# Thermal Performance Tests on an Electrical Heated Ceiling System

## 'Fleece' and 'Drytec' products

Carried out for

Energy Carbon Ltd

Report 101882/1

Compiled by Philip Stonard

10 December 2020




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## 'Fleece' and 'Drytec' products

Carried out for: Energy Carbon Ltd
Kemp House
152-160 City Road
London
EC1V 2NX

Contract: Report 101882/1

Issued by: BSRIA Limited
Old Bracknell Lane West
Bracknell
Berkshire
RG12 7AH
UK

Telephone: +44 (0)1344 465600

Fax: +44 (0)1344 465626

Email: bsria@bsria.co.uk
Website: www.bsria.com/uk/

## QUALITY ASSURANCE

| Issue | Date | Compiled by: | Approved by: | Signature |
|---|---|---|---|---|
| *Final* | *10-Dec-2020* | *P.Stonard*<br><br>*Senior Engineer* | *Tom Garrigan*<br><br>*Business Manager* |  |

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# 1 INTRODUCTION

This report details work carried out on two types of low voltage electrical heating panels installed on a ceiling. The work was requested, and product supplied by E-nergy carbon and conducted during the period 30 September to 20 October 2020. Test items were received on 09 September 2020.

# 2 PRODUCTS SUPPLIED FOR TEST

The products supplied consisted of:

Low voltage 'Drytec' heated strips 3.5m x 0.6m consisting of a flexible carbon impregnated substrate designed to be fitted directly above, and in contact with, a plasterboard ceiling. The 'active', carbon impregnated width of the product was approximately 0.3m. Eight pieces. Nominal 36W/lfm.

Low voltage 'Fleece' heated strips 3m x 0.6m consisting of a perforated flexible carbon impregnated substrate designed to be bonded to the underside of plasterboard ceiling and finished with a thin plaster coating. The 'active' carbon impregnated width of the product was 0.6m. Six pieces. Nominal 66 W/lfm[1]

Power supply unit (36V AC)

Temperature sensor

Temperature controller (thermostat)

# 3 OBJECTIVES

The objectives were to determine, for the two types of panel tested:

- The response time of the temperature rise within a test chamber at different positions during the heat up period.
- The comparative temperatures seen using different probe types (surface, globe and air shielded).
- The temperature variation at different heights in the centre of the chamber
- The temperature spread (in plan) using a single panel of each type.

# 4 APPROACH

The approach, following discussions with the client, was to utilise an existing BSRIA test chamber normally used to test radiators and convectors. Similarly, chamber setpoints were as agreed prior to test.

The chamber was the BSRIA BS EN 442 radiator test chamber, internal dimensions 4mx4mx3m and had the ability for cooling to be applied to up to five surfaces by means of circulating chilled water through walls, floor and ceiling. In this instance four surfaces were used (three walls and floor) with ceiling cooling isolated. The chamber construction was double skinned steel surfaces with waterways on the inner skin and 80mm of polyurethane insulation.

Temperature probes of different type were installed at various heights in the centre of the chamber and at one height in the centre of each floor quartile.

[1] Product supplied as 6 m lengths capable of being powered from both ends. Cut to 3m lengths for test purposes.

# 5 SCOPE AND METHODOLOGY

The test method consisted of initially installing a false ceiling in the chamber. This consisted of timber joists 75mm deep spaced at 400mm centres. Insulation was installed for the depth of the joist and the 'Drytec' strips rolled out, trimmed to match the joist centres, and fixed above the 10mm plasterboard ceiling. On completion of tests on the 'Drytec' system, it was disconnected from the electrical supply and the 'Fleece' product installed on the underside of the ceiling. This used a bonding plaster on the ceiling (Thistle bonding coat) with the fleece pinned at one end, then gradually rolled out on the underside of the ceiling while working the plaster through the perforated fleece using a plastic float. Once in place this was left overnight and later skimmed with a finishing plaster (Thistle multi finishing), before being left for a further 24 hours to dry.

The resistance of each heated strip was checked for comparison with the expected nominal value and for consistency between strips to ensure there was no damage to the test pieces.

The ceiling was then wired to the control box and the thermostat and sensor installed on a chamber wall at approximately 1.5m from floor level. Power was measured via a calibrated meter.

Calibrated thermocouples were installed on the chamber vertical centre and the centre of each floor quartile in an array including surface sensors, black globes, and shielded air arrangements.

Surface sensors consisted of a small (10mm square) contact pad glued to a 50mm diameter plywood disc, 12mm thick. Painted matt black.

Globe sensors were a 63mm diameter matt black metal globe with a sheathed probe installed such that the probe tip was at the centre of the globe.

Shielded air probes consisted of a sheathed probe in the centre of a metal tube 60mm long with a 70mm metal disc each end spaced to give a total length of 90mm, all coated in reflective foil. There was also an existing chamber shielded air probe using a resistance thermometer (reference air probe)

On the chamber centreline, surface probes were positioned at heights of 0.05m, 0.75m, and 1.5m. Globes were positioned at 0.05m, 0.75m and 1.5m. The existing reference air probe was at 0.75m.

Additionally, in the centre of each floor quartile at a height of 0.75m surface, globe and shielded air sensors were positioned. The quartiles were determined based on the heated ceiling area.

The height of 0.75m was chosen as it was common to standard thermal tests on radiators and similar 'wet' systems.

All sensors were connected to a data logging system and temperatures recorded at 100second intervals. Observations were made of the power meter at the start and at various times during the test.

The temperature controller was set to 28°C, with the intention that the test panels remained on throughout the test period.

Tests commenced by cooling the chamber to 18°C (measured at the reference air probe), without the heated ceiling in operation and allowing to stabilise at that temperature. The cooling was then switched off (no water circulating through the chamber surfaces) and the heated ceiling switched on and temperatures recorded over time. The heated ceiling was on for a minimum of three hours to allow sufficient data to be collected and temperatures trends plotted.

During the initial warm up of the panels, infra-red images were taken of a portion of the ceiling at five minute intervals for at least one hour or until the ceiling appeared to reach a stable temperature.

On completion of tests on the full ceiling, all bar one strip of each type was disconnected, the chamber cooled to 18°C and the test repeated, to observe the temperature spread indicated by those sensors at 0.75m (centreline and each quartile).

Photographs of the general arrangement are included in Appendix A of this report.

## 5.1 INSTRUMENTATION

| Description | Identifier | Calibration due |
|---|---|---|
| Agilent data logger & reference air probe | 266<br>329 | 09/11/21 |
| Agilent data logger+20 thermocouples | 954 | 24/09/21 |
| Yokogawa power meter | 130 | 29/10/21 |
| Flir E40 IR camera | 202031 | 19/08/21 |

The datum parameters set within the Infra-red camera were:

Emissivity 0.95
Reflected temperature 20°C
Distance 1m
Atmospheric conditions 20°C, 50% RH

# 6 RESULTS

The results are presented in a combination of chart, graphic and thermal images.

