# Xtralis

## Lara Prison Fire Detection Tests

# White Paper

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# Preface

A series of fire detection tests were conducted in a training facility of the Correctional Authority Victoria in Lara on 14th August 2019. Presented in this document are descriptions of the test set-up, detectors under testing and detection performances.

# Related Products

VESDA-E VES, VESDA VLF and FAAST LT.

# Introduction

With the generous support from Correctional Authority Victoria (CAV), Xtralis conducted a series of fire tests in a prison cell at CAV's training facility, Lara. The purpose of the tests was to investigate detection performances from a series of Xtralis products, which are commonly used in prisons applications across Australia, based on common fire scenarios found in a prison environment. The tests were performed on 14th August 2019, and witnessed by state correctional authorities and fire protection consultants.

# Test cell and set-up

The test cell's dimensions are 3.5m(L) x 2.6m(W) x 2.7m(H), as illustrated in Figure 1.

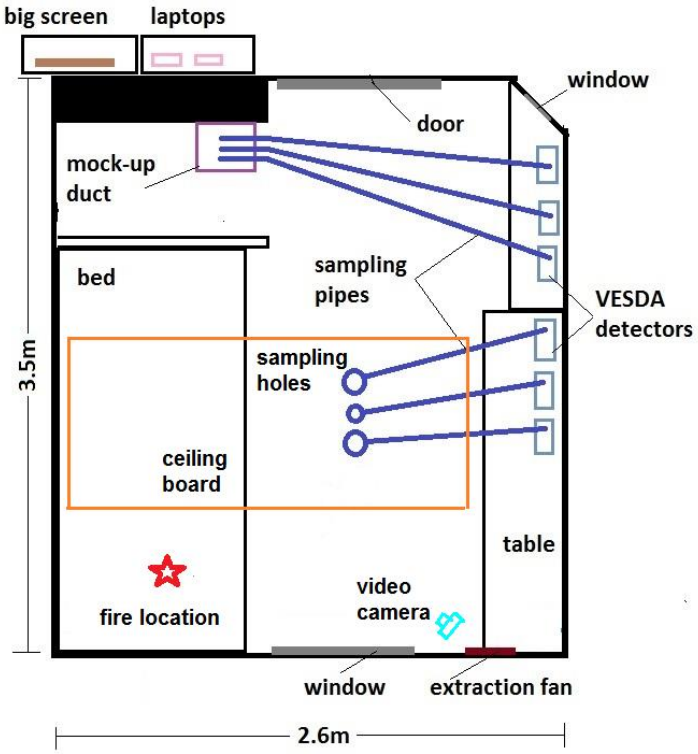


*Figure 1: Test cell layout*

A flat ceiling board was mounted in the centre of the cell, marked in orange colour (Figure 1). Three tamper-proof sampling points developed by Xtralis (Xtralis part number VSP-610) were mounted on the board to test under ceiling detection performance as shown in Figure 2.

*Figure 2: Tamper-proof sampling points on the board*

A mock-up duct work, illustrated in Figure 3, was mounted at the location of a normal ventilation grille to test in-duct detection performance. The air flow rate through the duct by its circulation fan was approximately 14 Litre/s.

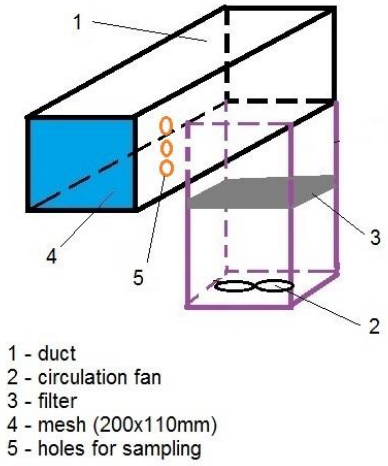


*Figure 3: Mock-up duct*

There was an extraction fan on back of the cell, which was turned on after each test to extract smoke out of the cell and was turned off during the tests. The cell environment for the tests was in still air condition.

