

CERTIFICATE OF CALIBRATION no T01493

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 + 23 °C
Humidity range from 0 to 100 %RH, calibrated from 0 to 97 %RH at + 23 °C
Read via serial port and analog outputs

Manufacturer Vaisala Oyj

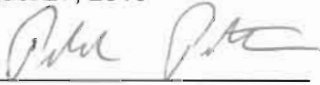
Model PTU300

Serial number C2610002

Instrument number - -

Calibration performed From August 18 to 20, 2010

Date August 27, 2010

Signature 
Pekka Puttonen
Calibration Engineer

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Documents attached -

NOTES

This Certificate may only be reproduced in full, except with the prior written permission by the issuing Laboratory.
The measurement results issued in this Certificate are traceable to national or international measurement standards either via ISO/IEC 17025 Accredited Laboratories and/or internal calibrations performed in Vaisala Measurement Standards Laboratory.

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

PRESSURE CALIBRATION

Description

The pressure calibration was done in the Measurement Standards Laboratory (MSL) of Vaisala Oyj on August 18, 2010 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 722, traceable to the National Institute of Standards and Technology (NIST, USA) via MSL and Centre for Metrology and Accreditation (MIKES, Finland).
Agilent 34970A Digital Multimeter, serial number MY44016640, traceable to the NIST, USA via Fluke Primary Standards Laboratory, USA and 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), 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	- 0,129	[hPa]
1100	- 0,048	[hPa]

Table 4. New Linear Correction -values

Reading	LC -corrections, P1	
500	- 0,174	[hPa]
1100	- 0,065	[hPa]

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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		With new coefficients	
	Reading p [hPa]	Correction [hPa]	Reading p [hPa]	Correction [hPa]
1099,97	1100,00	- 0,03	1099,98	- 0,01
1049,88	1049,89	- 0,01	1049,87	+ 0,01
1000,03	1000,05	- 0,02	1000,03	0,00
950,07	950,09	- 0,02	950,07	0,00
850,16	850,19	- 0,03	850,16	0,00
750,20	750,23	- 0,03	750,20	0,00
650,08	650,12	- 0,04	650,08	0,00
550,12	550,17	- 0,05	550,12	0,00
500,12	500,17	- 0,05	500,12	0,00
500,08	500,13	- 0,05	500,08	0,00
550,03	550,07	- 0,04	550,03	0,00
649,92	649,96	- 0,04	649,92	0,00
749,89	749,93	- 0,04	749,89	0,00
849,90	849,93	- 0,03	849,90	0,00
949,87	949,89	- 0,02	949,87	0,00
999,90	999,92	- 0,02	999,90	0,00
1049,90	1049,91	- 0,01	1049,89	+ 0,01
1099,94	1099,97	- 0,03	1099,95	- 0,01

The correction shall be added algebraically to the reading.

