An ad-hoc fire resistance test adopting the appropriate procedures and criteria of B.S. 476: Part 20: 1987 on a NuLite Ltd NL604(C) Fire Resistant Roof Light glazed with a Pilkington fire resistant insulating glass unit.

Prepared for:

PILKINGTON

SUMMARY

A NuLite NL604(C) Fire Resistant Rooflight glazed with a Pilkington glass system and mounted over an aperture, nominally 1370mm x 1370mm, in a 150mm-thick reinforced aerated concrete floor, nominally 3m x 2.4m, was submitted to an ad-hoc fire resistance test of 81 min duration on 7 November 2006. In the test the heating conditions and the appropriate procedures and criteria of British Standard 476: Part 20:1987 were used.

The rooflight comprised a frame with a kerb fabricated from 3mm mild steel, nominally 1390mm x 1390mm, with an upstand of 260mm along one edge and an upstand of 180mm along the opposite edge; the frame had a flange around its base through which fixings passed to secure it to the aerated concrete floor,. The sloping top of the frame also had a flange around its perimeter and was glazed with a Pilkington fire resistant Insulating Glass Unit held in place by a steel clamping angle around its perimeter. The inside faces of the rooflight and the vertical faces of the aperture made in the floor were covered by 20mm-thick British Gypsum GlasRoc FireCase S board which extended from the underside of the glazing to the level of the soffit of the floor. Mastic was used to seal junctions between the various components.

For the criteria adopted the rooflight achieved the following performance:

Integrity:	80min
Insulation:	64min

1 OBJECTIVE

To determine, at the request of Pilkington Ltd, the performance of a NuLite NL604(C) Fire Resistant Rooflight glazed with a Pilkington fire resistant Insulating Glass Unit mounted over an aperture in a 150mm-thick reinforced aerated concrete floor when subjected to an ad-hoc fire resistance test employing the furnace heating conditions and appropriate procedures and criteria of B.S. 476: Part 20: 1987[1].

2 TEST CONSTRUCTION

2.1 General

The rooflight, constructed by NuLite Ltd. and designated NL604(C), was mounted over a square aperture, nominally 1370mm x 1370mm, in a reinforced lightweight aerated concrete floor, nominally 3m x 2.4m x 150mm thick on the 2nd November 2006. The rooflight was glazed with a Pilkington fire resistant Insulating Glass Unit as detailed below. Details of the test construction were provided by NuLite Ltd. The specimen construction was as shown in Figures 1 to 6. The specimen before testing is shown in Plates ? and ?.

2.2 Rooflight

The rooflight comprised a frame with a kerb fabricated from 3mm mild steel, nominally 1390mm x 1390mm, with an upstand of 260mm along one edge and an upstand of 180mm along the opposite edge joined by a tapering kerb on the remaining two sides. The frame was of a fully-welded construction and had a base flange, 100mm wide, around its base with 8mm holes drilled at 100mm centres through which fixings passed to secure it to the aerated concrete floor. The sloping top of the frame also had a flange around its perimeter, 60mm wide which was extended to 80mm by a 25mmx 50mm x 3mm-thick steel angle fixed by 15mm stitch-welds at 200mm centres with the 25mm leg projecting downwards at the perimeter. A steel upstand, 12mm wide x 45mm high, was attached around the rim of the top flange by 5mm grub screws at 600mm centres and provided a 45mm deep rebate for the lower edge of the glazing whilst a Glasroc Multiboard strip, 6mm thick x 45mm wide, attached around the inside perimeter of the top flange provided a seating for the glazing. A bead of Firestop sealant applied against a 15mm-diameter polyethylene backing rod was applied between the top of the steel upstand and the upper edge of the glazing which had a 25mm-wide outwards step.

A clamping angle fabricated from 100mm x 65mm x 3mm-thick mild steel angle, nominally 1520mm x 1538mm, with the 100mm leg angled downwards around the perimeter located

over and around the top flange of the rooflight frame to fix the glazing in place. A Glasroc Multiboard strip, 6mm thick x 45mm wide, was retained around the perimeter of the clamping angle between the angle and the glazing The 100mm legs of the angle frame contacted the top flange of the rooflight frame on three sides whilst a clearance of 10mm was maintained between the 100mm leg and the top flange of the 180mm kerb, thereby providing a drainage channel. The clamping angle was fixed in place by three M8 x 35mm bolts along the two sloping sides which passed into the downwards return at the perimeter of the rooflight frame.

2.3 Glazing

The glazing used in the specimen construction was a Pilkington fire resistant Insulating Glass Unit supplied by Pilkington Glass. It comprised an upper assembly , nominally 1500mm x 1500mm x 7mm thick, formed by two layers of 3mm Pilkington Optifloat glass bonded together by a 0.76mm-thick PVB interlayer, set over a steel spacer 12mm–high attached around the perimeter of a lower assembly, to form an air gap between the two. The lower assembly, nominally 1450mm x 1450mm x 33mm thick, comprised a layer of 8mm Pilkington Optifloat glass bonded by a 1.5mm-thick cast-in–place interlayer, to an assembly of five layers of 2.6mm Pilkington Optifloat glass bonded together with 4 layers of 2.5mm-thick interlayer. The arrangement of the glazing assembly is shown in Figure 3.

The clear view provided by the rooflight measured approximately 1300mm x 1300mm.

2.4 Sealants

Two mastics were used in the installation of the specimen.

- Hilti Elastic Firestop Sealant CP 6015, described as a halogen and solvent free elastomeric sealant, light grey in colour, dispensed from a mastic tube.
- Everbuild Everflex Firemate Sealant, described as an intumescent acrylic sealant, off-white in colour, dispensed from a mastic tube.

2.5 Insulation

Two types of insulation board were used in the preparation of the specimen.

- British Gypsum Glasroc Multiboard used in strips, 6mm thick x 45mm wide was used between the glass and frame on either side of the glass. Glasroc Multiboard was described as a Class 0, non-combustible glass reinforced gypsum board.
- British Gypsum Glasroc FireCase S board, 20mm thick, was used to cover the inside faces of the rooflight kerbs and the vertical faces of the aperture made in the floor. Glasroc FireCase S board was described as a high performance glass reinforced gypsum building board.

2.6 Assembly of specimen

The rooflight was centred over the aperture in the floor and fixed in place by 7.5mm x 45mm Hilt HUS screw fixings (Ref HUS-A 7.5x45 M8) through the flange at its base, the flange was seated over beads of Firemate sealant which was also used to seal around the perimeter of the flange. A bead of Firestop sealant was then applied around the contact of the underside of the glazing with the top of the kerbs, the sealant also contacting the Glasroc Multiboard on the top flange of the kerbs. The inside faces of the rooflight kerbs and the vertical faces of the aperture made in the floor were then covered by 20mm-thick Glasroc FireCase S board which extended from the underside of the glazing to the level of the soffit of the floor. The Glasroc FireCase S board was set over Firemate Sealant applied to the inside faces of the kerbs and the vertical faces of the aperture made in the floor and was secured in place by 75mm-

longTapcon screws at 150mm centres. Due to the slight inwards protrusion of the kerb walls relative to the vertical faces of the aperture in the floor, the Glasroc FireCase S board sections sloped slightly inwards towards the top; the extent of the taper is shown in Figure6. To complete the assembly a bead of Firestop sealant was applied around the contact of the underside of the glazing with the top of the Glasroc FireCase S board sections and around the contact of the bottom of the Glasroc FireCase S board sections with the soffit of the floor around the perimeter of the aperture made in the floor.

