



Sustainable Engineering Worldwide

Dong Energy / ScottishPower

Shell Flats Offshore Meteorological Masts

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Sustainable Engineering Worldwide

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Dong Energy / ScottishPower Renewables

Shell Flats Offshore Meteorological Masts

SUMMARY:

This report details the refurbishment and commissioning of two offshore Francis and Lewis International lattice tower wind monitoring masts at Shell Flats wind farm. The masts were refurbished and commissioned by SgurrEnergy and sub-contractors on behalf of Dong Energy and ScottishPower Renewables.

CLIENT: Dong Energy / ScottishPower Renewables

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1 INTRODUCTION

SgurrEnergy is pleased to submit this report to Dong Energy confirming details of the recent refurbishment and commissioning of two Francis and Lewis International offshore lattice tower wind monitoring masts at Shell Flats wind farm. The masts were commissioned on the 12 July 2011.

2 MAST INSTALLATION DETAILS

This section provides details of the mast installation and commissioning.

2.1 MAST LOCATIONS

The mast location was verified using Global Positioning System (GPS) and is detailed in Table 1 and illustrated in Appendix A.

Table 1: Mast Location Coordinates	
Mast ID	Location
50m Mast	Lat: 53°52'24.9"N Long: 3°12'3.7"W
80m Mast	Lat: 53°51'35.4"N Long: 3°17'35.5"W

These values are indicative of the location of the mast and are subject to the usual inaccuracies associated with global positioning; typically of the order of 5 metres.

3 MAST REFURBISHMENT OVERVIEW

As part of the mast refurbishment the following works were carried out:

- Replacement of instrumentation
- Replacement of instrumentation junction boxes
- Replacement of Data Logger Panel (DLP)
- Replacement of booms with booms meeting best practise for wind measurement
- Replacement of the access hatches
- Replacement of wind turbine booms
- Replacement of the data logging power supply system on both platforms
- Replacement of the aviation light bulbs on both platforms
- Installation of lightning protection
- Replacement of 80m mast fall arrest system
- Replacement of 80m ladder splice joint bolts

The positioning and serial numbers of sensors were recorded during installation and commissioning. Appendix B contains specifications for the equipment installed on the mast, appendix C contains the MEASNET calibration certificates for the installed anemometers. Table 2 and Table 3 detail the equipment installed on the masts

A full schematic of the DLP installed on each mast is provided as Appendix D in addition Appendix E contains an overview of the entire measurement system. Appendix H details the program running on each data logger.

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Appendix F contains designs of the replacement booms installed as part of the refurbishment.

The following items were not carried out due to weather and time restrictions:

- Replacement of 50m mast navigation light system

The existing navigation light system was functioning with one light working on departure from the platform.

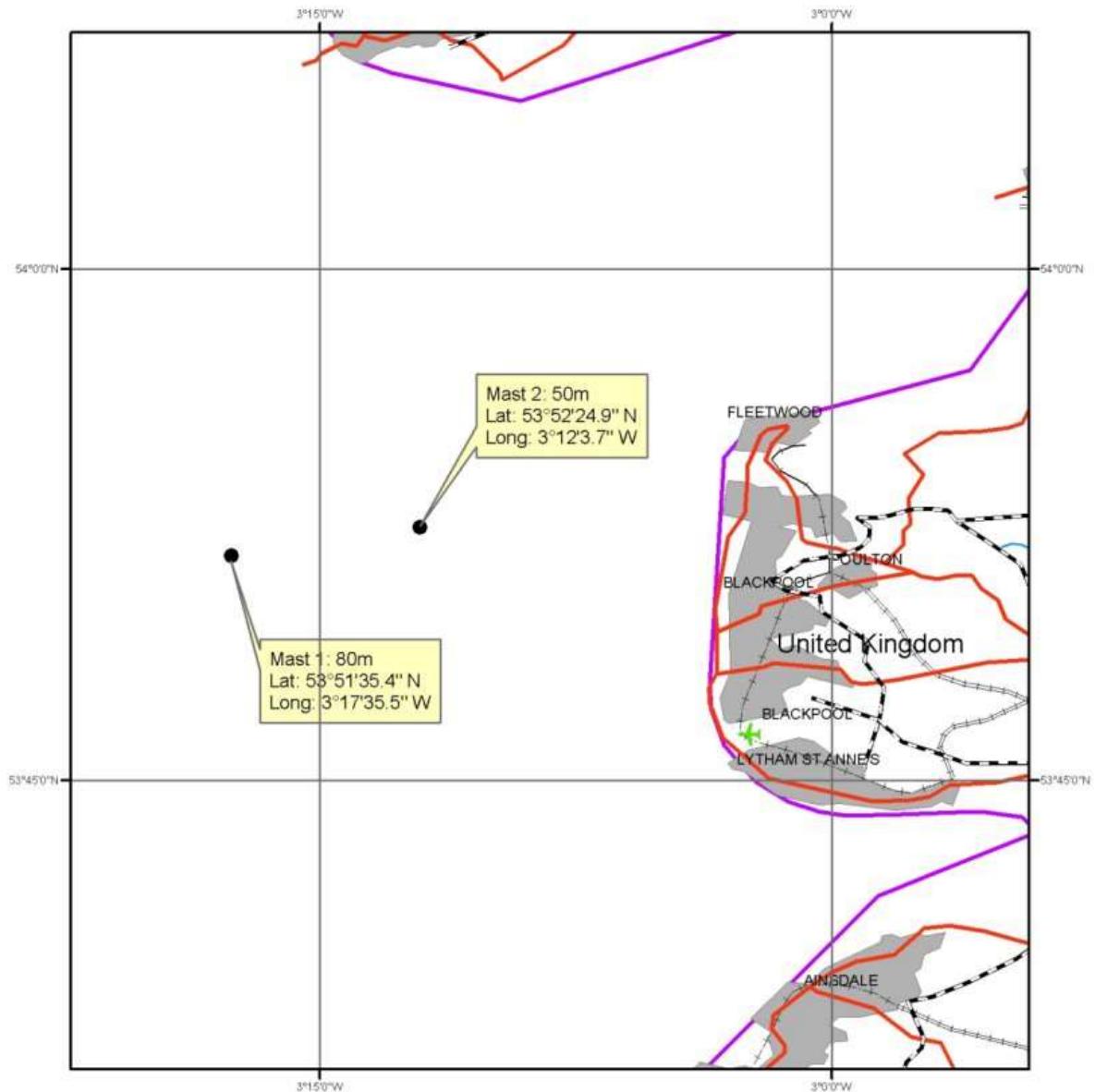
Instrument	Serial Number	Height	Orientation	Manufacturer/ Model	Calibrated		Logger Applied		Notes
					Slope	Offset	Slope	Offset	
Anemometer	13331	52m	N/A	Vector A100L2	0.05032	0.175	0.05148	0	
Anemometer	13333	50m	SE	Vector A100L2	0.05063	0.145	0.05148	0	
Anemometer	13339	40m	SE	Vector A100L2	0.05041	0.193	0.05148	0	
Anemometer	13338	40m	NW	Vector A100L2	0.05025	0.205	0.05148	0	
Ultrasonic Anemometer	F3460004	50m	NW	WS425 A1E2A	0.44704 (Wind speed)		0.44704 (Wind speed)		
Wind Vane	55749	48m	N	Vector W200P					North point aligned to North
Wind Vane	55753	48m	N	Vector W200P					North point aligned to North
Pressure Sensor	4288994	Platform Height		Setra 278			0.2	600	
Temperature / Relative Humidity	F260057	50m		Vaisala HMP45AC			0.1 0.1	-40 0	
Temperature / Relative Humidity	F2650056	Platform Height		Vaisala HMP45AC			0.1 0.1	-40 0	
Pyranometer		3m		Kipp and Zonen CMP3					
Data Logger	4841	Platform Height		Campbell Scientific CR3000					Scan Rate = 1Hz Averaging = 10 Minute

Instrument	Serial Number	Height	Orientation	Manufacturer/ Model	Calibrated		Logger Applied		Notes
					Slope	Offset	Slope	Offset	
Anemometer	13340	82m	N/A	Vector A100L2	0.05046	0.179	0.05148	0	
Anemometer	13341	80m	SE	Vector A100L2	0.05047	0.176	0.05148	0	
Anemometer	13336	70m	SE	Vector A100L2	0.05038	0.161	0.05148	0	
Anemometer	13334	70m	NW	Vector A100L2	0.05069	0.147	0.05148	0	
Anemometer	13329	50m	SE	Vector A100L2	0.05041	0.193	0.05148	0	
Anemometer	13327	50m	NW	Vector A100L2	0.05033	0.188	0.05148	0	
Ultrasonic Anemometer	F3460003	80m	NW	WS425 A1E2A	0.44704 (Wind speed)	-45	0.44704 (Wind speed)		North point aligned to along Boom (-45)
Wind Vane	55755	78m	N	Vector W200P					North point aligned to North
Wind Vane	55754	78m	N	Vector W200P					North point aligned to North
Pressure Sensor	4289001	Platform Height		Setra 278			0.2	600	
Temperature / Relative Humidity	F2650007	80m		Vaisala HMP45AC			0.1 0.1	-40 0	
Temperature / Relative Humidity	F1830039	Platform Height		Vaisala HMP45AC			0.1 0.1	-40 0	
Pyranometer				Kipp and Zonen CMP3					
Data Logger	4777	Platform Height		Campbell Scientific CR3000					Scan Rate = 1Hz Averaging = 10 Minute

4 OPERATIONS AND MAINTENANCE

Regular inspection of the mast and instrumentation is highly recommended. Table 4 contains the recommended maintenance checks for specific equipment:

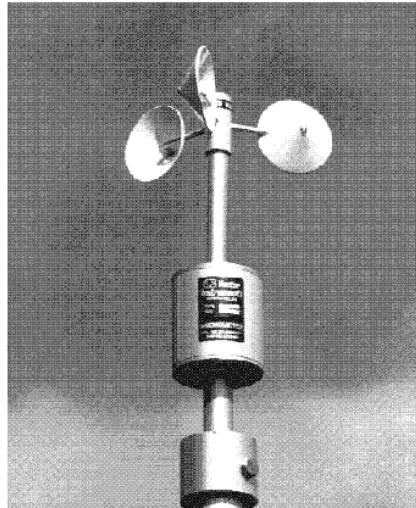
Table 4: Mast T1 Instrument Information	
Model	Recommended Maintenance
Vector A100L2	<ul style="list-style-type: none"> • Regular visual inspection. • Refurbishment and recalibration every two years.
WS425 B2D3B	<ul style="list-style-type: none"> • Regular visual inspection. • Periodic verification of accuracy (Procedure from manual included as Appendix I).
Vector W200P	<ul style="list-style-type: none"> • Regular visual inspection. • Refurbishment every four years.
CR3000	<ul style="list-style-type: none"> • Recalibration every two years.
Setra 278	<ul style="list-style-type: none"> • Regular Visual Inspection • Recalibrate every two years
Vaisala HMP45A C	<ul style="list-style-type: none"> • Regular visual inspection • Recalibrate every 2 years
Rutland 913	<ul style="list-style-type: none"> • Regular visual inspection

APPENDIX A: MAST LOCATIONS

APPENDIX B: EQUIPMENT SPECIFICATIONS

LOW POWER A100L2 ANEMOMETER (USING LPPL4 ANALOG OUTPUT MODULE)

SPEC SUMMARY



A LOW POWER CONSUMPTION ANALOGUE OUTPUT ANEMOMETER

In response to demand for an anemometer with an analogue voltage output like the proven Porton Anemometer but with reduced current consumption the type PL4 module from the Porton Anemometer has been developed to produce the LPPL4 resulting in an analogue output anemometer suitable for use with data loggers.

- TRIED & TESTED 'PORTON ANEMOMETER' MECHANICS AND ROTOR
- 0 TO 2½ V OUTPUT FOR 0 TO 150 KNOTS
- 5V PULSE/FREQUENCY OUTPUT, 0 TO 1500HZ = 0 TO 150 KNOTS
- VARIANT A100LPC3L2 INCLUDES ANTI-SURGE PROTECTION OPTION

Specification Summary:

Range of Operation:	Threshold: Max. windspeed: Standard measuring range:	0.3Kts (starting speed: 0.4Kts, stopping speed: 0.2Kts) 150Kts (75m/s) 0 to 150 Knots
Rotor:	Type: Distance Constant:	R30, 3-cup rotor. 2.3m ±10%
Pulse Output:	Rotor speed measurement: Accuracy:	By interruption of optical beam. 1% of reading (20 - 110Kts), up to 2% of reading (110 - 150Kts) 0.2Kts (0.2 - 20Kts).
	Non-linearity:	0.4% full range output frequency (correction curve supplied).
	Output Range:	0 to 1500Hz for 0 to 150Knots (10Hz per Knot)
	Resolution:	5.15cm.
	5V pulse output:	High 5V±5%, Low <0.2v, min. load res: 20K Ohms. Rise/Fall time approx. 25µs, duty cycle 50%(±25%).
Analogue Output:	Nominal Factory Calibration: Output Over-range: Overall Non-linearity:	0 to 2.500 V DC for 0 to 150 Knots single ended (16.67mV per Knot). 5V ±10% 0.9% full range output for 0 to 150Knots (correction curve supplied for rotor + anemometer).
	Temperature Coefficient:	±2% of output relative to 15°C value (-30 to +40°C)
	Response Time:	150ms first order lag typical (as Porton A100)
	Effect of supply variation:	±0.2% full range output over full supply range.
	Output Ripple:	Typically 13mV peak to peak at pulse frequency.
	Output Resistance:	Less than 500 Ohms.
	Recommended load resistance:	1M Ohm for calibrated output, (otherwise minimum 5K Ohms).
General:	Operating Temperature Range: Supply Voltage: Power-up Time: Current consumption: Standard Cable:	-30 to +70 °C 6½V to 28V DC 5 sec. 2mA max, 1.6mA typical (no output loads). 3m long, 6 core screened 7/0.2mm, PVC insulated.
Connections:	Red = Supply positive, Blue = Supply negative, Green = Analogue output +, Yellow = Analogue output - (Yellow is connected to Blue in the instrument permitting correction for zero offset caused by supply current in long cables), White = Pulse output, Black = Base plate, Screen = Not connected at anemometer.	
Calibration:	Calibration data for the anemometer and rotor are provided at one test speed to an accuracy of 1% at +15°C and +12V DC supply, with analogue output load = 1M Ohm. In-service calibrate/test facility is not fitted.	
Anti-surge options:	A100LPC3L2 variant has an extra surge protection module containing series resistance elements and clamping devices fitted to the base of the module in the standard anemometers. Note that these protection elements slightly affect certain specification parameters.	
Mechanical:	Dimensions, mm / Weight: Mounting:	195 height x 152 rotor diameter x 55 body diameter. Net Weight: 490g. 0.25 inch BSW/JNC screw into base (standard tripod fitting).

(Vector Instruments reserves the right to change this specification without notice in line with a policy of continued product improvement)

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050-107-06

 Vector Instruments

S-A100/L-LPPL4-5 (G:\NEW-DOCS\A100L2\A100LY3.SAW-1908\03-DS.D)

POTENTIOMETER WINDVANE**W200P**

This instrument incorporates a precision wire-wound potentiometer as shaft angle transducer, enabling wind direction to be accurately determined when used in suitable electronic circuits. The potentiometer has the lowest possible torque consistent with long life and reliability, the small gap at north being filled with an insulating material to ensure smooth operation over the full 360°. The vane-arm assembly is attached by the unique Porton™ gravity fastener, allowing rapid attachment and release; thus improving portability.

Construction is from anodised aluminium alloys and stainless steels for exposed parts. Combined with the hard plastic (upper) plain bearing and precision ball races, the result is an instrument with a long service interval which is suitable for permanent exposure to the weather.

In the marine version,* body/fin sealing is enhanced and a touching shaft-seal is fitted above the upper (replaceable) bearing for extra protection.

For applications where improved sensitivity is required, a larger vane version** is available.

An anti-icing heater can also be fitted to extend operation by removing hoar frost around the upper bearing.

**Range of Operation**

Maximum Wind Speed:	Over 75m/s (150Knots, 170mph)	[60m/s] ^{**}
Range:	360° mechanical angle, full-circle continuous rotation allowed.	
Temperature range:	-50 to +70°C	

Performance

Threshold:	0.6m/s (1.2Knot, 1.4mph) [0.75m/s] [*] [0.5m/s] ^{**} (the vane will commence movement when aligned at 45° to the flow).
Response:	Damped natural Wavelength: 3.4m [3.6m] ^{**} Damping Ratio: 0.2m [0.24m] ^{**}
Repeatability:	Recovery distance: 0.51m [0.54m] ^{**} Distance constant: 2.3m [2.4m] ^{**}
Life of potentiometer:	±0.5° vane removed and replaced (no measurable backlash movement during use).
Service Interval:	5 x 10 ⁷ cycles (10 years typical exposure).
Accuracy:	4 to 5 years. ±3° in steady winds >5m/s [6m/s] [*] [3.5m/s] ^{**} (±2° obtainable following calibration).

Electrical

Potentiometer resistance:	1000 Ω ±10%
Maximum dissipation:	0.5W, -50 to +20°C (de-rate linearly to 0.25W at 70°C)
Maximum wiper current:	50µA*, (20mA absolute max.)
Supply voltage:	1 to 5V*, (20V absolute max.) across terminals 1 & 3.
Case to pot. voltage:	72V max. (case or screen to any terminal on pot.)
Insulation resistance:	>50MΩ
Temperature coefficient of resistance:	±50 x 10 ⁻⁶ /°C
Electrical continuity angle:	357.7 ±1.5° (2.3° gap at north)
Electrical variation angle:	356.5 ±1.5° (3.5° dead-band)
Resolution:	±0.2°
Independent non-linearity:	±0.25% (unloaded)

Notes: Figures marked * refer to recommended operating conditions

Bracketed figures marked ** refer to parameters changed when options are fitted, (see options section overleaf)

 **Vector Instruments**

HMP45C Specifications

RH Measurement

MEASUREMENT RANGE: 0.8 to 100% RH
 OUTPUT SCALE: 0 -100% RH equals 0 -1V DC
 RH ACCURACY (at 20°C, including non-linearity and hysteresis):
 Against factory references: ±1% RH
 Against field references: ±2% RH (0 to 90% RH); ±3% RH (90 to 100% RH)
 TEMPERATURE DEPENDENCE: ±0.05% RH/°C
 LONG TERM STABILITY: Better than 1% RH per year
Temperature Measurement
 MEASUREMENT RANGE: -39.2°C to +60°C
 OUTPUT SCALE: -40°C to +60°C equals 0 to 1V DC
 ACCURACY: ±0.5°C at -39°C; ±0.2°C at +20°C; ±0.4°C at +60°C
 TEMPERATURE SENSOR: Pt 1000 IEC 751 1/3 Class B

Response

SETTLING TIME AFTER POWER APPLIED: 500ms
 RESPONSE TIME (at 20°C, 90% response): 15s with 0.2mm membrane filter
Electrical
 SUPPLY VOLTAGE: 12V DC nominal (7 to 35V DC possible)
 POWERCONSUMPTION: <4mA
 OUTPUT LOAD: >10kohm (to ground)
Electromagnetic Compatibility
 EMISSIONS: Radiated interference, test setup according to EN55022
 IMMUNITY: Radiated Interference (IEC 1000-4-3) Level 1 (3V/m); Electrostatic Discharge (IEC-801-4) Level 4

Physical

OPERATING TEMPERATURE RANGE: -40°C to +60°C
 STORAGE TEMPERATURE RANGE: -40°C to +80°C
 WEIGHT: 350g (incl. package)
 STANDARD CABLE LENGTH: 3m
 CABLE TYPE: Low-temperature cable with Santoprene outer jacket
 HOUSING MATERIAL: ABS plastic
 HOUSING CLASSIFICATION: (electronics): IP65 (NEMA 4)
 SENSOR PROTECTION: Standard membrane filter
 DIMENSIONS: Diameter 24mm; Length 240mm excluding cable strain relief; Length of removable probe head 132mm
 WEIGHT: 0.27 kg (0.6 lbs)

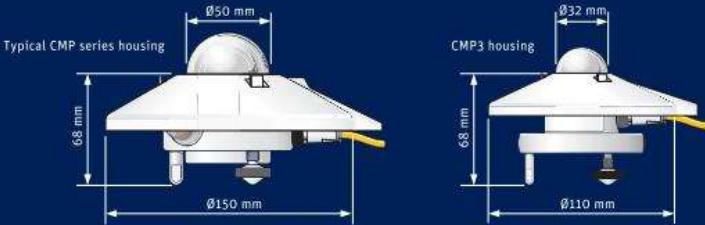
Mounting

When the sensor is used outdoors it is standard practice to install the sensor within a housing, known as a shield, to prevent solar radiation heating the sensor and thereby creating errors in the measurements. The shield also gives a degree of protection from adverse weather, e.g. hail, driving rain. The most common type of shield is a relatively small, naturally ventilated screen that is low maintenance and requires no power. Campbell Scientific offers and recommends the MET21 shield for this probe as it performs better than most other shields of a similar design. Please request a leaflet on that product for further details. For continuity with long term measurements some meteorological services require use of larger, more expensive, Stevenson screens. Alternatively, for best accuracy a ventilated shield can be used, although these require significant power. Please contact Campbell Scientific for further details of these options.

Campbell Scientific offers a complete range of sensors – ask for a summary leaflet

Campbell Scientific products are available from:

We reserve the right to alter specifications without notice



Specifications	CMP 3	CMP 6	CMP 11	CMP 21	CMP 22
ISO CLASSIFICATION	Second Class	First Class	Secondary Standard	Secondary Standard	Secondary Standard
Response time (95 %)	< 18 s	< 18 s	< 5 s	< 5 s	< 5 s
Zero offsets (a) thermal radiation (200 W/m ²) (b) temperature change (5 K/hr)	< 15 W/m ² < 5 W/m ²	< 12 W/m ² < 4 W/m ²	< 7 W/m ² < 2 W/m ²	< 7 W/m ² < 2 W/m ²	< 3 W/m ² < 1 W/m ²
Non-stability (change/year)	< 1 %	< 1 %	< 0.5 %	< 0.5 %	< 0.5 %
Non-linearity (0 to 1000 W/m ²)	< 1 %	< 1 %	< 0.2 %	< 0.2 %	< 0.2 %
Directional error (up to 80° with 1000 W/m ² beam)	< 20 W/m ²	< 20 W/m ²	< 10 W/m ²	< 10 W/m ²	< 5 W/m ²
Temperature dependence of sensitivity	< 5 % (-10 °C to +40 °C)	< 4 % (-10 °C to +40 °C)	< 1 % (-10 °C to +40 °C)	< 1 % (-20 °C to +50 °C)	< 0.5 % (-20 °C to +50 °C)
Tilt error (at 1000 W/m ²)	< 1 %	< 1 %	< 0.2 %	< 0.2 %	< 0.2 %
Other specifications					
Sensitivity	5 to 20 µV/W/m ²	5 to 20 µV/W/m ²	7 to 14 µV/W/m ²	7 to 14 µV/W/m ²	7 to 14 µV/W/m ²
Impedance	20 to 200 Ω	20 to 200 Ω	10 to 100 Ω	10 to 100 Ω	10 to 100 Ω
Level accuracy	1°	0.1°	0.1°	0.1°	0.1°
Operating temperature	-40 °C to +80 °C	-40 °C to +80 °C	-40 °C to +80 °C	-40 °C to +80 °C	-40 °C to +80 °C
Spectral range (50 % points)	300 to 2800 nm	285 to 2800 nm	285 to 2800 nm	285 to 2800 nm	200 to 3600 nm
Typical signal output for atmospheric applications	0 to 20 mV	0 to 20 mV	0 to 15 mV	0 to 15 mV	0 to 15 mV
Maximum irradiance	2000 W/m ²	2000 W/m ²	4000 W/m ²	4000 W/m ²	4000 W/m ²
Expected daily uncertainty	< 10 %	< 5 %	< 2 %	< 2 %	< 1 %
Recommended applications	Economical solution for routine measurements in weather stations, field testing	Good quality measurements for hydrology networks, greenhouse climate control	Meteorological networks, PV panel and thermal collector testing, materials testing	Meteorological networks, reference measurements in extreme climates, polar or arid	Scientific research requiring the highest level of measurement accuracy and reliability
CMP instruments have a standard cable length of 10 m. Optional cable lengths 25 m and 50 m					
Standard 10k Thermistor or optional Pt-100 temperature sensor with CMP 21 and CMP 22					
Individual directional response and temperature dependence test data with CMP 21 and CMP 22					
Note: The performance specifications quoted are worst-case and/or maximum values					



Go to www.kippzonen.com for your local distributor

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Kipp & Zonen B.V. reserve the right to alter specifications of the equipment described in this documentation without prior notice

4014470 - V101



Barometric Pressure Sensor Model CS100



The CS100 provides accurate, unattended measurements of barometric pressure over a wide range of elevations.

The CS100 Barometer uses Setra's Setraceram™ capacitive sensor and IC analog circuit to measure barometric pressure over a 600 to 1100 millibar range. The CS100 outputs a linear signal of 0 to 2.5 Vdc allowing it to be directly connected to Campbell Scientific dataloggers. The minimum sensor warm-up and measurement time is one second. The sensor features a built in power switch to minimise power use between measurements.

Construction and Mounting

The sensor is housed in a stainless steel and polyester case fitted with an 1/8" barbed fitting for pressure connection. A removable terminal strip provides for datalogger power and signal connections. The

barometer is intended to mount inside an ENC 12/14 or larger enclosure.

"High Altitude" Version

Campbell Scientific offers a version of the CS100 that measures barometric pressure over a 500 to 1100 millibar range. Contact us for more information.

High Reliability

The CS100 comes with a 3 year warranty.

Specifications

Total Accuracy¹:

- ±0.5 mb @ +20°C
- ±1.0 mb @ 0° to 40°C
- ±1.5 mb @ -20° to +50°C
- ±2.0 mb @ -40° to +60°C

Linearity:

±0.4 mb

Hysteresis:

±0.05 mb

Repeatability:

±0.03 mb

Resolution:

±0.01 mb

Long-Term Stability:

±0.1 mb per year

Response time:

<100 ms

Operating Temperature:

-40° to +60°C

Dimensions:

9.1 cm x 6.1

cm x 2.5 cm (3.6" x 2.4" x

1.0")

Weight:

135 g (4.8 oz)

Excitation:

9.5 to 28 Vdc

Current Consumption:

<3 mA (active), <1 µA (sleep mode)

Warm-up time:

1 s

CE Compliant

¹The root sum squared (RSS) of end point non-linearity, hysteresis, repeatability, and calibration uncertainty.

These are sensor errors only. Please refer to the relevant datalogger datasheets to consider the likely total measurement errors and resolution.

CSL 534

October 2005

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www.campbellsco.co.uk

WS425

WIND

Technical Data

Wind speed

Measurement range	0 ... 65 m/s (0 ... 144 mph, 0 ... 125 knots)
serial output	0 ... 65 m/s (0 ... 144 mph, 0 ... 125 knots)
analog output	0 ... 56 m/s (0 ... 124 mph, 0 ... 107 knots)
Starting threshold	virtually zero
Delay distance	virtually zero
Resolution	0.1 m/s (0.1 mph, 0.1 knots, 0.1 km/h)
Accuracy (range 0...65 m/s)	± 0.135 m/s (±0.3 mph, ±0.26 knots) or 3% of reading, whichever is greater

Wind direction

Measurement range	0 ... 360°
Starting threshold	virtually zero
Delay distance	virtually zero
Resolution	1°
Accuracy (wind speed over 1 m/s)	±2°

Outputs

Digital outputs	RS232, RS422 or RS485, four different message formats
type	
bit rate	adjustable from 1200 to 19200 bit/s
available averages	RS232: 1 to 9 seconds
SDI-12 Standard Data Interface	
type	3 wires for ground, signal and supply
bit rate	fixed 1200 bit/s
available averages	1 to 3600 seconds
Analog outputs	
wind speed	
frequency	5 Hz/mph
voltage	8.0 mV/mph
output impedance	10 kohm
wind direction	
simulated potentiometer	0 ... V _{ref} represents 0 ... 359°
reference voltage	1.0 ... 4.0 V
output impedance	24 kohm

Response characteristics

maximum reading rate	1 per second
sonic measurement time	0.2 s
signal processing time	0.15 s
response time	0.35 s

General

Operating power supply	10 ... 15 VDC, 12 mA typical (analog)
and for heated model	36 VDC ±10 %, 0.7 A
Operating temperature	-40 ... +55 °C (-40 ... +131 °F)
WS425 non-heated	-55 ... +55 °C (-67 ... +131 °F)
WS425 heated	
Material	
body	stainless steel (AISI 316)
sensor arms	stainless steel (AISI 316)
transducer heads	silicone rubber
Dimensions	
height	355 mm (14")
width	250 mm (10")
depth	286 mm (12")
Weight	1.7 kg (3.7 lbs)

Complies with EMC standard EN61326-1:1997 + Am1:1998 + Am2:2001; Generic Environment

Accessories

Cable supporting analog outputs, 10 m	ZZ45204
Cable supporting RS-232 outputs, 10 m	ZZ45203
Cable supporting RS-485/422 outputs, 10 m	010411
Cable supporting SDI-12 outputs, 10 m	WS425CABSDI
Adapter for 30-35 mm (1 1/4") diameter vertical tube	WS425FIX30
Adapter for 60 mm (2 1/4") diameter vertical tube	WS425FIX60
Bird Perch	WS425BIRDPERCH
Field verifier	WS425VERIFIER

Specifications subject to change without prior notice.
©Vaisala Oyj



Periodic Testing

Section Measuring Principle on page 75 explains that the sensor measures how long it takes for an ultrasonic signal to travel from transducer to receiver. Therefore, the accuracy of the sensor depends on the accuracy of two factors:

- The distance between the ultrasonic transmitter and receiver. This requires a measurement of the transducer arms length.
- The time-of-flight measurement circuit, which uses a crystal oscillator for its time reference.

