VAISALA

MEASUREMENT STANDARDS LABORATORY

CERTIFICATE OF CALIBRATION no S00276

Customer	OREGON STATE UNIVERSITY Oceanic & Atmos. Sciences 130 Burt Hall Corvallis OR 97331 USA
Item	PTU Transmitter Pressure range from 500 to 1100 hPa abs., calibrated from 500 to 1100 hPa Temperature range from - 40 to + 60 °C, calibrated at + 22 °C Humidity range from 0 to 100 %RH, calibrated from 0 to 97 %RH at + 23 °C
Manufacturer	Vaisala Oyj
Model	PTU307
Serial number	C2610002
Instrument number	- -
Calibration performed	From February 3 to 9, 2009
Date	February 13, 2009
Signature	Antti Leivonen Calibration Engineer
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Documents attached	-
NOTES	

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Configuration

The transmitter's configuration and settings were read from the transmitter's memory. The calibration is valid only with configuration and settings given in table 1.

Table 1. Configuration and settings

Software	PTU300 / 4.02		
Serial number	C2610002	Fixed P comp.	OFF
Batch number	C2430026	P1 offset	0
Module 1	AOUT-1	P1 multi adj.	ON
Module 2	BARO-1	P1 linear adj.	ON
P1 serial num.	C1720013	P1 poly adj.	OFF
Ch3 serial num.	C2310011	P1 meas per sec	1 s
EXT factor	0,03	P1 average	1 s
Filter	OFF	Mtim	512
Pressure	1013.25 hPa	Ta	ON
P comp.	ON		

PRESSURE CALIBRATION

Description

The pressure calibration was done in the Measurement Standards Laboratory (MSL) of Vaisala Oyj on February 9, 2009 by Pekka Puttonen.
Before measurements the transmitter was allowed to stabilize to the conditions of the laboratory for at least 2 hours with + 15,0 VDC ± 0,3 VDC power supply switched on.
Before the calibration the Multi Point Correction (MPC) and Linear Correction (LC) -values for the transmitter were read from the transmitter's memory.
The pressure readings of the transmitter were compared to the values of the reference pressure transmitter in the range from 500 to 1100 hPa absolute pressure.
Pressure readings of the transmitter were read with the MPC -corrections ON and the LC -corrections OFF. The pressure reading P was then calculated using the old LC -corrections. New LC -corrections were calculated using the least squares method, input into the memory of the transmitter and the final results were calculated using these new corrections.
The pressure calibration is valid only with the LC corrections switched ON.
Pressure values were read via serial port with resolution of 0,01 hPa.
The used pressure transmitting medium was air and/or nitrogen.

Reference

DHI PPC3 Pressure Controller/Calibrator, serial number 723, traceable to the National Institute of Standards and Technology (NIST, USA) via MSL and Centre for Metrology and Accreditation (MIKES, Finland).

Uncertainty

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 standard uncertainty of measurement has been determined in accordance with EA Publication EA-4/02.
- The uncertainty is calculated from the uncertainties caused from the reference equipment, calibration process and unit under calibration (UUC) including resolution, stability (short term), linearity, repeatability, hysteresis and rounding of the final results.
- The measurement results and uncertainty may be interpolated between measurement points.

The measurement uncertainty represents the situation at the time and conditions of calibration. When using the UUC at different conditions and at different time the effect of the conditions and stability of the UUC shall be evaluated separately.

Corrections

The MPC and LC -corrections were read from the transmitter's memory.

Table 2. Multi Point Correction -values

MPC -corrections, P1	
Reading [hPa]	Correction [hPa]
499,61	- 0,10
599,05	- 0,07
698,53	- 0,06
800,93	- 0,06
900,39	- 0,05
999,85	- 0,03
1061,29	- 0,03
1099,32	- 0,03

Table 3. Old Linear Correction -values

Reading	LC -corrections, P1	
500	- 0,059	[hPa]
1100	- 0,001	[hPa]

Table 4. New Linear Correction -values

Reading	LC -corrections, P1	
500	- 0,156	[hPa]
1100	- 0,056	[hPa]

Measurement results

The reference and the reading values presented in table 5 are averages of ten independent observations.

