REPORT ON THE LARGE-SCALE FIRE PROPAGATION PROPERTIES OF 80 mm THICK EXPANDED POLYSTYRENE (FR GRADE) UNDER-ROOF AND SIDE CLADDING INSULATION MATERIALS USING THE SANS 10177-11 TEST METHOD

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2. USE OF THIS REPORT

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3. PURPOSE OF THE INVESTIGATION

The purpose of the investigation was to evaluate the large-scale fire propagation properties of 80 mm thick expanded polystyrene (EPS) boards as an insulated system for thermal insulated building envelopes. The insulating system was tested for both under-roof and side cladding applications. The fire propagation properties of the thermal insulation system were also determined when installed in conjunction with a fixed sprinkler extinguishment system using slow response sprinkler heads.

The EPS material used in all of the evaluations was of the FR grade. The 80 mm thick boards had no facing, similar to those previously tested in the inverted channel tunnel (SANS 10177-10).

For all of the evaluations the specimen frames were aligned in such a way that the roof slope was equal to 3 degrees. The distance between the top of the fire source and the roof directly above it was 2.7 metres in all instances.

4. TEST PROCEDURE

The large-scale fire propagation properties of the system were evaluated by performing a series of three tests in the FIRELAB large-scale roof insulation test facility. A schematic diagram of the test facility with the specimen frames are shown in Figure 1.

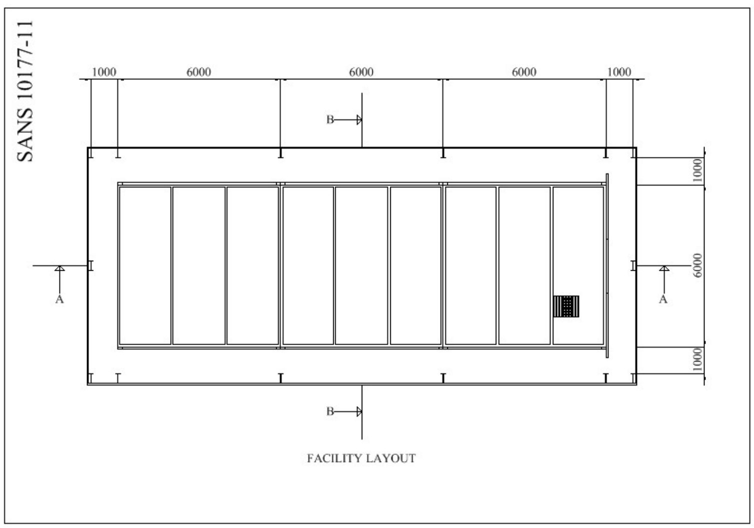

Figure 1: SANS 10177 test facility with specimen frames

The ignition source for the two under-roof evaluations was constructed from 60 kg dry 38mm x 38 mm SA Pine sticks stacked in an open-crib configuration to form a 1 000 mm x 750 mm x 480 mm high crib. The pack was ignited with 4 commercial firelighters, one at each corner, in order to simulate a fire with slow heat build-up. The fire source was located at one end of the facility, approximately 1.5 m from the front end, 1.5 m from the side and 1.5 m from the centre line of the specimen frame. The position of the crib was directly below the first sprinkler position on the right hand side of the facility as indicated on the attached schematic layout.

For the side cladding test two small SA Pine timber cribs (7.5 kg each) were used. The cribs were placed against the insulation on either side of the centre line of the side cladding frame 600mm apart.

No mass loss measurements were taken during the evaluations.

4.1 Evaluation without sprinklers

One test was performed simulating an under-roof installation without a sprinkler system. This evaluation (Test 1) investigated the fire propagation properties of the insulating material when used as an over-pulin application with the purlins positioned across the width of the test facility.

A schematic side view of a typical roof test installation is shown in Figure 2.