NOTE

The crystal oscillator is used by the communications circuit for the bit rate generator. If you use the serial communication modes and the oscillator loses accuracy, the sensor stops communicating. Thus, the sensor cannot send erroneous values produced by faulty timing.

Perform periodic testing to detect slow deterioration of the sensor before it significantly affects accuracy. Perform the test either in the field or in a laboratory. The periodic test uses the ventiler, which is a small actuator device. The ventiler is shown in Figure 14 on page 72.

The test consists of the following steps:

1. Slip the ventiler over the three transducers (see Figure 14 on page 72).
2. In outdoor conditions, secure the ventiler to the flow by covering the sensor and ventiler.
3. The sensor must read less than 0.7 miles per hour (0.22 m/s) with the ventiler in place.

NOTE

Some random data samples may be lost during the zero ventiler test. This, however, does not indicate that the sensor is faulty.

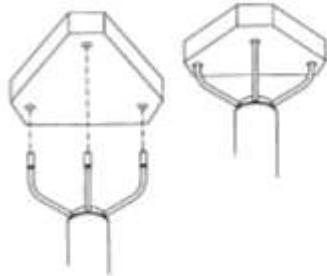


Figure 14 Ventiler

CR3000 Specifications

Electrical specifications are valid over a -25° to +50°C range unless otherwise specified; non-condensing environment required. To maintain electrical specifications, Campbell Scientific recommends recalibrating dataloggers every two years. We recommend that you confirm system configuration and critical specifications with Campbell Scientific before purchase.

ANALOG INPUTS (SE1-SE28 or DI1-DI14)

14 differential (DF) or 28 single-ended (SE) voltage measurements individually configured. Ratiometric resistive bridge, thermocouple, and period average (frequency) measurements also supported on all analog input channels. Channel expansion provided by AM16/32B and AM25T multiplexers.

RANGE: RESOLUTION: 16-bit basic resolution (Basic Res). Resolution of DF measurements with input reversal is half the Basic Res (17-bits).

Input Range (mV)	DF Res (µV) ¹	Basic Res (µV) ²
±5000	83.33	167
±1000	16.67	33.3
±200	3.33	6.67
±50	0.83	1.67
±20	0.33	0.67

¹Range overhead of ~9% exists on all ranges to guarantee that the full-scale range values will not cause overrange.

²Resolution of DF measurements with input reversal.

ACCURACY:

- ±(0.04% of reading + offset), 0° to 40°C
- ±(0.07% of reading + offset), -25° to 50°C
- ±(0.09% of reading + offset), -40° to 85°C (-XT only)

³Accuracy does not include sensor and measurement noise. Offsets are defined as:

- Offset for DF w/input reversal = 1.5 Basic Res + 1.0 µV
- Offset for DF w/o input reversal = 3 Basic Res + 2.0 µV
- Offset for SE = 3 Basic Res + 5.0 µV

MEASUREMENT SPEED: Time includes 250 µs for conversion to engineering units. For voltage measurements, the CR3000 integrates the input signal.

Integration Type	Integration Time	Setting	Measurement Total Time	Standard Input Res.
250	250 µs	200 µs	~0.7 ms	~1.4 ms
60 Hz filter	16.67 ms	3 ms	~20 ms	~40 ms
50 Hz filter	20.00 ms	3 ms	~23 ms	~46 ms

INPUT NOISE VOLTAGE: For DF measurements with input reversal on ±20 mV input range, digital resolution dominates for higher ranges.

250 µs Integration:	0.4 µV RMS
50/60 Hz Integration:	0.19 µV RMS

INPUT LIMITS: ±5 V

DC COMMON MODE REJECTION: >100 dB

NORMAL MODE REJECTION: 70 dB @ 60 Hz when using 60 Hz rejection

SUSTAINED INPUT VOLTAGE W/O DAMAGE: ±16 VDC max.

INPUT CURRENT: ±1 nA typical, ±6 nA max.

@ 50°C; ±120 nA @ 85°C

INPUT RESISTANCE: 20 Gohms typical

ACCURACY OF BUILT-IN REFERENCE JUNCTION THERMISTOR (for thermocouple measurements):

- ±0.3°C, -25° to 50°C;
- ±0.8°C, -40° to 85°C (-XT only)

PERIOD AVERAGE MEASUREMENTS: Any of the 28 SE analog inputs can be used for period averaging. Accuracy is ±0.01% of reading + resolution where resolution is 96 ns divided by the specified number of cycles to be measured.

Input Amplitude & Frequency:

Volt. Gain	Range Code	Signal (peak to peak)	Pulse W.	Max. Freq.	Min. (Hz) ⁴	(Hz) ⁵
1	mV1000	200	10	2.5	200	
5	mV200	20	2	5.0	100	
20	mV50	5	2	10.0	50	
50	mV20	2	2	25.0	20	

⁴Maximum signal must be centered at datalogger ground.

⁵Assuming 50% duty cycle.

ANALOG OUTPUTS (Vx1-Vx4, Ix1-Ix3, CAO1, CAO2)

4 switched voltage and 3 switched current outputs for ratiometric sensor/bridge excitation and 2 continuous voltage outputs. Switched outputs active only during measurement, one at a time.

Vx	Range	Res	Current Source/Sink	Compliance Voltage
Vx: CAO:	±5 V	0.17 mV	±50 mA	N/A
Ix:	±2.5 mA	0.08 µA	±15 mA	N/A
				±5 V

Vx & CAO ACCURACY:

- ±(0.04% of setting + 0.5 mV), 0° to 40°C
- ±(0.07% of setting + 0.5 mV), -25° to 50°C
- ±(0.09% of setting + 0.5 mV), -40° to 85°C (-XT only)

Ix ACCURACY:

- ±(0.1% of setting + 0.5 µA), 0° to 40°C
- ±(0.13% of setting + 0.5 µA), -25° to 50°C
- ±(0.15% of setting + 0.5 µA), -40° to 85°C (-XT only)

Vx FREQUENCY SWEEP FUNCTION: The switched outputs provide a programmable swept frequency, 0 to 5 V square wave for exciting vibrating wire transducers.

RESISTANCE MEASUREMENTS

MEASUREMENT TYPES: The CR3000 provides ratiometric measurements of 4- and 6-wire full bridges, and 2-, 3-, and 4-wire half bridges. Precise, dual polarity excitation for voltage or current excitations eliminates DC errors. Offset values are reduced by a factor of 2 when excitation reversal is used.

VOLTAGE RATIO ACCURACY¹: Assuming excitation voltage of at least 500 mV, and not including bridge resistor errors

- ±(0.02% of voltage reading + offset)V_x, 0° to 40°C
- ±(0.025% of voltage reading + offset)V_x, -25° to 50°C
- ±(0.03% of voltage reading + offset)V_x, -40° to 85°C (-XT)

¹Accuracy does not include sensor and measurement noise. Offsets are defined as:

- Offset for DF w/input reversal = 1.5 Basic Res + 1.0 µV
- Offset for DF w/o input reversal = 3 Basic Res + 2.0 µV
- Offset for SE = 3 Basic Res + 5.0 µV

ACCURACY WITH CURRENT EXCITATION¹:

Assuming excitation current of at least 500 µA.

- ±(0.02% of voltage reading + offset)V_x, 0° to 40°C
- ±(0.025% of voltage reading + offset)V_x, -25° to 50°C
- ±(0.03% of voltage reading + offset)V_x, -40° to 85°C (-XT)

¹Accuracy does not include sensor and measurement noise. Offsets are defined as:

- Offset for DF w/input reversal = 1.5 Basic Res + 1.0 µV
- Offset for DF w/o input reversal = 3-Basic Res + 2.0 µV
- Offset for SE = 3-Basic Res + 5.0 µV

DEDICATED PULSE COUNTERS (P1-P4)

Four inputs individually selectable for switch closure, high frequency pulse, or low-level AC. Independent 24-bit counters (16.8 x 10⁶ counts) for each input.

SWITCH CLOSURE MODE:

Minimum Switch Closed Time: 5 ms
Minimum Switch Open Time: 6 ms
Max. Bounce Time: 1 ms open/wk being counted

HIGH FREQUENCY PULSE MODE:

Voltage Thresholds: Count upon transition from below 0.9 V to above 2.2 V after input filter with 1.2 µs time constant.

Maximum Input Voltage: ±20 V

Maximum Input Frequency: 250 kHz

LOW LEVEL AC MODE: Internal AC coupling removes DC offsets up to ±0.5 V.

Input Hysteresis: 12 mV @ 1 Hz

Maximum AC Input Voltage: ±20 V

Minimum ac Input Voltage:

Sine wave (mV RMS)	Range (Hz)
20	1.0 to 20
200	0.5 to 200
2000	0.3 to 20,000
5000	0.3 to 20,000

DIGITAL CONTROL PORTS (C1-C8, SDM)

8 digital control ports (C1-C8) having multiple function capability including digital control outputs, digital control interrupts, pulse counting, switch closure, frequency/period measurements, edge timing, SDI-12 communication, and asynchronous communications (UARTs). 3 ports are dedicated for SDM communications.

INPUT STATE: high 3.8 to 16 V; low -8.0 to 1.2 V

INPUT HYSTERESIS: 1.4 V

INPUT RESISTANCE: 100 kohms

HIGH FREQUENCY MAX: 400 kHz

SWITCH CLOSURE FREQUENCY MAX: 150 Hz

OUTPUT VOLTAGES (no load): high 5.0 V ±0.1 V; low <0.1

OUTPUT RESISTANCE: 330 ohms

ADDITIONAL DIGITAL PORTS: SDM-C1, SDM-C2, SDM-C3 are dedicated for measuring SDM devices.

SWITCHED 12 V (SW12V)

Two independent 12 V unregulated sources switched on and off under program control. Thermal fuse hold current = 900 mA @ 20°C, 650 mA @ 50°C, 360 mA @ 85°C.

CE COMPLIANCE

STANDARD(S) TO WHICH CONFORMITY IS DECLARED: IEC61326:2002

COMMUNICATION

RS-232 PORTS:

9-pin: DCE (electrically isolated) for computer or non-CSI modem connection

COM1 to COM4: Four independent Tx/Rx pairs on control ports (non-isolated); 0 to 5 V UART

Baud Rate: Selectable from 300 to 115.2 kbps.

Format: 7, 8 data bits; 1, 2 stop bits; odd, even, or no parity

CS1/I/O PORT: Interface with CSI peripherals.

SDI-12: Digital Control ports 1, 3, 5, and 7 are individually configurable and meet Standard version 1.3 for datalogger mode. Up to ten SDI-12 sensors are supported per port.

SDM PORT: Interface with CSI Synchronous Devices for Measurement

PERIPHERAL PORT: 40-pin interface for attaching CompactFlash or Ethernet peripherals

SYSTEM

PROTOCOLS SUPPORTED: PakBus, Modbus, DNP3, FTP, HTTP, XML, POP3, SMTP, Telnet, NTCIP, NTP, SDI-12, SDM

PROGRAM EXECUTION INTERVALS: 10 ms to 30 min @ 10 ms increments

PROCESSOR: Renesas H8S 2674 (16-bit CPU with 32-bit internal core)

MEMORY: 2 MB of Flash for operating system; 4 MB of battery-backed SRAM for CPU usage, program storage and data storage

CLOCK ACCURACY: ±3 min. per year

SYSTEM POWER REQUIREMENTS

VOLTAGE: 10 to 16 VDC

TYPICAL CURRENT DRAIN: Sleep Mode: 2 mA

1 Hz Sample Rate (one fast SE meas.): 3 mA

100 Hz Sample Rate (one fast SE meas.): 10 mA

100 Hz Sample Rate (one fast SE meas. w/RS-232 communications): 38 mA

Display on: add 1 mA to current drain

Backlight on: add 42 mA to current drain

INTERNAL BATTERIES: 10 Ah alkaline or 7 Ah rechargeable base. 1200 mAh lithium battery for clock and SRAM backup typically provides 3 years of back-up.

EXTERNAL BATTERIES: 12 VDC nominal; reverse polarity protected.

PHYSICAL SPECIFICATIONS

SIZE: 9.5" x 7.0" x 3.8" (24.1 x 17.8 x 9.6 cm).

Terminal strips extend 0.675" (2.2 cm) and terminal strip cover extends 1.575" (4.0 cm) above the panel.

WEIGHT: 3.6 lbs (1.6 kg) with low profile base; 8.3 lbs (3.8 kg) with alkaline base; 10.7 lbs (4.8 kg) with rechargeable base.

WARRANTY

3 years against defects in materials and workmanship.



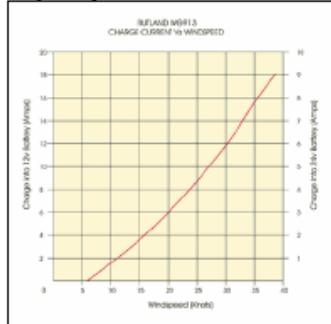
Campbell Scientific, Inc. | 815 W 1800 N | Logan, Utah 84321-1784 | (435) 753-2342 | www.campbellsci.com

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Printed March 2010

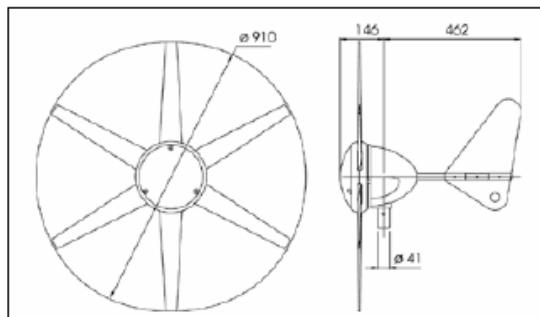
Rutland 913 Windcharger

Specifications:

Output Graph:



Dimensions:



Low wind speed start up of just 5 knots
Generates 90w @ 19 knots, 24w @ 10 knots
Delivers up to 300w

Part Nos: CA-01/15 (12V) CA-01/16 (24V)
Net Weight: 10.5Kg Packing Specifications: 375x375x620mm 13Kg

What else is needed to complete a system?

Marine Mounting Kit – a stainless steel mounting kit with deck bracket is available or a mount may be constructed using a tube of 41mm internal diameter (max external diameter 48mm). Short sections of tube to affix to users own pole are also available.
Land Tower & Rigging Kit – a 6.4m tower made of 3 sections, ground spike and rigging kit for permanent land installation.
Voltage Controller – a choice of HRS913 Regulator to avoid overcharge or the HRDX Controller with digital display, dual charging facility, windcharger and solar panel up to 100W.
Cable – for installations using less than a 20m run of cable we recommend 2.5mm² cable, available per metre from Marlec.
Batteries – Deep cycle or leisure batteries are recommended. Gel and Absorbed Glass Matt ranges are available from Marlec.

APPENDIX C: CALIBRATION CERTIFICATES

50m Mast

52m Anemometer

DEUTSCHER KALIBRIERDIENST **DKD**

Kalibrierlaboratorium / Calibration laboratory

Akkreditiert durch die / accredited by the

Akkreditierungsstelle des Deutschen Kalibrierdienstes



Deutsche WindGuard
Wind Tunnel Services GmbH
Varel



DKD-K- 36801

Kalibrierschein Calibration Certificate

Kalibrierzeichen
Calibration label

10/5452
DKD-K-36801
07/2010

Gegenstand Object	A 100 L2	Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI). Der DKD ist Unterzeichner der multi-lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Hersteller Manufacturer	Windspeed LTD Denbighshire LL18 2AB	Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
Typ Type	A 100 L2	This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).
Fabrikat/Serien-Nr. Serial number	Body: 13331 Cup: E87P	The DKD is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
Auftraggeber Customer	SgurrEnergy UK G42 8AT Glasgow	The user is obliged to have the object recalibrated at appropriate intervals.
Auftragsnummer Order No.	VT10473	
Anzahl der Seiten des Kalibrierscheines Number of pages of the certificate	3	
Datum der Kalibrierung Date of calibration	15.07.2010	

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Auszüge oder Änderungen bedürfen der Genehmigung sowohl der Akkreditierungsstelle des DKD als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift und Stempel haben keine Gültigkeit.

This calibration certificate may not be reproduced other than in full except with the permission of both the Accreditation Body of the DKD and the issuing laboratory. Calibration certificates without signature and seal are not valid.

Stempel Seal	Datum Date	Leiter des Kalibrierlaboratoriums Head of the calibration laboratory	Bearbeiter Person in charge
	15.07.2010	Dipl. Phys. D. Westermann	Dipl. Ing. (FH) Catharina Herold

Deutsche WindGuard Wind Tunnel Services GmbH
Oldenburger Str. 65
26316 Varel ; Tel. ++49 (0)4451 95150



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Kalibrierergebnis:

Result:

Test Item (1/s)	Tunnel Speed (m/s)	Uncertainty (k=2) (m/s)
78.960	4.125	0.05
117.786	6.094	0.05
156.025	8.013	0.05
192.225	9.849	0.05
231.591	11.818	0.05
271.051	13.794	0.05
309.821	15.755	0.05
288.560	14.709	0.05
251.236	12.810	0.05
210.800	10.804	0.05
172.360	8.892	0.05
135.122	6.975	0.05
98.793	5.155	0.05

Angegeben ist die erweiterte Messunsicherheit, die sich aus der Standardmessunsicherheit durch Multiplikation mit dem Erweiterungsfaktor k=2 ergibt. Sie wurde gemäß DKD-3 ermittelt. Der Wert der Messgröße liegt mit einer Wahrscheinlichkeit von 95 % im zugeordneten Wertintervall.

Der Deutsche Kalibrierdienst ist Unterzeichner der multilateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine. Die weiteren Unterzeichner innerhalb und außerhalb Europas sind den Internetseiten von EA (www.european-accreditation.org) und ILAC (www.ilac.org) zu entnehmen.

The expanded uncertainty assigned to the measurement results is obtained by multiplying the standard uncertainty by the coverage factor k = 2. It has been determined in accordance with DKD-3. The value of the measurand lies within the assigned range of values with a probability of 95%.

The DKD is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.

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1 Detailed MEASNET¹ Calibration Results

DKD calibration no. 10/5452

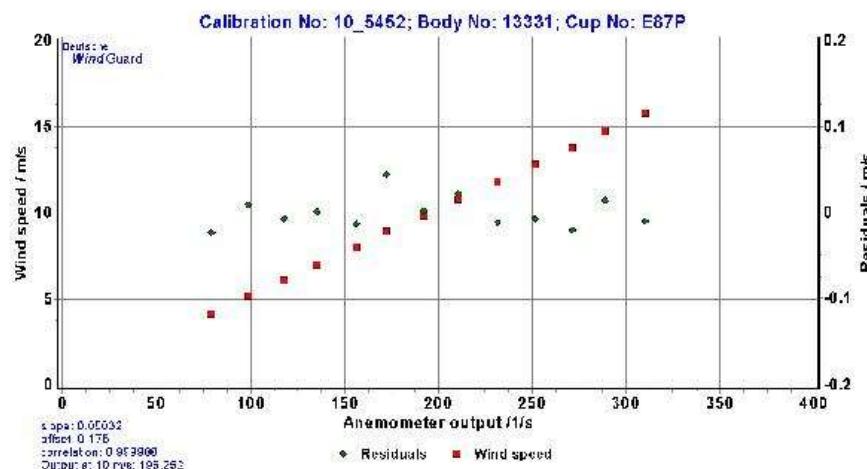
Body no. 13331
 Cup no. E87P
 Date 15.07.2010
 Air temperature 28.6 °C
 Air pressure 1012.4 hPa
 Humidity 40.1 %



Linear regression analysis

Slope 0.05032 (m/s)/(1/s) ± 0.00008 (m/s)/(1/s)
 Offset 0.175 m/s ± 0.015 m/s
 Sterr(Y) 0.020 m/s
 Correlation coefficient 0.999988

Remarks no



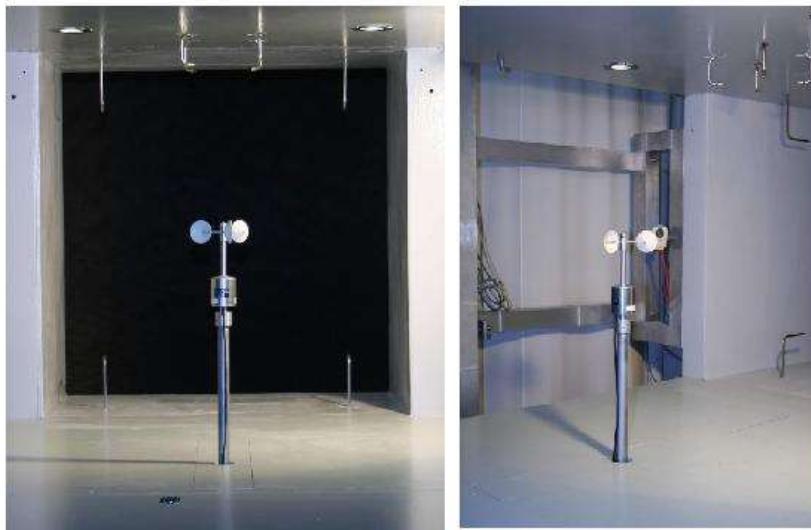
¹) According to MEASNET Cup Anemometer Calibration Procedure 09/1997.
 Deutsche WindGuard Wind Tunnel Services is accredited by MEASNET and by the Deutscher Kalibrierdienst – DKD (German Calibration Service). Registration: DKD – K – 36801

2 Instrumentation

Pos.	Sensor	Manufa.	Identification	Year
1	Pitot static tube	Airlow	483/8 Nr. 000142	02
2	Pitot static tube	Airlow	483/8 Nr. 000143	02
3	Pitot static tube	Airlow	483/8 Nr. 000144	02
4	Pitot static tube	Airlow	483/8 Nr. 000145	02
5	Pressure transducer	Setra	C 239 Nr. 1688081	02
6	Pressure transducer	Setra	C 239 Nr. 1688082	02
7	Pressure transducer	Setra	C 239 Nr. 1688083	02
8	Pressure transducer	Setra	C 239 Nr. 1688084	02
9	El. Barometer	Vassala	100 A Nr. X2010004	02
10	El. Thermometer	Galec	KPK 1/6-ME	02
11	El. Humidity sensor	Galec	KPK 1/6-ME	02
12	Wind tunnel control	-	-	-
13	CAN-BUS / PC	esd	-	04
14	Anemometer	-	-	-
15	Universal isolator	Knick	P2700 - 98430	05

Table 1 Description of the data acquisition system

Remark: Last Re-accreditation see page 2

3 Photo of the calibration set-up

Calibration set-up of the anemometer calibration in the wind tunnel of Deutsche WindGuard, Varel. The anemometer shown is of the same type as the calibrated one.

Remark: The proportion of the set-up are not true to scale due to imaging geometry.

4 Deviation to MEASNET procedure

The calibration procedure is in all aspects in accordance with the IEC 61400-12-1 Procedure

5 References

- [1] D. Westermann, 2009 - Verfahrensanweisung DKD-Kalibrierung von Windgeschwindigkeitssensoren
- [2] IEC 61400-12-1 12/2005 - Wind Turbine Power Performance Testing
- [3] ISO 3966 1977 - Measurement of fluid flow in closed conduits
- [4] MEASNET 09 1997 - Cup Anemometer Calibration Procedure

50m Anemometer**DEUTSCHER KALIBRIERDIENST **

Kalibrierlaboratorium / Calibration laboratory

Akkreditiert durch die / accredited by the

Akkreditierungsstelle des Deutschen Kalibrierdienstes

Deutsche WindGuard
Wind Tunnel Services GmbH
Varel

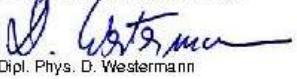
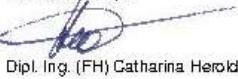
10/5450
DKD-K-36801
07/2010

Kalibrierschein
*Calibration Certificate*Kalibrierzeichen
Calibration label

Gegenstand <i>Object</i>	A 100 L2	Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI). Der DKD ist Unterzeichner der multi-lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Hersteller <i>Manufacturer</i>	Windspeed LTD Denbighshire LL18 2AB	Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
Typ <i>Type</i>	A 100 L2	This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).
Fabrikat/Serien-Nr. <i>Serial number</i>	Body: 13333 Cup: E89P	The DKD is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
Auftraggeber <i>Customer</i>	SgurrEnergy UK G42 8AT Glasgow	The user is obliged to have the object recalibrated at appropriate intervals.
Auftragsnummer <i>Order No.</i>	VT10473	
Anzahl der Seiten des Kalibrierscheines <i>Number of pages of the certificate</i>	3	
Datum der Kalibrierung <i>Date of calibration</i>	15.07.2010	

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Stempel Seal	Datum Date	Leiter des Kalibrierlaboratoriums Head of the calibration laboratory	Bearbeiter Person in charge
	15.07.2010	Dipl. Phys. D. Westermann 	Dipl. Ing. (FH) Catharina Herold 

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Kalibriergegenstand <i>Object</i>	Anemometer	
Kalibrierverfahren <i>Calibration procedure</i>	IEC 61400 12 1 - Wind Turbine Power Performance Testing 12 2005 MEASNET - Cup Anemometer Calibration Procedure – 09 1997 ISO 3966 – Measurement of fluid in closed conduits - 1977	
Ort der Kalibrierung <i>Place of calibration</i>	Windtunnel of Deutsche WindGuard, Varel	
Messbedingungen <i>Test Conditions</i>		
	wind tunnel area ¹⁾	10000 cm ²
	anemometer frontal area ²⁾	200 cm ²
	diameter of mounting pipe ³⁾	27 mm
	blockage ratio ⁴⁾	0.020 [-]
	blockage correction ⁵⁾	1.000 [-]

Umgebungsbedingungen <i>Test conditions</i>	air temperature	28.5 °C	± 0.2 K
	air pressure	1012.2 hPa	± 0.3 hPa
	relative air humidity	40.0 %	± 2.0 %
Akkreditierung <i>Accreditation</i>	08 / 2009		
Anmerkungen <i>Remarks</i>	calibrated with 405 Type Single Mount		
Auswertesoftware <i>Software version</i>	5.0		

¹⁾ Querschnittsfläche der Auslassdüse des Windkanals

²⁾ Vereinfachte Querschnittsfläche (Schattenwurf) des Prüflings inkl. Montagerohr

³⁾ Durchmesser des Montagerohrs

⁴⁾ Verhältnis von 2) zu 1)

⁵⁾ Korrekturfaktor durch die Verdängerung der Strömung durch den Prüfling

Anmerkung: Aufgrund der speziellen Konstruktion der Messstrecke ist keine Korrektur nötig.

Remark: Due to the special construction of the test section no blockage correction is necessary

Dieser Kalibrierschein wurde elektronisch erzeugt
This calibration certificate has been generated electronically

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Kalibrierergebnis:*Result:*

Test Item (1/s)	Tunnel Speed (m/s)	Uncertainty (k=2) (m/s)
78.622	4.128	0.05
117.893	6.120	0.05
155.924	8.012	0.05
191.043	9.847	0.05
231.109	11.823	0.05
269.696	13.789	0.05
307.673	15.758	0.05
287.766	14.707	0.05
249.959	12.814	0.05
211.368	10.808	0.05
172.384	8.884	0.05
134.730	6.977	0.05
98.667	5.147	0.05

Angegeben ist die erweiterte Messunsicherheit, die sich aus der Standardmessunsicherheit durch Multiplikation mit dem Erweiterungsfaktor k=2 ergibt. Sie wurde gemäß DKD-3 ermittelt. Der Wert der Messgröße liegt mit einer Wahrscheinlichkeit von 95 % im zugeordneten Wertintervall.

Der Deutsche Kalibrierdienst ist Unterzeichner der multilateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine. Die weiteren Unterzeichner innerhalb und außerhalb Europas sind den Internetseiten von EA (www.european-accreditation.org) und ILAC (www.ilac.org) zu entnehmen.

The expanded uncertainty assigned to the measurement results is obtained by multiplying the standard uncertainty by the coverage factor k = 2. It has been determined in accordance with DKD-3. The value of the measurand lies within the assigned range of values with a probability of 95%.

The DKD is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.

