# Annex C – Cavity Closures

### Introduction

The objective of this study was to investigate the effectiveness of different types of window frame constructions at mitigating the entry of fire into a timber frame cavity.

The experimental scenario selected for this study was based upon a post flashover fire within an enclosure breaking out through a window opening, which is set within a timber frame cavity wall construction.

The cavity wall construction was based upon the robust design details produced by DEFRA and DTLR in the 'Limiting thermal bridging and air leakage: Robust construction details for dwellings and similar buildings'. 2002 Edition. These design details are reproduced in Figure C1 and show a timber beading closing in the cavity around the window frame opening. Duplicate tests were therefore run with and without the timber beading for each frame type to assess the influence of this feature on the performance of each of these window frame types. Four, commercially supplied, window frame systems were identified by the project advisory group for consideration. These were:

- Aluminium frame systems
- PVCu frame systems
- Hardwood frame systems
- Softwood frame systems

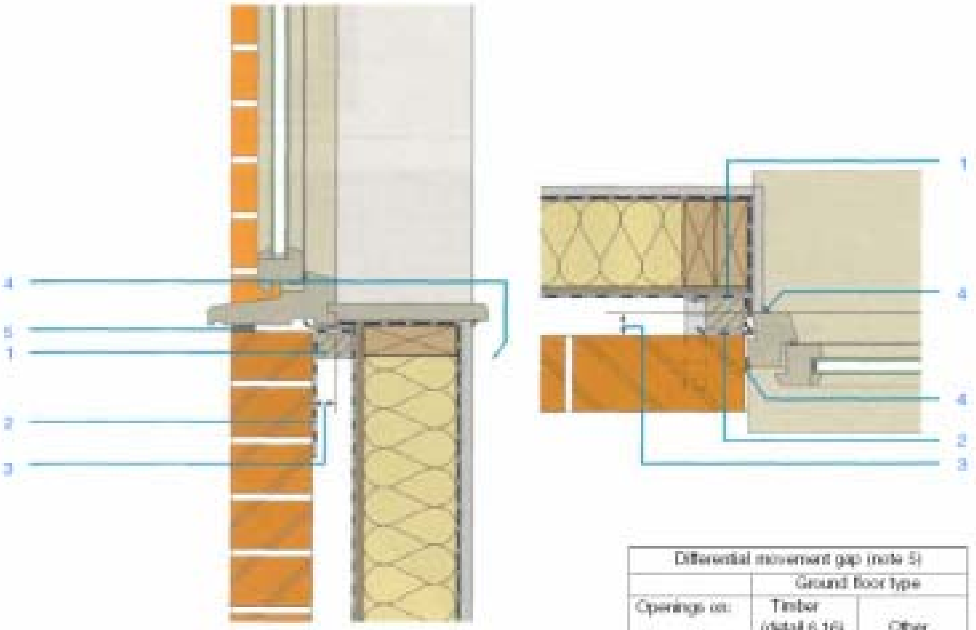
All the window frames were purchased from commercial suppliers. The window units were screw fitted into the test frame with 3 fixings on each side.

Unglazed frames were used throughout this study as the investigation was concerned with the fire performance of the window framing system and not the failure time or mechanism of failure of the glazing units.

## Experimental

### Room enclosure

The test room was constructed from a steel box-section frame, 2.4m square, lined with single sheets of 12 mm thick plasterboard. The front wall of the enclosure was 3 m in height and constructed as a timber frame stud wall, with a 55mm cavity, using the robust design details shown in Figure C1. A 1.2m x 1.0m high window opening was incorporated into the front wall construction as shown in Figure C2.




| Differential movement gap (note 5) | | |
|---|---|---|
| | Ground floor type | |
| Openings on: | Timber (detail 6.16) | Other |
| Ground floor | 5mm | 3mm |
| 1st floor | 12mm | 9mm |
| 2nd floor | 18mm | 15mm |

*Notes*

1. Either: proprietary closer with minimum thermal resistance path of 0.45m²K/W (manufacturer's certified data), or treated softwood batten.
2. DPC fitted to jamb/cill (timber closers).
3. Minimum frame/closer overlap:
   Exposure zones Sheltered – Severe* - 30mm.
   Exposure zones 'Very Severe* - Fully rebated (check reveals).
4. Sealant to front and back of frame/sills (see note 5).
5. Differential movement gap (see table) sealed with compressible foam or sealant.

