



Committente:

**RWE**

RWE RENEWABLES ITALIA S.R.L.  
via Andrea Doria, 41/G - 00192 Roma  
P.IVA/C.F. 06400370968

Titolo del Progetto:

**PARCO EOLICO "ALAS 2"**

- Comuni di Ittiri e Villanova Monteleone (SS) -

Documento:

ANEMOLOGIA

N° Documento:

**PEALAS2-RC19**

ID PROGETTO:

**ALAS 2**

SEZIONE:

**A**

TIPOLOGIA:

**T**

FORMATO:

**A4**

Elaborato:

**STUDIO ANEMOLOGICO DI ANALISI DI PRODUCIBILITÀ**

FOGLIO:

SCALA:

Nome file:

PEALAS2-RC19 Studio anemologico e analisi producibilità

A cura di:

**RWE**

RWE RENEWABLES ITALIA S.R.L.  
via Andrea Doria, 41/G - 00192 Roma  
P.IVA/C.F. 06400370968

Rev:	Data Revisione	Descrizione Revisione	Redatto	Controllato	Approvato
00	24/10/2023	PRIMA EMISSIONE	RWE	RWE	RWE

## I. Indice

1. Introduzione.....	2
2. Descrizione del sito .....	2
3. Risorsa Eolica e Producibilita' .....	4
3.1 Caratteristiche delle Stazione di Misura .....	4
3.2 Profilo verticale del vento .....	8
3.3 Correlazione di lungo periodo.....	9
3.4 Stima della produzione nel lungo periodo .....	10
3.5 Software SiteWind .....	10
3.6 Software OpenWind .....	11
3.7 Producibilità lorda.....	12
3.7 Perdite energetiche generali.....	13
3.8 Risultati .....	16
Appendice .....	18
Report di installazione – Anemometro Ittiri .....	18
Report di installazione – Anemometro Villanova .....	30
Certificati di calibrazione – Anemometro Ittiri .....	41
Certificati di calibrazione – Anemometro Villanova .....	74

## 1. Introduzione

Il presente documento rappresenta la valutazione preliminare di ventosità e di produzione del sito eolico situato nel comune di Villanova Monteleone, Provincia di Sassari (Sardegna). Il progetto ha una potenza massima di immissione in rete complessiva pari a 50,4 MW e consiste nella installazione di 7 aerogeneratori il cui modello commerciale di riferimento risulta avere le seguenti caratteristiche dimensionali: diametro del rotore pari a 170 m ed una altezza la mozzo pari a 115 m.

## 2. Descrizione del sito

L'area di ubicazione degli aerogeneratori è caratterizzata da una complessità orografica media con un' altezza compresa tra 382 e 462 metri sul livello del mare.

Attualmente, l'uso del suolo è in gran parte agricolo. Vi è scarsa copertura vegetazionale arborea e perciò l'area di studio si caratterizza per una rugosità media, caratteristica favorevole per lo sfruttamento eolico.

Gli aerogeneratori sono stati posizionati a livello territoriale sulla base di un criterio di massimo sfruttamento della risorsa eolica e di ottimizzazione della resa energetica dell'impianto tenendo conto dei vincoli tecnici, ambientali e paesaggistici.

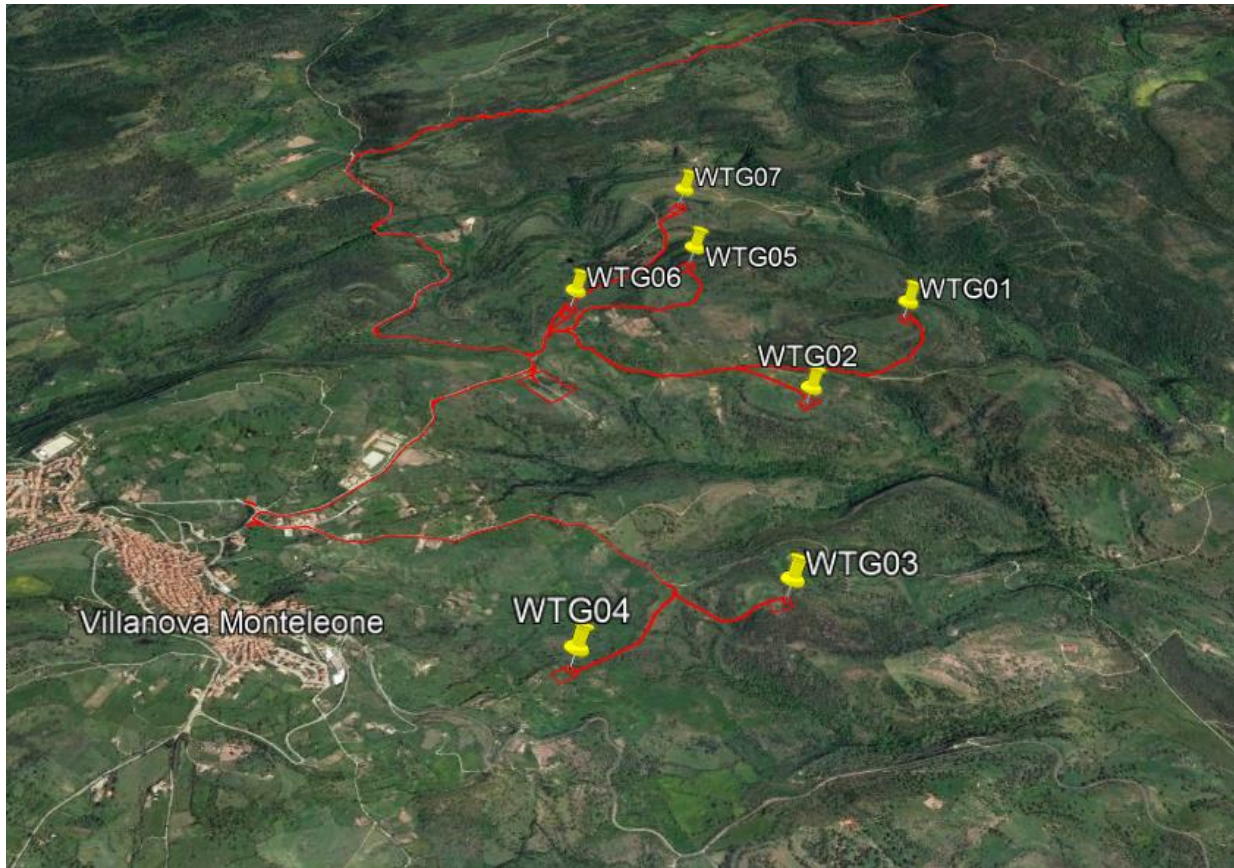


FIGURA 1 - INQUADRAMENTO PARCO EOLICO "ALAS 2"

Si riportano nella tabella seguente le coordinate geografiche di ubicazione delle turbine nel sistema di riferimento UTM WGS84.

ID Turbina	Est	Nord	Comune
WTG01	457931	4485434	VILLANOVA MONTELEONE
WTG02	457479	4484862	VILLANOVA MONTELEONE
WTG03	457301	4483715	VILLANOVA MONTELEONE
WTG04	456560	4483366	VILLANOVA MONTELEONE
WTG05	457073	4485750	VILLANOVA MONTELEONE
WTG06	456568	4485444	VILLANOVA MONTELEONE
WTG07	457055	4486286	VILLANOVA MONTELEONE

TABELLA 1 – COORDINATE GEOGRAFICHE DI UBICAZIONE DELLE TURBINE NEL SISTEMA DI RIFERIMENTO

### 3. Risorsa Eolica e Producibilita’

#### 3.1 Caratteristiche delle Stazione di Misura

Per la caratterizzazione anemologica del sito sono stati utilizzati i dati misurati presso le stazioni di misurazione anemometrica installate sul sito dalla RWE Renewables Italia Srl in data 20/11/2020 nel Comune di Ittiri, presso la turbina WTG03 dell’impianto “Alas”<sup>1</sup> e in data 13/03/2021 nel Comune di Villanova Monteleone presso la turbina WTG07 dello stesso impianto.

La stazioni anemometriche sono state installate seguendo le norme IEC 61400 per quanto riguarda il posizionamento dei sensori e le dimensioni caratteristiche delle diverse parti che compongono la sua struttura.

Si riportano nella seguente tabella le coordinate della posizione delle stazioni anemometriche nel sistema di riferimenti UTM WGS 84 Fuso 32.

ID	Est	Nord	Altitudine
Stazione anemometrica Ittiri	461974	4489916	452 m
Stazione anemometrica Villanova	459500	4489050	470 m

TABELLA 2 – COORDINATE GEOGRAFICHE DI UBICAZIONE DELLE STAZIONE ANEMOMETRICHE

In appendice sono allegati:

- Report di installazione
- Certificati di Calibrazione dei sensori

**Le stazioni presentano le seguenti caratteristiche:**

#### **Stazione Anemometrica Ittiri:**

- Altezza: 99 metri
- Periodo di misurazione: 20 novembre 2020 / 23 marzo 2023.

#### **Stazione Anemometrica Villanova:**

<sup>1</sup> L'impianto eolico "Alas" è stato presentato da RWE Renewables Italia nel 16/12/2020 presso il Ministero dell’Ambiente e della Sicurezza Energetica.

- Altezza: 99 metri
- Periodo di misurazione: 15 marzo 2021 / 23 marzo 2023.

Si riportano nelle seguenti tabelle le caratteristiche dei sensori installati nelle stazioni anemometriche.

Strumento	Altezza (m)	Sensore	Tipo	Numero di serie	Orientazioni (°)	Copertura dei dati (%)
AN1	99	Anemometro	THIES F.C.	01180272	Top	82,49
AN2	95	Anemometro	THIES F.C.	07101411	25	99,50
AN3	95	Anemometro	RISOE P2546C	40655	205	99,17
AN4	74	Anemometro	THIES F.C.	0207766	25	99,41
AN5	74	Anemometro	RISOE P2546C	40657	205	99,55
AN6	49	Anemometro	THIES F.C.	0709397	25	99,55
AN7	49	Anemometro	RISOE P2546C	70978	205	99,54
WV1	93	Bandaruola	THIES F.C.	10200118	25	99,55
WV2	47	Bandaruola	THIES F.C.	1020119	25	99,55
T1	96	Termometro	VAISALA HMP155	1830818	-	99,50
T2	46	Termometro	VAISALA HMP155	1830821	-	99,55
Pressure	96	Barometro	THIES		-	99,59
Logger		Data Logger	ORBIT 360	5774312697		

TABELLA 3 - SENSORI INSTALLATI NELLA STAZIONE ANEMOMETRICA DI ITTIRI

Strumento	Altezza (m)	Sensore	Tipo	Numero di serie	Orientazioni (°)	Copertura dei dati (%)
AN1	99	Anemometro	Thies FC Advanced II 4.3351.10.000	01212599	Top	89,40
AN2	95	Anemometro	Thies FC Advanced II 4.3351.10.000	01212600	25	93,04
AN3	95	Anemometro	RiSo WS P2546C-OPR	40656	205	93,24
AN4	74	Anemometro	Thies FC Advanced 4.3351.10.000	01212595	25	93,94
AN5	74	Anemometro	RiSo WS P2546C-OPR	40654	205	94,05
AN6	74	Anemometro	Thies FC Advanced 4.3351.10.000	01212590	25	94,52
AN7	74	Anemometro	RiSo WS P2546C-OPR	40653	205	94,38

WV1	93	Bandaruola	Thies FC 4.3151.00.173	12200127	205	99,52
WV2	47	Bandaruola	Thies FC 4.3151.00.173	12200131	205	99,52
T1	96	Termometro	Vaisala HMP155	S4941089	0	99,52
T2	46	Termometro	Vaisala HMP155	S4941090	0	99,52
Pressure	97	Barometro	Thies 3.1157.10.000	1210246	-	99,51
Logger		Data Logger	Kintech Orbit 360	7212412928		

TABELLA 4 - SENSORI INSTALLATI NELLA STAZIONE ANEMOMETRICA DI VILLANOVA MONTELEONE

Ciascun sensore anemometrico è stato calibrato da parte di una struttura accreditata dal MEASNET. La stazione è conforme alle raccomandazione della IEC (IEC, 2017).

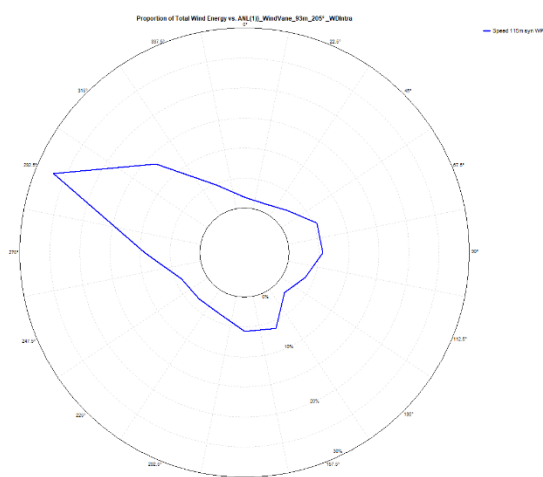


FIGURA 2 - ROSA DEI VENTI DEL SITO "ALAS 2"

m/s	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0-0,5	0,051	0,076	0,046	0,036	0,044	0,046	0,025	0,046	0,040	0,027	0,044	0,038
0,5-1,5	0,303	0,282	0,432	0,482	0,586	0,558	0,421	0,464	0,352	0,312	0,394	0,314
1,5-2,5	0,544	0,449	0,527	0,754	1,003	1,013	0,910	0,537	0,598	0,619	0,948	0,940
2,5-3,5	0,752	0,624	0,605	0,763	0,917	1,567	1,176	0,660	0,596	0,849	1,616	1,612
3,5-4,5	0,803	0,617	0,666	0,801	0,815	1,664	1,525	0,731	0,636	1,420	2,008	1,730
4,5-5,5	0,740	0,501	0,611	0,891	0,659	1,340	1,441	0,929	0,632	1,475	2,134	1,820
5,5-6,5	0,695	0,364	0,485	1,119	0,638	1,083	1,395	0,693	0,522	1,393	2,075	1,247
6,5-7,5	0,617	0,219	0,453	0,982	0,539	0,954	1,266	0,464	0,440	1,460	1,835	1,106
7,5-8,5	0,324	0,188	0,388	0,885	0,371	0,862	1,222	0,343	0,346	1,045	1,197	0,708
8,5-9,5	0,152	0,236	0,367	0,596	0,247	0,653	0,931	0,247	0,177	0,660	0,900	0,346

9,5-10,5	0,069	0,185	0,251	0,316	0,206	0,343	0,442	0,249	0,183	0,440	0,897	0,209
10,5-11,5	0,019	0,131	0,177	0,169	0,135	0,249	0,164	0,152	0,133	0,396	0,796	0,145
11,5-12,5	0,010	0,070	0,148	0,139	0,105	0,051	0,042	0,089	0,093	0,308	0,796	0,156
12,5-13,5	0,008	0,048	0,133	0,065	0,046	0,011	0,025	0,084	0,059	0,194	0,523	0,095
13,5-14,5	0,002	0,021	0,040	0,042	0,015	0,004	0,019	0,053	0,046	0,133	0,384	0,069
14,5-15,5	0,000	0,004	0,015	0,034	0,004	0,002	0,006	0,019	0,023	0,072	0,238	0,036
15,5-16,5	0,000	0,002	0,002	0,023	0,000	0,000	0,006	0,011	0,029	0,044	0,148	0,034
16,5-17,5	0,000	0,002	0,000	0,010	0,000	0,000	0,002	0,008	0,013	0,027	0,088	0,015
17,5-18,5	0,000	0,000	0,000	0,011	0,000	0,002	0,002	0,006	0,006	0,032	0,112	0,008
18,5-19,5	0,000	0,000	0,000	0,006	0,000	0,000	0,000	0,000	0,004	0,015	0,078	0,000
19,5-20,5	0,000	0,000	0,000	0,006	0,000	0,000	0,000	0,000	0,006	0,002	0,065	0,000
20,5-21,5	0,000	0,000	0,000	0,011	0,000	0,002	0,000	0,000	0,000	0,000	0,057	0,000
21,5-22,5	0,000	0,000	0,000	0,000	0,000	0,002	0,000	0,000	0,000	0,000	0,027	0,000
22,5-23,5	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,006	0,000
23,5-24,5	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,006	0,002
24,5-25,5	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,004	0,002
25,5-26,5	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,004	0,000
26,5-27,5	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
27,5-28,5	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
28,5-29,5	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
29,5-30,5	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Overall	5,088	4,018	5,349	8,141	6,329	10,404	11,017	5,787	4,932	10,924	17,379	10,633

TABELLA 5 - DISTRIBUZIONE DEL VENTO AD ALTEZZA MOZZO



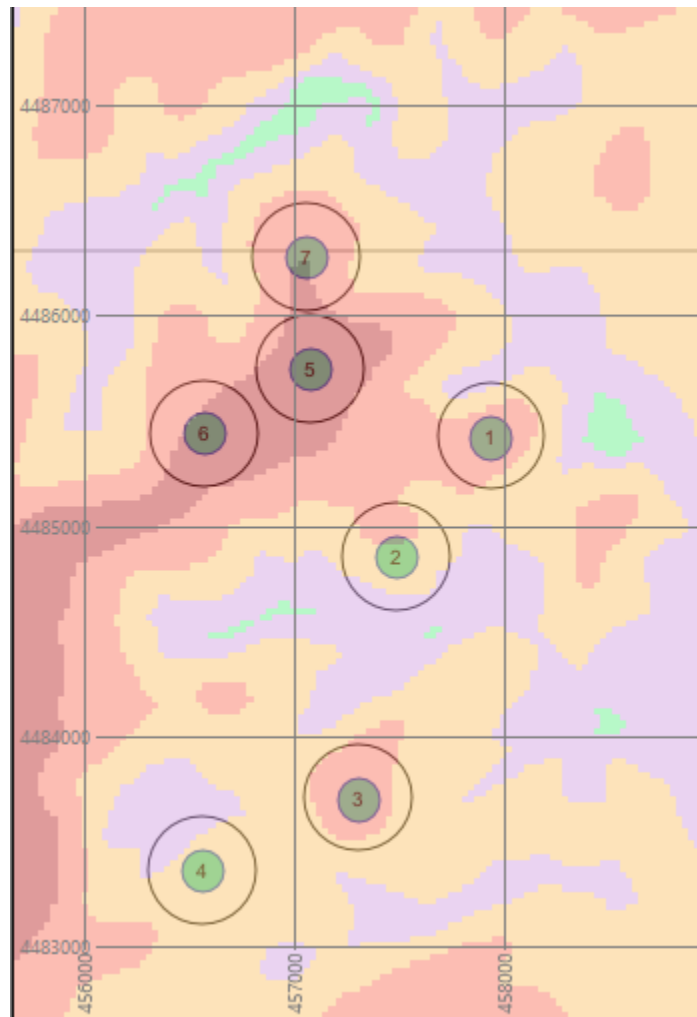


FIGURA 3 - MAPPA DEL VENTO LAYOUT "ALAS 2"

### 3.2 Profilo verticale del vento

La velocità media all'altezza del mozzo è stata estrapolata sulla base della seguente legge di potenza

$$U = U_0 \left( \frac{Z}{Z_0} \right)^p$$

Dove:

U = velocità del vento incognita alla altezza Z dal suolo;

U<sub>0</sub> = valore noto della velocità; alla altezza di riferimento the Z<sub>0</sub>;

p = coefficiente del profilo verticale del vento .

Questa equazione è una relazione empirica ampiamente utilizzata nella valutazione della risorsa eolica. Spesso la difficoltà principale consiste nel determinare l'esponente del profilo verticale tra il sensore posizionato nel punto più alto della stazione anemometrica e l'altezza del mozzo della turbina. Un presupposto comunemente considerato è che l'esponente del profilo verticale non cambia con l'altezza.

Al fine di estrapolare la velocità del vento all'altezza del mozzo pari a 115 m è stato utilizzato il valore dell'esponente del profilo verticale misurato presso la stazione anemometrica. La velocità media del vento prevista, alla altezza del mozzo di 115 m, applicando tale coefficiente risulta pari a 5,94 m/s.

Per la creazione delle distribuzioni di frequenza della velocità del vento all'altezza del mozzo ai fini della modellazione del flusso del vento e dei calcoli della produzione di energia sono stati utilizzati gli esponenti del profilo verticale calcolati per ogni singolo record di 10 minuti presso la stazione anemometrica.

### 3.3 Correlazione di lungo periodo

Per stimare la produzione media di energia durante la vita del progetto, è tipicamente necessario correlare i dati misurati sul sito con i dati a più lungo termine misurati presso una stazione meteorologica (di riferimento) e/o un set di dati di rianalisi su un periodo coerente considerato rappresentativo del lungo termine. Questo metodo implica di stabilire relazioni statistiche tra set di dati simultanei nel sito e quelli delle fonti di riferimento, quindi selezionare fonti di riferimento adeguate in base alla attendibilità di queste relazioni e all'incertezza associata. Queste relazioni vengono prima valutate utilizzando una serie di tecniche e quindi, ove giustificato, viene condotto il processo MCP (Measure – Correlate – Predict) per estendere il periodo di misurazione in loco al fine di renderlo rappresentativo del lungo termine.

È stata condotta una revisione delle fonti di riferimento a lungo termine per determinare se fossero presenti incongruenze in questi set di dati e per escludere potenzialmente qualsiasi fonte di riferimento come non rappresentativa del clima eolico regionale. Per verificare la validità di questi rispettivi dataset in esame, sono stati esaminati gli andamenti annuali della velocità del vento, oltre alle correlazioni tra le fonti di riferimento di lungo periodo.

Le equazioni di regressione lineare sono state determinate utilizzando le velocità medie giornaliere del vento simultanee presso la stazione di Ittiri e ogni potenziale riferimento. La correlazione più forte è stata trovata con la stazione di riferimento VORTEX ERA5 ( $r^2 = 0.89$ ).

Sito	Fonte di riferimento	Altezza di misura (m)	R2	Velocità media misurata (m/s)	Velocità del vento di lungo termine (m/s)
Ittiri	Vortex ERA5	99	0,894	5,737	5,864

TABELLA 6 – CORRELAZIONE TRA VELOCITÀ DEL VENTO MISURATA E A LUNGO TERMINE

### 3.4 Stima della produzione nel lungo periodo

La produzione di energia del progetto "Alas 2" proposto è stata stimata utilizzando il software Openwind®.

Openwind è stato sviluppato da AWS Truepower ed è un software specialistico a supporto per la progettazione, l'ottimizzazione e la valutazione di progetti di energia eolica. L'input primario è una griglia di risorse eoliche generata da un modello numerico del flusso del vento, in questo caso il sistema SiteWind®. Altri input includono elementi del layout e le specifiche tecniche come le posizioni della turbina, l'altezza del mozzo, la curva di potenza e i coefficienti di spinta delle turbine. Il sistema SiteWind e il software Openwind e le loro applicazioni in questo progetto sono brevemente descritti di seguito.

### 3.5 Software SiteWind

I modelli numerici del flusso del vento vengono utilizzati per calcolare la variazione della risorsa eolica in un'area del progetto a causa delle variazioni del terreno e della rugosità superficiale.

AWS Truepower ha sviluppato il sistema SiteWind per eseguire questi calcoli.

SiteWind utilizza modelli su mesoscala e microscala per simulare il clima del vento su un'ampia gamma di scale. Il modello su mesoscala valuta le condizioni climatiche regionali e simula complessi fenomeni meteorologici come i venti catabatici (discendenti), la canalizzazione attraverso i passi di montagna, le brezze lacustri e marine, i getti di bassa quota e le inversioni di temperatura. Il modello in microscala tiene conto delle influenze localizzate della topografia e dei cambiamenti di rugosità della superficie e produce una mappa e una griglia dettagliate delle risorse eoliche. Come passaggio finale, la velocità e la direzione previste vengono correlate con i dati misurati in sito provenienti dagli anemometri installati all'interno dell'area del progetto.

