THE EFFECT OF THERMOMETER SCREEN DESIGN ON THE OBSERVED TEMPERATURE

by

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FOREWORD

The fact that a thermometer screen creates its own micro-environment has been realized since temperature measurements were first taken on a systematic basis. The magnitude of the effects of the screen and screen design have thus been studied by investigators in many parts of the world.

Mr. W. R. Sparks has reviewed a large number of published studies to identify the aspects of thermometer screen design, exposure and use that affect the temperature measured inside the screen. In addition he has compiled an extensive bibliography and completed a survey of the types of thermometer screens currently used by meteorological services.

I believe that the present report will be welcomed as a very thorough review of this subject and it gives me great pleasure to extend my appreciation, on behalf of the WMO, to Mr. Sparks for the time and effort he has put into its preparation.

D. A. Davies
Secretary-General
SUMMARY

The author has stated that the purpose of this publication is to identify, through a review of existing literature, those aspects of thermometer screen design, exposure and use that affect the temperature measured in a screen. In carrying out this comprehensive review he has referred to a large number of published studies, the earliest dating back to 1869, the most recent being published in 1969. They include comparisons made on board ships at sea as well as at land stations, in equatorial and polar regions as well as in temperate zones.

In sections 1 and 2, Mr. Sparks outlines the scope of his study and discusses the WMO standards for temperature measurement. He points out that differences in measurement due to differences in screen height may occur even though heights are within the range specified in WMO publications.

Sections 3, 4 and 5 deal with comparisons of "identical instruments" and discuss the characteristics of forced ventilated screens in comparison with the traditional naturally ventilated screens.

Section 6 contains a review of the various types of thermometer screens which have evolved in the course of time through attempts to improve performance and reduce weight and costs of construction. The performance of the tropical screen is discussed and compared with the standard wooden Stevenson screen. Other types of screens of various sizes and materials are also described.

Section 7 examines the factors affecting temperatures measured in screens, such as colour, exposure, thermal inertia and temperature distribution within a screen.

Section 8 summarizes the essential features of a well-designed screen and section 9 contains recommendations for further work.

A comprehensive list of reference publications is given in sections 10 and 11. The Annex contains descriptions of thermometer screens in current use in various countries.
Cette publication, comme l'indique son auteur, a pour but de déterminer, par une analyse des travaux publiés sur cette question, les aspects de la conception, de l'exposition et de l'utilisation de l'abri météorologique qui exercent une influence sur la température mesurée sous abri. Pour mener à bien cette analyse approfondie du problème, l'auteur s'est référé à un grand nombre d'études publiées dont les plus anciennes remontent à 1869, tandis que les plus récentes furent publiées en 1969. Parmi ces études figuraient notamment des comparaisons faites à bord de navires en mer et à des stations terrestres, dans des régions équatoriales et polaires, aussi bien que dans des zones tempérées.

Dans les sections 1 et 2, M. Spurks définit la portée de son étude et examine les normes établies par l'OMM pour mesurer la température. Il fait remarquer que des différences de mesures peuvent se produire du fait de différences dans la hauteur de l'abri, même si cette hauteur est comprise dans la gamme de valeurs prescrites dans les publications de l'O MM.

Les sections 3, 4 et 5 traitent des comparaisons "d'instruments identiques" et examinent les caractéristiques des abris à ventilation forcée par rapport à celles des abris classiques à ventilation naturelle.

La section 6 passe en revue les divers modèles d'abris météorologiques que les spécialistes ont mis au point au cours des années en s'efforçant d'améliorer les performances des abris, d'en réduire le poids et le coût de construction. L'auteur compare les performances de l'abri tropical à celles du traditionnel abri Stevenson en bois. Il décrit également d'autres types d'abris, de toitures et de conceptions diverses.

La section 7 est consacrée aux facteurs qui exercent une influence sur les températures relevées sous abri : couleur, exposition, inertie thermique et distribution des températures dans l'abri.

La section 8 résume les caractéristiques essentielles d'un abri bien conçu, tandis que la section 9 contient des recommandations concernant les travaux à entreprendre dans ce domaine.

Les sections 10 et 11 contiennent une liste bibliographique bien fournie et l'annexe comporte des descriptions d'abris météorologiques utilisés dans les divers pays.
РЕЗЮМЕ

Автор указал, что цель этой публикации является определение, путем рассмотрения существующей литературы, тех аспектов конструкция термометрической будки, ее экспозиции и использования, которые влияют на температуру, измеряемую в будке. При осуществлении своего обзора он ссылается на большое количество опубликованных исследований, самое раннее из которых относится к 1869 г., а самое позднее было опубликовано в 1969 г. Эти работы касаются сравнений, проводившихся на борту судов в море, а также на наземных станциях, в экваториальных и полярных районах, а также в умеренных зонах.

В разделах 1 и 2 Спаркс делает масштабы своего изучения и рассматривает стандарты IMO по измерению температуры. Он отмечает, что рассхождения в измерениях в связи с различными в высоте будок могут наблюдать даже в тех случаях, когда высоты не выходят за пределы, установленные в публикациях IMO.

В разделах 3, 4 и 5 рассматриваются сравнения "идентичных приборов" и характеристики будок с искусственной вентиляцией по сравнению с традиционными будками с естественной вентиляцией.

В разделе 6 рассматриваются различные типы термометрических будок, при конструировании которых делались попытки усовершенствовать их характеристики и сократить их вес и стоимость производства. Тропическая будка обсуждается и сравнивается со стандартной деревянной будкой Стикемсона. Также описываются другие типы будок различных размеров и сделанные из различных материалов.

В разделе 7 рассматриваются факторы, влияющие на температуру в будках, такие факторы, как цвет, экспозиция, тепловая инерция и распределение температуры в будке.

В разделе 8 обобщаются важные характеристики будки хорошей конструкции, а в разделе 9 содержатся рекомендации относительно дальнейшей работы.

Ичерпывающий список публикаций для описок приводится в разделах 10 и 11. В приложении содержится описание термометрических будок, которые в настоящее время используются в различных странах.
RESUMEN

El autor manifiesta que el objeto de esta publicación es determinar, mediante el estudio de los textos actualmente disponibles, los efectos que ejercen las garritas termométricas, así como la instalación y utilización del termómetro, en los valores de temperatura medidos dentro de dichas garritas. Para realizar este completo estudio, el Sr. Sparks hace referencia a numerosas publicaciones, en la más antigua de las cuales se expone un trabajo realizado en 1869, y la más reciente de las mismas data de 1969. En estos estudios se resaltan comparaciones efectuadas en el mar a bordo de buques, así como en las estaciones terrestres, en las regiones ecuatoriales, polares y templadas.

En las Secciones 1 y 2, el Sr. Sparks explica el alcance de su estudio y expone las normas que la OMM ha fijado para la medida de la temperatura. Indica que pueden producirse diferencias de medida con motivo de las distintas alturas de la garita incluso cuando éstas cumplen los requisitos especificados en las publicaciones de la OMM.

Las Secciones 3, 4 y 5 tratan de las comparaciones de "instrumentos idénticos" y en ellas se especifican las características de las garritas de ventilación forzada, en comparación con las garritas tradicionales de ventilación natural.

En la Sección 6 se hace un estudio de los distintos tipos de garritas termométricas y de la evolución que han experimentado a través de los años, con objeto de perfeccionar su funcionamiento y reducir su peso y gastos de construcción. Se estuda también el funcionamiento de la garita tropical en comparación con la garita normalizada de Stevenson. También se describen otros tipos de garritas de distintos tamaños construidas con diferentes materiales.

La Sección 7 trata de los factores que afectan a la medida de las temperaturas en las garritas, tal como el color, orientación, inercia térmica y distribución de la temperatura dentro de la garita.

En la Sección 8 se resumen las características esenciales que ha de reunir una garita bien diseñada y en la Sección 9 se formulan recomendaciones destinadas a los futuros trabajos que se realicen en esta materia.

Las Secciones 10 y 11 contienen una lista de publicaciones de referencia y en el anexo figuran descripciones de las garritas termométricas que actualmente se utilizan en distintos países.
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1. Introduction

The main aim of this report is to identify, through a review of the existing literature, those aspects of thermometer screen design, exposure and use that affect the temperature measured in a screen.

It will be seen from the references that the literature on this subject is extensive; it would make the text of this report almost unreadable if reference were made to every paper lending support to each hypothesis. I have, therefore, followed a course of quoting only sufficient references to substantiate a conclusion, but where contrary evidence has been traced it is always referred to. When further data are required on a topic, the effect of colour or material for example, use may be made of the subject guide in section 10, which shows that references G3, G5, NL and T1 contain information on that subject.

2. Implications of the present WMO Technical Regulations on the measurement of air temperature

The present Technical Regulations (WMO - No. 49.BD.2/3) permit temperature observations to be made with the thermometers at any level between 1.25 m and 2 m above the ground and at any time within 10 minutes before the nominal time of observation.

The effect of screen height has been investigated by a number of workers and all give consistent results. Hellmann (1922) compared two identical screens in Potsdam exposed 2.3 m apart, one with the thermometer bulb at 2.08 m and the other with the thermometer at 1.4 m above the ground. The maximum temperature was generally higher, and the minimum lower, in the lower screen. The largest monthly mean difference in the maximum was 0.4°C in May and the largest individual difference was 0.8°C also in May. The largest monthly mean difference in the minimum temperature was 0.28°C in July and the largest individual difference was 0.7°C in March. The amplitude of the diurnal temperature change was generally larger in the lower screen. The minimum difference in the monthly mean amplitude was 0.09°C in November and the maximum 0.66°C in May and July.

Ramanathan (1929) describes the comparison of temperatures in screens at 1.5 m and 1.85 m at Agra. Again the maximum temperature in the lower screen was generally higher but the largest monthly mean difference was only 0.17°C, in June. Differences of 0.44°C or more occurred on about 3.6 per cent of occasions. The minimum temperature showed more difference, with the lower screen giving the lower temperature. The largest monthly difference was 0.44°C in November and differences of 0.61°C or more occurred on 5.1 per cent of occasions. No differences of more than 0.9°C occurred.
### TABLE 1

**The effect of screen height on temperature measurements**

<table>
<thead>
<tr>
<th>Observer</th>
<th>Location</th>
<th>Height of upper screen metres</th>
<th>Height of lower screen metres</th>
<th>Largest monthly mean difference</th>
<th>Largest individual difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Maximum °C Month</td>
<td>Minimum °C Month</td>
</tr>
<tr>
<td>Hellman</td>
<td>Potsdam</td>
<td>2.08</td>
<td>1.40</td>
<td>0.40 May</td>
<td>0.28 May</td>
</tr>
<tr>
<td>Ramanathan</td>
<td>Agra</td>
<td>1.85</td>
<td>1.25</td>
<td>0.17 June</td>
<td>0.44 November</td>
</tr>
<tr>
<td>Nawa</td>
<td>Obanazawa</td>
<td>2.5 Variable 1.0 above snow surface</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Variable 1.0 above snow surface</td>
<td>1.0</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
During two winters at Obanazwa, Nova (1965) compared screens with their bottoms 1.0 m and 2.5 m above the ground with a special shelter that could be adjusted to keep it 1.0 m above the snow surface. Over the period for which the results are given, the depth of snow varied from 30 cm to 150 cm. He found that the higher screen was in much better agreement with the adjustable screen. The maximum temperature in the lower screen differed by more than 0.6°C from that in the adjustable screen on about 20 per cent of occasions, while that in the higher screen differed by the same amount on only 3 per cent of occasions. The minimum temperature in the lower screen was considerably lower than that in the adjustable screen; the largest difference was 2.0°C and (estimating from the published graph) about 9% of the differences were greater than 1.0°C. The differences decreased with increasing wind speed.

None of the differences between the minimum measured in the higher screen and that in the adjustable screen exceeded 0.5°C.

The tolerance in the time of observation can have a considerable effect on the measured temperature. For example, over the period 1901 to 1930, the mean rise of temperature between 0800 GMT and 0900 GMT at Kew (southern England) in September was more than 1.33°C. Thus a systematic difference of about 0.2°C could be produced in the 0900 temperature by changing the time of observation by 9 minutes which is a change within the present tolerance. Changes of the same magnitude could be produced by similar timing changes in the evening. The rate of change of temperature at Kew will certainly be exceeded in less temperature climates.

3. Comparisons between "identical" instruments

It is well known from studies of turbulence that irregular temperature variations of several °C occur over short periods of time and short horizontal distances. These variations were noted by Best as long ago as 1931. Best also noted that at night differences of almost 2°C occasionally persisted for periods of 10 to 30 minutes between aspirated thermometers set 15.5 m apart, 1.25 m above level ground.

Although we have been aware of these rigid temperature fluctuations for many years, the knowledge is not fully reflected in recommendations for temperature measurement. The Guide to Meteorological Instruments and Observing Practices (WMO No. 8 TP3, paragraph 4.3) recommends that a thermometer should have a lag of 30 to 60 seconds in a wind speed of 5 m s⁻¹. It should be pointed out that if such a thermometer is used in a double louvered wooden screen the lag of the complete system in a wind speed of 5 m s⁻¹ will be from about 200 to 600 seconds depending on the type of screen, and is almost independent of the lag of the thermometer itself. The effects of system lag on temperature fluctuations are apparent when the papers of Smith (1951) and Wiggins (1956) are compared.

Wiggins compared the temperature given by two Meteorological Service of Canada Standard Psychrometers 5 ft (1.55 m) apart over a grass plot in the City of Toronto. The MSC psychrometer is basically a Stevenson screen, but the thermometers are suspended in a duct through which air is drawn at a nominal rate of 2 000 ft min⁻¹ (10 m s⁻¹). There were no systematic differences between the instruments but the standard deviation of the differences between the two screens was 0.23°C. Smith compared
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temperature readings in four Stevenson screens at Kew in 1949. The screens were on a level grass site with apparently identical exposures. There were no systematic differences between the screens and the standard deviation of the differences between any two screens was approximately 0.18°C.

