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फ्लूइड कंट्रोल रिसर्च इंस्टिट्यूट, पालक्काड

FLUID CONTROL RESEARCH INSTITUTE, PALAKKAD

An Autonomous R&D Organisation under Ministry of Heavy Industries & Public Enterprises, Govt. of India.

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Air Flow

एफ.सी.आर.आई.



CERTIFICATE OF CALIBRATION

PITOT TUBE ANEMOMETER

For

M/s. NATIONAL CENTRE FOR QUALITY CALIBRATION
AHMEDABAD 380058



Certificate No:
CC-2395

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ULR No: - CC23951890000028F

DATE OF RECEIPT
01.11.2018

DATE OF CALIBRATION
08.11.2018

DATE OF ISSUE
02.04.2019

CERTIFICATE NUMBER
CAW 1839 1811 153A

Approved Signatory

ए. एस. मुरली / A. S. MURALI

उप निदेशक / DEPUTY DIRECTOR

SUMMARY

Amendment to the certificate no: - CAW 1839 1811 153 dated 07.12.2018 incorporating Id No & without incorporating due date, ULR No. unchanged.

Device under calibration	: Pitot Tube Anemometer
Serial No.	: 130411754
Model No.	: HD350
Make	: EXTECH INSTRUMENTS
Id No.	: NCQC/V-01
Requested Calibration Range	: (1 -80) m/s
Resolution (Test Meter)	: 0.01 m/s
Condition When Received	: Used
Reference Meter	: Thermal Anemometer/Pitot Static Tube
Reference Standard	: ISO 3966:2008
Calibration Medium	: Air
Calibration Procedure Code	: WP-AFW-C01

RESULTS:

Calibrated Actual Velocity Range m/s	Error Range % FS	Difference Range m/s	Expanded Uncertainty in actual Velocity Measurement
(2.15 - 3)	(-1.43 to 0.23)	(-1.14 to 0.19)	3.0 % reading
(3.01 - 80.26)	(-3.17 to -0.24)	(-2.54 to -0.19)	1.1 % reading

Calibrated by

Certificate Prepared by

Certificate Checked by

Abdul Safeeq.S

Abdul Safeeq.S

C.E Suresh

NCQC System Certificate No. 219
Ajesh.A

NCQC
Valid up to 07-11-2024
Reviewed

NCQC
Valid up to 07-11-2024
Reviewed

NCQC System Certificate No. 219

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Calibration Details:-

Ambient conditions (Nominal) 999±1 mbar 29±1 °C 44±5 %

Calibration method The calibration is done as per FCRI procedure WP-AFW-C01. The Meter under calibration and reference "Thermal Anemometer/Pitot Static Tube" is held at the exit of test section size (300×300) mm of the wind tunnel facility. The static Pressure is measured using Absolute pressure Transmitter. The Differential Pressure is measured using Differential Pressure Transmitter. Different velocities in the tunnel are achieved by varying the speed of the blower by means of the frequency inverter of the motor.

Data The data of Calibration are given in Table 1.

Results The results of Calibration are given in Table 2.

Uncertainty The uncertainty in calibration is estimated as per NABL 141 Guidelines for Estimation and Expression of Uncertainty in Measurement and FCRI Procedure WP-UE-01. Accredited uncertainty of the reference system is 0.015 m/s or 3.0 % reading whichever is high for reference Thermal Anemometer & 1.1 % reading for reference Pitot Static Tube as per NABL Accreditation Certificate No: CC-2395, Valid until 30-06-2019. The uncertainty budget is given in Table 3&4.

Traceability Calibration of all instruments, meters used are traceable to National standards (NPL, New Delhi) and their calibrations are current.

File No Computer IdNo:2 C:\CALIB\ANEMO\2018\NOVEMBER

FCRI Reference Major equipment used and selected from Equipment List, WT/QLTY/01, Rev 01, 13-08-2018 is listed below.

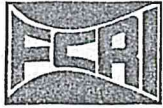
Equipments Used	File No	Calibration Due
Thermal Anemometer	FCRI/WT/V13/EQ/32	29.11.2018
Pitot Static tube	FCRI/WT/PT/EQ/12	16.06.2019
Diff.Pressure Transmitter	FCRI/WT/P/EQ/17	13.03.2019
Absolute Pressure Transmitter	FCRI/WT/P/EQ/03	19.12.2018
Digital Temperature Transmitter	FCRI/WT/T/EQ/05	09.02.2019
R. Transmitter	FCRI/WT/R/EQ/01	19.06.2019

