TERM PAPER

ON

STEVENSON SCREEN
(GROUP F)

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CHAPTER ONE

1.0.0 INTRODUCTION

Current day concerns about enhanced greenhouse warming and the impact of changes in climate, has given rise to question about the accuracy of data used to identify to the expected rises in temperature. Measurements of temperature to the uncertainty equired for identifying enhanced greenhouse warming are by no means simple.

Aside from effects such as urbanization, the uncertainty of temperature measurements is affected by a variety of factors. These include the accuracy of the temperature sensor, the time constant of the sensor, the enclosure used to house the sensor, suitability of the sensor to the screen (Richardson and Brock 1995) and the representatives of the site. To measure atmospheric temperature accurately the temperature sensor must be shielded from both direct and indirect sources of radiation. To achieve this there have been many different designs of temperature screen manufactured over the past century. Designs have varied from small buildings through multi-louvered boxes to aspirated shields that draw the air over the sensing element. Most countries have for the past fifty years used a wooden screen approximately 70cm wide, 50cm deep and 70cm high with double louvered sides, a double skin top and three overlapping plates to form the base. This design is called a STEVENSON SCREEN.

This design of screen has remained basically unchanged since the turn of the century and has provided a continuous reference. It has been recognised since the early part of the century (Koppen 1913) that the Stevenson screen impacts significantly on the temperature measured. Its large thermal mass results in a large thermal lag and as a consequence underestimates the maximum and minimum temperature. Despite this it remains a useful screen.

1.2.0 DEFINITION OF TERMS.

A weather station is a facility with instrument to make weather observation manually or electronically/digitally, when reading are taken automatically in a weather station, it is called an AUTOMATED WEATHER STATION.

Typical weather stations have the following instruments;

- Thermometer for measuring temperature
- Barometer for measuring pressure
- Hygrometer for measuring humidity
- Anemometer for measuring wind speed
- Wind vane for measuring wind direction
- Rain gauge for measuring precipitation
- Dynamometer for measuring solar radiation
- Sun dial for measuring direction of sun.

1.3.0 RESEARCH METHODOLOGY.
The approach for accessing data information for this term paper is in two folds;
- The primary data and
- The secondary data.

- **The primary data:** This is the documentation of fact, figures, tables from the weather station located in Obakekere, through interview, opinionaire and observation. These are to serve as a background information on the state of the station and the details concerning Stevenson screen i.e. concerning it’s origin, usage, component, and the present state. Also the information gathered will also serve as a weighing pan for the weather of Federal University of Technology, Akure and its environs, as a school of technology, the station ought to be a tool for researchers in the state for proper weather forecast.

- **The secondary data:** These are information gathered from other sources which is not directly from the weather station. Literature review, use of the electronic library.

1.4.0 LIMITATIONS
Stepping stones and rock of offences encountered during the documentation of this term paper were not easy to sub-mantle. There were restrictions from the Federal University of Technology, Akure Meteorological department to give out helping hand, as we were treated like children of a lesser God when we made an approach to gather our primary data. Till the end of this successful term paper, they remained Adamant and blunt and unrepentant. This is however, an unfortunate development which is equally a slap to the Meteorological department of the Federal University of Technology, Akure on their fundamental existence and more importantly in an academical environment.
CHAPTER TWO

2.0.0 STEVENSON SCREEN

A Stevenson screen or Instrument shelter is a meteorological screen to shield instruments against precipitation and direct heat radiation from outside sources, while still allowing air to circulate freely around them. It forms part of a standard weather station. The screen creates, as near possible, a uniform environment in relation to the air outside. The Stevenson screen is usually designed to hold various instruments including thermometers (ordinary, maximum and minimum), a hygrometer, a dewcell, a psychrometer, a barometer and a thermograph. Stevenson screens may also be known as a cotton region shelter, an instrument shelter, a thermometer shelter, a thermostream or a thermometer screen. The use of a standard screen allows temperatures to be compared accurately with those measured in earlier years and at different places.