Questo metodo è risultato essere più accurato nel complesso rispetto ai soli modelli di flusso del vento su microscala.

Il modello su mesoscala utilizzato per questa analisi è il Mesoscale Atmospheric Simulation System (MASS), un modello meteorologico utilizzato in applicazioni commerciali e di ricerca.

MASS è stato eseguito in una serie di griglie annidate, con la griglia più interna con una risoluzione spaziale di 1,2 km. Utilizzando i dati meteorologici regionali, MASS ha simulato le condizioni meteorologiche storiche per un campione rappresentativo di giorni. L'output di MASS è stato quindi accoppiato a WindMap – un modello a conservazione di massa – che è stato elaborato su una scala di 50 m. Infine, l'output di WindMap è stato adattato sulla base della velocità del vento e della distribuzione della direzione del vento misurate all'anemometro di sito.

### 3.6 Software OpenWind

Una volta elaborato il modello della risorsa eolica, il file della griglia viene importato in Openwind per definire la risorsa eolica per l'area del progetto. I parametri Weibull nel file vengono convertiti in rapporti di accelerazione mettendo in relazione la velocità del vento in ciascun punto della griglia, con la velocità in corrispondenza dell'anemometro di riferimento. Associando i dati del modello a un file di istogramma della velocità del vento per l'anemometro di riferimento, il programma è in grado di aggiustare la distribuzione della velocità sulla base della distribuzione della velocità reale osservata nel punto di misura. Questo metodo di solito produce una stima più accurata della produzione di energia rispetto all'affidarsi alle sole distribuzioni del vento modellate.

AWS Truepower utilizza l'Openwind Deep Array Wake Model (DAWM) per calcolare le perdite energetiche per effetto di scia. Questo modello contiene in realtà due modelli di calcolo delle scie separati che operano in modo indipendente. Il primo è il modello Eddy Viscosity, che si basa sull'approssimazione agli elementi finiti delle equazioni di Navier-Stokes assumendo scie assialmente simmetriche con forma Gaussiana della sezione trasversale, come originariamente postulato da Ainslie. Le equazioni del modello assicurano che la quantità di moto e la conservazione della massa siano osservate simultaneamente.

Come input, il modello di scia richiede l'intensità della turbolenza ambientale all'altezza del mozzo, che influenza il deficit di scia iniziale dietro ogni turbina e la velocità di dissipazione della scia; la distribuzione della frequenza di velocità e direzione, basata su una griglia della risorsa

eolica e sui file degli anemometri associati; le posizioni delle turbine; e le curve del coefficiente di spinta della turbina.

In risposta all'evidenza che i modelli di scia convenzionali come il modello Eddy Viscosity sottostimano le perdite di scia in array profondi (multi-file) di turbine eoliche, AWS Truepower ha implementato un secondo modello progettato per gestire tali situazioni. Questo modello è basato su una teoria sviluppata da Frandsen, il quale ha postulato che l'effetto di un layout di turbine eoliche sull'atmosfera potrebbe essere rappresentato come una regione di maggiore resistenza superficiale, rappresentata da una specifica lunghezza di rugosità superficiale. Dal momento in cui il flusso del vento investe la prima fila di turbine, viene creato uno strato limite interno (IBL), all'interno del quale il profilo del vento è determinato dalla rugosità determinata dal layout piuttosto che dalla rugosità ambientale. Questo IBL cresce con la distanza sottovento tra le turbine, e una volta che la sua altezza supera l'altezza del mozzo della turbina, la velocità dell'altezza del mozzo che colpisce le turbine più lontane sottovento viene progressivamente ridotta. Secondo la teoria di Frandsen, la rugosità effettiva del layout è compresa tra 1 m e 3 m, o tipica di una foresta, per le velocità medie e le distanze tipiche delle turbine. AWS Truepower ha modificato il modello Frandsen per trattare ogni turbina come un'isola isolata di rugosità, una modifica necessaria per consentire modifiche rapide al layout della turbina per l'ottimizzazione dell'array. Inoltre, si assume che l'IBL creato da ciascuna turbina sia centrato sull'altezza del mozzo della turbina.

Combinando i due modelli, la DAWM definisce implicitamente le zone "superficiali" e "profonde" all'interno di un layout di turbine. Nella zona poco profonda, dominano gli effetti di scia diretta delle singole turbine e il modello Eddy Viscosity (EV) non modificato viene utilizzato per calcolare le perdite di scia; nella zona profonda, l'effetto di matrice profonda è più evidente e quindi viene impiegato il modello di rugosità. Il DAWM è stato convalidato in diversi progetti sia offshore che onshore.

### 3.7 Producibilità lorda

Si riporta nella tabella il risultato di producibilità calcolata per il progetto al lordo delle perdite energetiche generali:

Modello turbina	Altezza mozzo	Potenza di progetto [MW]	Velocita' media [m/s]	Energia Lorda [GWh/y]	NCF <sup>2</sup> (%)
SG170 7,2MW <sup>3</sup>	115	50,4	5,94	113,79	21,73

TABELLA 7 – VALORE DI PRODUCIBILITÀ LORDA

### 3.7 Perdite energetiche generali

#### a) Perdite per effetto scia (Wake effect)

Le turbine eoliche alterano il flusso del vento libero che le investe, tale alterazione può ridurre la produzione di energia di un progetto eolico. Le perdite dovute a questo effetto scia sono suddivise nelle seguenti categorie:

- Effetto scia interno del progetto: questa perdita rappresenta l'effetto scia delle turbine all'interno del progetto analizzato.
- Effetto scia di progetti esistenti o futuri: questa perdita rappresenta l'effetto scia di progetti esistenti o pianificati e situati adiacenti al progetto analizzato per i quali sono disponibili informazioni sufficienti per effettuare una stima precisa del loro impatto sul progetto oggetto di studio. Non ci sono turbine previste in prossimità del progetto "Alas 2".

#### b) Perdite Elettriche

**Perdite elettriche operative:** si verificano perdite in tutti i componenti elettrici del progetto eolico, inclusi il trasformatore elettrico, il sistema di collegamento elettrico e il trasformatore ubicato in sottostazione di utente. Queste perdite derivano dalla progettazione dell'impianto elettrico.

Il valore tipico del 3% assunto nel presente studio tiene conto di tutte le perdite elettriche di trasformazione e nei conduttori tra i terminali di bassa tensione della turbina (dove l'uscita è misurata in un test della curva di potenza) e il contatore di entrata situato sul lato di alta tensione della sottostazione elettrica.

<sup>2</sup> Net capacity factor

<sup>3</sup> Il modello di turbina utilizzato per il progetto Alas 2 fa riferimento a una turbina da 7,2 MW con diametro di 170 metri, come modello commerciale di riferimento è stata presa in considerazione la SG170 da 7,2 MW.

**Autoconsumo del parco eolico:** questa perdita è destinata a tenere conto degli autoconsumi delle turbine eoliche.

### c) Perdite per riduzione della performance degli aerogeneratori

**Regolazione della curva di potenza:** questa perdita tiene conto delle prestazioni reali previste della turbina rispetto alle prestazioni modellizzate utilizzando la curva di potenza trasmessa dal fornitore.

**Isteresi nel controllo dei venti elevati:** per la maggior parte delle turbine, una volta che la velocità del vento supera la velocità del vento massima di funzionamento della turbina (velocità di cut-off) e la macchina si spegne, il software di controllo attende che la velocità scenda al di sotto di una soglia di velocità inferiore rispetto a quella massima (la velocità di ripristino dopo l'interruzione) prima di consentire il riavvio della turbina. Questa attesa comporta l'energia persa in questo ciclo di isteresi. Il coefficiente di isteresi viene calcolato sulla base dei dati del vento misurati nel sito e delle velocità di spegnimento e ripristino specificate dal produttore delle turbine.

**Regolazione della curva di potenza specifica del sito:** questa perdita è stata inclusa per tenere conto dell'impatto stimato del flusso inclinato (non orizzontale) sulla produzione di energia, dei valori estremi del profilo verticale e dell'effetto dell'intensità della turbolenza.

### d) Perdite di tipo ambientale

**Degrado delle pale:** questa perdita riflette le modifiche all'efficienza aerodinamica delle pale della turbina nel tempo ed è costituita da componenti a lungo e breve termine. Gli impatti a lungo termine derivano dalla normale usura e sono causati da fattori quali gli effetti permanenti dell'esposizione al sole, della sabbia trasportata dal vento e del ciclo di congelamento/scongelo dell'umidità all'interno delle microfessure delle pale. Questi fattori in genere influenzano il bordo anteriore della pala e determinano un degrado delle prestazioni nel tempo. Gli effetti a breve termine derivano generalmente dall'accumulo di insetti e sporcizia. Questo fattore è stimato sulla base della previsione di accumulo di polvere e insetti nell'area e dalla frequenza delle precipitazioni, che puliscono le pale.

**Ghiaccio:** questa perdita riflette la diminuzione dell'efficienza aerodinamica del rotore causata dall'accumulo di ghiaccio sulle turbine durante il funzionamento dell'impianto, nonché gli arresti

delle turbine causati da un eccessivo accumulo di ghiaccio. Le perdite di ghiaccio sono stimate dai dati meteorologici del sito, compresa la frequenza e la durata previste delle precipitazioni gelide e della formazione di ghiaccio di brina.

**Arresto per bassa/alta temperatura:** questo valore di perdita viene calcolato in base all'energia che verrà persa quando la turbina si spegne a causa di temperature al di fuori dell'involuppo di progetto operativo.

**Accesso al sito:** le condizioni meteorologiche avverse possono limitare l'accesso ad alcuni siti, il che può compromettere la produzione di energia in siti particolarmente remoti poiché i tempi di risposta per le riparazioni sono maggiori. Questa situazione si verifica spesso in aree soggette a forti nevicate. Questa perdita è stimata in base ai dati meteorologici e ad altre informazioni specifiche del sito.

#### e) Perdite per Curtailments

**Gestione del settore di vento:** se le turbine sono distanziate l'una dall'altra a meno di tre diametri di rotore, il produttore può imporre una strategia di riduzione direzionale per limitare le perdite di fatica sulle turbine interessate causate dalla turbolenza indotta dalla scia.

**Riduzione della produzione imposta dal Gestore di Rete:** perdite dovute alla riduzione di livello di produzione della rete elettrica per motivi collegati alla gestione del dispacciamento elettrico;

**Sfarfallio di rumore e ombre:** se il parco eolico è tenuto a rispettare determinati standard operativi a causa di vincoli ambientali, è possibile stimare una perdita di riduzione ambientale. La produzione può essere ridotta a causa di problemi di habitat, limitazioni del rumore, sfarfallio delle ombre e altri problemi ambientali simili.

#### f) Perdite per Disponibilità

**Disponibilità della rete elettrica:** questa perdita rappresenta le interruzioni del sistema di connessione e della sottostazione. Tipicamente viene assegnato un valore dello 0,2%, che corrisponde a 2 eventi all'anno di durata media di 8 ore.

**Disponibilità del BoP e della turbina:** questa perdita è relativa alla disponibilità delle opere di impianto (Balance of Plant) e della turbina. Tempi di fermo della turbina coperti dalle garanzie di disponibilità e tempi di fermo della turbina aggiuntivi a causa di eventi di forza maggiore,



manutenzione programmata e ritardi di riparazione dovuti a venti forti o mancanza di pezzi di ricambio, che in genere non sono coperti dalle garanzie tradizionali.

Si riportano nella tabella seguente i valori assunti per le diverse voci di perdita. Le perdite generali complessive risultano pari a 84,4 %.

Voce di perdita	Efficienza [%]
Effetto Scia	92,0
Elettriche	97,0
Performance delle turbine	97,9
Ambientale	99,0
Curtailments	100,0
Disponibilità	97,5
RISULTATO	84,4

TABELLA 8 – PERDITE PER TIPOLOGIA

### 3.8 Risultati

Si riportano nella tabella seguente i risultati di producibilità energetica stimata con riferimento al layout costituito da N. 7 turbine aventi un diametro del rotore di 170 m e un'altezza del mozzo di 115 m e una singola capacità pari a 7,2 MW, usate come modello di riferimento per la tecnologia ipotizzata. L'energia elettrica al netto delle perdite generali è stata calcolata pari a 95,998 GWh/anno che corrispondono a 1905 ore equivalenti.

Modello turbina	Altezza mozzo	Potenza di progetto [MW]	Velocità media [m/s]	Produzione netta [GWh/anno]	NCF (%)	Ore Equivalenti (h)
SG170 7,2MW	115	50,4	5,94	113,793	21,73	1905


TABELLA 9 - RISULTATI PER IL SITO "ALAS 2"

WTG	Easting	Northing	Elevazione (m)	Altezza mozzo (m)	Velocità del vento (m/s)	Produzione Netta (MWh/anno)	NCF	Ore Equivalenti (h)
							(%)	
WTG01	457931	4485434	396	115	5,9	12827	20,34	1782
WTG02	457479	4484862	382	115	5,7	12224	19,38	1698
WTG03	457301	4483715	420	115	5,9	13932	22,09	1935
WTG04	456560	4483366	436	115	5,6	12748	20,22	1771
WTG05	457037	4485710	462	115	6,4	15260	24,19	2119
WTG06	456510	4485310	446	115	6,2	15008	23,79	2084
WTG07	457047	4486280	427	115	6,1	14000	22,19	1944

TABELLA 10 - RISULTATI PER SINGOLO AEREOGENERATORE

## Appendice

### Report di installazione – Anemometro Ittiri

	<b>MET MAST INSTALLATION REPORT</b>	Template code: Release date: Revision num: Pag.	DTP: 15.MO 02/2017 1 1 of 21
---	---	--	---------------------------------------

#### CUSTOMER

**RWE-Renewables Italia S.r.l.**  
Via Andrea Doria, 41  
00192 Roma

#### MEASURING MAST NAME

**ITTIRI (SS) H99**

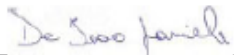
#### LOCATION

**ITTIRI**

#### MET MAST CODE


**MM2**

**Installation report  
Annexes to the work procedure**

Date: <b>20/11/2020</b>	Author: <b>Daniele De Ieso</b>	
-------------------------	-----------------------------------	--

	<b>MET MAST INSTALLATION REPORT</b>	Template code: Release date: Revision num: Pag.	DTP: 15_MO 02/2017 1 2 of 21
--	---	--	---------------------------------------

<b>Annex - A1 to the work procedure</b>							
<b>Measuring station first installation report</b>							
Measurement Station of				<b>ITTIRI (SS) H99</b>			
Station Code				<b>MM2</b>			
<b>S I T E</b>	Grid <b>UTM</b>	Map datum: <b>European 1950</b>	Altitude: <b>qt. s.l.m. 452</b>	Zone: <b>32T</b>	Longitude X: EST <b>462057</b>	Latitude Y: NORD <b>4490110</b>	
	Grid <b>UTM</b>	Map datum: <b>WGS 84</b>	Altitudine: <b>qt. s.l.m. 452</b>	Zone: <b>32T</b>	Longitude X: EST <b>461974</b>	Latitude Y: NORD <b>4489916</b>	
	Soil	Prevalence ground <b>X</b>		Mix of rock and ground		Prevalence rock	
	Terrain usage	Uncultured <b>X</b>	Seeded	Orchard	Residential	Industrial	Pasture
	Vegetation	Absent		Bare <b>X</b>	Stain	Forest	Scattered trees
	Morphology	Plain	Hill <b>X</b>	Valley	Highland	Peak	Ridge
	<b>I N S T R U M E N T S</b>	Description	Serial Num	Type	Direction orientation	Booms orientation	Boom lenght
Speed Sensor at m 99		01180272	THIES F.C.	---	ON TOP	ON TOP	
Speed Sensor at m 95		07101411	THIES F.C.	---	202°	300 cm	
Speed Sensor at m 95		40655	RISOE P2546C	---	22°	300 cm	
Speed Sensor at m 74		0207766	THIES F.C.	---	202°	300cm	
Speed Sensor at m 74		40657	RISOE P2546C	---	22°	300cm	
Speed Sensor at m 49		0709397	THIES F.C.	---	202°	300cm	
Speed Sensor at m 49		70978	RISOE P2546C	---	22°	300cm	
Wind Vane at m 93		10200118	THIES F.C.	22°	202°	300cm	
Wind Vane at m 47		10200119	THIES F.C.	22°	202°	300cm	
Barometer at m 98		-	THIES	--	Box	Box	
Thermo-hygrometer at m96		1830818	VAISALA HMP155	--	180°	--	
Thermo-hygrometer at m46		1830821	VAISALA HMP155	--	180°	--	
Logger		5774312697	Orbit 360				
Beaconing system		<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO	A 2000cd lamp at 99m, A 32cd lamp at 50m and a 32cd lamp at 33m				
Memory Card		Orbit 360		ORBIT 360			
Mast structure type		Televee H99		Height: m 99			
Shielded three-core cable	Shielded Cable		Lenght: m				
Shielded two-core cable	Shielded Cable		Lenght: m				
Copper grounding cable	φ 35		Lenght: m 106				
Lightning rod (boom mounted at 0° North)			Lenght: m				
Grounding rod			Lenght: m				
<b>M O U N T I N G</b>	Installation Company		<b>IDNAMIC ITALIA S.r.l.</b>				
	Installation date		Date: <b>20/11/2020</b>				
	Datalogger measurement start time		Date: <b>20/11/2020</b>	Time: <b>13:00</b>			
	Installation correctness check and real time verification (See Annex 7)			<input checked="" type="checkbox"/> YES	<input type="checkbox"/> NO		
Date: <b>20/11/2020</b>	Mounting responsible: <b>Daniele De Ieso</b>		Signature				
	Technical department responsible:		Signature				

	<b>MET MAST INSTALLATION REPORT</b>	Template code: Release date: Revision num: Pag.	DTP: 15.MO 02/2017 1 3 of 21
---	---	--	---------------------------------------

Annex - A2 to the work procedure

**Measuring station first installation report**

Measurement Station of		<b>ITTIRI (SS) H99</b>	
Station Code		<b>MM2</b>	
<b>S T R U C T U R A L  C O M P O N E N T S</b>	Description	Supplier	Notes
	<p><b>Elenco componenti strutturali ed elettrici</b></p> <ul style="list-style-type: none"> <li>➢ n. 1 Tramo di base M450 con montanti tubolari 40x5 mm acciaio tipo S355, diagonali tondo 12mm S275;</li> <li>➢ n. 6 tralicci intermedi M450 mm di lato da m 3,00 con montanti tubolari 40x5 mm acciaio tipo S355, diagonali tondo 12mm S275;</li> <li>➢ n. 25 Tralicci intermedi 450 mm di lato da m 3,00 costituito da tubolare 40x3 acciaio tipo S235, diagonali tondo 12mm S275;</li> <li>➢ n. tramo punta superiore 450, 3,00 costituito da tubolare 40x3 acciaio tipo S235, diagonali tondo 12mm S275;</li> <li>➢ n. 1 supporto parafulmine di Ø 42 da m 3 rosso;</li> <li>➢ n. 11 stralli di adeguata lunghezza (vedi fig. 1) composti da funi in acciaio zincate Ø 8;</li> <li>➢ n. 1 piastra di base 1200x1200 con relativi picchetti di ancoraggio formato T40;</li> <li>➢ n. 12 piastre per fondazioni (fig. 3);</li> <li>➢ n. 99 morsetti per cavi d'acciaio</li> <li>➢ n. 33 tenditori a focella Ø 16;</li> <li>➢ n. 1 calata di rame per scarico a terra;</li> <li>➢ n. 2 dispersori di terra in acciaio ramato da m 1,50 (uno per il data-logger ed uno per il sistema parafulmine);</li> <li>➢ n. 1 captatore di fulmini in rame;</li> <li>➢ n. 1 cassetta box in vetro-resina con adeguate staffe per alloggiamento data logger;</li> <li>➢ Data logger;</li> <li>➢ Sensore/i di velocità;</li> <li>➢ Sensore/i di direzione;</li> <li>➢ Sensore/i di temperatura;</li> <li>➢ Sensore/i di umidità;</li> <li>➢ Sensore/i di pressione;</li> <li>➢ Altri tipi di sensori indicati dal committente;</li> <li>➢ Cavi per collegamenti elettrici ai sensori/data logger.</li> </ul>		
<b>M O U N T I N G</b>	Installation Company	<b>IDNAMIC ITALIA S.r.l.</b>	
	Installation date	Date: <b>20/11/2020</b>	
	Datalogger measurement start time	Date: <b>20/11/2020</b>	Time <b>13:00</b>
	Installation correctness check and real time verification (See Annex 7)	<input checked="" type="checkbox"/> <b>YES</b>	<input type="checkbox"/> <b>NO</b>
Date: <b>20/11/2020</b>	Mounting responsible: <b>Daniele De Ieso</b>	Signature <i>De Ieso Daniele</i>	

	<b>MET MAST INSTALLATION REPORT</b>	Template code: Release date: Revision num: Pag.	DTP.15.MO 02/2017 1 4 of 21
--	---	--	--------------------------------------

ANNEX - A 3/1 to the work procedure

**Measuring station first installation report**

Measurement Station of

**ITTIRI (SS) H99**

Station Code

**MM2**

**SECTION CODES**

1 Torre 99m ITALIA		
Metros	Sección	99m 450XL 28ms, 10mm
99	33	313311
96	32	313312
93	31	313312
90	30	313312
87	29	313313
84	28	313313
81	27	313313
78	26	313313
75	25	313312
72	24	313312
69	23	313312
66	22	313312
63	21	313312
60	20	313313
57	19	313313
54	18	313313
51	17	313313
48	16	313313
45	15	313312
42	14	313312
39	13	313312
36	12	313312
33	11	313312
30	10	313313
27	9	313313
24	8	313313
21	7	313213
18	6	313213
15	5	313212
12	4	313212
9	3	313212
6	2	313212
3	1	313011
		313412

1	313412
1	313011
4	313212
2	313213
13	313112
12	313113
1	313311

33	Tramos
99	Metros

Date: **20/11/2020**

Operator signature: **Daniele De Ieso**



	<b>MET MAST INSTALLATION REPORT</b>	Template code: Release date: Revision num: Pag.	DTP.15.MO 02/2017 1 5 of 21
--	---	--	--------------------------------------

