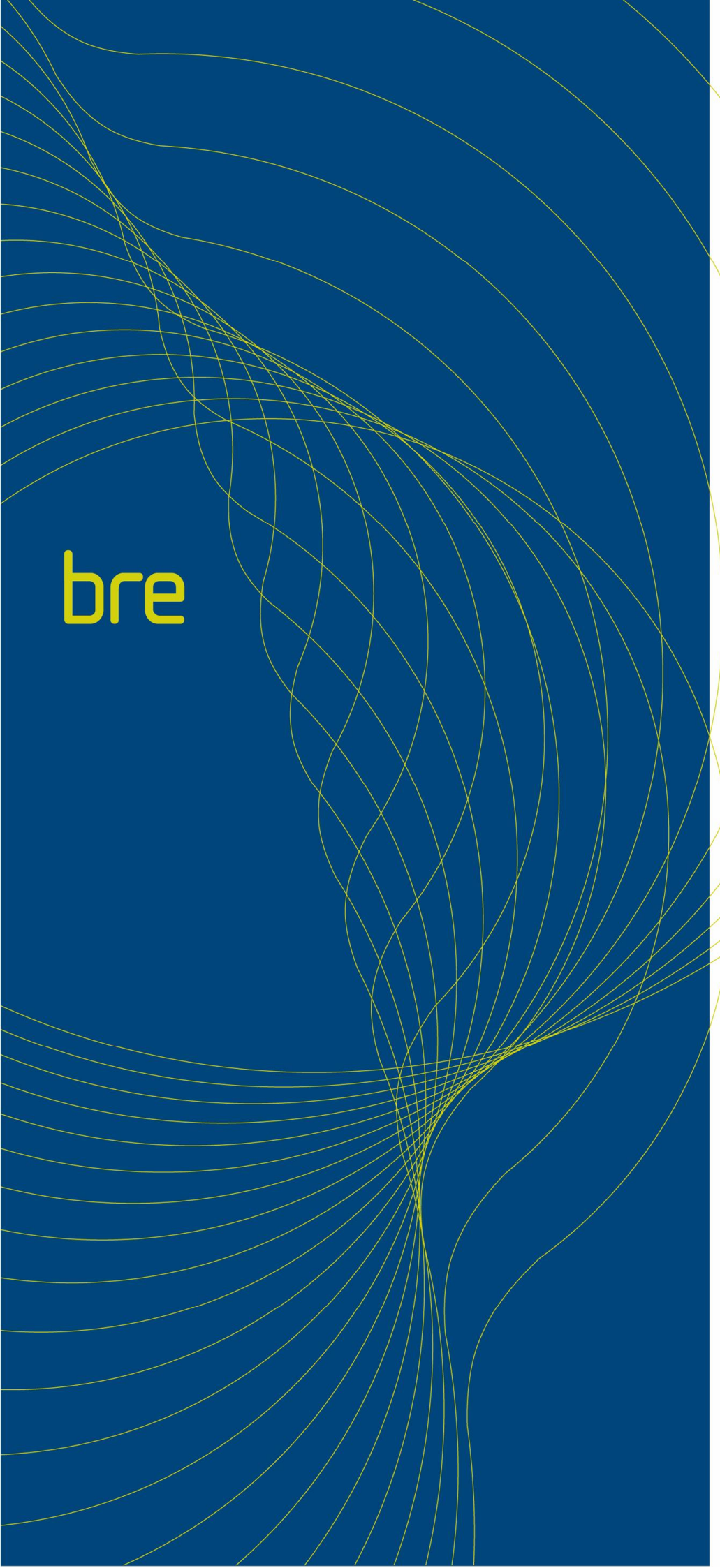


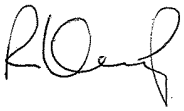
Performance testing of the Solar Star photovoltaic powered fan

Prepared for: Ian Bell, SolaLighting Ltd

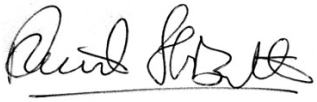
22 August 2008

Test report number 245-817

Prepared by

Name	Richard Kemp
Position	Senior Consultant
Date	28 August 2008
Signature	

Approved on behalf of BRE

Name	David Butler
Position	Manager, Building Diagnostics & HVAC Engineering
Date	28 August 2008
Signature	

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Contents

1 Introduction

Discussions between Ian Bell of SolaLighting and BRE representatives took place on the 9th May 2008 regarding Solalighting's requirements for testing and evaluation of the Solar Star photovoltaic-powered loft extract fan. Written acceptance of the work, as per BRE's proposal number 122460 dated 14th May 2008, was subsequently received by BRE. The work program comprised three tasks and this report details the results of the laboratory performance testing (Task 1 of the agreed works). Of interest to SolaLighting was the pressure and volume flow characteristics of the Solar Star under varying irradiance levels with a single and dual photovoltaic (PV) panel configuration.

