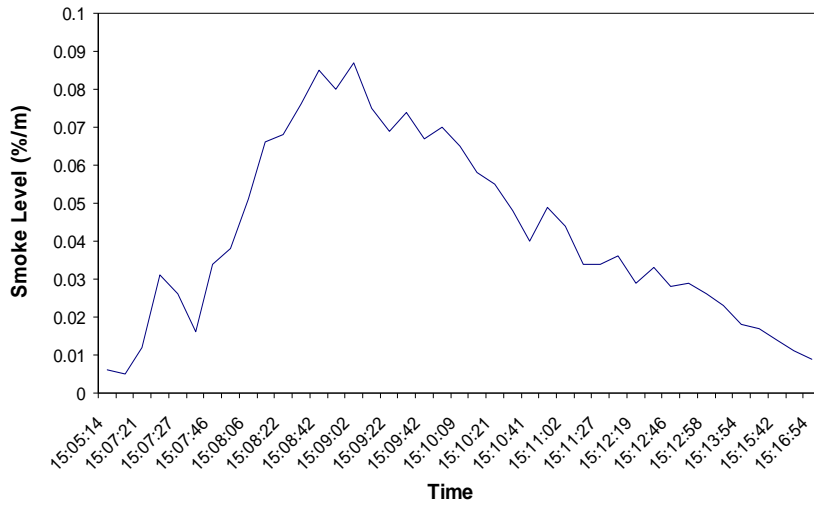


Figure 14 – VLP Smoke Trend of Test 1 (Session 2, 22nd Aug).

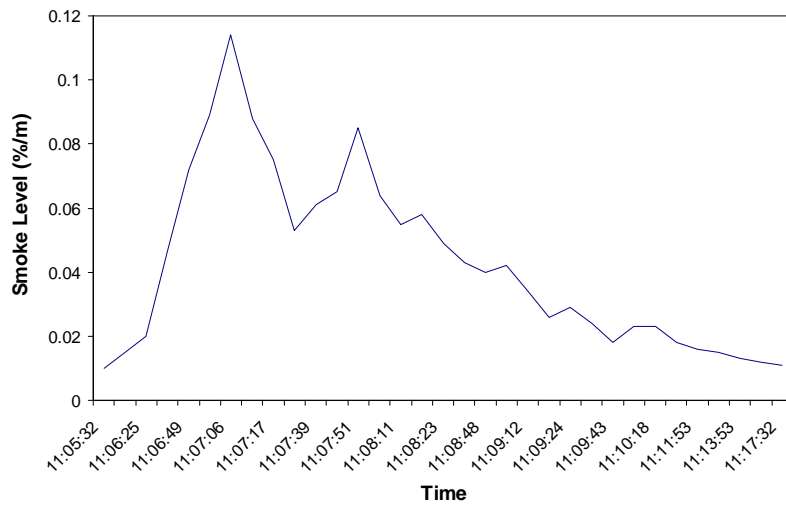


Figure 15 – VLC (Return) Smoke Trend of Test 2 (Session 1, 21st Aug)

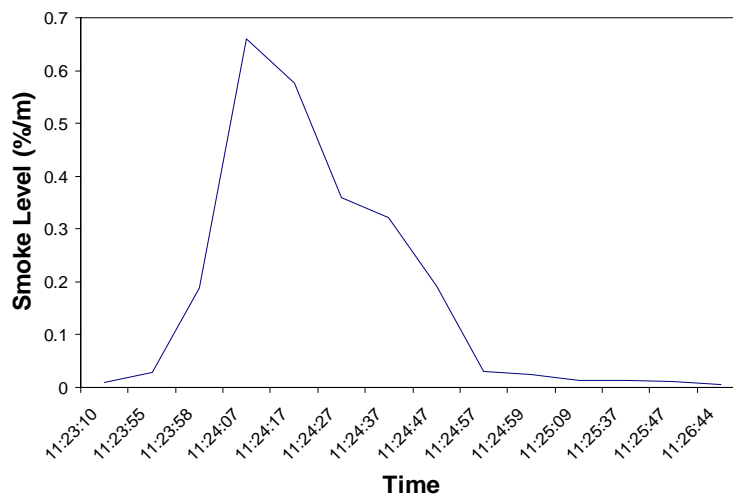


Figure 16 – VLC (Duct) Smoke Trend of Test 3 (Session 1, 23rd Aug).