# Test Methods and Fuels

Four tests were performed to represent fire risks in a correctional application. The test methods were developed from standardised tests from number of international codes/standards with necessary adjustments on the fuel quantities.

## PU Foam – Flaming

Representing a mattress fire, as shown in Figure 4, which is a worst-case scenario for life safety. It is referred to TF4 of EN 54-20; details of the test method are presented in Appendix A. The actual foam size tested is 150mm x 150mm x 20mm.

*Figure 4: PU foam fire – captured by the video camera*

## Newsprint – Smouldering to Flaming

Representing burning of newspaper and books which normally exist in a prison cell, as shown in Figure 5. It is a normal-case scenario for fire detection. It is modified from UL 268; details of the test method are presented in Appendix B. The actual fuel quantity tested is approximately 6g.

*Figure 5: newsprint burning – captured by the video camera*

## Cotton Wicks – Smouldering

Representing initial stage of burning clothes and beddings, shown in Figure 6. It's a worst-case scenario for fire detection. It is referred to TF3A of EN 54-20; details of the test method are presented in Appendix C. The actual fuel quantity tested is 6 pcs in length of 15cm each.

*Figure 6: cotton wick burning – captured by the video camera*

## Smoke Pellet – Smouldering

A standardized method to investigate smoke movement and test detector response in various environments, shown in Figure 7. It is referred to FIA CoP for ASD; details of the test method are presented in Appendix D. The actual fuel quantity tested is half of a 3g pellet.

*Figure 7: Smoke pellet burning – captured by the video camera*

The above four tests were repeated during the day. Schedule of the tests in the two rounds is shown in Table 1.

Table 1: Schedule of the prison cell tests

| Test No. | Test Method | Duct Fan |
|---|---|---|
| 1 | Smoke pellet | On |
| 2 | Smouldering newsprint | On |
| 3 | Smouldering cotton wicks | On |
| 4 | Flaming PU foam | On |
| 5 | Flaming PU foam | Off |

# Detectors and Configurations

There are 3 models of air sampling smoke detectors (ASDs) tested at the two sampling locations, under the ceiling and in-duct.

- VESDA VLF – device for protecting single cell
- VESDSA-E VES – next generation of scanning type VESDA detector, protecting 4 cells
- FAAST LT – device for protecting two cells

The detectors were configured to sampling point sensitivities shown in Table 2. Zero delay (verification) time was applied to the alarms. Where multiple inlets (pipes) is available in a detector, the inlets other than the one sampling smoke supplied clean air.

Table 2: Alarm sensitivities of the detectors

| Detector | Alarm 1 | | Alarm 2 | |
|---|---|---|---|---|
| VLF | Class A | 1.5%/m | Class C | 6%/m |
| VES | | | | |
| LT | | | | |

The detector arrangements in the two rounds of the tests are shown in Table 3.

Table 3: Detector arrangements

| Test Round | Under Ceiling | In-duct |
|---|---|---|
| 1 | VLF-C<br>VES-C | VLF-D<br>VES-D |
| 2 | VLF-C<br>LT-C | VLF-D<br>LT-D |

# Results

The test results are shown in Table 4 to

Table 12. The cells with the alarm times in blank mean the alarm thresholds were not reached at the detectors.

## Round 1: Morning tests

Table 4: Alarm times (seconds) and peak levels in Test 1 – smoke pellet

| | Test 1 | | | |
|---|---|---|---|---|
| **Detector** | **Class A** | **Class C** | **Peak** | **Note** |
| VLF-C | 34 | 35 | 32%/m | Saturated |
| VES-C | 59 | | 4%/m | |
| VLF-D | 48 | 52 | 8.9%/m | |
| VES-D | 68 | | 2.4%/m | |

**Note:** 22 seconds delay in ignition was subtracted from all the times.

Table 5: Alarm times (seconds) and peak levels in Test 2 – newsprint

| | Test 2 | | | |
|---|---|---|---|---|
| **Detector** | **Class A** | **Class C** | **Peak** | **Note** |
| VLF-C | 159 | 233 | 32%/m | Saturated |
| VES-C | 267 | 267 | 17.7%/m | |
| VLF-D | 196 | 244 | 14.4%/m | |
| VES-D | 204 | 267 | 13.8%/m | |