A Solar Star fan, in the High Profile Roof Mount configuration, with integral PV and two additional PV panels (identical to the integrated panels) was provided by SolaLighting.

2 Details of tests carried out

The Solar Star supplied by SolaLighting was tested between the 27th July and 22nd August 2008.

The integral PV was disconnected and the additional PV panels provided were used in single and parallel electrical configurations for the purposes of the testing.

A schematic drawing of the purpose-built test rig is shown in **Figure 1** and selected photographs of the rig are given in Appendix A.

The rig was located internally in a laboratory with the exception of the solar components. The SolarStar was mounted at the end of the plenum chamber with the exhaust to the laboratory (draw through configuration). The PVs were mounted on a frame along with a Kipp and Zonen solarimeter in the same plane. A perpendicular rod was also mounted on this frame to check for incidence angle of the beam radiation. This frame could be moved to match the azimuth and altitude of the sun and throughout the tests the frame was always orientated normal to the sun's beam. The panels and the solarimeter were connected to the Solar Star and datalogger respectively by cables of 2.5mm^2 copper cores to ensure negligible voltage drop and resistive heating compared to the integrally mounted PV.

The tests were carried out in accordance with the recommendations of *BS 848 : Part 1 1997 ISO 5801 : 1997 Fans for general purposes Part 1. Performance testing using standardised airways* using the type A installation (inlet side test-chamber).

The plenum and supply ductwork was sealed, thus by installing air flow measuring devices in the makeup duct to the plenum, the extract rate of the SolarStar could be measured. The air flow rate supplied to the Solar Star was measured using a Furness FCO96H-2000L Laminar flow element or a 52.73mm or 70.84mm orifice diameter Poddymeter orifice plate, depending on the flowrates for the particular test condition, installed within a 104mm internal diameter duct. A Furness FCO12 differential pressure micromanometer and an Airflow Developments PVM100 micromanometer were used to measured pressure difference across the laminar flow element and the orifice plates respectively. The variables irradiance, plenum pressure, plenum temperature, room temperature and relative humidity were logged by a Grant 1000 Series Squirrel datalogger with the airflow measuring devices' differential pressure and atmospheric pressure recorded manually.

A variable speed auxiliary fan was installed at the measuring duct inlet. The speed was adjusted to create varying degrees of static pressure in the test plenum. Static pressure at this point was measured using a Furness micromanometer type FC012. Calibration certificates for the micromanometer instruments are shown in Appendix B to this report. A butterfly damper was installed at the inlet of the plenum to allow testing of low flow rates with higher differential pressures between the plenum and atmosphere when the auxiliary fan was switched off.