Both the above sets of observations were made by normal observers on a routine basis and are, therefore, representative of network observations, with the exception that because more than one instrument was used obvious reading errors could be eliminated from the data. The difference between the standard deviations of the two sets of data is almost certainly due to the more rapid response of the forced ventilated instruments.

Kramer, Post and Woudenberg (1954) obtained standard deviations ranging from 0.03°C to 0.25°C for the individual readings of a series of observations made in rapid succession, of the same Assmann type psychrometer. The results from 24 series of observations are quoted, each series consisting of 10 readings of the thermometer.

These Assmann readings are not directly comparable with the screen readings quoted by Wiggins and Smith because they were made with extreme care and represent the best performance that could be achieved with mercury in glass thermometers in an Assmann psychrometer.

Approaching the comparison of identical instruments in a different way Orozdog (1950) has investigated the variability of the standard air temperature readings in the U.S.S.R. He fitted the observational data with an equation of the form

$$[\Delta T(\rho)]^2 = \phi(\rho) + 2\alpha^2,$$

where \(\rho\) is the distance between stations, \(\Delta T(\rho)\) is the temperature difference between stations separated by a distance \(\rho\) and \(\phi(\rho) \to 0\) as \(\rho \to 0\). In the limit as \(\rho \to 0\), \(\Delta T(\rho) \to 0\).

In the middle zone of European U.S.S.R. (ETC) he found \(\alpha = 0.11°C\) in winter and 0.13°C in summer. In the western part of Siberia in January \(\alpha = 0.6°C\) at 0700 LMT and 0.4°C at 1300 LMT and in July it is 0.5°C at 0700 LMT and 0.6°C at 1300 LMT. These results show clearly the great influence of topographic and climatic features on the value of \(\alpha\) and, therefore, on the representativeness of temperature observations.

There is a very good agreement between Orozdog's calculated value of \(\alpha\) for the ETC and Smith's direct comparison of screens at Kew in southern England which gives an \(\alpha\) of 0.127°C for observations over the whole year.

4. Screens with forced ventilation

Relatively few papers have been written on the performance of screens with forced ventilation since Assmann (1892) designed his elegant and versatile psychrometer. It would appear from the literature that it has been generally assumed that if one puts a thermometer on the common axis of two concentric polished metal tubes
and draws air through the tubes at more than $3 \text{ m s}^{-1}$ the thermometer will indicate the "true" air temperature.

There have, however, been some criticisms of the performance of the Assmann type instrument. Berger (1944) performed experiments on four different fan ventilated psychrometers, all described by the name Assmann. He showed that there were considerable differences between the instruments in their rates of ventilation and their thermal capacities. He found that some of them could give errors of several $^\circ$C in extreme cases. Kramer, Post and Woudenberg (1954) have noted that several readings (following Langlo they recommend ten) are required to obtain a representative air temperature and that during the series of readings the presence of the observer may increase the observed temperature by several tenths of a degree. They also noted that the indicated temperature could be lowered by as much as $1^\circ$C by shielding the instrument from direct sunlight.

It appears from the literature that, apart from the WMO Working Group on Hygrometry, only Nakigima, Akita and Kondo (1956) have attempted to improve on the performance of Assmann's psychrometer for the measurement of air temperature. They performed experiments with a number of different shaped screens made from a variety of materials (polished aluminium, cardboard and corrugated board) and with different surface finishes. They found that a ventilated double-walled tube is only fully effective as a radiation shield if the diameter of the inner tube is considerably greater than that of the thermometer and the outer tube has a diameter about 60 mm larger than the inner tube. They chose, as a standard against which to compare naturally ventilated screens, a tube with an internal diameter of 45 mm and a small bead thermistor as a thermometer. They found that material and surface finish exert little influence if the tube diameter is large enough and the ventilation range is not less than $4 \text{ m s}^{-1}$.

It has not generally been assumed necessary to protect the open end of the force ventilated concentric tube type of shield from indirect longwave radiation, although Berger (1943) has shown that the temperature indicated by an Assmann type psychrometer may be reduced by about $0.15 ^\circ$C by shielding it from radiation from the ground, and a shield made commercially in the U.S.A. has such protection.

5. **Comparisons between different naturally ventilated screens and between forced ventilated screens and traditional naturally ventilated screens**

The earliest recorded systematic comparisons of thermometer screens were made on the lawns of the rectory at Strathfield Turgess in southern England by the Reverend Griffiths from November 1868 to April 1870. The observations were analysed by Gaster and the results were published in the London Quarterly Weather Report in 1879.

Griffiths' observations showed quite clearly that the open shelters typified by Glaisher's stand, and the north wall exposures, then common, were inferior to Stevenson's screen. However, more important for the present study were the comparisons between the Stevenson screen and the Kew stand; those two screens differed more in size and detail of construction than any two double louvered screens in current
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The internal dimensions of Stevenson's screen were $380 \text{ mm} \times 370 \text{ mm} \times 190 \text{ mm}$; the roof which was solid but not double, rose to a height of $100 \text{ mm}$ at the centre and was fitted with a small capped chimney intended to prevent the accumulation of heated air. The screen had no floor. The Kew stand was a screen within a screen, both screens appear to have been double louvered from the illustration in Gaster's paper. The outer box was $1.8 \text{ m} \times 1.8 \text{ m} \times 1.5 \text{ m}$ and the bottoms of both boxes were completely open with the exception of the beams necessary to support the inner box.

Despite the considerable differences in the size and construction of the Kew stand and the Stevenson screen their temperatures, in Gaster's words, "Agree very closely indeed .............. the range being only slightly less in the former than the latter". The agreement was so good that Gaster, unfortunately, did not bother to give the figures but we can assume that the differences were less than $0.2^\circ\text{C}$, for he describes screens giving such differences as "very similar".

The Stevenson's screen did not meet with universal approval as a result of Gaster's paper. This was probably because there was no satisfactory forced ventilated thermometer at Strathfield Turges which could be accepted as a standard.

In 1913 Köppen published a classic paper on the exposure of thermometers. By drawing on experimental evidence from all sources then available he showed that, although the Stevenson type screen was the most satisfactory screen then in use, it was subject to considerable over-heating in the afternoons. Table 2 shows the figures quoted by Köppen for the mean temperature differences between the screen thermometers and aspirated thermometers at Potsdam and Pavlovsk. The observations cover two years at both stations. Only the mid-afternoon observations show a systematic error, but that error is considerable. Köppen proposed that a thatched roof should be put over an English type screen to reduce this over-heating in the afternoons. Köppen's papers lead to the almost universal adoption of the double louvered box type screen but his suggestion of an additional roof over the screen was not widely adopted.

<table>
<thead>
<tr>
<th>TABLE 2</th>
<th>English type screens minus aspirated thermometer at Potsdam and Pavlovsk ($^\circ\text{C}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Observations</td>
</tr>
<tr>
<td></td>
<td>0700</td>
</tr>
<tr>
<td>January and February</td>
<td>.03</td>
</tr>
<tr>
<td>March and April</td>
<td>-.07</td>
</tr>
<tr>
<td>May and June</td>
<td>.03</td>
</tr>
<tr>
<td>July and August</td>
<td>.03</td>
</tr>
<tr>
<td>September and October</td>
<td>-.13</td>
</tr>
<tr>
<td>November and December</td>
<td>-.05</td>
</tr>
<tr>
<td>Mean</td>
<td>-.03</td>
</tr>
</tbody>
</table>
Mawley (1884) compared temperature observations in the "old" Stevenson screen and those in "new" Stevenson type screen. It is of note that even in 1884 what was described as the "old" Stevenson screen differed considerably from Stevenson's original model. The internal dimensions of the "old" screen were 405 mm x 228 mm x 420 mm. Those of the "new" screen were 456 mm x 280 mm x 420 mm. The new screen differed from the old in that the inner and outer louvers were joined at their upper edges instead of being separated. The inner louvers on the new screen were 32 mm wide and the outer louvers 57 mm wide, whereas those in the old screen were both 32 mm wide. The distance between the louvers of the new screen was 12.5 mm compared with 9.5 mm in the old screen. The new screen had a double roof and a floor of three overlapping boards while the old screen had a single roof and only one narrow board running across the centre of the bottom. In spite of these considerable differences, the performance of the two screens was remarkably similar. Table 3 shows the difference between the screens over the months July, August and September 1883. These results show how little the detailed design of a Stevenson type screen affects the observed temperature in the temperate climate of southern England. It will be seen from the 1500 GMT and 2100 GMT temperatures that the new screen, with its wider spaced louvers, overheated slightly less than the old screen and showed slightly less lag.

**TABLE 3**

<table>
<thead>
<tr>
<th></th>
<th>Temperature in &quot;new&quot; Stevenson screen minus temperature in &quot;old&quot; Stevenson screen (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean temperature differences</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
</tr>
<tr>
<td>July</td>
<td>-0.07</td>
</tr>
<tr>
<td>August</td>
<td>-0.03</td>
</tr>
<tr>
<td>September</td>
<td>-0.08</td>
</tr>
<tr>
<td>Mean</td>
<td>-0.06</td>
</tr>
</tbody>
</table>

Except for a few minor changes, the most important being the separation of the louvers at their apex once again, the new screen described above represents the Stevenson screen as we now know it.

Bilham (1937) designed a small double louvered screen with clear internal dimensions 304 mm x 420 mm x 152 mm. The screen had a double roof and a floor of three overlapping boards. The louvers were spaced 12.5 mm apart as in the Stevenson screen. Comparisons against the Stevenson screen at Kew Observatory showed that the smaller screen had less lag, which resulted in the average maximum temperature for the year 1932 being 0.1°C higher and the average minimum being 0.08°C lower in the
smaller screen. Further comparisons between the two screens at Poona were reported by Gadre and Narayanan (1939). Their observations showed that the smaller screen gave a slightly higher maximum temperature (0.05°C) and a considerably lower average minimum temperature (0.26°C).

Kissne Toth (1959) compared temperatures observed in Russian and Hungarian screens during the months from August to December. The Hungarian screen was very slightly cooler than the Russian screen at 0700 LMT and slightly warmer at 1400 LMT, the largest monthly mean difference was 0.16°C at 1400 LMT in September.

Waibel (1951/1952) compared Norwegian and English screens at Feldberg. He found that they were generally in good agreement, the annual mean difference in both the maximum and minimum temperatures recorded in the two screens was only 0.04°C. The largest monthly mean difference between the maximums was 0.37°C in May and the largest monthly mean difference between the minimums was 0.18°C in October. The Norwegian screen gave a higher temperature in every case. Unfortunately the type of Norwegian screen is not specified.

Langlo (1947) describes comparisons between temperatures in three types of Norwegian screens and Assmann temperatures. The screen type MI 30 is 720 mm x 720 mm x 1050 mm. The roof is gabled, the east and west sides are single louvered whereas the north and south sides are solid double panels with a vertical ventilation space of about 40 mm between inner and outer walls, the floor is similar to that in the Stevenson screen.

The thermometers are placed in an inner metal box which has no floor, single louvered sides north and south but solid sides east and west. The screen MI 33 is identical to the MI 30 except that the two single louvered sides are replaced by solid double walls like the north and south sides. The third screen studied by Langlo, the MI 46, is identical to the MI 30 except that the east and west sides are double louvered with a space of 10 mm between inner and outer louvers. No inner box surrounds the thermometers in either the MI 33 or the MI 46.

The results of Langlo's comparisons against the Assmann are quoted in a convenient form by Utaaker (1956) along with his own comparisons between the MI 33 and the Mork screen and the Assmann. The results are summarized in Table 4.

The Mork screen has doubled louvered walls and a double four-sided sloping roof with ventilation space. The internal dimensions are 850 mm x 430 mm x 850 mm.

It is worthy of note that Utaaker also included two single louvered screens in his investigations, the Sterten and the Link, but found them to be considerably less satisfactory than any of the double louvered screens.

It is dangerous to put too much weight on the comparative results in Table 4 because of the different exposures of the various screens, but it is clear that the MI 30 is less satisfactory than the other screens both as a radiation shield and because of its very long lag, the effect of which is shown at the 1900 LMT observations.
The effect on temperature measurements of forced ventilation of thermometers inside a normal double louvered screen has been investigated by D'Jackova and Kaulin (1965). They applied forced ventilation to the thermometers in a standard Russian screen, taking care to ensure that ventilation was independent of windspeed and direction and that heat from the fan motor did not affect the observed temperatures. Comparisons between the forced ventilated screen and a naturally ventilated screen during four summer months showed a negligible mean temperature difference with a standard deviation of only 0.12°C (calculated from the published histogram). The mean wind speed over the period was 3.4 m s⁻¹ with few calms. This standard deviation of differences is smaller than that obtained by Wiggins and Smith for differences between identical instruments.
One might think that the forced ventilation of a thermometer in a screen would change the time constant of the system and therefore increase the standard deviation of differences between it and an unventilated thermometer screen. However, a simple calculation will show that if the thermometer were mounted in a tube of 25 mm diameter and air were drawn past the thermometer at 4 m s\(^{-1}\) the rate of flow through the louvers of the screen would be extremely low, certainly less than 0.05 m s\(^{-1}\) and could have very little effect on the temperature in the screen or the response of the screen to temperature changes. This type of ventilation could, of course, have a considerable effect on wet bulb temperature.