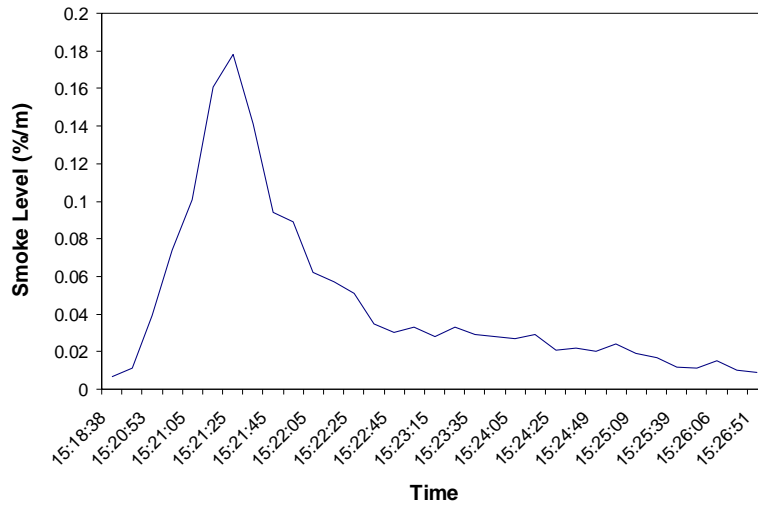


Figure 17 – VLF Smoke Trend of Test 4 (Session 2, 22nd Aug).

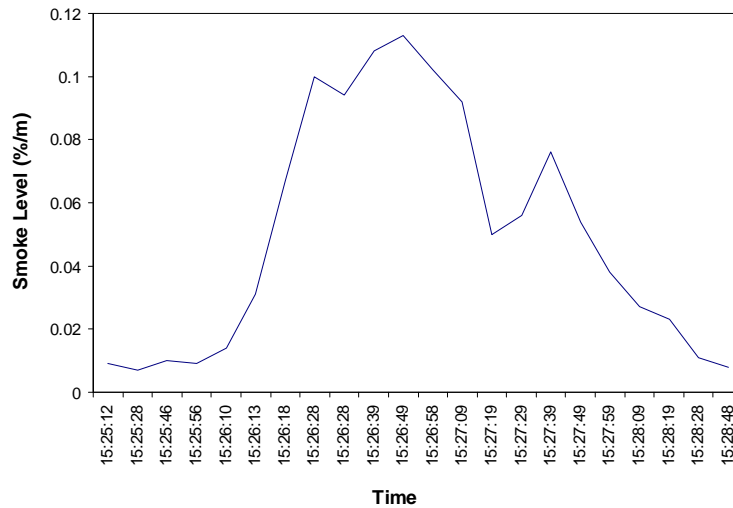


Figure 18 – VLF Smoke Trend of Test 5 (Session 1, 23rd Aug).

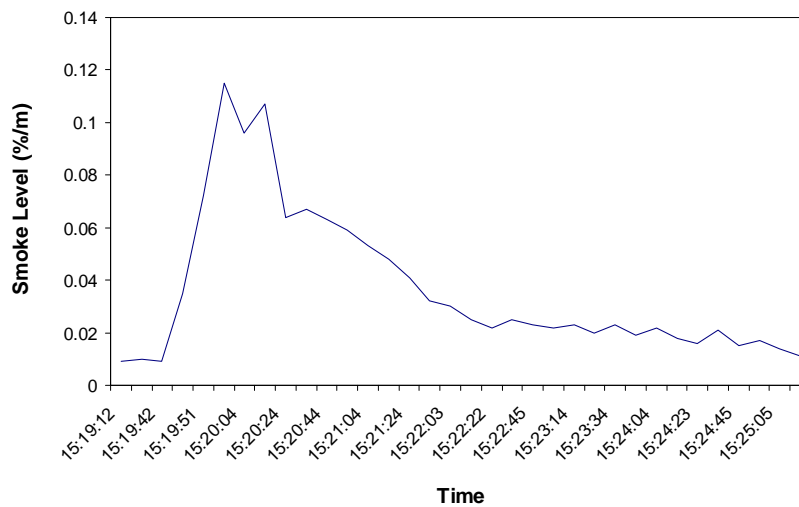


Figure 19 – VLF Smoke Trend of Test 6 (Session 1, 24th Aug).