Table 5. Measurement results, pressure

Reference [hPa]	With old coefficients Reading P [hPa]	With old coefficients Correction [hPa]	With new coefficients Reading P [hPa]	With new coefficients Correction [hPa]
1100,05	1100,11	- 0,06	1100,06	- 0,01
1050,21	1050,27	- 0,06	1050,21	0,00
1000,20	1000,26	- 0,06	1000,20	0,00
950,17	950,24	- 0,07	950,17	0,00
850,16	850,24	- 0,08	850,16	0,00
750,19	750,27	- 0,08	750,19	0,00
650,20	650,29	- 0,09	650,20	0,00
550,18	550,27	- 0,09	550,18	0,00
500,10	500,21	- 0,11	500,11	- 0,01
500,04	500,15	- 0,11	500,05	- 0,01
550,09	550,18	- 0,09	550,09	0,00
650,11	650,19	- 0,08	650,10	+ 0,01
750,07	750,14	- 0,07	750,06	+ 0,01
850,06	850,13	- 0,07	850,06	0,00
949,93	949,99	- 0,06	949,93	0,00
999,88	999,94	- 0,06	999,88	0,00
1049,92	1049,98	- 0,06	1049,92	0,00
1099,87	1099,93	- 0,06	1099,88	- 0,01

The correction shall be added algebraically to the reading.

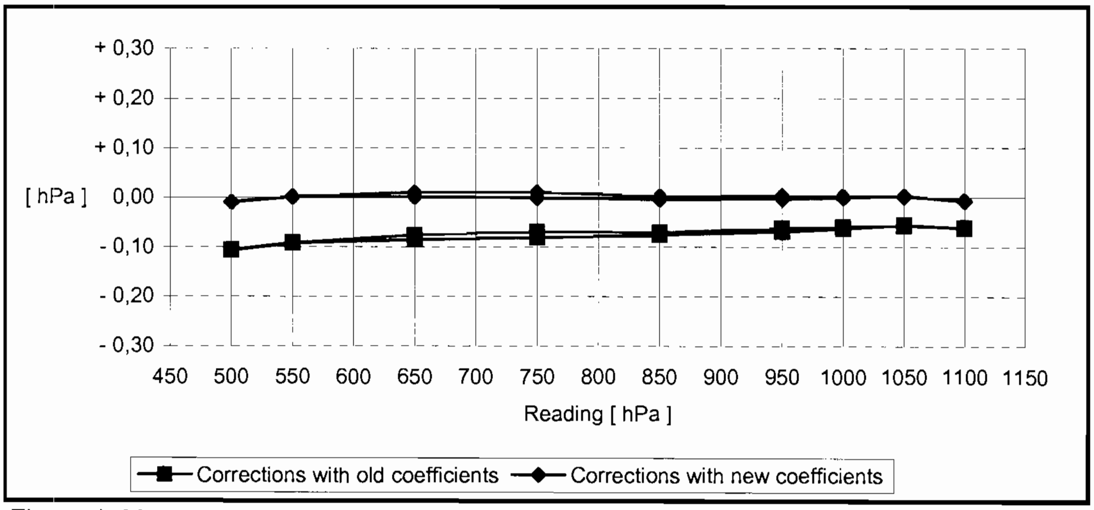

Figure 1. Measurement results

Final results

The reading value is an average of the readings of the pressure transducer installed in the transmitter.

Table 6. Final results, pressure

Reference [hPa]	With old coefficients Reading P [hPa]	Correction [hPa]	With new coefficients Reading P [hPa]	Correction [hPa]	Uncertainty [hPa]
1099,96	1100,02	- 0,06	1099,97	- 0,01	± 0,04
1050,06	1050,12	- 0,06	1050,06	0,00	± 0,04
1000,04	1000,10	- 0,06	1000,04	0,00	± 0,04
950,05	950,12	- 0,07	950,05	0,00	± 0,04
850,11	850,18	- 0,07	850,11	0,00	± 0,04
750,13	750,21	- 0,08	750,13	0,00	± 0,04
650,16	650,24	- 0,08	650,15	+ 0,01	± 0,04
550,14	550,23	- 0,09	550,14	0,00	± 0,04
500,07	500,18	- 0,11	500,08	- 0,01	± 0,04

The correction shall be added algebraically to the reading.