6. Novel Screens

6.1 Introduction. A study of the literature on thermometer screens shows almost continuous attempts to produce thermometer screens which are better than the conventional Stevenson type. Most of these attempts are prompted by desires for economy or reductions of weight and size. Many are based on inadequate knowledge of previous work and little idea of what is needed to produce a good thermometer screen. Open shelters of the Glasher type, single louvered screens and screens without floors are repeatedly reinvented and found to be inadequate. However, some workers have succeeded in producing naturally ventilated screens which are, at least in some respects, superior to the Stevenson screen. Alternatives to the traditional wooden Stevenson type of screen may be divided into three classes: improved louvered screens, "chimney" screens which maximize the effects of natural convention and "sandwich" screens which maximize the effects of advection.

6.2 Improved louvered screens. Köppen's suggestion of erecting a roof over a louvered screen has been mentioned in section 5. No performance figures have been traced for screens made exactly to Köppen's design but a screen was erected at Apia in Samoa, some time between 1908 and 1920, which embodied some of Köppen's most important principles. This screen consisted of a louvered box with the following clear internal dimensions, height 510 mm, width 520 mm and depth 540 mm. The roof was double and in the form of a gable with an air space of 45 mm between the two roofs, neither roof having ventilation holes. The floor consisted of six T section cross members and five plain slats arranged to allow adequate circulation of air but very effectively preventing radiation from the ground reaching the thermometer bulbs. The sides were double louvered only for the lower 250 mm and single louvered above. An additional thatched gabled shelter was erected about 350 mm above the roof of the screen and this outer shelter had very open single louvered walls to the east and west, about 250 mm from the sides of the screen. This screen was described by Sapsford (1940) as a Tropical screen.

In 1932 a Stevenson screen was set up five metres from the Tropical screen and temperatures in the two screens were compared over the seven year period 1933-1939 inclusive. The heights of the thermometers were 1.8 m in the Tropical screen and 1.25 m in the Stevenson screen. In his analysis of the data obtained Sapsford used Ramanathan's results from Agra to allow for the height difference between the thermometers. He showed that after adjustment for the height there was very little difference in the minimum temperatures recorded in the two screens but that the maximum temperatures averaged over the whole of the seven years were 0.25°C higher in the Stevenson screen than in the Tropical screen.
Apia is subject to frequent light winds with an easterly component during the mornings. In those conditions the air entering the Stevenson screen passed over the louvers of the screen which were heated by direct solar radiation. The effect of these factors is shown by the temperatures at 0900 LMT which average 0.22°C higher in the Stevenson screen than in the tropical screen.

The value of the shelter over the tropical screen as a radiation shield was, therefore, conclusively demonstrated. There is also some evidence in Sapsford's paper that, by protecting the inner screen from precipitation, the shield prevented the air passing into the screen from being cooled by evaporation from wet louvers, as it often was as it entered a Stevenson screen.

In a series of three papers Berger (1941-43) describes improvements to an "English" screen. His main changes were to separate the double louvers at the top (making it similar in that respect to the Stevenson screen used in the United Kingdom) and to modify the roof to promote better vertical ventilation. Berger found that these modifications produced temperatures lower than those in an unmodified screen. Surprisingly he found that afternoon temperatures in his modified screen were lower than those given by the "Assmann". At that time Berger had confidence in the "Assmann" temperatures and thought that his modified screen temperatures were too low. He, therefore, painted the roof of his screen black to produce strong convection above the screen and thus induce better vertical ventilation through it. This had the effect of raising the temperature in the screen on clear sunny afternoons to that given by the "Assmann". Berger did, however, have some doubts about the accuracy of the "Assmann" temperatures and in 1944 he reported work showing that some so called "Assmanns" could give errors of several °C in extreme cases (see section 4). It seems probable that Berger's first modifications produced the best results and that painting the top of the screen black was not beneficial.

Thaller (1957) describes three forms of plastic screen which performed well in comparison with the Stevenson screen and the Assmann. MacHattie (1965) did an independent valuation of a Thaller screen in conditions of strong sun and light winds. The Thaller and Stevenson screen were in excellent agreement during the morning and early afternoon while the temperature was rising or steady. Both were about 0.4°C above the Assmann temperature during the afternoon. However, as the temperature began to fall in the evening the Thaller screen came into agreement with the Assmann while the positive error of the Stevenson screen increased, reaching 0.6 to 0.7°C at 1850 LMT. Other Thaller screens are described under Israel in the Annex.

The French Meteorological Service (1965) has produced a large plastic screen with the interior dimensions 1.10 m x 0.5 m x 0.65 m. The screen is double louvered with a gap between inner and outer louvers, the floor and ceiling are also double, with slots "en chicane" to allow vertical ventilation. The screen is topped by a double pagoda type roof.

Comparisons with an old type wooden screen and a force ventilated cylindrical screen have shown the new plastic screen to be considerably better than the former and to compare well with the latter. On cloudy days the temperatures measured in the three screens agreed in the overall mean to better than 0.3°C, the reference screen
having a tendency to be slightly warmer than the plastic screen and slightly colder than the wooden screen. On sunny days the temperatures in the plastic screen and the reference screen were in agreement between 0001 LMT and 1000 LMT and 1800 LMT and 2359 LMT except in certain cases where the different thermal time constants of the screens caused differences of more than 0.3°C momentarily. Between 1000 LMT and 1800 LMT the reference screen recorded temperatures lower than the plastic screen (maximum difference 1.0°C on 13 October 1965, mean difference 0.4°C). The temperatures agreed to better than 0.3°C for more than 70 per cent of the time. The temperatures measured in the wooden screen were higher than those in the reference screen during 90 per cent of the time. The errors were often large, the maximum being 3.2°C on the 13 October 1965.

The following examples of the percentages of observations in agreement to better than 0.3°C give a general idea of the comparative performance of the three screens. September 1965: difference between reference and plastic screens ≤ 0.3°C on 82 per cent of occasions; difference between reference and wooden screens ≤ 0.3°C on 52 per cent of occasions. October 1965: difference between reference and plastic screens ≤ 0.3°C on 92 per cent of occasions; difference between reference and wooden screens ≤ 0.3°C on 73 per cent of occasions.

A form of Stevenson screen designed in Rhodesia is described in CIMO-IV/Document 28 Annex II. The internal dimensions of the Rhodesian screen are approximately 670 mm by 300 mm by 350 mm, the double louvers are formed from inverted V section aluminium strip mounted in a wooden frame, the floor and ceiling are solid block board. The roof is white flat asbestos sheet. The metal work is painted with titanine anti-heat white enamel paint and the wood-work with two coats of white enamel paint. No precise performance figures are quoted but it is stated that the systematic difference between the temperature in this new screen and that given by the Assmann is less than the random short period fluctuation of temperature i.e. less than 0.3°C. The new screen shows much less lag than the old wooden version.

6.3 Chimney screens. Aitken (1883) described a chimney screen approximately 1.25 m high and 100 mm in diameter (the screen is illustrated by Middleton 1966). The chimney was capped by a hollow cone to allow freedom for the air to flow out but to prevent ingress of precipitation. The bottom of the chimney where the thermometer was situated, was surrounded by louvers to protect it from direct radiation. The thermometer bulb was additionally protected from radiation by two inner concentric cylinders. The object of this construction was to draw air upwards past the thermometer by natural convection. No performance figures are quoted but since there was no protection from terrestrial radiation some error must be expected.

Sauer (1955) reported that a polished aluminium tube 0.2 mm thick, 50 mm in diameter and 450 mm high provided temperatures closer to those given by the Assmann than any of the more conventional louvered screens that he also compared.

However, the effect of radiation entering the bottom of this type of screen must not be underestimated. Parry (1966) in a letter, quotes an occasion on 13 February 1962 at Stirling, Virginia, of a clear winter day with a snow cover and with winds of 3 kn to calm on which the maximum temperatures recorded in four white fibreglass cylindrical shields were from 5.7 to 6.1°C above the maximum temperature recorded in a ventilated shield.
6.4 Sandwich screens. The "sandwich" screen in its simplest form consists of a number of horizontal plates protecting the thermometer bulb from both solar and terrestrial radiation but allowing free horizontal movement of air. Aitken (1921) was the first to use this type of screen, his final design (which is illustrated by Middleton) consists of four discs with the thermometer bulb between the lowest pair and protected from horizontal radiation by a ring. Comparisons between this screen and a Stevenson screen from 17 August until 8 November 1921 showed the maximum temperature to be nearly always higher in the Stevenson screen, the greatest difference was 2.5°C on a calm day in October.

Bellaire and Anderson (1951) produced an elegant variant of the sandwich screen by introducing four semicircular vanes between the plates either side of the thermometer bulb, so that the bulb was completely protected from direct radiation but air could still flow easily past it. A large shallow angle metal cone, like a "coolie" hat was mounted above the screen to shield it from direct solar radiation and precipitation. They found that light winds (0-3 mph) passed through the central area undiminished but that winds of 20 mph were reduced by 50 per cent. The performance of this screen is quite remarkable; the results are given in Table 5. The "coolie" hat undoubtedly made a large contribution to the excellent results. Others who have found the sandwich type screen to be superior to other types of naturally ventilated screen are Thornthwaite (1954), Kramer, Post and Woudenberg (1954), Nakajima, Akita and Kondo (1956), Franssila (1961) and MacHattie (1965). However, not all sandwich screens are better than all other screens. Nakajima found that a form of "Bellaire" screen with only three vanes and no "coolie" hat overheated by 1.5°C in bright sunshine.

| TABLE 5 | Performance in radiation of the Bellaire and Anderson screen |
|-----------------|-----------------|-----------------|-----------------|
| Elevation angle of radiation source | Intensity of radiation (cal cm⁻² m⁻¹) | Temperature rise °C (Wind speed 0, 1, 2 (mph)) |
| 30° | 1.5 | 0.0 | 0.0 | 0.0 |
| 20° | 1.2 | 0.3 | 0.1 | 0.0 |
| 10° | 1.0 | 0.3 | 0.1 | 0.0 |

Dr. Baumbach has designed a screen which could, perhaps, be described as a sandwich screen with curved plates and provision for vertical escape of heated air. A photograph of the screen is given in the Annex under Federal Republic of Germany.
7. Some factors affecting the temperatures measured in screens

7.1 Introduction. The effects of screen height and the tolerance in the times of observations were discussed in section 1, but there are other factors that require consideration.

7.2 Colour and material. Fuchs and Tanner (1965) investigated the rise in temperature above that of the ambient air, of various surfaces exposed to solar and terrestrial radiation. They showed that the excess temperature of a surface exposed to the sun, but covered by a double layer of polythene to reduce convective heat loss, is related to the ratio $a_s/a_t$, where $a_s$ is the absorptivity of the surface for solar radiation and $a_t$ is its absorptivity for terrestrial radiation. The excess temperature of the surface decreased as $a_s/a_t$ decreased. On the 17 April 1964 they obtained excess temperatures of 92.1°C for chrome plating, 44.7°C for aluminium foil but only 25.6°C for aluminized Mylar and 25.3°C for Alkyd gloss white paint. These results were obtained under very artificial conditions and if the convective heat loss is larger the advantage passes to the low $a_s$ surfaces and is less dependent on $a_t$.

Takizawa (1948), Godecke (1957) and Gebhart (1964) have compared temperature in similar black and white painted screens. Takizawa and Gebhart found the black screen to give afternoon temperatures from 1°C to 2°C above those in the white screen on sunny days, but Godecke found the mean difference between the screen temperatures at 1600 to be negligible and the maximum excess temperature of the black screen to be 0.8°C.

Theory predicts that the difference between a black and white screen will only be large when the wind speed is very low, but under those conditions the error in the black screen will be unacceptably large.

7.3 Exposure. Little has been written on the errors due to the exposure of thermometer screens since the controversy over "open" and "north wall" exposures at the turn of the century.

The difficulties of exposing screens on aerodromes are well known but even when care is taken to avoid aircraft engine exhausts and close proximity to heated buildings, busy roads and parked cars the indicated temperatures, although correct for aviation purposes, are not always suitable for climatological studies. A large and busy aerodrome, like a town, is a source of heat.

There have been some studies of the effect of smaller features on screen temperature. Floyd (1952) describes a comparison between two similar screens; one heavily shaded by bushes except to the northeast and the other openly exposed. The screens were about 45 m apart with the open one northeast of the shaded one. In August and September the maximum temperatures in the exposed screen were about 1.4°C higher and the minimum temperatures about 0.4°C lower than those in the shaded screen. These differences were due partly to the inadequacies of the screen in an open situation and partly to the real temperature differences between the air over shaded ground and that above sunlit ground. There is no way of apportioning the error.

Hogg (1949) shows that the mean daily minimum temperature at Wye increased by about 0.2°C in the winter months after the erection of glass-houses. There was one
glass-house 2.4 m high and 8.4 m from the screen and another 5.7 m high and 20 m from
the screen. Both glass-houses were kept at about 15°C.

Exposure of thermometers over snow presents special difficulties. The Sapporo
District Meteorological Observatory (1962) reported on the performance of a small
louvered cover designed to protect a thermometer, exposed in a screen, from wind driven
snow. It performed its task well but increased the lag of the system. An alternative
method of keeping snow away from thermometers is that adopted by the Norwegians in
their "hard weather" screen type MI 33 (described in section 5) but this method also
increases the lag of the system. Nawa's study of the influence of snow depth and
Parry's observations over snow at Stirling, Virginia have been mentioned in section 1.
Hamilton (1958), using a Weston exposure meter, has shown that short wave radiation in
a Stevenson screen is about 20 times more over snow than over grass. He also showed
that if large black bodies are in the screen (a hygrograph for example) they can be
heated appreciably and cause temperature errors of 0.3°C or more. These observations
support Köppen's (1915) recommendation that recording instruments should not be put
in the thermometer screen.

