

**Energy Research and Development Division  
FINAL PROJECT REPORT**

**THE USE OF WIND BARRIERS TO  
MITIGATE THE EFFECT OF WIND ON  
AIR-COOLED CONDENSERS**

**Appendix A: Instrumentation and Data  
Acquisition System — Howden Report  
No. ECD 1307**

Prepared for: California Energy Commission  
Prepared by: Maulbetsch Consulting



JULY 2016  
CEC-500-2016-047-APA

**ECD1307 (Caithness 2013)**

Measurements on Fan 3.4 (34ELF9) at  
different wind conditions.  
Location Caithness Power Generation Station  
Yaphank USA

H.J.B.Olthof

Tel: **+31 74 2556044** E-mail: [harry.olthof@howden.nl](mailto:harry.olthof@howden.nl)

Project 800029

Distribution:

SV

# Set-up sensors on Fan 3.4 (34ELF9 Caithness) measuring at different wind conditions.



## Summary.

To start the measurements on the ACC at the Caithness Generation Plant in Yaphank, USA a number of sensors are positioned around Fan 3.4.

This report presents the position of the sensors and the first measurements and monitoring at different wind conditions.

Measuring over a period of one year (December 2013 – December 2014).

## Table of contents.

1. General.
2. The Caithness installation.
3. Sensors.
  - 3.1 Temperature sensor.
  - 3.2 Wind speed and direction sensor.
  - 3.3 Tacho sensor.
  - 3.4 Tape sensor.
  - 3.5 Flow sensor.
  - 3.6 Amps sensor.
  - 3.7 Force sensor.
  - 3.8 Pressure sensor.
  - 3.9 Cabinet.
4. Calibration

## Set-up sensors on Fan 3.4 (34ELF9 Caithness) measuring at different wind conditions.



### 1. General.

Howden wants to know more about the dynamical behavior of GRP cooling fans at different conditions in field applications.

We will do this on the ACC at Caithness Power Generation Station Yaphank USA  
ACC with 18 fans Howden 34ELF9 (horizontal)

This rapport gives an explanation more in detail of the sensors.

### 2. The Caithness installation.

Howden wants to measure on the ACC at Caithness Power Plant at Yaphank USA by remote control.

The measurement is controlled in Europe via an internet connection. From the weather station at the Brookhaven Airport nearby we know that the main wind direction the last years is West to South-West.

Fan 3.4 is situated at the West side of the ACC and also in the main wind direction.

This fan is mostly running with more operational hours.



Fig 1. Caithness ACC

#### Fan 3.4 data:

Fan type:	34ELF9
Air flow:	610 m <sup>3</sup> /s (measured 800 m <sup>3</sup> /s)
Static Pressure:	123 Pa
Blade number:	9
Fan speed high:	93 rpm
Fan speed low:	47 rpm
Blade tip speed:	51 m/s
Blade tip angle:	6.8°
Fan shaft power:	116 kW

From October 29<sup>th</sup> till November the 19<sup>th</sup> 2013 Michael Smith (Howden Technology GB) and Harry Olthof (Howden Cooling Fans NL) placed the 64 sensors on the ACC.  
(software assistance from Ayodele Olukotun (Howden Technology GB))  
See also the work plan ECD922b.

We appreciate the good corporation from Bill Wareham (Plant Manager Siemens/Caithness) , Jason Middleton (Plant Engineer Siemens/Caithness) and staff.