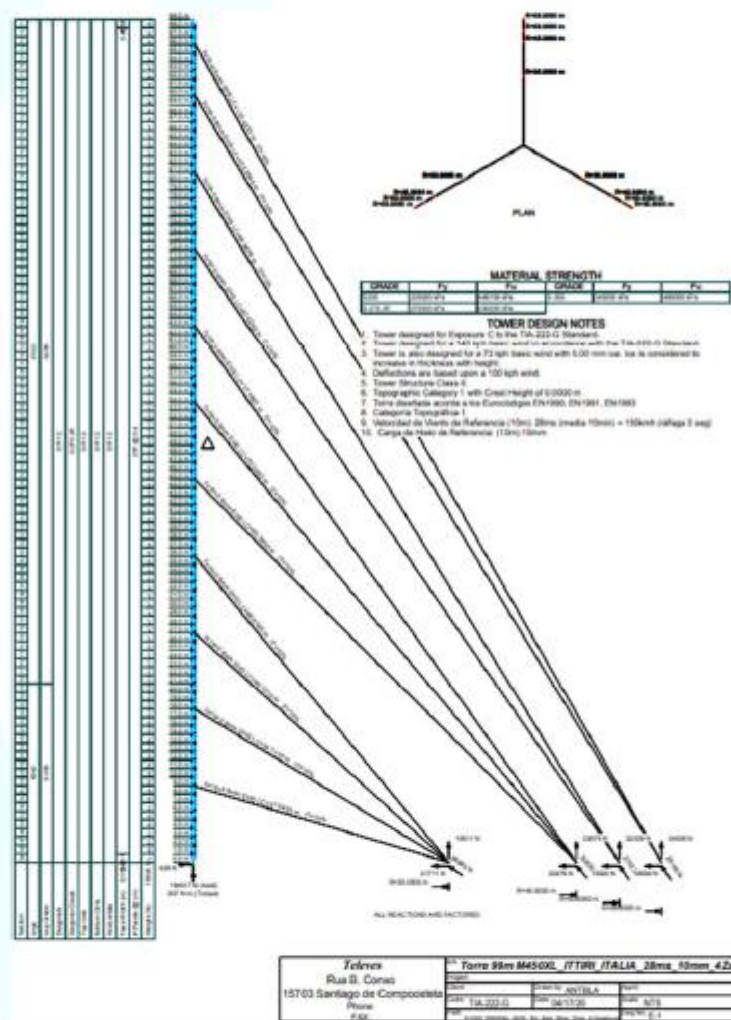
ANNEX - A 3/1 to the work procedure

**Measuring station first installation report**

Measurement Station of	<b>ITTIRI (SS) H99</b>
Station Code	<b>MM2</b>

**TOWER PROJECT**

- For a better resolution, check the ITTIRI-TowerProject annex



Date: 20/11/2020

Operator signature: **Daniele De Ieso**

*De Ieso Daniele*

	<b>MET MAST INSTALLATION REPORT</b>	Template code: DTP-15.MO
		Release date: 02/2017
		Revision num: 1
		Pag. 6 of 21

**ANNEX – A 3/1 to the work procedure**

**Measuring station first installation report**

Measurement Station of	<b>ITTIRI (SS) H99</b>
Station Code	<b>MM2</b>

**TOWER PROJECT - LIGHTS**

- For a better resolution, check the ITTIRI-H99VistaFrontEnavEnac annex

Disegnato da	Disegnato da	Disegnato da	Disegnato da	Disegnato da	Disegnato da
Verificato da	Verificato da	Verificato da	Verificato da	Verificato da	Verificato da

**Progetto ITTIRI Vista frontale**  
Schema di segnalazione diurna e notturna

**The beaconing System has been installed  
in accordance with the provisions of the aviation organizations  
(PROT ENAC-TSU-17/09/2020-0017086)**

Date: <b>20/11/2020</b>	Operator signature: <b>Daniele De Ieso</b> <i>De Ieso Daniele</i>
-------------------------	--



	<b>MET MAST INSTALLATION REPORT</b>	Template code:	DTP-15.MO
		Release date:	02/2017
		Revision num:	1
		Pag.	7 of 21

ANNEX - A 3/2 to the work procedure

**Measuring station first installation report**

Measurement Station of	<b>ITTIRI (SS) H99</b>
Station Code	<b>MM2</b>

**TOWER LAYOUT**

- For a better resolution, check the ITTIRI-H99Layout annex

*This Layout is property IDNAMIC. Data must not be copied or transferred without our permission*



Fondazioni dal canto TA 30M 40M 45M 10M Orientata 60° 180° 300°

BOOM -----7777

Coordinate punto N 48°33' 32.83" E 8°33' 3.95" qam -

Fondaz 30M 100x100  
Fondaz 40-45-50M 100x100

Descr	Qty	Unit	Material	Sign
20x20x20	120	kg	Steel	
20x20x20	120	kg	Steel	

Project: LAYOUT H 99-45TV MAST SITE ITTIRI MM2  
Title: \_\_\_\_\_  
Project N°: \_\_\_\_\_  
Layout N°: \_\_\_\_\_

The foundations are orientated at 65° - 185° - 305°

Date: 20/11/2020

Operator signature: **Daniele De Ieso**

ANNEX - A 4/1 to the work procedure

**Measuring station first installation report**

Measurement Station of

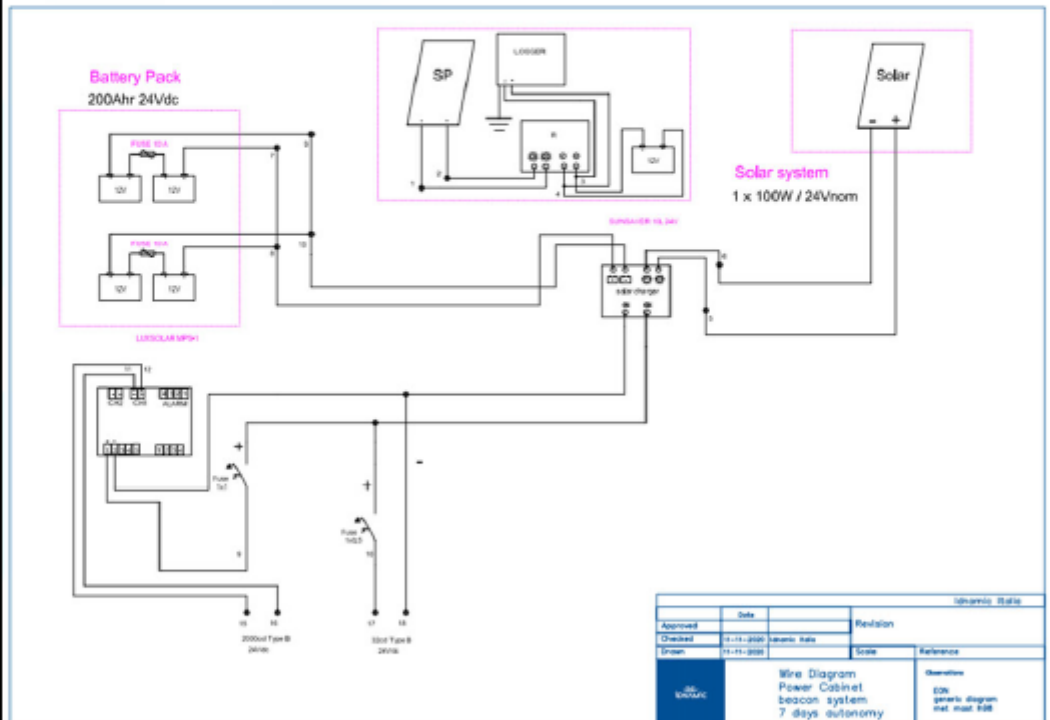
**ITTIRI (SS) H99**

Station Code

**MM2**

**BEACONING LIGHTS CIRCUIT DIAGRAM:**

- For a better resolution, check the Annex BCNG\_ELCTR\_Ittiri



Date: **20/11/2020**

Operator signature: **Daniele De Ieso**

ANNEX - A 4/2 to the work procedure

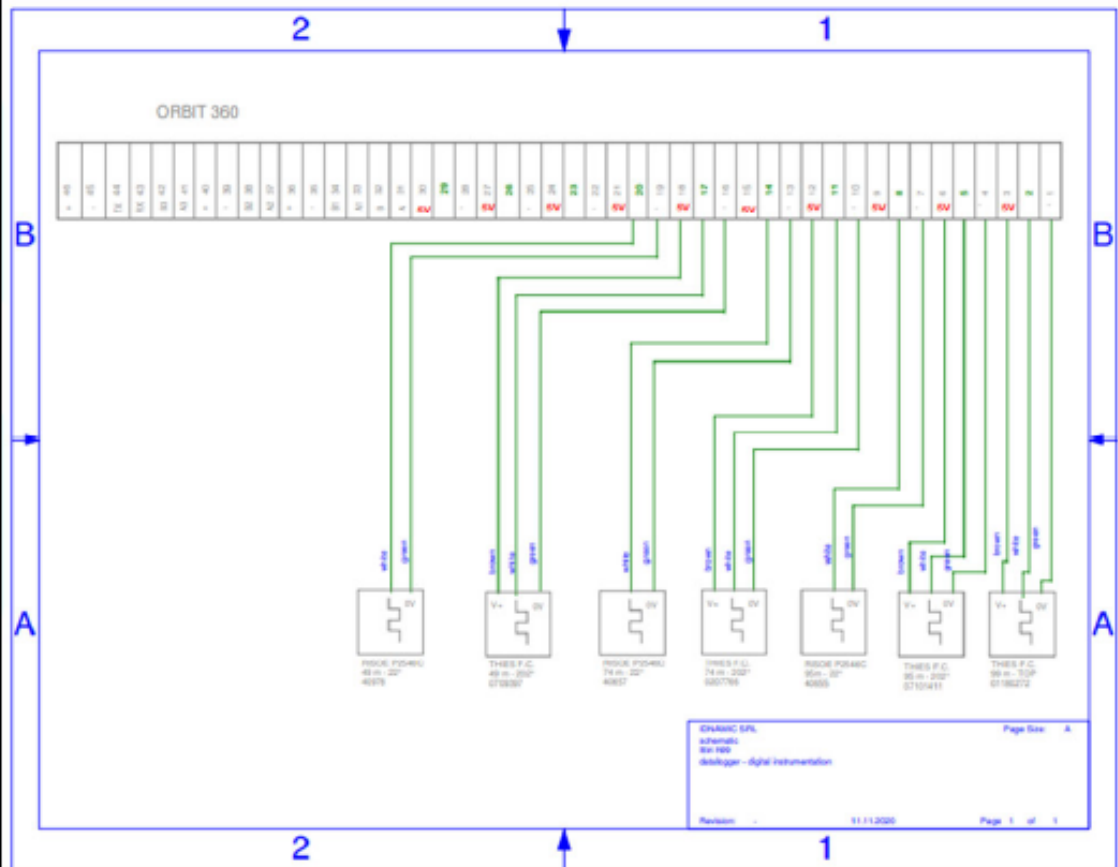
**Measuring station first installation report**

Measurement Station of  
Station Code

**ITTIRI (SS) H99  
MM2**

**ANEMOMETERS CIRCUIT DIAGRAM:**

- For a better resolution, check the Annex Orbit360\_Counters



Date: 20/11/2020

Operator signature: **Daniele De Ieso**

*D. De Ieso*

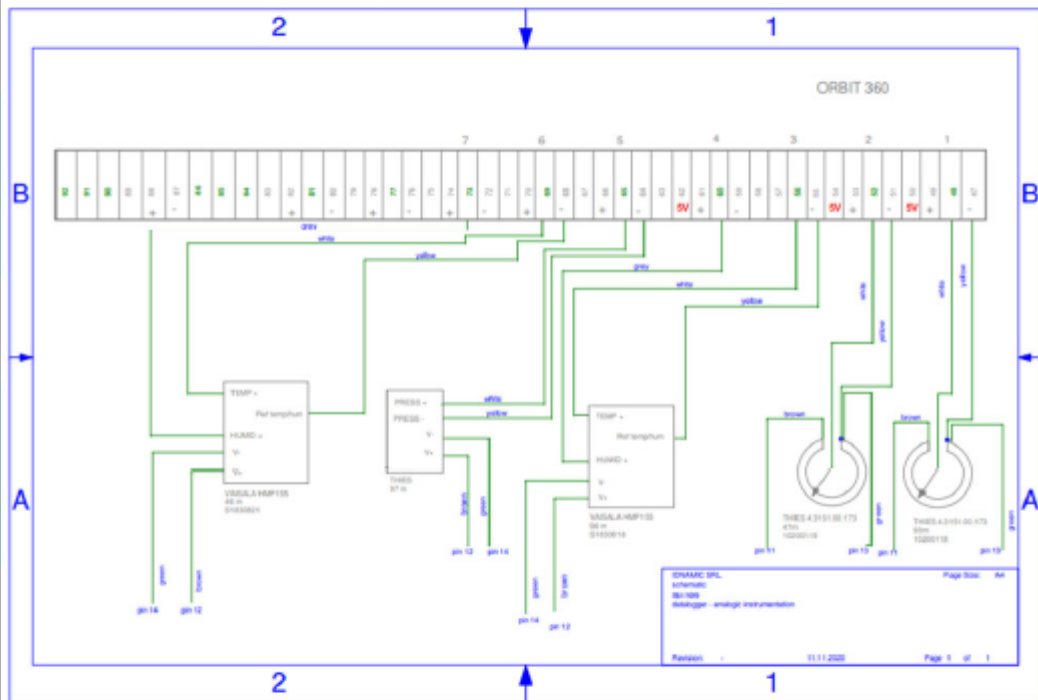
ANNEX - A 4/3 to the work procedure

Measuring station first installation report

Measurement Station of  
Station Code

**ITTIRI (SS) H99  
MM2**

**ANALOGIC CIRCUIT DIAGRAM:**  
For a better resolution, check the Annex Orbit360\_Analogic



Date: **20/11/2020**

Operator signature: **Daniele De Ieso**

*D. De Ieso*

ANNEX - A 4/4 to the work procedure

Measuring station first installation report

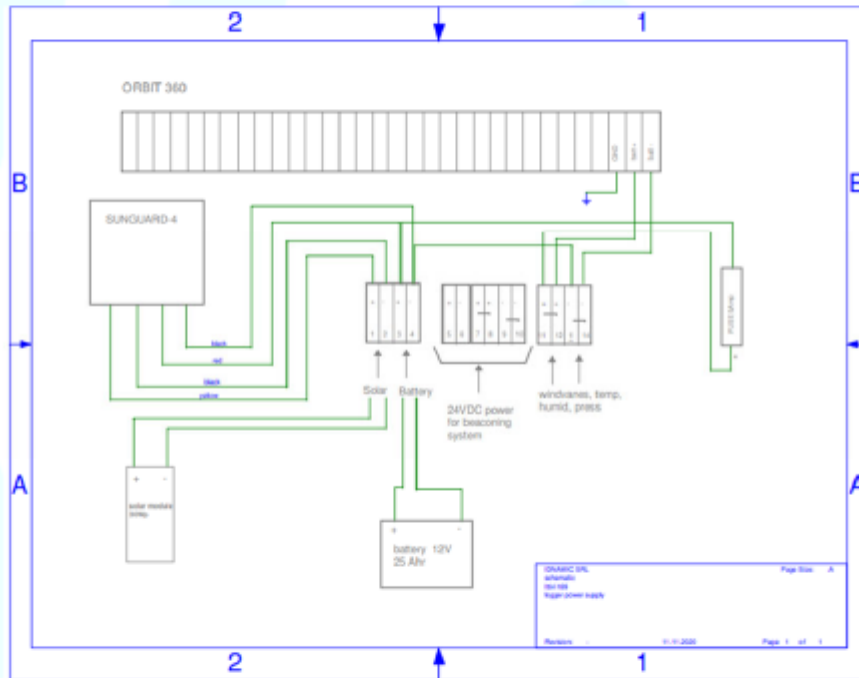
Measurement Station of

**ITTIRI (SS) H99**

Station Code

**MM2**

**ALIMENTATION CIRCUIT DIAGRAM:**  
For a better resolution, check the Annex Orbit360\_PS



Date: **20/11/2020**

Operator signature: **Daniele De Ieso**

*D. De Ieso*



ANNEX - A 5/1 to the work procedure

**Measuring station first installation report**

Measurement Station of

**ITTIRI (SS) H99**

Station Code

**MM2**

**Wind speed sensors height and orientation**

ANE 99 m / TOP



ANE 95 m / 202°



ANE 95 m / 22°



ANE 75 m / 202°



ANE 75 m / 22°



ANE 49m / 202°




ANE 49m / 22°



Date: **20/11/2020**

Operator signature: **Daniele De Ieso**

# Report di installazione – Anemometro Villanova

	<b>MET MAST INSTALLATION REPORT</b>	Template code: Release date: Revision num: Pag.	DTP: 15.MO 02/2017 1 1 of 26
---	---	--	---------------------------------------

## CUSTOMER

**RWE-Renewables Italia S.r.l.**  
Via Andrea Doria, 41  
00192 Roma

## MEASURING MAST NAME

**VILLANOVA (SS) H99**


## LOCATION

**VILLANOVA MONTELEONE**

## MET MAST CODE

**01**

**Installation report  
Annexes to the work procedure**

Date: <b>15/03/2021</b>	Author: <b>Daniele De Ieso</b>	
-------------------------	-----------------------------------	--



## MET MAST INSTALLATION REPORT

Template code:  
Release date:  
Revision num:  
Pag.

DTP. 15.MO  
02/2017  
1  
2 of 26

Annex - A1 to the work procedure							
Measuring station first installation report							
Measurement Station of				VILLANOVA (SS) H99			
Station Code				01			
<b>S I T E</b>	Grid Decimal / degrees	Map datum: WGS 84	Altitude: qt. s.l.m. 470	N	40.55122	E	8.52167
	Grid UTM	Map datum: WGS 84	Altitude: qt. s.l.m. 470	Zone	Longitude X: EST 459500	Latitude Y: NORD	4489050
	Soil	Prevalence ground X		Mix of rock and ground		Prevalence rock	
	Terrain usage	Uncultured X	Seeded	Orchard	Residential	Industrial	Pasture
	Vegetation	Absent		Bare X	Stain	Forest	Scattered trees
	Morphology	Plain X	Hill	Valley	Highland	Peak	Ridge
	Description	Channel	Serial Number	Type & model	Direction orientation	Booms orientation	Boom lenght
	Speed sensor at m 99	Frq 1	01212599	Thies FC Advanced II 4.3351.10.000		TOP	0.8 m
	Speed sensor at m 95	Frq 2	01212600	Thies FC Advanced 4.3351.10.000		202°	3.00 m
	Speed sensor at m 95	Frq 3	40656	RiSo WS P2546C-OPR		22°	3.00 m
Speed sensor at m 74	Frq 4	01212595	Thies FC Advanced 4.3351.10.000		202°	3.00 m	
Speed sensor at m 74	Frq 5	40654	RiSo WS P2546C-OPR		22°	3.00 m	
Speed sensor at m 74	Frq 6	01212590	Thies FC Advanced 4.3351.10.000		202°	3.00 m	
Speed sensor at m 74	Frq 7	40653	RiSo WS P2546C-OPR		22°	3.00 m	
Wind Vane at m 93	Anl 1	12200127	Thies FC 4.3151.00.173	202°	202°	3.00 m	
Wind vane at m 47	Anl 2	12200131	Thies FC 4.3150.00.173	202°	202°	3.00 m	
Pressure sensor at m 97	Anl 5	1210246	Thies J.1157.10.000			Box	
Thermo-Hygrometer at m 96	Anl 3/4	S4941089	Vaisala HMP155		0°	//	
Thermo-Hygrometer at m 46	Anl 6/7	S4941090	Vaisala HMP155		0°	//	
Datalogger	//	7212412928	Kintech Orbit 360			Box	
Power Supply System	<input checked="" type="checkbox"/> YES	NO	One 190 W Solar Panel with two 12V / 150Ah batteries				
Beaconing system	<input checked="" type="checkbox"/> YES	NO	1x2000cd at 99m + 1x32cd at 50m				
Memory Card				Orbit 360			
Mast structure type				TELEVES 450 XL		Height: m 99	
Copper grounding cable				Ø 35		Lenght: m 105	
Lightning rod (boom mounted at 45° North)				N45° - Ø35/ Ø10		Lenght: m 3.00 + 1.00	
Grounding rod				2		Lenght: m 2.00 X 1.5	
<b>M O U N T I N G</b>	Installation Company		IDNAMIC ITALIA S.r.l.				
	Installation date		Date: 15/03/2021				
	Datalogger measurement start time		Date: 15/03/2021			Time: 15:00	
	Installation correctness check and real time verification (See Annex 7)					<input checked="" type="checkbox"/> YES	<input type="checkbox"/> NO
Date: 15/03/2021	Mounting responsible: Daniele De Ieso		Signature <i>De Ieso Daniele</i>				



**Annex - A1 to the work procedure**
**Measuring station first installation report**

Measurement Station of	<b>VILLANOVA (SS) H99</b>
Station Code	<b>01</b>

**SENSORS' SLOPE & OFFSET**

Description	Height	Serial Number	Type & model	Slope	Offset	Channel
Speed sensor	99	01212599	Thies FC Advanced II 4.3351.10.000	0.04628	0.22772	Frq 1
Speed sensor	95	01212600	Thies FC Advanced 4.3351.10.000	0.04623	0.23236	Frq 2
Speed sensor	95	40656	RiSo WS P2546C-OPR	0.62015	0.23174	Frq 3
Speed sensor	74	01212595	Thies FC Advanced 4.3351.10.000	0.04624	0.23622	Frq 4
Speed sensor	74	40654	RiSo WS P2546C-OPR	0.62025	0.21620	Frq 5
Speed sensor	49	01212590	Thies FC Advanced 4.3351.10.000	0.04632	0.22452	Frq 6
Speed sensor	49	40653	RiSo WS P2546C-OPR	0.62152	0.20238	Frq 7
Wind Vane	93	12200127	Thies FC 4.3151.00.173	1.00	202	Anl 1
Wind Vane	47	12200131	Thies FC 4.3150.00.173	1.00	202	Anl 2
Pressure Sensor	97	1210246	Thies 3.1157.10.000	60	794	Anl 5
Temperature Sensor	96	S4941089	Vaisala HMP155	100	-40	Anl 3
Humidity Sensor	96	S4941089	Vaisala HMP155	100	0	Anl 4
Temperature Sensor	46	S4941090	Vaisala HMP155	100	-40	Anl 6
Humidity Sensor	46	S4941090	Vaisala HMP155	100	0	Anl 7

**Notes about the installation:**

The installation has been successfully completed and everything was working properly.  
Attached to the mail, you can find all the calibration certificates of the Anemometers, as well as the Setup file of the Logger.

<b>M O U N T I N G</b>	Installation Company	<b>IDNATIC ITALIA S.r.l.</b>		
	Installation date	Date: <b>15/03/2021</b>		
	Datalogger measurement start time	Date: <b>15/03/2021</b>	Time: <b>15:00</b>	
	Installation correctness check and real time verification (See Annex 7)	<input checked="" type="checkbox"/> <b>YES</b>		<input type="checkbox"/> <b>NO</b>
Date: <b>15/03/2021</b>	Mounting responsible: <b>Daniele De Ieso</b>	Signature <i>De Ieso Daniele</i>		

Annex - A2 to the work procedure

**Measuring station first installation report**

Measurement Station of		<b>VILLANOVA (SS) H99</b>	
Station Code		<b>01</b>	
<b>S T R U C T U R A L  C O M P O N E N T S</b>	Description	Supplier	Notes
	n.33 meters sections	IDNAMIC	M450
	n.1 anchoring base plate	IDNAMIC	M450
	n. 1 lightning rod support (Mastill)	IDNAMIC	Ø35
	n. 11 steel cables	IDNAMIC	Ø8 - Ø11
	n. 99 cable clamps	IDNAMIC	--
	n. 33 cable turnbuckles	IDNAMIC	Ø16
	n. 9 sensor booms	IDNAMIC	3.00m
	n. 1 copper grounding cable	IDNAMIC	104 m
	n. 2 Grounding rods	IDNAMIC	2.00x1.5 m
	n. 1 lightning rod	IDNAMIC	N45° - Ø10
	n. 1 datalogger + box	IDNAMIC	Kintech Orbit 360
Notes:			
<b>M O U N T I N G</b>	Installation Company	IDNAMIC ITALIA S.r.l.	
	Installation date	Date: 15/03/2021	
	Datalogger measurement start time	Date: 15/03/2021	Time: 15:00
	Installation correctness check and real time verification (See Annex 7)	<b>YES</b>	<b>NO</b>
Date:	Mounting responsible:	Signature	
15/03/2021	Daniele De Ieso	<i>De Ieso Daniele</i>	

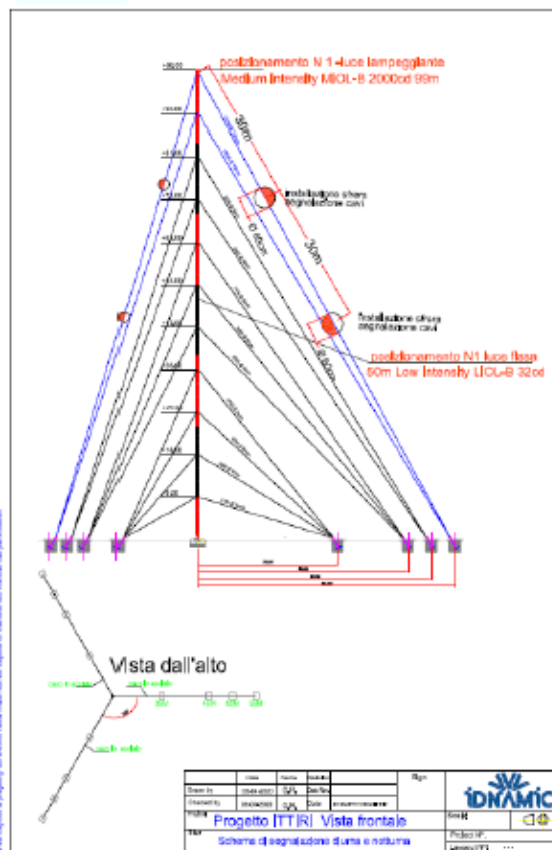
ANNEX - A 3/1 to the work procedure

**Measuring station first installation report**

Measurement Station of	<b>VILLANOVA (SS) H99</b>
Station Code	<b>01</b>

The Beaconsing System has been installed in compliance with  
the provisions of the aviation authorities  
**PROT ENAC-TSU-17/09/2020-0017086:**

For a better resolution, check the Annex "Villanova H99 - EnavEnac.pdf" attached to the E-mail



Date: **15/03/2021**

Operator signature: **Daniele De Ieso**



# MET MAST INSTALLATION REPORT

Template code:  
Release date:  
Revision num:  
Pag.