1 Detailed MEASNET¹ Calibration Results

DKD calibration no. 10/5450

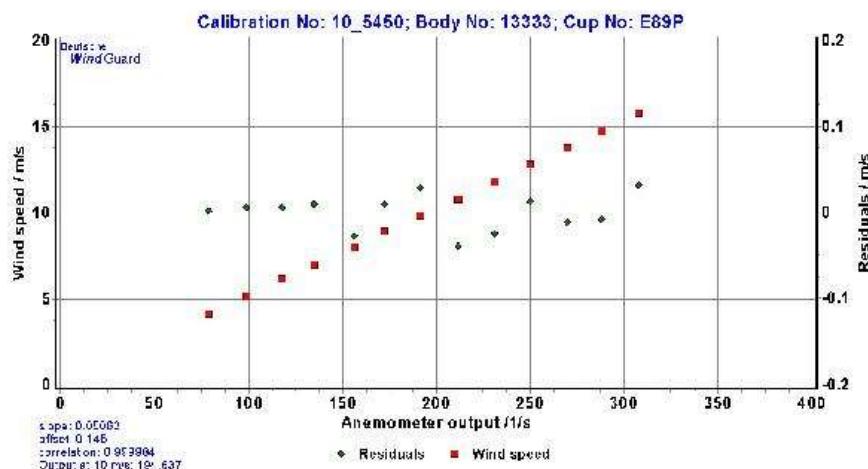
Body no. 13333
 Cup no. E89P
 Date 15.07.2010
 Air temperature 28.5 °C
 Air pressure 1012.2 hPa
 Humidity 40.0 %



Linear regression analysis

Slope 0.05063 (m/s)/(1/s) ± 0.00009 (m/s)/(1/s)
 Offset 0.145 m/s ± 0.018 m/s
 Sterr(Y) 0.024 m/s
 Correlation coefficient 0.999984

Remarks no



¹) According to MEASNET Cup Anemometer Calibration Procedure 09/1997.
 Deutsche WindGuard Wind Tunnel Services is accredited by MEASNET and by the Deutscher Kalibrierdienst – DKD (German Calibration Service). Registration: DKD – K – 36801

2 Instrumentation

Pos.	Sensor	Manufa.	Identification	Year
1	Pitot static tube	Airlow	483/8 Nr. 000142	02
2	Pitot static tube	Airlow	483/8 Nr. 000143	02
3	Pitot static tube	Airlow	483/8 Nr. 000144	02
4	Pitot static tube	Airlow	483/8 Nr. 000145	02
5	Pressure transducer	Setra	C 239 Nr. 1688081	02
6	Pressure transducer	Setra	C 239 Nr. 1688082	02
7	Pressure transducer	Setra	C 239 Nr. 1688083	02
8	Pressure transducer	Setra	C 239 Nr. 1688084	02
9	El. Barometer	Vassala	100.A Nr. X2010004	02
10	El. Thermometer	Galec	KPK 1/6-ME	02
11	El. Humidity sensor	Galec	KPK 1/6-ME	02
12	Wind tunnel control	-	-	-
13	CAN-BUS / PC	esd	-	04
14	Anemometer	-	-	-
15	Universal isolator	Knick	P2700 - 98430	05

Table 1 Description of the data acquisition system

Remark: Last Re-accreditation see page 2

3 Photo of the calibration set-up

Calibration set-up of the anemometer calibration in the wind tunnel of Deutsche WindGuard, Varel. The anemometer shown is of the same type as the calibrated one.

Remark: The proportion of the set-up are not true to scale due to imaging geometry.

4 Deviation to MEASNET procedure

The calibration procedure is in all aspects in accordance with the IEC 61400-12-1 Procedure

5 References

- [1] D. Westermann, 2009 - Verfahrensanweisung DKD-Kalibrierung von Windgeschwindigkeitssensoren
- [2] IEC 61400-12-1 12/2005 - Wind Turbine Power Performance Testing
- [3] ISO 3966 1977 - Measurement of fluid flow in closed conduits
- [4] MEASNET 09 1997 - Cup Anemometer Calibration Procedure

40m SE Anemometer**DEUTSCHER KALIBRIERDIENST DKD**

Kalibrierlaboratorium / Calibration laboratory

Akkreditiert durch die / accredited by the

Akkreditierungsstelle des Deutschen Kalibrierdienstes



Deutsche WindGuard
Wind Tunnel Services GmbH
Varel



DKD-K- 36801

Kalibrierschein
Calibration Certificate

Kalibrierzeichen
Calibration label

10/5443
DKD-K- 36801
07/2010

Gegenstand Object	A 100 L2	Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI). Der DKD ist Unterzeichner der multi-lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Hersteller Manufacturer	Windspeed LTD Denbighshire LL18 2AB	Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
Typ Type	A 100 L2	<i>This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).</i>
Fabrikat/Serien-Nr. Serial number	Body: 13339 Cup: E95P	<i>The DKD is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.</i>
Auftraggeber Customer	SgurrEnergy UK G42 8AT Glasgow	<i>The user is obliged to have the object recalibrated at appropriate intervals.</i>
Auftragsnummer Order No.	VT10473	
Anzahl der Seiten des Kalibrierscheines Number of pages of the certificate	3	
Datum der Kalibrierung Date of calibration	15.07.2010	

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Auszüge oder Änderungen bedürfen der Genehmigung sowohl der Akkreditierungsstelle des DKD als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift und Stempel haben keine Gültigkeit.

This calibration certificate may not be reproduced other than in full except with the permission of both the Accreditation Body of the DKD and the issuing laboratory. Calibration certificates without signature and seal are not valid.

Stempel Seal	Datum Date	Leiter des Kalibrierlaboratoriums Head of the calibration laboratory	Bearbeiter Person in charge
	15.07.2010	Dipl. Phys. D. Westermann 	Dipl. Ing. (FH) Catharina Herold

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Oldenburger Str. 65
26316 Varel ; Tel. ++49 (0)4451 95150



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Kalibriergegenstand <i>Object</i>	Anemometer	
Kalibrierverfahren <i>Calibration procedure</i>	IEC 61400 12 1 - Wind Turbine Power Performance Testing 12 2005 MEASNET - Cup Anemometer Calibration Procedure – 09 1997 ISO 3966 – Measurement of fluid in closed conduits - 1977	
Ort der Kalibrierung <i>Place of calibration</i>	Windtunnel of Deutsche WindGuard, Varel	
Messbedingungen <i>Test Conditions</i>		
	wind tunnel area ¹⁾	10000 cm ²
	anemometer frontal area ²⁾	200 cm ²
	diameter of mounting pipe ³⁾	27 mm
	blockage ratio ⁴⁾	0.020 [-]
	blockage correction ⁵⁾	1.000 [-]

Umgebungsbedingungen <i>Test conditions</i>	air temperature	28.0 °C	± 0.2 K
	air pressure	1011.4 hPa	± 0.3 hPa
	relative air humidity	41.1 %	± 2.0 %
Akkreditierung <i>Accreditation</i>	08 / 2009		
Anmerkungen <i>Remarks</i>	calibrated with 405 Type Single Mount		
Auswertesoftware <i>Software version</i>	5.0		

- ¹⁾ Querschnittsfläche der Auslassdüse des Windkanals
 - ²⁾ Vereinfachte Querschnittsfläche (Schattenwurf) des Prüflings inkl. Montagerohr
 - ³⁾ Durchmesser des Montagerohrs
 - ⁴⁾ Verhältnis von 2) zu 1)
 - ⁵⁾ Korrekturfaktor durch die Verdängung der Strömung durch den Prüfling
- Ämmerung: Aufgrund der speziellen Konstruktion der Messstrecke ist keine Korrektur nötig.
Remark: Due to the special construction of the test section no blockage correction is necessary

Dieser Kalibrierschein wurde elektronisch erzeugt
This calibration certificate has been generated electronically

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07/2010

Kalibrierergebnis:

Result:

Test Item (1/s)	Tunnel Speed (m/s)	Uncertainty (k=2) (m/s)
78.417	4.130	0.05
117.604	6.130	0.05
155.023	8.006	0.05
191.895	9.857	0.05
230.701	11.829	0.05
270.093	13.803	0.05
308.903	15.757	0.05
287.918	14.722	0.05
250.529	12.812	0.05
211.169	10.812	0.05
172.365	8.909	0.05
134.182	6.974	0.05
98.851	5.167	0.05

Angegeben ist die erweiterte Messunsicherheit, die sich aus der Standardmessunsicherheit durch Multiplikation mit dem Erweiterungsfaktor k=2 ergibt. Sie wurde gemäß DKD-3 ermittelt. Der Wert der Messgröße liegt mit einer Wahrscheinlichkeit von 95 % im zugeordneten Wertintervall.

Der Deutsche Kalibrierdienst ist Unterzeichner der multilateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine. Die weiteren Unterzeichner innerhalb und außerhalb Europas sind den Internetseiten von EA (www.european-accreditation.org) und ILAC (www.ilac.org) zu entnehmen.

The expanded uncertainty assigned to the measurement results is obtained by multiplying the standard uncertainty by the coverage factor k = 2. It has been determined in accordance with DKD-3. The value of the measurand lies within the assigned range of values with a probability of 95%.

The DKD is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.

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1 Detailed MEASNET¹ Calibration Results

DKD calibration no. 10/5443

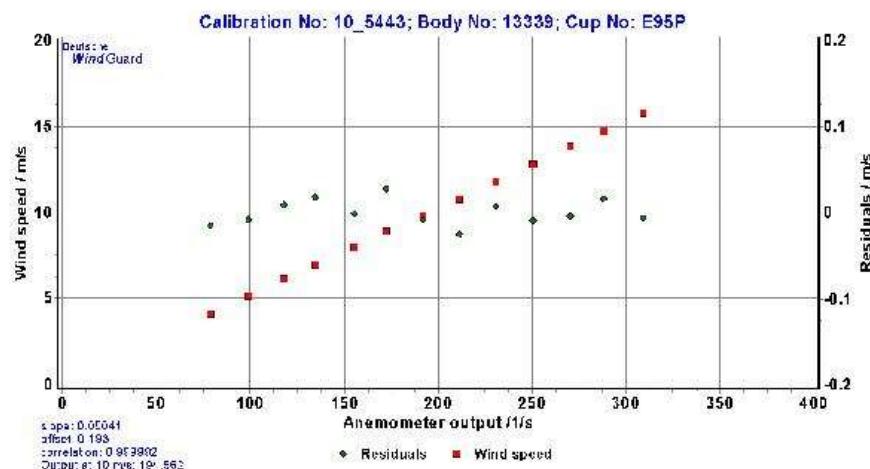
Body no. 13339
 Cup no. E95P
 Date 15.07.2010
 Air temperature 28.0 °C
 Air pressure 1011.4 hPa
 Humidity 41.1 %



Linear regression analysis

Slope 0.05041 (m/s)/(1/s) ± 0.00006 (m/s)/(1/s)
 Offset 0.193 m/s ± 0.012 m/s
 Sterr(Y) 0.015 m/s
 Correlation coefficient 0.999992

Remarks no



¹) According to MEASNET Cup Anemometer Calibration Procedure 09/1997.
 Deutsche WindGuard Wind Tunnel Services is accredited by MEASNET and by the Deutscher Kalibrierdienst – DKD (German Calibration Service). Registration: DKD – K – 36801

2 Instrumentation

Pos.	Sensor	Manufa.	Identification	Year
1	Pitot static tube	Airlow	483/8 Nr. 000142	02
2	Pitot static tube	Airlow	483/8 Nr. 000143	02
3	Pitot static tube	Airlow	483/8 Nr. 000144	02
4	Pitot static tube	Airlow	483/8 Nr. 000145	02
5	Pressure transducer	Setra	C 239 Nr. 1688081	02
6	Pressure transducer	Setra	C 239 Nr. 1688082	02
7	Pressure transducer	Setra	C 239 Nr. 1688083	02
8	Pressure transducer	Setra	C 239 Nr. 1688084	02
9	El. Barometer	Vassala	100.A Nr. X2010004	02
10	El. Thermometer	Galec	KPK 1/6-ME	02
11	El. Humidity sensor	Galec	KPK 1/6-ME	02
12	Wind tunnel control	-	-	-
13	CAN-BUS / PC	esd	-	04
14	Anemometer	-	-	-
15	Universal isolator	Knick	P2700 - 98430	05

Table 1 Description of the data acquisition system

Remark: Last Re-accreditation see page 2

3 Photo of the calibration set-up

Calibration set-up of the anemometer calibration in the wind tunnel of Deutsche WindGuard, Varel. The anemometer shown is of the same type as the calibrated one.

Remark: The proportion of the set-up are not true to scale due to imaging geometry.

4 Deviation to MEASNET procedure

The calibration procedure is in all aspects in accordance with the IEC 61400-12-1 Procedure

5 References

- [1] D. Westermann, 2009 - Verfahrensanweisung DKD-Kalibrierung von Windgeschwindigkeitssensoren
- [2] IEC 61400-12-1 12/2005 - Wind Turbine Power Performance Testing
- [3] ISO 3966 1977 - Measurement of fluid flow in closed conduits
- [4] MEASNET 09 1997 - Cup Anemometer Calibration Procedure

40m NW Anemometer**DEUTSCHER KALIBRIERDIENST **

Kalibrierlaboratorium / Calibration laboratory

Akkreditiert durch die / accredited by the

Akkreditierungsstelle des Deutschen Kalibrierdienstes

Deutsche WindGuard
Wind Tunnel Services GmbH
Varel

DKD-K- 36801

Kalibrierschein
*Calibration Certificate*Kalibrierzeichen
Calibration label

10/5442
DKD-K-36801
07/2010

Gegenstand Object	A 100 L2	Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI). Der DKD ist Unterzeichner der multi-lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Hersteller Manufacturer	Windspeed LTD Denbighshire LL18 2AB	Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
Typ Type	A 100 L2	This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).
Fabrikat/Serien-Nr. Serial number	Body: 13338 Cup: E94P	The DKD is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
Auftraggeber Customer	SgurrEnergy UK G42 8AT Glasgow	The user is obliged to have the object recalibrated at appropriate intervals.
Auftragsnummer Order No.	VT10473	
Anzahl der Seiten des Kalibrierscheines Number of pages of the certificate	3	
Datum der Kalibrierung Date of calibration	15.07.2010	

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Auszüge oder Änderungen bedürfen der Genehmigung sowohl der Akkreditierungsstelle des DKD als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift und Stempel haben keine Gültigkeit.

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Stempel Seal	Datum Date	Leiter des Kalibrierlaboratoriums Head of the calibration laboratory	Bearbeiter Person in charge
	15.07.2010	Dipl. Phys. D. Westermann	Dipl. Ing. (FH) Catharina Herold

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Kalibriergegenstand <i>Object</i>	Anemometer	
Kalibrierverfahren <i>Calibration procedure</i>	IEC 61400 12 1 - Wind Turbine Power Performance Testing 12 2005 MEASNET - Cup Anemometer Calibration Procedure – 09 1997 ISO 3966 – Measurement of fluid in closed conduits - 1977	
Ort der Kalibrierung <i>Place of calibration</i>	Windtunnel of Deutsche WindGuard, Varel	
Messbedingungen <i>Test Conditions</i>		
wind tunnel area ¹⁾	10000 cm ²	
anemometer frontal area ²⁾	200 cm ²	
diameter of mounting pipe ³⁾	27 mm	
blockage ratio ⁴⁾	0.020 [-]	
blockage correction ⁵⁾	1.000 [-]	

Umgebungsbedingungen <i>Test conditions</i>	air temperature	27.9 °C	± 0.2 K
	air pressure	1011.3 hPa	± 0.3 hPa
	relative air humidity	41.2 %	± 2.0 %
Akkreditierung <i>Accreditation</i>	08 / 2009		
Anmerkungen <i>Remarks</i>	calibrated with 405 Type Single Mount		
Auswertesoftware <i>Software version</i>	5.0		

¹⁾ Querschnittsfläche der Auslassdüse des Windkanals

²⁾ Vereinfachte Querschnittsfläche (Schattenwurf) des Prüflings inkl. Montagerohr

³⁾ Durchmesser des Montagerohrs

⁴⁾ Verhältnis von 2) zu 1)

⁵⁾ Korrekturfaktor durch die Verdängerung der Strömung durch den Prüfling

Anmerkung: Aufgrund der speziellen Konstruktion der Messstrecke ist keine Korrektur nötig.

Remark: Due to the special construction of the test section no blockage correction is necessary

Dieser Kalibrierschein wurde elektronisch erzeugt
This calibration certificate has been generated electronically

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Kalibrierergebnis:

Result:

Test Item (1/s)	Tunnel Speed (m/s)	Uncertainty (k=2) (m/s)
78.579	4.131	0.05
117.877	6.126	0.05
155.456	8.010	0.05
191.400	9.855	0.05
231.135	11.825	0.05
271.752	13.797	0.05
309.694	15.768	0.05
288.863	14.714	0.05
250.241	12.819	0.05
211.332	10.829	0.05
172.857	8.902	0.05
134.571	6.974	0.05
99.275	5.187	0.05

Angegeben ist die erweiterte Messunsicherheit, die sich aus der Standardmessunsicherheit durch Multiplikation mit dem Erweiterungsfaktor k=2 ergibt. Sie wurde gemäß DKD-3 ermittelt. Der Wert der Messgröße liegt mit einer Wahrscheinlichkeit von 95 % im zugeordneten Wertintervall.

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The expanded uncertainty assigned to the measurement results is obtained by multiplying the standard uncertainty by the coverage factor k = 2. It has been determined in accordance with DKD-3. The value of the measurand lies within the assigned range of values with a probability of 95%.

The DKD is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.

Deutsche WindGuard Wind Tunnel Services GmbH
Oldenburger Str. 65
26316 Varel ; Tel. ++49 (0)4451 95150



1 Detailed MEASNET¹ Calibration Results

DKD calibration no. 10/5442

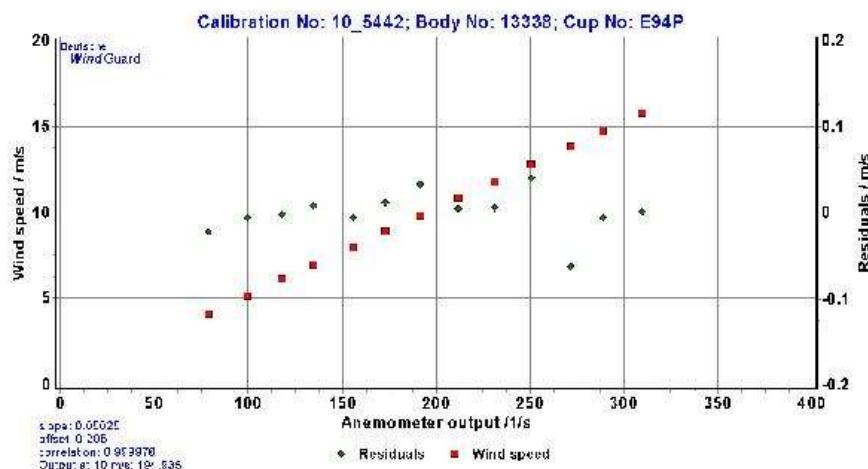
Body no. 13338
 Cup no. E94P
 Date 15.07.2010
 Air temperature 27.9 °C
 Air pressure 1011.3 hPa
 Humidity 41.2 %



Linear regression analysis

Slope 0.05025 (m/s)/(1/s) ± 0.00010 (m/s)/(1/s)
 Offset 0.205 m/s ± 0.021 m/s
 Sterr(Y) 0.027 m/s
 Correlation coefficient 0.999978

Remarks no



¹) According to MEASNET Cup Anemometer Calibration Procedure 09/1997.
 Deutsche WindGuard Wind Tunnel Services is accredited by MEASNET and by the Deutscher Kalibrierdienst – DKD (German Calibration Service). Registration: DKD – K – 36801

Anhang
Annex

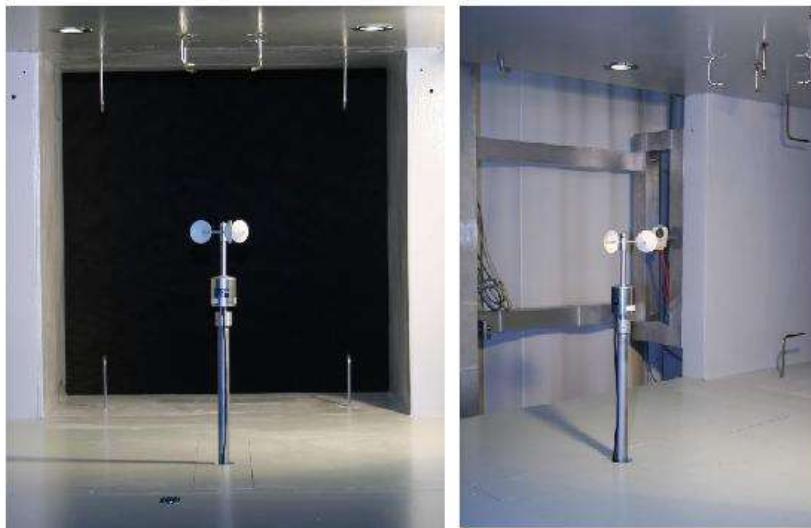
10/5442

2 Instrumentation

Pos.	Sensor	Manufa.	Identification	Year
1	Pitot static tube	Airlow	483/8 Nr. 000142	02
2	Pitot static tube	Airlow	483/8 Nr. 000143	02
3	Pitot static tube	Airlow	483/8 Nr. 000144	02
4	Pitot static tube	Airlow	483/8 Nr. 000145	02
5	Pressure transducer	Setra	C 239 Nr. 1688081	02
6	Pressure transducer	Setra	C 239 Nr. 1688082	02
7	Pressure transducer	Setra	C 239 Nr. 1688083	02
8	Pressure transducer	Setra	C 239 Nr. 1688084	02
9	El. Barometer	Vassala	100.A Nr. X2010004	02
10	El. Thermometer	Galec	KPK 1/6-ME	02
11	El. Humidity sensor	Galec	KPK 1/6-ME	02
12	Wind tunnel control	-	-	-
13	CAN-BUS / PC	esd	-	04
14	Anemometer	-	-	-
15	Universal isolator	Knick	P2700 - 98430	05

Table 1 Description of the data acquisition system

Remark: Last Re-accreditation see page 2

3 Photo of the calibration set-up

Calibration set-up of the anemometer calibration in the wind tunnel of Deutsche WindGuard, Varel. The anemometer shown is of the same type as the calibrated one.

Remark: The proportion of the set-up are not true to scale due to imaging geometry.

4 Deviation to MEASNET procedure

The calibration procedure is in all aspects in accordance with the IEC 61400-12-1 Procedure

5 References

- [1] D. Westermann, 2009 - Verfahrensanweisung DKD-Kalibrierung von Windgeschwindigkeitssensoren
- [2] IEC 61400-12-1 12/2005 - Wind Turbine Power Performance Testing
- [3] ISO 3966 1977 - Measurement of fluid flow in closed conduits
- [4] MEASNET 09 1997 - Cup Anemometer Calibration Procedure

Deutsche WindGuard Wind Tunnel Services GmbH
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Deutsche
WindGuard

50m Ultrasonic**VAISALA**

Test report nr. H29-10340026

TEST REPORT

Instrument WS425 A1E2A
Serial number F346004
Manufacturer Vaisala Oyj, Finland
Calibration Date 2010-08-28
Test procedure P120254-A

This instrument has been carefully inspected and subjected to rigid tests. This test report certifies that the instrument was thoroughly tested and inspected, and found to meet its published specifications when it was shipped from the factory.

Vaisala is ISO 9001 Certified

Test results

Test Name	Result	Limits
Current	16.2 mA	(10 ... 35) mA
V out Direction 359 Degrees	1.99 V	(1.988 ... 2.01) V
V out Speed 125 mph	1.000 V	(0.995 ... 1.005) V
V out Direction 100 Degrees	0.55 V	(0.55 ... 0.56) V
V out Speed 50 mph	0.399 V	(0.397 ... 0.403) V
Zero Wind Speed	0.35 mph	(0 ... 0.5) mph
Wind tunnel Speed	15.04 mph	(13.2 ... 17.7) mph
Wind tunnel Direction	150.00 Degrees	(148 ... 152) Degrees
SDI-12	PASS	(PASS ... FAIL)

This instrument has successfully passed the test.

Signature


Technician

Vaisala Oyj | PO Box 26, FI-00421 Helsinki, Finland
Phone +358 9 884 91 | Fax +358 9 8949 2227
Email firstname.lastname@vaisala.com | www.vaisala.com
Domicile Vantaa, Finland | VAT FI01244162 | Business ID 0124416-2

50m Temperature / Relative Humidity Sensor**VAISALA**1 (1)
Certificate report no. H06-10290058**CALIBRATION CERTIFICATE**

Instrument HMP45AC Humidity and temperature probe
Serial number F2650057
Manufacturer Vaisala Oyj, Finland
Calibration date 21st July 2010

50m mast A
 Shell flunks
 50m level

The above instrument was calibrated by comparing the relative humidity and temperature readings to two HMP233 factory working standards. At the time of shipment, the instrument described above met its operating specifications.

The relative humidity readings of the two HMP233 factory working standards have been calibrated at the Vaisala factory by using Hygro M-3 dewpoint meter. Hygro M-3 dewpoint meter has been calibrated at Centre for metrology and accreditation (MIKES) by using a MIKES working standard traceable to National Institute of Standards and Technology (NIST). The temperature readings of the two HMP233 factory working standards have been calibrated at Vaisala Measurement Standards Laboratory (MSL) by using the MSL working standard traceable to the NIST. The temperature calibration at MSL has been accredited by the FINAS according to the ISO/IEC 17025.

Calibration results

Reference humidity*	Observed humidity	Difference	Permissible difference
% RH	% RH	%RH	%RH
0.4	1.3	+ 0.9	± 2.0
44.2	44.1	- 0.1	± 2.0
72.3	72.9	+ 0.6	± 2.0
Reference temperature*	Observed temperature	Difference	Permissible difference
°C	°C	°C	°C
+ 23.40	+23.33	- 0.07	± 0.2

*Average of two references.

Equipment used in calibration

Type	Serial number	Calibration date	Certificate number
HMP233 / RH	B2050020	2010-05-03	H06-10180001
HMP233 / RH	B2050015	2010-05-03	H06-10180002
Vaisala HMT337	B2050020	2009-12-04	K008-S02922
Vaisala HMT337	B2050015	2009-12-04	K008-S02921
HYGRO M-3	361095	2009-06-22	M-09H036
HP 34401A	3146A24281	2010-02-10	K004-10S077

Uncertainties (95 % confidence level, k=2)

Humidity $\pm 1.0\%$ RH @ 0..15%RH, $\pm 1.5\%$ RH @ 15..78%RH

Temperature ± 0.13 °C

Ambient conditions / Humidity 46 \pm 5%RH, Temperature 23 \pm 1 °C, Pressure 1014 \pm 1 hPa.



 Technician

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Doc21425-B

Vaisala Oyj | PO Box 26, FI-00421 Helsinki, Finland
 Phone +358 9 894 91 | Fax +358 9 8949 2227
 Email firstname.lastname@vaisala.com | www.vaisala.com
 Domicile Vantaa, Finland | VAT FI01244162 | Business ID 0124416-2

Platform Level Temperature / Relative Humidity Sensor

VAISALA

1 (1)

Certificate report no. H06-10290D57

CALIBRATION CERTIFICATE

Scm shell flats
Platform
Height m

Instrument	HMP45AC Humidity and temperature probe
Serial number	F2650056
Manufacturer	Vaisala Oyj, Finland
Calibration date	21st July 2010

The above instrument was calibrated by comparing the relative humidity and temperature readings to two HMP233 factory working standards. At the time of shipment, the instrument described above met its operating specifications.

The relative humidity readings of the two HMP233 factory working standards have been calibrated at the Vaisala factory by using Hygro M-3 dewpoint meter. Hygro M-3 dewpoint meter has been calibrated at Centre for metrology and accreditation (MIKES) by using a MIKES working standard traceable to National Institute of Standards and Technology (NIST). The temperature readings of the two HMP233 factory working standards have been calibrated at Vaisala Measurement Standards Laboratory (MSL) by using the MSL working standard traceable to the NIST. The temperature calibration at MSL has been accredited by the FINAS according to the ISO/IEC 17025.

Calibration results

Reference humidity*	Observed humidity	Difference	Permissible difference
% RH	% RH	%RH	%RH
0.4	1.3	+ 0.9	± 2.0
44.2	44.1	- 0.1	± 2.0
72.3	73.0	+ 0.7	± 2.0
Reference temperature*	Observed temperature	Difference	Permissible difference
°C	°C	°C	°C
+ 23.40	+23.31	- 0.09	± 0.2

*Average of two references.

Equipment used in calibration

Type	Serial number	Calibration date	Certificate number
HMP233 / RH	B2050020	2010-05-03	H06-10180001
HMP233 / RH	B2050015	2010-05-03	H06-10180002
Vaisala HMT337	B2050020	2009-12-04	K008-S02922
Vaisala HMT337	B2050015	2009-12-04	K008-S02921
HYGRO M-3	361095	2009-06-22	M-09H036
HP 34401A	3146A24281	2010-02-10	K004-10S077

Uncertainties (95 % confidence level, k=2)

Humidity ±1.0%RH @ 0..15%RH, ±1.5%RH @ 15..78%RH

Temperature ± 0.13 °C

Ambient conditions / Humidity 46 ± 5%RH, Temperature 23 ± 1 °C, Pressure 1014 ± 1 hPa.



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Email firstname.lastname@vaisala.com | www.vaisala.com
Domicile Vantaa, Finland | VAT FI01244162 | Business ID 0124416-3

Data Logger**CAMPBELL SCIENTIFIC LIMITED**

Campbell Park
80 Hathern Road
Shepshed
Loughborough
LE12 9GX

Telephone: +44 (0) 1509 601141
Fax: +44 (0) 1509 601091
Email: support@campbellsci.co.uk

***Certificate of Calibration*****Customer:**

Company Name: Sgurr Energy Ltd.
Address: 225 Bath street,
Glasgow,
G2 4GZ.