2.0.1 History

Thermometers (and sometimes other instruments) are housed in a white, louvered box called the Stevenson Screen. The father of Robert Louis Stevenson designed and invented it. The louvred sides and door enable a stable airflow over the thermometers. It was designed by Thomas Stevenson (1818-1887), a British civil engineer and father of the author Robert Louis Stevenson.

In order to prevent direct sunlight falling on and affecting the instruments when the door is opened it is designed so that the door opens to the north in the northern hemisphere. This is because the Sun never shines from the north.

It is painted white to reflect incoming radiation from the Sun and is set at a height of 1.25 metres above the ground, so as not to be affected by the Earth's low-level radiation. The screen should be kept clean from dust and dirt.

The thermometers inside are usually the dry bulb, wet bulb, maximum and minimum. They are read in that order.

The dry thermometer is a mercury filled thermometer, recording changes in temperature in degrees and tenths Centigrade. The temperature rises and falls as the temperature changes. This is the air temperature reported on TV and in the press. The wet bulb is an ordinary thermometer with a muslin wick covering the bulb. This is fed by water from an adjacent
reservoir. The comparison between the dry and the wet bulb temperatures enables the DEW POINT and relative humidity of the air to be calculated.

The maximum thermometer is filled with mercury, which moves up the central tube as the temperature increases. There is a constriction just above the bulb of the thermometer, which stops the mercury returning to the bulb when the temperature falls. Therefore, the highest temperature (the max) is recorded regardless of the temperature at the observation.

2.0.2 Composition
The traditional Stevenson screen is a box shape, constructed of wood, in a double-louvered design. However, it is possible to construct a screen using other materials and shapes. The World Meteorological Organization (WMO) agreed standard for the height of the thermometers is between 1.25 m (4 ft 1 in) and 2 m (6 ft 7 in) above the ground.

The standard housing for meteorological thermometers designed by Thomas Stevenson, civil engineer (father of Robert Louis Stevenson). It consists of a wooden cupboard, with hinged door, mounted on a steel or timber stand, so that its base is about 3 ft 6 in. above the ground, the whole painted white. Indirect ventilation is provided through the bottom, double roof and louvered sides, and instruments placed within it give a close approximation to the true air conditions, undisturbed by the effects of direct solar or terrestrial radiation

Equipment Inside (mounted on wood and attached to back wall):

- Thermometer
- Hygrometer
- Barometer

2.0.3 Size
The interior size of the screen will depend on the number of instruments that are to be used. A single screen may measure 765 mm high by 610 mm wide by 593 mm deep (30.1 in by 24.0 in by 23.3 in) and a double screen 765 mm high by 1050 mm wide x 593 mm deep (30.1 in by 41.3 in by 23.3 in). The unit may be mounted on a wooden stand or a metal pipe.

The top of the screen was originally comprised of two asbestos boards with an air space between them. These asbestos boards have generally been replaced by a laminate due to
health and safety reasons. The whole screen is painted with several coats of white paint to reflect radiation and will usually require repainting every two years.

Figure 2.1 Back of Stevenson Screen prototype constructed by Brian Burley.

Figure 2.2 Bottom of Stevenson Screen prototype constructed by Brian Burley.
Figure 2.3  Front Door of Stevenson Screen prototype constructed by Brian Burley.

Figure 2.4  Louvered detail and Roof of Stevenson Screen prototype constructed by Brian Burley
2.0.4 Sitting
The sitting of the screen is very important to minimise the effects of buildings and trees. Environment Canada for example recommends that the screen be placed at least twice the distance of the height of the object (e.g. 20 m from any tree that is 10 m high, or 40 ft from one 20 ft high). In the northern hemisphere, the door of the screen should always face north so as to prevent direct sunlight on the thermometers. However, in Polar regions with twenty-four hour sunlight the observer must take care to shield the thermometers from the sun and at the same time avoiding a rise in temperature being caused by the observers body heat.