DTP.15.MO  
02/2017  
1  
6 of 26

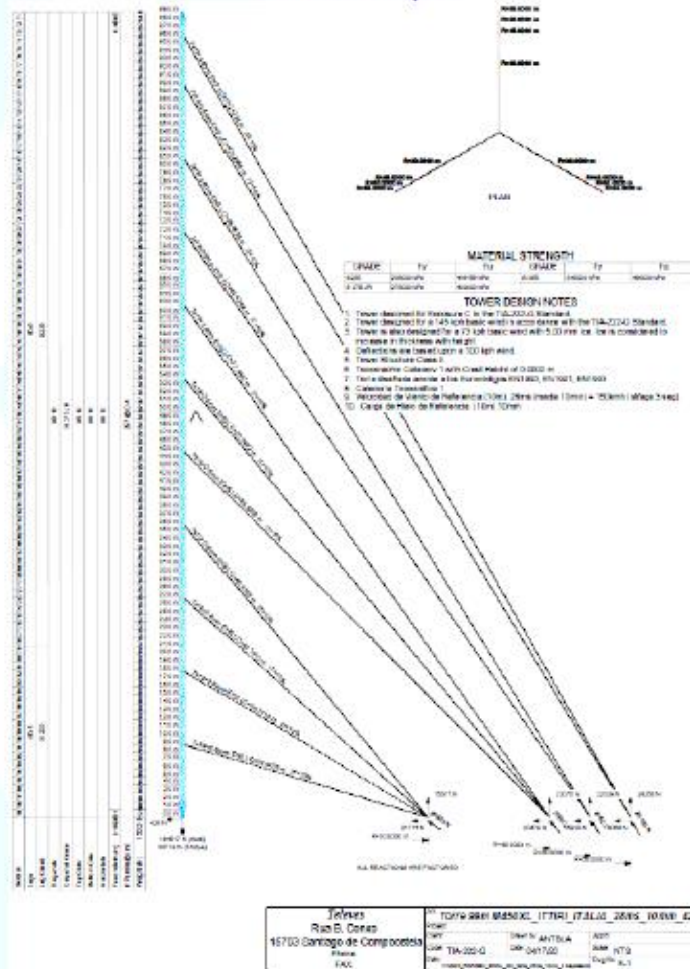
ANNEX – A 3/1 to the work procedure

## Measuring station first installation report

Measurement Station of  
Station Code

**VILLANOVA (SS) H99**  
**01**

### Met Mast Project:



For a better resolution, check the Annex "Villanova Tower.pdf" attached to the E-mail

Date: 15/03/2021

Operator signature: Daniele De Ieso



**ANNEX – A 3/1 to the work procedure**

**Measuring station first installation report**

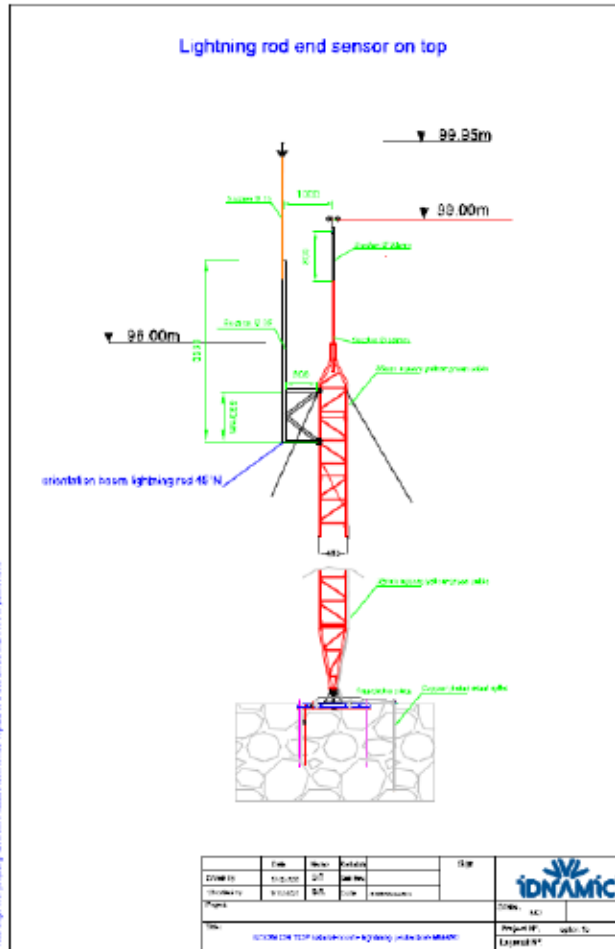
Measurement Station of

**VILLANOVA (SS) H99**

Station Code

**01**

**Lightning Rod Configuration**



For a better resolution, check the Annex "Lightning Rod VILLANOVA.pdf" attached to the E-mail

Date: **15/03/2021**

Operator signature: **Daniele De Ieso**



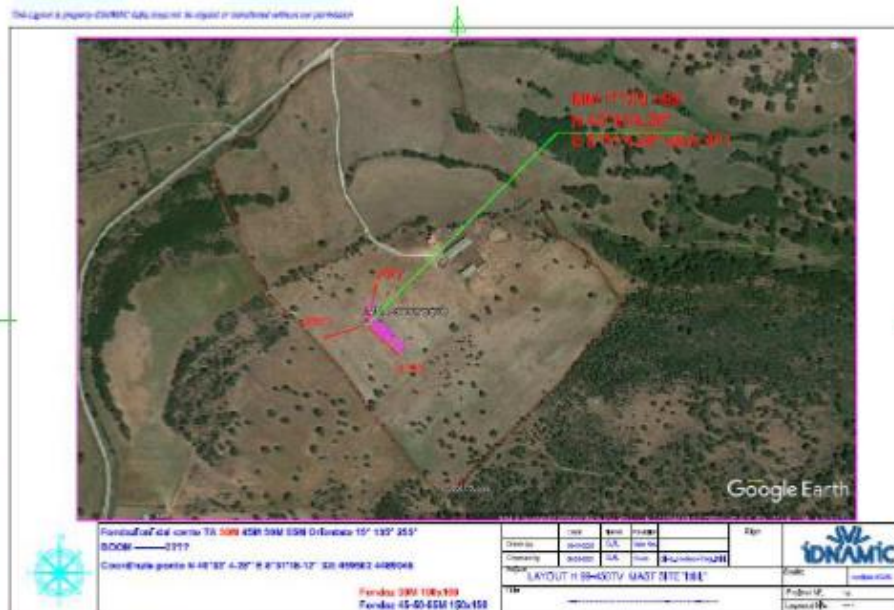
ANNEX - A 3/2 to the work procedure

**Measuring station first installation report**

Measurement Station of  
Station Code

**VILLANOVA (SS) H99  
01**

**LAYOUT OF THE TOWER**



For a better resolution, check the Annex "VILLANOVA Layout.pdf" attached to the E-mail

**The anchors are oriented at 15° - 135° - 255°**  
 The foundations are placed at 35-45-50-55m from the tower.

Date: **15/03/2021**

Operator signature: **Daniele De Ieso**



ANNEX - A 4/1 to the work procedure

**Measuring station first installation report**

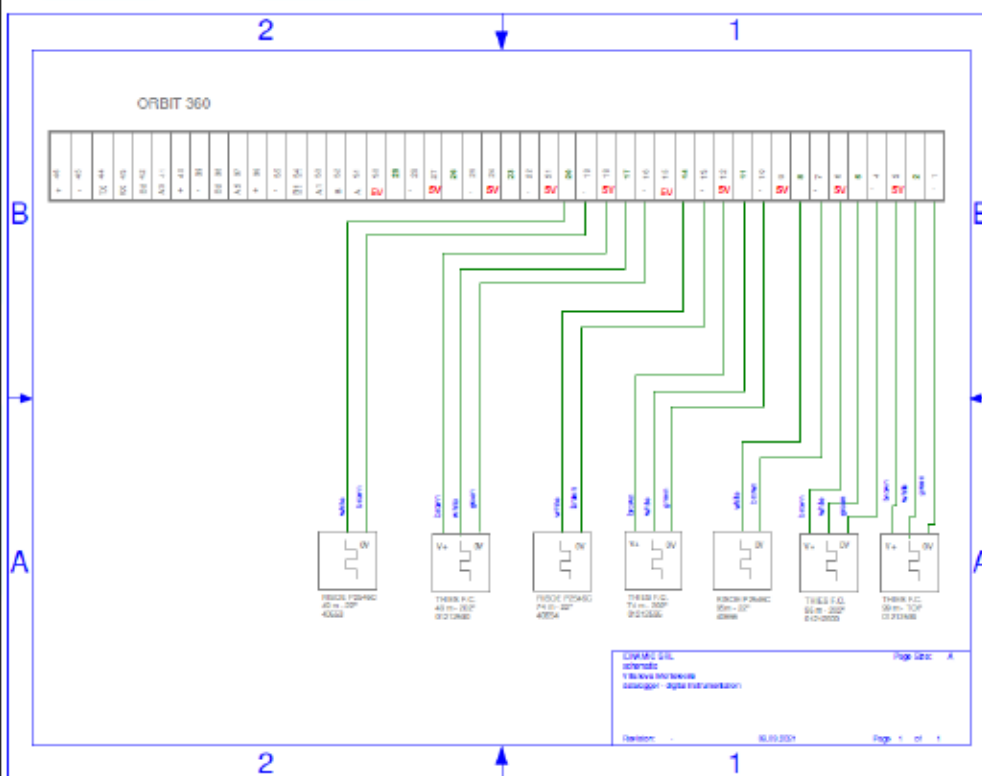
Measurement Station of

**VILLANOVA (SS) H99**

Station Code

**01**

**ANEMOMETER DIAGRAM:**



For a better resolution, check the Annex "Orbit360\_CNTRS.pdf" attached to the E-mail

Date: 15/03/2021

Operator signature: **Daniele De Ieso**



ANNEX - A 4/1 to the work procedure

**Measuring station first installation report**

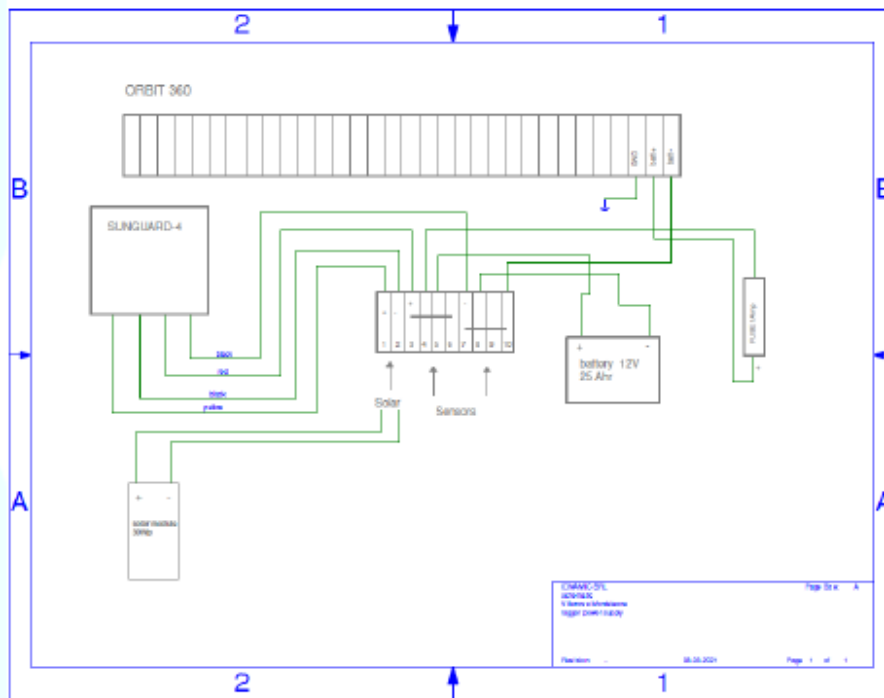
Measurement Station of

**VILLANOVA (SS) H99**

Station Code

**01**

**ALIMENTATION DIAGRAM:**



For a better resolution, check the Annex "Orbit360\_PS.pdf" attached to the E-mail

Date: **15/03/2021**

Operator signature: **Daniele De Ieso**

ANNEX - A 5/1 to the work procedure

**Measuring station first installation report**

Measurement Station of

**VILLANOVA (SS) H99**

Station Code

**01**

**Wind speed sensors height and orientation**

**SPEED 99 m / TOP°**



**SPEED 95 m / 202°**



**SPEED 95 m / 22°**



**SPEED 74 m / 202°**



**SPEED 74m / 22°**



**SPEED 49m / 202°**



**SPEED 49m / 22°**



Date: **15/03/2021**

Operator signature: **Daniele De Ieso**

## Svend Ole Hansen ApS

SCT. JØRGENS ALLÉ 5C · DK-1615 KØBENHAVN V · DENMARK  
TEL: (+45) 33 25 38 38 · [WWW.SOHANSEN.DK](http://WWW.SOHANSEN.DK)



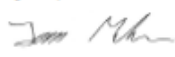

WIND  
ENGINEERING  
FLUID  
DYNAMICS

### CERTIFICATE OF CALIBRATION

#### Calibrated item

Type WindSensor P2546C-OPR Cup Anemometer  
Serial no. 40655  
Manufacturer WindSensor, Frederiksborgvej 399, 4000 Roskilde Denmark  
Item received May 29, 2020  
Remarks -

#### Calibration

Calibration institute Svend Ole Hansen ApS, Sct. Jørgens Allé 5C, DK-1615 København V  
Procedure IEC 61400-12-1:2017, Annex F  
Client WindSensor, Frederiksborgvej 399, 4000 Roskilde Denmark  
Calibrated by Calibrator, jvm   
Date of calibration May 31, 2020  
Approved by Calibration engineer, sfo   
Post calibration No  
Re-calibration due -

#### Certificate

Certificate no. 20.02.01399  
Date of issue June 03, 2020  
Issued by ca  
Number of pages 4

#### Accreditation

Accredited to ISO 17025:2017 by DANAK. DANAK is signatory to the European co-operation for Accreditation (EA) Multilateral Agreement and to the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement.

The calibration institute is approved by MEASNET and IECRE.





### Calibration conditions

Turbulence intensity	1-2 % (alongwind)
Air temperature	35.0 °C (average value)
Barometric pressure	1024.2 hPa (average value)
Relative humidity	27.9 % (average value)
Air density	1.15 kg/m <sup>3</sup> (average value)
Flow inclination	< 0.2°
Anemometer yaw orientation	Not relevant
Remarks	(none)

### Calibration results

Calibration equation  $v \text{ [m/s]} = 0.62066 \cdot f \text{ [Hz]} + 0.21486$

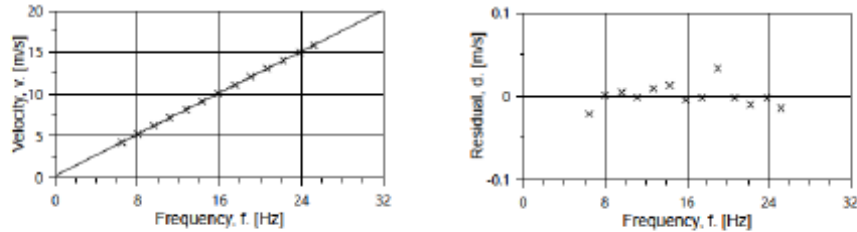
The calibration equation is obtained from a linear regression of the reference air velocity upon the Device Under Test (DUT) output. The residual is the deviation of the calibration equation prediction from the reference air velocity.

The calibration results relate only to the calibrated item.

Succession #	Velocity pressure [Pa]	Air temperature [°C]	Air density [kg/m <sup>3</sup> ]	Ref. air velocity, $v$ [m/s]	Uncertainty $u_c (k=2)$ [m/s]	DUT output Frequency, $f$ [Hz]	Residual, $d$ [m/s]
2	10.17	35.1	1.15	4.205	0.025	6.4632	-0.022
4	15.54	35.2	1.15	5.198	0.029	8.0265	0.001
6	22.06	35.2	1.15	6.194	0.033	9.6267	0.004
8	29.23	35.1	1.15	7.128	0.037	11.1410	-0.002
10	38.06	35.0	1.15	8.133	0.042	12.7433	0.009
12	47.76	34.9	1.15	9.110	0.046	14.3108	0.013
13-last	58.36	34.9	1.15	10.069	0.050	15.8849	-0.005
11	70.55	34.9	1.15	11.071	0.055	17.4951	-0.002
9	83.69	35.0	1.15	12.060	0.059	19.0315	0.033
7	97.73	35.1	1.15	13.034	0.064	20.6573	-0.002
5	112.70	35.1	1.15	13.998	0.069	22.2246	-0.010
3	129.41	35.1	1.15	15.000	0.073	23.8254	-0.002
1-first	144.52	34.9	1.15	15.845	0.077	25.2066	-0.014



**Visual presentation of calibration results**



**Linear regression results**

Method	Least squares linear regression
Slope	0.62066 (m/s)/Hz
Offset	0.21486 m/s
Coefficient of correlation	$\rho = 0.999994$
Standard error of estimate	0.0141 m/s
Slope standard error	0.00066 (m/s)/Hz
Offset standard error	0.01125 m/s
Slope and offset covariance	-0.000007004 (m/s) <sup>2</sup> /Hz
Remarks	Linearity complies with IEC 61400-12-1:2017, Annex F.

**Uncertainties**

The uncertainties stated under *Calibration results* relate to the reference air velocity at each calibration point. The uncertainty is the total combined uncertainty at 95 % confidence level (coverage factor  $k = 2$ ) in accordance with EA-4/02. The uncertainty complies with the requirements in IEC 61400-12-1:2017, Annex F. The uncertainty due to the wind tunnel correction function has been documented to be 0.1 % ( $k = 2$ ).

The slope and offset uncertainties and their covariance stated under *Linear regression results* are related to the linear regression only, and do not relate to the reference air velocity uncertainties. The slope and offset uncertainties have  $\nu = 11$  degrees of freedom.



**Calibration wind tunnel**

ID DK1  
 Test section Octagonal, hwxw = 1.20x1.75 m  
 Effective area of test section 2.10 m<sup>2</sup>  
 Setup report SOH document no. 18.1.001  
 Blockage ratio\* ~1.0 % (Anemometer and mounting pole)

\* The effect of blockage is taken into account in the calibration results.

**Equipment used**

Function	ID	Model / comments	Re-calibration due
QC Anemometer	11641	11641	-
Mounting	-	Mounting tube, diameter = 25 mm	-
Tunnel Temperature	T3	PT100 Temperature sensor	2021-03-05
Differential Pressure	1501197	FCO560 Pressure manometer	2021-03-08
Relative Humidity	Z0420014	HMW71U Humidity transmitter	2021-03-05
Barometric Pressure	U4220037	PTB100A Analogue barometer	2021-03-05
Pitot tube	A37AB	Ellipsoidal tip pitot tube	2027-02-22
Data acquisition	PCI-DAS6036	Computer Board. 16 bit A/D data acq. board	-
Computer	-	PC dedicated to data acquisition	-

Calibrations of the relevant equipment are carried out by external accredited institutions, and are traceable to national standards. A real-time analysis module within the data acquisition software detects pulse frequency.

**Setup photo**

The shown anemometer is of the same type as the one calibrated.



End of certificate



# Svend Ole Hansen ApS

SCT. JØRGENS ALLÉ 5C · DK-1615 KØBENHAVN V · DENMARK

TEL: (+45) 33 25 38 38 · [WWW.SOHANSEN.DK](http://WWW.SOHANSEN.DK)





WIND  
ENGINEERING  
FLUID  
DYNAMICS

## CERTIFICATE OF CALIBRATION

### Calibrated item

Type	WindSensor P2546C-OPR Cup Anemometer
Serial no.	40657
Manufacturer	WindSensor, Frederiksborgvej 399, 4000 Roskilde Denmark
Item received	May 29, 2020
Remarks	-

### Calibration

Calibration institute	Svend Ole Hansen ApS, Sct. Jørgens Allé 5C, DK-1615 København V
Procedure	IEC 61400-12-1:2017, Annex F
Client	WindSensor, Frederiksborgvej 399, 4000 Roskilde Denmark
Calibrated by	Calibrator, jvm 
Date of calibration	May 31, 2020
Approved by	Calibration engineer, sfo 
Post calibration	No
Re-calibration due	-

### Certificate

Certificate no.	20.02.01401
Date of issue	June 03, 2020
Issued by	ca
Number of pages	4

### Accreditation

Accredited to ISO 17025:2017 by DANAK. DANAK is signatory to the European co-operation for Accreditation (EA) Multilateral Agreement and to the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement.

The calibration institute is approved by MEASNET and IECRE.





### Calibration conditions

Turbulence intensity	1-2 % (alongwind)
Air temperature	35.4 °C (average value)
Barometric pressure	1024.2 hPa (average value)
Relative humidity	27.5 % (average value)
Air density	1.15 kg/m <sup>3</sup> (average value)
Flow inclination	< 0.2°
Anemometer yaw orientation	Not relevant
Remarks	(none)

### Calibration results

Calibration equation  $v \text{ [m/s]} = 0.62035 \cdot f \text{ [Hz]} + 0.21931$

The calibration equation is obtained from a linear regression of the reference air velocity upon the Device Under Test (DUT) output. The residual is the deviation of the calibration equation prediction from the reference air velocity.

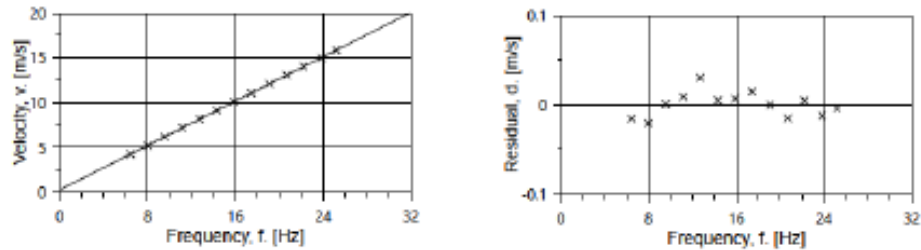
The calibration results relate only to the calibrated item.