The test specimen is shown before the test in Plates 1 to ?.

3 TEST PROCEDURE

3.1 General

The test, carried out on 7th November 2005 using the BRE large-scale horizontally orientated furnace, employed the furnace heating conditions, appropriate procedures and criteria of B.S. 476 : Part 20 : 1987[1].. The ambient temperature at the start of the test was 15°C. The test was witnessed by Mr Brian Pye and Mr Peter Gilbert representing Pilkington Glass and Mr Bill Harris representing NuLite Ltd.

3.2 Furnace control

The furnace temperature was measured using six bare-wire chromel/alumel thermocouples positioned symmetrically in the furnace with their measuring junctions nominally 100mm below the soffit of the floor construction. The furnace was controlled so that the mean of the six readings followed the time/temperature relationship specified in B.S. 476 : Part 20 : 1987[1].

After the first 5min of the test, the pressure in the furnace at the level of the soffit of the floor was maintained as closely as possible to 18Pa ± 2Pa above that in the laboratory.

3.3 Specimen temperature

The temperature of the rooflight was measured by means of eleven thermocouples of the type specified in B.S. 476: Part 20 : 1987[1]. The thermocouples were positioned as described in Table 1 and shown in Figure ?.

Table 1: Thermocouple locations

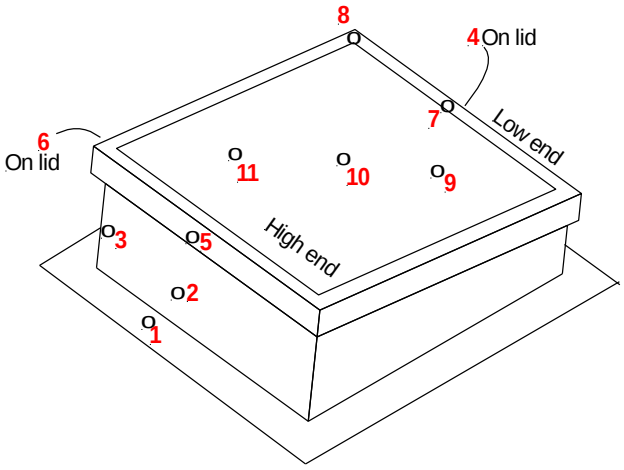
Thermocouple Number	Thermocouple Location
1	On mounting flange at base of kerb.
2	On kerb of high end, at mid-height and mid-span.
3	On kerb of high end, at mid-height near corner.
4	On side of clamping angle at mid-span of low end.
5	On side of clamping angle at mid-span of high end.
6	On side of clamping angle near corner of high end.
7	On top of clamping angle at mid-span of low end.
8	On top of clamping angle near corner of low end.

9	On glazing at centre of quarter section at low end.
10	On glazing at centre.
11	On glazing at centre of quarter section at high end.

4 RESULTS

4.1 Observations

Observations made during the course of the test are given in Table 2, these relate to the unexposed face unless otherwise stated.



1-11 Thermocouple locations

Table 2 Observations

Time min:sec	Observation
0:00	Test started.
4:15	Crack formed in an inner glass layer, spreads from edge at mid-span of high end and extends to approx. centre of glazing.
4:45	More cracks formed in inner glass layers, across corners of glazing.
5:10	Increased cracking of inner glass layers. Whitening of intumescent interlayer over central portion of glazing.
5:30	Whitening of intumescent interlayer over most of specimen, apart from band approx. 100mm wide at periphery, continued cracking of internal glass layers.
6:06	Some bubbling of an interlayer observed, initially at centre of glazing but spreading rapidly outwards.
7:00	Can see other interlayers reacting. Interlayers have activated over complete area of glazing exposed to furnace.
8:30	Some small areas of reacted interlayer near centre of glazing have a slight brown

Time min:sec	Observation
	discolouration.
9:45	Discolouration of reacted interlayer near centre of glazing is darkening slightly.
16:00	Interlayer has reacted giving a uniform white appearance over whole of exposed area of glazing apart from small discoloured areas near corners. Only a few cracks in inner glass layers visible around perimeter of glazing.
17:20	Some bubbling of an interlayer observed, around area of thermocouple 11 location.
19:30	Bubbling of interlayer more widespread.
26:00	Interlayer has reacted giving a uniform white appearance over whole of exposed. No apparent distortion of top of glazing or rooflight.
28:00	On exposed face can see board and mastic seal over inside faces of rooflight glowing red. Underside of glazing is cracked with shards of glass hanging down and occasionally falling away as are flaming droplets. A few small pieces of mastic seal around boards at perimeter of floor aperture and around glazing have fallen away with some flaming from voids exposed.
30:00	No appreciable change in appearance of unexposed face. Photographs taken.
32:00	On exposed face can see shards of glass hanging down from cracked underside of glazing melting and falling away.
37:00	On exposed face can see brighter glow of board and mastic seal over inside faces of rooflight. A few more small pieces of mastic seal around boards at perimeter of floor aperture and around glazing have fallen away. Molten glass continues to drip from underside of ceiling.
39:00	On unexposed face there is a uniform white appearance over whole of exposed area of glazing apart from a small slightly discoloured area, approximately 100mm in diameter, in vicinity of thermocouple 11 locations. Only a few cracks in inner glass layers visible around perimeter of glazing. No appreciable distortion of top of glazing or rooflight.
49:00	On unexposed face slightly discoloured area in vicinity of thermocouple 11 location has increased in size to approximately 200mm in diameter.
51:00	On exposed face no appreciable change apart from brighter glow.
60:00	No appreciable change in appearance of unexposed face. Photographs taken.
65:00	On exposed face no appreciable change in appearance.
70:00	On unexposed face slight swelling of mastic protruding around bolt fixings through flange at base of high side kerb.
72:00	On unexposed face a number of slightly discoloured areas forming over whole of

Time min:sec	Observation
	exposed area.
76::00	On exposed face small crack formed in floor slab, crack extends over a distance of approx. 150mm from corner lying beneath position of thermocouple 3 on unexposed face. On unexposed face a portion of the underlying glass and interlayer assembly falls away. Area is approx. 300mm in diameter and is approx. mid-way between the centre of the glazing and the mid-span of the glazing frame in the vicinity of thermocouple 7. Flames visible through top layers of glass in this region.
78::00	On unexposed face roving thermocouple applied in area where flames visible through top layers of glass records a temperature of approximately 90^{o}C.
79::00	On unexposed face in area where flames visible through top layers of glass, underlying layer of 3mm Optifloat cracks into small pieces.
80::00	On unexposed face roving thermocouple applied in area where flames visible through top layer of glass records a temperature of 200^{o}C and rising.
80::30	On unexposed face cracks forming in top layer of glass above cracked 3mm Optifloat layer, fames issue from crack – Failure of Integrity. Hole formed through glazing.
81::00	Hole formed through glazing is approx. 400mm in diameter. Photographs taken. Test terminated.

4.2 Temperature data

4.2.1 Furnace temperature

The mean furnace temperature is shown plotted against time in Graph 1 together with the standard time/temperature curve for comparison.

4.2.2 Specimen temperature

The maximum temperature recorded by all the thermocouples is shown plotted against time in Graph 2 together with the mean temperature recorded by thermocouples 9, 10 and 11, attached to the glazing.

The temperature recorded by thermocouples 1 to 3 attached to the base flange and the sides of the kerbs is shown plotted against time in Graph 3.

The temperature recorded by thermocouples 4 to 8 attached to the top clamping angle is shown plotted against time in Graph 4.