**Set-up sensors on Fan 3.4 (34ELF9 Caithness) measuring at different wind conditions.**

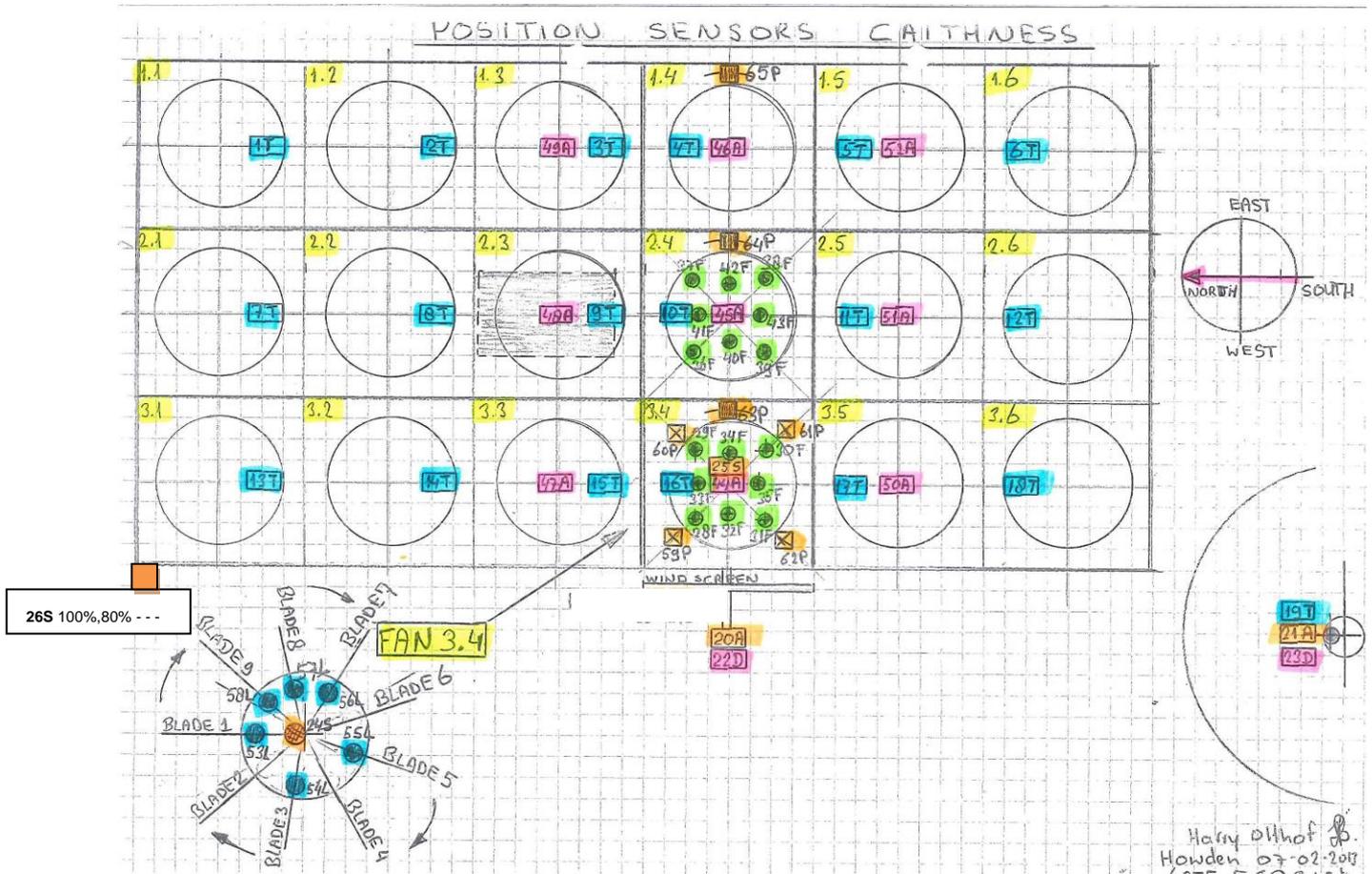


**3. Sensors.**

Nr.	Sensor	Purpose	Number
a.	Temperature	Measuring the temperature of the air and at all the cells.	19
b.	Wind speed	Measuring the wind speed in front of the wind screen, at the ACC	1
c.	Wind speed	Measuring the main wind speed on a vessel nearby the ACC	1
d.	Wind direction	Measuring the wind direction in front of the wind screen, at the ACC	1
e.	Wind direction	Measuring the wind direction on a vessel nearby the ACC	1
f.	Tacho	Measuring 1.the position of the fan, pulsation. 2. running, stand still 3.Revolutions per minute.	2
g.	Pulse	Measuring the position of the wind screen, open, half open, closed	1
h.	Flow	Measuring the flow at fan 3.4 and 2.4	16
i.	Amps	Measuring the amps on the E-motor cables of 9 cells	9
j.	Force	Measuring the force in the bolts of six blades.	6
k.	Pressure	Measuring the pressure at fan 3.4, 2.4 and 1.4	7
Total			64

(see also report ECD1306 and ECD1304)

This drawing gives the position of every sensor.