The charts show the reaction of the sensor when the ceiling heating was switched on. The full ceiling tests for the Fleece and Drytec show the centre line response at various heights and for the three sensor types.

The single panel tests show the response at 0.75m in centre and the four quartiles for the three sensor types.

Note that the temperature scales are 30$^0$C for the full ceiling tests and 22$^o$C for the single panel tests. The total run time for each test varied, with some being run overnight.

The graphics give a summary of response time and maximum temperatures achieved at the end of the test period. The response times are based on an initial increase of 0.2$^o$C after heating was switched on, with temperature continuing to increase thereafter. For the single panel tests the maximum temperatures are taken after the same elapsed time for both products.

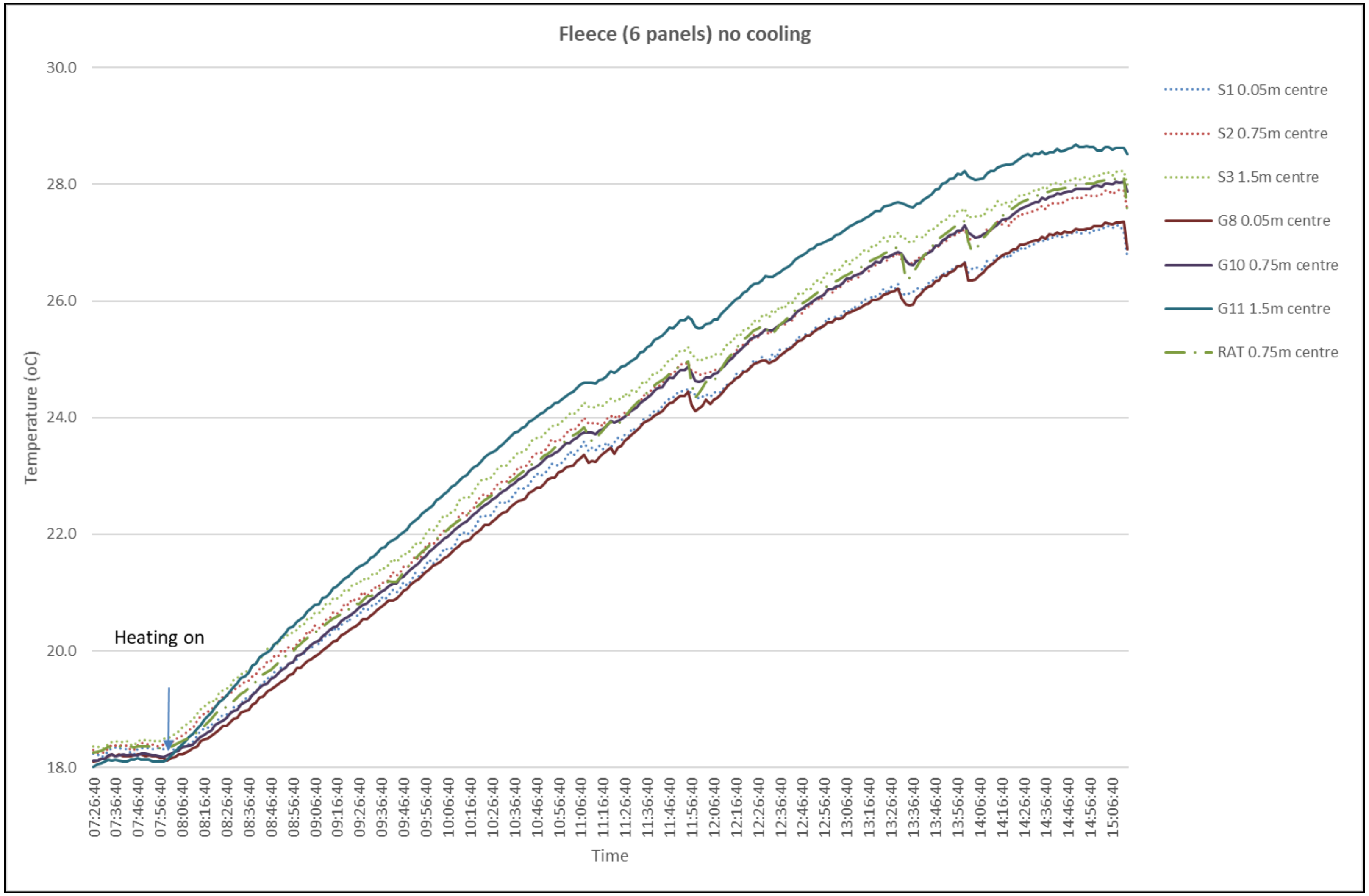
The thermal images show the panel response, as part of a full ceiling arrangement, during the initial warm up period.