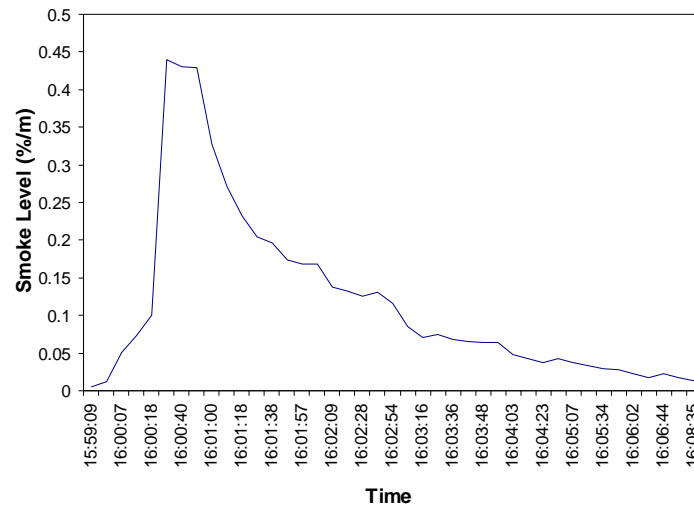


Figure 20 – VLP Smoke Trend of Test 7 (Session 2, 25th Aug).

Discussion

Table 2 shows the activation times from tests performed at four positions on the IT/Server room floor for point detectors and VESDA systems located on the ceiling, across the return air grille and in the first exhaust duct. The results show that the VESDA detectors for Ceiling and Return Air protection are capable of detecting low energy fires in the room within two minutes of activation, except when the fire source is close to the air return grille. The purpose for performing tests close to the return air grille (Test Location 3) was to assess smoke detection performance inside the duct. The point (spot-type) detectors did not detect smoke from tests performed in most locations.

The activation times for the in-cabinet tests are shown in Table 3 for the point (spot-type) detectors and VESDA systems installed for cabinet protection and at the return air grille. Results show that the VLF that was designed to protect those cabinets responded quickly (30 to 60 seconds) to fire/smoke inside the cabinets. In addition, the VLC for the Return Air protection detected smoke in the majority of the in-cabinet tests. Point (spot-type) detectors did not detect smoke from most in-cabinet tests.

The tests highlight the VESDA system consistency. For Test 1 and 2 (tests performed on the IT/Server room floor), the response times for VESDA smoke systems located at the Ceiling and Return Air are within approximately $\pm 35\%$ of the mean response times. For the in-duct and cabinet detection tests (Test 3 to 6), this response time range is reduced to approximately $\pm 20\%$ of the mean value.

The smoke trend graphs (Figure 14 to Figure 20) illustrate some typical low smoke obscuration levels the installed VESDA systems were able to detect, and the progression of the smoke level over time. Point (spot-type) detectors were mostly unable to produce any alarm events from these levels of smoke during the tests.

Conclusion

Reliable and very early fire detection is a vital requirement in IT/server rooms in allowing early intervention, preventing excessive damage to electronic equipment and operational downtime and the release of costly suppression agents.

The fire test demonstrations in the Xtralis IT/server room have highlighted the reliability and consistency of the VESDA system in providing very early warning (VEW) detection by successfully detecting fire incidents in their early developing (overheating) stage.

Point (spot-type) detectors proved incapable of providing VEW or EW detection.

Appendix A – Response Times

In following tables, “NA” means not available, and “ND” means no detection.

21st Aug., Session 1

Test No. & Location	VESDA time to Alert (seconds) (highest alarm)				Point Detector	Test requirement
	Ceiling (VLP)	Return (VLC)	Duct (VLC)	Cabinet (VLF)		
1. Cable x1m, Room L1	98 s (Alert)	109 s (Alert)	109 s (Alert)	85 s (Action)	ND	180 s (60+120)
2. Cable x1m, Room L2	88 s (Action)	89 s (Fire1)	89 s (Alert)	83 s (Fire1)	ND	180 s (60+120)
3. Cable x1m, Cabinet L3	ND	190 s (Alert)	23 s (Fire1)	ND	ND	180 s (60+120)
4. Cable x1m, Cabinet1	ND	88 s (Alert)	110 s (Alert)	50 s (Fire1)	ND	130 s (10+120)
5. Resistor x2, Cabinet 2	NA	NA	NA	28 s (Fire1)	NA	130 s (10+120)
6. Resistor x1, Cabinet 3	ND	28 s (Alert)	ND	26 s (Fire1)	ND	130 s (10+120)
7. Smoke Pellet, Room L2	37 s (Fire1)	39 s (Fire1)	39 s (Fire1)	30 s (Fire1)	(Pre-Alarm & Action)	135 s (15+120)