The temperature recorded by thermocouples 9 to 11 attached to the glazing is shown plotted against time in Graph 5.

The adopted criterion for insulation (180^{o} C rise) was first exceeded by thermocouple 2 after 64min from the start of the test.

5 PERFORMANCE CRITERIA

In the absence of a specific test for rooflights, the following criteria for failure under integrity and insulation specified in B.S. 476 : Part 20 : 1987[1] were used.

Integrity : Failure is deemed to occur:

a) when sustained flaming for not less than 10s on the unexposed face occurs;

b) when (before the exposed face in the vicinity indicates a temperature of 300°C) cracks, gaps or fissures allow flames or hot gases to cause flaming or glowing of a cotton fibre pad;

c) when, a 6mm-diameter gap gauge can penetrate over a distance of at least 150mm, or a 25mm-diameter gap can penetrate through a gap into the furnace (only applicable when the cotton pad test is not suitable).

Insulation: Failure is deemed to occur:

a) when the mean unexposed face temperature increases by more than 140°C above its initial value.

b) when the temperature recorded at any position on the unexposed face is in excess of 180°C above the initial mean unexposed face temperature;

c) when integrity failure occurs.

The results only relate to the behaviour of the specimen of the element of construction under the particular conditions of test; they are not intended to be the sole criteria for assessing the potential fire performance of the element in use nor do they reflect the actual behaviour in fires.

6 CONCLUSION

A NuLite NL604(C) Fire Resistant Rooflight glazed with a Pilkington fire resistant Insulating Glass Unit mounted over an aperture in a 150mm-thick reinforced aerated concrete floor, as described in this report, was submitted to an ad-hoc fire resistance test employing the furnace heating conditions and appropriate procedures and criteria of B.S. 476 : Part 20 : 1987[1] on 7th November 2006 for a duration of 81min.

For the criteria adopted the rooflight achieved the following performance:

Integrity:	80min
Insulation:	64min

This report covers a test which was conducted to a procedure which is not the subject of any British Standard specification, but the test utilised the general principles of fire resistance testing given in B.S. 476 : Parts 20-22. Since fire tests are the subject of a continuing Standardisation process, and because existing standards are the subject of review and possible amendment and new interpretations, it is recommended that the report be referred back to the test laboratory after a period of five years to ensure that the methodology adopted and the results obtained remain valid in the light of the situation prevailing at that time.

7 REFERENCE

1 Fire tests on building materials and structures. Part 20. Method of determination of the fire resistance of elements of construction (general principles). British Standard 476 : Part 20 : 1987. British Standards Institution, London, 1987.

8 FIGURES

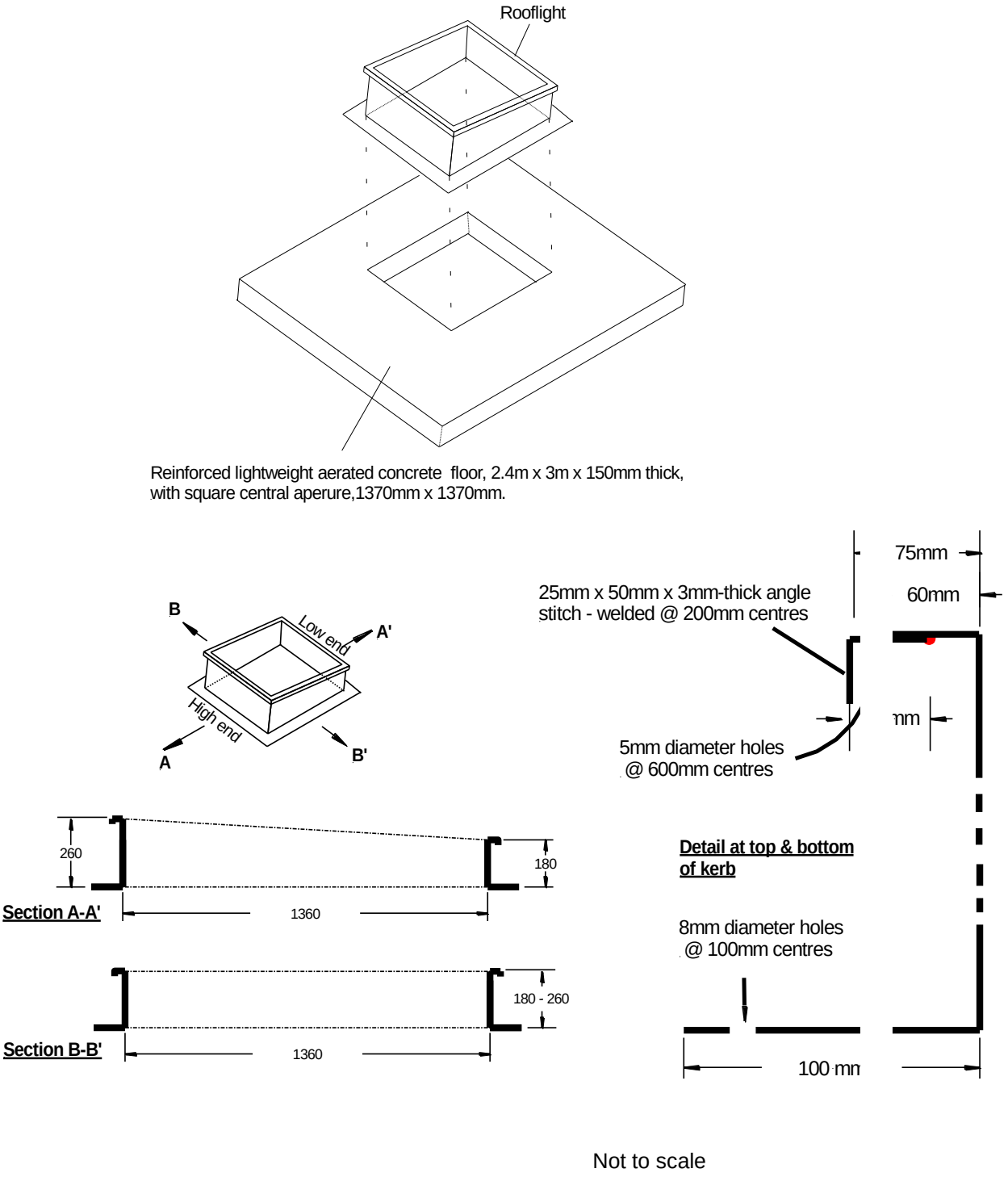


Figure 1 Alignment of rooflight and detail of kerbs.