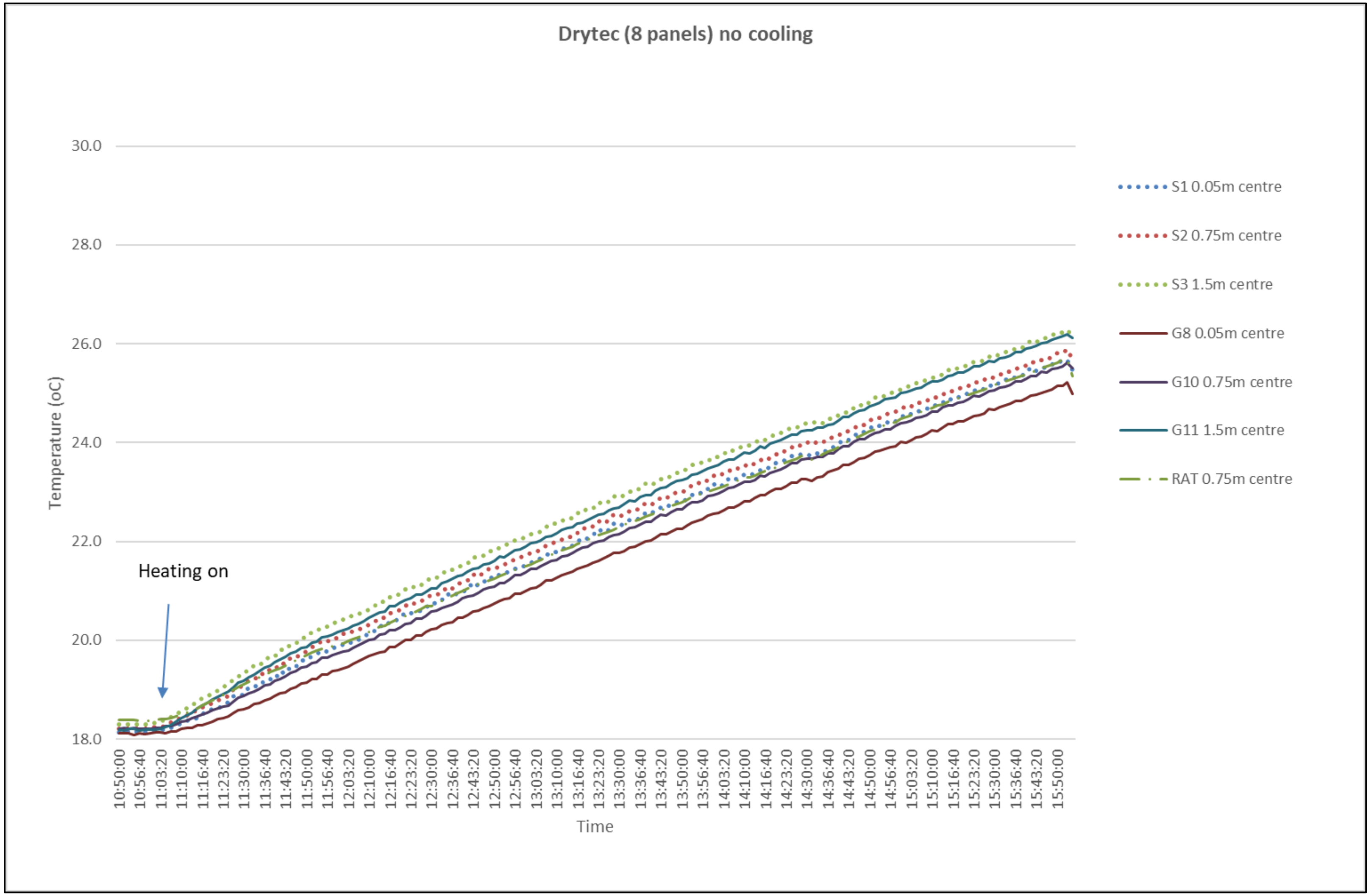
The power consumption of the Drytec ceiling was 980Watts at the start of the test, rising to 1005Watts maximum. Supply voltage varied between 241.5V to 243.6V

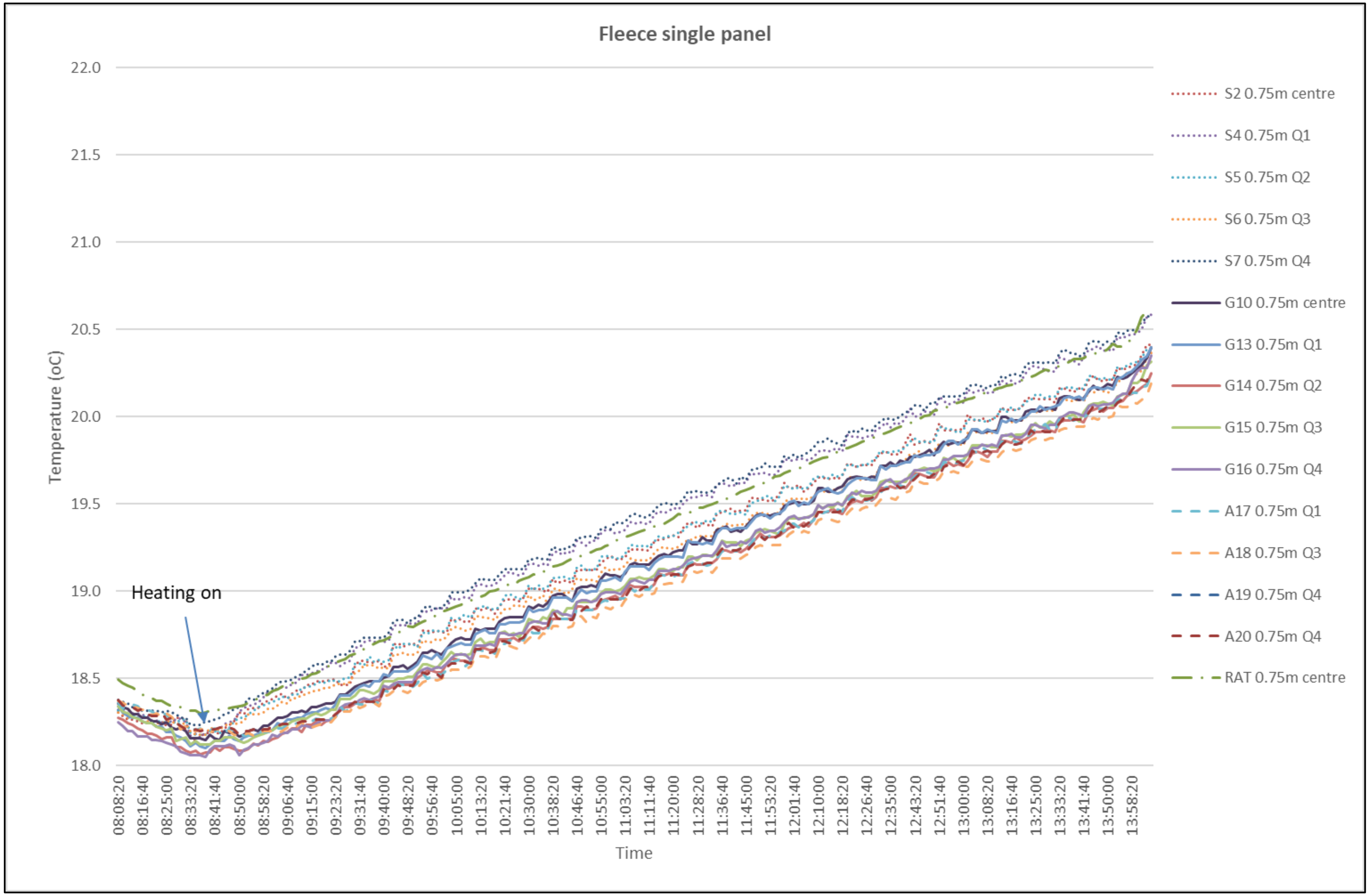
The power consumption of the Fleece ceiling was 1336Watts at the start of the test, with a maximum of 1346Watts. Voltage varied between 239.8V and 242.2V.