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ULR NO:- CC239518 0000028F

Table 1
Data of Calibration

Relative Humidity = 44.02 %

Sl. No.	Reference meters		Thermal Anemometer	Air Temperature T_a (°C)	Meter under Calibration
	Pitot Static Tube				
	Differential pressure ΔP_r Pa	Static pressure P_r mbar(abs)	Indicated velocity U_r (m/s)	Indicated velocity U_i (m/s)	
1	2	3	4	5	6
1	-	-	2.11	29.48	1.01
2	-	-	2.37	29.75	2.14
3	-	-	2.96	29.80	3.19
4	8.02	998.27	-	29.87	3.53
5	15.55	998.30	-	29.88	5.03
6	60.51	998.31	-	30.01	10.00
7	240.43	998.25	-	30.36	20.01
8	541.48	998.20	-	30.86	30.01
9	964.53	998.15	-	31.64	40.02
10	961.63	998.12	-	31.79	40.01
11	962.29	998.12	-	31.82	40.01
12	963.71	998.09	-	31.87	40.02
13	963.50	998.08	-	31.93	40.01
14	2167.84	998.02	-	33.39	60.04
15	3625.97	996.68	-	36.18	77.72
16	2961.59	996.66	-	35.89	70.04
17	1511.01	996.60	-	34.29	50.02
18	740.05	996.51	-	33.51	35.02
19	378.58	996.42	-	32.86	25.02
20	138.01	996.38	-	32.59	15.02
21	41.34	996.30	-	32.44	8.03
22	12.42	996.30	-	32.38	4.02
23	-	-	2.57	32.25	2.52
24	-	-	2.28	32.07	1.51

Ambient Pressure 998.94 mbar (abs), Temperature 29.25 °C

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Table 2
Results of Calibration

Sl No.	Meter under calibration	Reference Meter	Error	Difference [U ₁] - [U ₂] m/s
	Indicated Velocity U ₁ m/s	Actual Velocity U ₂ m/s	(U ₁ - U ₂)/[80]* 100 E _i % Full Scale	
1	2	3	4	5
1	1.01	2.155	-1.43	-1.14
2	2.14	2.416	-0.35	-0.28
3	3.19	3.005	0.23	0.19
4	3.53	3.751	-0.28	-0.22
5	5.03	5.224	-0.24	-0.19
6	10.00	10.306	-0.38	-0.31
7	20.01	20.551	-0.68	-0.54
8	30.01	30.853	-1.05	-0.84
9	40.02	41.209	-1.49	-1.19
10	40.01	41.159	-1.44	-1.15
11	40.01	41.176	-1.46	-1.17
12	40.02	41.210	-1.49	-1.19
13	40.01	41.210	-1.50	-1.20
14	60.04	61.852	-2.26	-1.81
15	77.72	80.257	-3.17	-2.54
16	70.04	72.580	-3.17	-2.54
17	50.02	51.823	-2.25	-1.80
18	35.02	36.267	-1.56	-1.25
19	25.02	25.926	-1.13	-0.91
20	15.02	15.653	-0.79	-0.63
21	8.03	8.567	-0.67	-0.54
22	4.02	4.694	-0.84	-0.67
23	2.52	2.637	-0.15	-0.12
24	1.51	2.344	-1.04	-0.83

Actual Velocity Range (2.15 ≤ U₂ ≤ 3 m/s)

Difference Range -1.14 m/s to 0.19 m/s

Expanded uncertainty, U [k=2]
in actual velocity measurement 3.0 % reading

Actual Velocity Range (3.01 < U₂ ≤ 80.26 m/s)

Type A Standard uncertainty
for repeated datas (sl.nos 9 -13) 0.01 m/s 0.03 %
Difference Range -2.54 m/s to -0.19 m/s

Expanded uncertainty, U [k=2]
in actual velocity measurement 1.1 % reading

Note :- Full Scale range as per meter specification manual - 80 m/s.

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Table 3

Sample Calculation & Uncertainty budget

Actual Velocity Range: 2.15-3 m/s

Data point : SI No:1 of Table 1

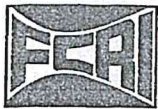
Source of uncertainty	Estimate	Expanded uncertainty	Probability distribution		Standard uncertainty	Sensitivity coefficient	Uncertainty contribution	Degree of freedom	
X_i	x_i	$\pm kx_i$	n (Type B)	Divisor	$u(x_i)$	c_i	$u(y)$	n	
Reference velocity, U_r (m/s)	2.06	6.19E-02	Normal	2	3.10E-02	1.04E+00	3.23E-02	∞	
Air temperature, T_a (°C)	29.483	8.00E-02	Normal	2	4.00E-02	7.12E-03	2.85E-04	∞	
Ambient pressure, P_b (mbar)	998.94	6.00E-01	Normal	2	3.00E-01	2.16E-03	6.47E-04	∞	
Actual velocity, U_a (m/s)	2.155	Combined standard uncertainty, u_c			0.032	m/s			
Best Fit Line			Type A	1	5.61E-04	m/s	1.00E+00	5.61E-04	4
		Combined standard uncertainty, u_c			3.24E-02	m/s			
		Effective degrees of freedom, nu_{eff}			4.43E+07				
		Coverage factor, k			2				
		Expanded uncertainty, U (For k=2)			0.0647	m/s	3.0 % reading		
Refer Table. 2 for corresponding actual velocities					$U_a = U_r \frac{(273 + T_a)}{294} \times \frac{1014}{P_b} \text{ m/s}$				