Succession #	Velocity pressure [Pa]	Air temperature [°C]	Air density [kg/m <sup>3</sup> ]	Ref. air velocity, $v$ [m/s]	Uncertainty $u_c$ ( $k=2$ ) [m/s]	DUT output Frequency, $f$ [Hz]	Residual, $d$ [m/s]
2	10.15	35.5	1.15	4.203	0.025	6.4464	-0.016
4	15.36	35.5	1.15	5.171	0.029	8.0153	-0.021
6	21.76	35.5	1.15	6.154	0.033	9.5659	0.001
8	29.38	35.4	1.15	7.151	0.037	11.1591	0.009
10	38.13	35.3	1.15	8.144	0.042	12.7265	0.030
12	47.62	35.3	1.15	9.101	0.046	14.3101	0.004
13-last	58.41	35.2	1.15	10.079	0.051	15.8828	0.006
11	70.24	35.3	1.15	11.053	0.055	17.4411	0.014
9	83.59	35.3	1.15	12.060	0.059	19.0870	0.000
7	97.68	35.4	1.15	13.038	0.064	20.6878	-0.015
5	112.62	35.5	1.15	14.001	0.069	22.2090	0.004
3	128.99	35.5	1.15	14.983	0.073	23.8200	-0.013
1-first	144.32	35.2	1.15	15.842	0.077	25.1908	-0.004





### Visual presentation of calibration results



### Linear regression results

Method	Least squares linear regression
Slope	0.62035 (m/s)/Hz
Offset	0.21931 m/s
Coefficient of correlation	$\rho = 0.999993$
Standard error of estimate	0.0146 m/s
Slope standard error	0.00069 (m/s)/Hz
Offset standard error	0.01168 m/s
Slope and offset covariance	-0.000007551 (m/s) <sup>2</sup> /Hz
Remarks	Linearity complies with IEC 61400-12-1:2017, Annex F.

### Uncertainties

The uncertainties stated under *Calibration results* relate to the reference air velocity at each calibration point. The uncertainty is the total combined uncertainty at 95 % confidence level (coverage factor  $k = 2$ ) in accordance with EA-4/02. The uncertainty complies with the requirements in IEC 61400-12-1:2017, Annex F. The uncertainty due to the wind tunnel correction function has been documented to be 0.1 % ( $k = 2$ ).

The slope and offset uncertainties and their covariance stated under *Linear regression results* are related to the linear regression only, and do not relate to the reference air velocity uncertainties. The slope and offset uncertainties have  $\nu = 11$  degrees of freedom.



### Calibration wind tunnel

ID	DK1
Test section	Octagonal, hcxw = 1.20x1.75 m
Effective area of test section	2.10 m <sup>2</sup>
Setup report	SOH document no. 18.1.001
Blockage ratio*	~1.0 % (Anemometer and mounting pole)

\* The effect of blockage is taken into account in the calibration results.

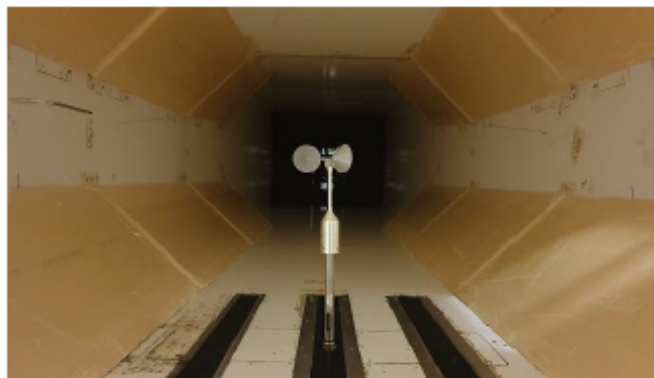
### Equipment used

Function	ID	Model / comments	Re-calibration due
QC Anemometer	11641	11641	-
Mounting	-	Mounting tube, diameter = 25 mm	-
Tunnel Temperature	T3	PT100 Temperature sensor	2021-03-05
Differential Pressure	1501197	FCO560 Pressure manometer	2021-03-08
Relative Humidity	Z0420014	HMW71U Humidity transmitter	2021-03-05
Barometric Pressure	U4220037	PTB100AA analogue barometer	2021-03-05
Pitot tube	A37AB	Ellipsoidal tip pitot tube	2027-02-22
Data acquisition	PCI-DAS6036	Computer Board. 16 bit A/D data acq. board	-
Computer	-	PC dedicated to data acquisition	-

Calibrations of the relevant equipment are carried out by external accredited institutions, and are traceable to national standards. A real-time analysis module within the data acquisition software detects pulse frequency.

### Setup photo

The shown anemometer is of the same type as the one calibrated.



End of certificate

# Svend Ole Hansen ApS

SCT. JØRGENS ALLÉ 5C · DK-1615 KØBENHAVN V · DENMARK  
TEL: (+45) 33 25 38 38 · [WWW.SOHANSEN.DK](http://WWW.SOHANSEN.DK)





WIND  
ENGINEERING  
FLUID  
DYNAMICS

## CERTIFICATE OF CALIBRATION

### Calibrated item

Type WindSensor P2546C-OPR Cup Anemometer  
Serial no. 40978  
Manufacturer WindSensor, Frederiksborgvej 399, 4000 Roskilde Denmark  
Item received October 02, 2020  
Remarks -

### Calibration

Calibration institute Svend Ole Hansen ApS, Sct. Jørgens Allé 5C, DK-1615 København V  
Procedure IEC 61400-12-1:2017, Annex F  
Client WindSensor, Frederiksborgvej 399, 4000 Roskilde Denmark  
Calibrated by Calibrator, jab   
Date of calibration October 04, 2020  
Approved by Calibration engineer, sfo   
Post calibration No  
Re-calibration due -

### Certificate

Certificate no. 20.02.02289  
Date of issue October 06, 2020  
Issued by ca  
Number of pages 4

### Accreditation

Accredited to ISO 17025:2017 by DANAK. DANAK is signatory to the European co-operation for Accreditation (EA) Multilateral Agreement and to the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement.

The calibration institute is approved by MEASNET and IECRE.





### Calibration conditions

Turbulence intensity	1-2 % (alongwind)
Air temperature	32.0 °C (average value)
Barometric pressure	991.8 hPa (average value)
Relative humidity	38.0 % (average value)
Air density	1.12 kg/m <sup>3</sup> (average value)
Flow inclination	< 0.2°
Anemometer yaw orientation	Not relevant
Remarks	(none)

### Calibration results

Calibration equation  $v \text{ [m/s]} = 0.61958 \cdot f \text{ [Hz]} + 0.22191$

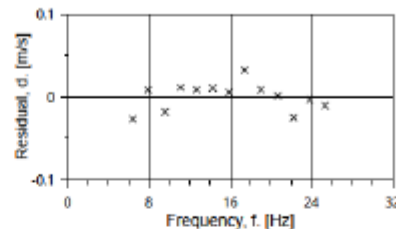
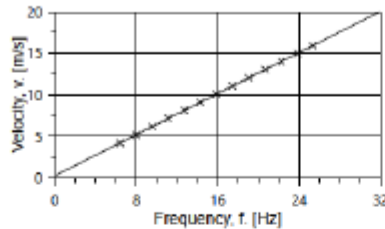
The calibration equation is obtained from a linear regression of the reference air velocity upon the Device Under Test (DUT) output. The residual is the deviation of the calibration equation prediction from the reference air velocity.

The calibration results relate only to the calibrated item.

Succession #	Velocity pressure [Pa]	Air temperature [°C]	Air density [kg/m <sup>3</sup> ]	Ref. air velocity, $v$ [m/s]	Uncertainty $u_c (k=2)$ [m/s]	DUT output Frequency, $f$ [Hz]	Residual, $d$ [m/s]
2	9.78	32.0	1.12	4.170	0.025	6.4161	-0.027
4	14.90	32.1	1.12	5.149	0.029	7.9389	0.008
6	21.23	32.0	1.12	6.145	0.033	9.5891	-0.018
8	28.50	31.9	1.12	7.119	0.037	11.1136	0.011
10	36.95	31.9	1.12	8.105	0.041	12.7094	0.009
12	46.35	31.8	1.12	9.078	0.046	14.2768	0.010
13-last	56.92	31.8	1.12	10.059	0.050	15.8696	0.005
11	68.66	31.8	1.12	11.049	0.055	17.4230	0.032
9	81.28	31.9	1.12	12.023	0.059	19.0328	0.009
7	95.43	32.0	1.12	13.030	0.064	20.6696	0.001
5	109.81	32.1	1.12	13.978	0.068	22.2435	-0.025
3	126.06	32.2	1.12	14.979	0.073	23.8231	-0.004
1-first	142.24	31.9	1.12	15.906	0.077	25.3311	-0.011



**Visual presentation of calibration results**



**Linear regression results**

<b>Method</b>	Least squares linear regression
<b>Slope</b>	0.61958 (m/s)/Hz
<b>Offset</b>	0.22191 m/s
<b>Coefficient of correlation</b>	$\rho = 0.999990$
<b>Standard error of estimate</b>	0.0174 m/s
<b>Slope standard error</b>	0.00082 (m/s)/Hz
<b>Offset standard error</b>	0.01382 m/s
<b>Slope and offset covariance</b>	-0.000010563 (m/s) <sup>2</sup> /Hz
<b>Remarks</b>	Linearity complies with IEC 61400-12-1:2017, Annex F.

**Uncertainties**

The uncertainties stated under *Calibration results* relate to the reference air velocity at each calibration point. The uncertainty is the total combined uncertainty at 95 % confidence level (coverage factor  $k = 2$ ) in accordance with EA-4/02. The uncertainty complies with the requirements in IEC 61400-12-1:2017, Annex F. The uncertainty due to the wind tunnel correction function has been documented to be 0.1 % ( $k = 2$ ).

The slope and offset uncertainties and their covariance stated under *Linear regression results* are related to the linear regression only, and do not relate to the reference air velocity uncertainties. The slope and offset uncertainties have  $\nu = 11$  degrees of freedom.



### Calibration wind tunnel

ID	DK1
Test section	Octagonal, hxcw = 1.20x1.75 m
Effective area of test section	2.10 m <sup>2</sup>
Setup report	SOH document no. 18.1.001
Blockage ratio*	~1.0 % (Anemometer and mounting pole)

\* The effect of blockage is taken into account in the calibration results.

### Equipment used

Function	ID	Model / comments	Re-calibration due
QC Anemometer	11641	11641	-
Mounting	-	Mounting tube, diameter = 25 mm	-
Tunnel Temperature	T2	PT100 Temperature sensor	2022-03-16
Differential Pressure	9904031	PPC500 Pressure manometer	2022-05-14
Relative Humidity	X4650038	HMW71U Humidity transmitter	2022-03-16
Barometric Pressure	X4350042	PTB100A Analogue barometer	2022-03-12
Pitot tube	A37AB	Ellipsoidal tip pitot tube	2027-02-22
Data acquisition	USB-1608GX	Computer Board. 16 bit A/D data acq. board	-
Computer	-	PC dedicated to data acquisition	-

Calibrations of the relevant equipment are carried out by external accredited institutions, and are traceable to national standards. A real-time analysis module within the data acquisition software detects pulse frequency.

### Setup photo

The shown anemometer is of the same type as the one calibrated.



End of certificate



# Svend Ole Hansen ApS

SCT. JØRGENS ALLÉ 5C · DK-1615 KØBENHAVN V · DENMARK

TEL: (+45) 33 25 38 38 · [WWW.SOHANSEN.DK](http://WWW.SOHANSEN.DK)



WIND  
ENGINEERING  
FLUID  
DYNAMICS

## CERTIFICATE OF CALIBRATION

### Calibrated item

Type Thies 4.3350.10.000  
Serial no. 0207766  
Manufacturer ADOLF THIES GmbH & Co.KG, Hauptstrasse 76, 37083 Göttingen, Germany  
Item received September 07, 2020  
Remarks -

### Calibration

Calibration institute Svend Ole Hansen ApS, Sct. Jørgens Allé 5C, DK-1615 København V  
Procedure IEC 61400-12-1:2017, Annex F  
Client IDNAMIC Italia S.r.l., S.S. 212 km 9 Area PIP, 82020 Pietrelcina (BN), Italy  
Calibrated by Calibrator, fim *Felix Muelly*  
Date of calibration September 12, 2020  
Approved by Calibration engineer, sfo *Jan J. Olsen*  
Post calibration No  
Re-calibration due -

### Certificate

Certificate no. 20.02.02079  
Date of issue September 18, 2020  
Issued by ca  
Number of pages 4

### Accreditation

Accredited to ISO 17025:2017 by DANAK. DANAK is signatory to the European co-operation for Accreditation (EA) Multilateral Agreement and to the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement.

The calibration institute is approved by MEASNET and IECRE.





### Calibration conditions

Turbulence intensity	1-2 % (alongwind)
Air temperature	27.3 °C (average value)
Barometric pressure	1011.0 hPa (average value)
Relative humidity	40.3 % (average value)
Air density	1.17 kg/m <sup>3</sup> (average value)
Flow inclination	< 0.2°
Anemometer yaw orientation	Not relevant
Remarks	(none)

### Calibration results

Calibration equation  $v \text{ [m/s]} = 0.04793 \cdot f \text{ [Hz]} + 0.28099$

The calibration equation is obtained from a linear regression of the reference air velocity upon the Device Under Test (DUT) output. The residual is the deviation of the calibration equation prediction from the reference air velocity.

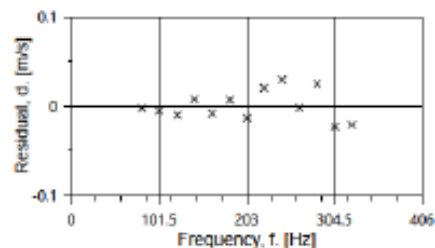
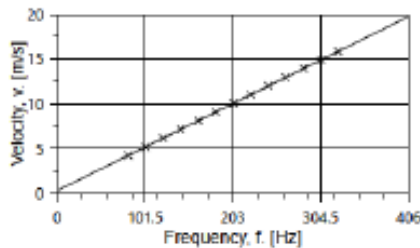
The calibration results relate only to the calibrated item.

Succession #	Velocity pressure [Pa]	Air temperature [°C]	Air density [kg/m <sup>3</sup> ]	Ref. air velocity, $v$ [m/s]	Uncertainty $u_c$ ( $k=2$ ) [m/s]	DUT output Frequency, $f$ [Hz]	Residual, $d$ [m/s]
2	10.32	27.3	1.17	4.207	0.025	81.9736	-0.003
4	15.54	27.4	1.17	5.164	0.029	101.9947	-0.006
6	22.07	27.3	1.17	6.153	0.033	122.7240	-0.010
8	29.55	27.3	1.17	7.120	0.037	142.5226	0.007
10	38.24	27.2	1.17	8.098	0.041	163.2554	-0.008
12	48.06	27.2	1.17	9.078	0.046	183.3949	0.007
13-last	58.73	27.2	1.17	10.035	0.050	203.7862	-0.014
11	70.59	27.2	1.17	11.003	0.054	223.2695	0.020
9	84.11	27.3	1.17	12.012	0.059	244.1279	0.029
7	97.55	27.4	1.17	12.938	0.063	264.1020	-0.002
5	113.38	27.5	1.17	13.950	0.068	284.6654	0.025
3	128.88	27.5	1.16	14.875	0.072	304.9537	-0.023
1-first	146.18	27.3	1.17	15.836	0.076	324.9550	-0.021





**Visual presentation of calibration results**



**Linear regression results**

<b>Method</b>	Least squares linear regression
<b>Slope</b>	0.04793 (m/s)/Hz
<b>Offset</b>	0.28099 m/s
<b>Coefficient of correlation</b>	$\rho = 0.999990$
<b>Standard error of estimate</b>	0.0175 m/s
<b>Slope standard error</b>	0.00006 (m/s)/Hz
<b>Offset standard error</b>	0.01391 m/s
<b>Slope and offset covariance</b>	-0.000000835 (m/s) <sup>2</sup> /Hz
<b>Remarks</b>	Linearity complies with IEC 61400-12-1:2017, Annex F.

**Uncertainties**

The uncertainties stated under *Calibration results* relate to the reference air velocity at each calibration point. The uncertainty is the total combined uncertainty at 95 % confidence level (coverage factor  $k = 2$ ) in accordance with EA-4/02. The uncertainty complies with the requirements in IEC 61400-12-1:2017, Annex F. The uncertainty due to the wind tunnel correction function has been documented to be 0.1 % ( $k = 2$ ).

The slope and offset uncertainties and their covariance stated under *Linear regression results* are related to the linear regression only, and do not relate to the reference air velocity uncertainties. The slope and offset uncertainties have  $\nu = 11$  degrees of freedom.



### Calibration wind tunnel

ID	DK1
Test section	Octagonal, hrxw = 1.20x1.75 m
Effective area of test section	2.10 m <sup>2</sup>
Setup report	SOH document no. 18.1.001
Blockage ratio*	~1.3 % (Anemometer and mounting pole)

\* The effect of blockage is taken into account in the calibration results.

### Equipment used

Function	ID	Model / comments	Re-calibration due
QC Anemometer	03113415	03113415	-
Mounting	-	Mounting tube, diameter = 35 mm	-
Tunnel Temperature	T2	PT100 Temperature sensor	2022-03-16
Differential Pressure	9904031	PPC500 Pressure manometer	2022-05-14
Relative Humidity	X4650038	HMW71U Humidity transmitter	2022-03-16
Barometric Pressure	X4350042	PTB100A Analogue barometer	2022-03-12
Pitot tube	A37AB	Ellipsoidal tip pitot tube	2027-02-22
Data acquisition	USB-1608GX	Computer Board. 16 bit A/D data acq. board	-
Computer	-	PC dedicated to data acquisition	-

Calibrations of the relevant equipment are carried out by external accredited institutions, and are traceable to national standards. A real-time analysis module within the data acquisition software detects pulse frequency.

### Setup photo

The shown anemometer is of the same type as the one calibrated.



End of certificate

# Svend Ole Hansen ApS

SCT. JØRGENS ALLÉ 5C · DK-1615 KØBENHAVN V · DENMARK  
TEL: (+45) 33 25 38 38 · [WWW.SOHANSEN.DK](http://WWW.SOHANSEN.DK)



WIND  
ENGINEERING  
FLUID  
DYNAMICS

## CERTIFICATE OF CALIBRATION

### Calibrated item

Type Thies 4.3350.10.000  
Serial no. 0709397  
Manufacturer ADOLF THIES GmbH & Co.KG, Hauptstrasse 76, 37083 Göttingen, Germany  
Item received September 07, 2020  
Remarks -

### Calibration

Calibration institute Svend Ole Hansen ApS, Sct. Jørgens Allé 5C, DK-1615 København V  
Procedure IEC 61400-12-1:2017, Annex F  
Client IDNAMIC Italia S.r.l., S.S. 212 km 9 Area PIP, 82020 Pietrelcina (BN), Italy  
Calibrated by Calibrator, fim *Felipe Anselmi*  
Date of calibration September 12, 2020  
Approved by Calibration engineer, sfo *Jan J. Brin*  
Post calibration No  
Re-calibration due -

### Certificate

Certificate no. 20.02.02075  
Date of issue September 18, 2020  
Issued by ca  
Number of pages 4

### Accreditation

Accredited to ISO 17025:2017 by DANAK. DANAK is signatory to the European co-operation for Accreditation (EA) Multilateral Agreement and to the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement.

The calibration institute is approved by MEASNET and IECRE.





### Calibration conditions

Turbulence intensity	1-2 % (alongwind)
Air temperature	28.4 °C (average value)
Barometric pressure	1012.1 hPa (average value)
Relative humidity	39.8 % (average value)
Air density	1.16 kg/m <sup>3</sup> (average value)
Flow inclination	< 0.2°
Anemometer yaw orientation	Not relevant
Remarks	(none)

### Calibration results

Calibration equation  $v \text{ [m/s]} = 0.04802 \cdot f \text{ [Hz]} + 0.24842$

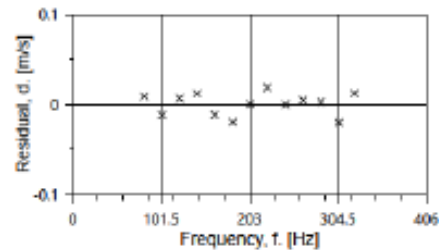
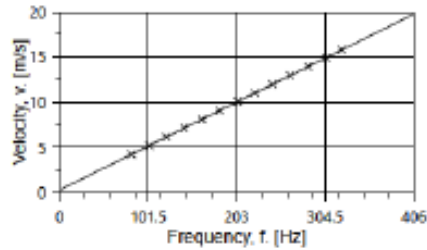
The calibration equation is obtained from a linear regression of the reference air velocity upon the Device Under Test (DUT) output. The residual is the deviation of the calibration equation prediction from the reference air velocity.

The calibration results relate only to the calibrated item.

Succession #	Velocity pressure [Pa]	Air temperature [°C]	Air density [kg/m <sup>3</sup> ]	Ref. air velocity, $v$ [m/s]	Uncertainty $u_c$ ( $k=2$ ) [m/s]	DUT output Frequency, $f$ [Hz]	Residual, $d$ [m/s]
2	10.26	28.4	1.16	4.201	0.025	82.1211	0.009
4	15.53	28.4	1.16	5.169	0.029	102.7235	-0.012
6	21.90	28.4	1.16	6.138	0.033	122.5043	0.007
8	29.43	28.3	1.16	7.114	0.037	142.7226	0.012
10	37.87	28.3	1.16	8.069	0.041	163.1085	-0.012
12	47.57	28.2	1.16	9.043	0.046	183.5502	-0.020
13-last	58.74	28.2	1.16	10.048	0.050	204.0577	0.000
11	70.37	28.3	1.16	11.000	0.054	223.4825	0.019
9	83.48	28.4	1.16	11.983	0.059	244.3547	0.000
7	97.43	28.5	1.16	12.948	0.063	264.3544	0.004
5	112.79	28.5	1.16	13.933	0.068	284.9035	0.003
3	128.88	28.6	1.16	14.895	0.072	305.4127	-0.020
1-first	145.12	28.3	1.16	15.799	0.076	323.5589	0.012



### Visual presentation of calibration results



### Linear regression results

Method	Least squares linear regression
Slope	0.04802 (m/s)/Hz
Offset	0.24842 m/s
Coefficient of correlation	$\rho = 0.999995$
Standard error of estimate	0.0131 m/s
Slope standard error	0.00005 (m/s)/Hz
Offset standard error	0.01043 m/s
Slope and offset covariance	-0.000000470 (m/s) <sup>2</sup> /Hz
Remarks	Linearity complies with IEC 61400-12-1:2017, Annex F.

### Uncertainties

The uncertainties stated under *Calibration results* relate to the reference air velocity at each calibration point. The uncertainty is the total combined uncertainty at 95 % confidence level (coverage factor  $k = 2$ ) in accordance with EA-4/02. The uncertainty complies with the requirements in IEC 61400-12-1:2017, Annex F. The uncertainty due to the wind tunnel correction function has been documented to be 0.1 % ( $k = 2$ ).

The slope and offset uncertainties and their covariance stated under *Linear regression results* are related to the linear regression only, and do not relate to the reference air velocity uncertainties. The slope and offset uncertainties have  $\nu = 11$  degrees of freedom.





**Calibration wind tunnel**

ID DK1  
 Test section Octagonal, h<sub>rw</sub> = 1.20x1.75 m  
 Effective area of test section 2.10 m<sup>2</sup>  
 Setup report SOH document no. 18.1.001  
 Blockage ratio\* ~1.3 % (Anemometer and mounting pole)

\* The effect of blockage is taken into account in the calibration results.