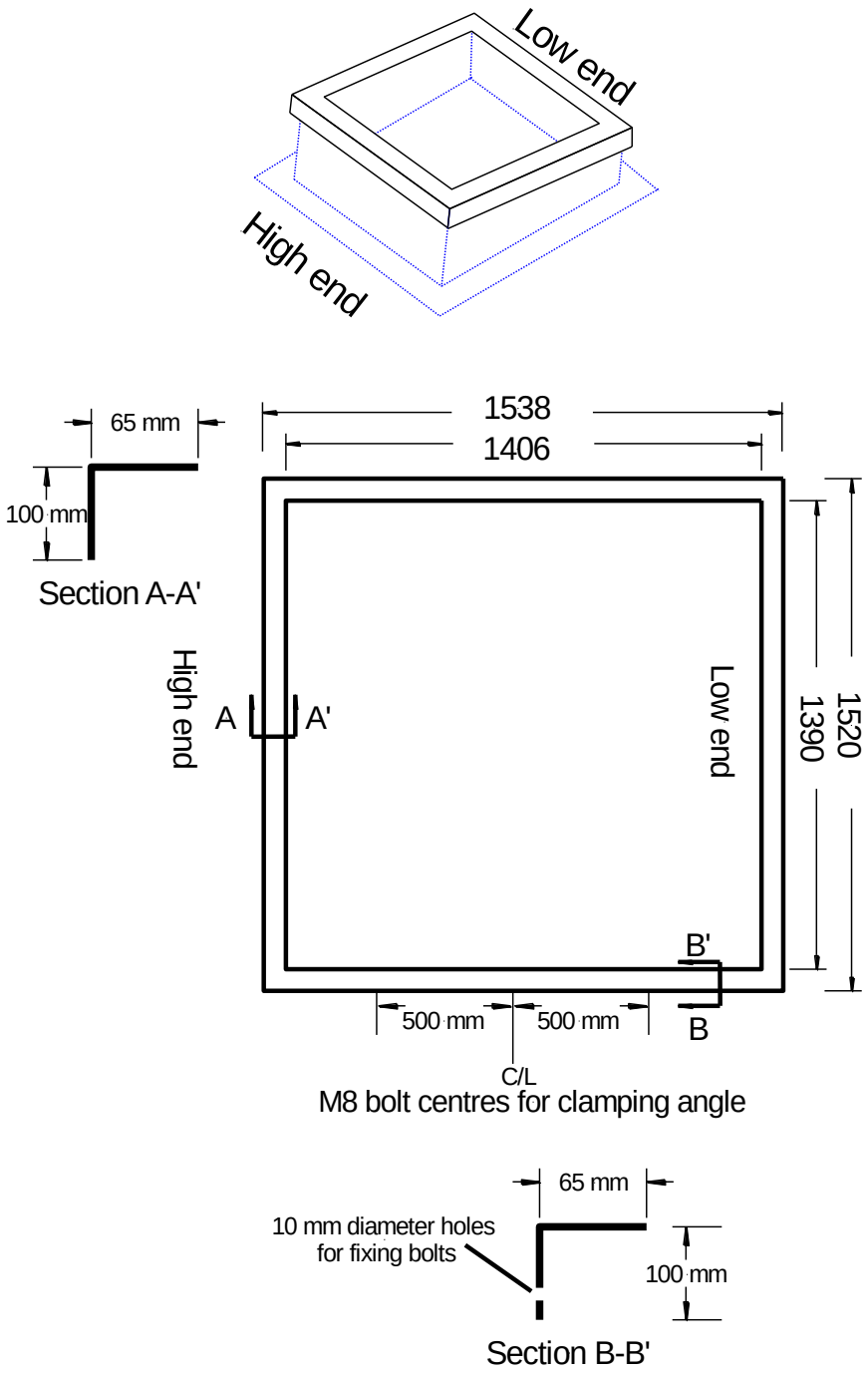
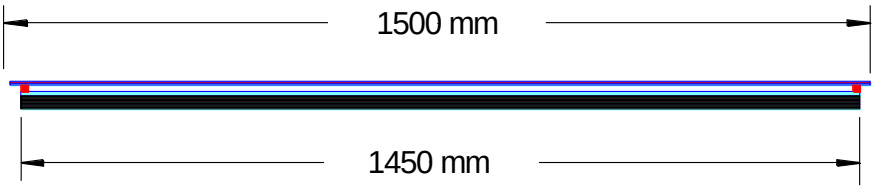
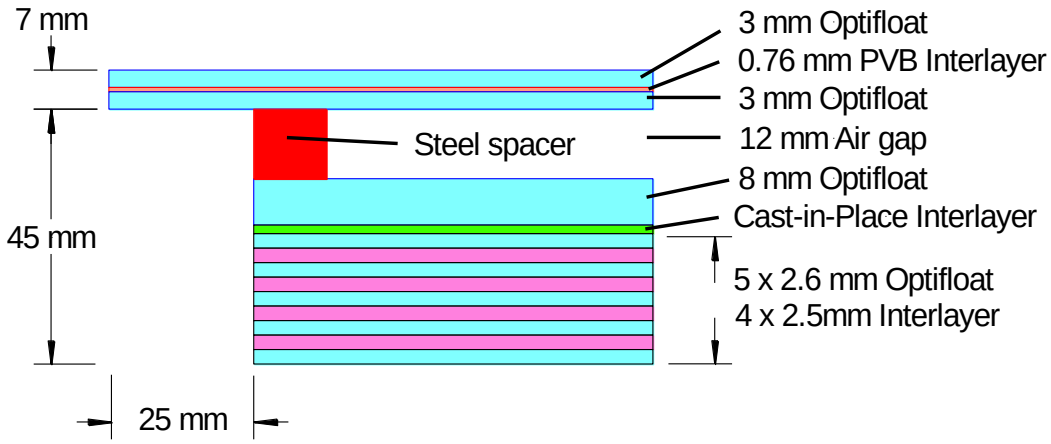


Figure 2 Arrangement of clamping angle.



Section of glazing



Edge detail, showing arrangement of layers

Not to scale

Figure 3 Pilkington fire resistant glass unit used in specimen construction.