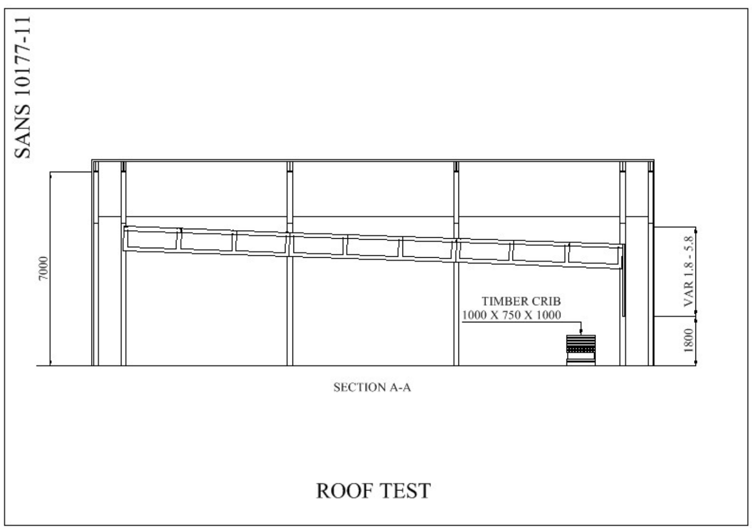

Figure 2: Typical roof test installation in the SANS 10177 Part 11 facility

4.2 Evaluation with sprinklers

Another evaluation (Test 2) was performed on the insulation system, installed similarly to the Test 1 installation, using slow response sprinkler heads (which activate at 141 ºC). Only the first two panels nearest to the fire source were fitted with a sprinkler system. Seven sprinklers were utilised, one at the centre of each quadrant of the specimen frame with the sprinkler head directly above the fire source being blocked off. In all cases the sprinklers were installed 300 mm below the insulation material.

4.3 Side cladding evaluation

The fire propagation properties associated with the use of this insulation system in a side cladding application were investigated during this evaluation (Test 3). A vertical specimen frame was fitted to the front end of the test installation against the first horizontal hanging frame. The insulation material was installed onto the inside between the horizontal purlins and the cladding as would be done in practice for vertical applications. The fire source was placed in the centre of the vertical frame as described earlier in this section. A typical installation is shown schematically in Figure 3.

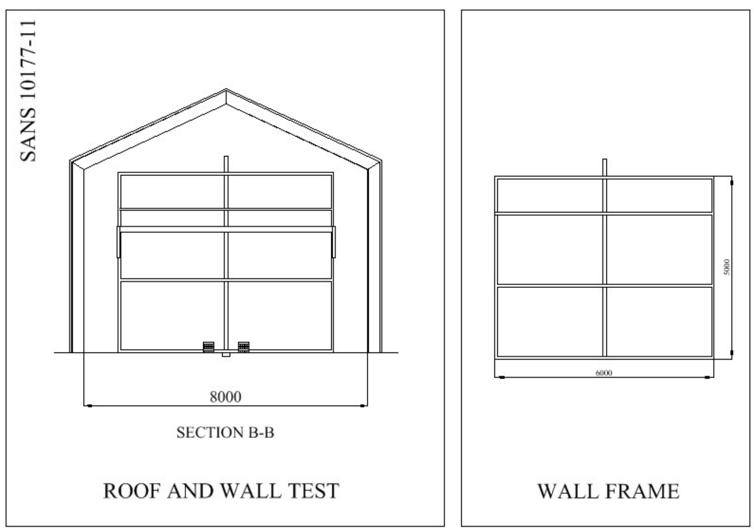

Figure 3: Typical side-cladding installation in SANS 10177 Part 11 facility

5. RESULTS

5.1 Test 1 (under-roof application without sprinklers)

The temperatures measured during the test are included in Annexure A1 with the photographic record contained in Annexure B1. The maximum heat output of the fire source (approximately 2.5 MW based on previous research) occurred after approximately 8 minutes.