7.4 Thermal inertia. The lag of naturally ventilated thermometer screens has been
briefly mentioned in section 1. Langlo (1949) used measurements made in 56 screens
throughout Norway during the solar eclipse of July 1945 to determine a lag co-efficient
for Norwegian screens and its relationship with wind speed. To define the lag co­
efficient \( \alpha \) he used the equation \( T - T_s = \alpha \frac{dT_s}{dt} \). Where \( T \) is the air temperature
and \( T_s \) is the temperature in the screen. He found \( \alpha \), in minutes, to be approximately
\( \frac{24}{\sqrt{v}} \) where \( v \) is the wind speed in m s\(^{-1}\) at a height of 6 m. This formula was valid
for windspeeds between 1 and 4 m s\(^{-1}\); at higher wind speeds the lag was less than that
given by the formula.

Aria (1961) gives the lag of the JMA Standard Large Shelter at 8.3/ \( \sqrt{v} \) min
with a maximum value of about 30 minutes for \( v = 0.2 \) m s\(^{-1}\). The lag of the JMA Climato­
logical Small Shelter is 4.6/ \( \sqrt{v} \) minutes.

Bryant (1968) measured the lag of the Stevenson screen and found it to be
approximately 8.2/ \( \sqrt{v} \) minutes. This value is in excellent agreement with
MacHattie's (1965) estimation of ten minutes in a wind speed of about 0.6 m s\(^{-1}\).

7.5 Non-uniformity of temperature in a screen. The variation of temperature within
a louvered screen has been investigated by Hirayama (1944) and Parry (1962); there
are also some data on this subject in the unpublished records of the British Meteorolo­
logical Office. These investigations show that there is a small vertical temperature
gradient within the screen during the day time, the top being about 0.2°C warmer than
the bottom. The side of the screen nearest the sun is always warmer than the centre
on clear days. Hirayama's observations show the difference between a thermometer 50 mm
from the wall of the screen and one in the centre of the screen to be about 0.7°C on
a sunny day. The British data, which relate to measurements in a Stevenson screen at
Cranwell in 1929, show the maximum difference between a thermometer 100 mm from the
wall and one in the normal dry bulb position 150 mm from the wall to be 0.8°F (0.45°C).
8. Summary and Conclusions

The tolerance in the height and time of temperature observations permitted by the present Technical Regulations can introduce systematic differences in reported temperatures. Permitted height differences have been shown to produce differences in the monthly mean maximum and minimum temperature of about 0.4°C. Differences due to timing have not been directly reported in the literature but it is calculated in section 1 that a timing change within the permitted tolerance could change the mean temperature reported at 0900 in the month of September at Kew Observatory, England by 0.2°C. Also, it has been shown by Drozdov (section 1) that the "representativeness" of a temperature measurement depends on climate and topography. These factors are independent of the instruments used to measure the temperature and it is against this background, and the accuracy requirements of the WMO Technical Commissions that screen performances must be set.

Despite all that has been written on screens for air temperature thermometers it is not yet possible to state exactly how accurate our measurements of air temperature are under all possible conditions. The most important reason for this is that instruments that are called by the same name are not always identical. The name Assmann psychrometer is applied, indiscriminately, to any portable instrument which has two thermometers in pairs of concentric metal tubes through which air is drawn by a suction fan. Such instruments can vary considerably in their rate of ventilation and their properties as radiation shields. Some "Assmanns" have been shown to give temperatures up to 1°C too high in bright sunshine while others with better ventilation and better radiation shielding are certainly much more accurate. Even more uncertainty exists with "Stevenson" and "English" screens, almost any double louvered screen, and occasionally even a single louvered screen, is described by one of these names, regardless of the details of its construction. However, these uncertainties are not so great that nothing can be learned from the literature, but caution must be exercised.

Under most conditions good instruments of the Assmann type will give air temperature with sufficient accuracy for meteorological purposes but with bright sun and a ground surface with a high albedo, or with ground temperature very much above the air temperature, unacceptably large errors may result from radiation entering the open ends of the radiation shields. The Assmann is not, in its standard form, a suitable instrument for routine observations since its response to temperature fluctuations is so rapid that several readings are required to obtain a "representative" result.

Traditional wooden screens of the Stevenson type give self-consistent results; and quite large variations in size and construction produce only small differences in the indicated temperatures. There are, however, essential features that a screen of this type must have if it is to perform reasonably well. These are: (a) it must be double louvered, (b) there must be no direct path for radiation to enter, (c) the roof must be at least double, (d) there must be provision for free vertical ventilation by convection.
Even when it meets the above requirements a screen of the Stevenson type has a number of defects. It overheats in bright sunshine, the magnitude of the error depends not only on the windspeed but also on the wind direction relative to the azimuth angle of the sun. Arai calculates that for the Japanese Meteorological Service Standard Screen this error will be about 1°C and this is in agreement with most observational evidence, although greater errors have been noted by some observers. The Stevenson screen has a lag which is highly dependent on the windspeed and which is probably too long in low windspeeds. Its louvers get wet in precipitation and then cool the air passing over them as the water evaporates. Finally it is easily blocked by drifting snow and is not a good shield for radiation reflected from a snow surface.

If a thermometer is exposed in a large louvered screen, enclosing the bulb in a small tube and ventilating the tube with a suction fan has a negligible effect on the dry bulb temperature because the amount of air drawn into the screen is not sufficient to significantly change the temperature in the screen, or to change the lag of the complete system.

The optimum naturally ventilated screen has not yet been designed. From the study of existing screens it may be concluded that the optimum ventilated screen would have the following characteristics; (a) there must be no direct path for radiation to enter the screen from any angle, (b) there must be freedom for heated air to move vertically from the screen, (c) the walls and the top of the screen must be protected from precipitation and direct solar radiation, at least when the sun’s elevation is more than 20°, by an outer roof, (d) the screen should be made of the material which would provide the necessary strength with the minimum louver thickness, (e) the outer surfaces of the screen should be painted white and the inner surfaces black, (f) bulky recording instruments such as the thermograph and hygrograph should not be housed in the screen, (g) if mercury-in-glass thermometers are used in the screen their bulbs should not be exposed to radiation when readings are made.

It is unlikely that a single type of thermometer screen could be designed to produce optimum measurements under all climatic conditions. In high latitudes, where the main problems are associated with icing, drifting snow and strong winds, the type of screen used in Iceland gives good results. It would not be satisfactory in the tropics. Conversely, a screen with a large overhanging roof and louvers designed to take full advantage of any light winds, which could be expected to perform well in the tropics, would be quite unsuitable for arctic regions.

The three Technical Commissions that have specified requirements for the accuracy of maximum and minimum temperatures have set the standard at ± 0.5°C. It is certain that a good design of naturally ventilated screen can meet that required accuracy except perhaps under some snow conditions.

The situation is quite different when one considers the timed observations of air temperature. The majority of WMO Technical Commissions require the dry bulb temperature to be accurate to ± 0.1°C. It is not explicitly stated, but perhaps one may assume, that this means that 95 per cent of observations must be within ± 0.1°C of the "true" air temperature.
Before it is possible to discuss the accuracy of air temperature measurements to ± 0.1°C it is necessary to define an averaging period for the measurement, or at least a response time of the standard instrument. Assuming that such a definition is produced, the requirement could only be met if the effective height of the standard thermometer were fixed to within ± 50 mm and the observations were timed to within ± 30 seconds of the standard times. Improved temperature measuring systems would be needed because comparisons between identical instruments have shown that, even if systematic errors are ignored, the standard error of individual temperature measurements with equipment now in routine use is about ± 0.13°C. To decrease this random error by a factor of 2.6 throughout an observational network would be a difficult and expensive task.

9. **Recommendations for further work**

(a) A stricter definition of "air temperature for routine meteorological use" should be agreed. This definition should include a standard height and an averaging time for the observation.

(b) The Reference Psychrometer specified by the WMO Working Group on Hydrometry should be adopted as a reference instrument for temperature observations (ref. CIMO-V General Summary paragraph 6.2.1 and CIMO-V/Doc. 22).

(c) Members of WMO should be requested to compare the reference instrument, exposed at the standard height and with its readings averaged over the agreed interval, with their standard equipment for routine temperature measurements used in its normal way.
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10. **Subject guide to references**

Comparisons between identical instruments B10, B4, K4, S6, W3.

Comparisons between different forced K4, N1.

ventilated screens

Comparisons between different naturally A1, B1, B8, D1, F5, F6, G1, G2, G3, G7,

ventilated screens K2, K4, K5, K6, K7, L1, M1, M2, M5, M6,
P2, R1, S3, T2, U1, W1, W2, W4.

Comparisons between forced and naturally B1, B3, B4, B5, D2, F6, G3, K6, K7, M1,

ventilated screens N1, U1.

Colour or material G3, G5, N1, T1.

Descriptions of simple instrument shelters B1, C1, F3, G4, K3, L3, M1, M2, R1, S1,

T2, U1, W2.

Exposure F1, H5.

Height A1, H1, H6, N2, R3, U1.

Novel naturally ventilated screens A2, A5, A6, B1, B2, B3, B4, B5, F2, K6,

K7, S3, T2, T3.

Non-uniformity of temperature within a H4, I1, P1.

screen

Observations at sea B9, H3.

Radiation H2, S3.

Response time A2, A3, B11, K2, M1, P2, U1.

Snow N2, S2, S4.

Temperature fluctuations and rate of change B7, B10, G8, P2.

Ventilation studies S7, V3.
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ANNEX

THERMOMETER SCREENS IN CURRENT USE

This annex contains replies to a questionnaire distributed by the WMO Secretariat on 27 February 1970. In addition to completing the questionnaire, countries were invited to send photographs of their screens and to comment on the problems of screen designed temperature measurement. These photographs, and any comments that have not been covered adequately in the text, are reproduced in this Annex under the name of the country concerned.

I. Countries which have provided information on thermometer screens in current use

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<td>Tanzania and Uganda)</td>
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<td>Ecuador</td>
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<td>Germany, Federal Republic of</td>
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<td>Iceland</td>
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<td>India</td>
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<tr>
<td>Indonesia</td>
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</tbody>
</table>
II. Information for each thermometer screen is given below in accordance with the following key

1. Country/Pays/Pais/Страна

2. Description of screen/Description de l'abri/Descripción de la garita/Описание будки

3. Name or number of screen/Nom ou numéro de l'abri/Nombre o número de la garita/Название или номер будки

4. Percentage of network equipped with the screen/Pourcentage du réseau équipé de cet abri/Порcentaje de la red equipado con esta garita/

5. Internal dimensions of screen; width, depth (or diameter) and height/Dimensions internes de l'abri; largeur, profondeur (ou diamètre) et hauteur/Dimensiones internas de la garita; anchura, profundidad (o diámetro) y altura/Внутренние размеры будки: ширина, глубина (или диаметр) и высота

6. Weight (excluding stand)/Poids (à l'exclusion du support)/Peso (sin incluir el soporte)/Вес (исключая подставку)

7. Weight of contents/Poids du contenu/Peso del contenido/Вес содержимого

8. Height of thermometer bulbs above the ground/Hauteur des réservoirs du thermomètre par rapport au sol/Altura de los termómetros con respecto al terreno/Высота резервуара термометра над земной поверхностью

9. Principal materials used in the construction of the screen/Principaux matériaux utilisés pour la construction de l'abri/Materiales principales utilizados en la construcción de la garita/Основные материалы, используемые для изготовления будки

| Syrian Arab Republic | U.S.A. |
| Thailand            | U.S.S.R. |
| Trinidad and Tobago | Venezuela |
| Tunisia             | Viet-Nam, Republic of Yugoslavia |
| Turkey              | Zaire |
| United Kingdom      | Upper Volta |

Non-Member country

German Democratic Republic
10. Design features/Caractéristiques particulières du modèle/Características del diseño/Особенности конструкции

11. References to publications describing the screen and its performance, summary of the most important findings from those investigations/ Références à des publications décrivent l'ébri et son fonctionnement, résumé des conclusions les plus importantes tirées de ces études/ Referencias a las publicaciones en las que se describe la garita y sus características de funcionamiento, con un resumen de los resultados más importantes de dichos investigaciones/ Ссылки на публикации, в которых дается описание будки и её технических характеристик, резюме наиболее важных выводов этих исследований
1. **AFGHANISTAN**

2. The BP - I louvered shelter is intended for shielding meteorological instruments such as thermometers, hygrometer, psychrometer from the effects of precipitation, wind gusts and solar radiation.

3. **BP - I**

4. **100%**

5. Overall dimensions of screen are 1.260 x 1.900 x 2.575 metres

6. **85 kg**

7. **- - -**

8. **2 metres**

9. Since wood is not a heat conductor, screen is made of wood and its stands from angle iron in the work-shop of the Afghan Air Authority.

10. The Afghan Air Authority does not have any plan, for the time being, to make major changes in the features of screens.

11. **- - -**
1. REPUBLICA ARGENTINA
2. Abrigo termométrico
3. Tipo "A"
4. 40%
5. 1,07 x 0,67 x 0,69 metros
6. 25 kg
7. 1,5 a 2 kg
8. 1,50 metros
9. Adjúntanse especificaciones*
10. Véanse las especificaciones y los planos adjuntos*
11. Publicación del Servicio Meteorológico Nacional, Serie "D" N° 6 (Termométrica)

Se realizaron ensayos para valorar diferencias de temperatura medidas dentro del abrigo meteorológico Tipo "B" instalado en la estación meteorológica y dentro de otro abrigo del mismo tipo instalado en las proximidades de las pistas de carreteras de líneas aéreas comerciales. Se determinaron diferencias medias no superiores a 1°C.

* No figuran en esta publicación
1. REPUBLICA ARGENTINA
2. Abrigo meteorológico polar
3. Tipo "Pagoda"
4. 100% de estaciones polares
5. 0,86 x 0,86 x 0,45 metros
6. 80 kg
7. 3 a 5 kg
8. 1,6 metros, aproximadamente
9. Adjúntanse especificaciones*
10. Véanse las especificaciones y los planos adjuntos*
11. — —

* No figuran en esta publicación
THERMOMETER SCREENS IN CURRENT USE

1. AUSTRALIA

2. Screen, thermometer large size - Stevenson type


4. 67%

5. 0.711 x 0.533 x 0.711 metres

6. Approximately 50.0 kg

7. Approximately 10.0 kg

8. 1.22 metres (dry and wet bulb) (min. 1.33, max. 1.41 thermometers)

9. Timber with brass fittings

10. The sides, front and back are double louvered, the roof is double, and the floor consists of overlapping boards separated vertically by an air space. There is a series of holes in the inner roof.