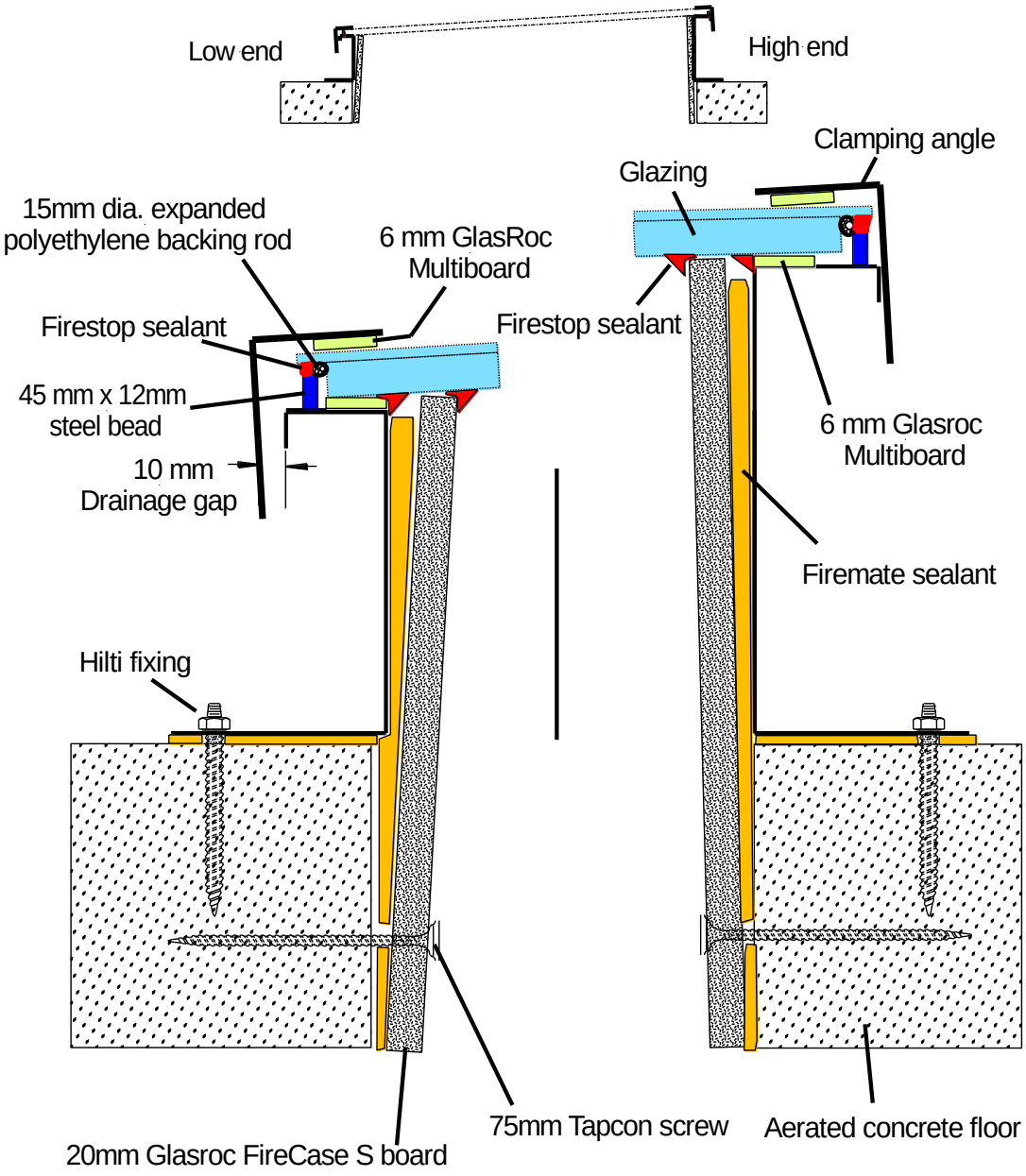


Figure 4 Section through construction showing detail at low and high ends of rooflight.

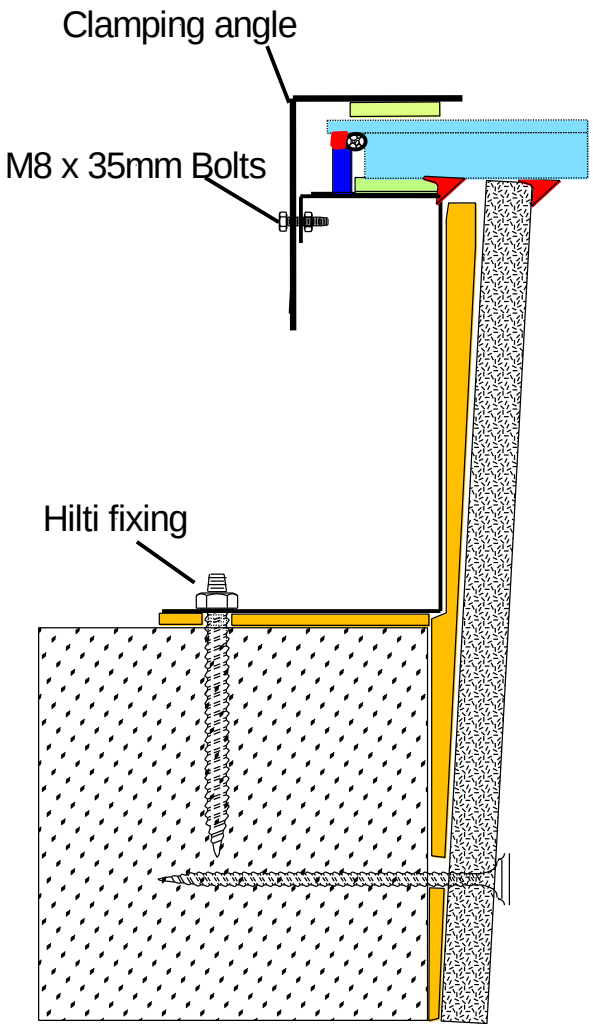


