INSTRUMENT TEST REPORT NUMBER 657

ALMOS AWS MSI2 - Sensor Interface Card Testing

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24 November 1999

Authorisation

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8 Pages

1. AIM

An Almos Sensor Interface Card (MSI2 board) was tested for conformance to the existing Equipment Specification. The board was also tested for effects of ambient temperature on the temperature measurements, in particular, on the electronics used for temperature measurement. Effects of changes in impedance load to the sensor card were also tested.

The MSI2 board was intended by Almos to supersede the existing sensor interface card. The aim of this testing was to determine if the new MSI2 board was suitable for new installations or replacements of old cards in existing Automatic Weather Station (Almos AWS) systems.

2. BACKGROUND

Any electronics interface contributes to the uncertainty of an associated measurement. The magnitude of the uncertainty for the sensor with its electronic interface needs to be determined if a combined uncertainty for the measurement network is to be gauged. This combined uncertainty needs to be re-established whenever either the sensor or the electronic interface of this equipment changes.

The MSI2 board was tested to determine these new uncertainties in accordance with the specifications set down in A2672 equipment specification.

Further environmental testing was performed to determine the performance of the electronics under conditions of systematically varying temperature.

3. DESCRIPTION OF TESTS PERFORMED

3.1 Temperature Cycling Tests

The Almos Automatic Weather Station (Almos AWS) fitted with the MSI2 board was placed inside a climate chamber (Hereaus Vötsch HC 4030). A Rosemount Slimline RTD (S.No 363) was placed in the centre of the climate chamber to monitor climate chamber temperature.

Using decade box resistors (Serial No: 3312, 4585) a constant resistance was applied across each of the channels of the wet and dry bulb inputs of the MSI2 board. The decade box resistors were placed outside the climate chamber. The temperature outside the climate chamber was monitored with a Rosemount Slimline RTD (S.No. 474).

The ambient temperature in the climate chamber was cycled four times from -10°C to +55°C back to -10°C. Each complete cycle took approximately twenty-four hours.

The Almos AWS was configured to output diagnostic data, and 1-minute data for the duration of the test. Diagnostic data is the high-resolution data from the relative humidity (RH), dry bulb (DB) and wet bulb (WB) channels. These diagnostic data are used in the generation of all the message formats.

During each cycle the resistance across the temperature channel inputs remained fixed. To monitor the value and stability of the input resistance the decade box resistances were measured during the test using a Hewlett Packard Digital Multimeter. During the measurement of the decade box resistance the Almos AWS with the MSI2 board was not exposed to any ambient temperature change that was not part of the programmed cycle of temperature change.

3.2 Dry Bulb and Wet Bulb Temperature Channel Specifications

Decade box resistors were used to input the resistance in the wet and dry bulb temperature channels. The input resistances and resultant temperature outputs were measured across the measurement range of the Almos AWS. The temperature output was compared against the expected theoretical temperature and compared to the equipment specification.

Humidity Channel Specification

A Philips PM2813 programmable power supply was used to supply a 0-1 Volt signal to the humidity channel of the MSI2 board. The stability and accuracy of the power supply were measured with the Hewlett Packard Multimeter (SN 3457A).

Impedance Loading of the MSI2 board

The MSI2 board was tested with different configurations of input sensors across the range of temperature and humidity values to determine if the impedance load on the board affected the measurements of any of the RH, DB or WB channels.

3.3 Wind Speed Channel Specification

A frequency generator (HP 33120A SN US34017185) was used to input a range of frequencies corresponding to the range of frequencies accepted by the MSI2 boards anemometer channel. The input frequency was converted using the algorithm as specified in A2672 and compared to the 1second wind speed output of the Almos AWS. The output of the frequency generator was measured using a universal counter (HP53131A SN 3736A23981).

4. RESULTS AND DISCUSSION

4.1 Temperature Cycling Tests

At a 95% confidence level, the output of the Almos AWS did not show statistically significant variation dependent on the ambient temperature of the MSI2 board. Over the range there was no statistically significant correlation between the output of the temperature channels and the ambient temperature of the MSI2 board.

The 95% uncertainty in the average of the measurement of the entire temperature range was no greater than 0.0007°C[1]. This indicates a very small shift in the mean of the temperature recorded over the ambient temperature range compared to the total uncertainty of the instrument. This component of the uncertainty is derived from the data alone, no uncertainty of the test method is included in this value.