22nd Aug., Session 1

Test No. & Location	VESDA time to Alert (seconds) (highest alarm)				Point Detector	Test requirement
	Ceiling (VLP)	Return (VLC)	Duct (VLC)	Cabinet (VLF)		
1. Cable x1m, Room L1	122 s (Alert)	154 s (Action)	217 s (Action)	154 s (Alert)	ND	180s (60+120)
2. Cable x1m, Room L2	123 s (Fire1)	103 s (Fire1)	109 s (Action)	126 s (Action)	ND	180s (60+120)
3. Cable x1m, Cabinet L3	ND	ND	24 s (Fire1)	ND	ND	180s (60+120)
4. Cable x1m, Cabinet1	ND	ND	103 s (Fire1)	56 s (Fire1)	ND	130s (10+120)
5. Resistor x2, Cabinet 2	NA	NA	NA	26 s (Fire1)	NA	130s (10+120)
6. Resistor x1, Cabinet 3	ND	ND	ND	25 S (Fire1)	ND	130s (10+120)
7. Smoke Pellet, Room L2	39 s (Fire1)	36 s (Fire1)	30 s (Fire1)	26 s (Fire1)	ND	180s (60+120)

22nd Aug., Session 2

Test No. & Location	VESDA time to Alert (seconds) (highest alarm)				Point Detector	Test requirement
	Ceiling (VLP)	Return (VLC)	Duct (VLC)	Cabinet (VLF)		
1. Cable x1m, Room L1	81 s (Action)	125 s (Action)	150 s (Alert)	120 s (Alert)	ND	180s (60+120)
2. Cable x1m, Room L2	105 s (Action)	108 s (Fire1)	119 s (Action)	107 s (Fire1)	ND	180s (60+120)
3. Cable x1m, Cabinet L3	ND	ND	19 s (Fire1)	ND	ND	180s (60+120)
4. Cable x1m, Cabinet1	ND	ND	100 s (Alert)	47 s (Fire1)	ND	130s (10+120)
5. Resistor x2, Cabinet 2	NA	NA	NA	25 s (Fire1)	NA	130s (10+120)
6. Resistor x1, Cabinet 3	ND	47 s (Alert)	ND	26 S (Fire1)	ND	130s (10+120)
7. Smoke Pellet, Room L2	48 s (Fire1)	36 s (Fire1)	40 s (Fire1)	38 s (Fire1)	ND (Fire *)	180s (60+120)

*: After more fuel added and VESDA reached Fire2 alarm.

23rd Aug., Session 1

Test No. & Location	VESDA time to Alert (seconds) (highest alarm)				Point Detector	Test requirement
	Ceiling (VLP)	Return (VLC)	Duct (VLC)	Cabinet (VLF)		
1. Cable x1m, Room L1	108 s (Action)	110 s (Action)	130 s (Alert)	140 s (Alert)	ND	180s (60+120)
2. Cable x1m, Room L2	128 s (Action)	138 s (Action)	138 s (Action)	114 s (Action)	ND	180s (60+120)
3. Cable x1m, Cabinet L3	ND	ND	24 s (Fire1)	ND	ND	180s (60+120)
4. Cable x1m, Cabinet1	ND	67 s (Alert)	67 s (Alert)	48 s (Fire1)	ND	130s (10+120)
5. Resistor x2, Cabinet 2	NA	NA	NA	26 s (Fire1)	NA	130s (10+120)
6. Resistor x1, Cabinet 3	ND	38 s (Alert)	ND	26 S (Fire1)	ND	130s (10+120)
6B. Cable x1m, Cabinet 3	63 s (Alert)	52 s (Action)	50 s (Alert)	46 S (Fire1)	ND	180s (60+120)
7. Smoke Pellet, Room L2	60 s (Fire2)	51 s (Fire2)	51 s (Fire2)	48 s (Fire2)	(Fire *)	150s (30+120)

*: After more fuel added and VESDA reached Fire2 alarm.

23rd Aug., Session 2

Test No. & Location	VESDA time to Alert (seconds) (highest alarm)				Point Detector	Test requirement
	Ceiling (VLP)	Return (VLC)	Duct (VLC)	Cabinet (VLF)		
1. Cable x1m, Room L1	91 s (Alert)	99 s (Action)	96 s (Action)	89 s (Fire1)	ND	180s (60+120)
2. Cable x1m, Room L2	71 s (Fire1)	80 s (Action)	81 s (Action)	62 s (Action)	ND	180s (60+120)
3. Cable x1m, Cabinet L3	ND	24 s (Action)	20 s (Fire1)	ND	ND	180s (60+120)
4. Cable x1m, Cabinet1	ND	64 s (Alert)	ND	64 s (Fire1)	ND	130s (10+120)
5. Resistor x2, Cabinet 2	NA	NA	NA	26 s (Fire1)	NA	130s (10+120)
6. Resistor x1, Cabinet 3	ND	36 s (Alert)	ND	28 S (Fire1)	ND	130s (10+120)
6B. Cable x1m, Cabinet 3	65 s (Fire1)	42 s (Fire1)	53 s (Action)	30 S (Fire1)	ND	180s (60+120)
7. Smoke Pellet, Room L2	44 s (Fire2)	43 s (Fire2)	58 s (Fire2)	30 s (Fire2)	(Action *)	150s (30+120)