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Figure 5 Section through construction showing detail at sides of rooflight.

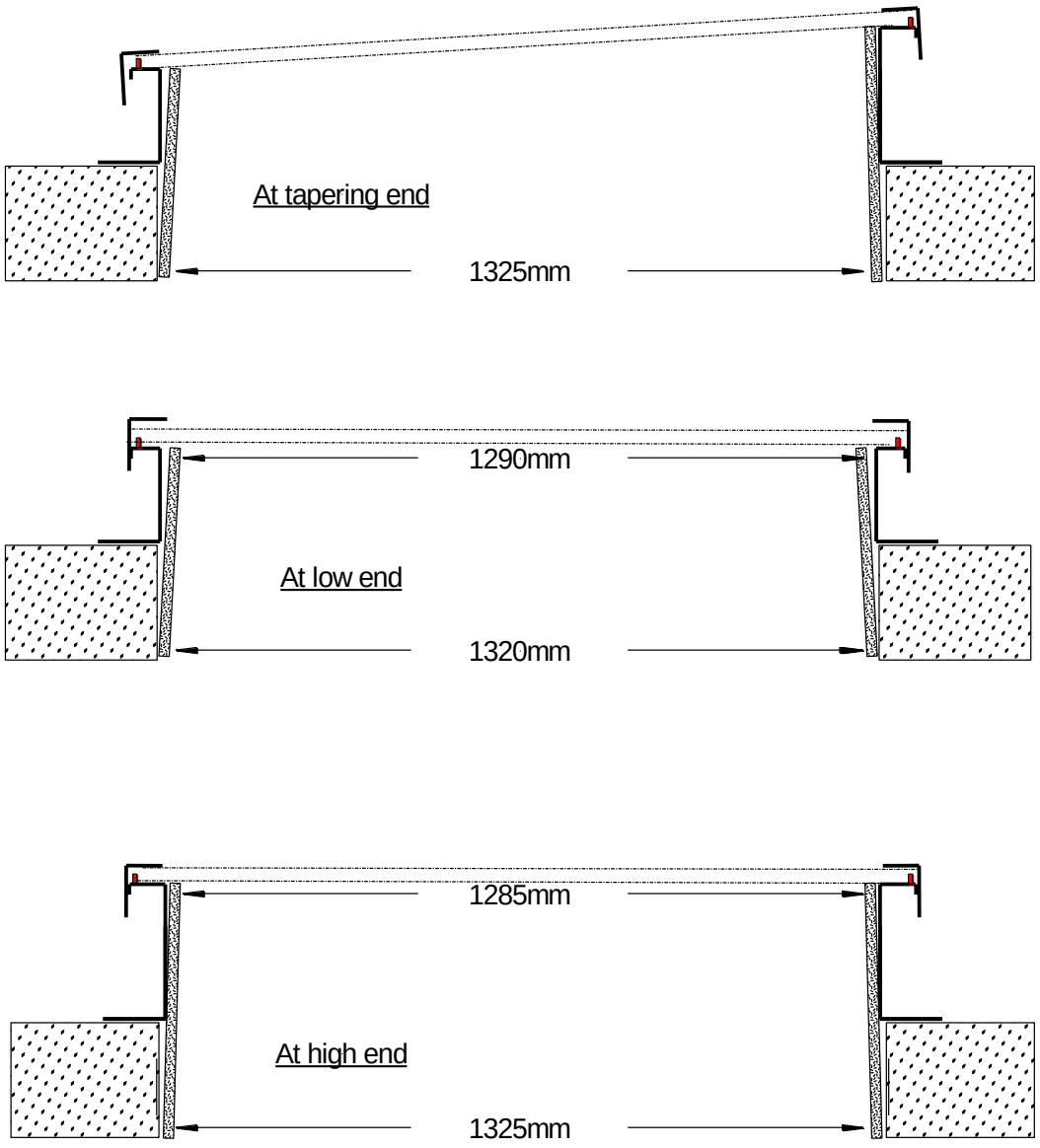
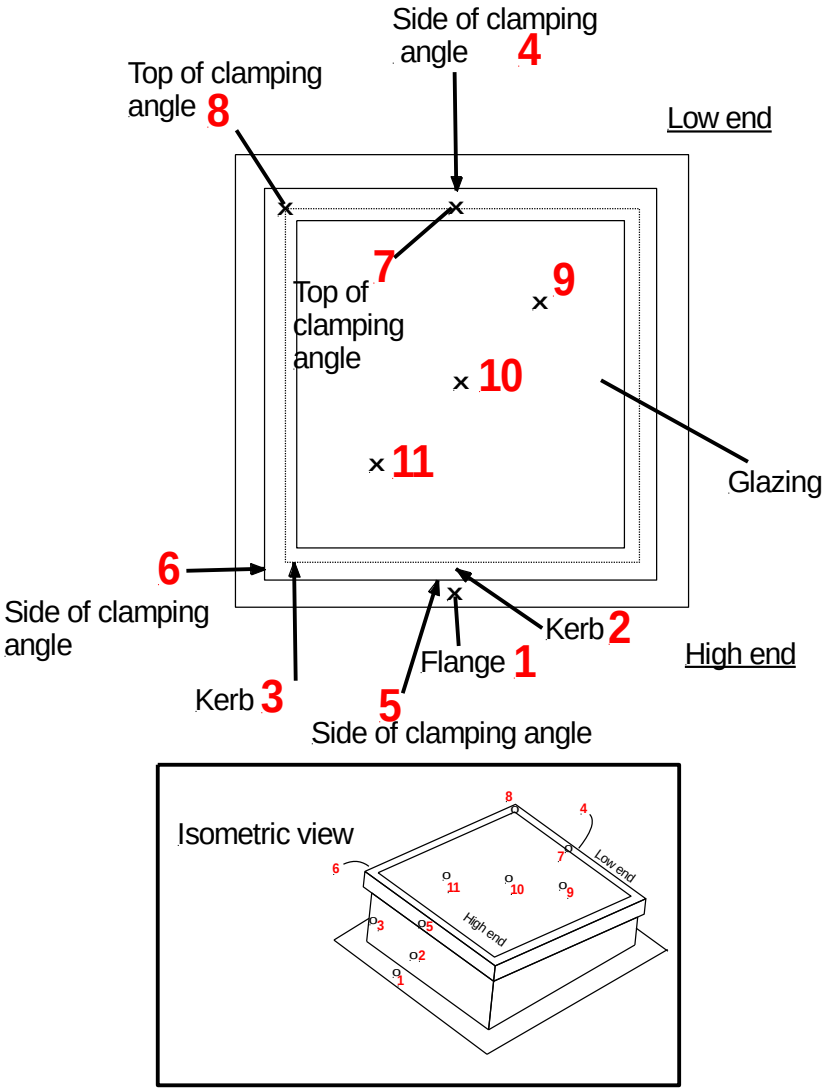