A special type of Stevenson screen with an eye on the roof is designed to be used on ship. The unit is hung from the ceiling and remains vertical despite the movement of the vessel.

2.1.0 STEVENSON SCREEN
To improve our understanding of the influence of temperature screens on temperature measurements a comparison of ten different screens was establish at the Bureau of Meteorology’s field test site at Broadmeadows. The study has run continuously since December 1994. Each screen is equipped with a platinum resistance thermometer with an uncertainty of less than 0.06°C and a time constant of 18s. An Instrulab 4212 is used to measure the resistance of each temperature sensor every 12s. The average and sample standard deviation for each minute are calculated and stored. In addition to this the wind speed, wind direction, pressure and rainfall from a nearby automatic weather station and the global irradiance from a pyranometer are logged.

The study includes both aspirated and non-aspirated thermometer screens. Initially it consisted of a small Stevenson Screen, five beehive type screens and three aspirated screens. All except one of the aspirated screens were commercially available. Table 2.1 shows the types of screens used and their basic construction. In October 1995 a large Stevenson screen was added to the comparison and in December 1995 the Monitor, Steedman and Lambrecht screens were removed. They were replaced with three sensors at different locations in the small Stevenson screen. Two Vaisala screens were used in the study; one that was new and another that had been in use in the field for two years. The Steedman screen is similar to the Lambrecht in design except it is constructed of plastic and is smaller in diameter; 12cm compared to 16cm. The BMRC screen was designed and built in the Bureau of Meteorology Research Centre for use in the tropics. It has a double skin and two shades one just below the
fan and a smaller one 20cm lower just above the intake. The intake has an inverted cone to minimise collection of water. (Keenan 1998).

Table 2.1 Description of the screens used in this study. The columns in order from left to right are the manufacturer or design of screen, the type of screen, size, the effective internal height of the screen, the diameter, number of louvers or plates, the approximate volume to surface area ratio for the screen, the colour and the material it is manufactured from.

<table>
<thead>
<tr>
<th>Screen</th>
<th>Type</th>
<th>Size</th>
<th>Effect. Height (cm)</th>
<th>Diameter (cm)</th>
<th>No. of Plates</th>
<th>Volume/Area (m)</th>
<th>Color</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stevenson</td>
<td>Louvered</td>
<td>Medium</td>
<td>43</td>
<td>52*27</td>
<td>12</td>
<td>0.058</td>
<td>White</td>
<td>Wood</td>
</tr>
<tr>
<td>Stevenson</td>
<td>Louvered</td>
<td>Large</td>
<td>71</td>
<td>71*53</td>
<td>20</td>
<td>0.046</td>
<td>White</td>
<td>Wood</td>
</tr>
<tr>
<td>Vaisala</td>
<td>Beehive</td>
<td>Medium</td>
<td>26</td>
<td>19</td>
<td>12</td>
<td>0.038</td>
<td>White</td>
<td>Fibre Glass</td>
</tr>
<tr>
<td>Merlin</td>
<td>Beehive</td>
<td>Large</td>
<td>36</td>
<td>24</td>
<td>15</td>
<td>0.047</td>
<td>White</td>
<td>Fibre Glass</td>
</tr>
<tr>
<td>Monitor</td>
<td>Beehive</td>
<td>Large</td>
<td>30</td>
<td>26</td>
<td>8</td>
<td>0.052</td>
<td>White / Black</td>
<td>Metal</td>
</tr>
<tr>
<td>Steedman</td>
<td>Beehive</td>
<td>Small</td>
<td>27</td>
<td>12</td>
<td>19</td>
<td>0.020</td>
<td>White</td>
<td>Plastic</td>
</tr>
<tr>
<td>Lambrecht</td>
<td>Beehive</td>
<td>Small</td>
<td>30</td>
<td>16</td>
<td>7</td>
<td>0.052</td>
<td>Grey / Black</td>
<td>Metal</td>
</tr>
<tr>
<td>Teledyne</td>
<td>Aspirated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>White</td>
<td>Metal/Plastic</td>
</tr>
<tr>
<td>Vector</td>
<td>Aspirated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>White</td>
<td>Metal/Plastic</td>
</tr>
<tr>
<td>BMRC</td>
<td>Aspirated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>White</td>
<td>Metal/Plastic</td>
</tr>
</tbody>
</table>