**Fig.2 Position of all the sensors.**

## Set-up sensors on Fan 3.4 (34ELF9 Caithness) measuring at different wind conditions.

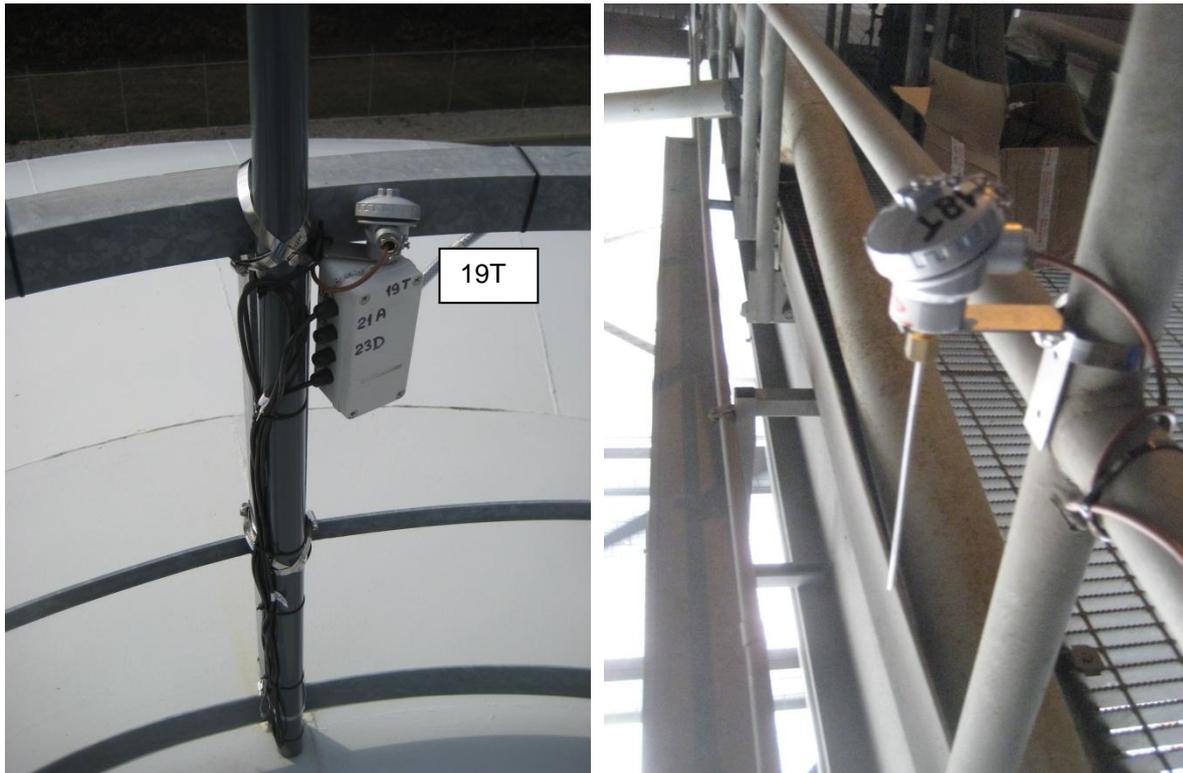
The sensors more in detail.

### 3.1 Temperature sensor 01T-18T and 19T.

On every cell the incoming air temperature is measured (at the bridge).

Also on the met mast at the top of the vessel there is a temperature sensor T19.

Sensors 1T, 2T, 3T, 4T, 5T, 6T, 7T, 8T, 9T, 10T, 11T, 12T, 13T, 14T, 15T, 16T, 17T, 18T and 19T.



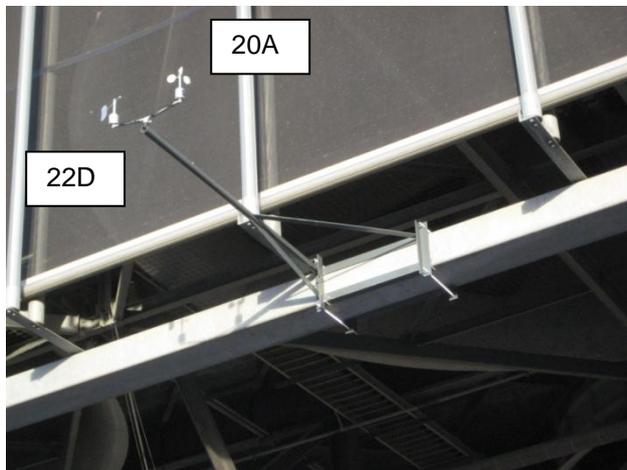
**Fig.3 Temperature sensors.**

### 3.2 Wind Speed 20A-21A and Wind direction 22D-23D.

The wind vane (23D) measure the main wind direction at the meteo mast on top of the vessel (South-West).

Also a wind vane (22D) is positioned at the front of the wind screen (2 meter) at Fan 3.4. On the same meteo masts the wind speed (21A) is measured with an anemometer. Also one (20A) is positioned at the front of the wind screen at Fan 3.4.

Set-up sensors on Fan 3.4 (34ELF9 Caithness) measuring at different wind conditions.