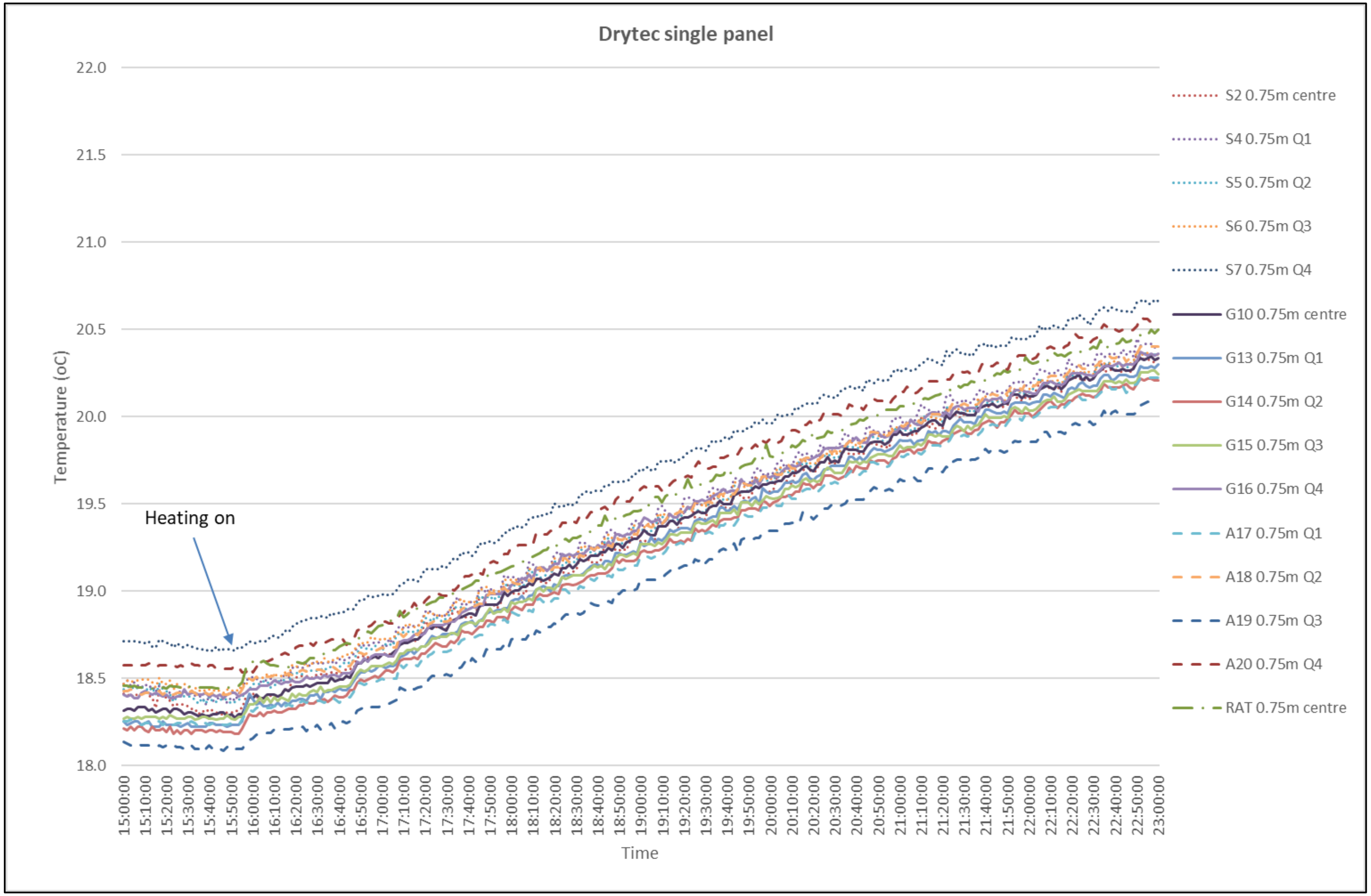
The single Fleece panel consumed 242Watts
The single Drytec panel consumed 156Watts

## 6.1 TEMPERATURE RESPONSE CHARTS



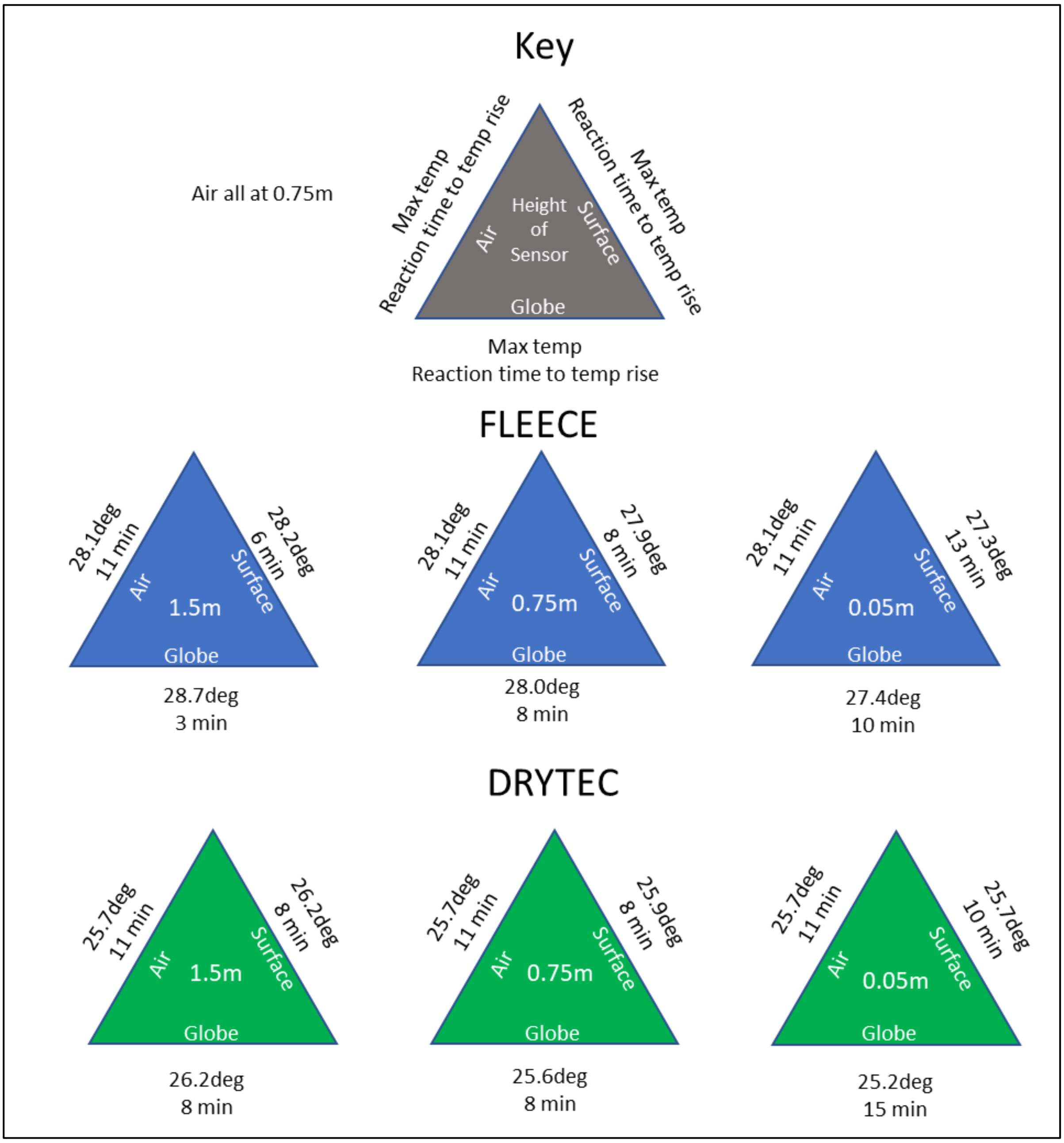

Drytec (8 panels) no cooling
30.0
28.0
26.0
24.0
22.0
20.0
18.0
Temperature (oC)
Heating on
Time
S1 0.05m centre
S2 0.75m centre
S3 1.5m centre
G8 0.05m centre
G10 0.75m centre
G11 1.5m centre
RAT 0.75m centre