2.2.0 RESULTS AND DISCUSSION

The Bureau of Meteorology commonly uses the average of the maximum and minimum temperatures as an estimate of the average temperature. This estimate of average temperature has been used to determine the difference in performance of the screens studied. Table 2.2 and Figure 2.5 show the difference between the average temperature as measured in the small Stevenson screen (or reference screen) and the other screens. Data collected for the period December 1994 to November 1996 was used to create the plot. From this graph it is clear that the larger fibre glass beehive screens (Vaisala and Merlin) and two of the aspirated screens (Teledyne and Vector) do not differ greatly from the reference screen. However the small beehive screens (Lambrecht and Steedman) and the larger metal beehive screen (Monitor) produced average temperatures 0.07 to 0.19°C warmer than the reference screen. The BMRC screen results in temperatures 0.08°C cooler on average.
Table 2.2  The difference in the average temperature as estimated from the average monthly maximum and minimum temperatures compared to a small Stevenson screen.

<table>
<thead>
<tr>
<th></th>
<th>Average Max Diff (°C)</th>
<th>Average Min Diff (°C)</th>
<th>Average Ave Diff (°C)</th>
<th>U95 Ave (°C)</th>
<th>Skew</th>
<th># of Months</th>
<th>Range of Ave. (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aspirated</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teledyne</td>
<td>-0.250</td>
<td>0.236</td>
<td>-0.007</td>
<td>0.028</td>
<td>-1.011</td>
<td>24</td>
<td>-0.316</td>
</tr>
<tr>
<td>Vector</td>
<td>-0.095</td>
<td>0.098</td>
<td>0.002</td>
<td>0.039</td>
<td>-0.300</td>
<td>24</td>
<td>-0.407</td>
</tr>
<tr>
<td>BMRC</td>
<td>-0.052</td>
<td>0.204</td>
<td>0.076</td>
<td>0.041</td>
<td>-0.672</td>
<td>24</td>
<td>-0.372</td>
</tr>
<tr>
<td><strong>Beehive</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitor</td>
<td>-0.209</td>
<td>0.068</td>
<td>-0.070</td>
<td>0.029</td>
<td>-1.237</td>
<td>13</td>
<td>-0.180</td>
</tr>
<tr>
<td>Lambrecht</td>
<td>-0.537</td>
<td>0.150</td>
<td>-0.194</td>
<td>0.034</td>
<td>-0.179</td>
<td>13</td>
<td>-0.173</td>
</tr>
<tr>
<td>Vaisala New</td>
<td>-0.081</td>
<td>0.064</td>
<td>-0.009</td>
<td>0.018</td>
<td>-0.196</td>
<td>24</td>
<td>-0.185</td>
</tr>
<tr>
<td>Vaisala Old</td>
<td>-0.083</td>
<td>0.066</td>
<td>-0.009</td>
<td>0.017</td>
<td>-0.777</td>
<td>24</td>
<td>-0.177</td>
</tr>
<tr>
<td>Merlin</td>
<td>-0.020</td>
<td>0.041</td>
<td>0.011</td>
<td>0.020</td>
<td>-0.135</td>
<td>24</td>
<td>-0.188</td>
</tr>
<tr>
<td>Steedman</td>
<td>-0.295</td>
<td>0.042</td>
<td>-0.127</td>
<td>0.043</td>
<td>-1.343</td>
<td>13</td>
<td>-0.254</td>
</tr>
<tr>
<td><strong>Louvered</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large Stev’s</td>
<td>0.094</td>
<td>-0.082</td>
<td>0.006</td>
<td>0.015</td>
<td>-0.632</td>
<td>14</td>
<td>-0.105</td>
</tr>
<tr>
<td>Small Stev’s C</td>
<td>-0.015</td>
<td>-0.003</td>
<td>-0.009</td>
<td>0.009</td>
<td>-1.983</td>
<td>11</td>
<td>-0.048</td>
</tr>
<tr>
<td>Small Stev’s D</td>
<td>0.018</td>
<td>-0.016</td>
<td>0.001</td>
<td>0.014</td>
<td>-0.469</td>
<td>11</td>
<td>-0.075</td>
</tr>
<tr>
<td>Small Stev’s E</td>
<td>-0.014</td>
<td>0.002</td>
<td>-0.006</td>
<td>0.018</td>
<td>-0.520</td>
<td>11</td>
<td>-0.091</td>
</tr>
<tr>
<td>Small Stev’s B (Ord)</td>
<td>0.101</td>
<td>-0.054</td>
<td>0.024</td>
<td>0.017</td>
<td>2.246</td>
<td>24</td>
<td>-0.194</td>
</tr>
<tr>
<td>Small Stev’s A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 2.5** The average difference between the temperature in the small Stevenson screen and all other measurements of temperature. (See Table 2.2)
Table 2.3 Response time of screens to a 25°C step change in temperature.