11. ---

1. AUSTRALIA

2. Screen, thermometer medium size - Stevenson type


4. 33%

5. 0.521 x 0.270 x 0.425 metres

6. Approximately 15.0 kg

7. Approximately 1.5 kg

8. 1.22 metres (dry and wet bulb) (min. 1.33, max. 1.41 thermometers)

9. Timber with brass fittings

10. The sides, front and back are double louvered, the roof is double, and the floor consists of overlapping boards separated vertically by an air space. There is a series of holes in the inner roof.

11. ---
1. AUSTRIA
2. See instruction material
3. Large thermometer screen
4. 100%
5. 0.760 x 0.455 x 0.577 metres
6. 45 kg
7. Variable, maximum about 5 kg
8. 2.00 metres
9. Dry pine-wood, for mountain stations oak-wood
10. - - -
11. Instruction for the making of the large thermometer screen with fittings (standardized)
1. BELGIQUE (Service météorologique de la R.V.A.)
2. Abri Stevenson en bois, ventilation naturelle, persiennes et toit doubles (voir détail)
3. Abri Stevenson grand modèle
4. 100 pour cent
5. 1,040 x 0,325 x 0,420 mètre
6. 41,200 kg
7. 4,800 kg
8. 1,580 mètre
9. Bois, zinc (recouvrement partie extérieure du toit), laiton (charnières et fermeture)
10. Largeur des persiennes extérieures et intérieures 25 mm; distance entre une persienne extérieure et une persienne intérieure 22 mm; partie inférieure du toit formée par trois planches disposées dans un même plan et séparées par un intervalle de 8 mm, porte unique, planche en chicane; le tout étant recouvert intérieur et extérieur d'une peinture blanche
11. ---
1. BELGIQUE (Institut royal météorologique)
2. Abri doublepersiennes
3. Type Stevenson
4. 100 pour cent
5. 1,05 x 0,60 x 0,72 (avant)
   0,55 (arrière) mètre
6. 60 kg
7. ---
8. 1,5 mètre
9. Bois, support en fer
10. ---
11. ---

1. BELGIQUE (Météo Wing - Force aérienne)
2. Abri Stevenson
3. ML 41
4. 100 pour cent
5. 0,41 x 0,70 x 0,70 mètre
6. 50 kg
7. 21 kg
8. 1,50 mètre
9. Bois : sapin rouge du nord
10. Peint en blanc
1. BRASIL
2. Abrigo de 2ª classe dupla conforme planta anexa
3. Abrigo de 2ª classe
4. 80%
5. 0,78 x 0,61 x 100 metros
6. De 70 a 90 kg
7. Variável de acordo c/ equip
8. 1,70 metros acima do solo
9. Madeira de lei, usada geralmente Cedra, bases de cimento e tijolo
10. Planta anexa
11. ---
1. **BULGARIA**
2. English type
3. ---
4. 99.99 - 100%
5. 0.635 x 0.475 x 0.485 metres
6. 45 kg
7. 5.5 kg
8. 2 metres
9. Wood - of pine wood
10. Double ceiling, the inner part is with 14 holes of 2 cm diameter, the bottom is made of a special floor for ventilation
11. ---

---

1. **CAMEROUN**
2. Abri Stevenson type anglais
3. ---
4. 90 pour cent
5. 1.25 x 0.60 x 0.65 mètre
6. ---
7. ---
8. 2 mètres
9. Bois de menuiserie pour les persiennes, le cadre et le toit intérieur. Plaque plane d'évérite pour le toit extérieur
11. ---
1. CANADA
2. Double-louvered Stevenson type
3. M.S.C. Thermometer screen - type B
4. 100%
5. 0.52 x 0.28 x 0.49 metres
6. 32 kg
7. Forced ventilation 6 kg. Natural ventilation 1 kg
8. 1.5 metres
9. Cypress or cedar (1st grade) for frame and floor. Waterproof fir plywood \( \frac{1}{4} \) in thick for louvers. White asbestos cement board \( \frac{1}{4} \) in thick for roof.
10. Double roof construction. Asbestos cement board whitens with age. Wooden portions of screen painted inside and out with one coat preservative and sealer and two coats exterior white enamel. Door swings downward on brass hinges.
1. CHILE
2. Cubo de madera con doble celosía en los cuatro costados
3. Cobertizo meteorológico tipo aviación
4. 64, 1%
5. 0,92 x 0,66 x 0,85 metros
6. 75 kg
7. 6,2 kg
8. 1,50 metros
9. a) Estructura: madera de raulí y alerce
   b) Anclaje: pernos, tornillos y bisagras de hierro
   c) Ensamble: cola fría
   d) Pintura: duco, blanco, brillante
   e) Cumbrera: cinc
10. Cubo de maderas de raulí y alerce de 0,92 x 0,66 x 0,85 mts., con tres paredes de doble celosía; doble puerta abisagrada, también de doble celosía cada uno; cielo raso de madera compacta; piso de madera de 5" con separación de 2" entre sí y techo separado de dos aguas con cumbrera de zinc
11. Referencias a las publicaciones en las que se describe la garita y sus características de funcionamiento: Guide to meteorological instrument and observing practices (WMO - N° 8.TP.3), pág. IV, 3, párrafo 4.2.2
1. **COLOMBIA**
2. Standard, pero con celosías sencillas
3. Tipo A
4. 50%
5. \(0,78 \times 0,73 \times 0,71\) metros
6. 43 kg
7. 6,5 kg
8. 1,80 metros
9. Madera de cedro
10. Diseño Standard
    Están construidos con persianas sencillas
11. - - -

---

1. **CYPRUS**
2. Louvered screen
3. Large thermometer screen
4. 100%
5. \(1,00 \times 0,30 \times 0,40\) metres
6. 35 kg
7. 12 kg
8. 1,2 metros
9. Good quality timber
10. Sides are double-louvered, roof is double, floor consists of overlapping boards
1. CZECHOSLOVAKIA
2. Double louvered wooden screen
3. Meteorological screen
4. 100%
5. 0.8 x 0.5 x 0.5 metres
6. Approximately 50 kg
7. Approximately 5 kg
8. 2 metres
9. Wood of the coniferous tree
10. ---
11. ---
1. DENMARK
2. Double louvered small screen
3. - - -
4. About 50%
5. 0.60 x 0.50 x 0.50 metres
6. About 20 kg
7. About 2.0 kg
8. 1.5 - 2 metres
9. Wood stand: wood or light steel frame
10. All sides double louvered, floor and ceiling of overlapping boards for ventilation, roof slightly inclined, separated from ceiling by air space about 5 cm
11. - - -

1. DENMARK
2. Large screen
3. - - -
4. 95%
5. 0.80 x 0.46 x 0.56 metres
6. 30 kg
7. 1.3 kg
8. 1.80 - 2.0 metres
9. White-painted wood (pine) roof plated with asbestos-cement, stand of wood (oak) or profiled steel
10. - - -
11. - - -
1. REPUBLICA DOMINICANA
2. Garita de celosía
3. ML-41-B (Weather Bureau)
4. 97%
5. 0.74 x 0.43 x 0.69 metros
6. 16 kg
7. 0.156 kg
8. 1.50 metros
9. Madera de roble
10. De madera, con celosías y doble techo inclinado en una sola dirección

1. EAST AFRICAN COMMUNITY (KENYA, TANZANIA AND UGANDA)
2. East African Meteorological Department Thermometer Screen
3. Standard screen
4. 100%
5. 0.762 x 0.762 x 0.686 metros
6. 157 kg
7. 7 kg
8. 1.22 metres
9. Wooden screen, aluminium sheeting on the roof, iron stand
10. Two sets of doors, facing north and south; each set being used for six months of the year, depending on the position of the overhead sun south or north of the Equator.
11. ---
1. ECUADOR
2. Abrigo termométrico de madera
3. Para estaciones de I y II orden
4. 35%
5. 0,790 x 0,495 x 0,505 metros
6. 70,750 kg
7. 5,990 kg
8. 2,00 metros
9. Madera incorruptible, todo vez que las casetas deben instalarse en sitios muy húmedos. La caseta está pintada interior y exteriormente con pintura al aceite, de color blanco
10. La caseta de este tipo posee una visera de madera en el frente de la misma para protección contra la entrada de radiación directa; el piso de la caseta está constituido por dos niveles que impiden el paso de lo contrarradiación
11. ---
1. ECUADOR
2. Abrigo termométrico de madera
3. Para estaciones de III orden
4. 65%
5. 0,455 x 0,365 x 0,505 metros
6. 44,500 kg
7. 2,090 kg
8. 2,00 metros
9. Madera incorruptible, una vez que las casetas deben instalarse en sitios muy húmedos. La caseta está pintada interior y exteriormente con pintura al aceite, de color blanco.
10. La caseta de este tipo posee una visera de madera en el frente de la misma para protección contra la entrada de radiación directa; el piso de la caseta está constituido por dos niveles, que impiden el paso de la contrarradiación.
11. - - -
1. ARAB REPUBLIC OF EGYPT

2. A rectangular louvered wooden box, with front door made of metal mesh; the ceiling is made of wood and the base made from metal mesh. The screen is covered with a solid wooden board 20 cm above it. The screen is fixed upon an iron stand 140 cm above the ground. Both the stand and the screen are painted white.

3. Egyptian screen (modified Stevenson screen)

4. 100%

5. $0.92 \times 0.66 \times$ front $0.86$ metres
   $0.66 \times$ back $0.66$ metres

6. 73 kg

7. Thermometers 2.5 kg
   Thermographs 13 kg

8. 1.60 metres

9. Wood, galvanized iron mesh, and iron stand

10. Modifications using metal mesh on the construction permit more natural ventilation within the screen

11. Observers handbook in meteorological instruments, Meteorological Department, Arab Republic of Egypt (in arabic)
1. **EL SALVADOR**

2. La experiencia adquirida en casi veinte años demuestra que la garita meteorológica normal de las latitudes medias (garita inglesa o Stevenson) con un techo pequeño no es apropiada para las regiones tropicales cuyos problemas más grandes son:

   i) ventilación suficiente para ambos termómetros, el seco y el húmedo (normalmente, velocidad del viento muy reducida)

   ii) protección contra las lluvias torrenciales, especialmente los chubascos fuertes y las tormentas súbitas que van acompañados con ráfagas de viento

   iii) protección contra los efectos de la radiación térmica (se realizaron ensayos con techos dobles)

   iv) estabilidad suficiente, especialmente de los techos ampliados, contra los vientos fuertes y persistentes durante la primera parte de la estación seca (Noviembre - Febrero)


4. 51%

5. **1,00 x 1,00 x 0,70 metros**

<table>
<thead>
<tr>
<th>Dimensiones del techo</th>
<th>anchura</th>
<th>largo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tipo TI</td>
<td>2,70 m</td>
<td>3,20 m</td>
</tr>
<tr>
<td>Tipo TII</td>
<td>2,70 m</td>
<td>3,20 m</td>
</tr>
<tr>
<td>Tipo TIII</td>
<td>3,30 m</td>
<td>3,30 m</td>
</tr>
</tbody>
</table>

6.  

7.  

8. **2,00 metros**

9. Tipo TI : madera - lámina de aluminio acanalada  
    Tipo TII : hierro - madera - lámina de aluminio acanalada  
    Tipo TIII: hierro - madera - lámina de aluminio acanalada
10. **Tipo TI**: Todo la estructura de madera; caja de instrumentos forrada de zaranda metálica de 1/4" mesh, techo de dos vertientes de lámina de aluminio. Al lado de la puerta de la garita se ha puesto zaranda fina entre la tijera, como "rompe lluvias"

**Tipo TII**: Estructura de hierro; caja de instrumentos de madera forrada de zaranda metálica de 1/4" mesh. Techo de dos vertientes de lámina de aluminio. También tiene "rompe lluvias"

**Tipo TIII**: Características semejantes a TII. La torre que sostiene la caja de instrumentos es independiente de la estructura del techo, para disminuir las vibraciones. Piso doble. El techo tiene "rompe lluvias"

11. **EL SALVADOR**

2. Véase la descripción en el párrafo 10.

3. **Tipo 1962**

4. **17%**

5. 1,00 x 1,00 x 0,60 metros
   Dimensiones del techo: 1,20 m de anchura; 1,20 m de largo.

6. **- - -**

7. **- - -**

8. 2,00 metros

9. madera, hierro, lámina de aluminio acanalada

10. Estructura de hierro; caja de instrumentos de madera con persiana doble en los cuatro costados, inclusive puertas. Piso sencillo de listones de madera. Techo de dos vertientes de lámina galvanizada o de aluminio
    Esta garita se parece más al tipo original de las latitudes medias. Fue un intento para simplificar la construcción y bajar los costos. El resultado fue que se empió el agua dentro de la caseta. Posteriormente fue prolongado el techo hasta más de 2,00 m. de largo sin dar resultados satisfactorios. Las pocas garitas existentes serán reemplazadas por los tipos TII o TIII

11. **- - -**
1. EL SALVADOR

2. Véase la descripción en el párrafo 10.

3. Tipo B (1968)

4. 32%

5. 0,60 x 0,60 x 0,60 metros
   Dimensiones del techo: 2,25 m de anchura; 1,20 m de largo.