**Fig.4 Wind sensors**

## Set-up sensors on Fan 3.4 (34ELF9 Caithness) measuring at different wind conditions.



### 3.3 Tacho sensor 24S and 25S.

At the gearbox shaft, the tacho sensor 25S is placed in horizontal direction to give the exact position of blade 1 (North) 24S and the RPM (half/full speed) 25S of the fan.



### 3.4 Tape sensor 26S.

At the North-West windscreen motor, the tape sensor 26S measures the position of the windscreen.

(open, 100% = 0,2m, 80%, 60%, 40%, 20%, closed = 4,8m).

### 3.5 Flow sensors 28F-35F and 36F-43F.

With 8 flow sensors (propeller anemometer) the velocity of the incoming air is measured at Fan 3.4. The position is under the fan and the protecting grid.

The sensors 28F, 29F, 30F and 31F are positioned at a radius of  $0.8R = 4140$  mm.

The sensors 32F, 33F, 34F and 35F are positioned at a radius of  $0.6R = 3100$  mm.  
( $D=2R=10355$ mm)

Also the sensors 36F, 37F, 38F and 39F ( $0.8R=4140$ mm) and 40F, 41F, 42F and 43F ( $0.6R=3100$ mm) are positioned at Fan 2.4.

The rotor of the propeller anemometer is robust and made off carbon fiber thermoplastic (dirt, birds) diameter 200mm.

Set-up sensors on Fan 3.4 (34ELF9 Caithness) measuring at different wind conditions.

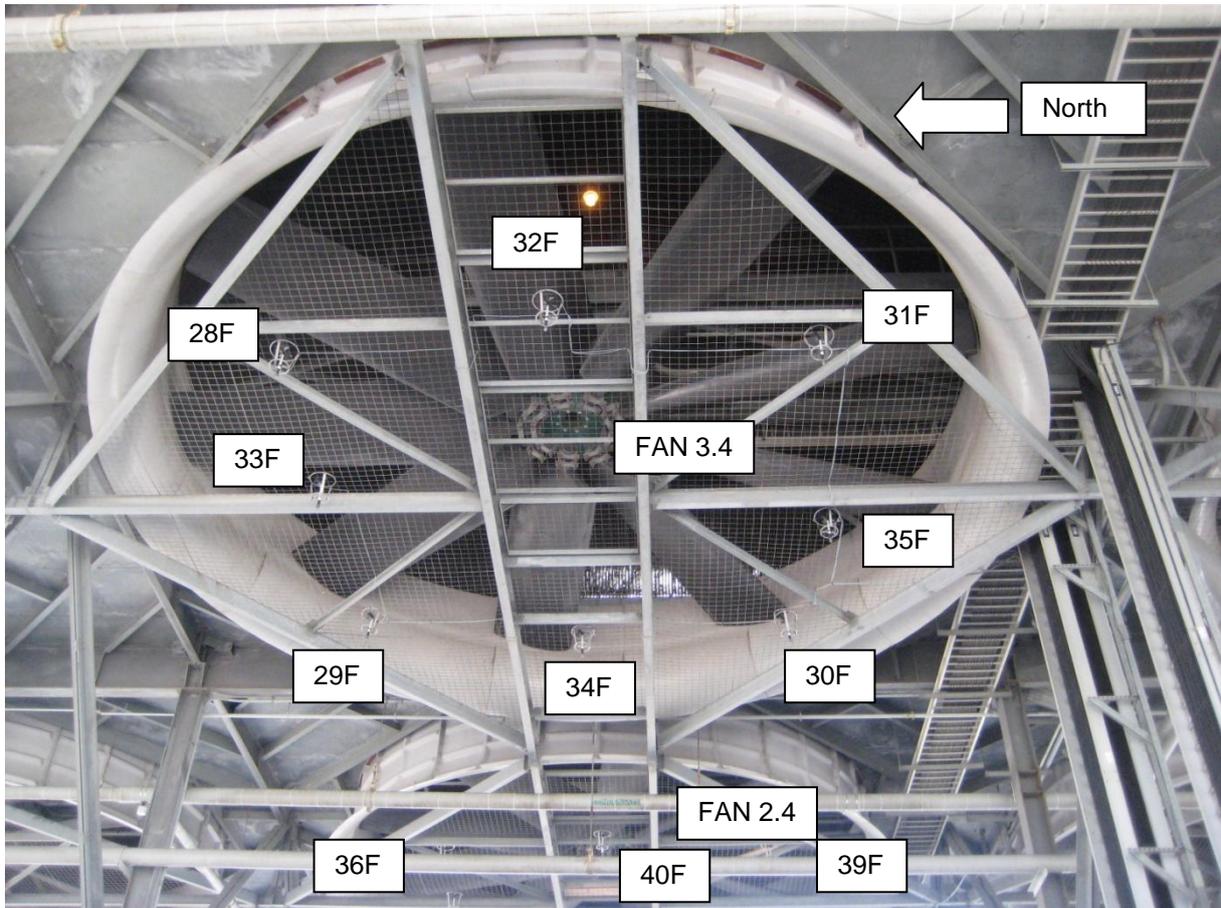


Fig. 5 Positions of the flow sensors on the grid.