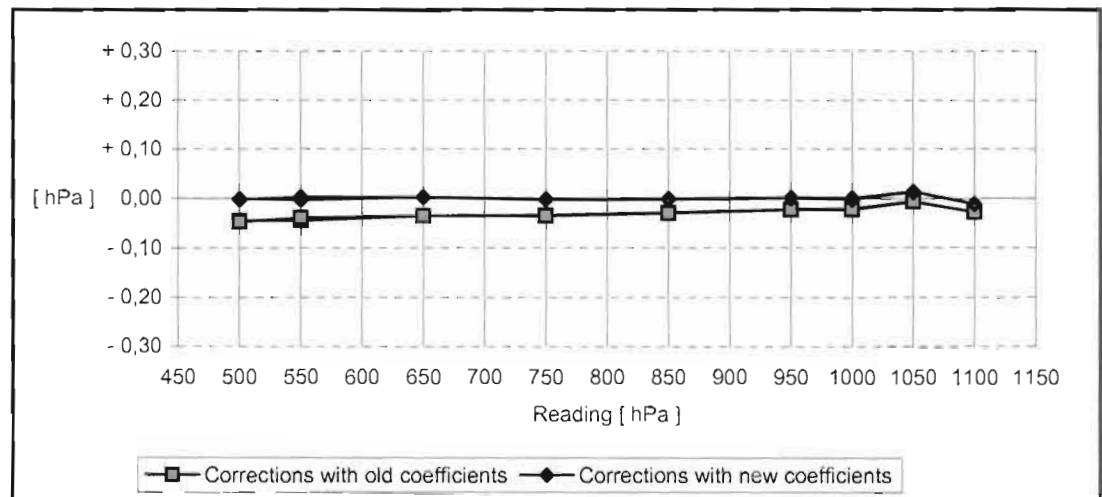


Figure 1. Measurement results

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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		With new coefficients		Uncertainty [hPa]
	Reading p [hPa]	Correction [hPa]	Reading p [hPa]	Correction [hPa]	
1099,95	1099,98	- 0,03	1099,96	- 0,01	± 0,04
1049,89	1049,90	- 0,01	1049,88	+ 0,01	± 0,04
999,97	999,99	- 0,02	999,97	0,00	± 0,04
949,97	949,99	- 0,02	949,97	0,00	± 0,04
850,03	850,06	- 0,03	850,03	0,00	± 0,04
750,04	750,07	- 0,03	750,04	0,00	± 0,04
650,00	650,04	- 0,04	650,00	0,00	± 0,04
550,08	550,12	- 0,04	550,08	0,00	± 0,04
500,10	500,15	- 0,05	500,10	0,00	± 0,04

The correction shall be added algebraically to the reading.

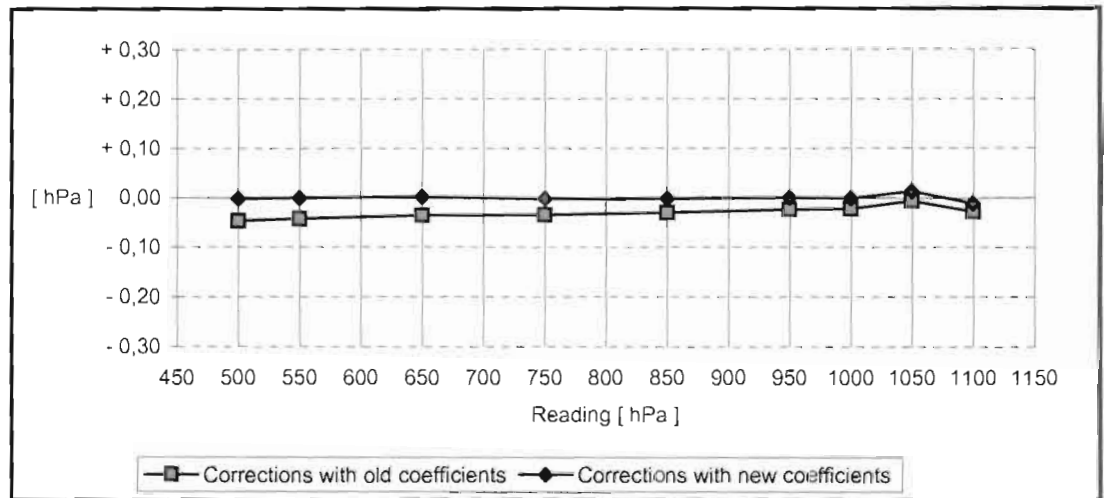


Figure 2. Final results

Conditions

Pressure 1000,4 hPa ± 0,3 hPa
Temperature + 23,6 °C ± 0,5 °C
Humidity 35 %RH ± 3 %RH

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TEMPERATURE CALIBRATION

Description	<p>The temperature calibration was done in the Measurement Standards Laboratory (MSL) of Vaisala Oyj on August 19, 2010 by Antti Leivonen.</p> <p>Before measurements the transmitter was allowed to stabilize to the conditions of the laboratory for at least 2 hours with + 15,0 VDC \pm 0,3 VDC power supply switched on. The temperature readings of the transmitter were compared to the values of the reference thermometer at + 23 °C in a calibration chamber.</p> <p>Temperature values were read via serial port with resolution of 0,01 °C.</p> <p>The 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.</p>
Reference	<p>Vaisala PTU200 PTU Transmitter, serial number U0350007, traceable to National Institute of Standards and Technology (NIST, USA) via MSL.</p>
Uncertainty	<p>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.</p> <ul style="list-style-type: none">- 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.

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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.

$$T = T \text{ offset} + T \text{ gain} \cdot T', \text{ where} \quad (1)$$

$T' = \text{Reading without offset- and gain corrections [} ^\circ\text{C]}$

$$T_a = T_a \text{ offset} + T_a \text{ gain} \cdot T_a', \text{ where} \quad (2)$$

$T_a' = \text{Reading without offset- and gain corrections [} ^\circ\text{C]}$

New coefficients were input into the transmitter's memory.