Fleece single panel
22.0
21.5
21.0
20.5
20.0
19.5
19.0
18.5
18.0
Temperature (oC)
Heating on
Time
08:08:20
08:16:40
08:25:00
08:33:20
08:41:40
08:50:00
08:58:20
09:06:40
09:15:00
09:23:20
09:31:40
09:40:00
09:48:20
09:56:40
10:05:00
10:13:20
10:21:40
10:30:00
10:38:20
10:46:40
10:55:00
11:03:20
11:11:40
11:20:00
11:28:20
11:36:40
11:45:00
11:53:20
12:01:40
12:10:00
12:18:20
12:26:40
12:35:00
12:43:20
12:51:40
13:00:00
13:08:20
13:16:40
13:25:00
13:33:20
13:41:40
13:50:00
13:58:20
S2 0.75m centre
S4 0.75m Q1
S5 0.75m Q2
S6 0.75m Q3
S7 0.75m Q4
G10 0.75m centre
G13 0.75m Q1
G14 0.75m Q2
G15 0.75m Q3
G16 0.75m Q4
A17 0.75m Q1
A18 0.75m Q3
A19 0.75m Q4
A20 0.75m Q4
RAT 0.75m centre


Drytec single panel
Temperature (oC)
Time
Heating on
S2 0.75m centre
S4 0.75m Q1
S5 0.75m Q2
S6 0.75m Q3
S7 0.75m Q4
G10 0.75m centre
G13 0.75m Q1
G14 0.75m Q2
G15 0.75m Q3
G16 0.75m Q4
A17 0.75m Q1
A18 0.75m Q2
A19 0.75m Q3
A20 0.75m Q4
RAT 0.75m centre

## 6.2 TEMPERATURE RESPONSE GRAPHICS

### 6.2.1 Fleece and Drytec. Full ceiling vertical centreline

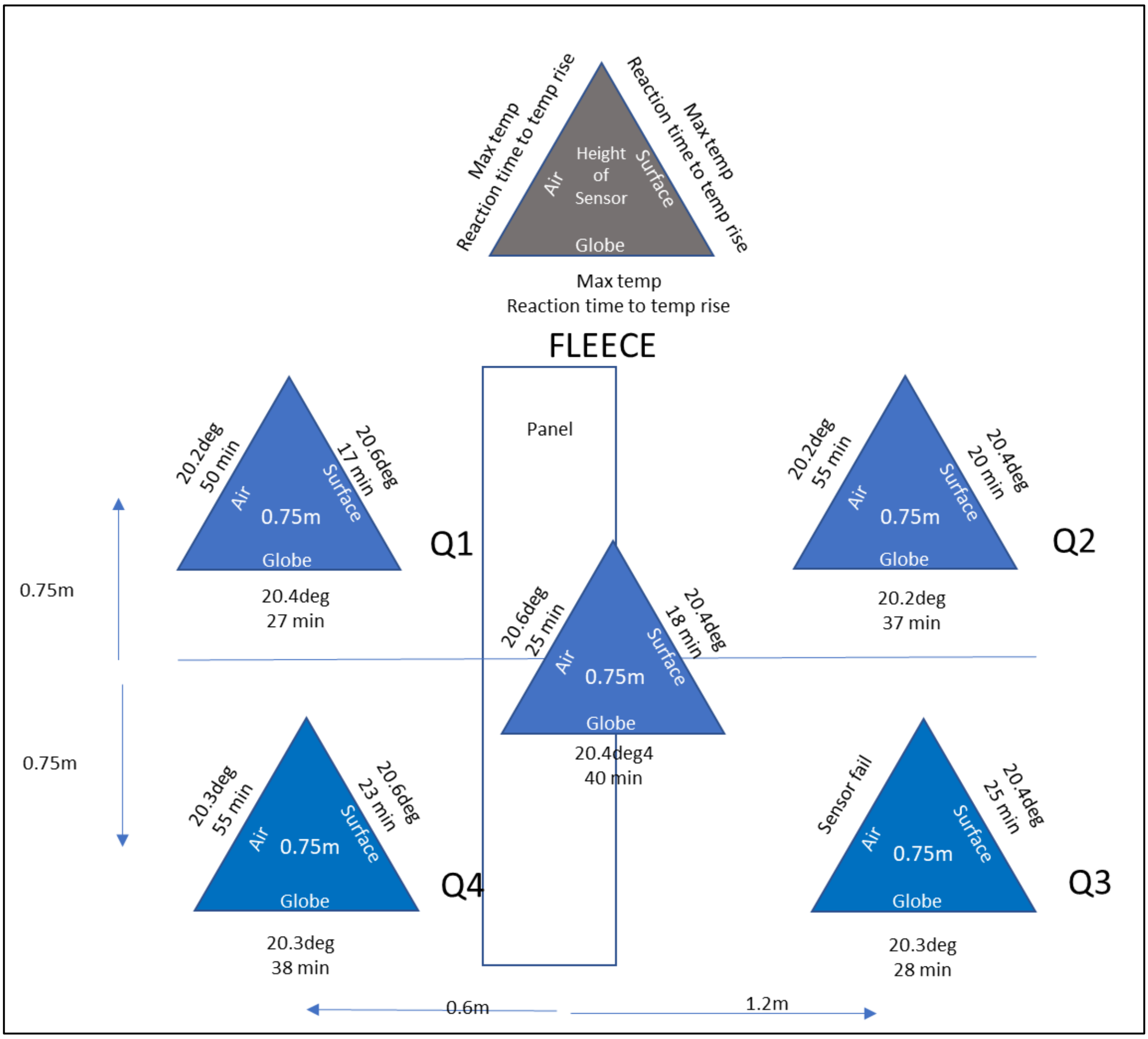



Maximum ceiling surface temperature (by thermal image)