The use of closers, minimum overlaps and sealants also apply to junctions between external walls and bay windows/conservatories.

For level threshold details see section 8 "General Arrangements".

See 6.00 for key to membranes.

* As given in BR262 'Thermal Insulation : Avoiding Risks', NHBC Standards, and Zurich Building Guarantees Technical Manual.

**Figure C1. Robust Design Details**

### Fuel Load

The fire load was provided by a wooden crib consisting of 120 lengths of nominal 50mm x 50mm sawn softwood timber cut into 1.0m lengths. The crib was laid in 12 layers with 10 lengths per layer with a gap of 50mm between each length. The timber crib was positioned on a $1m^2$ sheet of plasterboard, located 450mm above the floor of the enclosure, see Figure C2.

Fibreboard strips, pre-soaked in white spirit, were inserted into the lower layer of the crib to assist in obtaining a simultaneous ignition of the crib. The nominal test duration was thirty minutes or until fire was observed in the cavity, whichever occurred first.

**Instrumentation**

Figure C2 shows a schematic of the instrumentation locations. 0.5mm diameter sheathed type K thermocouples were used to monitor the temperature within the cavity and the test room. Each cavity thermocouple was set at the mid depth of the cavity to monitor air temperature. A thermocouple was also located in the ceiling of the test room to monitor the room temperature.

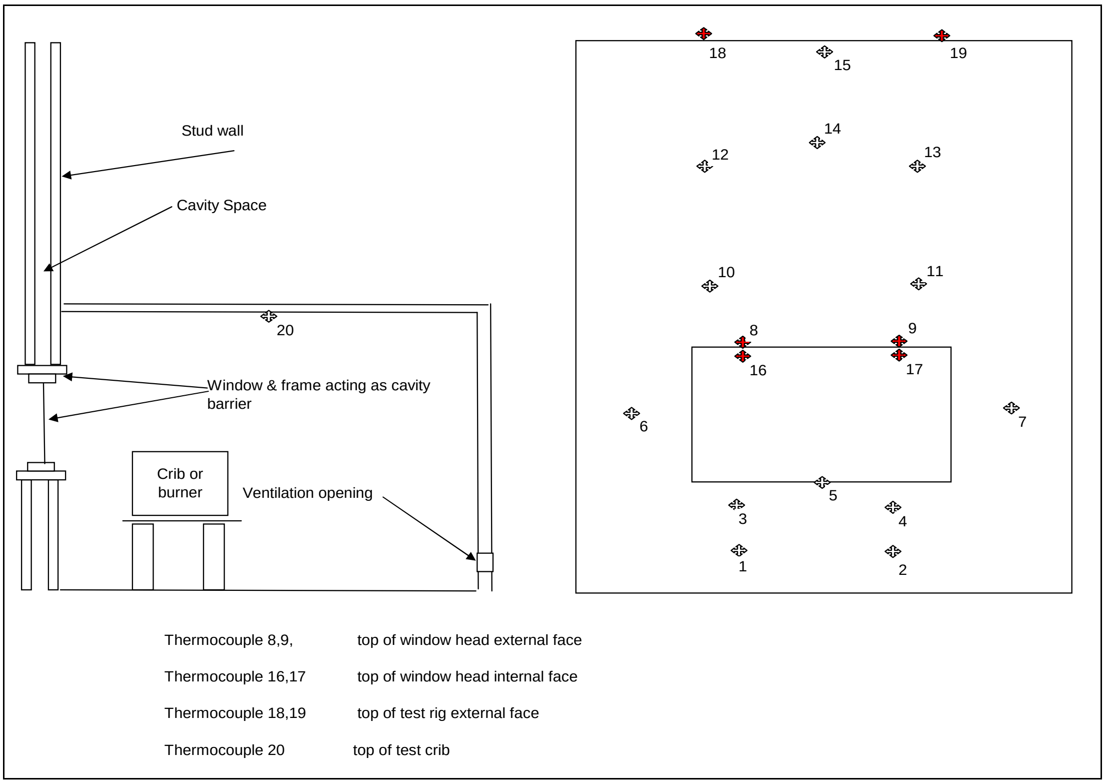



**Figure C2. Layout of thermocouple on test rig**

TC10 and 11 - 400mm either side of the centre line above the window opening, 200 mm above the opening,

TC12 and 13 - 400mm either side of the centre line above the window opening, 500 mm above the opening, TC 14 and 15 – on the centre line above the window opening, 500 mm and 1000mm respectively, above the opening.