*: After more fuel added and VESDA reached Fire2 alarm.

24th Aug., Session1

Test No. & Location	VESDA time to Alert (seconds) (highest alarm)				Point Detector	Test requirement
	Ceiling (VLP)	Return (VLC)	Duct (VLC)	Cabinet (VLF)		
1. Cable x1m, Room L1	78s (Fire1)	122 s (Alert)	137 s (Alert)	113 s (Alert)	ND	180 s (60+120)
2. Cable x1m, Room L2	63 s (Fire1)	90 s (Fire1)	90 s (Fire1)	77 s (Fire1)	ND	180s (60+120)
3. Cable x1m, Cabinet L3	ND	21 s (Action)	18 s (Fire1)	ND	ND	180s (60+120)
4. Cable x1m, Cabinet1	ND	92 s (Action)	69 s (Alert)	54 s (Alert)	ND	130s (10+120)
5. Resistor x2, Cabinet 2	NA	NA	NA	28 s (Action)	NA	130s (10+120)
6. Resistor x1, Cabinet 3	ND	33 s (Alert)	ND	25 S (Fire1)	ND	130s (10+120)
7. Smoke Pellet, Room L2	51 s (Fire1)	46 s (Fire1)	46 s (Fire1)	40 s (Fire2)	(Action *)	150s (30+120)

*: After more fuel added and VESDA reached Fire2 alarm.

25th Aug., Session 1

Test No. & Location	VESDA time to Alert (seconds) (highest alarm)				Point Detector	Test requirement
	Ceiling (VLP)	Return (VLC)	Duct (VLC)	Cabinet (VLF)		
1. Cable x1m, Room L1	74 s (Fire1)	101 s (Action)	144 s (Alert)	92 s (Alert)	ND	180s (60+120)
2. Cable x1m, Room L2	71 s (Action)	79 s (Fire1)	79 s (Fire1)	59 s (Fire1)	ND	180s (60+120)
3. Cable x1m, Cabinet L3	ND	ND	18 s (Fire1)	ND	ND	180s (60+120)
4. Cable x1m, Cabinet1	ND	ND	ND	54 s (Action)	ND	130s (10+120)
5. Resistor x2, Cabinet 2	NA	NA	NA	22 s (Fire1)	NA	130s (10+120)
6. Resistor x1, Cabinet 3	ND	33 s (Alert)	ND	25 S (Fire1)	ND	130s (10+120)
7. Smoke Pellet, Room L2	94 s (Fire1)	60 s (Fire1)	60 s (Fire1)	52 s (Fire1)	ND	150s (30+120)

25th Aug., Session 2

Test No. & Location	VESDA time to Alert (seconds) (highest alarm)				Point Detector	Test requirement
	Ceiling (VLP)	Return (VLC)	Duct (VLC)	Cabinet (VLF)		
1. Cable x1m, Room L1	99s (Fire1)	129 s (Action)	145 s (Action)	137 s (Alert)	ND	180s (60+120)
2. Cable x1m, Room L2	75 s (Action)	86 s (Fire1)	78 s (Action)	68 s (Fire1)	ND	180s (60+120)
3. Cable x1m, Cabinet L3	ND	ND	17 s (Fire1)	ND	ND	180s (60+120)
4. Cable x1m, Cabinet1	ND	68 s (Alert)	71 s (Alert)	50 s (Fire1)	ND	130s (10+120)
5. Resistor x2, Cabinet 2	NA	NA	NA	28 s (Fire1)	NA	130s (10+120)
6. Resistor x1, Cabinet 3	ND	ND	ND	24 s (Fire1)	ND	130s (10+120)
7. Smoke Pellet, Room L2	70 s (Fire1)	35 s (Fire1)	36 s (Fire1)	31 s (Fire2)	(Fire on Return *)	150s (30+120)

*: After more fuel added and VESDA reached Fire2 alarm.

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