Observations made during Test 1: Under-roof without sprinklers

Time (min:sec)	Observation
0:00	Ignition of SA Pine ignition source.
3:52	Deformation of insulation panel above and around ignition source noted.
4:17	Deformation of material up to first purlin (2m) – no flaming.
6:42	Material deforming and melting to form fragments resembling snow flakes – no flaming.
8:23	Material melted away up to first purlin with sheets of material starting to drop out.
13:24	Most of the material in the first section of the front panel have either dropped out or have distorted.
14:40	Material melted away on the surface of the second section of the front panel while also pulling away at the joints. No flaming noted.
16:21	The fire source starting to collapse. No flaming of the specimen occurred during the entire test duration.
16:45	Material in the third section of the front panel starting to hang as a result of the heat exposure.
20:00	No change. Observations stopped. Temperature recording stopped at 38 minutes.

5.2 Test 2 (under-roof application with slow response sprinkler installation)

The temperatures recorded during this evaluation are included in Annexure A2 with the photographic record shown in Annexure B2. The dynamic pressure of the fire engine used to supply water to the sprinkler system was measured to be 6 bar prior to the ignition of the starter pack. The maximum heat output of the fire source occurred approximately 6 minutes after the start of the test. A substantial decrease in the heat output was noted during this evaluation in comparison with the heat output noted during Test 1. This can be ascribed to the water released by the activated sprinklers influencing the rate of combustion of the starter crib. The temperature plot clearly indicates this decrease in heat output.

Observations made during Test 2: Under-roof with sprinklers

Time (min:sec)	Observation
0:00	Ignition of SA Pine ignition source.
3:08	Deformation and melting of the material noted above the ignition source.
4:10	Material dropping down onto the floor of the facility.
7:26	The first sprinkler activated.
9:37	The second sprinkler activated.
13:05	The ignition source starting to collapse
15:00	The sprinklers were de-activated while the ignition source continued to burn.

5.3 Test 3

No temperatures were recorded during this evaluation. The photographic record for this test is included in Annexure B3. The main aim of this investigation was to determine the suitability of the material for use in vertical applications. The criteria for this evaluation were to establish whether flame would propagate vertically with the installation and whether the propagation, if any, is likely to spread to and ignite an adjacent horizontal application.

Observations made during Test 3: Under-roof & side cladding

Time (min:sec)	Observation
0:00	Ignition of SA Pine ignition sources.
2:51	Deformation of insulation material observed behind the ignition sources.
4:27	Deformation of material up to first horizontal purlin (2m high) with insulation material starting to open on the joint.
6:00	Melted opening in material increasing in size and deformation above first purlin noted.
10:00	Material behind ignition sources melted away up to the first purlin with the joint above starting to open. No flaming of the material was observed.
16:00	Left-hand ignition source collapse against the insulation.
16:43	Right-hand ignition source collapse against the insulation.
18:36	Flaming of the material noted between the bottom purlin and the IBR sheeting.
22:00	Slight vertical flame spread between the collapsed ignition sources and the vertical support element noted. Flaming was limited to approximately 1m above the ignition source
24:00	Ignition sources nearly burnt out with flaming of the insulation material having stopped.

6. DISCUSSION OF RESULTS

Test 1 (under-roof without sprinklers)

No flaming of the insulation material occurred during the evaluation period, yielding similar results to those gained from the medium-scale test in the inverted channel tunnel as previously performed.

The results of the large-scale evaluation without sprinklers confirmed the suitability of the 80mm thick FR grade EPS insulating board without any facing as an under-roof insulating system. The classification of B1, as tested in SANS 10177-10, is awarded based on these results.

Although the material is classified as a combustible material, it can be used from a fire safety point of view for all horizontal applications in all buildings except where non-combustible materials are required in terms of SANS 10400 Part T.

The evaluation also showed that no ignition of the insulation took place during the test and that the heat damage was limited to first four metres of the installation. Although all the material in the installation was pre-heated by the fire source, only shrinkage of the joints was visible on the second 6 m x 6 m panel of the test installation with the last 6 m x 6 m panel remaining undamaged.