Table 6: Alarm times (seconds) and peak levels in Test 3 – cotton wicks

| | Test 3 | | | |
|---|---|---|---|---|
| **Detector** | **Class A** | **Class C** | **Peak** | **Note** |
| VLF-C | 46 | 72 | 13.5%/m | |
| VES-C | 80 | | 5.6%/m | |
| VLF-D | 200 | | 5%/m | |
| VES-D | 348 | | 2%/m | |

Table 7: Alarm times (seconds) and peak levels in Test 4 – PU foam

| | Test 4 | | | |
|---|---|---|---|---|
| **Detector** | **Class A** | **Class C** | **Peak** | **Note** |
| VLF-C | 42 | | 3.9%/m | |
| VES-C | 64 | | 5.99%/m | |
| VLF-D | 75 | | 3.8%/m | |
| VES-D | 82 | 106 | 6.4%/m | |

Table 8: Alarm times (seconds) and peak levels in Test 5 – PU foam (duct fan off)

| | Test 5 - Duct fan OFF | | | |
|---|---|---|---|---|
| **Detector** | **Class A** | **Class C** | **Peak** | **Note** |
| VLF-C | 35 | | 4.2%/m | |
| VES-C | 69 | | 5.8%/m | |
| VLF-D | 88 | | 3.1%/m | |
| VES-D | 86 | | 5.7%/m | |

## Round 2: Afternoon tests

Table 9: Alarm times (seconds) and peak levels in Test 6 – smoke pellet

| | Test 6 | | | |
|---|---|---|---|---|
| **Detector** | **Class A** | **Class C** | **Peak** | **Note** |
| VLF-C | 21 | 24 | 20%/m | |
| LT-C | 35 | 35 | >=6%/m | |
| VLF-D | 110 | 160 | 10%/m | |
| LT-D | 126 | | >=4.5%/m | |

Table 10: Alarm times (seconds) and peak levels in Test 7 – newsprint

| | Test 7 | | | |
|---|---|---|---|---|
| **Detector** | **Class A** | **Class C** | **Peak** | **Note** |
| VLF-C | 36 | 38 | 18.7%/m | |
| LT-C | 37 | | >=1.5%/m | |
| VLF-D | 40 | 55 | 13.2%/m | |
| LT-D | 42 | | >=4.5%/m | |

Table 11: Alarm times (seconds) and peak levels in Test 8 – cotton wicks

| | Test 8 | | | |
|---|---|---|---|---|
| **Detector** | **Class A** | **Class C** | **Peak** | **Note** |
| VLF-C | 66 | 101 | 7.3%/m | |
| LT-C | 90 | | >=1.5%/m | |
| VLF-D | 390 | | 2.1%/m | |
| LT-D | >7min | | >=1.5%/m | |

Table 12: Alarm times (seconds) and peak levels in Test 9 – PU foam

| | Test 9 | | | |
|---|---|---|---|---|
| **Detector** | **Class A** | **Class C** | **Peak** | **Note** |
| VLF-C | 40 | | 4.2%/m | |
| LT-C | 72 | | >=1.5%/m | |
| VLF-D | 77 | | 3.8%/m | |
| LT-D | 103 | | >=1.5%/m | |

## Additional Smoking Trials

Two additional trials of detecting smoking cigarettes inside the cell were performed by a voluntary staff. The trials involve “normal” smoking of a single cigarette, with the duct fan off and on. Shown in Table 13 are the alarm times and peak smoke levels reached.