## Results

The temperature-time curves recorded from each test are presented in Graphs 1 to 20. The results from each test are also summarised in Table C1 below.

**Table C1 . Summary of Test Results**

| No | Frame type | Entry time based on observation | Entry time based on graphical data | Cavity Breach | Graph Reference (C) | Photograph Reference (C) |
|---|---|---|---|---|---|---|
| 1 | PVCu with timber head | 1495sec (24mins 55sec) | 1414sec (23mins 3sec) | Head of window frame | 1 | 1,2 |
| 2 | PVCu without timber head | 340sec (5mins 40sec) | 352sec (5mins 51sec) | Head of Window frame | 2 | 3 |
| 3 | Aluminium With timber head | 917sec (15mins 17sec) | 820sec (13mins 40sec) | Side of timber head | 3 | 4,5 |
| 4 | Aluminium Without timber head | 540sec (9mins) | 446sec (7mins 26sec) | Head of window frame | 4 | 6 |
| 5 | Hardwood with timber head | 1403sec (23mins 23sec) | 1403sec (23mins 23sec) | Inside enclosure (see note 1) | 5 | 7,8 |
| 6 | Hardwood without timber head | 1145sec (19mins 5sec) | 1016sec (16mins 56sec) | Inside enclosure (see note 1) | 6 | 9,10 |
| 7 | Softwood with timber head | 1557sec (25mins 57sec) | 1661sec (27mins 41sec) | Inside enclosure (see note 1) | 7 | 11,12 |
| 8 | Softwood without timber head | 885sec (14mins 45sec) | 880sec (14mins40sec ) | Inside enclosure (see note 1) | 8 | 13 |

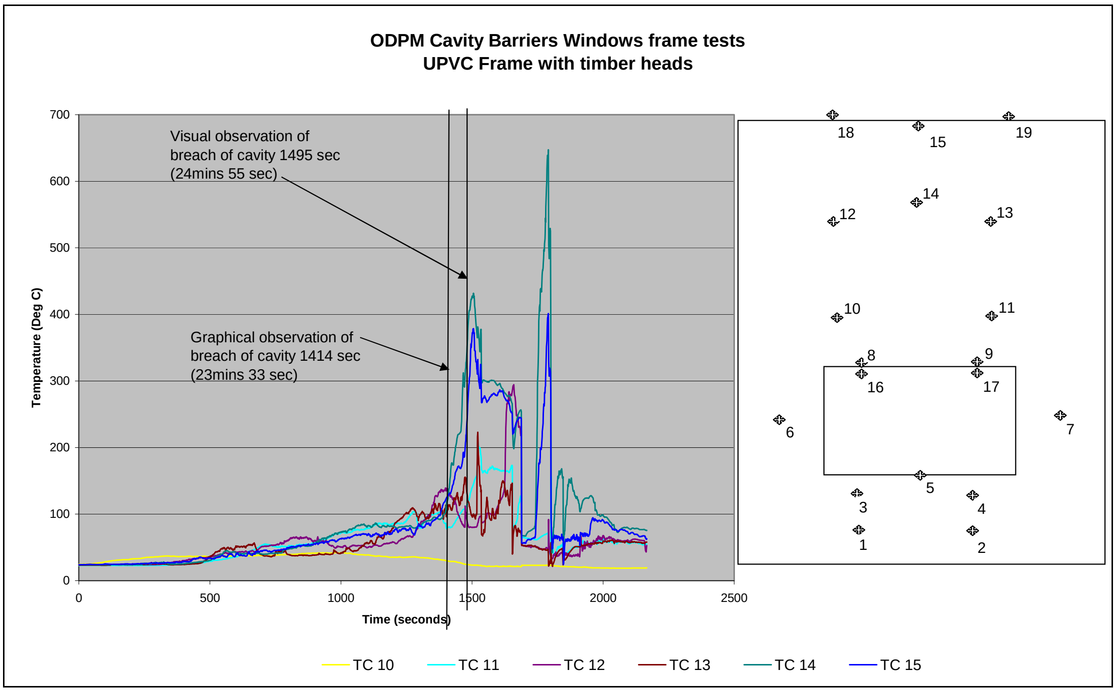
Note 1: post test inspection suggested that the window frame systems were still intact and that the breach may have been due to the failure of the joint detail between the enclosure and the window framework.