Model: CR3000**Serial Number: 4841**

Calibration Date:	28-Jun-10
CSL Calibration Number:	100628165
Calibration Procedures:	W/T/0072, 73, 74

Test Panel Loc. 1

Instrument Calibration Condition

Received Disposition:	In Tolerance	Out of Tolerance	Operational Failure
Returned Disposition:	In Tolerance *		

Report of Calibration Standards Used

Make/ Model	Test Equipment Number	Calibration Service Certificate Number
Krohn Hite 523	TE2164	AG50112
CSI Oscillator	TE2165	CSI

Campbell Scientific Limited certifies that the above instrument meets or exceeds published specifications and has been calibrated using standards and instruments whose accuracies are traceable to UK National Standards. All standards have been calibrated by a U.K.A.S. accredited calibration service. The uncertainties, including those attributable to the standards used, together with those contributed by personnel, procedures and environment are estimated not to exceed a 4:1 accuracy ratio for any given measurement.

Quality Control Officer responsible for content of certificate: Steve Sharratt

Remarks:

Based on the selected report options, some fields are intentionally left blank.
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Page 1 of 2

Instrument Data Report

Analog Inputs

Log Option: 1 S/N 4841

Range	Input (mV)	Tolerance (mV)	Single-Ended (Full Scale)		Differential		Temp (C)
			Before (mV)	After (mV)	Before (mV)	After (mV)	
6	5000	+4				5000.0	28
6	-5000	+4				4999.88	28
5	2500	+2				200.01	28
4	250	+0.2				50.005	28
3	25	+0.02				20.002	28
2	7.5	+0.006				-20.002	28
1	2.5	+0.002				-4999.3	-25
1	-2.5	+0.002				4999.3	50
6	5000	+7.5	4999.2			5000.7	-40
6	5000	+7.5	5000.7				80
6	5000	+12.5					
6	5000	+12.5					

Quiescent System Power

Tolerance Max (mA)	As Received (mA)	As Returned (mA)	Temp (C)
3.0		2.03	28.0

Real-Time Clock

Clock accuracy: Meets or exceeds +/- 3 min/year (-40 to 80C)

Laboratory temperature and relative humidity at the time of calibration

Temperature: 28 C

Relative Humidity: 33 %

Functions tested per test document (see page 1):

Analog:

- Excitation Channels
- CAO Channels
- Analog Input ranges over temperature

Frequency:

- Pulse Counters
- Period Averaging

Calibration by:

P. Redmile

Title: Test Technician

P Redmile

Based on the selected report options, some fields are intentionally left blank.

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Page 2 of 2

80m Mast**82m Anemometer****DEUTSCHER KALIBRIERDIENST **

Kalibrierlaboratorium / Calibration laboratory

Akkreditiert durch die / accredited by the

Akkreditierungsstelle des Deutschen Kalibrierdienstes

Deutsche WindGuard
Wind Tunnel Services GmbH
Varel

DKD-K- 36801

Kalibrierschein
*Calibration Certificate*Kalibrierzeichen
Calibration label

10/5444
DKD-K-
36801

07/2010

Gegenstand Object	A 100 L2	Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI). Der DKD ist Unterzeichner der multi-lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Hersteller Manufacturer	Windspeed LTD Denbighshire LL18 2AB	Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
Typ Type	A 100 L2	This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).
Fabrikat/Serien-Nr. Serial number	Body: 13340 Cup: E96P	The DKD is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
Auftraggeber Customer	SgurrEnergy UK G42 8AT Glasgow	The user is obliged to have the object recalibrated at appropriate intervals.
Auftragsnummer Order No.	VT10473	
Anzahl der Seiten des Kalibrierscheines Number of pages of the certificate	3	
Datum der Kalibrierung Date of calibration	15.07.2010	

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Auszüge oder Änderungen bedürfen der Genehmigung sowohl der Akkreditierungsstelle des DKD als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift und Stempel haben keine Gültigkeit.

This calibration certificate may not be reproduced other than in full except with the permission of both the Accreditation Body of the DKD and the issuing laboratory. Calibration certificates without signature and seal are not valid.

Stempel Seal	Datum Date	Leiter des Kalibrierlaboratoriums Head of the calibration laboratory	Bearbeiter Person in charge
	15.07.2010	Dipl. Phys. D. Westermann	Dipl. Ing. (FH) Catharina Herold

Deutsche WindGuard Wind Tunnel Services GmbH
Oldenburger Str. 65
26316 Varel ; Tel. ++49 (0)4451 95150



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DKD-K-
36801
07/2010

Kalibriergegenstand <i>Object</i>	Anemometer	
Kalibrierverfahren <i>Calibration procedure</i>	IEC 61400 12 1 - Wind Turbine Power Performance Testing 12 2005 MEASNET - Cup Anemometer Calibration Procedure – 09 1997 ISO 3966 – Measurement of fluid in closed conduits - 1977	
Ort der Kalibrierung <i>Place of calibration</i>	Windtunnel of Deutsche WindGuard, Varel	
Messbedingungen <i>Test Conditions</i>		
	wind tunnel area ¹⁾	10000 cm ²
	anemometer frontal area ²⁾	200 cm ²
	diameter of mounting pipe ³⁾	27 mm
	blockage ratio ⁴⁾	0.020 [-]
	blockage correction ⁵⁾	1.000 [-]

Umgebungsbedingungen <i>Test conditions</i>	air temperature	28.0 °C	± 0.2 K
	air pressure	1011.6 hPa	± 0.3 hPa
	relative air humidity	39.9 %	± 2.0 %
Akkreditierung <i>Accreditation</i>	08 / 2009		
Anmerkungen <i>Remarks</i>	calibrated with 405 Type Single Mount		
Auswertesoftware <i>Software version</i>	5.0		

¹⁾ Querschnittsfläche der Auslassdüse des Windkanals

²⁾ Vereinfachte Querschnittsfläche (Schattenwurf) des Prüflings inkl. Montagerohr

³⁾ Durchmesser des Montagerohrs

⁴⁾ Verhältnis von 2) zu 1)

⁵⁾ Korrekturfaktor durch die Verdängerung der Strömung durch den Prüfling

Anmerkung: Aufgrund der speziellen Konstruktion der Messstrecke ist keine Korrektur nötig.

Remark: Due to the special construction of the test section no blockage correction is necessary

Dieser Kalibrierschein wurde elektronisch erzeugt
This calibration certificate has been generated electronically

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Oldenburger Str. 65
26316 Varel ; Tel. ++49 (0)4451 95150



10/5444
DKD-K-
36801
07/2010

Kalibrierergebnis:*Result:*

Test Item (1/s)	Tunnel Speed (m/s)	Uncertainty (k=2) (m/s)
78.181	4.126	0.05
118.010	6.126	0.05
154.855	8.013	0.05
192.134	9.840	0.05
230.953	11.816	0.05
269.443	13.801	0.05
308.836	15.757	0.05
287.594	14.725	0.05
250.856	12.805	0.05
210.986	10.809	0.05
172.643	8.907	0.05
134.619	6.977	0.05
98.429	5.156	0.05

Angegeben ist die erweiterte Messunsicherheit, die sich aus der Standardmessunsicherheit durch Multiplikation mit dem Erweiterungsfaktor k=2 ergibt. Sie wurde gemäß DKD-3 ermittelt. Der Wert der Messgröße liegt mit einer Wahrscheinlichkeit von 95 % im zugeordneten Wertintervall.

Der Deutsche Kalibrierdienst ist Unterzeichner der multilateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine. Die weiteren Unterzeichner innerhalb und außerhalb Europas sind den Internetseiten von EA (www.european-accreditation.org) und ILAC (www.ilac.org) zu entnehmen.

The expanded uncertainty assigned to the measurement results is obtained by multiplying the standard uncertainty by the coverage factor k = 2. It has been determined in accordance with DKD-3. The value of the measurand lies within the assigned range of values with a probability of 95%.

The DKD is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.

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26316 Varel ; Tel. ++49 (0)4451 95150



1 Detailed MEASNET¹ Calibration Results

DKD calibration no. 10/5444

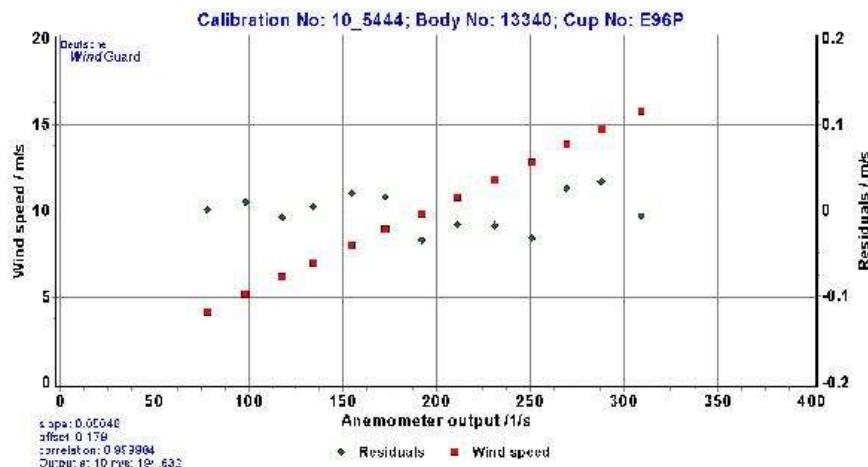
Body no. 13340
 Cup no. E96P
 Date 15.07.2010
 Air temperature 28.0 °C
 Air pressure 1011.6 hPa
 Humidity 39.9 %



Linear regression analysis

Slope 0.05046 (m/s)/(1/s) ± 0.00009 (m/s)/(1/s)
 Offset 0.179 m/s ± 0.018 m/s
 Sterr(Y) 0.023 m/s
 Correlation coefficient 0.999984

Remarks no



¹) According to MEASNET Cup Anemometer Calibration Procedure 09/1997.
 Deutsche WindGuard Wind Tunnel Services is accredited by MEASNET and by the Deutscher Kalibrierdienst – DKD (German Calibration Service). Registration: DKD – K – 36801

2 Instrumentation

Pos.	Sensor	Manufa.	Identification	Year
1	Pitot static tube	Airlow	483/8 Nr. 000142	02
2	Pitot static tube	Airlow	483/8 Nr. 000143	02
3	Pitot static tube	Airlow	483/8 Nr. 000144	02
4	Pitot static tube	Airlow	483/8 Nr. 000145	02
5	Pressure transducer	Setra	C 239 Nr. 1688081	02
6	Pressure transducer	Setra	C 239 Nr. 1688082	02
7	Pressure transducer	Setra	C 239 Nr. 1688083	02
8	Pressure transducer	Setra	C 239 Nr. 1688084	02
9	El. Barometer	Vassala	100.A Nr. X2010004	02
10	El. Thermometer	Galec	KPK 1/6-ME	02
11	El. Humidity sensor	Galec	KPK 1/6-ME	02
12	Wind tunnel control	-	-	-
13	CAN-BUS / PC	esd	-	04
14	Anemometer	-	-	-
15	Universal isolator	Knick	P2700 - 98430	05

Table 1 Description of the data acquisition system

Remark: Last Re-accreditation see page 2

3 Photo of the calibration set-up

Calibration set-up of the anemometer calibration in the wind tunnel of Deutsche WindGuard, Varel. The anemometer shown is of the same type as the calibrated one.

Remark: The proportion of the set-up are not true to scale due to imaging geometry.

4 Deviation to MEASNET procedure

The calibration procedure is in all aspects in accordance with the IEC 61400-12-1 Procedure

5 References

- [1] D. Westermann, 2009 - Verfahrensanweisung DKD-Kalibrierung von Windgeschwindigkeitssensoren
- [2] IEC 61400-12-1 12/2005 - Wind Turbine Power Performance Testing
- [3] ISO 3966 1977 - Measurement of fluid flow in closed conduits
- [4] MEASNET 09 1997 - Cup Anemometer Calibration Procedure

80m Anemometer**DEUTSCHER KALIBRIERDIENST DKD**

Kalibrierlaboratorium / Calibration laboratory
 Akkreditiert durch die / accredited by the
 Akkreditierungsstelle des Deutschen Kalibrierdienstes



Deutsche WindGuard
 Wind Tunnel Services GmbH
 Varel



DKD-K- 36801

Kalibrierschein
Calibration Certificate

Kalibrierzeichen
Calibration label

10/5445
DKD-K-36801
07/2010

Gegenstand <i>Object</i>	A 100 L2	Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI). Der DKD ist Unterzeichner der multi-lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Hersteller <i>Manufacturer</i>	Windspeed LTD Denbighshire LL18 2AB	Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
Typ <i>Type</i>	A 100 L2	<i>This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).</i>
Fabrikat/Serien-Nr. <i>Serial number</i>	Body: 13341 Cup: E97P	<i>The DKD is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.</i>
Auftraggeber <i>Customer</i>	SgurrEnergy UK G42 8AT Glasgow	<i>The user is obliged to have the object recalibrated at appropriate intervals.</i>
Auftragsnummer <i>Order No.</i>	VT10473	
Anzahl der Seiten des Kalibrierscheines <i>Number of pages of the certificate</i>	3	
Datum der Kalibrierung <i>Date of calibration</i>	15.07.2010	

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Auszüge oder Änderungen bedürfen der Genehmigung sowohl der Akkreditierungsstelle des DKD als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift und Stempel haben keine Gültigkeit.

This calibration certificate may not be reproduced other than in full except with the permission of both the Accreditation Body of the DKD and the issuing laboratory. Calibration certificates without signature and seal are not valid.

Stempel <i>Seal</i>	Datum <i>Date</i>	Leiter des Kalibrierlaboratoriums <i>Head of the calibration laboratory</i>	Bearbeiter <i>Person in charge</i>
	15.07.2010	 Dipl. Phys. D. Westermann	 Dipl. Ing. (FH) Catharina Herold

Deutsche WindGuard Wind Tunnel Services GmbH
 Oldenburger Str. 65
 26316 Varel ; Tel. ++49 (0)4451 95150



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Kalibriergegenstand <i>Object</i>	Anemometer	
Kalibrierverfahren <i>Calibration procedure</i>	IEC 61400 12 1 - Wind Turbine Power Performance Testing 12 2005 MEASNET - Cup Anemometer Calibration Procedure – 09 1997 ISO 3966 – Measurement of fluid in closed conduits - 1977	
Ort der Kalibrierung <i>Place of calibration</i>	Windtunnel of Deutsche WindGuard, Varel	
Messbedingungen <i>Test Conditions</i>		
	wind tunnel area ¹⁾	10000 cm ²
	anemometer frontal area ²⁾	200 cm ²
	diameter of mounting pipe ³⁾	27 mm
	blockage ratio ⁴⁾	0.020 [-]
	blockage correction ⁵⁾	1.000 [-]

Umgebungsbedingungen <i>Test conditions</i>	air temperature	28.1 °C	± 0.2 K
	air pressure	1011.7 hPa	± 0.3 hPa
	relative air humidity	39.8 %	± 2.0 %
Akkreditierung <i>Accreditation</i>	08 / 2009		
Anmerkungen <i>Remarks</i>	calibrated with 405 Type Single Mount		
Auswertesoftware <i>Software version</i>	5.0		

¹⁾ Querschnittsfläche der Auslassdüse des Windkanals

²⁾ Vereinfachte Querschnittsfläche (Schattenwurf) des Prüflings inkl. Montagerohr

³⁾ Durchmesser des Montagerohrs

⁴⁾ Verhältnis von 2) zu 1)

⁵⁾ Korrekturfaktor durch die Verdängerung der Strömung durch den Prüfling

Anmerkung: Aufgrund der speziellen Konstruktion der Messstrecke ist keine Korrektur nötig.

Remark: Due to the special construction of the test section no blockage correction is necessary

Dieser Kalibrierschein wurde elektronisch erzeugt
This calibration certificate has been generated electronically

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Page

10/5445
DKD-K-
36801
07/2010

Kalibrierergebnis:

Result:

Test Item (1/s)	Tunnel Speed (m/s)	Uncertainty (k=2) (m/s)
78.313	4.125	0.05
117.153	6.098	0.05
155.659	8.021	0.05
191.836	9.857	0.05
230.852	11.825	0.05
270.697	13.794	0.05
308.698	15.760	0.05
287.792	14.713	0.05
250.027	12.813	0.05
210.637	10.815	0.05
172.917	8.905	0.05
134.548	6.973	0.05
99.511	5.190	0.05

Angegeben ist die erweiterte Messunsicherheit, die sich aus der Standardmessunsicherheit durch Multiplikation mit dem Erweiterungsfaktor k=2 ergibt. Sie wurde gemäß DKD-3 ermittelt. Der Wert der Messgröße liegt mit einer Wahrscheinlichkeit von 95 % im zugeordneten Wertintervall.

Der Deutsche Kalibrierdienst ist Unterzeichner der multilateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine. Die weiteren Unterzeichner innerhalb und außerhalb Europas sind den Internetseiten von EA (www.european-accreditation.org) und ILAC (www.ilac.org) zu entnehmen.

The expanded uncertainty assigned to the measurement results is obtained by multiplying the standard uncertainty by the coverage factor k = 2. It has been determined in accordance with DKD-3. The value of the measurand lies within the assigned range of values with a probability of 95%.

The DKD is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.

Deutsche WindGuard Wind Tunnel Services GmbH
Oldenburger Str. 65
26316 Varel ; Tel. ++49 (0)4451 95150



1 Detailed MEASNET¹ Calibration Results

DKD calibration no. 10/5445

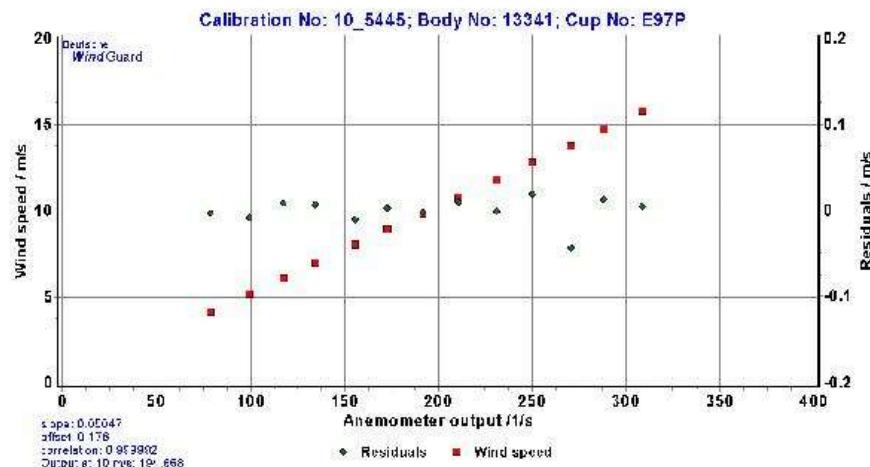
Body no. 13341
 Cup no. E97P
 Date 15.07.2010
 Air temperature 28.1 °C
 Air pressure 1011.7 hPa
 Humidity 39.8 %



Linear regression analysis

Slope 0.05047 (m/s)/(1/s) ± 0.00006 (m/s)/(1/s)
 Offset 0.176 m/s ± 0.013 m/s
 Sterr(Y) 0.016 m/s
 Correlation coefficient 0.999992

Remarks no



¹) According to MEASNET Cup Anemometer Calibration Procedure 09/1997.
 Deutsche WindGuard Wind Tunnel Services is accredited by MEASNET and by the Deutscher Kalibrierdienst – DKD (German Calibration Service). Registration: DKD – K – 36801

2 Instrumentation

Pos.	Sensor	Manufa.	Identification	Year
1	Pröt static tube	Airlow	483/8 Nr. 000142	02
2	Pröt static tube	Airlow	483/8 Nr. 000143	02
3	Pröt static tube	Airlow	483/8 Nr. 000144	02
4	Pröt static tube	Airlow	483/8 Nr. 000145	02
5	Pressure transducer	Setra	C 239 Nr. 1688081	02
6	Pressure transducer	Setra	C 239 Nr. 1688082	02
7	Pressure transducer	Setra	C 239 Nr. 1688083	02
8	Pressure transducer	Setra	C 239 Nr. 1688084	02
9	El. Barometer	Vassala	100 A Nr. X2010004	02
10	El. Thermometer	Galec	KPK 1/6-ME	02
11	El. Humidity sensor	Galec	KPK 1/6-ME	02
12	Wind tunnel control	-	-	-
13	CAN-BUS / PC	esd	-	04
14	Anemometer	-	-	-
15	Universal isolator	Knick	P2700 - 98430	05

Table 1 Description of the data acquisition system

Remark: Last Re-accreditation see page 2

3 Photo of the calibration set-up

Calibration set-up of the anemometer calibration in the wind tunnel of Deutsche WindGuard, Varel. The anemometer shown is of the same type as the calibrated one.

Remark: The proportion of the set-up are not true to scale due to imaging geometry.

4 Deviation to MEASNET procedure

The calibration procedure is in all aspects in accordance with the IEC 61400-12-1 Procedure

5 References

- [1] D. Westermann, 2009 - Verfahrensanweisung DKD-Kalibrierung von Windgeschwindigkeitssensoren
- [2] IEC 61400-12-1 12/2005 - Wind Turbine Power Performance Testing
- [3] ISO 3966 1977 - Measurement of fluid flow in closed conduits
- [4] MEASNET 09 1997 - Cup Anemometer Calibration Procedure

70m Anemometer**DEUTSCHER KALIBRIERDIENST DKD**

Kalibrierlaboratorium / Calibration laboratory

Akkreditiert durch die / accredited by the

Akkreditierungsstelle des Deutschen Kalibrierdienstes



Deutsche WindGuard
Wind Tunnel Services GmbH
Varel



DKD-K- 36801

Kalibrierschein
Calibration Certificate

Kalibrierzeichen
Calibration label

10/5447
DKD-K-36801
07/2010

Gegenstand <i>Object</i>	A 100 L2	Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI). Der DKD ist Unterzeichner der multi-lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Hersteller <i>Manufacturer</i>	Windspeed LTD Denbighshire LL18 2AB	Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
Typ <i>Type</i>	A 100 L2	<i>This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).</i>
Fabrikat/Serien-Nr. <i>Serial number</i>	Body: 13336 Cup: E92P	<i>The DKD is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.</i>
Auftraggeber <i>Customer</i>	SgurrEnergy UK G42 8AT Glasgow	<i>The user is obliged to have the object recalibrated at appropriate intervals.</i>
Auftragsnummer <i>Order No.</i>	VT10473	
Anzahl der Seiten des Kalibrierscheines <i>Number of pages of the certificate</i>	3	
Datum der Kalibrierung <i>Date of calibration</i>	15.07.2010	

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Auszüge oder Änderungen bedürfen der Genehmigung sowohl der Akkreditierungsstelle des DKD als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift und Stempel haben keine Gültigkeit.

This calibration certificate may not be reproduced other than in full except with the permission of both the Accreditation Body of the DKD and the issuing laboratory. Calibration certificates without signature and seal are not valid.

Stempel <i>Seal</i>	Datum <i>Date</i>	Leiter des Kalibrierlaboratoriums <i>Head of the calibration laboratory</i>	Bearbeiter <i>Person in charge</i>
	15.07.2010	 Dipl. Phys. D. Westermann	 Dipl. Ing. (FH) Catharina Herold

Deutsche WindGuard Wind Tunnel Services GmbH
Oldenburger Str. 65
26316 Varel ; Tel. ++49 (0)4451 95150



10/5447
DKD-K-
36801
07/2010

Kalibriergegenstand <i>Object</i>	Anemometer	
Kalibrierverfahren <i>Calibration procedure</i>	IEC 61400 12 1 - Wind Turbine Power Performance Testing 12 2005 MEASNET - Cup Anemometer Calibration Procedure – 09 1997 ISO 3966 – Measurement of fluid in closed conduits - 1977	
Ort der Kalibrierung <i>Place of calibration</i>	Windtunnel of Deutsche WindGuard, Varel	
Messbedingungen <i>Test Conditions</i>		
	wind tunnel area ¹⁾	10000 cm ²
	anemometer frontal area ²⁾	200 cm ²
	diameter of mounting pipe ³⁾	27 mm
	blockage ratio ⁴⁾	0.020 [-]
	blockage correction ⁵⁾	1.000 [-]

Umgebungsbedingungen <i>Test conditions</i>	air temperature	28.2 °C	± 0.2 K
	air pressure	1012.0 hPa	± 0.3 hPa
	relative air humidity	39.8 %	± 2.0 %
Akkreditierung <i>Accreditation</i>	08 / 2009		
Anmerkungen <i>Remarks</i>	calibrated with 405 Type Single Mount		
Auswertesoftware <i>Software version</i>	5.0		

- ¹⁾ Querschnittsfläche der Auslassdüse des Windkanals
²⁾ Vereinfachte Querschnittsfläche (Schattenwurf) des Prüflings inkl. Montagerohr
³⁾ Durchmesser des Montagerohrs
⁴⁾ Verhältnis von 2) zu 1)
⁵⁾ Korrekturfaktor durch die Verdängung der Strömung durch den Prüfling
 Anmerkung: Aufgrund der speziellen Konstruktion der Messstrecke ist keine Korrektur nötig.
 Remark: Due to the special construction of the test section no blockage correction is necessary

Dieser Kalibrierschein wurde elektronisch erzeugt
This calibration certificate has been generated electronically

Kalibrierergebnis:*Result:*

Test Item (1/s)	Tunnel Speed (m/s)	Uncertainty (k=2) (m/s)
79.148	4.126	0.05
118.173	6.122	0.05
155.917	8.002	0.05
192.506	9.854	0.05
232.178	11.825	0.05
270.393	13.800	0.05
309.667	15.758	0.05
288.990	14.716	0.05
250.924	12.814	0.05
211.471	10.820	0.05
172.946	8.906	0.05
135.275	6.967	0.05
99.179	5.179	0.05

Angegeben ist die erweiterte Messunsicherheit, die sich aus der Standardmessunsicherheit durch Multiplikation mit dem Erweiterungsfaktor k=2 ergibt. Sie wurde gemäß DKD-3 ermittelt. Der Wert der Messgröße liegt mit einer Wahrscheinlichkeit von 95 % im zugeordneten Wertintervall.

Der Deutsche Kalibrierdienst ist Unterzeichner der multilateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine. Die weiteren Unterzeichner innerhalb und außerhalb Europas sind den Internetseiten von EA (www.european-accreditation.org) und ILAC (www.ilac.org) zu entnehmen.

The expanded uncertainty assigned to the measurement results is obtained by multiplying the standard uncertainty by the coverage factor k = 2. It has been determined in accordance with DKD-3. The value of the measurand lies within the assigned range of values with a probability of 95%.

The DKD is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.

1 Detailed MEASNET¹ Calibration Results

DKD calibration no. 10/5447

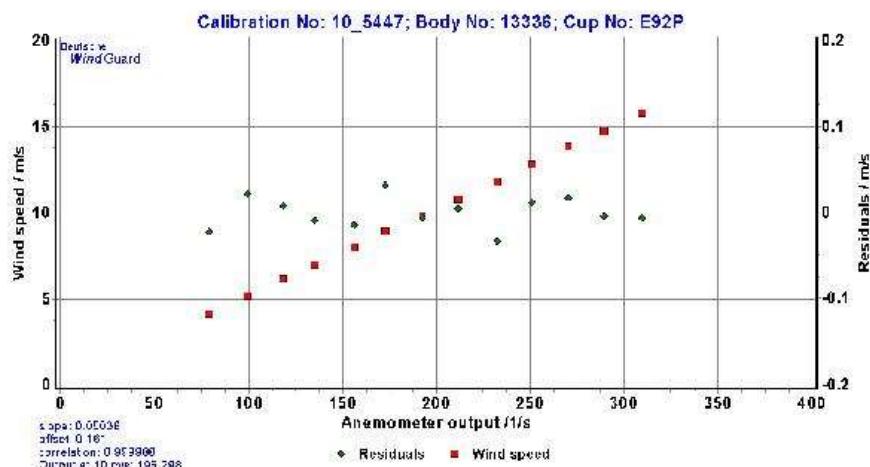
Body no. 13336
 Cup no. E92P
 Date 15.07.2010
 Air temperature 28.2 °C
 Air pressure 1012.0 hPa
 Humidity 39.8 %



Linear regression analysis

Slope 0.05038 (m/s)/(1/s) ± 0.00007 (m/s)/(1/s)
 Offset 0.161 m/s ± 0.015 m/s
 Sterr(Y) 0.020 m/s
 Correlation coefficient 0.999988

Remarks no



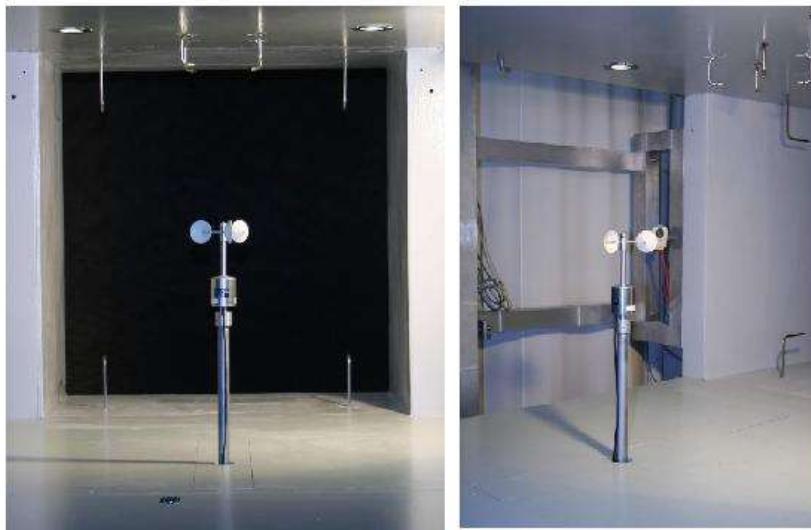
¹) According to MEASNET Cup Anemometer Calibration Procedure 09/1997.
 Deutsche WindGuard Wind Tunnel Services is accredited by MEASNET and by the Deutscher Kalibrierdienst – DKD (German Calibration Service). Registration: DKD – K – 36801

2 Instrumentation

Pos.	Sensor	Manufa.	Identification	Year
1	Pitot static tube	Airlow	483/8 Nr. 000142	02
2	Pitot static tube	Airlow	483/8 Nr. 000143	02
3	Pitot static tube	Airlow	483/8 Nr. 000144	02
4	Pitot static tube	Airlow	483/8 Nr. 000145	02
5	Pressure transducer	Setra	C 239 Nr. 1688081	02
6	Pressure transducer	Setra	C 239 Nr. 1688082	02
7	Pressure transducer	Setra	C 239 Nr. 1688083	02
8	Pressure transducer	Setra	C 239 Nr. 1688084	02
9	El. Barometer	Vassala	100 A Nr. X2010004	02
10	El. Thermometer	Galec	KPK 1/6-ME	02
11	El. Humidity sensor	Galec	KPK 1/6-ME	02
12	Wind tunnel control	-	-	-
13	CAN-BUS / PC	esd	-	04
14	Anemometer	-	-	-
15	Universal isolator	Knick	P2700 - 98430	05

Table 1 Description of the data acquisition system

Remark: Last Re-accreditation see page 2

3 Photo of the calibration set-up

Calibration set-up of the anemometer calibration in the wind tunnel of Deutsche WindGuard, Varel. The anemometer shown is of the same type as the calibrated one.