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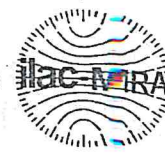
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Table 4

Sample Calculation & Uncertainty budget
Actual Velocity Range: 3.01 - 80.26 m/s

Data point : SI No.: 4 of Table 1

Source of uncertainty	Estimate	Limits	Probability distribution	Standard uncertainty	Sensitivity coefficient	Uncertainty contribution	Degree of freedom
X_i	x_i	$\pm \Delta x_i$	n (Type B)	Divisor	$u(x_i)$	c_i	$u(y)$
Air temperature, T_a , °C	29.87	8.00E-02	Type B, Normal	2	4.00E-02 °C	2.42E+02	9.67E+00
Best fit line			Type B, Rectangular	1.732	7.00E+00 Pa	1.00E+00	7.00E+00
Relative humidity, R_h , %	44.02	5.72E-01	Type B, Normal	2	2.86E-01 %	4.20E+01	1.20E+01
Vapour pressure, P_s (100%), Pa	4204.594	2.39E+01	Type B, Normal	2	1.19E+01 Pa	4.40E-01	5.25E+00
Vapour pressure, P_s (%Rh)	1850.735	Combined standard uncertainty, uc			1.31E+01 Pa		
Molecular weight, M_a , kg/kmol	28.966	0.00E+00	Type B, Rectangular	1.732	0.00E+00 kg/kmol	9.81E-01	0.00E+00
Molecular weight, M_s , kg/kmol	18.016	0.00E+00	Type B, Rectangular	1.732	0.00E+00 kg/kmol	1.85E-02	0.00E+00
Vapour pressure, P_s , Pa	1850.735	2.62E+01	Type B, Normal	2	1.31E+01 Pa	1.10E-04	1.44E-03
Barometric pressure, P_b , mbar	998.94	6.00E-01	Type B, Normal	2	3.00E+01 Pa	2.03E-06	6.09E-05
Molecular weight, M_e , kg/kmol	28.76313	Combined standard uncertainty, uc			1.44E-03 kg/kmol		
Pressure at Reference meter, P_r , mbar	998.27	6.03E-01	Type B, Normal	2	3.02E+01 Pa	1.14E-05	3.44E-04
Molecular weight, M_a , kg/kmol	28.76313	2.88E-03	Type B, Normal	2	1.44E-03 kg/kmol	3.96E-02	5.70E-05
Gas constant, R, J/kmol K	8314.4	1.00E-02	Type B, Rectangular	1.732	4.80E-01 J/kmol K	1.37E-04	5.58E-05
Temperature at Reference meter, T_r , (°C)	29.87	8.00E-02	Type B, Normal	2	4.00E-02 °C	3.76E-03	1.50E-04
Density of air at reference meter, ρ_r , kg/m ³	1.13970	Combined standard uncertainty, uc			3.86E-04 kg/m ³		
Pressure at Reference meter, P_r , mbar	998.27	6.030E-01	Type B, Normal	2	3.015E+01 Pa	1.44E-10	4.33E-09
Differential pressure, ΔP_r , Pa	8.02	1.800E-01 %	Type B, Normal	2	7.215E-03 Pa	1.36E-06	9.85E-09
Isentropic exponent, k	1.4	0.000E+00	Type B, Rectangular	1.732	0.000E+00	1.02E-05	0.00E+00
Compressibility correction factor, $(1-\epsilon)$	0.99999	Combined standard uncertainty, uc			4.3E-09		
Calibration factor, α_r	1	1.00E+00	Type B, Normal	2	5.00E-03	3.75E+00	1.88E-02
Compressibility correction factor, $(1-\epsilon)$	0.99999	8.66E-09	Type B, Normal	2	4.33E-09	3.75E+00	1.62E-08
Differential pressure, ΔP_r , Pa	8.02	1.800E-01 %	Type B, Normal	2	7.215E-03 Pa	2.34E-01	1.69E-03
Density at reference meter, ρ_r , kg/m ³	1.13970	7.71E-04	Type B, Normal	2	3.86E-04 kg/m ³	1.65E+00	6.35E-04
Reference velocity, U_r (m/s)	3.751	Combined standard uncertainty, uc			1.88E-02 m/s		
Best fit line			Type A	1	9.76E-04 m/s	1.00E+00	9.76E-04
				Combined standard uncertainty, uc		1.89E-02 m/s	
				Effective degrees of freedom, ν_{eff}		5.58E+05	
				Coverage factor, k		2	
				Expanded uncertainty, U (For $k=2$)		0.040 m/s	1.1 % reading

Refer Table. 2 for corresponding actual velocities

$$U_a = \alpha_r \times (1 - \epsilon) \times \sqrt{\frac{2 \Delta P_r}{\rho_r}} \text{ m/s}$$

>>>End of Certificate<<<

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