Table 7. Coefficients

	Old coefficients	New coefficients	
T offset	- 3,900000100E-02	- 1,900000000E-02	[°C]
T gain	1,000000000E+00	1,000000000E+00	
Ta offset	- 4,800000190E-02	- 3,799999950E-02	[°C]
Ta gain	1,000000000E+00	1,000000000E+00	

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 results, temperature, T

Reference [°C]	With old coefficients		With new coefficients		Uncertainty [°C]
	Reading T [°C]	Correction [°C]	Reading T [°C]	Correction [°C]	
+ 23,06	+ 23,04	+ 0,02	+ 23,06	0,00	± 0,07

The correction shall be added algebraically to the reading.

Table 9. Final results, temperature, Ta

Reference [°C]	With old coefficients		With new coefficients		Uncertainty [°C]
	Reading Ta [°C]	Correction [°C]	Reading Ta [°C]	Correction [°C]	
+ 23,06	+ 23,05	+ 0,01	+ 23,06	0,00	± 0,07

Conditions

Temperature + 23,7 °C ± 0,3 °C
Humidity 35 %RH ± 3 %RH

HUMIDITY CALIBRATION

Description	<p>The humidity calibration was done in the Measurement Standards Laboratory (MSL) of Vaisala Oyj on August 20, 2010 by Antti Leivonen.</p> <p>Before measurements the transmitter was allowed to stabilize to the conditions of the laboratory for at least 12 hours with + 15,0 VDC \pm 0,3 VDC power supply switched on. Chemical purge was done at least 12 hours before the measurements.</p> <p>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. The new coefficients RHI_0, RHI_1, RHI_2, RHI_3 and RHI_4 were calculated from the observed humidity values and input into the transmitter's memory.</p> <p>Measurements were made in Salt Solution Generator, where the temperature was + 23,22 °C \pm 0,03 °C. The 0,1 %RH value was measured in dry nitrogen flow which temperature was + 23,26 °C \pm 0,03 °C.</p>
References	<p>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.</p> <p>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/.</p>
Uncertainty	<p>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.</p> <ul style="list-style-type: none">- 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. <p>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.</p>

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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.

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

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

	Old coefficients	New coefficients	
RHI_0	+ 1,070000050E-01	+ 3,539999960E-01	[%RH]
RHI_1	- 2,229202750E-02	- 1,019702200E-01	
RHI_2	+ 5,389499660E-04	+ 3,217969890E-03	[%RH ⁻¹]
RHI_3	- 2,539999960E-06	- 2,227000000E-05	[%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	

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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		With new coefficients	
	Reading RHout [%RH]	Correction [%RH]	Reading RHout [%RH]	Correction [%RH]
0,10	0,04	+ 0,06	0,29	- 0,19
11,30	11,15	+ 0,15	10,82	+ 0,48
32,89	32,47	+ 0,42	32,30	+ 0,59
53,42	52,75	+ 0,67	53,38	+ 0,04
75,36	74,20	+ 1,16	75,27	+ 0,09
84,61	82,65	+ 1,96	83,54	+ 1,07
97,40	97,76	- 0,36	97,52	- 0,12
97,40	97,99	- 0,59	97,72	- 0,32
84,61	83,81	+ 0,80	84,65	- 0,04
75,36	74,39	+ 0,97	75,47	- 0,11
53,42	53,77	- 0,35	54,44	- 1,02
32,89	33,38	- 0,49	33,24	- 0,35
11,30	11,54	- 0,24	11,20	+ 0,10
0,10	0,05	+ 0,05	0,30	- 0,20

The correction shall be added algebraically to the reading.