Remark: The proportion of the set-up are not true to scale due to imaging geometry.

4 Deviation to MEASNET procedure

The calibration procedure is in all aspects in accordance with the IEC 61400-12-1 Procedure

5 References

- [1] D. Westermann, 2009 - Verfahrensanweisung DKD-Kalibrierung von Windgeschwindigkeitssensoren
- [2] IEC 61400-12-1 12/2005 - Wind Turbine Power Performance Testing
- [3] ISO 3966 1977 - Measurement of fluid flow in closed conduits
- [4] MEASNET 09 1997 - Cup Anemometer Calibration Procedure

70m Anemometer**DEUTSCHER KALIBRIERDIENST DKD**

Kalibrierlaboratorium / Calibration laboratory

Akkreditiert durch die / accredited by the

Akkreditierungsstelle des Deutschen Kalibrierdienstes



Deutsche WindGuard
Wind Tunnel Services GmbH
Varel



DKD-K- 36801

Kalibrierschein
Calibration Certificate

Kalibrierzeichen
Calibration label

10/5449
DKD-K-36801
07/2010

Gegenstand <i>Object</i>	A 100 L2	Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI). Der DKD ist Unterzeichner der multi-lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Hersteller <i>Manufacturer</i>	Windspeed LTD Denbighshire LL18 2AB	Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
Typ <i>Type</i>	A 100 L2	<i>This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).</i>
Fabrikat/Serien-Nr. <i>Serial number</i>	Body: 13334 Cup: E90P	<i>The DKD is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.</i>
Auftraggeber <i>Customer</i>	SgurrEnergy UK G42 8AT Glasgow	<i>The user is obliged to have the object recalibrated at appropriate intervals.</i>
Auftragsnummer <i>Order No.</i>	VT10473	
Anzahl der Seiten des Kalibrierscheines <i>Number of pages of the certificate</i>	3	
Datum der Kalibrierung <i>Date of calibration</i>	15.07.2010	

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Auszüge oder Änderungen bedürfen der Genehmigung sowohl der Akkreditierungsstelle des DKD als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift und Stempel haben keine Gültigkeit.

This calibration certificate may not be reproduced other than in full except with the permission of both the Accreditation Body of the DKD and the issuing laboratory. Calibration certificates without signature and seal are not valid.

Stempel Seal	Datum Date	Leiter des Kalibrierlaboratoriums Head of the calibration laboratory	Bearbeiter Person in charge
	15.07.2010	Dipl. Phys. D. Westermann 	Dipl. Ing. (FH) Catharina Herold

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Kalibriergegenstand <i>Object</i>	Anemometer	
Kalibrierverfahren <i>Calibration procedure</i>	IEC 61400 12 1 - Wind Turbine Power Performance Testing 12 2005 MEASNET - Cup Anemometer Calibration Procedure – 09 1997 ISO 3966 – Measurement of fluid in closed conduits - 1977	
Ort der Kalibrierung <i>Place of calibration</i>	Windtunnel of Deutsche WindGuard, Varel	
Messbedingungen <i>Test Conditions</i>		
	wind tunnel area ¹⁾	10000 cm ²
	anemometer frontal area ²⁾	200 cm ²
	diameter of mounting pipe ³⁾	27 mm
	blockage ratio ⁴⁾	0.020 [-]
	blockage correction ⁵⁾	1.000 [-]

Umgebungsbedingungen <i>Test conditions</i>	air temperature	28.4 °C	± 0.2 K
	air pressure	1012.1 hPa	± 0.3 hPa
	relative air humidity	40.0 %	± 2.0 %
Akkreditierung <i>Accreditation</i>	08 / 2009		
Anmerkungen <i>Remarks</i>	calibrated with 405 Type Single Mount		
Auswertesoftware <i>Software version</i>	5.0		

¹⁾ Querschnittsfläche der Auslassdüse des Windkanals

²⁾ Vereinfachte Querschnittsfläche (Schattenwurf) des Prüflings inkl. Montagerohr

³⁾ Durchmesser des Montagerohrs

⁴⁾ Verhältnis von 2) zu 1)

⁵⁾ Korrekturfaktor durch die Verdängung der Strömung durch den Prüfling

Anmerkung: Aufgrund der speziellen Konstruktion der Messstrecke ist keine Korrektur nötig.

Remark: Due to the special construction of the test section no blockage correction is necessary

Dieser Kalibrierschein wurde elektronisch erzeugt
This calibration certificate has been generated electronically

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26316 Varel ; Tel. ++49 (0)4451 95150



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Kalibrierergebnis:

Result:

Test Item (1/s)	Tunnel Speed (m/s)	Uncertainty (k=2) (m/s)
78.510	4.123	0.05
117.865	6.121	0.05
155.381	8.004	0.05
191.549	9.848	0.05
230.107	11.824	0.05
269.667	13.787	0.05
307.263	15.757	0.05
287.392	14.703	0.05
249.816	12.799	0.05
210.618	10.815	0.05
172.182	8.904	0.05
134.578	6.969	0.05
98.862	5.169	0.05

Angegeben ist die erweiterte Messunsicherheit, die sich aus der Standardmessunsicherheit durch Multiplikation mit dem Erweiterungsfaktor k=2 ergibt. Sie wurde gemäß DKD-3 ermittelt. Der Wert der Messgröße liegt mit einer Wahrscheinlichkeit von 95 % im zugeordneten Wertintervall.

Der Deutsche Kalibrierdienst ist Unterzeichner der multilateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine. Die weiteren Unterzeichner innerhalb und außerhalb Europas sind den Internetseiten von EA (www.european-accreditation.org) und ILAC (www.ilac.org) zu entnehmen.

The expanded uncertainty assigned to the measurement results is obtained by multiplying the standard uncertainty by the coverage factor k = 2. It has been determined in accordance with DKD-3. The value of the measurand lies within the assigned range of values with a probability of 95%.

The DKD is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.

Deutsche WindGuard Wind Tunnel Services GmbH
Oldenburger Str. 65
26316 Varel ; Tel. ++49 (0)4451 95150



1 Detailed MEASNET¹ Calibration Results

DKD calibration no. 10/5449

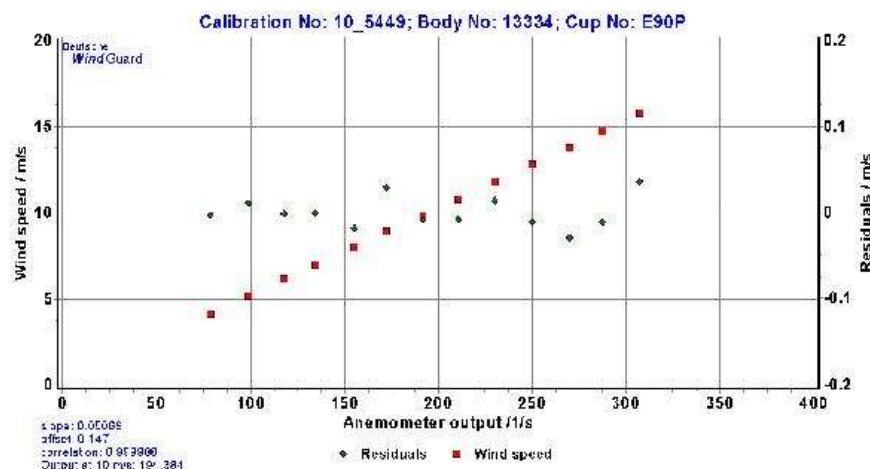
Body no. 13334
 Cup no. E90P
 Date 15.07.2010
 Air temperature 28.4 °C
 Air pressure 1012.1 hPa
 Humidity 40.0 %



Linear regression analysis

Slope 0.05069 (m/s)/(1/s) ± 0.00007 (m/s)/(1/s)
 Offset 0.147 m/s ± 0.015 m/s
 Sterr(Y) 0.020 m/s
 Correlation coefficient 0.999988

Remarks no



¹) According to MEASNET Cup Anemometer Calibration Procedure 09/1997.
 Deutsche WindGuard Wind Tunnel Services is accredited by MEASNET and by the Deutscher Kalibrierdienst – DKD (German Calibration Service). Registration: DKD – K – 36801

2 Instrumentation

Pos.	Sensor	Manufa.	Identification	Year
1	Pitot static tube	Airlow	483/8 Nr. 000142	02
2	Pitot static tube	Airlow	483/8 Nr. 000143	02
3	Pitot static tube	Airlow	483/8 Nr. 000144	02
4	Pitot static tube	Airlow	483/8 Nr. 000145	02
5	Pressure transducer	Setra	C 239 Nr. 1688081	02
6	Pressure transducer	Setra	C 239 Nr. 1688082	02
7	Pressure transducer	Setra	C 239 Nr. 1688083	02
8	Pressure transducer	Setra	C 239 Nr. 1688084	02
9	El. Barometer	Vassala	100.A Nr. X2010004	02
10	El. Thermometer	Galec	KPK 1/6-ME	02
11	El. Humidity sensor	Galec	KPK 1/6-ME	02
12	Wind tunnel control	-	-	-
13	CAN-BUS / PC	esd	-	04
14	Anemometer	-	-	-
15	Universal isolator	Knick	P2700 - 98430	05

Table 1 Description of the data acquisition system

Remark: Last Re-accreditation see page 2

3 Photo of the calibration set-up

Calibration set-up of the anemometer calibration in the wind tunnel of Deutsche WindGuard, Varel. The anemometer shown is of the same type as the calibrated one.

Remark: The proportion of the set-up are not true to scale due to imaging geometry.

4 Deviation to MEASNET procedure

The calibration procedure is in all aspects in accordance with the IEC 61400-12-1 Procedure

5 References

- [1] D. Westermann, 2009 - Verfahrensanweisung DKD-Kalibrierung von Windgeschwindigkeitssensoren
- [2] IEC 61400-12-1 12/2005 - Wind Turbine Power Performance Testing
- [3] ISO 3966 1977 - Measurement of fluid flow in closed conduits
- [4] MEASNET 09 1997 - Cup Anemometer Calibration Procedure

50m Anemometer**DEUTSCHER KALIBRIERDIENST **

Kalibrierlaboratorium / Calibration laboratory

Akkreditiert durch die / accredited by the

Akkreditierungsstelle des Deutschen Kalibrierdienstes

Deutsche WindGuard
Wind Tunnel Services GmbH
Varel

DKD-K- 36801

Kalibrierschein
*Calibration Certificate*Kalibrierzeichen
Calibration label

10/5443
DKD-K-36801
07/2010

Gegenstand Object	A 100 L2	Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI). Der DKD ist Unterzeichner der multi-lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Hersteller Manufacturer	Windspeed LTD Denbighshire LL18 2AB	Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
Typ Type	A 100 L2	This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).
Fabrikat/Serien-Nr. Serial number	Body: 13339 Cup: E95P	The DKD is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
Auftraggeber Customer	SgurrEnergy UK G42 8AT Glasgow	The user is obliged to have the object recalibrated at appropriate intervals.
Auftragsnummer Order No.	VT10473	
Anzahl der Seiten des Kalibrierscheines Number of pages of the certificate	3	
Datum der Kalibrierung Date of calibration	15.07.2010	

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Auszüge oder Änderungen bedürfen der Genehmigung sowohl der Akkreditierungsstelle des DKD als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift und Stempel haben keine Gültigkeit.

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Stempel Seal	Datum Date	Leiter des Kalibrierlaboratoriums Head of the calibration laboratory	Bearbeiter Person in charge
	15.07.2010	Dipl. Phys. D. Westermann	Dipl. Ing. (FH) Catharina Herold

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Kalibriergegenstand <i>Object</i>	Anemometer	
Kalibrierverfahren <i>Calibration procedure</i>	IEC 61400 12 1 - Wind Turbine Power Performance Testing 12 2005 MEASNET - Cup Anemometer Calibration Procedure – 09 1997 ISO 3966 – Measurement of fluid in closed conduits - 1977	
Ort der Kalibrierung <i>Place of calibration</i>	Windtunnel of Deutsche WindGuard, Varel	
Messbedingungen <i>Test Conditions</i>		
	wind tunnel area ¹⁾	10000 cm ²
	anemometer frontal area ²⁾	200 cm ²
	diameter of mounting pipe ³⁾	27 mm
	blockage ratio ⁴⁾	0.020 [-]
	blockage correction ⁵⁾	1.000 [-]

Umgebungsbedingungen <i>Test conditions</i>	air temperature	28.0 °C	± 0.2 K
	air pressure	1011.4 hPa	± 0.3 hPa
	relative air humidity	41.1 %	± 2.0 %
Akkreditierung <i>Accreditation</i>	08 / 2009		
Anmerkungen <i>Remarks</i>	calibrated with 405 Type Single Mount		
Auswertesoftware <i>Software version</i>	5.0		

¹⁾ Querschnittsfläche der Auslassdüse des Windkanals

²⁾ Vereinfachte Querschnittsfläche (Schattenwurf) des Prüflings inkl. Montagerohr

³⁾ Durchmesser des Montagerohrs

⁴⁾ Verhältnis von 2) zu 1)

⁵⁾ Korrekturfaktor durch die Verdängerung der Strömung durch den Prüfling

Anmerkung: Aufgrund der speziellen Konstruktion der Messstrecke ist keine Korrektur nötig.

Remark: Due to the special construction of the test section no blockage correction is necessary

Dieser Kalibrierschein wurde elektronisch erzeugt
This calibration certificate has been generated electronically

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Kalibrierergebnis:

Result:

Test Item (1/s)	Tunnel Speed (m/s)	Uncertainty (k=2) (m/s)
78.417	4.130	0.05
117.604	6.130	0.05
155.023	8.006	0.05
191.895	9.857	0.05
230.701	11.829	0.05
270.093	13.803	0.05
308.903	15.757	0.05
287.918	14.722	0.05
250.529	12.812	0.05
211.169	10.812	0.05
172.365	8.909	0.05
134.182	6.974	0.05
98.851	5.167	0.05

Angegeben ist die erweiterte Messunsicherheit, die sich aus der Standardmessunsicherheit durch Multiplikation mit dem Erweiterungsfaktor k=2 ergibt. Sie wurde gemäß DKD-3 ermittelt. Der Wert der Messgröße liegt mit einer Wahrscheinlichkeit von 95 % im zugeordneten Wertintervall.

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The expanded uncertainty assigned to the measurement results is obtained by multiplying the standard uncertainty by the coverage factor k = 2. It has been determined in accordance with DKD-3. The value of the measurand lies within the assigned range of values with a probability of 95%.

The DKD is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.

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26316 Varel ; Tel. ++49 (0)4451 95150



1 Detailed MEASNET¹ Calibration Results

DKD calibration no. 10/5443

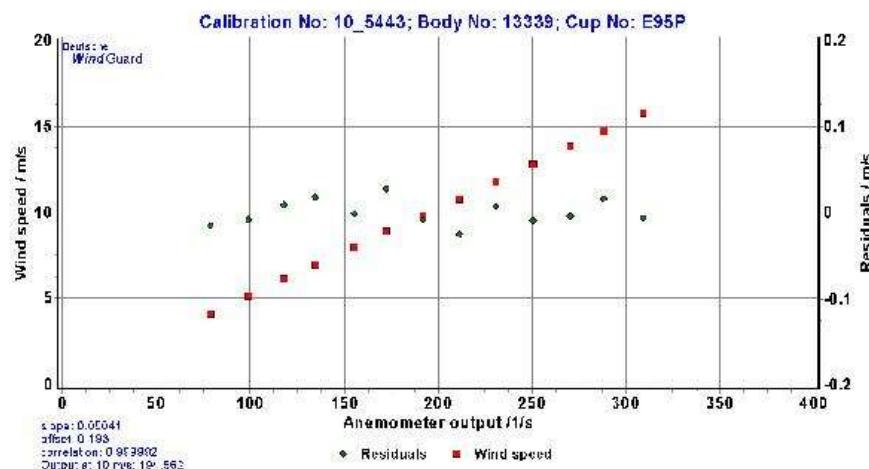
Body no. 13339
 Cup no. E95P
 Date 15.07.2010
 Air temperature 28.0 °C
 Air pressure 1011.4 hPa
 Humidity 41.1 %



Linear regression analysis

Slope 0.05041 (m/s)/(1/s) ± 0.00006 (m/s)/(1/s)
 Offset 0.193 m/s ± 0.012 m/s
 Sterr(Y) 0.015 m/s
 Correlation coefficient 0.999992

Remarks no



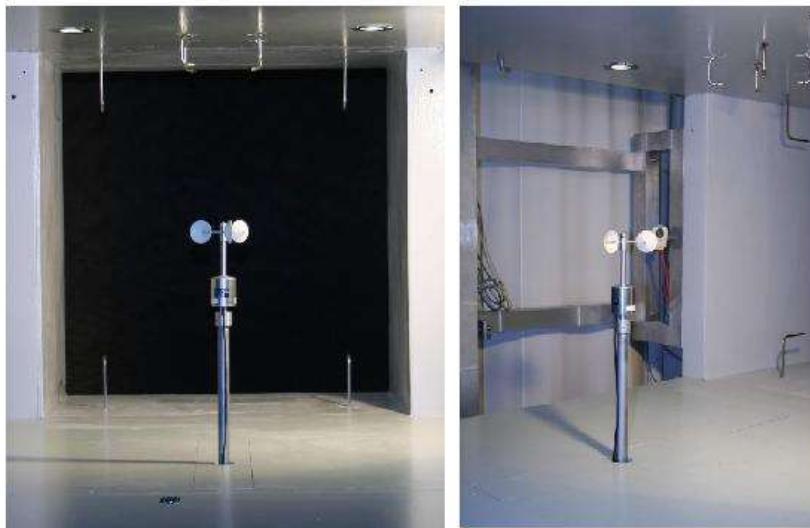
¹) According to MEASNET Cup Anemometer Calibration Procedure 09/1997.
 Deutsche WindGuard Wind Tunnel Services is accredited by MEASNET and by the Deutscher Kalibrierdienst – DKD (German Calibration Service). Registration: DKD – K – 36801

2 Instrumentation

Pos.	Sensor	Manufa.	Identification	Year
1	Pitot static tube	Airlow	483/8 Nr. 000142	02
2	Pitot static tube	Airlow	483/8 Nr. 000143	02
3	Pitot static tube	Airlow	483/8 Nr. 000144	02
4	Pitot static tube	Airlow	483/8 Nr. 000145	02
5	Pressure transducer	Setra	C 239 Nr. 1688081	02
6	Pressure transducer	Setra	C 239 Nr. 1688082	02
7	Pressure transducer	Setra	C 239 Nr. 1688083	02
8	Pressure transducer	Setra	C 239 Nr. 1688084	02
9	El. Barometer	Vassala	100 A Nr. X2010004	02
10	El. Thermometer	Galec	KPK 1/6-ME	02
11	El. Humidity sensor	Galec	KPK 1/6-ME	02
12	Wind tunnel control	-	-	-
13	CAN-BUS / PC	esd	-	04
14	Anemometer	-	-	-
15	Universal isolator	Knick	P2700 - 98430	05

Table 1 Description of the data acquisition system

Remark: Last Re-accreditation see page 2

3 Photo of the calibration set-up

Calibration set-up of the anemometer calibration in the wind tunnel of Deutsche WindGuard, Varel. The anemometer shown is of the same type as the calibrated one.

Remark: The proportion of the set-up are not true to scale due to imaging geometry.

4 Deviation to MEASNET procedure

The calibration procedure is in all aspects in accordance with the IEC 61400-12-1 Procedure

5 References

- [1] D. Westermann, 2009 - Verfahrensanweisung DKD-Kalibrierung von Windgeschwindigkeitssensoren
- [2] IEC 61400-12-1 12/2005 - Wind Turbine Power Performance Testing
- [3] ISO 3966 1977 - Measurement of fluid flow in closed conduits
- [4] MEASNET 09 1997 - Cup Anemometer Calibration Procedure

50m Anemometer**DEUTSCHER KALIBRIERDIENST **

Kalibrierlaboratorium / Calibration laboratory

Akkreditiert durch die / accredited by the

Akkreditierungsstelle des Deutschen Kalibrierdienstes

Deutsche WindGuard
Wind Tunnel Services GmbH
Varel

DKD-K- 36801

Kalibrierschein
*Calibration Certificate*Kalibrierzeichen
Calibration label

10/5457
DKD-K-
36801

07/2010

Gegenstand Object	A 100 L2	Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI). Der DKD ist Unterzeichner der multi-lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Hersteller Manufacturer	Windspeed LTD Denbighshire LL18 2AB	Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
Typ Type	A 100 L2	This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).
Fabrikat/Serien-Nr. Serial number	Body: 13327 Cup: E83P	The DKD is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
Auftraggeber Customer	SgurrEnergy UK G42 8AT Glasgow	The user is obliged to have the object recalibrated at appropriate intervals.
Auftragsnummer Order No.	VT10473	
Anzahl der Seiten des Kalibrierscheines Number of pages of the certificate	3	
Datum der Kalibrierung Date of calibration	16.07.2010	

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Auszüge oder Änderungen bedürfen der Genehmigung sowohl der Akkreditierungsstelle des DKD als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift und Stempel haben keine Gültigkeit.

This calibration certificate may not be reproduced other than in full except with the permission of both the Accreditation Body of the DKD and the issuing laboratory. Calibration certificates without signature and seal are not valid.

Stempel Seal	Datum Date	Leiter des Kalibrierlaboratoriums Head of the calibration laboratory	Bearbeiter Person in charge
	16.07.2010	Dipl. Phys. D. Westermann	Techniker Dirk Henniges

Deutsche WindGuard Wind Tunnel Services GmbH
Oldenburger Str. 65
26316 Varel ; Tel. ++49 (0)4451 95150



10/5457
DKD-K-
36801
07/2010

Kalibriergegenstand <i>Object</i>	Anemometer	
Kalibrierverfahren <i>Calibration procedure</i>	IEC 61400 12 1 - Wind Turbine Power Performance Testing 12 2005 MEASNET - Cup Anemometer Calibration Procedure – 09 1997 ISO 3966 – Measurement of fluid in closed conduits - 1977	
Ort der Kalibrierung <i>Place of calibration</i>	Windtunnel of Deutsche WindGuard, Varel	
Messbedingungen <i>Test Conditions</i>		
	wind tunnel area ¹⁾	10000 cm ²
	anemometer frontal area ²⁾	200 cm ²
	diameter of mounting pipe ³⁾	27 mm
	blockage ratio ⁴⁾	0.020 [-]
	blockage correction ⁵⁾	1.000 [-]

Umgebungsbedingungen <i>Test conditions</i>	air temperature	25.1 °C	± 0.2 K
	air pressure	1013.6 hPa	± 0.3 hPa
	relative air humidity	42.5 %	± 2.0 %
Akkreditierung <i>Accreditation</i>	08 / 2009		
Anmerkungen <i>Remarks</i>	calibrated with 405 Type Single Mount		
Auswertesoftware <i>Software version</i>	5.0		

- ¹⁾ Querschnittsfläche der Auslassdüse des Windkanals
²⁾ Vereinfachte Querschnittsfläche (Schattenwurf) des Prüflings inkl. Montagerohr
³⁾ Durchmesser des Montagerohrs
⁴⁾ Verhältnis von 2) zu 1)
⁵⁾ Korrekturfaktor durch die Verdängung der Strömung durch den Prüfling
 Anmerkung: Aufgrund der speziellen Konstruktion der Messstrecke ist keine Korrektur nötig.
 Remark: Due to the special construction of the test section no blockage correction is necessary

Dieser Kalibrierschein wurde elektronisch erzeugt
This calibration certificate has been generated electronically

Kalibrierergebnis:*Result:*

Test Item (1/s)	Tunnel Speed (m/s)	Uncertainty (k=2) (m/s)
78.730	4.144	0.05
118.308	6.132	0.05
155.146	8.007	0.05
192.434	9.858	0.05
231.138	11.822	0.05
270.522	13.792	0.05
309.067	15.759	0.05
288.361	14.709	0.05
251.012	12.804	0.05
211.102	10.825	0.05
173.072	8.902	0.05
134.524	6.966	0.05
99.297	5.202	0.05

Angegeben ist die erweiterte Messunsicherheit, die sich aus der Standardmessunsicherheit durch Multiplikation mit dem Erweiterungsfaktor k=2 ergibt. Sie wurde gemäß DKD-3 ermittelt. Der Wert der Messgröße liegt mit einer Wahrscheinlichkeit von 95 % im zugeordneten Wertintervall.

Der Deutsche Kalibrierdienst ist Unterzeichner der multilateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine. Die weiteren Unterzeichner innerhalb und außerhalb Europas sind den Internetseiten von EA (www.european-accreditation.org) und ILAC (www.ilac.org) zu entnehmen.

The expanded uncertainty assigned to the measurement results is obtained by multiplying the standard uncertainty by the coverage factor k = 2. It has been determined in accordance with DKD-3. The value of the measurand lies within the assigned range of values with a probability of 95%.

The DKD is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.

1 Detailed MEASNET¹ Calibration Results

DKD calibration no. 10/5457

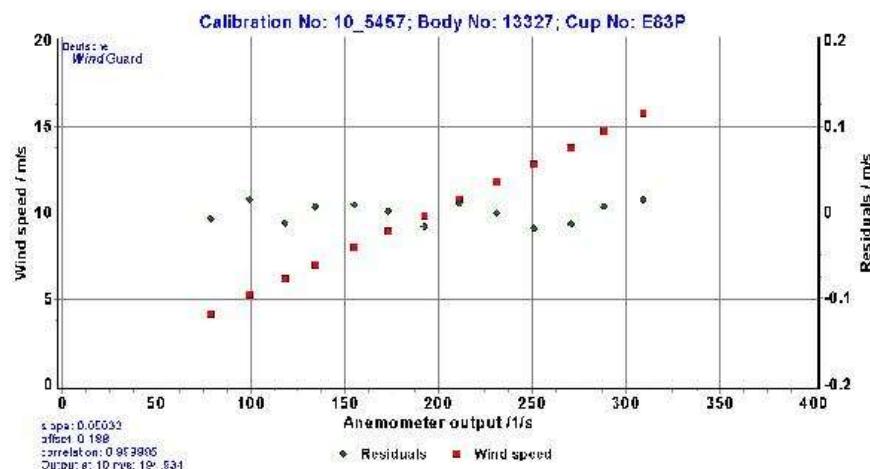
Body no. 13327
 Cup no. E83P
 Date 16.07.2010
 Air temperature 25.1 °C
 Air pressure 1013.6 hPa
 Humidity 42.5 %



Linear regression analysis

Slope 0.05033 (m/s)/(1/s) ± 0.00005 (m/s)/(1/s)
 Offset 0.188 m/s ± 0.010 m/s
 Sterr(Y) 0.012 m/s
 Correlation coefficient 0.999995

Remarks no



¹) According to MEASNET Cup Anemometer Calibration Procedure 09/1997.