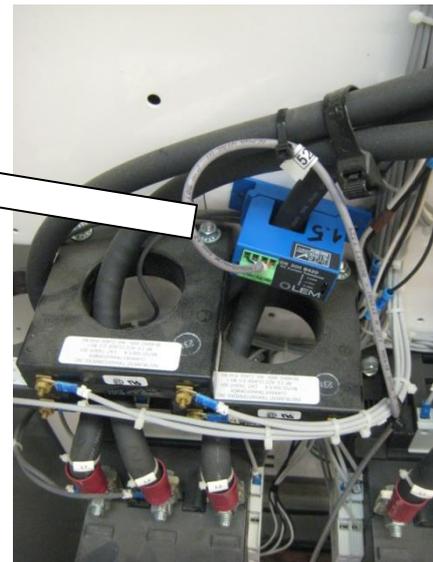


**Set-up sensors on Fan 3.4 (34ELF9 Caithness) measuring at different wind conditions.**

**3.6 Amps sensor 44A-52A.**

On the E-motor cables of some fans a sensor is mounted to measure the amps at a full speed. This sensor is connected at 44A Fan 3.4, 45A Fan 2.4, 46A Fan 1.4, 47A Fan 3.3, 48A Fan 2.3, 49A Fan 1.3, 50A Fan 3.5, 51A Fan 2.5 and 52A Fan 1.5.

The connections are made on the cables at the switch house. It is now possible to measure the influence of the wind to the Fan power and it is visible which fans are running or are in a stand still position.