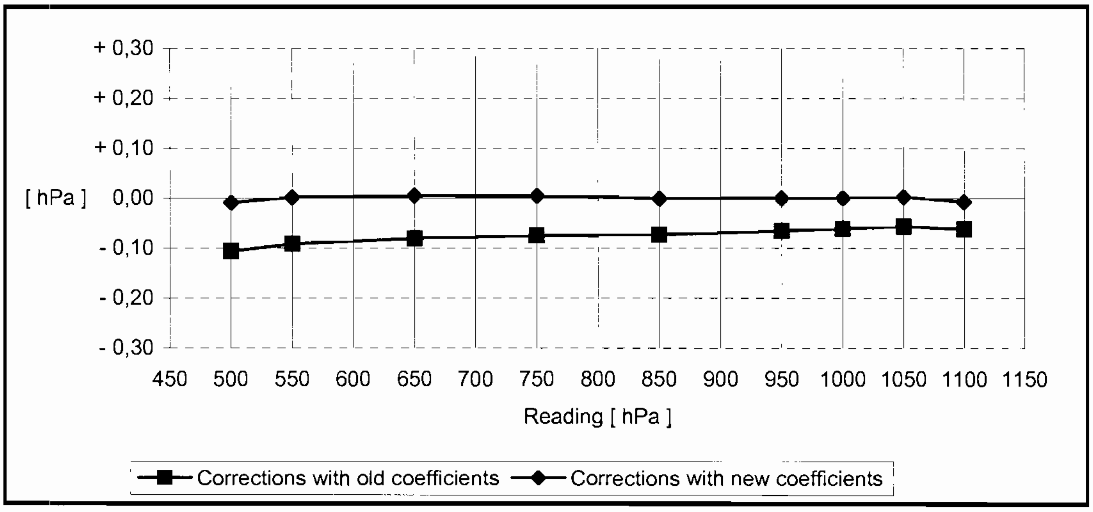

Figure 2. Final results

Conditions

Pressure	995,3 hPa ± 0,6 hPa
Temperature	+ 23,8 °C ± 0,3 °C
Humidity	34 %RH ± 3 %RH

VAISALA

Measurement Standards Laboratory
Antti Leivonen

Certificate number	**S00276**
Date	February 13, 2009
Item	PTU Transmitter
Manufacturer	Vaisala Oyj
Model	PTU307
Serial number	C2610002
Instrument number	- -

TEMPERATURE CALIBRATION

Description

The temperature calibration was done in the Measurement Standards Laboratory (MSL) of Vaisala Oyj on February 4, 2009 by Antti Leivonen.
Before measurements the transmitter was allowed to stabilize to the conditions of the laboratory for at least 2 hours with + 15,0 VDC ± 0,3 VDC power supply switched on.
The temperature readings of the transmitter were compared to the values of the reference thermometer at + 22 °C in a calibration chamber.
Temperature values were read via serial port with resolution of 0,01 °C.
New correction coefficients were calculated and input into the transmitter's memory.
Temperature values are given according to the International Temperature Scale of 1990, ITS-90.

Vaisala PTU200 PTU Transmitter, serial number U0350007, traceable to National Institute of Standards and Technology (NIST, USA) via MSL.

Uncertainty

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 standard uncertainty of measurement has been determined in accordance with EA Publication EA-4/02.

- The uncertainty is calculated from the uncertainties caused from the reference equipment, calibration process and unit under calibration (UUC) including resolution, stability (short term), repeatability, self heating and rounding of the final results.
- The measurement results and uncertainty are representing the measurement point only.