## Discussion and Recommendations

From both the visual observations and temperature measurements, as shown in Table C1 that it can be seen that in all cases the fire entered the cavity within the thirty minute exposure period. It is therefore important to identify the failure mode for each type of window system as also given in Table C1. As can be seen from the note associated with Table C1 that the failure mechanism of the timber frame windows appears to be primarily a breach of integrity at the interface between the window frame and the enclosure, with the window frames remaining effectively intact when inspected after removal from the test frame. This finding suggests that, as has been seen throughout this work, the interface detail between the cavity closure and the primary substrate is critical to the overall performance of the system.

This work has also shown that where the frame or primary structure has distorted or been consumed, such that the cavity has become exposed, the performance of the timber bead has provided some additional mitigation against fire spread within the cavity.

## Graphs




Graph C1. Temperature versus time of thermocouple PVCu frames with timber heads.

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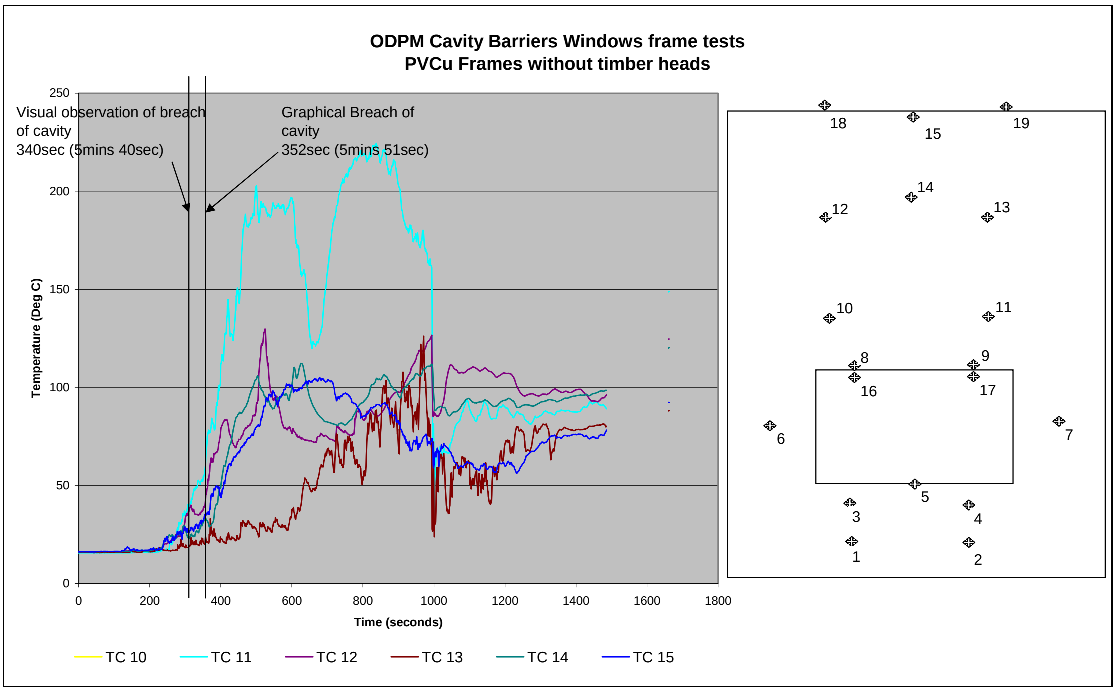
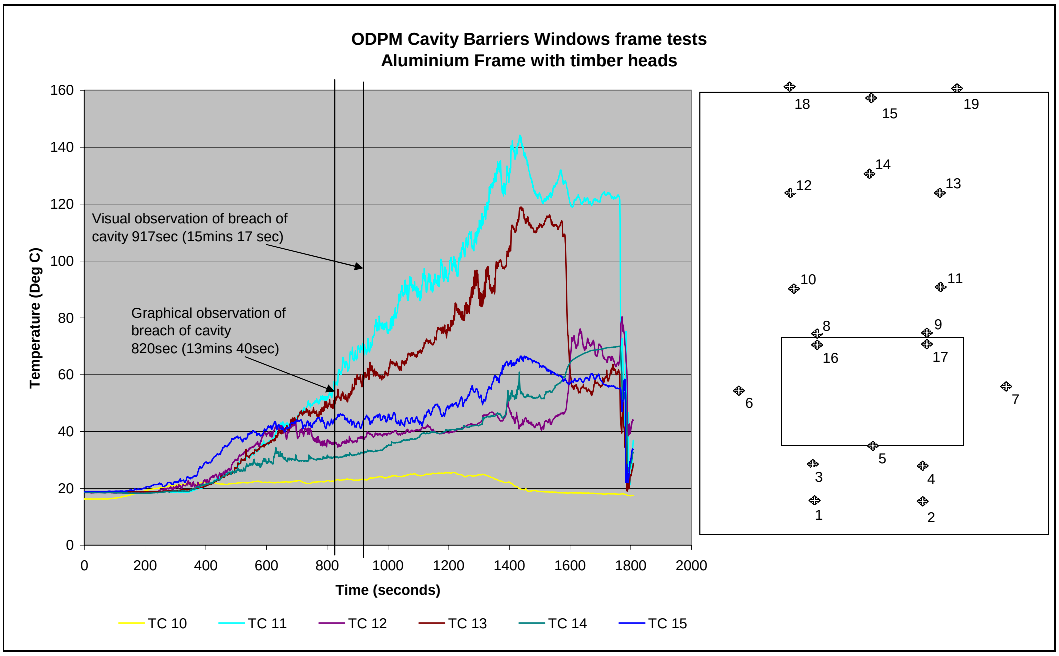
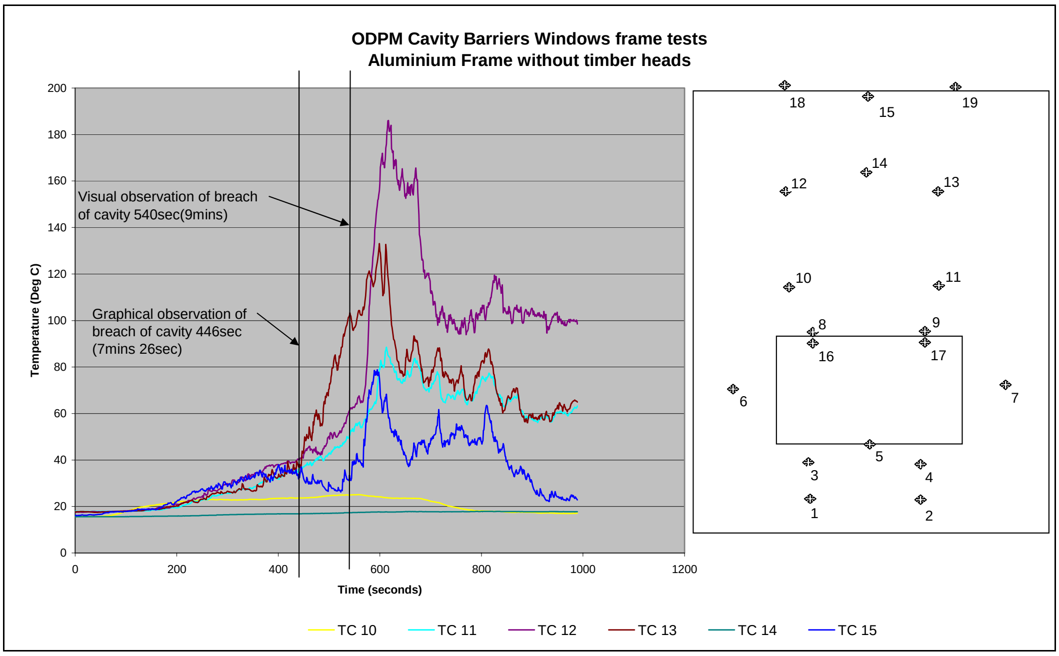