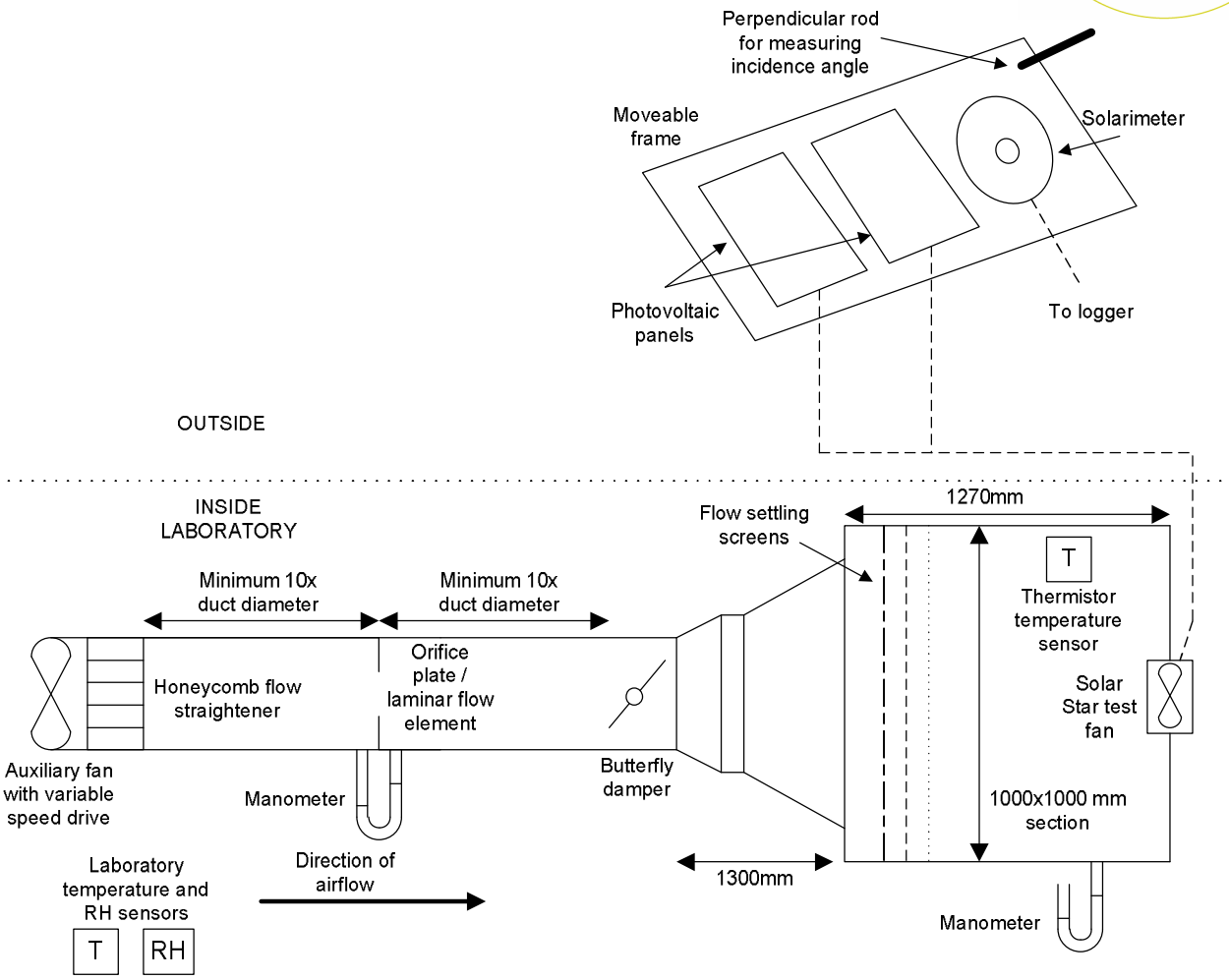


Figure 1 Fan test rig (not drawn to scale)

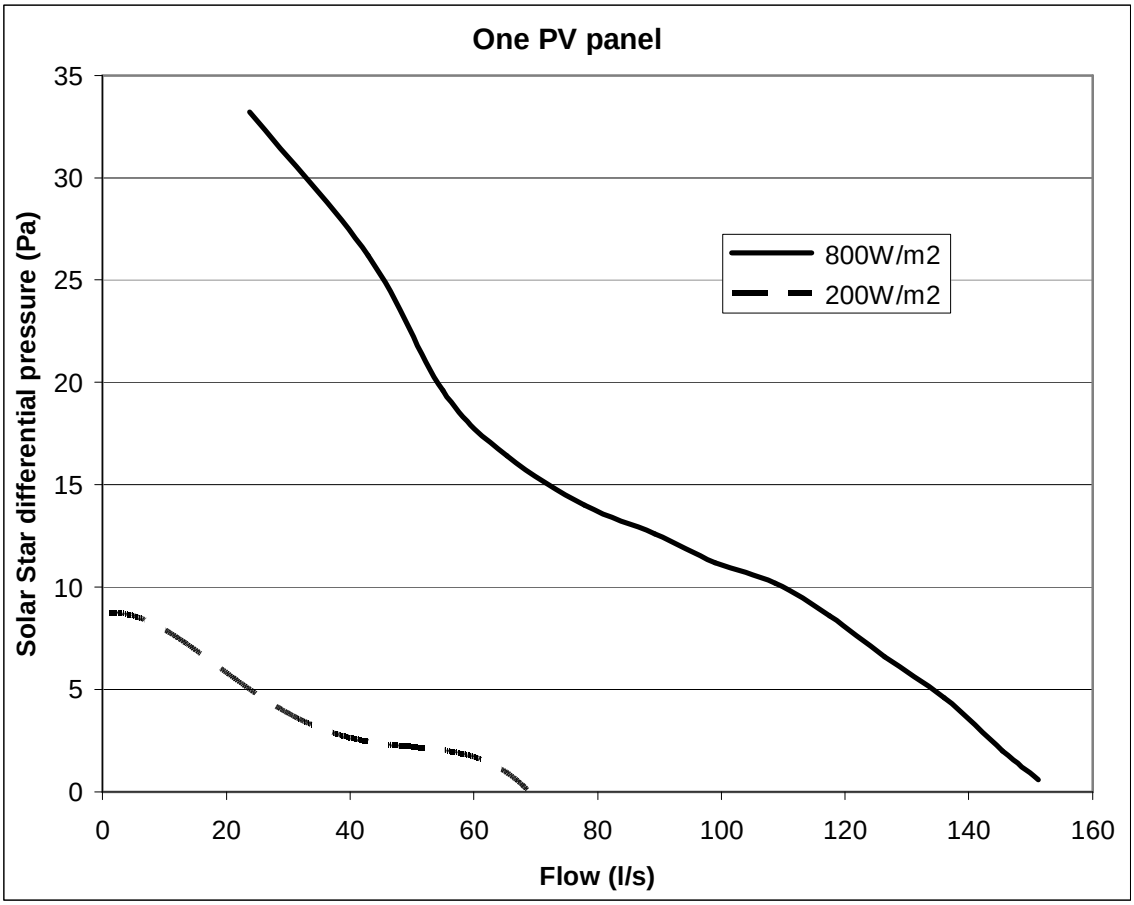
The temperature of the air at the Solar Star inlet was measured using a thermistor calibrated against a Hewlett Packard 2804A Quartz Thermometer. The relative humidity in the laboratory was measured by a Vaisala RH probe. A Calibration certificate for the quartz thermometer is reproduced in Appendix B to this report.