Table 13: Alarm time (seconds) and peaks in cigarette smoking tests

| Trial 1 (duct fan off) | | | | Trial 2 (duct fan on) | | | |
|---|---|---|---|---|---|---|---|
| **Detector** | **Class A** | **Class C** | **Peak Level** | **Detector** | **Class A** | **Class C** | **Peak Level** |
| VLF-C | 28 | 53 | 8.2%/m | VLF-C | 24 | 115 | 8.1%/m |
| VES-C | 62 | | 2.6%/m | LT-C | 126 | | >=1.5%/m |
| VLF-D | 160 | | 1.5%/m | VLF-D | 100 | | 2%/m |
| VES-D | | | 0.7%/m | LT-D | | | >=0.33%/m |

# Observations and Findings

In tests with productions of dense smoke (like smoke pellet test) and certain heat (like PU foam test), it is found that the ceiling detection was quick at reporting Class A alarms, at a time from 21 to 72 seconds, as shown in Test 1, 3, 6 and 9. A flaming PU foam burning, like from a mattress, will spread quickly and widely if no intervention applied in the first time. Therefore, it is quite possible to trigger Class C detections from both detection locations very quickly. The in-duct detections in these tests are late, approximately 30 seconds from the same model of the detectors, except in the smoke pellet test (Test 6) in which over 80 seconds alarm time difference exists.

Great variation exists in the paper burning tests. When longer smouldering stage exists, as in Test 2, slower responses were found from all the detectors, but Class C alarms registered. As the smouldering transits into flaming quickly, as in Test 7, alarm times of Class A were reduced from the range of 159 to 267 seconds (in Test 2) to the range of 36 to 42 seconds (in Test 7). However, no Class C alarms registered by all the detectors in Test 7. Therefore, Class A detection is preferred to detect paper burning with varying combustion profiles.

The cotton wick burning shows challenge to the detections particularly in-duct detection. In-duct detection is 150 to 330 seconds later than the ceiling detection at Class A alarm. Only VESDA VLF under ceiling registered Class C alarm in the two tests. Therefore, the detector with high sensitivity and sampling from a single cell, such as VLF, is required to detect cotton wick burning at such an early stage.

Comparing the peak smoke levels reached in the tests, the in-duct sampling has approximately ½ to ¼ of the ceiling sampling readings, except the flaming PU foam burning, in which similar peak levels were reached at the two detection locations.

# Conclusions and Recommendations

All the tested ASD detectors are capable of registering a Class A alarm in response to the incipient fires tested. The ceiling detection times were between 30 and 90 seconds. The in-duct detection Alarm times were longer than the ceiling detections, by 15 to 150 seconds.

Class C alarms were generated in tests where dense smoke was produced, such as smoke pellet and newsprint. Sampling from single cell, VLF registered the most number of Class C alarms. It may be selected if Class C is desired for prison cell protection and alarms should be registered to the fire sizes of the tested.

Multi-zone ASDs, such as VESDA-E VES, registered Class A alarms in all the tests, but few number of Class C alarms. Class C detection may be achieved from bigger size fires than the tested incipient fires.

For in-duct detection option, particularly from the multi-zone of ASDs, higher level of protection such as Class B is recommended. This achieves a compromise between earlier detection and the possibility of nuisance alarms.

# Appendix A – Flaming PU foam test (EN54-20)

## Annex F
(normative)

## Flaming plastics (polyurethane) fire (TF4)

### F.1 Fuel

Soft polyurethane foam, without flame retardant additives and having a density of approximately 20 kg $m^{-3}$ . Three mats, approximately 50 cm x 50 cm x 2 cm are usually found sufficient, however the exact fuel quantity may be adjusted to obtain valid tests.

### F.2 Arrangement

The mats shall be placed one on top of the another on a base formed from aluminium foil with the edges folded up to provide a tray.

### F.3 Ignition

The mats shall normally be ignited at a cornet of the lower mat, however the exact position of ignition may be adjusted to obtain valid tests. A small quantity of a clean burning material (e.g. 5$cm^3$ of methylated spirit) may be used to assist the ignition.

### F.4 End of test condition

$y_E$=6

### F.5 Test validity criteria

The development of the fire shall be such that the curves of *m* against *y*, and *m* against time fall within the limits shown in Figures F.1 and F.2 respectively, up to the time when *y* =6, or the specimen has generated an alarm signal, whichever is the earliest.