**Equipment used**

Function	ID	Model / comments	Re-calibration due
QC Anemometer	03113415	03113415	-
Mounting	-	Mounting tube, diameter = 35 mm	-
Tunnel Temperature	T2	PT100 Temperature sensor	2022-03-16
Differential Pressure	9904031	PPC500 Pressure manometer	2022-05-14
Relative Humidity	X4650038	HMW71U Humidity transmitter	2022-03-16
Barometric Pressure	X4350042	PTB100A Analogue barometer	2022-03-12
Pitot tube	A37AB	Ellipsoidal tip pitot tube	2027-02-22
Data acquisition	USB-1608GX	Computer Board. 16 bit A/D data acq. board	-
Computer	-	PC dedicated to data acquisition	-

Calibrations of the relevant equipment are carried out by external accredited institutions, and are traceable to national standards. A real-time analysis module within the data acquisition software detects pulse frequency.

**Setup photo**

The shown anemometer is of the same type as the one calibrated.



End of certificate

# Svend Ole Hansen ApS

SCT. JØRGENS ALLÉ 5C · DK-1615 KØBENHAVN V · DENMARK  
TEL: (+45) 33 25 38 38 · [WWW.SOHANSEN.DK](http://WWW.SOHANSEN.DK)





WIND  
ENGINEERING  
FLUID  
DYNAMICS

## CERTIFICATE OF CALIBRATION

### Calibrated item

Type Thies 4.3352.10.000  
Serial no. 01180272  
Manufacturer ADOLF THIES GmbH & Co.KG, Hauptstrasse 76, 37083 Göttingen, Germany  
Item received March 20, 2020  
Remarks -

### Calibration

Calibration institute Svend Ole Hansen ApS, Sct. Jørgens Allé 5C, DK-1615 København V  
Procedure IEC 61400-12-1:2017, Annex F  
Client IDNAMIC Italia S.r.L., S.S. 212 km 9 Area PIP, 82020 Pietrelcina (BN), Italy  
Calibrated by Calibrator, ca   
Date of calibration April 01, 2020  
Approved by Calibration engineer, sfo   
Post calibration No  
Re-calibration due -

### Certificate

Certificate no. 20.02.00809  
Date of issue April 14, 2020  
Issued by ca  
Number of pages 4

### Accreditation

Accredited to ISO 17025:2017 by DANAK. DANAK is signatory to the European co-operation for Accreditation (EA) Multilateral Agreement and to the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement.

The calibration institute is approved by MEASNET and IECRE.







### Calibration conditions

Turbulence intensity	1-2 % (alongwind)
Air temperature	31.7 °C (average value)
Barometric pressure	1010.2 hPa (average value)
Relative humidity	21.7 % (average value)
Air density	1.15 kg/m <sup>3</sup> (average value)
Flow inclination	< 0.2°
Anemometer yaw orientation	Not relevant
Remarks	(none)

### Calibration results

Calibration equation  $v \text{ [m/s]} = 0.04625 \cdot f \text{ [Hz]} + 0.22923$

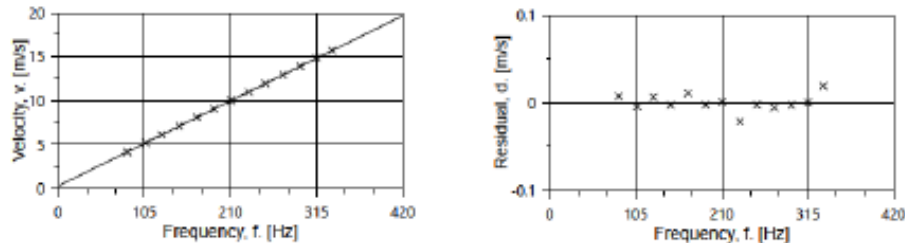
The calibration equation is obtained from a linear regression of the reference air velocity upon the Device Under Test (DUT) output. The residual is the deviation of the calibration equation prediction from the reference air velocity.

The calibration results relate only to the calibrated item.

Succession #	Velocity pressure [Pa]	Air temperature [°C]	Air density [kg/m <sup>3</sup> ]	Ref. air velocity, $v$ [m/s]	Uncertainty $u_c$ ( $k = 2$ ) [m/s]	DUT output Frequency, $f$ [Hz]	Residual, $d$ [m/s]
2	9.85	31.7	1.15	4.138	0.025	84.3619	0.007
4	15.32	31.8	1.15	5.163	0.029	106.7845	-0.004
6	21.30	31.8	1.15	6.088	0.033	126.5549	0.006
8	28.62	31.7	1.15	7.056	0.037	147.6790	-0.003
10	37.38	31.7	1.15	8.064	0.041	169.1711	0.011
12	46.89	31.6	1.15	9.031	0.046	190.3659	-0.003
13-last	57.27	31.6	1.15	9.979	0.050	210.7991	0.001
11	69.06	31.6	1.15	10.959	0.055	232.4703	-0.022
9	81.79	31.7	1.15	11.927	0.059	252.9991	-0.003
7	95.78	31.7	1.15	12.908	0.064	274.2740	-0.006
5	110.61	31.8	1.15	13.872	0.068	295.0537	-0.003
3	125.99	31.8	1.15	14.804	0.072	315.1324	0.000
1-first	141.75	31.4	1.15	15.693	0.076	333.9514	0.019



### Visual presentation of calibration results



### Linear regression results

Method	Least squares linear regression
Slope	0.04625 (m/s)/Hz
Offset	0.22923 m/s
Coefficient of correlation	$\rho = 0.999997$
Standard error of estimate	0.0101 m/s
Slope standard error	0.00004 (m/s)/Hz
Offset standard error	0.00807 m/s
Slope and offset covariance	-0.000000272 (m/s) <sup>2</sup> /Hz
Remarks	Linearity complies with IEC 61400-12-1:2017, Annex F.

### Uncertainties

The uncertainties stated under *Calibration results* relate to the reference air velocity at each calibration point. The uncertainty is the total combined uncertainty at 95 % confidence level (coverage factor  $k=2$ ) in accordance with EA-4/02. The uncertainty complies with the requirements in IEC 61400-12-1:2017, Annex F. The uncertainty due to the wind tunnel correction function has been documented to be 0.1 % ( $k=2$ ).

The slope and offset uncertainties and their covariance stated under *Linear regression results* are related to the linear regression only, and do not relate to the reference air velocity uncertainties. The slope and offset uncertainties have  $\nu = 11$  degrees of freedom.



**Calibration wind tunnel**

**ID** DK1  
**Test section** Octagonal, hxcw = 1.20x1.75 m  
**Effective area of test section** 2.10 m<sup>2</sup>  
**Setup report** SOH document no. 18.1.001  
**Blockage ratio\*** ~1.3 % (Anemometer and mounting pole)

\* The effect of blockage is taken into account in the calibration results.

**Equipment used**

Function	ID	Model / comments	Re-calibration due
QC Anemometer	03113415	03113415	-
Mounting	-	Mounting tube, diameter = 35 mm	-
Tunnel Temperature	T3	PT100 Temperature sensor	2021-03-05
Differential Pressure	1501197	FCO560 Pressure manometer	2021-03-08
Relative Humidity	Z0420014	HMW71U Humidity transmitter	2021-03-05
Barometric Pressure	U4220037	PTB100A Analogue barometer	2021-03-05
Pitot tube	A37AB	Ellipsoidal tip pitot tube	2027-02-22
Data acquisition	PCI-DAS6036	Computer Board. 16 bit A/D data acq. board	-
Computer	-	PC dedicated to data acquisition	-

Calibrations of the relevant equipment are carried out by external accredited institutions, and are traceable to national standards. A real-time analysis module within the data acquisition software detects pulse frequency.

**Setup photo**

The shown anemometer is of the same type as the one calibrated.



End of certificate

# Svend Ole Hansen ApS

SCT. JØRGENS ALLÉ 5C · DK-1615 KØBENHAVN V · DENMARK

TEL: (+45) 33 25 38 38 · [WWW.SOHANSEN.DK](http://WWW.SOHANSEN.DK)





WIND  
ENGINEERING  
FLUID  
DYNAMICS

## CERTIFICATE OF CALIBRATION

### Calibrated item

Type Thies 4.3351.10.000  
Serial no. 07101411  
Manufacturer ADOLF THIES GmbH & Co.KG, Hauptstrasse 76, 37083 Göttingen, Germany  
Item received March 20, 2020  
Remarks -

### Calibration

Calibration institute Svend Ole Hansen ApS, Sct. Jørgens Allé 5C, DK-1615 København V  
Procedure IEC 61400-12-1:2017, Annex F  
Client IDNAMIC Italia S.r.l., S.S. 212 km 9 Area PIP, 82020 Pietrelcina (BN), Italy  
Calibrated by Calibrator, ca   
Date of calibration April 01, 2020  
Approved by Calibration engineer, sfo   
Post calibration No  
Re-calibration due -

### Certificate

Certificate no. 20.02.00810  
Date of issue April 14, 2020  
Issued by ca  
Number of pages 4

### Accreditation

Accredited to ISO 17025:2017 by DANAK. DANAK is signatory to the European co-operation for Accreditation (EA) Multilateral Agreement and to the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement.

The calibration institute is approved by MEASNET and IECRE.





### Calibration conditions

Turbulence intensity	1-2 % (alongwind)
Air temperature	31.9 °C (average value)
Barometric pressure	1009.9 hPa (average value)
Relative humidity	21.7 % (average value)
Air density	1.15 kg/m <sup>3</sup> (average value)
Flow inclination	< 0.2°
Anemometer yaw orientation	Not relevant
Remarks	(none)

### Calibration results

Calibration equation  $v \text{ [m/s]} = 0.04621 \cdot f \text{ [Hz]} + 0.22659$

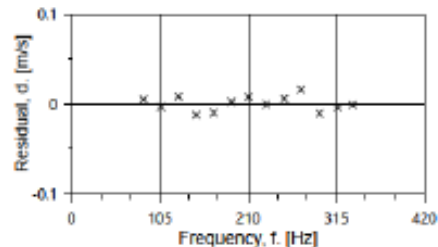
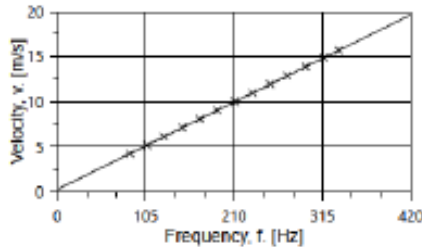
The calibration equation is obtained from a linear regression of the reference air velocity upon the Device Under Test (DUT) output. The residual is the deviation of the calibration equation prediction from the reference air velocity.

The calibration results relate only to the calibrated item.

Succession #	Velocity pressure [Pa]	Air temperature [°C]	Air density [kg/m <sup>3</sup> ]	Ref. air velocity, $v$ [m/s]	Uncertainty $u_c (k=2)$ [m/s]	DUT output Frequency, $f$ [Hz]	Residual, $d$ [m/s]
2	10.14	31.9	1.15	4.202	0.025	85.9267	0.005
4	15.23	32.0	1.15	5.149	0.029	106.6213	-0.004
6	21.41	32.0	1.15	6.106	0.033	127.0648	0.008
8	28.78	31.9	1.15	7.079	0.037	148.5821	-0.013
10	37.17	31.8	1.15	8.044	0.041	169.4056	-0.010
12	46.76	31.8	1.15	9.021	0.046	190.2793	0.002
13-last	57.20	31.7	1.15	9.977	0.050	210.8632	0.007
11	68.80	31.8	1.15	10.943	0.054	231.9440	-0.001
9	81.85	31.8	1.15	11.936	0.059	253.2939	0.005
7	95.03	31.9	1.15	12.863	0.063	273.1481	0.016
5	110.15	32.0	1.15	13.850	0.068	295.0672	-0.011
3	126.80	31.9	1.15	14.858	0.073	316.7465	-0.004
1-first	141.42	31.7	1.15	15.684	0.076	334.5584	-0.001



**Visual presentation of calibration results**



**Linear regression results**

<b>Method</b>	Least squares linear regression
<b>Slope</b>	0.04621 (m/s)/Hz
<b>Offset</b>	0.22659 m/s
<b>Coefficient of correlation</b>	$\rho = 0.999998$
<b>Standard error of estimate</b>	0.0087 m/s
<b>Slope standard error</b>	0.00003 (m/s)/Hz
<b>Offset standard error</b>	0.00699 m/s
<b>Slope and offset covariance</b>	-0.000000204 (m/s) <sup>2</sup> /Hz
<b>Remarks</b>	Linearity complies with IEC 61400-12-1:2017, Annex F.

**Uncertainties**

The uncertainties stated under *Calibration results* relate to the reference air velocity at each calibration point. The uncertainty is the total combined uncertainty at 95 % confidence level (coverage factor  $k = 2$ ) in accordance with EA-4/02. The uncertainty complies with the requirements in IEC 61400-12-1:2017, Annex F. The uncertainty due to the wind tunnel correction function has been documented to be 0.1 % ( $k = 2$ ).

The slope and offset uncertainties and their covariance stated under *Linear regression results* are related to the linear regression only, and do not relate to the reference air velocity uncertainties. The slope and offset uncertainties have  $\nu = 11$  degrees of freedom.





**Calibration wind tunnel**

ID DK1  
 Test section Octagonal, hxcw = 1.20x1.75 m  
 Effective area of test section 2.10 m<sup>2</sup>  
 Setup report SOH document no. 18.1.001  
 Blockage ratio\* ~1.3 % (Anemometer and mounting pole)

\* The effect of blockage is taken into account in the calibration results.

**Equipment used**

Function	ID	Model / comments	Re-calibration due
QC Anemometer	03113415	03113415	-
Mounting	-	Mounting tube, diameter = 35 mm	-
Tunnel Temperature	T3	PT100 Temperature sensor	2021-03-05
Differential Pressure	1501197	FCO560 Pressure manometer	2021-03-08
Relative Humidity	Z0420014	HMW71U Humidity transmitter	2021-03-05
Barometric Pressure	U4220037	PTB100A Analogue barometer	2021-03-05
Pitot tube	A37AB	Ellipsoidal tip pitot tube	2027-02-22
Data acquisition	PCI-DAS6036	Computer Board. 16 bit A/D data acq. board	-
Computer	-	PC dedicated to data acquisition	-

Calibrations of the relevant equipment are carried out by external accredited institutions, and are traceable to national standards. A real-time analysis module within the data acquisition software detects pulse frequency.

**Setup photo**

The shown anemometer is of the same type as the one calibrated.



End of certificate





Vaisala is ISO 9001, ISO 14001 and  
AQuP 2110 certified company.

## CALIBRATION CERTIFICATE

This certificate may only be reproduced in full, except with  
the prior written permission by the issuing laboratory.

Certificate Number:

HEL201910023



Instrument: Humidity and Temperature Probe HMP155  
Order code: A3GB11A0A2A1A0A  
Serial Number: S1830818  
Manufacturer: Vaisala Oyj, Finland  
Calibration date: 2020-04-29

Approved by:

*Sami Mikkola*

Digitally signed by SAMIK  
Date: 2020.05.04 08:38:19 +03:00  
Reason: Calibration responsible  
Location: Vaisala Oyj, Finland

The analog outputs of the instrument were calibrated by using working standards of the manufacturer. The outputs were forced by digital input to three output values and measured with a calibrated voltmeter.

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor  $k = 2$ , which for a normal distribution corresponds to a coverage probability of approximately 95 %. The measurement results are traceable to the international system of units (SI) through national metrology institutes (NIST USA, MIKES Finland, or equivalent) or via ISO/IEC 17025 accredited calibration laboratories.

### Analog output channel 1 calibration results

Channel 1 scaling: T -40...60 °C 0...5 V

Output forced to [V]	Observed output [V]	Difference [V]	Acceptance limit [V]	Pass/Fail
0.5000	0.5000	0.0000	±0.0025	Pass
2.5000	2.5001	0.0001	±0.0025	Pass
4.5000	4.5001	0.0001	±0.0025	Pass

### Analog output channel 2 calibration results

Channel 2 scaling: RH 0...100 % 0...5 V

Output forced to [V]	Observed output [V]	Difference [V]	Acceptance limit [V]	Pass/Fail
0.5000	0.5000	0.0003	±0.0025	Pass
2.5000	2.5001	0.0001	±0.0025	Pass
4.5000	4.5004	0.0004	±0.0025	Pass

### Reference equipment used in calibration

Type	Identity Number	Certificate Number	Calibration Date
PXI-E-4080	18483	C03651	2018-10-30

### Calibration uncertainties (k=2, ~95% confidence level):

Voltage ± 0.0005 V

### Ambient conditions:

Humidity [%RH]      Temperature [°C]      Pressure [hPa]  
22 ± 4                      23 ± 2                      1008 ± 20

## CALIBRATION CERTIFICATE

This certificate may only be reproduced in full, except with  
the prior written permission by the issuing laboratory

Certificate Number:

HEL201910024



Instrument: Humidity and Temperature Probe HMP155  
Order Code: A3GB11AQA2A-AQA  
Serial Number: S1830818  
Manufacturer: Vaisala Oyj, Finland  
Calibration Date: 2020-04-29

Approved by:

*Sami Mikkola*

Digitally signed by SAMIK  
Date: 2020.05.04 06:38:45 +03:00  
Reason: Calibration responsible  
Location: Vaisala Oyj, Finland

The humidity sensor of the instrument was calibrated by comparing the instrument's humidity reading to a generated reference humidity reading. The reference humidity reading was calculated based on two-pressure humidity generation principle, using the measurement results of saturator pressure and temperature and calibration chamber pressure and temperature.

The temperature sensor(s) of the instrument was calibrated by comparing the instrument's temperature readings to a reference thermometer.

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor  $k = 2$ , which for a normal distribution corresponds to a coverage probability of approximately 95 %. The measurement results are traceable to the international system of units (SI) through national metrology institutes (NIST USA, MIKES Finland, or equivalent) or via ISO/IEC 17025 accredited calibration laboratories.

### Humidity calibration results

Reference Humidity [%RH]	Reference Temperature [°C]	Observed Humidity [%RH]	Observed Temperature [°C]	Humidity Error [%RH]	Acceptance Limit [%RH]	Pass/Fail
0.0	22.82	0.0	22.82	0.0	±1.0	Pass
15.0	22.82	14.7	22.82	-0.3	±1.0	Pass
33.0	22.83	32.6	22.83	-0.4	±1.0	Pass
54.0	22.83	53.8	22.83	-0.2	±1.0	Pass
75.1	22.83	75.1	22.83	0.0	±1.0	Pass
95.1	22.84	95.2	22.83	0.1	±1.7	Pass

### Temperature calibration results

Reference Temperature [°C]	Observed Temperature [°C]	Error [°C]	Acceptance Limit [°C]	Pass/Fail
22.83	22.83	0.00	±0.10	Pass

### Additional temperature probe calibration results

Reference Temperature [°C]	Observed Temperature [°C]	Error [°C]	Acceptance Limit [°C]	Pass/Fail
-	-	-	-	-

### Reference equipment used in calibration

Type	Identity Number	Certificate Number	Calibration Date	Calibration Due Date
PTJ307	18469	K008-C03549	2019-10-18	2020-10-31
HMP307	18465	K008-C03655	2019-10-29	2020-10-31
GE Druck DPS 823B	16737	K008-C04150	2019-12-17	2020-06-30
AM1612	18466	K008-C03653	2019-10-29	2020-10-31
PX E-4080	18463	C03651	2019-10-30	2020-10-31

### Calibration uncertainty (k=2, ~95% confidence level):

Humidity ± 0.8 %RH @ 0...40 %RH, ± 1.0 %RH @ 40...95 %RH  
Temperature ± 0.10 °C

### Ambient conditions:

Humidity [%RH] 22 ± 4      Temperature [°C] 23 ± 2      Pressure [hPa] 1008 ± 20

## CALIBRATION CERTIFICATE

This certificate may only be reproduced in full, except with the prior written permission by the issuing laboratory

Certificate Number: HEL201910045



Instrument: Humidity and Temperature Probe HMP155  
 Order code: A3GB11ADA2A1ADA  
 Serial Number: S1B30821  
 Manufacturer: Vaisala Oyj, Finland  
 Calibration date: 2020-04-29

Approved by:

*Sami Mikkola*

Digitally signed by SAMIK  
 Date: 2020.05.04 06:58:22 +03:00  
 Reason: Calibration responsible  
 Location: Vaisala Oyj, Finland

The analog outputs of the instrument were calibrated by using working standards of the manufacturer. The outputs were forced by digital input to three output values and measured with a calibrated voltmeter.

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor  $k = 2$ , which for a normal distribution corresponds to a coverage probability of approximately 95 %. The measurement results are traceable to the international system of units (SI) through national metrology institutes (NIST USA, MIKES Finland, or equivalent) or via ISO/IEC 17025 accredited calibration laboratories.

### Analog output channel 1 calibration results

Channel 1 scaling: T -40...60 °C 0...5 V

Output forced to [V]	Observed output [V]	Difference [V]	Acceptance limit [V]	Pass/Fail
0.5000	0.5002	0.0002	±0.0025	Pass
2.5000	2.5000	0.0000	±0.0025	Pass
4.5000	4.5001	0.0001	±0.0025	Pass

### Analog output channel 2 calibration results

Channel 2 scaling: RH 0...100 % 0...5 V

Output forced to [V]	Observed output [V]	Difference [V]	Acceptance limit [V]	Pass/Fail
0.5000	0.5002	0.0002	±0.0025	Pass
2.5000	2.5002	0.0002	±0.0025	Pass
4.5000	4.5003	0.0003	±0.0025	Pass

### Reference equipment used in calibration

Type	Identity Number	Certificate Number	Calibration Date
PX E-4080	18463	C03651	2019-10-30

### Calibration uncertainties (k=2, 95% confidence level):

Voltage ± 0.0005 V

### Ambient conditions:

Humidity [%RH]      Temperature [°C]      Pressure [hPa]  
 22 ± 4                      23 ± 2                      1008 ± 20

## CALIBRATION CERTIFICATE

This certificate may only be reproduced in full, except with  
the prior written permission by the issuing laboratory.

Certificate Number: HEL201910046



Instrument: Humidity and Temperature Probe HMP155  
Order Code: A3GB11A0A2A1A0A  
Serial Number: S1830821  
Manufacturer: Vaisala Oyj, Finland  
Calibration Date: 2020-04-29

Approved by:

*Sami Mikkola*

Digitally signed by SAMIK  
Date: 2020.05.04 06:58:37 +03:00  
Reason: Calibration responsible  
Location: Vaisala Oyj, Finland

The humidity sensor of the instrument was calibrated by comparing the instrument's humidity reading to a generated reference humidity reading. The reference humidity reading was calculated based on two-pressure humidity generation principle, using the measurement results of saturator pressure and temperature and calibration chamber pressure and temperature.

The temperature sensor(s) of the instrument was calibrated by comparing the instrument's temperature readings to a reference thermometer.

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor  $k = 2$ , which for a normal distribution corresponds to a coverage probability of approximately 95 %. The measurement results are traceable to the international system of units (SI) through national metrology institutes (NIST USA, MIKES Finland, or equivalent) or via ISO/IEC 17025 accredited calibration laboratories.