Figure 6 Section through construction showing tapering sides of rooflight.



1-11 Location of thermocouples

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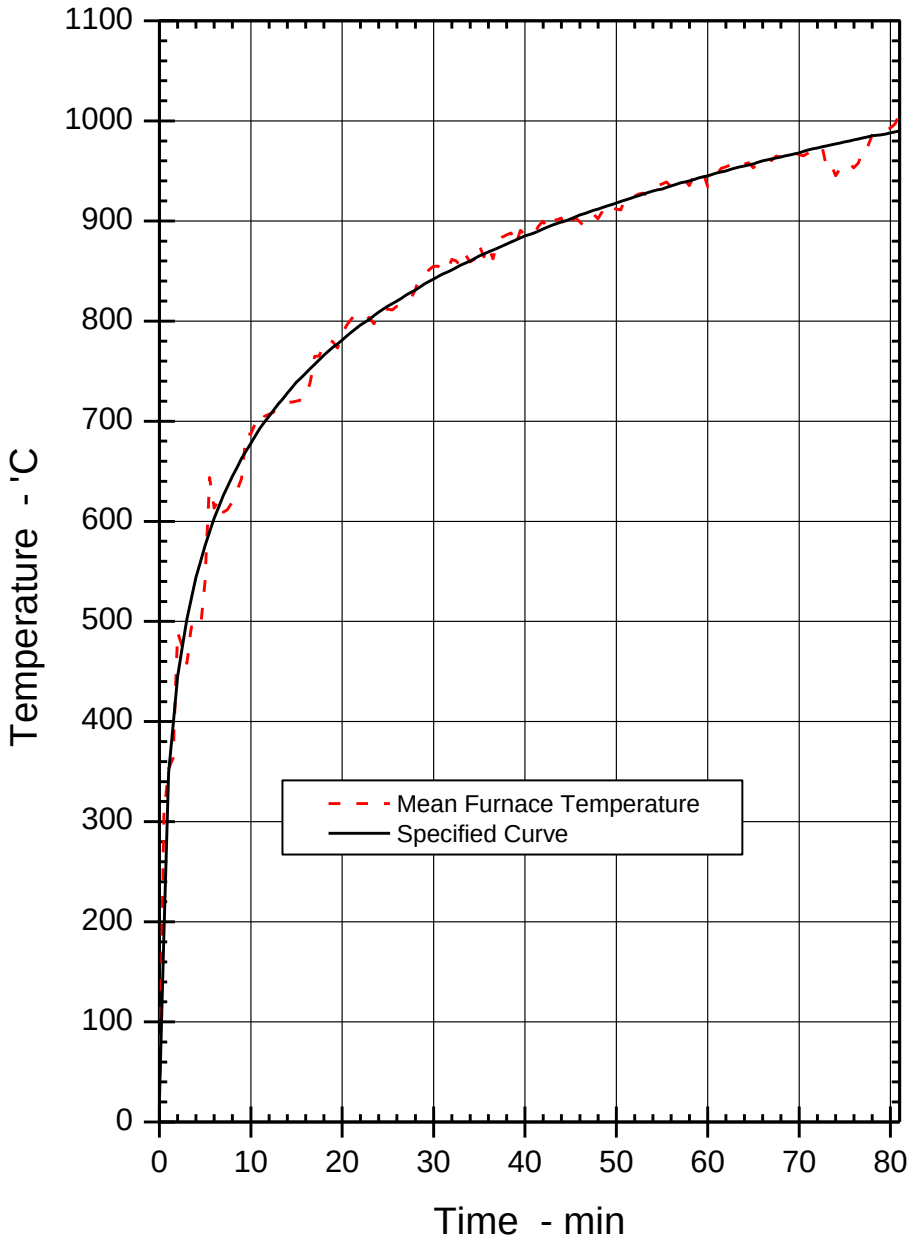
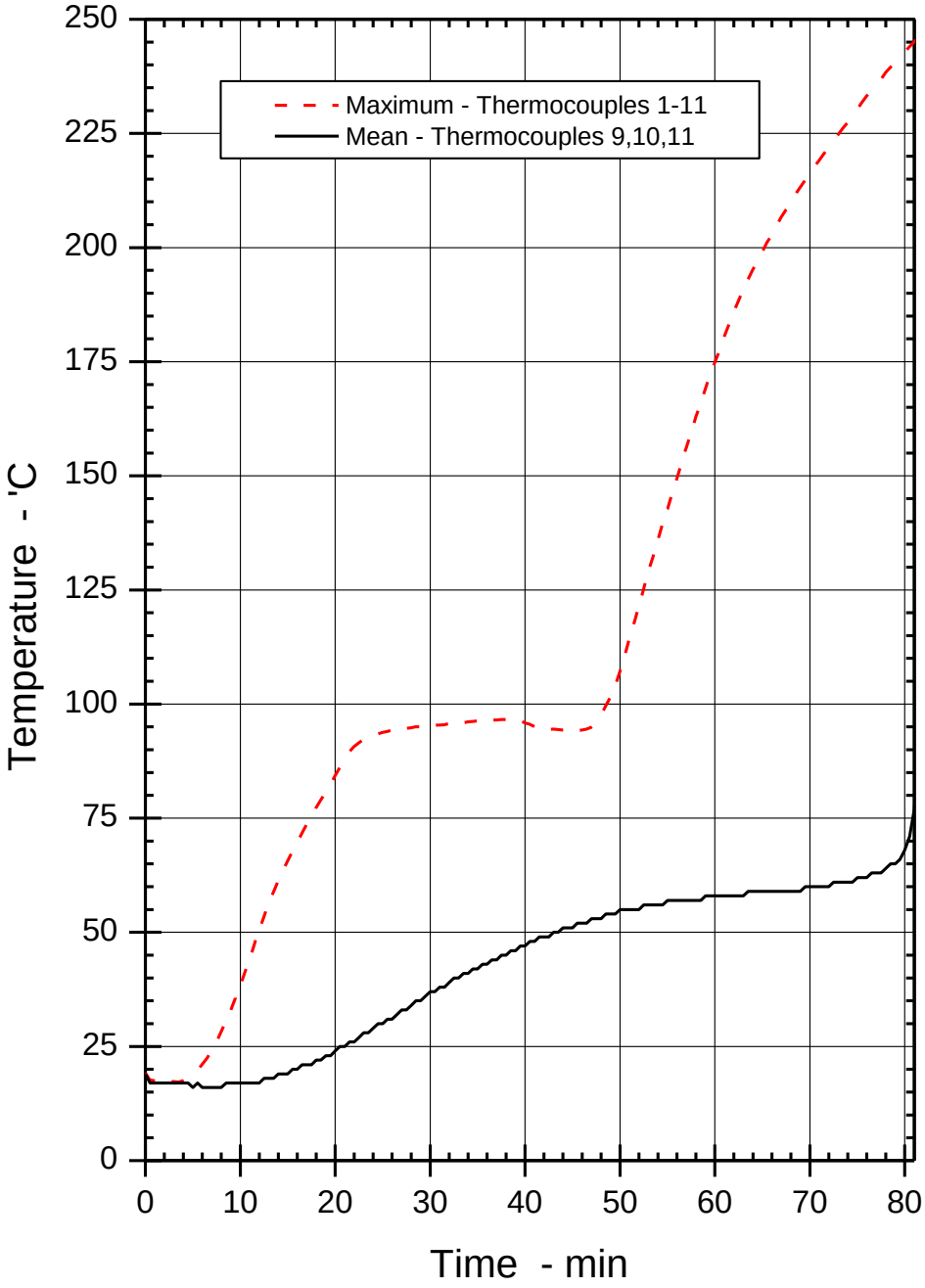
Figure 7 Arrangement of thermocouples on rooflight.