# Appendix B – Smouldering to Flaming paper test (UL 268)

### 41.2 Paper fire

41.2.1 The following materials and procedures shall be used for the paper fire test. Dimensions and locations of test apparatus are intended for reference only. The smoke produced in this Subsection (Paper Fire) shall have a particle composition that falls within specified profiles and may require the adjustment of the fuel quantity to achieve that result.

### 41.2.2 The materials and procedures shall be used as follows:

a) Combustible – Shredded newsprint is to be cut in strips as follows:

| | In the United States | In Canada |
|---|---|---|
| **Width** | 6 – 10 mm (0.25 – 0.375 inch) | 6 -10 mm (0.25 – 0.375 inch) |
| **Length** | 25.4 – 102 mm (1 – 4 inches) | 25.4 – 102 mm (1 – 4 inches) |
| **Total Weight** | 42.6 g (1.5 oz) | 28.3 g (1 oz) |

1) In the United States – The paper is to be placed into the receptacle, see (b), with the bottom covered temporarily by a flat plate. The receptacle is to be tamped periodically during the pouring operation until the paper contents are even with the top of the receptacle. The paper is then to be further tamped by hand or by a rod 25.4 mm (1 inch) in the diameter until the paper level is 102 mm (4 inches) below the top edge of the receptacle. A hole 25.4 mm (1 inch) in diameter is to be formed through the centre from top to bottom of the paper. The temporary bottom plate is then to be removed and the assembly mounted 0.9 m (3 feet) above the floor on a 127-mm (5-inch) diameter ring support.
2) In Canada – The paper should be placed into the receptacle to a height of 115 mm with 25 mm diameter hole in centre.

b) Receptacle – To be formed of sheet metal seamed together with no air gap at the seam (open at both ends). Dimensions are as follow:

| | In the United States | In Canada |
|---|---|---|
| **Thickness** | 0.40 mm ±2 mm (0.031 inch ±0.08 inch) | 0.40 mm ±2 mm (0.031 inches ±0.08 inch) |
| **Diameter** | 101 mm ±2 mm (4 inches ±0.08 inch) | 101 mm ±2 mm (4 inches ±0.08 inch) |
| **Height** | 300 mm ±2 mm (12 inches ±0.08 inch) | 175 mm ±2 mm (6.9 inches ±0.08 inch) |
| Support flange at the bottom 152 mm ±2 mm (6 inch ± .08 inch). Wire screen of 18 AWG (0.82 $mm^2$) wire, 6.4 mm (1/4 inch) minimum mesh. | | |

c) Point of Ignition – The probe tips of the igniter shall be placed at the bottom centre of the receptacle and arcing sustained for up to 5 seconds.

d) Smoke profile – The test fire shall follow the test profile for the respective country. The test shall be terminated 4 minutes after ignition. The response time of each detector shall not be more than 4 minutes.

1) In the United States refer to Figure 9. Additionally, the following conditions apply:
   i. Flame breakthrough is to occur at between 1 and 3 minutes.
   ii. The first principle peak is to occur at between 1 and 3 minutes.

# Appendix C – Smouldering cotton wick test (EN54-20)

## Annex E
(normative)

## Reduced glowing smouldering cotton fire (TF3A and TF3B)

### E.1 Fuel

Approximately 30 or 40 pieces of braided cotton wick, each approximately 80 cm long and weighing approximately 3 g. The wicks shall be free from ant protective coating and shall be washed and dried if necessary.

### E.2 Arrangement

The wicks shall be fastened to a ring approximately 10 cm in diameter and suspended approximately 1 m above a non-combustible plate. The wicks shall be positioned adjacent to one another and the remaining open part of the arc shall be completed using a curved sheet on non-combustible material to complete the “chimney” as shown in Figure E.1.