### Humidity calibration results

Reference Humidity [%RH]	Reference Temperature [°C]	Observed Humidity [%RH]	Observed Temperature [°C]	Humidity Error [%RH]	Acceptance Limit [%RH]	Pass/Fail
0.0	22.82	0.0	22.82	0.0	±1.0	Pass
15.0	22.82	14.7	22.82	-0.3	±1.0	Pass
33.0	22.83	32.5	22.83	-0.5	±1.0	Pass
54.0	22.83	53.7	22.83	-0.3	±1.0	Pass
75.1	22.83	75.1	22.83	0.0	±1.0	Pass
95.1	22.84	95.2	22.84	0.1	±1.7	Pass

### Temperature calibration results

Reference Temperature [°C]	Observed Temperature [°C]	Error [°C]	Acceptance Limit [°C]	Pass/Fail
22.83	22.83	0.00	±0.10	Pass

### Additional temperature probe calibration results

Reference Temperature [°C]	Observed Temperature [°C]	Error [°C]	Acceptance Limit [°C]	Pass/Fail
-	-	-	-	-

### Reference equipment used in calibration

Type	Identity Number	Certificate Number	Calibration Date	Calibration Due Date
PT J307	18469	K008-C03549	2019-10-18	2020-10-31
HMP307	18465	K008-C03655	2019-10-29	2020-10-31
GE Druck DPS 823B	16737	K008-C04150	2019-12-17	2020-06-30
AM1612	18466	K008-C03653	2019-10-29	2020-10-31
PX E-4080	18463	C03651	2019-10-30	2020-10-31

### Calibration uncertainty (k=2, ~95% confidence level):

Humidity ± 0.8 %RH @ 0...40 %RH, ± 1.0 %RH @ 40...95 %RH  
Temperature ± 0.10 °C

### Ambient conditions:

Humidity [%RH] 22 ± 4      Temperature [°C] 23 ± 2      Pressure [hPa] 1008 ± 20

# Svend Ole Hansen ApS

SCT. JØRGENS ALLÉ 5C · DK-1615 KØBENHAVN V · DENMARK

TEL: (+45) 33 25 38 38 · [WWW.SOHANSEN.DK](http://WWW.SOHANSEN.DK)



WIND  
ENGINEERING  
FLUID  
DYNAMICS

## CERTIFICATE OF CALIBRATION

### Calibrated item

Type Thies 4.3351.10.000  
Serial no. 01212600  
Manufacturer ADOLF THIES GmbH & Co.KG, Hauptstrasse 76, 37083 Göttingen, Germany  
Item received January 14, 2021  
Remarks -

### Calibration

Calibration institute Svend Ole Hansen ApS, Sct. Jørgens Allé 5C, DK-1615 København V  
Procedure IEC 61400-12-1:2017, Annex F  
Client IDNAMIC Italia S.r.l., S.S. 212 km 9 Area PIP, 82020 Pietrelcina (BN), Italy  
Calibrated by Calibrator, fim *Felipe Marley*  
Date of calibration January 16, 2021  
Approved by Calibration engineer, sfo *Jan J. Olsen*  
Post calibration No  
Re-calibration due -

### Certificate

Certificate no. 21.02.00142  
Date of issue January 19, 2021  
Issued by ca  
Number of pages 4

### Accreditation

Accredited to ISO 17025:2017 by DANAK. DANAK is signatory to the European co-operation for Accreditation (EA) Multilateral Agreement and to the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement.

The calibration institute is approved by MEASNET and IECRE.







### Calibration conditions

Turbulence intensity	1-2 % (alongwind)
Air temperature	26.6 °C (average value)
Barometric pressure	1018.2 hPa (average value)
Relative humidity	21.2 % (average value)
Air density	1.18 kg/m <sup>3</sup> (average value)
Flow inclination	< 0.2°
Anemometer yaw orientation	Not relevant
Remarks	(none)

### Calibration results

Calibration equation  $v$  [m/s] = 0.04623 ·  $f$  [Hz] + 0.23236

The calibration equation is obtained from a linear regression of the reference air velocity upon the Device Under Test (DUT) output. The residual is the deviation of the calibration equation prediction from the reference air velocity.

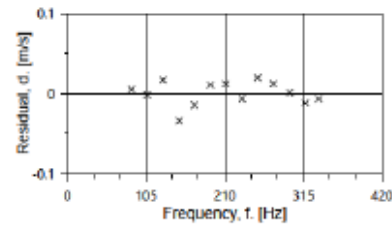
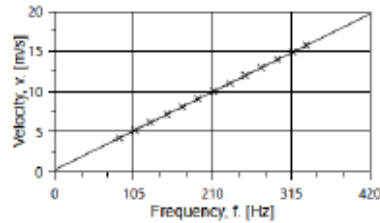
The calibration results relate only to the calibrated item.

Succession #	Velocity pressure [Pa]	Air temperature [°C]	Air density [kg/m <sup>3</sup> ]	Ref. air velocity, $v$ [m/s]	Uncertainty $u_c$ ( $k=2$ ) [m/s]	DUT output Frequency, $f$ [Hz]	Residual, $d$ [m/s]
2	10.40	26.6	1.18	4.197	0.025	85.6607	0.005
4	15.69	26.7	1.18	5.158	0.029	106.5704	-0.002
6	22.23	26.7	1.18	6.138	0.033	127.3797	0.017
8	29.86	26.6	1.18	7.114	0.037	149.5791	-0.034
10	38.39	26.6	1.18	8.066	0.041	169.7574	-0.015
12	48.52	26.5	1.18	9.066	0.046	190.8532	0.011
13-last	59.31	26.5	1.18	10.024	0.050	211.5290	0.012
11	71.51	26.6	1.18	11.008	0.055	233.2225	-0.007
9	84.77	26.6	1.18	11.987	0.059	253.8243	0.019
7	99.01	26.7	1.18	12.957	0.064	274.9706	0.012
5	114.75	26.8	1.18	13.950	0.068	296.6969	0.001
3	131.13	26.8	1.18	14.913	0.072	317.8005	-0.012
1-first	146.30	26.5	1.18	15.743	0.076	335.6431	-0.007





### Visual presentation of calibration results



### Linear regression results

Method	Least squares linear regression
Slope	0.04623 (m/s)/Hz
Offset	0.23236 m/s
Coefficient of correlation	$\rho = 0.999992$
Standard error of estimate	0.0156 m/s
Slope standard error	0.00006 (m/s)/Hz
Offset standard error	0.01247 m/s
Slope and offset covariance	-0.000000646 (m/s) <sup>2</sup> /Hz
Remarks	Linearity complies with IEC 61400-12-1:2017, Annex F.

### Uncertainties

The uncertainties stated under *Calibration results* relate to the reference air velocity at each calibration point. The uncertainty is the total combined uncertainty at 95 % confidence level (coverage factor  $k = 2$ ) in accordance with EA-4/02. The uncertainty complies with the requirements in IEC 61400-12-1:2017, Annex F. The uncertainty due to the wind tunnel correction function has been documented to be 0.1 % ( $k = 2$ ).

The slope and offset uncertainties and their covariance stated under *Linear regression results* are related to the linear regression only, and do not relate to the reference air velocity uncertainties. The slope and offset uncertainties have  $\nu = 11$  degrees of freedom.



**Calibration wind tunnel**

ID DK1  
 Test section Octagonal, hcrw = 1.20x1.75 m  
 Effective area of test section 2.10 m<sup>2</sup>  
 Setup report SOH document no. 18.1.001  
 Blockage ratio\* ~1.3 % (Anemometer and mounting pole)

\* The effect of blockage is taken into account in the calibration results.

**Equipment used**

Function	ID	Model / comments	Re-calibration due
QC Anemometer	03113415	03113415	-
Mounting	-	Mounting tube, diameter = 35 mm	-
Tunnel Temperature	T2	PT100 Temperature sensor	2022-03-16
Differential Pressure	9904031	PPC500 Pressure manometer	2022-05-14
Relative Humidity	X4650038	HMW71U Humidity transmitter	2022-03-16
Barometric Pressure	X4350042	PTB100A Analogue barometer	2022-03-12
Pitot tube	A37AB	Ellipsoidal tip pitot tube	2027-02-22
Data acquisition	USB-1608GX	Computer Board. 16 bit A/D data acq. board	-
Computer	-	PC dedicated to data acquisition	-

Calibrations of the relevant equipment are carried out by external accredited institutions, and are traceable to national standards. A real-time analysis module within the data acquisition software detects pulse frequency.

**Setup photo**

The shown anemometer is of the same type as the one calibrated.



End of certificate





## CERTIFICATE OF CALIBRATION

### Calibrated item

Type	Thies 4.3351.10.000
Serial no.	01212599
Manufacturer	ADOLF THIES GmbH & Co.KG, Hauptstrasse 76, 37083 Göttingen, Germany
Item received	January 14, 2021
Remarks	-

### Calibration

Calibration institute	Svend Ole Hansen ApS, Sct. Jørgens Allé 5C, DK-1615 København V
Procedure	IEC 61400-12-1:2017, Annex F
Client	IDNAMIC Italia S.r.l., S.S. 212 km 9 Area PIP, 82020 Pietrelcina (BN), Italy
Calibrated by	Calibrator, <i>fm</i> 
Date of calibration	January 16, 2021
Approved by	Calibration engineer, <i>sfo</i> 
Post calibration	No
Re-calibration due	-

### Certificate

Certificate no.	21.02.00134
Date of issue	January 19, 2021
Issued by	ca
Number of pages	4

### Accreditation

Accredited to ISO 17025:2017 by DANAK. DANAK is signatory to the European co-operation for Accreditation (EA) Multilateral Agreement and to the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement.

The calibration institute is approved by MEASNET and IECRE.





**Calibration conditions**

Turbulence intensity	1-2 % (alongwind)
Air temperature	25.7 °C (average value)
Barometric pressure	1019.5 hPa (average value)
Relative humidity	21.9 % (average value)
Air density	1.19 kg/m <sup>3</sup> (average value)
Flow inclination	< 0.2°
Anemometer yaw orientation	Not relevant
Remarks	(none)

**Calibration results**

Calibration equation  $v \text{ [m/s]} = 0.04628 \cdot f \text{ [Hz]} + 0.22772$

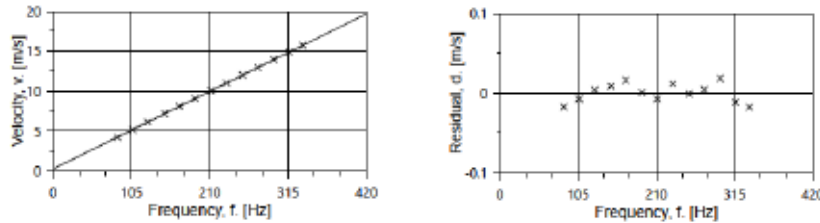
The calibration equation is obtained from a linear regression of the reference air velocity upon the Device Under Test (DUT) output. The residual is the deviation of the calibration equation prediction from the reference air velocity.

The calibration results relate only to the calibrated item.

Succession #	Velocity pressure [Pa]	Air temperature [°C]	Air density [kg/m <sup>3</sup> ]	Ref. air velocity, $v$ [m/s]	Uncertainty $u_c$ ( $k=2$ ) [m/s]	DUT output Frequency, $f$ [Hz]	Residual, $d$ [m/s]
2	10.40	25.7	1.19	4.188	0.025	85.9580	-0.017
4	15.71	25.8	1.18	5.150	0.029	106.5204	-0.007
6	22.16	25.8	1.18	6.116	0.033	127.1556	0.004
8	30.32	25.7	1.19	7.152	0.037	149.4458	0.009
10	38.66	25.7	1.19	8.076	0.041	169.2474	0.016
12	48.58	25.6	1.19	9.052	0.046	190.6691	0.001
13-last	59.47	25.6	1.19	10.016	0.050	211.6685	-0.007
11	71.64	25.7	1.19	10.994	0.054	232.3920	0.011
9	85.16	25.7	1.19	11.988	0.059	254.1471	-0.001
7	99.16	25.8	1.18	12.938	0.063	274.5740	0.004
5	115.05	25.9	1.18	13.938	0.068	295.8648	0.019
3	130.69	25.9	1.18	14.855	0.072	316.3325	-0.012
1-first	146.61	25.6	1.19	15.725	0.076	335.2598	-0.018



### Visual presentation of calibration results



### Linear regression results

Method	Least squares linear regression
Slope	0.04628 (m/s)/Hz
Offset	0.22772 m/s
Coefficient of correlation	$\rho = 0.999995$
Standard error of estimate	0.0124 m/s
Slope standard error	0.00004 (m/s)/Hz
Offset standard error	0.00995 m/s
Slope and offset covariance	-0.000000412 (m/s) <sup>2</sup> /Hz
Remarks	Linearity complies with IEC 61400-12-1:2017, Annex F.

### Uncertainties

The uncertainties stated under *Calibration results* relate to the reference air velocity at each calibration point. The uncertainty is the total combined uncertainty at 95 % confidence level (coverage factor  $k = 2$ ) in accordance with EA-4/02. The uncertainty complies with the requirements in IEC 61400-12-1:2017, Annex F. The uncertainty due to the wind tunnel correction function has been documented to be 0.1 % ( $k = 2$ ).

The slope and offset uncertainties and their covariance stated under *Linear regression results* are related to the linear regression only, and do not relate to the reference air velocity uncertainties. The slope and offset uncertainties have  $\nu = 11$  degrees of freedom.



**Calibration wind tunnel**

ID DK1  
 Test section Octagonal, hxcw = 1.20x1.75 m  
 Effective area of test section 2.10 m<sup>2</sup>  
 Setup report SOH document no. 18.1.001  
 Blockage ratio\* ~1.3 % (Anemometer and mounting pole)

\* The effect of blockage is taken into account in the calibration results.

**Equipment used**

Function	ID	Model / comments	Re-calibration due
QC Anemometer	03113415	03113415	-
Mounting	-	Mounting tube, diameter = 35 mm	-
Tunnel Temperature	T2	PT100 Temperature sensor	2022-03-16
Differential Pressure	9904031	PPC500 Pressure manometer	2022-05-14
Relative Humidity	X4650038	HMW71U Humidity transmitter	2022-03-16
Barometric Pressure	X4350042	PTB100A Analogue barometer	2022-03-12
Pitot tube	A37AB	Ellipsoidal tip pitot tube	2027-02-22
Data acquisition	USB-1608GX	Computer Board. 16 bit A/D data acq. board	-
Computer	-	PC dedicated to data acquisition	-

Calibrations of the relevant equipment are carried out by external accredited institutions, and are traceable to national standards. A real-time analysis module within the data acquisition software detects pulse frequency.

**Setup photo**

The shown anemometer is of the same type as the one calibrated.



End of certificate



# Svend Ole Hansen ApS

SCT. JØRGENS ALLÉ 5C · DK-1615 KØBENHAVN V · DENMARK  
TEL: (+45) 33 25 38 38 · [WWW.SOHANSEN.DK](http://WWW.SOHANSEN.DK)



WIND  
ENGINEERING  
FLUID  
DYNAMICS

## CERTIFICATE OF CALIBRATION

### Calibrated item

Type Thies 4.3351.10.000  
Serial no. 01212595  
Manufacturer ADOLF THIES GmbH & Co.KG, Hauptstrasse 76, 37083 Göttingen, Germany  
Item received January 14, 2021  
Remarks -

### Calibration

Calibration institute Svend Ole Hansen ApS, Sct. Jørgens Allé 5C, DK-1615 København V  
Procedure IEC 61400-12-1:2017, Annex F  
Client IDNAMIC Italia S.r.l., S.S. 212 km 9 Area PIP, 82020 Pietrelcina (BN), Italy  
Calibrated by Calibrator, fim *Felipe Marly*  
Date of calibration January 16, 2021  
Approved by Calibration engineer, sfo *Jan J. Olsen*  
Post calibration No  
Re-calibration due -

### Certificate

Certificate no. 21.02.00132  
Date of issue January 19, 2021  
Issued by ca  
Number of pages 4

### Accreditation

Accredited to ISO 17025:2017 by DANAK. DANAK is signatory to the European co-operation for Accreditation (EA) Multilateral Agreement and to the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement.

The calibration institute is approved by MEASNET and IECRE.





### Calibration conditions

Turbulence intensity	1-2 % (alongwind)
Air temperature	25.5 °C (average value)
Barometric pressure	1019.8 hPa (average value)
Relative humidity	22.0 % (average value)
Air density	1.19 kg/m <sup>3</sup> (average value)
Flow inclination	< 0.2°
Anemometer yaw orientation	Not relevant
Remarks	(none)

### Calibration results

Calibration equation  $v \text{ [m/s]} = 0.04624 \cdot f \text{ [Hz]} + 0.23622$

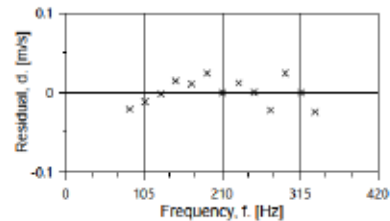
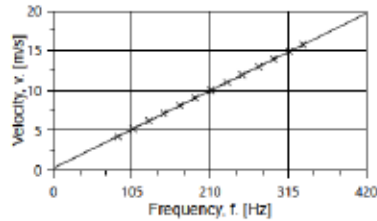
The calibration equation is obtained from a linear regression of the reference air velocity upon the Device Under Test (DUT) output. The residual is the deviation of the calibration equation prediction from the reference air velocity.

The calibration results relate only to the calibrated item.

Succession #	Velocity pressure [Pa]	Air temperature [°C]	Air density [kg/m <sup>3</sup> ]	Ref. air velocity, $v$ [m/s]	Uncertainty $u_c (k=2)$ [m/s]	DUT output Frequency, $f$ [Hz]	Residual, $d$ [m/s]
2	10.45	25.5	1.19	4.197	0.025	86.1226	-0.021
4	15.82	25.6	1.19	5.165	0.029	106.8638	-0.012
6	22.52	25.5	1.19	6.162	0.033	128.2101	-0.002
8	29.82	25.5	1.19	7.090	0.037	147.9197	0.014
10	38.77	25.4	1.19	8.084	0.041	169.4815	0.011
12	48.58	25.4	1.19	9.048	0.046	190.0587	0.024
13-last	59.27	25.4	1.19	9.994	0.050	211.0369	-0.001
11	71.96	25.4	1.19	11.013	0.055	232.8087	0.012
9	84.75	25.5	1.19	11.953	0.059	253.3888	0.000
7	99.56	25.6	1.19	12.957	0.064	275.5971	-0.022
5	114.83	25.7	1.19	13.917	0.068	295.3493	0.024
3	131.32	25.7	1.19	14.882	0.072	316.7531	0.000
1-first	146.83	25.3	1.19	15.727	0.076	335.5432	-0.025



**Visual presentation of calibration results**



**Linear regression results**

<b>Method</b>	Least squares linear regression
<b>Slope</b>	0.04624 (m/s)/Hz
<b>Offset</b>	0.23622 m/s
<b>Coefficient of correlation</b>	$\rho = 0.999990$
<b>Standard error of estimate</b>	0.0174 m/s
<b>Slope standard error</b>	0.00006 (m/s)/Hz
<b>Offset standard error</b>	0.01386 m/s
<b>Slope and offset covariance</b>	-0.000000799 (m/s) <sup>2</sup> /Hz
<b>Remarks</b>	Linearity complies with IEC 61400-12-1:2017, Annex F.

**Uncertainties**

The uncertainties stated under *Calibration results* relate to the reference air velocity at each calibration point. The uncertainty is the total combined uncertainty at 95 % confidence level (coverage factor  $k = 2$ ) in accordance with EA-4/02. The uncertainty complies with the requirements in IEC 61400-12-1:2017, Annex F. The uncertainty due to the wind tunnel correction function has been documented to be 0.1 % ( $k = 2$ ).

The slope and offset uncertainties and their covariance stated under *Linear regression results* are related to the linear regression only, and do not relate to the reference air velocity uncertainties. The slope and offset uncertainties have  $\nu = 11$  degrees of freedom.



**Calibration wind tunnel**

ID DK1  
 Test section Octagonal, h<sub>xw</sub> = 1.20x1.75 m  
 Effective area of test section 2.10 m<sup>2</sup>  
 Setup report SOH document no. 18.1.001  
 Blockage ratio\* ~1.3 % (Anemometer and mounting pole)

\* The effect of blockage is taken into account in the calibration results.

**Equipment used**

Function	ID	Model / comments	Re-calibration due
QC Anemometer	03113415	03113415	-
Mounting	-	Mounting tube, diameter = 35 mm	-
Tunnel Temperature	T2	PT100 Temperature sensor	2022-03-16
Differential Pressure	9904031	PPC500 Pressure manometer	2022-05-14
Relative Humidity	X4650038	HMW71U Humidity transmitter	2022-03-16
Barometric Pressure	X4350042	PTB100AA Analogue barometer	2022-03-12
Pitot tube	A37AB	Ellipsoidal tip pitot tube	2027-02-22
Data acquisition	USB-1608GX	Computer Board. 16 bit A/D data acq. board	-
Computer	-	PC dedicated to data acquisition	-

Calibrations of the relevant equipment are carried out by external accredited institutions, and are traceable to national standards. A real-time analysis module within the data acquisition software detects pulse frequency.

**Setup photo**

The shown anemometer is of the same type as the one calibrated.



End of certificate

# Svend Ole Hansen ApS

SCT. JØRGENS ALLÉ 5C · DK-1615 KØBENHAVN V · DENMARK  
TEL: (+45) 33 25 38 38 · [WWW.SOHANSEN.DK](http://WWW.SOHANSEN.DK)



WIND  
ENGINEERING  
FLUID  
DYNAMICS

## CERTIFICATE OF CALIBRATION

### Calibrated item

Type Thies 4.3351.10.000  
Serial no. 01212590  
Manufacturer ADOLF THIES GmbH & Co.KG, Hauptstrasse 76, 37083 Göttingen, Germany  
Item received January 14, 2021  
Remarks -

### Calibration

Calibration institute Svend Ole Hansen ApS, Sct. Jørgens Allé 5C, DK-1615 København V  
Procedure IEC 61400-12-1:2017, Annex F  
Client IDNAMIC Italia S.r.l., S.S. 212 km 9 Area PIP, 82020 Pietrelcina (BN), Italy  
Calibrated by Calibrator, fim *Felipe Marly*  
Date of calibration January 16, 2021  
Approved by Calibration engineer, sfo *Jan J. Olsen*  
Post calibration No  
Re-calibration due -

### Certificate

Certificate no. 21.02.00130  
Date of issue January 19, 2021  
Issued by ca  
Number of pages 4

### Accreditation

Accredited to ISO 17025:2017 by DANAK. DANAK is signatory to the European co-operation for Accreditation (EA) Multilateral Agreement and to the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement.

The calibration institute is approved by MEASNET and IECRE.





### Calibration conditions

Turbulence intensity	1-2 % (alongwind)
Air temperature	25.3 °C (average value)
Barometric pressure	1020.2 hPa (average value)
Relative humidity	22.1 % (average value)
Air density	1.19 kg/m <sup>3</sup> (average value)
Flow inclination	< 0.2°
Anemometer yaw orientation	Not relevant
Remarks	(none)

### Calibration results

Calibration equation  $v \text{ [m/s]} = 0.04632 \cdot f \text{ [Hz]} + 0.22452$

The calibration equation is obtained from a linear regression of the reference air velocity upon the Device Under Test (DUT) output. The residual is the deviation of the calibration equation prediction from the reference air velocity.

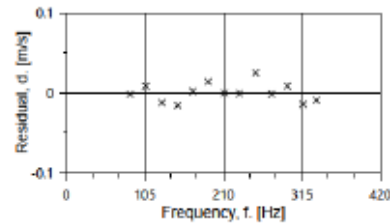
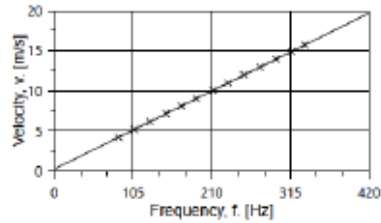
The calibration results relate only to the calibrated item.