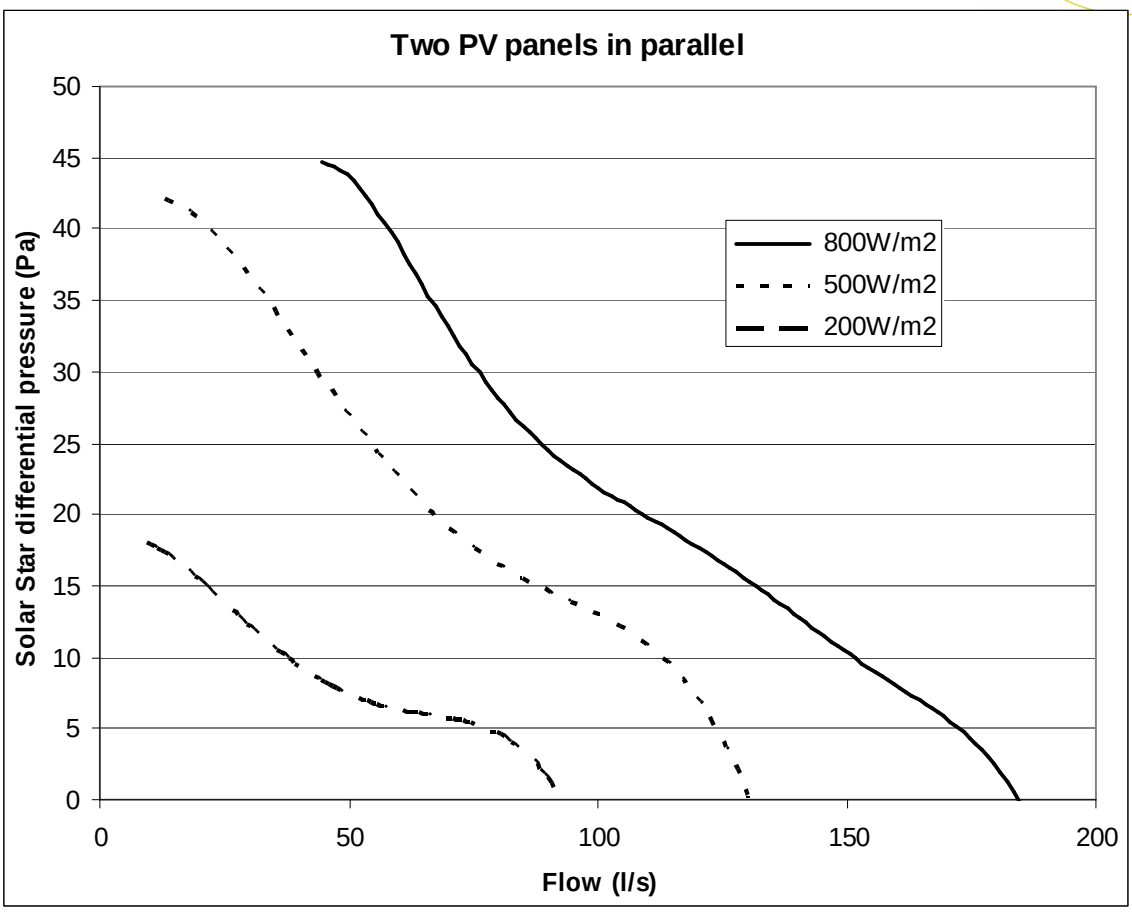
The tests were carried out at different levels of irradiance, namely 800 and 200W/m^2 (as measured on the beam-normal plane) as representative of a typical clear and overcast day during summer in the U.K. with an additional test series carried out at 500W/m^2 for two PVs in parallel. For each condition, the static pressure in the plenum was incrementally varied from the near-minimum achievable by closing the inlet damper, through to equalisation with the atmosphere by opening the inlet damper and increasing the auxiliary fan speed such that the SolarStar was operating against no pressure differential. For each plenum pressure, the SolarStar flowrate was measured via the pressure difference across the measuring device.