6. - - -

7. - - -

8. 2,00 metros

9. madera, hierro, lámina de aluminio acanalada

10. Estructura de hierro; caja instrumental de madera, costados Norte y Sur (puerta) de doble persiana. Costados Oeste y Este de zaranda metálica de 1/4" mesh.
   Techo de dos vertientes de lámina de aluminio, con "rompe lluvias"

   Esta garita se usa para estaciones climatológicas ordinarias sin registros automáticos de temperatura y humedad relativa

11. - - -
1. FINLAND
2. --
3. Finnish standard screen
4. 100%
5. 0.44 x 0.30 x 0.47 metres
6. 18.0 kg
7. 2.7 kg
8. 2.00 metres
9. Wood (birch panel, plywood and timber), screws, nails and white glossy paint
10. --
11. --
1. FRANCE
2. Voir la photographie
3. Abri plastique modèle réduit
4. 2%
5. 0,49 x 0,49 x 0,45 mètre
6. 35 kg
7. De 0,5 à 4,7 kg
8. 1,40 mètre
9. Polyester armé fibre de verre et ABS
10. Parois à doubles persiennes séparées par une cheminée centrale
11. ---

1. FRANCE
2. Voir la photographie
3. Abri météorologique simplifié pour mesures d'évaporation et des températures extrêmes
4. (Abri expérimental) 0%
5. Abri ouvert
6. 15 kg
7. 0,2 kg
8. 1,50 mètre
9. Bois ou polyester
10. L'encombrement hors tout de l'abri, exprimé en cm, est 60 (largeur) x 60 (profondeur) x 86 (hauteur)
11. ---
1. FRANCE
2. Voir la photographie
3. Abri plastique grand modèle
4. 95%
5. 1,10 x 0,50 x 0,65 mètre
6. 100 kg (avec les pieds)
7. 6 kg
8. 1,50 mètre
9. Polyester armé fibre de verre et ABS
10. Parois à doubles persiennes séparées par une cheminée centrale
11. ---
THERMOMETER SCREENS IN CURRENT USE

1. FEDERAL REPUBLIC OF GERMANY
2. Weather screen (naturally ventilated, wet bulb thermometer: forced ventilation)
3. Model RWD 3
4. 100%
5. $0.720 \times 0.460 \times 0.580 - 0.575$ metres
6. 38.5 kg
7. 5.0 kg (thermometers + mounting 1.4 kg; thermohygrograph 3.6 kg)
8. 1.95 - 2.00 metres
9. Wood
10. Double louvered screen with double roof and a floor of three overlapping boards, inner and outer louvers jointed at their upper edges
11. 1. E. Kleinschmidt, Handbuch der meteorologischen Instrumente, Berlin 1935,
2. Deutsche Normen, DIN Vornorm 5451, Berlin, April 1933,
3. Richtlinien für Wetterdienstgerät, Reichsamt für Wetterdienst.

1. FEDERAL REPUBLIC OF GERMANY
2. Thermometer screen for resistance thermometers (with natural ventilation)
3. Kugelhütte type Prof. Dr. Baumbach
4. Not used within the network
5. (Diameter about 70 mm)
6. 0.2 kg
7. (Different)
8. About 2 metres
9. Aluminium
10. Aerodynamically formed thermometer screen for electric temperature measurements with reduced radiation error
11. ---
1. **GHANA**

2. A rectangular wooden box provided with doors at the back and front. The sides, back and front are double louvered.

3. Stevenson

4. 100%

5. $1.04 \times 0.45 \times 0.55$ metres

6. 42.18 kg

7. 12.25 kg

8. 1.10 metres


10. Double roof, base consists of overlapping boards separated vertically by an air space. Series of holes of one inch diameter with brass liners in the inner roof to help the air circulation between the inner and outer roof. Screen painted white and top covered with sheet aluminium.

11. *Handbook of Meteorological Instruments Part I.*
1. GREECE
2. Rectangular double louvered wooden box
3. EMY/66
4. 100%
5. 0.88 x 0.55 x 0.70 metres
6. 100 kg
7. 8 kg
8. 1.70 metres
9. Good quality Swedish timber
10. Double louvered wooden box provided with two doors at the front. The screen itself is supported on a stand consisting of four upright wooden legs and is painted white. The roof is double and the main roof is provided with a series of holes in order to facilitate air circulation in the screen. The outer roof is separated from the inner and its top is covered with sheet zinc
11. This type of screen has been used for many years with good performance by the Hellenic National Meteorological Service.
1. HONDURAS
2. 4 lados ventilados por medio de persianas sencillas
3. Abriga meteorológica
4. 100%
5. 0,70 x 0,45 x 0,72 metros
6. 40 kg
7. 7,5 kg
8. 1,50 metros
9. Madera, Precol (pegamento), tornillos y clavos
10. De acuerdo con el plano de abrigo meteorológico modelo ML-41B, soporte ML-42B
1. ICELAND
2. A wooden naturally ventilated screen on iron stand, designed for windy conditions and blowing snow
3. VI 1
4. Approximately 95%
5. 0.45 x 0.31 x 0.51 - 0.67 metres
6. 33 kg
7. 1 kg
8. 2.0 metres
9. Wood and plywood
10. Solid double walls, double roof and floor or overlapping boards. Smaller but otherwise similar to the Norwegian hard weather screen of 1933.
11. No printed report describing the Icelandic screen and its performance is available at present, but the screen has for some years been compared with a large English screen of the Stevenson type (inside dimension 39 in wide by 11½ in deep by 16½ high) at the weather station Hveravellir in the central highland of Iceland, and a report is in preparation.

During the summer months June to August the mean temperature in the Icelandic screen was 0.05 - 0.07°C lower than in the English screen, in May and September there was no difference, but from October to April the mean temperature in the Icelandic screen was 0.06 - 0.16°C higher than in the English screen. Due to slight variation of thermometer corrections with temperature, however, the highest winter differences should possibly be lowered by 0.04°C, i.e. the mean difference in January should be corrected from 0.16 to 0.12°C. In the summer half of the year there was a clear daily amplitude in the difference, the Icelandic screen being slightly warmer at night and colder during the day than the Stevenson type screen.

Individual differences of ± 0.8°C or more occurred in 1.9% of the observations but differences of ± 0.3°C or less were recorded in 86.5% of the cases.

The most important cause for the observed differences is considered to be difference in height between the two screens. The thermometer bulb in the Icelandic screen was 2.0 m above a sandy sparsely vegetated surface, while the corresponding figure for the English screen was 1.3 m.
1. **INDIA**
2. Conventional Stevenson screen with double louvers and double floor and ceiling
3. Stevenson screen
4. 100%
5. $0.560 \times 0.315 \times 0.412$ metres
6. 25.5 kg
7. 1.0 kg
8. 1.25 metres
9. Wood (Deodar)
10. See photograph
11. India Meteorological Department, Instructions to Observers at the Surface Observatory Part I (1954) published by the Manager of Publications, Government of India Delhi, pp. 89 - 92.
THERMOMETER SCREENS IN CURRENT USE

1. INDONESIA
2. - - -
3. S.M. 1
4. 5%
5. 1.14 x 0.83 x 0.95 metres
6. 150 kg
7. 20 kg
8. 1.38 metres
9. Teak - wood
10. Double roof, double louvered walls, two doors, double floor of nine overlapping boards. Height top of outer roof 1500 mm
11. - - -

1. INDONESIA
2. - - -
3. S.M. 2
4. 75%
5. 0.82 x 0.53 x 0.62 metres
6. 40 kg
7. 9 kg
8. 1.38 metres
9. Teak - wood
10. Single roof and single louvered walls, one door. Height in front (of the roof) 820 mm
11. - - -
1. INDONESIA
2. ---
3. S.M. 3
4. 20%
5. 0.82 x 0.53 x 0.63 metres
6. 75 kg
7. 9 kg
8. 1.38 metres
9. Teak - wood
10. Double roof, doubled louvered walls, two doors, double floor of three overlapping boards. Holes of 25 mm diameter in the inner roof. Height at centre of outer roof 990 mm

11. ---

1. IRAN
2. ---
3. (i) - Stevenson model, (ii) - American Standard model
4. (i) = 33%, (ii) = 67%
5. (i) = 1.0 x 0.40 x 0.58 metres, (ii) = 0.65 x 0.52 x 0.58 metres
6. (i) = 62 kg, (ii) = 57 kg
7. (i) = 30 kg, (ii) = 28 kg
8. 1.35 metres
9. Pine wood covered by white paint
10. ---
11. H.M.S.O. publication
   U.S. Weather Bureau - technical publication
1. ISRAEL

2. Israel Standard Shelter for climatological, synoptic and regional agrometeorological stations

3. Stevenson screen

4. 95%

5. 0.93 x 0.75 x 0.77 metres

6. 100 kg

7. 2.5 kg

8. 2.0 metres

9. Wood (pine)

10. Double louvered Stevenson screen with double roof and overlapping floor boards, painted white.


1. ISRAEL

2. Ship - Psychrometer screen

3. Thaller screen type I

4. 100%

5. Diameter 0.07 metres; Height 0.35 metres

6. 2.5 kg

7. 0.2 kg

8. Variable

9. Fibreglass


11. A new type of instrument shelter for agrometeorological and topoclimatological purposes; submitted to CIMO II Paris 1957. Tests showed that this type of shelter will give readings which are comparable with Assmann psychrometer values.
1. ISRAEL
2. Maximum-minimum shelter for agrometeorological and topoclimatological survey (under crop cover).
3. Thaller screen type 2
4. 100%
5. 0.4 x 0.12 x 0.11 metres
6. 4.0 kg
7. 0.2 kg
8. 1.5 metres or as required
9. Fibreglass
10. Portable louvered radiation shield for two thermometers, horizontally exposed (maximum, minimum or dry-wet), with vessel for distilled water. Naturally ventilated. Upper and outer surfaces white; undersides, except floor, black.

11. Reference I. A new type of instrument shelter for agrometeorological and topoclimatological purposes; submitted to CIMO II, Paris 1957. Tests showed that this type of shelter (at that time called type 3) will give readings which are comparable with Assmann psychrometer values.

Reference II. MacHattie 1965, found that this screen was in agreement with a Stevenson screen in rising or steady temperatures. Both were about 0.4°C above Assmann temperature during the afternoon. As the temperature began to fall, however, the Thaller screen came into agreement with the Assmann while the positive error of the Stevenson increased reaching 0.6 to 0.7°C at 1850 LMT.
1. ISRAEL

2. Shelter for four thermometers for agrometeorological and topoclimatological survey

3. Thaller type 3

4. 100%

5. $0.4 \times 0.16 \times 0.16$ metres

6. 5.2 kg

7. 0.4 kg

8. 1.5 metres or as required

9. Fibreglass

10. Portable louvered radiation shield for four thermometers, horizontally exposed, (maximum-minimum, dry and wet bulb) with hinged door and vessel for distilled water. Naturally ventilated. Upper and outer surfaces white; undersides, except floor, black.

THERMOMETER SCREENS IN CURRENT USE

1. ISRAEL

2. Shelter for one recording instrument (thermo-hygrograph) for agrometeorological and topoclimatological survey

3. Thaller screen 4

4. 100%

5. 0.4 x 0.16 x 0.3 metres

6. 5.2 kg

7. 2.0 kg

8. 1.5 metres or as required

9. Fibreglass


   Note: The screen can be supplied with increased internal height to accommodate maximum and minimum thermometer in addition to the recording instrument.

11. --

1. ISRAEL

2. Shelter for two elements (mercury-in-steel or other sensors of recording instruments) for agrometeorological, topoclimatological stations

3. Thaller screen type 5

4. 100%

5. 0.4 x 0.16 x 0.07 metres

6. 3.2 kg

7. 0.5 kg

8. 1.5 metres or as required

9. Fibreglass

10. Portable louvered radiation shield for two sensors, horizontally exposed near ground, with hinged cover. Naturally ventilated. Upper and outer surfaces white; undersides, except floor, black.

11. --
1. ISRAEL
2. New Israel Standard shelter for climatological and synoptic stations
3. Thaller screen type 6
4. 5%
5. Diameter 0.55; height 0.45 metres
6. 25.5 kg
7. 2.5 kg
8. 1.65 metres
9. Fibreglass
10. Louvered radiation shelter for four thermometers and one recording instrument. Two hinged doors and chart compartment. Naturally ventilated. Upper and outer surfaces white; undersides, except floor, black.