Deutsche WindGuard Wind Tunnel Services is accredited by MEASNET and by the Deutscher Kalibrierdienst – DKD (German Calibration Service). Registration: DKD – K – 36801

2 Instrumentation

Pos.	Sensor	Manufa.	Identification	Year
1	Pitot static tube	Airlow	483/8 Nr. 000142	02
2	Pitot static tube	Airlow	483/8 Nr. 000143	02
3	Pitot static tube	Airlow	483/8 Nr. 000144	02
4	Pitot static tube	Airlow	483/8 Nr. 000145	02
5	Pressure transducer	Setra	C 239 Nr. 1688081	02
6	Pressure transducer	Setra	C 239 Nr. 1688082	02
7	Pressure transducer	Setra	C 239 Nr. 1688083	02
8	Pressure transducer	Setra	C 239 Nr. 1688084	02
9	El. Barometer	Vassala	100.A Nr. X2010004	02
10	El. Thermometer	Galec	KPK 1/6-ME	02
11	El. Humidity sensor	Galec	KPK 1/6-ME	02
12	Wind tunnel control	-	-	-
13	CAN-BUS / PC	esd	-	04
14	Anemometer	-	-	-
15	Universal isolator	Knick	P2700 - 98430	05

Table 1 Description of the data acquisition system

Remark: Last Re-accreditation see page 2

3 Photo of the calibration set-up

Calibration set-up of the anemometer calibration in the wind tunnel of Deutsche WindGuard, Varel. The anemometer shown is of the same type as the calibrated one.

Remark: The proportion of the set-up are not true to scale due to imaging geometry.

4 Deviation to MEASNET procedure

The calibration procedure is in all aspects in accordance with the IEC 61400-12-1 Procedure

5 References

- [1] D. Westermann, 2009 - Verfahrensanweisung DKD-Kalibrierung von Windgeschwindigkeitssensoren
- [2] IEC 61400-12-1 12/2005 - Wind Turbine Power Performance Testing
- [3] ISO 3966 1977 - Measurement of fluid flow in closed conduits
- [4] MEASNET 09 1997 - Cup Anemometer Calibration Procedure

80m Ultrasonic**VAISALA**

Test report nr. H29-10340025

TEST REPORT

Instrument WS425 A1E2A
Serial number F3460003
Manufacturer Vaisala Oyj, Finland
Calibration Date 2010-08-28
Test procedure PI210254-A

This instrument has been carefully inspected and subjected to rigid tests. This test report certifies that the instrument was thoroughly tested and inspected, and found to meet its published specifications when it was shipped from the factory.

Vaisala is ISO 9001 Certified

Test results

Test Name	Result	Limits
Current	16.2 mA	(10 ... 35) mA
V out Direction 359 Degrees	1.99 V	(1.988 ... 2.01) V
V out Speed 125 mph	0.997 V	(0.995 ... 1.005) V
V out Direction 100 Degrees	0.55 V	(0.55 ... 0.56) V
V out Speed 50 mph	0.398 V	(0.397 ... 0.403) V
Zero Wind Speed	0.00 mph	(0 ... 0.5) mph
Wind Tunnel Speed	15.38 mph	(13.2 ... 17.7) mph
Wind tunnel Direction	150.00 Degrees	(148 ... 152) Degrees
SDI-12	PASS	(PASS ... FAIL)

This instrument has successfully passed the test.

Signature



Technician

Vaisala Oyj | PO Box 26, FI-00421 Helsinki, Finland
Phone +358 9 894 91 | Fax +358 9 894 9 2227
Email firstname.lastname@vaisala.com | www.vaisala.com
Domicile Vantaa, Finland | VAT FI0124162 | Business ID 0124416-2

80m Temperature / Relative Humidity Sensor

VAISALA

1 (1)

Certificate report no. H09-10290007

CALIBRATION CERTIFICATE 

Instrument HMP45AC Humidity and temperature probe
Serial number F2650007
Manufacturer Vaisala Oyj, Finland
Calibration date 20th July 2010

The above instrument was calibrated by comparing the relative humidity and temperature readings to two HMP233 factory working standards. At the time of shipment, the instrument described above met its operating specifications.

The relative humidity readings of the two HMP233 factory working standards have been calibrated at the Vaisala factory by using Hygro M-3 dewpoint meter. Hygro M-3 dewpoint meter has been calibrated at Centre for metrology and accreditation (MIKES) by using a MIKES working standard traceable to National Institute of Standards and Technology (NIST). The temperature readings of the two HMP233 factory working standards have been calibrated at Vaisala Measurement Standards Laboratory (MSL) by using the MSL working standard traceable to the NIST. The temperature calibration at MSL has been accredited by the FINAS according to the ISO/IEC 17025.

Calibration results

Reference humidity* % RH	Observed humidity % RH	Difference %RH	Permissible difference %RH
0.5	1.4	+0.9	±2.0
44.6	44.5	-0.1	±2.0
73.8	74.6	+0.8	±2.0
Reference temperature* °C	Observed temperature °C	Difference °C	Permissible difference °C
+23.00	+22.93	-0.07	±0.2

*Average of two references.

Equipment used in calibration

Type	Serial number	Calibration date	Certificate number
HMP233 / RH	B2050019	2010-05-05	H09-10180001
HMP233 / RH	B2050018	2010-05-05	H09-10180002
Vaisala HMT337	B2050019	2009-09-10	K008-S02287
Vaisala HMT337	B2050018	2009-09-10	K008-S02288
HYGRO M-3	361095	2009-06-22	M-09H036
HP 34401A	3146A30507	2009-12-30	K004-09S885

Uncertainties (95 % confidence level, k=2)

Humidity ±1.0%RH @ 0..15%RH, ±1.5%RH @ 15..78%RH

Temperature ± 0.13 °C

Ambient conditions / Humidity 45 ± 5%RH, Temperature 23 ± 1 °C, Pressure 1014 ± 1 hPa.


 Technician

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Doc21425-B

Vaisala Oyj | P.O. Box 26, FI-00421 Helsinki, Finland
 Phone +358 9 894 91 | Fax +358 9 8949 2227
 Email firstname.lastname@vaisala.com | www.vaisala.com
 Domicile Vantaa, Finland | VAT FI01244163 | Business ID 0124416-2

Platform Level Temperature / Relative Humidity Sensor



1(1)

Certificate report nr. H06-10200091

CALIBRATION CERTIFICATE

Instrument	HMP45AC Humidity and temperature probe
Serial number	F1830039
Manufacturer	Vaisala Oyj, Finland
Calibration date	18th May 2010
Test procedure	Doc210426-A

The above instrument was calibrated by comparing the relative humidity and temperature readings to two HMP233 factory working standards. At the time of shipment, the instrument described above met its operating specifications.

The relative humidity readings of the two HMP233 factory working standards have been calibrated at the Vaisala factory by using Hygro M-3 dewpoint meter. Hygro M-3 dewpoint meter has been calibrated at Vaisala Measurement Standards Laboratory (MSL) by using the MSL primary standard traceable to the NIST. The temperature readings of the two HMP233 factory working standards have been calibrated at MSL by using the MSL working standard traceable to the NIST. The temperature calibration at MSL has been accredited by the FINAS according to the ISO/IEC 17025.

Calibration results

Reference humidity* % RH	Observed humidity % RH	Difference %RH	Permissible difference %RH
0.4	1.3	+ 0.9	± 2.0
45.5	45.6	+ 0.1	± 2.0
75.0	75.7	+ 0.7	± 2.0
Reference temperature* °C	Observed temperature °C	Difference °C	Permissible difference °C
+ 23.20	+ 23.24	+ 0.04	± 0.2

*Average of two references.

Equipment used in calibration

Type	Serial number	Calibration date	Certificate number
HMP233 / RH	B2050020	2010-05-03	H06-10180001
HMP233 / RH	B2050015	2010-05-03	H06-10180002
Vaisala HMT337	B2050020	2009-12-04	K008-S02922
Vaisala HMT337	B2050015	2009-12-04	K008-S02921
HYGRO M-3	361095	2009-06-22	M-09H036
HP 34401A	3146A24281	2010-02-10	K004-10S077

Uncertainties (95 % confidence level, k=2)

Humidity ±1.0%RH @ 0..15%RH, ±1.5%RH @ 15..78%RH

Temperature ± 0.13 °C

Ambient conditions / Humidity 46 ± 5%RH, Temperature 23 ± 1 °C, Pressure 1012 ± 1 hPa.

For Vaisala Oyj


Kari Rilmala

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Doc210425-B

Vaisala Oyj
Vanha Nurmijärventie 21
FIN-01670 Vantaa, Finland

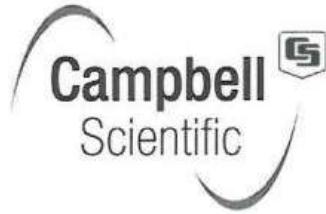
Tel. (+ 358 9) 8949 2658
Fax (+ 358 9) 8949 2295
<http://www.vaisala.com>

Domicile Vantaa, Finland
Trade Reg. No. 96.607

Data Logger**CAMPBELL SCIENTIFIC LIMITED**

Campbell Park
80 Hathern Road
Shepshed
Loughborough
LE12 9GX

Telephone: +44 (0) 1509 601141
Fax: +44 (0) 1509 601091
Email: support@campbellsco.co.uk

***Certificate of Calibration*****Customer:**

Company Name: Sgurr Energy Ltd.
Address: 225 Bath street,
Glasgow,
G2 4GZ.

Model: CR3000**Serial Number: 4777**

Calibration Date:	28-Jun-10	Test Panel Loc. 2
CSL Calibration Number:	100628166	
Calibration Procedures:	WI/T/0072, 73, 74	

Instrument Calibration Condition

Received Disposition:	In Tolerance	Out of Tolerance	Operational Failure
Returned Disposition:	In Tolerance *		

Report of Calibration Standards Used

Make/ Model	Test Equipment Number	Calibration Service Certificate Number
Krohn Hite 523	TE2164	AG50112
CSI Oscillator	TE2165	CSI

Campbell Scientific Limited certifies that the above instrument meets or exceeds published specifications and has been calibrated using standards and instruments whose accuracies are traceable to UK National Standards. All standards have been calibrated by a U.K.A.S. accredited calibration service. The uncertainties, including those attributable to the standards used, together with those contributed by personnel, procedures and environment are estimated not to exceed a 4:1 accuracy ratio for any given measurement.

Quality Control Officer responsible for content of certificate: Steve Sharratt

Remarks:

Based on the selected report options, some fields are intentionally left blank.
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Page 1 of 2

Instrument Data Report

Analog Inputs

Log Option: 1 S/N 4777

Range	Input (mV)	Tolerance (mV)	Single-Ended (Full Scale)		Differential		Temp (C)
			Before (mV)	After (mV)	Before (mV)	After (mV)	
6	5000	+4					28
6	-5000	+4					28
5	2500	+2			5000.7		28
4	250	+0.2			1000.1		28
3	25	+0.02			200.05		28
2	7.5	+0.006			50.012		28
1	2.5	+0.002			20.004		28
1	-2.5	+0.002			-20.004		28
6	5000	+7.5	4999.2		4998.7		-25
6	5000	+7.5	5001.5		5002.0		50
6	5000	+12.5					-40
6	5000	+12.5					80

Quiescent System Power

Tolerance Max (mA)	As Received (mA)	As Returned (mA)	Temp (C)
3.0		2.00	28.0

Real-Time Clock

Clock accuracy: Meets or exceeds +/- 3 min/year (-40 to 80C)

Laboratory temperature and relative humidity at the time of calibration

Temperature: 28 C

Relative Humidity: 33 %

Functions tested per test document (see page 1):

Analog:	Frequency:
Excitation Channels	Pulse Counters
CAO Channels	Period Averaging
Analog Input ranges over temperature	

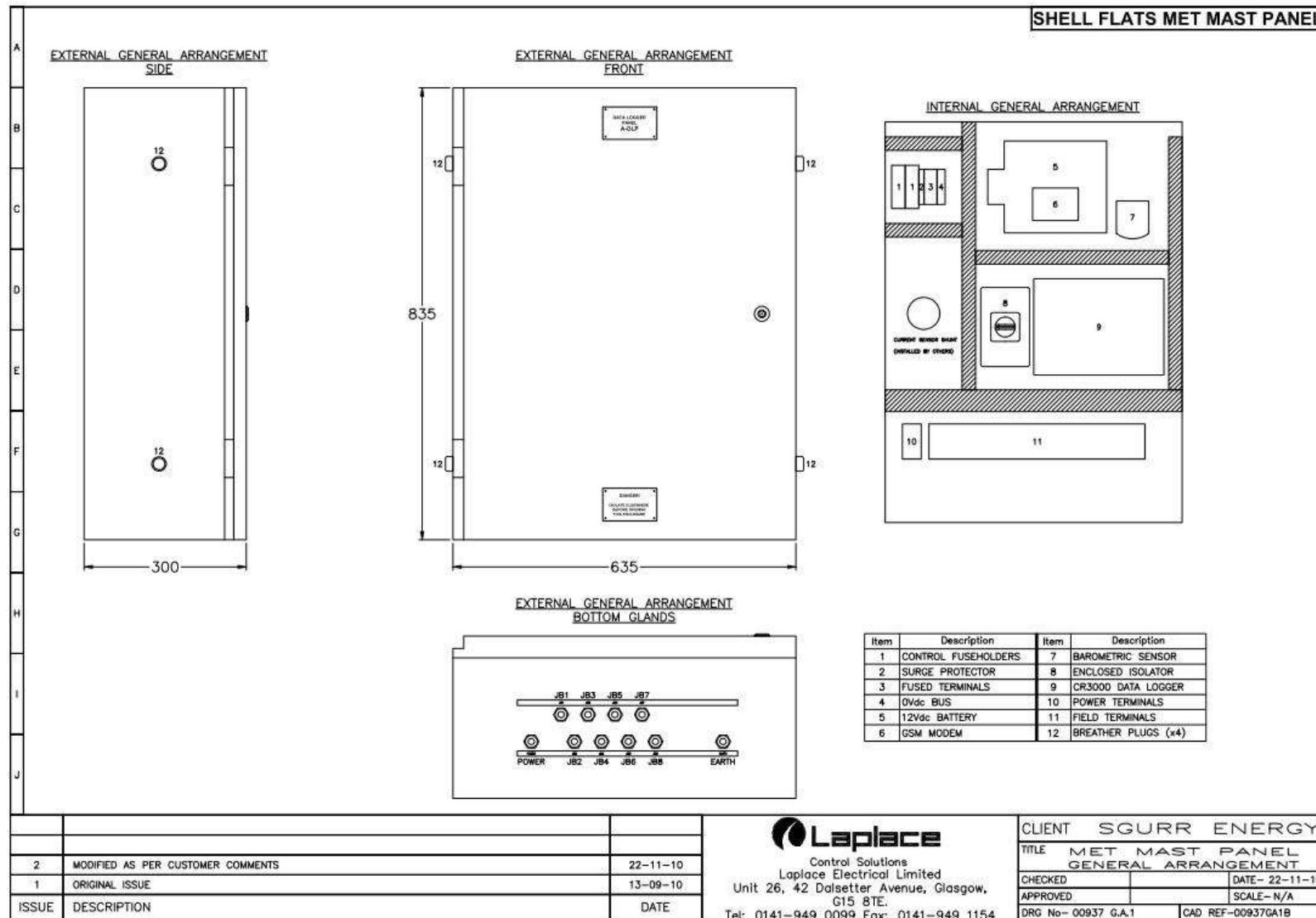
Calibration by: P Redmile Title: Test Technician
P Redmile

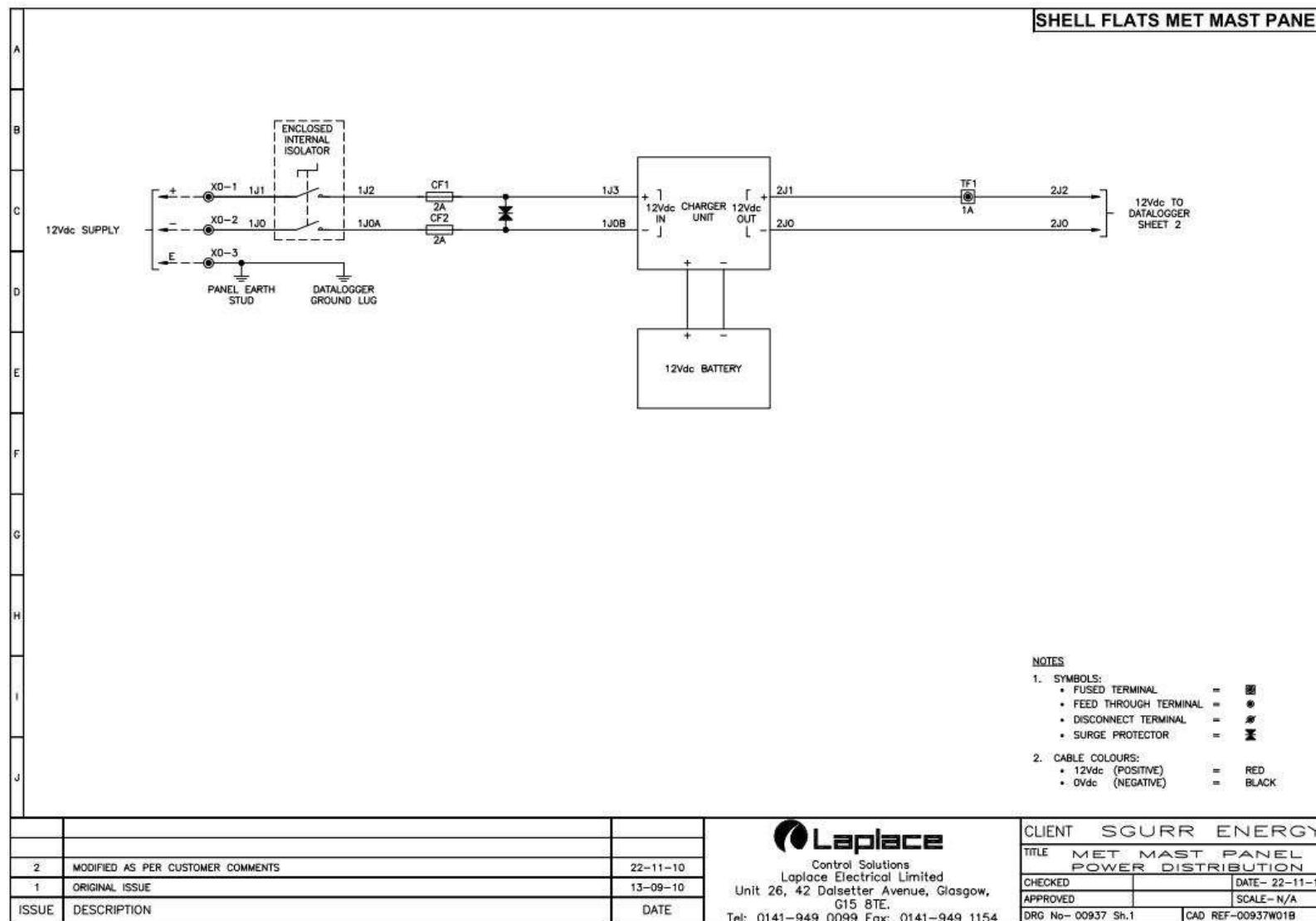
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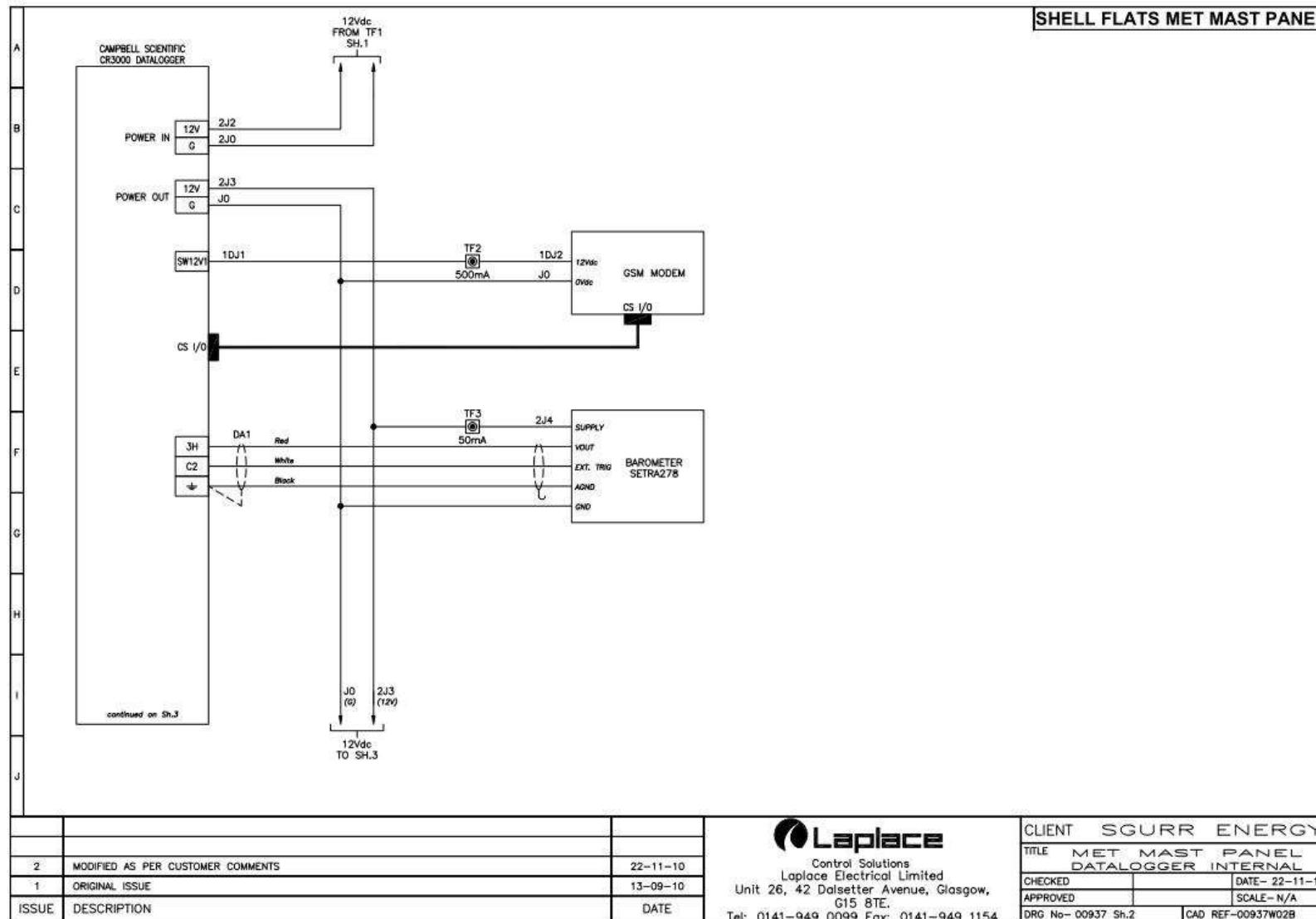
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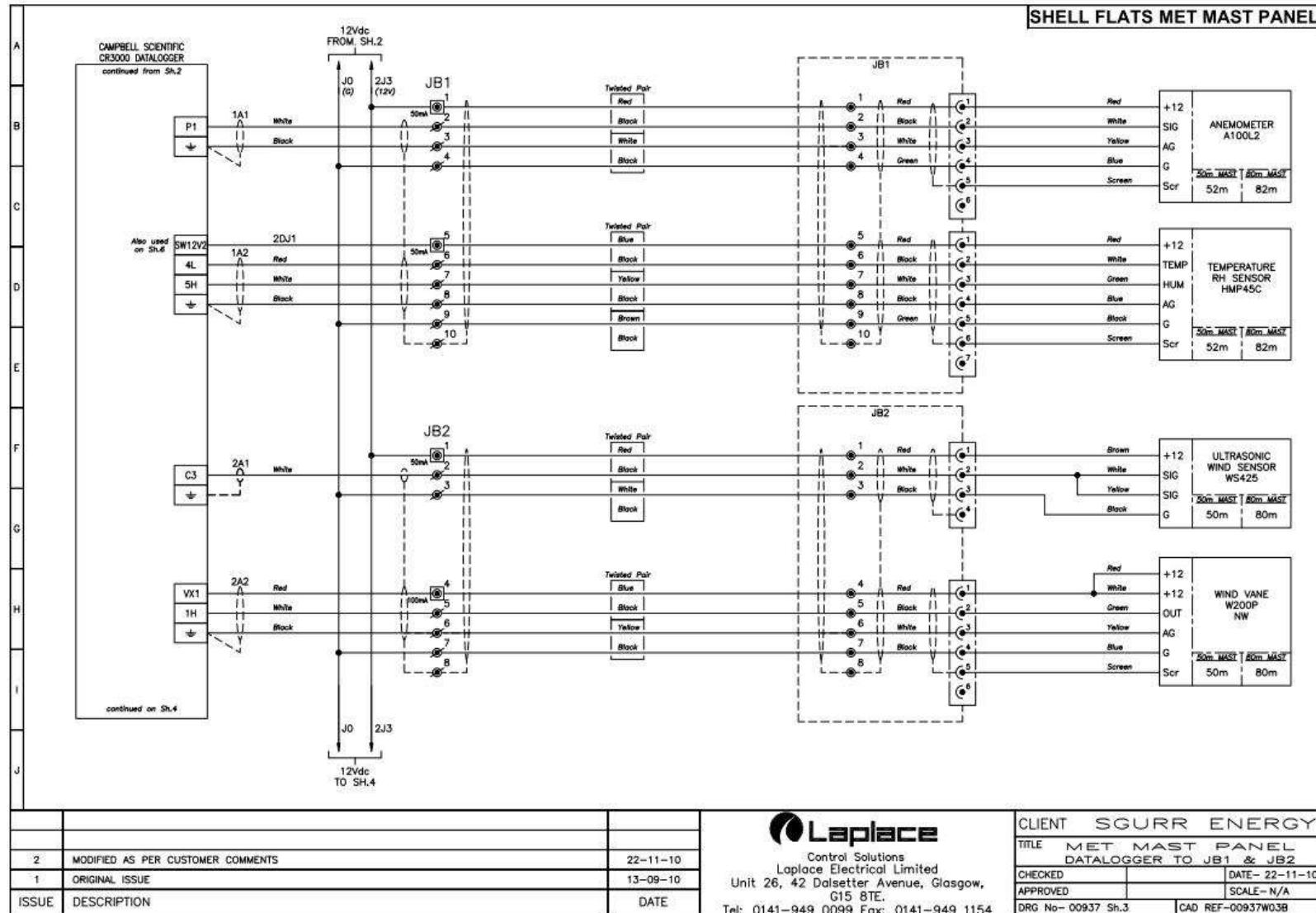
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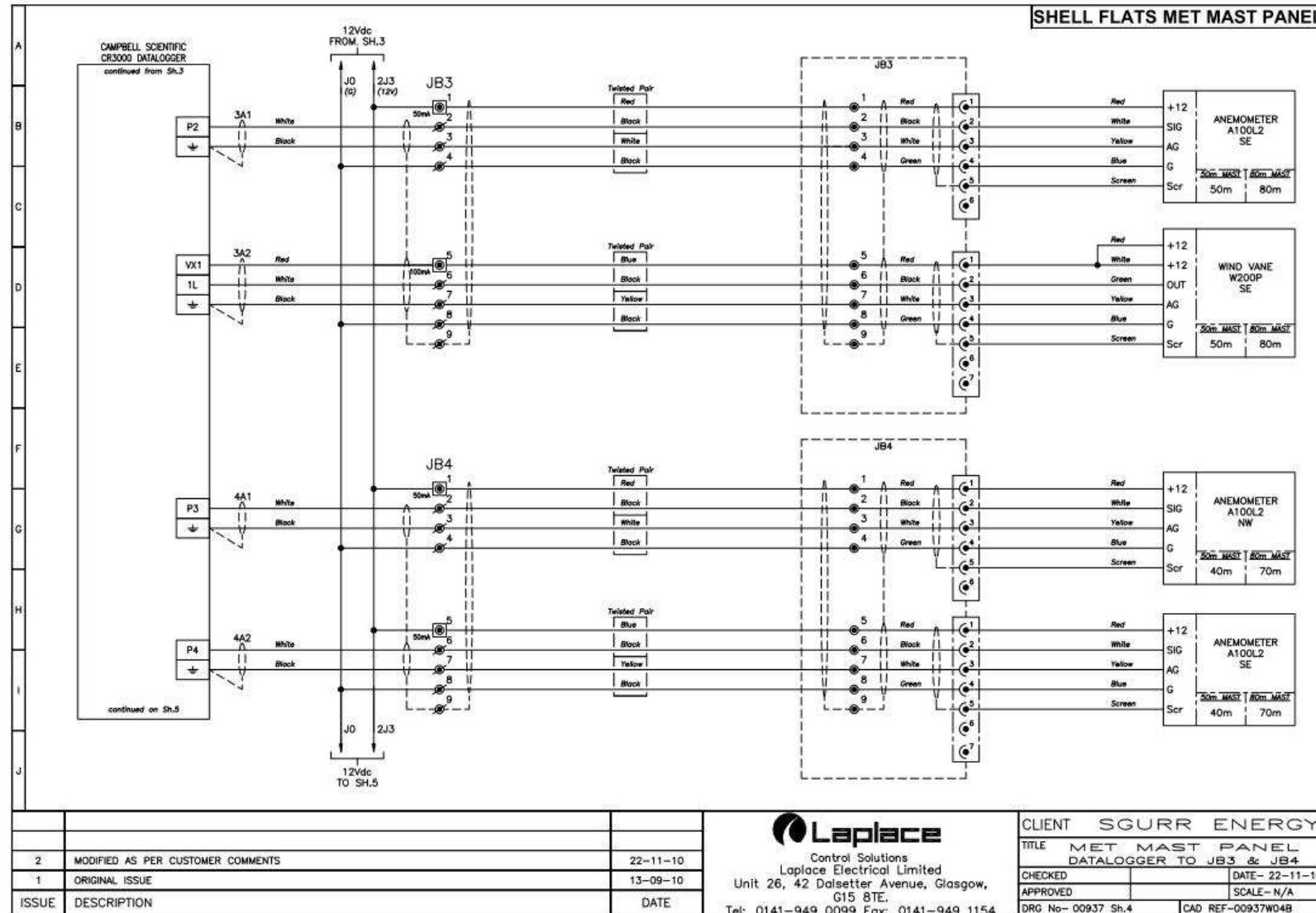
APPENDIX D: DATA LOGGER PANEL DESIGN

