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Performance tests on Vaisala DTS-12A Temperature Sensors

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Authorisation

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Distribution
All RDs, ROMs, RESMs, CCSs
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SRSL, SRUM, BAPS, P. Morabito, R. Hibbins,
STCC, SRDS, SRCA, R Hutchinson.
STTR, J. Halford, CSR, LIB.
1. Introduction

Two Vaisala Platinum Resistance Thermometers (Part No. DTS-12A) were tested in the Physics Laboratory to determine if they met the Bureau of Meteorology’s requirements.

2. Tests Performed

2.1 Accuracy tests.

The probes were tested by completely immersing the sensor body in a silicon oil bath. The probes were connected to an Instrulab 4312 Temperature Measurement system (s/n 30,077), which performs the conversion from resistance to temperature using the International Practical Temperature Scale (IPTS-90). The Instrlab 4312 also recorded the temperature as measured by the Physics Lab working standard thermometer (s/n 947), which was used as the reference temperature. A second working standard thermometer was also recorded as a quality check (s/n 948). The temperature of the bath was varied over a range of -10°C to 60°C in 5°C steps.

2.2 Stem Correction - Tests for suitability as a wet bulb thermometer.

The probes were also investigated as to their suitability as wet bulb thermometers. In normal operation, the exposed metal portion of the probe is covered with a cloth wick. These tests simulated this by only immersing the probes in the silicon oil up to the end of the exposed metal section, as shown in Figure 1. The temperature of the bath was then varied over a temperature range of +60°C to –10°C in 10°C steps. At each temperature the temperature of the probe body varied according to the difference between the temperature of the oil and ambient air temperature. The ambient room temperature was 22°C however the air immediately above the oil is warmer or cooler, depending on the temperature of the oil. This results in a slight under estimate of the probe stem correction.

Figure 1    Probe and oil bath configuration.
2.3 *Response Time.*

The response time of the probes was measured by recording the time taken to reach 63% of a step change from ambient temperature to the oil bath at 60°C. It was then repeated for the change from 60°C to ambient in air. This gives both the response times in air and in stirred oil.

3.0 *Results*

3.1 *Accuracy tests.*

The results of the test of accuracy of the Vaisala probes are shown in Figure 2. It displays the difference between the Reference thermometer and the Vaisala temperature probes. A summary of the test results is shown in Table 1.

![Figure 2](image-url)  
*Figure 2*  
Plot of results of Vaisala DTS-12A Accuracy Tests.

![Table 1](image-url)  
*Table 1*  
Summary of Accuracy Tests

<table>
<thead>
<tr>
<th>Serial Number</th>
<th>R04413</th>
<th>R38308</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average bias °C</td>
<td>0.123</td>
<td>0.015</td>
</tr>
<tr>
<td>Standard Deviation °C</td>
<td>0.006</td>
<td>0.012</td>
</tr>
<tr>
<td>Number of samples</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>95% Confidence Interval</td>
<td>0.012</td>
<td>0.025</td>
</tr>
<tr>
<td>Max Error °C</td>
<td>0.139 (at –10°C)</td>
<td>0.042 (at –10°C)</td>
</tr>
</tbody>
</table>
3.2 Stem Correction Tests for suitability as a wet bulb thermometer.

The results of the stem correction tests are given in Figure 3. It displays the difference between the Reference thermometer and the temperature probes. A summary of the test results is shown in Table 2.

Figure 3  Plot of results of Stem Correction tests. The shaded bar indicates the range of temperatures relevant to field conditions.

Table 2  Summary of Stem Correction Tests

<table>
<thead>
<tr>
<th>Serial Number</th>
<th>R04413</th>
<th>R38308</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average bias °C</td>
<td>-0.002</td>
<td>-0.251</td>
</tr>
<tr>
<td>Standard Deviation °C</td>
<td>0.21</td>
<td>0.40</td>
</tr>
<tr>
<td>Number of samples</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>95% Confidence Interval °C</td>
<td>0.42</td>
<td>0.80</td>
</tr>
<tr>
<td>Max difference °C</td>
<td>-0.4 (at –10°C)</td>
<td>-1.21(at –10°C)</td>
</tr>
</tbody>
</table>
3.3 Response Time tests.

The response time test results are tabulated in Table 3, below.

Table 3  Response time of Vaisala probes and Bureau mercury in glass thermometers in both air and stirred oil.

<table>
<thead>
<tr>
<th>Response Time (Sec)</th>
<th>R04413</th>
<th>R38308</th>
<th>Hg Thermometer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stirred Oil</td>
<td>7</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Air</td>
<td>162</td>
<td>153</td>
<td>-</td>
</tr>
</tbody>
</table>

4. Discussion of Results

The accuracy tests of the probes tested showed that one probe had a significant bias, 0.123 degrees low. For operational purposes, this probe is not acceptable for use in the Bureau network because the accuracy is outside acceptable limits. However, the standard deviation of the results for both probes indicates that the precision of both is acceptable.

The data from the stem correction tests demonstrate that at temperatures less than ambient the probes have a significant stem correction error. At temperatures above ambient the error is less, however this region does not correspond to the physical situation in a temperature screen, where the wet bulb is always less than or equal to the dry bulb temperature. This region is marked as a shaded area on Figure 3.

The stem correction error is a result of the design of the probe. The probe has only the bottom 15% covered by the wick. This means in low relative humidity conditions the upper portion of the probe is acting as a heat source, causing the probe to measure higher temperatures and therefore higher relative humidities by between 3 and 10%RH (non-ventilated). This effect is similar to that seen on the older bulky “Canon Connector” style RTD probes used by the Bureau, which was one of the reasons the RTD probe design was changed to the “slimline” style.

The response time tests on the probes showed that the probes had a very fast response time in the stirred oil (Approx. 6 seconds for both). This is approximately twice as fast as current Bureau temperature probe (12 to 15 sec) and the standard mercury in glass thermometer (9 to 11 sec).

5. Conclusion

The DTS-12a probes display good precision but poor reproducibility of the accuracy of the probes. Each probe would need to be tested because of the possibility of a significantly different temperature offset in each probe (as seen in probe s/n R04413).

The DTS-12a probes are unsuitable for use in psychometric measurement systems as a wet bulb sensor. This is because a wet bulb wick does not cover the entire body of the probe, and as a result produces unacceptable errors in the wet bulb temperature.
The faster response times of these probes is likely to cause a small increase in the maximum and minimum temperatures read by an automatic weather station fitted with these probes, compared to the standard sensors.

6. Recommendation

As,

1) the response time of the probes does not meet Bureau requirements;
2) the accuracy of the sensors is inconsistent; and
3) the probes are not suitable for use as wet bulb sensors

These sensors are therefore not recommended for installation in Australian Bureau of Meteorology observation network.