The total uncertainty for the Almos AWS, over the ambient temperature range, which includes the uncertainty of the test method, for 95% confidence interval was 0.02°C[2]

The ambient temperature of the Almos AWS MSI2 sensor interface card has an insignificant effect on the output for the wet and dry bulb temperature channels, over the ambient range of –10 to 55°C.

4.2 Dry Bulb and Wet Bulb Temperature Channel Specification

The α385 scale was used to convert input resistance values to expected temperature values. The accuracy of the output temperature at various resistances gives an indication of 1) how accurately the Almos AWS measures the input resistance, and 2) how precisely the applied equations are employed. The maximum resolution for the temperature is 0.0001°C in diagnostics mode.

The accuracy over an appropriate range of input resistances was measured. The correction and uncertainty for the dry bulb and wet bulb inputs are shown in the tables 1 & 2 below.

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[1] The uncertainty quoted here, is that of the temperature data component only. No other system uncertainty components are included. Coverage factor k = 1.96, v = 1425

[2] Where the coverage factor k, was 2.0 and the effective degrees of freedom ν_{eff} = 60.

Table 1 Dry Bulb Channel Results

Dry Bulb		
Nominal Resistance Ω	MSI2 Diagnostic Value (MDV)	Correction (Tα385 – MDV)
90.00	-25.47°C	0.02°C
100.00	-0.01°C	-0.00°C
105.00	12.81°C	0.00°C
110.00	25.67°C	-0.01°C
120.00	51.54°C	-0.01°C

Table 2 Wet Bulb Channel Results

Wet Bulb		
Nominal Resistance Ω	MSI2 Diagnostic Value (MDV)	Correction (Tα385 – MDV)
90.00	-25.50°C	0.03°C
100.07	0.19°C	-0.02°C
105.07	13.01°C	-0.01°C
110.08	25.87°C	-0.00°C
120.07	51.74°C	-0.03°C

The maximum uncertainty at the 95% confidence level for the corrections tabled in Tables 1&2 is 0.02°C, where the coverage factor k=2.6 and the effective degrees of freedom $\nu_{eff} = 10$.

The accuracy over the range of -10°C to +55°C meets the specification as laid out in Equipment Specification A2672 of ±0.05°C.

4.3 Dew Point and Relative Humidity Measurements Derived from Wet Bulb and Dry Bulb Measurements

Dry bulb and wet bulb measurements are used by the Almos AWS to calculate RH and dew point (DP). The Almos AWS RH and DP output messages were cross checked with the input and output temperatures, to determine if the correct algorithms were used in determining RH and DP values as specified by the data formats specification A2669.

The algorithms used in determining RH and DP depend on the pressure recorded by the Almos AWS if there is a pressure sensor attached, or by using a constant QFE of 998.3hPa as specified by the ‘Specification for Data Formats’ A2669. It appears that, for an Almos AWS sensor that does not have a height above mean sea level assigned and does not have a barometer attached to it, an incorrect pressure constant is applied to the algorithms. This incorrect pressure constant shifts the derived DP several degrees and the derived RH. This difference may not be immediately obvious for certain temperatures. The exact value of the incorrect pressure constant was not determined but was estimated to be 265hPa whereas the correct constant is a QFE of 998.3hPa.

The probability of an Almos AWS being installed without a pressure constant and without station details including station height above mean sea level may be small, however the source of this software bug must be located and corrected.

In addition to the above, the Almos AWS software assumes a DP equal to the dry bulb temperature when the wet bulb temperature is greater the dry bulb temperature. Furthermore, if the dry bulb temperature is less than zero, the Almos AWS reports the DP as equal to the dry bulb temperature. This is incorrect and not in accordance with the specification A2669. The policy for the format of the reported DP at temperatures close to and below zero needs to be reported.[3]

[3] It is understood that this software algorithm was being modified by Instruments and Engineering sub-section at the time this report was being finalised.

4.4 Humidity Channel Specification

The stability and accuracy of the humidity channel was tested. The correction for the voltage across the range of 0 to 1 Volt was within 0.1%RH. The corrections for the range are given below.

Table 3 Humidity Channel Results

ALMOS AWS Humidity Channel Input	
Nominal Volts	Correction (%RH)
0.05	-0.05
0.10	-0.05
0.20	-0.05
0.30	-0.03
0.40	-0.03
0.50	-0.01
0.60	-0.01
0.70	0.00
0.80	0.02
0.90	0.01
1.00	0.01

The maximum uncertainty (95% confidence level) was 0.003%RH, where coverage factor k=2.00, and effective degrees of freedom $\nu_{eff} = 60$.