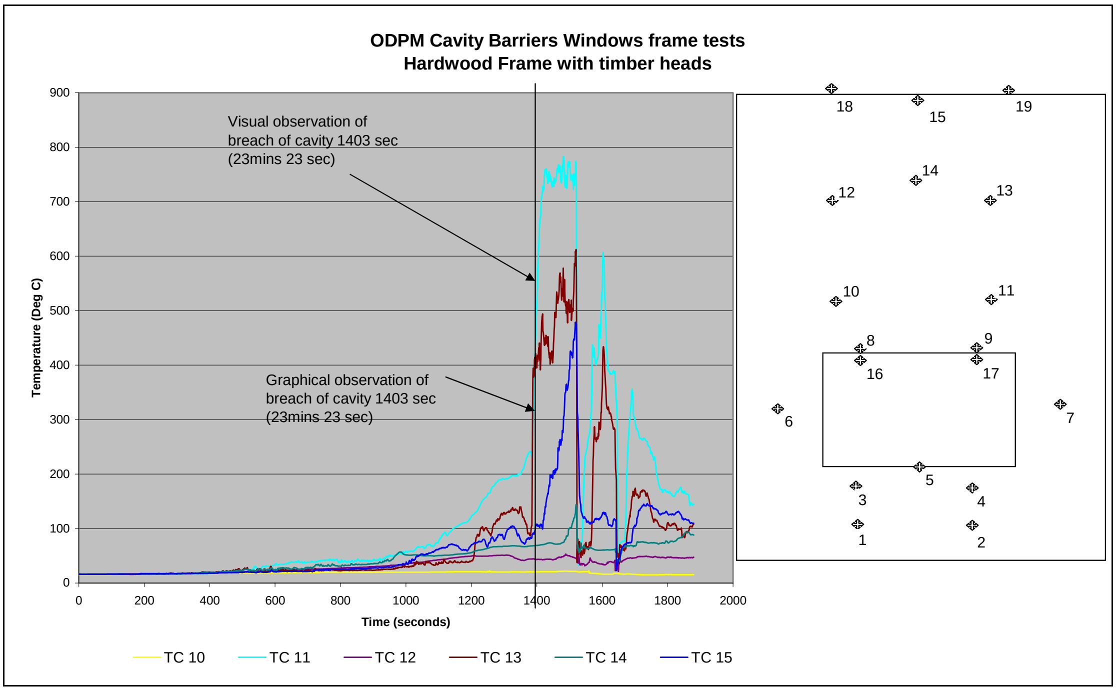

Graph C2. Temperature versus time of thermocouple PVCu frames without timber heads.



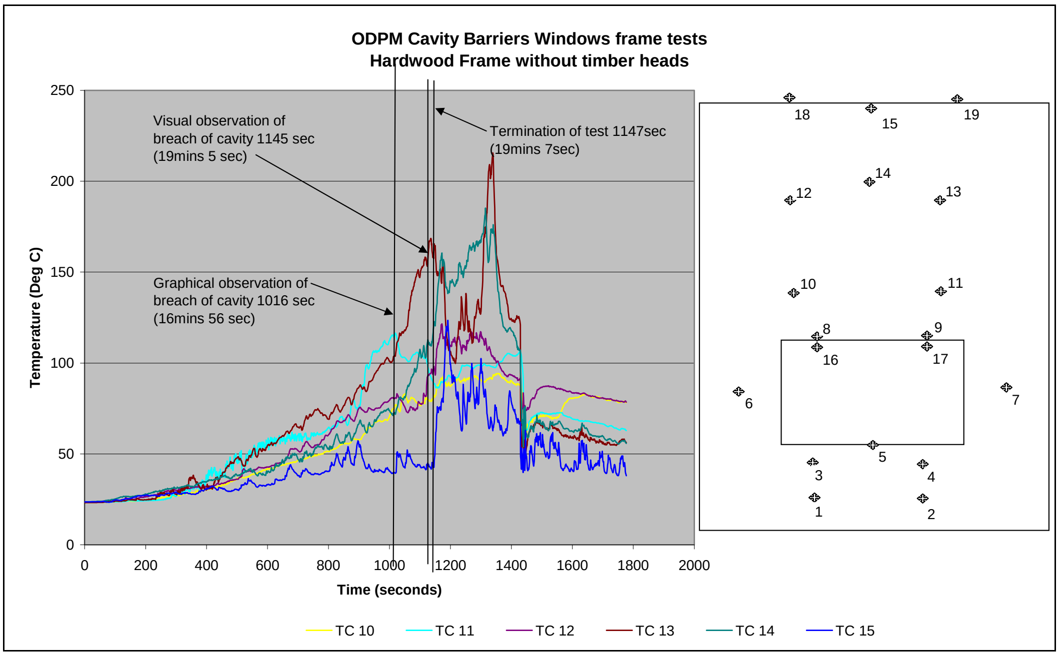

Graph C3. Temperature versus time of thermocouple Aluminium frames with timber heads.