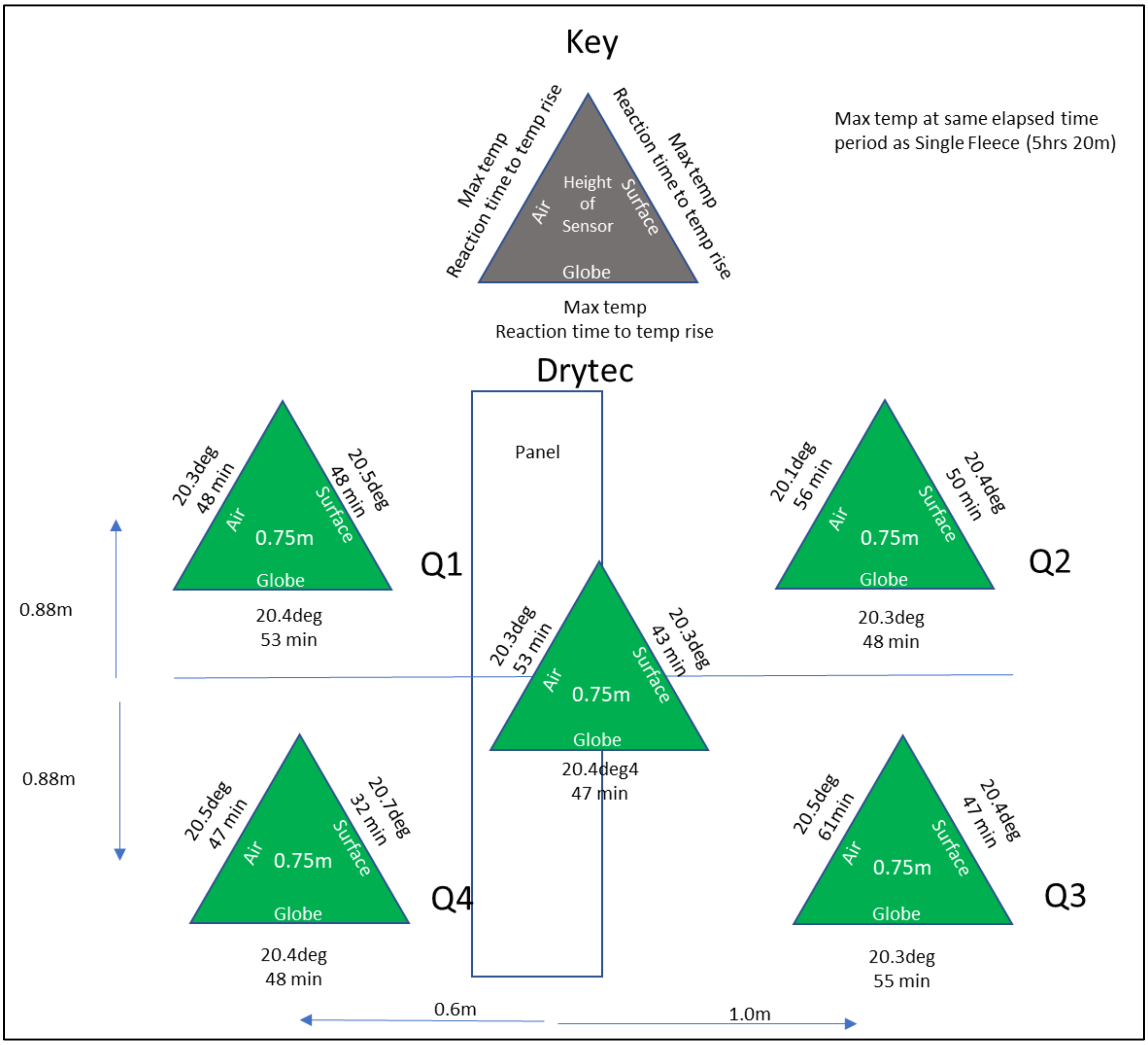
Fleece: 41.5deg

Drytec: 44.4deg

### 6.2.2 Single panel test graphic. Fleece, plan view



### 6.2.4 Single panel test graphic. Drytec, plan view



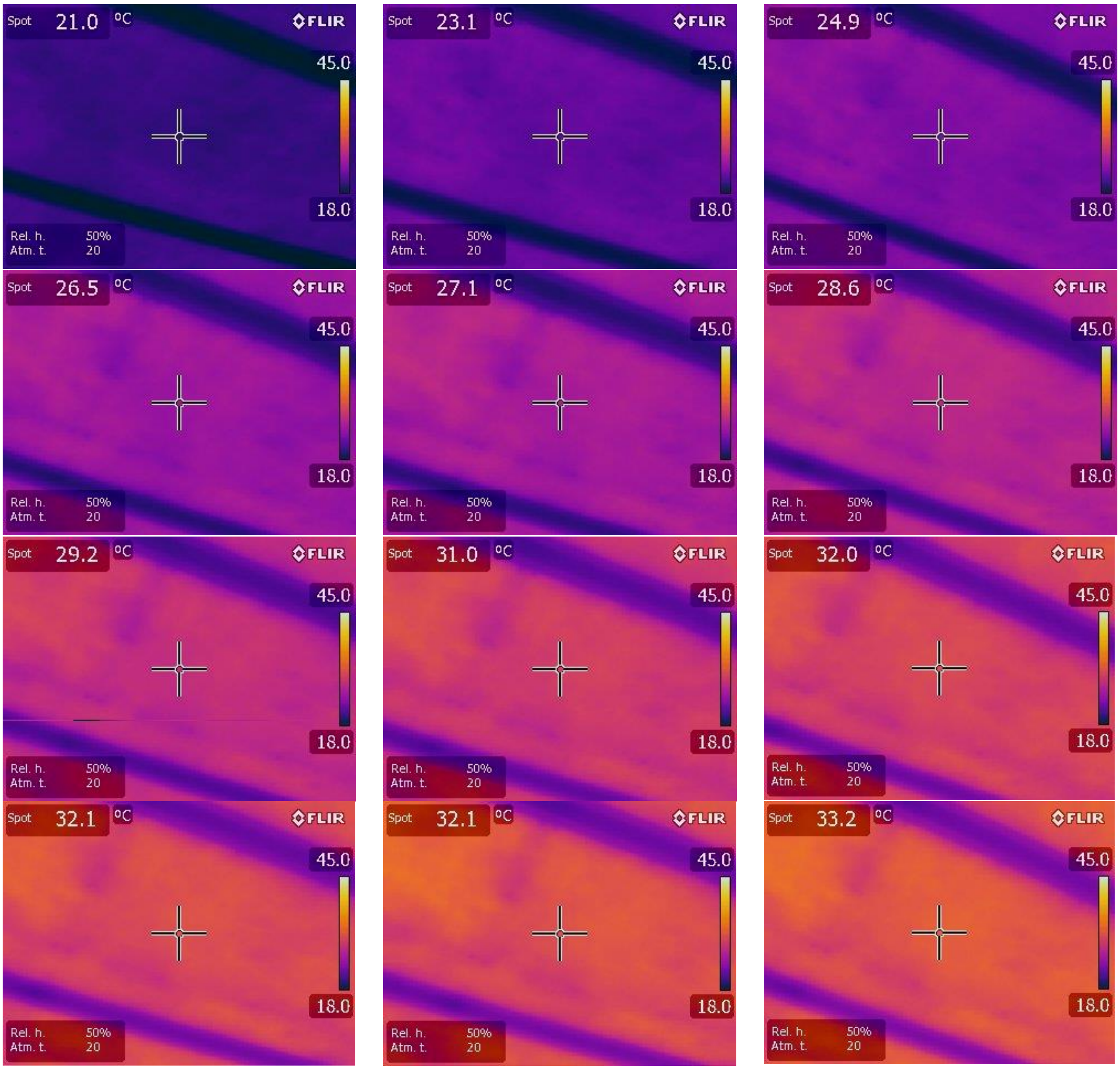
## 6.4 THERMAL IMAGES (FULL CEILING HEAT UP)