The corrections for 0 to 1 Volt range are within the acceptable limits of uncertainty. The humidity channel meets the specification for direct measurement of a RH probe as specified in A2672.

4.5 Impedance Load Testing

Output uncertainty for temperature and relative humidity channels remained unchanged by the number of sensors attached to the instrument and the value of the inputs. For the normal specified operation range of the Almos AWS the DB, WB and RH channels are electronically isolated from one another. The attachment of wind sensors, TBRG's and lightning sensors was not tested in this evaluation as the primary scope was to determine the performance of the sensor card for temperature over a range of ambient temperatures of the MSI2 board itself.

4.6 Wind Speed Channel Performance

The MSI2 board meets the wind speed channel specification as stated in A2672. Across the valid frequency range and using the stated conversion formula[4] all values were either ±1knot or within ±1knot of the theoretical expected value of the input frequency. The results are shown in Figure 1.

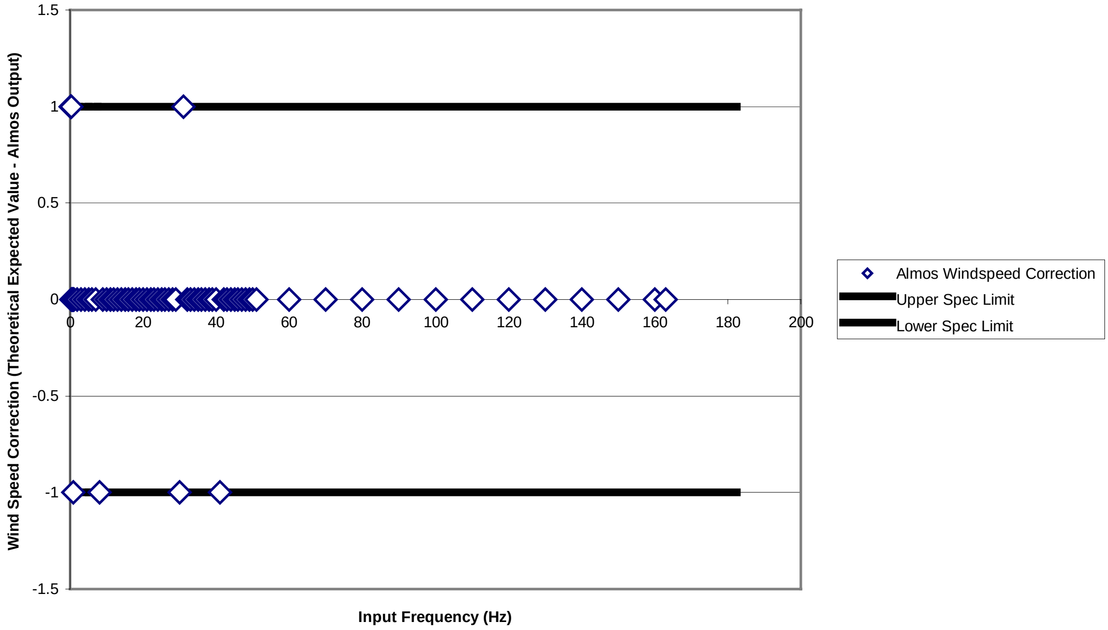

Figure 1 Almos Correction

[4] Stated conversion formula as found in Equipment Specification A2672.

5. FURTHER WORK PROPOSED

The sensor card electronics for existing and new type Almos AWS needs to be tested for effects of current loading of attached anemometers, lightning sensors and TBRG's.

A closer testing of the digital channels is also required but was not within the scope of this round of testing.

6. CONCLUSIONS

The MSI2 board performed well in the environmental cycling test, showing no significant dependence on the ambient temperature of the MSI2 board.

The temperature, relative humidity and wind speed channels met the A2672 equipment specification for those components tested.

Some software issues were identified and have been actioned. However this was not part of the scope of the sensor card accuracy testing.

The MSI2 board is an improvement on the performance of the existing MSI board. As a result the MSI2 board is approved for replacing the MSI boards and appropriate for new Almos AWS.

7. REFERENCES:

1. IEC 68-2-14 Basic Environmental Testing Procedures.
2. Equipment Specification A2672 (incorporating A2671) *Provision of an Automatic Weather Station Type II (Continuous Data Version) Version 4.1*
3. Equipment Specification A2669 *Digital Telemetry System Equipment Data Formats Document*
4. Cal Certificates DB99_001_C, DB99_003_C, TP98097, TP99050.
5. ISO Guide to Expression of Uncertainty in Measurement.