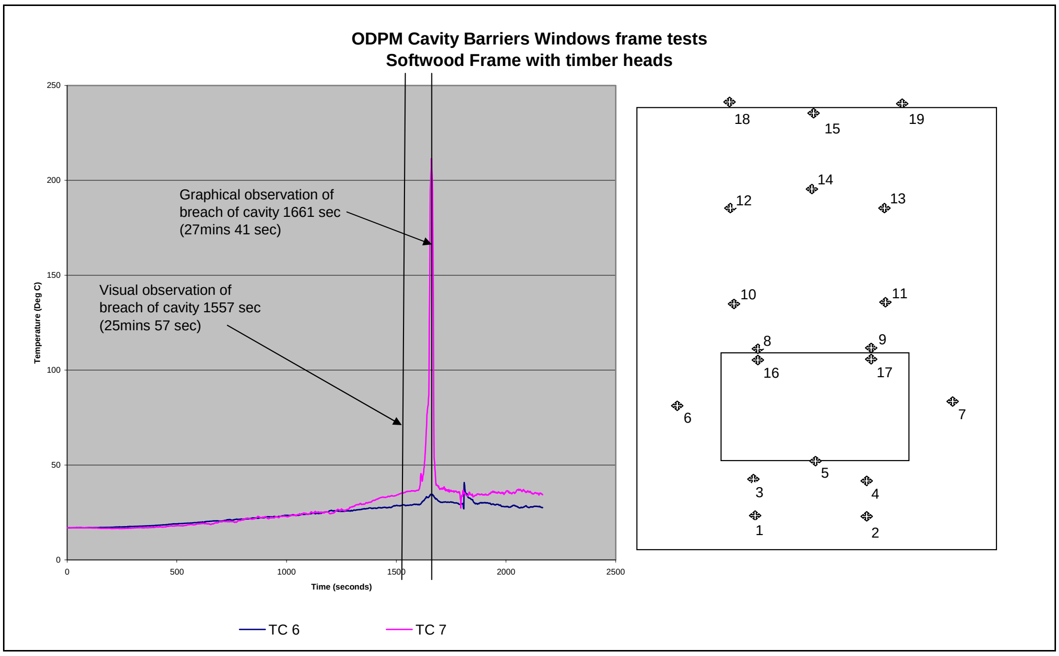

Graph C4. Temperature versus time of thermocouple Aluminium frame without timber heads.