3 Test results

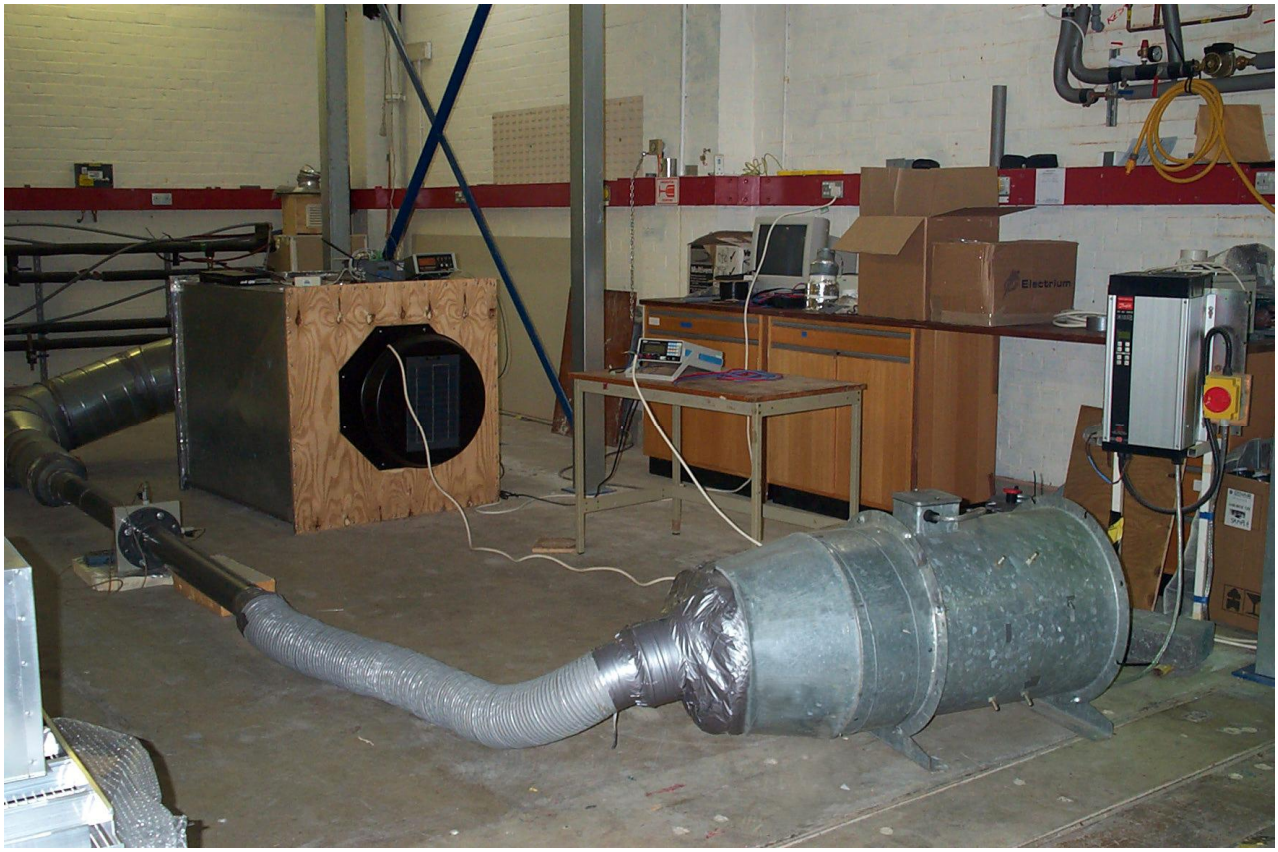
The fan tests were conducted over several days thus the plenum temperature, atmospheric pressure and relative humidity varied slightly from day to day but in all cases the values were measured and accounted for accordingly in the flow measurements.