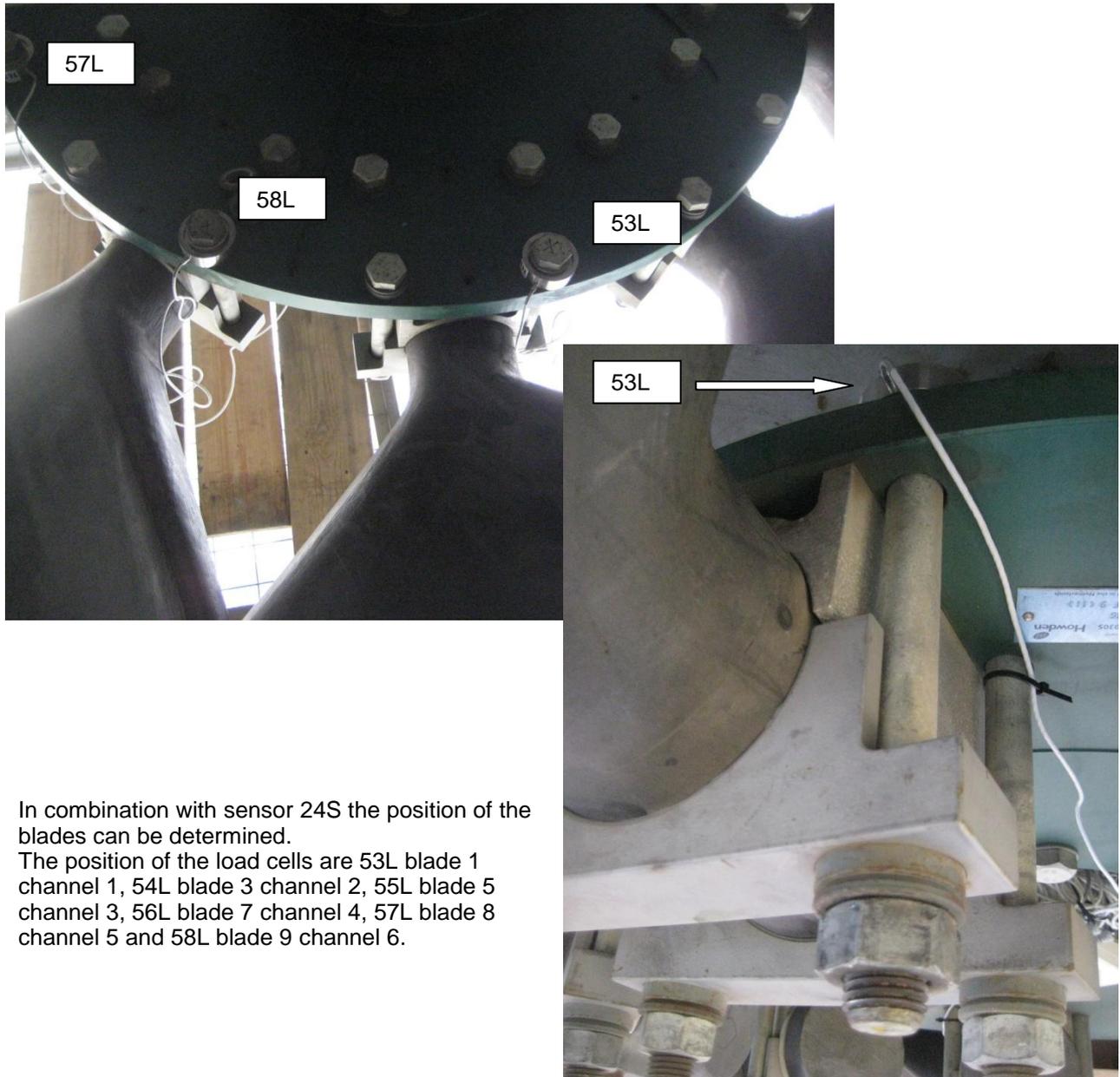
**Fig. 6 Amps sensor**

**Set-up sensors on Fan 3.4 (34ELF9 Caithness) measuring at different wind conditions.**



**3.7 Force sensor 53L-58L.**

With six donut load cells the dynamical and statical force in the bolts and the movement (bending moment) of the blades is measured at Fan 3.4.



In combination with sensor 24S the position of the blades can be determined.

The position of the load cells are 53L blade 1 channel 1, 54L blade 3 channel 2, 55L blade 5 channel 3, 56L blade 7 channel 4, 57L blade 8 channel 5 and 58L blade 9 channel 6.

**Fig. 7 Force sensors**

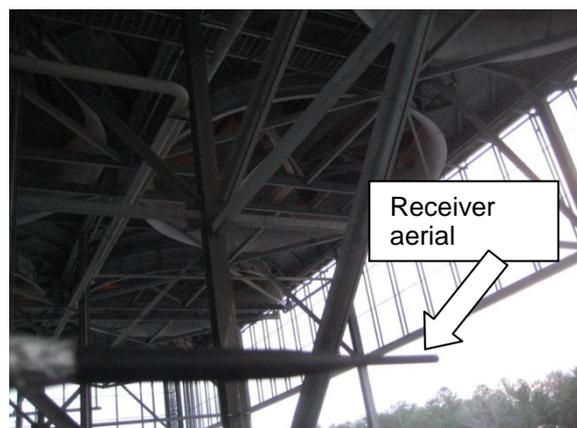
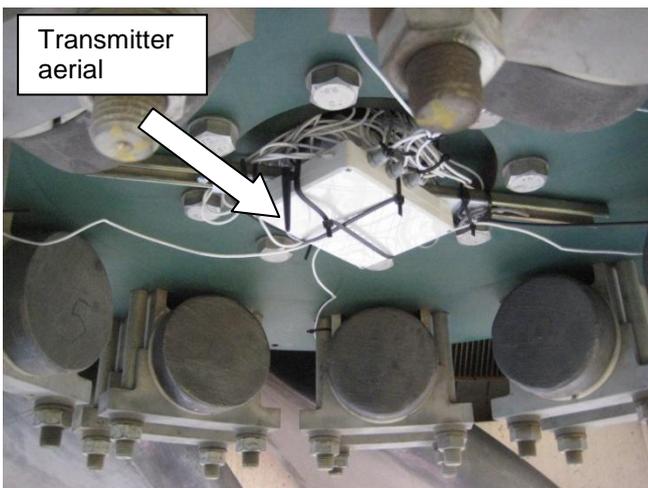
The signals from the load cells are transmitted with the V-link transmitter on the rotating hub. This transmitter is powered with a RF power system at the gear box.

Set-up sensors on Fan 3.4 (34ELF9 Caithness) measuring at different wind conditions.



The static coil is connected under the gear box and the rotating coil is connected to the gear box shaft

The signals from the load cells are transmitted from the V-link (in the white box on the hub) to the receiver in the cabinet.