Test revealed that shelter Type 6 is colder than the Israel Standard with all values of run of wind and radiation. Scattered radiation inside this screen, with closed doors, was found to be 0.04% of solar radiation between 0.6 and 1.27 g cal cm⁻² min⁻¹ as against

<table>
<thead>
<tr>
<th>Shelter Type</th>
<th>Radiation Inside (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Israel Standard</td>
<td>0.60%</td>
</tr>
<tr>
<td>American cotton shelter</td>
<td>0.80%</td>
</tr>
<tr>
<td>British Stevenson Type 3</td>
<td>0.60%</td>
</tr>
<tr>
<td>Type 3 (Thaller)</td>
<td>0.40%</td>
</tr>
</tbody>
</table>

Ventilation inside T₆ was between 44% and 55% of ambient for winds of 1.1 to 2.0 m s⁻¹.
1. ITALY
2. Capannina meteorologica
3. IA/S - 3
4. 100%
5. 1.00 x 0.55 x 0.90 metres
6. Approximately 120 kg
7. Approximately 10 kg
8. Approximately 1.60 metres
9. Larch wood, double louvered walls, double layered roof, floor with overlapping boards, white painted inside and outside. Ordinary temperatures are measured using ventilated psychrometers inside the screen.
10. --
1. JAPAN
2. - - -
3. Aspirated thermal shield
4. 9%
5. Diameter 35 mm; length 200 mm
6. Approximately 10 kg
7. Approximately 200 g. Content: platinum resistance thermometer
8. 1.5 metres (height of intake for air)
9. Polished aluminium plate with thermal insulator inside
10. This screen is a thin cylinder. At the top, a motor driven fan is mounted, and the inside of the cylinder is covered with thermal insulator to avoid the influence of solar radiation.
1. JAPAN

2. — —

3. Instrument shelter Type: JMA No. 1

4. 91%

5. 1.125 x 0.98 x 1.51 metres

6. Approximately 200 kg

7. Approximately 7 kg. Contents: glass-thermometer, ventilated psychrometer, bimetalic-thermograph, hair-hygrograph

8. 1.5 metres

9. Wood painted white

10. Conventional type

11. — —
1. JORDAN
2. Rectangular double louvered and white pointed
3. Cosella/London
4. 16%
5. 1.000 x 0.320 x 0.415 metres
6. --
7. 9 kg
8. Dry and wet: 1.200 metres, Minimum 1.250 metres, Maximum 1.300 metres
9. Wood, glue and non-hygroscopic paint
11. --

1. JORDAN
2. Rectangular double louvered and white pointed
3. Jordanian screen (i) No. 01 and (ii) No. 02
4. (i) 48% (ii) 36%
5. (i) 0.995 x 0.480 x 0.560 metres, (ii) 0.990 x 0.335 x 0.450 metres
6. (i) 38 kg (ii) 36 kg
7. (i) 9 kg (ii) 6 kg
8. Dry and wet (i) 2.200 m, (ii) 1.100 m. Min. (i) 2.320 m, (ii) 1.150 m, Max. (i) 2.360 m, (ii) 1.200 m.
9. Wood, glue and non-hygroscopic paint
11. --
1. **REPUBLICHE KHMERE**

2. ---

3. Ferme grand modèle

4. 100 pour cent

5. $0.93 \times 0.53 \times 0.63$ mètre

6. 71 kg

7. 6,60 kg

8. 1,8 mètre

9. L'abri est en bois de cheou Teal (Dipterocarpus) peint en blanc.

10. Quelques décorations sur la toiture (voir photo ci-jointe)

11. ---

---

1. **KUWAIT**

2. Double louvered (large pattern)

3. Stevenson (BMO specification)

4. 100%

5. $0.99 \times 0.292 \times 0.42$ mètres

6. 39 kg

7. 7 kg

8. 1.25 mètres

9. Seasoned wood

10. This screen, manufactured to a British Meteorological Office specification, is designed to house two recording instruments usually a thermograph and a hygrograph as well as maximum, minimum and wet and dry bulb thermometers of the sheathed pattern.

11. The screen is widely used and hence its performance characteristics can be obtained from British Meteorological Office.
1. LUXEMBOURG
2. En bois de chêne
3. DIN 58656 type Lambrecht
4. ---
5. 0,76 x 0,46 x 0,51 mètre
6. Environ 45 kg
7. ---
8. 2,20 mètres
9. Bois de chêne
10. ---
11. ---
THERMOMETER SCREENS IN CURRENT USE

1. MADAGASCAR
2. Simples persiennes, base: planches disposées en chicane, plafond avec trous de ventilation, simple toit, ventilation naturelle
3. Modèle local
4. 80,8%
5. 0,51 x 0,25 x 0,50 mètre
6. 22,800 kg
7. 0,790 kg
8. 1,41 mètre
9. Bois, laiton, fer
10. ---
11. ---

1. MADAGASCAR
2. Doubles persiennes, base: planches disposées en chicane, plafond avec trous de ventilation, double toit ayant la forme de celui d'une pagode, ventilation naturelle
3. Modèle français (moyen format)
4. 12,0%
5. 0,59 x 0,33 x 0,63 mètre
6. 49,600 kg
7. 7,640 kg
8. 1,41 mètre
9. Bois, laiton, fer
10. ---
11. ---
1. MADAGASCAR
2. Doubles persiennes, base : planches disposées en chicane, plafond avec trous de ventilation, double toit ayant la forme de celui d'une pagode, ventilation naturelle
3. Modèle français (grand format)
4. 7,2%
5. 0,92 x 0,53 x 0,63 mètre
6. 95,300 kg
7. 7,640 kg
8. 1,63 mètre
9. Bois, laiton, fer
10. ---
11. ---
1. MALAWI
2. Wooden frame, aluminium louvers, asbestos roof
3. MK II Aluminium screen
4. 100%
5. ---
6. ---
7. ---
8. 1.37 metres
9. ---
10. The basic framework consists of eight pieces of angle iron onto which are bolted the wooden floor and ceiling, and the wooden box frames which contain the louvers. The four vertical pieces also act as stub legs at the bottom, and carry the roof on top.

    The louvers are made of aluminium strips, bent on each side of the centre at an angle of 40°. They are held in position by two locating strips of aluminium, slotted at one inch intervals, and the entire louver sections which total six in number are contained in wooden box frames as mentioned above.

    The roof of the screen consists of a single flat sheet of 3/8 in asbestos, bolted to the projecting angle iron frame a few inches above the ceiling, with a slight downward slope from front to back.

    The angle iron legs are bolted to the corners of a wooden box frame, the nut locking on a short piece of angle iron placed on the inside of each corner. This box frame also acts as the support for the screen stub legs.

    The aluminium louvers are treated with chrome-etch and are then spray painted with two coats of Titonine white heat-resistant paint.

11. ---
1. MAURITIUS
2. Large Stevenson screen M.O. pattern (but using tropical woods)
3. ---
4. 100%
5. As M.O. pattern
6. 39 kg
7. Approximately 0.25 kg, except 2.5 kg at Plaisance and Vacoas where the thermometer bracket is displaced to the right to accommodate recording instruments.
8. 1.22 metres
9. Wood
10. ---
11. ---
1. MAROC
2. Abri météorologique réduit
3. Abri ONM type marine
4. (Réseau climatologique) 80%
5. 0,50 x 0,32 x 0,45 mètre
6. 40 kg
7. 0,8 kg
8. ---
9. Sapin rouge et chêne, peinture laquée blanc neige
10. Les persiennes de largeur 30 et 40 mm sont réunies au sommet; la distance entre persiennes est de 15 mm.
11. Les études comparatives entreprises depuis 1969 à Casablanca, Division de Climatologie, Météorologie Agricole et Hydrométéorologie, entre les caractéristiques des éléments météorologiques mesurés sous l'abri grand modèle et l'abri réduit du Service Météorologique du Maroc démontrent l'urgence de la définition précise d'un abri standardisé si l'on veut obtenir pour les températures une précision supérieure à 0,5°C.

Cas deux abris, en bois peint laqué blanc neige, sont du type Stevenson à doubles persiennes dissymétriques réunies à leur partie supérieure. Ils diffèrent par leur hauteur au-dessus du sol (1,75 et 1,35 m), leurs dimensions (0,92 x 0,52 x 0,63 et 0,50 x 0,32 x 0,45) et leur toit, qui est double, en forme de pagode, pour le grand modèle et simple pour l'abri réduit.

La comparaison, effectuée sur les extrêmes diurnes de température, confirme les résultats obtenus par différents chercheurs, à savoir que l'abri placé le plus bas accentue l'amplitude thermique diurne. Il majore de 0,43°C la température moyenne maximale diurne annuelle et réduit de 0,41°C la moyenne minimale. Le détail mensuel montre que l'écart sur les températures maximales est plus important en été qu'en hiver (respectivement 0,68°C et 0,33°C sur les températures maximales moyennes d'août et de janvier) et que le phénomène est inversé pour les températures moyennes minimales mensuelles (0,07°C en juillet et 0,59°C en février).

Les différences constatées étant plus importantes que dans les travaux semblables effectués en Europe, un programme d'étude actuellement en cours cherche à discerner la part de l'imperfection dans la conception des abris et celle de la structure thermique verticale dans les basses couches propre au climat marocain.
1. MAROC
2. Grand modèle à double toit
3. Anglais modifié ONM
4. (Réseau synoptique) 100%
5. 0,92 x 0,52 x 0,63 mètre
6. 75 kg
7. 8 kg
8. Psychromètre 1,95 mètre, max. - min. 2,15 mètres
9. Sapin rouge et chêne, peinture laquée blanc neige
10. Les persiennes, de largeur 30 et 40 mm, sont réunies au sommet; la distance entre persiennes est de 17 mm.
11. Voir rapport pour l'abri ONM type marine ci-dessus.
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>NETHERLANDS</td>
</tr>
<tr>
<td>2.</td>
<td>Type Stevenson</td>
</tr>
<tr>
<td>3.</td>
<td>K.N.M.I. 04.1.004</td>
</tr>
<tr>
<td>4.</td>
<td>Nearly 100%</td>
</tr>
<tr>
<td>5.</td>
<td>0.64 x 0.49 x 0.52 metres</td>
</tr>
<tr>
<td>6.</td>
<td>35 kg</td>
</tr>
<tr>
<td>7.</td>
<td>Approximately 9 kg</td>
</tr>
<tr>
<td>8.</td>
<td>1.50 metres</td>
</tr>
<tr>
<td>9.</td>
<td>Wood</td>
</tr>
<tr>
<td>10.</td>
<td>Easy dismantling into parts (walls, roof and bottom)</td>
</tr>
</tbody>
</table>

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1.</td>
<td>NETHERLANDS</td>
</tr>
<tr>
<td>2.</td>
<td>Screen with American louvers</td>
</tr>
<tr>
<td>3.</td>
<td>Mobile-type screen 04.2.003</td>
</tr>
<tr>
<td>4.</td>
<td>Used for temporary extension of network only</td>
</tr>
<tr>
<td>5.</td>
<td>0.36 x 0.30 x 0.34 metres</td>
</tr>
<tr>
<td>6.</td>
<td>8 kg</td>
</tr>
<tr>
<td>7.</td>
<td>4.6 kg</td>
</tr>
<tr>
<td>8.</td>
<td>1.50 metres</td>
</tr>
<tr>
<td>9.</td>
<td>Wood</td>
</tr>
<tr>
<td>10.</td>
<td>Small, easily transportable screen</td>
</tr>
<tr>
<td>11.</td>
<td>On average, the amplitude of the mean daily course measured in a mobile-type screen is 7% greater than the amplitude measured in a Stevenson screen. The mean daily course measured in the mobile-type screen shows on average a negative time-lag of about 10 minutes compared with that measured in a Stevenson screen (unpublished).</td>
</tr>
</tbody>
</table>
1. NETHERLAND ANTILLES
2. U.S. Weather Bureau type
3. So-called cotton-region type
4. 100%
5. 0.70 x 0.46 x 0.70 - 0.66 (slant roof) metres
6. Approximately 30 kg
7. Approximately 6 kg
8. 1.53 metres
9. Wood
10. At two stations (in near future at three stations) temperature measured with electrical resistance thermometers. For this purpose the screens were converted by adding a wooden housing for the ventilation-motor under the bottom of the screen. A one-gallon bottle for supplying water to a porous-tube is mounted inside the screen. Locally constructed with the aid of pictures and known dimensions
11. -- --
1. NEW ZEALAND
2. Large, double louvered thermometer screen
3. Large thermometer screen LTS Drawing 102
4. 25%
5. 1.0 x 0.3 x 0.42 metres
6. 38 kg
7. 9.9 kg
8. Height of ordinary thermometer bulb above the ground: 1.22 metres nominal
9. Wood
10. Double louvers and double roof. Substantially the same as British Meteorological Office large thermometer screen (Stores Ref. Met 226)
11. ---
1. **NEW ZEALAND**
2. Small double louvered thermometer screen
3. Small thermometer screen, Drawing 116
4. 75%
5. $0.14 \times 0.18 \times 0.29$ metres
6. 9.5 kg
7. 0.3 kg
8. Height of ordinary thermometer bulb above the ground: 1.27 metres nominal
9. Wood
10. Double louvers and double roof. Substantially the same as British Meteorological Office small thermometer screen (Stores Ref. Met 578)
11. ---

![Thermometer Screen Diagram](image-url)
1. **NIGERIA**
2. Large thermometer screen
3. Casella Model W.3720
4. 100%
5. 0.99 x 0.29 x 0.42 metres
6. 39 kg
7. 0.4 kg
8. 1.37 metres
9. Strong, well seasoned wood, painted white
10. The screen is made locally to the above specifications
11. Meteorological Instruments Catalogue No. 877 by C. F. Casella and Co. Ltd.,

1. **NORWAY**
2. --
3. MI 33 and MI 46
4. MI 33: 41%, MI 46: 59%
5. 0.730 x 0.730 x 1.080 metres
6. 140.0 kg
7. 3.0 kg
8. 2.0 metres
9. Wood
10. --
11. Meteorologiske Annaler
   BD 2 nr. 12 1947, Kåre Langlo; Investigations on
   the air temperature observed in various types
   of Norwegian thermometer screens.
1. **PAKISTAN**

2.) Stevenson screen of British Meteorological Office specification

4. - - -

5. - - -

6. - - -

7. - - -

8. - - -

9. - - -

10. - - -

11. - - -

---

1. **PERU**

2. De madera, de celosía doble, sostenida sobre cuatro soportes

3. Abrigo meteorológico, Modelo "A"

4. 37%

5. 1,00 x 0,60 x 0,85 metros

6. 52,500 kg

7. 10,500 kg

8. 1,65 metros

9. (a) Madera pino oregón  
   (b) Tornillos de bronce

10. Celosía doble; techo doble, con agujeros en el techo interno para facilitar la ventilación vertical libre; pintada de blanco

11. Diseñada por la Misión de Expertos de la OMM en el año 1962

   No se han efectuado investigaciones
1. PHILIPPINES

2. Shelter has louvered sides, double roof, slatted bottom and contains cross board spanning interior for mounting of thermometers. Door opens downward and is oriented to the true North.


4. 90%

5. 0.850 x 0.710 x 1.210 metres

6. 127 kg

7. 6.42 kg

8. 1.83 metres

9. Philippine hord wood, iron angles, iron straps, galvanized iron for flash hips and ridges, iron wire mesh, brass hinges, latch and barrel bolt, wood screws, lead paint and exterior white enamel paint.