The following charts show fan performance curves for the Solar Star with one PV panel and with two PV panels in parallel, for different levels of incident solar irradiance. A differential pressure of 0 Pa represents operation in free air with no inlet ducting.

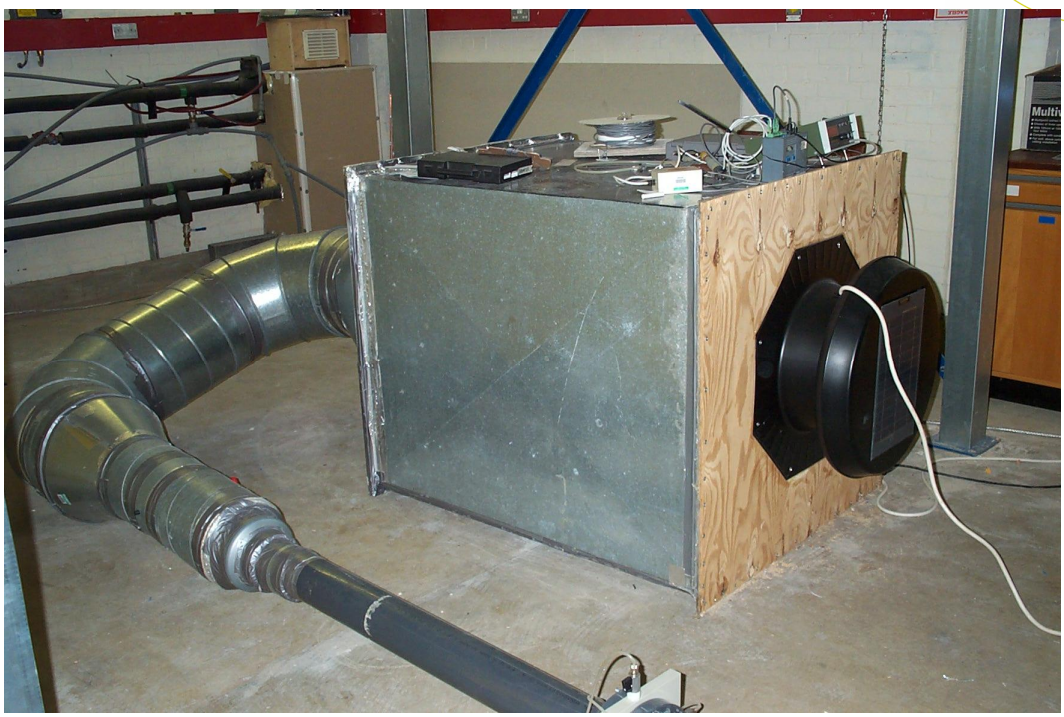




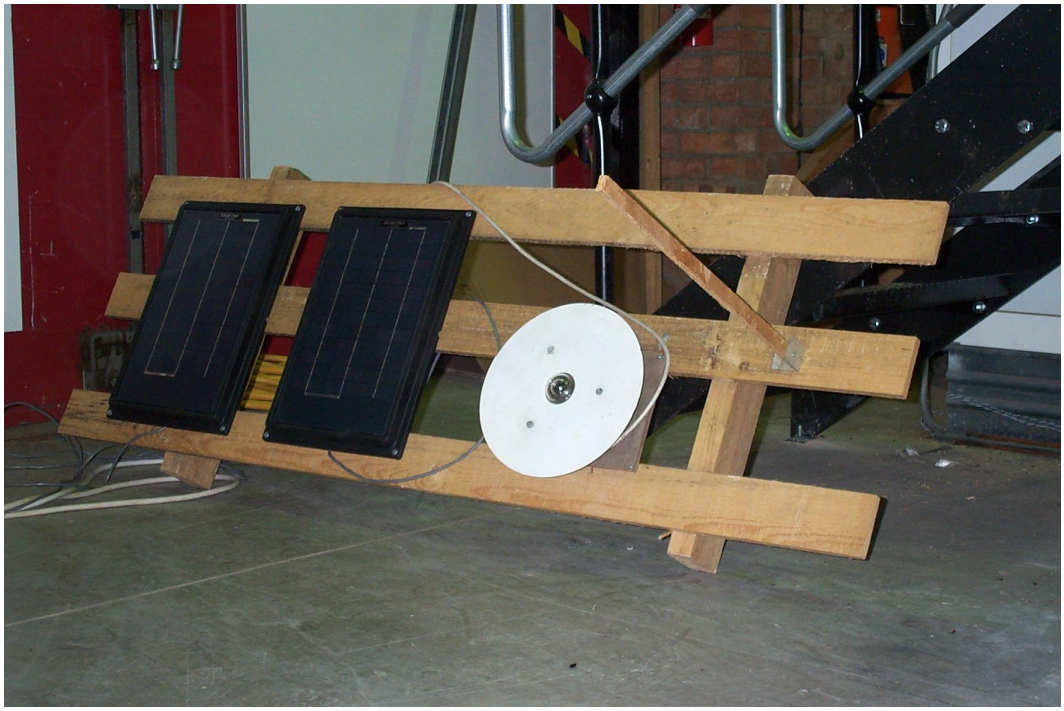
Appendix A Rig photographs



General layout of internal laboratory apparatus showing Solar Star test fan mounted on the plenum with orifice plates in the supply duct connected to the supply fan with variable speed drive



Above: plenum with Solar Star test fan



Frame with surface mounted PV panels, solarimeter and incidence angle measuring rod (shown indoors but in practice located externally in direct sunlight orientated normal to beam radiation)

Appendix B Instrument calibration certificates

CERTIFICATE OF CALIBRATION

DATE OF ISSUE 25 March 2008 CERTIFICATE NUMBER N1177276T

UKAS CALIBRATION 0013

ASAP Calibration Services Ltd
Romsey Laboratory
UNIVERSAL HOUSE
ROMSEY INDUSTRIAL ESTATE
ROMSEY
HAMPSHIRE
SO51 0HR
Telephone 01794 523935
Facsimile 01794 523910
Email info@asap-cal.co.uk
Website www.asap-cal.co.uk

ASAP CALIBRATION SERVICES

PAGE 1 OF 5 PAGES

APPROVED SIGNATORY
[ ] C.C-Smith
[✓] D.Minton
[ ]
[ ]

Customer :	BRE LTD
Address :	GARSTON GOODS INWARDS BUCKNALLS LANE, GARSTON WATFORD HERTS. WD25 9XX
Order No :	000226015
Apparatus Tested -	DIGITAL QUARTZ THERMOMETER & 2 RTD PROBES
Type No :	2804A, RTD