Succession #	Velocity pressure [Pa]	Air temperature [°C]	Air density [kg/m <sup>3</sup> ]	Ref. air velocity, $v$ [m/s]	Uncertainty $u_c (k=2)$ [m/s]	DUT output Frequency, $f$ [Hz]	Residual, $d$ [m/s]
2	10.38	25.3	1.19	4.182	0.025	85.4731	-0.002
4	15.85	25.4	1.19	5.167	0.029	106.5200	0.008
6	22.32	25.4	1.19	6.131	0.033	127.7929	-0.013
8	30.10	25.3	1.19	7.119	0.037	149.1928	-0.016
10	38.77	25.3	1.19	8.080	0.041	169.5545	0.002
12	48.26	25.2	1.19	9.014	0.046	189.4753	0.014
13-last	59.84	25.2	1.19	10.037	0.050	211.8641	0.000
11	71.31	25.3	1.19	10.958	0.054	231.7478	-0.001
9	85.29	25.3	1.19	11.985	0.059	253.3711	0.025
7	99.47	25.4	1.19	12.945	0.063	274.6523	-0.002
5	115.16	25.5	1.19	13.930	0.068	295.7030	0.008
3	131.29	25.5	1.19	14.873	0.072	316.5658	-0.014
1-first	146.59	25.2	1.19	15.708	0.076	334.4751	-0.009





### Visual presentation of calibration results



### Linear regression results

Method	Least squares linear regression
Slope	0.04632 (m/s)/Hz
Offset	0.22452 m/s
Coefficient of correlation	$\rho = 0.999995$
Standard error of estimate	0.0123 m/s
Slope standard error	0.00004 (m/s)/Hz
Offset standard error	0.00982 m/s
Slope and offset covariance	-0.000000402 (m/s) <sup>2</sup> /Hz
Remarks	Linearity complies with IEC 61400-12-1:2017, Annex F.

### Uncertainties

The uncertainties stated under *Calibration results* relate to the reference air velocity at each calibration point. The uncertainty is the total combined uncertainty at 95 % confidence level (coverage factor  $k = 2$ ) in accordance with EA-4/02. The uncertainty complies with the requirements in IEC 61400-12-1:2017, Annex F. The uncertainty due to the wind tunnel correction function has been documented to be 0.1 % ( $k = 2$ ).

The slope and offset uncertainties and their covariance stated under *Linear regression results* are related to the linear regression only, and do not relate to the reference air velocity uncertainties. The slope and offset uncertainties have  $\nu = 11$  degrees of freedom.



**Calibration wind tunnel**

ID DK1  
 Test section Octagonal, h<sub>xw</sub> = 1.20x1.75 m  
 Effective area of test section 2.10 m<sup>2</sup>  
 Setup report SOH document no. 18.1.001  
 Blockage ratio\* ~1.3 % (Anemometer and mounting pole)

\* The effect of blockage is taken into account in the calibration results.

**Equipment used**

Function	ID	Model / comments	Re-calibration due
QC Anemometer	03113415	03113415	-
Mounting	-	Mounting tube, diameter = 35 mm	-
Tunnel Temperature	T2	PT100 Temperature sensor	2022-03-16
Differential Pressure	9904031	PPC500 Pressure manometer	2022-05-14
Relative Humidity	X4650038	HMW71U Humidity transmitter	2022-03-16
Barometric Pressure	X4350042	PTB100A Analogue barometer	2022-03-12
Pitot tube	A37AB	Ellipsoidal tip pitot tube	2027-02-22
Data acquisition	USB-1608GX	Computer Board. 16 bit A/D data acq. board	-
Computer	-	PC dedicated to data acquisition	-

Calibrations of the relevant equipment are carried out by external accredited institutions, and are traceable to national standards. A real-time analysis module within the data acquisition software detects pulse frequency.

**Setup photo**

The shown anemometer is of the same type as the one calibrated.



End of certificate

# Svend Ole Hansen ApS

SCT. JØRGENS ALLÉ 5C · DK-1615 KØBENHAVN V · DENMARK  
TEL: (+45) 33 25 38 38 · [WWW.SOHANSEN.DK](http://WWW.SOHANSEN.DK)





WIND  
ENGINEERING  
FLUID  
DYNAMICS

## CERTIFICATE OF CALIBRATION

### Calibrated item

Type WindSensor P2546C-OPR Cup Anemometer  
Serial no. 40656  
Manufacturer WindSensor, Frederiksborgvej 399, 4000 Roskilde Denmark  
Item received May 29, 2020  
Remarks -

### Calibration

Calibration institute Svend Ole Hansen ApS, Sct. Jørgens Allé 5C, DK-1615 København V  
Procedure IEC 61400-12-1:2017, Annex F  
Client WindSensor, Frederiksborgvej 399, 4000 Roskilde Denmark  
Calibrated by Calibrator, jvm   
Date of calibration May 31, 2020  
Approved by Calibration engineer, sfo   
Post calibration No  
Re-calibration due -

### Certificate

Certificate no. 20.02.01400  
Date of issue June 03, 2020  
Issued by ca  
Number of pages 4

### Accreditation

Accredited to ISO 17025:2017 by DANAK. DANAK is signatory to the European co-operation for Accreditation (EA) Multilateral Agreement and to the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement.

The calibration institute is approved by MEASNET and IECRE.





### Calibration conditions

Turbulence intensity	1-2 % (alongwind)
Air temperature	35.2 °C (average value)
Barometric pressure	1024.2 hPa (average value)
Relative humidity	27.7 % (average value)
Air density	1.15 kg/m <sup>3</sup> (average value)
Flow inclination	< 0.2°
Anemometer yaw orientation	Not relevant
Remarks	(none)

### Calibration results

Calibration equation  $v$  [m/s] = 0.62015 ·  $f$  [Hz] + 0.23174

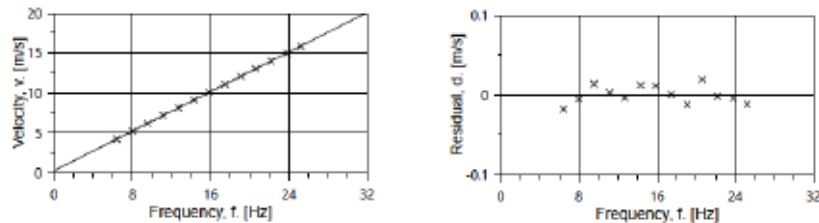
The calibration equation is obtained from a linear regression of the reference air velocity upon the Device Under Test (DUT) output. The residual is the deviation of the calibration equation prediction from the reference air velocity.

The calibration results relate only to the calibrated item.

Succession #	Velocity pressure [Pa]	Air temperature [°C]	Air density [kg/m <sup>3</sup> ]	Ref. air velocity, $v$ [m/s]	Uncertainty $u_c$ ( $k=2$ ) [m/s]	DUT output Frequency, $f$ [Hz]	Residual, $d$ [m/s]
2	10.09	35.3	1.15	4.190	0.025	6.4119	-0.018
4	15.53	35.4	1.15	5.199	0.029	8.0185	-0.006
6	21.85	35.3	1.15	6.165	0.033	9.5467	0.013
8	29.34	35.3	1.15	7.143	0.037	11.1401	0.003
10	37.82	35.2	1.15	8.110	0.042	12.7100	-0.004
12	47.84	35.1	1.15	9.120	0.046	14.3129	0.012
13-last	58.27	35.1	1.15	10.064	0.050	15.8365	0.011
11	70.35	35.1	1.15	11.060	0.055	17.4594	0.000
9	83.54	35.2	1.15	12.052	0.059	19.0810	-0.013
7	97.57	35.3	1.15	13.027	0.064	20.6014	0.019
5	112.36	35.3	1.15	13.981	0.069	22.1735	-0.002
3	129.04	35.3	1.15	14.982	0.073	23.7927	-0.004
1-first	144.60	35.1	1.15	15.854	0.077	25.2100	-0.012



### Visual presentation of calibration results



### Linear regression results

Method	Least squares linear regression
Slope	0.62015 (m/s)/Hz
Offset	0.23174 m/s
Coefficient of correlation	$\rho = 0.999996$
Standard error of estimate	0.0117 m/s
Slope standard error	0.00055 (m/s)/Hz
Offset standard error	0.00936 m/s
Slope and offset covariance	-0.000004851 (m/s) <sup>2</sup> /Hz
Remarks	Linearity complies with IEC 61400-12-1:2017, Annex F.

### Uncertainties

The uncertainties stated under *Calibration results* relate to the reference air velocity at each calibration point. The uncertainty is the total combined uncertainty at 95 % confidence level (coverage factor  $k = 2$ ) in accordance with EA-4/02. The uncertainty complies with the requirements in IEC 61400-12-1:2017, Annex F. The uncertainty due to the wind tunnel correction function has been documented to be 0.1 % ( $k = 2$ ).

The slope and offset uncertainties and their covariance stated under *Linear regression results* are related to the linear regression only, and do not relate to the reference air velocity uncertainties. The slope and offset uncertainties have  $\nu = 11$  degrees of freedom.



**Calibration wind tunnel**

ID DK1  
 Test section Octagonal, h<sub>xw</sub> = 1.20x1.75 m  
 Effective area of test section 2.10 m<sup>2</sup>  
 Setup report SOH document no. 18.1.001  
 Blockage ratio\* ~1.0 % (Anemometer and mounting pole)

\* The effect of blockage is taken into account in the calibration results.

**Equipment used**

Function	ID	Model / comments	Re-calibration due
QC Anemometer	11641	11641	-
Mounting	-	Mounting tube, diameter = 25 mm	-
Tunnel Temperature	T3	PT100 Temperature sensor	2021-03-05
Differential Pressure	1501197	FCO560 Pressure manometer	2021-03-08
Relative Humidity	Z0420014	HMW71U Humidity transmitter	2021-03-05
Barometric Pressure	U4220037	PTB100AA Analogue barometer	2021-03-05
Pitot tube	A37AB	Ellipsoidal tip pitot tube	2027-02-22
Data acquisition	PCI-DAS6036	Computer Board. 16 bit A/D data acq. board	-
Computer	-	PC dedicated to data acquisition	-

Calibrations of the relevant equipment are carried out by external accredited institutions, and are traceable to national standards. A real-time analysis module within the data acquisition software detects pulse frequency.

**Setup photo**

The shown anemometer is of the same type as the one calibrated.



End of certificate



# Svend Ole Hansen ApS

SCT. JØRGENS ALLÉ 5C · DK-1615 KØBENHAVN V · DENMARK  
TEL: (+45) 33 25 38 38 · [WWW.SOHANSEN.DK](http://WWW.SOHANSEN.DK)



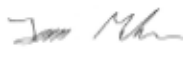

WIND  
ENGINEERING  
FLUID  
DYNAMICS

## CERTIFICATE OF CALIBRATION

### Calibrated item

Type WindSensor P2546C-OPR Cup Anemometer  
Serial no. 40654  
Manufacturer WindSensor, Frederiksborgvej 399, 4000 Roskilde Denmark  
Item received May 29, 2020  
Remarks -

### Calibration

Calibration institute Svend Ole Hansen ApS, Sct. Jørgens Allé 5C, DK-1615 København V  
Procedure IEC 61400-12-1:2017, Annex F  
Client WindSensor, Frederiksborgvej 399, 4000 Roskilde Denmark  
Calibrated by Calibrator, jvm   
Date of calibration May 31, 2020  
Approved by Calibration engineer, sfo   
Post calibration No  
Re-calibration due -

### Certificate

Certificate no. 20.02.01398  
Date of issue June 03, 2020  
Issued by ca  
Number of pages 4

### Accreditation

Accredited to ISO 17025:2017 by DANAK. DANAK is signatory to the European co-operation for Accreditation (EA) Multilateral Agreement and to the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement.

The calibration institute is approved by MEASNET and IECRE.





### Calibration conditions

Turbulence intensity	1-2 % (alongwind)
Air temperature	35.0 °C (average value)
Barometric pressure	1025.9 hPa (average value)
Relative humidity	28.4 % (average value)
Air density	1.15 kg/m <sup>3</sup> (average value)
Flow inclination	< 0.2°
Anemometer yaw orientation	Not relevant
Remarks	(none)

### Calibration results

Calibration equation  $v \text{ [m/s]} = 0.62025 \cdot f \text{ [Hz]} + 0.21620$

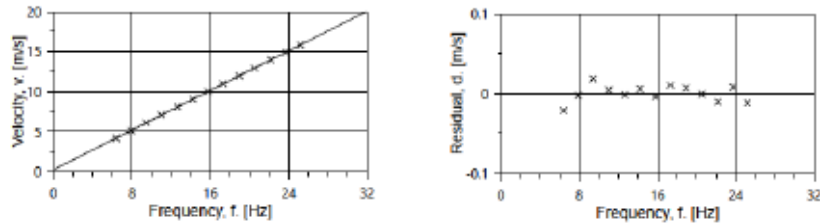
The calibration equation is obtained from a linear regression of the reference air velocity upon the Device Under Test (DUT) output. The residual is the deviation of the calibration equation prediction from the reference air velocity.

The calibration results relate only to the calibrated item.

Succession #	Velocity pressure [Pa]	Air temperature [°C]	Air density [kg/m <sup>3</sup> ]	Ref. air velocity, $v$ [m/s]	Uncertainty $u_c (k=2)$ [m/s]	DUT output Frequency, $f$ [Hz]	Residual, $d$ [m/s]
2	9.97	35.1	1.15	4.160	0.025	6.3935	-0.021
4	15.06	35.2	1.15	5.113	0.028	7.8988	-0.003
6	21.35	35.1	1.15	6.087	0.033	9.4361	0.018
8	28.61	35.1	1.15	7.046	0.037	11.0054	0.004
10	37.44	35.0	1.15	8.060	0.041	12.6487	-0.002
12	47.09	34.9	1.15	9.038	0.046	14.2133	0.006
13-last	57.55	34.9	1.15	9.990	0.050	15.7644	-0.004
11	69.32	34.9	1.15	10.965	0.054	17.3135	0.010
9	82.46	35.0	1.15	11.961	0.059	18.9250	0.007
7	96.24	35.1	1.15	12.924	0.064	20.4889	-0.001
5	112.20	35.1	1.15	13.956	0.069	22.1692	-0.011
3	128.40	35.1	1.15	14.929	0.073	23.7077	0.008
1-first	144.36	34.9	1.15	15.824	0.076	25.1828	-0.012



### Visual presentation of calibration results



### Linear regression results

Method	Least squares linear regression
Slope	0.62025 (m/s)/Hz
Offset	0.21620 m/s
Coefficient of correlation	$\rho = 0.999996$
Standard error of estimate	0.0111 m/s
Slope standard error	0.00052 (m/s)/Hz
Offset standard error	0.00878 m/s
Slope and offset covariance	-0.000004282 (m/s) <sup>2</sup> /Hz
Remarks	Linearity complies with IEC 61400-12-1:2017, Annex F.

### Uncertainties

The uncertainties stated under *Calibration results* relate to the reference air velocity at each calibration point. The uncertainty is the total combined uncertainty at 95 % confidence level (coverage factor  $k = 2$ ) in accordance with EA-4/02. The uncertainty complies with the requirements in IEC 61400-12-1:2017, Annex F. The uncertainty due to the wind tunnel correction function has been documented to be 0.1 % ( $k = 2$ ).

The slope and offset uncertainties and their covariance stated under *Linear regression results* are related to the linear regression only, and do not relate to the reference air velocity uncertainties. The slope and offset uncertainties have  $\nu = 11$  degrees of freedom.



### *Calibration wind tunnel*

ID	DK1
Test section	Octagonal, h <sub>rw</sub> = 1.20x1.75 m
Effective area of test section	2.10 m <sup>2</sup>
Setup report	SOH document no. 18.1.001
Blockage ratio*	~1.0 % (Anemometer and mounting pole)

\* The effect of blockage is taken into account in the calibration results.

### *Equipment used*

Function	ID	Model / comments	Re-calibration due
QC Anemometer	11641	11641	-
Mounting	-	Mounting tube, diameter = 25 mm	-
Tunnel Temperature	T3	PT100 Temperature sensor	2021-03-05
Differential Pressure	1501197	FCO560 Pressure manometer	2021-03-08
Relative Humidity	Z0420014	HMW71U Humidity transmitter	2021-03-05
Barometric Pressure	U4220037	PTB100AA Analogue barometer	2021-03-05
Pitot tube	A37AB	Ellipsoidal tip pitot tube	2027-02-22
Data acquisition	PCI-DAS6036	Computer Board. 16 bit A/D data acq. board	-
Computer	-	PC dedicated to data acquisition	-

Calibrations of the relevant equipment are carried out by external accredited institutions, and are traceable to national standards. A real-time analysis module within the data acquisition software detects pulse frequency.

### *Setup photo*

The shown anemometer is of the same type as the one calibrated.



End of certificate

# Svend Ole Hansen ApS

SCT. JØRGENS ALLÉ 5C · DK-1615 KØBENHAVN V · DENMARK  
TEL: (+45) 33 25 38 38 · [WWW.SOHANSEN.DK](http://WWW.SOHANSEN.DK)





WIND  
ENGINEERING  
FLUID  
DYNAMICS

## CERTIFICATE OF CALIBRATION

### Calibrated item

Type WindSensor P2546C-OPR Cup Anemometer  
Serial no. 40653  
Manufacturer WindSensor, Frederiksborgvej 399, 4000 Roskilde Denmark  
Item received May 29, 2020  
Remarks -

### Calibration

Calibration institute Svend Ole Hansen ApS, Sct. Jørgens Allé 5C, DK-1615 København V  
Procedure IEC 61400-12-1:2017, Annex F  
Client WindSensor, Frederiksborgvej 399, 4000 Roskilde Denmark  
Calibrated by Calibrator, jvm   
Date of calibration May 31, 2020  
Approved by Calibration engineer, sfo   
Post calibration No  
Re-calibration due -

### Certificate

Certificate no. 20.02.01397  
Date of issue June 03, 2020  
Issued by ca  
Number of pages 4

### Accreditation

Accredited to ISO 17025:2017 by DANAK. DANAK is signatory to the European co-operation for Accreditation (EA) Multilateral Agreement and to the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement.

The calibration institute is approved by MEASNET and IECRE.





### Calibration conditions

Turbulence intensity	1-2 % (alongwind)
Air temperature	34.7 °C (average value)
Barometric pressure	1024.1 hPa (average value)
Relative humidity	28.3 % (average value)
Air density	1.15 kg/m <sup>3</sup> (average value)
Flow inclination	< 0.2°
Anemometer yaw orientation	Not relevant
Remarks	(none)

### Calibration results

Calibration equation  $v \text{ [m/s]} = 0.62152 \cdot f \text{ [Hz]} + 0.20238$

The calibration equation is obtained from a linear regression of the reference air velocity upon the Device Under Test (DUT) output. The residual is the deviation of the calibration equation prediction from the reference air velocity.

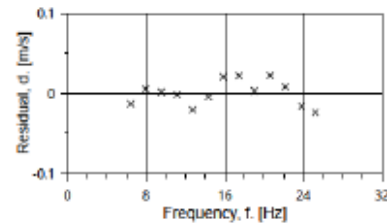
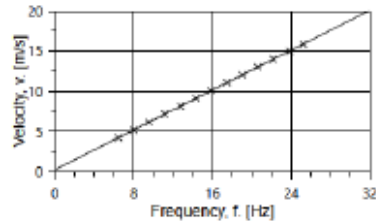
The calibration results relate only to the calibrated item.

Succession #	Velocity pressure [Pa]	Air temperature [°C]	Air density [kg/m <sup>3</sup> ]	Ref. air velocity, $v$ [m/s]	Uncertainty $u_c$ ( $k=2$ ) [m/s]	DUT output Frequency, $f$ [Hz]	Residual, $d$ [m/s]
2	10.15	34.7	1.15	4.198	0.025	6.4497	-0.013
4	15.36	34.8	1.15	5.165	0.029	7.9768	0.005
6	21.72	34.8	1.15	6.141	0.033	9.5531	0.002
8	29.26	34.7	1.15	7.127	0.037	11.1453	-0.002
10	37.90	34.6	1.15	8.111	0.042	12.7587	-0.021
12	47.73	34.6	1.15	9.101	0.046	14.3254	-0.005
13-last	58.45	34.5	1.15	10.071	0.050	15.8458	0.020
11	70.66	34.6	1.15	11.074	0.055	17.4571	0.022
9	83.33	34.6	1.15	12.027	0.059	19.0210	0.003
7	97.68	34.7	1.15	13.023	0.064	20.5924	0.022
5	112.59	34.8	1.15	13.982	0.069	22.1588	0.008
3	129.33	34.7	1.15	14.986	0.073	23.8118	-0.016
1-first	144.79	34.5	1.15	15.849	0.077	25.2133	-0.024





### Visual presentation of calibration results



### Linear regression results

Method	Least squares linear regression
Slope	0.62152 (m/s)/Hz
Offset	0.20238 m/s
Coefficient of correlation	$\rho = 0.999992$
Standard error of estimate	0.0163 m/s
Slope standard error	0.00077 (m/s)/Hz
Offset standard error	0.01301 m/s
Slope and offset covariance	-0.000009381 (m/s) <sup>2</sup> /Hz
Remarks	Linearity complies with IEC 61400-12-1:2017, Annex F.

### Uncertainties

The uncertainties stated under *Calibration results* relate to the reference air velocity at each calibration point. The uncertainty is the total combined uncertainty at 95 % confidence level (coverage factor  $k = 2$ ) in accordance with EA-4/02. The uncertainty complies with the requirements in IEC 61400-12-1:2017, Annex F. The uncertainty due to the wind tunnel correction function has been documented to be 0.1 % ( $k = 2$ ).

The slope and offset uncertainties and their covariance stated under *Linear regression results* are related to the linear regression only, and do not relate to the reference air velocity uncertainties. The slope and offset uncertainties have  $\nu = 11$  degrees of freedom.



### Calibration wind tunnel

ID	DK1
Test section	Octagonal, hxcw = 1.20x1.75 m
Effective area of test section	2.10 m <sup>2</sup>
Setup report	SOH document no. 18.1.001
Blockage ratio*	~1.0 % (Anemometer and mounting pole)

\* The effect of blockage is taken into account in the calibration results.

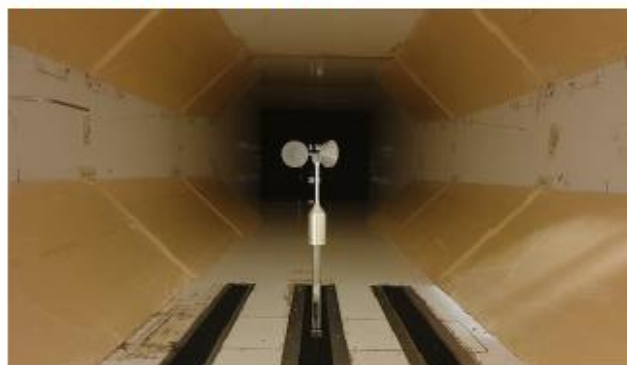
### Equipment used

Function	ID	Model / comments	Re-calibration due
QC Anemometer	11641	11641	-
Mounting	-	Mounting tube, diameter = 25 mm	-
Tunnel Temperature	T3	PT100 Temperature sensor	2021-03-05
Differential Pressure	1501197	FCO560 Pressure manometer	2021-03-08
Relative Humidity	Z0420014	HMW71U Humidity transmitter	2021-03-05
Barometric Pressure	U4220037	PTB100AA analogue barometer	2021-03-05
Pitot tube	A37AB	Ellipsoidal tip pitot tube	2027-02-22
Data acquisition	PCI-DAS6036	Computer Board. 16 bit A/D data acq. board	-
Computer	-	PC dedicated to data acquisition	-

Calibrations of the relevant equipment are carried out by external accredited institutions, and are traceable to national standards. A real-time analysis module within the data acquisition software detects pulse frequency.

### Setup photo

The shown anemometer is of the same type as the one calibrated.



End of certificate