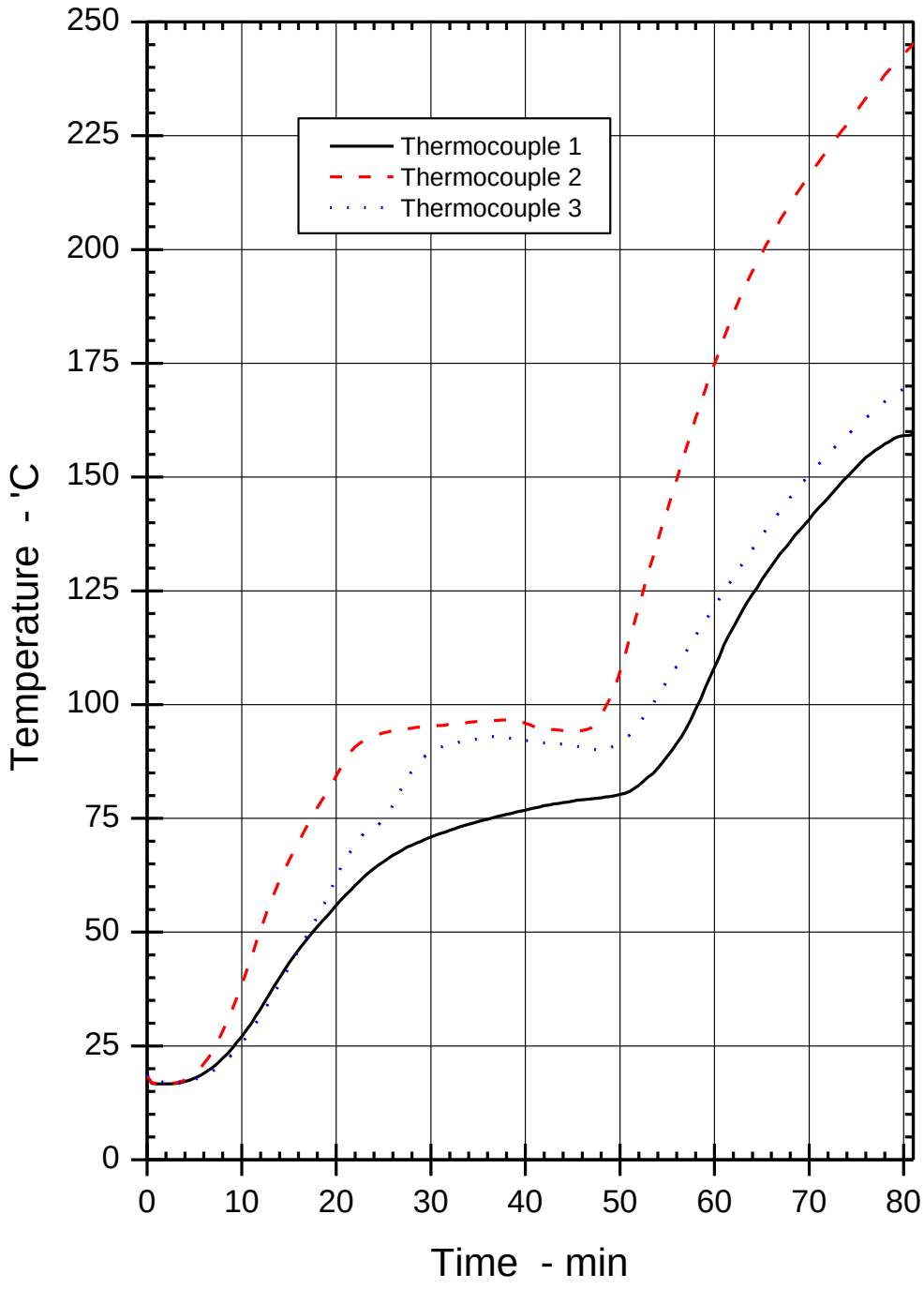
9 GRAPHS



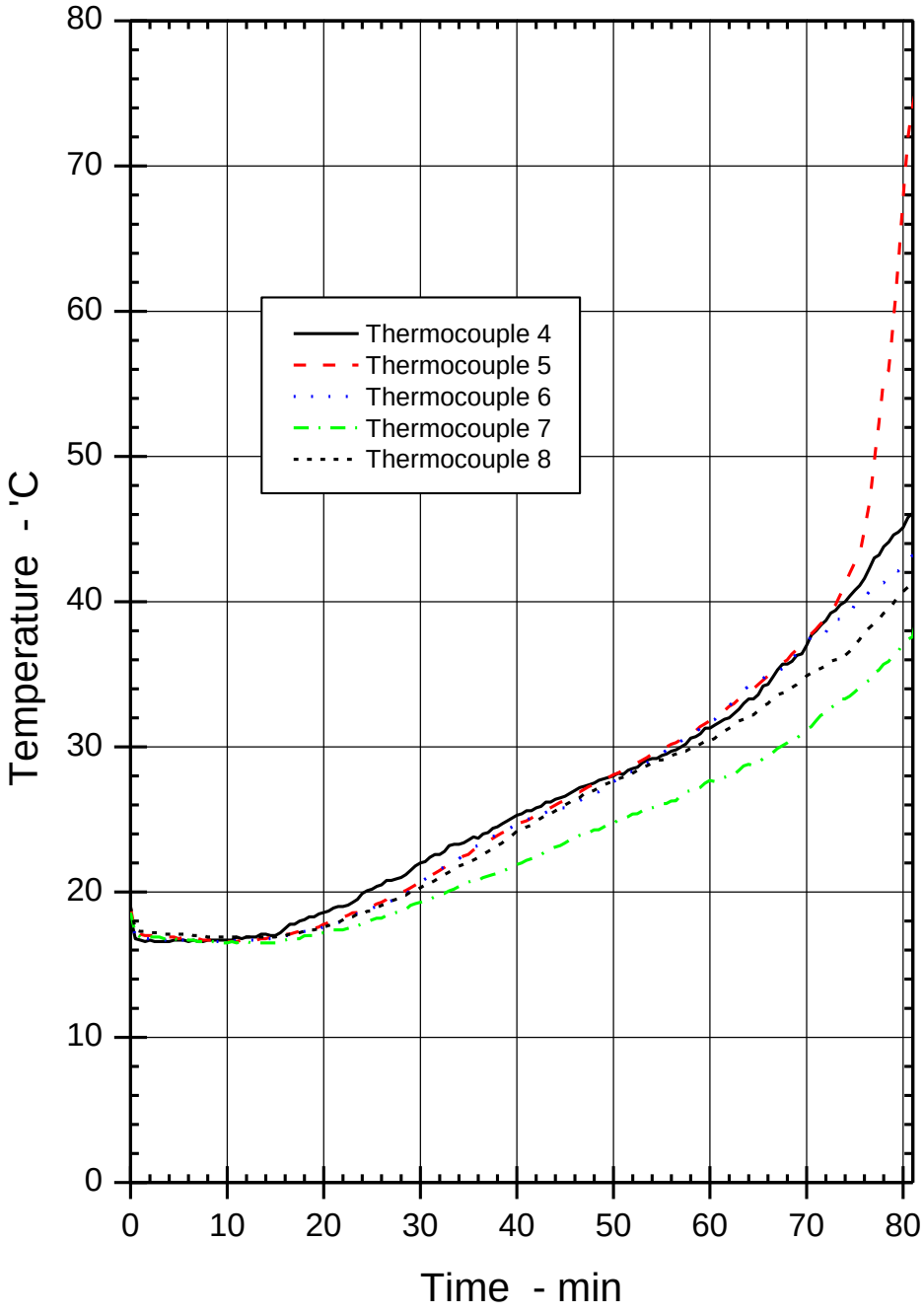
Graph 1 Furnace temperature



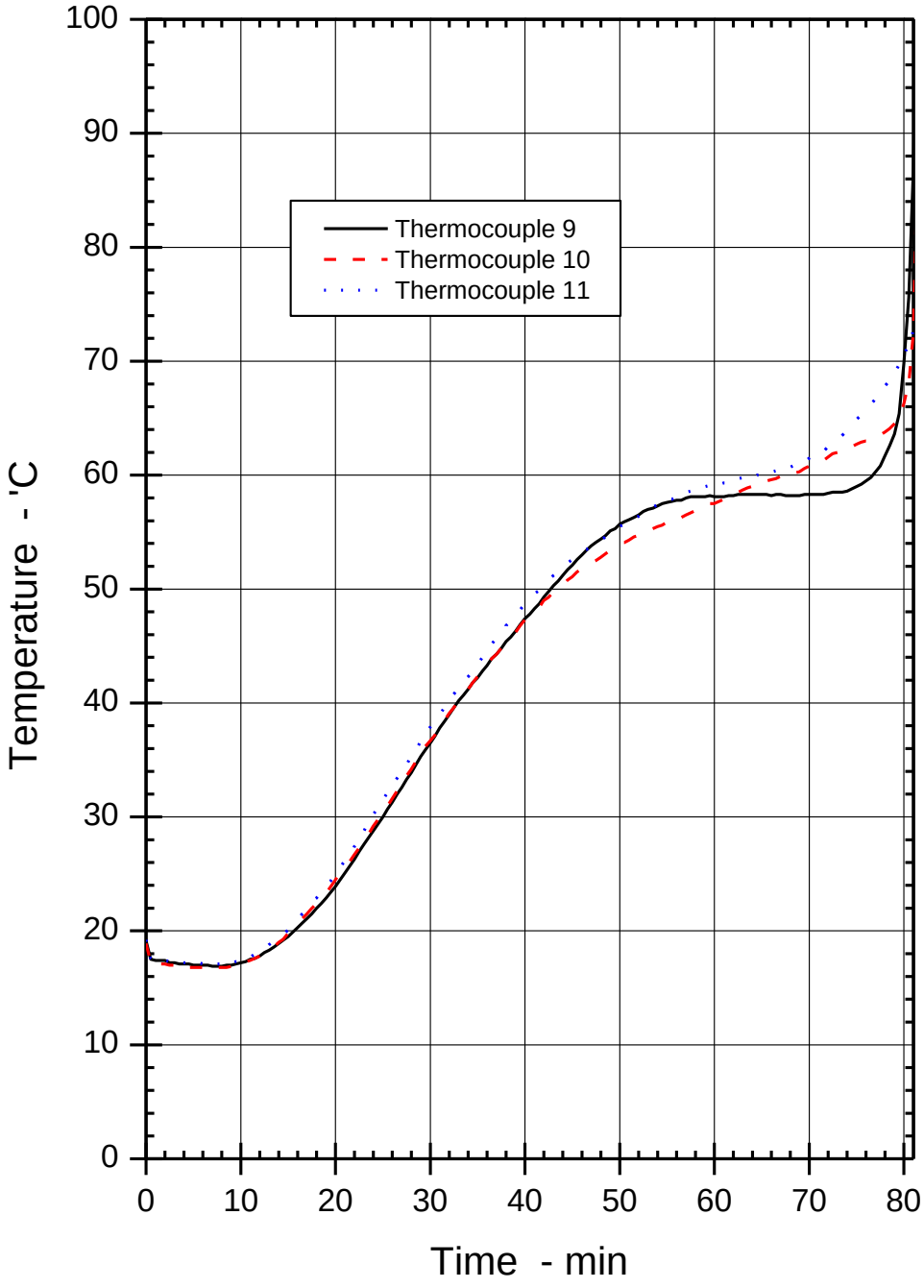
Graph 2 Maximum temperature recorded by all unexposed face thermocouples together with mean temperature recorded on glazing.



Graph 3 Temperature recorded by thermocouples 1 to 3 attached to flange and kerb.



Graph 4 Temperature recorded by thermocouples 4 to 8 attached to top clamping angle.



Graph 5 Temperature recorded by thermocouples 9 to 11 attached to glazing.