The measurement uncertainty represents the situation at the time and conditions of calibration. When using the UUC at different conditions and at different time the effect of the conditions and stability of the UUC shall be evaluated separately.

Calculations

New offset- and gain coefficients were calculated from the measurement results. The coefficients are presented in table 7. The final results were calculated using equations 1 and 2.

T = T offset + T gain · T', where (1)
T' = Reading without offset- and gain corrections [°C]

Ta = Ta offset + Ta gain · Ta', where (2)
Ta' = Reading without offset- and gain corrections [°C]

New coefficients were input into the transmitter's memory.

Table 7. Coefficients

	Old coefficients	New coefficients	
T offset	0,014419999100	0,029230001400	[°C]
T gain	1,000000000000	1,000000000000	
Ta offset	0,010010000500	0,023609998200	[°C]
Ta gain	1,000000000000	1,000000000000	

Final temperature results

The reference and the reading values are averages of ten independent observations. The standard deviations are included in the calculated uncertainties.

Table 8. Final temperature results, T

Reference [°C]	With old coefficients Reading T [°C]	With old coefficients Correction [°C]	With new coefficients Reading T [°C]	With new coefficients Correction [°C]	Uncertainty [°C]
+ 22,15	+ 22,14	+ 0,01	+ 22,15	0,00	± 0,07

The correction shall be added algebraically to the reading.

Table 9. Final temperature results, Ta

Reference [°C]	With old coefficients Reading Ta [°C]	With old coefficients Correction [°C]	With new coefficients Reading Ta [°C]	With new coefficients Correction [°C]	Uncertainty [°C]
+ 22,15	+ 22,14	+ 0,01	+ 22,15	0,00	± 0,07

Conditions

Temperature + 23,3 °C ± 0,3 °C
Humidity 34 %RH ± 3 %RH

HUMIDITY CALIBRATION

Description

The humidity calibration was done in the Measurement Standards Laboratory (MSL) of Vaisala Oyj on February 4, 2009 by Antti Leivonen.
Before measurements the transmitter was allowed to stabilize to the conditions of the laboratory for at least 12 hours with + 15,0 VDC ± 0,3 VDC power supply switched on.
Chemical purge was done at least 12 hours before the measurements.
The humidity readings of the transmitter were compared to the reference humidity values at room temperature in Salt Solution Generator in the range from 0 to 97 %RH.
The humidity readings were read via serial port with resolution of 0,01 %RH.
Coefficients RHI_0, RHI_1, RHI_2, RHI_3 and RHI_4 were calculated from the observed humidity values and input to the transmitter's memory.
Measurements were made in Salt Solution Generator, where the temperature was + 22,50 °C ± 0,03 °C. The 0,1 %RH value was measured in dry nitrogen flow which temperature was + 22,31 °C ± 0,03 °C.

References

Salt Solution Generator UG 8195, traceability is based on the physical phenomenon in which the equilibrium relative humidity values associated with certain saturated salt solutions are known.
The operation principle and values of the Salt Solution Generator are based on Lewis Greenspan's research /1/ and on the international standard ASTM E 104 - 85 /2/.

Uncertainty

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 standard uncertainty of measurement has been determined in accordance with EA Publication EA-4/02.

- The uncertainty is calculated from the uncertainties caused from the reference equipment, calibration process and unit under calibration (UUC) including resolution, stability (short term), linearity, repeatability, hysteresis and rounding of the final results.
- The measurement results and uncertainty may be interpolated between measurement points.

The measurement uncertainty represents the situation at the time and conditions of calibration. When using the UUC at different conditions and at different time the effect of the conditions and stability of the UUC shall be evaluated separately.

Calculations

The new RHI_0 to RHI_4 coefficients were calculated from the measurement results using the least squares method and input into the transmitter's memory.
Complete description of calculations performed is available in the Measurement Standards Laboratory.
During the measurement only temperature T was recorded and the Ta value was calculated using temperature measurement results. With this method the exact humidity readings were calculated with old and new coefficients using equation 3.