Thermal images were taken at the start of full ceiling tests at five minute intervals beginning five minutes after power switch on.

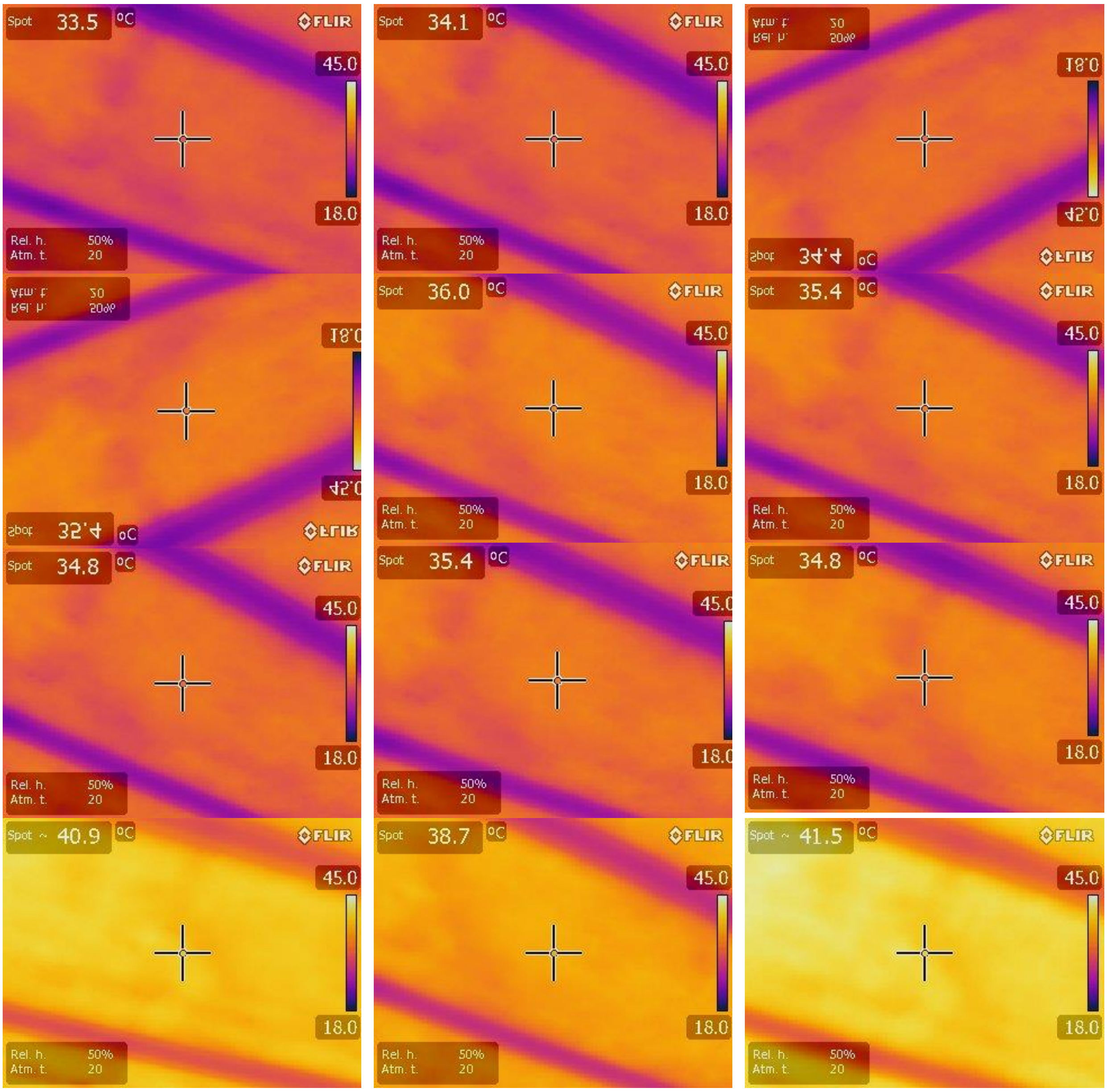
The Fleece achieved a maximum surface spot reading of 41.5°C