Serial No :	1744A00580, Z120A-01425, 1731A01110
Inventory No :	IN3895
Manufacturer :	HEWLETT PACKARD
Range/Scale :	CALIBRATED RANGE:0 TO 85 °C, 0.01 °C RESOLUTION

Test Conditions -

Date Instrument Received :	13 March 2008
Date Calibration Completed :	25 March 2008
Ambient Temperature :	20 ± 2 °C
Reference No :	1177276

Certified by

22-005-079/009/FEB2007

CERTIFICATE OF CALIBRATION

UKAS Accredited Calibration Laboratory No. 0013

CERTIFICATE NUMBER
N1177276T

PAGE 2 OF 5 PAGES

CALIBRATED "AS FOUND" {i.e. NO ADJUSTMENTS MADE}

CHANNEL: T1 THUMB-WHEEL SETTING: 540 (AS FOUND)

SERIAL NO: INDICATOR:1744A00580 PROBE:2120A-01425

THE INSTRUMENT WAS CALIBRATED BY IMMERSING THE PROBE IN CLOSELY CONTROLLED TEMPERATURE REFERENCE ENVIRONMENTS TOGETHER WITH TWO REFERENCE STANDARD INSTRUMENTS HAVING KNOWN AND TRACEABLE VALUES OF UNCERTAINTY. THE INSTRUMENT WAS CALIBRATED BY USING THE COMPARISON METHOD.

THE FOLLOWING RESULTS ARE DERIVED FROM THE MEAN VALUES OF A NUMBER OF OBSERVATIONS.

THE PROBE WAS IMMERSED TO A MINIMUM DEPTH OF 200mm.

TEST TEMPERATURE °C	INSTRUMENT READING °C
0.003	0.02
10.030	10.05
20.031	20.06
40.004	40.04
60.039	60.09
85.169	85.26
0.002	0.03

THE UNCERTAINTY ASSOCIATED WITH ABOVE MEASUREMENTS IS ± [0.01°C + INSTRUMENT RESOLUTION].

THE ABOVE UNCERTAINTY REFERS TO THE MEASUREMENT AND IS NOT INTENDED TO INDICATE THE SPECIFICATION, OR REPEATABILITY OF THE INSTRUMENT.

THE TEMPERATURE SCALE IN USE IS THE INTERNATIONAL TEMPERATURE SCALE OF 1990. ITS - 90.