Test 2 (under-roof with sprinklers)

During the evaluation where a sprinkler system was installed, the damage to the material where notably less than during the evaluation without sprinklers. As before, no ignition of the material occurred. It can be stated, therefore, that the sprinkler activation decreased the heat damage to the insulation material. It was also shown that the insulation material did not affect the efficiency of the sprinkler installation.

Test 3 (vertical application)

The observations made during this assessment showed that the material is not likely to spread fire when installed in a vertical application. The only ignition or fire propagation resulted towards the end of the test when the timber cribs (ignition sources) collapsed against and on top of the insulation material that dropped down during the test. The fire damage was limited to less than a metre above the floor, which can be regarded as neglible. Should a sprinkler system be installed, as would be the case in many buildings, no ignition of the material is likely to have occurred.

7. CONCLUSION

The fire safety properties of the 80 mm thickness FR grade EPS material without any facing as supplied by ESASA for evaluation is as follows:

- The EPS FR grade material, tested in accordance with SANS 10177-5, is classified as combustible (**B)**.

- The classification awarded to the material based on the performance as tested in accordance with the SANS 428 protocol is **Class B / B1 / 2/ H&V.**

From a fire safety point of view the FR grade EPS thermal insulation system as tested under specific test conditions may be used as part of the thermal insulated building envelope in all industrial and commercial buildings as an under-roof and side cladding insulation material, both with or without sprinklers.

Provision of adequate roof ventilation and/or a sprinkler protection system for each individual installation would however need to be considered based on the size, slope and configuration of the roof and should be part of the fire safe design of the building to satisfy the requirements as contemplated by SANS 10400-T.

Although the material can be safely utilised in side cladding applications from a fire point of view, it is recommended that no insulation be installed at low levels in order to avoid subsequent damage that may occur in any building. In instances where racking and shelving are present, side cladding insulation should generally not be fitted below a metre above the maximum stacking height. Although the above comment is not a requirement as such, consideration should always be given to the use, occupancy and contents of a specific building structure. A good fire safety design should address this issue however.

The above results does not relate to fire resistance. In instances where fire resistance is a requirement, this property needs to determined in terms of SANS 10177-2.

Report compiled by:

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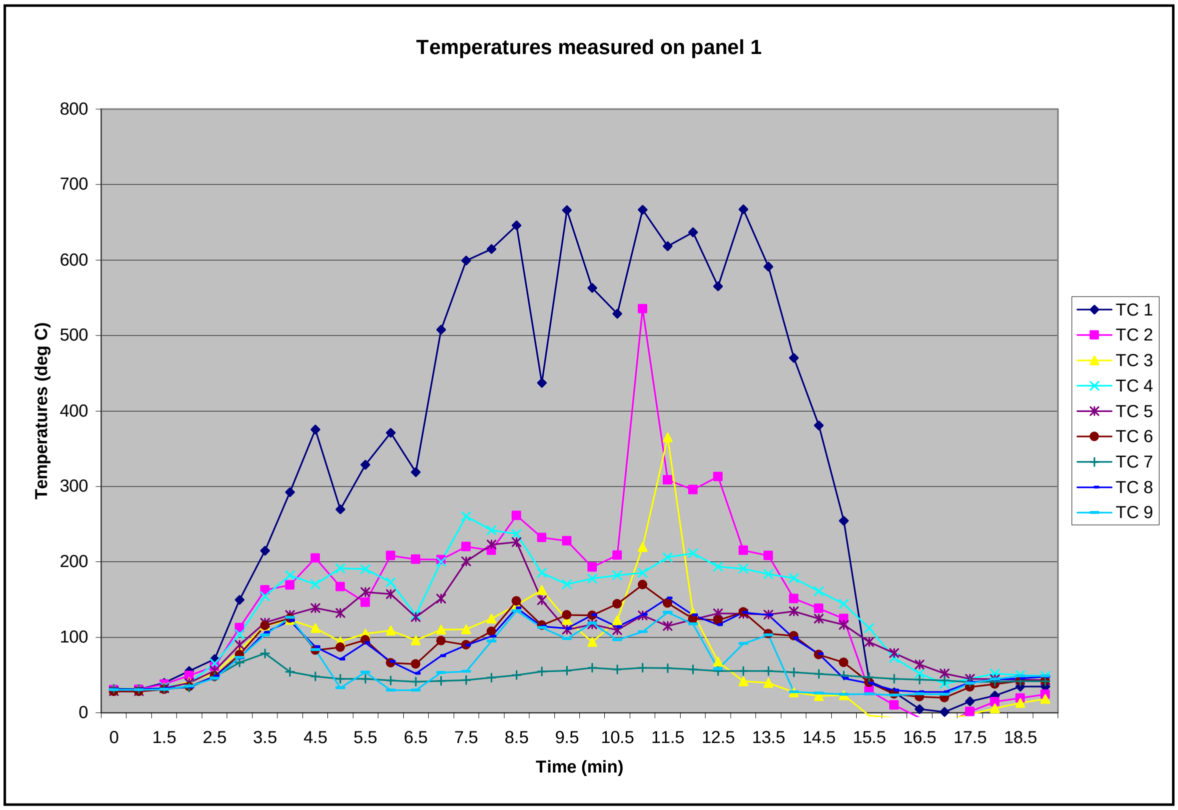
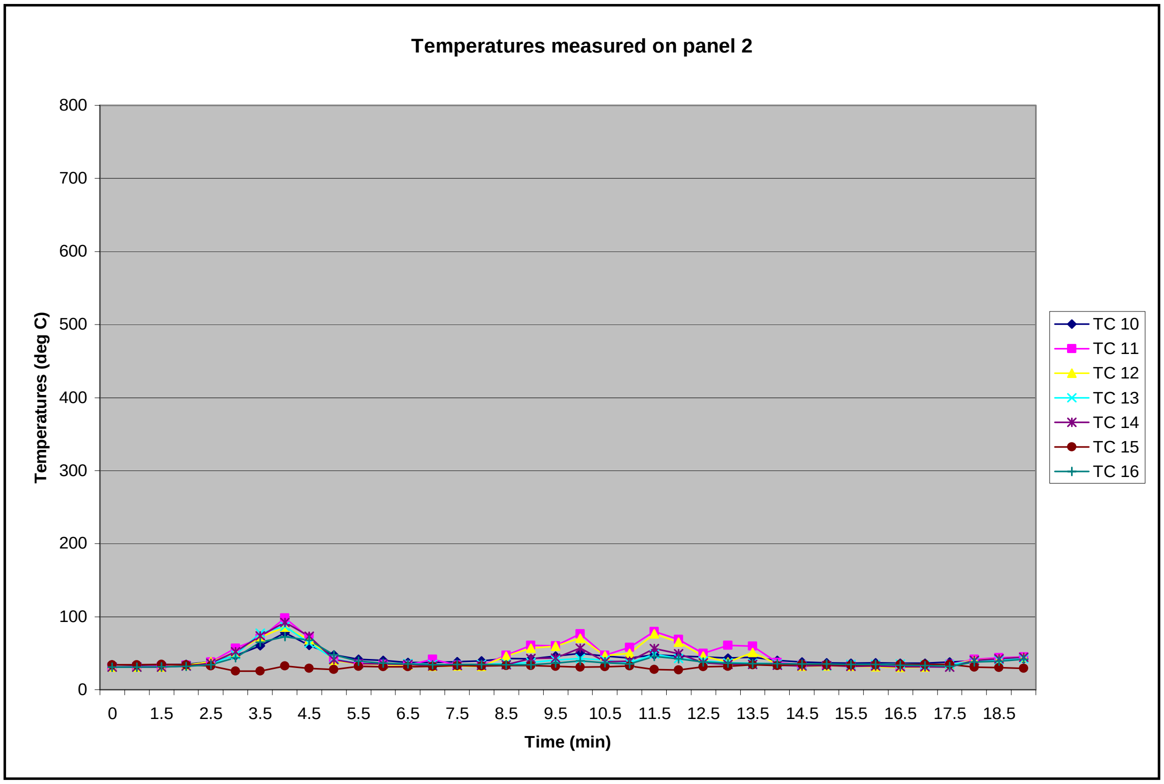
Date: 2006-12-13