10. Designed for exposure to direct sunlight; mounted on wooden support anchored to concrete footings by means of iron straps bolted to the base of the support. Louvered sides allow free flow of the air over the thermometer bulbs.

11. ---
1. Poland
2. 
3. Meteorological screen
4. 100%
5. $0.71 \times 0.47 \times 0.56$ metres
6. 44.0 kg
7. 2 - 10 kg depending on equipment
8. 2 metres
9. Wood
10. 

1. Portugal
2. 
3. Stevenson
4. 97.5%
5. $0.71 \times 0.43 \times 0.52$ metres
6. 48 kg
7. 5.2, 3.9 or 3.2 kg
8. 1.5 metres

9. Yellow pine, brass screws and pins, fibre-cement roof and enamel paint
10. 
1. SINGAPORE
2. Louvered wooden screen
3. Conventional Stevenson screen
4. 100%
5. 1.3 x 0.5 x 0.8 metres
6. 20 kg
7. 3 kg
8. 1.5 metres
9. Wood
10. Conventional Stevenson screen
11. ---
1. SOUTH AFRICA
2. Standard large Stevenson screen
3. Drawing No. W.301
4. 100%
5. $0.77 \times 0.34 \times 0.55$ metres
6. 60 kg
7. 6 kg
8. 1.2 metres (dry bulb and wet bulb)
9. Wood, with solid brass hinges, screws, hasp and staple
1. ESPAÑA
2. Stevenson, con doble techo y ventilación natural
3. Grande
4. 
5. \(0.68 \times 0.58 \times \) anterior \(0.65\) metros \(0.59\) posterior
6. 100 kg
7. 
8. 1.40 metros
9. Madera y cubierta de zinc
10. 
11. 

1. SURINAM
2. Double louvers
3. 
4. 100%
5. \(0.70 \times 0.50 \times 0.70\) metros
6. 40 kg
7. 
8. 1.25 metros
9. 
10. 10 louvers per 50 cm
11. 

1. Sweden
2. Louvered screen
3. - - -
4. 100%
5. 0.610 x 0.420 x 0.550 metres
6. 40 kg
7. 0.5 to 6.6 kg depending on selection of instruments:
   - Thermograph: 3.8 kg
   - Thermometer: 0.1 kg
   - Remote temperature sensor: 1.2 kg
   - Assmann: 1.1 kg
   - Hair-hygrometer: 0.2 kg
8. 1.50 metres
9. Wood
10. The walls of the screen are double louvered, the floor is made of overlapping boards and the roof is double layered with provision for ventilation of the space between the two layers
11. - - -
THERMOMETER SCREENS IN CURRENT USE

1. SUISSE
2. Type Stevenson
3. Modèle anglais ISM
4. 100 pour cent
5. 0.88 x 0.51 x 0.60 mètre
6. Environ 50 kg
7. Environ 7.5 kg
8. 2.00 mètres
10. Double porte pivotant autour d'un axe vertical
11. ---

1. SYRIAN ARAB REPUBLIC
2. Double louvered wooden box
3. ---
4. 90% : 20% of them with metal stand, the rest with wooden stand
5. 0.86 x 0.53 x 0.60 metres
6. Approximately 50 kg
7. Approximately 5 kg
8. 1.67 metres
9. Wood, white painted with screws and a sheet of zinc to cover the roof.
10. The roof sloping to the back; front height of screen from outside 77 cm; back height outside 68 cm
11. ---
1. THAILAND
2. Double louvered screen
3. Thermometer screen
4. 100%
5. 0.57 x 0.54 x 0.48 metres
6. 35 kg
7. 50 kg
8. 1.50 metres
9. Teak
10. According to Stevenson screen type
11. --

1. TRINIDAD AND TOBAGO
2. --
3. Large Stevenson pattern thermometer screen
4. All surface synoptic reporting stations
5. 0.99 x 0.29 x 0.42 metres
6. 40 kg
7. Approximately 5 kg
8. 1.2 metres
9. Wood
10. --
11. --
1. TUNISIE
2. Abri en bois avec persiennes dont les lames ont une section en V renversé. Double toit incliné
3. Abri anglais
4. 90 pour cent
5. 0,905 x 0,51 x 0,57 mètre
6. 46 kg
7. 8 kg
8. 1,50 mètre
9. Bois
10. ---
11. ---

1. TURKEY
2. ---
3. 250
4. 100%
5. 0.86 x 0.38 x 0.63 metres
6. 67 kg
7. Approximately 10 kg
8. 1.60 metres
9. Wood
10. The screen is double louvered, double roofed, painted white and it has one door. Provision for free vertical ventilation by convection. The walls and the top of the Screen are protected from precipitation and direct solar radiation.
11. ---
1. UNITED KINGDOM
2. Marine thermometer screen
3. Mk IB.MET 21761
4. 700 selected and supplementary observing ships
5. 0.18 x 0.13 x 0.39 metres
6. Approximately 8 kg
7. 0.23 kg (2 thermometers, water bottle)
8. Height of thermometer bulbs above the deck: approximately 1.5 metres
9. Wood
10. Sides, back and door single louvered. It has a double roof, the top roof
double pitch, and a floor of three louvers at 45°. Door at the front hinged
at the right-hand side. Painted white inside and out.
11. — —
1. UNITED KINGDOM
2. Large thermometer screen
3. MET 21771
4. 50.2%
5. 0.99 x 0.29 x 0.42 metres
6. Approximately 34 kg
7. 12.11 kg (thermograph, hygrograph, 4 thermometers, water bottle)
8. 1.25 metres
9. Wood
10. Sides, back and door are double louvered. It has a double roof and a floor of overlapping boards separated vertically by an air space. Door at the front hinged at the bottom. Painted white inside and out.
1. UNITED KINGDOM
2. Standard thermometer screen
3. MET 21772
4. 25.9%
5. 0.44 x 0.29 x 0.42 metres
6. Approximately 23 kg
7. 0.37 kg (4 thermometers, water bottle)
8. 1.25 metres
9. Wood
10. Sides, back and door are double louvered. It has a double roof and a floor of overlapping boards separated vertically by an air space. Door at the front hinged at the bottom. Painted white inside and out.

Köppen, W., 1913: Met Z, Braunschweig, 30, p. 474.

Standard deviation of the differences between two screens on the same site is about 0.18°C. On days with bright sunshine the afternoon screen temperature is about 0.4°C higher than that measured by an aspirated thermometer. The log of the screen in minutes is given approximately by \( 8.2 V^{-2} \) where \( V \) is the wind speed \( m \ s^{-1} \). The screen is penetrated by radiation reflected from a snow surface.
1. UNITED KINGDOM
2. Small thermometer screen
3. MET 21773
4. 13.1%
5. 0.42 x 0.16 x 0.31 metres
6. Approximately 11 kg
7. 0.37 kg (4 thermometers, water bottle)
8. 1.25 metres
9. Wood
10. Sides, back and door double louvered. It has a double roof, the top roof double pitch, and a floor of overlapping boards separated vertically by an air space. Door at the front hinged at the bottom. Painted white inside and out.
11. Apart from small differences which can be attributed to its shorter lag this screen gives temperatures very similar to those from the Standard thermometer screen MET 21772


1. HAUTE-VOLTA
3. BMO-1150 nomenclature française
4. 70 pour cent
5. 1,05 x 0,50 x 0,65 mètre
6. 100 kg
7. ---
8. 1,68 mètre
9. Plastique
10. L'abri est essentiellement conçu pour assurer la ventilation des instruments et leur protection contre les rayonnements réfléchis ou diffus (parois à doubles persiennes, fond constitué par deux rangées de plaques perforées en chicane, double tait peint en blanc).
11. Recueil de fiches instrumentales
1. UNITED STATES OF AMERICA

2. Box with louvered sides, double roof, slatted bottom and hinged door

3. Instrument shelter, medium standard (cotton region type), specification number 450.0615

4. 95%

5. 0.76 x 0.51 x 0.80 metres

6. Approximately 36 kg

7. 2 to 4 kg

8. 1.5 metres

9. Wood

10. - - -

11. Description given in: Shelter, instrument, medium standard (cotton region type)


1. UNITED STATES OF AMERICA

2. Aluminum thermal shield, motor aspirated

3. Thermal shield, HO61-A101

4. 5%

5. Diameter 0.34; height 0.98 metres

6. 41 kg

7. 2-3 kg

8. Height of air intake to thermometer bulbs above the ground 1.2 metres

9. Aluminum, glass

10. Thermometers are protected from radiation by an outside aluminum skirt, an aluminium shield inside the skirt, and a double-walled silver-coated glass flask inside the inner aluminium shield. A motor aspirator creates a rapid flow of air past the temperature elements.

11. - - -
1. U.S.S.R.
2. Double louvered, floor with air penetration, closed ceiling
3. Psychrometric louvered screen COST (Government Standard) 4189-48
4. 100%
5. 0.46 x 0.29 x 0.525 metres
6. --
7. --
8. 2 metres
9. Wood (metal is also accepted for supporting stand). After priming the internal and external surfaces are painted with white oil-base paint
10. --

1. СССР
2. Стенки двойные жалюзийные, полок продувной, потолок слоеной
3. Будка психрометрическая жалюзийная ГОСТ 4189-48
4. 100%
5. 0,46 x 0,29 x 0,525 метров
6. --
7. --
8. 2 метра
9. Дерево, для подставок допускается металла. После грунтовки внутренние и наружные поверхности покрываются белой масляной краской
10. --
1. **VENEZUELA**
2. Garita con simples celosías; doble techo
3. Garita tropical
4. - - -
5. $0,75 \times 0,42 \times 0,90$ metros
6. 50 kg, aproximadamente
7. 8 kg
8. 1,80 metros
9. Caoba a cedro
10. Garita con simples celosías en los 4 lados, debido a que hay un alto porcentaje de calmas nocturnas; doble techo; exterior e interior en blanco
11. - - -
1. REPUBLIQUE DU VIET-NAM
2. ---
3. Abri météorologique Type "Indochine"
4. 95%
5. 0,500 x 0,300 x 0,600 mètre
6. 50 kg
7. Environ 8 kg
8. 1,58 mètre
9. Bois de teck
   Fer plat (pattes de fixation et équerres de consolidation)
10. Porois à double persienne
    Toit plein, double
    Plancher ajouré
11. Dessin No. 195 du 22-4-1950 communiqué par l'Office Météorologique National de France
1. REPUBLIQUE DU VIET-NAM
2. Abri thermométrique
3. "Small Shelter" HARZA Engineering Company International Mekong River Project
4. 3\%
5. 0,45 x 0,32 x 0,37 mètre
6. Environ 10 kg
7. Environ 0,30 kg
8. 1,60 mètre
9. Bois Fer (fixation et assemblage)
10. Toit plein, double Parois pleines (non persiennées) Face Nord fermée par 2 battants Face Sud non fermée Plancher ajouré
11. ---

1. REPUBLIC OF VIET-NAM
2. ---
3. "Big Shelter" HARZA Engineering Company International Mekong River Project
4. 2\%
5. 0,97 x 0,50 x 0,60 mètre
6. Inconnu
7. Environ 8 kg
8. 1,60 mètre
9. Bois Fer plat (pattes de fixation - équerres de consolidation (pattes d'assemblage
10. Toit plein non doublé Parois à double persienne Plancher ajouré
11. ---
1. YOUGOSLAVIE
2. Une caisse parallélepipédique en bois, montée sur un support en bois ou métallique. C'est un type modifié de l'abri Stevenson.
3. Abri météorologique type I et II
4. 95 pour cent
5. 0,76 (type I) 0,64 (type II) x 0,475 (type I et II) x 0,485 (I et II) mètre
6. Environ 55 kg
7. Environ 10 kg
8. 2 mètres
9. Bois de pin
10. Abris météorologiques du type I et II de fabrication standard, utilisés dans le Service hydrométéorologique de Yougoslavie. La caisse est faite en bois de pin, le support est en bois ou métallique (fer profilé). Les abris sont tous peints en blanc. Si besoin est, la caisse peut être houblonnée.
11. ---
1. ZAïRE
2. Abri météorologique
3. INEAC
4. 100%
5. 1,10 x 1,10 x 0,75 mètre
6. 85 kg
7. 7 kg
8. 1,50 mètre
10. Persiennes simples de 20 cm de large et espacées de 6 cm. Toit à double paroi avec circulation d'air entre les parois
11. L'abri : Type INEAC a été étudié par la section de climatologie de cet organisme.

L'abri INEAC a été adopté par le Service météorologique en 1957 et a remplacé un modèle d'abri plus petit, mais également équipé de persiennes simples. Les lectures de comparaison ont montré que l'abri INEAC est en moyenne plus frais de 0,2°C que l'ancien modèle utilisé avant 1957.

Le principe des persiennes simples a été adopté au Zaïre en se basant sur le fait que l'accroissement éventuel de la température sous abri dû au rayonnement réfléchi est largement compensé par une meilleure ventilation; ce qui n'est pas le cas, dans le bassin du fleuve Congo, avec des persiennes doubles, étant donné que les vents sont généralement faibles.

L'ancien modèle d'abri météorologique avait les dimensions intérieures suivantes : 0,90 m x 0,80 m, hauteur 0,75 m, persiennes simples larges de 6,5 cm et espacées de 2 cm.

Aucun des deux abris n'a de plafond intérieur, indépendant du toit, mais le plancher est monté en chicane.
1. GERMAN DEMOCRATIC REPUBLIC
2. Synthetic plastic screen
3. --
4. --
5. 0.76 x 0.45 x 0.56 metres
6. --
7. --
8. --
9. Synthetic plastic and metal
10. It is of the same construction and size as the conventional wooden model which has been used for many years
11. --