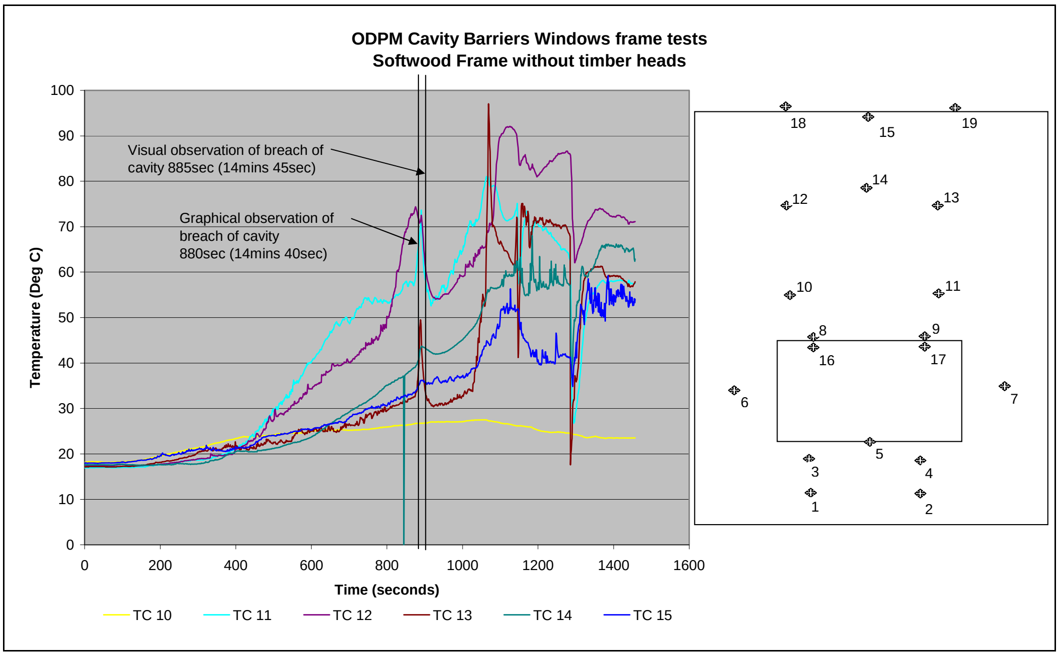

Graph C5. Temperature versus time of thermocouple Hardwood frame with timber heads.




Graph C6. Temperature versus time of thermocouple Hardwood frame without timber heads.




Graph C7. Temperature versus time of thermocouple softwood with timber heads.




Graph C8. Temperature versus time of thermocouple softwood without  timber heads.

## Photographs

### PVCu with timber bead

Photograph C1. Showing the break through of flames out of the enclosure

Photograph C2. Showing post test damage.

**PVCu without timber bead**

Photograph C3. Showing distortion of the window frame.

## Aluminium with timber bead

Photograph C4. Showing flaming entering the cavity.

Photograph C5. Showing post test damage.

**Aluminium without timber bead**

Photograph C6. Showing post test damage.

**Hardwood with timber bead**

Photograph C7. Showing flaming in the cavity above the window

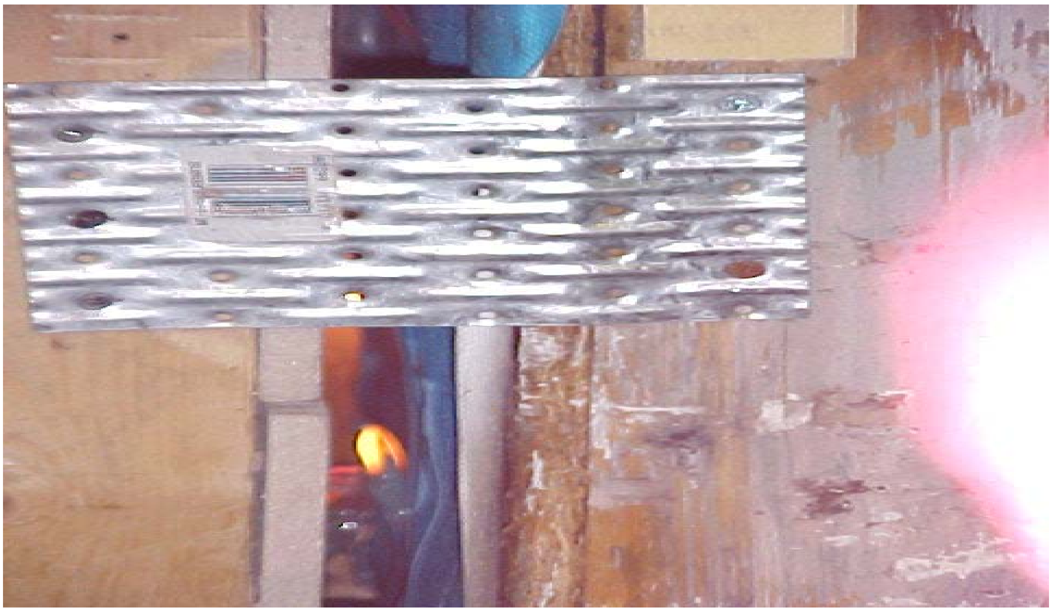
Photograph C8. Showing post test damage.

**Hardwood without timber bead**

Photograph C9. Showing flames entering the cavity.

Photograph C10. Showing post test damage.

**Softwood with timber bead**



Photograph C11. Showing flames entering the cavity

Photograph C12. Showing post test damage.

**Softwood without timber bead**

Photograph C13. Showing post test damage.