## Set-up sensors on Fan 3.4 (34ELF9 Caithness) measuring at different wind conditions.

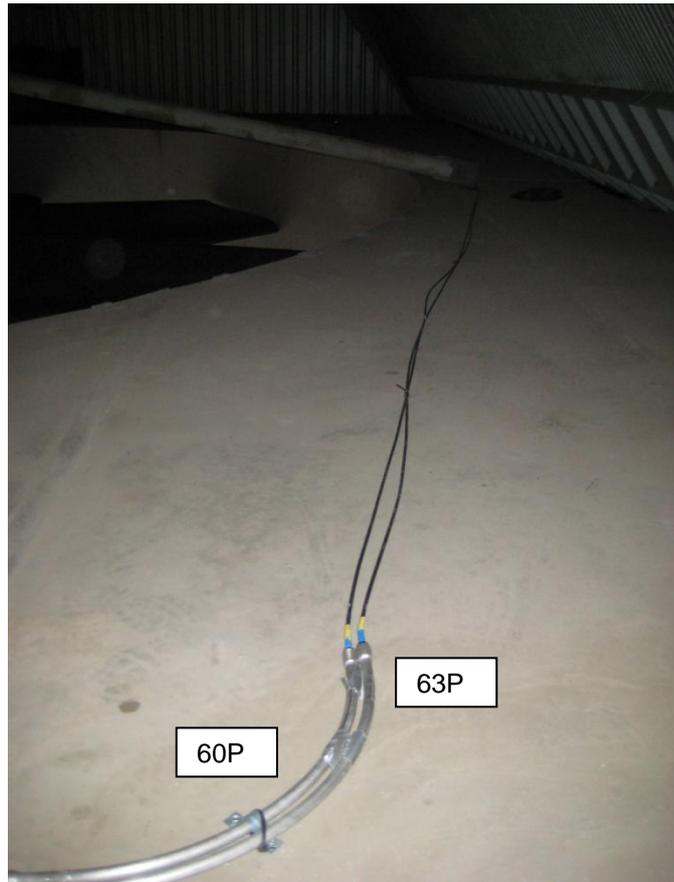
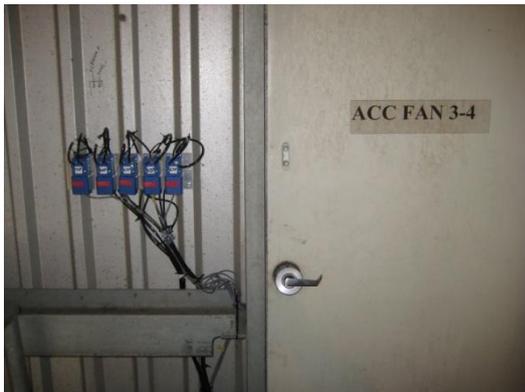
### 3.8 Pressure sensor 59P-65P.

On the plenum of Fan 3.4 there are four pressure sensors in the corners to measure the pressure. These are sensor 59P, 60P, 61P and 62P.

An extra sensor 63P is measuring the average pressure on the plenum.

Also at Fan 2.4 (64P) and at Fan 1.4 (65P) the average pressure is measured.

The sensors are connected to plastic hoses and pipes with holes of 2 mm



**Fig.8 Pressure sensors**

### 3.9 Cabinet in ACC switch house.

All the sensor signals will be processed in the device with the Data Logging Software at the Rio computer.

The program will store all the values, 24/7 for one year

The computer is connected to the internet and can be remotely controlled from Europe.

The computer and all the wires from the 64 sensors are connected in a cabinet at the switch house below Fan 2.3.

Also 2x hard disc drives will store all the data.

**Set-up sensors on Fan 3.4 (34ELF9 Caithness) measuring at different wind conditions.**



With the dash board it is possible to see directly live, the status of all the sensors.