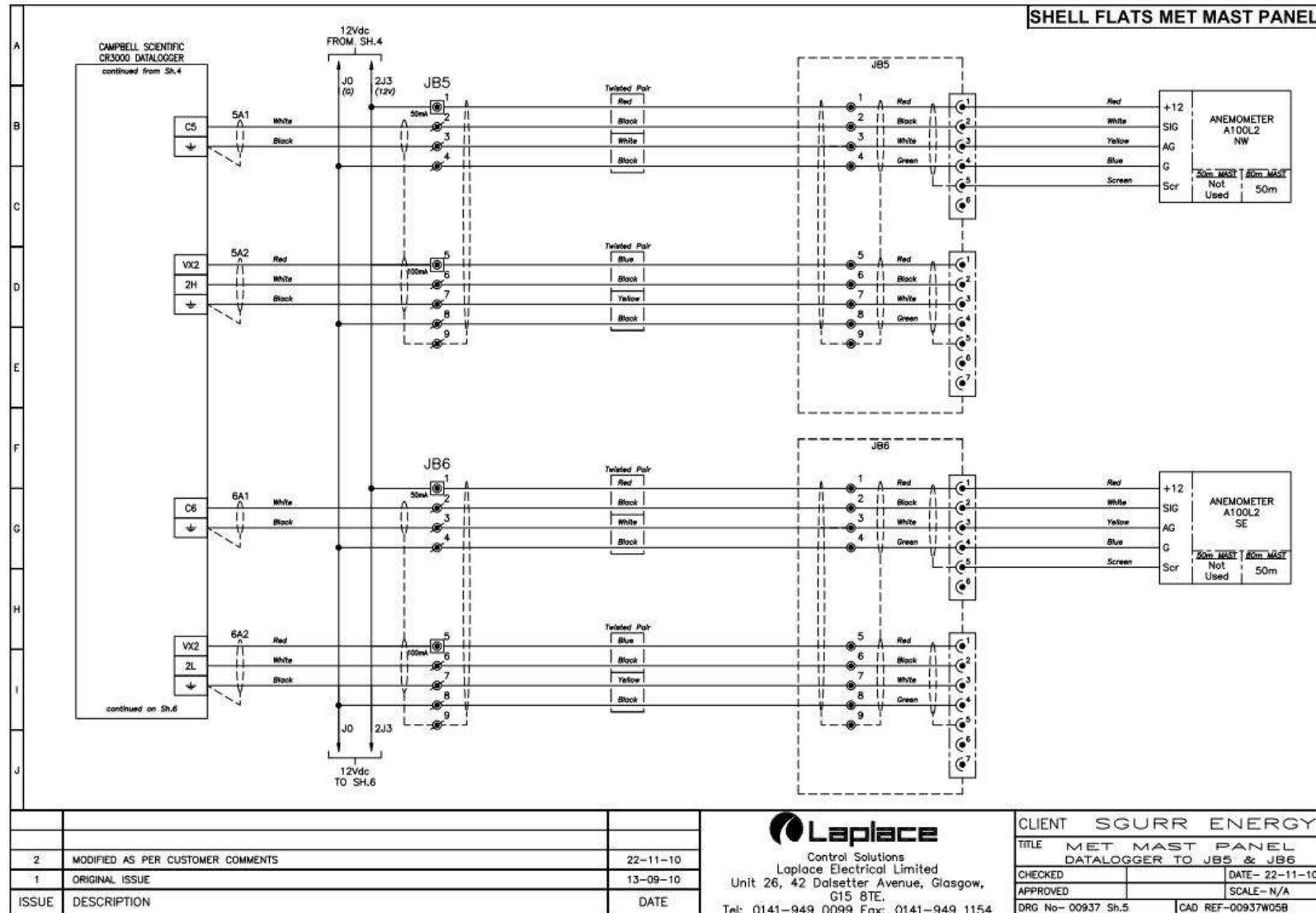


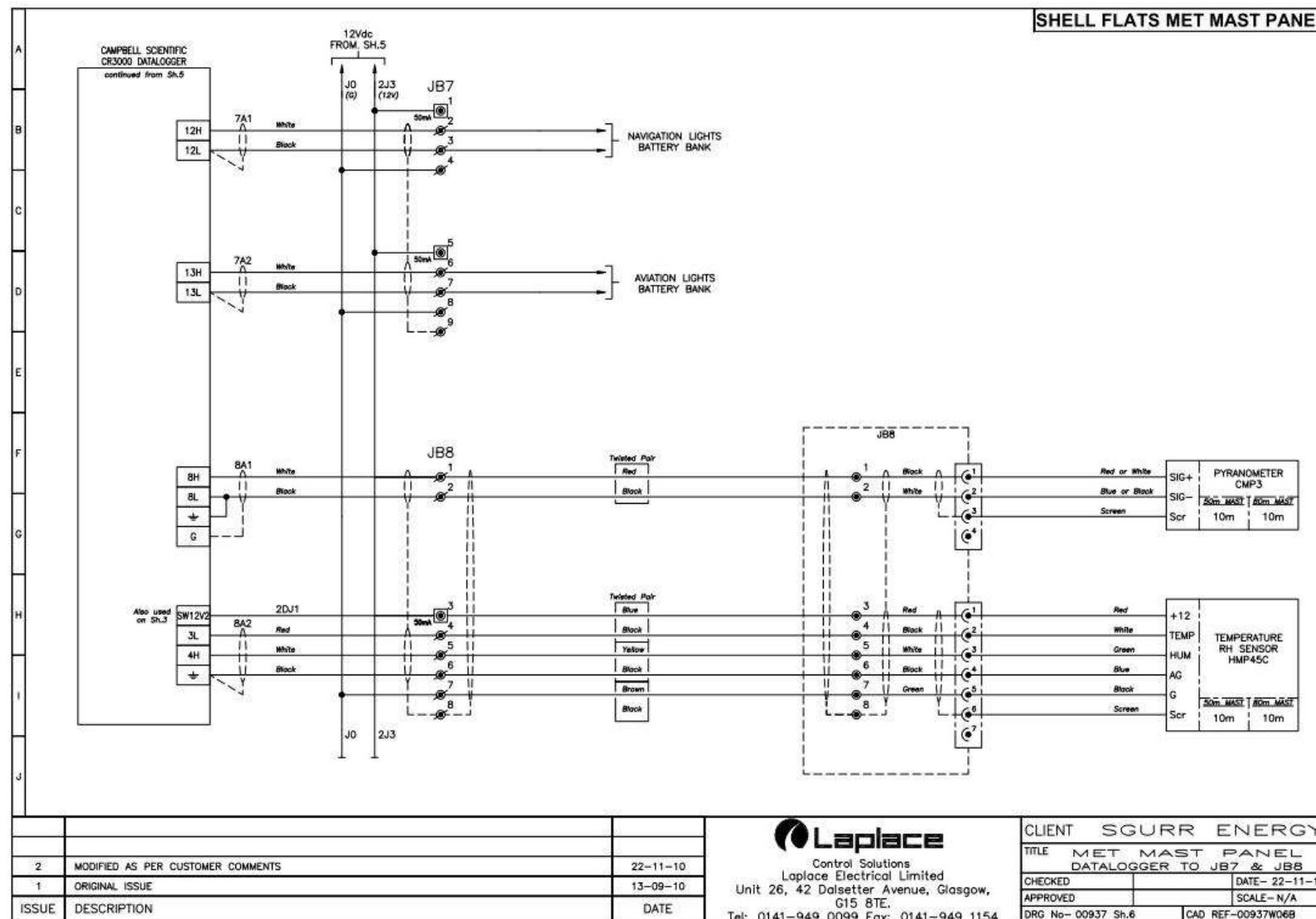


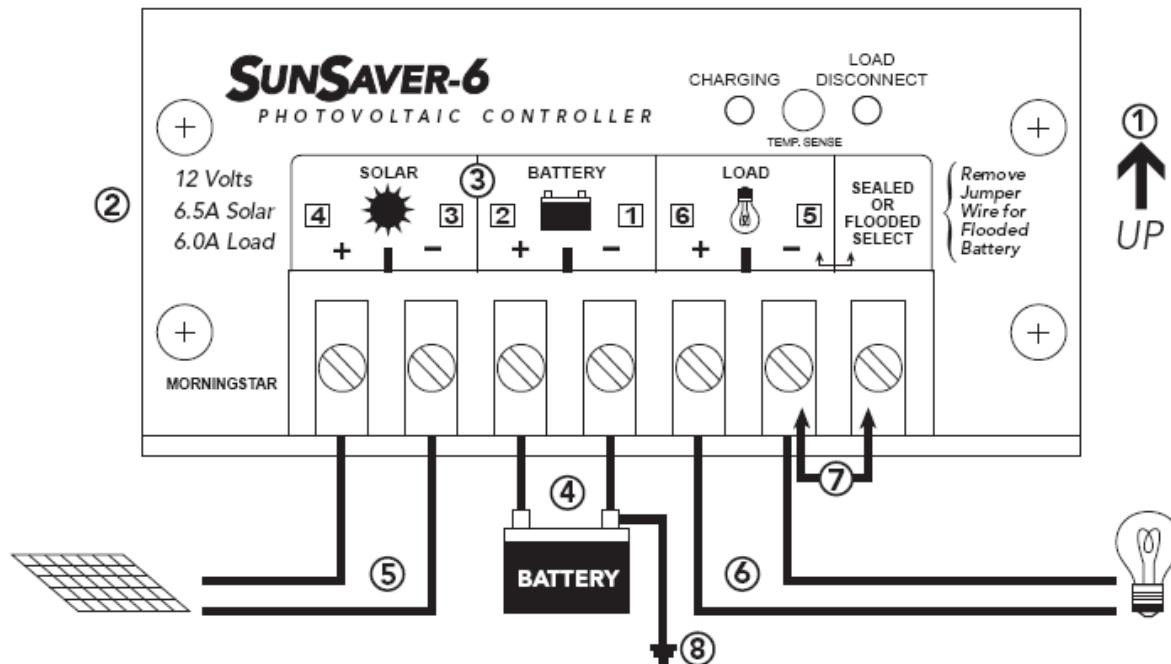






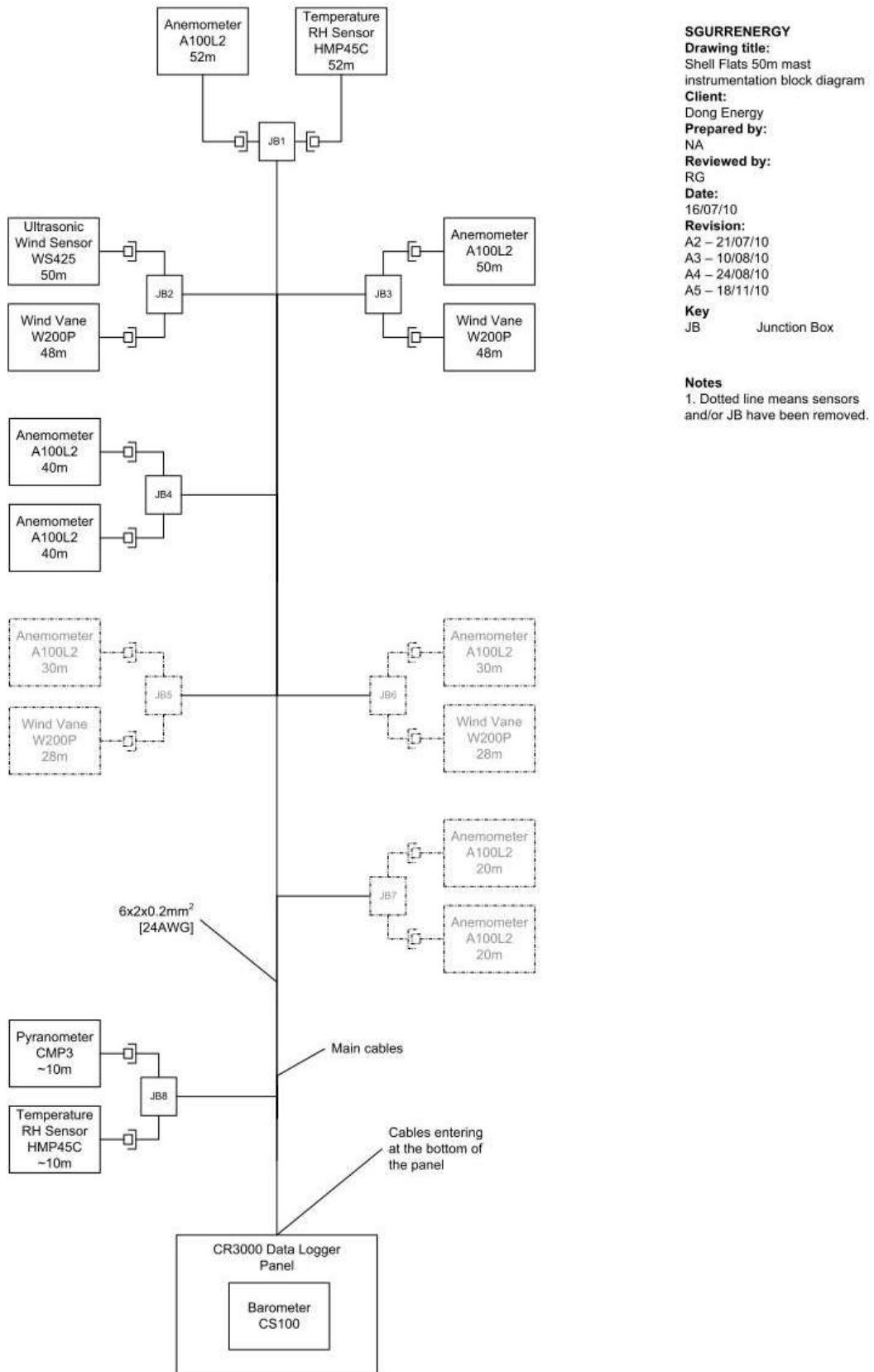


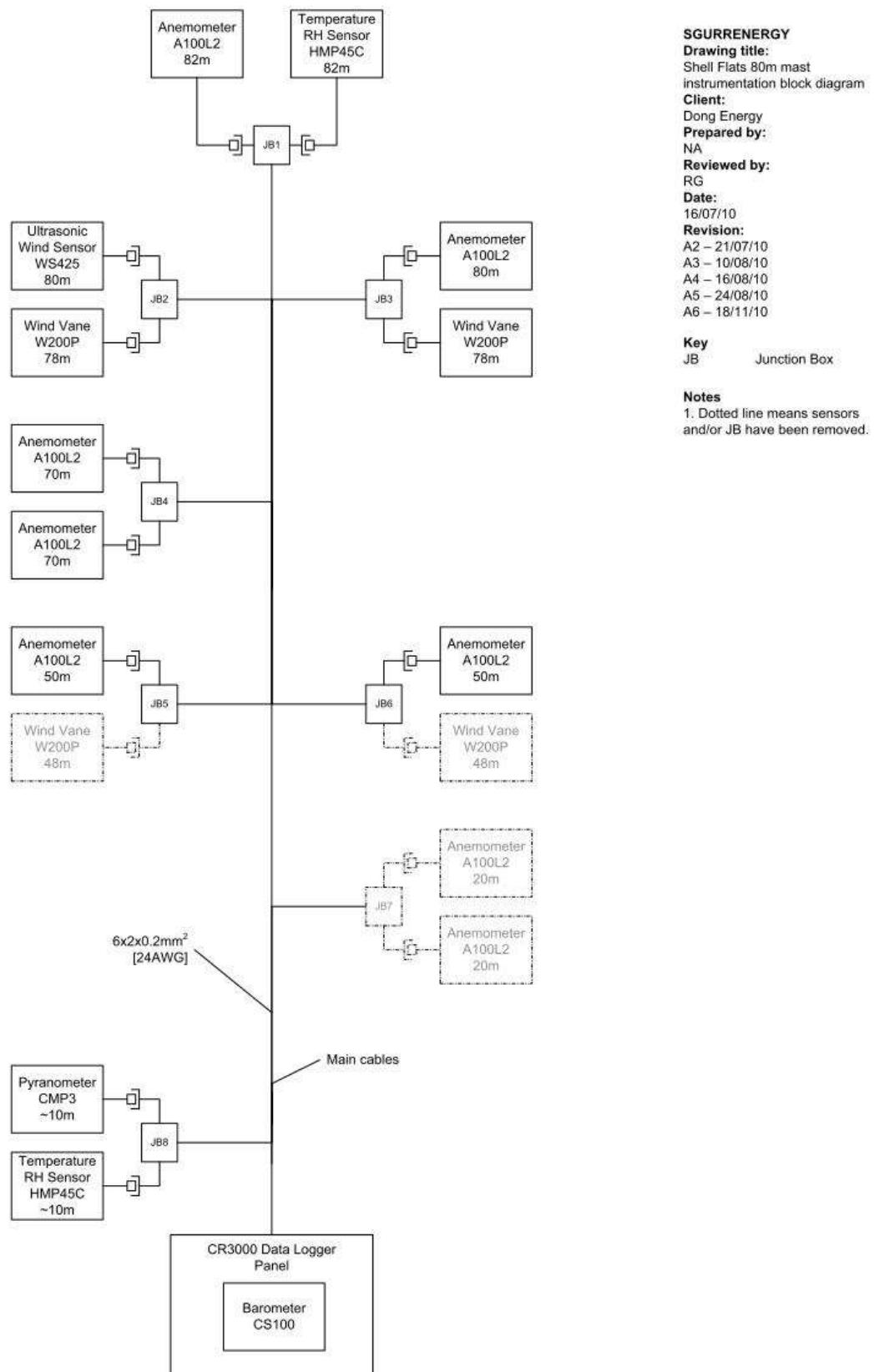


APPENDIX E – DATA LOGGER

APPENDIX E: INSTRUMENTATION BLOCK DIAGRAMS

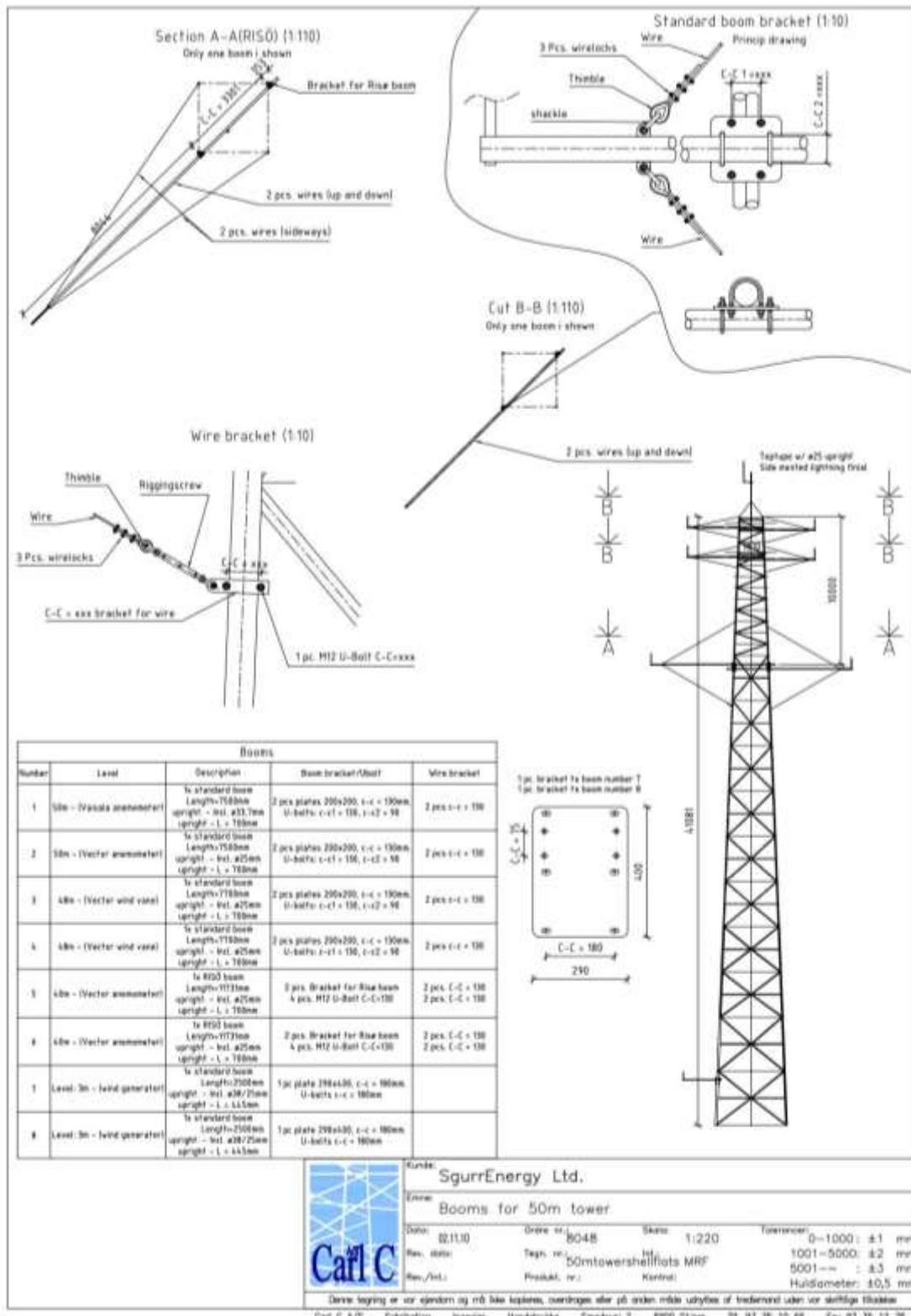
50m Mast

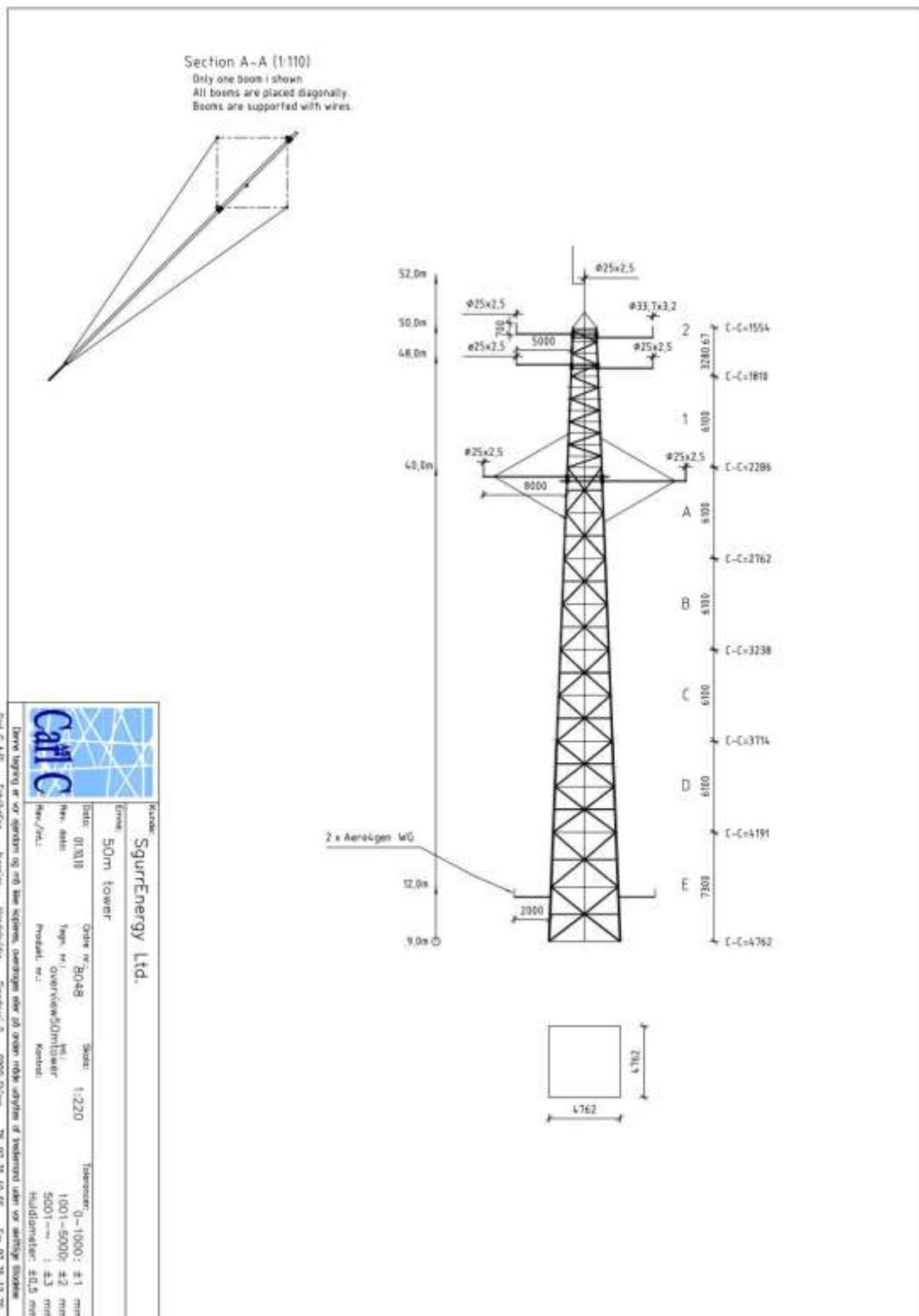


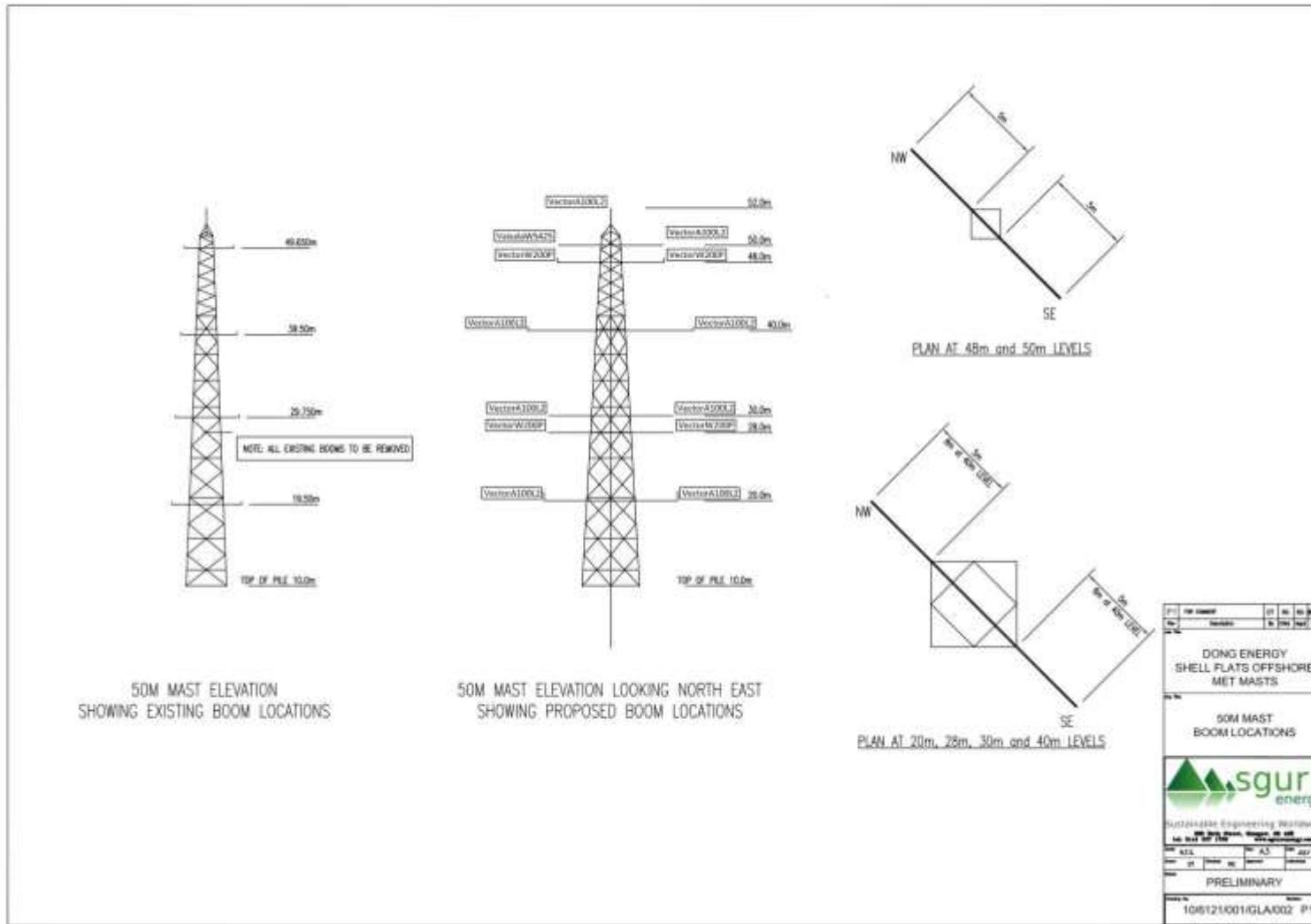
80m Mast

APPENDIX F: BOOM CONFIGURATIONS

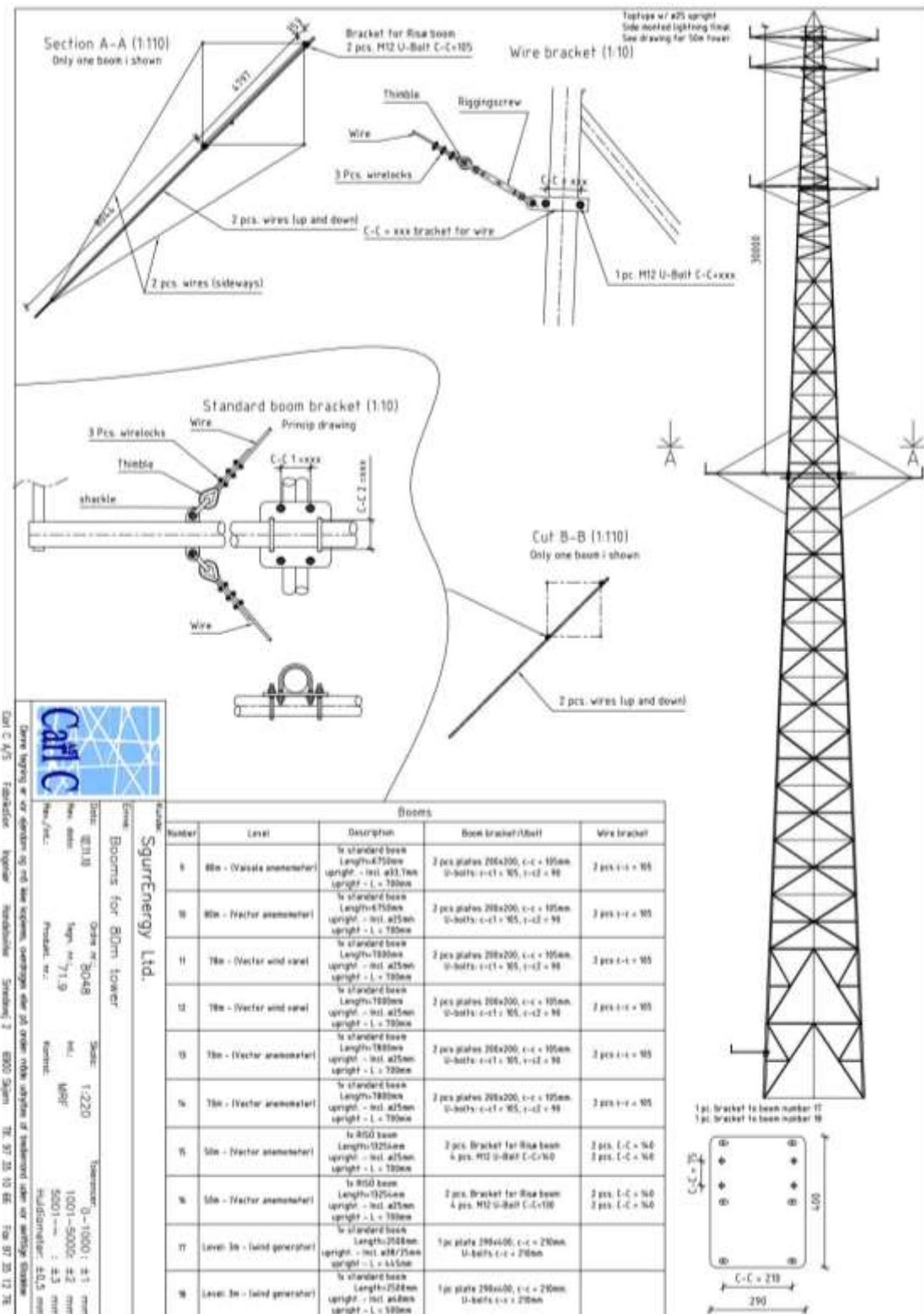
50m Mast

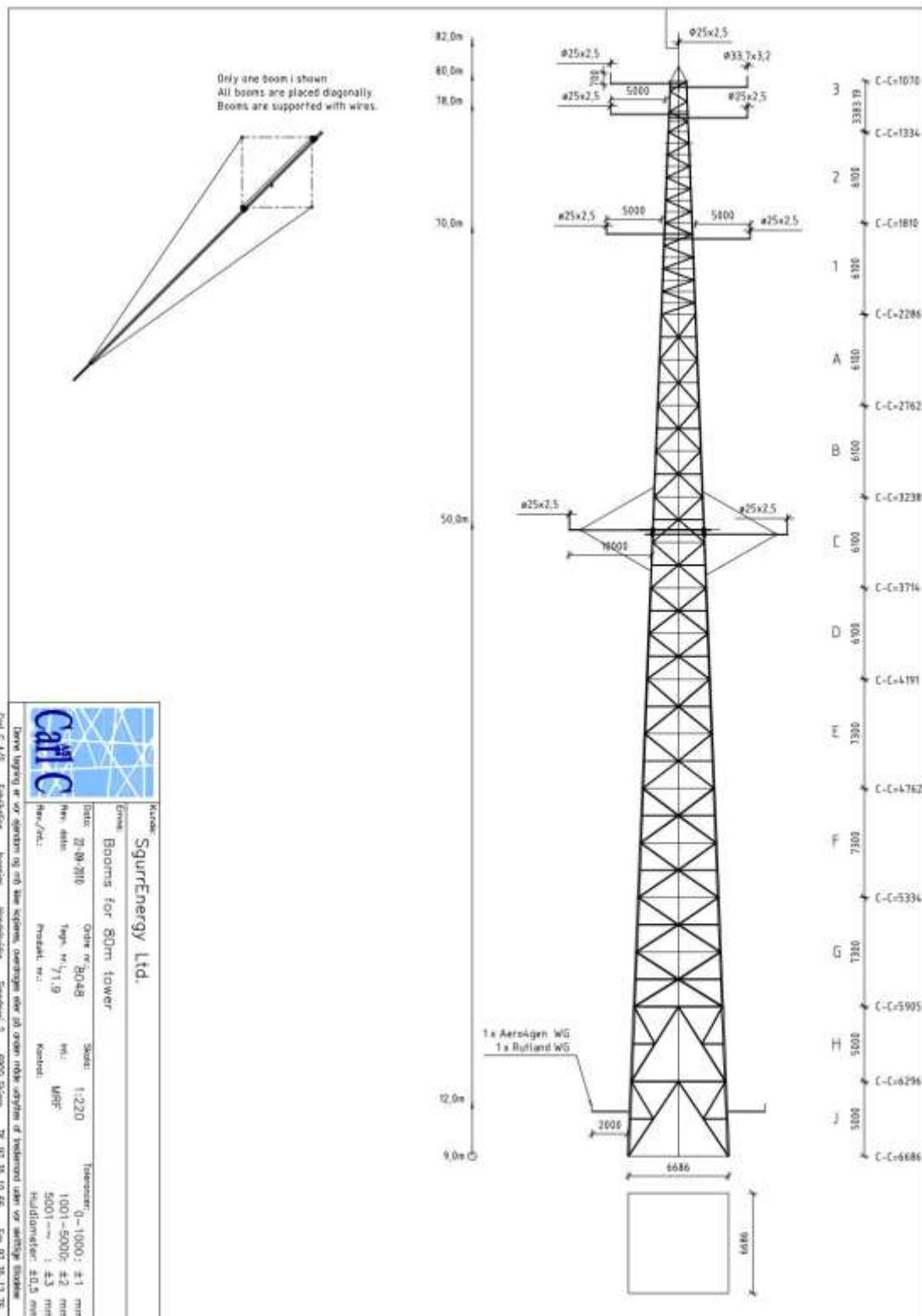


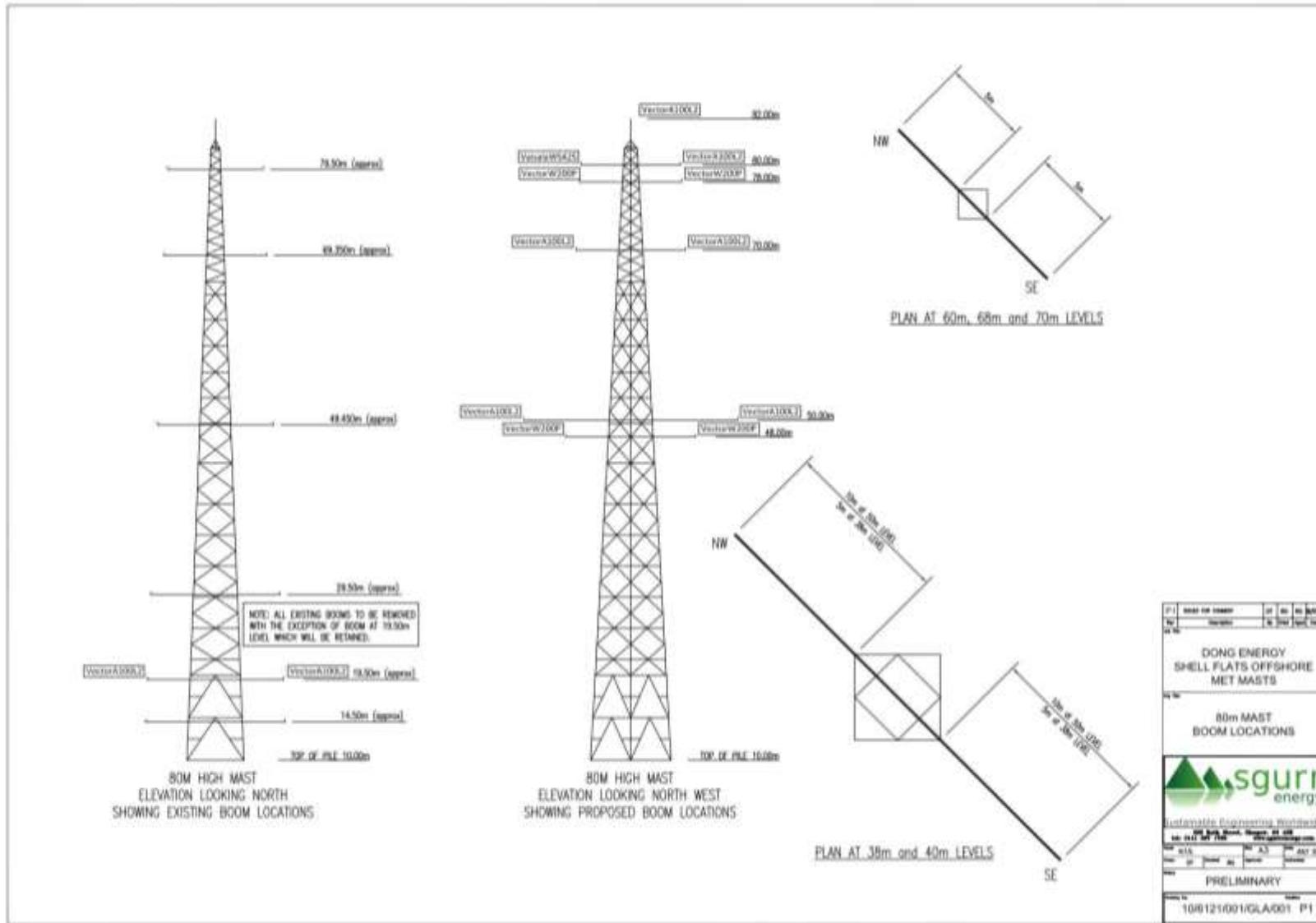




80m Mast







APPENDIX G: DATA LOGGER PROGRAM

50m Mast

```
'CR3000 Series Datalogger
SequentialMode
'Declare Variables and Units
Public Batt_Volt
Public WS_ms(9)
Public Gust(9)
Public WindDir(5)
Public BP_mbar
Public AirTC
Public RH
Public AirTC2
Public RH2
Public SIRW
Public SIRkW
Public SIRkJ
Public SIRMJ
Public RTime(9)
Public WS425(4)
Public WS425Initialise(4)As String
Alias WS_ms(1)=WS50mWS425NW
Alias WS_ms(2)=WS52mA100Top
Alias WS_ms(3)=WS50mA100SE
Alias WS_ms(4)=WS40mA100NW
Alias WS_ms(5)=WS40mA100SE
Alias WS_ms(6)=WS30mA100NW
Alias WS_ms(7)=WS30mA100SE
Alias WS_ms(8)=WS20mA100NW
Alias WS_ms(9)=WS20mA100SE

Alias WindDir(1)=WD50mWS425NW
Alias WindDir(2)=WD50mW200PNW
Alias WindDir(3)=WD50mW200PSE
Alias WindDir(4)=WD30mW200PNW
Alias WindDir(5)=WD30mW200PSE

Public Elevation 'in metres
Dim dP 'pressure difference for calculating barometric pressure at sea level

Dim CM3M
Public CM3CalFac
```

Dim NowMin

Dim CellCo

Dim(i)

Units Batt_Volt=Volts

Units WS_ms()=meters/second

Units Gust()=meters/second

Units WindDir()=Degrees

Units BP_mbar=mbar

Units AirTC=Deg C

Units RH=%

Units SlrW=W/m^2

Units SlrkW=kW/m^2

Units SlrkJ=kJ/m^2

Units SlrMJ=MJ/m^2

'Define Data Tables

DataTable(TenMin,True,-1)

DataInterval(0,10,Min,10)

Average (9,WS_ms(),FP2,False)

Maximum (9,Gust(),FP2,False,False)

StdDev (9,WS_ms(),FP2,False)

WindVector (5,WS_ms(),WindDir(),FP2,False,0,0,4)

FieldNames

("WD50mWS425NW_VAvg,WD50mWS425NW_Std,WD50mW200PNW_VAvg,WD50mW200PNW_Std,WD50mW200PSE_VAvg,WD50mW200PSE_Std,WD30mW200PSE_Std,WD30mW200PNW_VAvg,WD30mW200PNW_Std,WD30mW200PSE_VAvg,WD30mW200PSE_Std")

Average (1,AirTC,FP2,False)

Sample (1,RH,FP2)

Average (1,AirTC2,FP2,False)

Sample (1,RH2,FP2)

Sample (1,BP_mbar,FP2)

Sample (1,SlrkW,FP2)

Totalize (1,SlrkJ,FP2,False)

Minimum(1,Batt_Volt,FP2,False,False)

EndTable

'Define Data Tables

DataTable(Hourly,True,-1)

DataInterval(0,60,Min,10)

Average (9,WS_ms(),FP2,False)

StdDev (9,WS_ms(),FP2,False)

```

Maximum (9,Gust(),FP2,False,False)
WindVector (5,WS_ms(),WindDir(),FP2,False,0,0,4)
FieldNames
("WD80mWS425NW_VAvg,WD80mWS425NW_Std,WD80mW200PNW_VAvg,WD80mW200PNW_Std,WD80mW2
00PSE_VAvg,WD80mW200PSE_Std,WD50mW200PNW_VAvg,WD50mW200PNW_Std,WD50mW200PSE_VAvg,
WD50mW200PSE_Std")
Average (1,AirTC,FP2,False)
Sample (1,AirTC,FP2)
Maximum (1,AirTC,FP2,False,False)
Minimum (1,AirTC,FP2,False,False)
Average (1,RH,FP2,False)
Sample (1,RH,FP2)
Maximum (1,RH,FP2,False,False)
Minimum (1,RH,FP2,False,False)
Average (1,AirTC2,FP2,False)
Sample (1,AirTC2,FP2)
Maximum (1,AirTC2,FP2,False,False)
Minimum (1,AirTC2,FP2,False,False)
Average (1,RH2,FP2,False)
Sample (1,RH2,FP2)
Maximum (1,RH2,FP2,False,False)
Minimum (1,RH2,FP2,False,False)
Sample (1,BP_mbar,FP2)
Sample (1,SirkW,FP2)
Maximum (1,SirkW,FP2,False,False)
Minimum (1,SirkW,FP2,False,False)
Totalize (1,SirkJ,FP2,False)
Minimum(1,Batt_Volt,FP2,False,False)
EndTable

```

'Main Program

BeginProg

Elevation = 10

CM3CalFac = 15

'Initialisation.

SDI12Recorder (WS425Initialise(),3,0,"XQ1;0.0;1;0001!",1.0,0)

Scan(1,Sec,1,0)

'Calculation to find pressure difference between mounting height

'and sea level (Wallace & Hobbes 1977)

dP=1013.25*(1-(1-Elevation/44307.69231)^5.25328)

'CM3 multiplier calculation using user entered calibration factor
'taken from CM3 calibration certificate
CM3M=1000/CM3CalFac

'Default Datalogger Battery Voltage measurement Batt_Volt:
Battery(Batt_Volt)

SDI12Recorder (WS425(),3,0,"R0!",1,0)

If NOT (WS425(1) = NaN) Then
 WS_ms(1)=WS425(1)*0.44704
 WindDir(1)=WS425(2)
EndIf

'A100L2 Switching Anemometer measurement WS_ms(2-5):

PulseCount(WS_ms(2),4,1,0,1,0.05148,0.0)

'A100L2 Switching Anemometer measurement WS_ms(6-9):
PulseCount(WS_ms(6),4,15,0,1,0.05148,0.0)

For i = 1 To 9
 If WS_ms(i)<0.01 Then WS_ms(i)=0
Next i

AvgRun(Gust(),9,WS_ms(),3)

'W200P Wind Direction Sensor measurement WindDir(1-2):
BrHalf(WindDir(2),4,mV5000,1,Vx1,2,5000,False,20000,_50Hz,357,0)

For i = 1 To 5
 WindDir(i) = WindDir(i) MOD 360
Next i

'CM3 Pyranometer measurement in Wm-2
VoltDiff(SlrW,1,mV50,8,True,0,250,CM3M,0)
'Set any negative readings to zero
If SlrW<0 Then SlrW=0

'Calculate solar output in kWm-2
SlrkW = SlrW*0.001

' Calculate solar output in kJ
SlrkJ = SlrW*0.001

' Calculate solar output in kJ

SirMJ = SirW*0.000001

If IfTime(9,10,Min) Then PortSet(2,1)

If IfTime(9,10,Min) Then SW12(2,1)

If IfTime(0,10,Min) Then

'CS100 Barometric Pressure Sensor Measurement BP_mbar

VoltSe(BP_mbar,1,mV5000,5,1,0,_50Hz,0.2,600)

'HMP45C Temperature & Relative Humidity Sensor measurements AirTC and RH

VoltSe(AirTC,1,mV1000,6,0,0,_50Hz,0.1,-40)

VoltSe(RH,1,mV1000,7,0,0,_50Hz,0.1,0)

VoltSe(AirTC2,1,mV1000,8,0,0,_50Hz,0.1,-40)

VoltSe(RH2,1,mV1000,9,0,0,_50Hz,0.1,0)

If (RH>100) AND (RH<108) Then RH=100

PortSet(2,0)

SW12(2,0)

EndIf

'Cellular Phone Control using the SW12V (Port 9)

RealTime(RTime(1)) 'Get the time array

'1=year, 2=month, 3=day of month, 4=hour of day, 5=minutes,

'6=seconds, 7=microseconds, 8=day of week, 9=day of year

NowMin=RTime(4)*60+RTime(5)

CellCo=0 'Default set to off

If (NowMin>=540 AND NowMin<960 AND (NowMin-420) MOD 60<30) OR VIEW_GPRS_ModemOn Then

CellCo=1

EndIf

If Batt_Volt <11 Then

CellCo=0 'Switch off if battery is low

EndIf

If NowMin=0 Then

SDI12Recorder (WS425Initialise(),3,0,"XQ1;0.0;1;0001!",1.0,0)

EndIf

SW12(1,CellCo)

'Call Data Tables and Store Data

CallTable(TenMin)

CallTable(Hourly)

NextScan

EndProg

80m Mast

```
'CR3000 Series Datalogger
SequentialMode
'Declare Variables and Units
Public Batt_Volt
Public WS_ms(9)
Public Gust(9)
Public WindDir(5)
Public BP_mbar
Public AirTC
Public RH
Public AirTC2