Test Engineer

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2.00, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

BRE

CERTIFICATE OF CALIBRATION

Technical & Calibration Services

TITLE: FURNESS MICROMANOMETER

CERTIFICATE Nº : 4197

INSTRUMENT TYPE: FCO12

T.S. JOB Nº : 51003

SERIAL Nº : 9002509

BRE Nº : IN 3986

CALIBRATION PROCEDURE: SP5/08/R

DATE OF TEST: 25 SEP 07

NEXT CALIBRATION DUE: 25 SEP 08

CALIBRATION EQUIPMENT: FURNESS FCO510 MICROMANOMETER, SERIAL Nº 0407141, BRE Nº IN3307, UKAS CALIBRATION CERTIFICATE Nº 03972, DATED 28 AUG 07.

FCO510 APPLIED TRUE PRESSURE	MICROMANOMETER INDICATED PRESSURE, 10%Δp range				
	UP	DOWN	UP	DOWN	MEAN
Pa	Pa	Pa	Pa	Pa	Pa
0	±0.01	±0.01	±0.01	±0.01	±0.02
5	4.93	4.98	4.94	4.94	4.87
10	9.90	9.90	9.88	9.89	9.75
15	14.83	14.85	14.81	14.84	14.61
20	19.77		19.75		19.49
			100%Δp range		
Pa	Pa	Pa	Pa	Pa	Pa
0	0	0	0	0	0
20	19.6	19.8	19.6	19.8	20.3
30	29.5	29.7	29.4	29.6	30.4
40	39.3	39.6	39.3	39.5	40.4
50	49.2	49.5	49.2	49.4	50.7
100	98.5	98.7	98.4	98.6	100.8
150	147.7	148.0	147.6	147.7	150.4
200	197.0		196.8		199.3

The expanded uncertainty of the micromanometer indicated pressures, after correction, is stated in two parts:
Relative uncertainty: ±0.13% for the 10%Δp range and ±0.14% for the 100%Δp range,
Absolute uncertainty: ±0.6Pa for the 10%Δp range and ±1.2Pa for the 100%Δp range.

The reported two-part expanded uncertainty is in each case based on a standard uncertainty multiplied by a coverage factor k = 2, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements. For each stated result the user may, if required, combine the uncertainties shown by quadrature summation in either relative or absolute units as appropriate.

Calibrated By: S. C. Wright

Test Area Temperature: 20ºC ±2ºC

Signature:

Date:

BRE

CERTIFICATE OF CALIBRATION

Technical & Calibration Services

TITLE: AIRFLOW MICROMANOMETER

CERTIFICATE Nº : 4198

INSTRUMENT TYPE: PVM100

T.S. JOB Nº : 51003

SERIAL Nº : 079716

BRE Nº : IN 3987

CALIBRATION PROCEDURE: SP5/08/R

DATE OF TEST: 26 SEP 07

NEXT CALIBRATION DUE: 26 SEP 08

CALIBRATION EQUIPMENT: FURNESS FCO510 MICROMANOMETER, SERIAL Nº 0407141, BRE Nº IN3307, UKAS CALIBRATION CERTIFICATE Nº 03972, DATED 28 AUG 07.
BUDENBERG AIR DEAD WEIGHT TESTER TYPE 451, SERIAL Nºs 126E & 3145, BRE Nºs IN1491, 2 & 3
UKAS CALIBRATION CERTIFICATE Nº 09272, DATED 13 SEP 05.

FCO510 & D.W.T. APPLIED PRESSURE Pa	MICROMANOMETER INDICATED PRESSURE UP Pa	DOWN Pa	UP Pa	DOWN Pa
0	0	0	0	1
50.0	50	50	50	50
100.0	99	100	100	100
200.0	199	199	199	200
400.0	399	399	399	400
600.0	599	600	599	600
800.0	800	801	800	801
1000.0	1001	1001	1001	1001
1500.8	1504	1505	1505	1506
2001.1	2005	2006	2006	2006
2501.3	2505	2506	2506	2506
3001.6	3007	3007	3008	3008
3501.9	3510		3511	

The above deadweight tester applied pressure values (1500 to 3500Pa) have been corrected for local gravity.

The expanded uncertainty of the micromanometer indicated pressures, after correction, is stated in two parts:
Relative uncertainty: ±0.13% ≤ 1000Pa < ±0.05%,
Absolute uncertainty: ±3.0 Pa.

The reported two-part expanded uncertainty is in each case based on a standard uncertainty multiplied by a coverage factor k = 2, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements. For each stated result the user may, if required, combine the uncertainties shown by quadrature summation in either relative or absolute units as appropriate.

Calibrated By: S. C. Wright

Test Area Temperature: 20ºC ±2ºC

Signature:

Date:

==========REPORT ENDS==========