$RH_{OUT} = RH \cdot P_{ws}(T) / P_{ws}(Ta)$, where (3)

RH = Humidity reading with offset- and gain corrections [%RH]
$P_{ws}(T)$ = Water vapor saturation pressure at temperature T
$P_{ws}(Ta)$ = Water vapor saturation pressure at temperature Ta

Table 10. Coefficients, humidity

Coefficient	Old coefficients	New coefficients	
RHI_0	+ 1,130000000E-01	+ 7,199999810E-02	[%RH]
RHI_1	- 3,258119110E-02	- 8,663789750E-03	
RHI_2	+ 8,639499660E-04	- 7,481999400E-05	[%RH-1]
RHI_3	- 5,059998510E-06	+ 3,019999980E-06	[%RH-2]
RHI_4	0,000000000E+00	0,000000000E+00	[%RH-3]
RH offset	0,000000000E+00	0,000000000E+00	[%RH]
RH gain	1,000000000E+00	1,000000000E+00	

Measurement results

The measurements were made for ascending and descending humidity values. The probe was allowed to stabilize to each humidity for 10 minutes before the reference values were recorded and the humidity and temperature values were recorded ten times. The humidity values were then calculated using the equation 3 and coefficients given in table 10. The calculated humidity values in table 11 are averages of these values.

Table 11. Measurement results, humidity

Reference [%RH]	With old coefficients Reading RHout [%RH]	With old coefficients Correction [%RH]	With new coefficients Reading RHout [%RH]	With new coefficients Correction [%RH]
0,10	0,01	+ 0,09	-0,03	+ 0,13
11,30	11,22	+ 0,08	11,34	- 0,04
32,93	32,63	+ 0,30	32,65	+ 0,28
53,64	53,10	+ 0,54	52,89	+ 0,75
75,39	74,79	+ 0,60	74,67	+ 0,72
84,72	84,42	+ 0,30	84,56	+ 0,16
97,45	95,94	+ 1,51	96,66	+ 0,79
97,45	96,88	+ 0,57	97,66	- 0,21
84,72	85,72	- 1,00	85,91	- 1,19
75,39	76,01	- 0,62	75,91	- 0,52
53,64	54,05	- 0,41	53,84	- 0,20
32,93	33,36	- 0,43	33,37	- 0,44
11,30	11,51	- 0,21	11,63	- 0,33
0,10	0,03	+ 0,07	-0,01	+ 0,11

The correction shall be added algebraically to the reading.