ANNEXURE A1:

Temperatures recorded during Test 1


Temperatures measured on panel 1
Temperatures (deg C)
800
700
600
500
400
300
200
100
0
0
1.5
2.5
3.5
4.5
5.5
6.5
7.5
8.5
9.5
10.5
11.5
12.5
13.5
14.5
15.5
16.5
17.5
18.5
Time (min)
TC 1
TC 2
TC 3
TC 4
TC 5
TC 6
TC 7
TC 8
TC 9


Temperatures measured on panel 2
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700
600
500
400
300
200
100
0
Temperatures (deg C)
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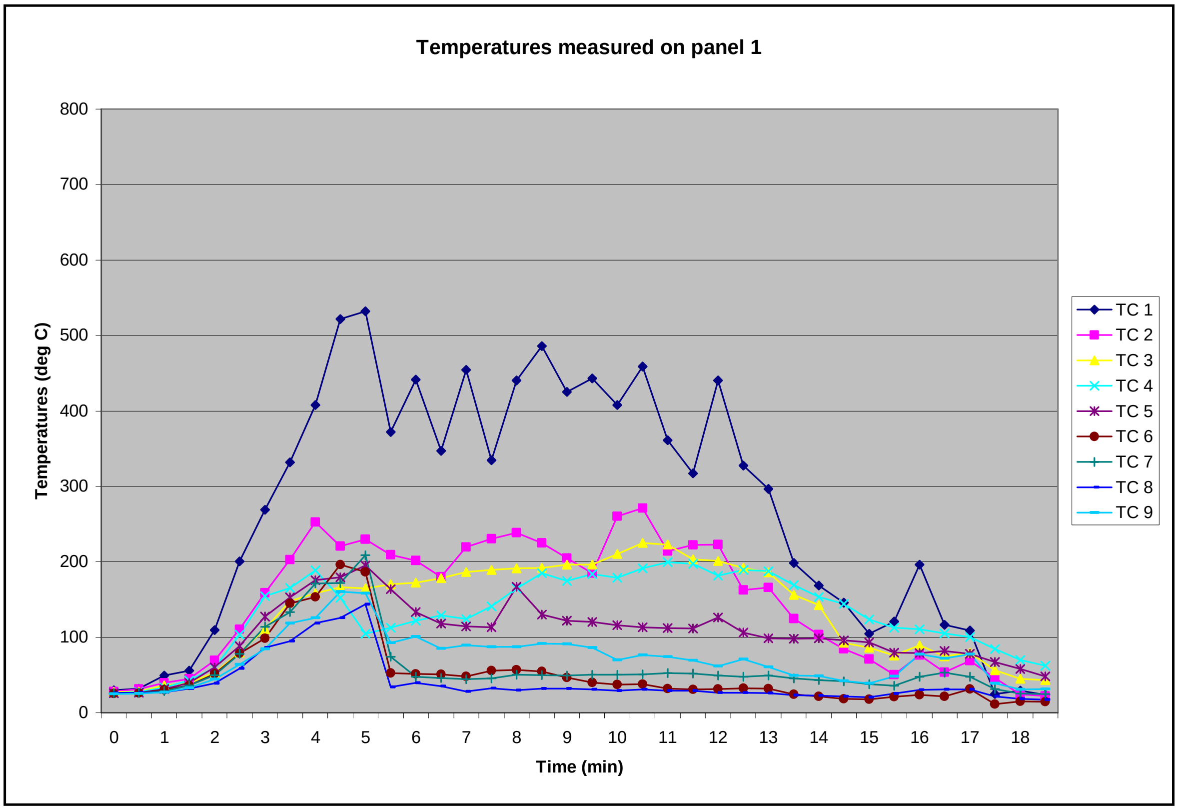