Public RH2
Public SlrW
Public SlrkW
Public SlrkJ
Public SlrMJ
Public RTime(9)
Public WS425(4)
Public WS425Initialise(4)As String
Alias WS_ms(1)=WS80mWS425NW
Alias WS_ms(2)=WS82mA100Top
Alias WS_ms(3)=WS80mA100SE
Alias WS_ms(4)=WS70mA100NW
Alias WS_ms(5)=WS70mA100SE
Alias WS_ms(6)=WS50mA100NW
Alias WS_ms(7)=WS50mA100SE
Alias WS_ms(8)=WS20mA100CB1
Alias WS_ms(9)=WS20mA100CB2

Alias WindDir(1)=WD80mWS425NW
Alias WindDir(2)=WD80mW200PNW
Alias WindDir(3)=WD80mW200PSE
Alias WindDir(4)=WD50mW200PNW
Alias WindDir(5)=WD50mW200PSE
```

Public Elevation 'in metres

Dim dP 'pressure difference for calculating barometric pressure at sea level

Dim CM3M

Public CM3CalFac

Dim NowMin

```
Dim CellCo
```

```
Dim(i)
```

```
Units Batt_Volt=Volts
```

```
Units WS_ms()=meters/second
```

```
Units Gust()=meters/second
```

```
Units WindDir()=Degrees
```

```
Units BP_mbar=mbar
```

```
Units AirTC=Deg C
```

```
Units RH=%
```

```
Units SlrW=W/m^2
```

```
Units SlrkW=kW/m^2
```

```
Units SlrkJ=kJ/m^2
```

```
Units SlrMJ=MJ/m^2
```

```
'Define Data Tables
```

```
DataTable(TenMin,True,-1)
```

```
DataInterval(0,10,Min,10)
```

```
Average (9,WS_ms(),FP2,False)
```

```
Maximum (9,Gust(),FP2,False,False)
```

```
StdDev (9,WS_ms(),FP2,False)
```

```
WindVector (5,WS_ms(),WindDir(),FP2,False,0,0,4)
```

```
FieldNames
```

```
("WD80mWS425NW_VAvg,WD80mWS425NW_Std,WD80mW200PNW_VAvg,WD80mW200PNW_Std,WD80mW200PSE_VAvg,WD80mW200PSE_Std,WD50mW200PNW_VAvg,WD50mW200PNW_Std,WD50mW200PSE_VAvg,WD50mW200PSE_Std")
```

```
Average (1,AirTC,FP2,False)
```

```
Sample (1,RH,FP2)
```

```
Average (1,AirTC2,FP2,False)
```

```
Sample (1,RH2,FP2)
```

```
Sample (1,BP_mbar,FP2)
```

```
Sample (1,SlrkW,FP2)
```

```
Totalize (1,SlrkJ,FP2,False)
```

```
Minimum(1,Batt_Volt,FP2,False,False)
```

```
EndTable
```

```
'Define Data Tables
```

```
DataTable(Hourly,True,-1)
```

```
DataInterval(0,60,Min,10)
```

```
Average (9,WS_ms(),FP2,False)
```

```
StdDev (9,WS_ms(),FP2,False)
```

```
Maximum (9,Gust(),FP2,False,False)
```

```
WindVector (5,WS_ms(),WindDir(),FP2,False,0,0,4)
```

```
FieldNames
("WD80mWS425NW_VAvg,WD80mWS425NW_Std,WD80mW200PNW_VAvg,WD80mW200PNW_Std,WD80mW2
00PSE_VAvg,WD80mW200PSE_Std,WD50mW200PNW_VAvg,WD50mW200PNW_Std,WD50mW200PSE_VAvg,
WD50mW200PSE_Std")

Average (1,AirTC,FP2,False)
Sample (1,AirTC,FP2)
Maximum (1,AirTC,FP2,False,False)
Minimum (1,AirTC,FP2,False,False)
Average (1,RH,FP2,False)
Sample (1,RH,FP2)
Maximum (1,RH,FP2,False,False)
Minimum (1,RH,FP2,False,False)
Average (1,AirTC2,FP2,False)
Sample (1,AirTC2,FP2)
Maximum (1,AirTC2,FP2,False,False)
Minimum (1,AirTC2,FP2,False,False)
Average (1,RH2,FP2,False)
Sample (1,RH2,FP2)
Maximum (1,RH2,FP2,False,False)
Minimum (1,RH2,FP2,False,False)
Sample (1,BP_mbar,FP2)
Sample (1,SIRkW,FP2)
Maximum (1,SIRkW,FP2,False,False)
Minimum (1,SIRkW,FP2,False,False)
Totalize (1,SIRkJ,FP2,False)
Minimum(1,Batt_Volt,FP2,False,False)

EndTable
```

'Main Program

BeginProg

Elevation = 10

CM3CalFac = 15

'Initialisation.

SDI12Recorder (WS425Initialise(),3,0,"XQ1;0.0;1;0001!",1.0,0)

Scan(1,Sec,1,0)

'Calculation to find pressure difference between mounting height

'and sea level (Wallace & Hobbes 1977)

dP=1013.25*(1-(1-Elevation/44307.69231)^5.25328)

'CM3 multiplier calculation using user entered calibration factor

'taken from CM3 calibration certificate

CM3M=1000/CM3CalFac

'Default Datalogger Battery Voltage measurement Batt_Volt:
Battery(Batt_Volt)

SDI12Recorder (WS425(),3,0,"R0!",1,0)

If NOT (WS425(1) = NaN) Then
 WS_ms(1)=WS425(1)*0.44704
 WindDir(1)=WS425(2)
EndIf

'A100L2 Switching Anemometer measurement WS_ms(2-5):
PulseCount(WS_ms(2),4,1,0,1,0.05148,0,0)

'A100L2 Switching Anemometer measurement WS_ms(6-9):
PulseCount(WS_ms(6),4,15,0,1,0.05148,0,0)

For i = 1 To 9
 If WS_ms(i)<0.01 Then WS_ms(i)=0
Next i

AvgRun(Gust(),9,WS_ms(),3)

'W200P Wind Direction Sensor measurement WindDir(1-2):
BrHalf(WindDir(2),4,mV5000,1,Vx1,2,5000,False,20000,_50Hz,357,0)

For i = 1 To 5
 WindDir(i) = WindDir(i) MOD 360
Next i

'CM3 Pyranometer measurement in Wm-2
VoltDiff(SlrW,1,mV50,8,True,0,250,CM3M,0)
'Set any negative readings to zero
If SlrW<0 Then SlrW=0

'Calculate solar output in kWm-2
SlrkW = SlrW*0.001

' Calculate solar output in kJ
SlrkJ = SlrW*0.001

' Calculate solar output in kJ
SlrMJ = SlrW*0.000001

```
If IfTime(9,10,Min) Then PortSet(2,1)
If IfTime(9,10,Min) Then SW12(2,1)
If IfTime(0,10,Min) Then
    'CS100 Barometric Pressure Sensor Measurement BP_mbar
    VoltSe(BP_mbar,1,mV5000,5,1,0,_50Hz,0.2,600)
    'HMP45C Temperature & Relative Humidity Sensor measurements AirTC and RH
    VoltSe(AirTC,1,mV1000,6,0,0,_50Hz,0.1,-40)
    VoltSe(RH,1,mV1000,7,0,0,_50Hz,0.1,0)
    VoltSe(AirTC2,1,mV1000,8,0,0,_50Hz,0.1,-40)
    VoltSe(RH2,1,mV1000,9,0,0,_50Hz,0.1,0)
    If (RH>100) AND (RH<108) Then RH=100
    PortSet(2,0)
    SW12(2,0)
EndIf
```

```
'Cellular Phone Control using the SW12V (Port 9)
RealTime(RTime(1)) 'Get the time array
'1=year, 2=month, 3=day of month, 4=hour of day, 5=minutes,
'6=seconds, 7=microseconds, 8=day of week, 9=day of year
NowMin=RTime(4)*60+RTime(5)
CellCo=0           'Default set to off
```

```
If (NowMin>=600 AND NowMin<900 AND (NowMin-420) MOD 60<45) Then
```

```
    CellCo=1
```

```
EndIf
```

```
If Batt_Volt <11 Then
```

```
    CellCo=0     'Switch off if battery is low
```

```
EndIf
```

```
SW12(1,CellCo)
```

```
If NowMin=0 Then
```

```
    SDI12Recorder (WS425Initialise(),3,0,"XQ1;0.0;1;0001!",1.0,0)
```

```
EndIf
```

```
'Call Data Tables and Store Data
```

```
CallTable(TenMin)
```

```
CallTable(Hourly)
```

```
NextScan
```

```
EndPro
```

APPENDIX J – PHOTOGRAPHS OF 80M MAST EQUIPMENT INSTALLED**82m Anemometer****80m Ultrasonic NW Anemometer**



80m SE Anemometer



78m NW Wind Vane



78m SE Wind Vane



70m NW Anemometer



70m SE Anemometer



50m NW Anemometer



50m SE Anemometer



Installed Access Hatch 80m Mast



Installed Fall Arrest System 80m Mast

Photographs of 50m Mast Equipment Installed**52m Anemometer****50m NW Ultrasonic**



50m SE Anemometer



48m NW Wind Vane



48m SE Wind Vane



40m NW Anemometer



Installed Wind Turbine Booms 50m Mast



Installed DLP 50m Mast



Installed Access Hatch 50m Mast