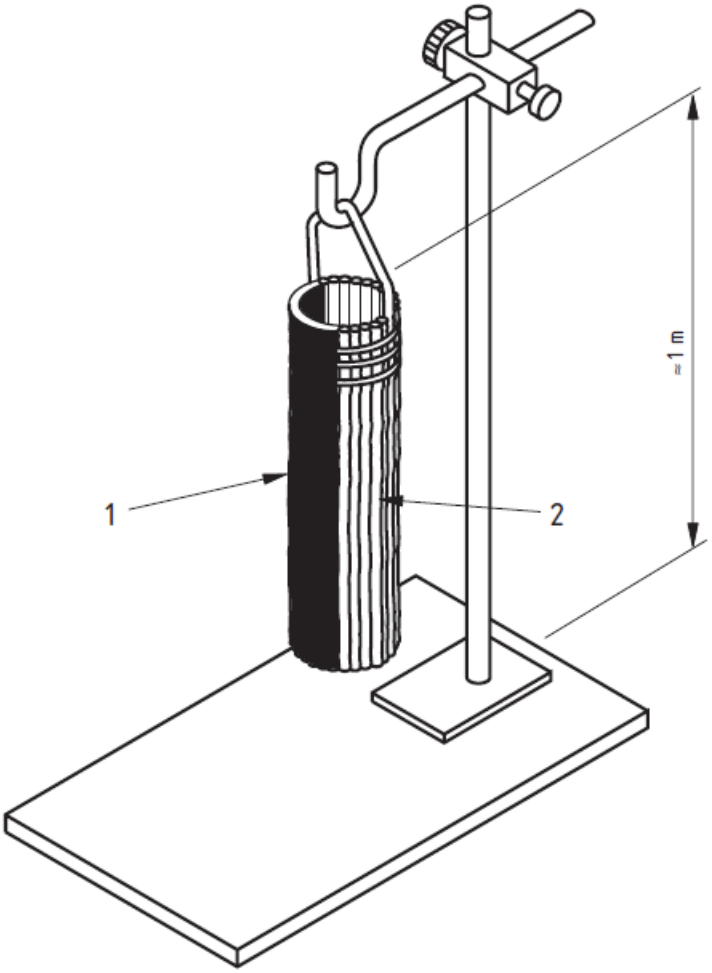


Figure E.1: Arrangmnet of theh cotton wicks

### E.3 Ignition

The lower end of each wick shall be ignited so that the wicks continue to glow. Any flaming shall be blown out immediately. The test time shall start when all wicks are glowing.

# Appendix D – Smouldering cotton wick test (FIA CoP)

### B.1 System Performance Test Using a Single 7-9g Smoke Pellet

#### B.1.1 Apparatus

B.1.1.1 Butane gas burner (or equivalent electrical heater) with an output of 5.8 KW.

Note: A 58 KW burner burn ~10 g of butane is 70 seconds.

B.1.1.2 Metal plate, at least 200 mm square.

B.1.1.3 Metal chimney, 2 mm to 6 mm thick, formed into a cylinder of at least 100 mm diameter and at least 150 mm high. Either the base of the chimney or the metal plate should have holes to provide ventilation for the chimney.

B.1.1.4 Calibrated stop clock or stop watch, capable of measuring in 1 s intervals.

B.1.1.5 One smoke pellet of weight 7 g to 9 g.

#### B.1.2 Procedure

B.1.2.1 Place the metal platen upon the burner and place the pellet(s) centrally on the platen.

B.1.2.2 Place the chimney centrally around the pellet.

B.1.2.3 Ignite the burner and start the tines when the pellet starts producing smoke.

B.1.2.4 Operate the burner for the appropriate length of time as indicated by Table B.1.

B.1.2.5 When the determined time (see Table B.1) has elapsed, extinguish the burner.

Note: The pellet will continue to produce smoke when the burner has been extinguished (typically 30 seconds to 60 seconds) but thermal lift will not occur.

#### B.1.3 Pass/Fail criteria

The system is deemed to have passed the test if the detection system registers a response within 180 seconds of the burner being switched off.

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