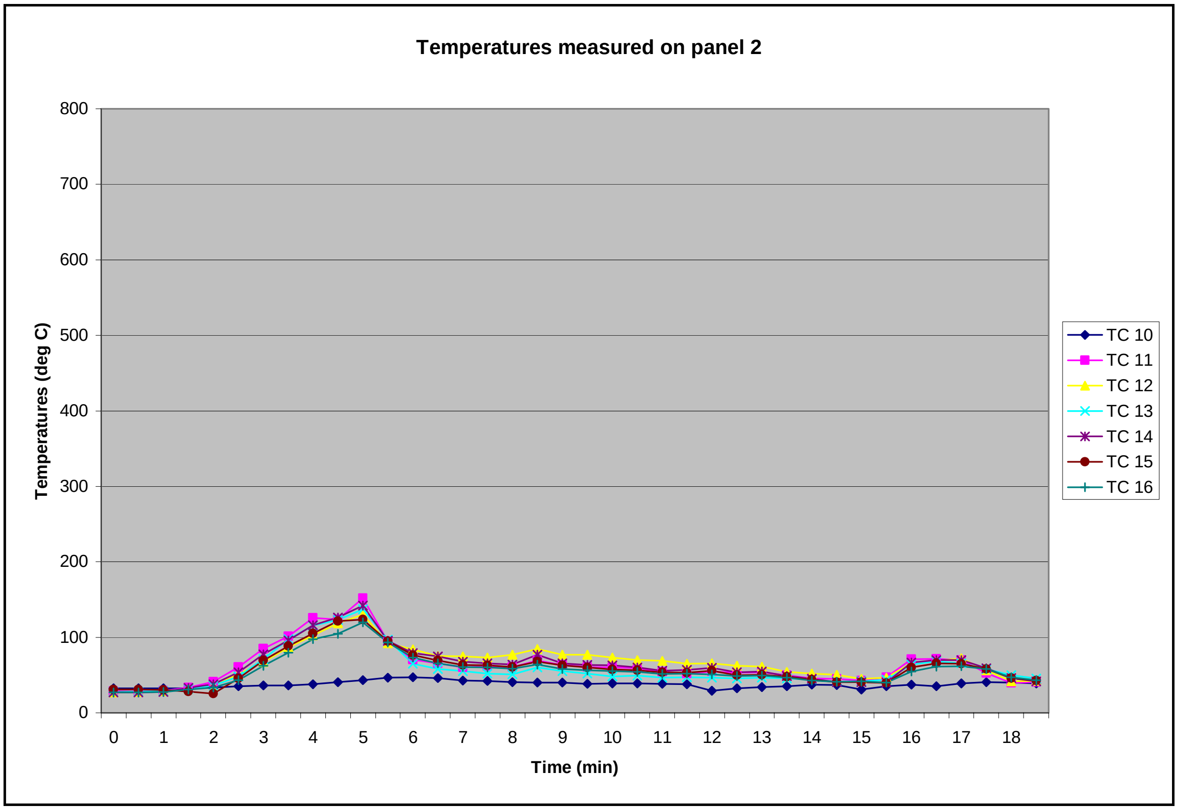
2.5
3.5
4.5
5.5
6.5
7.5
8.5
9.5
10.5
11.5
12.5
13.5
14.5
15.5
16.5
17.5
18.5
Time (min)
TC 10
TC 11
TC 12
TC 13
TC 14
TC 15
TC 16

ANNEXURE A2:

Temperatures recorded during Test 2


Temperatures measured on panel 1
Temperatures (deg C)
0
100
200
300
400
500
600
700
800
Time (min)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
TC 1
TC 2
TC 3
TC 4
TC 5
TC 6
TC 7
TC 8
TC 9