The Drytec achieved a maximum surface spot reading of 44.4°C

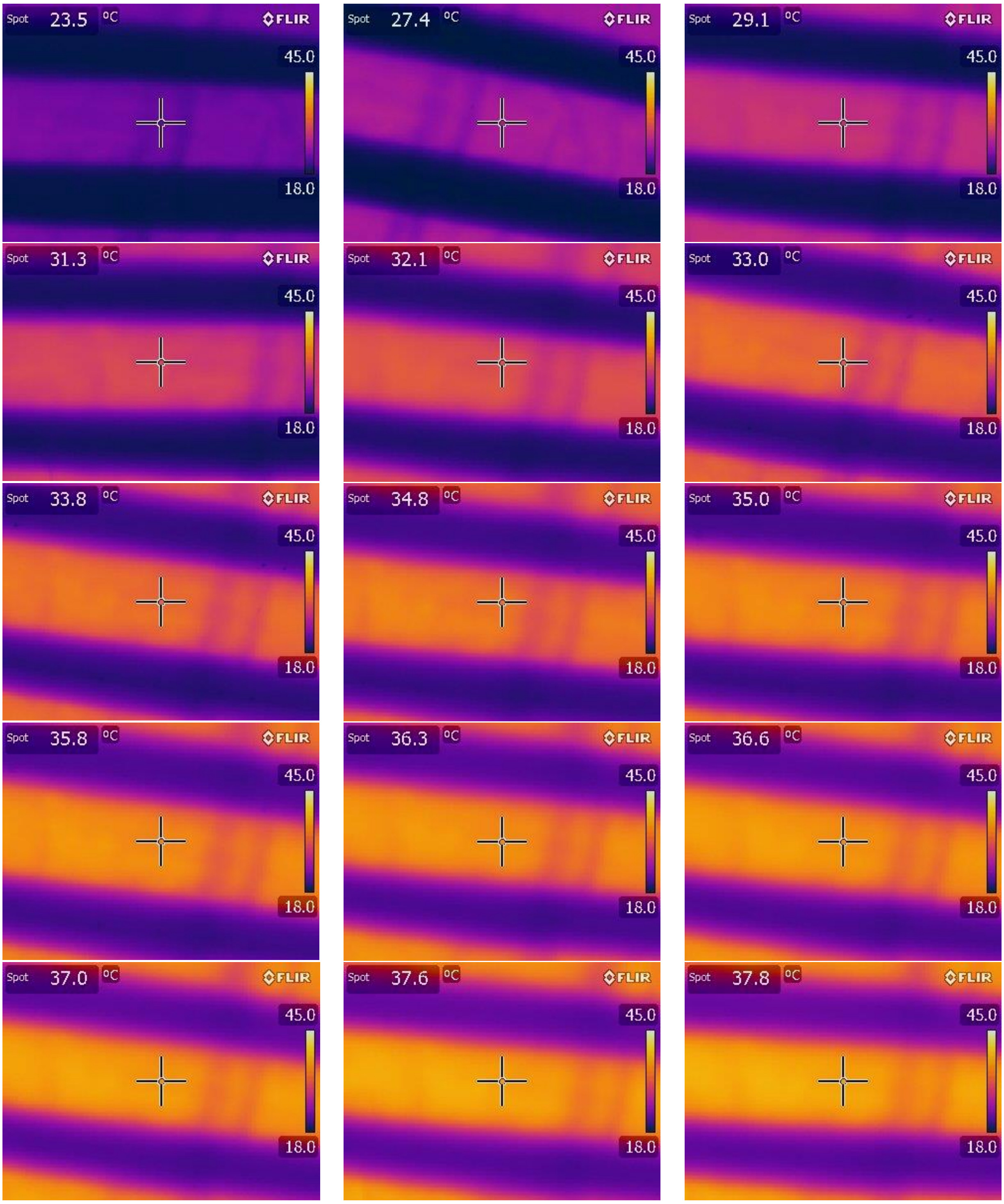
### 6.4.1 Fleece



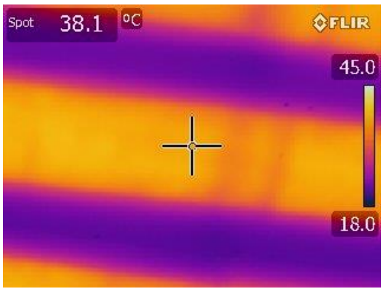
Fleece images continued.

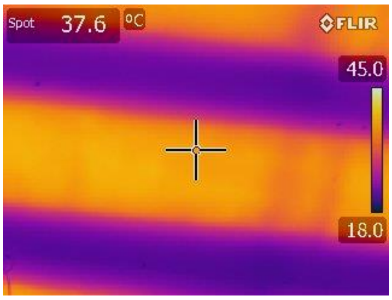


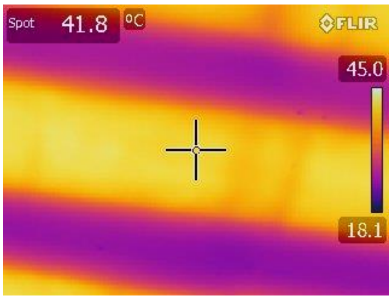
### 6.4.2 Drytec

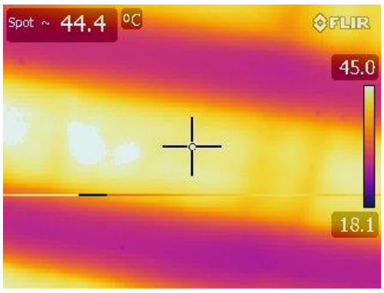

Spot 23.5 °C
FLIR
45.0
18.0
Spot 27.4 °C
FLIR
45.0
18.0
Spot 29.1 °C
FLIR
45.0
18.0
Spot 31.3 °C
FLIR
45.0
18.0
Spot 32.1 °C
FLIR
45.0
18.0
Spot 33.0 °C
FLIR
45.0
18.0
Spot 33.8 °C
FLIR
45.0
18.0
Spot 34.8 °C
FLIR
45.0
18.0
Spot 35.0 °C
FLIR
45.0
18.0
Spot 35.8 °C
FLIR
45.0
18.0
Spot 36.3 °C
FLIR
45.0
18.0
Spot 36.6 °C
FLIR
45.0
18.0
Spot 37.0 °C
FLIR
45.0
18.0
Spot 37.6 °C
FLIR
45.0
18.0
Spot 37.8 °C
FLIR
45.0
18.0

Drytec images continued.



# 7 COMMENTS/ANALYSIS

It should be noted that the test chamber is not a typical domestic or commercial building construction and, in common with other heating systems, response times and effects will be influenced by both the product characteristics and the building thermal properties and operating parameters for any given installation.

Maximum temperatures achieved and response times are therefore applicable to the particular test installation only. Globe temperature response is generally considered as similar to the thermal response of a human body (a combination of radiation, air temperature and air velocity effects). Thus, faster response times are indicative of a similar effect being felt on the body.

The full Fleece ceiling saw the thermostat briefly switch during the tests, as seen by the slight 'sawtooth' profile of the chart. However, it continued to supply power throughout the test allowing the panels to increase chamber temperature.

Care is needed when observing response time variations between types of sensor, specifically for single panel (spread tests) where the chamber temperature rose very slowly, due to the small power input, as the variations in time shown equate to an approximate temperature change of only 0.1°C. Thus, they should be considered as an indicator that the quartile response tracked the centre probes giving an indication of temperature spread being detected, rather than a basis for precise extrapolation of response times at individual probe positions.

# 8 CONCLUSIONS

The 'full' ceiling tests on the Drytec and Fleece systems showed that both appeared capable of supplying heat to near floor level (0.05m), with surface and globe probes showing faster response times than the shielded air probes, indicating a radiant heating effect.

The 'single' panel heating tests showed detection of temperature change was seen up to 1m from the panel horizontal centre line for the Drytec product and up to 1.2m for the Fleece product at a height of 0.75m above floor level.

# APPENDIX A: PHOTOGRAPHS OF TEST ARRANGEMENT

**Figure 1 General view of test chamber with Fleece system**

**Figure 2 Typical probe array**

**Figure 3 Power supply unit**


**Figure 4 Temperature controller**