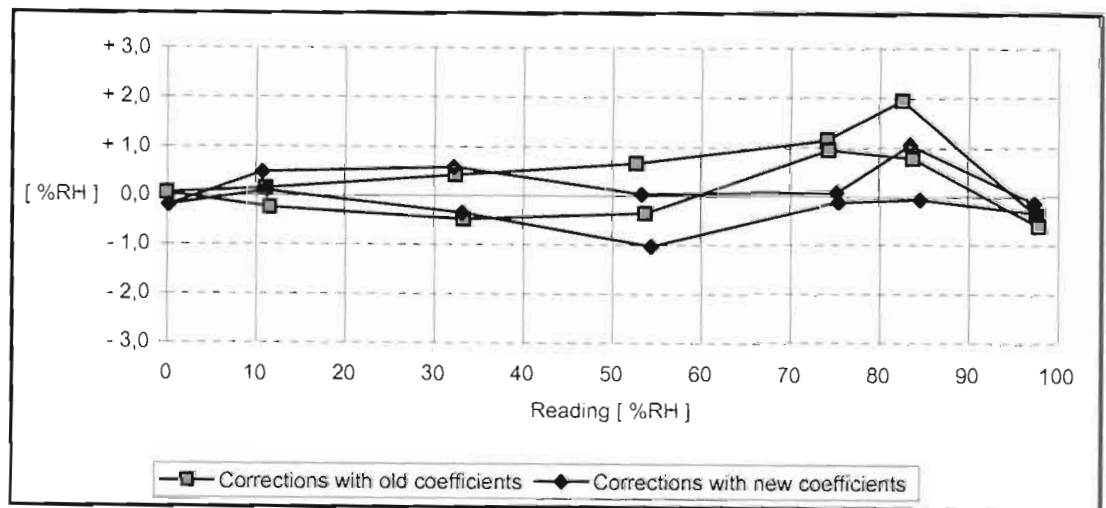


Figure 3. Measurement results

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Final results

The final humidity calibration results are averages of measured values.

Table 12. Final results, humidity

Reference [%RH]	With old coefficients		With new coefficients		Uncertainty [%RH]
	Reading RHout [%RH]	Correction [%RH]	Reading RHout [%RH]	Correction [%RH]	
0,1	0,0	+ 0,1	0,3	- 0,2	± 1,2
11,3	11,3	0,0	11,0	+ 0,3	± 1,3
32,9	32,9	0,0	32,8	+ 0,1	± 1,2
53,4	53,2	+ 0,2	53,9	- 0,5	± 1,3
75,4	74,3	+ 1,1	75,4	0,0	± 1,3
84,6	83,2	+ 1,4	84,1	+ 0,5	± 1,4
97,4	97,9	- 0,5	97,6	- 0,2	± 1,7

The correction shall be added algebraically to the reading.

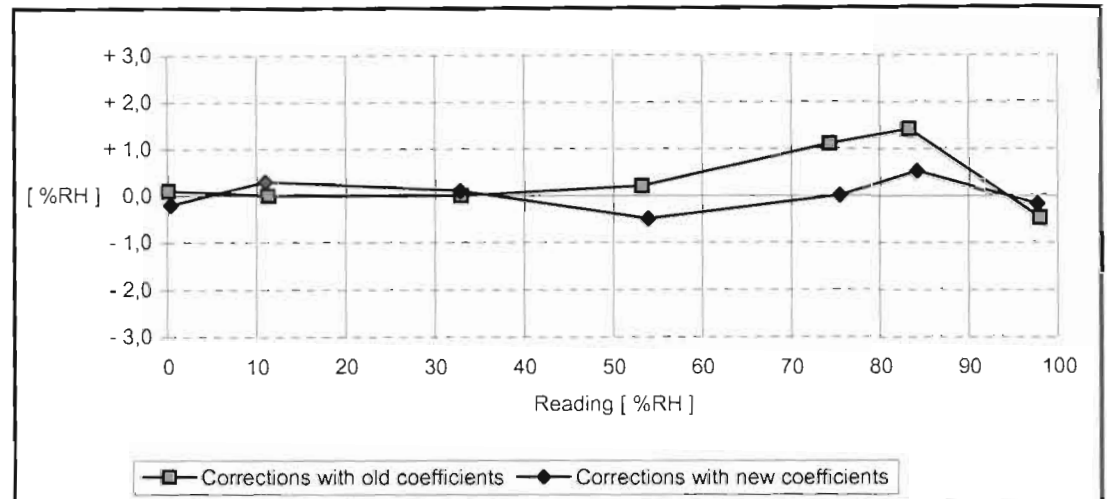


Figure 4. Final results

Conditions

Pressure 1009,4 °C ± 0,5 hPa
 Temperature + 23,8 °C ± 0,3 °C
 Humidity 36 %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

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Handled by
Scpc, Luigi
Forwarding agent

Service Report

Date
02-JUL-2010

Seller's reference
16600

Buyer's reference

Consignee
OREGON STATE UNIVERSITY
130 Burt Hall
Corvallis OR 97330
United States

Invoicing address(if not consignee)
Vaisala Inc.
Boulder Operations
194 South Taylor Ave.
Louisville CO 97330
United States

Pos	Description	Serial number	Quantity
14881	PTU300 Pressure, Humidity and Temperature Transmitter --NON CONFORMANCE DESCRIPTION FROM CUSTOMER-- Calibration. --NON CONFORMANCE CAUSE -- No fault found. --CORRECTIVE ACTION-- Operation tested, adjustments made and unit was calibrated. Calibration certificate number T01493.	C2610002	1