Temperatures measured on panel 2
Temperatures (deg C)
800
700
600
500
400
300
200
100
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Time (min)
TC 10
TC 11
TC 12
TC 13
TC 14
TC 15
TC 16

ANNEXURE B1:

Photographic record for Test 1:

Figure B1-1: Installation prior to ignition of fire source

Figure B1-2: Material deforming and opening up in area above heat source (t = 4 min)

Figure B1-3: Larger area above fire source damaged but no ignition (t = 8 min)

Figure B1-4: Fire source decaying – no further spread of damage to installation (t = 15 min)

ANNEXURE B2:

Photographic record for Test 2:

Figure B2-1: Test installation shortly after ignition of ignition source

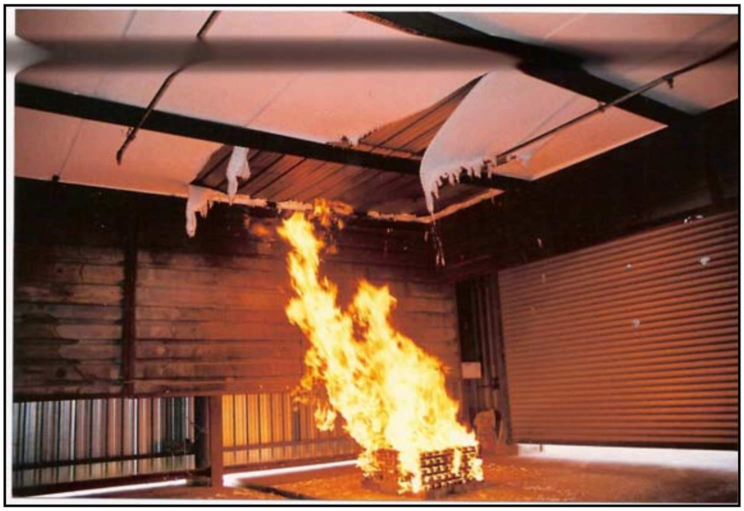


Figure B2-2: Installation damaged in area above fire source (t = 5 min)

Figure B2-3: First sprinkler activated and operating unhindered (t = 7 min 30 s)

Figure B2-4: Second sprinkler activated, no further damage to test installation (t = 9 min 30 s)

ANNEXURE B3:

Photographic record for Test 3:

Figure B3-1: Test installation shortly after ignition of fire sources

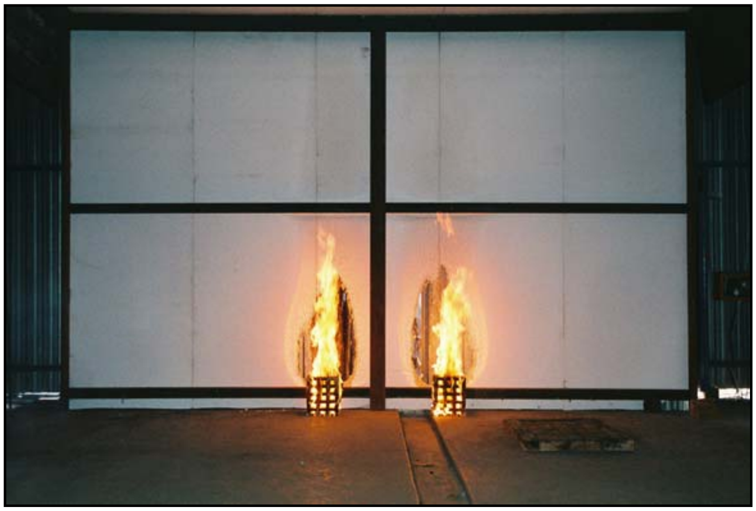


Figure B3-2: Material deforming up to purlin on both sides (t = 5 min)

Figure B3-3: Starter packs collapsed against installation with some fallen material burning between bottom purlin and IBR sheeting (t = 19 min)

Figure B3-4: Limited flaming along vertical support element (t = 22 min), which seized at t = 24 min)