**Fig.9 Cabinet inside and the dash board screens.**

**Set-up sensors on Fan 3.4 (34ELF9 Caithness) measuring at different wind conditions.**



**4 Calibration.**

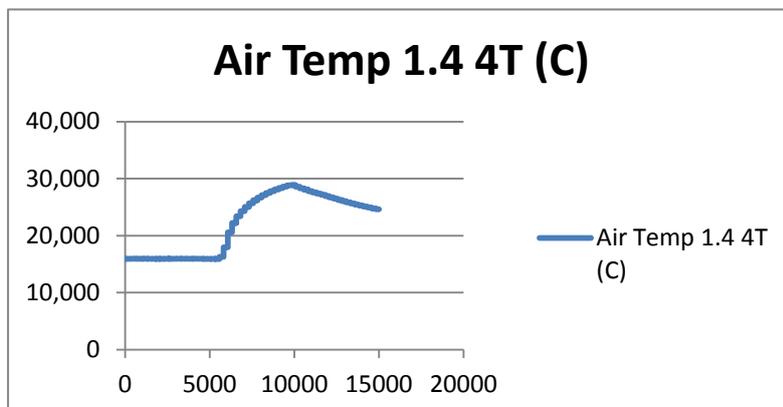
**Temperature sensors.**

*Measured temperature air on bridge.*

*Measured temperature sensor.*

*Heated up by hand.*

<b>Temperature sensors on Monday 11-18-2013</b>					
Sensor	Fan	Time	Temperature Measured	Temperature Sensor	Difference %
01T	1.1	10:23	16.1	15,5	4
02T	1.2	10:24	16.0	15,9	1
03T	1.3	10:26	16.0	15,7	2
04T	1.4	10:27	16.0	15,9	1
05T	1.5	10:28	15.9	15,9	0
06T	1.6	10:29	15.9	16,5	4
07T	2.1	10:33	16.0	16,1	1
08T	2.2	10:34	16.0	16,4	3
09T	2.3	10:35	16.2	16,5	2
10T	2.4	10:36	16.3	16,1	1
11T	2.5	10:37	16.2	15,6	4
12T	2.6	10:39	16.1	16,1	0
13T	3.1	10:42	16.4	16,1	2
14T	3.2	10:44	16.3	16,2	1
15T	3.3	10:45	16.3	16,5	1
16T	3.4	10:46	16.3	16,5	1
17T	3.5	10:47	16.4	16,5	1
18T	3.6	10:48	16.2	16,3	1
19T	Top Vessel	10:10	17.0	17,3	2
<i>Wind direction</i>					
23D	Top Vessel	10:06	North		
		10:07	East		
		10:08	South		
		10:09	West		



*Measured temperature on sensor, then heated up by hand.*

Set-up sensors on Fan 3.4 (34ELF9 Caithness) measuring at different wind conditions.



**Pressure sensors**

**Running Fan 2.4 and 3.4 and measuring pressure. Date 11-17-2013. Time 15:59 till 16:04.**

Doors open Fan 3.4 30Pa  
 Doors closed Fan 3.4 35Pa  
 Doors open Fan 2.4 60Pa  
 Doors closed Fan 2.4 80Pa

**Load sensors**

**Date 11-17-2013 Load cell Load 1100 N position 4,4 meter from clamping piece (Moment 4840 Nm)**

Blade	No load Volt	With load Volt	Sensor	Channel	Time	Difference Volt	Moment Nm
1	1.3004	1.2817	53L	1	10:08	-0.0187	4840
2	-	-	-	-	-		
3	1.3286	1.3129	54L	2	10:11	-0.0157	4840
4	-	-	-	-	-		
5	1.2770	1.2574	55L	3	10:13	-0.0196	4840
6	-	-	-	-	-		
7	1.3349	1.3188	56L	4	10:16	-0.0161	4840
8	1.6886	1.7058	57L	5	10:19	0.0172	4840
9	1.7192	1.7366	58L	6	10:22	0.0174	4840

Puls = Blade 1 pointing to North

**Tape sensor**

11-17-2013

**Fan 3.4 on full speed**

Screen closed 13:56  
 Screen half open 13:58  
 Screen open 14:00  
 Screen half open 14:01  
 Screen closed 14:02

**Fan 2.4 and 3.4 on full speed**

Screen closed 14:40  
 Screen half open 14:41  
 Screen open 14:42  
 Screen half open 14:43  
 Screen closed 14:44

Set-up sensors on Fan 3.4 (34ELF9 Caithness) measuring at different wind conditions.



Weather situation at Airfield Brookhaven Long Island in November.

### Weather History for KNYSHIRL3

JJD Weather, Shirley, NY — [Current Conditions](#)

See this PWS on the [New Dashboard](#)

Temperature  
**74.6°**

**November, 2013**

« Previous Month

November
25
2013
View

Next Month »

Daily
Weekly
Monthly
Yearly
Custom

	High:	Low:	Average:
Temperature:	18.1 °C	-4.6 °C	7.1 °C
Dew Point:	15.4 °C	-21.2 °C	1.4 °C
Humidity:	89.0%	21.0%	68.7%
Wind Speed:	24.1km/h from the West	-	5.2km/h
Wind Gust:	48.3km/h from the NNW	-	-
Wind:	-	-	SW
Pressure:	1038.8hPa	1001.6hPa	-
Precipitation:	26.2mm		

#### KNYSHIRL3 Weather Graph for November 2013