<table>
<thead>
<tr>
<th>Screen Type</th>
<th>Response Time (h:mm:ss)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Stevenson</td>
<td>00:03:5</td>
</tr>
<tr>
<td>Small Stevenson (Old)</td>
<td>00:04:1</td>
</tr>
<tr>
<td>Large Stevenson</td>
<td>00:03:7</td>
</tr>
<tr>
<td>Vaisala New</td>
<td>00:02:8</td>
</tr>
<tr>
<td>Vaisala Old</td>
<td>00:02:6</td>
</tr>
<tr>
<td>Merlin</td>
<td>00:02:7</td>
</tr>
<tr>
<td>Teledyne</td>
<td>00:03:5</td>
</tr>
<tr>
<td>Vector</td>
<td>00:02:8</td>
</tr>
<tr>
<td>BMRC</td>
<td>00:02:4</td>
</tr>
</tbody>
</table>

The large thermal mass of the wooden screens slows their response to changes in temperature. Table 2.3 is an estimate of the response time of some of the sensor screens combinations used in this study. They were determined by examining the change in temperature over a short period during passage of a cold front. The temperature dropped from a high of 36.7°C to a low of 21.7°C in a matter of a few minutes. For the sake of this exercise it was assumed that the drop in temperature was more rapid than the response of the screens. The uncertainty of the relative response times is ± 0.5s. From this data it can be seen that all screens excepting the large Stevenson and Teledyne had response times significantly less than the small Stevenson screen. This correlates well with the observation that only the large Stevenson and Teledyne...
CONCLUSIONS
The effects of radiant exchange on thermometer readings of air temperature were recognized over 150 years ago, and eventually led to the design of the Stevenson screen in 1864. This white wooden cupboard has since become the standard instrument screen, whereby indirect ventilation is provided through the bottom, double roof and louvered sides, and thermometers placed within it give a close approximation to the true air temperature, undisturbed by the effects of direct solar or terrestrial radiation. However, the Stevenson screen is unsuitable for many applications: It is too bulky to be portable; it is too large for measurements in confined spaces; it is too obtrusive to be installed in locations accessible to the public; it may be considered too expensive when a large number of screens is required for simultaneous measurements in different locations; and it does not give full protection from radiant exchange.

Determination of a screen that allows accurate measurement of temperature is very difficult. All screens by their very presence impact on the measurement of temperature.
APPENDIX

Figure A: Side View SC. EMU
Figure B: Interior View SC. EMU
Figure C: Louvered Panel SC. EMU
Figure D: Side View SC. FUTA
Figure E: Opened SC. FUTA
Figure F: Interior View SC. FUTA
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