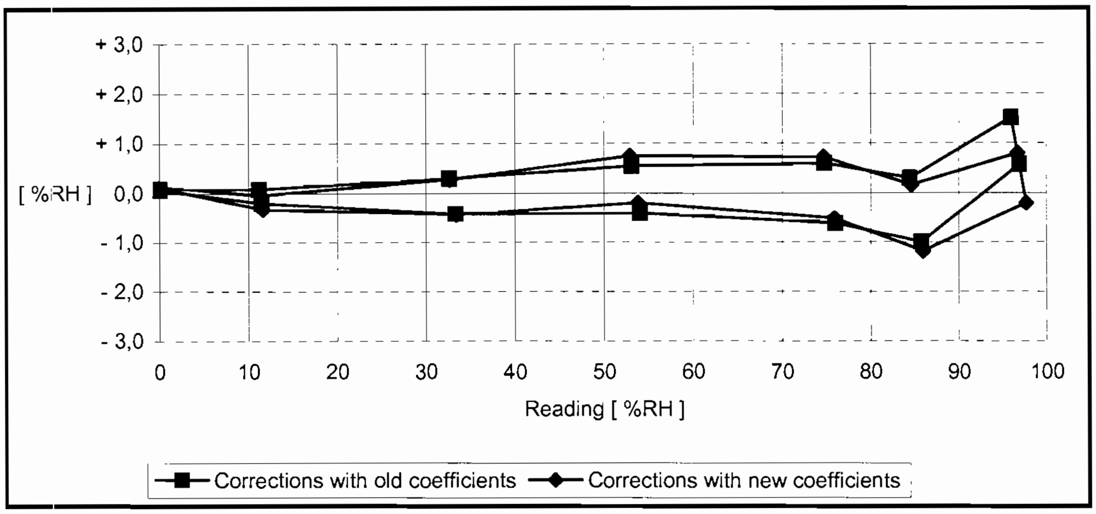

Figure 3. Measurement results

Measurement Standards Laboratory
Antti Leivonen

Certificate number	**S00276**
Date	February 13, 2009
Item	PTU Transmitter
Manufacturer	Vaisala Oyj
Model	PTU307
Serial number	C2610002
Instrument number	- -

Final results

The final humidity calibration results are averages of measured values.

Table 12. Final results, humidity

Reference [%RH]	With old coefficients Reading RHout [%RH]	Correction [%RH]	With new coefficients Reading RHout [%RH]	Correction [%RH]	Uncertainty [%RH]
0,1	0,0	+ 0,1	0,0	+ 0,1	± 1,1
11,3	11,4	- 0,1	11,5	- 0,2	± 1,3
32,9	33,0	- 0,1	33,0	- 0,1	± 1,2
53,6	53,5	+ 0,1	53,3	+ 0,3	± 1,3
75,4	75,4	0,0	75,3	+ 0,1	± 1,2
84,7	85,1	- 0,4	85,2	- 0,5	± 1,3
97,4	96,4	+ 1,0	97,1	+ 0,3	± 1,6

The correction shall be added algebraically to the reading.

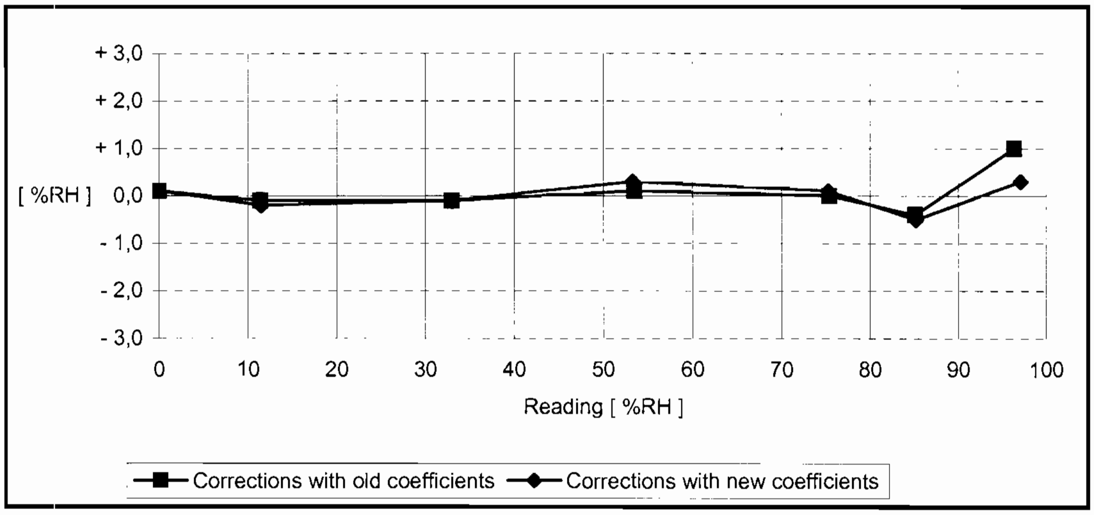

Figure 4. Final results

Conditions

Pressure	1000,6 °C ± 0,5 hPa
Temperature	+ 23,5 °C ± 0,3 °C
Humidity	35 %RH ± 3 %RH

REFERENCES

1. Humidity Fixed Points of Binary Saturated Aqueous Solutions. Lewis Greenspan. Journal of Research. Vol. 81A, No. 1, January - February 1977

2. ASTM E 104-85. Standard practice for maintaining constant relative humidity by means of aqueous solutions. ASTM. American Society for Testing and Materials. 1985